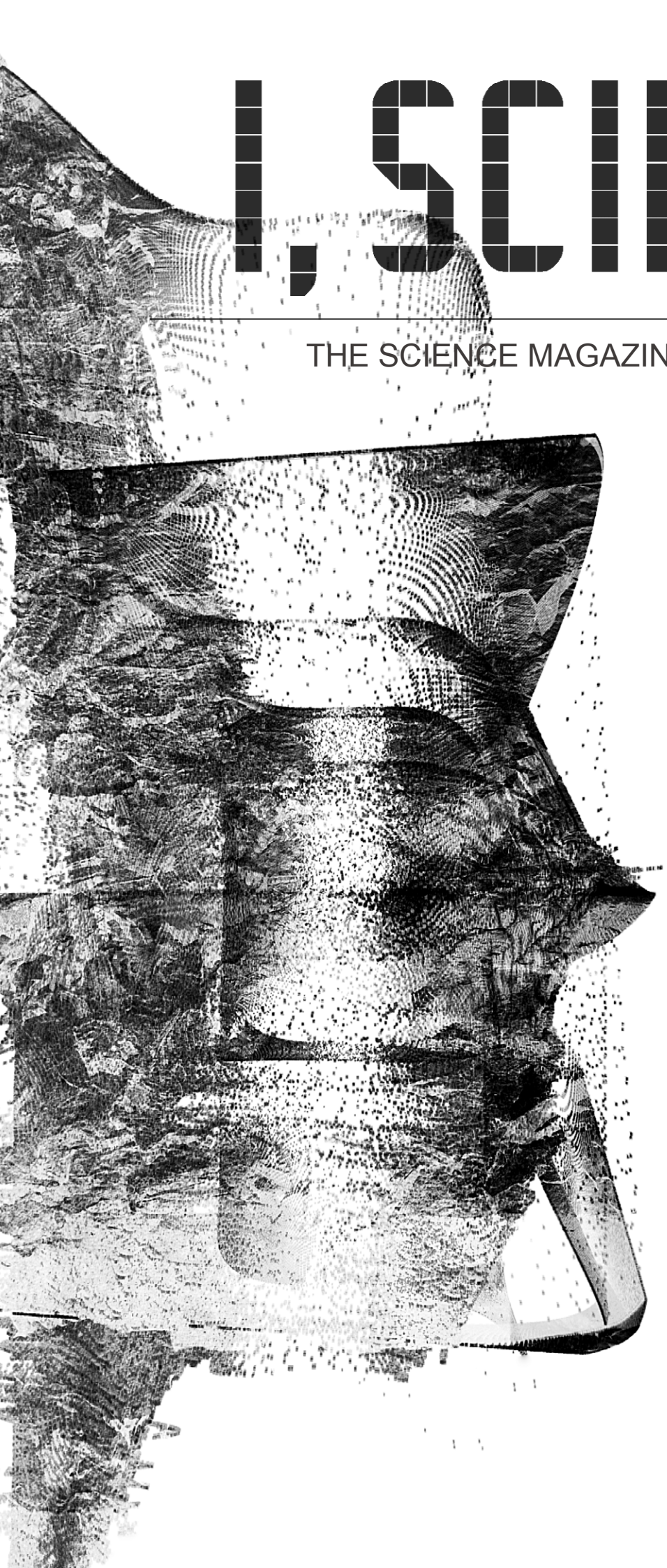
I,SCIENCE

THE SCIENCE MAGAZINE OF IMPERIAL COLLEGE



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Falling forward

ISSUE 55
SUMMER 2023

CONNECTIONS

I, SCIENCE

Dear Readers,

We hope you enjoy this issue of I, Science. Our time as Editors-in-Chief has ended as we hand over the baton to another brilliant editorial team for the 2023 – 2024 cycle. We wanted our final issue as a team to explore the relationships that bring us together before we depart Imperial. In doing so, we decided that the issue's theme would be "Connections," allowing us to think about the ties that bind communities and other aspects of the world together.

Our brilliant writers have been hard at work researching and interviewing to examine connections woven within science. In this issue, you will find articles covering topics ranging from forest communication via the 'Wood Wide Web' to the importance of human connection in treating Alzheimer's Disease. Furthermore, in our final issue, we have included reflections from the editorial team and from our former course director Dr Stephen Webster.

Thank you for all your support this year, for we couldn't have done it without you.

Happy reading!

Imaan Moin and Coral Billingham
Editors-in-Chief

We are always looking for new contributors for both the magazine and online. If you would like to get involved as a writer, illustrator, or photographer, please get in touch with us.

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Photo by Lucas George Wendt on Unsplash

Tropical plants rediscovered all thanks to community science

GABRIELLA SOTELO

A plant, hidden deep in the tropical Andes, discovered, and then forgotten. And it wasn't just one plant, but many that were thought to have been extinct. The plants once forgotten, were rediscovered after more than 100 years.

The plants, which belong to the genus Nasa were found thanks to botanists from Ecuador, Germany, Costa Rica, Peru, in addition to amateur plant enthusiasts. The recent findings were described in the journal PhytoKeys.

One of the species, Nasa colanii, had only been recorded once before in 1978 until the research team found a photograph from 2019.

The plants within the Nasa genus have caused difficulties for scientists in the past. Among other factors, most of the plants are rare, endemic, and around for short periods of time. But now thanks to biodiversity data, like georeferencing and photos shared on apps, it has made relevant information accessible.

The platform iNaturalist is based on citizen science and is a platform where users can record observations of living things, like plants. The platform helped report another 'lost' plant, Nasa ferox, which hadn't been reported for more than 100 years. It didn't get a scientific description until 2000 and was confirmed to still exist in 2022 when someone uploaded a photo of the plant to iNaturalist.

"The platform iNaturalist is based on citizen science and is a platform where users can record observations of living things, like plants. "

"Hopefully, as more scientists and members of the public contribute to the database, and more professionals get involved in the curation, more undescribed or 'long lost' taxa will be found," the researchers said in their study. "Our examples of the rediscovery of Nasa ferox after 130 years and Nasa hastata after 100 years, both 'found' on iNaturalist underscore this point."

Nasa hasta was discovered again after a photo was taken of it. Other plants that were rediscovered include Nasa humboldtiana and Nasa solaria which were both rediscovered after more than 100 years of being in the dark.

"All these discoveries serve as a reminder that even well-studied regions harbour diversity that can so easily remain overlooked and unexplored," stated Tilo Hennin, the leading author from the Leibniz Center for Agricultural Landscape Research. "And point[s] to the role of botanists in documenting biodiversity which is an essential prerequisite for any conservation efforts.

Photos by Sherrin Wu

Delving into dialogue: Building connections in the aging population

SHERRIN WU

Imagine yourself adrift in a disordered realm of time and space. It's a place where the ability to recognize your loved ones and everyday objects eludes you, they have lost their inherent associations and names. Every spatial anchor has lost its purpose, leaving you unable to know your position or direction. Time, too, loses its sense of continuity as experiences from the past and present jumble together in your consciousness. You are a solitary being on a secluded island, ensnared amidst the vast turmoil of your inner universe, obstructing your connection with the world beyond.

"Every spatial anchor has lost its purpose, leaving you unable to know your position or direction."

Sounds helpless, doesn't it? But that is the stark reality for people with severe Alzheimer's disease (AD).

The loss of neurons and synapses within the cerebral cortex and specific subcortical areas impairs their learning, memory, and cognition. From mild flickers of attention loss to profound memory deficits, every facet of life becomes entangled in the labyrinth of forgetfulness. This is a painful experience not only for the sufferers themselves but also for their loved ones. "Initially, my grandma's mind radiated with clarity, but it deteriorated after we became busy and didn't speak to her frequently." Maya Zheng, a family member of an Alzheimer's patient, said, "Within only two years, she became trapped in an endless loop, revisiting the same topics and occasionally erupting into nocturnal cries. At times, I even found myself evading moments of companionship with her."

