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MANCHESTERS' STUDENT VOICE ON SCIENCE

On the 9th of April, WHO director general Tedros Adhanom Ghebreyesus begged world leaders to not politicise the coronavirus pandemic. In doing so, he was trying to stuff a genie back in its bottle. As well as being a tragically deadly disease, Covid-19 is the single biggest political event of our times. It has fundamentally changed how we live our lives. It has shut down schools, shops, and parliaments. It has separated us from loved ones. It has also become a political weapon, being used by diverse groups to promote vastly different agendas. Donald Trump used coronavirus to shut borders and condemn China, whereas Bernie Sanders used the same virus to argue for universal healthcare. Online we see memes which proclaim, "guillotine the billionaires", as well as memes which portray the "Wuhan flu" in an overtly racist manner. In many parts of the UK, local councils have suddenly found the urge to house the homeless in empty hotels, but at the same time lockdown affects the poorest most, who lack the financial security, large houses, and spacious gardens to make life bearable.
Covid-19 demonstrates how science and politics are often inseparable. The UK went into lockdown later than other European nations, largely because of the influence of a single scientific advisor – there is no such thing as listening to "the" science. Due to chronic shortage of testing (itself a political issue), statistics regarding coronavirus cannot really be trusted even if they are honest. Politicians make decisions about which coronavirus science should be funded, as well as which science should be listened to – the latter of which was shown by Donald Trump describing protesters against social distancing measures as "very sensible".
From the very start, Covid-19 was deeply politicised, and there is no way that the disease can be sanitised of its political implications. Coronavirus has shaken society to its core. The question should not be whether the disease should become politicised, but how the post-coronavirus world should look. Planet bee approaches science in a way which explores its integral societal aspect – an approach which is needed now more than ever.
Planet Bee would like to extend it's deepest condolences to the loved ones of everyone who has lost their lives during this pandemic. Our heart also goes out to all those who have had their lives, jobs, or education disrupted during this trying time. We would also like to applaud all essential staff for helping to keep the country afloat in such difficult circumstances.

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What have the realms of the scientific world achieved in the last 60 years? From sequencing the human genome to even announcing the birth of a three-parent baby, science, technology and medicine have progressed immensely. It has also been 60 years since the first oral contraceptive pill for women was approved for use. Yet, in this same time period, there is still one thing that remains to be a challenge: developing a male contraceptive.

For some people, they have never even considered it as a possibility. It is the norm that the responsibility of birth control is endured mainly by women and it is just accepted that they deal with the side effects, and well, if one doesn't work for them, they try another. Or another. Because there seems to be an extensive list of contraceptive options for women from the combined pill (aka 'the pill') to female condoms, the implant, the injection, the contraceptive patch, diaphragms, the intrauterine device (IUD), the intrauterine system (IUS), progestogen-only pill, a vaginal ring and female sterilisation [1], but very few developments for men.

To say it is unfair is quite the understatement, but it is true. For men to not be given the same control over conception, and the assumption that women should take the responsibility, promotes a very archaic view.
But for a long time, views have been changing with many men agreeing that there should be equal responsibility for contraception and even saying that they would take a hormonal contraceptive given the choice. Yet how can they do this when they are only offered two viable options. One, which encompasses a surgical procedure and irreversible sterilization, is a vasectomy, and the other is to use condoms. The irreversibility of vasectomies means they are unlikely to be offered to a person under 30 without children, rendering them quite useless for a huge proportion of the population.

While condoms, although extremely important as protection against sexually transmitted diseases, in reality only have 85% effectiveness [1], [2]. The concept of condoms has also been utilised for hundreds of years, and although a goat bladder is very different to the modern condom used today, there really have been no substantial developments since [3]. These options undoubtedly have their roles in contraception, but they are very limited in both number and suitability, and simply to say that they are all that is available for men is astounding.

If you are wondering "Why do we need male contraception when we already have so many for women?" or "What's the need to develop more?" you probably do not have to take contraceptives, or are someone that has never experienced severe side effects. While many women are able to use these contraceptives without significant problems, as could be the case for many men, there are still those that endure extreme adverse reactions with migraines, vomiting, mood swings, and longer, more painful menstruation to name a few. Even more so with contraindications to medical conditions including diabetes, obesity and hypertension. One example is the increased risk of hypertension from oral contraceptives which can be life-threatening for someone with high blood pressure. Many of these women already rely on their partner for contraception. [4], [5], [6]

So why is developing a male contraceptive proving to be so difficult?
The lack of novel male contraception on the market is not to say there have not been any developments, or even certain drugs being brought to clinical trials, but beyond this there have been no solid advancements.

Scientifically, developing hormonal contraception, for females or males, is in itself extremely challenging. It has to be designed in a way that balances preventing pregnancy with lessening side effects and overall needs to be effective, reversible and safe. There is the argument that physiologically developing effective male hormonal contraception is more challenging in terms of having to prevent the production of millions of sperm daily, compared to one oocyte (egg) a month for females [5], [7]. However, it is impossible to conclude that it is "just too complicated" to develop a male contraceptive without investing the same time, expertise and money as has been for female contraception.

WHY DO WE NEED MALE CONTRACEPTION WHEN WE ALREADY HAVE SO MANY FOR WOMEN?

A major contributor to the poor understanding of contraception in terms of male physiology, is the lack of investment in this research area. Large pharmaceutical companies have been less inclined to invest due to the lack of economic incentive, thinking the potential market is not there. There is the perceived idea that men would not want to take the contraception or that women would not trust their partners to take it. But investigating the attitudes towards male contraceptives, when discussing a hypothetical situation without facts of efficacy, safety and side effects, is extremely difficult to be conclusive. Of course, more people are likely to say no to something that does not have the research evidence to say the method is effective, tested and safe. These results accentuate the cycle of less economic investment, less research and slow developments.
Certain factors can also influence the results of surveys, such as whether people questioned are in stable relationships or if their partner already uses contraception. Despite this, many have suggested there is widespread interest for novel hormonal, reversible male contraception internationally [8], [9]

In one YouGov survey, a third of men opted for yes to considering using hormonal contraception with those that opted for no or unsure choosing 'I am concerned about side effects' as the second most common reason. This, along with the fact that 1 in 6 males were not aware of the option, highlights that in a world where more investment is put into informing about novel contraceptives and developing safe, viable options with limited side effects, it could be likely that the number of males that would utilise the contraception would increase [9].

Current Trials

Despite the lack of funding and problems in the research area, there are some promising advances currently taking place.

NES/T (Nestorone/Testosterone)

There are international phase-IIb clinical trials for a novel male contraceptive taking place in the US with collaborating study sites at the University of Manchester and elsewhere [10]–[12]. The trial is for a gel called NES/T which combines key hormones testosterone and Nestorone and is applied topically to the shoulders and back. After being tested in humans for safety and tolerability during phase I trials, NES/T is now being tested for efficacy and determining the optimum dose range- an exciting point to be at in bringing this contraceptive to reality.

Nestorone is a synthetic form of the natural hormone progesterone, and unlike other progestins it has minimal activity at the body's receptors for testosterone and oestrogen. By using mechanisms other than via these receptors, as well as having a relatively low dose of testosterone and progestogen in the gel, it is anticipated it to have minimal side effects. It is designed to reduce sperm production reversibly and without affecting libido and early studies have shown promising results whereby daily application has effectively and safely suppressed the hormones important for sperm production. While trials are still ongoing, preliminary results seem positive and could be a real possibility in the future. [8], [10]

Male Contraceptive Pill 11-Beta-Methyl-19-Nortestosterone 17-Beta-Dodecylcarbonate (11-mntdc)

One of the major considerations for contraception is how convenient it is for a person to take. Obviously, preference has been towards a pill as opposed to an injection or implant [13] but finding a dose that can overcome metabolism while still being effective and safe is challenging. It requires higher doses of testosterone or increasing the number of doses which has been associated with hepatoxicity (liver toxicity) and severe side effects[5].
11-βmntdc is just one of a number of novel androgens (a group of hormones involved in male reproductive activity), that are being developed as potential oral hormonal contraceptive. It has been shown to have the least hepatoxicity when taken orally, making it extremely promising.

TO SAY IT IS UNFAIR IS QUITE THE UNDERSTATEMENT, BUT IT IS TRUE. FOR MEN TO NOT BE GIVEN THE SAME CONTROL OVER CONCEPTION, AND THE ASSUMPTION THAT WOMEN SHOULD TAKE THE RESPONSIBILITY, PROMOTES A VERY ARCHAIC VIEW.

RISUG

Another alternative, which is non-hormonal, is a method designed to stop the transfer of sperm reversibly. RISUG uses a synthetic polymer which prevents sperm from being released by blocking the tube that carries sperm to the ejaculatory duct. This polymer can be dissolved to make it reversible. Trials have been carried out in rats, non-human primates and humans, although reversibility is yet to be shown in humans. Further studies are needed to determine the long-term ability of RISUG to be a safe contraceptive, but the concept has potential. [5], [14], [15]
Driving Research Forward
Seeing these few developments with such huge potential, in a research field that has been forgotten by a lot of people, emphasises how much could be achieved with the right investment. But the major obstacle is that society has made it acceptable to forget, to the point where people have stopped questioning why there are no developments and simply accept that a woman will take her contraception and deal with it. People might agree with equal responsibility but also think there is nothing they can do without a new contraceptive on the market. But it is changing attitudes and increasing awareness of the possibilities and why they are needed that drives the research forward.

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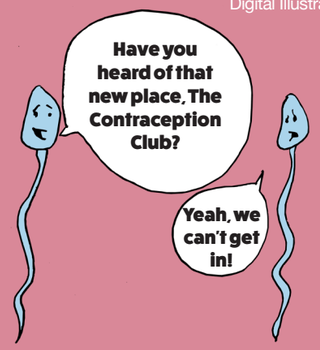

Is Nuclear Energy Doomed?

By the end of this decade only one of the UK's eight nuclear power plants is projected to still be producing electricity. Contributing around a fifth of the UK's total electricity supply [1], nuclear power has provided the country with a reliable energy source for over half a century. In 1956 the UK led the way with the world's first commercial nuclear power station at Calder Hall but we're now starting to move away from nuclear energy. In fact, the last plant to be built (Sizewell B) finished construction all the way back in 1995 causing the UK's nuclear capacity to peak, but since then it has been dwindling. Since then the energy mix of the National Grid has changed significantly: in 1996 nuclear power accounted for 93.8% of the UK's low carbon energy supply, in 2018 it is now at 35.8% [2]. This drastic reduction is chiefly due to a boom in renewables and in particular offshore wind farm development [3]. Whilst this move towards renewables should be welcomed, should it be at the expense of our nuclear industry?

If we look further into these renewable energy sources we find that more than 70% of them are weather-dependent [2]. This by no means makes these sources useless, but we must consider the need for a consistent base-load energy supply. It is vital that we have a reliable source of energy whatever the weather, and nuclear power is the best low carbon option.

In any discussion of nuclear energy the effect of public opinion must be considered. Born out of the arms race of WWII nuclear energy seems to have always been controversial, but the Three Mile Island, Chernobyl, and Fukushima disasters may have turned people against nuclear power for good [4]. Countries such as Austria, Sweden, and Italy have even held referendums concerning future nuclear power projects and overwhelmingly voted to halt the progress of building new plants. We also see many parties and organisations that lobby for action to fight climate change do not support nuclear energy, but is this justified?

While we should be concerned about the risk of another nuclear accident, lessons can be learned from the previous disasters and improved operation can mitigate the risk of meltdown. It is analogous to the risks of flying in a plane and driving a car; a plane crash will often make headlines and so we're acutely aware of the risk of boarding a flight even though the risk of being involved in a car accident is much greater. In fact, contrary to public opinion we find that nuclear energy is actually just as safe as renewable energy sources. Nuclear and renewables are estimated to cause less than 0.1 deaths per TWh of electricity produced, for comparison burning natural gas (the cleanest of the fossil fuels) causes 2.82 deaths per TWh produced [5]. So, what is actually far more dangerous is the common scenario where countries, such as Germany [6] and Japan [7], divest for fear of a nuclear disaster but then need to use the cheaper fossil fuels as a reliable base-load to make up the deficit.

So, whilst we see that the public have turned their backs on nuclear power and many governments have followed suit it still remains an incredibly reliable, relatively clean source of energy. Decarbonising the National Grid is a huge challenge and so it makes sense to use all the infrastructure and resources currently available to help achieve that. Nuclear energy is by no means perfect, but if properly utilised it could prove to be incredibly useful in tackling the climate crisis.

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100 Seconds to Midnight

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The end of the human race might be closer than you think.

The end of the human race might be closer than you think. At least, according to the *Bulletin of the Atomic Scientists*, that is. The Doomsday Clock, a metaphorical indicator of the likelihood of a man-made global catastrophe, was shifted in January 2020 from two minutes to 100 seconds to midnight. The closer to midnight, the greater the risk – and 100 seconds is the closest the clock has ever been.[1]

But where does the clock come from, and who decides what time it should be set to?

The Doomsday Clock was created by the *Bulletin of the Atomic Scientists*, a not-for-profit communications organisation who write about topics they believe are man-made risks to our continued survival as a species.[2] The *Bulletin* was formed after World War II by some of the scientists who worked on the Manhattan Project to develop the world's first nuclear weapons. [3] Their original purpose was to warn of the threat to humanity posed by these new weapons, but the *Bulletin* have since expanded their remit to include climate change and what they call "disruptive technologies".[2]

Each year, the *Bulletin*'s Science and Security Board decide where to position the clock's hands. Over the years, the clock's hands have swung backwards and forwards, but in the past decade they have crept ever-closer to midnight and destruction.[1] The most recent step in this countdown to catastrophe occurred this January when the Board moved the clock forward by 20 seconds, citing the dual threats of nuclear war and climate breakdown.[2] But is this really cause to panic?

