THE SCIENCE MAGAZINE OF IMPERIAL COLLEGE

I, SCIENCE

ISSUE 59
SPRING 2026

BEGINNINGS

YZ.

EDITOR'S NOTE

DEAR READERS,

Welcome to the first ***I, Science*** issue of 2025-2026.

When deciding the theme for this issue, we came across the idea to view our tenure at the magazine like a journey. And so, the only logical thing was to start where journeys usually do: at the beginning.

In this issue, we aim to showcase all types of beginnings and fresh starts in science: things that move us, inspire us, and make us feel like anything is possible. This can mean a flowering tree blooming in Madagascar, the unfolding and survival of friendship or the origins of life on Earth.

Beginnings in science are not only about discovery, but also about perspective. They invite us to pause and ask new questions and to challenge what we think we know. In that sense, beginnings are not just moments in time, they are turning points that shape where we go next.

Whatever starting over means for you and wherever this journey takes you, we hope that among these pages you'll find something fun, interesting and relatable. Thank you for walking with us through these exciting new beginnings for *I, Science*.

CATALINA SÁNCHEZ & NATALIA LEO
EDITORS-IN-CHIEF 2025-2026

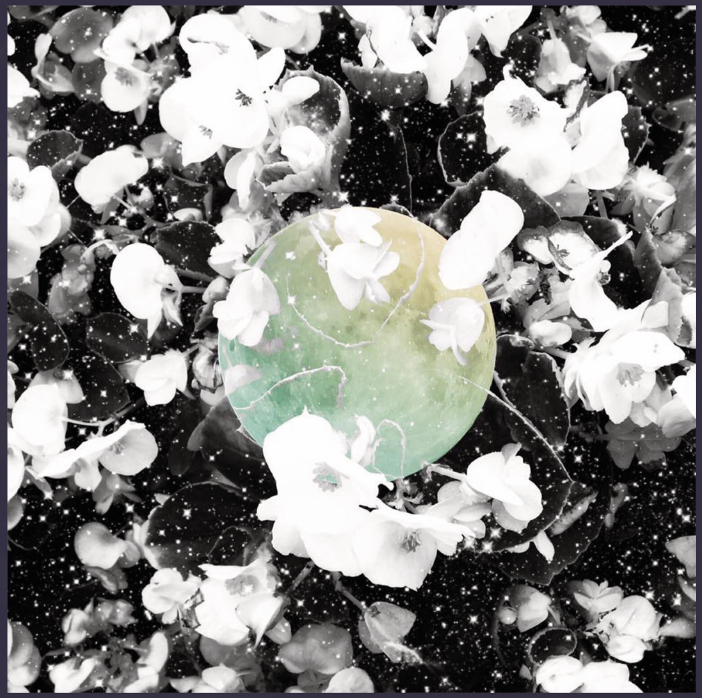
FRONT COVER ART:
YILIN ZHANG
THE FIRE HORSE
In the Chinese Zodiac's Great Race, the Snake secured sixth place by hitching a ride on the Horse's leg. As we bid farewell to the Year of the Snake, we welcome the Year of the Fire Horse - an occurrence every 60 years. In Chinese mythology, The Fire Horse possesses a volatile energy - an opportunity to take big leaps in your academic, career and personal life this year.

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.

Email us at **i.science@imperial.ac.uk**
Follow us on X and Instagram at **@isciencemedia**
Like us on Facebook at ***I, Science***
Find more great content on our website:
www.isciencemag.co.uk

scan for our website

MOONBUBBLE BY YEDAM PARK



MOONFLOWER BY YEDAM PARK

CONTENTS

FEATURES

GAMES

BEFORE THE 'AHA'

BY JACK HOOPER

The first problem with writing an article is that you have to decide what it's about. This is not, on reflection, an unreasonable requirement for an article to make. I sat down to think of an idea and waited for one to appear. Nothing did – in any useful sense, anyway. My mind was busy enough, full of thoughts, distractions, fragments of sentences, just not anything that could reasonably be described as an idea. It was like waiting for a train the announcer keeps promising is minutes away, except the train is inside your own head and you suspect it's been cancelled.

This lack was compounded by the theme: Beginnings. Beginnings of what? Ideas? Civilisations? Pasta dishes? It's not even a category; it's a temporal direction. Granted, as Features Editor, I had helped choose it, but there is something uniquely galling about being trapped by your own administrative decisions. Surely a beginning should make things easier, not harder.

Instead, I found myself waiting for an idea to arrive, as if it were a parcel delayed in transit – which is an odd way to describe thought. We say we "have" ideas. We "get" them. Occasionally, they "come" to us. The language makes ideas sound like parcels with postcodes, until you discover there's no tracking, no delivery date, no customer service, and you just have to stand by the door and hope. The metaphor is so familiar it feels literal, until you try to locate the warehouse. Where are these ideas kept, exactly, before they're dispatched? Who's packing them?

Because while it's easy to say you've had an idea, it's much harder to describe what it was doing just beforehand. You don't feel it assembling. One moment it isn't there, the next it is.

A team at Northwestern University, back in 2004, had people solving anagrams while wired to EEG and fMRI machines. Again and again, the same pattern appeared: the brain changes before the person knows it has. They recorded a burst of high-frequency activity roughly 300 milliseconds before participants reported the "aha." Consciousness, it turns out, is less workshop and more press conference. The real work occurred in your absence, and you're just being briefed on it now.

> *"DECADES OF RESEARCH SUGGEST THAT RELENTLESS FOCUS CAN SUPPRESS THE VERY RESTRUCTURING REQUIRED FOR INSIGHT."*

The mechanisms driving this involve regularised gating and neural noise – background static that helps the brain break out of rigid patterns, try alternatives it would otherwise ignore. Your brain has been quietly assembling the answer while you've been staring at the ceiling. Insight also triggers a dopamine reward: not because thinking happened, but because uncertainty has been eliminated. The feeling arrives when the brain registers that the problem is no longer open.

All of which is deeply inconvenient when you are sitting at a desk trying to generate an idea on command. The obvious response is effort: sit still, apply discipline, wait. If nothing happens, wave your pen like a wand and attempt "accio inspiration." This feels virtuous; it resembles thinking. It also, in my experience, closely resembles sitting very still while nothing happens.

Unfortunately, decades of research suggest that relentless focus can suppress the very restructuring required for insight. Problem-solving studies find a reliable "incubation effect": people are more likely to solve problems after stepping away. The effect is strongest when the break involves something simple – walking, showering, making tea – and when the task requires a shift in perspective. The traditional explanation was that unconscious work continues during the break. But more recent research suggests something subtler: the break diverts attention, releasing the mind from a false organising assumption. The benefit comes from getting out of the way.

In neural terms, when focused attention relaxes, activity shifts towards the Default Mode Network – associated with mind-wandering, spontaneous cognition. Its counterpart, the Executive Control Network, handles focused attention. These networks were long thought to be mutually exclusive. They're supposed to take turns. The Default Mode Network daydreams; the Executive Control Network works. They are not, on paper, collaborators. But during creative thought, they are.

> *"IF SCIENCE IS GOING TO TELL ME MY CONSCIOUS MIND IS A PASSENGER, THE LEAST IT COULD DO IS TELL ME HOW LONG THE JOURNEY TAKES."*

A 2008 neuroimaging study in Neuropsychologia found consistently that creative states involve dynamic interactions between these two systems. The Default Mode Network generates associations, trawls the semantic deep for material linear thought wouldn't encounter. The Executive Control Network evaluates, selects, filters coherence from noise. Creativity emerges from alternation. The mind wanders, but it wanders with purpose. It daydreams on company time.

A 2025 study in Cerebral Cortex pushed this further. It showed that it is possible to increase coupling between these systems with training. Twenty-four hours later, participants showed measurable increases in idea originality. Strengthen the communication between the wandering mind and the working mind, and ideas emerge that weren't there before.

Which explains why, when I stopped trying to think of an idea, I had my "aha" moment. I now had something to say about having nothing to say.

Perhaps the real difficulty lies in the word "create." Classic theories suggest creativity is not conjuring something from nothing but recombining existing material. Memory behaves less like a filing cabinet and more like a network: concepts are nodes; associations are edges. Most thought travels along well-worn pathways. Creative thought involves traversing weaker, less obvious links. The architecture of your memory predicts how likely you are to have ideas at all.

My article did not begin with an idea. It began with accumulation: fragments, research, frustration inside a network that continued operating despite my insistence that nothing was happening. At some point, the writing stopped being about absence and started being about arrival. The restructuring happened first. The awareness followed. I am, apparently, the last to know.

Which part, then, was the beginning? The burst that lasted less than a third of a second? The hours of incubation during which I stared at walls and complained internally? The moment I first sat down and resented the theme? The research suggests the brain reorganises before informing you. This feels like an oversight. If science is going to tell me my conscious mind is a passenger, the least it could do is tell me how long the journey takes. Is it a hop on the Tube or am I going to Australia? The science captures the spike. It does not capture the waiting.

The more carefully I examine the problem, the more the beginning retreats, replaced by accumulation, restructuring, neural noise, and the quiet, invisible labour of networks I cannot directly control. Explanation generates more material. The material requires explanation. The loop tightens.

I set out to write an article about where ideas come from and have instead written an article about how writing an article about where ideas come from produces an article.

Is that recursive? Is it self-indulgent? Is it just a long way of admitting that I didn't have an idea to begin with, and have been padding ever since? It may simply be accurate. But accuracy is not the same as usefulness, and neither of them is the same as having something to say.

If the idea arrived after most of this article was written – if it emerged, as the research suggests, during the process of documenting its absence – then perhaps the article isn't about beginnings at all. It is a beginning. Or it is about the gap between trying and having: the space in which the brain is busy, but the self feels idle; the space in which nothing appears to be happening while something is. I am writing about being in a loop while inside the loop.

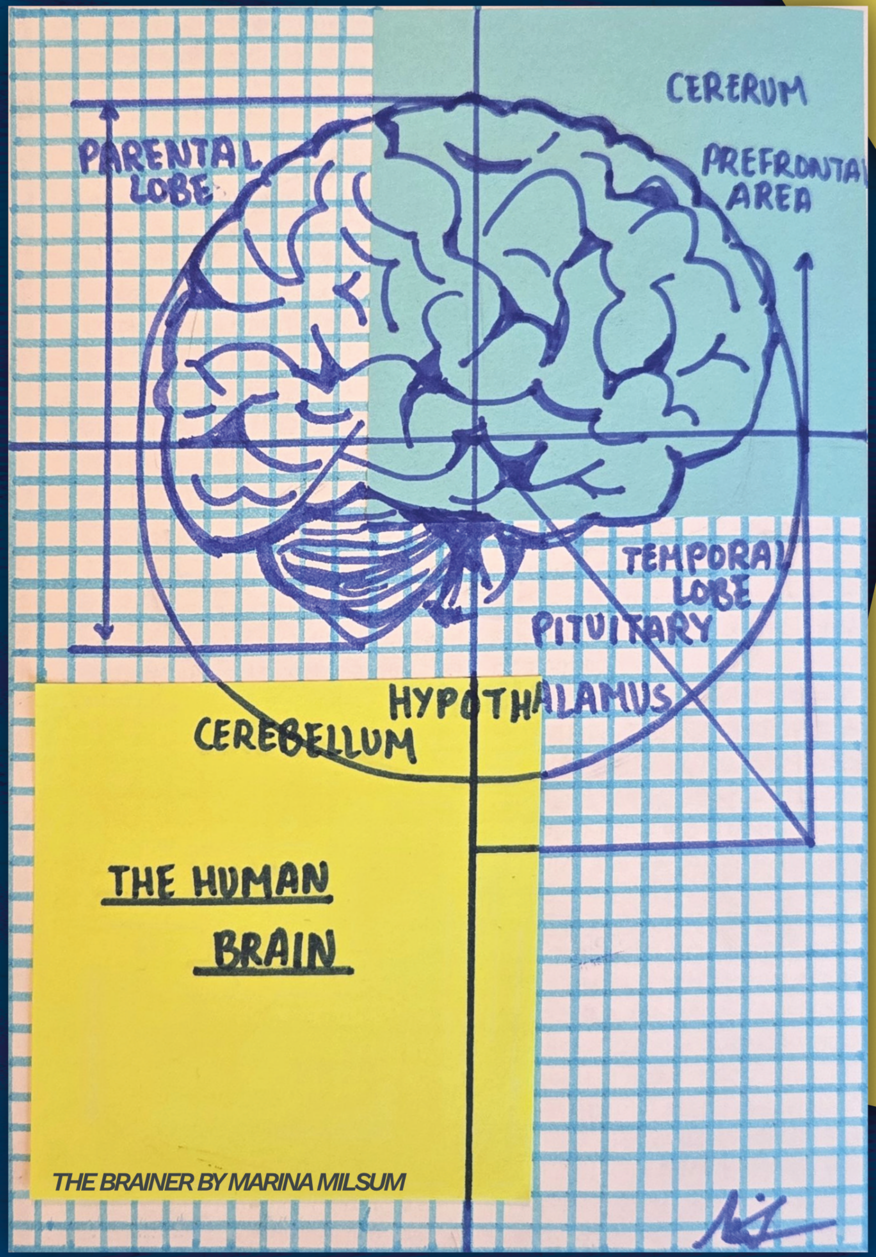
I was hoping it would resolve into something neater. It didn't.

I just stopped.

Ah sod it – next time I'll just use AI.

Does it have ideas?

Do I?



THE BRAINER BY MARINA MILSUM

OPENING THE BRAIN BISTRO

WAKING UP THE WORLD INSIDE YOUR HEAD

BY CLARA CARROLL

As the holiday season festivities wear off and reality creeps back in, it is time to return to the swing of life's daily hustle and bustle. Whether it's work, school, or other events that bring you out of bed in the morning, it may be time to return to a healthy sleep schedule (or start one, if that was your New Year's resolution). Before your mind wanders to work stressors or starts dreading the day ahead, let us rewind the clock to the wee hours of this past early morning.