Gaining lines, losing ties

AD and the widening chasm between generations has pushed innumerable older adults to the fringes of their existence. "Many older adults affected by cognitive impairments experience unfulfilled social needs, leading to the emergence of psychotic and affective symptoms. This, in turn, plunges them into isolation, anxiety, and other distressing emotions, significantly impacting their mental wellbeing and quality of life," remarked Congchen Dai, a PhD student at Tongji University.

"Language is a vital tool for fostering communication within social interactions."

Language is a vital tool for fostering communication within social interactions. For older adults, the aging process often results in declining hearing abilities, such as hearing loss and auditory lapses, leading to challenges in language recognition. Similarly, when attempting to convey information, the aging of articulatory organs (such as the tongue and lips) contributes to dysarthria (difficulty speaking due to muscle weakness) and reduced articulation loudness, which impedes comprehension. The loss of language proficiency can become a self-perpetuating cycle, as it discourages those around them from engaging in meaningful communication, gradually eroding their ability to express themselves.

Another problem is the caregivers' subconscious tendency to avoid conversations and a lack of concern for the mental health of older adults. Research indicates that conversations in the daily care of older adults often gravitate toward silence or remain confined to "task-oriented" activities such as assisting with meals or dressing. "There exists an imbalance of power in communications between older adults and caregivers," explained Professor Lihe Huang from the Research Center for Ageing, Language, and Care at Tongji University. "Caregivers may unintentionally employ threatening language or adopt 'elderspeak,' 'patronizing talk' in conversations. Overtly criticizing, demeaning or hastily interrupting older persons also occurs frequently." Together, these result in older adults' decreased desire for communication, hindering them from establishing connections with others.

"I sometimes think that if I had talked to her more before, it could have slowed down the decline of her cognitive abilities, or at least not as fast as they did in reality," reflected Zheng.

Seeking Memories, Crafting Moments

While scientific and clinical research focuses on molecular characteristics of the disease, such as beta-amyloid proteins, alpha-tubulin, and glial cells to unravel the causes of Alzheimer's disease, social scientists take different approaches. Linguistic researchers are trying to find the language "markers" of AD that might serve as an external reflection of cognition.

Over the past five years, the "Memory Seeker (Shi Yi)" team in Shanghai has diligently accumulated a dataset concerning language and cognition in the older adult population. Drawing data from diverse sources – including neurology departments within hospitals, senior communities, and nursing homes – they have created a robust aggregation of data for gerontolinguistics. Their objective is to utilize language as a catalyst to improve the overall cognition of older adults.

"Linguistic researchers are trying to find the language 'markers' of AD that might serve as an external reflection of cognition."

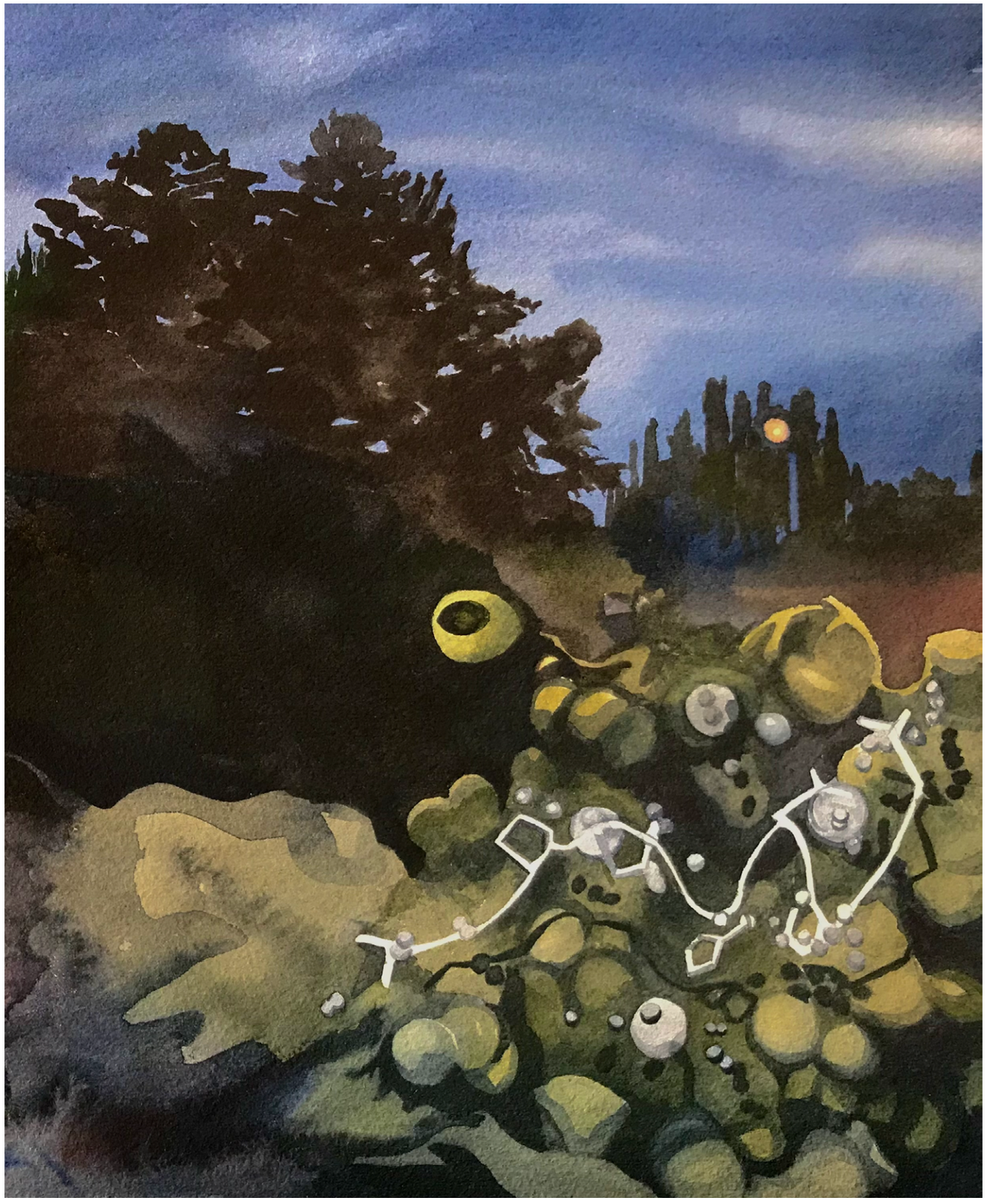
Notably, their focus extends beyond verbal communication to multimodal interactions, such as gestures, body language, and facial expressions. As neurodegeneration impacts verbal abilities, nonverbal expressions may remain relatively intact. These multimodal behaviors enable individuals to convey their thoughts and feelings. For instance, cognitively impaired older adults may employ hand gestures as substitutes for specific directions instead of verbal expressions. Nonverbal cues can offer additional information, such as saying "yes," while frowning can convey inconsistent meanings. By acknowledging these subtle cues and grasping both literal and implied meanings, we can truly comprehend the communicative intent of older individuals.

"Our current study focuses on interventions in functional communication by recording task-based interactions between volunteers and the elderly. Furthermore, we hope to amass a large body of work that covers the full range of scenarios in the elderly population's daily life." Joining the Memory Seeker team this year, Dai shares a common aspiration with her fellow members—to establish connections with older people by immersing themselves in their lives and harmonizing through shared experiences. As Dai states, "If we 'flap the wings' at the forefront of research, the potential for significant changes is boundless. By combining academic findings and personal connections with older adults, we seek to truly comprehend and help them."