In some ways, it's hard to tell. The Board is made up of research scientists and other individuals with expertise in the areas the *Bulletin* is concerned with. Now, I'm of the opinion that we should listen to experts, but it is worth pointing out that the clock's position is a collective judgement made by the Board. It is not an exact calculation of the probability of disaster. This means the clock has no clear scale: closer to midnight is worse, but how much worse is anyone's guess. Combine this with the discovery that the clock was originally set to seven minutes to midnight because "it looked good to [the] eye" of the artist who designed the clock, and it all starts to feel a bit arbitrary.[1]

This feeling is intensified by the *Bulletin's* expansion to include climate change in their considerations. By altering the factors which inform their decision, the *Bulletin* have re-defined the very meaning of the clock. What began as an indicator of how close we were to nuclear war is now meant to simultaneously represent a variety of existential threats. This keeps the clock perpetually on the edge of disaster, which could be counterproductive, as fear-based narratives can cause those who hear them to ignore or deny the message, rather than engaging with it.[4]

The departure from nuclear issues could cynically be viewed as simply a move to stay relevant. Whilst there has been a revival of interest in nuclear disarmament, it certainly doesn't grab as much interest

The clock doesn't work if taken literally.

as dying polar bears.[5] I'm not denying that anthropogenic climate change is an incredibly serious issue, but campaigning on multiple issues risks complicating the clock's message and adding to its feeling of doom and powerlessness.

Perhaps I'm being too harsh on the clock's custodians. After all, I agree with them about the seriousness of the threats posed by climate change and nuclear war, and the importance of engaging with a wide range of voices on these issues. As with any metaphor, the clock doesn't work if taken literally. Instead of absolute levels of proximity to destruction, what the clock can tell us about is trends over time. Its slow ticking reminds us that human-caused problems aren't going to disappear without us fixing them. On this clock at least, we can still turn back time.

Into the Heart of Darkness:

Colonialism and the Natural Sciences

The science of empire

One of the most challenging ethical dilemmas a scientist will face is the issue of colonialism, both in its historical and present day context. Colonial administration and science often went hand-in-hand. The motivation, means, and justification of colonialism were supplemented by scientific imperatives. Namely, they played crucial roles in justifying and enabling capitalist expansion into colonies, universalising Western frameworks for studying and understanding natural laws, and cementing Eurocentric racial and cultural superiority.

This article will look at one practice in particular: colonial taxonomy, the act of 'discovering' and classifying natural species. Taxonomy became the hobby and career of many prolific Victorian naturalists during the 19th century such as Charles Darwin, Robin Wright and Alfred Wallace Russel. In many ways, taxonomy embodied the power of industrial science. The chaotic and diverse body of nature could be divided, organised, understood and put on display in museums or private collections.

Colonial institutions became an essential part of knowledge production in taxonomy, be it through resources, laws or protection. Robin Wright's project to create a universal taxonomy of botany was funded by the East India Company (EIC). Information about potential lucrative species was of great interest to state-backed companies like the EIC.[1] With the help of research bodies such as Kew Gardens, the botanical properties of plants could be developed to fulfil market demands at the time. After selective breeding and hybridisation, the improved plants could be optimised for their mass production in the colonies with cheap slave labour. The crops could then be processed into goods (like pharmaceuticals, beauty products, or food and beverages) that were sold to the European public at an extraordinary mark-up.[2]

Other scientists were funded by private citizens or, in Wallace's case, by themselves. However, this does not mean they did not benefit from colonial enterprise. Colonialism in the Dutch East Indies acted as a conduit for Wallace to act freely with Dutch protection and to acquire resources through colonial outposts, which meant that he could employ local peoples in his private venture to collect and document natural species. In particular, Wallace's most loyal field assistant was a young Malay man known as Ali, who accompanied him in his journeys in the Malay archipelago.

By the end of his travels in the East Indies and Malaya, during which he would rest in British-established outposts, Wallace amassed a vast collection of more than 110,000 insects, 7,500 shells, 8,050 birds and 410 assorted mammals and reptiles.[1] It is highly doubtful that Wallace would have had equal success without pre-existing British power and control in the region.

A history of colonial taxonomy would be remiss if it did not mention how taxonomists became major proponents of Victorian eugenics. Proto-evolutionary discourses fuelled perceived connections between 'inferior' races and apes. When Wallace had added a baby orangutan to his collection, he explicitly evoked colonial perceptions of indigenous characteristics in describing the orangutan in a letter to his family.[3] Such comparisons were the norm and the assumptions of racial and gender superiority was the backbone of phrenology that used analogies to compare the similar characteristics between women, the 'inferior races' and animals.

Scientific notions of hereditary traits and of natural selection were used to justify the 'objective' inferiority of colonised peoples. In a chapter titled "The Comparative Worth of Different Races", Francis Galton, Darwin's cousin, stated: "Every long-established race has necessarily its peculiar fitness for the conditions under which it has lived, owing to the sure operation of Darwin's law of natural selection."[4] The argument goes that if, by their genetic nature and environmental pressures, colonised peoples were immutably less intelligent and less cultured, then the colonial mission is not only ethically acceptable, it is necessary. Victorian discourse made colonialism a charitable 'civilising mission' – the light of European science and technology could enlighten the dark corners of the world through the racial hierarchisation that emerged from colonial taxonomies.

Of course, pre-colonial societies were not 'dark'. Regions in Asia, Africa, and South America were the birthplace of many scientific and mathematical achievements, and indigenous peoples across the world had already developed knowledge about their natural environment in order to hunt, farm, and create medicines. It was this knowledge that allowed Ali, Wallace's assistant, to locate and shoot rare species of birds in the dense rainforest. In order to cement supremacy, however, it was necessary for European colonists to delegitimize indigenous scientific knowledge and to elevate their own ideologies. This was often done by framing the East as masters of spiritual matters, but not 'scientific' and rational ones.5

The persistence of colonialism in modern science

We are currently said to live in a 'knowledge economy', where the production and use of knowledge is critical to sustained material prosperity. But we see that the fruits of science are still distributed inequitably. Due to historical advantage, European research institutions have enjoyed centuries of uninterrupted success in science. Top university rankings for scientific research are dominated by familiar names: Oxford, Cambridge, Harvard, Stanford. Such bodies often directly benefitted from slavery and colonialism. Many colonial administrators and slave-owners such as Cecil Rhodes were educated and trained at such institutions, and donated generously back to their alma mater after creating their personal wealth from exploitation.

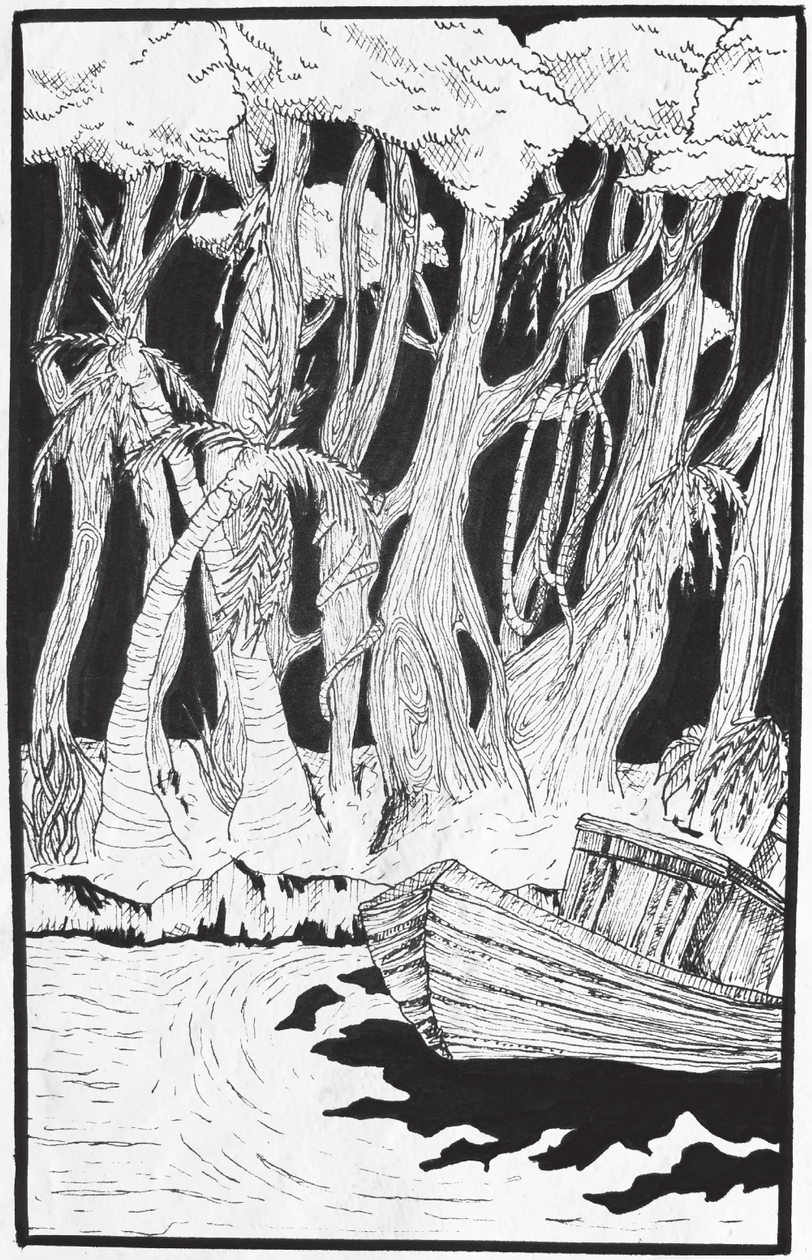
Rhodes himself had set up scholarships for Oxford and had donated £100,000 in 1899 (roughly equivalent to £11-13 million today) under the instructions of his will.[6]

Furthermore, many of these institutions and their researchers continue to enjoy the prestige of a historically venerated university. Though acknowledging that these universities do contain exceptional talent pools, part of their ability to retain and attract such talent is due to their historical exclusivity. This exclusivity was and is drawn along the lines of gender, race, and nationality. In contrast, many research institutions outside the West struggle with a scarcity of available resources. They often suffer from a severe brain drain and a lack of funding in economies that are under-developed, themselves still in the shadows of colonialism.

As such, many developing countries form strong dependencies on former colonial powers, embodied in organisations like the British Commonwealth and Communaute Francophone. In 2009, researchers found that around 80% of Central Africa's scientific output (measured in the number of published scientific papers) were made with foreign collaborators, principally their former coloniser.[7] However, these collaborative relationships may not even benefit those in developing countries. 70% of published research conducted in the 48 least developed countries do not state local research institutes as co-authors.[8] It was found that the most frequent role of local researchers was conducting fieldwork.

This persistent phenomenon has even been termed 'helicopter research', in which scientists from wealthy countries use local labour and resources, sometimes from local scientists themselves. They leave without sharing the information they collected, making themselves the main, if not sole, beneficiaries of such engagements. Collaboration is of course, a key driver of scientific research, yet it is clear from most of these interactions that 'international' researchers are often only interested in exploiting the skills of local researchers and not in collaborating to ensure mutual gain.[9] This dynamic disturbingly echoes that of Ali and Wallace. The gruelling work of collecting data and specimens is left to local populations while the academic recognition accrues disproportionately among Western scientists.

But what of the content of science itself? Bodies such as the World Health Organisation state that diseases that hamper economic development in poor populations, such as tropical diseases, are largely ignored by researchers. The economic inequality established by colonialism results in the neglect of research that pertains predominantly to former colonies.[10] Scientific prejudice is sadly far from a historical artefact. Race science has seen a recent popular resurgence despite being proven to have no real substantiating evidence, parroting taxonomic arguments from centuries prior.



What now?

It is often constructive to explore how a body of knowledge is influenced by the imperatives that begot it. Without discrediting the objective value of the advancements made by scientists during the colonial era, their contributions should be understood in its context. It allows us to see the patterns that the past has imprinted upon science now. With this knowledge, we can craft political-scientific policy that not only redresses historical crimes but also critically interrogates how perceptions of these disciplines continue to be affected by their history of abetting colonialism.

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FAKE NEWS
AND FLAT EARTHERS:
Is YouTube's Algorithm to Blame?

Today, the internet is vital for our society. Individual online exposure influences our thoughts, attitudes and behaviour immeasurably. In small amounts, this outcome is healthy. We read articles, consume YouTube videos and retweet opinions on Twitter, and we'd like to think that this makes us a more aware, well-informed society. Usually, it does – but what happens when this goes too far? What happens when we fall down the rabbit hole of false information and fake news? Does our blind faith in the internet make us vulnerable to a false perception of the truth?

Does our blind faith in the internet make us vulnerable to a false perception of the truth?

In short, yes. The birth of social media has evolved knowledge consumption into something globalised and participatory.[1] YouTube has directly fed into this participatory environment, fundamentally altering who can contribute to the co-construction of scientific knowledge. When YouTube began in 2005, they asked users to 'broadcast' themselves and that's exactly what users did, flocking to the site to express their opinions, share experiences, and learn from others online.[2]

This all sounds great, doesn't it? And it was. But, over time, YouTube has shifted away from amateur-produced bedroom vlogs to high quality, commercialised content, validating the site as a source of information. This has falsely given us the perception that we can trust everything on the site. But should we? You can get reliable information on just about anything, from fixing cars to furry cats. Yet with this comes the spread of false information, dispersed by groups with harmful ulterior motives. What's worse is that YouTube's algorithm has just got better and better at learning what we want to watch – and this can become very dangerous, very quickly.

The algorithm, designed to streamline the service for users, has actually contributed to conspiracy communication growth on the platform. Flat Earth activists, such as Mark Sargent, have caught on to this and utilised it to grow their audience. "Wow, YouTube has a lot of information on Flat Earth, maybe there is some truth to it." Thoughts like this are all too common in the YouTube space. It creates a false reality that can become dangerous if an individual eventually believes it to be true. YouTube sends viewers down a seemingly infinite rabbit hole of like-minded videos, recommending more conspiracy videos to users who already actively engage with this genre.[3] Scarily, YouTube can strengthen constructed realities by hiding perspectives that clash with a user's viewing history and this only heightens the problems of confirmation bias.[4] If you don't see it yourself, it's not true, right?

