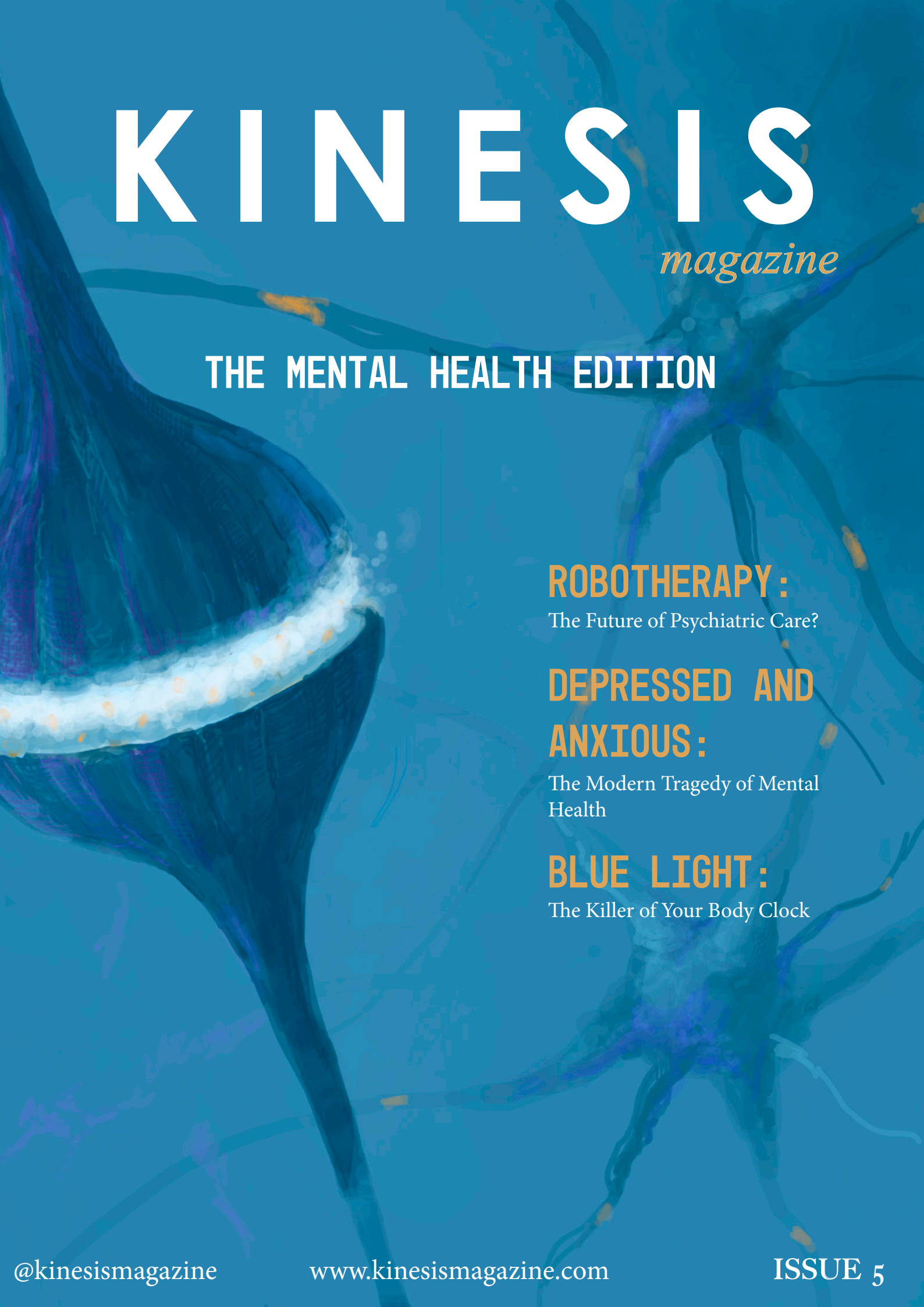

KINESIS

magazine

THE MENTAL HEALTH EDITION

ROBOTHERAPY:
The Future of Psychiatric Care?

DEPRESSED AND ANXIOUS:
The Modern Tragedy of Mental Health

BLUE LIGHT:
The Killer of Your Body Clock

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BLUE LIGHT:
THE KILLER OF YOUR BODY CLOCK

How phones are waking up our fish brains.

Written by **Ben Freeman**
Art by **Wenanlan Jin**

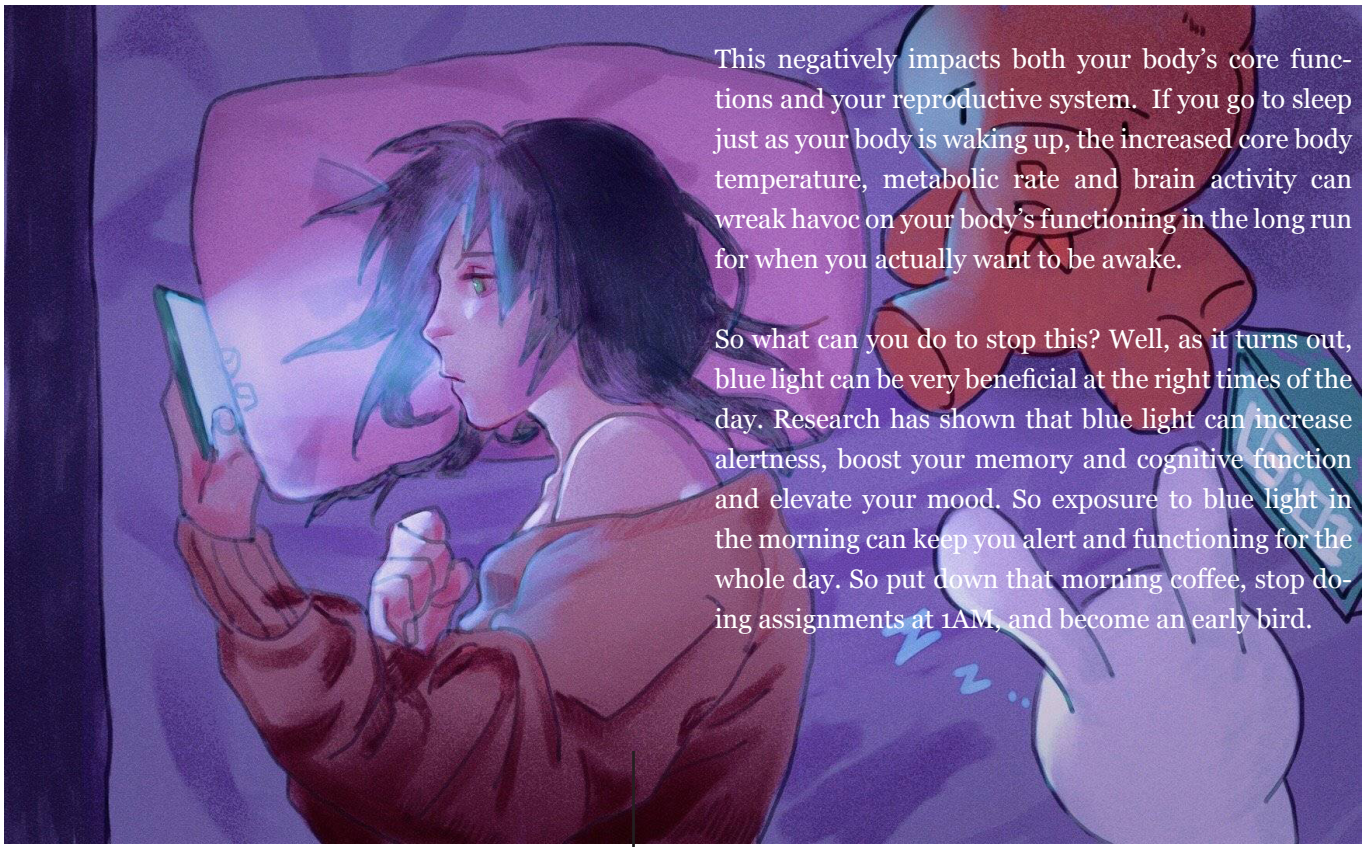
I'm sure you've heard of this phenomenon everywhere: in the news, on billboards, maybe even more ironically, on your phones. We know blue light is harmful when we're exposed to it before we go to sleep, but have you ever wondered why?

Well, to answer this question we have to go back a few years... Okay, a few million years, to when it was simply aquatic life that inhabited earth. During this period, our body clock (or circadian rhythms, if we're trying to be smart) began to develop. The body began to develop cryptochromes; by sensing the levels of blue light in the water (the only light that can penetrate water), cryptochromes kept track of day and night and changed the body's activity appropriately. For example, when cryptochromes detected a decrease in blue light levels, they would prompt a decrease in the fish's metabolic rate and an increase in its melatonin production.

Fast forward a few million years and mammals began to evolve from the same fish, retaining the blue light sensitive cryptochromes. However, mammals' cryptochromes became light independent, because they were exposed to the whole spectrum of light. Instead, mammals require a set amount of sleep dependent on the body's activities, irrespective of what time of day it was, which explains why some teenagers are close enough to being nocturnal.

Life ran perfectly well for another few million years until the development of technology, specifically monitors on phones, tablets and laptops. The artificial light these devices emit is composed prima been in use for millions of years. As a result, your brain is tricked into believing that the sun is coming up and responds by releasing signals to the body to wake up.

This doesn't just have short term effects on the body. With the use of this blue light, the body is essentially running on two body clocks: one that is built within all mammals and is independent of light, and another that is archaic and solely responds to blue light. Mixing these two body clocks has catastrophic effects on the body, mainly on the production of melatonin. The body produces excessively large amounts of melatonin in response to the blue light emitted by monitors at night.



This negatively impacts both your body's core functions and your reproductive system. If you go to sleep just as your body is waking up, the increased core body temperature, metabolic rate and brain activity can wreak havoc on your body's functioning in the long run for when you actually want to be awake.

So what can you do to stop this? Well, as it turns out, blue light can be very beneficial at the right times of the day. Research has shown that blue light can increase alertness, boost your memory and cognitive function and elevate your mood. So exposure to blue light in the morning can keep you alert and functioning for the whole day. So put down that morning coffee, stop doing assignments at 1AM, and become an early bird.

02 Why Do We Find Animals So Cute?

The biology behind why we can't help fawning over creaters great, small and fluffy.

Written by **Lucy White**
Art by **Emma Maia Smith**

It's undeniable that we find baby mammals (especially the sweet, fluffy ones) indescribably adorable. Even the most stoic of people can melt when presented with a particularly gorgeous puppy. But why do we find some animals so darn cute, and others - like the great white shark, or the naked mole rat - decidedly unpleasant?

The answer is, in many ways, surprisingly simple. We are biologically programmed to have an emotional response to human babies. This is an essential evolutionary adaptation - we have to like our offspring to want to look after them when they are young and vulnerable.

When humans evolved to walk on two legs (bipedalism), the positions of our pelvises had to change, and pelvises became narrower. The result of this is that women cannot give birth to anything larger than a baby's head, and hence human babies are born at an early stage in their development compared to other animals, like fish, which are essentially independent from birth. Human babies need to be taken care of for a long time after birth, and so an emotional response towards them is essential.

Traits that animals share with babies tend to elicit the strongest responses in people. Characteristics such as having big eyes and heads, prominent foreheads and retreating chins, round and pudgy bodies, and soft textures are all features of babies that are also seen in many young mammals. Scientists believe that dogs, having been domesticated, may have evolved by this logic, exploiting our preferences for things like the classic "puppy dog eyes".

However, our responses may also be rooted in behaviours, rather than merely physical features. Elephants, for example, share few physical characteristics with human babies, but do share some behaviours. They often appear to be clumsy, and look vulnerable and fragile next to their much larger parents. We relate this to the similar traits seen in our offspring, so baby elephants can trigger just the same "cute response" as a puppy does.

Our neurological response to human babies and animals we find unbearably sweet is very much the same, and is rooted in the reward pathways of our brains. The "cute response" stimulates the limbic system, which contains structures such as the amygdala and the hippocampus. These structures are involved in emotion, learning, and memory. The reward pathway in the limbic system is triggered, and large amounts of dopamine (a neurotransmitter associated with motivation and reward) are released. This emotional response is designed to encourage us to look after our offspring and ensure the survival of the species.

Our biological tendencies are also frequently exploited by companies for marketing purposes. For example, the Andrex company uses a Labrador puppy to help sell their toilet roll, and car companies (such as VW with the Beetle, and Mini with the Mini Cooper) produce cars with baby-like features: rounded bodies, large headlights, and a short front.

In essence, our brains have evolved to have such a strong response to human babies that we have the same response to a much wider range of things. The more similar an animal is to a human baby, the stronger our "cute response", and the more likely we are to be caught out sighing dreamily at passing puppies or cooing at a neighbour's cat.

ROBOTHERAPY

The future of Psychiatric Care?

