

the Oxford Scientist

Oxford University's independent, student-produced science magazine

POWER

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Editor's Letter

Dearest readers,

This term, the world marked David Attenborough's hundredth birthday — a century of a man who has, by most reckonings, done more than anyone alive to make people fall in love with the natural world. I find that a useful example of how power can be used for good. We tend to picture it as something imposed, but Attenborough's is the gentler, more durable kind — the power to make millions care, to turn indifference into curiosity and action. That, in many ways, is what this magazine aims to do, and it felt a fitting note on which to open an issue themed Power.

Power is one of those words that fractures the moment you look at it closely. It is force and energy; it is influence and authority; it decides whose questions get asked and whose answers get heard. So where does Science stand in this complicated network? Often it is imagined to be outside all of this, a neutral, objective appraisal of the world. But science is done by people, funded by institutions, and shaped by the politics of its moment.

You will find that tension running through this issue. We examine how research has been politicised across history and conscripted into war and conflict; the gaps in menopause care, where who is studied and who is left waiting is a question of power as much as biology; and the patriarchal assumptions buried in our ecological theories that queer ecology is now prying loose. Power lives in nature too: in the molecular arms race between

viruses and the immune system, in the conservation potential of animal culture we too often overlook through our own bias, and in the bioelectricity humming through living tissue. It runs through the abstract as well: in global dependencies for clean energy, in the strange leverage of quantum computers, in the power laws that describe life more honestly than any bell curve, and even in the number zero, an absence that became one of our most powerful ideas.

The role of a science magazine, I think, is not only to marvel at power in all these forms, but to ask ourselves: who wields it, who is shaped by it, and what does it cost us to leave it unchallenged?

While I am given the privilege to write to you, our reader, directly, this edition would not exist without the team behind it. I am deeply grateful to the senior editors, who give so much on top of already demanding degrees. Thank you to the writers who, every term, surprise us with their creative interpretations of our themes, and to the subeditors whose behind the scenes work is absolutely fundamental. My most heartfelt thanks go to the Print and Creative teams who assembled the beautiful magazine you now hold. A special thank you to Adele, for her indispensable support in the running of the magazine this term.

So, without further ado, look closely at the things that move the world and never stop asking who set them moving.

Happy reading,

Iulia Kis

Editor-in-Chief, TT26

The power they hold



Anastasia Prokhorov



Power is held by a few. We've known this for centuries, yet the past few decades have reshaped what power looks like. Historically, governments played an integral role in crafting public trust in scientific innovation. Now, this opinion is built from the actions of major organisations, including Big Pharma and Big Tech. However, their guise of operating for the public good is beginning to fray as we realise the dangerous shift that has been undertaken, prioritising lucrative financial investments over true innovation.

Big pharma wasn't always bad. However, in the last 30 years their mission has shifted from long-term investments in research and development (R&D) to short-term, strategic "ever-greening". This means companies now make modifications to their drugs that are major enough to be considered "inventive" to extend their dominating patents but minor enough to be functionally identical.

When a company has monopoly over a drug, they control everything about it. Without any competition, innovation is stifled because resources are focused

on renewing patents rather than improving healthcare. Consequently, 57% of new medications offer no additional therapeutic value, yet their prices are higher than their predecessors. To avoid 100% US tariffs on imported, branded medications, Big Pharma attempted to raise drug prices in other markets instead of lowering them in the US. In the UK, the NHS, which is the single purchaser and prescriber of all medication, was pushed to agree to price increases of up to 25% by 2035. This succeeded because the UK needs Big Pharma investments. Hence, when AstraZeneca threatened to leave the London Stock Exchange and MSD proposed cancelling a £1bn London research centre, the UK fell to its knees. As a result, more NHS money will be spent on purchasing already expensive patent-protected drugs instead of implementing systemic change.

Patents further prevent the development of much cheaper generic medications. The brunt of this is felt in developing countries. While effective tuberculosis (TB) treatment has existed for over 80 years, over one million people still die from it annually. One reason for this is the lack of incentives for companies

to target “poorer” markets who cannot afford their drugs. However, a global trend is emerging where governments are increasingly stringent on renewing pharmaceutical patents. In 2023, the Indian Patent Office rejected Johnson & Johnson’s (J&J) attempts to renew their patent on the TB drug bedaquiline, allowing generic manufacturers to produce much cheaper versions of the same drug.

While cheaper drugs may be legally produced, the resources to do so are not always available. The outbreak of Israel/US-Iran war and American tariffs resulted in skyrocketing oil prices. India, who supplies 20% of the generic pharmaceutical market, now struggles to import active ingredients, stifling production. Fewer products mean higher prices globally, with UK pharmacists charging patients 20–30% more for paracetamol than in February 2026.

While patents mean that Big Pharma owns the intellectual property of drugs, often, they were not the original owners. Pfizer only develops 23% of their drugs in-house, while J&J created



a staggeringly low 11% of their own medications. The remainder are purchased from biotech companies, labs, or universities after they conduct the initial, riskiest stages of development, often funded by government grants. So, the public pays twice: once through their taxes to fund grants and then to gain access to high-priced medications. Globally, it is estimated that the public fronts two-thirds of all upfront drug R&D costs, while Big Pharma spends considerably more on sales and marketing than R&D. This initial research must often be sold to Big Pharma because the cost of bringing a drug to market is something most institutions simply cannot afford. And so, our innovation becomes trapped in Big Pharma’s grasp.

Just like Big Pharma is integral to the production of pharmaceuticals, Big Tech is the linchpin for the development of current technological innovations. However, like Big Pharma, their monopolies stifle innovation as they become increasingly influential in government decision-making.

Big Tech’s focus on profits results in unethical practices, selling its technology to the highest bidder. In

their Pulitzer Prize winning piece, the Associated Press found that global tech companies developed and sold technology marketed to governments for ethnic repression and surveillance. IBM's anti-terror software, Dell's targeted "military-grade" and "all-race recognition" technology, and Thermo Fisher Scientific's Uyghur and Tibetan DNA testing kits were knowingly advertised and sold to the Chinese government to facilitate human rights abuses. However, because we are so deeply reliant on this tech and these abuses of power do not directly affect most of us, we ignore these concerns. This is how we fuel Big Tech's power to get close with governments, reshaping policies and growing their influence.

By having access to so much data, companies create monopolies. Having centralised datasets is incredibly convenient for consumers, empowering Big Tech to seep into other sectors including healthcare (Amazon's PillPack), agriculture (Microsoft's FarmBeats) and transport (Alphabet's Waymo). Yet, this guise of convenience raises questions of data privacy, consumer choice, competition, innovation, and, like Big Pharma, pricing. So, while

Big Tech continues innovating, their policies and venture capital divisions, buy up smaller companies, preventing any outside competition. Governments are attempting to regulate Big Tech through legislation, mirroring their actions with Big Pharma. However, when the technology evolves faster than the bureaucracy can control it and when a fine is merely a drop in their ocean of wealth, these actions will only do so much to regulate Big Tech.



With government innovation struggling to keep up, states are forced to work with these companies. In 2023, the NHS has signed contracts with American software company Palantir to create a Federated Data Platform where patient

records are to be kept. This means that the same company used by ICE to surveil American citizens is now used to manage all UK health datasets, establishing a dangerous precedent for the UK government.

When trust in the healthcare system and governments is already crumbling, the question is whether people will turn a blind eye to moral and ethical concerns to gain access to a, supposedly, more efficient healthcare system. Is giving

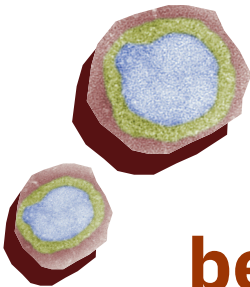
your data to companies designing mass surveillance and war apparatus a sacrifice you are willing to make?

