

I, SCIENCE

THE SCIENCE MAGAZINE OF IMPERIAL COLLEGE



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LIFE & DEATH

Chestertons: Helping Imperial Students with Accommodation

London has one of the most complex and competitive property markets in the world, which means that many students find it difficult to find a suitable property when they move here.

Every year, I,Science's sponsor, Chestertons, – one of London's largest and oldest estate agents – helps thousands of students from all London universities, including Imperial, find rented accommodation.



To help students and their families understand the process and avoid making costly errors, Chestertons has produced a 'A student's guide to renting' which can be downloaded for free at www.chestertons.co.uk/students



Local South Kensington manager Cory McNally gives his top tips for renting a property in London:

- **Consider searching 'off-season':** the rental market is busiest between July and September. If possible, start your search outside of this period to get the best deals.
- **Prepare to pay rent in advance:** As students don't have a guaranteed income, most landlords will ask for six months of rent in advance and the second payment due in the fourth month. Be prepared for this!
- **Choose agency-managed:** Some landlords manage their own properties but they are sometimes slow to respond to maintenance issues. If you can, choose a property which is professionally managed by an estate agency.
- **Consider longer term:** Most rental tenancies are 12-months but consider getting a longer-term contract with a break clause as this will save you the stress of having to search for a new property after a year.
- **Know when to negotiate... and when not to:** So competitive is the market that properties will often come on and off the market within a matter of hours. If you try and negotiate on popular properties, you will miss out.
- **Use video viewings:** Many agents now allow you to view properties by video. This is a great option if you are not able to view physically due to time constraints or not being in the UK at the time.



If you have any questions or would like any help with renting a property in London, please contact Cory on [020 7368 3042](tel:02073683042) or cory.mcnally@chestertons.com

CHESTERTONS

I, SCIENCE

DEAR READERS,

We hope you enjoy this issue of *I, Science* centred around the theme of 'Life and Death.' We wanted to indulge our morbid interests and enter the world of the macabre – from a purely scientific perspective of course!

Please join us as we examine the line between life and death and how our understanding of this cycle is complicated through models of grief and challenged through abstract concepts of immortality in art and ancient concrete.

Our fantastic writers have not disappointed and have crafted articles to give you a glimpse into these murky waters. We explore restoration ecology, apocalypse preparation, and the environmental impact of human deaths. As you delve into these uncharted areas of science, we hope you appreciate the importance of this work and the need for its communication.

Before you begin reading, we urge you to note that content in this issue covers sensitive topics of grief and death.

Thank you for your support, and we wish you happy reading!

Imaan Moin and Coral Billingham
Editors-in-Chief 2022-2023

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YUCHEN LIU
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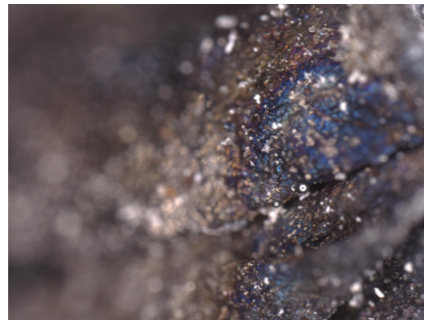


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I, Science was highly commended for both Magazine Design and Best Science Publication/Section at the Student Publication Awards 2023. Congratulations to all!

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WATER ON MARS

GABRIELLA SOTELO

Almost, but not quite yet.

China's Zhurong rover recently discovered evidence of water on Mars. The key word is 'evidence', as the liquid itself has not yet been found. Evidence of the Red Planet's watery past has been collected before. NASA's Curiosity rover spotted rippled rock textures that suggested the existence of lakes on the planet, while NASA's Phoenix lander detected water vapor on Mars' north polar region, but the evidence of water at lower latitudes has not been completely known until now.

The Zhurong rover, which landed on Mars in May 2021 but has been dormant since May 2022, was observing and investigating dunes in its landing area. The rover analyzed the features and found crusts and cracks, as well as layers that contained chemicals that commonly occur by interactions with salt water. These are dunes that have been hydrated.

"According to the measured meteorological data by Zhurong and other Mars rovers, we inferred that these dune surface characteristics were related to the involvement of liquid saline water formed by the subsequent melting of frost/snow falling on the salt-containing dune surfaces when cooling occurs," Qin Xiaoguang, professor and lead of this recent Mars study, said in a statement.

The research has been published in *Science Advances* and gives us more information regarding water on the planet. The research states it hopes to "provide critical insights into the possibility of water activity at low latitudes during the contemporary period on Mars."

The formation of ridges, crusts, and cracks also has led researchers to believe



Credit to NASA/JPL-Caltech
NASA's Perseverance Mars rover captured image of "Betty's Rock" on June 20, 2022

that the features were first formed between 1.4 million and 400,000 years ago. This still may seem like a long time ago but to put it in perspective, research has found that *Homo sapiens*, or the first modern human, was thought to have evolved 300,000 years ago. This is a more recent time in Martian history, as it was thought that conditions in that period of Mars history was similar to Mars today: a Mars with lakes and rivers dried up.

Water vapour likely traveled from the Martian poles to Mars' lower latitudes, like where the Zhurong rover is currently sitting, on the southern edge of Utopia Planitia, about a few million years ago, according to the research. The water vapor basically traveled from the planet's polar ice caps and sheets to its equator,

which made the planet's lower latitudes more humid.

The age of the dunes and the chemical composition, which were rich in hydrated sulfates, hydrated silica, iron oxide minerals, and possible chlorides, suggest water on Mars during this period of time. The understanding of this is important for how we continue to research Mars.

"This is important for understanding the evolutionary history of the Martian climate, looking for a habitable environment, and providing key clues for the future search for life," Professor Qin said in the statement.

Which leads us to the question...

Is there life on Mars?

ATROPINE: POISON OR ANTIDOTE?

JAIMEE EVANS

"This bitter fruit has a bad reputation, but its extract has proven to be valuable not just in chemical weaponry, but as a substance that has saved countless lives."



ATROPA BELLADONNA
ANGELA HADRILL

Extracted from the shiny black berries of deadly nightshade, atropine is a notorious poison with a murderous legacy. This bitter fruit has a bad reputation, but its extract has proven to be valuable not just in chemical weaponry, but as a substance that has saved countless lives.

On March 20th 1995, a large amount of the nerve gas sarin was released into the Tokyo subway system, killing twelve people and injuring over 5,000. At the base of Mount Fuji, Japanese authorities found a substantial supply of chemicals used to produce sarin gas in a camp belonging to the "Supreme Truth" cult. They also found Masami Tsuchiya, the chemist who admitted to making the weapon.

Despite being known as a nerve gas, sarin is a liquid at room temperature. It is volatile enough, however, that it vaporises into the air quickly and easily, and once airborne poses a serious risk to those nearby. Sarin is absorbed by cholinesterase enzymes in the brain, effectively putting them out of action. These enzymes break down acetylcholine, a molecule which, in excess, can cause overstimulation of nerve cells. Without the action of these enzymes, acetylcholine accumulates, causing a variety of complications, the most severe of which is organ paralysis. The most common antidote to sarin is a swift injection of atropine. By blocking acetylcholine receptors, atropine prevents even large amounts of acetylcholine shutting down important physiological processes. Atropine has saved many lives this way.

However, atropine is not always the hero of the story, and has a villainous reputation for good reason. Sometimes referred to as belladonna, or deadly nightshade, atropine is a popular poison among fiction authors. It was allegedly used against an army of Danes by Macbeth, King

"We can be assured that, in any situation, atropine is definitely not a chemical to underestimate."

of Scotland, and was responsible for the deaths of Emperors Augustus and Claudius of Rome. The chemical also makes appearances in two of Agatha Christie's murder mysteries, *The Caribbean Mystery* and *The Big Four*. Additional adverse effects include tremor, ataxia, delirium and, after paralysis, circulatory collapse and respiratory failure. Atropine is a colourless substance and would be a very attractive weapon for a prospective poisoner if not for one major drawback: its bitterness can be detected even in minuscule concentrations. One biologist, however, would use this to his advantage.

In August 1994, eight people were admitted to hospital for suspected atropine poisoning. The only connection between them was that they had all drunk bottles of tonic water from the same shop. But how had they come to be contaminated? The answer laid with Paul Agutter.

A member of the University of Napier biomedicine research group specialising in toxicology, Paul knew of atropine's qualities and came up with an impressive plot to murder his wife. It would be easy for him to order in the chemical without suspicion due to his position at the university, and even easier to spike Mrs Agutter's gin and tonic, knowing the bitterness of the nightshade would be masked by the bitterness of the tonic. However, due to their marital issues, Agutter knew he would be the prime suspect should foul play be suspected. He therefore took steps to avoid detection. By spiking several bottles of tonic water at the local supermarket, he hoped to cause a spate of poisonings that would misdirect the police.

However, he was not as clever

as he thought. Due to the larger than necessary dose, Mrs Agutter noticed her drink was more bitter than usual and so drank only part of it. Unfortunately, the amount she consumed could still prove deadly and it wasn't long before Mrs Agutter began displaying symptoms of atropine poisoning. In an effort to appear innocent, Paul Agutter called his local doctor for help. He wrongly assumed the doctor would not answer at that time of night and that his call would be ignored. Unluckily for him, an on-duty practitioner heard the urgent message and immediately called for help. Mrs Agutter was saved that night, and her husband was later arrested for attempted murder. The poisonings set in motion a nationwide panic, and 50,000 bottles of tonic water were destroyed as a result. Of those tested from the same supermarket, along with the eight confirmed victims' bottles, a further six bottles contained traces of atropine.

Agutter had also failed to dispose of his own bottle, which suspiciously contained a much larger amount of atropine than the others analysed. Further traces were found in his car, and this evidence was enough for Paul Agutter to be convicted and sentenced to 12 years in prison.

Atropine, whilst poisonous, can be used in controlled circumstances for anaesthesia. But mistakes have been made. In 1971, three children were accidentally given a 600 mg dose of atropine sulphate, instead of the recommended 0.6 mg. They all suffered from severe hallucinations and hypertension, but luckily treatment was available at the hospital and all three children survived. We can be assured that, in any situation, atropine is definitely not a chemical to underestimate.