YouTube's algorithm is so finely tuned that it can work out our preferences and interests without us even noticing.[5] Ultimately, YouTube is a business and so their machine learning algorithm, analysing huge databases to predict future behaviour, is designed to entice users to continue watching.[5] When you search something on YouTube, the results are shaped by the algorithm. When watching a video, sidebar recommendations are selected by the algorithm. When a video finishes, YouTube selects another video to autoplay afterwards, chosen by (you guessed it) the algorithm. Unfortunately, there is evidence suggesting that the algorithm may recommend harmful, right-wing media to susceptible individuals, which could be damaging to society as a whole.[5] This attempted personalisation of content can actually become fairly restrictive, creating an 'online bubble' reducing content diversity by hiding videos that don't align with previous viewing habits.

With Donald Trump re-energising the 'fake news' narrative in 2016, there has been an explosion of mainstream media mistrust. The idea that these outlets may be lying to us has led consumers to seek 'alternative' sources of reliable information. YouTube fits that bill comfortably and although now heavily commercialised, YouTube still holds on to its organic, user-generated narrative. This post-truth era now frames fact synonymously with fiction and evidence is replaced with emotion.[6]

While this may seem a fairly dire situation, overall, YouTube has allowed more accurate science to become accessible to new audiences (it's just a shame that their algorithm isn't clever enough yet to recognise fact from fiction). And, whilst Flat Earth videos have now eclipsed Illuminati videos as the number one conspiracy theory, YouTube is fighting back, blocking Eric Dubay's channel (another Flat Earther) and reminding viewers on every Flat Earth video that it is based on archaic beliefs (see for yourself).[7] Ultimately though, YouTube needs its algorithm – a double-edged sword that helps and hinders its users in the 'Web 2.0' world.

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It's comfortable to stay with your parents, even if you are a young adult and supposed to take care of yourself… by yourself! Indeed, by clinging to your mother's skirt as a child, you benefit from the board and lodging without paying any rent- the perfect life! Well, not really. You will soon feel quite oppressed by your parent's glance, and it could become quite problematic when you want to invite your new significant other around. Then there comes a time for everybody to spread their wings and begin their own independent journey. Or maybe not everybody, because at least one animal seems to break this otherwise nearly universal dispersal rule: the killer whale.

I grant you, the name 'killer whale' is not really synonymous with sociability. But don't be fooled, these highly intelligent creatures, with their astonishing black and white colourations, have almost nothing in common with serial-killers. Also named orcas (or more informally, sea pandas), they inhabit every ocean of the world, from the poles to tropical regions.[1] These fascinating marine mammals - the biggest of the dolphins - are the ultimate mama's boys and girls. Indeed, most populations of this species show long and unbreakable family bonds. In some areas off the West Coast of the United States, males and females can even stay with their mother for life.[2] These social units, called matrilines, are led by the oldest female relative of the group, members of which benefit from her knowledge and wisdom. Matrilines are extremely stable, and the orcas are constantly interacting with each other.[3] They cannot rely on mobile phones, but they have a far better tool: sounds. Indeed, orcas belonging to the same family share group-specific dialects[, with each matriline having its own repertoire of calls.[4] These songs are culturally passed on to the next generation, emphasizing how fundamental communication and sociality are for these highly intelligent marine mammals.[5] In fact, members of the same matriline are rarely separated for more than a few hours and often share their prey together.[6] Adult killer whales are efficient teachers for their young and train them to catch prey, making them the most formidable predator of the sea.[7]

Orcas keep strong bonds with their families during their entire life, and even after

But for orcas, there is something that is more important than food. Something that, until recently, scientists were persuaded to be a feature specific to human emotions. Indeed, thanks to recent studies, it becomes more and more obvious that orcas can experience empathy, self-awareness and even grief.[8] One of the most heart-breaking examples of the latter was recently observed in the Southern Residents community, the most endangered killer whale population in the world. These orcas keep strong bonds with their families during their entire life, and even after. In August 2018, a female orca named Tahlequah gave birth to a daughter who passed away within a few minutes. But the desperate mother did not give up, and constantly tried to push her baby's body towards the surface. This unquestionable demonstration of grief lasted for 17 days, during which Tahlequah was never observed feeding on her own, appearing too saddened to think about her own wellbeing. Her family members were seemingly very affected by the immense distress of the lonely mother, since they constantly brought food to her and also carried her dead calf on their own backs.[9]

The incredible complexities of orcas and their similarities with humans are not limited to the emotional aspect - killer whales also show remarkable cognitive abilities. They belong to the Delphinidae family, already famous for their ability to recognise their own reflections and understand symbols.[10] In fact, orcas' brains are extremely large, being on average more than 5 times heavier than human brains.[9] Perhaps most importantly, they have the highest brain to body size ratio of all non-human animals, including great apes.[11] They possess a highly developed neocortex, with a total surface even larger than that of humans.[12] As this part of the brain is dedicated to complex information processing such as problem-solving and self-awareness, some scientists have recently argued that dolphins deserve to be juridically considered as people.[13,14] This acknowledgement encouraged people to start to reassess cetaceans' well-being, especially in captivity. In 2013, the release of Blackfish sparked a mainstream discussion on such topics. The documentary tells the story behind the death of a trainer killed by the orca Tilikum at Seaworld, a marine facility that has displayed captive cetaceans since the early 70s. The movie also shed lights on controversial practices of the park, such as the separation of families and poorly-adapted pools, and emphasises the fact that orca captivity leads to a form of psychosis in these highly social and intelligent animals.[9] Behind the scenes, the luxurious marine parks become murky. Profit is often the watchword in this industry, to the detriment of the unfortunate captive orcas. These amazing cetaceans, born to travel several hundred miles per day, and capable of diving to more than 700m, do not have their say while human's rake in the profits.[15] As a result of human delusions of grandeur, captive killer whales' emotions are sometimes completely destroyed. Several, previously hidden, dark facts have recently been brought to light, emphasising the terrible fate of orcas in captivity. Indeed, although wild killer whale families stay highly interconnected for generations, separation is common practice in marine parks.[16] The examples are too numerous to be counted, but some of them are particularly heart-breaking. This was the case in the deliberate separation of Kasatka and her daughter Takara, where the latter was sent to a different park, mainly to make her pregnant. But just after her beloved child was taken away from her, the trainers noticed that the saddened mother started to produce a different set of sounds, that they had never heard before. This song was made of "long range" vocalisations, usually used by wild killer whales to keep contact when they travel separately.[17] Kasatka was trying to reunite with her daughter. She was searching for her baby, and singing a song of grief. Recent captures conducted in Russian waters were even worse, tearing young orcas away from both their freedom and beloved families, just to sell them to brand new Chinese aquariums, thirsty for profit.[18]

Orcas' brains are extremely large, being on average more than 5 times heavier than human brains

We have previously seen how strong family bonds are in these social mammals, and can easily imagine how breaking up these close groups can result in terrible psychological consequences. Shocked by the hidden practices of marine parks, a growing number of people now campaign in favour of releasing the orcas. They dream of saving them from their concrete tanks and transporting them to the oceans, where they can reunite with their families. They fantasise about seeing these prisoners finally enjoying the freedom that they deserve, swimming in the sunset against a backdrop of peaceful music as in the Free Willy movies. But is that the solution? Sadly, it is difficult for captive orcas to adapt to freedom, since they have known nothing but captivity.[19] Therefore, is it kinder to leave them to their sad fate? Certainly not, as better solutions start to come to light. A large number of scientists are actively working to create a "Whale Sanctuary" where orcas could still benefit from human care while enjoying the life of an (almost) free killer whale.[20] This large enclosed bay[21] would allow more than 3,000 orcas and dolphins currently kept in captivity around the world to live in semi-natural conditions. As the popularity of Seaworld and other marine parks continue to plummet , the possibility to move captive orcas to this sanctuary becomes more and more plausible. The directors of the project recently posted a press release announcing that a site has been selected]: the small community of Port Hilford, located in the province of Nova Scotia on the Eastern Shore of Canada, has been designated as the best place to retire orcas from their lives as performers.[22] Scientists, managers, and animal rights activists from all over the world are now moving mountains to provide a better environment for retired performing orcas. Officials declared that the sanctuary will be ready for its first residents by the end of 2021.

It is difficult for captive orcas to adapt to freedom, since they have known nothing but captivity

In 2017, Tilikum passed away without having the chance to experience freedom again. Since then, the debate is still raging between Seaworld and the Sanctuary to decide the fate of captive orcas. Whereas the first provides good care and protection against natural threats experienced by killer whales in the wild[23,24,25], it also prioritises making profit on these sentient creatures. The discussions go on between the two main actors, but orcas do not have time to waste- the situation is critical, both for captive and wild individuals. Thus, perhaps we should take a leaf out of the orca's book and become inspired by their incredible ability to learn from each other, to finally together create a better future for these amazing marine creatures.

Creating a Better Future for Captive Orcas

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Watercolour, Pencil, Ink, Fineliner

ALGAE: NATURE'S GREEN MACHINES

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Picture algae, and you might imagine scummy ponds, or slimy seaweed: but chances are that these aquatic creatures will soon be a part of everyday life. Microalgae are so abundant, that their swirling ocean blooms can be seen from space, or can turn an entire beach red. From food ingredients, to raincoats, a wave of new materials made from or inspired by algae are being used to combat environmental issues, like climate change and plastic pollution. Could algae be part of a greener future for us all?

Could algae be part of a greener future for us all?

One of the earliest proposed industrial uses for algae back in the 1980's was as a biofuel. Numerous companies were formed proclaiming that they would soon revolutionise the world's energy production. However, these schemes never proved profitable, and the companies either closed or switched to more lucrative outputs. [1] With the resurgence of climate change discourse, scientists are revisiting the possibility of using algae as an alternative to fossil fuels, but this time focusing on algae's ability to photosynthesise. Algae are much better at photosynthesis than plants because they have evolved funnel-like machines that capture the maximum amount of available light. Scientists are trying to copy this in order to make solar panels more efficient.[2] A more direct approach is being employed by Grow Energy, a company that specialises in "algal technology for a greener world".[3] Their 'Verde' solar panels are marketed towards the public and are made of living algae. The algae grow, and are subsequently consumed, which powers an internal generator, producing energy. The main advantage of the technology is its affordability compared to traditional solar panels, which typically take 10-15 years to see any personal returns on. In comparison, Grow Energy claim their 'Verde' solar panels will pay for themselves within 3-5 years, making the technology accessible to a wider range of people. [3]

Plastic pollution is a huge problem for the world's oceans. It impacts practically every marine species: from tiny plankton that have been found to feed on microplastics, to giant whales with stomachs filled with plastic waste. There are almost 8 million pieces of plastic entering the ocean every day, and by 2050 a trip to the beach could surround you with more plastic than fish. [4] It's fitting that an alternative to this harmful material could be found in the ocean. Notpla is a British start-up that aims to replace our use of single use plastics, such as sauce packets and plastic bottles. [5] Their flagship product is a flexible packaging material made from brown seaweed, called Ooho. Unlike plastic, Ooho biodegrades in 4-6 weeks, or, cutting out any waste, the material can also be eaten. Although it might appear to be just a fun novelty, Notpla has had support from large organisations such as Just Eat and the London Marathon. It can be used to contain drinks: the material is soft, so once it is popped the liquid must be drunk immediately, making it perfect for holding a single mouthful. However, this limits its applications for holding larger quantities of liquid like you would find in a plastic bottle. Luckily another company, Loliware, has produced a much stronger "plastic" product from algae, which they use to make straws and cups. Their central ethos is that single use products should not be built to last forever, so their "straw of the future" will degrade after just 18 hours of use.[6]

Artwork:
Kulsum Karolia
Digital Illustration

Algae aren't just being used as a material to replace single use plastics. Charlotte McCurdy, an award winning designer, has created an anorak style raincoat made entirely from algae. The raincoat is a statement regarding both the problem of plastic pollution and climate change, but also highlighting reasons for optimism, and the solutions that science and nature can provide to these problems.[7] Although unlikely to be hitting the high street anytime soon, there are some current options if you want to wear your love of algae on your sleeve.

The environmental impact of the fashion industry has recently come into focus, and the dyeing process is particularly polluting. The lifecycle of a piece of clothing, from production through to disposal in landfill, has a devastating impact on our environment. Numerous clothing companies have cropped up claiming to provide more sustainable alternatives, such as Vollebak, an American company with the catchy tagline "clothes from the future". They make a T-shirt made from algae and sustainably grown eucalyptus, which will biodegrade in just 12 weeks.[8] However, with an £85 price tag, is this actually a realistic alternative to current clothing materials, or simply a marketing tool?

Algalife certainly believes that the future of fashion lies in renewable textiles.[9] The Israeli company is developing both fibres and pigments from algae that they claim are not only better for the environment, but also for our health. They claim that their "bio-fiber" releases anti-oxidants and other nutrients directly onto the wearer's skin. With no commercial products yet it is hard to verify these claims, but the health benefits of algae have been touted for years: that's why you'll often find spirulina, a microalgae, in your smoothie.

As the public's understanding of environmental issues increases there will inevitably be companies that aim to profit from people's desire to shop more responsibly. Materials made from algae are a promising solution to some of the environmental crises we currently face, particularly as a replacement for plastic. However, there is the risk that some companies will just ride the eco-trend, especially with regard to unsubstantiated claims about the health advantages of algae. Currently there is a relative lack of knowledge over the ecology and biology of algae, meaning that they are not being utilised to their full extent. A positive aspect of the increase in biotechnology and commercial companies working with algae is the increase in research into these species, which will certainly improve cultivation techniques, and find new uses for these fascinating organisms.

OPT-OUT:

A new life-saving law for organ donation

We all have the ability to save multiple lives, even after we die. How is this possible? Organ donation. One small plastic card that has the power to save numerous lives, providing a lifeline for many. Despite this, there is currently a shortage of organs in the UK. So, how can this shortage of organs be managed?