The unfortunate reality is that even when activists attempt to resist, someone else will take their place. When Anthropic was designated a supply chain risk by the Pentagon for refusing to allow its software for 'any lawful use,' including domestic surveillance and autonomous weapons systems, OpenAI swooped in to secure a contract within hours. While used nefariously to blacklist Anthropic in this case, the actions of the US government indicate that no company is above the law.

This creates hope that in the hands of responsible governments who are willing to act, this technology can be regulated.

These revelations leave us wondering who, if anyone, the good guy is. By turning a blind eye, we allow power to be funnelled into the hands of a few while we are left grappling with the ethical, health-related and commercial consequences. To regain control of technological and pharmacological innovation, we must develop and decisively implement regulatory systems that adapt with these technologies, instead of lagging behind. Because if we leave this power unchecked, who knows what will happen next.





Power without force: the evolutionary arms race between viruses and immunity

Emily Howes

When thinking of a power struggle, the fight between a virus and its host may not

be the first idea that

springs to mind.

But that is exactly what viral

infection consists

of; a constant battle

between virus and

host, each competing

to adapt, hijack the

other, and ultimately

win the evolutionary

race to gain control. But

how does this invisible power

dynamic function in the biological

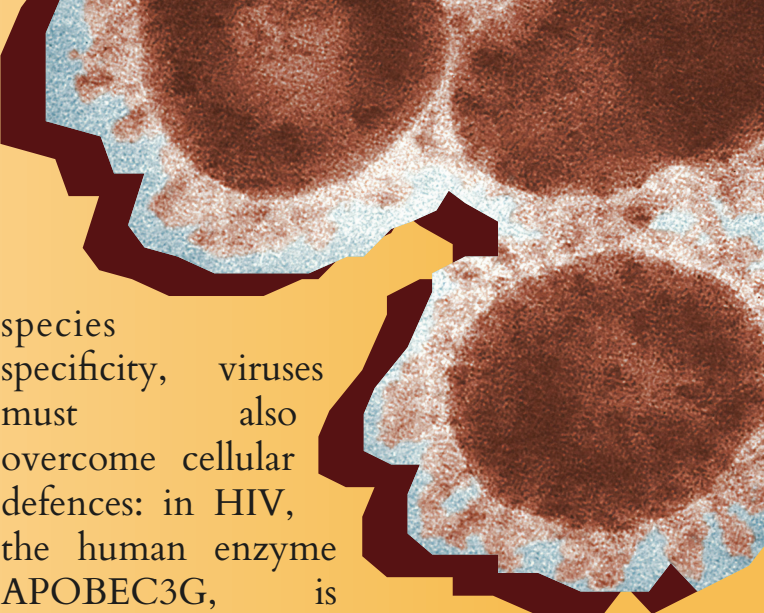
world, and which side comes out on

top?

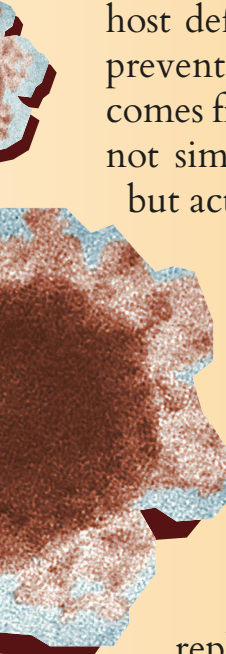
Viral infection is not a one-size-fits all phenomenon; each species of viruses is highly evolved to target different components of the human host, strategizing to leverage its genetic makeup. Entry into host cells is essential for successful infection: the virus must bind to a receptor on the cell surface membrane, hijack the host's cellular machinery to replicate, and exit the cell. In turn, the human immune system has evolved sophisticated ways to detect

and eliminate infected cells, which the virus must evade to persist.

Some viruses, such as influenza A, take a highly adaptable approach to immune evasion: their rapid mutation rates allow them to remain undetected forcing the immune system to continually evolve. They use antigenic drift (minor mutations in their surface proteins) to gradually change their composition. These changes are small enough to support persistence, but are incompatible with the existing immune response and so partially escape detection; it is for this reason that different influenza vaccines are developed annually. A rarer event is seen in antigenic shift (abrupt, larger-scale genetic reassortments), producing entirely new viral subtypes, and it is here that pandemics can occur (e.g. the 1918 Spanish Flu), as the host displays little pre-existing immunity. The key to influenza's bid for power is constant change: the host always reacts, rather than anticipates.



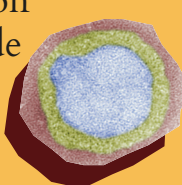
For HIV, avoiding immune detection means taking this strategy further: mutation is even faster, rapidly altering its surface proteins to stay ahead of the human host. This constant evolution is the primary mechanism by which the virus evades the immune response and is among the highest mutation rates observed in biology, with estimates that ~0.3–1 mutations occur in every viral genome replicated. With replication occurring 10 billion times per day, this means that almost every possible point mutation is generated multiple times each day. The virus exhibits high genetic diversity, existing as a cluster of closely related variants within the same host; this makes drug resistance highly likely, and unlike influenza, vaccine development difficult. It encodes proteins that directly disable host defences, including enzymes that prevent viral replication. HIV's power comes from speed and precision: it does not simply evade the immune system but actively undermines it.



While viral pressures can dismantle host defences, the human immune system has targeted mechanisms for exerting evolutionary pressure on viruses. Influenza A relies on host proteins like ANP32A to support viral replication, and differences in its structure create high species specificity, preventing transmission to other hosts: this is particularly relevant between humans and birds. Beyond

species specificity, viruses must also overcome cellular defences: in HIV, the human enzyme APOBEC3G, is capable of introducing damaging mutations to the viral genome during replication. In response, HIV encodes the Vif protein to degrade APOBEC3G, reflecting a highly specialised cycle of adaptation from both sides. This host-virus relationship is not defined by domination from either side, but instead, a continual cycle of evolution in response to selection pressures.

These examples illustrate the invisible power struggle between viruses and their human host: each must respond to the other to survive. For viruses, success means persisting long enough to establish a stable infection and transmit to a new host; for hosts, the goal is to detect and eliminate infection before damage occurs. So which side comes out on top? Perhaps there is no one true winner. This ongoing arms race is not defined by single, decisive victories, but by constant adaptation on both sides. In biology, power is not about domination—it is about staying one step ahead.



Menopause: a neglected frontier in global health

Mollie Hutton

It is well established that women's health has been historically underfunded and under-researched. In the United States, women of childbearing age were largely excluded from early-phase clinical drug trials between 1977 and 1993, leaving significant gaps in understanding how medications affect female physiology. This bias extended beyond human studies: female animals were often excluded from preclinical research due to concerns that hormonal fluctuations would complicate results. The consequence is a persistent data gap that continues to shape medical knowledge today. This inequality demonstrates how power within medical research, healthcare systems, and government policy has historically shaped which health issues are prioritised, and which are neglected.

Within the realm of women's health, menopause remains particularly overlooked. Typically occurring around the age of 51, menopause is experienced by half the global population. A 2016 symptom

survey conducted by the British Menopause Society found that up to 79% of women report hot flushes, while 22% report insomnia. Around a quarter of women experience severe symptoms, yet nearly half do not seek medical advice—highlighting a substantial gap between need and care.

By 2030, nearly 500 million women worldwide will be in perimenopause, menopause, or post menopause—around 6% of the global population. However, our understanding remains heavily skewed. Most menopause research is based on small, relatively homogeneous cohorts in high-income countries, with only around 8% of clinical trials including populations from low- and middle-income countries.

This lack of representation has consequences. In many parts of the Global South, menopause is underreported and poorly understood, with symptoms often attributed to “ageing,” “stress,” or general ill health,



rather than recognised as a distinct biological transition. Limited access to healthcare, combined with stigma and a lack of culturally appropriate information, means many women are never formally diagnosed or recorded. This leads to a biased dataset and stagnates progress on devising effective treatments. Emerging evidence suggests that menopause may occur earlier in some of these settings, particularly in sub-Saharan Africa and South/Southeast Asia, with links to poor nutrition, air and water pollution, and as well as several other factors.