- 1. **Red Wolf** USA
last wild sighting: 1980
reintroduced: 1987
current wild population: 15
- 2. **Golden Toad** Costa Rica
last sighting: 1989
- 3. **Crested Ibis** East Asia
last sighting in Japan: 2003
reintroduced: 2008
current wild population (Japan): 480
- 4. **Acorn pearly mussel** USA
last sighting: 1974
- 5. **Spix's Macaw** Brazil
last wild sighting: 2016
reintroduced: 2022
current wild population: ~20
- 6. **Pait** Phillipines
last sighting: 1982
- 7. **St. Helena Olive** S. Pacific
last wild sighting: 1994
- 8. **Large Blue Butterfly** Europe
last sighting (UK): 1979
reintroduction: 2022
- 9. **Yunnan Lake Newt** China
last wild sighting: 1979
- 10. **Jalpa False Brook Salamander** Guatemala
last wild sighting: 1976
- 11. **Chiriqui Harlequin Frog** S. America
last wild sighting: 1996
- 12. **Western Black Rhino** Cameroon
last wild sighting: 2006
- 13. **Longjaw Cisco** USA
last wild sighting: 1967
- 14. **Marsh Fritillary** UK
lowest population: 1970s
reintroduction: 2018
- 15. **Villa Lopez Pupfish** Mexico
last wild sighting: 1990
- 16. **Cambarellus alvarezii** N. America
declared extinct 2010
- 17. **Magnolia sinica** China
lowest population: 10, early 2000s
restoration: 2005
current wild population: 400+
- 18. **Socorro Elf Owl** Mexico
last wild sighting: 1931
- 19. **Christmas Island Shrew**
last wild sighting: 1908

FOR SOME, A SECOND CHANCE
MOLLY RAINS

BACK FROM THE BRINK

MOLLY RAINS

"We live in an age of mass extinction. Can species reintroduction programmes breathe life back into the Anthropocene?"

Rapid panting and quick footsteps in the mud: I heard the red wolves before I ever saw them. When the sound reached us through the trees, the other interns and I drew a collective breath, glancing at one another as we scrambled through the undergrowth behind our guide. The wolves knew we were coming. When we emerged from the thicket and approached to peer at them through the towering chain-link fence, they were already staring back.

There were two wolves waiting within the enclosure, secured behind a series of locked fences and tucked away among the swamps, forests, and farmlands of

eastern North Carolina. The female paced incessantly along a slick path she'd worn into the mud. The male, more subdued, settled down to watch us. He was thirteen years old, and weighed about sixty to seventy pounds, caretaker Kim Wheeler told me. When the male wolf's last den mate died, she said, he covered up the body with soil and pine needles. Kim had never seen another wolf display such behaviour.

Even in captivity, a red wolf is an impressively rare sight. The pair I encountered in 2021 were members of a captive population numbering about 240 animals. In the wild, the red wolf population consisted of only ten known wolves, all found within one remote patch of swampy North Carolina wilderness. At the time of writing, that number has increased to about fifteen. This is a far cry from the thousands-strong population of red wolves that roamed the eastern US before their extirpation – but considering that these animals were declared extinct in the wild only 43 years ago, their presence on the landscape today is remarkable.

"Today, reintroductions are becoming more commonplace."

The initiative that brought red wolves back to North Carolina was groundbreaking when it began in the late 1980s. Today, reintroductions are becoming more commonplace. In Kent, wild bison graze on British grass for the first time in over 12,000 years. The California Condor soars again after its 1987 extinction from the wild. And, this year, after a four-century absence from the UK, the Eurasian Beaver is busy damming streams in Scotland once more. These cases represent tentative successes in the young field of restoration ecology, in which researchers attempt to remedy human disturbance by managing habitats and reintroducing species to their native ranges.

I say tentative because ecosystem restoration is uncertain business. No species demonstrates this better

than the red wolf. In the 2010s, after increasing for more than two decades to a high of 130 animals, the wild red wolf population began to shrink rapidly. "There were some really dark days in there," Kim Wheeler told me when we spoke this spring. In addition to helping care for the programme's captive wolves, Wheeler is also the Executive Director of the Red Wolf Coalition in Columbia, NC, an organization which supports the restoration of the red wolf by US Fish and Wildlife.

Since its inception, the red wolf programme has contended with habitat loss, climate change, and the long-term effects of inbreeding, as the population was founded by only fourteen survivors back in the 1980s. But notably, Wheeler said, the drop in numbers within the last decade has been driven by direct human activity. This is supported by US Fish and Wildlife's data on wolf deaths. It wasn't until 2012 that gunshot and vehicle strike became the first and second causes, respectively, of red wolf mortality. That was the same year that the population began its rapid decline.

"Ultimately, it seems that public opinion will determine the fate of the red wolf."

"Wolves really resonate with people, either positively or negatively," Wheeler told me, referencing the wide range of opinion surrounding the reintroduction project. Either extreme can pose a challenge to the programme. On one end of the spectrum, some anti-wolf vigilantes illegally kill the animals ("people are taking things into their own hands," warned one local landowner at a 2018 town hall meeting). On the other, overenthusiastic wildlife watchers can inadvertently habituate the wolves to human presence, setting the stage for future encounters with those who may have darker intentions.

Ultimately, it seems that public opinion will determine the fate of the red wolf. Fortunately for the wolves, there are many people with whom they resonate positively. "They're beautiful, resilient

animals. Even with all the human persecution, they just want to survive," said Wheeler. She told me about the many people who have dedicated their lives to this project; the programme's US Fish and Wildlife Field Coordinator even printed his personal cell number on several local billboards. Now, locals call him day and night to share sightings or concerns.

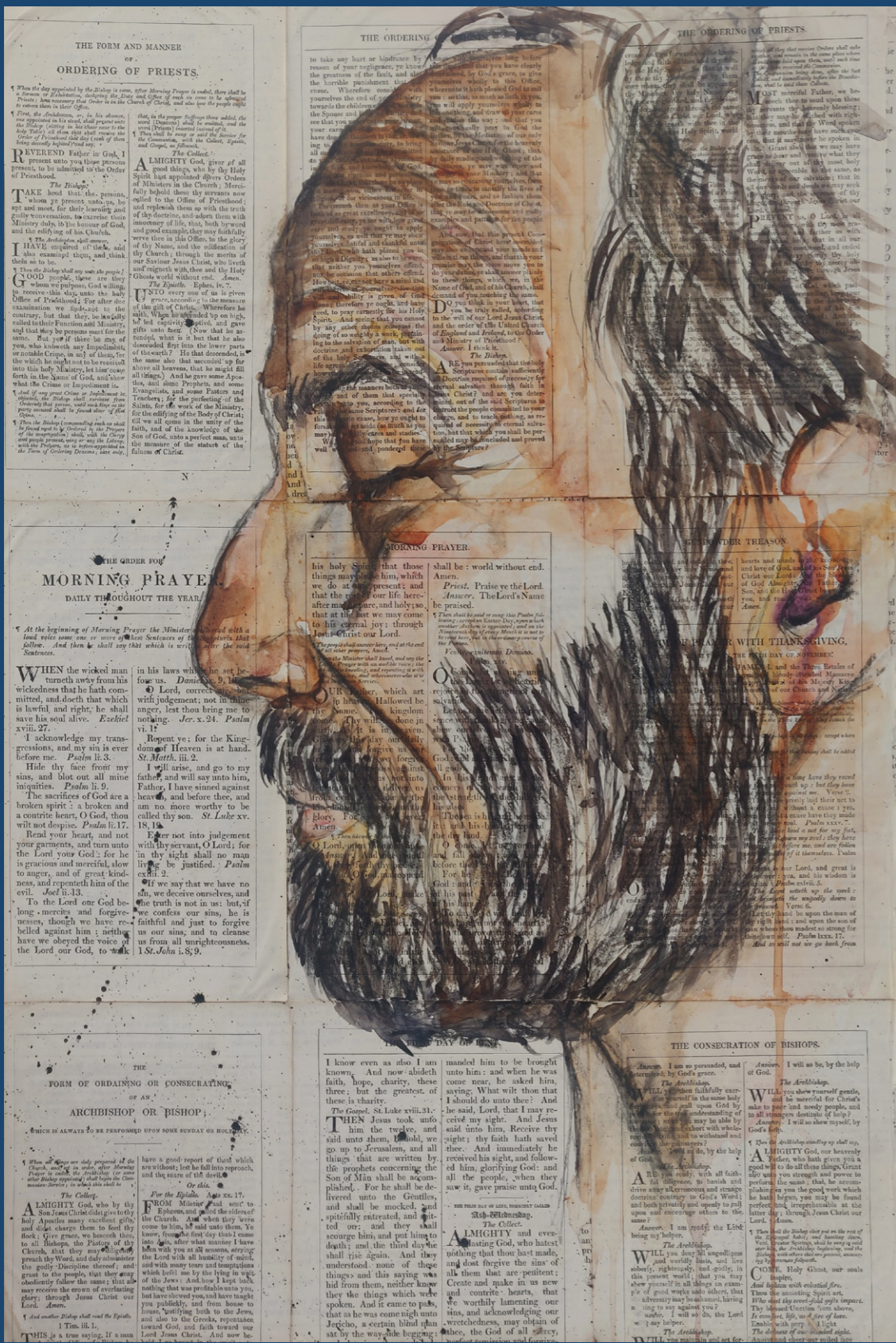
"In order to keep the programme running, the red wolf team must demonstrate consistent progress, and now is a crucial moment."

This is all part of an effort to increase transparency, strengthen trust with local communities, and build the red wolf programme back better. In order to keep the programme running, the red wolf team must demonstrate consistent progress, and now is a crucial moment. Wheeler says she is optimistic, describing improved relationships between the programme and partners at the state and federal levels, as well as ongoing conversations with local communities. Another good sign is that the wild population is growing once more: last spring, for the first time in four years, a litter of pups was born in the wild. For now, at least, things are looking up.

As global biodiversity fades daily, extinction has become a hallmark of our era. Embarking on efforts at species reintroduction in the face of such destruction requires intrepid optimism. In restoration ecologists' vision of the Anthropocene, human technologies breathe life back into dying ecosystems instead of hastening their demise. Forests, grasslands, and fisheries thrive. Balance is restored. The optimism of these scientists empowers us to strive for a better, richer future. It is the hope inherent to restoration ecology that makes the discipline so promising, not only for each bison, condor, and dark-eyed wolf, but also for each one of us that shares their world.

DIVING INTO GRIEF

MINI MUDANNAYAKE



CHRISTIAN DEPARTURE
SOPHIE BRYER @SOPHIEBRYERART

Love, longing and loss. Not long after the pandemic was in full swing, and everyone was becoming all too familiar with that odd crack in their ceiling they had never noticed before, I found myself soaking in these feelings. Reaching my hand out into the air, I began to trace its intricate branches whilst my thoughts drifted to my uncle, who had passed only a year before.

It seemed that in the absence of seven-hour workdays, my mind had finally caught up with the loss I had experienced. As my arm flopped back down and my eyes looked over to the photo of my uncle carefully pinned against the wall, I realised that I was in the depths of grief.

What are these feelings?

Since lockdown had given me plenty of extra time, I decided to dive head-first into these feelings and uncover their complexities. To do this, I first had to ask: what even is grief?

This is harder to answer than you would think, because grief is so personal - there is no consensus on how people feel and behave.

Generally, grief covers any form of distress in response to loss, whilst bereavement specifically describes experiencing the death of someone close to you.

“We need only to look at the greatest works of literature to observe how people have made the connection between love and grief.”

As definitions go, these offer very little, and don't mention that grief encompasses not only sorrow, but happiness and love too. We need only to look at the greatest works of literature to observe how people have made the connection between love and grief. Shakespeare famously had our star-crossed lovers choose death in favour of living with the loss of each other.

But, putting aside the need for an exciting plot, the devastating end of Romeo and Juliet raises the question: why does grief exist in the first place?