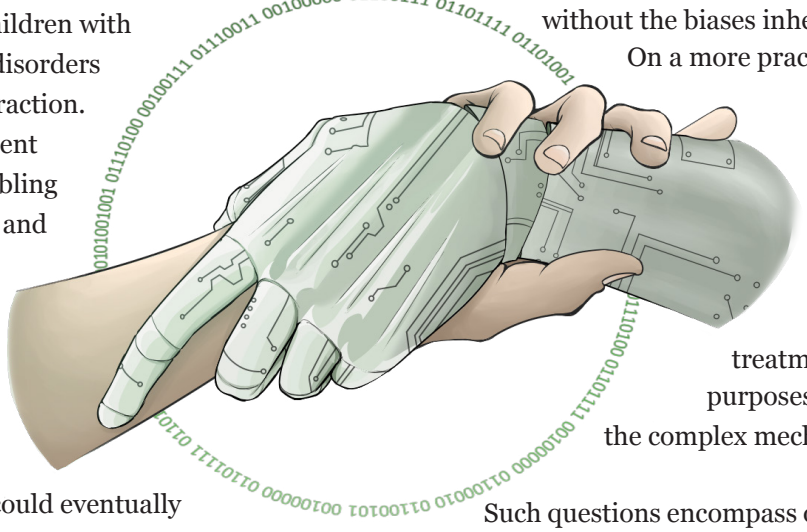
Future therapeutic treatments are being revolutionised by AI. But what are the implications of this?

Written by **Tasha Kleeman**
Art by **Elena Natsumi**

Ellie is a therapist who works with US veterans. She talks to her patients about their military experiences, providing a therapeutic space for them to explore their trauma, and detecting signs of PTSD. However, Ellie is no ordinary therapist: she's a humanoid robot, designed by researchers at Southern California's Institute for Creative Technologies. Using sophisticated Multisense processing and video monitoring, Ellie can detect verbal and behavioural indicators of psychological stress, and can respond in real-time with her own computer-generated speech and gestures.

Ellie represents the most recent leap in Artificial Intelligence, but she isn't the first of her kind. Cognitive behavioural therapy (CBT) chatbots like Tess, Wysa and Woebot have been offering virtual therapy to online users for several years now, with promising results. Initial studies saw a decrease in symptoms of depression in Woebot users compared to a self-help control group, while another study found reduced symptoms of depression and anxiety in users of Tess.

Embodied AI, like Ellie, represent the next phase of this blossoming technology. Already, animal-like robots are being developed to assist patients with dementia, while robots like Kaspar and Nao have been designed to help children with Autistic spectrum disorders practice social interaction. With the development of Emotion AI, enabling machines to detect and respond to the nuances of human emotion, these interventions are likely to become increasingly sophisticated and could eventually enter mainstream therapeutic practice.



With mental health services vastly oversubscribed and under-resourced, AI-powered psychiatric care could provide an efficient solution, overcoming the financial and geographical barriers that block many from accessing therapy. In some cases, robot therapy might even prove more effective, with several studies finding participants able to open up more quickly to robot therapists, given the reduced risk of social judgement.

Yet the prospect of AI therapy isn't without its concerns. The first comprehensive study into the use of embodied AI in the treatment of mental illness was conducted this year at the Technical University of Munich. While researchers drew attention to the enormous potential benefits of AI in this field, they also raised some substantial ethical considerations.

AI is still in its infancy, and we don't yet know the full effects of human interaction with robots. The little we do know, for example, of the attachments that humans can develop to robots, and the 'uncanny valley' phenomenon whereby androids closely resembling humans are perceived as deeply unsettling, is enough to raise significant concern, particularly given the vulnerability of those that would be engaging with robot therapists. Beyond this, the widespread use of AI therapy would pose significant challenges for data protection and privacy, while requiring complex and stringent procedures to ensure that machines are programmed without the biases inherent in human interaction.

On a more practical level, it seems difficult to conceive of a robot that could fully match the capabilities of a human therapist.

Computerised therapy may work for CBT-based treatments or for basic diagnostic purposes,but could a machine learn the complex mechanisms of psychoanalysis?

Such questions encompass our hopes and fears regarding the capabilities of AI. Will it ever be possible for us to create Artificial Intelligence that can successfully emulate humanity's capacity for empathy, social interaction and autonomous thought, and, perhaps most unsettlingly, what will it mean for us humans if we do?

OBESITY: A DISEASE OF THE GUT MICROBOME?

Our bacterial lodgers need attention too!

Written by **Lucy Masdin**
Art by **Jamie Hau**

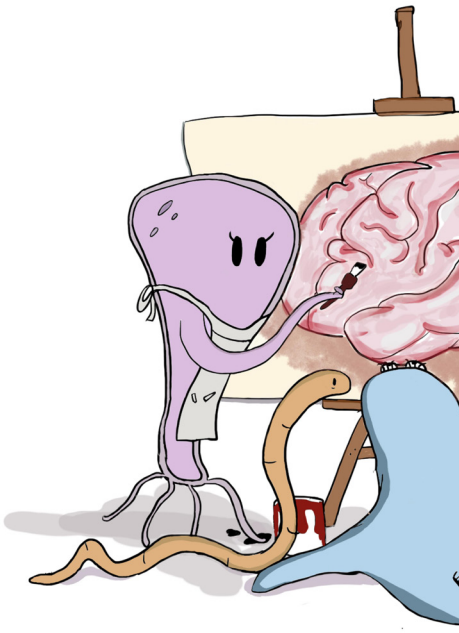
Obesity is a pandemic, taking over the planet at an alarming rate. The World Health Organisation (WHO) suggests that by 2030, 20% of the adult population will be obese. In other words, 1 in 5 adults would be at risk from a multitude of chronic diseases. No doubt, eating McDonalds every day will help you put on the pounds. However, researchers are straying away from the over-simplified narrative of 'EAT LESS' and are delving deeper into the whys and hows of obesity, uncovering that the gut microbiome may be playing a large role.

One of the pioneering points of research in the field, compared the microbiome of obese and lean people, which led to the proposal that a shifted ratio of bacterial families (specifically Bacteroidetes: Firmicutes) could be of significance. The Human Microbiome Project then linked a specific species of bacteria (Christensenella minuta) to weight-loss, given its increased presence in leaner people, reinforced by its weight-loss effects after introducing it into mice. Much of the literature suggests that leaner people's microbiome contain bacteria which are more efficient at breaking down carbohydrates.

Another study, compared the faecal composition of children in Italy, living on a largely westernised diet, with children in Burkina Faso, with a diet more similar to early settlers'. Italian children were found to be completely lacking in two genera of bacteria, indicating that changing the diet changed what was able to live in the gut. It's all pointing to the fact that we are responsible for changing our gut microbiome, potentially to the detriment of our health.

The danger with fixating on key bacteria having an explicit role in obesity then implies simplicity of the microbiome. Should the microbiome be considered as a human organ in its own right, having its own web of complex and delicate interactions that have an impact on various metabolic processes in the body? We understand the genome is not as simple as just a set list of genes independently having one distinct effect, so why do we do this for the microbiome? Little is understood about precisely what certain bacteria are doing to make us healthier, but these early findings are proof enough that this is a growing area of research.

However, another issue that scientists must account for is, how vastly different the bacterial colonisers of different organs are. While, the easiest way to assess the microbiome is through our faeces, this may not provide the most representative picture, but stomach and intestinal samples are more difficult to obtain.



Faecal transplants are emerging as an important subject, not only in monitoring the effects of microbiome changes, but also as a potential therapeutic procedure. Sterile mice receiving faecal bacteria from obese women accumulated body fat and developed metabolic complications. This was a key finding, as it infers that directly changing the microbiome could change the host metabolic phenotype.

An alternative view emphasises the gut microbiome's role in appetite control and whether bacterial metabolites are stimulating signalling pathways. For example, Acetobacter and Lactobacillus bacteria were found to suppress flies' appetite for protein and increase it for sugar. A more critical evaluation of how the microbiome interacts with hosts may shed light on how to focus on long-term solutions for weight-loss control, as many current strategies are difficult to maintain with patients often resorting to costly bariatric surgeries.

Perhaps we should start cherishing our microbiome, or else it might fight back with obesity!

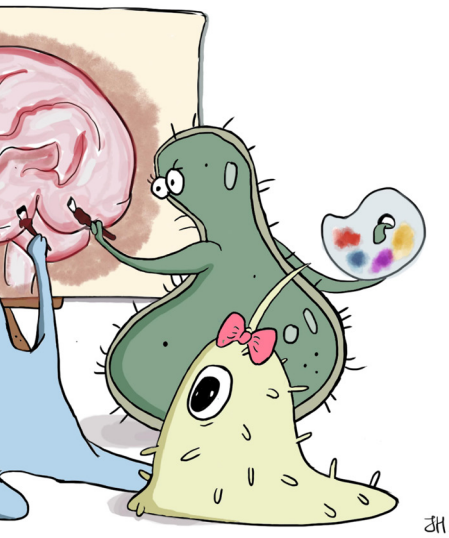
ARE YOUR GUT BACTERIA CONTROLLING YOUR THOUGHTS?

The link between brain and gut is now being considered as a peek into the mystery of human behaviour.

Written and Illustrated by **Jamie Hau**

The possibility that your stomach influences your brain might sound like something out of a sci-fi movie, or an amusing birthday card, but there is increasing evidence that your gut microbes may be influencing your day-to-day thoughts and behaviour.

For decades, scientists have been deciphering the complex link between the bacteria in our gut and a myriad of metabolic, neurodegenerative and autoimmune disorders. The classic example is the causative role of Helicobacter. Pylori in patients with gastritis and peptic ulcers, which earned its discoverers the Nobel Prize in 1982. Until recently, the idea that our gut and central nervous system are associated was widely reviled. Now, there is an emerging hypothesis that the microbiome plays an important role in the gut-brain axis.



The gut-brain axis is a bidirectional link between the central nervous system and our intestines. Chronic stress has been shown to alter intestinal permeability, which is associated with low-grade inflammation that can be linked to psychiatric disorders, such as depression. Other studies have suggested that the gut microbiota can produce neuroactive substances influencing the key symptoms of neurodegenerative disorders, such as Parkinson's or Alzheimer's disease.

So how does this "gut-brain axis" work?

The bacteria in our gut produce metabolites that are important for our general well-being. In healthy humans, commensal microbiota and their host display a pleasant symbiotic relationship. In states of dysbiosis, however, shortage of advantageous metabolic end-products may contribute to several neurological issues. For example, many species of Lactobacillus and Bifidobacterium produce GABA, the main inhibitory neurotransmitter in the brain. Likewise, Candida, E. coli, and Enterococcus produce serotonin, whereas some Bacillus species have been shown to produce dopamine, neurotransmitters strongly implicated in pleasure and depressive disorders. Our gut bacteria also break down dietary fibres into short-chain fatty acids that stimulate serotonin release.

To address the mechanisms underlying microbiota-gut-brain communication, a group of researchers, in 2019, developed a DNA sequencing method for characterising the neuroactive potential of gut bacteria, and their impact on quality of life (QoL) and depression. They analysed microbiota in the faeces of participants, and then correlated different microbial taxa with the participants' QoL and incidence of depression. With these data, the researchers described the microbiota's capacity to produce or degrade molecules that can interact with the human nervous system. They found that the relative abundance of two groups of bacteria populations, Coprococcus and Dialister, were reduced in people with depression. There was also a positive correlation between QoL and the ability of the gut microbiome to synthesise a breakdown product of dopamine. These are the strongest results yet, to show that a person's microbiota can influence their mental health.

Despite the increasing evidence of the association between microbiome dysfunction and central nervous system-related comorbidities, much of what we know so far is based on studies showing correlations between specific gut bacteria, their metabolites and neurological symptoms, without proving a direct causal link. The challenge at present is to find out how these microbe-derived molecules interact with our central nervous system, and whether that alters a person's behaviour or disease risk. At least for now, answering these questions is a sensible pursuit, and not a ludicrous one.

THE SCIENCE OF ATTRACTION:

WHAT DOES EVOLUTION TELL US ABOUT OUR PARTNER PREFERENCES?

In what ways do our modern dating and mating behaviours reflect our biology?

Written by **Sophie Chan**
Art by **Will Ning**

We say that "beauty lies in the eye of the beholder"—that beauty does not exist independently, but as a social construct. However, many scientists are now claiming otherwise.

Evolutionary psychology has been a budding field of research over the last few decades, producing much literature explaining modern human behaviour in terms of Darwinian laws of natural selection. A particular topic that has been receiving attention is the application of evolutionary psychology in the context of human mate preferences. Many researchers are now claiming that they can reasonably predict, explain and even substantiate that there are universal patterns in what people look for in a partner — a lot of which concern physical characteristics.