One potential solution to this is the introduction of the new 'opt-out' law in England coming into force on 20th May, 2020, with a similar law also being introduced in Scotland. This seemingly simple change in the law will hopefully have significant impacts, saving and enhancing the lives of many.

So, what does the new 'opt-out' system involve? Once introduced, all adults in England will be considered organ donors when they die, with the exception of 'excluded groups'. These groups include under 18s, visitors to the UK and adults that may not be able to make a fully informed choice themselves [1]. If more people are registered as organ donors, this change will hopefully enable more organ transplants to take place, enabling life-changing improvements to organ donation.

This is hugely important as currently there are 6,130 people waiting for an organ transplant in the UK and since April 2019, only 3,635 people have received transplants [1]. Last year, over 400 people died waiting for a transplant [2]. By having more people on the organ donation register, the chances of finding a suitable match are increased, which can save lives. This change in law will hopefully be a turning point in helping to address this urgent need for donors.

So what can you donate? Organ donation is down to the individual's choice and you can choose to donate as many or few organs as you wish. Organs that can be donated include: the heart, kidneys, lungs, liver, pancreas, and small bowel. Tissue can also be donated, including cornea and bone [1]. In addition to being on the organ donor register, it is also important that family members are aware of your decision to become an organ donor.

Voices in favour of this 'opt-out' system say that it will increase the supply and availability of organs and also address the issue that often, people want to donate but never get 'round to registering' [3]. Also, it will hopefully reduce the pressure currently put on grieving relatives who are required to give consent [3]. Opposing views state that organ donation is a sensitive subject for many due to religious beliefs, and therefore the decision should remain completely voluntary [3]. However, this is accounted for in the new law as people are able to 'opt-out', in an easy process that still respects peoples' own opinions. Other voices against this change in law caution that this change may be costly and difficult to implement [3].

England is not the first country to switch to 'opt-out'; Spain and Sweden already adhere to this system. Spain is often considered as having a successful 'opt-out' system [4]. In 1979, Spain introduced a 'soft opt-out' system; individuals are considered organ donors after death, unless they have opted out, but approval from families is required [5]. In Spain, no significant increase in donations were seen for a decade after the change in law, although now, organ donation rates there are the highest in the world [5]. Hopefully, England will follow suit and in the years following this change, organ donation will increase. As the increase in organ donation rates were only seen in Spain years later, perhaps further changes in the system in addition to a change in law are required to increase organ donation. This change in law will hopefully be a crucial platform for increasing the numbers of organ donors and the accessibility of organ donation in England in the future.

The change in law is also known as 'Max and Keira's Law'. This is in honour of two brave, inspirational young people. Keira Ball was a young girl who tragically passed away aged nine following a road traffic accident in the Summer of 2017. Keira's donation helped four people: her kidneys were received by adults, her liver was received by a baby and her heart was received by a young boy called Max Johnson, also aged nine [6]. Keira's parents set up a charity called 'Inspired by Keira', and Max Johnson and his family campaigned for the change to the 'opt-out system'. These are two inspirational young people that have paved the way for the introduction of this new law.

Organ donation is a truly life-changing gift that we can give. In the moments of sadness and grieving that come with death, this lifeline of a gift can be given. Organ donation has the potential to save multiple lives and enhance the quality of lives for many. Although there are reasons why people choose not to donate, if you are able to, then why not consider it? If you are unsure as to whether you would like to donate, why not ask yourself: if you needed an organ transplant, would you accept one?

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MADE IN MANCHESTER:
A NEW HERO IN THE FIGHT AGAINST VIRUSES

You might think of sugar as just something you put in your cup of tea, but what if I told you it could do so much more...

How would you kill a virus? If you're going to be brazen about it, you might use something like bleach. Bleach can rip open the shell of a virus, killing it on contact. Pretty effective, sure, but no one's taking a dose of bleach to get rid of a cold. If you want to make an antiviral medicine, perhaps go for something a bit more subtle. That's the approach our current medicines take. [1] But whilst our current medicines are definitely more bio-friendly, this gentle approach has its own set-back: anti-viral resistance. [2]

Imagine a Venn diagram. You've got "kills viruses on contact" on one side and "bio-friendly" on the other, but what you really need is something that falls in the overlapping section – here' where your superhero, Dr Sam Jones, his team in Manchester and collaborating teams in Switzerland come in. They think they've found just what you're looking for: it's called modified cyclodextrin and it's made from sugar. [2]

Before we dive into how modified cyclodextrin works, let's look at how viruses work. Viruses are little more than shells containing genetic information. They cannot replicate on their own, creating debate in the scientific community as to whether they can really be considered to be alive. They come equipped with tools to latch onto the cells of the infected host (read: us!), inject host cells with their genetic material, and hijack the cellular machinery. Our hijacked cells cease all normal activity to focus on one thing: replicating viral genes and making viral proteins, all to build new viruses. The cell eventually bursts, releasing the next generation of viruses to find new cells and infect new hosts. [3]

The antivirals we're using right now target host cells, to block the hijack mission going on to create new viruses. [2] This can work really well, for example most HIV-treatment regimens see patients achieving such low viral levels that they can no longer pass on the disease. [4] The problem is that most antivirals target just one pathway. Viruses can mutate – this means changing their genes to their advantage – and with just one pathway under attack, it's pretty easy for them to evade the antivirals. Just one small mutation can give the virus resistance to a medicine. [1] Unfortunately, this means that some people suffering from long-term, serious, viral infections cannot be treated. For example, over 10% of HIV patients were found to be resistant to antiviral treatments, in two thirds of countries surveyed by the World Health Organisation. [5]

Viruses are little more than shells containing genetic information.

A whole new way of killing viruses is clearly needed. I sat down with Dr Jones to chat to him about his research, why he looked to sugar molecules in the first place, and why it looks so promising. After experimenting with using gold-nanoparticles to kill viruses on contact, he was tasked with finding a more bio-friendly alternative. It was experience from his PhD in Cambridge that led Dr Jones to pick cyclodextrin as the starting point, seeing some similarity that gave it potential. [1]

Cyclodextrin is a sugar molecule, derived from glucose. The team then modified it to resemble a pretty complex sugar called heparan sulphate. Heparan sulphate is found on the surface of our cells, and many viruses use it to latch on to as they infect us. Add the modified cyclodextrin into the mix and the viruses will latch onto that instead. This is a bit of a poor trade for the viruses, who – rather than getting to latch onto a host cell – will find that the sugar breaks their outer shell, killing them on contact. [1,2] This means that modified cyclodextrin can be used to treat any illnesses caused by viruses that latch onto heparan sulphate. Such illnesses include herpes, HIV and even the disease caused by novel coronavirus: COVID-19. [1]
So, this new sugar molecule can kill viruses on contact, that's one thing ticked off our list. But is it bio-friendly? Well, as a sugar, it's biodegradable and soluble, meaning it will dissolve in water, making it easier to be given as a medicine. In fact, it's been used before as a tool for easy delivery of other medicines to the body. It's even used in cosmetics, as the active ingredient in some deodorants. [1] All in all, that's a tick for bio-friendly, too.

At this point, you might be thinking "well that's great, but won't viruses just become resistant to this too?" That's a great question, and one I asked Dr Jones. He explains that, as we saw above, viruses needed to undergo mutations to become resistant to a medicine. In a ground-breaking success, modified cyclodextrin passed a "mutation resistance test" that many standard antivirals fail. This means that it does not mutate, or develop resistance, when treated with modified cyclodextrin. [2] Secondly, and perhaps more importantly, even if it does show the ability to mutate one day, that does not mean it can develop resistance. Dr Jones the tells me that whilst only small changes, a single mutation, is needed for a virus to become resistant to current antivirals, this is not the case for modified cyclodextrin. Since modified cyclodextrin latches onto the virus and rips open its outer shell, a multitude of mutations, leading to an "evolutionary, biological change" would be needed for a virus to become resistant to this attack. A virus is highly unlikely to have the chance to do this before it is killed by modified cyclodextrin. [1] It's still too soon to declare modified cyclodextrin a medicine that viruses will never become resistant to, but the outlook is clearly positive.

So, finally, what's next? Well, for modified cyclodextrin, it's been patented and licenced to a company in Switzerland. This sets the wheels in motion for it to be developed as an antiviral medicine – and perhaps even a preventative one. For Dr Jones and his team, they're looking into more molecules that seem to behave in the same way. He's hopeful that these new molecules have the potential to be easier or cheaper to make, an important factor in real-world medicine. And, after reading this article, I hope you're feeling a little hopeful too. Scientific news can seem a little bleak at times, but pioneering research, some of it done right here in Manchester, really does have the potential to make our world better.

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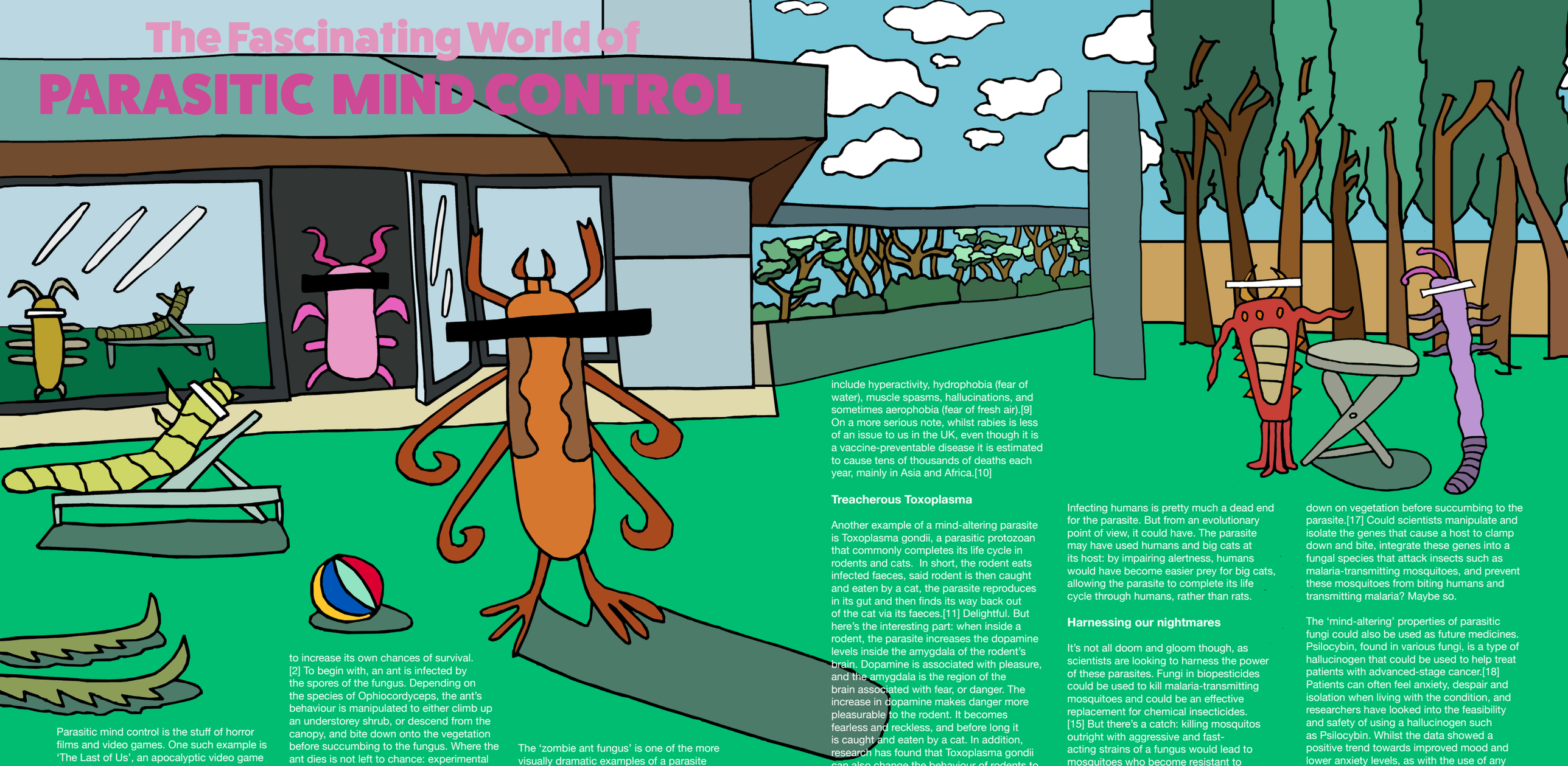
The Fascinating World of
PARASITIC MIND CONTROL



Parasitic mind control is the stuff of horror films and video games. One such example is 'The Last of Us', an apocalyptic video game in which the world's population has been decimated by a fungus that infects people, spreads to their brain, and turns them into highly aggressive and blood-thirsty monsters. In the game the 'host' will go through four stages of infection – Runner, Stalker, Clicker and Bloater – before finding a dark, damp place to die, allowing the fungus to reproduce and ultimately spread to other helpless victims.[1] An alarming concept! Whilst in reality humans are unlikely to be infected by a mind controlling fungus, there happens to be a very real parasitic fungus that exists in nature. These horrifying entities aren't just the stuff of fiction.

Obnoxious Ophiocordyceps

Ophiocordyceps, or the 'zombie ant fungus', is a type of parasitic fungi found in tropical forests worldwide. What is fascinating about this particular fungus is that it has evolved to manipulate the behaviour of its host in order to increase its own chances of survival.[2] To begin with, an ant is infected by the spores of the fungus. Depending on the species of Ophiocordyceps, the ant's behaviour is manipulated to either climb up an understorey shrub, or descend from the canopy, and bite down onto the vegetation before succumbing to the fungus. Where the ant dies is not left to chance: experimental evidence has shown that ants tend to bite down on vegetation and die in a place that favours the fungi's own reproduction and spore dispersal.[3] For example, an ant may be perfectly positioned in a place where other ants are likely to pass. Here's the gruesome part: once the ant is dead, the fungus feeds on the innards of the ant, before sprouting a long stalk through the ant's head, spreading new spores and infecting new ants.[4] When reading up on this, I wondered, why doesn't the fungus manipulate the ant's behaviour to make it die in the ant colony, increasing the chances of infecting more ants? Luckily, ants have their own tricks up their sleeves. They have their own defence mechanism against the fungus, and if an ant is acting strange, another ant will detect this and rapidly expel the infected ant from the colony.[5] The relationship between the fungus and its host is fascinating, disturbing, and yet strangely beautiful.

