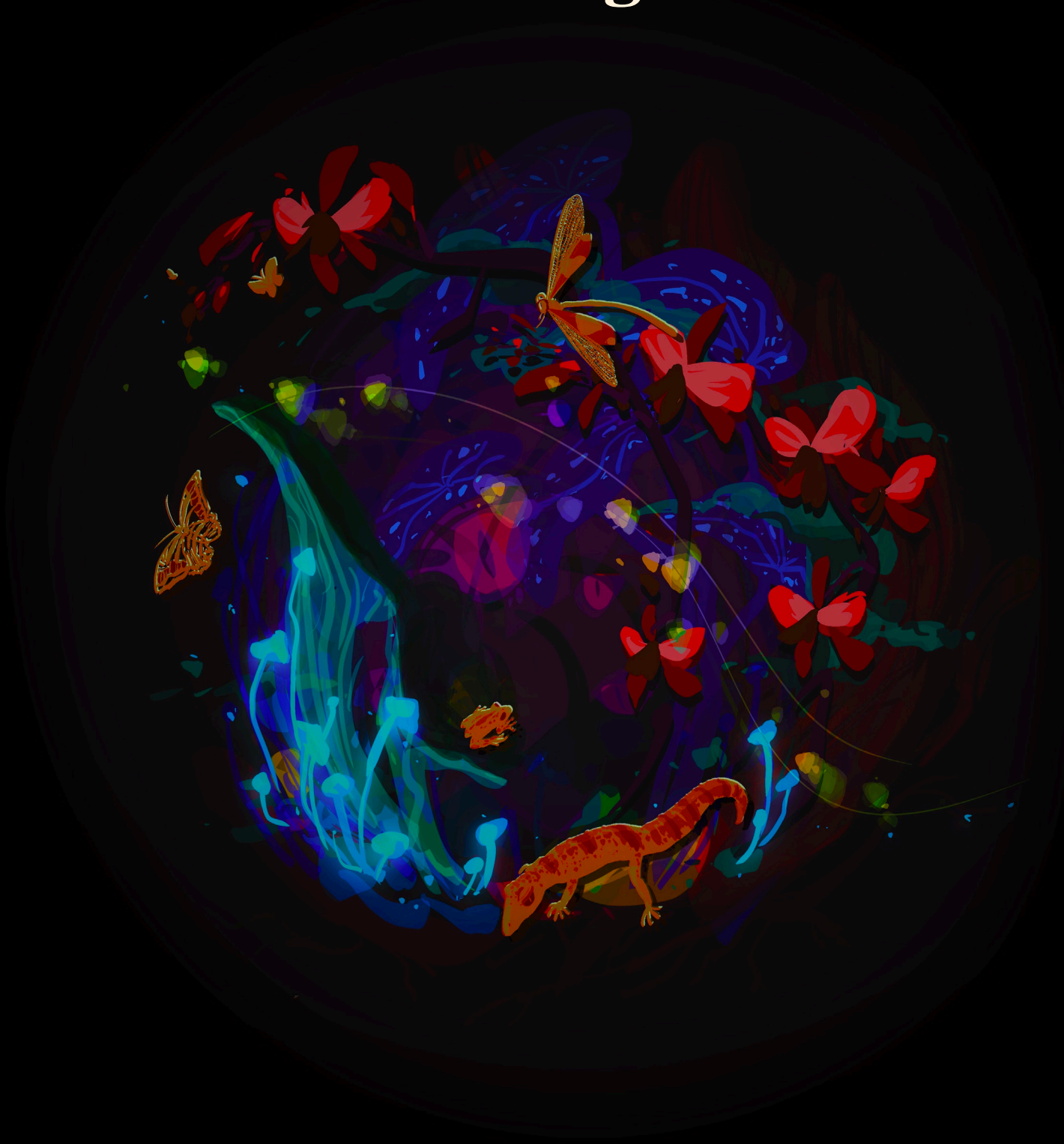
KINESIS

magazine



ISSUE 10

CONTENTS

BRAIN AND BEHAVIOUR

BIOLOGY AND THE WORLD

FASCINATING FLORA AND FAUNA

REVIEWS AND STORIES

A LETTER FROM THE EDITOR

As the academic year winds down, we at Kinesis Magazine are proud to be publishing our final issue of the year. This issue is an amalgamation of the incredible talent, passion and skill of all our contributors. Between forensic botany, the science of psychedelics, the 'body horror' film genre and more, this issue takes its readers on an electrifying journey to the frontiers of science. We are very grateful to everyone who has taken the time to contribute to it.

Over the past year, Kinesis Magazine society has become bigger than it ever was before. It was truly amazing to witness all the new talent, perspectives and ideas that have come to shape our various publications. From pitching out-of-the-box ideas to our magazine to formulating fascinating episodes of our podcast — the influx of new talent has invigorated our society. Although many members of our current committee and larger society will graduate and leave UCL this year, we are proud to know that we are leaving Kinesis Magazine in capable and enthusiastic hands.

Speaking personally, this society has been a keystone of my university experience and I feel emotional at the thought of leaving it behind. Amidst the whirlwind of pursuing a bachelor's degree in science, Kinesis helped me keep my child-like sense of wonder alive. Here was a space where science nerds could congregate to research their hearts out — for fun. I met some of my closest friends at Kinesis, and I will be forever grateful for the supportive and welcoming environment fostered by this society. Not to mention, the keen editing skills I gained have definitely saved me a few marks here and there.

To everyone who partook in this adventure with me and made the past few years at Kinesis as memorable as they were, I truly hope that it was as wonderful for you as it was for me. To those of you continuing on at UCL, I hope you enjoy Kinesis as much as we did and I can't wait to see how you continue to shape this society in the future.

Priyanka Peres
Managing Editor

THE SCIENTIFIC REASONS BEHIND BEREAVEMENT

THE ORIGINS OF GRIEF AND HOW IT AFFECTS US

WRITTEN BY ALICE HO
ART BY ALIA MUSTAFA

Grief is a universal emotion. In fact, grief even extends to animals — a recent study discovered that dogs grieved after losing other canines they had lived with, becoming less playful, more fearful, more attention-seeking and eating less. The most well-known model of grief outlines five stages: denial, anger, bargaining, depression and acceptance. However, the model was never actually about bereavement, but the process of coming to terms with death. The truth is, everyone grieves differently, and the grieving process does not necessarily occur in any particular order.

The effects of grief start in the brain. Grief is perceived as a threat, and the brain rewires to adapt. The prefrontal cortex, which typically oversees reasoning and decision-making, becomes overtaken by the limbic system, a more primal brain region responsible for survival behaviours. Our fight-or-flight response gets activated, releasing the hormone cortisol which may induce stress reactions such as panic attacks. This is also how the brain enforces rest for itself. The limbic system, also known as the 'emotional brain', filters which emotions and memories are perceived. Once the prefrontal cortex returns to its original level of functioning, we can reflect deeply on our loss and our own life, giving us potential for personal growth. However, negative health impacts can also arise from grief. Grief heightens levels of inflammation, and chronic inflammation is known to contribute towards type 2 diabetes and cardiovascular disease.

Although grieving seems like the most instinctive and humane response to loss, it seems counter-intuitive to think that the potential emotional pain and health impairment could have enhanced the survival of our hunter-gatherer ancestors, which raises questions regarding its evolutionary origin. One popular explanation from psychology and evolutionary theory is the 'attachment theory', which frames grieving as a reaction to being separated from loved ones. For children in the hunter-gatherer era, close attachments to family members are crucial to survival. Upon separation, an intense 'protest' phase is elicited, involving lots of crying which should urge the parent to return. This behaviour persists today and is also reflected in grieving adults as the same separation is experienced. Crying can also draw support from others in the community, helping to comfort and protect the grieving individual in a time of vulnerability. Another response during this phase is 'searching' for the loved one that has been lost and may manifest as behaviours like believing to have seen the deceased alive, or a strong desire to find and see their body.

Following the 'protest' phase is the 'despair' phase. For infants, if their parents fail to return after an extended period of time, they begin to withdraw. Similarly, the withdrawal period supplies time for grieving individuals to process their loss. Therefore, the 'protest' phase of grief may have evolved to achieve a balance between seeking for the presence of loved ones and becoming detached when there is no hope of finding them. The attachment theory has been corroborated by MRI scans of the brain's reward centre, the nucleus accumbens, showing increased activity when grieving individuals recalled the deceased fondly.

Another explanation is derived from the 'social learning theory', which suggests that grief may be a warning not to repeat mistakes that compromise survival -– hunter gatherers would be sure to never eat a certain mushroom if they knew someone died after consuming it.

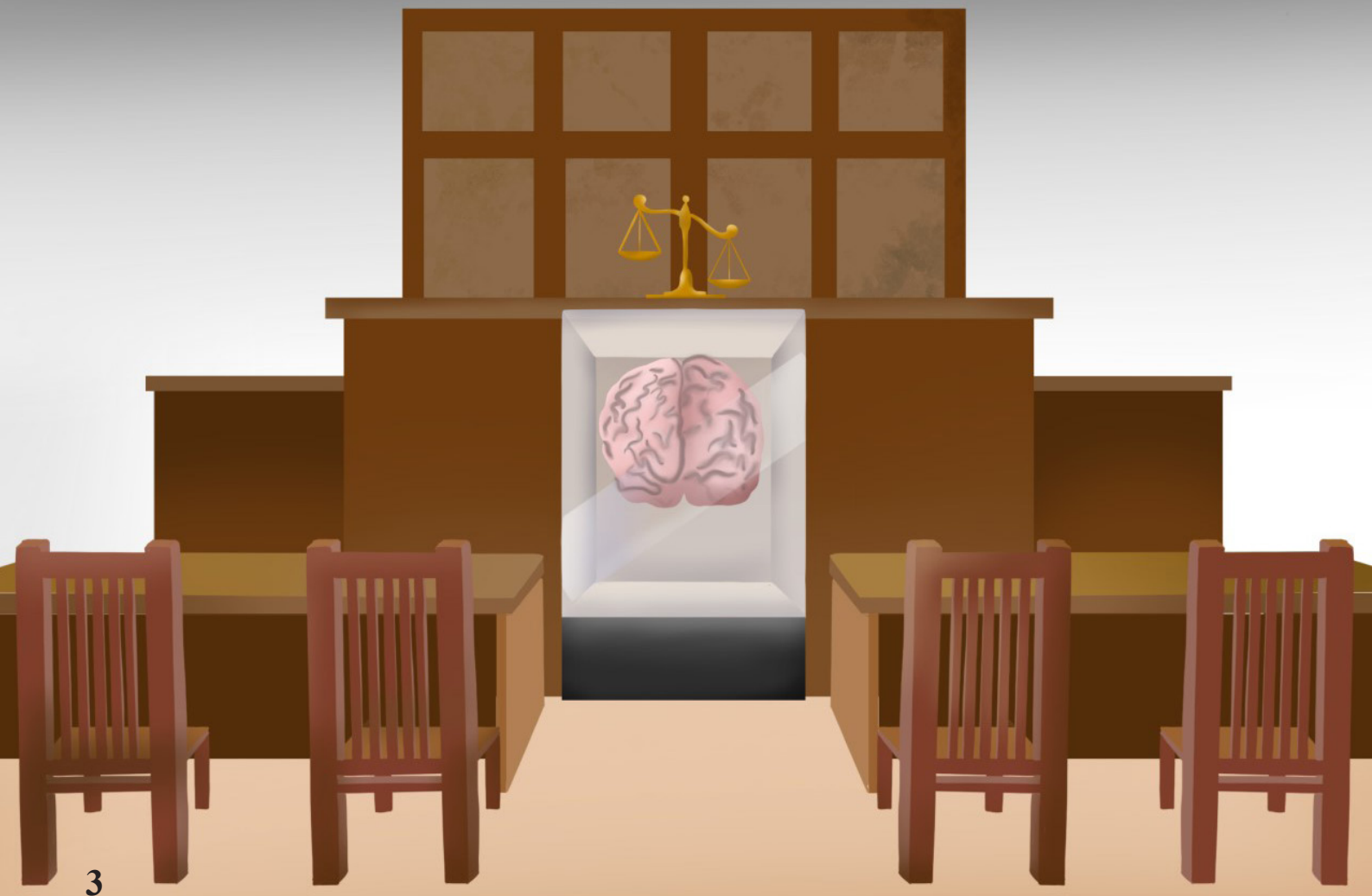
Lastly, the 'assumptive world theory' revolves around the value of feeling secure and stable for survival. Sudden loss disrupts our world and shatters existing beliefs, causing disorientation and even panic. This may explain why when we face more abstract losses, such as a disrupted relationship with a loved one, we also experience feelings of grief - termed as 'ambiguous grief".

Despite addressing its evolutionary advantages, these theories do not explain why some grieve differently, or do not experience much grief at all. The reason may simply be that evolution is a blunt instrument and the same response mechanisms may not be instilled in everyone. While no formulaic response exists, 'complicated' or 'prolonged grief", where grief is experienced intensely over extended periods of time, may necessitate treatment. Nonetheless, it is important to support everyone grieving, not necessarily by trying to make them feel better – simply providing company and a listening ear makes all the difference.

The Brain in the COURTROOM

"Once it becomes clinically relevant, it will become legally relevant"

- Francis Shen



In 2002, Sheila Berry bashed her friend to death using a large cinder block in a fit of inexplicable rage. Only months later, Berry had a brain tumour removed. This tumour was shown to be connected to Berry's rage – as the tumour grew, so did her aggression. Post-surgery, Berry's aggressive behaviour essentially vanished. Years later, a jury in Massachusetts found her guilty of first-degree murder. However, in 2014, the Massachusetts Supreme Court decided that it was a miscarriage of justice to hold Berry responsible, especially after the testimonial of a neuroscience expert detailing how the location of her tumour was apt to cause problems with disinhibition and aggression.

This is just one of the ways the brain is finding its way into the courtroom. Over 1500 judicial opinions between 2005 and 2012 have mentioned neurobiological evidence – essentially an argument suggesting that their "brains made them do it". Evidence, which can be anything from brain scans to neuropsychological exams, is being used in more and more legal cases of all kinds. An analysis of US criminal cases found that 60% of sampled cases involved non-capital crimes, such as robbery and fraud – cases that we don't necessarily think require neurobiological evidence.