Imagine it's 4:00am and you are fast asleep in the quiet sanctuary of your bedroom. The blankets are pulled up high to combat the cool night air. Your mind still exists in a fantasy world where you are flying over the city. To you, the chaos of daily life has not yet begun but hidden inside your brain, a little manager has already clocked in. The size of a grain of rice, the suprachiasmatic nucleus, or SCN, is in control of your master clock, preparing you for the daily opening of your body's personal bistro.

Whether you wake up each day to your blaring alarm clock or not, your body intuitively follows a general eating and sleeping schedule, your circadian rhythm. If you've travelled long distances during the recent holidays and suffered the inconvenience of jet lag, you'll know the importance of this daily programming. How is your body tracking time? The answer is this miniature manager: the SCN. This tiny region is composed of two nuclei, each a cluster of about 10,000 cells. It sits in the brain's hypothalamus, just above where your optic nerves cross and connect your eyes to your brain.

> *"AS YOU LIE CURLED UP IN BED, YOUR BODY IS PREPARING FOR ITS DAILY AWAKENING, READY TO OPEN THE DOORS TO YOUR BRAIN'S BISTRO."*

As you lie curled up in bed, your body is preparing for its daily awakening, ready to open the doors to your brain's bistro. The SCN manager is ensuring time is ticking away in the back office. However, without a physical clock on the wall or a smartphone to pull out to see the time, the SCN checks on your bistro's chefs to make sure everything is on schedule.

It's still the early morning, near dawn, as you lie tucked under the covers. Your brain bistro's kitchen is empty, and the chefs begin to file in to start cooking. The chefs are the CLOCK and BMAL1 proteins, which team up to form a joint workforce. This duo binds to your DNA, specifically the period (Per) and cryptochrome (Cry) genes. These genes contain the instructions to enable your body's master clock to work properly. The CLOCK/BMAL1 complex's job is to ensure that these time genes are read correctly. Accurate processing of these genetic instructions - through DNA transcription and translation - results in the formation of PER and CRY proteins.

Thankfully, your brain's internal bistro doesn't overflow with PER and CRY proteins because this cooking process is self-regulated. As the PER and CRY protein levels build up during the day while you are awake and peak in the evening, they shut down the CLOCK/BMAL1 chef complex.

Imagine your bistro is at full capacity, with meals covering every table eventually blocking the chefs from making any more food. As a result, the Per/Cry gene instructions stop being read and no more PER/CRY proteins are made. Then, when your bistro closes for the night and old meals are cleared out, the CLOCK/BMAL1 complex is activated again, and the chefs can go back to work. High PER and CRY levels indicate the evening, when meals pile up, whereas low levels signal daytime.

This delicious negative feedback loop forms the basis of the circadian rhythm and allows the SCN manager to keep time by monitoring the food, or more precisely, the PER and CRY protein levels.

So, as you are fast asleep and the morning creeps closer, your SCN manager is already watching the clock. As we all know, having safety nets and internal checks can be lifesaving, and your body has them too. It's important that your body's internal clock is synced with the environmental day-night cycle. Even if the SCN manager might think it's almost time to open the restaurant doors, the arrival of the morning delivery truck is just the signal it needs to ensure everything is going to plan.

The mystery delivery man? Light.

While you lie in your bed and wake-up time beckons, small streams of morning light slip through your curtains and slowly fill your room. Specialised cells in your eye, called intrinsically photosensitive retinal ganglion cells, helpfully abbreviated as ipRGCs, detect this light. The ipRGCs send signals through the retino-hypothalamic tract (RHT), a pathway from the retina to the SCN in the hypothalamus. This triggers the release of glutamate, a chemical messenger, onto the SCN cells. Glutamate's message is simple: increase the production of PER proteins. Shifting the levels of these proteins therefore adjusts the internal clock to match the environment. Congratulations! You've officially woken up and your brain's bistro has opened.

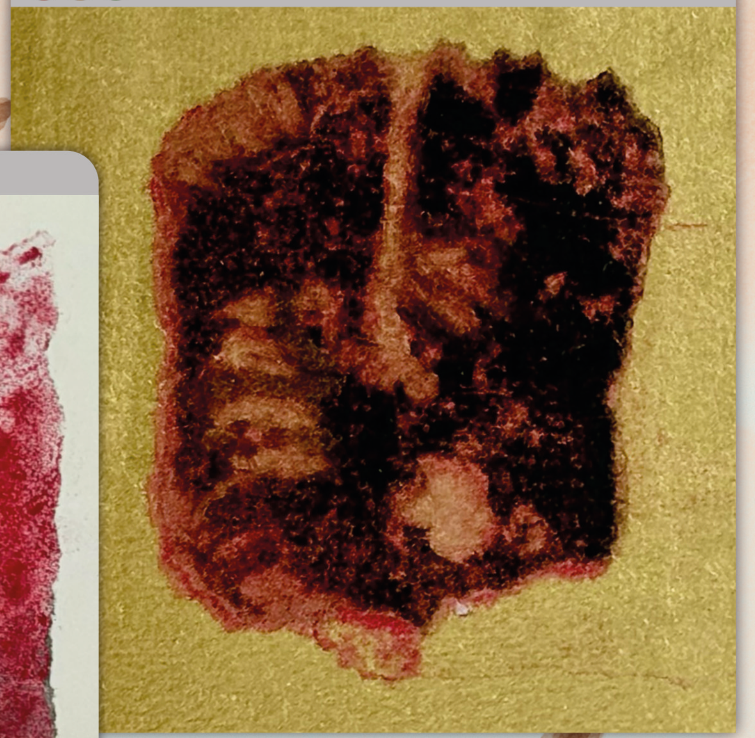
The light in your room also serves another purpose: alerting the SCN manager to signal the pineal gland to suppress melatonin release. Think of melatonin, a hormone that signals when it is time to sleep, as your bistro's nightly janitor. Working best in the quiet dark of the night, the janitor can clock out before the day's rush begins.

As the nightly janitor melatonin clocks out, it's also time for the manager to fire up the kitchen fan so that the bistro can open smoothly. Although you might be "awake," you may still wallow in the warmth of your bed or engage in a morning social media scroll. You need that extra push to get up and out.

Inside your brain, the SCN sends signals to the paraventricular nucleus of the hypothalamic-pituitary-adrenal axis, a long name for the body's main stress response system. Just as an extractor fan hums and whirs, this signalling causes a rapid increase in cortisol levels, the main stress hormone. This brief, purposeful spike is known as the cortisol awakening response (CAR), aiding in preparing our bodies for the day's demands. Cortisol levels peak approximately thirty minutes after waking, making this stress helpful to boost alertness and cognitive function.

As your bistro manager looks happily at the kitchen fan fired up, the food beginning to fill the kitchen, and the janitor long since clocked out, it finally flips the closed sign over. Now you can go brush your teeth, commute to work, or read fascinating science articles, like this one. Take a moment to appreciate your brain for this morning's wake-up call. Tomorrow morning, when your eyes flutter open to take the world in, or as you take your first bites of breakfast, remember the tiny bistro in your brain. Whether you're excited or worried about the day's plans, know that your body has already prepared a workspace for you to take on a new day.

The bistro doors are open.
The food is warm.
Your day has begun.



OXYGENATION (LEFT) & MORNING LIGHT (RIGHT) BY ROHINI CONTRACTOR

UNTITLED NO.33
BY ANNE SIKORA

A BEGINNING WRITTEN IN THE STARS

BY MUMINAH AL-ISLAM

The clues to our beginnings were unlocked with the fiery end of the Murchison meteorite. It fell to its death through the blazing atmosphere in 1969, giving birth to ripples in theories on the origins of life. It immediately captured the attention of scientists worldwide with its rich content of organic compounds, including over 70 types of amino acids. As scientists tried to make sense of this evidence, one voice rose higher than all others: the Panspermia theory that life's chemical building blocks arrived from space.

For centuries, we have searched for clues within ourselves, among the animals around us, and in the rocks that reveal sediments telling stories of aeons past. Scientists around the world have long since presented competing theories. Some say that life began in hot hydrothermal vents where conditions allowed organic compounds to assemble into complex cells. Conversely, some scientists argue that it was the interplay of clay and ice that created isolated conditions where life could form uninhibited by the environment. One particularly prominent theory, however, is Panspermia; the theory that life's building blocks of complex organics were delivered to Earth from outer space. This theory unveils a picture far bigger than what we previously imagined: to understand our beginnings, we must start with the most explosive ending of all – the death of a supermassive star.

This supermassive star lived many millions of years before our sun. Over the course of its life, hydrogen and helium atoms furiously collided together under crushing pressure at the star's core. The heat and pressure were so intense that the very nuclei of atoms fused together, forming new and heavier atoms. Thus, elements like carbon, nitrogen, and oxygen formed in the core, and there they remained until the fateful day that the star's inward gravitational pull finally won against the outward pressure of the fusing atoms. The result? A total collapse of the star, crunching in on itself before erupting in one of the most spectacular explosions in the observable universe: a supernova. In this death, the promise of life was made.

Carrying the power of several octillion nuclear warheads going off all at once, the heavy elements were hurled out in shockwaves, spewing out across interstellar space in a devastating display of technicolour. After expanding for thousands of years, in the wake of the star's ashes, a phoenix rose.

The dust finally settled into a nebula as the wreckage of the dead star became the seed of one yet to be born. Here, in the swirling clouds of gas and dust, a nursery for new stars began to form. Clumps of material in the nebula clung together, gradually increasing in size and gravitational pull. One such clump of material, a giant molecular cloud, formed a gravitational pull so strong that it crushed the material in its centre until it reached the point of collapse, marking another ending that became the raw material for a new beginning.

> "TO UNDERSTAND OUR BEGINNINGS, WE MUST START WITH THE MOST EXPLOSIVE ENDING OF ALL - THE DEATH OF A SUPERMASSIVE STAR."

Most of the material in the cloud collapsed into a protostar: the birth of our very own sun. Spinning rapidly around the newborn star was an accretion disc, a swirling mass of gas and dust left over from the star's formation that would one day form the planets, moons, and asteroids of our solar system. Most crucially, they would contain the heavier elements that formed in the core of the now-exploded parent star. Carbon, nitrogen, oxygen, and hydrogen: the stuff of life. It was this stuff of life that would eventually embed itself into the millions of asteroids whizzing around the sun as the Earth began to form. And what a dramatic formation it would be.

Much like the sun's formation, the planets, moons, and asteroids also formed through a process of accretion. Ice, dust and gas in the accretion disc surrounding the sun clumped together, creating a snowball effect that would clear the haze of the early solar system into the form we recognise it in today.

While the Earth was still forming, a rocky object called Theia, the size of planet Mars, collided into it. This collision was so violent that it tore off a sizeable chunk of our planet's matter. Most of it was flung out in spirals that briefly formed a ring system around the Earth, much like Saturn's! Some of the ejected material clung together to form our moon.

This impact was devastating for the Earth's temperatures. Now scorching at above 2000 degrees Celsius, the planet was one giant ball of lava; an unforgiving hellscape where no life could form. The early Earth also had no atmosphere. And most crucially, its surface was barren of water and elements that make the stuff of life. Despite these conditions, more turmoil was in store for the young Earth. A period of around 4 billion years ago marked the Late Heavy Bombardment, where the asteroids whizzing around the sun changed course, raining down on the Earth for millions of years. The relentless shower of fireballs from the sky seemed to seal the Earth's fate as a doomed planet, where conditions would never be gentle enough to cradle life.

Eventually, the bombardment stopped. And something curious happened. As the Earth finally cooled, liquid water began to pool across its scarred surface. In a twist of fate, the meteorites that once seemed to be agents of destruction were, in fact, stealthy chemical couriers, carrying complex organic molecules forged far beyond Earth.

As oceans formed and the planet's atmosphere thickened with carbon- and nitrogen-based gases, Earth was finally becoming ready to support the formation of life. The very impacts that appeared to seal the planet's doomed fate had instead delivered the conditions necessary for life to emerge, its origins scattered across space and time, written into the debris of long-dead stars.

The evidence left by meteorites like Murchison reveal clues that complicate where we look for life's origins. We must reckon with widened horizons, where complex organic molecules formed in the distant blackness of space and survived journeys that once seemed impossible, carried intact through violence that should have erased them. All so that fragments of stellar death could be repurposed into something living, blurring the line between destruction and creation. By uncovering these clues, we learn that when we search for beginnings, we must first examine endings. And when we look for signs in the rocks beneath our feet, we may be missing the clues written in the stars above our heads.

THE FIRST WATCHERS OF THE COSMOS

BY GABBY ZIOBRO

The endless dark blues of the night sky, speckled with eternal, twinkling flecks of light, have mesmerised humanity for hundreds of thousands of years. From stargazing to astronomy, the cosmos has long held our fascination. Our stories are intertwined: we would not be here without the limitless universe that we glimpse in fragments, and we have searched for meaning in its breathtaking expanse for as long as we have been looking up.

Today, we study the universe with a precision that allows us to delve into its vastness in ways our ancestors could never have imagined. Yet astronomy is not a modern invention, nor did it begin with Nicolaus Copernicus or Galileo Galilei. It is one of the most ancient forms of science; one of our longest-held legacies that emerged from the beginnings of civilisation. To appreciate the accomplishments of contemporary astronomy, we must first pay tribute to the people who once read the sky with wonder, ritual, and story. Without them, the way we study the universe would not exist in the form we recognise today. And among the earliest readers of the sky were women, quietly shaping how its knowledge was observed, preserved, and passed on.

To trace the beginnings of astronomy, we must return to humanity's earliest cities in ancient Mesopotamia. These cities were made of monumental structures of sun-dried mud bricks and dominated by massive step-pyramids, ziggurats, built in devotion to their patron deities. In the city of Ur, that deity was Nanna, the Moon god, and serving him around 2300 BCE was Enheduanna, the city's high priestess.