How we evolved to love and grieve ?

From an evolutionary perspective, our expression of grief doesn't make sense. Losing sleep and having no appetite aren't

conducive to survival. But in nature, we see extraordinary cases of animals using copious amounts of energy to engage in mourning rituals.

The most unusual can be observed in primates, where mothers are known to carry their dead infants' corpse for several days or even weeks. Researchers have proposed theories to explain why primates might engage in this behaviour.

“It's a bit of a tricky one because there are so many theories, but my money is on it being an extension of maternal care,” explained UCL evolutionary anthropologist Alecia Carter, whilst speaking on the Many Minds podcast. “Primates particularly are very well bonded with their offspring. They have to be because they lactate for them.”

Furthermore, a compilation of over 400 cases of primate mourning behaviours have suggested that these behaviours were the by-product of a strong mother-infant bond. Infant age was correlated with how long a mother spent carrying her dead infant, with the deaths of younger infants producing more bouts of corpse carrying.

At this age, when an infant is at its most vulnerable, female primates experience the highest level of maternal hormones, which drive their mothering instinct. Once an infant is weaned, the concentration of maternal hormones decreases in the blood, and so the bond is less intense and less grieving behaviour is observed.

“The avoidance of loss is reminiscent of a much broader issue in our society - the avoidance of death.”

The pornography of death

After mustering up the energy, I walked over to my uncle's photo. As I studied his smiling face, I wondered why my grief had returned. It had been over a year since he had died, and I remember making peace with his death at a life celebration, surrounded by my family and friends. But then it occurred to me; I had allowed myself only three weeks to mourn before I flew back home. No more mourning. No more feelings of loss - or so I thought.

The avoidance of loss is reminiscent of a much broader issue in our society - the avoidance of death. Anthropologist Geoffrey Gorer highlighted this culture of avoidance in his argument that, just as sex has become increasingly unmentionable, death has become

increasingly unmentionable. The eventuality of death and the subsequent grief we all face have become unappealing to us.

“In other words, sharing the burden of our fears can allow us to be better prepared for the end of our lives.”

But there is hope. As Gorer puts it, the ‘pornography of death’ can be overcome if we collectively embrace the reality that what we have will eventually be lost. This could include conversations with friends and family about their own expectations of death. In other words, sharing the burden of our fears can allow us to be better prepared for the end of our lives.

Inspirational mourning

We can look to other cultures acceptance of grief as ‘inspiration’. Psychologist Pittu Laungani has described traditional mourning rituals in India. Here, an entire community comes together to grieve. More than fifty neighbours, relatives and friends will visit a widow's house every day for mourning, where participants talk about the deceased in turn and weep communally without holding back.

While these rituals may seem bizarre, similarities can be drawn between their features and conventional therapy for complicated grief. In a 2014 study by Columbia University, a holistic complicated grief treatment was twice as effective as standard interpersonal psychotherapy.

The complicated grief therapy required participants to take an active role in their mourning: a grief-monitoring diary was introduced, and therapy was undertaken in conjoint sessions with a significant other. Participants also engaged in ‘imaginal’ and ‘situational’ revisiting, where they underwent prolonged exposures to scenarios that reminded them of their deceased. Like mourning rituals in the East, these procedures encourage individuals to share their grief with others, but they also ask them to acknowledge the permanence of death through exposure to that they have lost.

My journey to acceptance

And so, by diving into the depths of grief in search of answers, I instead found myself appreciating it. It was an expression that I had loved, and I could see the beauty in it. What I had once avoided, I now embraced with open arms.

THE ENVIRONMENTAL IMPACT OF DYING

VANESSA HAYES

“And burial, like anything else humans do, has an environmental impact.”

You’ve probably thought about how you want to be buried: “a coffin sounds too constricting, but cremation lacks fanfare—I want to be cryogenically frozen and catapulted into space.” For some, it may be pleasant to think of death as a return to nature: an end to your use of natural resources and a beginning to your payment back as nutrients and energy. However, as the number of humans on earth has skyrocketed in the past few centuries, so has the number of humans who need to be buried. And burial, like anything else humans do, has an environmental impact.

Last year, 75% of all UK burials were cremations and 25% were traditional ground burials. Whilst some other methods are legal in the UK, they make up a negligible portion of burials overall. Average costs in the UK are £4,794 for traditional burial, £3,673 for standard cremation, and £1,511 for direct cremation (where loved ones are not present). When deciding on a burial method, many consider the wishes of the deceased, religious beliefs and practices, and cost. Whilst an increasing number of people want to consider environmental impact, many lack knowledge of, or access to, some of the most eco-friendly methods.

Traditional forms of burial negatively impact the environment in three primary ways. First, they release carbon dioxide and other greenhouse gases into the atmosphere. Additionally, toxins in the body, either from medications and exposures a person had in their lifetime, or from those introduced during the burial process, are released during decomposition, threatening the health of

the living. Lastly, space used by the dead means less space for the living, leading to urban expansion and sprawl, which harms biodiversity and increases carbon emissions over time.

Cremation, the most popular burial method, directly releases an average of 534.6 pounds of carbon dioxide per body. Approximately 485,000 cremations happened in the UK in 2022, releasing almost 118,000 metric tonnes of carbon dioxide. Additionally, toxins in bodies and sentimental objects cremated with the dead get released into the atmosphere, affecting air quality for the living. Despite its popularity, cremation is not ideal from an ecological perspective.

“Despite its popularity, cremation is not ideal from an ecological perspective.”

The second most popular method, traditional burial, has different environmental impacts depending on whether loved ones choose a natural or embalmed burial. Embalming is used to preserve the body by draining blood vessels and body cavities of natural fluids and filling them with a preservative solution of formaldehyde, alcohols, emulsifiers, and other substances. This allows more time for loved ones to plan a funeral, as opposed to the time constraint for natural burials. These bodies will still

decompose eventually—but at a much slower rate, taking up space for longer. Furthermore, the toxic chemicals from the preservative fluid leach into the soil and groundwater, posing health risks to wildlife and humans.

“Another choice impacting the eco-friendliness of a burial is casket selection... Fortunately, these sustainable options are all more affordable than traditional coffins.”

Another choice impacting the eco-friendliness of a burial is casket selection. Most coffins are hardwood, metal, or concrete, which biodegrade slowly and require significant energy to acquire and construct. More eco-friendly options include cardboard, wool, bamboo, willow, and banana leaf caskets. Many of these are accepted at Natural Burial Grounds, which are sites designed to develop into woodland or meadows once full. Fortunately, these sustainable options are all more affordable than traditional coffins.

Yet, eco-friendly coffins and natural burials just scratch the surface of the sustainable possibilities. If you expand beyond traditional methods, terramation



THE FADING/DAWNING OF THE LIGHT
BENEDICT DOUGLAS-SCOTT

and aquamation are two options that will substantially decrease the environmental toll of your final rest.

In terramation, or compost burial, the body is laid on organic material (like straw and alfalfa) in a large metal box. Whilst there, loved ones say goodbye and offer any organic, biodegradable sentimental items. Next, the lid is closed and oxygen is cycled through the vessel, stimulating natural microbes to decompose the body rapidly over just 30-60 days. Lastly, inorganic materials, like implants and medical devices, are removed and the soil is left to rest for an additional 30 days. The resulting nutrient-rich soil is returned to the family and can be used in gardens or scattered like cremated remains. Terramation is not yet legal in the UK, but at the time of writing the Church of England is considering supporting it. This method uses one tenth the energy that cremation uses and decomposes a body much faster than when buried. Currently, in the US

where terramation is legal, its price tag, of \$4,950 USD, is most comparable to traditional burial.

“Cremation and burial are so 2022; I want to go green and dissolve in water like the Wicked Witch of the West.”

Aquamation, also known as alkaline hydrolysis, resomation, or water cremation, is a sustainable option coming to the UK in the very near future. The body is placed in a stainless steel vessel filled with a solution of 95% hot water and 5% strong base, usually either potassium hydroxide or sodium

hydroxide (lye). Over the course of just 4 hours, the organic matter of the body is degraded by the basic solution, leaving only bones. These are ground down until they resemble ashes and then returned to loved ones. Companies claim the resulting liquid can be used as a nutrient-rich fertilizer. In the UK, aquamation is already legal, though it has not yet been used in practice. Resomation Ltd., which developed the process in Leeds, is looking to open its first facility in spring of this year. Like terramation, aquamation uses one tenth the energy that cremation uses. In the US, where it is legal and practised in 28 states, the average cost is \$1,695, making it comparable to direct cremation and one of the cheapest options available.

So, the next time you find yourself considering how to go, give a thought to sustainability: “cremation and burial are so 2022; I want to go green and dissolve in water like the Wicked Witch of the West.”

“We often live our lives not thinking about death. For some people, ignoring the subject isn’t really an option.”

We often live our lives not thinking about death. For some people, ignoring the subject isn’t really an option.

Dr Omer Aziz is constantly preparing for death. Aziz is a Consultant Colorectal Surgeon at The Christie, Manchester’s comprehensive cancer centre, where he treats people with advanced gastrointestinal cancers or rare tumours. His patients often have less than a 50% chance of being cured but could live longer with treatment.

According to Aziz, in the cases of routine illnesses and clean-cut treatments, decisions are made by looking at the black-and-white facts. But when it comes to cancer treatment, it’s more of a grey area. Cancer isn’t always curable, but there are opportunities to improve patients’ quality of life.

“When you spend a lot of time with them [cancer patients], you get perspectives on life that you don’t get normally,” Aziz says. “Some people are willing to go through hell and back to achieve something, and others will say, ‘I don’t want to do that, I want to live my life the way I do as long as I can, and then I’ll go.’”

“Making decisions on whether to have treatments and what paths to pursue can be difficult.”

Everyone has different thresholds of risk that they are willing to accept. Aziz notices that there are often different trends for people of different ages. For example, he noted that people in their 30s or 40s may lean towards getting intensive surgery in the hopes they live longer, but people in their 70s or 80s might decline extra exhausting treatment because their bodies might not be able to handle it as well. Making decisions on whether to have treatments and what paths to pursue

can be difficult.

“When you’re the person who has cancer, you’re focused on yourself and know your situation better than anyone else. You are able to make cold, calculated decisions,” Aziz says.

For the patient’s family members, the decisions can be much more difficult, especially if the patient’s choice is not one the family wants. “For the family, it’s a very emotional decision, so you have to get your family on board with whatever decision you’ve made.”

Aziz has these conversations about treatments, risk, and difficult decisions several times a week as part of his work. Before the conversations with the patients, he and the entire medical team go through the patient’s past treatment and current scans to determine the best paths forward. Then, they meet the patient and discuss the conclusions they’ve made. It’s important to understand and get to know the patient during this consultation to figure out what sort of person they are and which options they might lean towards. Some patients might want to be guided by the medical team, while others might have a clear view of what they want.