The 'zombie ant fungus' is one of the more visually dramatic examples of a parasite infecting and manipulating the behaviour of its host, but what about us? Are there any parasites out there which can alter the behaviour of humans? Well, the answer is, unfortunately, 'yes'.

Repulsive Rabies

Perhaps the most well-known disease that can change the behaviour of humans is rabies. Rabies is a viral infectious disease that humans typically catch from the bite or scratch of an infected animal, such as a bat.[6] Whilst it is not typically referred to as a 'parasite', when an animal or human is bitten, the virus travels from the area of the bite through the spinal cord to the brain and nerves, where it can change the behaviour of its host.[7] The virus is later excreted in saliva, ready to pass to another victim. Dogs, for example, become more aggressive and more likely to attack and bite, thus the virus is transmitted to another victim, or 'host'.[8] Symptoms in humans include hyperactivity, hydrophobia (fear of water), muscle spasms, hallucinations, and sometimes aerophobia (fear of fresh air).[9] On a more serious note, whilst rabies is less of an issue to us in the UK, even though it is a vaccine-preventable disease it is estimated to cause tens of thousands of deaths each year, mainly in Asia and Africa.[10]

Treacherous Toxoplasma

Another example of a mind-altering parasite is Toxoplasma gondii, a parasitic protozoan that commonly completes its life cycle in rodents and cats. In short, the rodent eats infected faeces, said rodent is then caught and eaten by a cat, the parasite reproduces in its gut and then finds its way back out of the cat via its faeces.[11] Delightful. But here's the interesting part: when inside a rodent, the parasite increases the dopamine levels inside the amygdala of the rodent's brain. Dopamine is associated with pleasure, and the amygdala is the region of the brain associated with fear, or danger. The increase in dopamine makes danger more pleasurable to the rodent. It becomes fearless and reckless, and before long it is caught and eaten by a cat. In addition, research has found that Toxoplasma gondii can also change the behaviour of rodents to become more attracted, rather than averted, to cat urine.[12] Success for Toxoplasma gondii!

Toxoplasma gondii is a common parasitic protozoan that is found worldwide, and in addition to infecting cats and rodents it can also infect other warm-blooded animals including humans.[13] The parasite is typically ingested by humans through eating raw, undercooked or contaminated meat, or through close contact with cats. A research study into a cohort of men in Prague showed those infected by Toxoplasma gondii experienced subtle changes to their personality and even their reaction times.[14] The research demonstrated that those who had been infected had a higher incidence of traffic related accidents than those who had not been infected. But how does this help the parasite to move onto its next host? Well, it doesn't.

Infecting humans is pretty much a dead end for the parasite. But from an evolutionary point of view, it could have. The parasite may have used humans and big cats at its host: by impairing alertness, humans would have become easier prey for big cats, allowing the parasite to complete its life cycle through humans, rather than rats.

Harnessing our nightmares

It's not all doom and gloom though, as scientists are looking to harness the power of these parasites. Fungi in biopesticides could be used to kill malaria-transmitting mosquitoes and could be an effective replacement for chemical insecticides.[15] But there's a catch: killing mosquitos outright with aggressive and fast-acting strains of a fungus would lead to mosquitoes who become resistant to these biopesticides, so there needs to be a smarter way of manipulating the mosquitoes to stop them biting humans and transmitting malaria. One idea is to use parasitic fungi to influence what their hosts (in this case, mosquitoes) feed on. Instead of locating and feeding on humans, could the mosquito be manipulated via the mind-altering properties of parasitic fungi to feed on another animal, which the malaria pathogen, Plasmodium falciparum, cannot infect? Hypothetically yes, and this would solve the issue of resistant mosquitoes evolving as well as preventing the spread of malaria in humans.[16]

Scientists are also investigating the genomes of parasitic fungi in order to discover genes linked with the manipulation of the behaviour of its host. Researchers exploring the genome of Ophiocordyceps have found an increase in activity of certain genes when the ant host is compelled to bite down on vegetation before succumbing to the parasite.[17] Could scientists manipulate and isolate the genes that cause a host to clamp down and bite, integrate these genes into a fungal species that attack insects such as malaria-transmitting mosquitoes, and prevent these mosquitoes from biting humans and transmitting malaria? Maybe so.

The 'mind-altering' properties of parasitic fungi could also be used as future medicines. Psilocybin, found in various fungi, is a type of hallucinogen that could be used to help treat patients with advanced-stage cancer.[18] Patients can often feel anxiety, despair and isolation when living with the condition, and researchers have looked into the feasibility and safety of using a hallucinogen such as Psilocybin. Whilst the data showed a positive trend towards improved mood and lower anxiety levels, as with the use of any hallucinogen, there are significant ethical and moral factors implications to consider before we see any kind of medicinal use in patients.

Parasitic mind control truly is the stuff of horror films and video games, but the potential to harness the power of these mind-altering parasites is fascinating and exciting. It is a highly challenging and complex area with much research to be done, but the possibility and motivation is there. Perhaps the stuff of nightmares can be harnessed to make the world a better place.

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MAKING A MURDERER

COULD YOUR DNA CONVICT YOU OF A CRIME YOU DIDN'T COMMIT?

Everybody loves a true crime thriller. We all know how it usually plays out: DNA is discovered, DNA provides a positive match to a known person, person becomes a suspect. But have you ever doubted the infallibility of DNA evidence and its role in our justice system? Because you should.

First let me introduce the case of Lukis Anderson. In 2012, Anderson was arrested and charged with the murder of 66 year old investor Raveesh Kumra during a violent home invasion in California.[1] Kumra was found to have suffocated after the intruders left duct tape covering his mouth. Anderon's DNA was later found under Kumra's fingernails, so it appeared to be an open and shut case. However, in a Silent Witness-worthy turn of events, Anderson had an indisputable alibi, as he was in hospital at the time of the murder. This raised the question of how his DNA was found under the victim's fingernails. Was a national conspiracy at play? Or was it something far simpler, something dangerously mundane?

Unlike the other perpetrators, there was no evidence that Anderson knew the victim: he had no connection to local home invasion gangs, and no history of violent crime.[1] With a solid alibi, his attorney only had to explain the DNA evidence.

After ruling out any laboratory errors or the possibility that Anderson and Kumra had met earlier in the day, the defence case hit a brick wall. That is until a police officer recognised the names of two paramedics on Anderson's hospital admittance paperwork; the same names that appeared on Kumra's medical file from the day he was murdered.

This led to an eventually exculpating discovery. On the day of the murder, paramedics dropped Anderson off at hospital, during which they placed a pulse oximeter over his finger to measure oxygen saturation.[1] Later that same day, the same paramedics checked the murder victim's vitals. They were wearing the same uniform, using the same equipment, and in particular the same pulse oximeter. While it is impossible to know for sure how exactly the DNA transfer occurred, it is clear that at some point during this interaction, the paramedics transferred Anderson's DNA onto the victim's fingertips. Anderson was subsequently cleared of all charges.

In order to uncover the truth of Anderson's case, we must first understand the use of DNA in criminal investigations. Crime scene investigation (CSI) first came to fruition over a century ago when Edmond Locard, a French criminologist, proposed his Exchange Principle. It was based on his belief that "every contact leaves a trace".[2] Locard's Exchange Principle states that at every crime scene the perpetrator will leave behind trace evidence, and in turn will take evidence away from the scene. As no two people have identical DNA, there is a long held belief that if a person's DNA is found at a crime scene they are linked to the crime.[4] Since the formation of Locard's Principle, CSI has developed greatly, becoming the focal point of countless investigations. In the UK alone, the National DNA Database is used prolifically, containing over 6 million suspect profiles and 600,000 crime scene profiles.[8]

However, the solid ground that DNA evidence once stood on is growing increasingly shaky. In Anderson's case, a startling theory arose suggesting the DNA sample was a result of secondary DNA transfer. Secondary DNA transfer, at the time new and controversial, involves the movement of DNA from the primary source to a secondary location, via an intermediate object or person.[2] Say if you pick up a tomato at the supermarket and then decide to put it back on the shelf, you will leave behind traces of your DNA. Then if a complete stranger comes along and picks up the same tomato, they could end up with your DNA on their hands,

The average human sheds 50 million skin cells a day, leaving a trail of DNA everywhere we go.[1]

even though you've never come into direct contact.

Roland van Oorschot and Maxwell Jones were the first scientists to write about secondary DNA transfer in their 1997 paper 'DNA fingerprints from fingerprints'.[3] As part of their research, they passed polypropylene tubes between groups of 2 or 3 people, who each held the tube for 10 minutes. Afterwards, they swabbed the tubes for DNA and found DNA samples of everyone that had come into contact with the tubes. They then swabbed the hands of the participants and on some found the DNA of another participant that had touched the tube, even though they had never come into direct contact with that person. This provided the first evidence of secondary DNA transfer. Their most surprising discovery was that the strongest DNA sample obtained was not necessarily from the last person to come into contact with the tube. It depended on the extent to which a person is a DNA shedder.

In an individualistic culture, like the one that's developed in the UK, people are slower to mature to adulthood in general[13].

The average human sheds 50 million skin cells a day, leaving a trail of DNA everywhere we go.[1] However, there are a range of factors that can increase the amount we shed. Skin conditions, such as eczema and the presence of sebum or sweat on the skin increase the amount of DNA we transfer.[5] Recognising our 'shedder status' can prove to be vital in understanding DNA evidence in individual crimes, for example in the David Butler case, another innocent man jailed for murder based on DNA evidence. Similarly to Anderson, Butler's DNA was found under the fingernails of the murder victim, with the prosecutor declaring it a "one billion-to-one chance" that the DNA could belong to anyone else.[6] So the question wasn't whose DNA is this, but how did this DNA get there?

Butler was known to his friends as "flaky" because he had a severe dry skin condition that led to skin peeling.[6] So in short,

Butler was a **'super shedder'** who shed more skin cells than the average person. At the conclusion of the case, Butler was cleared of all charges, based on the possibility that as a taxi driver, he probably picked up the murderer during the day, and transferred some of his fast-shedding DNA onto them. The murderer then transferred this DNA to the crime scene. DNA samples are closely tracked once they are collected, however, this case demonstrates the importance of tracing DNA's journey from before it got to the crime scene.

Van Oorschot and Jones also performed a second test, to determine whether DNA could be transferred by direct human contact.[3] Participants were asked to shake hands for one minute, then their hands were again swabbed for DNA. In one quarter of the hands tested, DNA evidence from the other person was found. So, when that person goes to touch something later, they could transfer not only their own DNA to that object, but the other person's as well. This research demonstrates the importance of recognising secondary DNA transfer as a common occurrence that could contaminate a crime scene. Investigators need to question the assumption that DNA evidence infers direct contact, an outdated notion which could link an innocent person to a crime, like in Anderson's case.[2]

As DNA analysis technology improves, it is able to analyse increasingly smaller DNA samples.[7] Low Count DNA, which is a sample that contains a miniscule amount of DNA, can now be tested and used as the basis of a court case. But with this comes increasing risk that the DNA could be a result of DNA transfer. In the majority of cases, DNA evidence is merely used to support a story with a significant amount of other evidence to create a strong case. However, in Anderson's case, amongst many others, a story and timeline of the crime was created based entirely on a small DNA sample. Traditional police work was discarded in favour of relying almost entirely on DNA technology, and it resulted in a wrongful arrest and an unnecessary court case. In order to combat this risk and avoid wrongful convictions, we need to accept the issues associated with DNA evidence and technology, and ensure we don't come to the point where DNA evidence is even more heavily relied upon.

Anderson's story is but one known case; a shocking example of the issues with DNA testing. In exposing the doubt that clouds DNA evidence, this growing body of research leads to the haunting questioning of past trials, convictions, and suspects. It also leaves us questioning our own movements. If we continue to place total confidence in DNA evidence, could a simple handshake or a touch of a public railing leave us all vulnerable to being victims of wrongful arrests by our own DNA?

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IS ORGANIC ALL IT'S CRACKED UP TO BE?

£2.45 billion on organic food and drink in 2019. [1] But what does organic actually mean? How are organic foods different from conventionally grown produce? Is it all just a huge capitalist trick to make environmentally conscious people pay more?

You walk into Lidl after a long day at university, along with all the other students. You're tired, yearning to get some cheap produce and booze using what's left of that student loan. You want to get some supposedly fresh vegetables to have that one vitamin-packed meal of your week. You realise today is your lucky day- the mushrooms are not yet out of stock! The Lidl gods are shining down upon you. As you come closer, it seems there are only two varieties of mushrooms left – normal chestnut ones for 69p or ORGANIC ones for 89p. You examine them closely. You scrutinise the price difference. You take note of the feel-good green packaging.

Sadly, they look identical, making your choice even more difficult. Finally, after careful consideration and dozens of other hungry students eyeing up the same mushrooms, you pick the organic ones. You feel like a good person – because organic foods are better for the environment, right? This is a view you share with all the other shoppers all over the UK that spent over

It is argued by some researchers that although organic farming generally has a positive impact on environment over a given area, 'it doesn't necessarily translate to being better for the environment per unit of eventual product'. [2] Take, for example, almond farming for plant-based milk. While it still produces significantly lower emissions than the dairy industry, it is common for a variety of pesticides to be used to maximise the yield, which affects populations of important pollinators like bees. Such is the case in California, where 80% of almonds are farmed. [3]

Surprisingly, there is in fact very little research suggesting that organic food has any real benefit to health or the environment, despite what we, as consumers, have been led to believe. So next time you think about reaching for those organic vegetables, take a moment to ask yourself, are they really as good as you think they are?