In ancient Sumer, religion and astronomy were inseparable. The movements of the heavens governed ritual, agriculture, and time itself, placing priestesses at the centre of celestial knowledge. Enheduanna's role would have required careful attention to the Moon's cycles, which formed the basis of early lunar calendars and allowed Sumerians to anticipate planting and harvest seasons.

Yet Enheduanna was much more than a ritual timekeeper and priestess. She is the earliest known author in human history, writing at a moment when cuneiform itself was still new. Her surviving poems offer a rare glimpse into how the ancient sky was understood. In her poetry, Enheduanna writes of measuring the heavens, using celestial imagery to weave together movements of the planets and the rhythms of human life.

She writes especially of Inanna; the goddess associated with the planet Venus. Inanna is described as volatile and powerful, a characterisation that mirrors Venus's strange visibility, appearing brilliantly in the sky, then vanishing for months at a time as it passes behind the Sun. While Venus could seem unpredictable, the regular motions of the surrounding stars and planets suggested an underlying order. This predictability allowed the Sumerians to link the sky not only to ritual, but also to prophecy. In Enheduanna's world, the stars offered a language through which time and fate could be understood, as if it were a sacred text.

Centuries later, the ancient city of Alexandria inherited and reshaped that gaze. Founded in the 3rd century BCE, the city of Alexandria rose as a beacon of knowledge along the Mediterranean, its identity shaped by scholarship and stone. At its heart stood the Library of Alexandria, not just a single building, but a vast intellectual ecosystem. It was a complex of lecture halls, gardens, dining rooms, and laboratories; collectively known as the Museum of Alexandria, a place that resembled a modern university. Within its walls were hundreds of thousands of scrolls, each one a fragment of the world's accumulated thought. Unfortunately, no specific descriptions of the library have survived its tragic fate, and it now exists partly as fact and partly as myth: imagined columns, shadowed towers, rooms heavy with papyrus and dust.

> "AMONG THE EARLIEST READERS OF THE SKY WERE WOMEN, QUIETLY SHAPING HOW ITS KNOWLEDGE WAS OBSERVED, PRESERVED, AND PASSED ON."

It was in this city, where knowledge was preserved and revered in scrolls, that Hypatia walked, taught, and observed the sky.

By Hypatia's time, astronomy had shifted from ritual interpretation to mathematical precision. The universe was understood as geocentric, with Earth fixed at its centre, while the stars and planets traced careful, calculable paths around it. Astronomers devoted themselves to measuring these movements with increasing accuracy, turning observation into geometry. The most influential of these efforts was The Almagest, written by Ptolemy, a comprehensive model of the heavens that would shape Western astronomy for over a thousand years.

Hypatia did not seek to rewrite the cosmos, but to refine how it was understood, and ensure the knowledge was passed on. Working within the intellectual tradition of Alexandria, she taught astronomy as something both observed and reasoned, something that could be measured by instruments as well as contemplated through philosophy. She instructed her students in the use of the astrolabe, a delicate and precise device capable of locating stars and planets in the sky, an instrument that would remain essential to navigation and astronomy for centuries. She also added her own commentary to The Almagest, helping to preserve and clarify Ptolemy's work, therefore, ensuring that the heavens could continue to be read long after the library itself was lost. In Alexandria, astronomy was no longer only a matter of prophecy and pattern, but of scientific inquiry. The sky had become a system; still wondrous, still distant, but now mapped, measured, and taught beneath marble columns and open air.

From the mud-brick cities of ancient Sumer to the marble halls of Alexandria, astronomy began not as a quest for answers, but as an act of attention. Enheduanna read the sky as a sacred text, its patterns woven into ritual, poetry, and time itself. Centuries later, Hypatia taught others to measure that same sky with instruments and mathematics, refining wonder into a system without extinguishing it.

What connects these women is not merely their proximity to the stars, but their way of seeing them. In both worlds, the heavens were something to be read. The tools might have changed, but the impulse and fascination did not. To look up was to seek meaning, order, and belonging in something vast and unknowable.

Modern astronomy, with its telescopes and equations, is often framed as a break from the past. Yet it is better understood as a continuation. The night sky we study today is the same one Enheduanna described in verse, and Hypatia mapped through numbers. Each generation inherits the same darkness, the same scattered light, and the same questions.

To overlook the careful attention of those who came before is to risk turning modern astronomy into a collection of data rather than a conversation with the cosmos. Across time, the stars remain fixed in the same dark expanse, but our ways of seeing them have shifted, from myth and poetry to measurement and precision, and now to images and data carried across unimaginable distances. Losing sight of the wonder, patience, and meaning that first compelled us to read the sky does a disservice to all watchers of the cosmos, both modern and ancient.

Astronomy's beginning was never a single moment, but a long, unbroken gaze, passed from one generation to the next, written in darkness and light.

VISIONS OF ENHEDUANNA BY YILIN ZHANG & LUIS FREIRE

FROM STELLAR BEGINNINGS TO FUSION FUTURES

BY DANIEL BROWNE

PHOTOGRAPHY BY SEBASTIAN JINGOI

Throughout the cosmos, great clouds of dust and gas, remaining from an extinguished star, gather through gravity to begin a new creation. These dazzling clouds, called nebulae, are the foundation for the formation of stars. On 26th October 2025, NASA's James Webb Space Telescope captured a picture of a nebula called the Red Spider Nebula. Using a new infrared detecting camera, a bright red centre and blue 'legs' were shown. To astronomers, these 'legs' show that hydrogen molecules contained in the nebula are necessary for star formation.

To nuclear physicists, star formation from hydrogen molecules demonstrates the blueprint for a new renewable energy source: nuclear fusion.

Nuclear fusion generates a large amount of energy from a small amount of lighter elements, like hydrogen, fusing to create a heavier element, such as helium. The current method to generate fusion energy is to fuse deuterium, a variant of hydrogen that is twice as heavy, with tritium, a hydrogen variant that is three times as heavy, resulting in helium. The fusion between deuterium and tritium produces so much energy that with only a few grams, a person would have enough energy to last them 60 years. As its only byproduct is non-reactive helium, nuclear fusion will not cause further unforeseen damage to the ecosystem. Also, fusion has a much greater energetic yield compared to coal, oil and gas, meaning it could reduce the effects of climate change within the energy sector.

To pioneer this clean and renewable energy source promised by nuclear fusion, Chancellor Rachel Reeves stated in a spending review speech on 11th June 2025 that the government would be spending "£2.5 billion on nuclear fusion". Primarily, this funding will go into the construction of the Spherical Tokamak for Energy Production.

A tokamak is a ring-shaped structure that uses magnetic fields to contain the fusion reactions. This is required because deuterium and tritium naturally repel each other, so extremely high heat is needed to force them together (over a million degrees). This intense heat within a vacuum creates a region of ions (charged particles) and free electrons known as plasma, which is prevented from hitting the walls of the tokamak by the magnetic fields, which would stop the fusion reaction and melt the container. A magnetic field strong enough to contain this incinerating plasma is generated from coils cooled by liquid nitrogen, known as superconductors. This magnetic field is needed to confine the plasma close enough that a point called ignition can be reached, where the fusion reaction in the plasma is self-sustaining.

However, nuclear scientists have known about the existence of tokamaks for over 70 years, and in that time, commercial nuclear fusion has stayed theoretical. Previous nuclear fusion development discovered that as the deuterium and tritium fuel becomes hot enough to use, the particles move further away, preventing the plasma from reaching ignition. There is also the issue of obtaining enough rare tritium. The current proposed solution is to create a blanket of lithium with 3 neutrons for the free excited neutrons to collide with from the nuclear fusion reaction. The lithium breaks down into tritium, helium, and energy. However, this is still a theory and has yet to be shown to be commercially feasible. Can scientists innovate to find a way around this issue or is the Chancellor misplacing taxpayers' money?

"STAR FORMATION FROM HYDROGEN MOLECULES DEMONSTRATES THE BLUEPRINT FOR A NEW RENEWABLE ENERGY SOURCE: NUCLEAR FUSION."

The UK government's plan is to test the commercial viability of a prototype tokamak called the Spherical Tokamak for Energy Production. This will be integrated into a single energy-producing facility. The target is for the tokamak to be built by 2040 for the UK to become a world leader in fusion technology. Nottinghamshire County Council has said, that at the height of operation, more than 6,500 jobs a year could be created for the benefit of residents, as well as boosting the county's economy by £86 to £210 million each year for the next 40 years. In July 2025, Professor Sir Ian Chapman stated that Spherical Tokamak for Energy Production is transitioning from research and development towards industrial delivery, improving technical confidence through prototype and testing, confirming regulatory compliance and maximising regional economic benefits.

Whether the theoretical science can reach the stars remains to be seen. However, if the Spherical Tokamak for Energy Production proves capable of generating commercially viable nuclear fusion, humanity could be in a position where the nebulae in space above us forming stars, will be made here on Earth.

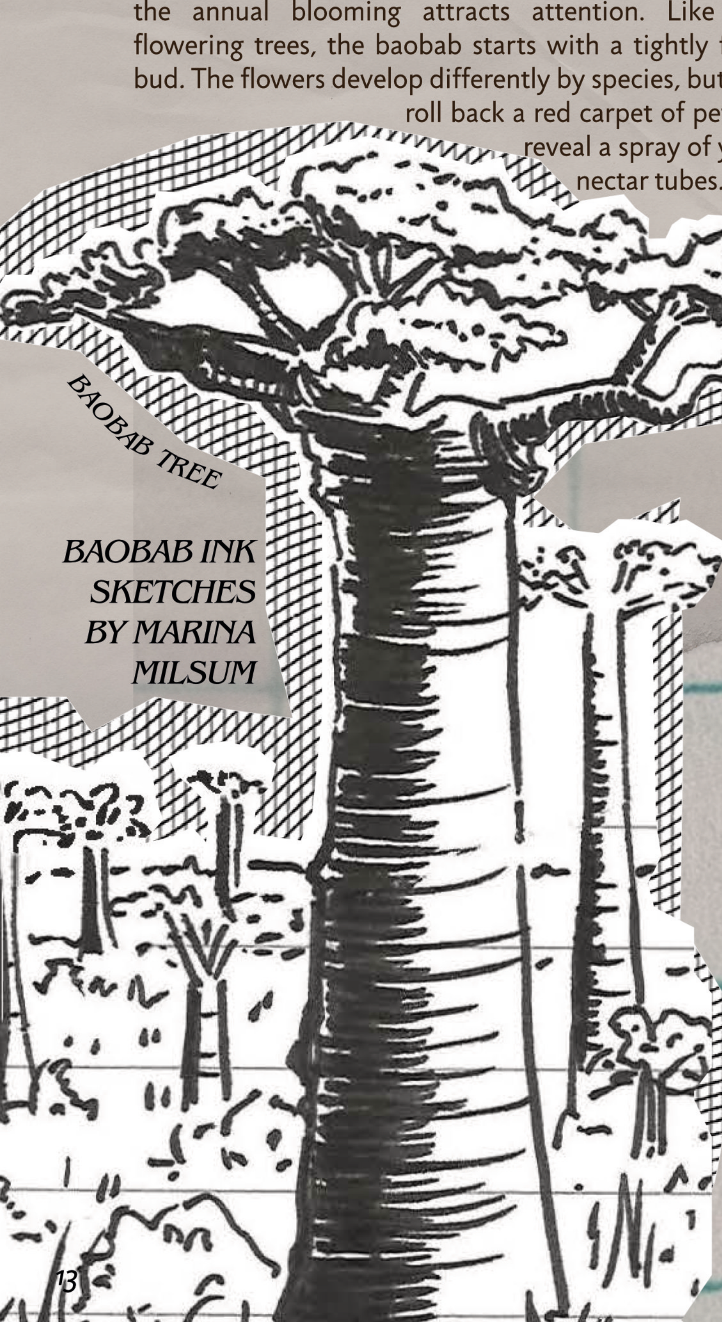
DUSK TO DAWN

NEW HORIZONS FOR THE BAOBAB TREE

BY KELLY KIRKLAND

The sun is setting and Madagascar's famous baobab trees are gearing up to put on their much-anticipated, once-a-year show. For the past decade, local expert Dr. Onja Razanamaro has had a front-row seat. "I have studied many aspects of the tree's lifecycle, but natural regeneration is so difficult, almost zero. I'm trying to understand why."

The people of Madagascar are the natural experts baobab owing to countless generations of cultural knowledge and also from their active academic research community. It's no wonder: baobab trees' ability to provide shade and habitat, to be used for water storage, and to provoke a sense of awe by their massive size have earned them the nickname 'tree of life' in many parts of Africa. Naturally, the annual blooming attracts attention. Like most flowering trees, the baobab starts with a tightly folded bud. The flowers develop differently by species, but some roll back a red carpet of petals to reveal a spray of yellow nectar tubes.



BAOBAB INK SKETCHES BY MARINA MILSUM

Others create a single creamy plate of petals that present a dense cluster of stamens and pistols. These large, white, nocturnal flowers are often chiropterophilous, meaning they specialise in being pollinated by bats.

When the curtain goes up, an intensely fragrant symphony of scents advertises to pollinators that it's time to take their place. All of the tree's effort goes into 'opening night' and they pump out maximum nectar for the first 6 hours as their audience makes a beeline to the treetops. While flowers may stay open for a few more days, they usually attract few, if any, pollinators in that time.

"THE FLOWERS DEVELOP DIFFERENTLY BY SPECIES, BUT SOME ROLL BACK A RED CARPET OF PETALS TO REVEAL A SPRAY OF YELLOW NECTAR TUBES."