Every communication occurs only in the present, where each word, gesture, and expression holds transient significance, akin to nodes in a network. As we try to uncover the interconnections, an intangible network begins to unfold, serving as a conduit that binds together emotions, meanings, and understanding. For older adults, every moment of attentive listening and heartfelt communication becomes a treasured opportunity to reclaim temporarily lost memories and cultivate shared experiences for the future. This intricate and delicate network intertwines our "present moments," forging a resilient bond between us and older adults, where time and memory converge in the here and now.

A science sustainability sprint

JACLYN ESTRIN



UNDERNEATH
ELLA MIODOWNIK

The race against climate change cannot be run by environmental scientists alone. Scientists from all disciplines must join together, as members of a global, collaborative team, to innovate for a more sustainable world.

The race against climate change is being run as a marathon. Solo entrants, primarily climate and environmental scientists, have been trudging on an uphill, long-haul race for decades. The format of the race must change. The prolonged race to the finish line, demarcated by the 1.5-degree Celsius planetary warming cap established in the 2015 Paris Agreement, should be run as a sprint relay instead. This requires an interdisciplinary team of scientists to step up to run a leg of the race and share the weight of the baton as it is passed from collaborator to collaborator.

"The format of the race must change. "

Because planetary warming has impacts that encompass the entire globe, sustainable solutions must come as a result of international partnerships. Following the twenty-seventh annual Conference of Parties to the United Nations Framework Convention on Climate Change (COP 27), I wrote about how global environmental responsibility should be pictured through a "Round Table of Sustainability." I imagined a world in which the responsibility of addressing climate change is not owned by one sole entity. Rather, it is shared among different parties, including businesses, governments, scientists, and members of society. The same notion can be applied to the diverse fields of science. Scientists from a wide array of disciplines need to take their seats at the round table in addition to assembling as members of the sprint relay team.

"Climate change mitigation cannot be the sole responsibility of environmental scientists. "

Science has been historically undertaken as a key to unlock solutions to some of the world's greatest challenges. Yet, many scientific disciplines operate in silos, with environmental science and climate science often seen as distinct fields lying outside of the hard sciences. Climate change mitigation cannot be the sole responsibility of environmental scientists. The interconnections between diverse scientific fields are key facets in the layers of innovation required to cultivate a more sustainable world.

Scientific collaboration was placed on a global stage during the COVID-19 pandemic, showing a proven track record of a successful deconstruction of scientific silos. The pandemic highlighted international, cross-sectoral collaboration as a key asset to quickly solve an unprecedented challenge at an unprecedented rate. Lessons learned from the collaboration of the pandemic should be applied in the case of climate change, a pandemic in its own right. The planet has been plagued with pollution, overexploitation of natural resources, and greenhouse gas emissions. Unlike the COVID-19 pandemic, which was wrought with uncertainties that required novel research and innovations, there is overwhelming agreement from the scientific community that the climate is warming and changing due to human activity. Strategies and solutions to mitigate environmental impacts are well known yet are being enacted at a snail's pace. If climate change is treated as the pandemic it is, then the urgency for rapid, collective problem solving would propel action to heal our planet.

There are resources to support a collaborative and collective approach to science and sustainability. The United Nations Sustainable Development Goals (SDGs) provide an international blueprint to accelerate progress towards a more socially and environmentally sustainable globe. Many scientists already undertake research that aligns with the goals set forth within the SDGs, and science forums can convene researchers to share and discuss relevant, corresponding work. Additionally, there are cross-sectoral forums and organisations that provide a hub for collaboration. For example, the nonprofit organisation, Project Drawdown, has collated research from scientists around the world to develop a list of nearly one hundred sustainability innovations and climate change solutions. This list incorporates sustainable solutions proposed for a variety of sectors ranging from agriculture and land use to transportation, industry, electricity, and infrastructure.

Each science discipline has a thread of knowledge and tools that can be used to evoke positive environmental impacts. For instance, chemists can innovate green processes for sustainable and clean products and manufacturing. Physicists and engineers can work to design environmentally conscious, adaptive, and resilient infrastructure with low-impact material use and renewable energy expansion. Biologists can operate on a micro-level, exploring how human, floral, and faunal health is impacted by climate change, or on a more macro-level, looking at ecosystem biodiversity and broader public health implications of sustainable solutions.

One technology on its own is not going to galvanise transformative change, but it may spark the butterfly effect and create the momentum that pushes for a greater sustainability movement. These disciplines can interweave their technical skills to form more holistic sustainability strategies. As a possible example of scientific collaboration, the future of sustainable aviation may arise through a combination of innovations. Chemists' work to develop cleaner biofuels can be paired with engineers' and physicists' efforts to improve aerodynamic construction of planes to increase efficiency, shortening airtimes, and reducing fossil fuel use.

"It takes more than a village to address climate change. It takes the entire world. "

Similarly, science and sustainability collaboration can be found within the rewilding movement, an effort to restore natural habitats and improve biodiversity in lands altered by human intervention. Rewilding may call on chemists to treat polluted waterways; biologists, zoologists, and environmental scientists to advise on habitat reconstruction; and physicists, engineers, and landscape architects to construct wildlife bridges that connect habitats across roads or human-made developments. These examples are only a drop in the bucket in the ways that scientists with diverse backgrounds and expertise can come together. It takes more than a village to address climate change. It takes the entire world.

All scientific fields can and should contribute to sustainability solutions. The planet is warming at an alarming pace, but together, as a global scientific team, we can find ways to be faster at halting the rapid progression of planetary warming. There is no time for a sustainability marathon. Instead, the world needs to see a swift, team-driven relay to the finish line. The only way to win the race against climate change is to establish a team with the ability to foster connected, collective action and interdisciplinary collaboration. A team effort will drive transformative change.

Britain’s “little Galápagos”

MENGMENG TU

Photos provided by the Lundy research team

The renowned Galápagos Islands have long been associated with Charles Darwin and his groundbreaking theory of evolution. Now, researchers from Imperial College London are establishing their own scientific haven on a much smaller scale – welcome to Britain's "little Galápagos" on Lundy Island.

Lying off the coast of North Devon, where the Atlantic Ocean meets the Bristol Channel, is Lundy Island. Three miles long and half a mile wide, this small habitat is home to around 35 species of birds.

Lundy—which means “puffins island” in Old Norse—has a tiny residential population of 28 people but attracts around 20,000 tourists each year for diving, sightseeing, and casual birdwatching.

For a group of scientists, however, it’s the house sparrows that have captured their attention.

House sparrows are among the most widespread wild birds globally, found on every continent except Antarctica. They have a remarkable history of coexistence with humans, dating back as far as 11,000 years in the Middle East. Instead of building natural nests, sparrows have adapted to favour manmade structures like eaves and walls. They have also developed the ability to digest starchy human-produced foods such as potatoes, corn, and wheat, alongside their regular diet of seeds and insects.

"Researchers have been working from a research base located in a barn on the island, diligently collecting data to establish a robust database that now contains over 10,000 sparrow observations."

The house sparrow system project on Lundy Island started in 2000. Researchers have been working from a research base located in a barn on the island, diligently collecting data to establish a robust database that now contains over 10,000 sparrow observations. Additionally, extensive genetic data and family trees have been compiled. The Lundy Island house sparrow system serves as an invaluable research resource, enabling scientists to conduct various studies.

“The main project looks at parental care, but we also observe sexual selection, aging, and social behaviours,” says Dr. Julia Schroeder, a senior lecturer and Director of Imperial College’s MSc in Ecology, Evolution and Conservation, who runs a research group on the island.

SPARROWS IN A BAR
MENGMENG TU

The nest boxes of the house sparrows are located high up on the beams of the barn, and researchers require ladders to access the nesting colony amidst the sheep on the ground floor. “The sparrows are used to having farm animals around,” says Heung Ying Janet Chik, a Ph.D. student who worked on site. “The sheep are very tame, and they don’t interrupt much... Sometimes when I was working up from the top of the ladder, there would be a couple of lambs wandering in, and it was always a little bit of a surprise to see them there.”