When it comes to making tricky decisions, it is more nuanced than perceiving the glass as half-empty or half-full. Patients have to weigh up the benefits and the risks. As Aziz explains, if there’s a 90% chance that the treatment may not work and could end up doing more harm to healthy cells in the body, there are generally two very different approaches: ‘90% is too high, I’m not going to risk it’ or ‘10% is better than nothing, it’s a no brainer – I’ve got to try!’

“Do something every day that means something to you and your life”

“It’s a privilege to go through that part of people’s lives with them. As difficult as

that might be, in times like this – that’s when you see the best in humanity,” Aziz says. “It makes you value your life a lot more, it makes you live your life a lot more. If you’re not in this space, you might take your life for granted.”

To Aziz, valuing life means appreciating and enjoying things instead of letting them go by. For example, he takes time each day to speak with his children and wife; he lives a part of their lives with them every single day instead of saving the effort and connection for the holidays. He acknowledges that he might have to sacrifice parts of his career or be late to an event in order to spend time where he wants to. There was a time when he would never drop his children at school, but now he makes a conscious effort to spend that special time with them a few times a month. In the past decade he took up running and now runs marathons. “Do something every day that means something to you and your life. I understand the value of life more than I’ve ever understood it.”

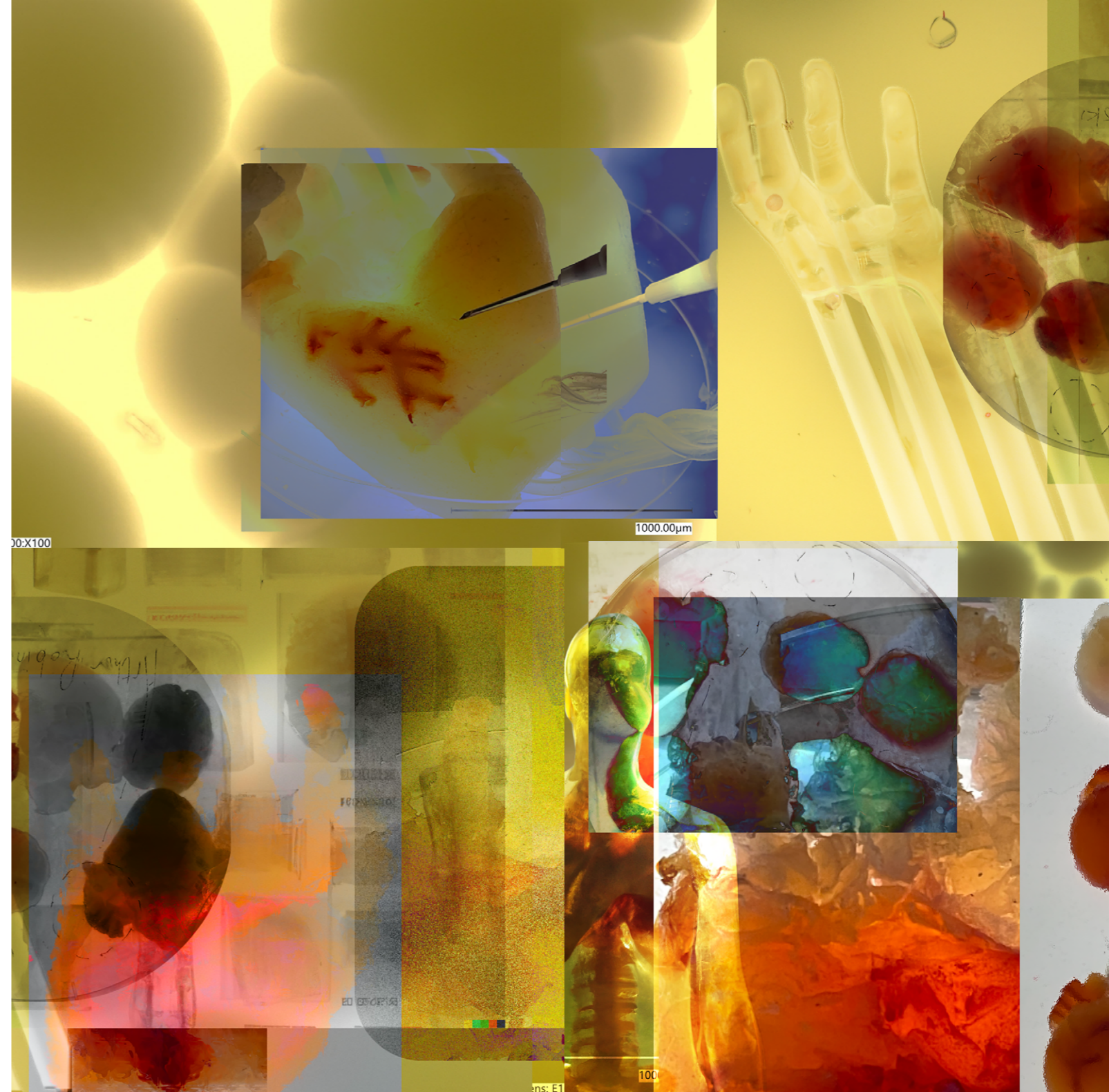
“It’s not as if I want to die, but I’m not afraid of it.”

Aziz is not afraid of death. He lives his life by asking himself the question: “if I were to die tomorrow, would I die happy? Would I be satisfied with what I have achieved?”

“I’ve lived a very full life,” he says. “I’m in my early forties, I’m pretty happy, no regrets, nice family, rich experiences in my career. It’s not as if I want to die, but I’m not afraid of it.”

Aziz is constantly preparing himself for death as a consequence of his line of work. He doesn’t think constantly being reminded of his mortality is the best side effect of the field, but it’s true and pushes him to live better.

“Death is obviously inevitable and you’re on this life journey, but there’s something other than living and dying: it’s how you live your life.”



AUS BERLIN; 5-METHYLCYTOSINE
GUS ROBINS('GUSKI')

LESSONS ON LIVING FROM A CANCER SURGEON

IMAAN MOIN



RIDING THE MAIN SEQUENCE



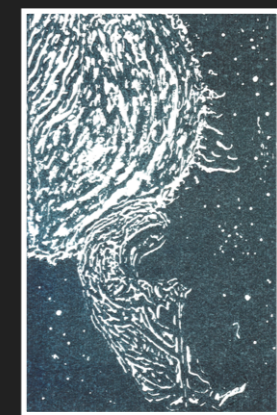
THE GIANT'S LABOUR

ART OF THE ISSUE

This series of woodcuts is focused on the life cycle of a medium sized star, like our Sun, and its trajectory over the next few billion years. Our Sun is a main sequence star: it fuses hydrogen to form helium. When it has depleted its hydrogen stock, it will swell to become a red giant several thousand times bigger than its current size, before collapsing back into a white dwarf, fuelled not by fusion but by electron degeneracy. Here it will remain for many tens of billions of years until it becomes the (currently theoretical) black dwarf, emitting no heat or light.



THE WATCH OF THE WHITE DWARF



THE WANING DWARF



THE LIGHTLESS STAR

“It was the brightest light you could ever imagine,” Mr Zanville shares. “Everything you could ever want, it was.”

On November 8th 2013, a family friend of mine, David Zanville, was playing indoor tennis on a Friday afternoon in his hometown of Toledo, Ohio, just like always. Forty-five years old and in great health, Mr Zanville was a bit thrown off when he started feeling uneasy with a cramp in his leg. Walking off the courts, Mr Zanville headed down to the lobby to call his wife.

Everything leading up to this moment and afterwards is a blur: just seconds later, Mr Zanville’s arteries would block all blood flow to his heart, causing him to lose consciousness and collapse to the floor. His heart would stop beating altogether, and all oxygen flow to his brain would cease. Mr Zanville would be rushed to the hospital, where doctors would discover that he had suffered a cardiac arrest, and he would be put into an induced coma where his body temperature would be lowered to 32° - 34°C. The hospital staff would have no idea how much damage Mr Zanville’s brain had suffered, or if he would wake up at all. On the fifth day, however, he would wake up – though without the slightest clue about what had happened.

But Mr Zanville would recall one memory from this time; or rather, a continuous loop of a memory so profound that it would permanently alter his outlook on life. What was it, then, that Mr Zanville saw in those moments that his heart had stopped beating completely?

What Mr Zanville experienced is known as a near death experience, or an NDE. A near death experience is classically defined as “an intense psychological experience... characterised by an atypical state of consciousness occurring during an episode



David Zanville pictured with his granddaughter Gwendolyn
Photograph taken by Lucy Zanville

of apparent unconsciousness and usually in life-threatening conditions”. NDE’s share a number of patterns from person to person: floating out of the body, “seeing the light”, meeting loved ones, and having one’s life flash before their eyes. In addition to these visual themes, survivors of NDE regularly report feeling completely pain free and euphoric. Whilst not all of these experiences are blissful - in fact, some can be described as frightening- extreme peace seems to be quite common.

Mr Zanville’s experience aligns with several of these themes. He describes his experience as a highly visual one, in which he left his body and ascended rapidly into the sky and then solar system, where he approached a vortex of bright white light. “It was the brightest light you could ever imagine,” Mr Zanville shares. “Everything you could ever

want, it was.”

After reaching the light, Mr Zanville says that he instantly reversed direction, began hurtling back down toward an unrecognisable town and ultimately crashed into the earth with an explosion of green and blue colour, accompanied by an indescribable feeling of beauty. He takes his time recounting this cathartic scene to me, choosing each word carefully in attempt to properly convey just how comforting it was. “It was the best thing I’ve ever experienced. I can take myself there any time. It makes me emotional just thinking about it.”

Related experiences have been reported with certain psychedelics, particularly ones that activate serotonin 2A receptors. Interestingly, research has shown that directly stimulating these receptors with electrodes triggers

feelings of “mystical oneness”, or a general feeling of goodwill toward and connectedness to all things. A hallucinogenic known as N,N-Dimethyltryptamine (DMT) in particular is a very powerful, short-acting hallucinogen, that has been known to induce out of body experiences, meeting godlike entities, and experiencing themes of death, along with other related NDE characteristics.

Such observations led neuroscientists to examine the possible link between DMT and NDEs. One study found that, as mice were dying following cardiac arrest, their brains released massive amounts of DMT. There is also evidence that humans have the two enzymes required to synthesize DMT, though it is still unknown whether the human brain truly produces this molecule.

The theory of DMT release in the dying brain

PEERING INSIDE THE DYING BRAIN

JULIE HOEFLINGER

could explain the psychedelic quality of near-death experiences, but there is something very unique that separates them from psychedelic trips: the themes are strikingly similar from person to person. And why, from an evolutionary standpoint, would the brain develop a mechanism that starts releasing massive quantities of a hallucinogen in the last moments of life? How might that increase our chances of survival? This is a question that science cannot yet answer – and may never be able to.

“Scientists initially believed that brain activity would be decreased in the seconds leading up to death as the brain starts shutting down – but this was not the case.”

It is impossible to say exactly what was happening in Mr Zanville’s and other NDE survivors’ brains during these experiences. The closest scientists have ever come to finding out was revealed in an unlikely study published in July of 2021. An 87-year-old man was connected to an electroencephalography (EEG), which measures brain activity, when he went into cardiac arrest and passed away. Scientists initially believed that brain activity would be decreased in the seconds leading up to death as the brain starts shutting down –

but this was not the case.

