MARGINALIZED

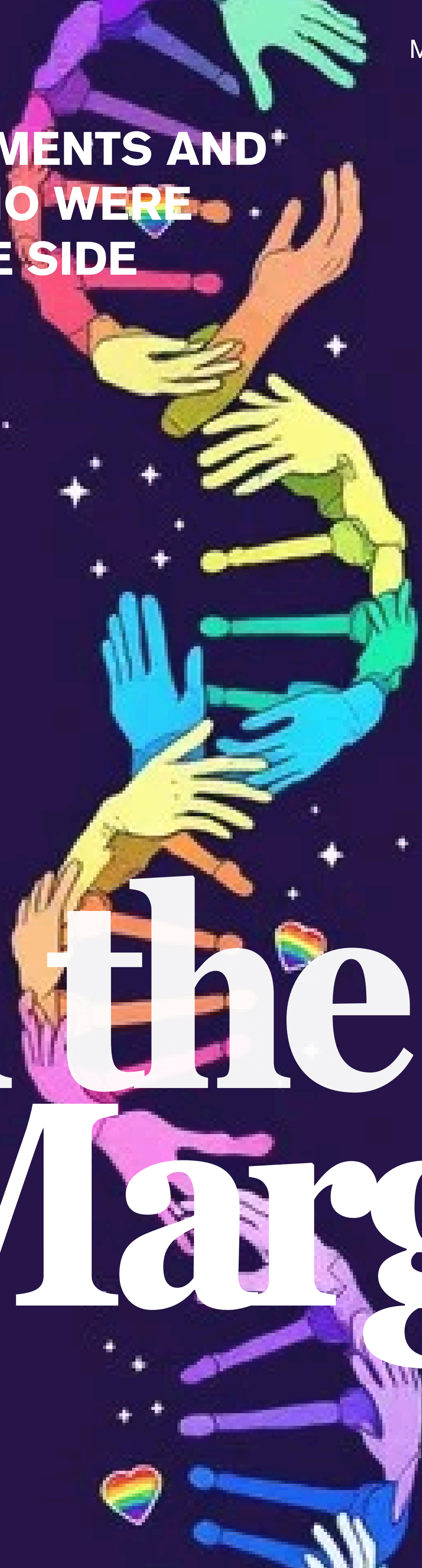
THE IDEAS, MOMENTS AND SCIENTISTS WHO WERE PUSHED TO THE SIDE

JUNE 2026 ISSUE #3

MEASURING THE UNIVERSE

MIND OVER MISTERY: THE NEW ERA OF NEUROMEDICINE

FROM MAGNETIC WHISPERS TO COMPLEX ANATOMY



On the Margin

THE CENTRIFUGE

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OUR THEME - ON THE MARGIN

Throughout the last few centuries, the

The evolution of society and the human mindset has shown that the best way to advance and develop, as a collective and as an individual, is through empirical evidence, scientific inquiry, questioning, and critical thought. However, people, most often than not, tend to fall into inclinations, prejudices and maintain themselves in the comfortable status quo they have found.

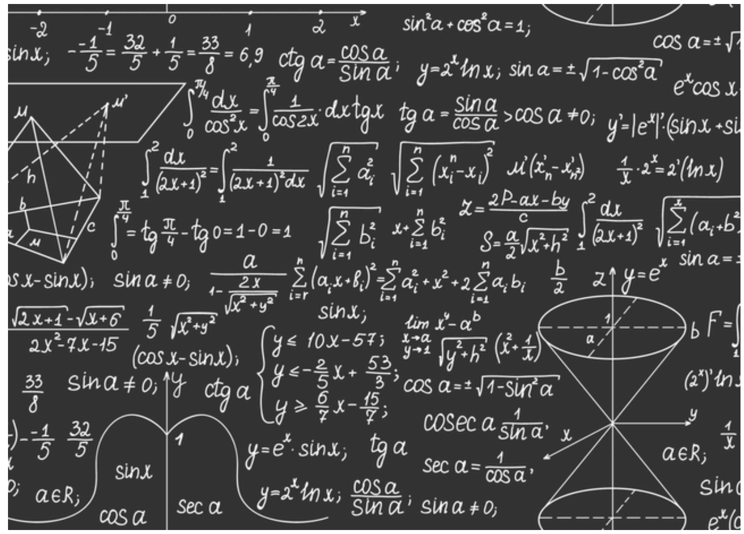
In honour of Pride Month and to increase awareness to those wrongfully secluded from the scientific world, our issue presents the ideas, moments and people who, in spite of scientific and empirical evidence supporting and marking their position, have been marginalized by the scientific community. Not because of strong, deliberate thinking nor due to unadequate methodology but because society in spite of all our experience has demonstrated, tends to say in the comfortable zone we have created and the hardships of keeeping an open mind.