The cast of characters who come to visit can be surprisingly variable, but many are adapted for their favourite baobab species. In addition to bats, Dr Razanamaro says, "we often see hawk moths, and the length of their proboscis has a strong correlation with the size of the flower." One such moth, the Comma Nephele, uses its natural agility to hover at the blooms of a grand baobab tree, Adansonia grandidieri. Its extra-long tongue is just the right length to reach the nectar.

But if pollination seems to be successful, why aren't these magnificent trees thriving?
After pollination, small fruits appear within a couple of weeks, and over the next four to six months the mature fruit develops. There is a great deal of diversity in fruit size and shape across baobab species, but in general they are fuzzy, with a stiff exterior, and dangle from long stalks. The hard seed pods protect large, fleshy seeds which are surrounded by a nutrient-rich pulp—something that lovers of plants and chocolate might recognize as similar to a cacao fruit.
When mature, they fall unceremoniously to the ground.

And wait.

Sadly, baobab have very poor germination rates. At least one study attributes this to the absence of large animals that were likely ingesting the fruit, softening the seeds, and dispersing them across the landscape. Now that these animals are extinct, it has become extremely difficult for the trees to reproduce on their own.

That's not to say that the seeds go to waste. Local people collect the fruits and use the pulp for a variety of traditional foods. "One species, A. grandidieri, has high commercial value" says Dr. Razanamaro. "Seeds can be ground into oils, and the pulp can be powdered to make into a food additive." Increasingly, as the baobab is branded as a superfood, the fruit and seeds have direct commercial value, and international businesses are swooping in.

FUTURE OF BAOBAB STUDY AND CONSERVATION

The pressure of international demand, climate change, local land use needs for agriculture and grazing, and low natural germination rates combine to paint a concerning picture for the baobab. Of the 8 species worldwide, only 1 is classified as stable, and 2 have been classified as endangered on the IUCN Red List. It's also tricky to study the life cycle of trees that may take decades to produce their first blossom. That's a fast pace for a tree that can live to thousands of years old, but a long time for researchers racing to ensure the health of these ecologically significant trees.

"THE PRESSURE OF INTERNATIONAL DEMAND, CLIMATE CHANGE, LOCAL LAND USE NEEDS FOR AGRICULTURE AND GRAZING, AND LOW NATURAL GERMINATION RATES COMBINE TO PAINT A CONCERNING PICTURE FOR THE BAOBAB."

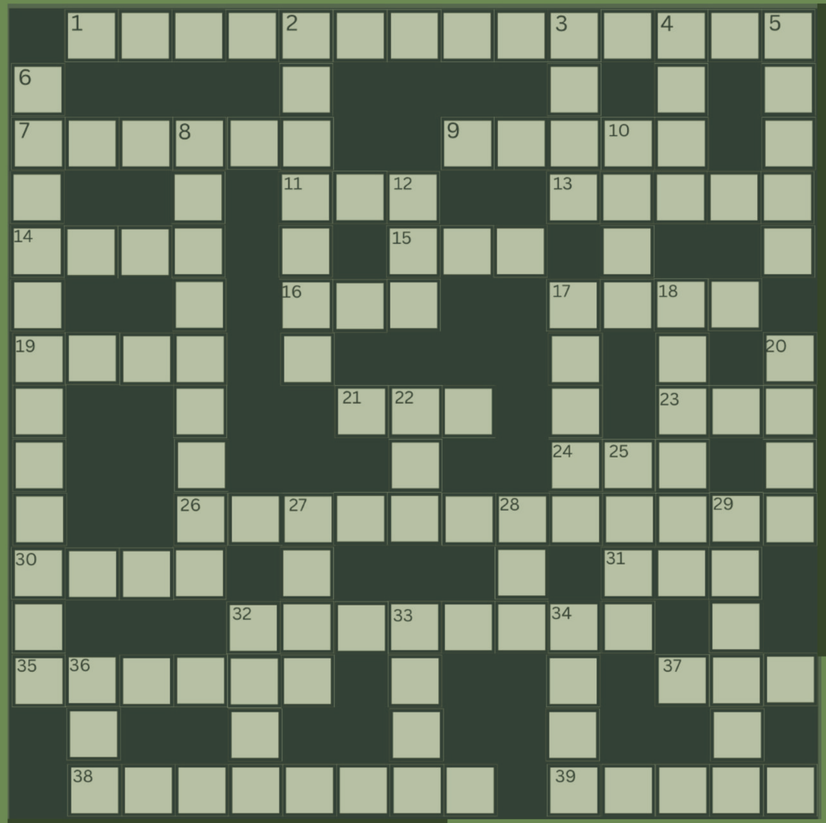
Fortunately, Dr. Razanamaro and her colleagues in Madagascar aren't going it alone; international collaborators are a key part of the plan. As a partner in protecting the world's botanical heritage, Kew Royal Botanical Gardens not only stores samples from African baobab trees in a London herbarium but has provided support directly to the herbarium at Parc Botanique et Zoologique de Tsimbazaza in Antananarivo, Madagascar. That support has included expensive, specialty paper that's required for mounting the thousands of specimens waiting to be catalogued, and staff support for digitising the herbarium collection. This makes scanned images of the dried leaves, flowers and seeds accessible to researchers worldwide, accelerating research insights. Furthermore, Dr. Razanamaro partnered with Kew on a pollinator research project called BaoBat to get direct observation of bats visiting the flowers.

To ensure future floral performances bring both economic development and ecological health, Dr. Razanamaro is planning ahead. She is working to establish a baobab nursery, enlisting local support to ensure some of the vital seeds successfully germinate and grow to keep the iconic species thriving. She's exploring eco-tourism as a way to raise awareness and funds for conservation. And her pollinator research continues, bringing together chemical analysis, genetic studies, and field observation of pollinator behaviour to provide new insights into the ecological communities who appreciate everything the baobab has to offer. For those dedicated season ticketholders, the baobab is destined to outlast anything on the West End.

GAMES OF THE ISSUE

CROSSWORDS

SCIENCE AND BEGINNINGS



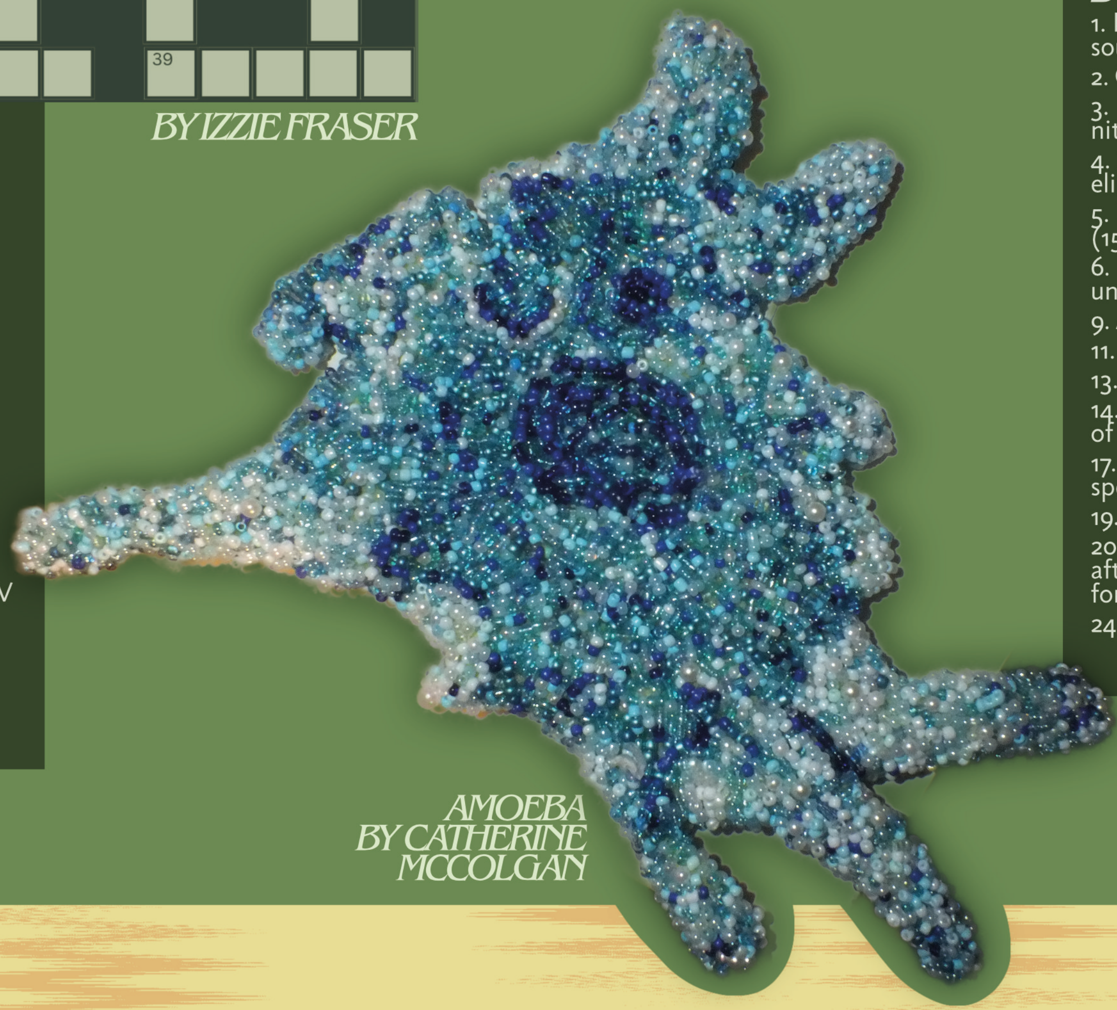
ACROSS

1. 2-Down tries to contradict the second law of this (14)
7. Plug hole motion(6)
9. Protein-building acid(5)
11. Doctor of sci-fi (3)
13. Blood-bank visitor (5)
14. Table salt, chemically (4)
15. Genetic messenger (3)
16. Scientist's room (3)
17. Mechanical, heat and chemical stimuli cause your body to feel it (4)
19. Shades (4)
21. Recede, as the tide (3)
23. Ozone (3)
24. UK antiseptic (3)
26. Study of life through fossils (12)
30. Area (4)
31. Mathematician, ___ Lovelace (3)
32. Cancer department (8)
35. The beginning of many star life-cycles (6)
37. Sleep stage (3)
38. Rate of change (8)
39. Prescribed amounts (5)

BY IZZIE FRASER

DOWN

2. Whose demon controls the door between two gas chambers (7)
3. A pH less than 7 (4)
4. Metal in steel (4)
5. Group of insects or drones (5)
6. Boundary of a black hole (12)
8. Galileo's instrument (9)
10. Bright star (4)
12. Sphere (3)
17. Dwarf planet since 2006 (5)
18. Crustacean (6)
20. Three ____ problem (4)
22. Prefix meaning living things (3)
25. Fine-grained soil (4)
27. Roman moon goddess (4)
28. The amount of hydrogen atoms inwater (3)
29. Reproductive cell (6)
32. Organic devices often used in TV displays (4)
33. ____ source, a software project that anyone can contribute to (4)
34. Au (4)
36. Measures the heart's electrical activity (3)



AMOEBA BY CATHERINE MCCOLGAN

ACROSS

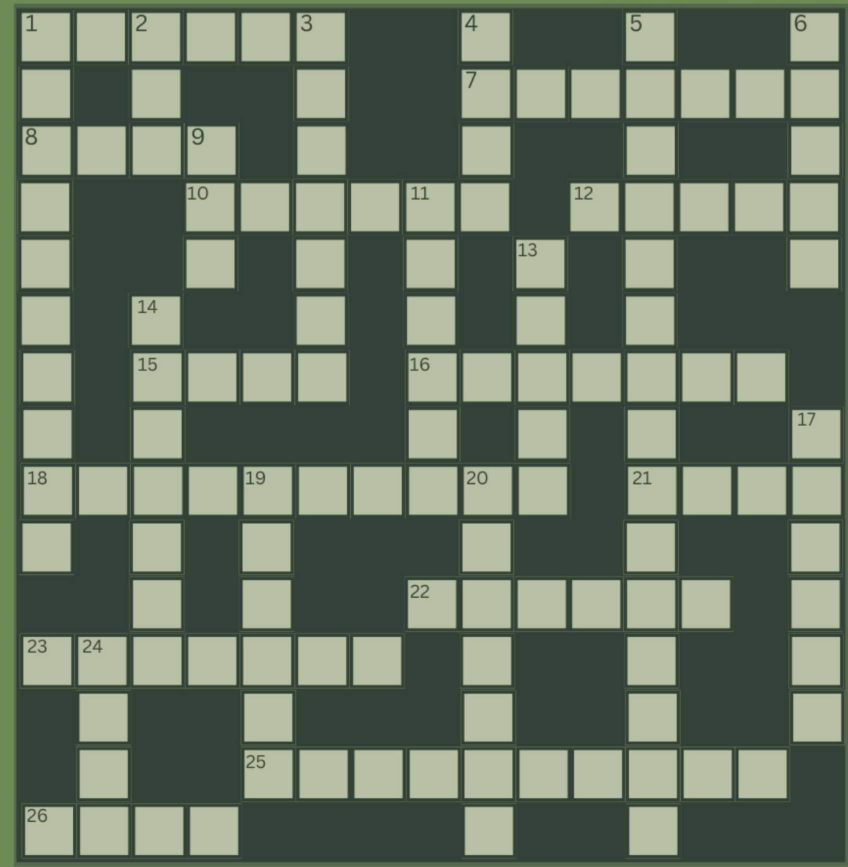
1. A tiny particle expert weighs a lot of (6)
7. Disease left an age after echo ends (7)
8. Without directions NATO is reversed a little bit (4)
10. Pulled back bow initially, but left empty quiver (6)
12. Dicing without death is sweet (5)
15. He turned north-west into a rock wall? (4)
16. Inside a cell, Lou turns within a winding cave (7)
18. At most endless sound of fear surrounds the Earth (10)
21. For starters, all people expect x-rays at the top (4)
22. "May it be the end of this?!" Half gasp, raising head of decapitated king (6)
23. Keep mixing up the fourth Greek letter after initially counting incorrectly (7)
25. Creating new order: First woman deputy head, taking strides (10)
26. Daydream rings through men lacking energy (4)

DOWN

1. Prim Lord Ian is agitated without nice starter soup (10)
2. Oh, you heard? Time it is exposed! (3)
3. Baby played with bower surrounded by nitrogen (7)
4. Spots the beginnings of all collusion needing elimination (4)
5. Elect or swayed by alluring quality of waves? (15)
6. A century ago, Romeo was inside a storage unit (5)
9. Are we lacking regarding wonder (3)
11. Distorted strain of carnival ear worms? (6)
13. Revolution corrupts ye 250! (5)
14. Splitting earache? Sounds like missed place of medicine (7)
17. Short Texan muddled through for each specialist (6)
19. Spy, heard dead, started rumour (6)
20. Docile PhD graduate shortly disappeared after appointed spokesperson mentioned "Tea for T-Rex?"(7)
24. Rebel leader vanishes! In for details (4)

ASPERGILLUS BY CATHERINE MCCOLGAN

SCIENCE AND BEGINNINGS CRYPTIC



BY JODIE YOUNG

SURVIVAL OF THE FRIENDSHIPS

BY ROSANNE CHOONG

PHOTOGRAPHY BY GLYNIS DAVIES

Whether manufactured by a matter of circumstance, or by serendipitous chance, friendship must have a beginning. You may not remember exactly how you made your first childhood friend, but that connection may have scientific roots.