Policy plays a central, although often invisible, role in shaping these experiences. It determines whether healthcare providers receive training in menopause care, whether information is available in accessible formats and languages, and whether treatments are affordable and widely available. In this sense, menopause is not only a biological process, but also a reflection of how power operates within health systems.

Hormone replacement therapy (HRT) remains one of the most effective treatments for many women, particularly when initiated before the age of 60 or within ten years of menopause onset.. However, HRT is not suitable for everyone. Women with certain medical conditions, including breast cancer, liver disease, blood clotting disorders, or a high risk of heart disease, may be advised not to take it due to associated risks. This highlights

how menopause treatment is influenced not only by biology, but also by medical guidelines, healthcare systems, and government policy. Women who cannot use HRT often depend on non-hormonal treatments such as antidepressants, anticonvulsants and antihypertensives, but these are not easily accessible. Recent UK policies, including reducing HRT prescription costs and improving menopause support, show growing recognition of menopause as an important public health issue. However, access to both hormonal and non-hormonal treatments remain unequal across different countries and social groups, demonstrating how power and public policy can affect who receives effective menopause care. how power and public policy can affect who receives effective menopause care.

There are also clear economic incentives for action. Menopause-related symptoms contribute to billions in lost productivity worldwide, as women reduce working hours or leave the workforce entirely. Without greater investment in research, more inclusive data collection, and targeted policy action—particularly in low- and middle-income countries—these disparities will persist. If global health systems are to respond effectively, menopause must be recognised not as a marginal issue, but as a critical intersection of biology, inequality, and power.

menopause

art by Kat Gannon

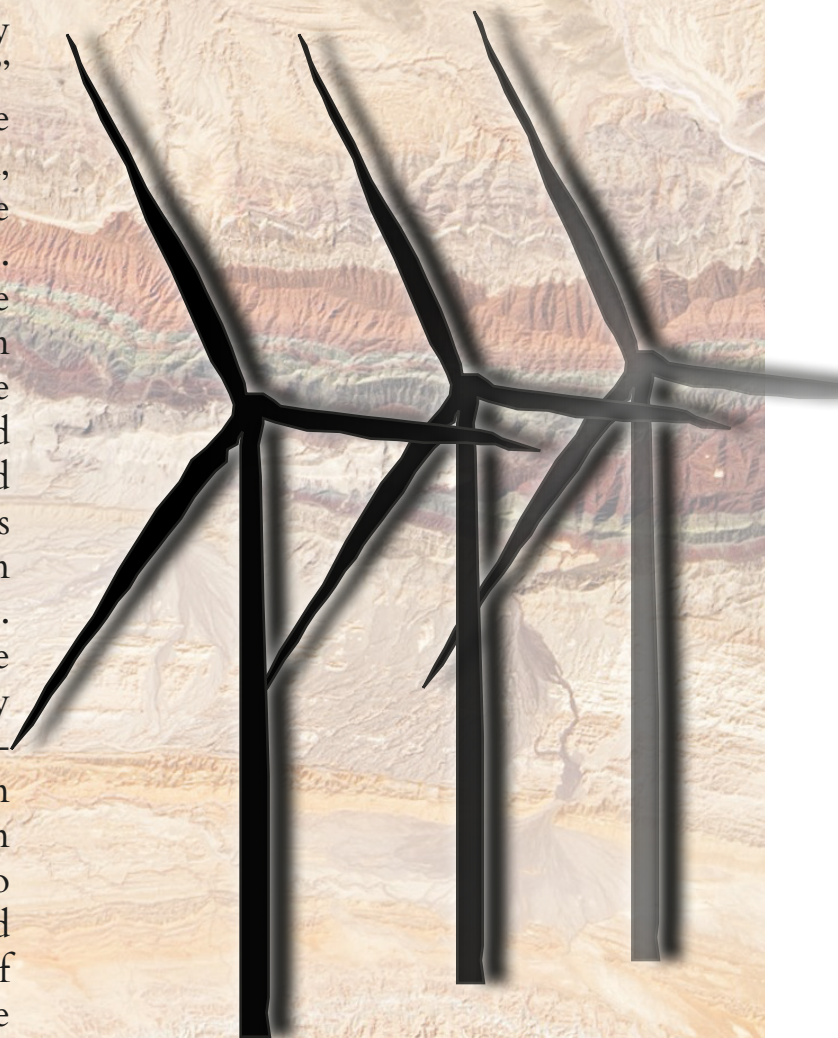
How clean power gets dirty

Ellie Yau

There is a particular irony in the phrase “rare-earth elements” in that the 17 metals that share that name, including neodymium, cerium and dysprosium, are not actually particularly rare. For example, cerium is more abundant in the Earth's crust than copper, and neodymium is more common than gold. The word “rare” in this context was coined by 18th century mineralogists who had simply never seen them concentrated in one place before. This fact has come to be quite the problem for 21st century energy and geopolitics, where “rare-earth” has become a buzzword in international dialogue. The clean energy transition is supposed to be the story of how the world broke free from the grip of environmentally destructive resources; but what it runs on risks showing otherwise.

If you hold a neodymium magnet, you'll notice that it feels disproportionately strong for its size. That's because neodymium magnets are the strongest permanent magnets commercially available. Their unique properties arise from their electron configurations: unlike common magnetic materials,

rare-earth elements have multiple unpaired electrons in an f-orbital inner shell, and the metal's crystal lattice structure locks their magnetic fields into a specific orientation rather than letting them cancel each other out. This creates a strong internal electric field that can hold many times its own weight, producing a force far greater than iron or ferrite magnets can achieve.



A direct-drive offshore wind turbine relies on several tonnes of these rare-earth magnets to efficiently generate electricity via electromagnetic induction. In a turbine, the stronger the magnet, the more current you can generate from the same movement. A conventional electromagnet needs an external power supply to maintain its field, but a permanent rare-earth magnet does not. A single neodymium magnet can generate a field around ten times more powerful than a standard ferrite magnet in a fraction of the volume and maintain it indefinitely. This allows electric vehicle motors to fit where an engine used to be, reducing mechanical complexity and maintenance, and making the whole system viable offshore. It makes the difference between a generator the size of a house and one compact enough to sit at the top of a tower in the North Sea.

But extracting these metals requires crushing enormous quantities of ore, bathing the resulting slurry in sulfuric acid, and repeating variations of this process across dozens of extraction stages. For every tonne of rare-earth product, the process generates up to 2,000 tonnes of toxic waste in total, including 75 cubic metres of acidic

wastewater and a tonne of radioactive residue (a byproduct of the thorium and uranium that are usually in their vicinity). Engineers have spent decades trying to find alternatives, but they have consistently been heavier, weaker, or both. What makes rare-earth elements so valuable and so difficult to extract also makes them almost impossible to replace.

Solar panels tell the same story through a different material. Again, scarcity is not an issue: silicon is the second most abundant element in the Earth's crust. The problem is that although raw silicon from quartzite is around 98.5% pure, solar-grade polysilicon must reach 99.9999% purity before it can convert sunlight into electricity; a single impure atom per million disrupts the crystalline structure enough to measurably reduce a cell's output. One megawatt of solar



capacity requires seven tonnes of polysilicon, and global solar capacity is now in the terawatts, requiring millions of times that.

This is what the clean energy transition runs on, and is the same transition everyone's scrambling for, with renewables projected to supply up to 45% of the world's electricity by 2030. All this is happening for good

reason: compared to traditional fossil fuels, the case for clean energy isn't in question. Solar panels and wind turbines produce electricity without burning anything, meaning no combustion, no continuous carbon dioxide emissions, no oil spills, no particulate pollution at the point of generation. Switching to them is not optional if we want to take climate targets seriously.