When thinking about using neuroscience in the courtroom, our imaginations often drift to situations where volition and choice of the perpetrator are questioned. However, these concepts are not well-understood by scientists yet. Although there may be some insight, it is mainly at the population-level, which does not tell us why a specific person acted the way they did. Thus, neurobiological evidence is not as commonly used to determine guilt or innocence as we might believe.

Rather, such evidence is intertwined in sentencing decisions. When dealing with juveniles, developmental neuroscience has aided constitutional prohibitions against life imprisonment. Understanding that the adolescent brain is in a transitional stage of limited executive control can inform long-term sentencing and culpability. Beyond juveniles, neurobiological claims aid in mitigating sentencing, including by arguing that the defendant's counsel was incompetent as they failed to introduce neurobiological evidence during the sentencing period of the trials. Introducing such evidence has been found to decrease death sentences, reduce guilty verdicts, and reduce sentence length in some cases.

As neuroscience is increasingly being used in the legal system, it opens the possibility to bring different sorts of claims, such as "invisible" tort injuries. This would include post-traumatic stress disorder, emotional suffering, and traumatic brain injuries. With the ability to peer into the brain's perception of pain, this could revolutionise how we think about tort law and compensation. We no longer should limit tort claims to physically visible injuries. Tort law should reflect the strides society has made in matters regarding mental health and recognise that invisible injuries can be as debilitating as those we can see.

Painting a utopian vision of neurolaw would be remiss. The differing paradigms between the scientific and legal communities creates murky waters. Neuroscience is objective and needs to meet a certain threshold of reliability. As useful as brain scans are, they are simply proxy measures of brain function. Human subjectivity is inherently embedded in the interpretation of neurobiological data, which could lead to doubts of credibility. The legal system and judges need to be aware of its interpretations and manipulations, and the impacts on jurors.

There are also issues with consistent definitions of behaviours. Behaviours are complex and subject to environmental influence, making them difficult to measure. Science can inform the law, but ultimately, cannot dictate it.

Written by Ebani Dhawan
Art by Sophie Maho Chan

WRITTEN BY MAHIDHAR SAI LAKKAVATAM
ART BY SUMMER CHIUH

MAGIC MUSHROOMS AND MENTAL TRAUMA

CAN PSYCHADELICS BE THE NEXT BIG GAME CHANGER IN THE FIELD OF MENTAL HEALTH?

Psychedelics, specifically "shrooms" or magic mushrooms, have always been at the forefront of controversy for their reality-altering effects. From feelings of euphoria to dizziness and blurred vision, these types of fungi hold a lot of power over one's body. Recent studies have found that psychedelics can help with mental trauma and are actively being considered for legalisation under medical conditions. So, how do these magic mushrooms work? Can they really help with mental trauma?

Firstly, it is not the mushrooms themselves that cause the hallucinations, but a chemical within them called psilocybin that is found in certain strains of fungi. These types of mushrooms are used as recreational drugs and can cause distortion in a way that's similar to other hallucinogens as well, like lysergic acid diethylamide (LSD).

Psilocybin mostly targets the prefrontal cortex of your brain, where it engages your serotonin receptors. This area is in control of your mood, cognition and perception, so when the psilocybin enters your system, all three of these can be altered, thereby bringing about the numerous effects that are associated with magic mushrooms. These effects are wide-ranging and depend on various factors like your history with the drug, the amount entering your system, and even your height and weight. Some examples of psilocybin's positive side effects are more elated emotions and a sense of relaxation, and the negative ones would be vomiting, irregular breathing, and blurred vision.

So, how could they help with mental trauma?

This brings us into the concept of psychedelic therapy. For context, people with Post-Traumatic Stress Disorder (PTSD) or those overcoming other forms of trauma responses often require some form of treatment to help with their mental health struggles. PTSD is a condition in which someone experiences a traumatic event and has difficulty recovering from it, thereby making it hard for them to function in their daily life. It can cause anxiety, nightmares, and even severe emotional distress when something reminds them of the traumatic event, amongst other symptoms. As such, people suffering from it are presented with two options for treatment: the first route is psychotherapy, which is the use of psychological methods to help the affected person process the trauma and look at different options for moving forward from it, and the other is with medication, like antidepressants.

While both methods have had tangible results, they do still have their flaws. For instance, medication often fails in aiding with chronic PTSD, or with those suffering from multiple traumas over a period of time. This is where psychedelics could come in.

Research has been conducted to understand the use of psychedelics as a new form of therapy for PTSD, especially given their long-term effects on the mind. A study on mice concluded that psilocybin can help activate nerve cell regrowth (neurogenesis) in the hippocampus, the part of the brain that controls traits like emotions and memories. In the study, the psilocybin was injected into the mice and then trace fear conditioning was used, which was measured as the amount of time the mice were immobile. The results showed that psilocybin helped the mice overcome their fear better as compared to the mice with a placebo, which would be crucial for people with PTSD as it could potentially help them with their fear as well.

Another study conducted on terminally-ill cancer patients also showed that a single use dose (0.3 mg/kg, which is roughly a microdose of shrooms) of psilocybin brought them relief from distress. The participants stated that after the dose they felt their quality of life improve—they became more energetic and active in their communities. Although one dose was able to have such an impact, the effect is short-term, so microdosing on a daily basis will bring about a more long-term effect. Based on these results, researchers believe that psilocybin-based products (like magic mushrooms) can be used to treat numerous other psychological medical conditions as well.

The legalisation of magic mushrooms for mental trauma

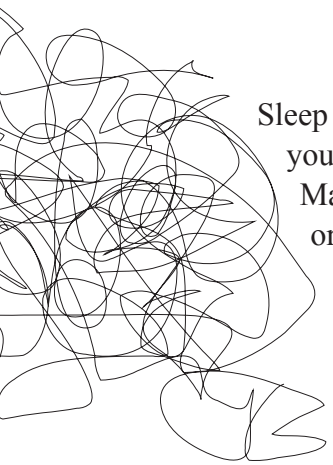
Given these promising results and the potential seen in psychedelic therapy, it would be ideal for magic mushrooms to be legalised for such forms of therapy. However, the concept is still a sharp double-edged sword: while there are a lot of positives with the idea of legalisation, psychedelics still can have harsh and adverse effects on one's mind, which may not necessarily be the safest method. If taken in a high dosage, magic mushrooms can induce anxiety attacks and panic attacks, or even facilitate visions that could remind patients of their trauma instead. Clinical trials are therefore the only way to determine whether psychedelics should be legalised for mental trauma. There are many variables that can't be accounted for with the given information, so deeper investigation is necessary.

With that said, 2022 is being called the "Year of Psychedelic Legalisation". Various states across the United States have already begun decriminalising these drugs in January, and Canada has also made progress towards the same goal. The United Kingdom is not too far behind, with Boris Johnson announcing in October 2021 that he will start examining the latest scientific advice on the legalisation of psilocybin.

Whether it is now or in a couple of years, magic mushrooms are promising to be revolutionary in the field of mental health, especially given how effective their usage can be. The next few years will be crucial in determining how psychedelics' potential will be maximizsd, and it'll be interesting to see the extent to which they can be legalised. Maybe one day you could buy shrooms just like any other medicine!

The Importance of Catching Zzz's;

WHAT HAPPENS WHEN WE DON'T GET ENOUGH SLEEP?



Sleep is a necessity for us all. Whether you fall asleep instantly after laying your head upon your pillow, or after tossing and turning during the night, we all get varied amounts of sleep. Many things can interfere with this process such as sleep disorders, occupational night shifts, or stress and anxiety. Despite spending a third of our lives sleeping, we underestimate the importance of sleep, believing that a few days of minimal sleep will have no long-term impact on ourselves. However, we are sadly mistaken.

Acute sleep deprivation is defined as being awake for more than 16-18 hours per day for two consecutive days. If this persists for 3 months or more, it becomes a chronic sleep disorder. These hours of missed slumber can result in sleep debt. This debt cannot be repaid with one night's worth of optimal sleep (7-9 hours). Instead, it's paid back over many nights if enough sleep is achieved. However, this is difficult to do; for instance, if you have young children or a sleep disorder such as insomnia. Although our bodies can adapt to surviving on less than substantial sleep, it does not mean that it's healthy for us in the long run. Lowered immunity has been related to sleep deficit. More fittingly in today's society, poor sleep relates to a decrease in vaccine immunological memory. A study from 2011 showed that sleep is necessary for the adaptive immune system to enhance the production of antibodies, an immunological response to pathogens, or in this case, the hepatitis A vaccine. Pathogens are recognised by the immune system, from the proteins on their cell surface known as antigens, which are differ from our own. This induces an innate immune response: your body's first action against invading pathogens, before the more tactical adaptive immune system is activated, making specific antibodies against the unfamiliar antigens. A higher antigen response, that generated more antibodies, was found in patients who had more sleep after their vaccination. Therefore, sleep is essential in enhancing the antigen-antibody response.

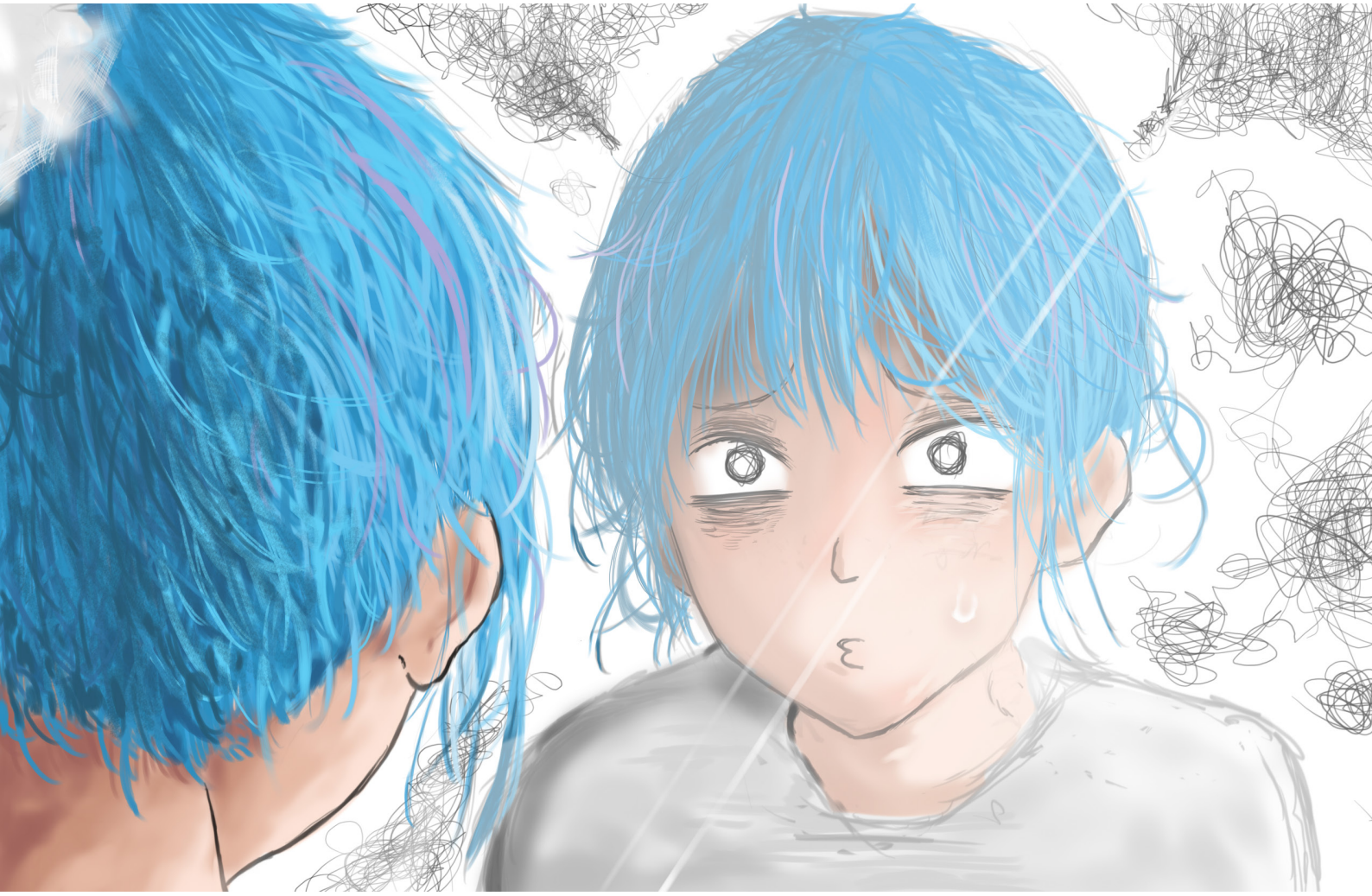
Inadequate sleep has also been associated with high blood pressure, known as hypertension. During sleep, your blood pressure dips naturally in a process known as "nocturnal dipping." Less time spent asleep decreases the time in which this dip can occur, increasing the risk of cardiovascular disease. Moreover, people who consistently don't get enough sleep tend to be hungrier during their waking hours, since sleep regulates our hormonal system. When deprived of sleep, we have more of the hormone ghrelin, which tells us when we're hungry, and less of leptin, which tells us when we're full. Thus, less sleep is associated with a higher risk of obesity. Furthermore, less sleep is also implicated in type 2 diabetes. This is when the beta cells in your pancreas produce insufficient amounts of the hormone insulin, in response to the increased sugar within your bloodstream, after a meal. Over time, your insulin receptors become resistant, so more insulin is required to achieve the normal physiological response that was previously seen. Excess glucose present in the bloodstream, known as hyperglycaemia, if left untreated, can induce a coma - not the type of unconscious state you want to be in to catch up on your sleep.

Insufficient sleep can negatively impact our psychological well-being, leading to increased irritability, diminished concentration and memory recall - all caused by depriving the body of the time it needs to rest. Moreover, there is a heightened risk of developing Alzheimer's disease associated with sleep deprivation. A 2018 study highlighted the necessity of sleep in clearing out unwanted proteins from cells, more specifically, the protein beta-amyloid. After one night of missed sleep, volunteers had increased beta-amyloid accumulation around their hippocampus, one of the brain regions affected in Alzheimer's disease. High levels of beta-amyloid can clump together to form plaques, which are associated with the demise of neurons in the brain, leading to memory loss.