We believe that, by showcasing this marginalised discoveries, we are able to remind us thatwe must be open to correct and fair deliberation. Because, sometimes, it is not only the giants that enable us to see further.

OUR WRITERS

RITISHA AGARWAL

HAILING FROM LONDON, RITISHA IS DRIVEN BY THE BELIEF THAT MATHEMATICS IS NOT JUST AN ABSTRACT LANGUAGE, BUT A PRACTICAL LENS THROUGH WHICH WE CAN DECODE THE WORLD. SHE IS PASSIONATE ABOUT THE REAL-WORLD APPLICATION OF MATHEMATICAL CONCEPTS, CONSTANTLY SEEKING TO BRIDGE THE GAP BETWEEN THEORY AND EVERYDAY LIFE. A LIFELONG LEARNER AT HEART, SHE THRIVES ON EXPLORING DIVERSE TOPICS AND CONNECTING WITH A GLOBAL COMMUNITY OF THINKERS WHO SHARE HER RELENTLESS DRIVE FOR DISCOVERY.

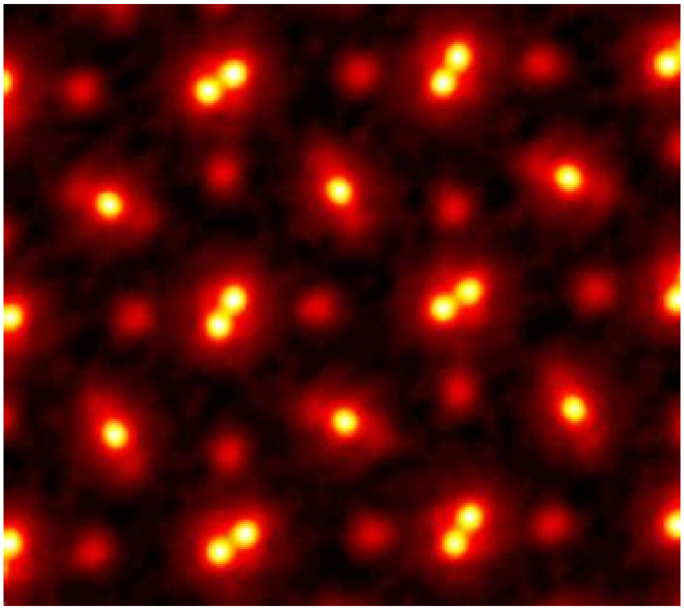


MARIA MATIAS:

MARIA IS A STUDENT OF SCIENCE AND TECHNOLOGY WITH A DEEP FASCINATION FOR THE INTERSECTIONS OF MATHEMATICS AND BIOLOGY. DRIVEN BY A CONTINUOUS SEARCH TO UNDERSTAND THE WORLD'S UNDERLYING MECHANISMS, SHE IS CONSTANTLY LOOKING TO CONNECT WITH OTHERS WHO SHARE A DRIVE FOR KNOWLEDGE AND A DESIRE TO MAP THE SYSTEMS THAT SURROUND US.

KEZIAH DAVID

BASED IN SURREY, UK, KEZIAH IS AN ENTHUSIAST OF ALL THINGS SCIENCE, WITH A DEEP APPRECIATION FOR THE INTRICATE WORKINGS OF THE BODY AND MIND. CAPTIVATED BY THE ELEGANCE OF HUMAN ANATOMY, SHE HOPES TO STUDY MEDICINE AT UNIVERSITY AND ASPIRES TO BECOME A NEUROSURGEON ONE DAY. BEYOND PONDERING THE ORIGINS OF HUMAN CONSCIOUSNESS, SHE ENJOYS PLAYING THE PIANO - A PASSION SHE HAS PURSUED FOR OVER A DECADE - AS WELL AS CHESS, LISTENING TO MUSIC, AND, OF COURSE, OCCASIONALLY DISAPPEARING ON A LONG WALK.