A Royal Society review article compiling over 250 studies concluded that there are certain facial features that seem to be deemed 'attractive' across cultures, sexes and even species. One such feature is facial symmetry. As far as the evolutionary view goes, the idea is that individuals differ in their ability to maintain facial symmetry under environmental pressures. Thus, symmetry is favoured by men and women alike, as it serves as an indication of a healthy partner and 'good' genes to pass onto potential offspring.

Symmetry has also been linked to survivability and fecundity, while asymmetry has been linked to respiratory diseases and mutations, which propels a selective pressure for being able to recognise and choose symmetrical mates. Other physical characteristics claimed to influence mate choices include 'averageness', masculinity/femininity and skin health.

Furthermore, through this biological lens, researchers have also postulated and evidenced sex differences in mate preferences, which arise from differential mating strategies between men and women.

Here, the general consensus among Darwinian scientists is that females, who spend greater time and energy to conceive children, have evolved to prioritise parental qualities in a partner, while males have 'genetically' evolved to seek short-term relationships and higher number of fertile sexual partners to increase the chances of passing on their genes to the next generation. Over the past decade, researchers have proposed that men are attracted to low waist-to-hip ratio and physical cues of youthfulness, while women put greater emphasis on non-visible qualities such as status and wealth.

As you may imagine, such studies are greatly controversial. While some (predominantly male) scientists have used this as a gateway for further research, others have heavily scrutinised such application of evolutionary theories to modern mating behaviours. Among the most common criticisms include the Western biased samples, self-reported subjective methodologies and male-focused perspectives.

But perhaps, the larger concern with evolutionary psychology is not the accuracy of the theories, but how the theories can come to influence our behaviour. There seems to be a widespread belief that having an evolutionary explanation of a behaviour which grounds it in fundamental biology, serves as an apt justification. However, do scientific explanations for infidelity or polygamy make them 'right'? A controversial example that illustrates this is Robert Kurzban, a former psychology professor at the University of Pennsylvania, who after publishing research arguing that men are more likely to mate with younger women, faced allegations of having multiple inappropriate sexual relationships with female students.

Furthermore, evolutionary psychologists are quick to neglect the influence of environment and culture. There is still much to be understood about the interaction between biology and culture in informing personal behaviours.

What is Genius?

Why are some minds able to change paradigms? Can science tell us how exceptional minds come to be?

Written by **Ebani Dhawan**
Art by **Vivienne Leech**

If you type in 'How to become a genius' into Google, about 261,000,000 results are spat out in under half a second. Links to memory exercises, reading lists and even cardiovascular exercises emerge with the goal of bringing you closer to becoming a genius. We live in a time in which all traits and terms are exaggerated. Just look at the standard size at Starbucks - tall! Our obsession with the individual who has achieved the impossible has led to the inflation of the term 'genius', which is now being used to describe any outstanding production.

But, what is a genius anyway? And why are we so obsessed with it?

'Genius' is an 18th century concept, a post-Enlightenment version of sainthood. However, philosophers have long been pondering the origins of genius. The Greeks believed that the creation of such an extraordinary mind was due to an excess of black bile, one of the four bodily humours defined by Hippocrates; while Thomas Edison, a renowned genius, was most famously known to have proclaimed that "Genius is one percent inspiration and ninety-nine percent perspiration". But, the search always proves futile. No one has ever discovered one single source of genius, and such a thing is unlikely to be identified.

So, what is it that sets the genius apart? I see 'genius' as the epitome of being human. Of course, we all want to attain the status of a genius. Currently, scientists and philosophers are attempting to bring us closer to understanding genius and its almighty power by unravelling its complex and tangled enablers - qualities that allow a person to become a genius and in due course, significantly impact the world.

Genius is synonymous with intelligence, often used to measure someone's genius. Stanford psychologist Lewis Terman, who made studying the gifted his life's work, devised the ubiquitous Intelligent Quotient (IQ) test. He thought that one's IQ was a key indicator of genius. In the 1920s, he sent out the test to California's elementary schools and identified around 1,500 kids with exceptional IQs. This group, known as "Termites", were subjects of one of the most famous psychological studies in history. Terman followed his Termites throughout their lifetime, noting down their success and anything that was 'genius-like'. However, by the time his Termites reached adulthood, Terman was left with no Nobel Prize winners in his pool of Termites. Having an IQ that is the 'crème de la crème of society' is no guarantee of genius. In fact, two elementary students, Luis Alvarez and William Shockley, who didn't make it into Terman's esteemed group, grew up to win Nobel Prizes in Physics. "We have seen", Terman disappointedly concluded, "that achievement and intelligence are far from perfectly correlated."

If it isn't intelligence, then what is it?

A strand of genius that Terman, or anybody for that matter, couldn't measure was creativity. Creativity is a process, as proposed by the American psychologist, Donald MacKinnon, which involves the following: concentration, withdrawal from the problem, the 'a-ha' moment, and the application of the insight one has experienced. It is this 'a-ha' moment that sparks the fire of genius. It is in this moment that the genius has been able to find the connection between two ideas that no one has even thought of.

As Schopenhauer, a German philosopher once said, "talent hits a target that no one else can hit, but genius hits a target that no one else can see." This was how da Vinci approached the world. His combinative thinking gave him the exceptional ability to interconnect between seemingly unrelated fields, recognising similarities in living forms that were connected to different aspects of the modern world. This is why his art is so realistic; it mirrors the authenticity of nature, for instance, ensuring that the rocks on his canvas had the right number of sedimentary layers.

Da Vinci's ability to make connections between seemingly disparate concepts may be due to richer communication links between different areas of the brain. Jazz improvisation is a perfect example of how neural

networks interact during the creative process. Charles Limb, an auditory surgeon at University of California San Francisco, asked six pianists to play a memorised piece of music and then to improvise solos. He found that the brain activity between these two tasks was fundamentally different. The brain's internal network, associated with self-expression, showed increased activity, while its outer network, linked to focused attention and also self-censoring, quieted down. "It's almost as if the brain turned off its own ability to criticize itself," he says.

In my opinion, the contemporary genius is the creative rebel who utilises their extraordinary faculty to remain significant throughout time, through their achievements. It may not encompass all that makes a genius; it is almost impossible to define and precisely characterise 'genius'. The quest to unravel the origins of genius may never reach an endpoint, but that is not an issue.

'Genius' defines the undefinable, since being easily definable is the very antithesis of what it means to be a genius.

Neurofeedback Therapy: SCIENTIFICALLY VALID OR NOT?

Effectiveness of neurofeedback therapy, a method straight from science fiction film, lies in the art of training brainwaves.

Written by **Maria Kossowska**
Art by **Iona Jenkins**

It has been reported that Neurofeedback is a non-invasive, high-tech, and drug-free method for training bioelectrical activity of brainwaves. Sounds like science fiction? Definitely! Yet, it has been widely used for the past 50 years – but how does it work? To acquire a signal from the brain, Neurofeedback measures the electrical fields generated by the activity of neurons. The bioelectrical signal of brainwaves is detected by electrodes fastened against the scalp. Bioelectrical signal is converted into digital data, whilst specialised software, such as BioTrace+, processes it to enable the execution of Neurofeedback therapy.

Neurofeedback therapy is a learning process based on real-time feedback. During a therapy session, the naturally-occurring frequencies of brainwaves are presented to the patient in real-time through visual and auditory modality – that is the feedback paradigm. Meanwhile, a therapist sets a threshold to control the feedback. Given that, any excess brainwave frequency is trained down. Correspondingly, insufficient brainwave frequency is trained up to increase brain activity. Therefore, the goal is to return the distribution of brainwaves frequencies back to 'normal' or typical for the person's age. The patient is able to train their brainwaves, when achieving a state of relaxation, whilst remaining focused. Each time the patient reaches a normalised frequency of trained brainwave, they are rewarded with a visual and/or auditory stimulus – that is the learning paradigm. However, Neurofeedback is rather controversial, and there is no general consensus about its effectiveness.

Whether suffering from epilepsy, ADHD, alcoholism or post-traumatic stress disorder in childhood or adulthood, researchers suggest that Neurofeedback therapy is effective in changing neurological functions. Nevertheless, Neurofeedback has not been immune from criticism. A psychologist and scientific sceptic, Barry Beyerstein, wrote that, "alpha wave production can produce a meditative state", in no more correlation than, "opening an umbrella can make it rain". Across literature, Neurofeedback therapy does not show consistent and successful outcomes for disorders such as anxiety or dyslexia. However, a Neurofeedback therapy clinician, Dr Tony Steffert, points out that much of the academic research that fails to demonstrate beneficial effects, comes from groups that lack the experience of working with Neurofeedback on a daily basis. The following interview reveals why he believes Neurofeedback therapy is as much an art as it is a science.

Interviewer: Why there is a controversy on the efficiency of Neurofeedback therapy?

Tony: Neurofeedback is a really complicated topic and people are really complicated; you cannot just read a few papers and copy the methodology, but many researchers seem to think you can. There are many complexities that you don't see from a paper, so when you spent months doing a study that does not get a good result, what are the chances of you doing a replication study to find out where you went wrong. It's quicker and easier to conclude that Neurofeedback doesn't work and move onto a different topic. I have read some papers on the efficiency of Neurofeedback therapy from some really good research groups. It is a wonderful paper, yet the authors make a really odd decision, where to set threshold, at one point that no clinician would ever do with a real patient. Thus, the authors conclude Neurofeedback doesn't work. Well, of course this study is not going to have positive outcomes, if you set the threshold 400 times higher than the participants brainwave ever gets.

The researchers should come and talk to some Neurofeedback clinicians who are doing Neurofeedback therapy on a daily basis, I'm sure they would all be very happy to help.

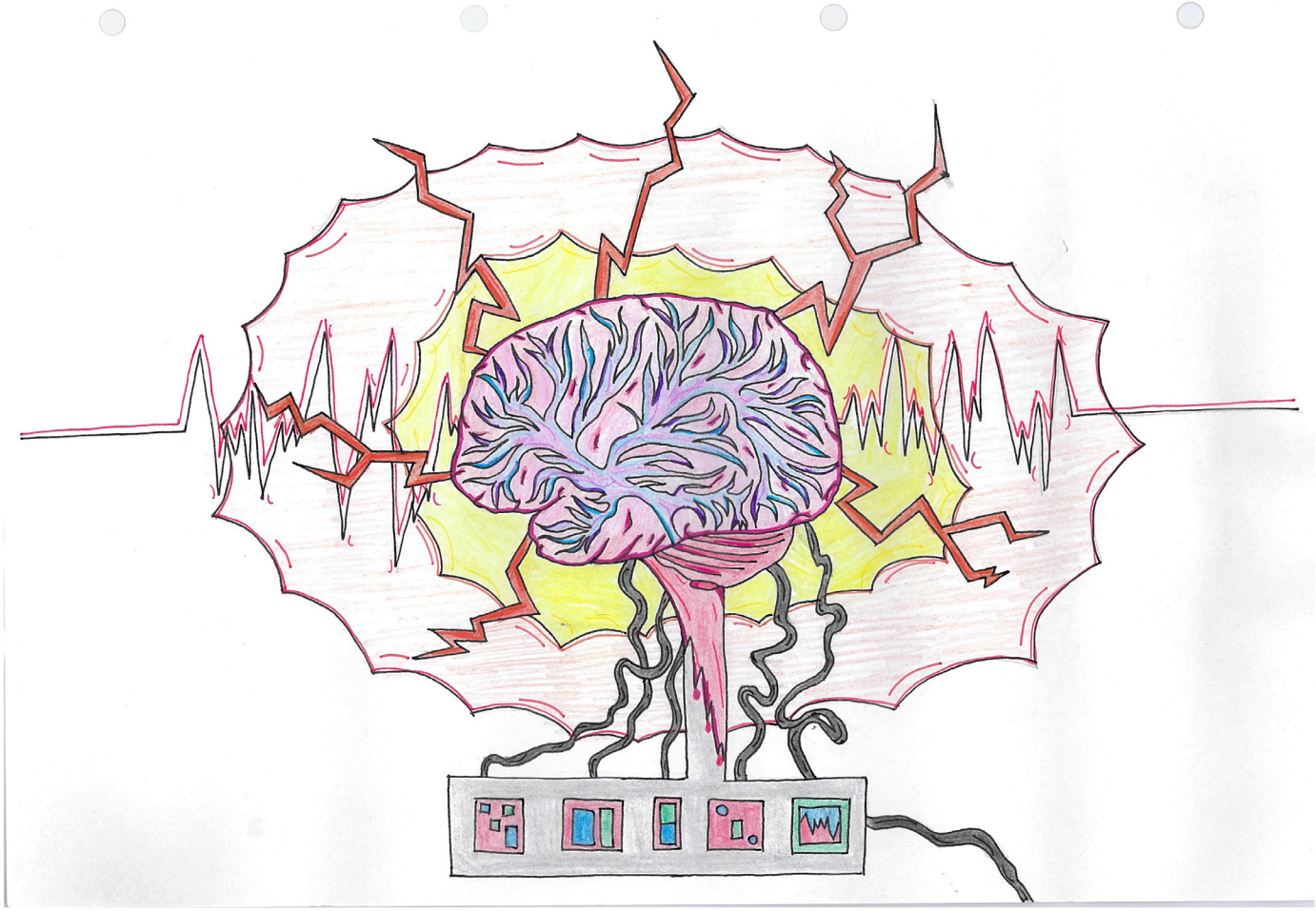
Interviewer: In one of your workshops you've said that Neurofeedback is a form of art, what do you mean by that?