Written by Catherine Turnbull
Art by Zach Ng

However, there is one rare neurological disease that has rapidly fatal implications associated with sleep deprivation. Once symptoms occur, these patients will eventually lose all ability to sleep and their inevitable death will occur within months of onset. This disease is known as fatal familial insomnia (FFI). FFI is genetically inherited by a parent carrying the mutated copy of the PRPN gene which encodes the prion protein. In this disease, the mutated prion protein cannot be cleared out effectively from cells. It spreads throughout the brain, causing neuronal death, like beta-amyloid plaques in cases of Alzheimer's disease. FFI targets the thalamus, which is vital for regulating our sleep/wake cycle, causing complete disarray to a core brain function that permits us to fall asleep each night. This leads to the most severe consequence of no sleep: death. However, this is nothing to lose sleep over. Although there is no cure, FFI is very rare, so any impact on your sleep is likely to be less destructive and more manageable than this incurable genetic disorder.

We may not yet understand the full reasons behind why we sleep, but what we do know is that getting enough sleep is healthy for us - without it, we would die. So take the time out of your day, if you can, to ensure you can have the best sleep possible. Looking after yourself should ensure that you get the sleep your body so desperately needs, for both your physical and psychological well-being.



REMYELINATION

Axons in whales can be up to 30 meters long and yet the information has to go from one neuron to the next one in a matter of milliseconds. How is that possible? Luckily, evolution provided vertebrates with myelinated axons. This means that the axon is covered with a membrane that insulates and protects it. Just like the electrical cables of your computer charger which are also covered to insulate and protect them against damage. The only difference is that myelin is not a continuous sheath around an axon, unlike a cable around a wire, but rather there are periodical gaps called nodes of Ranvier. Now imagine your neuronal system is just like the roads in your country, and the axons are the highways communicating from one city to another. Your car is about to transport the electrical information from one city to the next, but since you are driving at super speed, and the two cities are far away, you need to stop at some gas stations along the way in order to keep up that speed. This is just like the nodes of Ranvier, which increase the conduction speed, allowing the potentiation of the electrical signal.

In an emergency, who are you going to call? OPCs at your service.

Who are the construction workers in charge of creating this myelin? It is the oligodendrocytes, a type of glial cell found in the central nervous system, that take charge of this domain. Analogously, Schwann cells can fulfil this same role for the peripheral nervous system. These cells wrap around the axons and protect them using

myelin. Sometimes, this myelin can be broken down or degraded due to injury, pathogenic attacks or by an immune system response. In those cases, your car runs out of fuel and will eventually stop before arriving at its destination, interrupting the flow of information. In other words, the axon becomes vulnerable, unable to transmit the electrical signal, and will eventually degenerate and die. This loss of myelin, also known as demyelination, can be solved by making new myelin sheaths. Easy peasy, right? But who will you hire for the job? Our main protagonists for the task are the oligodendrocyte progenitor cells (OPCs). Under normal conditions, adult OPCs are quiescent (inactive). When there is demyelination, the adult OPCs are activated by the alarm, just like firefighters, and then they migrate to the site of injury whilst proliferating to increase in number. Finally, once they have reached their target, they start differentiating into new oligodendrocytes which will then remyelinate the axons.

When remyelination fails: treatments and therapies.

In some diseases, such as multiple sclerosis, this process is inefficient, leading to remyelination failure. This is most commonly due to an inability of OPCs to differentiate into new oligodendrocytes. To surpass this remyelination failure, scientists have come up with two different strategies: either enhance endogenous remyelination or utilise OPC exogenous transplants.

To enhance endogenous remyelination, researchers normally enhance positive regulators of OPC differentiation (by upregulating the molecules that propitiate their differentiation) or inhibit negative regulators of it (by removing what is preventing their differentiation).

In contrast, if your OPCs are on strike or overworked, you might need external help. In those cases, a transplant of OPCs is the solution. The market of OPCs includes samples from different origins: fetal and adult brain tissue, embryonic stem cells or induced pluripotent stem cells (iPSCs). Each one of these sources has its own pros and cons. Fetal tissue must be obtained from abortuses or pathological samples. Moreover, adult brain tissue and fetal tissue can only undergo very limited rounds of replication, and so their progeny is scarce. This can be solved by using embryonic stem cells or iPSCs. These are pluripotent cells, meaning that they can differentiate into any type of cell from the body and self-replicate many times over. This can be both a pro, as we will obtain many OPCs, but also a con, as with a high cell proliferation rate, there is an increased risk of developing tumours. Furthermore, with all exogenous transplants, we need to be aware of the rejection risk of the donor cells. The recipient body will see it as unfamiliar tissue and start attacking and destroying the foreign cells. A solution would be to use tissue or cells taken from the same body. To do this, we obtain cells from the recipient themselves, normally skin cells as these are easily accessible. Then we can reverse these differentiated cells into iPSCs, which can be later redifferentiated into any type of cell that is required, like OPCs or oligodendrocytes. These lab generated OPCs can now be placed into the recipient's brain and won't be attacked as they are the patient's own cells. This might look like magic, but it's not - it's just science! This strategy is particularly attractive for patients with remyelination failure due to mutations in their OPCs. In those cases, the mutations can be corrected during the iPSC stage and then these will differentiate into healthy OPCs that will be grafted back into the patient.

Overall, we can see how scientists are coming up with new and imaginative strategies to treat remyelination defective diseases. It's clear that this field is moving at a vertiginous speed, just like the electrical information in finely myelin-coated axons.

Written by Anna Pujol Castiblanque
Art by Patrick Marenda

IN ABNORMALITIES LIE NORMALITY

Questioning the medical definition of disability by at milestones in genetic engineering.

During a typical rainy-gloomy London February week, I made my trip to the Francis Crick Institute for an exhibition concerning genome editing, and the shining star of the evening was CRISPR-Cas9. Created in 2012, CRISPR-Cas 9 has quickly made its way into becoming the trendiest, most prominent tool for "tweaking" genetics of any species, with its precision, scientific efficiency and economic nature. CRISPR arrays enable bacteria to "remember" viruses (or closely related ones). If the viruses strike again, the bacteria employ the CRISPR arrays to generate RNA segments that target the viruses' DNA. The bacteria then employ Cas9 or a similar enzyme to cleave the DNA apart, rendering the virus inoperable.

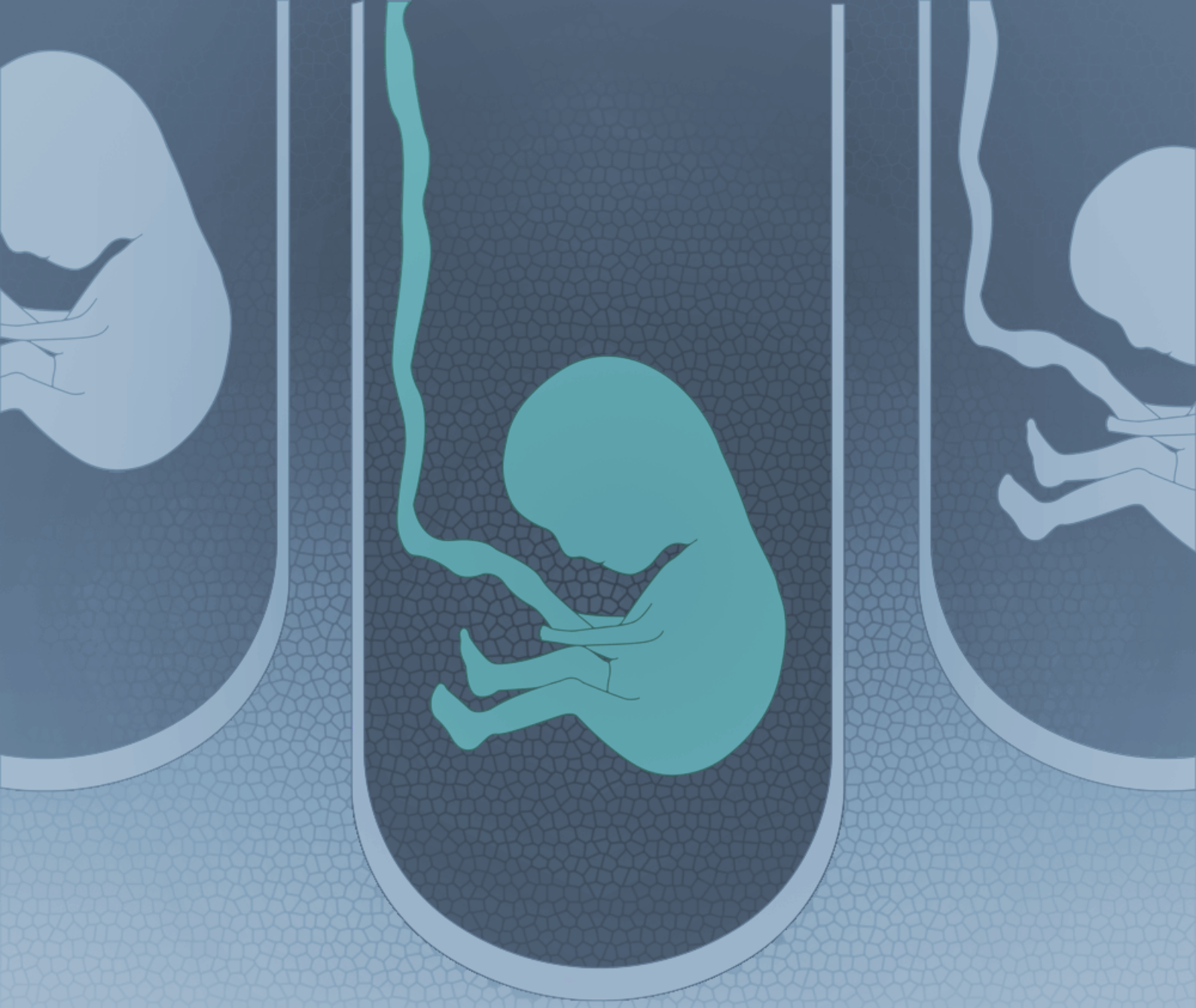
The invention was so significant that its two co-researchers, Emmanuelle Charpentier and Jenifer Doudna, were awarded the Nobel prize in Chemistry in 2020. Needless to say, the discovery offers the keys to numerous scientific issues, ranging from a drug to cure HIV, to studies of underlying molecular mechanisms of certain diseases. However, the most exciting possibility of all, that has scientists and medical practitioners raving is the complete eradication of genetic diseases or genetic transmissions.

Intriguing as the conference at the Francis Crick institute was, I was most affected after a conversation with a young researcher on the controversy of genetic engineering, especially germline genetic engineering. As our conversation sweeps from the basic structures of CRISPR-Cas9 to the utterly shocking event of November 2018, with the birth of two CRISPR-Cas9 gene-edited baby girls, targeted by the gene CCR5, with the aim to eradicate any possible HIV transmission. The rebellious attempt receives countless backlash and criticism, raising the fear of a possible "eugenics" future era.

The discussions were cycling in my head, and then one afternoon, I was reminded of a paper that I have read several years ago, where a deaf couple utilised PGD to ensure that their prospective offspring will be deaf.

The two stories were proposed distinctly, yet, what was similar between them is the criticism, the controversy and the "avant-garde" ness. Genetic selection and modifying tools have both been employed to achieve the most "desirable embryos".

What is it, then, that defines the characteristics of **a desirable embryo?** According to the Procreative Beneficence proposed by philosopher Savalescu, parents should conceive a child with no disability, and if possible with desirable features as outlined in general-purpose means. According to the current Equality Act 2010 definition of the UK government, you are disabled under the Equality Act 2010 if you have a physical or mental impairment that has a 'substantial'



and ‘long-term’ negative effect on your ability to do normal daily activities.

In order to dissect and critique the above definitions, I looked into several surveys concerning deaf individuals’ life satisfaction, who according to societal standards, are considered disabled and less advantaged due to their loss of a sense. However, rather than clinging to the social stigma, deaf people actually cherish their deafness, and it was given the name “deaf gain”, with next generations of deaf parents feeling more comfortable being within the deaf community compared to their hearing friends.

This perspective from the lens of people outside the social norm urges me to think about our definition of normalcy in today’s societies.

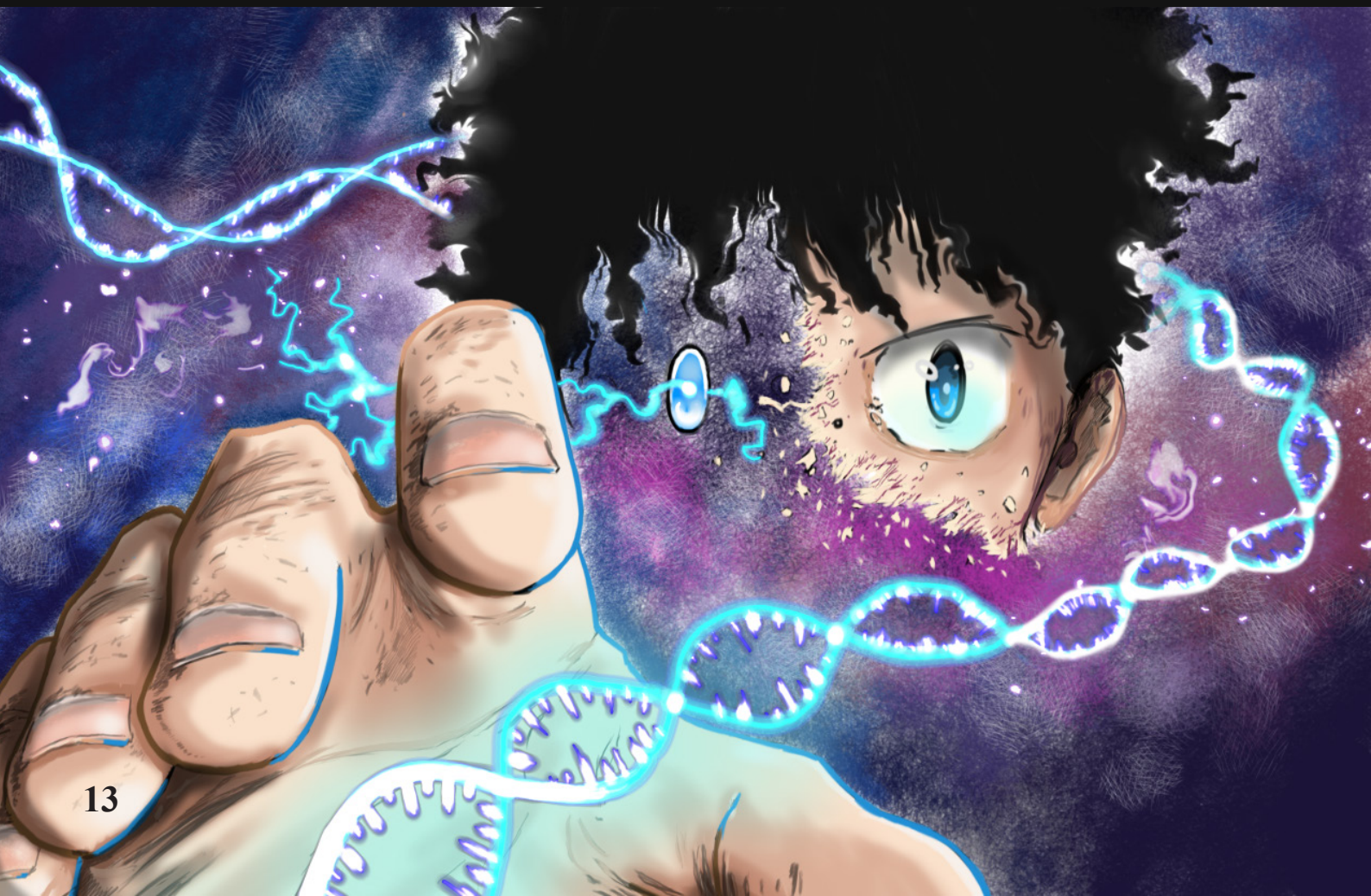
What are your thoughts, dear reader?