One of the key research foci within Schroeder's group centres on the mating habits of sparrows. Jamie Dunning, a Ph.D. student in the group, has made interesting findings. Contrary to common assumptions that sparrows with more opposite-sex friends (defined as close proximity when birds arrive at the feeder) have better chances of passing genes to their offspring, the team discovered that such benefits are short-lived. In the long run, sparrows with an average number of opposite-sex friends experience greater breeding success, ensuring the successful transfer of genetic information to their offspring.

But, this isn’t as counterintuitive as you might think. “Sometimes selection would favour the less sociable individuals,” says Dunning. “There are contexts like a disease. Take COVID-19 as an example: for our humans, it was beneficial not to be hanging around with a big group of people during COVID.” The same goes for sparrows.

"Lundy Island serves as a captivating microcosm for scientific research akin to the famed Galápagos Islands."

Dunning watched the birds at the feeders each day during his stay on the island. “My job is to pick who’s a friend and who’s not,” he says, adding that it’s like people-watching at a bar. "When waiting at the bar for a drink, you are surrounded by lots of people who may not be your friends. But you would have arrived at the premises with your friends – and that’s what we’re interested in.”

Summer is the busiest season for research, with the group doing their annual population count that allows the group to monitor how many survived the winter and observe their breeding. Some researchers stay on the island for up to two months. Chik, for example, lived on Lundy from June to late August last year.

To work in the wild, the researchers need to sacrifice some of the conveniences of modern life: there is little internet access and limited water and electricity. But, according to Chik, there is a real sense of scientific community on the island, and the teams enjoy breathtaking walks and drinks at the local tavern together.

Reflecting on his experience, Dunning describes Lundy Island as "an amazing place, though it's tiny," and wholeheartedly recommends a visit to this unique scientific haven.

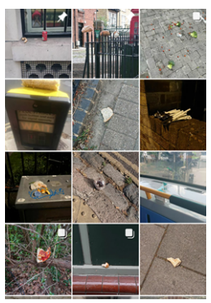
Lundy Island serves as a captivating microcosm for scientific research akin to the famed Galápagos Islands. With its diverse bird species and particularly the house sparrows, this small British island has provided valuable insights into evolutionary processes, social behaviours, and the intricate dynamics of natural selection. As researchers from Imperial College London continue their studies on Lundy, we can expect further discoveries that contribute to our understanding of the natural world.

Eating performance

Finger & palm hats for eating, made with celery+rhubarb from London farmers market

Eating experiment

Development for Knit knot soup



Instagram
Risa Ueno @ediblecat.leftover

NONSENSE MAKE SENSE WHEN YOU'RE HUNGRY (2023)

RISA UENO

Description:
Nonsense make sense when you're hungry (2023) texturises a glitch in food to identify (human and other-than-human) behaviours of communication/interaction with particular manipulation, using knitting as a tool of interpreting my idea and mathematical theorems as the guide; Tree (Graph theory) and Quaternion.

This is multisensory experience through knitted textile made with edible and inedible materials. From collecting food anecdotes; leftover food on street (food waste) to serving the transformation of data collection, this complex/chaos entanglement re-informs to navigate what everyday life is.

Expressing your inner virus

VANESSA HAYES

THE GARDEN OF VESICLES
JULIET WILLIAMS

Eight percent of your genome is viral DNA. We tend to characterize the relationship between a virus and our body as a fight to the death between two separate entities, but the viral genes in your DNA are not always at war with you. Some viral genes have contributed to key steps in our species' evolution and play essential roles in how our bodies function. So how did these viral genes make their way into your genome, and what good could they possibly be doing?

How Viral Genes Entered Our Genome

Only one family of viruses – retroviruses – are able to insert their genes directly into your genome. A retrovirus begins its infection by inserting its genetic information, RNA, into your cell, along with an enzyme known as reverse transcriptase. Next, reverse transcriptase turns the RNA into DNA. Finally, this DNA version of the virus' genes is inserted into specific locations in your genome with the help of another enzyme, called integrase. Once the genes are inserted, that infected cell and any future daughter cells will contain and express the virus' genes, manufacturing the virus' components with their own cellular structures.

However, not all retroviruses that successfully infect cells will have their genes passed on to that organism's offspring; only those that target reproductive cells—eggs or sperm—will ever have their genes passed on to future generations.

When a retrovirus infects a reproductive cell which is later fertilized, the cell replicates to become the embryo whilst simultaneously copying the virus's genes into every cell. This may lead to harmful genetic conditions within the progeny, but on rare occasions in our evolutionary history, the progeny ultimately benefitted because of the viral genes inside them.

The chances of a retrovirus infecting an egg or sperm cell that is later fertilized are already low, and the chances of that offspring surviving to pass on its own genes are even lower. However, retroviruses have been around for 450 million years, providing plenty of these rare chances for their genetic information to be passed down through human generations.

The Benefits of Viral Genes

For many years, scientists believed that the viral genes in our genome were useless to us as they are often incomplete due to degradation and mutation over time. However, recent studies have begun to reveal some of the beneficial roles these genes have played in the survival and success of our species.

"Arc genes, which likely entered an ancestor's DNA via an ancient retrovirus 397 million years ago, play an important role in long-term memory and learning."

Arc genes, which likely entered an ancestor's DNA via an ancient retrovirus 397 million years ago, play an important role in long-term memory and learning. Arc genes code for Arc proteins, which look and act like viral capsids—the outer packaging of a virus that carries its RNA. These capsid-like proteins are created in our neurons and sent from one neuron to the next. They are filled with our own RNA, forming a communication pathway between the two neurons. This communication between neurons can alter the strength of this neuronal connection, allowing you to form long-term memories and retain knowledge and skills. Since this form of communication usually requires Arc proteins, you can probably thank viruses for your ability to recall your favorite memories and how to tie your shoelaces.

Suppressyn is a protein made in early embryos and the human placenta. It is believed to play a role in blocking certain viruses from entering the embryo's cells, thus protecting it from infection. Viruses need to attach to cell receptors in order to infect that cell, and different viruses have evolved to target different receptors for access. Scientists believe that suppressyn was originally used by an ancient retrovirus to enter cells via one type of surface receptor. Today, the ancient virus that gave us its suppressyn gene no longer exists, but many other viruses still target the same receptor to get into our cells. The suppressyn that is made by embryonic cells attaches to these receptors, blocking any foreign viruses from being able to attach to them. Since they cannot attach, these viruses are unable to infect the embryo's cells. Therefore, suppressyn is responsible for protecting us from infections before we have our own immune systems; without it, you might not have survived to birth.

" It wasn't until 150-200 million years ago that another solution arrived: the placenta, the uterus, and syncytin."

Also involved in embryonic development is the viral protein **syncytin**, which has an essential role in attaching the placenta to the parent's uterus. The placenta is made from the embryo's cells and must attach to the uterus so that the embryo can receive nutrients from the parent's body. However, our immune systems are designed to see anything that is not our own cells as a dangerous invader—and for a parent, that includes the cells of the embryo. For millennia, this was a problem for reproduction; any offspring growing inside a parent would have been immediately attacked by the parent's immune system. Eggs were evolution's early solution, as they keep the offspring's cells separate from the parent's body and contain all the necessary nutrients for development. However, this leaves the offspring relatively unprotected from predators. It wasn't until 150-200 million years ago that another solution arrived: the placenta, the uterus, and syncytin.

"To put it succinctly: if we weren't part virus, we would be laying eggs."