Interview with an Academic
Professor Neil Shubin

"When I look at my fellow humans, I see ghosts of animals past. Glimpses of an epic story that's hidden inside us all.."
-Your Inner Fish, Neil Shubin

Neil Shubin is a professor of evolutionary biology and anatomy at the University of Chicago, and a distinguished paleontologist whose primary research concerns the mechanisms behind the evolutionary origin of new anatomical features. Neil is best known for his co-discovery of Tiktaalik rosea, a revolutionary transitional fossil between aquatic and land animals.[1,3] He is also well-known for his science communication after starring in an award-winning PBS documentary series Your Inner Fish, and writing several books.[2] Neil's new book, Some Assembly Required: Decoding Four Billion Years of Life, from Ancient Fossils to DNA, has also just been released.[4] I sat down to talk to him about his life, and his incredible career.

So just to start off with, what got you interested in biology and fossils to begin with?

When I was a kid, I was always interested in science in general. Astronomy, geology, natural history and the natural world always engaged me growing up. When I went to graduate school I thought that I wanted to be a veterinarian, to take care of pets and stuff like that. But I quickly realized that I wanted to study the evolution of history of life, because two of my passions growing up were Egyptology and archaeology. I mean, I was a nerd. I was interested in all kinds of things. Paleontology, particularly through evolution and studying evolutionary history, really appealed to me because it meant understanding the diversity of life, which had always captured my imagination. Then, probably in my third year of college, I had a realisation and I had some pivotal experiences. I was in New York City as an undergraduate, and I volunteered at the American Museum of Natural History. I got invited on a dig, and I was like, I want to do that! So that's kind of how it all came together for me.

So it was when you were doing fieldwork?

Yeah, that kind of sealed the deal because what really appealed was the fact that you could go into the field and crack rocks, and find objects that change the way we think about our relationship to the rest of the world. I mean, that's pretty powerful stuff. I was terrible at it in the beginning. I was really, really bad! You would never have predicted that I'd be somebody leading expeditions to Antarctica or the Arctic. But I stuck with it.

And it seems to have worked out for you!

So far, so good.

So you made the documentary series Your Inner Fish. What do you think the importance of communicating science through media like books and documentary series and that kind of thing?

I love telling the stories of science. So we all talk about the fact that we are a storytelling species. Stories are the way we link facts, and engage people, and capture imaginations, and link facts to fantasy. I enjoy telling stories, always have. My father was a writer - he was a mystery writer, and so I grew up in that tradition of telling the stories of science, particularly not just that we made a discovery, but also how we made the discovery. Because once you open the lid on that, what you find is there are all kinds of human connections that you can draw where people worked really hard, and they got lucky. They figured things out. I mean, it's a constellation of different things.

About fifteen years ago I started to write the book, Your Inner Fish. The book began as a comparative anatomy textbook. I was thinking at one point while I was writing, "does the world need another comparative anatomy textbook?" I was thinking that there are a lot of good ones already - I could barely do better than the ones that were out there. So, I decided to do something much more general. Same theme, but folding in some molecular biology, some paleontology, things like that. Tell the same story, but from the perspective of the human body, because I figured that would be much more relatable. So that's how the title 'Your Inner Fish' was born.

Then I got the offer to host the three part mini-series for PBS here, and so along with the book it was like a dream come true. And then I realized that it's a whole different way of storytelling! You have access to computer graphics, so we could bring Tiktaalik alive. I could stand in the Arctic and have the world behind me changed into the Devonian landscape - but it also has limitations. TV is a different medium. It's a much more linear narrative in some ways. Different media, I think, complement each other in a big way. They have different strengths, and it's all about connecting with people.

Could you briefly explain for us why finding Tiktaalik was so significant?

It's a visual example of the transition between the water and land, and it's beautiful in that way, but at the end of the day it's about the discovery story. It's using the tools of stratigraphy, using the tools of comparative anatomy to make a prediction, and then sticking to that prediction for six years.

Did you realize it was special as soon as you saw it or did it take you a little bit time to realize what it was?

It's a visual example of the transition between the water and land, and it's beautiful in that way, but at the end of the day it's about the discovery story.

Oh no, the second I saw it I knew. That was in the field July 17th, 2004. I remember the day, we were all lined up, and my colleague pulled up a rock, and then we found it.

What are some of the difficulties of making scientific information accessible to a wide audience?

At first I was writing the book for an educated layperson, and the model I had in my head as I was writing or actually as I was talking to the camera on TV, was that I was talking to my dad because he was completely flustered by science. Anything jargony-science, like the three letters DNA, and he would freak out! So as I was telling these stories I was imagining that dad was on the other end. And if he understood it I knew I was doing well; if he was engaged by it. So when you do that sort of thing, you realize that a lot of the jargon we use- it's very precise, but it can get in the way.

And so how do you write jargon free?

It's hard. It's really challenging because we use jargon for a reason, so you have to break out of the jargon.

Well, you don't realize what words people know, what words people don't know, because who doesn't know what DNA is when you're a master's student.

Right. Your Inner Fish is all about homology - but I never said that word in the entire book. It's about phylogenetic homology, and every chapter is a different kind, but I never use the H word. When we write as scientists, and when scientists first begin their attempts at scientific communication, invariably they'll begin with "well, we look at corresponding structures and different creatures and we call that homology." We always define our terms, and that's the best thing you do when you're writing a paper. In fact, when my students start to do scientific communication, they always reflexively go back to that because it's comforting. It's what they've been trained to do, so they have to break away from that.

Getting away from jargon means using powerful analogies. Good scientific communicators find great analogies, using the power of stories to show and don't tell. Don't tell people anything, show it all. For instance, with Your Inner Fish, my temptation was to go after creationism and intelligent design because it was a big deal back in 2005 when I was writing the book. But I never did, I just did it by example, and my favorite example of that is when I brought Tiktaalik into my kid's school, and the kids couldn't agree on whether it was a fish or a crocodile. I always like to use that. Examples are really important. Part of the challenge is that as scientists, we love the details. It's the details that motivate us. But it's the details often that you have to be judicious with, in that you have to figure out which details are essential to the story. That's the hardest part, honestly, because you want to capture the science and its true complexity. You want to dumb it down, but you want to generalize. So how do you do that? That's the challenging part.

Do you think that we need to change the way that we're teaching science?

Oh, I think absolutely. I think we are changing it. Honestly, I think digital technology is flipping classrooms. In my class, I'll give links to lectures for students to watch before I get there, so that we can have more discussion and more flexible things in the class.
People always ask, "what were the most important courses that you took in college?" They expect me to say something like biology, evolution, geology, paleontology. Actually, it was a Russian literature class, and the reason was that we had to write, and write, and write. We were writing about some great literature, and I was thinking about big themes, and so I had to distill them down. It was just a really foundational experience for me, that. We talk about STEM, but I think we need the humanities in that as well in a very big way. We just can't all be number crunchers if we want to tell the stories.

What role do you think that social media has in science communication. You think that it's a good thing or can it be a bad thing?

I struggle with social media. I think it's a great thing, right? It can be a wonderful thing - you can connect with people directly. So from a personal level, I think it's very powerful. And I love posting, but I kind of restrain myself for concentration's sake. I don't want to be too addicted to social media. I think younger people have an easier relationship with it. You can tell stories, you can build an audience, and I think it's just such an effective way for students to really exercise their science communication muscles, and I encourage my students to do that.

You have a wonderful new book coming out. Congratulations! Could you give us a brief description of what it's about?

How did the diversity of life come about? What are the genetic, developmental, and evolutionary mechanisms that gave rise to the great transitions in the history of life? How did fish start to walk, how did birds evolve to fly, how did cells get together to make bodies? How did the great transitions happen and how do we know about them? That's what the book is about. So, it's called Some Assembly Required. I go through a lot of stories and how it starts with some debates that Darwin had that had been lost to time and then go through embryology, genetics, evolutionary developmental biology, that sort of thing. This was just my chance to really

explore some themes that I couldn't do with Your Inner Fish.

What do you think the next stage in human evolution is going to be?

If you and I were to take a time machine like a million years into the future, even just ten thousand years, you know what would be driving the differences we'd see? People. A lot of it will be driven by our ideas, our technologies, our devices, our cultural practices or socioeconomic structures, how people access technologies. So if you think about that in terms of all aspects of human performance, intelligence, cognition, how fast we run, how long we will live, how susceptible we are to disease and things like that, a lot of things that are going to make a big difference are our devices, our innovations, our inventions, and the ways we transmit them to one another. It's kind of like we're largely in control of our own future. Yeah, Darwinian evolution happens with regards to our relationship with microbes and physiological things, and certainly some anatomic ones as well, but the operative environment is the one where culture and technology are really sort of at interplay.

If you were shipwrecked on a desert island and all of your human needs were taken care of, so your food and water and everything, what two items would you take with you and why?

Well, books, I'd say. I might take Darwin, the sixth edition of the Origin of Species because it's just so elegant. That would be a good one. I'd need pizza, though. Everybody who knows me knows there has to be pizza. I would also probably listen to a lot of jazz. Miles Davis.

I'd need pizza, though. Everybody who knows me knows there has to be pizza.

If you had to be transformed into an animal for a day, what would you be and why?

I'd be an eagle. Soaring high, looking down, loving life. They can't catch me and they wouldn't want to.

Would you still eat pizza as an eagle?

Well, definitely, I'd hover over the pizza parlor.

And swoop down and take it from people?

Exactly!

What upcoming developments in the field of evolutionary biology are you really excited for?

Oh, I love the way that we're able to really look at the genome in incredible detail. I mean, every day we're getting new genomes. And more than that, we're seeing how the genome is so utterly dynamic. We've seen how it opens and closes and twists and turns, turning genes on and off. We're seeing that at such an incredible level that really will impact how we think about evolution. That's why I spent a lot of time on that stuff in Some Assembly Required. That also gives a special role for paleontology and comparative anatomy, because those datasets are still highly important. No other dataset can really show the ancient world as well as paleontology, so these discoveries in molecular biology really sort of go together. I'm excited by that link, to be quite honest.

Something that I see an awful lot on my social media are Neil Shubin and Tiktaalik memes. How do you feel about it?

I don't honestly see all of that stuff, so I don't really know. I like it when I see it. I love Tiktaalik. The fact that Tiktaalik is in popular culture in a big way, I could never have foreseen that. There are other fossils that are really good like Tiktaalik. It's a story I love to tell, so I love seeing this stuff. I love seeing teachers and students excited by it: it really makes me happy when I go give public lectures, and I'll bring the cast with me. And it's just amazing to see people interact with

Well, definitely, I'd hover over the pizza parlor.

it, so that brings me endless joy. You have to remember, I spent years of my life freezing in the Arctic, so there's a level of reward there because I worked really hard. After going through all that, I definitely enjoy it.

If you had the opportunity to start again and pick a career completely different from this one, what would it be and why?

I don't know, that's a good question. I don't know really. I might have been an archaeologist. Oh yeah, I'd like to be an astronaut. I grew up during the Apollo program, when we walked on the moon, and every July, on the anniversary of Apollo 11, I get weak at the knees.

Maybe an archaeologist on Mars?

Yeah, that's how we can find life, right?

What's been the biggest change in academia, and in the science community since you first started your career?

Oh, the importance of scientific communication. Science communication is now respected, not derided. The National Academy of Sciences never elected Carl Sagan. He was up. He was on the list, but they squashed him in the 1980s. You couldn't imagine. Now, they have an award for scientific communication! I've never really suffered any criticism from colleagues for spending a significant amount of my time on scientific communication. I think they appreciate it, so that has been a big change in how we teach, how we learn, how we value and evaluate people.

What advice do you have for students going into paleontology and academia?

It's all about your passion, because the passion and commitment will get you through. You're not going to succeed at first. See yourself in the future, and stick to it. If you find yourself losing that passion, you need to tweak things a little bit, you know? Also don't be afraid to fail at first, because the story of my life is failing at first.

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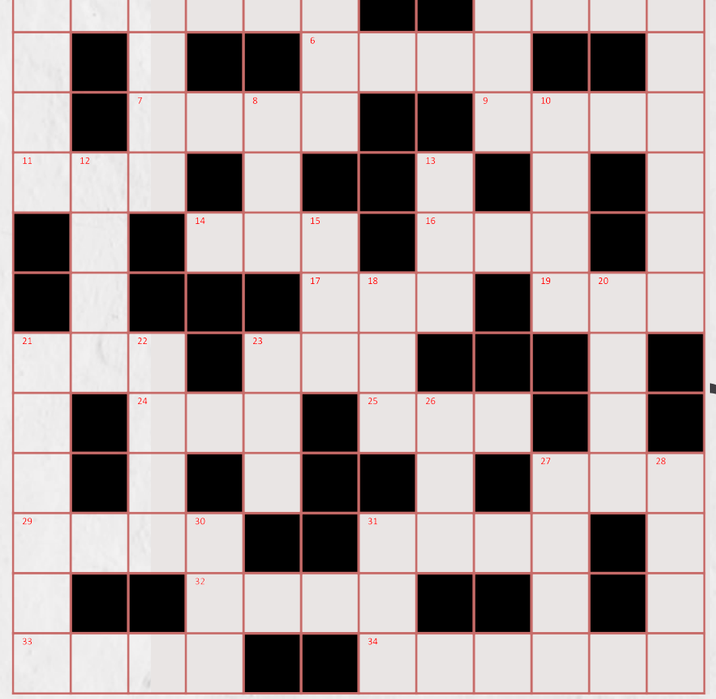
PLANET BEE
CROSSNUMBER



Artwork:
Ella Ward
Digital Illustration

BONUS CLUE: The number of times each digit appears in the grid is as follows: 0 – 20 times; 1 – 16 times; 2 – 12 times; 3 – 6 times; 4 – 8 times; 5 – 8 times; 6 – 11 times; 7 – 4 times; 8 – 7 times; 9 – 4 times