The distinction lies in where in the lifecycle the harm occurs. Fossil fuels cause damage continuously and diffusely across their entire life cycle, from extraction to manufacturing and throughout their use: every tank of petrol burned contributes to atmospheric CO₂, and every gas flare degrades local air quality. Rare-earth extraction causes concentrated harm in specific places at the beginning of the supply chain, and then largely disappears for the consumer at the end of it. While this does not make it better, it does make the harms easier to overlook, especially when rare-earth mining takes place near marginalised communities. There, the chemical issues from the production process are apparent, including metal toxicity, radiation exposure, and environmental acidification. Chronic exposure to the toxic leftovers, or tailings, generated from mining degrades soil and water quality in surrounding areas, impairing biodiversity and posing serious health risks for communities near extraction or processing sites.

For example, Bayan Obo in Inner Mongolia, China is the world's largest rare-earth mining site. By 2005, over 70,000 tonnes of radioactive thorium had been stored in the Weikuang Dam, a man-made lake built in the 1950s to dump mining waste. This “notorious” reservoir lacks standard lining, meaning its contents have been seeping into groundwater and making their way towards the Yellow River, which nearly 200 million people rely on for drinking water. Peer-reviewed measurements of thorium concentration in the dam found levels 34.6 times greater than in surrounding soil. In the early 2000s, villagers living near the Weikuang Dam were reported to suffer bone and joint deformities linked to fluoride-contaminated water and arsenic poisoning, prompting relocations from the area. Environmental surveys in the region have also found significant heavy-metal contamination in soils and road dust, with associated health risks for nearby residents.

The science of a cleaner extraction is advancing. Techniques such as bioleaching uses bacteria to extract rare-earth elements biologically rather than chemically, significantly reducing acid use and toxic byproduct generation. But under this pressure to produce, the temptation to cut corners and manage the environmental consequences later is rising, which is precisely what happened with fossil fuels. The rise of AI complicates this even further: the data centres AI run on are projected to double their electricity consumption by

‘Switching to them is not optional if we want to take climate targets seriously’

2030 to around 945 TWh annually. Countries that want to advance in the AI race will need enormous quantities of cheap, stable power; generating that amount of power cleanly will depend on these rare-earth elements. Think tank Chatham House warned earlier this year that in the rush to reduce rare-earth dependence on China or any single geopolitical force, environmental safeguards may be weakened or sidelined.

While the clean energy transition is necessary, that does not mean it will be costless. The 20th century's lesson about fossil fuels wasn't just that they were bad for the atmosphere, it's that the people burning them were rarely the same people who suffered most for it. Rare-earth extraction risks repeating that structure: we cannot forget that the cleanness of this transition is not only down to what comes out of the turbine, it must extend to how the turbine is built, and who lives parallel to that how. The science exists to do this better, but whether there is the will to do so remains, for now, the more difficult question.



The untapped power of animal culture

Jessica Sutton



Animal culture is a **rapidly expanding field** with a recent explosion of discoveries as it is identified in a vast range of taxa, from insects to humpback whales. Culture is defined as, ‘group-typical behaviour patterns shared by members of a community that relies on socially learned and transmitted information’. Many different species have populations reaching critically low levels due to anthropogenic disturbances such as habitat fragmentation and climate change. If we are to conserve populations successfully, **culture is a powerful tool we can employ**.

Animal culture produces a ratcheting mechanism, introducing progress within a population in a process similar to evolution, however on much faster timescales. As a result, it can act as a second inheritance system, increasing the ability of populations to adapt to anthropogenic stressors.

In 1871 anthropologist Edward Taylor defined culture as, ‘that complex whole which includes knowledge, belief, art, law, morals, custom, and any other capabilities and habitats acquired by man as a member of society’. It would have been inconceivable to include animals at this point, only 12 years after *On the Origin of Species* was published by Darwin. Nevertheless, even with this definition it is not impossible to see how ‘habits acquired [...] as a member of society’ could apply to socially learnt behaviour in animal communities. It took until 1980 for Mundinger to first argue culture should apply to animals and then Boyd and Richerson built on this idea in 1985, establishing a sound theoretical basis for cultural transmission. Animal culture

has now been studied in many endearing, exciting and confounding examples thanks to this theoretical base. For example, male humpback whale song is passed down through generations. Additionally, experiments have proven bees can learn tasks through cultural transmission. Animal culture was first learnt about by mistake. Big horn sheep were hunted to extinction in the nineteenth century in North America and reintroduction efforts began in the 1940s. The original sheep population migrated to exploit the environmental gradients in plant phenology, also known as green surfing. It was assumed that this behaviour was genetically transmitted, however the first reintroductions demonstrated otherwise, as introduced sheep lacked the ability to catch these “green waves”. The population declined to dangerously low levels and therefore further reintroductions ensued. As generations succeeded the next, surfing knowledge improved because each generation augmented the socially transmitted information through their own experience. This phenomenon is known as **cumulative cultural evolution**, involving the ratcheting of knowledge over generations without reversal. Though this example was discovered quite by accident, it eloquently shows how culture can have a large power in determining population survival.

Recently, exciting progress has been made as culture is now being seriously considered

in conservation efforts. Chimpanzee populations are expected to decline by more than 50% over the next 75 years. Cultural diversity within chimpanzee populations enables **behavioural flexibility**, but this is being lost as chimpanzee populations decline. Chimpanzees are the only terrestrial species in which culture has been formally recognised within conservation policy. This is an important distinction as it means **culture needs to be legally included in ecosystem management**. For example, some Chimpanzee populations crack open nuts using stones allowing them to exploit this food source, therefore efforts are being focused to protect this behaviour. It is hoped chimpanzees will

act as a flagship species for others, ensuring that the consideration of culture is embedded in conservation strategies.

Considering animal culture provides an interesting reflection into our own human condition. 'Are you saying ducks can do art?' I was asked when writing this article. Whilst I am in no way claiming the next DaVinci will be a mallard, I find it interesting how we are so quick to protect traits we consider to be "human". It raises the question as to **what power have we conceded in our ability to protect species** by being too preoccupied trying to distinguish ourselves from animals?

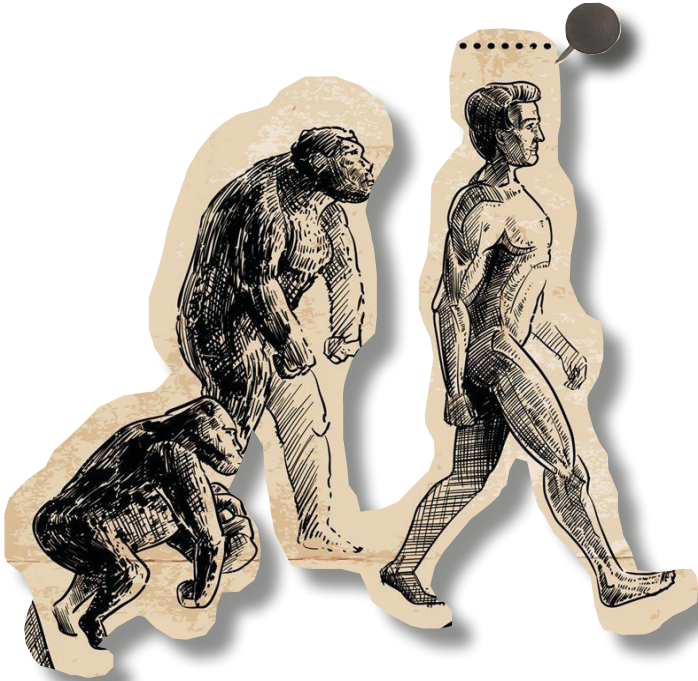


animal culture

The patriarchy's long shadow over evolutionary theories on sexual behaviour

Pei Jin Zhou

Patriarchal origins:

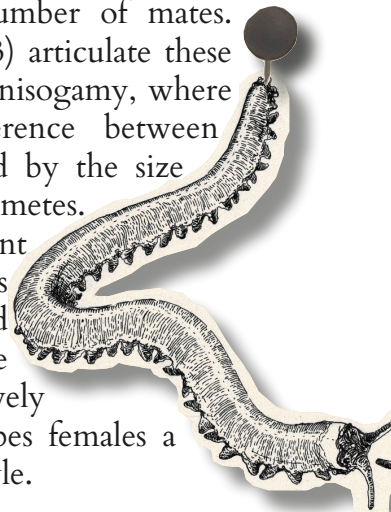


The patriarchy's long shadow over evolutionary theories on sexual behaviour. Although the natural sciences and the scientific method are often championed as being unbiased and objective, the conclusions scientists reach are often influenced by prevailing social attitudes. This is especially true for the life sciences, where the social interpretations of biology are often unconsciously applied to scientific theory. One such example is the evolution of sexual behaviour in animals, which are theories that analyse the fitness costs and benefits of sexually dimorphic behaviours and morphological traits.