As life goes on, we often take our friendships for granted. For many people, university is often the first time that we are suddenly picked up and dropped into a claw machine of unknown faces. We start from scratch, surrounded by strangers and are expected to adapt quickly to new environments. Your friends are an indication of who you are. Your likes, dislikes, occupation, age, and even the data fed into your instagram algorithm could invite a whole analysis about your character.

But as we have evolved as humans, the idea of friendship has morphed from an early hunter-gatherer tactic into something as simple as a follow request on social media. Can science explain whether we still need friendship as a means for survival?

WHY DO HUMANS BEGIN FRIENDSHIPS?

To answer my previous question, we must explore why humans even begin friendships in the first place. Why shouldn't we completely detach ourselves from the world and avoid forming connections at all costs? It would mean that we could avoid those nights lying awake overthinking everything we said to that friend in the corridor. Was it rude that we had to leave the conversation because we were running late for our lectures? Do they hate us? This whole spiral could be prevented if we completely dismissed the idea of friendship. If this spiral seems completely dramatic and over-exaggerated, please know I envy you.

Rituals of seeking connection originate from hunters realising that they needed companions to enhance their chances of sourcing food and ammunition for survival. In our modern, consumerist society, perhaps this idea of friendship has shifted from a life-or-death situation to a surface- level privilege. However, is this pre-conception really the case? While friendship may no longer determine whether we eat or survive the night, our bodies still respond as if it does.

"YOUR FRIENDS ARE AN INDICATION OF WHO YOU ARE. YOUR LIKES, DISLIKES, OCCUPATION, AGE, AND EVEN THE DATA FED INTO YOUR INSTAGRAM ALGORITHM COULD INVITE A WHOLE ANALYSIS ABOUT YOUR CHARACTER. "

The human need for healthy platonic relationships in psychology is often swept under the rug in our chaotic, daily lives. We cancel plans because work takes a toll, we are too afraid of embarrassing ourselves to make the first move in initiating a friendship, and the effort to meet up with our ever-so-dear best friends dissipates among 1000 other responsibilities.

Research has brought to light that we should not overlook the scientific benefits of friendship. Perhaps somewhat obviously, psychologists have found that people who maintain healthy friendships are less likely to be depressed and anxious. But what is often not discussed in modern society is the physical benefits to health that friendship offers, including longer life expectancy and a reduced risk of cardiovascular disease. When confiding in a supportive friend about a source of anxiety, your blood pressure reacts with less urgency than speaking to a friend you trust less. Our friends protect us from unhealthy stress responses. Therefore, in some respects, we do need our platonic connections to survive.

Despite this, the World Health Organisation recently announced that there is currently a global loneliness epidemic. Reports have highlighted that one in six people is affected by the gap between desired and genuine social connection. A disproportionate sense of loneliness has been associated with British 16- to 29-year-olds. Across the world, the highest levels of loneliness have also been found among young adults and adolescents.

Exacerbated by social distancing regulations introduced amidst the COVID-19 pandemic, a growing issue persists, contributing to poor mental and physical wellbeing. Transitions and instability strain the string used to make the friendship bracelets, but the importance of connection should be held tightly between the beads of misconceptions in the pursuit of improved health.

WE'VE DISSECTED WHY WE NEED FRIENDSHIP. HOW DO WE FORM THESE CONNECTIONS?

Indeed, there are pre-determining factors that may be linked to friendship. Think of this like genetic pre-dispositions to certain personality traits or physical appearance. Recent research has utilised advances in neuroimaging to investigate whether neural similarities are involved in the emergence of a new friendship. This study by Nature Communications recorded neural responses to snippets of certain movies and followed whether similarities in responses correlated with social connections. Participants were invited to observe this form of stimuli as this encouraged a range of socio-cognitive and emotional processes that mimic everyday life. Results showed that individuals who grew closer relationships did in fact, express significantly higher pre-existing neural similarity in different regions of the brain compared to subjects who had drifted over time. This idea is known as 'neural homophily', aligning yourself with others who have similarities.

"ULTIMATELY, BEGINNING A FRIENDSHIP IS RARELY THE HARDEST PART. THE GREATER CHALLENGE LIES IN SUSTAINING IT."

Though this idea has scientific probability, unlikely friendships also exist. Perhaps not to the extent of a fox and a rabbit becoming partners in crime but sharing pre-dispositions is certainly not a pre-requisite to every friendship. In some cases, they may emerge from serendipitous occasions; an encounter we like to regard as 'fate' - a pairing in a seating plan due to alphabetic placement of surnames in a register, a friend-of-a-friend-of-a-friend who happens to indulge in the same true crime documentaries or even a friendship that is forced upon proximity to a central romantic couple. Regardless, within every one of these situations, a friendship emerges and continues to grow with reciprocated effort and time. Just like cells that have been adhered to the bottom of a six-well plate, experiments rely on treatment. Friendships must be nurtured, to be sustained as healthy relationships. It is reliant on a two-way mutual effort. Perhaps this is where the difficulty begins as we grow as adults? Priorities displace the need for friendships, and we forget about the health benefits of maintaining social connections.

Ultimately, beginning a friendship is rarely the hardest part. The greater challenge lies in sustaining it. While modern life encourages independence, productivity and 'hustle' culture, our biology remains rooted in connection. Stress responses soften in trusted company and both physical and mental health can be improved by engaging in friendships.

Whilst friendship may no longer be instrumental for survival in a way it once was, science suggests our platonic relationships can shape our outlooks on life. Seek new connections, nurture existing ones and appreciate those unexpected bonding moments. Here's to the survival of friendships.

STARTING FROM SCRATCH: IS IT GOOD FOR YOU TO START A NEW HOBBY?

BY JULIET MAXTED

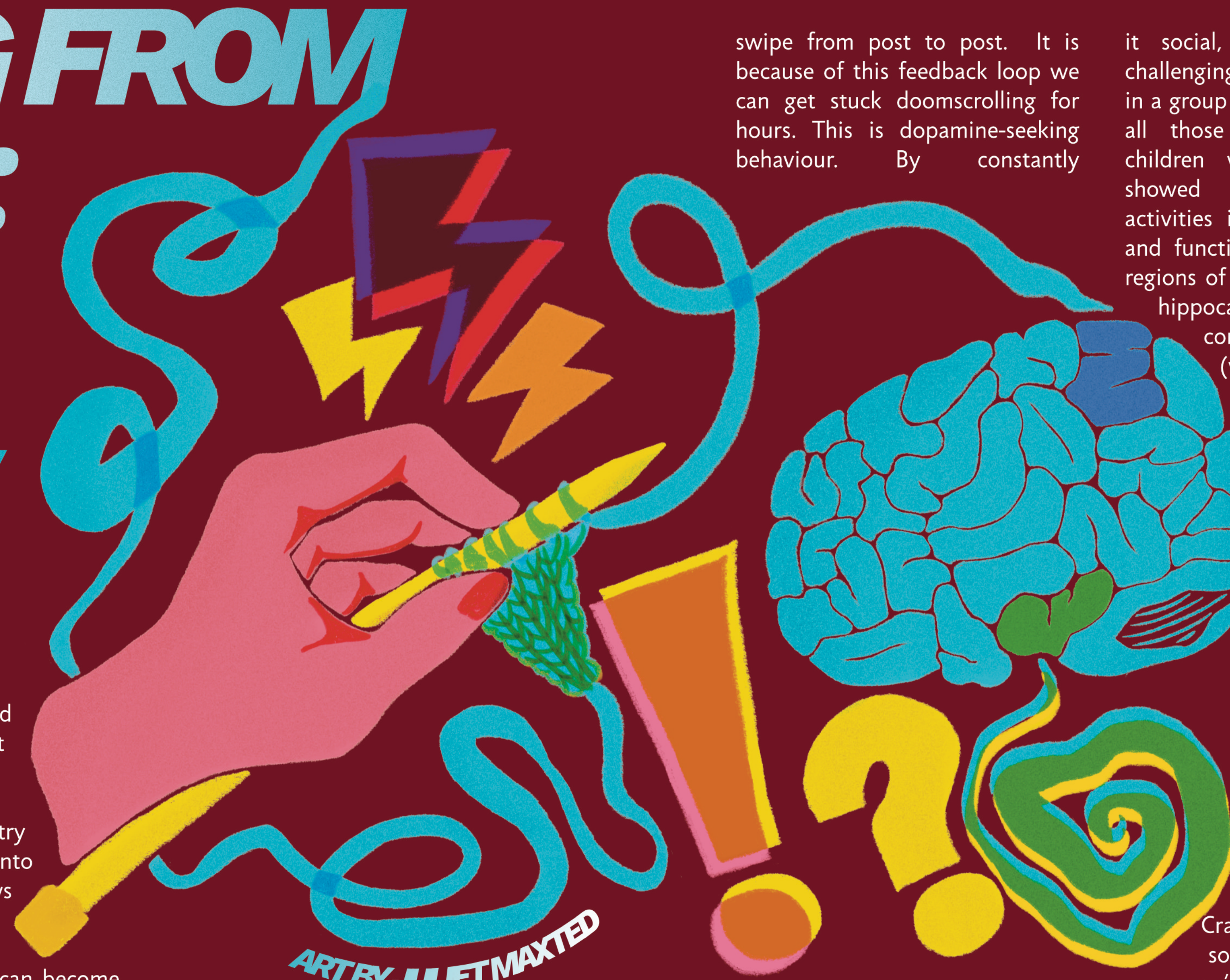
As a novice knitter, the pride I feel when finishing a project is intoxicating but, as my aching fingers fight their way through a knitted bandana pattern, I realise that I have dropped another crucial stitch and I can't help but wonder if hobbies are all they're cracked up to be.

Hobbies have taken on an almost mythical status in the social media wellness space. Slow living hobbies crafting, baking and gardening, reading (thanks to the all-powerful BookTok), and marathon running have become increasingly popular trends. If you follow these trends, you will see influencers and doctors alike imploring you to start a new hobby. They promise that hobbies can make us happier, smarter, and more interesting, all while increasing our popularity, and curing our terrible relationships with failure and rejection. If that's not enough, hobby content has the ability to turn regular people into famous influencers almost overnight. If this is all true, then what's not to love?Starting a hobby can make you a better person and give you a lucrative career! But is there a dark underbelly to the cutesy world of hobbies? Is starting a hobby actually good for you? Or is it just another wellness fad?

It can be daunting to try new things. Research into human behaviour shows that we are naturally inclined to create familiar habits which can become unconscious routines. In turn, these stale routines can stifle our desire to adapt or innovate.

"IS STARTING A HOBBY ACTUALLY GOOD FOR YOU? OR IS IT JUST ANOTHER WELLNESS FAD?"

Picking up a hobby seems like a fun way to break out of the mundane. If you google 'benefits of trying new things' most of the articles will reference boosting your dopamine levels. Dopamine is a neurotransmitter that plays a role in lots of important functions in our bodies including memory, learning, sleep, attention, and mood. Crucially, dopamine is a part of our brain's reward system. According to the Cleveland Clinic "as humans, our brains are hard-wired to seek out behaviours that release dopamine in our reward system". Novelty or, trying new things, is one such behaviour that activates this pathway, releasing dopamine for our receptors to soak up. So, starting a new hobby can put us in a good mood. Some suggest releasing more dopamine can even speed up our learning processes. So, if we can become happier and cleverer all by starting a new hobby, what's not to like?



But our relationship with dopamine is not quite that simple. Dopamine is just a chemical, and it in itself is neither good nor bad. Short bursts of dopamine are also released by scrolling on social media. Social media targets our brain's reward system so that we anticipate a dopamine hit as we swipe from post to post. It is because of this feedback loop we can get stuck doomscrolling for hours. This is dopamine-seeking behaviour. By constantly overloading this reward system, our brains get used to the increased levels of dopamine in our system, and we crave more dopamine than before to fill the void. This is why we can become addicted to dopamine-triggering activities, like doomscrolling or maybe even starting new hobbies. If we shouldn't be purely seeking that dopamine release, maybe it's better for us to stick to a hobby than to try them all only to abandon them when the novelty wears off.

If it's more beneficial to stick to one hobby, how do we choose the right one? Is there such a thing as the best hobby? Talking to the BBC, Professor Alan Gow, who researches how certain activities affect our brains, says "if you are trying something new, try incorporating elements that make it social, active and mentally challenging". Playing an instrument in a group could, for example, tick all those boxes. Research on children with musical hobbies showed that these musical activities improved the structure and function of several different regions of the brain including the hippocampus (memory), motor cortex and occipital region (visual processing).