Syncytin is particularly good at fusing things together—this may have allowed the ancient virus that syncytin came from to attach itself to cells. This quality also happens to make syncytin the perfect protein to connect the placenta and the uterus together. It acts as a glue, connecting the embryo's placental cells to the parent's uterine cells, whilst also keeping the two bloodstreams separate. The connection makes it possible for oxygen, carbon dioxide, nutrients, some medicines, and even protective antibodies to be passed between the parent and embryo. On the other hand, it prevents the parent's immune cells from being able to notice and kill the embryo's cells. Syncytin is certainly not the only gene responsible for the evolution of mammalian reproduction with its requirement for a uterus, placenta, umbilical cord, and much more, but without this ancient virus's contribution to our genome, humans would not exist today. To put it succinctly: if we weren't part virus, we would be laying eggs.

Not all viral genes in our DNA are beneficial—many are simply harmless and others rather harmful. Some may have a role in the development of various diseases like some cancers or multiple sclerosis. Still, the presence of these viral snippets in our human genome points to the interconnectedness of all organisms on Earth. Over time, genes of different organisms get transferred and repurposed, often leading to developments in evolution that would never have happened otherwise. Evolution is complex and non-linear, and the divisions between species—even between organisms as different as viruses and humans—are not as clear as they might seem.

Eco-Trips: Using psychedelics to connect with nature

ELLA MIODOWNIK

It's not exactly Woodstock.

Unlike the quintessential images of the 1960s psychedelic movement—long hair, tree-hugging, tie-dye and flower crowns—today's psychedelic research participants lie on cosy laboratory sofas, wearing headphones and eye masks. They are advised to focus within and "shine light on the darkest corners of their minds," as these drugs can help treat mental health issues ranging from addiction to depression to PTSD. But the roads into the depths of the human psyche are starting to lead psychedelic research back outdoors, as research shows that psychedelics enhance our connection to nature, which can in turn inspire pro-environmental behaviour.

Scientists quantify the urge to hug trees by measuring nature-relatedness, the subjective feeling of oneness with the natural world. It's the difference between coming home to nature and visiting it as a tourist.

"Nature-connectedness is very much tied to wellbeing."

"Before I enjoyed nature; now I feel part of it. Before I was looking at it as a thing, like TV or a painting…" says a study participant. "[But now I see] there's no separation or distinction, you are it."

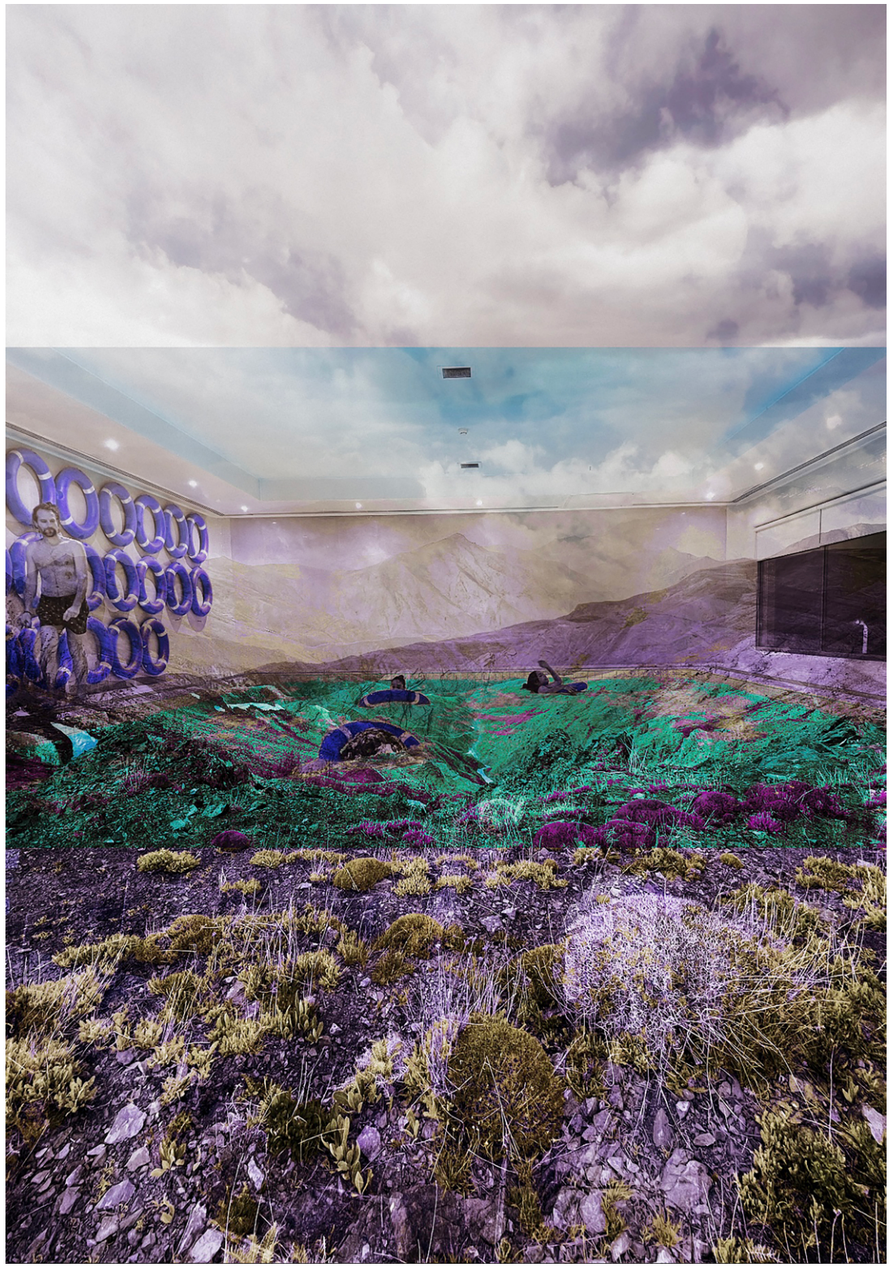
The study found that as well as improved mental health, subjects' feeling of nature-relatedness was significantly increased two weeks, four weeks and two years after the psychedelic experience. "We found that these drugs can be catalysts for connection," says Sam Gandy, an ecologist and researcher at the Beckley Foundation, a psychedelic research group in the U.K.

The benefits of feeling at one with nature are both personal and planetary: nature-relatedness or connectedness has been singled out as the most important factor predicting pro-environmental behaviour. "Nature-connectedness is very much tied to wellbeing," says Gandy. "But we are also seeing that more nature-connected people are much more likely to hold values of care and stewardship for nature, and more importantly, to act on them."

What is the psychological basis for these feelings of connection? Psychedelics' effects seem to derive from what researchers call "ego-dissolution," which blurs the boundary between self and world. The active molecules in drugs such as magic mushrooms, LSD or DMT affect numerous areas of the brain at once to produce the hallucinogenic experience itself, but crucially, they also have a longer lasting after-effect: an increase in brain plasticity. Brain plasticity, the ability to form new neural connections, decreases with age. As children, our minds are impressionable and open to forming new pathways, but over time, we quite literally become more stuck in our ways. Psychedelic molecules soften the established pathways of our egos, letting us rewire previously fixed mental patterns or beliefs.

"Ego dissolution is likely a key mechanism of an increase in nature-connectedness. "

Ego dissolution is likely a key mechanism of an increase in nature-connectedness. When we lose the boundary between our inner and outer world, it feels intuitive that we should care for the earth, just as we would care for ourselves.



UNTITLED (digital photomontage)
IDA HOSSEINIAN

A climate activist from New York City describes how her experience with mushrooms shifted her relationship with nature: "Being from the city, I had this distanced idea that we, as humans, should try and take care of nature. But what changed during the trip was seeing how profoundly nature takes care of us, and how silly the idea of us-versus-nature was in the first place."

The importance of connectedness is much bigger than psychedelics, and we should see these drugs as just one possible path towards connection; she notes that in many indigenous communities, nature-connectedness is a fundamental understanding of the world, not an epiphany. This way of being has been lost or violently stifled, and recapturing it is a matter of urgency.