Written by Evelyn Nguyen
Art by Vedika Rajavat

“Dark matter” genome driving new species evolution?

Genetic “dark matter” may drive the emergence of new species.

The findings suggest a way to rescue “doomed” animal hybrids.



According to Jagannathan et al. (2018), these lengthy, repeating segments of the genome, known as satellite DNA, may eventually prohibit mismatched animals from mating by scrambling the chromosomes in their hybrid offspring. If animals from distinct populations are unable to mate, they will diverge over time, resulting in speciation.

Only 1% of the 3 billion nucleotides in the human genome are 'coding' - used to build the proteins that define features like eye colour and height. Other regions of DNA may, among other things, inform the body how many copies of a protein to create or switch genes on or off in various organs. Despite this, over 10% of the human genome is made up of long, repetitive lengths of satellite DNA that scientists didn't believe accomplished anything for many years, according to research co-author Madhav Jagannathan, an assistant professor at the ETH Zurich Institute of Biochemistry in Switzerland. Satellite DNA repeats were quite prevalent in species and extensively seen in eukaryotes or life-forms with cell nuclei, however, they were mostly discarded as junk DNA according to Jagannathan.

However, in a 2018 study, Jagannathan, then at the Massachusetts Institute of Technology (MIT), and his former postdoctoral supervisor, biologist Yukiko Yamashita, also at MIT, revealed that part of this DNA fulfilled an important function: it organises DNA inside the nucleus of a cell. This research discovered that specific proteins capture DNA molecules and arrange them in tightly packed bundles of chromosomes known as chromocenters. They discovered that satellite DNA instructs these grabby proteins on how to bundle and order chromosomes.

Jagannathan and Yamashita discovered another job for satellite DNA in the latest research, which was published on July 24 in the journal Molecular Biology and Evolution. The researchers were looking at fertility in the fruit fly Drosophila melanogaster. The flies' chromosomes distributed outside the nucleus after the researchers removed a gene that codes for a protein called prod, which attaches to satellite DNA to generate chromocenters. The flies perished because they lacked the capacity to appropriately assemble their chromosomes.

Jagannathan found this noteworthy since the missing protein is unique to Drosophila melanogaster. This means that the proteins that attach to these fast-developing satellite DNA sequences must likewise be rapidly evolving. To put this theory to the test, Jagannathan crossed Drosophila melanogaster females with males of a different species, Drosophila simulants. The hybrids, as predicted, did not survive long. When the researchers examined the flies' cells, they saw malformed nuclei with DNA spread throughout, much as they had seen when the prod protein was eliminated in prior tests.

So how does this imply that satellite DNA might be the driving force for speciation? The researchers believe that if satellite DNA changes swiftly and two organisms create different satellite-DNA-binding proteins, they would not be able to produce healthy offspring. This incompatibility might occur fast because chromocenter binding proteins and satellite DNA segments evolve differently in various populations or species. To put this theory to the test, they altered satellite DNA-binding genes, causing incompatibility in both parents. They developed healthy hybrids after rewriting the flies' DNA to be compatible.

Such satellite DNA conflicts, according to Jagannathan, might play a significant role in the emergence of new species. He expects that more research will be able to verify their concept of hybrid incompatibility with other species. This discovery might eventually lead to a method for scientists to save "doomed" hybrids, or hybrids that do not live long after birth. This might open the path for hybridization to be used to save severely endangered animals like the Northern White Rhino, which has just two females left.

Finally, the new study validated Jagannathan's suspicion that satellite DNA had a role as the evolution could not be so wasteful. The finding of such a strange event undoubtedly raises issues about how genomes change and what current genome sequencing programmes may have overlooked. Perhaps, going back and looking again?

Written by Sara Maria Majernikova
Art by Zach Ng

A SAMPLE OF CHAOS

Some Observations on the unexpected Behaviour of the logistic Map

Written by Francesca Parrotta

Maths is in our everyday thoughts as a synonym of order, of precision, of clarity.

To many of us, it promises answers which are objective, measurable and, most importantly, reliable. However, such promise may turn out to be an illusion and a seemingly innocuous function may actually move towards chaos.

First question: what exactly is chaos? Reader, you might have heard of the butterfly effect. You might have heard the question "does the flap of a butterfly's wings in Brazil set off a tornado in Texas?". It's a suggestive image coming from the homonymous talk by Edward Lorenz, that wonders whether little variations in initial conditions could alter significantly the models for weather forecasts. This is one of the questions investigated by chaos theory, an interdisciplinary theory that analyses complex chaotic systems, those systems where seemingly small variations may produce behaviours that are hard to predict in the long run.

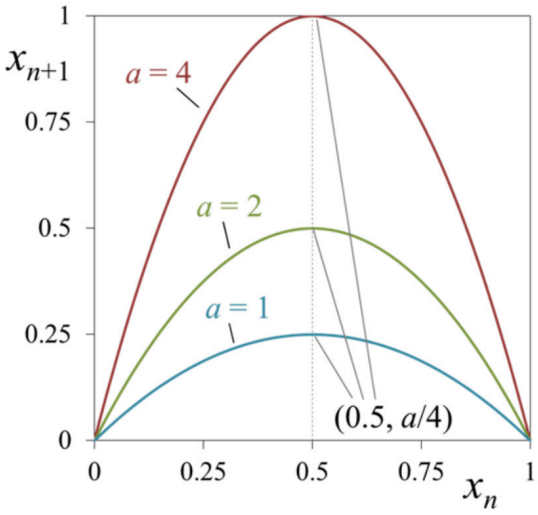
Second question then: how easily can chaos ensue?

Even as a mathematical student, I expected rather convoluted equations to appear in front of my eyes. Nevertheless, as shown by Robert May in his paper "Simple mathematical models with very complicated dynamics", the logistic map itself can present chaotic behaviour.

The logistic map is the following:

$$X_{n+1} = aX_n(1 - X_n)$$

At first glance, it seems quite simple. It turns out to be also very useful. One of its standard applications is to population biology, specifically concerning how communities of species vary through time, depending on habitat and resources. Here specifically we are considering a discrete time model with non-overlapping generations. This means we will be examining a population where every generation capable of breeding will die before the following breeding season; there will not be two breeding generations present at the same time. That isn't the case for many animals we may think of and surely not the case for humankind, where both parents and their children can be alive and capable of having kids. Thus, such an assumption may seem quite restrictive, but once taken it reveals some interesting behaviour in the logistic map. Moreover, as May observes, "Many natural populations, particularly among temperate zone insects (including many economically important crop and orchard pests), are of this kind".

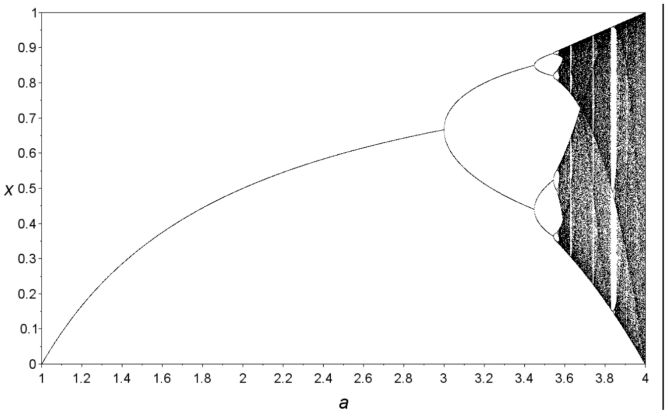


The logistic map represents the population density of a species, which refers to the number of individuals of a species per unit of area. X(n+1) is how many individuals of that population there will be in generation n+1, which depends on X(n), the number of individuals in generation t. Here, a represents the steepness of the curve, representing the growth rate of a population. And this little a turns out to be crucial for the development of chaos.

For a < 3, the logistic map does not prove to be particularly interesting. Its non-zero steady state, for simplicity a crucial point in the development of the function, is stable. Its behaviour is calm, unsurprising.

However, something starts to happen as the value of a grows. Already at a = 3 there are signs the stability of the function is starting to weaken. Crucial points in the function change their behaviour, internal structures of the logistic map become more and more complex. Again for simplicity, rather than delving into the mathematical details, it will be more useful to mention the appearance from a = 3 of a structure called a cycle of period 2, or 2-cycle. As a continues to increase, such a structure becomes a 4-cycle, then an 8-cycle and so on, basically increasing its period by 2n until the critical value a about 3.57. After such critical value, the increase of a will eventually create cycles of period n for any integer n.

Reader, think about it for a second. For any integer number, there will eventually be a cycle of such period. In other words, the function becomes like a tree expanding its branches in the air, with no way of saying exactly where a branch will start and where it will end up. As professor Geoff Boeing explains, this practically means that "the system is capable of eventually landing on any population value." And that is chaos: in the logistic map, if a population is growing at greater than a certain rate, knowing the current state of a population



will offer no useful information about what will happen to it in the long run.

There are practical applications to what we have just observed. Because if indeed, as seen above, the logistic map can assume any value and minimal initial differences might change the model drastically, how can you create a reliable long term model? As much as mathematicians may love precision, when approaching real-world data approximation must be used at some point. Moreover, even if there was no approximation of sorts, something as small as a butterfly could still intervene and disarray our model. Therefore May concluded that "even if we have a simple model in which all the parameters are determined exactly, long term prediction is nevertheless impossible".

This isn't to be generalised to signify the impossibility of any sort of population biology modelling. More than a declaration of surrender, it must be taken as a lesson simultaneously in humility and curiosity. Humility, because some mathematical models may not offer every answer, and therefore it will be useful to renounce this misleading promise. Curiosity, because some mathematical models may not provide every answer, but still might explain what lies behind some apparently messy data or encourage the development of more apt models. Or it might just remind us to never take order for granted, for unpredictability may lie even below the calmest waters.

Based on the lectures of Prof Karen M. Page

Money Can't Buy Time... Yet

Genetic techniques to delay ageing may one day be available to the world's wealthy

The number of billionaires that walk the earth seems to be ever-increasing. The exceedingly wealthy continue to live vastly different experiences than the majority of the world. Despite this, every human being, rich or poor, is bound by one universal constraint that even wealth cannot defy: the great equaliser of death. It is undeniable that money contributes to a long life; housing, food and medical care being notable examples. But ultimately, the process of ageing is inevitable for all of us… or is it?

The physiological study of ageing is far from novel. Research has been able to uncover numerous genetic mutations in non-human animals that significantly extend lifespan. As our understanding of ageing continues to develop, the potential for human application seems more likely. Genetic treatments that extend a human life beyond its natural length are well within the realm of possibility – DNA could be modified in such a way that slows ageing or even prohibits the process altogether.

Drosophila, colloquially known as fruit flies, are a popular model used by scientists to study ageing. Not only are they small with quick life cycles, but their DNA shares much similarity with that of a human. By inducing several genetic mutations in the DNA of fruit flies, a study by Rogina et al., was able to uncover two specific mutations that resulted in a near-doubling of the average lifespan (37 days vs 70 days). In other words, flies that carried one of these mutations could be expected to live almost twice as long as flies who did not.

Using a laboratory technique known as "chromosomal in situ hybridization," in which chromosomes become tagged with fluorescent markers, the researchers were able to identify that these two anti-aging mutations affected the same gene. This gene

was rather aptly named by the researchers as Indy, short for "I'm not dead yet".

The Indy gene appears to have direct links to the process of metabolism, and thus may reveal useful insights into how the ageing process naturally occurs. The precise mechanisms behind ageing or

Written by Flo Cornish
Art by Patrick Marenda

age-delaying may not have been identified as of yet, although with interest remaining abundant, research in this area will likely continue.

Despite Indy and several other genes that have been discovered to relate to ageing, the prospect of buying life still seems like an idea of fiction. However, there is an interesting dimension to ageing research that makes the possibility of commercial age-delaying treatment all the more plausible.

The World Health Organisation does not classify ageing as a disease. This limits both funding and development opportunities for age-delaying treatment because the Food and Drug Administration will only approve drugs that aid specific pathologies. To get around this hurdle, studies can be presented under the narrative of age-related diseases, such as cancer. Or, alternatively, they may seek sponsorship from elsewhere…

The value of life is arguably impossible to assign a number to, and not for lack of trying. So, what better candidate to sponsor ageing research than those wealthy enough to buy everything apart from life itself?

Jeff Bezos is just one example of how the world's most elite and powerful are pouring huge sums of money into the hope of cheating death. This may seem like an exciting prospect at first, however, upon deeper consideration, it is difficult to argue that the distribution of benefits here will be even.