Choosing a crafting activity might also be a wise choice. According to research from the University of Helsinki, when we practise a hobby like knitting that combines thinking and physically handling crafting materials, our brains reach a flow state where we are more present and mindful, which reduces our stress levels. Crafting is also often a social activity where you're learning from a more experienced friend. According to this research, learning from actions performed by other people is done by the mirror neuron system in our brains. Practising our mirroring muscles helps improve our motor and cognitive skills and helps us to align socially with the people around us.

In theory, by picking a hobby strategically, that works different areas of your brain at the same time, we can maximise the neurological benefits and avoid the dopamine-seeking need to shop around for new activities. This may seem like the perfect solution, but we've lost track of the bigger picture: you should enjoy your hobby (at least most of the time)! We lose lots of the important benefits of doing a hobby if it starts to feel like a chore. For example, research has shown that people who try to monetise their hobby report feeling more stressed and having worse mental health as they struggle to balance work and leisure.

It's important, then, to start a hobby that makes you happy. But starting a hobby is not the hard part. As we've seen, starting things is easy and fun, it's continuing your hobby that gives you the real benefits.

The benefits of playing an instrument don't all appear the moment you pick up a violin, they build slowly through repeated engagement. One study published by the Journal of Global Health found that people who engaged in a hobby had a 29% reduced risk of dying from any cause, sustaining that hobby over their lifetime time reduced this risk by 55%. We should take these results with a pinch of salt, there are many more relevant things that affect our longevity, but if you're looking to live for ever, starting a hobby seems like an easy place to start.

"AS WE'VE SEEN, STARTING THINGS IS EASY AND FUN, IT'S CONTINUING YOUR HOBBY THAT GIVES YOU THE REAL BENEFITS."

Starting a hobby makes us feel good, exercises our brain, and helps us to connect with other people. All these things make for a happier more self-fulfilled person, and doesn't that sound like a nice way to live? But these benefits come from mindful, joyful engagement with a hobby, not hacking your hobby to maximise the potential dopaminergic or monetary rewards. Do something you want to do and start as you mean to go on. Remember, while the beginning is important, it's the taking part that counts.

THE BIRTH OF KEVLAR BY IRIS GITIK

THE ACCIDENTAL BIRTH OF KEVLAR

BY CAMILLE EDOMBEN

Kevlar is quietly ubiquitous. We find it lining our trainers and table tennis paddles, stitched into our loudspeakers, strung onto our bows and suspending our bridges, without taking any credit and without most of us even knowing it's there. This super-strong, heat-resistant and lightweight polymer that is now wildly common may seem like the result of years of prior scientific research, however this is not the case for Kevlar, which began its life as a failure and an anomaly in the lab, but also marked the beginning of a new era of polymer chemistry and a shift in research mindset.

In the Mid-20th century, polymers were usually in the form of cheap, flexible and disposable plastics, whilst the more expensive big players, like steel and aluminium, were relied upon for strength. At this time, polymers were not expected to replace or even rival metals in that domain, until Kevlar.

In 1965, Stephanie Kwolek, a Polish-American scientist who had only been working as a chemist to save for medical school, was tasked by her employer DuPont to create a material that could be used to reinforce tyres, as the commonly-used steel proved to be too heavy and too expensive. This unextraordinary brief left almost no room for innovation, but as Kwolek followed pre-existing polymer chemistry to generate solutions that could be spun into useful fibres, she noticed one had behaved unexpectedly. She generated a polymer solution which was thin and milky, as opposed to the usual clear and viscous consistency. Although her peers considered her experiment to be a failure and the solution to be unusable, she trusted herself, and of course her chemical intuition. Kwolek conducted further experiments, where (against the advice of the technician who thought it would break the machines) she was able to spin her solution into fibres with the subsequent tests showing that this new polymer was five times stronger than steel (of the same mass), as well as flame-resistant!

THIS MOMENT, WHEN KWOLEK TOOK HER "FAILURE" SERIOUSLY, MARKED A NEW BEGINNING OF POLYMER SYNTHESIS, BUT MORE IMPORTANTLY, IT INSPIRED A DRAMATIC CHANGE IN THE MINDSET AND CURIOSITY TOWARDS SCIENTIFIC INVESTIGATION.

This moment, when Kwolek took her "failure" seriously, marked a new beginning of polymer synthesis, but more importantly, it inspired a dramatic change in the mindset and curiosity towards scientific investigation. At the time, efficiency and reproducibility within industrial research was prioritised, and curiosity was largely neglected. Kwolek's insistence, and act of scientific resistance, to pursue the anomaly in her experiment illustrates that beginnings are not always neat or intentional, or even welcomed by others, but can erupt from moments of uncertainty and can contradict expectations.

Outperforming metal, Kevlar highlighted the versatility of polymers and the importance of polymer chemistry at the forefront. Plastics now proved to be worthy contenders against traditional materials, by possessing similar protective and structural qualities, due to both intra- and inter-chain strength. DuPont took next to no time in trademarking Kevlar, and it quickly surpassed expectations, and its original purpose.

Kevlar was not the end product; it provoked a change in research priorities towards exploring the unknown potential of other high-performance and specialised polymers. This gave rise to the creation of other carbon and nitrogen-based fibres in composite materials and ballistics, as well as lightweight fibres fit for aerospace applications, demonstrating not just the establishment of a new material, but also the introduction of a new class of molecules.

Kevlar itself soon filtered down from tyre factories to our day-to-day lives. It allows for firefighters' protective suits to be flame-resistant, police officers' vests to be bulletproof, trainers to be flexible and climbing ropes to be high-tensile. Its impact proves to be dramatic whilst remaining relatively invisible, saving lives in times of crisis but also supporting us in our mundane, everyday activities. Kevlar's versatility is testament to its success.

By recognising the long-lasting effects across all sectors and aspects of our lives, we can clearly see the significance of Kwolek's resilience and perseverance. Her scientific mindset, to question and to push, reminds us that refusing to ignore the "failures" can initiate change and inspire innovation. From a suspect solution in a lab, rose not just a new material, but a new way of comprehending polymers, and a new understanding of the laborious yet rewarding beginning of progress.

THE BEGINNING OF AI LIFE
HOW PROTEIN NEURAL NETWORKS REWRITE NATURE'S CODES
BY DAVID CHEN

Proteins begin life as strings of letters. From that linear code, the cellular machinery folds them into three-dimensional objects capable of motion, recognition, and chemistry – with extraordinary precision. For billions of years, evolution alone explored this molecular landscape. Humans could read the code, but we couldn't write it. When we tried, we were up to a billion times slower than nature. Now, artificial intelligence is blurring that boundary. Protein folding is starting to look less like a scientific puzzle and more like a design problem.

Proteins are built from twenty amino acids, each carrying a chemically distinct side chain. The result is a combinatorially explosive permutation of 20^n – meaning even a modest-sized protein can exist in more possible sequences than atoms in the observable universe. These strings don't just carry information, they fold. Guided by chemical bonds, they assemble into precise three-dimensional shapes, like origami finding its form.

Protein folding is a tiny geometric miracle. A typical protein could theoretically occupy an astronomical number of shapes. If it searched randomly, it would take longer than the age of the universe to find the right one. Yet in nature, it folds in microseconds. This is known as Levinthal's paradox, and its solution is simple: folding is not random. Each protein encodes a free energy surface – think of it as a funnel – so proteins slide towards the minimum rather than stumbling randomly. Chemists and crystallographers could spend months resolving a single structure, limiting understanding of engineering, mutations, and rational drug design. Nature could explore protein space freely, yet we could only read genomes, never daring to ask how sequence really connects to structure.

Before AlphaFold, protein research largely treated folding as a discovery problem. You could imagine novel proteins – but turning imagination into reality was prohibitively expensive. The birth of AlphaFold crushes this barrier. Its impact is not simply improved accuracy, but also extremely fast, scalable, and accessible sequence–structure mapping. It extends humanity's reach into massive chemical space by creating entire AI-generated protein universes, such as the AlphaFold Database, a library with over 200 million predicted structures, where anyone can explore hypotheses, design candidates and mutations, and contribute to academia.

The AlphaFold story began with AlphaFold1 (AF1) entering CASP, the Olympics of protein structure modelling. AF1 has two stages: First, given a protein sequence, it builds a Multiple Sequence Alignment (MSA) of homologous sequences across species and looks for residue pairs that mutate and evolve together, signifying that two positions are likely close in 3D. A neural network then predicts a distogram (a probability distribution over pairwise distances), and those distance estimates are converted into an energy-like score and optimised into a 3D fold. AF1's true contribution wasn't just improved structures, but the realisation that evolution itself could be made computable: turning sequence families into geometric constraints you can engineer.

"GUIDED BY CHEMICAL BONDS, THEY ASSEMBLE INTO PRECISE THREE-DIMENSIONAL SHAPES, LIKE ORIGAMI FINDING ITS FORM."

Compared to AF1, AlphaFold2 is much more end-to-end: the neural network is trained to go straight from sequence to structure (i.e., predicted atomic coordinates). Its core engine, Evoformer, juggles two streams of information: an MSA matrix, rows of homologous sequences lined up residue-by-residue, and a pair representation matrix, the model's internal geometric map of residue relationships. These two iteratively exchange information, building a rich, coherent picture of the protein. Then, a geometry-aware neural network, Invariant Point Attention, places residues in 3D space in a way that remains accurate regardless of rotation or translation. This two-stage process runs many times until local chemistry and global topology agree.

Once structures became available at scale, their application changed. Mutations can be placed directly into three-dimensional context: embedded variants distinguished from surface ones, interfaces from active sites, disrupted hydrogen-bond networks from benign substitutions. The AlphaFold outputs are fed to machine learning classifiers like SIGMA to classify the pathogenicity of a variant. That shift matters most when multiplied. Most bacterial proteins don't have experimental structure. Researchers can now dock hundreds of antibacterial molecules against entire predicted bacterial proteomes in silico, discard targets that bind promiscuously, and prioritise the few that show specific, mechanistically plausible interactions for next-generation antibiotics. These workflows suggest that structures were no longer endpoints. They became cheap, iterative ingredients – propose, evaluate, optimise – and protein research began to behave more like engineering.

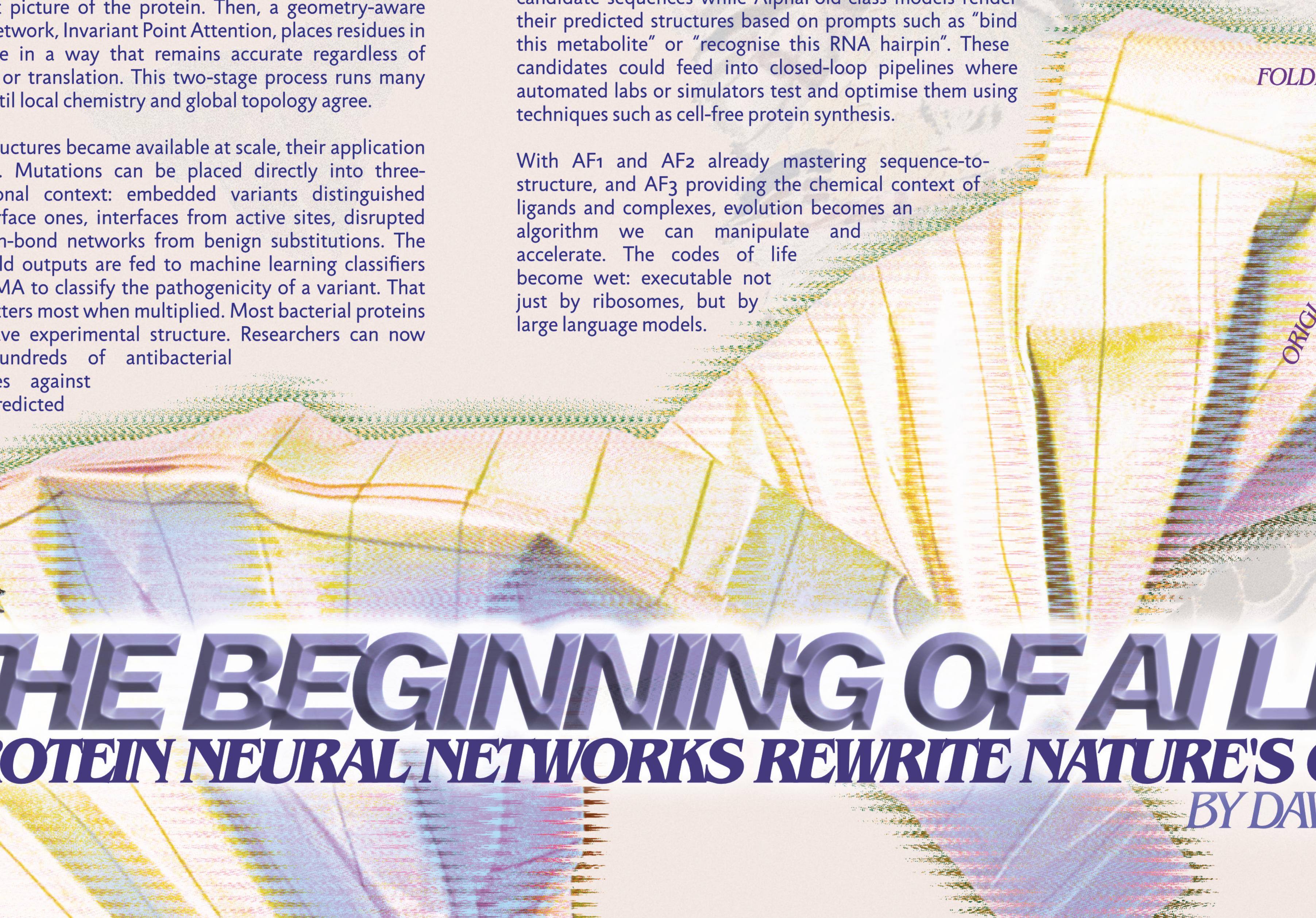
In nature, proteins live with neighbours. AF3 pushes prediction from single proteins to whole molecular complexes, proteins bound to DNA, RNA, small molecule ligands and ions. Replacing AF2's Evoformer with a Pairformer, it tokenises the entire complex, treating each amino acid, nucleotide, or ligand atom as a discrete unit. From these tokens, it builds a dense map of relationships across the whole assembly. The other major change is how AF3 turns that map into a 3D structure. AF3 uses a diffusion model trained to progressively refine rough arrangements into accurate coordinates. It is trained on perturbations that range from local stereochemical tweaks to large global rearrangements. Like AF2, AF3 uses recycling, iterating the representation building and coordinate generation so the model can perfect its self-consistency. Protein folding begins to feel less like looking through a microscope and more like working in molecular CAD software.