Across

1. The reverse of the most common password in 2019
4. The year the Human Genome Project was completed
6. The first 4 digits in Planck's constant, in joule-seconds
7. The first 4 digits of the golden ratio
9. The number of legs an insect has, times by the number of degrees in a circle
11. U-???, the most common fissile isotope of uranium
14. The typical number of bones in an adulhuman body
16. Error ???: Page Not Found
17. The number of chemical elements currently discovered or synthesised
19. Ten times the sum of the first five triangular numbers
21. The number of types (or flavours) of quark, cubed
23. The global average atmospheric carbon dioxide concentration in 2018, in ppm
24. The only three-digit perfect number
25. 2 to the power of the number of planet in the Solar system
27. The smallest 3-digit prime number
29. The latitude of the geographical North pole, squared
31. The international year of the periodic table
32. A number which is both prime and in the Fibonacci sequence, cubed
33. The number of hours in a non-leap year
34. The first 6 digits of pi

Down

1. The first 4 digits of Avogadro's constant
2. The number with prime factors 3, 5, 7, 43
3. The total number of spots on a double-six (standard) set of dominoes
4. The frequency, in Hz, of middle C on a piano (to the nearest whole number)
5. The speed of light in km/s, to 3 significant figures
8. The molar mass of glucose, C6H12O6
10. The year of publication of Copernicus' De Revolutionibus Orbium Coelestium and Vesalius' De Humani Corporis Fabrica
12. The twin prime of 61, squared
13. The atomic number of copper, multiplied by that of magnesium
15. The 15th Fibonacci number, counting the first two numbers as 1, 1
18. CD minus CCXXVIII
20. The number of sides of a heptagon, factorial
21. The first 6 digits of e, the base of the natural logarithm
22. The radius of the Earth, in km, to 2 significant figures
23. 10 times the number of chromosomes most humans have
26. The Dewey Decimal class for science
27. The year Marie Curie won the Nobel prize in Chemistry
28. Darwin's The Origin of Species was published in this year
30. The dialling code for London
31. The temperature at which water freezes, in degrees Kelvin

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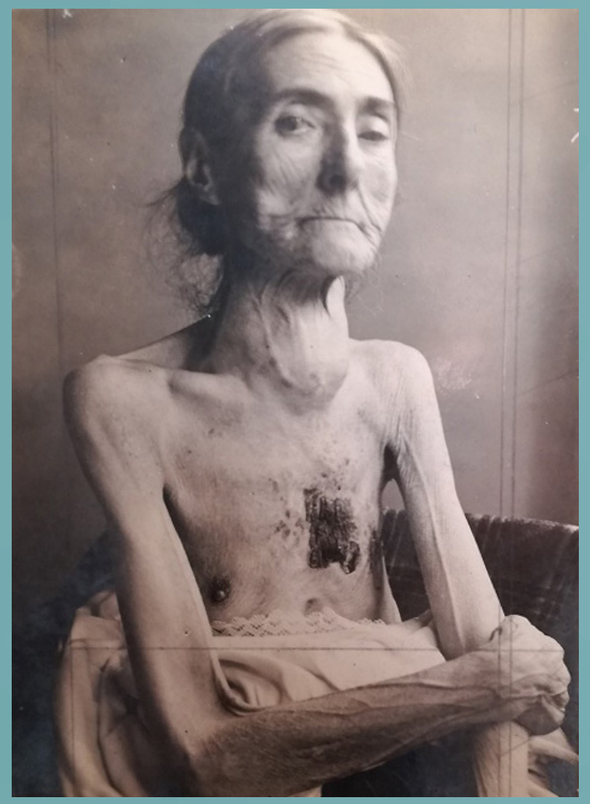
More than Medical:
Insights Into Clinical Photographs



She stares at you, out of the corner of her eye, as if she knows you are looking at her, watching her. You pause, frozen in place as you feel yourself captured by her gaze. Yet, despite this experience, you know this feeling is a fiction. The look directed your way was produced almost a hundred years ago, when it was aimed into the lens of a camera in the photographic studio of a teaching hospital.

This photograph is one of many made during the first decades of the 20th century that served to capture conspicuous symptoms of disease for clinical teaching, research, and publication purposes. But, like so many others, this image reveals more than mere medically relevant content – it offers a glimpse into the moment it was taken, into the experience of illness, into its material making, and into the medical economy of which it and its fellows formed a part.

To address some of these elements, I would like to start at the beginning of my journey with this photograph: when I first saw it online, in digital form, in an open access database of historical editions of the South African Medical Journal. She appeared in 1948, among others in a series of articles written by Prof Charles 'Charlie' Saint, the first head of surgery at Cape Town's medical school. Saint had moved to South Africa in 1920 after completing his surgical training at Durham University and early work experience in Newcastle-on-Tyne. His series of articles, titled 'A Clinical Atlas: Swellings of the Neck', were written during his retirement, after an impressive quarter-decade serving as surgical head at the University of Cape Town.

What first drew my attention to Saint's articles was the unusually large number of photographs used to illustrate not one disease (as is typical) but rather multiple conditions that can all cause similar symptoms: in this case, swelling in the neck area. In a nutshell, the articles use the combination of patient photographs with case histories to create a guide for differential diagnosis (the act of distinguishing between medical conditions that share similar signs) as made famous by TV shows like House. Nestled among other badly reproduced images, she is labelled 'Fig. 21'. Her 'case' is described in the text as "interesting" due to the "most unusual site for secondary breast glands" in the neck. But, for me, she is 'interesting' for very different reasons.

Unlike its surrounding counterparts, her image is not only the largest but the most like a portrait: a dramatically lit shot in which she sits at an angle, poised, shoulders down, looking directly out at the viewer. She is the oldest, frailest, and most exposed of the individuals featured in these published photographs, but she also appears the most dignified and self-aware, with her tightly clenched mouth and her sideways glance. A hint of textile is visible at the bottom-most edge of the image, offering a visual cue of decorative lace; it is feminine and personal – not the kind of fabric usually found in a state hospital.

But without a name, location, or date, her portrait remains without any clear backstory. Frozen between other clinical descriptions, she remains an anonymous example of 'Atrophic scirrhous carcinoma of the breast' – a hard and slow-growing form of breast cancer historically associated with old age. This description is typical of the medical jargon that so often revolves around the viewpoint of the clinician instead of those seeking clinical care. Indeed, the language of cancer as a whole is evidence of this.

Originating from the Greek 'karkinos' (translating to 'crab'), the word 'carcinoma' was used in some form since the ancient physician Hippocrates (460-370 BC) – the namesake of the Hippocratic Oath of 'do no harm' – to describe what was seen during surgery: a tumour (a crab-like body), surrounded by bloated blood vessels (resembling crab-like legs). Despite the common patient-experience of cancer as a burden or weight, it is the image of the crab that has stuck because it articulates what physicians, rather than patients, see and feel. Little is provided within this medical jargon to speak to the sense of dread that the very word 'cancer' instils.

In the journal's text, the diagnostic description of Fig. 21 is medically matter-of-fact: atrophic (wasting away) scirrhous (slow-growing) carcinoma (cancer). This is what the clinicians need to know, and so this is what prevails. But it is also distancing, alienating – turning the embodied and emotional experience of the patient into something abstract and detached from their person.

Medical photographs aim to aid this translation of disease into a clinically decipherable 'case': they direct a viewer's attention not to the patient, but to the disease. Rather than a portrait of a person, the clinical camera produces a portrait of pathology, one that highlights the diagnosable features of the illness rather than the characteristics of the individual. But this is not the be-all and end-all of such images.

Years after having found her in digitised journal form, this particular patient in this particular photograph re-materialised in a hospital archive. She remains nameless, one card among many in a box filled with so much abandoned documentation. Yet I recognise her immediately – that stare, that upright pose. Only here, in this photographic print, I am given much more detail than I was in her cheap, black and white published reproduction.

Here, in the archive, her appearance is crisp, details heightened by the glossy surface of the photographic paper on which her image appears, trapped in a light-sensitive emulsion. Her skin seems thinner – like tissue paper – the fine wrinkles more visible. Shadows are subtler, making it easy to see that her hair is tied into a low, wispy bun. Even the area of clinical interest – the necrotic opening in her chest – demonstrates a shift in texture, as healthy tissue becomes a pathological wound.

Context elided in the journal also comes to light: she is seated on a chair over which a tweed-patterned blanket hangs. And the hint of lace belongs to an item of clothing (perhaps a blouse?) that has been pulled down below her breasts to reveal the symptomatic site. The sense that she has been undressed rather than covered by a protective sheet becomes clear in this moment. She unveiled herself before the camera, half clothed, arms uncovered, her right hand cradling her left as if engaging in a self-comforting gesture. All of this screams exposure – her disease, her naked body, her face are on display for the greater good of medical education.

Even so, the photograph reveals that decisions were made to exclude elements for publication: pencil marks direct how this original was to be cropped – a trace of what this image went through to end up in Saint's article. So why were some details necessary? Was it ever important to include her face, or even the entirety of her chest, when only the left side of her upper body bears the signs of her diagnosis?

Often context is needed to help medically minded viewers get a sense of where a symptom is situated and how large the affected area might be. Both require reference-points granted by recognisable areas of the body (like the unaffected breast) or coordinating points (head above, arms on either side). Yet the inclusion of the face – the custodian of identity – appears wholly unnecessary. What, namely, can a clinician learn by looking into her eyes, when the point of medical concern resides in her breast (the primary cancerous lesion) and in her neck (secondary gland involvement)?

Medical archives reveal the tentative relationship clinicians have with their patients' faces. In the photographic studio, in the darkroom, or even after printing it can be decided to censor identifying markers. Sometimes the entire face is covered, other times only the eyes are blacked out; suggesting the old adage that these offer a 'window to the soul'. Protecting such clinically irrelevant areas is thus a commonsense means to safeguard the privacy of those otherwise exposed. So why has this patient, this photograph not been treated in this way?

Removing identifying features (while done with the best intentions) has a tendency to dehumanise those depicted; it removes the aspects of the face that we unconsciously look to in an effort to connect. The intention of clinical photography is to render the human a static object of scrutiny, a specimen to be deciphered. Without the eyes and the potential for (even imagined) eye-contact, this objectification is complete, and the patient is rendered little more than symptomatic flesh, a body rather than a person.

But in the 1948 journal, in the hospital archive, and even here, in this popular publication, she emerges as a 'someone' rather than a 'something'. Since the 19th century it was perceived that maintaining the potential for empathy and thus the overall morality of medical personnel was paramount. Yet, while it is unclear whether such thinking was the historical motivation for her past uncensored publishing, it certainly has contributed to her open presentation here, today.

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Is Gender-Based DISCRIMINATION All In Your Head?

Just how different are men and women's brains? It is a scientist's job to determine the physical basis of the world they observe. However, problems arise when we infer with certainty that stereotypes we observe must have strictly biological origins. We end up downplaying the role of society, and overstating the role of biology (or brain structure and function).

In The Descent of Man, Darwin wrote that the 'chief distinction in the intellectual powers of the two sexes is shown by man attaining to a higher eminence in whatever he takes up, than woman can attain'.[1] Fast-forward 200 years to 1981, when the president of Harvard University argued that there are fewer eminent women in STEM because men outperform women at a ratio of 13:1 on the maths section of the SAT. Women's academic performance and subsequent place in society have long been used as evidence for biological and physical 'differences' in male and female brains, but this ignores the impact of society discouraging women from pursuing STEM subjects. In fact, after introducing programs to encourage female enrolment, the ratio dropped to 3:1.

Neuroscience research has shown that our brains change as we learn and develop (neuroplasticity), and that the environment we grow up in affects how we learn and think: men and women have different experiences of the same environment. One study compared the in-class test results of Israeli primary school with their standard end of year exam results, and found that teachers regularly overmarked boys and undermarked girls.[2] In reality, boys and girls have similar performance in maths and girls achieve better scores in countries with lower inequality.[3,4] Stereotypes continue into adulthood. Another study had 127 scientists assess identical job applications - half of the names were male, half female - and both male and female scientists rated 'male' resumes higher.[5]

Ignoring the impact of society has led scientists down a treacherous path, searching for evidence of these stereotypes. At the end of the 19th century, neurologist Paul Broca discovered that a speech deficit was caused by damage to a particular area of the brain (now called Broca's area). This discovery linked intelligence to the structures of the brain itself. At that time, men were seen as more intelligent than women, so (without access to scans or experimental proof), it was assumed that physical differences in brain size and structure caused female inferiority, and so began a series of myths and misconceptions about the male and female brain.

MYTH 1: SIZE MATTERS

Broca himself stated that 'the relatively small size of the female brain depends in part upon her physical inferiority and in part upon her intellectual inferiority'. Whilst it is true that men's brains are on average 10% bigger than women's, it's also true to say that men's kidneys are 10% bigger, that their hearts are 10% bigger, or even that they themselves are 10% bigger. All of men's organs are bigger on average but that doesn't mean they work more efficiently. If you compare brain size in reference to total body size, the differences between male and female brains become negligible.

MYTH 2: STRUCTURES AND REGIONS IN THE BRAIN ARE BIGGER IN MEN

Brain scanning techniques like CT and MRI scans have allowed scientists to measure the sizes of specific structures in the brain. Over time the number of scans has increased and researchers can compare the results of more than one study (they call this meta-analysis). One meta-analysis compared the results of studies on the male and female hippocampus (a brain region important for memory). They found that in studies where they had not corrected for total brain volume, male hippocampus was about 0.4cm3 larger than female (4,418 scans). However, this sex difference was again eliminated in studies that corrected for overall brain size (2,183 scans), concluding that male and female hippocampus structures do not show significant sex differences.[6] So why do scientists keep finding structural sex-differences in these regions? Lise Eliot, author of Pink Brain, Blue Brain writes that there is a pressure among scientists to report results showing differences and that this leads to non-significant results not being reported.[7]

MYTH 3: BRAIN DIFFERENCES ARE EVIDENCE OF THIS STEREOTYPE

One meta-analysis of 913 brain scans found that women had more connections between the two halves of the brain than men.[8] The author writes: "men's lower brain connectivity may reflect optimisation of functions (e.g. spatial orienting), whilst women are integrating large networks like those to support language". However, neither individual language nor spatial orienting ability was measured. The authors interpreted the data with an unproven stereotype.