In the face of increased investment into ageing research, one might remember the unfortunate truth that, as the richest attempt to prolong their lavish lives, many across the globe will never reach adulthood. Prime causes of child mortality are so often underfunded, making for a difficult conversation surrounding where the focus of life-extending research should actually be.

The human desire for an elixir of life means that innovation here is unlikely to cease, and there is no saying what the impact will be. However, it seems safe to assume that a newfound ability for the rich to buy life will represent a huge step for mankind, one way or another.

The Spectrum of Sex

Exploring the Flawed Binary

Written by Luke Muschialli
Art by Eshka Chuck

The binary of sex has formed the basis of societies around the world for centuries. Over recent years, as society has begun to acknowledge the damaging effects of social classification surrounding sexuality and gender, many have found comfort in the seemingly defined categories of man and woman; testosterone and oestrogen; XX and XY. However, this classification system is undeniably flawed. As we dig deeper into what it means to be biologically a "man" or a "woman," the system breaks down, and with it the scientific justification for two biological sexes dissipates. Through investigating three established classifciation systems of biological sex (chromosomes, reproductive anatomy, and hormonal profile) and discussing their limitations, we will determine what science really says about biological sex and why it is important that we are vocal about this field of research.

In the past, it was widely accepted as a conclusive, scientific binary that an individual with XX chromosomes is "female" and one with XY is "male." This is not the case. Human sex chromosomes have been shown to have just as much inter-individual variety as their autosomal counterparts. Historically, the incidence of XXY individuals assigned male at birth (AMAB), or XXX individuals assigned female at birth (AFAB), or even XO AFAB was documented, but considered so rare that it was dismissed. In truth, if a karyotype (full chromosome screening) were to be performed on all of us, the results would reveal anything but a binary system. It is estimated that the incidence of XXX females is as high as 1/1,000 live births and the the incidence of XXY males is estimated to be even higher at 1/600 live births. The concept of sex chromosomes mosaicism has also been described, in which some of the individual's cells express XX chromosomes, and some XY. Clearly the science of sex chromosomes isn't quite as binary as we once thought.

Although karyotyping is an effective way to gain an insight into a person's sex, it is very rare that this is used in day-to-day life. Rather, it is usually a person's reproductive anatomy that would be used to assign sex. However, as it has been known for centuries, this is not a straightforward task. Numerous societies have written about intersex individuals. Khunthā are mentioned in Islamic texts as people who have ambiguous reproductive anatomy and the Native American population widely accepted intersex individuals within society. Even in 1 BCE, Siculus, a Greek historian, wrote of individuals who were born with ambiguous genitalia, describing them as prodiges. We now understand that up to 25 genes are responsible for coding our sexual characteristics and mutations in any of these can lead to ambiguous reproductive anatomy. It has also become clear that our chromosomal makeup is not always connected to our reproductive anatomy. Approximately 1/25,000 AMABs have XX chromosomes, but present with classically male external reproductive anatomy. It is clear that a binary does not exist here and that reproductive anatomy should also be seen as a spectrum.

Hormones are an important topic in this field as well, as they are often used to categorise people into the binary of sex. An important example of this is in sports, where the level of testosterone is used to determine if an individual is assigned to the male or female category. The International Association of Athletics Federation (IAAF) specifies that in order to compete in the female category, individuals must have a serum testosterone of < 5 nmol/L. This was introduced as the binaries of reproductive anatomy and chromosomal makeup would not suffice, already bringing into question the viability of a sex binary. This division has actually strengthened the argument against the binary of sex; although it was imposed as a seemingly definitive cut off, there are numerous case studies of athletes being excluded from their category because of it. Mokgadi Caster Semenya was banned from international competition for a year due to having higher serum testosterone levels than this arbitrary cut-off, despite being AFAB and having identified as such throughout her life. Once again, we see an arbitrarily imposed binary rise and fall.

It is vital that the scientific community acknowledges this body of research. The continued stratification of the sexes under a false scientific pretence continues to be used to deny the existence of intersex individuals and to intensify discrimination against them. Whether we intend it to or not, the scientific world's apathy towards this issue is the ammunition for the discrimination against the queer community. Numerous pieces of legislation limiting the freedom of intersex and gender non-conforming individuals around the world continue to be passed, which is a consequence of the lack of understanding about the spectrum of sex. We have the peer-reviewed evidence to counteract this, but due to continued discrimination and prejudice both within and outside of the scientific community, this has not gained traction.

This article does not intend to suggest the scientific community call for a dismantling of the biological sex structures that permeate all aspects of society. Rather, we need to use the data we have gathered to emphasise that sex is a spectrum and to facilitate a greater understanding of, and acceptance towards, individuals who do not fit into this flawed binary that society has constructed. As a scientific community, we need to be more fact-oriented, empathetic, and empowering. Nature doesn't create binaries, and neither should we.

Should the Justice System be Amended for Psychopaths?

The genetic basis of psychopathy may hold the key to a more compassionate justice system

Written by Nirvan Marathe
Art by Qiwen Liu

Psychopathy: a word that strikes fear into the heart of many because of its unsavoury portrayal in pop culture – but what exactly is a psychopath? Public opinion might depict a cold-blooded and emotionless individual, but I'd like to explore a different view – one in which psychopaths themselves are sufferers of a neurological disorder. Psychopathy clinically manifests itself in distinct phenotypes including a lack of empathy and guilt, poor emotional responses, and antisocial behaviour, with there being an ongoing debate about whether or not psychopathy is innately biological. If it is innate, it could lead to great changes in the current criminal justice system and how society interacts with psychopathic individuals. If psychopathy is something which an individual is born with, is it really fair to treat them the same way as a criminal who chose to commit a crime out of their own volition?

To start with, it's important to clarify the difference between a psychopath and a sociopath. Psychopathy, while there isn't a universal definition, is thought to affect the sufferer from birth and, in the medical world, is referred to as antisocial personality disorder, whereas sociopathy is an environmentally-influenced disorder. The initial debate of psychopathy's potential biological basis was sparked by the discovery that its extreme phenotypes were highly heritable. Prior to this, psychopathy was believed to solely be a product of the environment in which the sufferer was brought up in – a manifestation of neglective and disruptive parenting.

Following this, the environmental influence wasn't ruled out but rather regarded as something which shaped the biological framework for psychopathy, which was already present from birth. Additionally, further research found that this biological framework was not identical across psychopathic patients despite the characteristically similar phenotypes between psychopaths. Some of these include upregulation of the RPL1099 and ZNF132 genes, in tandem with the downregulation of the CDH5 and OPRD1 genes in neurons. These genes are associated with the prefrontal-temporo-limbic circuit in the brain, which encompasses regions associated with our emotional response and thus are directly linked to the classic lack of empathy and apparent callousness exhibited in psychopaths.

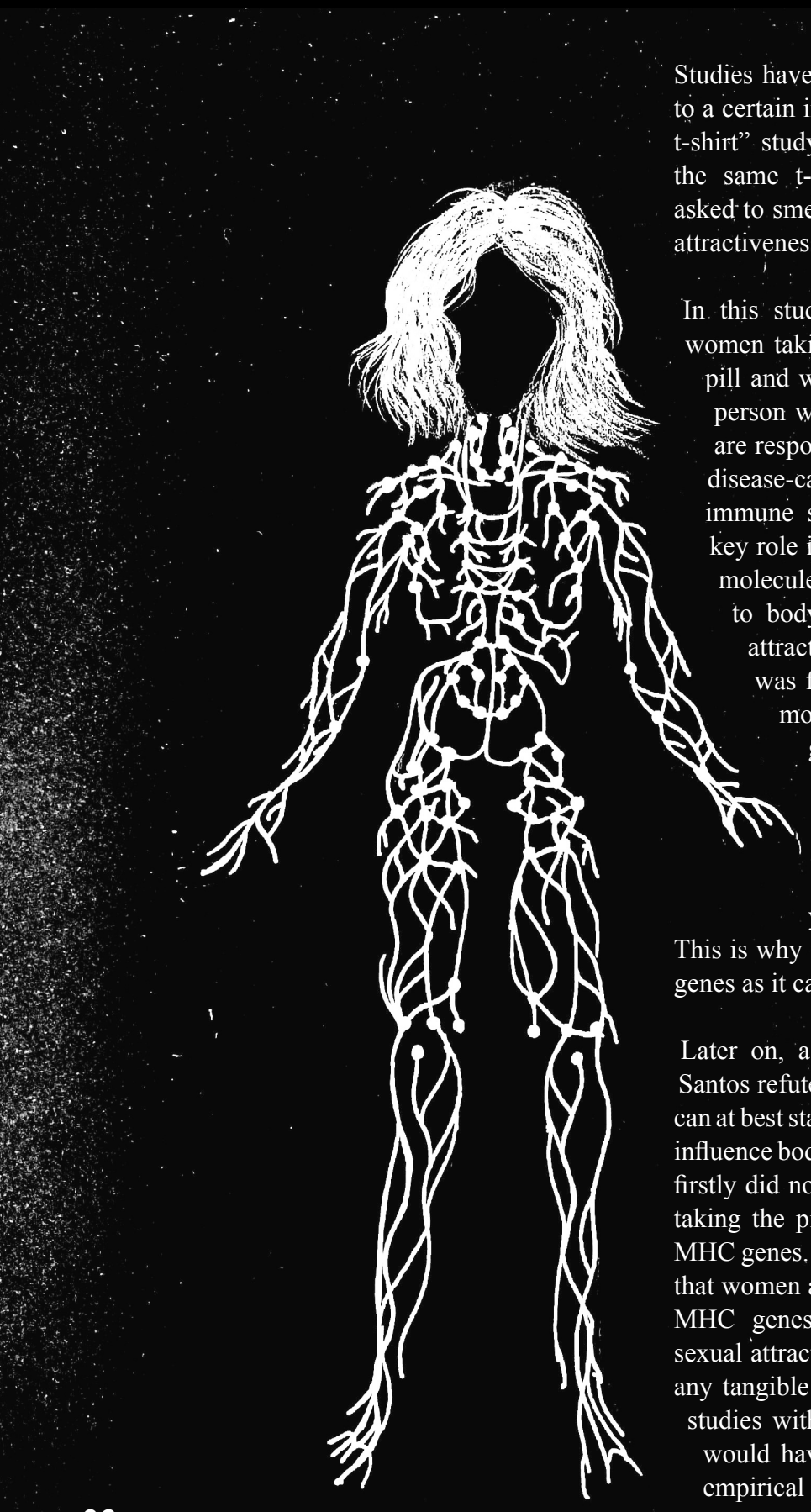
While an abundance of research has been produced supporting the hypothesis of a largely biological aetiology of psychopathy, it is still regarded as insufficient by the wider scientific community, so no explicit conclusions have been drawn. The lack of breakthroughs in the field is disconcerting because if the biological basis for psychopathy is to be believed, the current justice system has been mistreating sufferers for years. In fact, if a criminal is labelled as having antisocial personality disorder, it can lead to colossal ramifications such as a large increase in sentence severity, increased chance of execution, and harsher treatment in prison.

All of this raises a serious question: is jail time the most appropriate solution for psychopaths? Fundamentally, a crime deserves justice for the victim regardless of whether or not the perpetrator was born with a neurological disorder. However, would jail be the most appropriate setting for the rehabilitation of psychopaths, or would psychotherapy in a psychiatric institution be more appropriate? There is contrasting evidence for both sides of the argument here, with institutional treatments resulting in observed benefits in several studied psychopaths, but that is paired with a high risk of non-completion of programs and a large recidivism rate.

After reading all of that, you may wonder whether psychopathy is even worth further research funding.

I believe that significant advances in research still need to occur before we can conclude in either side's favour. However, I do not condone psychopaths being given harsher sentences over unafflicted criminals. As more neuroanatomical studies are conducted, our study of the brain's structures will improve, as will our understanding of psychopathy. Further research into the applications of neuroplasticity and epigenetics will determine whether psychopathy is treatable or not. My opinion is that if psychopathy is indeed found to be a condition individuals are born with, then the lack of guilt we see in them should be regarded more as a phenotype. As with any other phenotypes of neurological disorders, the afflicted deserve to be treated and rehabilitated to the best of our ability with the help of psychiatric institutions.

How is Your Immune Function Reflected in Your Smell and Your Face?



Studies have shown that people are more attracted to a certain individual's body odour. In the "sweaty t-shirt" study lead by Claus Wedekind, men wear the same t-shirt for two days and women are asked to smell the t-shirts and rank them on sexual attractiveness.

In this study they found a correlation between women taking the pill and women not taking the pill and whether or not they were attracted to a person with opposite MHC genes. MHC genes are responsible for how foreign molecules from disease-causing organisms are presented to the immune system. This means that they play a key role in how efficiently and to which foreign molecules your body can react to. They also link to body odour which explains the potential attraction to a certain individual's scent. It was found that women not on the pill were more attracted to men with opposite MHC genes to them. The same phenomena were observed when this experiment was conducted on mice initially. This makes sense because the more diverse your genes are, the better your chances are to fight off an infection. This is why you are attracted to the opposite MHC genes as it can maximise your range.

Later on, a study led by PabloSandro Carvalho Santos refuted this principle and concluded that we can at best state that MHC genes (or HLA in humans) influence body odour production or perception. They firstly did not find any correlation between women taking the pill and their attraction to the opposite MHC genes. They also found opposite data showing that women and men were more attracted to similar MHC genes. Therefore, concluding that human sexual attraction or mating preferences do not have any tangible proof to this day and new alternative studies with a broader view of different contexts would have to be led to support it and provide empirical proof.

Lately, it has been established that your immune system could also be reflected in your face. A study published in the Royal Society suggests that "a relationship between facial attractiveness and immune function is likely to exist." An examination of literature has led scientists to think that features such as clear skin, prominent cheekbones, bright eyes, and full, red lips have been deemed attractive throughout recorded human history in western civilization. But it was considered that this could be the result of beauty standards set by repeated western media exposure. Research also finds a consistent preference for symmetrical and average faces. Could this have something to do with the immune system's activity?