"The importance of connectedness is much bigger than psychedelics, and we should see these drugs as just one possible path towards connection"

Currently, psychedelic research is only approved in controlled indoor settings that facilitate inward focus. But the authors of the study suggest that administering psychedelics in nature-based settings could enhance nature connection even further.

"Of course, unlike the clinical setting, nature is more inherently uncontrollable, and unpredictable." But there could be benefits to administering these drugs outdoors. Gandy notes that nature-based experiences, with or without psychedelics, are known to inspire wonder and awe. "People report that during [recreational] psychedelic experiences, if they have a challenging time, they seek out nature-based settings as inherently soothing and restorative."

Can we eco-trip without the drugs?

The elephant in the room, of course, is that prescribing psychedelics to the world population is not a practical (or particularly advisable) route. But there are non-pharmaceutical ways to replicate the shifts in consciousness that psychedelics catalyse. The drugs can help because they change our minds, but those changes are also possible without their aid.

One is, of course, spend time in nature. Gandy emphasizes that there is a lot of work to be done to make green spaces more accessible, as urban planning in the UK often reinforces unequal access to nature—as anyone who has walked past the gated gardens of the super-rich can attest.

Education is another opportunity to transform our mindsets around nature and climate crisis. "When I teach ecology, I like to think of mind-shifts, rather than mind-sets," says Dr Ash Brockwell, a lecturer at the London Interdisciplinary School, "because they're not fixed, and they can change." He describes five mind-shifts that help students approach sustainability: from separation to interconnectedness, monoculture to diversity, individual to collective, rigidity to adaptations, and linear to circular. "One of the biggest barriers is that our language is just quite limited when it comes to thinking about ecology."

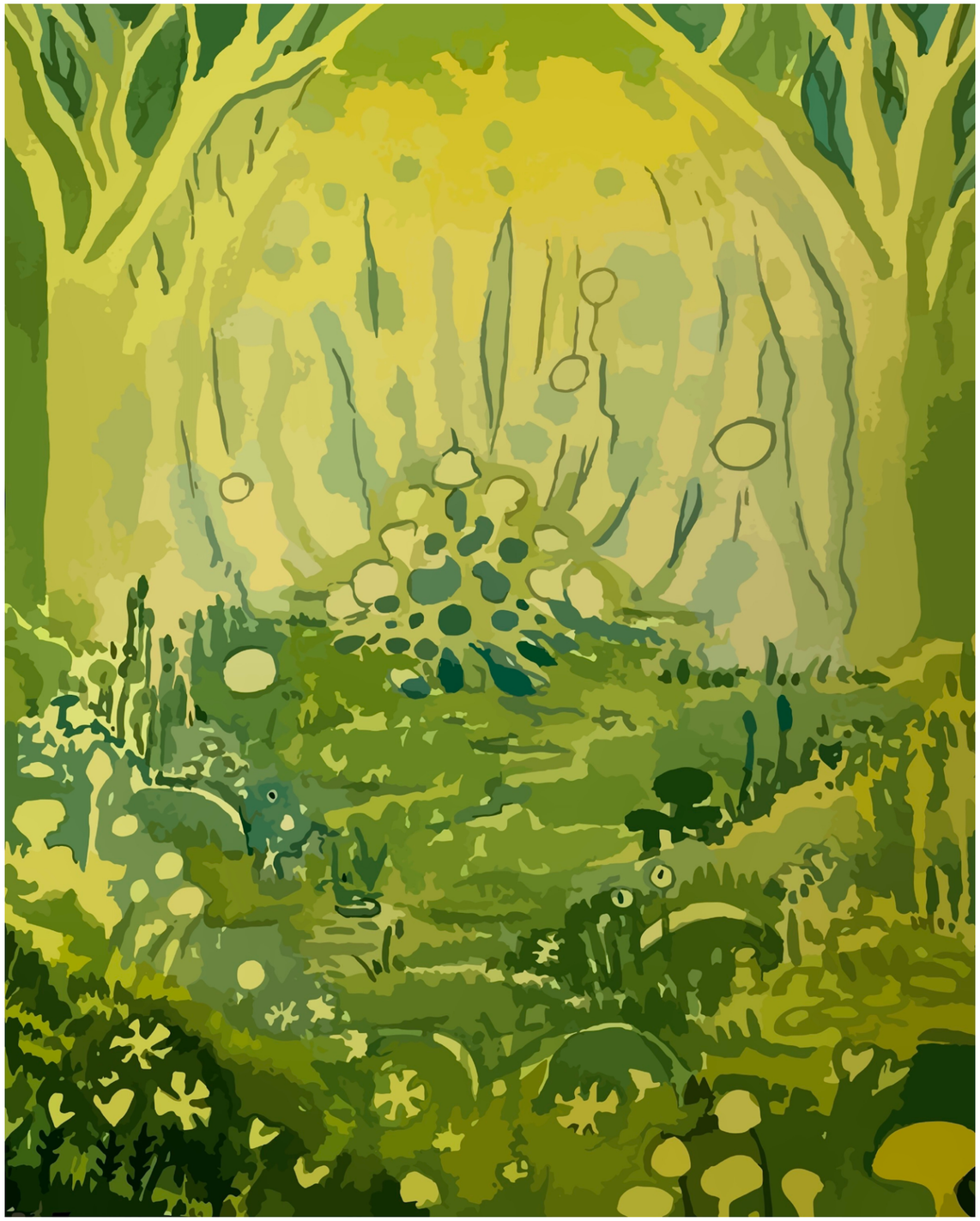
Language limitations often derive from "epistemic injustice," when peoples' knowledge is taken less seriously because of prejudice and discrimination against them. "I have seen this happen a lot with indigenous knowledge in particular, because the interconnectedness of everything is taken for granted in those languages."

In one upcoming ecosystems module, Brockwell plans to try out a new teaching method, in which students spend time in nature and create art based on their experience. "I'd love to see the students engage with the ecosystem on a deeper level through the art. Whatever practice they decide to focus on for their piece, whether it is through the journaling, or the poetry, or the visual art, I hope that it will let them relate differently to the ecosystem and see it differently, than if I just asked them to write an academic essay about it."

Embracing interconnectedness in climate solutions is both daunting and hopeful, says the New York climate activist. "We have to stand up to the governments and companies ignoring the crisis, reconnect with our communities, and address all these societal problems that might seem unrelated, like healthcare and wealth inequality, because it's all connected like a web. That can feel overwhelming in a way, but it also means that every small action can help because it's connected to the whole."

Uncovering the wood wide web

KATIE PORTER



DISSOLUTION
ELLA MIODOWNIK

Fungi have commonly been depicted in folklore as powerful, mystical organisms – think of the warnings you may have received as a child not to cross into fairy rings or risk being transported to distant kingdoms. Maybe you were forewarned of how the grass would poison animals that innocently graze within the fairy circle – a once widespread concern echoed in Shakespeare's *The Tempest*.

Perhaps now, such tales seem absurd, yet their frequency across folklore may reflect fungi's powerful properties which they provide through their connections with plants. These fungi-plant connections allow ecosystems to flourish and teem with life by transferring essential nutrients into plants from the soil and enabling plants to 'communicate' with one another. In this way, the connections that fungi provide to plants are invaluable – what scientists have thus far discovered has been spectacular and demonstrative of the importance of the interconnectivity fungi provide.

Fungi are a vast kingdom of organisms that evolved over one billion years ago and present a significant and diverse component of almost all ecosystems, from arid deserts to the deep seas. Contrary to popular belief, fungi are more than the fleshy-mushroom bodies found on our dinner plates; those are merely the reproductive fruiting body of the intricate fungal network that forms in the soil. Some fungi species will fruit seasonally, others as infrequently as every two years. Therefore, even in the absence of mushroom bodies, microscopic fungi are likely still present in the water or soil. There is much more going on than what is visible to the naked eye.