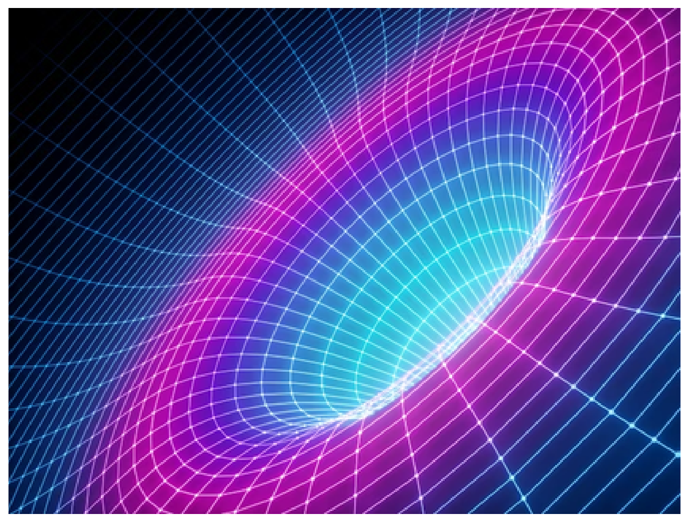


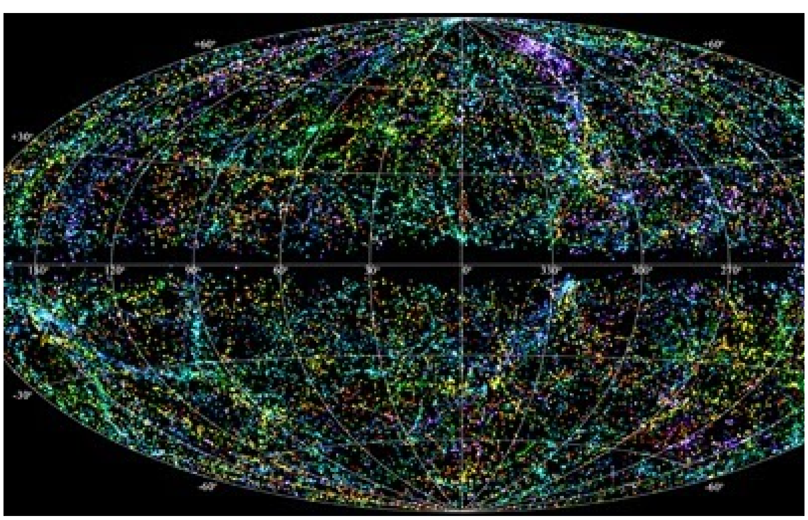
DAVID EKEH

DAVID IS AN A-LEVEL STUDENT STUDYING MATHS, FURTHER MATHS, PHYSICS AND CHEMISTRY IN LONDON. HE'S PASSIONATE ABOUT ATOMIC AND NUCLEAR PHYSICS AND ESPECIALLY THE VITAL ROLES THEY PLAY AS WE DEVELOP AS A SOCIETY IN SECTORS SUCH AS MEDICINE AND ENERGY. HE'S ALWAYS BEEN FASCINATED BY THE ATOMIC LEVEL PROCESSES AND INTERACTIONS THAT GOVERN SO MANY KEY PHENOMENA AND HE LOVE TO RESEARCH ANY WAY IN WHICH THESE PHENOMENA ARE BEING UTILISED IN REAL WORLD SCENARIOS. HE BELIEVES UNDERSTANDING ATOMIC- AND EVEN PARTICLE-LEVEL INTERACTIONS ARE THE WAY FORWARD FOR SCIENTIFIC INNOVATION AND HOPES THAT THROUGH HIS OWN RESEARCH AND EXPERIMENTATION HE CAN BE A PART OF THAT.

ERIN GALLEGO:

HAILING FROM ENGLAND, ERIN IS FASCINATED BY NOT JUST ASTROPHYSICS BUT HOW PHILOSOPHY TIES INTO SUCH A FACTUAL DRIVEN SUBJECT. FAVOURING THEORY OVER PRACTICAL WORK ERIN WOULD LOVE TO BE AT THE FRONTIERS OF DEVELOPING NEW SCIENCE. TO DO PHYSICS SHE BELIEVES IS ONE THING BUT TO ASK WHY WE DO SCIENCE OR HOW THIS SHAPES OUR MATHEMATICAL MODELS IS WHAT REALLY INSPIRES HER PERSONAL RESEARCH.





IBRAHIM CHISHTI

IBRAHIM CHISHTI IS A SIXTH FORM STUDENT FROM LONDON. HE IS FASCINATED BY THE UNIVERSE WE LIVE IN AND THE WAYS THAT WE QUANTIFY AND UNDERSTAND IT. WITH A PARTICULAR PASSION FOR ASTRONOMY AND ENGINEERING, HE IS DRIVEN BY THE IDEA OF HUMAN EXPLORATION BEYOND EARTH AND HOPES TO ONE DAY HELP WITH SUCH EXPLORATION. HE ENJOYS BOTH LEARNING ABOUT AND SHARING KNOWLEDGE ON OUR PLACE IN THIS VERY BIG WORLD.