Tony: Well, for me it is an art and a science. There is obviously a lot of science involved. But for example, setting the training thresholds is where I feel Neurofeedback training as a form of art for the clinician. It is true, you could mathematically calculate means and standard deviations etc., work it out statistically where you should put a threshold to achieve some criteria to train the brainwave in a desired direction. However, because the brain and the EEG are so dynamic, by the time you have done that, all the values would have changed again.

In one study we tried this, we did a full brain map assessment, and analysed the EEGs and spent ages calculating means and percentages of time etc., then fixed the training threshold for 15 sessions.

It didn't work at all, and in my opinion, this is because there is so much variability in people from day to day and minute to minute: how well they slept, what they eat, their mood or even the weather. For example, when setting the threshold there is a risk you make the training too difficult, which would demotivate the patient. But if you make it too easy the patient might be happy because he is doing nothing, yet they would not learn either. There isn't any rational, mathematical or algorithmic way that you could get the threshold right every time. I am not saying that a clinician is the only way, or they will always get the threshold right, but at least a human can consider the patients current mental state.

The art is in all those subtle decisions an experienced therapist makes without even realising it!



The Bridge between suicide and life

WHY DO SOME CHOOSE SUICIDE?

Sometimes, I wonder whether our species even wants to survive...

Written by **Grace Wellington**
Art by **Wenanlan Jin**

It is known that our bodies are programmed to survive; we have evolutionary origins that have adapted our central nervous system to function and respond to a constantly changing environment. From Darwin's theory of Natural Selection, it is clear that humankind has fought to remain alive and continue to survive. Yet, a question many people might ask themselves is: why do some go against their instinct to live? Why do people choose to commit suicide?

The fascination for suicide comes from the idea that those who unfortunately killed themselves were able to overcome that fear we all inhabit. The fear of death has deeply embedded in our subconscious, conserved through years of evolutionary adaptations, as well as social practices, as many religions condemn the act. The Nobel Prize Winner Herman Hesse, proposeda theory of the 'temptation of suicide' that suggests, suicide may appear to some as a rewarding act, and social psychologist Baumeister's view of suicide is a way of escaping our aversive self. In each of these cases, the fear of death is virtually non-existent, but why?

Very little research has been conducted to investigate such questions. Following a neuroscientific approach, it is a known fact that serotonin influences the calming emotions of the brain, and when this is lacking, individuals will suffer from impulsivity. In the autopsies of 20 suicide victims, a limited supply of serotonin was evident in reaching the white matter in the orbital cortex (a region regulating impulse control). In a similar study, they found that, it is clear that serotonin did not sufficiently reach a prime area of the brain.

In the analogy of the 'source and the sink', hormone imbalances (the sink) must stem from a source - the brain. Is there an anatomical aspect that could further explain why individuals choose suicide? A study conducted by a team of researchers at the? University of Pittsburgh sought to prove their hypothesis that suicide is a decision-making and 'prediction' disorder. FMRI computing modelling was used to examine the brains of patients while completing a task, and signals were found to be blunted in the ventromedial prefrontal cortex – the key area regulating risk and fear. What is the implication of this?

Therefore, these studies suggest a strong correlation between underlying biological defects and increased chance of committing suicide. Without risk perception and fear, the phobia of death is non-existent, and accompanied by poor decision-making ability, Hesse's 'temptation of suicide' will appeal more to such individuals. Their perceived perception between the boundary of life and death is gravely reduced to the point where life becomes less meaningful than death, and death is a prize they wish to take.

In conclusion, it is evident that, from a neuroscientific perspective, the brain activity and hormone levels are different in individuals of suicide-attempters. It is striking that such variations can result in a devastating decision to commit suicide, but what is even more outstanding is the fact that, this variation is global. Has a mutation in the rationality of our thoughts and behaviour become a common trait?

Throughout history, the act of suicide has been continuously rebuked; Plato expressed suicide as an act against society, whilst Aristotle deemed it a 'cowardly act'. Yet, time has transformed society's perception on suicide, establishing a rather glorified platform. Many articles now explore the 'right ways to commit suicide' and TV shows such as '13 Reasons Why' almost make suicide seem appropriate and a form of justice.

The rising rates of suicide and social acceptance makes us question whether our species are failing to adapt to Darwin's 'survival of the fittest'?

The questions I now pose is simple: do our species even want to survive and whether we are choosing to accept death over life?

DEPRESSED AND ANXIOUS:
THE MODERN TRAGEDY OF MENTAL HEALTH

We are often scared of that which we do not understand. Mental health isn't something to be scared or ashamed of; we should seek to understand and embrace it.

Written by **Isabelle Yuen**
Art by **Wenanlan Jin**

Ask anyone you know what they think about first aid, and chances are they will nod in approval and murmur with agreement. Over the years you learn life-saving tips about first aid – how to check for a pulse, performing CPR to the beat of 'Staying Alive' by Bee Gees, learning to do the Heimlich manoeuvre. Everyone can agree on how crucial it is to have knowledge of such aid, as well as the wisdom on how to apply it when situations call for its use.

Well, this is not much different to mental health first aid. Yet, so few people are aware of the dangers of leaving mental health problems untreated and have yet to understand that the use of mental health first aid has an equally important place in today's modern society as physical first aid does.

Anxiety in youths: what's changed?

In this era, where anything less than a fast-paced hustle is frowned upon and dismissed with disdain, the toll that continued societal stresses and pressures have on people have not gone unnoticed. According to the National Institutes of Health, approximately a third of adolescents aged between 13 and 18 will experience an anxiety disorder, with the numbers rising steadily since 2007, anxiety disorders in youths increasing by almost 20%.What's changed since then?

Societal pressures and social media

Whether it be in terms of academic performance or achieving financial independence, society is pushing youths to their breaking point with unrealistically high expectations to meet, from standardized testing in schools, to the not-so-subtle culture of achievement, until it no longer becomes possible to be working at one's own pace without being viewed as stagnant and 'lazy'.

Additionally, the newfound wonder that is social media in this digital age has not helped improve the situation either. Now, the push of a button can unleash a monstrous tidal wave of people shoving news and photos of their various shining accomplishments and successful endeavours down our unwilling, consumerist throats. Unsurprisingly, this has perpetuated a culture of competition, with more and more individuals, especially teenagers and youths, equating the quantity and grandeur of their achievements (be it academic, social or physical) to their self-worth, no thanks to social media for providing a perfect broadcasting platform.

What can we do to help?

Of course, it would be incredibly idealistic to believe that we can fix an entire society's ingrained culture overnight. What we CAN do, is to start the conversation. Mental health is often considered a taboo topic, especially in eastern cultures. Therefore, there is a lack of attention and understanding about it, which complicates matters since it is difficult to tackle a problem when often, people don't even realise that it is a problem. You don't need to be a trained professional or a certified clinical psychologist to help someone in need; a mental health first aider is someone who can listen calmly to their fears, give them simple information about mental health, and guide them in the right direction to seek appropriate help. With a little compassion and empathy, we can all do our part to make this world a little safer.

HOW SYNTHETIC BIOLOGY IS SHAPING THE FUTURE

Biotechnology has the potential to revolutionise our lives, but how are scientists setting about making this happen?

Written by **Harry Dodd**
Art by **Iona Jenkins**

It may seem like the plot of a particularly far-fetched science fiction novel, but artificial life is on its way. Imagine a world where viruses have no power, and disease is only encountered in history books. We have a long way to go until we reach this point, but pioneering researchers in Biotechnology are laying the foundations.

Recently the US based National Institute of Health awarded almost 2 million dollars of funding to a Rice University researcher who aims to create cells able to produce custom Amino Acids, unlike any found in nature. With these, a virtually endless array of problems can be tackled. Take genetically modified organisms, or GMOs, for example. One of the most controversial issues surrounding GM crops, is the potential for altered genes to spread into the surrounding environment, which could result in widespread ecological damage.

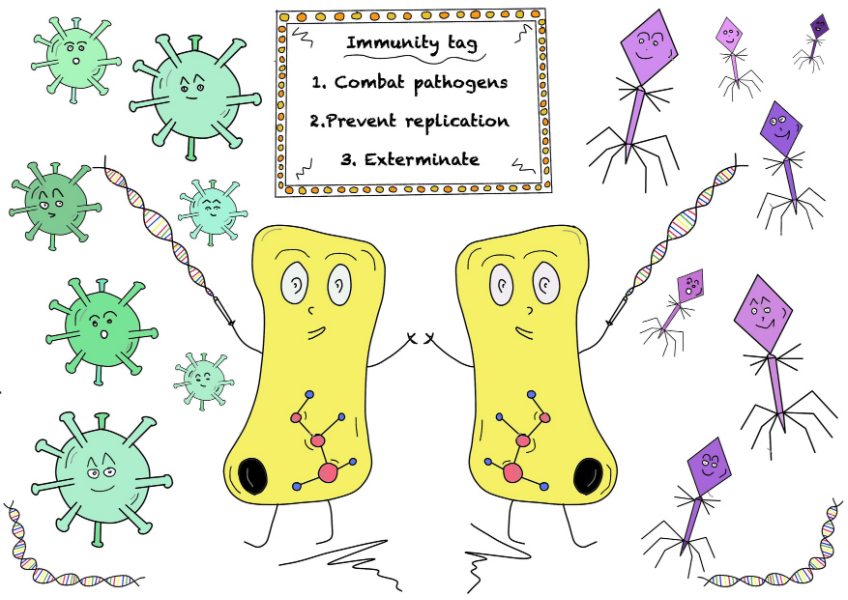
However, this could be circumvented by altering an organism's genome, so that it requires lab-made amino acids to produce proteins essential for survival. As a result, any genes that 'leak' into the environment will not survive long, as they won't have the requisite nutrients to survive. Researchers at Yale University have already managed to engineer bacteria in this manner, so the leap to multicellular organisms is foreseeable.

Others are more ambitious with their plans for engineering life. Professor George Church of Harvard Medical School believes that synthetic biology could be used for everything from resurrecting mammoths to creating the next step in human evolution. Possibly, his most ambitious, and practical, theory is the idea of mirror organisms. However, this is not a new idea at all. Louis Pasteur first postulated that life was asymmetric in 1846. Almost every molecule in your body is chiral, meaning it is either left or right handed. As a result, your body can only interact correctly with other molecules of the same 'handedness'.

Drastic consequences can arise when we get this wrong, such as the thalidomide crisis which was caused by the drug containing both chiral forms of itself. While the correct form resulted in a restful night's sleep, the incorrect one caused horrific birth defects.

Professor George Church believes this can be used to our advantage, however. If we were to take every chiral molecule in the body and flip it, in theory, we would end up with an organism completely immune to disease. This is because viruses would be unable to interact with the mirror cells and other pathogens would find no sugars available to digest, resulting in an inability to replicate and hence extinction.

Obviously this is a long way off, as currently only a few proteins have been produced in reverse, let alone entire cellular machinery. In order to survive, our mirror organism would also need to find mirror food, as regular food would be indigestible, with its new enzymes. Nevertheless, the prospect of a world free from the clutches of disease is, theoretically, possible.

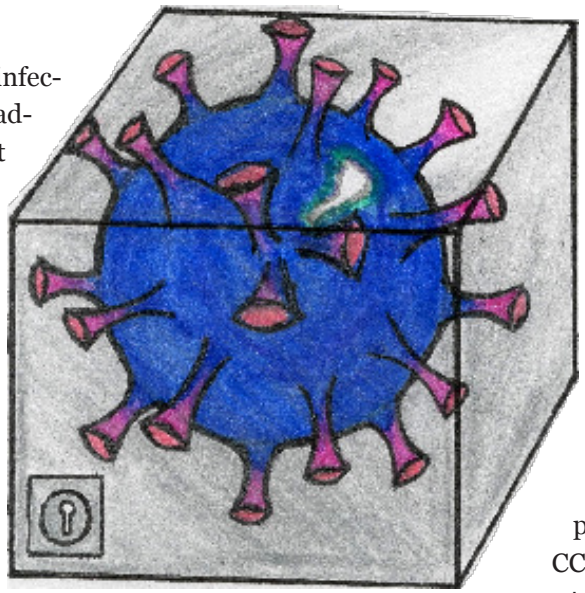


HIV and the Power of Modern Medicine

The battle with HIV goes on: how far along are we?