Historically, the evolution of sexual behaviour was first explained by the Darwin–Bateman paradigm, which presents a dichotomy between the active promiscuous male versus the passive monogamous female. This evolutionary biology concept was founded upon Charles Darwin's observations of animal courting behaviour in *The Descent of Man* (1871), where he notes the aggressive intrasexual competition between males to secure mating opportunities, while females were passive and courted by males.

These field observations were supported by Angus Bateman's 1948 experiments on *Drosophila*, which seemed to empirically prove male promiscuity, as male reproductive success alone positively correlated with the number of mates. Parker and Baker (2013) articulate these results as outcomes of anisogamy, where the fundamental difference between the sexes is determined by the size difference of the gametes.

The small and abundant nature of sperm explains male promiscuity and aggression, while the larger and comparatively less motile egg prescribes females a chaste and passive lifestyle.



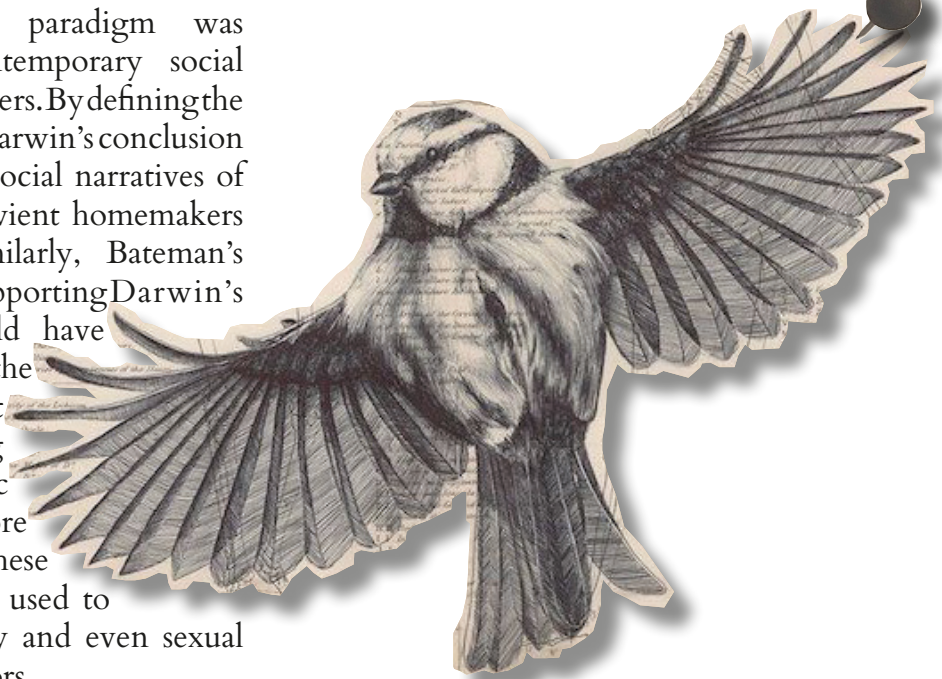
The Darwin–Bateman paradigm was reinforced by the contemporary social attitudes of its conceptualisers. By defining the female as the passive sex, Darwin’s conclusion aligned with prevailing social narratives of women as chaste, subservient homemakers to their husbands. Similarly, Bateman’s dedication to supporting Darwin’s initial observations could have been motivated by the post-World War II shift towards reinforcing traditional domestic roles for women. More problematically, these findings have even been used to justify marriage infidelity and even sexual assault by male perpetrators.

Challenging anisogamy:

Yet, to find counter-examples to the Darwin–Bateman paradigm, one does not need to look further than Darwin’s own unpublished notes. Darwin’s initial exploration of sexual behaviour was centred around what he called ‘reproductive anomalies’: gynoandromorphic chimeras that contained both male and female characteristics, sex-changing birds, and hermaphroditic slugs. He was fascinated by the apparent sexual fluidity of the natural world, but a fear of social backlash drove him to focus on dichotomies that were more palatable to himself and a wider Victorian audience.

The relatively recent rise in studying organisms that deviate from the Darwin–Bateman paradigm can be attributed to not only more nuanced experiment methods, but is also deeply intertwined with the advent of second wave feminism.

Fundamentally, second wave feminists identified gender as a social construct as opposed to a biological reality, which led to the re-examination of prescribing gender roles to certain