"These mycelial-plant connections are an ancient relationship, existing for at least 150 million years."

Fungi mediate complex and vital exchanges with plants through a thread-like mycelium that either winds around the plant roots or pierces them. The association between the plant and fungi is mutualistic – a symbiosis where both organisms benefit from their association. The fungal mycelia harbour enzymes that enable them to capture more soil nutrients including nitrogen, carbon, and other essential minerals for the plant and can move these nutrients across the plant roots. Additionally, the mycelia allow the roots increased access to soil space. In return, the fungi receive plant compounds produced in photosynthesis, which are necessary for their survival.

These mycelial-plant connections are an ancient relationship, existing for at least 150 million years. They are vital to maintaining ecosystems, with an estimated 80% of plants having mutualistic interactions with fungi, from kiwi plants to celery. Without this mutualistic relationship, many plants would become malnourished and unable to sustain themselves, resulting in reduced ecosystem biodiversity.

"Simply put, fungal connections are invaluable in protecting plants in challenging conditions."

Furthermore, mycelial-plant connections also improve the plant's resistance to environmental stressors. These connections resist drought through water transport facilitation, and ward off pathogenic attacks by out-competing harmful fungi and promoting the growth of beneficial, protective bacteria. As these stressors will increase in frequency due to climate change, plants will become especially and increasingly vulnerable without mutualistic interactions. Simply put, fungal connections are invaluable in protecting plants in challenging conditions.

Connecting individual plants in ecosystems to each other

The fungal mycelium also connects individual trees through the soil, enabling them to exchange water and nutrients in what has been comically dubbed the Wood Wide Web (WWW). Particularly in times of hardship, trees will rely on other trees in preferable conditions for survival. Those plants with comparably more sunlight will have enhanced photosynthetic rates and can thus send photosynthetic sugars to struggling trees via the WWW – acting as an essential lifeline.

Interestingly, a study on Douglas-fir trees indicated that this system is biased toward trees that are genetically similar, with trees able to recognise the root tips of their relatives and favour them when distributing carbon and nutrients through the fungal network. Such bias is believed to be evolutionarily significant due to its role in the survival of certain species, demonstrating the profound influence the connections can have.

The connections do not end there; extraordinarily, the WWW also allows plants to transmit warning signals to other interconnected plants. For example, it has been found that if one plant is under attack from aphids, it can send biochemical or electrical signals to connected plants. This inter-plant communication allows other plants to pre-emptively increase their defences against oncoming attack and better their chances of resistance.

The future of fungi

However, mycology is a nutritiously murky study area. This is partly due to its elusive nature, lack of historical research attention, and complexities associated with studying soil organisms that rely upon specific conditions to thrive. Of an estimated 1.5–5 million fungal species, only around 120,000 have been described. Therefore, there is much left to uncover. However, the appreciation for these mighty organisms is growing, and in conjunction, research efforts are increasing.

"Of an estimated 1.5–5 million fungal species, only around 120,000 have been described."

Whilst fungi still hold secrets that science is yet to uncover, one thing is for sure: although mysterious, fungi's connections to plants make them crucial to the survival of our planet. So, the next time you take a walk, remember what magnificent work fungi do beneath your feet. What was once an organism associated with decay, disease, and death has begun to emerge as a vitality provider. This once unrecognised ecosystem hero is slowly becoming better understood.

The gut-brain axis: It's not just a gut feeling

OLA HIGSON

Have you ever had butterflies in your stomach? Everyday language is full of phrases that link feelings to the gut. People commonly describe a 'pit' or 'knot' in their stomach when they're feeling nervous. Around the start of the medical revolution in 18th century Europe, bodily systems began to be better understood, often in terms of specific functions that could be treated directly. Many old sayings were dismissed as misguided, and therapeutic medicines were seen as the way forward. Biomedicine has since moved away from holistic thinking about wellbeing as there is usually a drug-based treatment available. However, recent research is finding physiological reasons that show that the body and the mind are in fact highly interconnected.

"There are 500 million neurons in the lining of the digestive tract which connect to the brain, which help regulate key digestive functions. "

The modern term for this connection is the "gut-brain" axis. It's how signals are sent between the gut and the brain! There are 500 million neurons in the lining of the digestive tract which connect to the brain, which help regulate key digestive functions. Interestingly, 95% of serotonin is produced in the gut. Serotonin is a neurotransmitter, which means it can travel up nerve cells into the brain. Among its many functions, it helps regulate mood and makes us feel good in the long-term by reducing feelings of anxiety and depression. Foods like oats, peanuts or chicken contain proteins made of certain amino acids that are needed to produce serotonin.

Recent findings show that the human gut cannot do it alone. There are millions of tiny microbes that inhabit all of us. They are a mix of viruses and bacteria that play a vital role in gut health. Collectively, gut microbes are known as the gut microbiome. Microbes compete for space throughout the gastrointestinal tract, feeding on the food you eat. Some of them are beneficial, helping break down our food so that nutrients can be absorbed more easily. During this process, microbes produce metabolites. For example, bacteria produce short-chain fatty acids which are responsible for making us feel full after eating. They have also been found to produce neurotransmitters like serotonin, noradrenaline and dopamine, impacting mood and excitability. A diet high in fried, refined grains and processed meats can cause certain bacteria to produce pro-inflammatory metabolites. These toxins can travel outside of the gut, triggering inflammation when they encounter immune cells. Those immune cells then destroy the toxins, sometimes damaging healthy tissues in the process.

"Interestingly, 95% of serotonin is produced in the gut. "

Like other species, microbial communities grow when they have food to eat. Food with high fibre content and compounds called polyphenols (famously found in dark chocolate and red wine) feed 'good' bacteria. On the other hand, foods high in processed sugars and fats feed the 'bad' ones. Accordingly, the 'good' species produce by-products with anti-inflammatory effects, whilst the 'bad' ones do the opposite. Fermented foods such as kefir or kimchi contain 'good' bacteria – also known as probiotics – and encourage these communities to grow. The question of whether the increasing consumption of ultra-processed foods is linked to the growing global mental health crisis remains up in the air. Yet, recent studies are finding more and more links, confirming medicinal knowledge from long ago.

"All disease begins in the gut."
- Hippocrates circa 2500 years ago

"The gut microbiome may therefore be a key indicator of overall health and wellbeing. "

Ancient Hippocratic medicine, traditional Chinese medicine, as well as South Asian Ayurvedic approaches all point to the links between diet and mental processes. Ayurveda, for example, encourages mindful practices such as yoga and meditation alongside the introduction of specific spices and whole foods. While it's been documented that individuals with depression and anxiety are highly likely to report stomach upset, studies are now finding that digestive issues may in fact contribute to disorders like anxiety and depression. This has inspired a recent shift towards cognitive behavioural therapy for people suffering from irritable bowel syndrome (IBS), as well as dietary interventions for mental health.

The gut microbiome may therefore be a key indicator of overall health and wellbeing. Part of the reason why the evidence is not clear-cut is because each individual is unique. The gut microbiome is constantly changing and evolving as it responds to what we eat. Deep-fried foods promote the growth of 'bad' bacteria, which create inflammatory by-products that can harm the intestinal lining, thus reducing its ability to absorb nutrients. When these bacterial colonies multiply, good bacteria die, and fewer beneficial compounds are produced. In turn, a large number of bad bacteria induce cravings for these types of foods, generating a cycle of suffering. Similarly, eating a variety of whole foods and probiotics can help create a positive environment that benefits not only the body, but the mind as well.

PSYCHOMICROBIOTICS
CHLOE MARSCHNER (@clo.glyphics)

POEMS

LUCY WALL

Older Growth

Storms would linger in the trees for days
even once the sun returned.
From leaves and needles
a forest of rain dripped and pooled
in silver streams
rinsing the sides of the trail
narrower each time we walked it.
Here, yesterday's downpour keeps falling
and the trees echo stories wind told
when it blew through years ago.