Written by **Adela Brzobohata**
Art by **Olivia Rani Bessant**

The human immunodeficiency virus (HIV) has risen to fame in the beginning of the 20th century, claiming approximately 35 million human lives worldwide since then. HIV invades CD4+ T cells, which are essential for generating appropriate immune response. It uses these cells to replicate its genome and assemble new HIV virus particles. Ideally, by this point, one's immune system would kick in and destroy the virus before it could spread into other cells. However, HIV has developed many strategies that undermine the immune response and allow it to live happily ever after in one's body. For now.



Throughout the course of HIV infection, the CD4+ T cell count gradually declines, as more cells get infected with HIV, causing gradual weakening of the immune system. Eventually, this leads to the last stop of HIV infection, acquired immune deficiency syndrome (AIDS), in which lethal opportunistic infections develop.

Tackling HIV has been, and still is, quite a pickle, yet highly effective treatments have been developed, which allow us to control the virus, slow down the progression of disease and reduce transmission. Most commonly, antiretroviral therapy (ART) involves an administration of different combinations of drugs, which target different viral activities, to patients. Plus, there are drugs that significantly lower one's chance of getting HIV, if they are taken prior to exposure (PrEP) or soon after possible encounter of HIV (PEP). All these drugs so far managed to decrease HIV related deaths by between 60-80%. They can't, however, cure the infection, so the hunt for an HIV vaccine and cure continues.

For viruses to survive, they need to transmit. Ideally, by putting every HIV positive person on ART and ensure that every unaffected person at risk of acquiring HIV infection takes PrEP/PEP, we could keep the viral load at levels which make transmission, and thus the survival of the virus, almost impossible. However, there are other factors that need to be considered. A huge stigma surrounding HIV discourages people to get tested and seek treatment if necessary; also, having to adhere to ART treatment everyday is highly inconvenient for patients, therefore the search for a cure and/or a vaccine must go on. So, is the future for an HIV cure bright?

Currently, only the two 'chosen ones', the former 'Berlin patient' and the latter 'London patient', who both suffered from HIV and a form of blood cancer resistant to chemotherapy, have been given a bone marrow transplant using stem cells from a healthy donor. Both donors possessed a rare mutation in the CCR5 gene, which codes for a receptor that allows HIV to attack white blood cells. Both patients have been free from HIV ever since.

Although the treatment might have been successful, it's too expensive and risky to be used widely on HIV patients. Despite that, it did highlight new areas for research and provided novel insights into possible locations of the yet undetected HIV reservoir in the body – the haematopoietic system.

Once a prominent killer, HIV has now been imprisoned by the power of modern medicine and more people with HIV are able to live normal lives and less succumb to HIV related infections every year.

Quantum Supremacy

The latest milestone in technology.

Written by **Enrico Caprioglio**
Art by **Victoria Kozlova**

Quantum Supremacy - these two words were first used together by John Preskill, in 2012. He defined this concept to describe the point where quantum computers could complete tasks and solve problems that normal computers would never be able to do. Just the word quantum sounds arcane, wrapped in mystery or hidden in some other dimension parallel to ours. The word supremacy, instead, is normally used to describe the highest authority or the greatest power. He carefully chose these two words, "to emphasize that this is a privileged time in the history of our planet, when information technologies based on principles of quantum physics are ascendant".

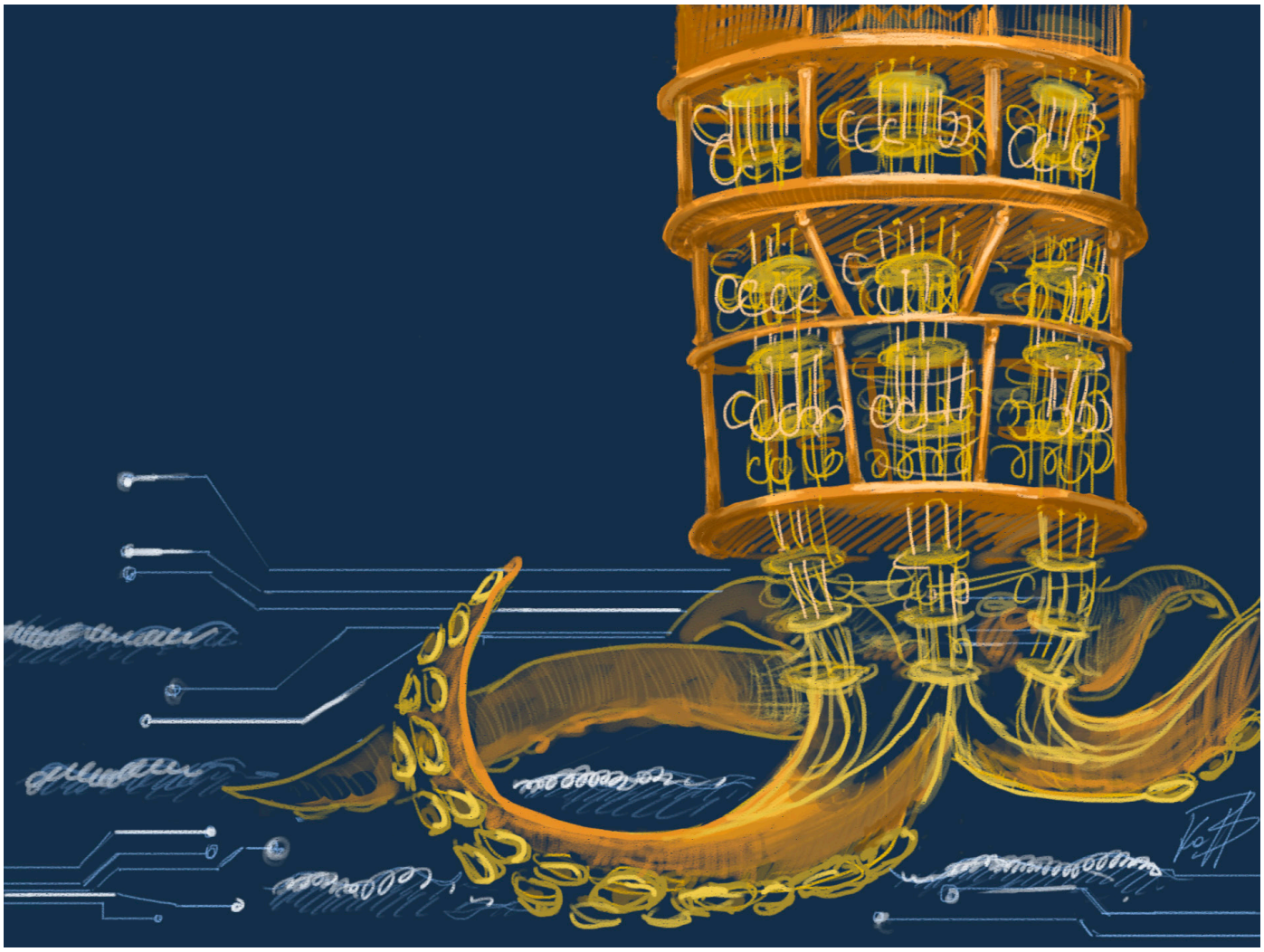
Google researchers claim to have reached the so-called quantum supremacy with their latest quantum processor, Sycamore, which was able to complete a task that would have taken "a state-of-the-art supercomputer" over 10,000 years. But for Sycamore, it took only 200 seconds to complete. In order to fully appreciate this milestone in information technology, let's try to understand how a quantum computer differs from a classical computer, and look at the effect that these technological devices could have in today's society.

A normal or "classical" computer is fundamentally made of very tiny switches called transistors. Just as a lamp can be turned on and off when current is provided or taken away, a transistor can be on or off. If it is on, we say it assumes value 1; if it is off, the value is 0. The state of a transistor (0 or 1) is the simplest form of information - we call this a bit. Multiple transistors can be combined to store more complex information or connected with each other to perform basic algebraic calculations. You might think computers are pretty stupid, and they are! Humans can compute more complex calculations; we wonder about life, love or whether we should put in milk or cereals first. However, just as we have billions of neurons in our brain, computers have billions of transistors as well. By reducing complex problems to simpler ones, we can teach computers how to solve them.

Quantum computers are fundamentally different. The smallest form of information in a quantum computer is called qubit, which can be 0 and 1 simultaneously. This might seem inconceivable, but that is what happens when we enter the quantum regime. In the quantum regime, the laws of quantum mechanics apply, which state that, before an object is observed or detected, this object is in a superposition of all its possible states. So until you observe or interfere with a qubit, the qubit is not 0, nor 1, but both at the same time! Exciting as this may sound, with only one qubit, we still have the same information we would have using one transistor (0 or 1). But what happens when we add one more qubit? A system of two qubits is simultaneously 00, 01, 10, 11 - that is four states. Thus, a normal computer would require four bits to match the same amount of states as a system of two qubits. With only 20 qubits, a quantum computer processor could potentially be in 1,048,576 states simultaneously. Google's quantum processor had 53 working qubits, with a stunning number of nine million billions simultaneous states. The same number of kilometers you travel if you walked from the earth to the sun 60 million times!

You may now be wondering if we should start worrying about the rise of an AI quantum machine which is going to take over the world using this computational power. This scenario is quite absurd - Sycamore was required to complete a task specifically designed to demonstrate quantum supremacy. The task consisted of producing a string of nine million billion bits, for a million times and then calculate the average string produced - it probably wouldn't be able to take over an ant colony. Moreover, qubits need to be at freezing cold temperatures and isolated from anything that could interfere with them to avoid errors in calculations, which is tremendously difficult to achieve.

Nonetheless, this is not a silly question to ask. A quantum computer could, in principle, be used to threaten cryptosecurity systems online. A normal computer would take thousands of years to break the encryption



would take thousands of years to break the encryption codes that safely store our bank or health details online, but more powerful quantum computers could break these codes, in the time it takes to make a cup of tea.

Fortunately, researchers foresaw this problem and organizations such as the National Institute of Standards and Technology (NIST) have been looking for potential post-quantum algorithms for encryption codes, since 2016.

Earlier this year, they narrowed down 26 algorithms that could potentially be implemented in future encryption systems to be quantum-computer proof.

Quantum computers are still far from being able to be used for these kinds of purposes, but it is reassuring to know that the scientific community is not only working to build incredible machines, but also to be safe from them.

Interested in being part of the next issue of Kinesis Magazine?

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THE AGE OF CYBORG

HOW BRAIN-COMPUTER INTERFACES COULD CHANGE THE WORLD

Humans and computers together as one.

Written by **Denis Duagi**
Art by **Emma Maia Smith**

We already have our first legally-recognized cyborg, Neil Harbisson, who wears an implant that helps him overcome his colour blindness. So if artificial "eyes" can be designed for the colour-blind, what about implants that can give us super senses? Let's not get ahead of ourselves, but let's see what we can do with a brain-computer interface.

Brain Computer Interfaces, or BCIs, are a set of electrodes that are superficial or implanted into the brain, which translate neuronal information into commands, such as controlling a computer or a robotic limb. BCIs can give your brain the ability to communicate wirelessly with the Cloud, with a computer, or with the brain of anyone who wears a similar interface. Paralyzed patients can now control robotic arms or even shop on Amazon with a tablet, using their mind. Elon Musk's Neuralink is similarly dedicated to developing BCIs for paralysed patients, deadlined for 2020.

While this may seem very futuristic, BCI technology has been commercially available for a few years now. EEG-Smart has recently launched a mind-controlled drone, which uses hands-free controls via a headset, that contains electroencephalography and electromyography sensors.

But this neurotech gets even crazier. There's been jaw-dropping claims in a recent study that reported technology is capable of transferring knowledge from one brain to another. According to a press release, the team measured the brain activity patterns of professional pilots, and then transmitted these patterns into novice subjects, as they learned to pilot an airplane in a flight simulator. The technology utilised in this study, called transcranial direct current stimulation, or tDCS, activated specific regions of the brain involved in motor control and decision making. The study showed that the people who received tDCS were able to learn the new skills much faster. Other than heightening creativity and learning processes with some electrical stimulation, there are more clinical applications to BCIs. Depression, anxiety, chronic pain and tremors in Parkinson's are the prime candidates for targeted stimulation therapy. Who knows, perhaps in the future we will be able to download knowledge directly into our brains like in the Matrix.

Embedding tiny computers into people's brains seems like a promising way to help ourselves keep up with the advances being made in the field of Artificial Intelligence (AI). In fact, during an interview, Elon Musk shared that the ultimate goal for the Neuralink brain implant is for people to achieve symbiosis with AI.

While simultaneously being exciting and scary, there are privacy and other ethical considerations associated with this technology. In terms of privacy, with a window into your mind, your thoughts are easily accessible and could be stolen or manipulated. Imagine having to pay premium for an ad-free brain!