In fact, the complete opposite occurred: researchers stood in bewilderment as they examined the EEG data revealing increased high-frequency activity in the patient’s brain in the final moments of his life, particularly coming from the visual cortex. Is it possible, then, that our lives may actually “flash before our eyes” as we pass away?

Mr Zanville recovered all functions from before the incident and is currently living a happy, healthy life with his wife, Carrie, and his adult children Lucy, Halley, and Jack. “Nothing is the same, not even ten years later. My life ended on that day,” Mr Zanville shares. As I speak to him, he smiles from ear to ear holding his newborn grandchild, Gwendolyn, who nestles into his long beard as she sleeps.

“I have a new life. I have this deep love for all people. Everything I see now, I’m looking through different eyes. And I’m not scared of death anymore.” Mr Zanville’s eyes twinkle with a profound sincerity, and I believe him – that maybe dying is not something I should spend so many of my days fearing.

Mr Zanville pauses for a moment, trying to fully encapsulate the lasting impact of this ineffable experience but shaking his head as all words fall short of it. He leaves me with this: “It changed everything, Julie. Everything.”

PARTUM CEREBRI

SOPHIE BRYER @SOPHIEBRYERART



PROTECTING AGAINST AN AGRICULTURAL APOCALYPSE

KATIE TOMSETT



INVEST IN YOUR FUTURE!
GRAPHICAI (MONTY GOULD W/ MIDJOURNEY)

The phrases ‘Doomsday Vault’, ‘Noah’s Ark’, or ‘Humanity’s Insurance Policy’ do not immediately conjure up images of shelves of unassuming boxes, brimming with seeds. Yet these grandiose labels have all been used to describe exactly that – the Svalbard Global Seed Vault, a repository of over 1 million seeds from around the world. In the event of an agricultural catastrophe, these seeds could prove a vital resource to protect against climate change and serve as a back-up against global crises.

Safely tucked away on Svalbard is a tunnel carved into the side of a mountain that leads to three chambers large enough to store up to 4.5 million seeds. For now, only one is in use, its door often encased in a layer of ice with the thermostat set permanently to a frosty -18°C . Freezing clean and dry seeds preserves them for longer and reduces the need for the regular replacement of viable seeds. The surrounding mountain and permafrost mean seeds would stay below freezing even in the event of a refrigeration meltdown.

“This open system, unimpeded by political constraints, has led to unlikely storage neighbours, like seed boxes from North Korea and the USA stacked side by side.”

Svalbard is an ideal location for a ‘Doomsday Vault’ for reasons beyond the climatic. The Norwegian archipelago is the midpoint between Norway and the North Pole. Its remoteness, good infrastructure, and political stability make it a secure host for the world’s largest collection of agricultural diversity. The size of the collection was enabled by the vault’s offer of free storage to any gene bank or nation that wishes to contribute to the safeguarding of global food security. This open system, unimpeded by political constraints, has led to unlikely storage neighbours, like seed boxes from North Korea and the USA stacked side by side.

The doomsday this vault is preparing for is not necessarily as apocalyptic as nuclear war or alien invasion, although it could still prove useful in these instances. Instead, one of its main purposes is to provide a back-up to individual seed collections against localised doomsdays like natural disasters or conflict. Since opening in 2008, Svalbard has only seen one withdrawal to replenish lost seeds. In 2012, the Syrian civil war forced the Aleppo-based headquarters for the International Center for Agricultural Research in Dry Areas (ICARDA) to relocate. After re-establishing themselves in Lebanon and Morocco, ICARDA made a withdrawal of their previously deposited seeds from Svalbard. These were then successfully planted, grown, harvested, and swiftly sent back to Svalbard, where they continue to provide ICARDA an agricultural safety net.

These are not the only seeds to have been caught up in a history of conflict before making their way to Svalbard. Seeds from St. Petersburg’s Vavilov Research Institute can be found inside the vault. The Vavilov Institute collection was thought to hold such importance in safeguarding humanity’s future that several scientists starved to death whilst defending it from the German army during the siege of Leningrad. During the siege, the scientists refused to indulge in any of the precious seeds or stores that surrounded them.

“Climate change exacerbates these issues and alters the growing conditions of crops worldwide, leaving our future food security in a precarious position.”

Seeds from the present-day Vavilov Institute contribute to Svalbard Global Seed Vault’s mission to futureproof humanity against disastrous food insecurity. So how close are we to a humanity-destroying crop crisis? Well, some argue we are currently watching one unfold. To cope with the rapidly growing world population, industrialised agriculture has turned to mass production

of standardised produce. The result is greatly reduced genetic diversity in crops, which leaves them vulnerable to pests, diseases, and extreme weather. Climate change exacerbates these issues and alters the growing conditions of crops worldwide, leaving our future food security in a precarious position. Should scientists ever need to increase the resilience of agricultural crops, it is hoped that the seed varieties stored on Svalbard will have the genetic material required to do so. The stored seeds might one day help to increase yield or provide disease resistance in the unpredictable environmental conditions that may lie ahead.

“The seed bank on Svalbard is currently home to almost 6,000 different species.”

The seed bank on Svalbard is currently home to almost 6000 different species. Their two largest deposits are rice and wheat – these grains, along with maize, are estimated to make up over half the world’s caloric intake. The facility on Svalbard is not alone in its efforts. Globally, there are around 1700 seed banks. These are not all back-up systems like Svalbard; many provide active genetic libraries and plant science research opportunities. Seed banks have their own role to play in global efforts to preserve plant genetic diversity and protect humanity against an agricultural apocalypse.

However, it is worth noting that the Svalbard Global Seed Vault is not infallible. A period of permafrost melting in 2016 caused a leak in the vault’s entrance tunnel. Although no seeds were impacted, and the leak has since been repaired, it was concerning that this fail-safe had failed.

Claims of a 21st century ‘Noah’s Ark’ or even the act of preparing for a doomsday may be seen as a tad overzealous. However, seed banks have proved themselves to be an effective component of global plant conservation, especially with the looming threat of even greater crop instability from climate change. In the case of Svalbard’s Global Seed Vault, its function remains, for now, unaltered: store seeds in case of emergency.

THE IMMORTAL ARTISTS

EMMA TEGG



BREAKTHROUGH
MORENIKE CAXTON-MARTINS

Roy Stride of Scouting for Girls said it best: “Elvis isn’t dead cause I heard him on the radio.”

“The artist dies yet continues to exist in our thoughts and feelings, leaving behind an eternal imprint of their consciousness.”

He understood how listening to the ‘King of Rock and Roll’ belt out an unchained melody can bring us to tears. Or how Mozart’s “Requiem” gives us goosebumps in thrillers at the cinema 200 years after his death. Long after Leonardo da Vinci’s last breath, the *Mona Lisa* still shyly smiles at tourists every day. The artist dies yet continues to exist in our thoughts and feelings, leaving behind an eternal imprint of their consciousness. The book, poem, song or painting is their legacy, akin to offspring; art carries on the name of the creator and embeds itself into people’s experiences and memories.

Such pieces are somehow able to bridge completely different cultures and form connections over centuries. For Katie Porter, a coursemate on the MSc Science Communication, the poem “To a Mouse”, written by Robert Burns in 1785, is a piece of poetic art that still resonates with her

two and a half centuries later:

*But Mousie, thou art no thy-lane,
In proving foresight may be vain:
The best laid schemes o’ Mice an’
Men
Gang aft agley,
An’ lea’e us nought but grief an’ pain,
For promis’d joy!*

Katie finds the poem to be a “stark depiction of humanities tyranny in nature”. “Although it was written many years ago”, she said, “this couldn’t be more topical than in the present. The poem evokes a powerful guilt within me.”

“However, I do also take a more positive message from “To a Mouse”: we cannot predict the future, and over-planning and stressing is futile. It reminds us to focus on the present moment - after all, we must continue onwards ‘For promis’d joy!’. The narrator admires the mouse for this ability, as do I, and I think we can take a lesson from this mouse!”

“At its core, art in all its forms is an amalgamation of signs relaying meaning to us.”

How does an artist achieve this immortal status? The road to eternal life is paved with semiotics; a field that delves into the ways that signs and symbols convey meaning, often through culturally established conventions. Signs and symbols can be anything that communicates meaning or stands for something else, from the colour red’s associations with danger or desire, to a skull and crossbones’ connotations of death.

At its core, art in all its forms is an amalgamation of signs relaying meaning to us. Our perceptions may change the interpretation of the signs over time, but they nonetheless allow

us to enter a channel of posthumous communication with the deceased artist. The emotions expressed by an artist are encoded through the text, colour, notes and phonetic sounds to be decoded and experienced by the recipient of the art.

From a psychological lens, the immortal artist stems from the emotional response and connection we feel with the art. Cognitive science suggests that art forms lasting impacts by triggering emotional cues that humans have come to understand over time. For example, paintings of tranquil waters or soothing landscapes can elicit calm, as the colours and symbols are recognisable to the viewer and are, therefore, capable of evoking emotion. MRI scans of the brain revealed that the region of the brain that experiences emotion is activated when shown a pleasing piece of art. This can occur even if the conscious mind isn’t fully aware of the reason for the emotional response. Similarly, the oxytocin in our brains cannot always differentiate between reality and a performance: that’s why we cry at the cinema or in the theatre.

“...science nor scientists can achieve the same immortality as artists, perhaps because science embodies the rational and analytical sphere of the human experience, while art imbues the empathetic and expressive.”

In this realm of unconsciousness, the father of psychoanalysis, Sigmund Freud was also concerned with how artists achieved such immortal status.

Freud was an ardent art collector, and was fascinated by the lives and personalities of artists, particularly those from the Renaissance and ancient art. He developed a theory around art called “ideational mimetics”, which posited that artwork could cause an impactful exchange of energy between the viewer and the work of art, much like the experience of empathy. Freud believed this experiential exchange was an instrumental part of humanity’s civilisation.

Besides making us feel, art is evidently useful in our attempts to understand the brain and its cognitive processes. Not all of Freud’s theories have stood the test of time; his views on homosexuality and women are damaging and completely obsolete. In fact, most of his ideas have been replaced with new approaches to human psychology, which is itself reflective of the nature of science.

Scientific theories cannot be immortal as they must constantly be tried and tested against time – whereas art can live forever in the connections it forms. Science can bring us knowledge, but art can make us feel. Science is a tool, a method of investigation that gives us theories, explanations and predictions, whilst helping us understand ourselves better. Yet, the value of science as a process lies in its ability to constantly improve on itself, coupled with humanity’s tendency to reach for what lies beyond our understanding. For this reason, science nor scientists can achieve the same immortality as artists, perhaps because science embodies the rational and analytical sphere of the human experience, while art imbues the empathetic and expressive.

Scientific theories come and go. The nature of science is one of improvement; any sense of immortality would inhibit such progress. But emotions do not change, and in this timelessness, artists take up residence for good.