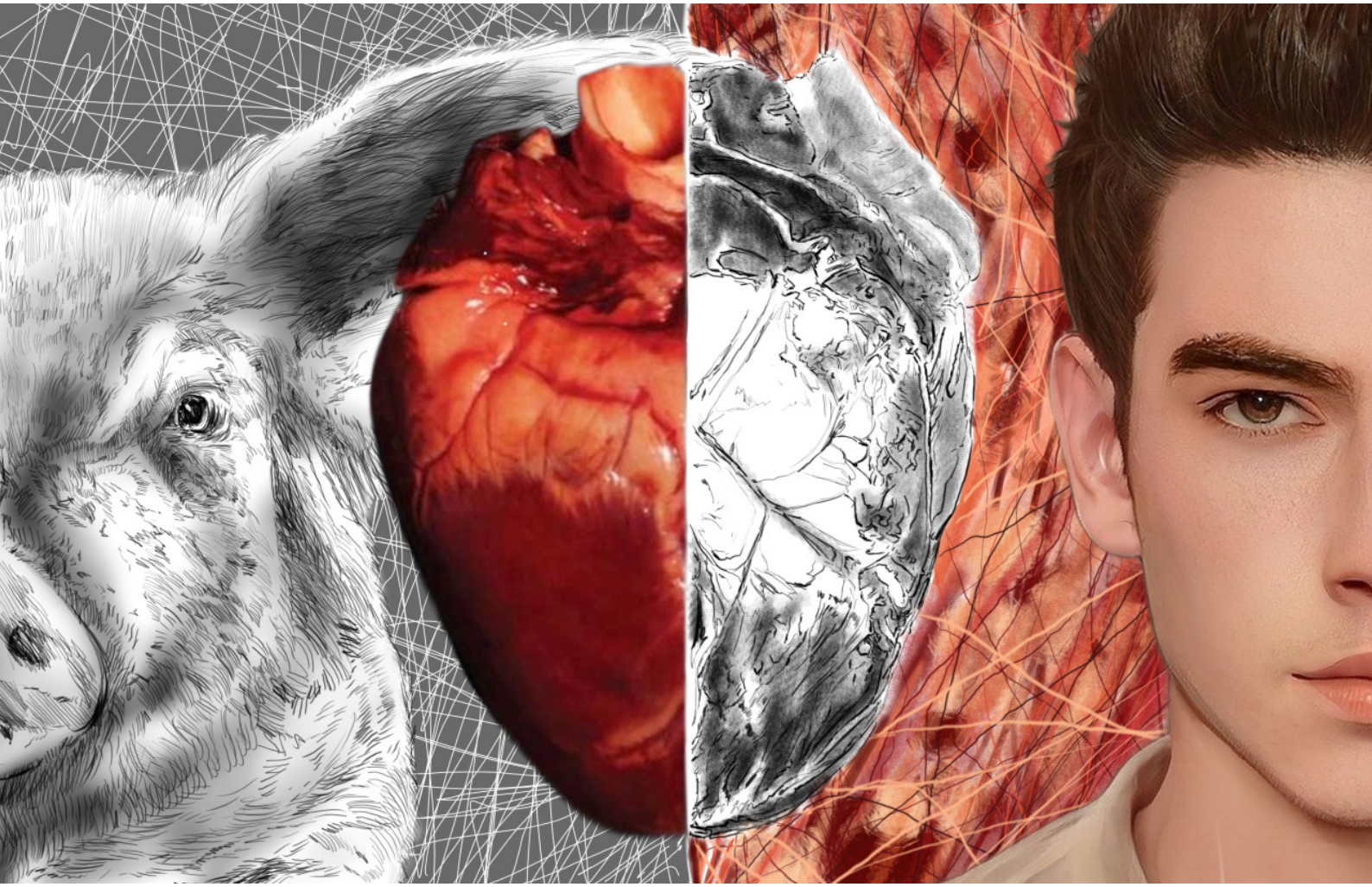
In the study led by Mengelkoch and published in the Royal Society 79 women and 80 men from Texas Christian University were photographed and had blood taken to be sampled. They wore no makeup or jewellery and bore neutral expressions on their faces. They then recruited 492 more people to rate 25 randomly selected photographs. The results given were cross-checked with the blood analysis of the individuals. They examined the link between targets' attractiveness and self reported health -measures of inflammation (in vivo), white blood cell count and in vitro tests of patients' immune functions. This was done by looking at leukocyte proliferation in response to stimulants, phagocytosis of Eschericia coli, as well as NK cell counts and Staphylococcus aureus growth in plasma. It was found that people ranked with higher levels of attractiveness (i.e "This person is physically attractive") had a higher count of phagocytes - the white blood cells that fight illness causing bacteria. Reciprocally, people with lower counts of attractiveness have fewer neutrophils which is an essential cell for phagocytosis.It was also found that the men ranked as more attractive had a greater NK cell cytotoxicity. This was not the case for women and it might be due to the fact that high NK activity is linked with decreased oestrogen activity i.e., lower fertility and therefore higher chances of miscarriages too.

It has long been hypothesised that perceptions of attractiveness are a reflection of inclinations for traits historically linked to health and therefore maybe even immune function. It isn't known yet whether it is due to specific facial features or whether an overall view of the person's face leads to a subconscious subjective evaluation of attractiveness. The research being led today proposes that attractiveness may provide insights into one's immune function. But similar to the hypothesis that links body odour and immune function or genes, there is no solid empirical proof suggesting that this can't be refuted. Further, more detailed research would be needed to replicate and add precision to these results. Current research suggests that a relationship between facial attractiveness (although very tricky to measure due to its subjectivity) and immune function is likely to exist, but to what extent is still to be explored.

Written by Justine Stanley
Art by Lucie Gourmet

Cardiac Xenotransplantation

– A new frontier or a double edge sword? –



Limitations of cardiac xenotransplantation and potential alternatives to address these drawbacks

In January 2022, a team of surgeons from the University of Maryland shook the world of medicine by announcing their successful attempt in transplanting a porcine heart into 57-years old David Benett who had been suffering from terminal heart failure. Although this was not the first-ever attempt at xenotransplantation as far as the history of the subject goes, it was certainly a first-of-its-kind project, combining the finest, state-of-the art knowledge from immunology, transplant surgery, and genetic editing technology.

Unlike other types of organ transplant, cardiac transplant is a tough case to crack for two reasons: Firstly, heart cells, unlike liver cells, are unable to regenerate inside a living organism; moreover, unlike kidney transplants, living donor heart transplants are impossible. Second - a person is only eligible to donate their heart when he or she is declared brain dead, and the donor cannot have died from cardiovascular diseases. This has created a crisis of heart scarcity, with over 100,000 patients with advanced cardiac failure being on the transplant list each year and many of whom die before they could receive a heart.

Immunological challenges

There are two types of immune responses associated with xenotransplants: hyperacute rejection (which happens over hours to days post-surgery) or delayed xenograft rejection (which happens over weeks to months post-surgery). Both of these responses are due to the presence of non-self entities (called antigens) on the outer-covering layer of porcine's tissue, which are detected and destroyed by the patient's immune system. To address this problem, scientists have attempted to genetically knock out these antigens. However, the high incidence of delayed xenograft rejection suggest that more research needs to be carried out to investigate other novel immune factors that confer this challenge.

Infectious challenges

One of the other major concerns with using pig organs is the risk of zoonotic infection, which, by definition, is "an infectious disease that has jumped from a non-human animal to humans". Pigs are known to be animal reservoirs for a number of infectious agents; considering the fact that transplanted patients are most likely to undergo immunosuppressive therapies post-op, trans-species infection will therefore put them at a high risk of fatality.

Pigs are not the only species targeted for cardiac xenotransplantation. Researchers have attempted to utilize organs from primates including chimpanzees, orangutans, and baboons. These species have the advantage of being concordant to humans, meaning that they share a common phylogenetic branch with us. Nevertheless, this concordance means that there is an extremely high chance of porcine virus "jumping" into a human being, resulting in a new viral strain that could potentially be lethal to humans - or worse, set off a pandemic.

A particular ethical challenge with cardiac xenotransplantation is religious condemnation. For example, Islamic cultures forbid medical procedures that utilize porcine organs, including organs that are devoid of living cells like heart valves (although this is subjected to mitigation under extenuating circumstances). On the other hand, Jewish and Judaism xenotransplantation is justified on the ground that the outcomes of such procedures outweigh religious constraints. Lastly, Catholics particularly prohibit the use of embryonic stem cells for any forms of medical purposes - this poses a huge challenge for both xenotransplantation and its potential alternatives.

Xenotransplantation is not the only competitor in the race for addressing the question of heart donor shortage. For decades, scientists have been trying to "grow" human organs inside animals - a technique known as blastocyst complementation using embryonic or induced pluripotent stem cells (iPSCs).

Although this technique triumphs over xenotransplantation by the fact that the resulting organ is technically derived from the patient's own body cells, thereby eliminating the risk of organ rejection, there are numerous challenges. Firstly, successful blastocyst complementation has only been done for pancreas and kidney models for animals, which means that no successful cases of human iPSCs heart transplant has been recorded. Secondly, a number of problems have been recorded, including: induced cell death of the transplant organs as they are considered "unfit" by the recipient's body, insufficient molecular pathways that are essential for the survival of the organ, and failure for the organ to "adhere", leading to it "being extruded from the embryo due to

their inability to form adequate cell-cell junctions with host cells". Lastly, as mentioned in the ethical challenges section, the use of embryonic stem cells is largely condemned by certain religions, making this technique unavailable to a number of populations.

Another competitor in the race for addressing the shortage of heart organ donors is tissue printing. Depending on the protocol, this technique typically involves 3D printing a bioink (i.e alginate) or onto an extracellular matrix-based gel, using an MRI scan of a heart as the "frame". After a period of culture, iPSCs are casted onto the newly-printed structure and differentiated into different structures within the heart. Recently, researchers from Harvard's Wyss Institute for Biologically Inspired Engineering and John A. Paulson School of Engineering and Applied Sciences (SEAS) have further reported successful attempts in printing sophisticated vessel systems necessary to support the printed organ with sufficient oxygen and nutrients.

Sounds promising, right? Well, the science is not that simple.

Quoting Professor James Yoo from Wake Forest School of Medicine, it is unclear whether "a printed heart of this sort could withstand the flow of blood under high pressure or that the printed structures would remain stable after implantation in the body". Another conundrum is the generation of a readily perfusable circulatory network, owing to the delay between implantation of the 3D-printed heart and vascular connection (medically known as anastomosis) with host vasculature. Without this vessel system, cardiac tissues are at risk of lacking nutrients and oxygen, and therefore being unviable to support the recipient.

So….What does that leave us with?

Scientists are still searching for a suitable animal model as a heart donor. Indeed, each candidate might have its own drawback, however, the development of CRISPR/Cas9 technology means that we can simultaneously knock out a multiplicity of genes that might contribute to adverse immune responses and pathogenic transmission. Moreover, the survival period for patients receiving xenogenic organs, especially xenogenic hearts, is progressively prolonged. Along with the development of blastocyst complementation and tissue printing, it might not be that far into the future until researchers could land the first-of-its-kind cardiac xenotransplant using 3D-printed hearts clinical trial.

Written by Rachel Nguyen
Art by Zach Ng

THE BIZARRE LIFE OF THE STAR-NOSED MOLE

With noses that touch instead of smell, and eyes that don't see, star-nosed moles are fascinating creatures. They eat at record-breaking speeds and are one of only two mammals that can 'smell' underwater.

Picture a mole. Picture a 22-sided star. Picture a mole whose nose is a 22-sided star - and you've got yourself a star-nosed mole!

Star-nosed moles (Condylura cristata), native to the wet lowlands of eastern North America, are peculiar-looking animals. Star-nosed moles show extreme evolutionary adaptations, and it is thought that their star evolved to aid hunting in the competitive wetland environment.

Funnily enough, they don't actually use their 'nose' to smell - instead, they use it for touch.

Their star is the most sensitive touch organ known in any mammal - approximately 30,000 sensory Eimer's Organs cover their 22 fleshy appendages.

Star-nosed moles use their star similarly to how we use our eyes to understand the environment. Research suggests that their brain is organised around signals from their stars, similar to how human brains are arranged by visual information from the eyes.

They spend much of their time burrowing underground, using their front legs as shovels; thus, they are functionally blind. To hunt, they touch their star against the soil at a rate of 10 or 12 different places per second. Each touch sends sensory information through 100,000 nerve fibres to the brain. The star contains five times more touch sensors than a human hand, despite the diameter of the star being smaller than that of an average human fingertip. Dr Ken Catania, Stevenson Professor of Biological Sciences at Vanderbilt University, said "Star-nosed moles have extremely efficient nervous systems that convey information from the environment to their brains at speeds approaching the physiological limits of neurons."

Carnivorous star-nosed moles are the fastest-eating mammals on Earth, and in less than a quarter of a second they can locate, identify and eat their prey. They take 200 milliseconds to identify the prey, and only eight milliseconds to determine if it is edible.

They are semi-aquatic, and they are one of few mammals (alongside the water shrew and Russian desman) that can 'smell' underwater. They achieve this by blowing bubbles (5-10 small air bubbles per second) towards an object or a scent trail and then quickly re-inhaling the odour molecule-containing bubbles to retrieve the scent.

Star-nosed moles are curious-looking creatures - but there is much more to them than their uncanny looks!

Written by Priya Ord ***Art by Suzie Mishima***

Native Bees:

The species that are Forgotten

Introduction

The status of bee populations is a prominent topic in conservation. Responsible for pollinating around 85% of the world's crops, these insects are vastly important for food production. They help to fertilize plants by transferring pollen from one to another, allowing them to develop edible products (such as fruit) for consumption. Widespread concern for honey bee colony losses is hence understandable, but there are over 20,000 bee species also essential for maintaining biodiversity, functioning ecosystems, and efficient pollination. Native bee species, such as wild, solitary bees, aren't commonly used in agriculture. They are often overlooked, increasing the severity of their decline.

The Importance of Native Bees

Honey bees are used in agriculture across the globe, but relying on a single species to pollinate the world's crops is highly precarious. Their limited genetic diversity increases the risk of colonies being wiped out by disease. This has been seen in recent years when "Colony Collapse Disorder" was discovered in 2006, causing a dramatic loss of honey bee colonies in California.