One of the biggest ethical concerns is the loss of autonomy, when we will not be able to choose which of our thoughts are turned into actions. For instance, if the BCI executed inappropriate or harmful actions that were not intended.

Looking on the bright side, this technology can help more people overcome limitations caused by injury disease. It is possible that BCIs will get as far as resolving brain disorder and damage with a chip.

CRISPR

How does gene editing influence regular life?

Written by **Zehra Evcil**
Art by **Vera Liu**

CRISPR-Cas9, standing for Clustered Regularly Interspaced Short Palindromic Repeats, is a new and exciting gene editing method. It enables a change to an organism's genome in a method that is cheaper, faster, more accurate and very efficient. A human-created piece of CRISPR RNAs (transcribed from CRISPR sequences) binds to a targeted area of DNA and the Cas9 enzyme. The modified RNA recognizes the DNA sequence, and the Cas9 enzyme cuts the targeted location of DNA. Afterwards, the cell's own DNA repair system is used to add, delete or change pieces of genetic material. In other words, CRISPR RNA identifies old DNA and places it with the new genetic material while the Cas9 enzyme cuts the old DNA out.

CRISPR system can be used in healthcare, to fight bacteria and viruses such as HIV, where vaccines fail. Immunologist Dr. Justin Taylor and his colleagues, in their preprint for a journal, said that using CRISPR to edit B cells could produce "immunity against pathogens for which traditional vaccination has failed." Changing the coding of the B-cells (protective cells) in their DNA could make them stronger and better adapted to create antibodies to fight viruses and bacteria. It would be an efficient and permanent way of immunizing human body against viruses and bacteria. "We can see gene editing [to protect against viruses] becoming feasible," said Dan Wattendorf, director of Innovative Technology Solutions at the Gates Foundation. These new ways of using CRISPR opens up a whole new world of healthcare and medical development.

CRISPR has other implementations in everyday life beyond fighting against viruses: it can, hypothetically, be utilized to change the characteristics of the human body. Josiah Zayner, a former NASA biochemist, became the first person to use CRISPR to change his own genes himself. He owns a company called ODIN that sells DIY (Do It Yourself) CRISPR kits, basically starter kits for gene editing, to include a free guide for anyone wanting to experiment on themselves.

He live-streamed an event, injecting himself on the arm with CRISPR that (theoretically) enhanced his muscles by editing the gene for myostatin, a protein that regulates muscle growth, while there is still no exact data showing the changes of his cells.

There are so many different approaches to CRISPR: while not all of them are very optimistic about gene editing.

Regarding the ethical concerns about CRISPR, a lot of people believe that CRISPR will devastate the variety of the gene pool and will provide a genetic advantage to those who can afford a gene therapy which will cause bigger differences between poor and rich. For example, He Jiankui, a professor in Shenzhen, altered twin girls' genes against HIV. This angered general public because it was not found ethical to change hereditary genes while he faced serious punishments about his opinions about CRISPR.

As a final thought, CRISPR can be implemented in our daily life as an alternative to vaccines and with DIY CRISPR kits. While it could be helpful to immune people with diseases that do not have a vaccination, many problems may arise if some untrained people attempt to use DIY CRISPR kits, without careful supervision, and if CRISPR is taken to extremes and used to change hereditary genes such as intellect and physical appearance, ethical problems might arise.

FENTANYL
A Drug Improving or RUINING Lives?

Written by **Simi Ayeni-Yegbe**
Art by **Vera Liu**

Fentanyl is a powerful prescribed drug used for patients in severe pain, but its illegal use has devastated communities.

Fentanyl belongs to a group of drugs called opioids. These are drugs having similar effects to morphine, which is found in the opium poppy. Opioids are analgesics, meaning they can relieve pain.

Opioid receptors are activated when bound by opioids. These receptors are found in various locations of the body, such as in the brain and spinal cord. Once these opioid receptors are bound, pain signals from the spinal cord to the brain are blocked, leading to pain relief.

As it's an analgesic, fentanyl is used by cancer patients to reduce severe pain. Since fentanyl has rapid onset, it's particularly advantageous in producing quick relief. As a result, cancer patients can greatly benefit from fentanyl when undergoing breakthrough pain (sudden and potentially severe pain caused by normal activities such as walking and coughing). Fentanyl is also widely used in anaesthesia.

As with all drugs, however, there are also negative impacts of taking fentanyl. Besides side effects such as drowsiness, nausea and confusion, fentanyl can cause further issues as it's an addictive drug. Users may enjoy taking fentanyl due to the feelings of happiness and pleasure that it produces, potentially becoming dependent on it. This means that if a patient suddenly stops taking it, they may experience withdrawal symptoms, so doctors often recommend gradually reducing the dose of fentanyl before stopping.

Due to its potent effects, fentanyl must be prescribed, but it can be misused if distributed to others or if the prescribed dose is not followed. The distribution of prescribed fentanyl to other people is a serious issue since the exact dose that can cause harm to the body differs from person to person. A dose that brings pain-relief to the patient could kill another person.

Recently, however, fentanyl has caused problems due to its illegal use as a street drug. Unlike some other opioids, fentanyl is easily synthesised. It is particularly dangerous as a street drug since it's often mixed with other drugs, such as cocaine and heroin. This has caused particular problems in the United States, where the opioid crisis has worsened in recent years. Tens of thousands of deaths each year in the U.S are due to synthetic opioids like fentanyl. According to the US 'Centers for Disease Control and Prevention', fentanyl is 50 times more potent than heroin (a class A drug in the UK). That's right – a drug bringing relief to cancer patients has effects potentially worse than heroin.

What can be done to reduce the issue of fentanyl abuse? Some states in America have implemented urine tests for patients using opioids. Increased use of opioid testing can be conducted to check if patients are taking more fentanyl than prescribed, and therefore if they are at risk of addiction. Besides illegal drugs, it's also important to raise greater awareness about the risks of abusing prescription opioids. Opioid prescriptions could be stricter, ensuring doctors are only giving them to patients when this is the best treatment option.

So, fentanyl - friend or foe? Offering hope or despair? Improving or ruining lives?

UCL & EUGENICS: TAKEAWAYS FROM THE SECOND TOWN HALL

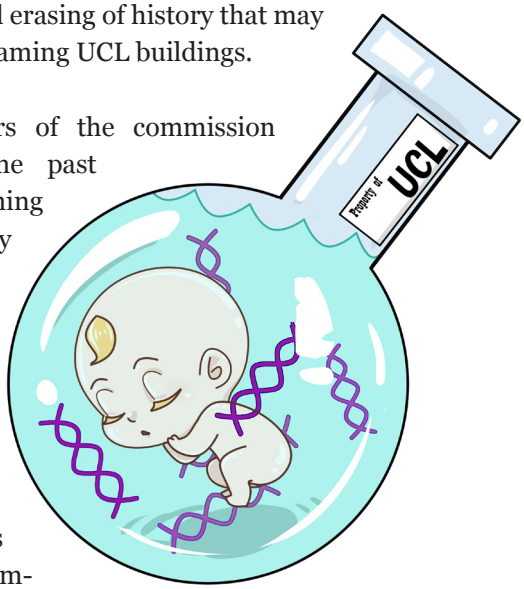
Written by **Jacqueline Hsing**
Art by **Chuyun Hou**

Every time you walk down Gower Street into UCL's Main Quad, you can see Pearson Building, just to the left of Wilkins Building. Similarly, if you walk down Torrington Place towards Tottenham Court Road, it's easy to catch a glimpse of Galton Lecture Theatre nestled right next to Costa Coffee. These two buildings have been the focus of UCL's Inquiry into Eugenics for the past year due to its commemoration of two men known for their pioneering of eugenics, a field used to justify racism, ableism, and classism. The Inquiry, established in 2017, is independently chaired by Professor Iyiola Solanke of the University of Leeds, while the commission is seated by UCL academics and members of the Students' Union. At the conclusion of the inquiry, the commission will consider possible actions on prizes, spaces and endowed professorships named after persons who founded and promoted eugenics, as well as how UCL should approach its historical role moving forward.

Sir Francis Galton, for whom the Galton Lecture Theatre is named for, is widely known and accepted as the father of eugenics. Galton's promotion of eugenics resulted in the implementation of policies that would supposedly improve the human species through controlled breeding. Upon his death, Galton endowed UCL with his personal collection and funds to create a Chair of Eugenics, which Karl Pearson was the first to hold. Though it may seem like UCL's history of eugenics is in the past, recent discoveries of eugenic conferences secretly held on campus has necessitated a renewed look into UCL's relationship with eugenics.

A second town hall meeting on the 11th of October 2019, aimed to provide an update on the Inquiry's work and address questions from members of the public. UCL's Inquiry into Eugenics has so far divided its investigation into two categories: empirical research and archival research. As part of its empirical research, the investigation has held hearings, focus groups, forums, and has received in-person and written submissions.

On the side of the investigation, the archival research into UCL's historical role has yielded proof of eugenics ties to UCL, as well as helped create an aid for future researchers. While the commission at the second town hall did not present any recommendations or conclusions, as the investigation is still ongoing, members of the commission provided early findings and responded to audience members' concerns. These concerns voiced by audience members in part focused on the potential erasing of history that may result from renaming UCL buildings.



While members of the commission have spent the past year researching UCL's history and its ties to eugenics, ultimately the most important factor of the inquiry is the opinion of the public. Less than 1,000 completed the online survey focusing on public opinion about eugenics, despite the 42,000 students who attend UCL. So have a think: how should UCL approach its historical role in the teaching and research of eugenics in the future? Should buildings named after prominent eugenicists at UCL be renamed? Or would that be erasing a part of history we should acknowledge? Should we treat the past as the past, or recognize the afterlife of eugenics at UCL?

A third and final town hall is scheduled to occur in February 2020 and will present the final report and recommendations of the commission.

SCIENCE'S HIDDEN PHILOSOPHICAL TRUTHS

When it comes to modern science, philosophy is alive and kicking.

Written by **Isabella Boyne**
Art by **Cveta Gotovats**

In 2011, the late renowned physicist Stephen Hawking declared that "philosophy is dead" based on the notion that "philosophers have not kept up with modern developments in science". However, it appears to me that, he failed to realise that the assumptions that science relies on are philosophical, and perhaps more importantly, that we admire science because of the philosophical truths it shows us.

The assumptions that science relies on are not scientific, but philosophical. For example, if I were to do a simple experiment in which I wanted to test for the presence of starch, I would add an iodine solution and look for a colour change from yellow-brown to dark blue. However, I am making the philosophical assumption that the dark blue colour that I see is the same as what everyone else sees. It is possible that someone sees dark blue where I see red, but I will never know if this is the case, because I cannot access someone else's mind to understand their independent experience.

This is an idea presented by philosopher Thomas Nagel, through the concept of qualia - individual instances of subjective conscious experience. Scientific observations disregard this possibility, and instead, we assume that everyone is experiencing the same thing. If it were not for this assumption, the scientific method would not be able to take place. In fact, there is no scientific reason to believe that what I am observing is actually happening. Science cannot demonstrate that we are not just a "brain in a vat", a disembodied brain floating in a jar, experiencing a simulated reality. When approaching the sciences, we are making the philosophical assumption that what we see is reality.

Even the reason why we admire science in the first place is not necessarily because of its good use of empirical evidence. If someone found the cure for cancer, the vast majority of people would not admire his ability to extrapolate data or conduct repeated trials, we would admire the reduction in the number of human lives lost and the advancement of human achievement. This raises a series of philosophical questions about what it means to be human: firstly, that there must be something inherently good about saving human lives or avoiding death; secondly, that we seek knowledge as a significant aspect of human life; and finally, that seeing science as human beings' biggest achievement, reflects a desire for humans to regard themselves as a superior species.

It could be suggested that the reason we value human life is purely biological, i.e. a scientific justification for a philosophical issue. It may be the case that we instinctively want to survive as a species. However, if we consider the question of, 'why is death inherently bad?', we might find some philosophical justification in something known as the 'harm thesis'. This thesis would compare the level of welfare (i.e. the general pleasure or happiness one receives) that they obtained in life before death, compared to the level of welfare they would have received if they had not died. This may be the reasoning behind why we admire science's ability to save lives.

Philosophy has often suggested that knowledge plays a significant role in human life. Plato, one of the early Western Philosophy's greatest philosophers, suggested that the meaning of life was to aim towards attaining the highest form of knowledge, the Form of the Good. Similarly, other philosophers, such as Enlightenment thinker Immanuel Kant, suggested that in order to live morally, we must follow our reason or rationality. This suggests that in both a pre- and post-science world, knowledge and rationality were considered to be the foundation of a good life. As the sciences similarly pride themselves on the utilisation of rationality, it seems absurd to suggest that philosophy has not kept up with modern science, when it was Philosophy that introduced this idea in the first place. This notion of rationality and reason may also be why scientific achievement is a reflection of the superiority that humans appear to have. For the ancient Greek philosopher Aristotle, humans had a "rational soul" whereas animals did not; it is this rationality that makes us special and differentiates us from non-humans.