In the future, protein design may resemble an IDE-like workflow. Protein language models could generate candidate sequences while AlphaFold-class models render their predicted structures based on prompts such as "bind this metabolite" or "recognise this RNA hairpin". These candidates could feed into closed-loop pipelines where automated labs or simulators test and optimise them using techniques such as cell-free protein synthesis.

With AF1 and AF2 already mastering sequence-to-structure, and AF3 providing the chemical context of ligands and complexes, evolution becomes an algorithm we can manipulate and accelerate. The codes of life become wet: executable not just by ribosomes, but by large language models.

The birth of deep learning models for protein folding expands our protein structural universe from experimentally solved (10^5) to AI-generated (10^8). Deep learning becomes a substrate for imagination, and the databases are starting to resemble the standard design libraries of life. Once structures exist at this scale, the mission gravitates from "what is the structure", at the rate of one structure publication per paper, to "can we find the right one – and can we design new ones by analogy", with many blueprints per week. This also shifts protein research from 'elite labs only' to 'anyone with a browser can explore proteins'. AlphaFold's achievement was in 2024, but the shockwave is still beginning to turn into infrastructure, products and a default tool in bioinformatics. As of 2026, most people still treat AlphaFold as a structure generator. But licensing debates and commercial applications, including AI-designed drugs entering human trials, mean the governance story is still evolving.

With human-AI collaboration, we can begin to rival – and sometimes surpass – nature's design. We are no longer merely observers of biological systems. We are becoming authors, actively contributing structures. Life's early breakthrough was the ability to fold proteins into the machinery of cells. One of humanity's first great achievements with artificial intelligence is learning the codes of protein folding well enough to write back to nature in the same language.



FOLDING LIFE BY YILIN ZHANG

ORIGLOBULAR BY LUIS FREIRE

STARTING THE EXPERIMENT AGAIN

RETHINKING THE 'DEFAULT' BODY IN IMMUNOLOGY

BY TENI GOMEZ

BACKGROUND: GARDNERELLA
BY CATHERINE MCCOLGAN

Historically, biomedicine has treated one kind of body as standard: white, cisgender, and male. Everyone else was an afterthought, if they were counted at all. Clinical signs and symptoms were assumed to look the same in men and women; sex and gender were rarely recorded with any nuance; trans and gender-diverse people were usually excluded altogether.

When those bodies are missing from studies, the results often don't translate to them in real life. That gap shows up in misdiagnoses, unexpected drug side-effects and treatment guidelines that don't fit more than half the population. This is particularly damaging for autoimmune diseases, given that many such conditions, like lupus and rheumatoid arthritis, affect cis women more than cis men – but the science behind these conditions has long been built on a narrow slice of humanity. So, what happens if you decide to start again and design immunology research around a wider range of bodies from the very beginning?

That's the question driving immunologist Hannah Peckham, whose work focuses on sex, gender and the immune system in adolescents and young adults. Peckham and her colleagues are pioneering inclusion of cis women and gender-diverse people – including trans individuals – in studies of autoimmune rheumatic disease.

Peckham traces the origins of this work back to 2016, when she was a research assistant recruiting young trans people for her department's studies. To do so, she attended initial appointments at the UK's Gender Identity Development Service (GIDS), where adolescents discuss starting puberty blockers or gender-affirming hormone therapy. Later, when she began her PhD on adolescent rheumatic autoimmune diseases, she went looking for previous work on trans immune systems. "There's a huge gap in the literature of anyone actually looking at trans immune systems as well as cis people," she explains – a gap that sharply limits what researchers can say about how sex and gender shape immunity.

> INCLUDING TRANS INDIVIDUALS "EVEN IF YOU DON'T CARE ABOUT DIVERSITY AND INCLUSION AT ALL" MAKES THE SCIENCE STRONGER, BECAUSE "IT JUST GIVES YOU SUCH A MORE COMPLETE PICTURE OF WHAT'S ACTUALLY BIOLOGICALLY GOING ON."

In 2020, the NHS commissioned the Cass Review into gender identity services for children and young people. This review has caused intense debate among clinicians, researchers and advocacy groups, particularly around its methodology and recommendations. NHS policy has shifted based on these recommendations and access to puberty blockers for under-18s is now dependent on participation in clinical trials.

The review's public impact has been unmistakable. In parts of the UK media, it was used to justify negative coverage of trans people and the clinicians who work with them, contributing to an increasingly polarised public conversation around trans healthcare.

Watching these shifts in policy while remembering the young people she'd met at GIDS, Peckham says she "felt incredibly protective". The glaring gap in scientific knowledge pushed her to centre trans and gender-diverse participants in her own research. Her recent paper, published in March 2025, investigates the frequency of class-switched memory B cells using blood samples of both cis and trans men and women. It also shows how much changes when you build inclusion into a study from day one.

B cells help defend us from disease by making antibodies: proteins that stick to invading microbes (or, in autoimmune disease, to the body's own tissues) and flag them for destruction. When a naïve B cell first encounters a new threat, it can differentiate into a plasma cell, which tends to produce only IgM antibodies. Peckham likens these to general purpose soldiers: they'll fight, but they're not especially efficient. After further activation, however, some B cells "class-switch" and start producing antibodies like IgG, IgA, or IgE instead. These class-switched memory B cells are more like highly trained snipers – precise, fast and very good at neutralising the specific target they've learned to recognise.

That's great when the target is a virus you know; less great when the target is your own tissue. Class-switched autoantibodies are known to make up the bulk of damage-causing autoantibodies found in patients with autoimmune diseases. Peckham's team wanted to understand how sex hormones and sex chromosomes shape the processes that lead to and expedite the autoimmune diseases they study.

To do that, they recruited a deliberately mixed cohort: pre- and post-pubertal cis boys and girls, menopausal women both on and off oestrogen replacement, and trans men and women. Trans men in the study had XX chromosomes, medically suppressed oestrogen and, in some cases, gender-affirming testosterone. Trans women had XY chromosomes, medically suppressed testosterone and, for some, oestradiol treatment.

The team expected oestrogen levels to be the main driver of class-switching in B cells. Oestradiol is often thought to stimulate immune activity, while testosterone is thought to dampen it. Instead, the data told a subtler story. The people with the highest levels of class-switched memory B cells were those who had both XX chromosomes and post-pubertal levels of oestrogen – regardless of whether that oestrogen was natural or synthetic.

Trans men (XX chromosomes, low oestrogen) and trans women (XY chromosomes, high oestrogen) both had relatively low frequencies of these cells. Among menopausal cis women, only those taking supplementary oestrogen had higher levels. That pattern pointed to an interaction: two X chromosomes, which carry more immune-related genes than any other chromosome, appear to combine with oestrogen to boost class-switching. One without the other isn't enough. Crucially, Peckham stresses, this conclusion only emerges when you include trans participants. Without people whose chromosomes and hormone profiles don't line up in the way medical textbooks assume, you can't disentangle which factor is doing what.

For Peckham, this is the heart of the argument for inclusive research. "Sex hormones and the sex chromosomes are hugely important," she says. Including trans individuals "even if you don't care about diversity and inclusion at all" makes the science stronger, because "it just gives you such a more complete picture of what's actually biologically going on." At the basic science level, this picture helps explain long-standing sex biases in autoimmune disease risk. Clinically, it could begin to inform doctors and patients about how gender-affirming hormone regimens might interact with autoimmunity. And at the level of research design, it challenges the tacit idea that there is a single "default" immune system to be studied.

Peckham's work represents the beginning of a shift towards building diversity into biomedical studies. It's one example of what "Beginnings" in science can look like: restarting an old experiment with different bodies at its centre. What keeps her going, Peckham says, are the people at the centre of the studies. Inclusive immunology isn't just about tweaking study design; it's about making sure trans and gender-diverse patients aren't invisible in the evidence base that shapes their care.

She's also keenly aware of how difficult it can be for trans people to trust research. Ongoing policy changes and new restrictions around puberty blockers have left many wary of medical institutions and research projects alike.

Peckham ends our conversation with a message for any trans readers, or their friends and family who might come across this article: "There are people who genuinely, really care and want to make science better for everyone and for them," she says. "I hope this gives them some good news in a world that is very full of bad news at the moment."

The beginning isn't just a new paper or a fresh experimental design. It's the decision to start an experiment again with different people in the room – and to treat that choice not as an optional extra, but as the foundation of good science.

(Hannah's research takes place within University College London's 'REINVENT' FOCIS Centre of Excellence, led by Professor Coziana Ciurtin, Professor Lucy Wedderburn, Associate Professor Elizabeth Rosser and Professor Elizabeth Jury.)

LACTOBACCILUS
BY CATHERINE MCCOLGAN

The bacteria depicted are *Lactobacillus* and *Gardnerella*, both species found in higher abundance in the female microbiome.

THE FIRST TIME I CALLED MYSELF A SCIENTIST

BY YEJIN LHEE

When I do a quick Google image search for "scientist", the results are filled with smiling people in lab coats holding beakers of colourful liquids. In the eyes of the public, people who pursue careers in academia are commonly called scientists. If we look at the Cambridge Dictionary definition, they are "people who are experts in a science field". But at the same time, when we run science-based programmes for children, we call them "little scientists" too, encouraging curiosity and experimentation in everyday life. So who, really, gets to be a scientist – and who decides?

Looking back, I realise that this question has been one at the back of my mind for most of my (relatively short) academic career. Having done a research-intensive undergraduate degree in Biochemistry, many of my friends have expressed to me that they were scientists, or in some cases, would like to become one. This suggested that there might be an unspoken threshold: a point at which someone feels permitted to claim the title "scientist", and before which they hesitate to do so.

Originally, this feature was supposed to be about the "aha" moments – a profile of how one became a scientist. But after a series of interviews with working professionals that I identified as scientists, this task shifted into a definition-based one. What makes someone a scientist? What does it mean for individuals to identify themselves as one?

THE UNDERGRADUATE EXPERIENCE

Despite spending my undergraduate years doing research, I never called myself a scientist. I wore a lab coat and safety goggles, micro-pipetted and inoculated samples, and carried out experiments – all the things that elicit stereotypical scientist imagery – yet it never occurred to me, at the time, to claim the title. The dissonance came from the fact that I wasn't actively pursuing questions of my own. I was doing the work required of the lab – necessary, but never quite owned.

I began to wonder whether this was the difference between friends who aspired to become scientists and those who already identified as one: the act of pursuing questions they had chosen themselves.

THE PHD EXPERIENCE

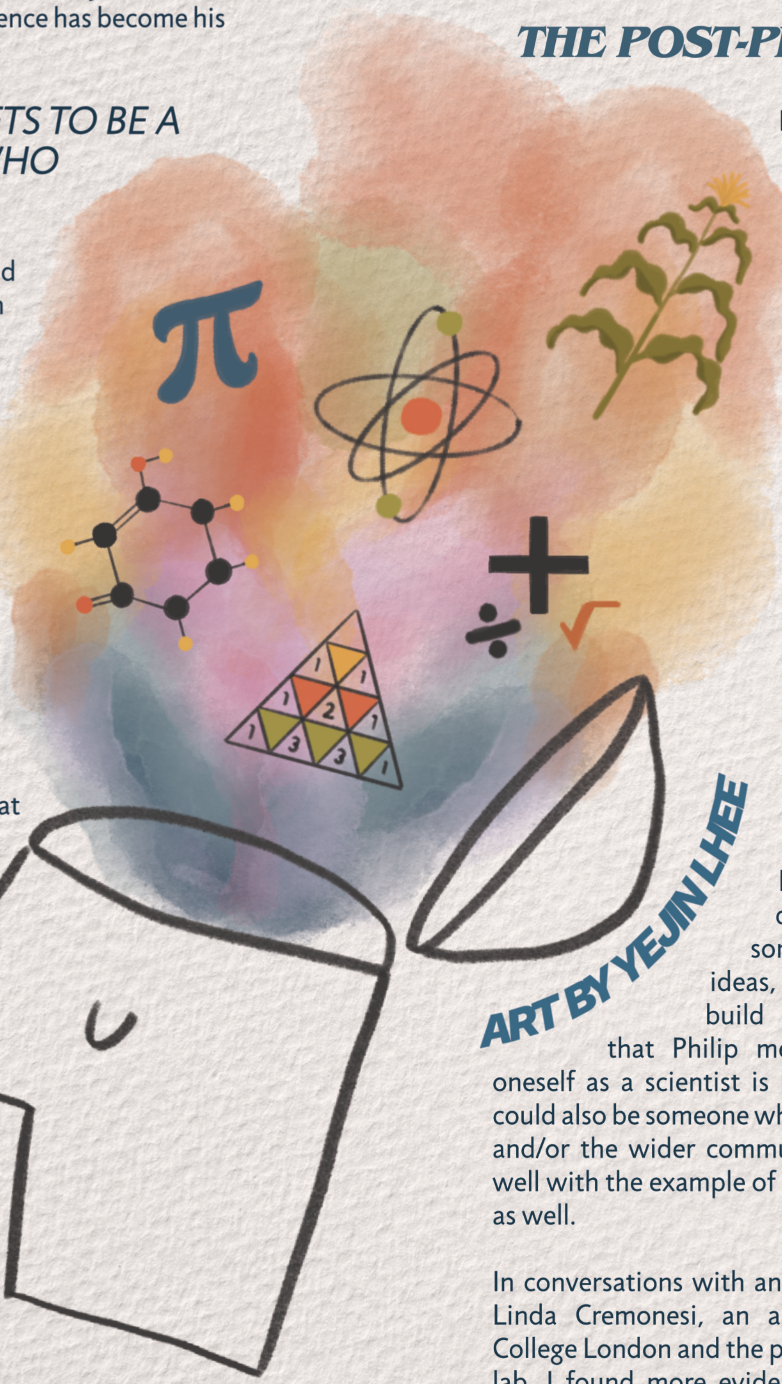
This notion guided my conversations with two current PhD students – Toby Clark and Georgi Geshev.
Toby Clark is in his first year of PhD at the Skene group at Imperial, working on machine learning models to capture genetic variation between DNA methylation patterns. His work doesn't resemble the public image of a scientist at all. Most of his days are spent coding, debugging, and working through abstract systems rather than handling physical experiments. In contrast to my experience, or lack thereof, of identifying as a scientist, Toby says he thought of himself as a scientist during his undergraduate degree, due to his confidence and joy in his science courses. His answer points to something less visible than qualifications: enjoyment, confidence, and a sense of belonging in the work itself. He explained that this identity now feels more cemented, in part because science has become his full-time work.