Native bees are species indigenous to a given region without human intervention and research has shown that some species are better pollinators than honey bees. Solitary species such as mason bees, leafcutters, and bumble bees are even being advised for agricultural use. Regardless of honey bee presence, these species of

bee maintain a high yield of many crop types. They are "messier" as they don't have secure pollen pouches, and this increases the chance of successful pollination. Some crops, such as tomatoes, can't be pollinated by honey bees. Tomato plants are pollinated by bumble bees, as they have a special technique called "Buzz Pollination" that honey bees lack. Tomato flowers maintain a tight hold on their pollen, so bumble bees vibrate their bodies close to the flowers to shake it out. Moreover, a larger diversity of pollinators will lead to a larger diversity of fertilized plants, allowing environmental stability for many animals that live in green habitats.

The survival of these lesser-known native species is essential for maintaining the ever-increasing demand for crop production. Unlike honey bees, other bee species don't live in colonies. Many native species are solitary and live alone in nests burrowed into trees or soil, making them hard to track. Despite having little information surrounding their abundance, scientists believe they are undoubtedly endangered. One study found ~25% less species were observed between 2006-2015 compared to the 1990s, and these numbers are declining still.

Do Honey Bees Affect Native Bees?

Pesticides, habitat loss and climate change are common culprits behind bee loss, although a more alarming factor has arisen which presents a disturbing truth about honey bees. There is evidence of declining native bee populations in areas introduced to apiculture. Interspecific (inter-species) competition ensues in beekeeping areas, forcing native species to feed from less nutritional plants or forage further from their nests.

Honey bees could also affect plant community compositions by invasive mutualism. When introduced to a new area, managed honey bees prefer to pollinate exotic plants. This causes a spread of invasive plant species, subsequently reducing the population of native plants which is the main food source for native bees.

Moreover, honey bees may affect wild bees through the spread of pathogens. They are social species, so live in dense populations as opposed to their solitary counterparts. Disease can spread through their colonies and further spread to other species. Such diseases include Deformed Wing Virus (DWV) which can easily wipe out native populations.

With this evidence, enthusiasm for beekeeping – although set with good intentions–may not be beneficial for conserving wild bee species. Beyond honey bees, we can't forget about native bees that are in desperate need for conservation efforts.

Potential Solutions and Conclusion

So how can we help native bees? One solution is to grow a micro-habitat of wildflowers in your back garden. Since each species requires a different set of natural resources, maintaining a large diversity of plants will greatly increase the diversity of native pollinators. Further conservation efforts include methods such as planting hedgerows or creating artificial nesting sites. Ecologists are also beginning to adapt systematic approaches to aid their conservation, such as restoring habitats formerly degraded by agriculture. Invasive plant species are removed and replaced with native plants to restore the optimal plant community for native bees.

Promoting these lesser-known bee species will greatly benefit both agriculture and the environment. Maintaining genetic variation will reduce disease susceptibility and support the ever-increasing demand for crop production. Wild ecosystems will be stabilized, and the biodiversity of both plants and animals will flourish. This is why native bees should not be forgotten.

Written by Rachel Cooper
Art by Zach Ng

Do Trees Have Social Lives?

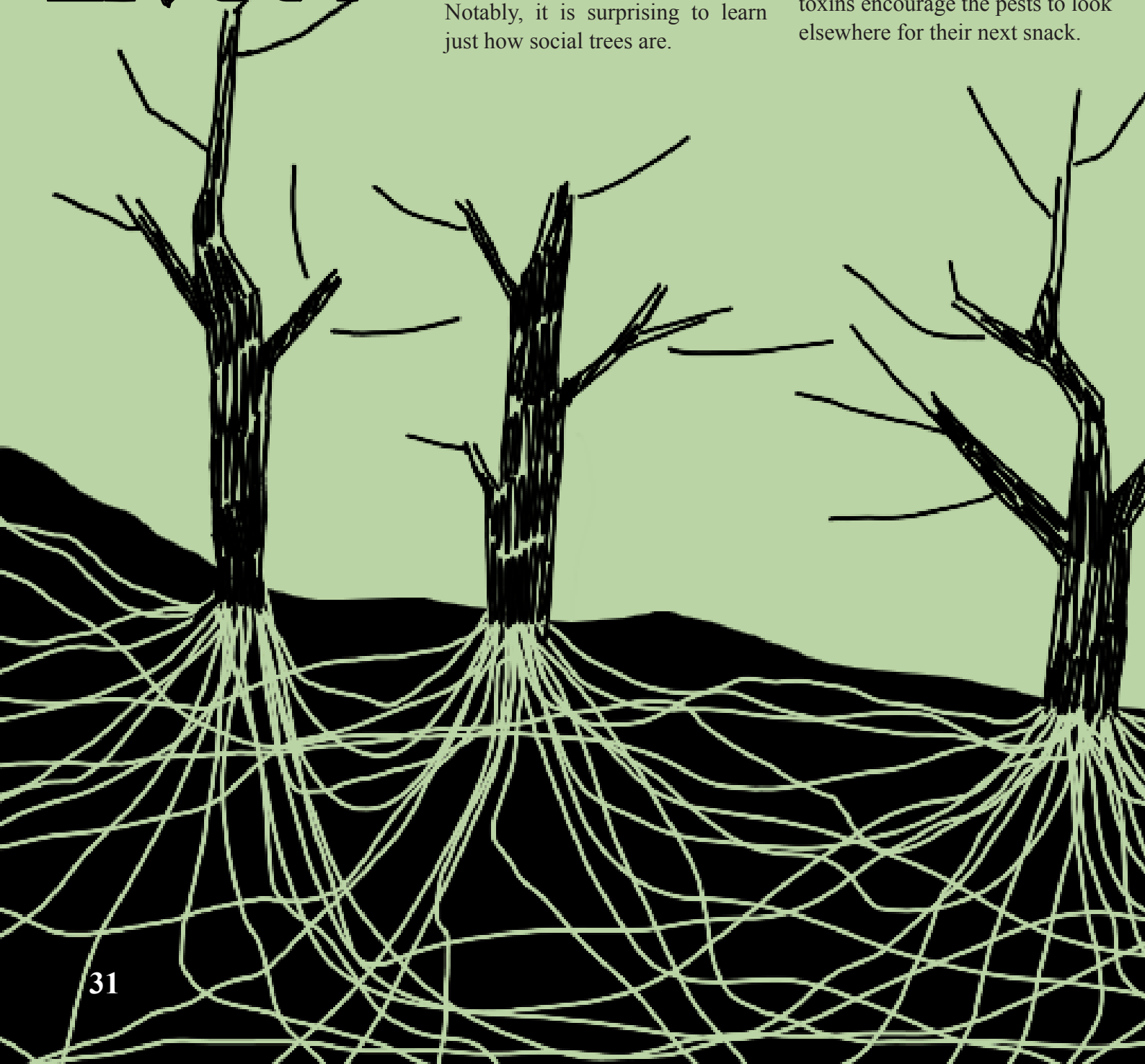
A deeper look into the social dramas played in your local forest

Written by Anna Wiecek

Art by Lola Artiles

Trees live their lives in the slow lane. They can live for thousands of years, and their growth and seasonal foliage changes occur at leisurely rates. However, this seemingly unhurried approach masks how their behaviour often resembles that of the animal kingdom's members, including us. Notably, it is surprising to learn just how social trees are.

Within forests, trees appear to use means similar to the basic human senses to perceive their surroundings and "talk" to the neighbouring trees of the same species. Strikingly, they show their collaborative nature by communally tackling problems such as pest control. For example, individual trees can register pain after being damaged by pests. In response, they release chemicals into the air, which act as warning signals. Upon "smelling" the alarm cues, the neighbouring trees can produce and direct toxins into their leaves. In turn, the bitter toxins encourage the pests to look elsewhere for their next snack.

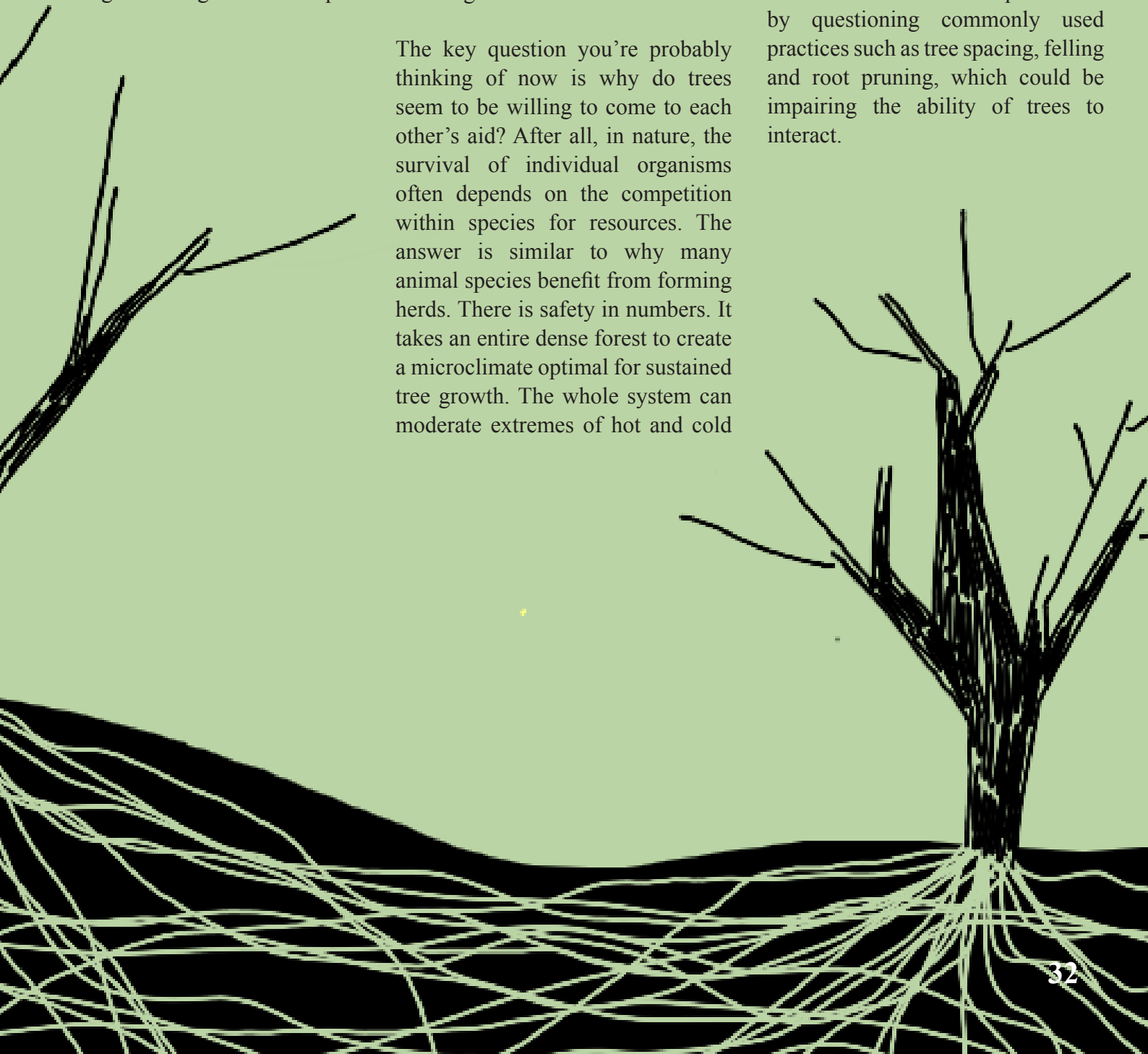


Aside from signals carried in the wind, a large part of the tree social scene is played out underground. Within densely packed forests, the interconnected tree roots exchange nutrients, and chemical and electrical signals. Importantly, these signals appear to be used by trees to care for each other by sending additional nutrients to weakened neighbours and sharing information about potential dangers. Support and communication are also sent further afield through the help of large-scale fungal networks surrounding the tree roots. After likening the fungi to fibre optic cables, these networks are now endearingly referred to as the "wood wide web" by scientists.

The examples above contribute to the mounting evidence that trees within forests can function as superorganisms. However, recent research indicates that we still might be underappreciating the wide range of methods used by trees to communicate. For example, initial findings suggest that trees can respond to specific sound frequencies based on the observation that laboratory grain seedlings could "hear" and react to the sound of root cracking.

The key question you're probably thinking of now is why do trees seem to be willing to come to each other's aid? After all, in nature, the survival of individual organisms often depends on the competition within species for resources. The answer is similar to why many animal species benefit from forming herds. There is safety in numbers. It takes an entire dense forest to create a microclimate optimal for sustained tree growth. The whole system can moderate extremes of hot and cold temperatures, generate high humidity levels and store large amounts of water. Trees within dense forests are also sheltered from high speed-winds by their neighbours, which reduces the amount of tree uprooting. Such conditions are essential for tree longevity. Accordingly, within the same species, trees living in isolation often have shorter lifespans than those living in forest communities.

Overall, these findings give a new appreciation of the complex lifestyle of trees we see on our nature walks. However, they also offer important insights into how forest farming can be made more productive by questioning commonly used practices such as tree spacing, felling and root pruning, which could be impairing the ability of trees to interact.



THE ART OF FORENSIC BOTANY

Felon vs Flora: How To Catch a Killer with a Plant

If I told you that you could catch a killer with a plant, you would probably laugh in disbelief. Yet forensic botany does exactly this. Analysis of plants can provide vital evidence in police investigations, from linking a suspect to a crime scene to finding where a body is buried.

Some of the most powerful poisons in the world are found in plants. In 2009, Lakhvinder Cheema was poisoned by his ex-lover. Plant forensic experts at Kew analysed samples from the victim's stomach and identified the poison as a deadly toxin from Aconitum ferox. This deadly plant is native to the Himalayas. Knowing this, the police uncovered that the murderer had planned the murder, travelling to India beforehand to obtain the poison. This evidence was used in court to convict the murderer of a pre-meditated attack. She was given a life sentence.