Modern French philosopher, René Descartes believed that animals, unlike humans, were merely mechanistic machines with no intellectual capabilities. Christian philosopher St Thomas Aquinas suggested non-human beings are instruments for humans to use, rather than existing for their own sake, and that only human beings are capable of attaining an understanding of God. Regardless of the philosophical branch, there is a clear pattern that reiterates that humans are inherently a superior species. Perhaps, modern science and the praise surrounding scientific achievement is just our new way of cementing humans' god-like status.

MEMORY EDITING: FROM THE MATRIX TO MEDICINE

Towards altering our concept of fear and addiction.

Written by **Alexandra Gilbert**
Art by **Will Ning**

The red pill that bestows the terrifying truths of reality or the blue pill that provides stability and safety; which would you pick?

During the Matrix movies, the main character, Neo, must choose between two worlds, each pill altering his memory either in favour of a virtual reality, or a devastatingly authentic one. Here, the writers of the movies raised a tantalising question: what if we could erase, or edit, our memories?

Other than blocking out cringey high school moments, there are plenty of clinical reasons why we might want to edit our memories. Forgetting the craving cues characteristic of drug addictions and painful pasts in post-traumatic stress disorder (PTSD) are a top priority in the field, along with dabbles in memory enhancement for educational purposes. Despite the attractive (or unattractive) sentiment, the specificity of memory alteration seen in sci-fi scenarios is not so easily reproduced. Emotional memory is normally the target for PTSD and addictive disorders. Let's consider what this entails.

Emotional memory starts with emotional arousal in the amygdala and hippocampus, with some involvement from the basal ganglia and hypothalamus. It's complicated. Next, our emotional memory is utilised in decision-making circuits of the prefrontal cortex, and also affects motor and reflexive action. And so, the emotional memory sinks its teeth into our behaviour.

To further complicate matters, the only success that scientists have had with directly inserting, deleting and replacing memories, involved invasive electrical stimulation in mice. Complete and targeted memory editing has eluded us, due to its complexity, and our lack of complete understanding of standard memory-forming mechanisms. But that doesn't stop science from giving this challenge a good shot.

Non-invasive techniques that aim to adjust unconscious learning patterns and behaviours have been around since Pavlov and his seminal 1890s classical conditioning experiments. Our very own Clinical Psychopharmacology Unit at UCL published an article in Translational Psychiatry (2015), on breaking the habits of alcoholics by relearning the motivational mechanisms behind the hunt for the next bottle.

What's important are the cues associated with drinking or fearful recollection of traumas. During a process called "reconsolidation", existing memories are reinforced. For example, the more time you spend drinking in the local pub, the more you associate the pub with drinking. The next time you visit the bar, you'll be more likely to indulge in a pint. But, by repeatedly exposing someone to the same stimulus, just without the alcohol consumption, new memories can be formed that don't induce drinking oneself into a stupor.

Other techniques involve "updating" memories using a combination of stress hormone manipulation and drug administration. By using these agents at particular segments during reconsolidation or relearning, one can disrupt or augment the target memory. Soon, clinicians will be able to give patients the memory-altering pill they need to alleviate the nightmares and addictions, to a certain extent. Not to mention the incredible uses for memory enhancement using similar approaches. The questions arise: where is the line for editing memories? Who qualifies for these procedures and drugs, and what implications lie ahead of us if we are able to manipulate the very essence of who we are?

The red or the blue pill, authentic or artificial - which would you choose?

The Recovery of WHALE Populations

A cause for hope in conservation

Saving our seas: the recovery of critically endangered whales.

Written by **Amy Wallis**
Art by **Ben Freeman**

With a climate emergency declared in the UK and talks of us entering a sixth global mass extinction, it often feels that any action now is too little, too late. Most media coverage of conservation focusses on the decline of biodiversity and the failures of conservation efforts, so far. But there are real cases of conservation efforts and species management leading to the recovery of species on the brink. A striking example of this can be seen in many baleen whale species. The practice of whaling grew massively from the 17th to 20th centuries, as demand for whale oil and baleen skyrocketed. Almost three million were killed in the 20th century alone. As a result, whale populations crashed. While some, like the North Pacific right whale, Eubalaena japonica, remain in the low hundreds, many species have shown remarkable recoveries.

One recent success story is the recovery of the humpback whale, Megaptera novaeangliae. The humpback whale is, arguably, the best studied baleen whale, and studies indicate a significant global population recovery. A 2019 study estimated the western South Atlantic population to have rebounded, from only 450 individuals, to 93% of its pre-exploitation size., from only 450 individuals. According to the IUCN red list, all breeding populations have recovered to pre-1942 levels, and the species is now listed as 'Least Concern'. The fact that a population can recover from such low levelsa shows us that, it is not too late to address the current biodiversity crisis.

The recovery of humpback whales is due to a managed reduction in exploitation and conservation management. A major driver of whale recoveries was the banning of commercial whaling by the International Whaling Commission in 1986. While commercial whaling has continued since the IWC ban, notably by Iceland, Norway and Japan, it is on a far smaller scale and generally targets less endangered species. Careful management and monitoring have also facilitated the recovery of the humpback whale. The habitats and breeding sites of the species have been well studied, and protected in many national and international agreements.

For example, the US government set a comprehensive recovery plan for the species in their waters, in as early as 1991. This management shows the effectiveness of international agreements and governmental legislation designed to protect species. We should push for further international meetings to bring about environmental protection and conservation, even when they seem to foster little action.

The resurgence of the humpback whale is not all good news; it has the potential to harm already struggling ecosystems. As large predators, a healthy humpback whale population consumeswill eat a lot of food – in this case, krill. This may have knock-on impacts onfor other krill-dependant organisms. Furthermore, there is evidence that the distribution of krill is shrinking with increasing ocean temperatures, which may further increase the impact of humpback whales on the community. While this needs to be monitored, there is no reason to believe the return of the humpback will have serious negative effects. It is important that both researchers, policy makers and the public take note of the successful return of humpback whales and other whale species. Research has shown that a message of hope is needed for conservation to be successful; we need to hear success stories to balance the bad news and empower people to help enact change.

Is Biology to Blame for the POVERTY Cycle?

Why we need to stop blaming the poor and help them take back control instead.

Written by **Karolay Lorenty**
Art by **Charlotte Capitanchik**

Despite all the pessimists and nostalgics, the world has been getting better: we have fewer wars, epidemics, deaths. But one issue remains elusive - poverty. As wealth avoids falling in certain hands, poverty concentrates. Usually affecting minorities, poverty creates a "neighbourhood effect", characterised by low education levels and high crime rates. Generation after generation, people in these areas make the same mistakes, trapped in cycles of poverty.

But who is to blame? Many people say that we choose our own fate. The American dream has become worldwide. You can get wherever you want if you work hard enough. It is inspiring, but is it true? Are people choosing to be poor? Is it a lack of drive or intelligence? Of course there are exceptions, we look at self-made billionaires that left behind their humble origins and we think it can't be that hard. But they're
just that - exceptions. What is happening to the rest? Why does poverty stay in the same neighbourhoods, in the same countries? I guess it can all be reduced to this: poor people make poor decisions. School leaving, delinquency, crime, gambling, alcohol, drugs... But why? A recent study suggested that just being in a situation of poverty, even when transient, results in cognitive underperformance due to financial anxiety. Stress has a profound effect on us.

As stress hormones like cortisol are overproduced, our body goes into 'fight or flight' mode, interfering with our decision-making. There is evidence that stress can reduce sensitivity to rewards, increasing the likelihood to develop pathologies like binge eating or pathological gambling. Moreover, stress increases the tendency to make high-risk decisions.

There is also a switch from goal-directed to habit-based behaviour, impairing someone's ability to adopt behaviours adequate for their long-term goals. Not only is our immediate future affected, our environment can also influence gene expression and change our biology for life.

There can be long-term effects on mental health, Mental health can be affected long-term, as shown in the famous study by Meany and colleagues, where young mice exposed to low grooming by their mothers grew up to be anxious adult mice. Growing up alongside bad parenting, violence and crime can result in mental health issues, an additional struggle for poor families. Other aspects of health can also be affected. Several studies have found that in utero experiences such as starvation can increase susceptibility to multiple diseases, including diabetes and heart disease.

Interestingly, in 2015, a studyfound that lower family income and shorter parental education, correlated with reduced brain surface area in children and adolescents. This does not mean that children from poor backgrounds are unmotivated or lazy, but rather that the circumstances they have been raised in have physical consequences. Stress can cause brain shrinkage and impair learning. But we can work around this; reducing family poverty can significantly affect children's brain function and cognitive development.

We need to stop blaming individuals, ignoring their circumstances, and turning our backs like it has nothing to do with us. This is not an opportunity to blame poverty on biology or say that "there is an interplay of genetic and environmental factors" and shrug our shoulders. It is our responsibility to ensure that everyone has similar opportunities. By changing someone's environment we have the power to influence their biology, improve their performance, and thus change their lives.

Social Mobility

The psychological effects of society's systematic barriers.

Written by **Raymond Danks**
Art by **Charlotte Capitanchik**

As a person who comes from a financially deprived background, my family has experienced homelessness, severe mental health issues, incarceration, abuse, addiction and they have come out the other side as the strongest, most loving and awe-inspiring people. However, the further I climb up the academic ladder, the fewer people I meet who come from a background similar to mine, or those who can empathise with the mental strain that comes with improving social mobility. The self-induced pressure to voraciously avoid failure can lead to stark and influential psychological problems in those attempting to socially mobilise themselves and provide a better life for their families.

What is the evidence?

The relation between poverty and mental illness has been investigated thoroughly - particularly within the last 2 decades. One study concluded that 17% of children whose parents had no educational background have a diagnosed mental illness, compared to 4% of children whose parents have degree-level educations. Moreover, the same study states that in families where no parents are working, 20% of children have a diagnosed mental illness, compared to 8% from families where both parents are working.

The psychological effects of social mobility itself have not been thoroughly investigated. A 2018 study conducted within the University of Oxford's Sociology Department investigated levels of allostatic load - the "wear and tear" on the body due to chronic stresses. The study concluded that far higher allostatic loads are found in those who have mobilised from 'lower' to 'higher' socioeconomic classes, than those who were born into and remained in higher classes. Another study published in the American Journal of Sociology, indicated that upwardly mobile people report higher than predicted levels of Manifest Anxiety and Psychosomatic symptoms - issues often reported in sufferers of chronic stress.

What causes this stress?

These stressors include the awareness of the lack of a safety net – if you fail then you and your family may remain in a cycle of poverty; housing struggles (no guarantors or large deposits), and disillusionment. When there are no role models for the path you have been chosen to take, adjusting to unknowns can be difficult; evident financial problems, and the self-imposed pressure that you have an opportunity to afford your family a better life, can have a significant impact on your mental health. Professor John Jacobs further acknowledges that disadvantaged people live with more uncertainty, which imposes a considerable mental burden.

A Humanitarian Approach

Disadvantaged young people worldwide are trying their best to seize their afforded opportunities, but are unfortunately falling victim to the desperation of their situations. The knowledge, that failing at any step of this process could mean a worse life for your family, is an excruciating mental burden. Nonetheless, this is the unjust and cold reality for many people. These pressures have a consistent tangible effect on the mental wellbeing of disadvantaged people and it should not be this way.

What Can Be Done?

In conclusion, in order to better understand and aid those with less privileged backgrounds, institutions which pride themselves as being facilitators for social mobility and change – such as Universities - need to actively encourage greater representation within their remit. This includes specifically encouraging students and staff from working class and disadvantaged backgrounds for higher education and work opportunities. Working with disadvantaged students in managing their mental health and encouraging more empathy from staff about the stressors placed on working class students and how this may seriously affect their psychological wellbeing is key to supporting those from disadvantaged backgrounds.

Eat Pray LIE:

HOLISTIC WELLNESS SCAMS IN THE AGE OF SOCIAL MEDIA

Taking a deeper look into the internet health gurus cashing in on alternative medicine.

Written by **Esmeralda Ypsilanti**
Art by **Cveta Gotovats**

The rise of social media has exposed the general public to many trends and personas. Facebook groups have become echo chambers where people's opinions and ideas are built upon and confirmed by others who think in the same way. However, for some, opinions have become facts, and years of study and research are no longer needed to back up substantial claims. This is more evident than ever in the holistic wellness industry. Crystals are sold at high prices to cure disease and bring health and happiness; sage is no longer a herb used for cooking;rather, it is burnt to help purify the air and generate wisdom.

At first glance, these trends may seem harmless, but it is those who stand to capitalise from them, who push the envelope, leading to serious ethical issues; the downplaying of scientific research and the spread of misinformation.