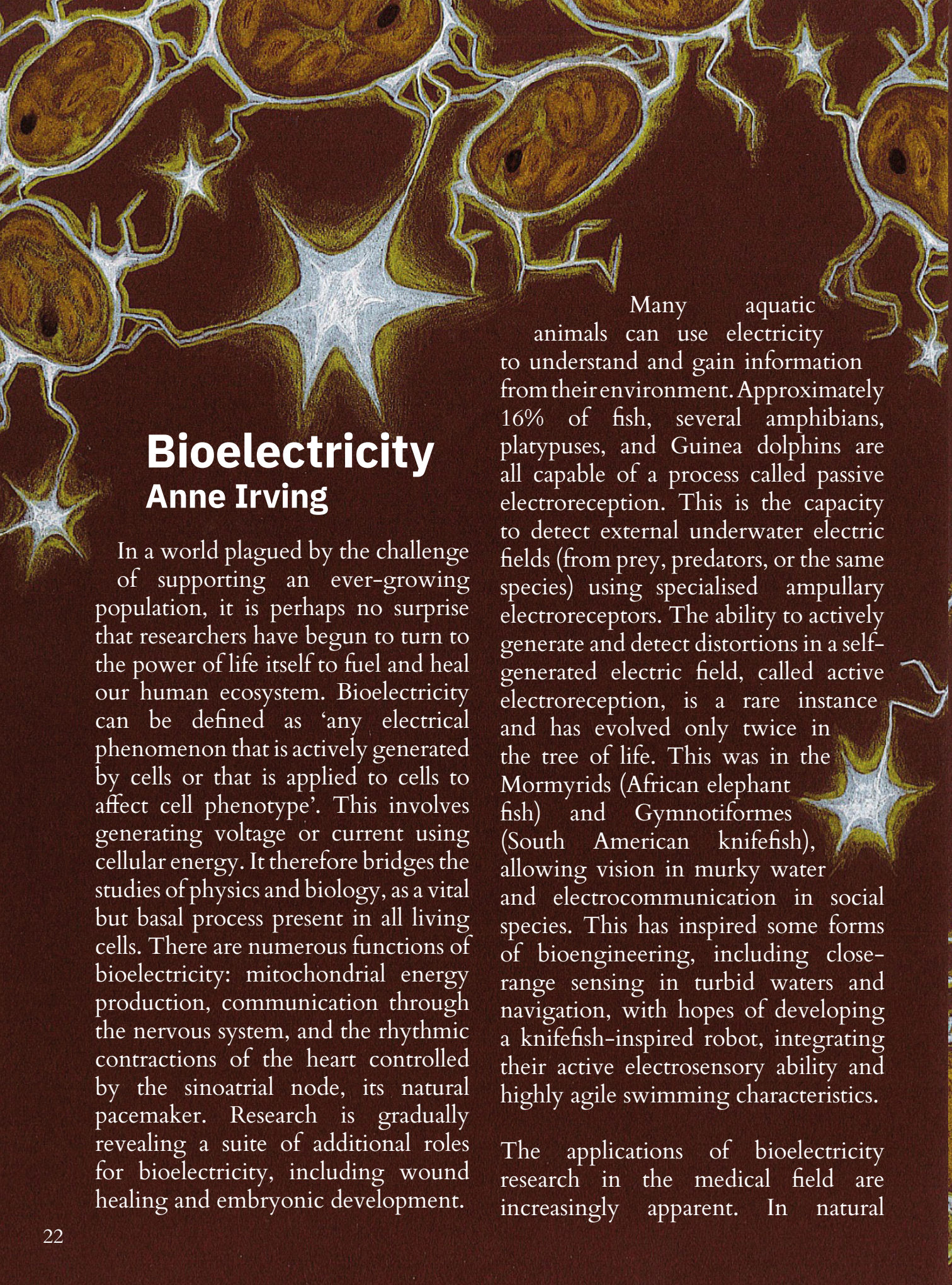


sexes and the re-interpretation of sexual behaviour in animals. From the aggressively matriarchal social structures of meerkats, to the sexual promiscuity of songbirds, and the ornamented and aggressive female wattled jacana, nature presents alternative situations where females act polygamously, dominate over males, and even vie for mates.

Towards a more nuanced future:

Given that social attitudes and scientific research can influence one another, the recent trend of dismissing humanities, particularly gender studies, is worrisome. For instance, increasingly dismissive legislation towards humanities research, such as the Trump administration’s plan to eliminate all funding for the National Endowment for the Humanities, both hurts those in the field, and communicates to scientists that a critical awareness of social studies is unimportant, if not counterproductive. A clearer recognition of how social attitudes interact with scientific research not only addresses the implicit biases that shape our understanding of the natural world but also reveals the power of cross-disciplinary communication in academia.





Bioelectricity

Anne Irving

In a world plagued by the challenge of supporting an ever-growing population, it is perhaps no surprise that researchers have begun to turn to the power of life itself to fuel and heal our human ecosystem. Bioelectricity can be defined as ‘any electrical phenomenon that is actively generated by cells or that is applied to cells to affect cell phenotype’. This involves generating voltage or current using cellular energy. It therefore bridges the studies of physics and biology, as a vital but basal process present in all living cells. There are numerous functions of bioelectricity: mitochondrial energy production, communication through the nervous system, and the rhythmic contractions of the heart controlled by the sinoatrial node, its natural pacemaker. Research is gradually revealing a suite of additional roles for bioelectricity, including wound healing and embryonic development.

Many aquatic animals can use electricity to understand and gain information from their environment. Approximately 16% of fish, several amphibians, platypuses, and Guinea dolphins are all capable of a process called passive electroreception. This is the capacity to detect external underwater electric fields (from prey, predators, or the same species) using specialised ampullary electroreceptors. The ability to actively generate and detect distortions in a self-generated electric field, called active electroreception, is a rare instance and has evolved only twice in the tree of life. This was in the Mormyrids (African elephant fish) and Gymnotiformes (South American knifefish), allowing vision in murky water and electrocommunication in social species. This has inspired some forms of bioengineering, including close-range sensing in turbid waters and navigation, with hopes of developing a knifefish-inspired robot, integrating their active electrosensory ability and highly agile swimming characteristics.

The applications of bioelectricity research in the medical field are increasingly apparent. In natural



wound healing, electrical signals help guide cell migration towards injury sites, promoting regeneration upon tissue damage. In medical devices like pacemakers and defibrillators, bioelectricity helps manage abnormal heart rhythms. Bioelectricity is also utilised in medical treatments like transcutaneous electrical nerve stimulation (TENS), an NHS-recommended treatment for temporary pain relief associated with conditions such as endometriosis. It involves passing a weak electrical current through the patient's nerves, encouraging the release of endorphins and inhibiting pain signals from reaching the brain. Another novel but seemingly powerful therapeutic strategy is electrical stimulation, a non-invasive technique that can accelerate wound healing, prevent infections, and maintain internal homeostasis in chronic wounds. Electrical signals can interact with physical cellular components, including the cytoskeleton and ion channels. Thus, they are being used in regenerative medicine to aid stem cell differentiation, cell proliferation, and remodel artificial tissue to encourage regeneration.

Finally, microbial fuel cells are a novel source of energy production, which

exploit the catalytic activity of microorganisms, converting the chemical bonds of organic compounds into electrical energy under anaerobic conditions. This can help confront multiple major sustainability issues, including energy security, global warming, and wastewater management (by using organic waste material as the substrate). Under the threat of dwindling natural resources and a warming climate, the demand for sustainable energy sources continues to surge. Microbial fuel cells have been prototyped in various configurations, with performance gradually improving as researchers search for a global solution. One promising route is the diversion of agricultural waste as a carbon-rich and low-cost electrode material for the fuel cells. While not yet in global usage, it is clear that bioelectricity has many valuable applications in healthcare, robotics, and energy, which are likely to become increasingly apparent as research continues!

*art by Imogen
Edmundson*

Computers with superpowers: quantum computing explained

Olivia Miller

Computers are bewildering, capable machines, but there are some things that even the most impressive classical computer cannot do — at least, not within a sensible time frame. For such tasks (like factorising huge numbers, or modeling the wave functions of complex quantum states to see the probability of finding a particle at a certain place and time), we can actually use the principles of quantum mechanics to expedite the computation process by trillions of years.

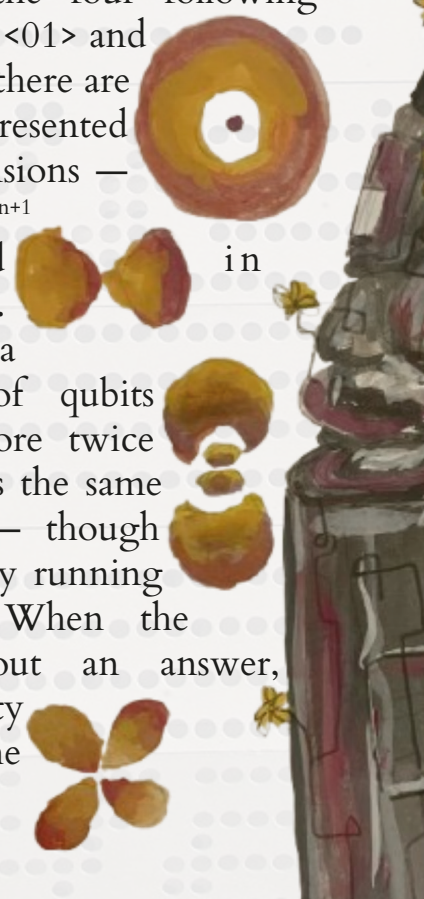
Quantum computers are like superheroes, in that they are different from all other computers on an atomic level and, as a result, have extraordinary powers. Classical computers store information in the form of 0s and 1s, in units called bits (binary digits). Encoded in these bits are text, audio, and images. In a classical computer, each bit is decidedly either a 0 or a 1. However, a quantum computer uses qubits, which contain a superposition of both 0 and 1, in the same way that Schrödinger's cat is both dead and alive until observed.

These qubits are made of subatomic particles, like electrons, with real physical characteristics correlating to 0 and 1 states. Until that physical

characteristic is measured, the qubit exists in a quantum state, and we can assign to it a probability amplitude — a mathematical function of the likelihood that the qubit is in either the 0 state or the 1 state.