Plants don't need to be directly involved in a crime for forensic botany to be useful. All self-respecting criminals know not to leave DNA at a crime scene, but few would think to worry about pollen. Although hay fever sufferers might disagree, pollen is generally thought to be a harmless powdery substance ferried from flower to flower by bees in summer gardens; however, pollen can cling to clothes and corpses, and bring murderers to justice. Don't believe me? Let's look at the murder of Mellory Manning in 2008 in New Zealand. Police suspected the notorious Mongrel Mob gang but had no evidence that the murder took place in their territory. When traditional forensics was unable to pinpoint the murder location, the pollen expert Dallas Mildenhall was called in to help following the discovery of residual pollen on the victim's body. For months, this pollen was studied and eventually he noticed a discrepancy: one of the pollen grains was mutated. This was then

matched to mutated pollen found in large amounts near the gang's headquarters. This evidence was enough to scare a gang member into revealing everything and the murderer received a life sentence. The gang may have thought about CCTV and cleaning up DNA from the crime scene, but little did they suspect that their downfall would be a few grains of mutated pollen.

You might be thinking that this is just standard forensics with a botanical twist. The story of forensic botany, however, extends further.

A key part of any murder investigation is finding the body. When a human body decays, around 2.6kg of nitrogen-containing compounds are released into the soil. Although this is a rather grisly image, the result is actually a surge in chlorophyll levels and a resulting bright patch of green vegetation near the rotting body. This might seem to be a crude method, yet studying plants above dead bodies can give surprisingly detailed results. For instance, if the missing person was known to be a heavy smoker, the leaves of plants above their body will be highly discoloured. This is because of the high levels of cadmium in the smoker's body leaking into the surrounding soil. Cadmium disrupts the molecular machinery of photosynthesis, severely impacting the wavelengths of light that can be absorbed, thus changing leaf colour. Although less useful in cities, this approach would be invaluable in the search for bodies in large natural areas, such as forests.

In the battle against felons, plants might be our greatest weapon. A knowledge of plants can help identify poisons, link suspects to a crime scene, or find buried bodies. A criminal may use increasingly sophisticated methods to evade DNA forensics. A murderer may choose a location far from CCTV or prying eyes to bury their victim. However, forensic botany has the power to trump both of these. Although we can't abandon all other police work and rely on plants entirely, when we are struggling to find clues, plants can provide some vital evidence. So, the next time you start to dismiss botany as boring, remember how a single grain of pollen can catch a killer.

Written by Clara Wilkinson
Art by Amaranta Chavez

Lets go profecional!

The process shaping the landscape of scientific writing

Did you notice the two mistakes in the title? If you did, it might've made you question the validity of this article, which is exactly what writers don't want.

Kinesis is to scientific publishing what Model United Nations is to the UN. Even though Kinesis doesn't publish academic papers, it continuously exposes us to the publishing process and allows us to gain new skills through individual practice in scientific journalism. This doesn't only enable us to judge the best tone and style to express a message but also gives us experience in guiding others in our ever-so-new editorial shoes. This gradually enhances our capability to give people advice on their writing while improving our own.

The peer review process is pivotal to ensure that published articles are fluent and clean, without grammar and spelling errors. The content of a piece is revised to make sure it aligns with the publisher's expectations because some publishing companies focus on niche fields of science. The formatting and images produced by graphic designers are also closely assessed as they are equally important for capturing and informing the audience. This also applies to scientific journalism. Usually, editors undertake two rounds of peer review, where the author can make amendments in between. This process can be blind and, therefore, less biased in the sense that the reviewer and author don't reveal their names.

Nevertheless, external noise impacts the publishing process. One aspect that influences whether a manuscript gets published is the temporal context. Take the field of ageing for example. The damage-maintenance era pumped out a vast magnitude of data in support of the free radical theory of ageing. However, with quite a bit of reluctance, the field has now shifted towards a programmatic theory, where articles stating that molecular damage doesn't play such a big role are being published. This is just one example showing that what gets published is highly reliant on the popular view at the time.

Elsevier, Wiley, Taylor & Francis, Springer Nature, and SAGE are the dominating publishing companies today. Universities also often have their own publishing platforms (e.g., Harvard Press, Oxford Press). Although the main aim of these companies is to share the discoveries, developments and ideas brought forth by science to further collective knowledge in subjects ranging from translational medicine to astronomy, publishing is still an industry. This means that there is money involved. Interestingly, the publishing business has been suggested to be more profitable than companies, such as Microsoft and Google, whereby the majority of profit comes from subscriptions made by individuals, educational institutions, or firms who require access to the information. Moreover, most peer review is voluntary, incurring no costs for the publishing companies.

Science continuously evolves, with the possibility of new theories and contradictions every day. This reminds us that "in science, a pencil is more valuable than a pen." Being able to erase, replace, and amend is not just essential but valuable in moving science forward. In fact, new techniques uncover flaws that were invisible to earlier methods. For instance, electron microscopes can visualise objects at the 10-10 m scale, which is a huge advance from light microscopes that measure to the 10-7 m scale.

Failure is a huge part of scientific publishing and journalism. As a matter of fact, an article can make it quite far down the line of the peer review process before it gets rejected. Being faced with rejection can be disappointing; however, communication and honesty ensure that the end product is reliable and appreciated by the readers. Without the publishing and editorial process, there would be no limitations on what reaches the public. Wed end up with sometings that sounds as this. Therefore, peer review and the larger publishing process are something we should appreciate and prepare for as we move onwards in our scientific careers.

Written by Marie Emilie Maeland
Art by Qiwen Liu

TELLING STORIES THROUGH OUR MORPHING BODIES

The ways our bodies morph and change offer significant potential for exciting, creative storytelling

In July 2021, French filmmaker Julia Ducournau became the second female director in history to win the prestigious Palme D'Or award at the Cannes Film Festival. However, Titane, Ducournau's second feature film, is far from your standard awards season drama. Amidst almost universal critical acclaim, David Ehrlich, writing for IndieWire, described Titane as "the most f***ed up movie ever made…or the sweetest". Cinemas reported panic attacks and fainting during screenings. Indeed, when I saw Titane, one viewer seemed to be retching, and I completely missed one scene as I would have covered both my eyes and ears.

Titane, like Ducournau's debut masterpiece Raw, belongs to a genre of film known as 'body horror'. Pioneered by directors like David Cronenberg and John Carpenter in the 1980's, body horror films provide their horror, and their storytelling, by depicting human bodies morphing and altering in grotesque, often disturbing, ways. Undeniably this genre is not for everybody, probably including me. However, if we take the idea that successful storytelling comes from showing how characters grow and change, body horror presents alluring

Written by Daniel Jacobson
Art by Lucie Gourmet

possibilities. Driven by talented, emotionally intelligent, young filmmakers like Ducournau, body horror seems to be experiencing a popular resurgence.

The central tenet of body horror is that a character transformation can be demonstrated by a loss of bodily autonomy, control and by painful metamorphosis. Such scenes, that draw on primal biological instincts of fear or disgust, are often used to convey a deeper message in the film. of In the 1983 film Videodrome, director David Cronenberg provides a very early and prescient, if on-the-nose, message about the overwhelming psychological power of new media by presenting a man slowly transforming into a television. Indeed, common film transformations differ between stories to reflect their various themes: the aggressive, angry, inescapable zombies of 28 Days Later are far removed from the lumbering, aimless masses of Shaun of the Dead.

Intriguingly, the stories told using this technique are often poignant and emotionally affecting, underneath a gory, visceral surface. For example, Ducournau's debut film, Raw, which tells the story of a young, vegetarian student who develops a taste for flesh, is actually considered an eloquent depiction of the struggles of fitting in and progressing into adulthood. In Relic, Natalie Erika James strikes at the heart of what makes dementia so scary by presenting how patients are often transformed into a shell of their former selves. Arguably the greatest transformation in modern literature, that of Gregor Samsa in Franz Kafka's Metamorphosis, can be interpreted in any variety of ways, from a loss of independence to a vivid portrayal of burnout.

A particularly interesting area of body horror's potential is in telling stories about cancer – possibly the ultimate triggered loss of bodily autonomy. Indeed, Alex Garland's Annihilation used principles surrounding the driving forces of cancer and how it evolves as a reflection of human drive and self-destruction.Body horror is undeniably not for everyone. However, what Ducournau and others are showing, is that our morphing bodies are storytelling tools, with shocking potential and poignancy.

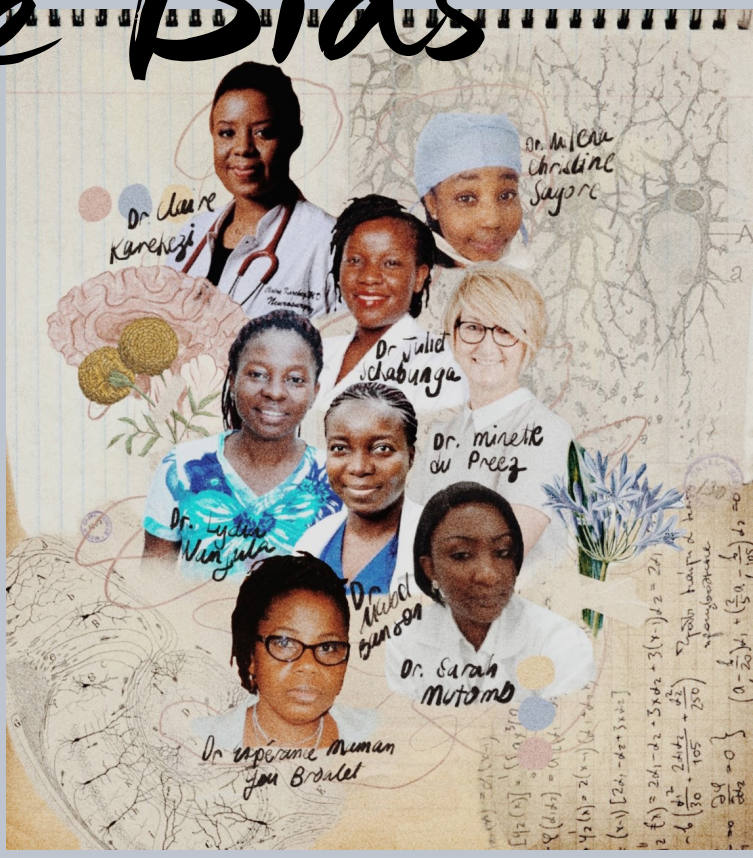
Break The Bias

Recent First Female Neurosurgeons in Africa

March 8th marked International Women's Day, a day to celebrate the achievements of women around the world as they continue to #BreakTheBias. One particular area that has seen breakthroughs is neurosurgery, with the rise in female neurosurgeons across Africa, a group that is otherwise severely under-represented in the medical field. Recently, Uganda, Burkina Faso, Ghana and several African countries have seen a rise of women in neurosurgery (WIN), which reflects the tremendous advancements in medicine as well as representation. Many have been inspired by their dedication and I, too, wish to acknowledge and honor the neurosurgeons paving the way for those to come.

Dr Juliet Sekabunga made headlines in 2018 when she was announced as Uganda's first female neurosurgeon. As of 2020, **Dr Lydia Nanjula** has now followed suit as the 2nd female neurosurgeon in the country. Burkina Faso received its first-ever female neurosurgeon in **Dr Milena Christine Sayore** in 2021. **Dr Mabel Banson** also achieved the same milestone last year as the first woman to join Ghana's neurosurgeons.

These new additions to the list of neurosurgeons is a necessity, since the neurosurgeon to population ratio remains high across the continent, with studies reporting approximately 1 neurosurgeon for every 1 million people. Furthermore, there is a significant under-representation of African WIN, stemming from intersectional inequalities within education, cultural norms and medical training. As such, it's important for me to highlight a recent article written by **Dr Claire Karekezi** (Rwanda's 1st female neurosurgeon) alongside several colleagues, outlining the history of African WIN. Their account provides an inspiring insight into the pioneering neurosurgeons within northern, western, central, eastern and southern Africa including **Dr Minette du Preez** (South Africa's 1st female neurosurgeon) and **Dr. Espérance Maman You Broalet** (Ivory Coast's 1st female neurosurgeon) just to name a few. Likewise, the authors expose the absence of female neurosurgeons in sub-saharan Africa, for instance



Dr. Sarah Mutomb is DRC's 1st and only female neurosurgeon and more than 10 African countries still have none. This disparity can be accredited to societal pressures, family obligations, lack of role models and lack of representation in academia; only eight out of the 243 african female neurosurgeons reported are senior-level professors (as of 2020).

The benefits, big and small, of representation for underserved communities are near-inexhaustible, and expanding the exposure of WIN will undoubtedly inspire the younger generation. As we continue with proactive, consistent advocacy and investment in women who venture into neurosurgery, there is great potential to grow the number of female African neurosurgeons in the future. The list of the existing neurosurgeons deserving applause is pleasantly too long to fit in this piece, but luckily, there are dedicated platforms like the **Young African Neurosurgeons Forum** (YoungCAANS) highlighting their accomplishments in medicine. Hopefully, this increasing prevalence of female role models will only encourage women to take on a field which has historically and systematically neglected them, and carve a new path that provides a voice for the under-represented in healthcare.

Written by Perside Ngani
Art by Lia Bote

EDITORS

Emily Vialls
Sophie Maho Chan
Mahidhar Sai Lakkavaram
Nirvan Marathe
Maria Stoica
Kate Hodgson
Daniel Jacobson
Gracie Enticknap
Catherine Turnbull
Madhumila Killamsetty
Evelyn Nguyen
Jasmine Lai
Madeleine Throssell
Sara Maria Majernikova
Emma Last
Priyanka Peres
Miranda Hitchens
Zoe Beketova
Ismat Ghuman

THE TEAM BEHIND THE ISSUE

PRESIDENT	Sophie Maho Chan
TREASURER	Daniel Jacobson
MANAGING EDITOR	Priyanka Peres
COPY EDITOR	Altay Shaw
COPY EDITOR	Anita Allikmets
MANAGING WEB EDITOR	Ebani Dhawan
CREATIVE DIRECTOR	Rahel Kiss
CREATIVE DIRECTOR	Lola Artiles
SOCIAL MEDIA OFFICER	Lia Bote
WELFARE OFFICER	Marta Sadlej
SOCIAL SECRETARY	Emma Wei
WEB EDITOR	Patrick Marenda

SPECIAL THANKS TO

Qiwen Liu for the fantastic cover art

STUDENTS' UNION UCL

KINESIS

magazine

www.kinesismagazine.com

@kinesismagazine

@UCL Kinesis Magazine