Ten years ago, Gwyneth Paltrow was known for her roles in blockbuster films such as Shakespeare in Love and Iron Man. Today she owns and runs a multimillion dollar website, GOOP, selling "cosmic health" and spirituality wellness products. These include the infamous "jade egg" which was advertised as having the ability to balance hormones and strengthen the pelvic floor by being inserted into the vaginal cavity. This specific product was eventually removed from Paltrow's GOOP website after a lawsuit claiming false advertising. However, Paltrow, who has had no formal (or informal) training in medicine or physiology continues to make more irresponsible assertions about her products, claiming that wearable stickers are able to "rebalance the energy frequency in our bodies".

Paltrow is not the only one who has sought to make money from people's naivety and love of branded products. Dr. Joe Dispenza is a self-proclaimed researcher of epigenetics, quantum physics and neuroscience and has almost one million followers on Instagram. In reality, he earned the title of doctor from a chiropractic degree. He, along with Bruce Lipton, a biologist who believes cells are reprogrammable through the power of God, teaches an online course at The Quantum University, which is not accredited by any agency recognized in the United States. Dispenza and Lipton teach their students that DNA is controlled through the power of thought, and that each of us are able to alter our genetics through our mind. Bruce Lipton published a book on this in 2010.

Dispenza regularly holds workshops where he claims to heal genetic disorders through the power of belief. At one convention he claims to have helped a woman named Petra regain her sight. "She could do surgery and drugs," he says, "but it wouldn't really change her gene expression". Instead, he believes that by believing her vision could return, this woman was able to change her genetic makeup in a way that would allow her to regain her sight. No research has been published on this, no clinical trials have been held, yet once again, all of Dispenza's followers, both in person and online, cheer and clap as he presents how he has miraculously helped Petra see again.

So why do their followers continue to vehemently believe everything these two men teach? Admittedly, listening to their televised lectures on Youtube, they speak concisely and in an understandable and engaging way. This is something that cannot be said for all lectures on medicine and science. For others, it might be the hope that a genetic disease could becured by belief, when conventional medicine has failed them. The combination of online communities propagating misinformation and semi-qualified doctors providing supporting content creates a vicious cycle. This leads to more dramatic outcomes such as the anti-vaccine movement and a general distrust of the pharmaceutical industry. Unfortunately, it is not only the believers who are affected but their children, who need an adult's consent to get vaccinated, and their families, who feel these opinions are forced on them.

The possible solutions to these differences in beliefs are multifaceted; there is a need to educate more people on the way scientific research in the medical and pharmaceutical industries is conducted and how it is used to develop drugs and cures.

Scientific research is the reason why the child mortality rate

has gone down by more than half in Burkina Faso since 1990, after health care centres started offering vaccinations and teaching basic sanitation practices. It is also why the number of deaths for young people infected with AIDS halved from 1.4 million deaths a year in 2007 to 670,000 in 2017 after countries like South Africa started promoting safe sex and HIV testing.

These statistics strongly suggest that there is more to healing than the power of the mind or the divine. They show that real healing is not done by shunned chiropractors on a power trip, masking nonsense claims under the guise of neuroscience, genetics and quantum physics, but rather through decades of vigorous research and through belief in the scientific method.

A FUTURE OF CRUELTY FREE FASHION WITH

BIOFABRICATED LEATHER

Welcome to the age of biofabrication – leather made in the laboratory.

Written by **Jennifer Marx**
Art by **Olivia (Diggy) Hill**

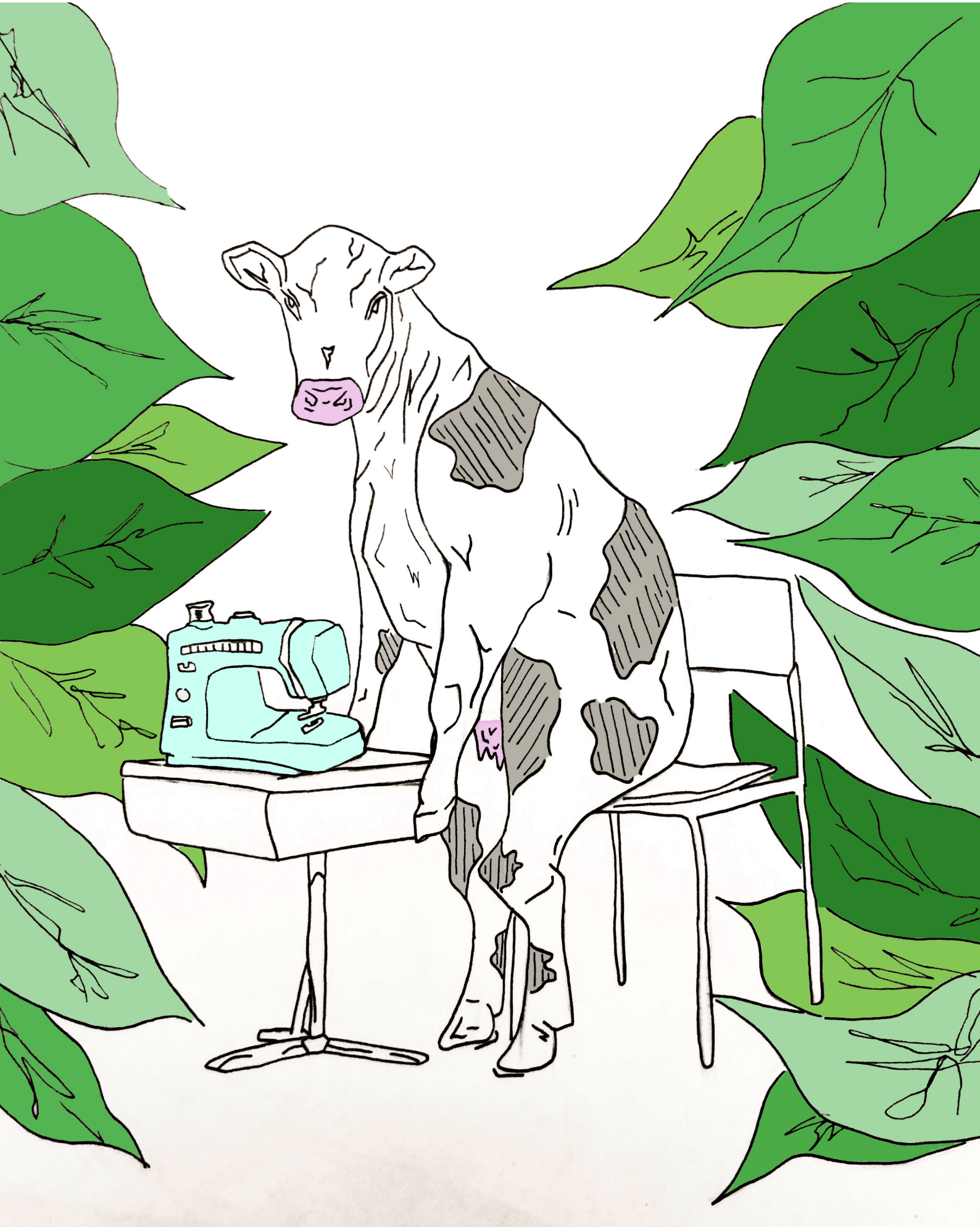
In the Stone Age, leather was one of humanity's most useful discoveries because of its ability to provide protection from harsh weather. A lot has changed in the production process and use of this versatile material. In the era of fast fashion, the pursuit of providing clothes as cheaply and quickly as possible, people have forgotten the impact that the production may have on the environment and the animal kingdom. Particularly the process of leather production has become harmful to the environment in recent years. Not only are natural ecosystems destroyed for the land needed to house and feed the cows but massive amounts of harsh chemicals, such as chrome, are used in the tanning process (a process that preserves leather). Leather is not just a waste product of killing animals for meat but a highly profitable by-product that leaves farmers with more profit generated from leather than from meat production. Therefore, it could be argued that buying leather is equivalent to supporting the meat industry.

Does this mean we should not buy any leather goods anymore? This is very unlikely to happen as leather is a crucial material in the fashion industry representing high quality products. As synthetic fabrics imitating leather could not replace it to date, other approaches must be considered. This is where new biotechnological advances come into play to revolutionise the fashion industry. Several start-up companies such as VitroLabs and Modern Meadow have developed new methods of growing leather without harming animals or the environment. VitroLabs uses advanced stem cell technology and 3D tissue engineering to create skin in the lab which can then be turned into leather: from a single biopsy of a healthy cow, isolated stem cells are set in an environment that allows them to reproduce on their own, indefinitely.

This technology enables an infinite resource that, together with tissue engineering, can be used to produce sustainable leather goods. However, this approach is not entirely animal-free as cells used in this process are derived from cows.

The first-ever biofabricated material brand "ZOA" will be soon launched by Modern Meadow. After decades of research, the company has chosen to focus on the main component of leather - the protein collagen. Entirely animal-free, they have developed a process that turns commercial yeast into collagen-producing cell factories by editing their genome and fermentation. Collagen is then purified and assembled into fiber-like structures that resemble the core building blocks for their materials. Just like real leather, these grown materials are biodegradable. The company is also exploring different approaches to tan and treat the fabric for more durability using less harmful chemicals.

Biofabrication is still in its early stages but the potential of the technology is massive. Besides leather, VitroLabs is working on lab-grown pelts from stem cells. Engineered spider silk threads are already commercially produced by Bolt Threads. But are we ready for the alternatives? Clearly, biofabrication has many advantages over livestock production in terms of land, water usage and CO2 emissions but research and development requires a lot of time, capital and a network of fashion contacts in order to establish a sustainable and efficient manufacturing process. Nonetheless, these novel approaches are a way to still enjoy the beautiful materials that we have become accustomed to while simultaneously leaving a lighter footprint on the planet.



An Obituary of

The most influential biochemist of recent times

Written by **Dan Jacobson**

Few recreational drugs have garnered the intrigue and idolisation of lysergic acid diethylamide. This substance, also known as LSD, is a synthetic drug thought to bind with serotonin receptors in the brain, making it ideal for treating psychiatric disorders such as PTSD. However, the hallucinogenic effects of LSD have bestowed upon it a certain legendary status. LSD was at the centre of the Woodstock-hosting, flower-power paradigm shift of 1960's culture, fronted by bands such as The Grateful Dead and Jefferson Airplane. It allegedly inspired masterpieces including Ken Kesey's One Flew Over The Cuckoo's Nest, The Beatles' Sgt. Pepper's Lonely Hearts Club Band, and Henri Michaux's Miserable Miracle.

Using LSD was also a hobby of the acclaimed biochemist Kary Mullis, who passed away earlier this year. The story goes that Mullis, who excitedly retold it during his 1993 Nobel Prize speech, conceived the idea of the polymerase chain reaction whilst on a drive in 1983 to a favoured surfing spot in Mendocino, California. He claimed to Albert Hoffman, the inventor of LSD, that his usage was instrumental in realising his ground-breaking discovery. Hoffman alleges that the heightened creativity experienced during these trips is ideal for investigating the secrets of nature, saying "if you don't turn into a mystic you are not a natural scientist."

The polymerase chain reaction, known as PCR, is a process that amplifies DNA segments, and the technique is deceptively, intriguingly simple. Beginning with a small amount of double-stranded DNA, the first step is to increase the temperature to around 95°C, causing the strands to denature and separate. The temperature then decreases, during which primers, short DNA segments designed to begin the DNA replication process, anneal to the strands. Finally, the temperature is increased, causing the DNA to be elongated . The temperature returns to 95°C, and the cycle begins again.

Each cycle takes around two minutes to complete. Within an hour, a single piece of DNA can yield more than one billion copies. All for the price of a few short DNA segments, an extensively produced enzyme, and a 3kg thermal cycler.

In Mullis' own words, with PCR, he had "solved the most annoying problems in DNA chemistry in a single lightning bolt". Since then, DNA amplification has allowed researchers to decode the human genome, decipher the genetic bases behind diseases such as sickle cell anaemia, and develop forensic scientific techniques. Despite these applications, though, Mullis maintained a cold relationship with the scientific community, citing its endless hunt for grants as replacing the natural curiosity that ought to be driving research.

Unfortunately, as with many great scientists, Mullis fell into some questionable stances following his great breakthrough. He labelled global warming and ozone depletion as conspiracies, and was doubtful of the association between HIV and AIDS, claiming that the symptoms are the result of a "hypothetical disease" caused by the growth of cells following latent viral infection. Even the lone hero, bolt-from-the-blue narrative he presents regarding PCR has faced intense scrutiny.

Whilst these developments may dampen one's perceptions of him, Kary Mullis has earned his place as one of the most unique thinkers of the past century, leaving a legacy concerning the roles, outlooks, and responsibilities of the modern scientist just as meaningful and influential as the scientific developments he enabled.

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