Probability amplitudes can be described by negative and imaginary numbers. Because of the nature of the interactions between negative and imaginary numbers, qubits can store far more values than traditional bits when placed in sequence. In n bits, there are only 2^n states represented in real dimensions. For example, two bits ($n = 2$; $2^2 = 4$) could represent the four following states: $\langle 00 \rangle$, $\langle 10 \rangle$, $\langle 01 \rangle$ and $\langle 11 \rangle$. In n qubits, there are 2^n basic states represented in complex dimensions — equivalent to 2^{n+1} states represented in real dimensions.

As a result, a given number of qubits can essentially store twice the information as the same amount of bits — though only while actively running a computation. When the machine spits out an answer, the probability amplitudes of the



qubits are squared to find probability, and squaring a complex or imaginary number turns it into a real number — 0 or 1, just like a regular bit has. Nonetheless, this computing power makes quantum computers far more efficient than classical computers.

Bits exist in sequences that are then processed through logic gates; the computer extracts information when gates change the state of certain bits to produce a new sequence. In quantum computers, quantum gates change the probability amplitudes of the collective sequence of qubits. The computer applies successive quantum gates, and each computation might use billions of such gates. Essentially, a quantum computer processes many classical states in each step, whereas a classical computer processes one state at a time, taking exponentially longer.

After the computer has applied all of the desired quantum gates, it reads the final state of the qubits. This observation collapses each qubit in the sequence from a state of superposition into a single measurable state (like opening Schrödinger's box and finding the cat alive). If you run the same computation many times, you won't get the same answer each time, but

you can calculate the probabilities of each result from how often the computer returns it, and from there, determine the correct (or most probable) answer. And, running the quantum computation about a thousand times (as is standard for less intricate tasks), or even hundreds of thousands of times (for complex problems), is still much, much faster than running the classical computation just once.

Even though it is quantum physics that makes these computers so powerful, it is also what makes them fragile. If the computing process is “observed” — affected by any external forces — before it is complete, the computation is altogether ruined. And an observation could be as simple as radiation escaping from the computer, because these radiation waves interact with the environment, meaning they have, technically, been observed.

But if we are able to minimize the effects of these issues, we expect to be able to use quantum computers to create complex and potentially revolutionary physical simulations in all sorts of fields — not just to learn more about quantum physics, but also to develop new, individualized healthcare solutions by modelling interactions between molecules, or to plan renewable energy grids by projecting supply and demand and optimising layouts. Qubit by qubit, quantum computing can help make the world a better place.

art by Kat Gannon

Power laws

Ava Carroll

The world doesn't always behave normally.

Humans intuitively understand “normal” behaviour, where measurements cluster around a mean value. For example, it is common for multiple choice exam scores to follow a normal distribution, whether naturally or because of an imposed curve fit to a target distribution by the instructor. Most scores will fall within ± 1 standard deviation from the mean, whilst a significantly smaller proportion will be a couple of standard deviations away. For data sets that follow a normal distribution, the mean value of the set provides a good representation of the set as a whole.

But not all data obey the normal distribution. Power law behaviour offers another way to understand certain systems. This behaviour is characterized by a system having a probability distribution given by:

In words, the probability of an outcome is inversely proportional to the size of the outcome. Statisticians have hypothesised that power laws are everywhere in the world around us, from the size of cities to the dynamics of diseases. A paper by Rhodes and Anderson illustrates this, exploring how power laws can describe the size and duration of measles outbreaks in the Faroe Islands, Bomholm and Reykjavik. They found that a power law fits the data better than another conventional model for infectious diseases, the SEIR (susceptible–exposed–infectious–recovered) model, which breaks down for small populations and incorrectly estimates the frequency of large outbreaks.

Disease outbreaks, alongside other natural and human-driven phenomena, behave in such a way

$$p(x) \propto x^{-\alpha}.$$

that small impact outcomes are highly likely. Interestingly, while large outcomes are unlikely, they still appear to be more probable than what would be expected from the normal distribution. This can feel counterintuitive because we expect high impact events to be exceedingly rare. For instance, in an area prone to earthquakes, a big earthquake can feel shocking because small ones are most common. If we follow intuition from our experience with the normal distribution, it seems reasonable to expect that the next quake will also be small. Understanding that earthquake magnitudes show power law behaviour (with a high magnitude cutoff, since there is a physical limit imposed on how large an earthquake can be) makes clear that outliers shouldn't be surprising. A power law distribution can reflect this behaviour with its characteristic long, fat, or heavy tail, showing that large values have a non-negligible probability of occurring.

Within the field, there has been an unfortunate practice of fitting data to a power law without much rigorous testing; some systems that were thought to behave according to a power law are being re-evaluated to see if a better fit exists. A non-rigorous way to decide if data fits a power law is to plot the data on a log-log scale (the log of both the x and y-axes are taken) and look for a straight line. However, this is not a statistically sound method of determining best fit because it only provides evidence that a power law

might be appropriate to describe the behaviour. It does not rule out fits by other distributions, such as lognormal and stretched exponential, that could also look linear on a log-log plot and have a heavy tail.

Throughout the ongoing debate surrounding power law overuse, some scientists have argued that general “heavy-tailed” behaviour is a pattern that might better describe real-world observations. Sometimes, simply knowing whether a distribution is heavy-tailed is sufficient, while the best-fit equation isn't particularly important. In other cases, for example, when extrapolating the frequency of large values far into the tail of a data set, it is important to know whether a power law describes behaviour because conclusions will differ depending on the equation used to fit the data.

Power laws, and more generally the whole class of “heavy-tailed” functions, are a powerful description of real-world phenomena. Understanding that not everything follows a normal distribution is important when constantly surrounded by statistics. The average value doesn't always accurately or appropriately represent reality, and, in certain cases, extreme values have a small yet practical chance of occurring. So, in anticipation of the next earthquake or disease outbreak, hope for the best, but prepare for the extreme.

Powered by the sun: mastering light exposure to advance human health

Jasmine Price

There are two light reception systems in the human body: the visual system and the circadian system. The latter synchronizes our “body clock,” which regulates a vast array of physiological processes. Decades of research identify the circadian rhythm as the foundation of health, yet it is entirely neglected by modern lifestyles.

The typical person can spend around 90% of their waking time indoors, under lighting that is visually bright but biologically dark, insufficiently stimulating the circadian light reception system. Electronic devices desynchronise the body clock

too, because the circadian system is significantly more sensitive to light in the evening. An effective intervention would be to wear blue light blocking glasses at this time.

Notably, tribes like the San and Tsimane, which have their body clocks in tune with their environment, have no term to describe “insomnia” — it’s a modern lifestyle problem. One way

that the body clock supports tiredness at night and alertness during the day is by timing the release of cortisol (the alertness hormone). In a healthy person, cortisol should sharply peak 30 to 60 minutes after waking. Clinical protocols, such as those derived from the work of Leproult et al., recommend

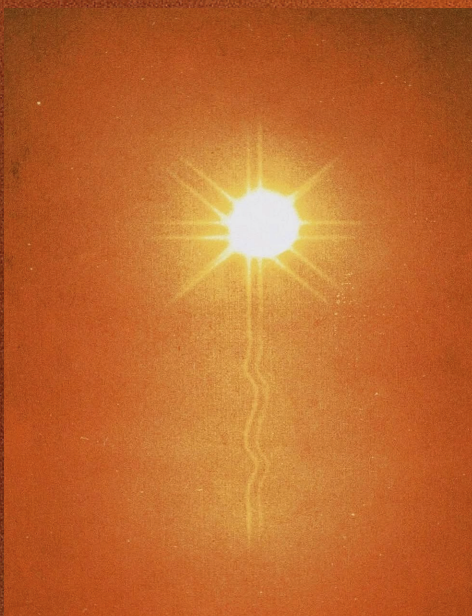
at least 10 minutes of daylight outdoors, first thing, to power the cortisol-awakening response. No facet of the human body is spared the damage of a desynchronised circadian rhythm; it is a risk factor for a host of physical and mental illnesses. This is illustrated during an annual

“experiment” that forces 1.5 billion people to advance their circadian clock by just one hour: daylight savings time. Analysing the hospital records the following day reveals a frighteningly sharp peak in heart attacks of 24%. This seemingly trivial clock shift is significant enough to bring forward such occurrences. But the damage extends to metabolic health too. The



body is around 40% less insulin sensitive at 8:00 pm than at 8:00 am. This was enough to send participants into pre-diabetic and diabetic states in a study by Scheer et al. (2009). Since demands of modern society force 14% of the UK workforce to work into the night, we put them at permanent risk for obesity, type 2 diabetes, and cardiovascular disease.