Homer Simpson, Obi Wan, even Big Bird – we’re used to seeing our favourite characters cycling through the five stages of grief on screen. The Kübler-Ross model - denial, anger, bargaining, depression and acceptance - is so ingrained in pop culture that it’s become an instantly recognisable signifier for grief. There are even fan theories about each member of the Avengers team representing a different stage of the model, and fans who believe each Loki film appearance portrays him cycling through a different stage. With such a culturally prevalent model, it’s not surprising that we’ve started to impose these ideas of grief onto our own experiences.

“The model was originally intended to help patients with their own diagnosis, and only later was it applied to family members or loved ones.”

Elisabeth Kübler-Ross was a Swiss doctor who moved to New York in 1958. It was here that she undertook her first psychiatry residency that began her drive for compassionate mental health care. Throughout her career she was a strong advocate for dignified palliative care and hospice care, becoming a spokeswoman for the ‘Death with Dignity’ campaign in 1972 after the release of her 1969 book, *On Death and Dying*. This book introduced the concept of the five stages of grief and was inspired by Kübler-Ross’s own previous work with terminally ill patients. The model was originally intended to help patients with their own diagnosis, and only later was it applied to family members or loved ones.

Regardless, the model seems to have

become synonymous with the grieving process, and whilst there is much debate in the psychology world about how helpful it is, we cannot deny its presence in the social psyche.

One of the problems with the five stages model of grief is that it shows a linear version of the grieving process. This sequential idea is often emphasised in TV shows and films, as grief often must be moved through quickly. 40-minute episodes and 100-minute films don’t often allow time to linger on grief, and audiences very rarely see a character regress or circle back in the process.

A 2016 study into grief counselling concluded that, although counsellors rejected the idea that grief was a finite process or had stages, many mentioned that the Kübler-Ross model was influential in their work. Some practitioners said clients were helped by the idea of a structured form of grief. Others emphasised the importance of helping a client through their own grieving process and wanting to shield patients from stigma related to ‘abnormal’ grieving practices.

“The repetition of this model throughout media gives us a preconception of what ‘normal’ grief is when, in reality, grief can strike us in all kinds of ways.”

On screen, the five stages model is often used as a comedic device, like when a character is grieving something trivial – Schmitt ‘grieving’ when Cece wants to get a boob reduction in *New Girl* comes to mind. What’s interesting about the comedic angle

is that it does ultimately signal to the watcher that there are ‘serious’ things to grieve about and ‘silly’ things to grieve about, and that the five stages model applies to both. The repetition of this model throughout media gives us a preconception of what ‘normal’ grief is when, in reality, grief can strike us in all kinds of ways. Because of this, people often don’t realise that leaving a job, moving house or having a long-term injury can all involve grieving.

There is much disagreement in the academic community about what can be considered a ‘normal’ grieving process. Due to grief models like Kübler-Ross’s five stages, anything more than ‘minor disruptions lasting a few months’ is categorised as a maladaptive grieving process. These ideas about what is or isn’t a normal grieving process have entered the social psyche and have resulted in some upsetting consequences.

Many assume grieving in stages is the ‘normal’ way to grieve, when, in fact, we have no idea for how many people that process might be natural. A 2022 study showed that some people can try to force themselves through a staged grieving process, and encourage others to do so, when it isn’t the natural grieving process for them. The need to force themselves to fit the social norm can even make the grieving process longer or more traumatic for some people. This pressure can also lead to some individuals seeking out grief therapy because they are concerned that they are not grieving ‘normally’, even if they don’t feel they need it. This can create negative associations with some forms of grief therapy.

Grieving is a complicated process, and not one that we understand particularly well. Grief can have physical impacts, last for vastly varied periods of time, and most importantly is not a linear process. It is extremely individual, so if the five stages don’t work for you like it did for Big Bird, that’s just your normal! The five stages model has provided some comedy classics as a writing device, but given the psychological uncertainty surrounding the model, perhaps that’s all it should be.



LOSING YOU
SOPHIE BRYER @SOPHIEBRYERART

THE KÜBLER-ROSS MODEL: SHOULD WE ACCEPT OR DENY THE FIVE STAGES OF GRIEF?

BECKY MCFARLAND

“Grieving is a complicated process, and not one that we understand particularly well.”

Over six million tourists each year make their way to Rome to visit the Colosseum, built by the ancient Romans between 70 and 80 A.D. The aqueduct Aqua Virgo, built in 19 BC, is still used to supply water to Rome. The same architect, Marcus Agrippa, built the Pantheon in 27 BC, which is still one of the most visited buildings in Rome due to its impressive dome. It is no secret that the Ancient Romans were very skilled architects. The infrastructure they built thousands of years ago is not only priceless artistically, but also sturdy enough to survive hundreds of generations. Ironically, despite considering ourselves to be the most technologically advanced generation, the quality of our infrastructure is much lower, and the concrete we use shows signs of corrosion faster than that of the ancient Romans.

What was the Ancient Romans' secret? Why were their buildings able to survive for millennia, while ours start cracking and decaying after mere decades?

Ancient Romans were very proud of their infrastructure and kept detailed accounts of their concrete production. Despite this comprehensiveness, it has been difficult for researchers to recreate the desired concrete in the lab. Previous theories suggested that the concrete strength arose solely from the presence of volcanic ash from near Naples. This ash, known as pozzolana, was very rare and expensive, and was even exported to other countries such as Egypt to be used for only the most structurally demanding constructions. While the presence of pozzolana does strengthen the concrete, Admir Masic and his team at the Civil and Environmental Engineering department at the Massachusetts Institute of Technology (MIT) have discovered that it isn't the whole story.

Admir Masic is a truly inspirational figure, not just because of his bright and innovative mind, but also because of the many challenges he has overcome. Before becoming a professor at MIT, he lived a very different life. In 1992, he was living with his family in Bosnia

when the war started. He and his family were forced to emigrate and became refugees, moving to Croatia and then Germany. He excelled in school, but his status as a refugee made him a victim of prejudice. Inspired by the Italian volunteers who brought his family food and resources during his time in Germany, he decided to learn Italian and moved to Turin to study Chemistry. After graduating in 2001, he went on to pursue a PhD in Physical Chemistry but was forced to leave Italy and moved back to Germany to work at a prestigious research centre. However, his lifelong dream was to become a professor, and eventually he accepted a position as a professor at MIT, where he has carried out his research aimed at unveiling the mystery behind Ancient Rome's concrete ever since.

“Modern concrete production accounts for 8% of global CO2 emissions... Furthermore, this self-healing concrete has the potential to prevent future structural disasters due to crumbling infrastructure, hence saving hundreds of lives.”

For years, it has been observed that Roman concrete contains white lumps. While most people attributed them to careless mixing, Masic and his team were not convinced. It did not seem typical of the Romans, who spent years perfecting their concrete, to leave in superfluous granules. In reality, these lime clasts, rich in calcium and not found in modern buildings, have been key to Masic's discoveries. These clasts were prominent and well-integrated features in the concrete and appeared to have reacted over time. After analysis in the lab, the team concluded that the material was made using a hot-mixing technique. They also deduced that, unlike previously hypothesized, quicklime was used instead of slaked lime. In the hot-mixing technique, quicklime, volcanic ashes and other

aggregates are mixed before adding water. When water is added to the mixture, an exothermic reaction occurs, which heats the mixture to over 200 °C and produces the famous white granules. As the concrete corrodes and water seeps through the cracks, the lime clasts dissolve and recrystallize along the crevices, sealing them over time.

To test their discovery, Masic and his team recreated this technique in the lab: they produced Roman-inspired concrete, mechanically fractured it and passed flowing water through it. The results were very promising: concrete containing lime clasts completely healed itself, while the control samples, which didn't contain lime clasts, remained fractured.

Modern concrete production accounts for 8% of global CO2 emissions: if concrete production were a country, it would have the third highest emissions, after China and the United States. Therefore, this research has the potential to revolutionize concrete production and drastically increase the longevity and sustainability of our infrastructure. Furthermore, this self-healing concrete has the potential to prevent future structural disasters due to crumbling infrastructure, hence saving hundreds of lives.

Recently, Masic founded a start-up called Dmat to start commercializing his new discovery. But his efforts have not been only academic, they also include a more humanitarian side. Unable to ignore his past as a refugee, and pushed by the desire to help others that share a similar life story he founded the MIT Refugee Action Hub (MIT ReACT), a free programme that gives refugees the opportunity to escape poverty and war through education.

This recent discovery should make us reflect on the grandiosity and intelligence of the Ancient Romans. Their empire dead for thousands of years has remained alive through art and architecture. This discovery should be taken as a sign that innovation can come from the past and not just the future. How many more secrets from ancient populations could revolutionize our modern world?

THE SECRET BEHIND THE IMMORTALITY OF ANCIENT ROMAN INFRASTRUCTURE

MARIA SOLE FRANCESCHI

“What was the Ancient Romans' secret? Why were their buildings able to survive for millennia, while ours start cracking and decaying after mere decades?”

THE EMBER
LI WANBO (EMBER)



TAPPING THE INEXHAUSTIBLE RESOURCE OF LIFE: ATMOSPHERIC WATER HARVESTING

MAHIL HOOLE

By March 2011, the Levant region had been ravaged by five consecutive years of drought. In desperation, 1.5 million rural Syrian inhabitants poured into urban centres, fuelling social unrest that would rapidly deteriorate into the bitter civil war that has since torn the country to pieces.

“Water scarcity has been, and increasingly will be, a driver of global inequality and conflict, bringing devastating consequences.”

This phenomenon is by no means unique. Water scarcity has been, and increasingly will be, a driver of global inequality and conflict, bringing devastating consequences. One potential solution is to directly condense water from the atmosphere – a ubiquitous source holding 13 quadrillion litres of water, around six times that of all the rivers on earth. Indeed, fog harvesting has been performed since antiquity, but is only possible in areas of high humidity. For large population centres around the Mediterranean, the Middle East, and Western USA, where water scarcity is a significant issue, this is not possible. So what hope is there for such dry climates where a third of the world’s population live?

A research team at the University of California, Berkeley have designed a miracle material that can pull significant amounts of water straight out of desert air. The material in question is an example of a metal organic framework (MOF). These are made of metal atoms that are joined together by linkers, which are small molecules largely made of carbon, to create an extended three-dimensional network. Within this network are tiny holes, or pores, where small molecules can adsorb – meaning they weakly adhere to the surface – before diffusing through the framework. Such materials have an endless range of applications, from filtration, to storage and drug delivery. The MOF in question is MOF-303, which is composed of aluminium atoms bound by linkers that contain nitrogen atoms. It is also sustainable: not only is aluminium an abundant and low-cost metal, but the MOF can be easily synthesised using green and non-toxic methods. Devices using the MOF to collect water

work on a system of water harvesting cycles. Upon exposure to arid air, the MOF begins to collect water molecules within its pores. Afterwards, the MOF is exposed to moderate heat – this could simply be the desert sun – which forces water out of the MOF. This creates a stream of warm, humid air, which, when cooled, produces slight condensation – pure, liquid water. The first prototypes the team used could only perform one cycle a day by adsorbing water at night and then releasing it during the heat of the day. Although this system required no electricity and a very basic set up, it was severely limited by the maximum water capacity of the MOF, which meant, overall, little water was produced. However, a more advanced set up described in the team’s 2019 report, complete with solar panel and fans, contains a system of cartridges that allows simultaneous adsorption and release. With this system they have generated 1.3L of water per kilograms of MOF per day – an amount approaching a person’s drinking water needs.