MYTH 4: THERE ARE MALE AND FEMALE WAYS OF THINKING, WE USE DIFFERENT AREAS OF THE BRAIN

You may have heard someone say 'I'm more of a right-brain thinker than a left' -the left brain being synonymous with 'male' characteristics (logic, analysis) and the right brain taking on more 'female' tasks (emotions, imagination, art). This has now been debunked by modern brain imaging techniques, which have shown that to perform more complicated tasks like solving a maths equation, both hemispheres are activated - not just the left side. Furthermore, there is a tendency towards describing women as 'emotional thinkers'. Observations of women expressing their emotions or crying (and men not) has been taken as evidence that they are 'emotional thinkers'. This ignores the possible influence of society. Society allows women to express their emotions, whilst being a cry-baby or a scaredy-cat is punished in boys, and there is a historic bias against women who don't show emotions (frigid mothers, or women in high-ranking corporate jobs considered ruthless).

MYTH 5: HORMONES MAKE OUR BRAINS DIFFERENT

Female emotions are often blamed on hormones. Given that men seem comparatively less emotional, it follows that testosterone be linked to less emotional, male logical thought. Male foetuses are exposed to a surge of testosterone in the womb, which influences how their brain develops. Throughout life men are then pumped full of testosterone, and this has been used to explain why men are more aggressive, assertive, and logical. Eliot argues that the role of testosterone has been overstated; that this idea that testosterone being linked to aggression is somehow a universal explanation of male behaviour, and that both men and women can be competitive or aggressive, but males and females might have different ways of expressing those traits based on social norms.[7]

So where do we stand? The modern view: a mosaic

Male and female brains are more similar than they are different.[9] In another meta-analysis study of 1400 brain scans across a wide age range, researchers found that whilst 29 regions did show sex differences, when they began to compare individuals, they found that only very few (0-8%) people had all of the 'male' or all of the 'female' features.[10] They found that most people had a mixture of 'male' and 'female' features – they were on a spectrum. This means that if you take an average over a large number of brains, you will find differences between men and women. However, if you look at individual brains, there is a spectrum or mosaic of male and female brain characteristics and the same can be said for behaviours.[10,11] No one characteristic is purely male or female, a range of characteristics can be seen in any individual brain. Although it is useful to patriarchal power-structures to say that gender-based descrimination is all in your head, neuroscience has something else to say on the issue.

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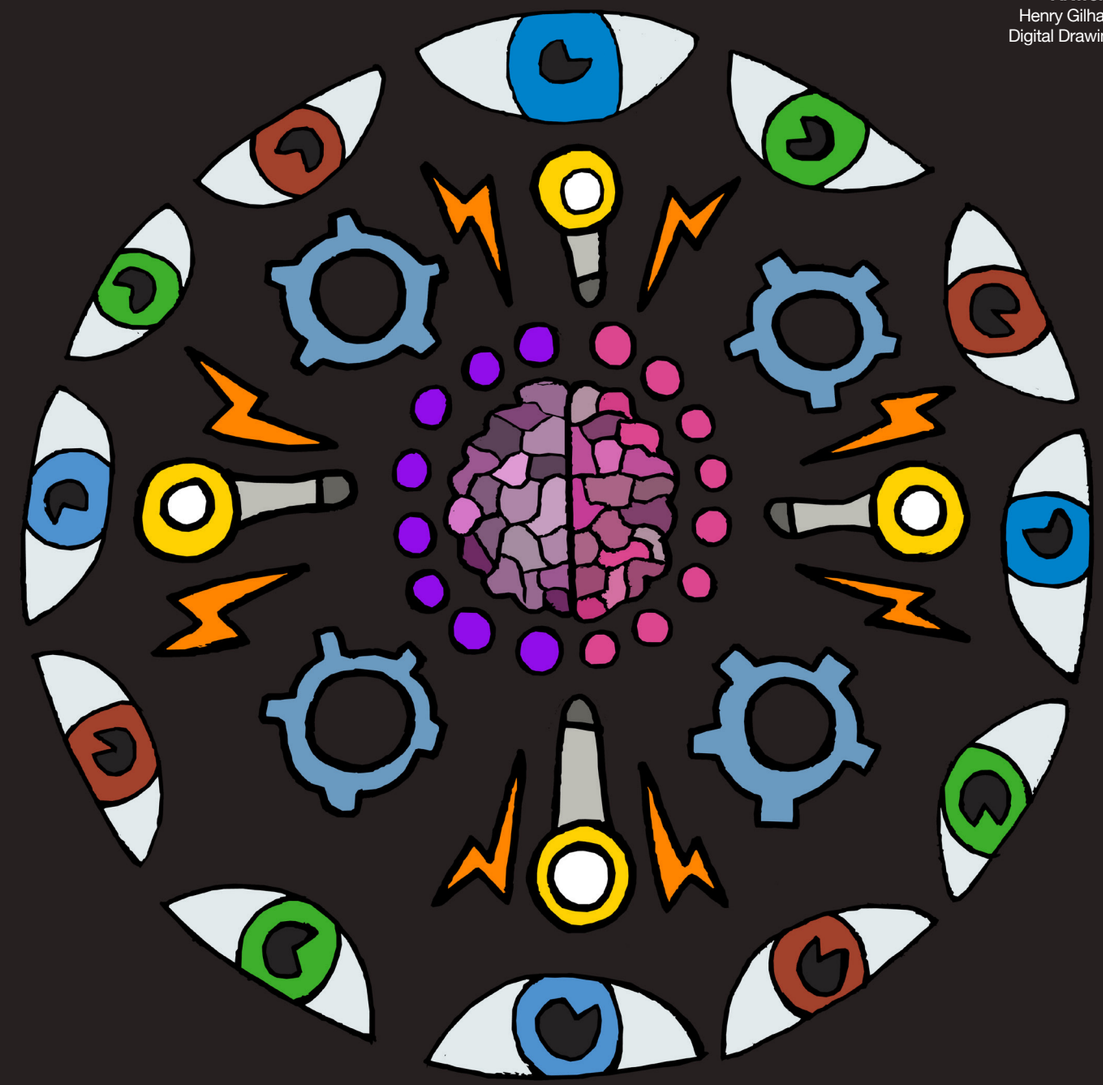

VACCINES:

a magic bullet or firing a blank into the frontline of disease?

Vaccines - we've all had them (I hope). They're described as dead or weakened versions of disease-causing microbes which train our immune systems to fight the disease if we encounter it for real.[1] The earliest well-known vaccine was against smallpox, created by Edward Jenner in his now infamous experiment on his gardener's son. Jenner infected the 8-year-old with the relatively benign cow pox in the hope it would give the boy resistance to the similar but far more deadly disease, smallpox.[2] Luckily for Jenner (and the boy), this worked and paved the way for many successful vaccines against deadly diseases, undoubtedly saving millions of lives worldwide.[3] However, I'm about to let you in on a little secret: we need to stop relying on vaccines.

One of the biggest failures of modern medicine is how we deal with new diseases. Emerging infectious diseases are defined as those which have appeared recently and increased in prevalence rapidly.[4] Examples which you might be familiar with include Ebola zaire, which caused the infamous outbreak in 2014, and of course SARS-CoV-2 (aka coronavirus).[5,6] The initial global responses to these diseases failed, allowing them to spread worldwide very quickly. As soon as it was realised these diseases posed a threat to many countries, vaccine development began, but this was already too little too late to stop their spread.

The process of developing a vaccine is long and complex and can take years of testing. During this time, an emerging disease can have already spread across countries, infecting and killing vast numbers of people.[7] The 2014 Ebola outbreak put immense pressure on scientists to develop a vaccine, but 6 years down the line there are still no formally licensed vaccines against Ebola.[8] The current COVID-19 outbreak has already spread worldwide and killed thousands, yet a vaccine isn't expected until at least March 2021.[9] Vaccine development is slow, costly and comes too late to stem the flow of these diseases. Yes, vaccines do incredible work to protect our population, but initial responses to stop the disease taking hold should be prioritised.

The first step in dealing with an emerging disease is recognising it in the first place. Many hotspots for these diseases to appear are rural areas in developing countries where there are few, if any, medical facilities to detect new diseases.[7] Naturally occurring epidemics do not always happen suddenly; Ebola was seen in Sierra Leone 10 years before the 2014 epidemic.[10] Investment into medical outreach centres to identify new cases of diseases are essential to fighting the disease before it gets a grip of the local community.

After recognising a new disease, the initial response is critical. Quarantining patients and tracing their contacts is essential to limiting the spread of disease, yet the facilities to do this are simply not available in many 'at risk' locations. It has been shown that basic health education and access to hygiene products can vastly reduce the spread of new diseases, and understanding the culture and environments of these locations is essential when training local people on how to respond.[10] These early responses are needed to slow the spread of disease and actually allow more time to develop a vaccine.

Vaccines have undoubtedly saved hundreds of thousands of lives across the globe, but the real answer to epidemics like Ebola and COVID-19 does not and should not rely solely on vaccines. Tackling a disease in its infancy in developing countries is far more effective than trying to battle it once it has reached a global scale, however there is a huge lack of funding to protect the people in poverty who are often hit by these diseases first. Too often a disease is only paid attention to when it spreads to developed countries, when basic aid to those living in poverty where these diseases first strike would have enormous benefits for everyone. We need to care before these diseases reach the rich, not after. Despite his amazing discovery and its astounding implications, we cannot be like Edward Jenner and put the lives of the less fortunate at risk in order to save ourselves; we must protect the vulnerable in order to protect all of us. Diseases are borderless, and investing in the people living on the frontline of disease is the best and only way we will be able to protect everyone from emerging diseases.

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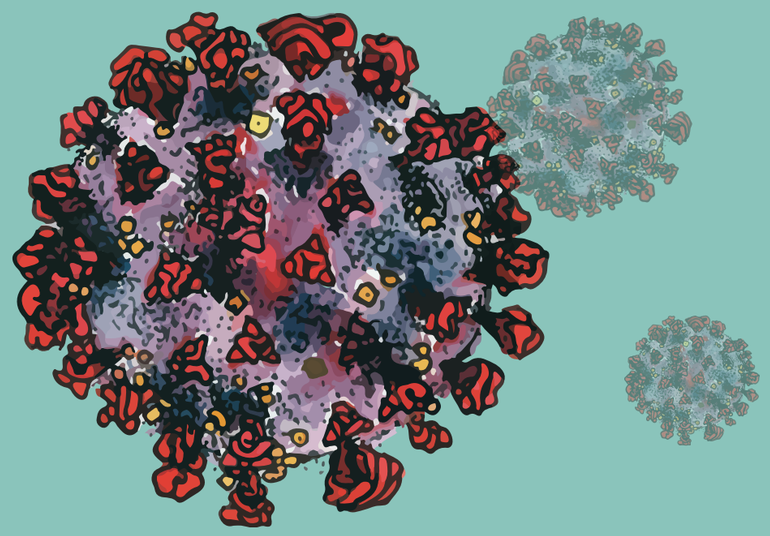

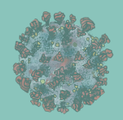

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Mary Beatrice Davidson Kenner

'Every person is born with a creative mind. Everyone has that ability.'
Mary Beatruce Davidson Kenner [4]

Imagine coming up with an amazing invention that affects the lives of most people around the world. Now imagine not being able to share this idea with the world because of the colour of your skin. Mary Beatrice Davidson Kenner was born on the 17th of May 1912 in North Carolina, USA. Raised in a family of inventors, she was encouraged to try new ideas in order to improve her everyday life. She was an inventor by nature who filed five patents in her lifetime - more patents than any other African-American woman in history.[1]

Her most recognised invention, developed in the 1920s, was also her first patented product: a sanitary belt with a moisture proof napkin pocket. A sanitary belt is a device made to be worn around the hips, with a hook in the front and in the back of the belt where a pad can be attached to secure it in place. This invention was a lot more practical and liberating compared to what was available at the time. The only other option was to use a cloth or a rag but this was unsanitary, impractical as they moved around a lot, and inconvenient as it required women to stay indoors during menstruation. This meant their monthly cycle prevented women from carrying out their day to day activities. Even though tampons were available, the use of them was considered indecent at the time, so women were discouraged from using them.[2]

The sanitary belt was such a revolutionary invention that a company approached her to use her idea. However, when they found out that she was an African-American woman, they decided not to fund her invention.[3] In America, due to the discrimination in 1920s against African-Americans, her invention wasn't adopted and women around the globe were robbed of a life changing product. Fortunately, there is sunshine after the storm. By opening her own business as a florist in 1956, she was able to fund her own patents. Thirty years later, in the 1960s, Kenner's sanitary belt finally became a reality, and maxi pads based on her initial idea became more readily available.[3]

There are a lot of period product options available to us now in 2020; however, using a pad is one of the easiest options. A lot of people use pads instead of tampons due to the lower risk of acquiring infections or toxic shock syndrome from them. Kenner's driving force for her inventions was simply to improve the quality of life of others and herself- she never sought money. Thanks to Kenner, developing the sanitary pad has helped millions of people around the world.

Altogether, Kenner patented five household and personal items, some of which were inspired by her sister, who suffered from multiple sclerosis. She improved the bathroom tissue holder, allowing the loose end of the roll to be accessible at all times. This is the toilet roll holder that we all use on a daily basis today.[4] She also invented a back washer mounted on the shower or bathtub wall, the carrier attachment for a walker, a portable ashtray, a sponge at the top of an umbrella (so that water is soaked by the sponge), among many other inventions.[3]

In the 1920s, Kenner's passion for improving the everyday lives of the people around her fuelled her in overcoming the obstacles she faced as a woman of colour, with little financial support. She played a hugely pivotal role in our day to day lives, and yet many people have no idea who she was. At the very least, Kenner is an unsung hero who made a trip to the bathroom in 2020 as pleasant as possible. Period.

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