Photos by Lucy Wall

Diurnal Diaphragm

Branching veins, coastal bound
Reaching in trickles of fresh water
Towards salty air thick with mist
Scattering off the tops of breaking waves,
The rise and fall of an oceanic chest
With each crashing breath
The sandy pulse of a shoreline
Swallows up rain and river
To fill unknowable depths

Falling forward

STEPHEN WEBSTER

Falling forward into retirement, I find I am organising a conference about doubt. What is doubt? It is the feeling that you don't know where you are heading, that the unknown looms large. Rather than face this feeling directly, I project it full-square on to the College. Thus The Day of Doubt is born.

As I write, I know that on September 27th, a good number of people in the College will be examining doubt as a resource for science. They will be trying to understand why not-knowing, and the humility and discomfort that goes with that, are an essential part of the life scientific.

The idea comes also from Dr Felicity Mellor, my successor as head of the Science Communication Unit. She and I awhile back organised a series of conferences on 'silences in science'. We thought that perhaps scientists don't spend enough time lolling around quietly. On the other hand, we also could see that while there are good silences in science, there are malign silences too.

Release for *I,Science* spring issue

The 'silence' symposia born from thoughts like these were remarkably interesting. In amongst the intellectual valour, we had a performance of John Cage's silent work 4'33, and a brief session of meditation, with Sara Mohr-Pietsch. And all of this was under the imprint of Imperial College.

Naturally then Felicity and I leapt at the idea of 'The Day of Doubt'. And, greatly to its credit, the College was keen too. But have you ever organised a conference? If it happens to you, just give me a ring. I think I know a few tricks.

Probably you need a star, or at least a name. Sir Paul Nurse FRS, CEO of the Crick Institute, seemed a good bet. He's so great, so non-pompous, so warm. But how do you begin, with someone so famous? Who handles their email? Do they even use email?

I decided to type a letter on an Imperial letterhead, and deliver it by hand. I felt the ultra-slow method might be best. I took the letter down to the Crick on New Year's Day, this year a Sunday. I had thought I would put the letter in a letter box but this was naïve of me. The Crick has no letter box, and apart from a few ashen-faced postdocs slipping in and out there was no sign of life. I found a bell and leant on it.

After a big pause security arrived and looked at my letter anxiously. Because of the 'Imperial College' branding, they took it. Probably it got stuck at some screening stage, for it never reached Sir Paul's office. In the end I had to send an email, and a scan of my letter. And because of all these absurd and comical comings-and-goings The Day of Doubt found some attention in the Crick, and Sir Paul decided to come.

I mention all this because it reminds me of what I value about the MSc Science Communication. It is the students' ability to take a side-view, to be critical, to be aware of unusual perspectives. If I can organise a Day of Doubt it is because this is a theme I have been exploring with my students for years. It is because I am doubtful.

It is worth remembering that doubt has utility. Sometimes it's the smart option. Naturally I wouldn't want to teach that directly, or emphatically. My tactic is to advise students to read Joseph Conrad's novella The Shadow Line. No text better expresses the truth that doubt can be the herald of success.

A young mariner, already with a good reputation for his skills, arrives in Singapore and decides he no longer has any interest in his trade. He feels terribly bored, never wants to sail again. Suddenly, as he waits to go home to England, a letter arrives from the Harbour Office. Will he take charge of a ship that needs a captain and is heading for Rangoon? Some time passes before he replies. Yes, he says, he will command the ship: his first command. He shifts from listless depression to full-on commitment. And in the very difficult voyage that follows, with the crew demolished by malaria amidst terrible becalmed conditions, Conrad is clear: our mariner's formidable skills and endurance, and his former sense of doubt, are intimately linked.

I don't think we teach you how to do your science communication. I think we teach you how to ask questions of science, of the media, of society. In short we teach you to doubt. And this in part is where your skills and your success will come from.

Reflections on the year

THE I, SCIENCE EDITORIAL TEAM

Coral Billingham

Co-Editor-in-Chief

Science communication is important because it has the ability to help everyone. Understanding the world around us and effectively communicating that information has never been more important. I hope that I, Science gives people the opportunity to learn about the passions of the Imperial College community and sparks a love for science in our readers!

Imaan Moin

Co-Editor-in-Chief

I've really enjoyed seeing all of our hard work and team efforts come together to create three spectacular print issues and keep up with our brilliant online multimedia content!

Bella Johnson-Martin

Website Manager

This year, I have learnt the importance of story. Constructing a smooth and sensical narrative is not easy but it is very powerful.

Mengmeng Tu

Magazine Designer

My favourite moment from this year was receiving our printed magazines from the publisher. It was thrilling to see the design finally to be printed out. We received wonderful artworks from Central Saint Martins each time, and it's a pleasure for me to present them in the layout.

Vanessa Hayes

Reviews Editor

Perhaps it's a bit cliche, but knowledge can be power, and I want to make sure the power of science knowledge is available to as many people as possible. People should have the ability to make informed health, career, and life decisions, and science communication plays a significant role in informing people. That said, I hope that science communication publications like I, Science will open dialogues and start conversations about the relationship between science and our lives.

Annalise Murray

Features Editor

Science doesn't have to be dry or boring or removed from everyday life - it can be funny and dramatic and entertaining and thoughtful and human.

Molly Rains

Deputy Features Editor

This year made me question many things, but I still believe that science can benefit us all. I hope that when people read I, Science and other SciComm work, it answers their questions, thrills, and entertains them -- and then leaves them curious, ready to ask more.

Gaby Sotelo

News Editor

I,Science is a good introduction into the larger field that is science communication. But in this case, you have students doing the work, which shows the range of who people might consider a science communicator. Though the news team liked to go more into recent research or space news, it is great to see what other science is going on around campus and in general around us. This allows us to highlight maybe more unknown research that is going on, or more playful science.

Reflections on the year

THE I, SCIENCE EDITORIAL TEAM

Katie Tomsett

Radio Production Team (Studio Manager)

I hope people get to find a piece of themselves in the myriad of science-y tales told in *I,Science*. Connecting with science isn't just for scientists and my favourite thing about I,Science is that it bursts the scientific bubble for all to share.

Emma Tegg

Radio Production Team (Presenter)

Science communication is a good reminder that creativity is needed (especially) when learning, discussing, and sharing science. I hope people gain a new perspective on how to connect 'facts' with a bit more fun fiction.

Sherrin Wu

Radio Production Team (Producer)

Through publications like *I,Science*, my aspiration is for our audience to encounter different perspectives and a broad spectrum of topics, extending beyond the traditional boundaries of science communication. I hope they discover the opportunity to explore these subjects at their own pace, empowering them with the tools and knowledge to delve deeper into the matters they find personally important.

Laia Mallafre

Events Manager

I,Science is a great place for new writers and artists to explore new and interesting topics, and I have loved helping out in the brainstorming process of every issue and coming up with ideas to explore there!

Lucy Davies

Sub-Editor

Science communication is important because it invites science back into the lives of people who gave up with it a long time ago, and shows them that they, and everyone else, have a place within it.

Ola Higson

Social Media Manager

This year I learned that good science communication can inspire learning without the potentially off-putting label of science or it's sub-disciplines. Framing things in a way that is inviting for non-scientists can help break down barriers and include everyone.

Jocelin Weiss

Co-Video Editor

Science communication is important because that scientific discovery means nothing if it doesn't reach the public.

Mini Mudannayake

Co-Video Editor

Science Communication is important because it bridges a gap between scientists and people (and everyone else in-between!). I hope publications like *I,Science* not only show that science influences every aspect of our lives, but also empower people to engage with science in their everyday lives.


I, SCIENCE