“So, MOF-303 can, quite literally, pull water out of thin air.”

So, MOF-303 can, quite literally, pull water out of thin air. But how? The answer, unsurprisingly, lies in its chemistry. The nitrogen atoms in the linkers are hydrophilic – they love water - meaning they ‘stick’ to any water molecules that enter the pores. But this is a balance. The Berkeley team have carefully tuned the ‘stickiness’ of the nitrogen atoms, and the MOF as a whole, so that water can still be removed upon heating. As you can imagine, creating a material that can both adsorb and release water quickly is no easy task. Nevertheless, the team have proven their MOF’s might by testing it against several similar porous materials. Whilst some of these materials may either adsorb or release faster, none can do both quite as well. Hence, MOF-303 is the best candidate for rapid cycling, which allows it to extract the maximum amount of water possible from the atmosphere.

Other noteworthy features of MOF-303 include its bonds, which don’t degrade in the presence of water- a surprisingly difficult feat which allows it to perform thousands of cycles without losing efficiency. The pores in the MOF are also highly interconnected, facilitating the rapid movement of water molecules throughout the framework.

“The UN warns that water shortages could affect 5 billion people by 2050.”

Back in Syria, the conflict drags onto its twelfth year and the country continues to grapple with drought that only serves to worsen the humanitarian crisis. Water scarcity is leading to instability between countries ranging from Ethiopia and Egypt to the USA and Mexico. The UN warns that water shortages could affect 5 billion people by 2050. If atmospheric water harvesters (AWHs) – devices containing materials like MOF-303 – are to go any distance in addressing this issue, efficiency must improve. Unfortunately, efficiencies reached in the lab have not been fully realised in the field. This suggests there is room for improvement, particularly in the device design. Notably, ensuring uniform heat distribution and circulation in the device could further boost productivity.

Research into AWHs has exploded in the last few years. The third generation MOF water harvester can complete a water harvesting cycle in just 10 minutes, producing a staggering 57 L of water per kilograms of MOF per day. More recently, a team at the Shanghai Jiao Tong University have created an AWH capable of constantly generating its own electricity from the temperature differences induced by the harvesting cycle. This renders the device completely self-sufficient and even allows it to power an LED bulb15.

The challenges remain. It is important to keep costs low, so that these devices can be made accessible to communities that are most vulnerable to the effects of water scarcity. The true scalability of AWHs have also been called into question. Given the amount of progress made in just the last 3 years, however, a day when all homes in arid regions are equipped with a water harvester is no longer something from science-fiction. Ultimately, the immense potential residing in the humble AWH cannot be understated. Not only does it boost resiliency on a community level, but this device also fosters independence on a personal level through the decentralisation of water supply, which is crucial for sustainable development.

This piece is the winner of the annual essay-writing competition for the 'Materials Chemistry' module.

THE INFINITE MONKEY CAGE: HOW TO COMMIT THE PERFECT MURDER

AMY RINGROSE

Everyone’s thought about murder at one time or another, even if they don’t want to admit it out loud.

“I would make a good murderer’s assistant... I’d have no trouble dismembering them and getting rid of the pieces.” The matter-of-fact statement ends with a chuckle, which sends a wave of nervous laughter through the audience. Still, those in the front row have no need to worry for their safety, for the statement comes from Professor Dame Sue Black, leading forensic anthropologist from Oxford University – if anything, thinking a lot about murder is in her job description.

Black is onstage at one of the BBC’s radio studios, primed to appear on an episode of *The Infinite Monkey Cage*. The hit podcast delights audiences for its ability to educate and entertain in equal measure, making even the most complex science accessible. This episode, aptly titled “How to commit the perfect murder”, was recorded in January 2023 in front of a live audience for broadcast on BBC Radio 4.

Dame Black, one of three panellists, looks over to the seat next to her, where Julia Shaw sits nodding in agreement. Shaw is a criminal psychologist and author, so she understands the sentiment. The panellist trio is completed by comedian and television presenter Susan Calman, and the podcast is enthusiastically hosted by the dynamic duo of comedian Robin Ince and physicist Brian Cox, who have presented the show since its debut in 2009.

Dame Black’s attention shifts back to Robin, where she begins the discussion with her experience of tracking the evidence left behind by a murderer. Telling a particularly grisly story of how one nightclub bouncer was apprehended, Black expresses that she’d learnt murdering somebody is mostly the easy part; in a moment of passion, with the right tools or motivation, the human body is a fragile thing. Murdering aside, you’re then left with the body, “a heavy, messy, unwieldy thing to move about,” that you now have to get rid of somehow – that’s the hard part, Black assures us.

Continuing with the story, she details exactly how the man, a proxy for an underground operation employing people to murder targets and dispose of their bodies, came to be discovered because of the way in which

he’d disposed of the body (well, its various pieces). Black’s advice for committing the perfect murder? “Don’t dismember the body, it’s awfully messy – most people think ‘I’ll go and drop the body parts in different places’, but every time you do that you’ve gone from one potential crime scene to about six – you’re much more likely to be caught, so don’t!”

As grim as the story was, I was surprised by how the room never felt too dark, being constantly infused with humour by Robin, who navigates through the episode’s topic in a way that made it feel less heavy. Some may say that making light of such serious subject matter is unsavoury, however I believe that just the right balance was struck between the realities of the use of forensic science and how it can be made interesting to anybody with the time to listen. Just as Robin keeps it light by poking fun at Brian whenever he can, Brian keeps the show on-track by asking the questions everyone is thinking. The bouncer story sparked deeper conversation between Black and Shaw, who began a fascinating discussion about the criminal justice system.

“The politics of the courtroom, it seems, are almost as important as the evidence in the case...”

Both professionals have given evidence in murder trials, with Black on the side of physical evidence and Shaw focused on psychological profiling. Much of Shaw’s work, including her bestselling book *Making Evil*, focuses on separating ‘criminals’ from the regular folk, the “good citizens of the world.” Shaw described examining beyond the murderers alone, and looking at the people too, particularly eyewitnesses. Researching out of UCL, Shaw’s specialism is based around memory – specifically, false memories. False memory is a phenomenon where, through time, countless recollections, and sometimes external suggestion, people begin to remember things that never were. Faces, sounds, actions, appearing from the ether of mind to solidify into something resembling a memory – even if you never saw, heard or did anything you recall! Shaw was met with captivated silence as she explained how the

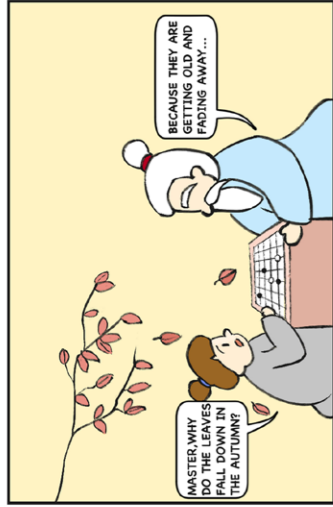
phenomenon makes her job more challenging, as court cases love presenting evidence from a good eyewitness testimony- even if it isn’t always accurate.

The politics of the courtroom, it seems, are almost as important as the evidence in the case: a notion which is even more true of the United States than here in the UK. Using her own experience to illustrate, Black builds on this image of courtroom procedures, describing how – unlike in the UK, where jurors are chosen at random – American juries are shaped by the defence and the prosecution using selection and mirror juries to get the ‘ideal’ balance of people to make a judgement on the case. Here, Robin pivots the conversation in the direction of Calman, who, prior to becoming a comedian, trained and practiced as a lawyer. Seeing a more sombre side to the usually cheerful travel show host was an interesting watch, made even more so by her account of the three months she spent working with criminals on death row in North Carolina. She was attempting to get cases re-examined and prisoners transferred with lesser sentences but found it near impossible. The American justice system is very final, especially in the case of death row inmates, and there was little she, or anybody else, could do to prevent it. Calman’s biggest takeaway from the experience, which sent chills around the otherwise toasty studio, was that the murderers she encountered were relatively normal people that you might, say, sit next to on the train – “They are just like us...and you cannot tell.”

All in all, we didn’t really learn how to commit the perfect murder. However, the journey through forensic science, courts of law and psychological profiling proved a whirlwind of information which gave viewers a real appreciation of the work that is done to prevent anybody getting away with such a heinous crime. Brian, of course, ever on-topic, ends the episode by asking the question anyway, to which Dame Black gives a witty reply:

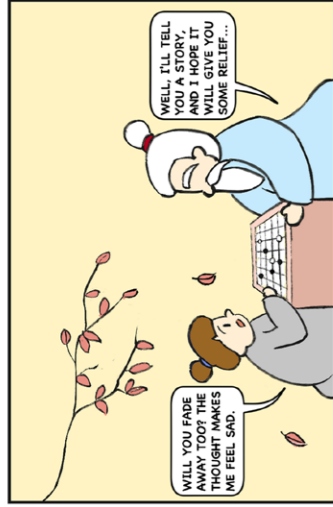
“Probably, but we don’t know what it is, because if it was perfect then we haven’t found it out.”

This episode of *The Infinite Monkey Cage* is available to listen to on the BBC Sounds website, or through the app.
<https://www.bbc.co.uk/programmes/p0f1wcp1>



MASTER WHY DO THE LEAVES FALL DOWN IN THE AUTUMN?

BECAUSE THEY ARE GETTING OLD AND FADING AWAY...

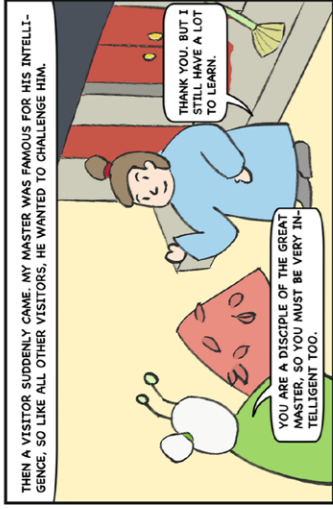


WILL YOU FADE AWAY TOO? I THOUGHT YOU WOULD FEEL SAD.

WELL, I'LL TELL YOU A STORY. IT WILL GIVE YOU SOME RELIEF...



WHEN I WAS YOUNG, I WAS ALSO A DISCIPLE AND ONE DAY I WAS SWEEPING THE COURTYARD OF OUR ACADEMY.



YOU ARE A DISCIPLE OF THE GREAT MASTER, SO YOU MUST BE VERY INTELLIGENT TOO.

THANK YOU, BUT I STILL HAVE A LOT TO LEARN.