But the impact of daylight starvation is also about the **quality of the light** reaching our cells. Research is beginning to reveal that the narrow blue spectrum in most LEDs is harmful. Consequently, mice exposed to LED light demonstrated anxiety-like behaviours, reduced mobility and weight gain in a study by Jeffery et al. (2025). Conversely, exposure to near infrared (NIR) wavelengths has been shown to improve immunity and decrease inflammation in humans. But in a push for energy efficiency, we have designed windows with coatings that filter out daylight's NIR to prioritise thermal insulation, worsening the spectral deficit introduced by LEDs.



At-home red light therapy devices have increased in popularity in light of the above results in an attempt to replicate a lifestyle once taken for granted.

A powerful light intervention comes from **seasonal affective disorder (SAD) therapy lamps**. Clinical meta-analyses, such as that of Almeida et al. (2025), confirm the ability of SAD lamps to significantly alleviate depressive symptoms and improve alertness, when compared to a placebo control or LED. This is because SAD lamps are engineered to maximize circadian wavelengths.

More natural light exposure patterns not only benefit health, but **productivity** too. For instance, a study by the Heschong Mahone Group measured test scores against the amount of daylight in the classroom for over 21,000 students. Those working with the most daylight progressed 20% faster on maths tests and 26% faster on reading tests than those with the least. Prioritising daylighting solutions could therefore be a powerful economic and public health intervention.

We face the paradox of having more access to light than ever whilst simultaneously being starved of it. Environments are engineered for thermal efficiency but neglect our biological clocks. Self-medication of chronic sleep debt with caffeine and pills has become far too normal, and the consequences are far reaching. We are dangerously out of sync with our biological clocks and cannot afford to keep neglecting this pillar of health and wellbeing.

Zero

Sophia Yvonne Hall

One may be the loneliest number in the universe, but zero is the most powerful. Today, zero is indispensable to science, calculus, and code. It is the foundation of the modern world.

For much of history, zero did not exist as a number. Ancient civilisations counted objects, such as sheep, but had no need to represent their absence. Ancient Greeks resisted the idea that 'nothing' could meaningfully exist. Accepting the existence of zero would have destabilised the philosophical order of ancient Greece.

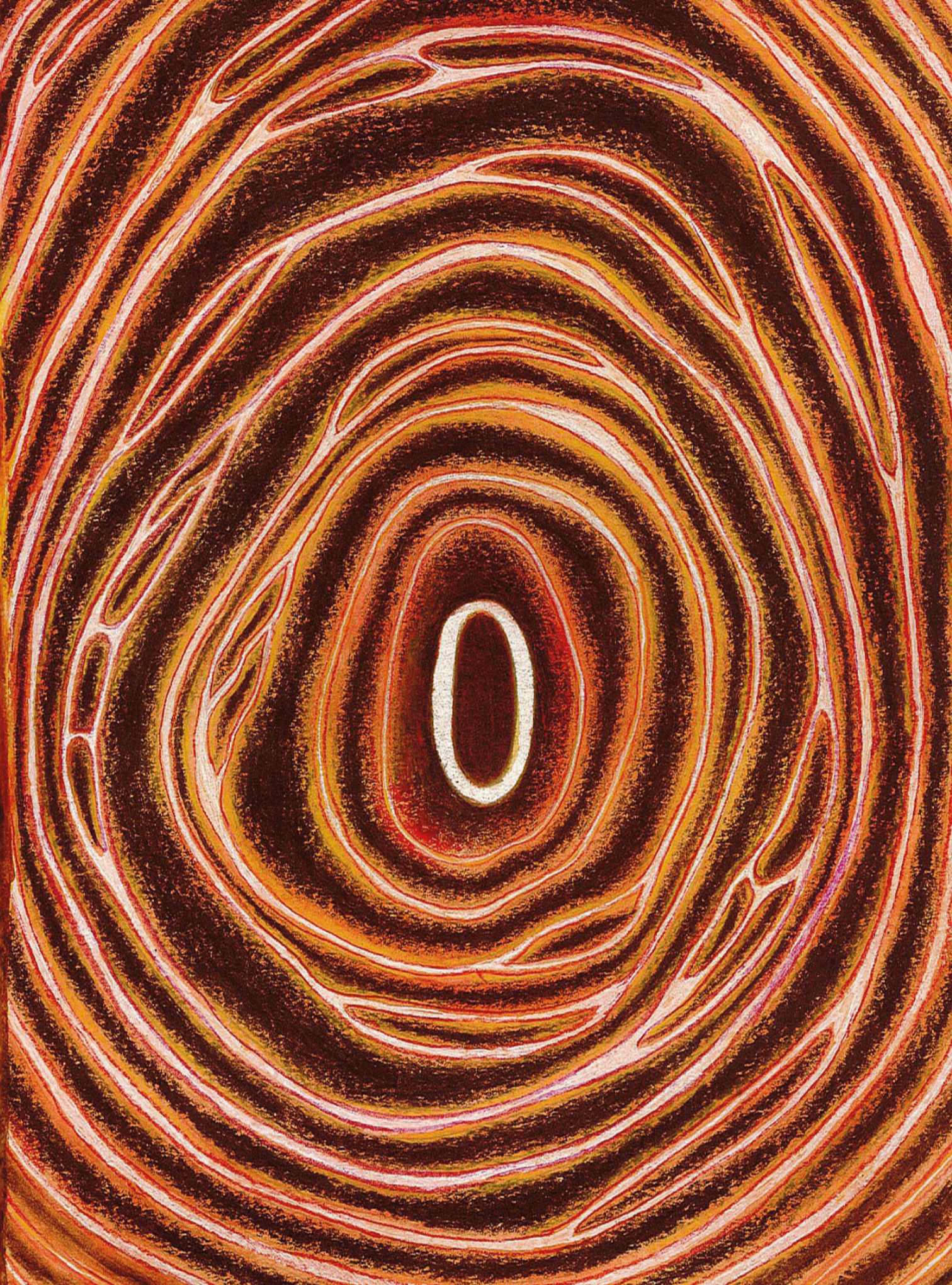
The origins of zero are most commonly associated with India. The concept later spread to the Islamic world, followed by Europe, where it faced challenges. Although contested among historians, some accounts suggest that the concept of nothingness was destabilising to the Church's teachings that God filled all of creation and therefore was suppressed.

Once zero was widely accepted, it transformed mathematics. Algebra,

algorithms, and calculus depend on having a working concept of nothing. Newton and Leibniz's work with calculus was, in part, a prolonged negotiation with zero. The machinery of limits and infinitesimals concerns the question: What happens when a quantity approaches nothingness?

Leibniz developed and formalised a binary system. He found philosophical significance in the distinction between something and nothing. Zero, once viewed with suspicion by theological leaders, was recast by Leibniz as evidence for divine creation – for Leibniz, the idea that everything could emerge from nothing reflected God's power to create ex nihilo. Leibniz's binary system, made of 1s and 0s, is the scaffolding of the digital age. Every text you send is a sequence of ones and zeros, signals that are either absent or present.

Zero is not a comfortable concept. Some have even argued that zero cannot be a number at all. Its power lies in contradiction: nothing is the foundation of everything.



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