> "SO WHO, REALLY, GETS TO BE A SCIENTIST – AND WHO DECIDES?"

Similarly to Toby, Georgi, a second year PhD student working on evolutionary beetle biology at the Natural History Museum, also falls out of the stereotypical representation of a scientist. Georgi described that when he started out as a taxonomist, he didn't identify as a scientist. Instead, he told me that he first began to think of himself as a scientist when he was completing his major in physics, saying that "doing experiments and working on methodology" made him feel like one. Over time, Georgi reflected that his sense of being a scientist came from "[having] curiosity and actively exploring [your curiosity]", which he describes as the "least you can do to be a scientist."

Notably, both accounts describe internal feelings rather than external recognition – a reminder that for many, scientific identity is felt long before it is formally granted, if it is granted at all.

The two reflections shown at this stage of the academic career reveal that there may be an element of enjoyment in claiming the identity of a scientist – Toby through pleasure and confidence in his work, and Georgi through curiosity-driven exploration. Perhaps a lack of enjoyment on my part when conducting research was the reason for my perception of not being a scientist myself.



THE POST-PHD EXPERIENCE

I wanted to then explore the perceptions of scientists who I personally identify as the apex scientists – those that have completed their formal education and graduated from their PhDs.

I had the chance to talk to Dr. Philip Leung, who is a post-doctoral researcher investigating the link between volatile organic compounds and lipid reprogramming in tumour microenvironments. As I thought, Philip identifies himself as a scientist without hesitation. That confidence seems shaped less by curiosity alone and more by contribution and recognition. He identified himself as one because his definition of a scientist is someone who "contributes new ideas, proofs that other people can build on." One stand-out comment that Philip mentioned was that identifying oneself as a scientist is based on context as a scientist could also be someone who expands their own knowledge and/or the wider community's – this definition marries well with the example of defining school kids as scientists as well.

In conversations with another member of academia, Dr. Linda Cremonesi, an associate professor at Imperial College London and the principal investigator for her own lab, I found more evidence for my mini-project. Linda described her scientist-awakening to be more of a slow realisation throughout her academic journey; she mentioned the "feelings" started during her PhD and when she went to Antarctica as part of her post-doctoral work she realised "this is not something that everybody gets to do" – it was only when she "became an academic" that she fully realised "now I am a scientist." Linda mentioned that a scientist is then someone who uses the scientific method to produce a novel contribution in the field of science. The PhD, she suggested, functions as a kind of institutional permission slip: formal recognition that curiosity has become legitimate knowledge. When asked about what makes a good scientist, Linda mentioned that a good scientist possesses qualities of curiosity, creativity, and tenacity to carry out the two. When we converse and talk about science to kids, these values are those that we instil in them.

Both Philip and Linda raise important points about how there is a contribution element to being a scientist that inherently is supported by one's curiosity, creativity in skill, and their tenacity to continue the pursuit of knowledge, even when it's against their odds. Through my highly informal self-investigation, it became clear that the standards by which individuals identify themselves as scientists vary widely.

> "SCIENTISTS FIND SCIENCE ENJOYABLE; THEY ARE CURIOUS; THEY ARE IN PURSUIT OF KNOWLEDGE FOR THE COLLECTIVE COMMUNITY AND THEMSELVES."

But perhaps the most notable thing that I have learned is that these standards are different amongst different people and the definition of a scientist is quite flexible. However, one common theme amongst my interviewees was that everyone was in pursuit of knowledge – they just used scientific methods to search for them.

Upon reflection in writing this article, a simple thought occurs to me. My personal investigation was my own pursuit of knowledge. Though I'm writing this at my laptop in casual clothing, no lab coat or personal protective equipment on my person, perhaps this investigation suggests that there is an emerging scientist in many of us – but whether that identity is nurtured, recognised, or quietly dismissed depends on far more than curiosity alone.

WRITE FOR US

I, SCIENCE is the science magazine of Imperial College London. We cover science stories from the wider scientific community and across the College. We publish a print edition once a term, while content online is published on a rolling basis.

WHO CAN WRITE FOR I, SCIENCE?

Any IC student can pitch a story. No writing experience necessary!

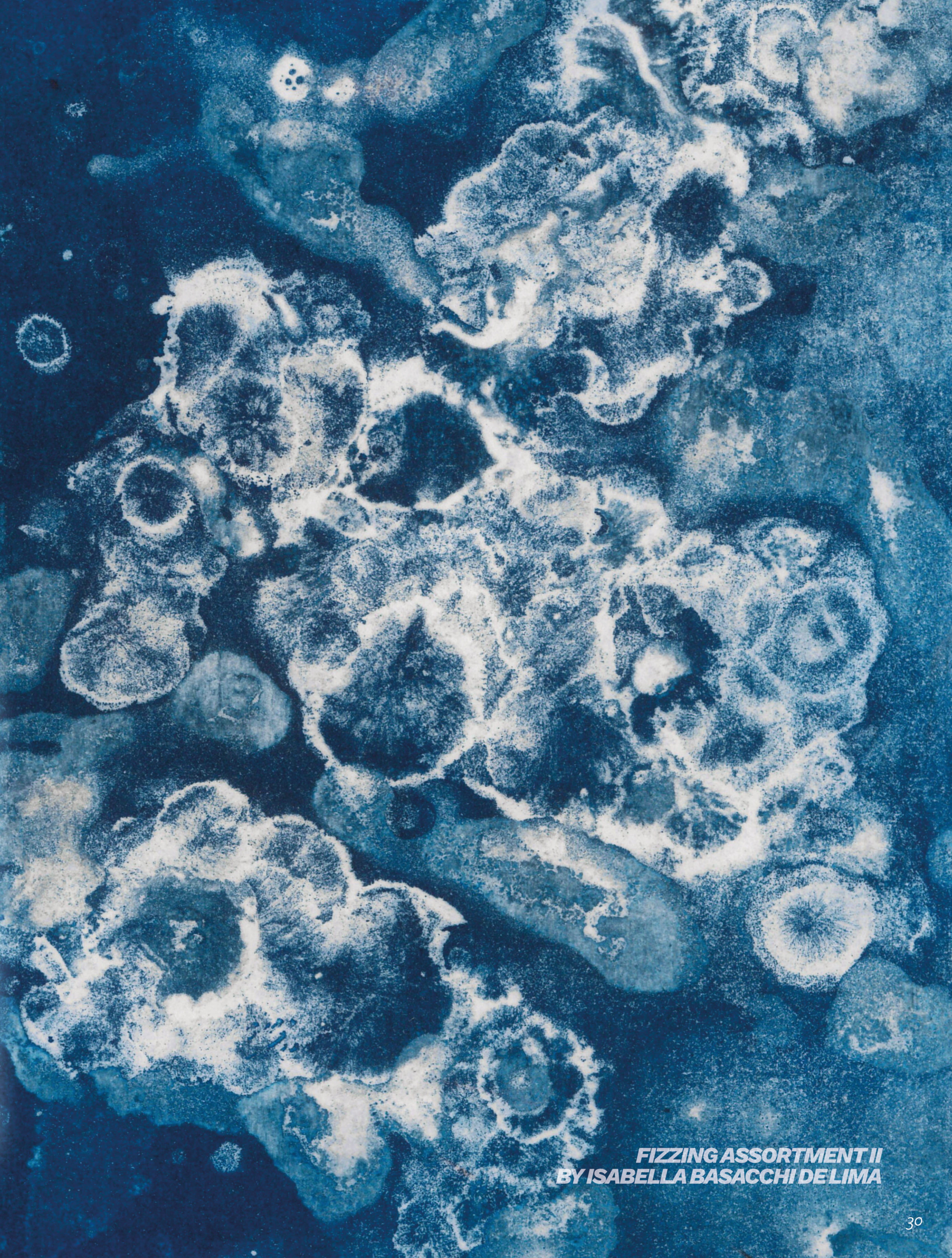
WHAT ARE WE LOOKING FOR?

All your article ideas! Articles can be news pieces, features, interviews, reviews, or friendly non-specialist explainers.

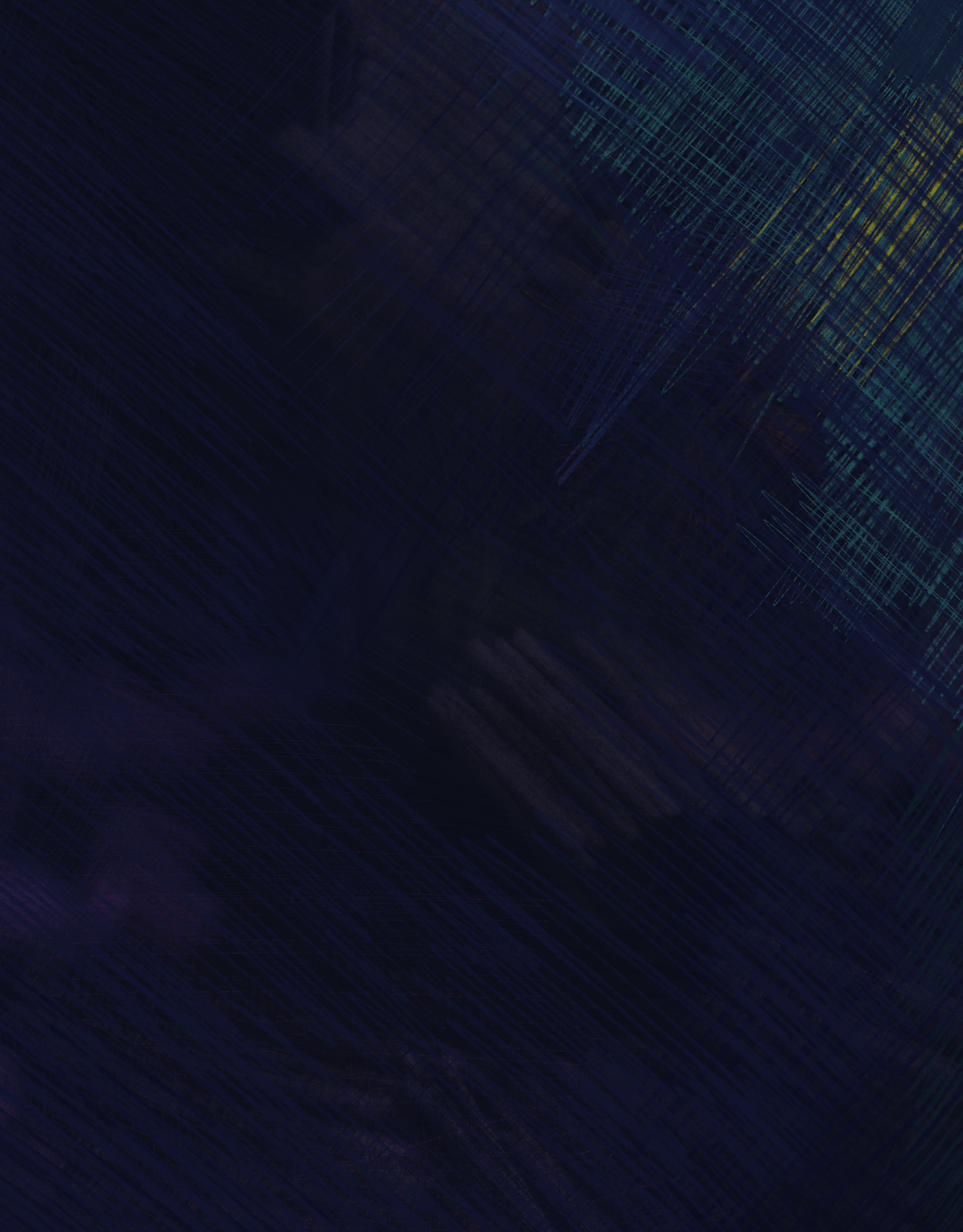
Topics must be relevant to Imperial College students and staff, and they should be broadly science related.

When pitching features and reviews, make sure that the tone of the piece shines through, and keep in mind that if you are writing news they need to be timely.

TELL US WHAT YOU WANT TO WRITE ABOUT IN 200 WORDS AND SEND IT TO I.SCIENCE@IMPERIAL.AC.UK



FIZZING ASSORTMENT II
BY ISABELLA BASACCHI DE LIMA



I, SCIENCE

THIS MAGAZINE WAS MADE BY REAL ARTISTS