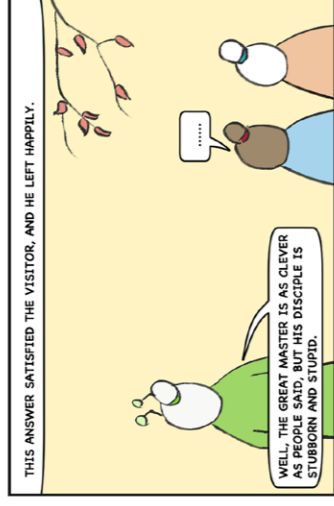
DO YOU KNOW HOW MANY SEASONS THERE ARE IN A YEAR?

SURE THAT'S A VERY EASY QUESTION. EVERYONE KNOWS A YEAR CONSISTS OF FOUR SEASONS.



THAT'S RIDICULOUS! I CAN'T AGREE WITH YOU.

YOU ARE WRONG. A YEAR CONSISTS OF THREE SEASONS.

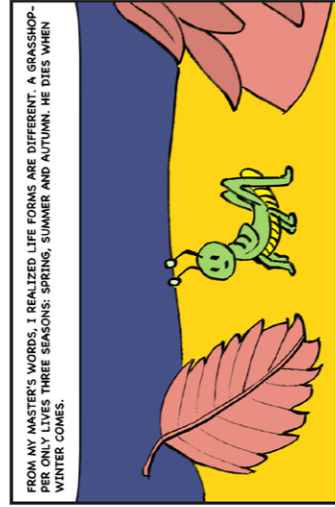


WELL, THE GREAT MASTER IS AS CLEVER AS PEOPLE SAID, BUT HIS DISCIPLE IS STUBBORN AND STUPID.

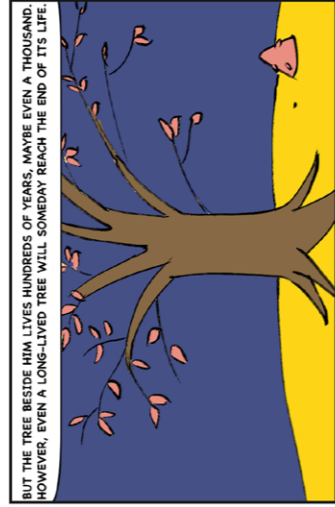


DID YOU NOTICE THAT MAN WORE GREEN AND HAD AN ANTENNAE ON HIS HEAD? HE IS A GRASSHOPPER, SO HE ONLY KNOWS THREE SEASONS BEFORE HE DIES BEFORE THE WINTER.

WHY DID YOU AGREE WITH THE WRONG ANSWER, MASTER? I REALLY DON'T UNDERSTAND.



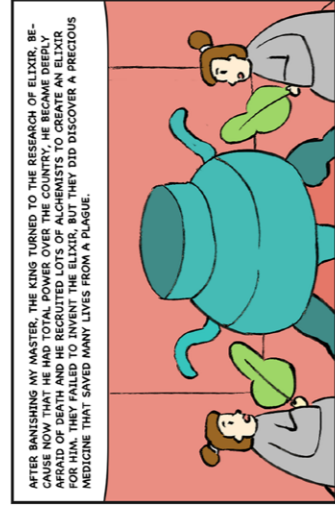
FROM MY MASTER'S WORDS, I REALIZED LIFE FORMS ARE DIFFERENT. A GRASSHOPPER'S THREE SEASONS: SPRING, SUMMER AND AUTUMN. HE DIES WHEN WINTER COMES.



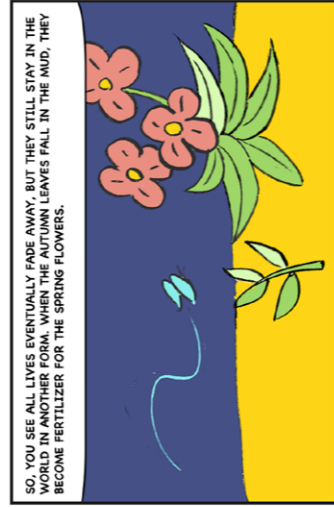
BUT THE TREE BESTRE HIM LIVES HUNDREDS OF YEARS, MAYBE EVEN A THOUSAND. HOWEVER, EVEN A LONG-LIVED TREE WILL SOMEDAY REACH THE END OF ITS LIFE.



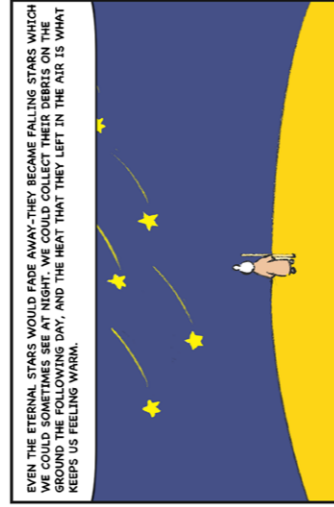
LATER, THE KING BANISHED MY MASTER BECAUSE HE REASD MY MASTER'S INTELLIGENCE. MY MASTER WAS BANNED TO A REMOTE ISLAND. HOWEVER, NUMEROUS STORIES WERE RECORDED DURING HIS JOURNEY AND HIS INTELLIGENCE THEREFORE BECAME ETERNAL.



AFTER BANISHING MY MASTER, THE KING TURNED TO THE RESEARCH OF ELIXIR. BECAUSE HE WAS AFRAID OF DEATH AND HE RECRUITED LOTS OF ALCHEMISTS TO CREATE AN ELIXIR FOR HIM. THEY FAILED TO INVENT THE ELIXIR, BUT THEY DID DISCOVER A PRECIOUS MEDICINE THAT SAVED MANY LIVES FROM A PLAGUE.



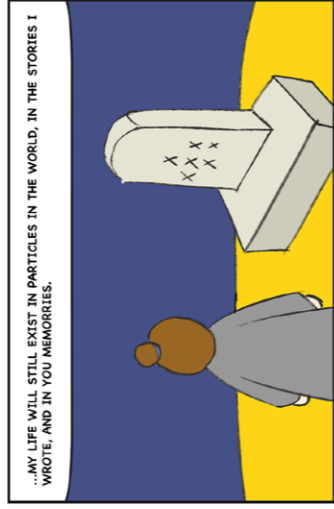
SO, YOU SEE ALL LIVES EVENTUALLY FADE AWAY, BUT THEY STILL STAY IN THE WORLD IN ANOTHER FORM. WHEN THE AUTUMN LEAVES FALL IN THE MUD, THEY BECOME FERTILIZER FOR THE SPRING FLOWERS.



EVEN THE ETERNAL STARS WOULD FADE AWAY-THEY BECAME FALLING STARS WHICH WE COULD SOMETIMES SEE AT NIGHT. WE COULD COLLECT THEIR DEBRIS ON THE GROUND THE FOLLOWING DAY, AND THE HEAT THAT THEY LEFT IN THE AIR IS WHAT KEEPS US FEELING WARM.



SO YOU NEEDN'T BE SAD IF I FADE AWAY ONE DAY, FOR I WILL ALWAYS STAY WITH YOU IN ANOTHER FORM.



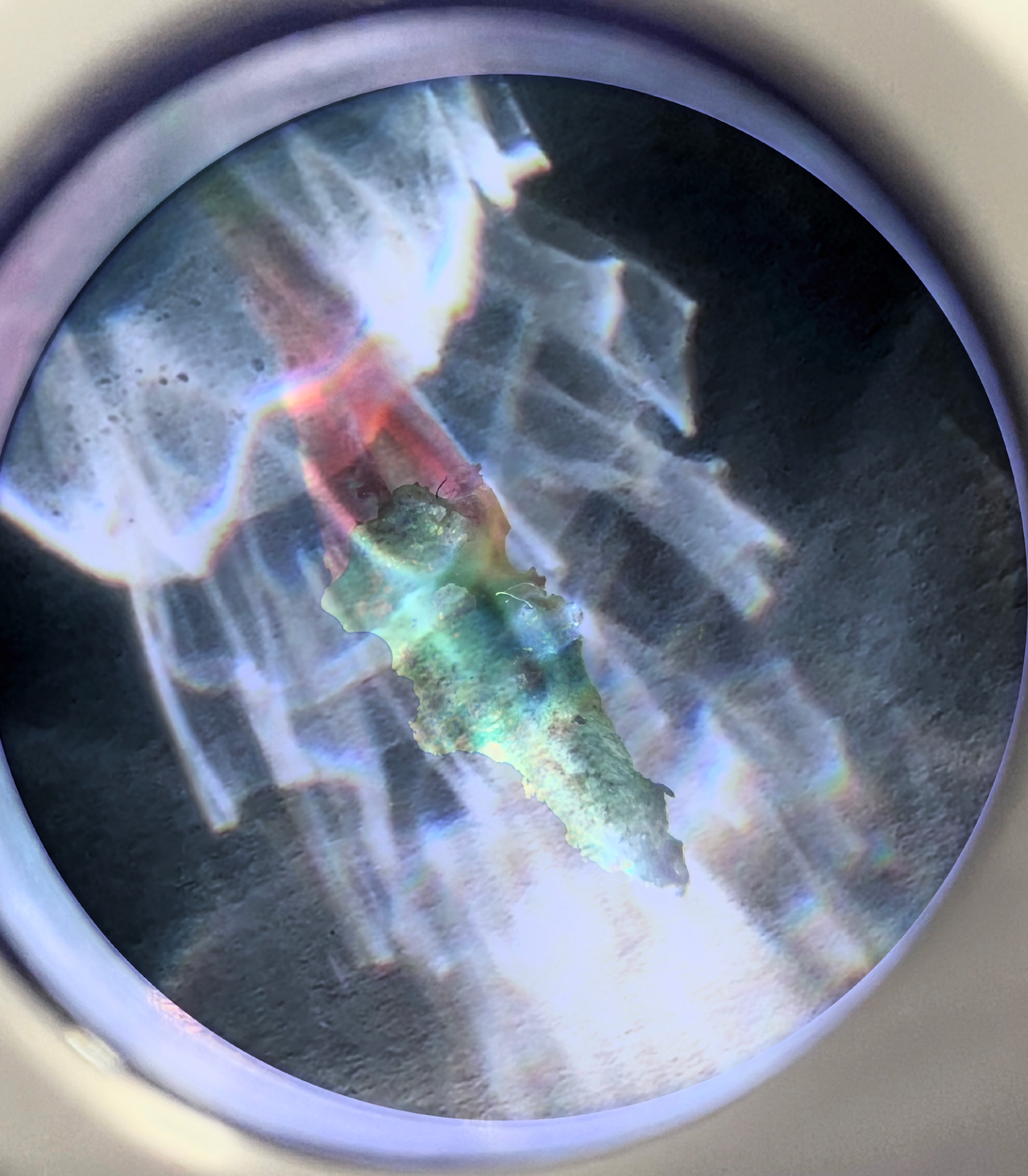
...MY LIFE WILL STILL EXIST IN PARTICLES IN THE WORLD, IN THE STORIES I WROTE, AND IN YOUR MEMORIES.



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