HIGHLIGHT #1

By Maria Matias

Grace Hopper

The mind behind eletronic computers

Grace was born in 1906, in New York City, and ever since she was a child, she showed interest in understanding how things worked, which eventually took her to study Mathematics, earning her PhD in Yale. During WWII, she enrolled in the Navy, where she was part of the team responsible for Mark I - the first ever eletronic computer. Her work during this time outlined the fundamental principles of computing machines.

Hopper was involved in the creation of UNIVAC - the first ever all eletronic computer and, if it wasn't enough, she also invented the first computer compiler: a program that translates written instruction into code that computers read directly. Her work proved essential for the American army to decode messages during the war.

She achieved the rank of Rear Admiral in 1985 and was awarded the Defense Distinguished Service medal, the highest decoration given to those who did not participate in combat. After leaving the army, she continued to teach computer science until her death in 1992.

FROM MAGNETIC WHISPERS TO COMPLEX ANATOMY: HOW MRI CREATES IMAGES FROM SIMPLE SIGNALS

BY DAVID EKEH

INTRODUCTION

Imagine yourself back in the early days of medicine, if you had any illness or injury, you would go to the local "doctor" and they would simply look at any symptoms or physical discomfort and make what was ultimately an educated guess at what the issue was – no tests and no real investigation. They would then prescribe some usually suboptimal remedy costing a significant portion of your income, and that would be the full extent of your treatment.

But fast-forward to the modern day and MRI scanners have been used in medical imaging for nearly 50 years and they are a staple of modern healthcare. They are used to image everything from torn knee ligaments in sports therapy to complex cancer tumours in oncology. However, these images aren't produced by photography or any other seemingly conventional method that you might expect, they are formed by taking advantage of the effects of magnetism on simple hydrogen atoms which make up as much as 63% of our bodily composition!

So, hydrogen atoms interact with precise magnetic fields – but why does this happen and how does that translate into the incredible images doctors use for vital disease diagnosis?

"Fast forward to the modern day and MRI scanners have been used for nearly 50 years. They are used to image everything."

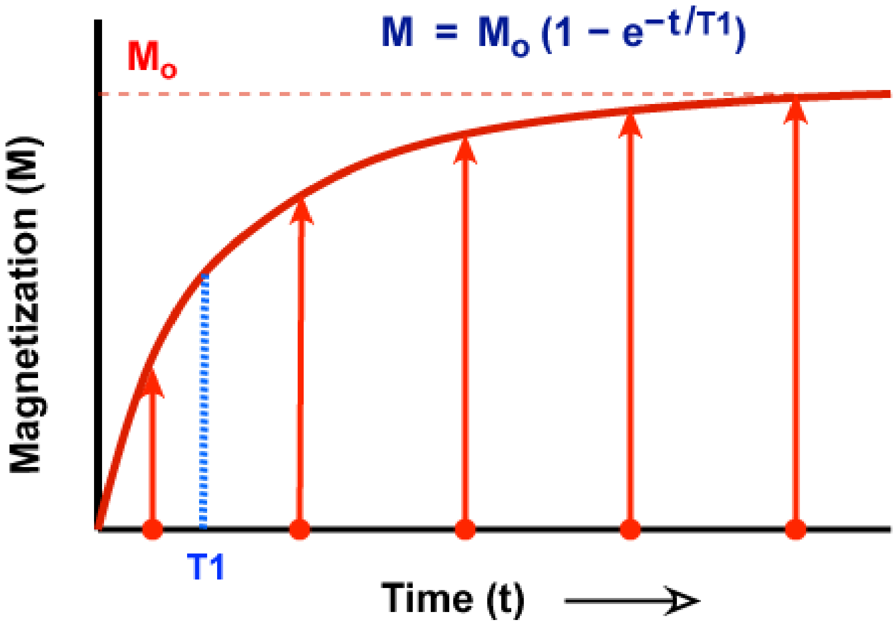
FIELDS IN PHYSICS

In physics, a field is defined as a force or effect that has a value in space and time. MRI employs both magnetic and electromagnetic fields to generate its images. It does this with 3 key components.

1. Main Magnetic Field (BO)

The main magnetic field spans and along the length of the scanner and has a magnetic field strength of 1.5T (tesla) in clinical settings – tens of thousands of times stronger than the Earth's own magnetic field!

The purpose of this field is to try and align all of the hydrogen atoms within the patient's body such that they are all rotating around the axis parallel B0. This magnetic field has to be strong because the detectable MRI signal ultimately comes from the difference between atoms in a high-energy state aligned anti-parallel to the field and those in a low-energy state aligned parallel; but the actual energy difference between these 2 exact states is so small and not all of them align properly making it harder to measure the overall net magnetic signal given off by the more prevalent low-energy nuclei which is why the field must be as strong as possible ideally to amplify this overall difference that is actually measured.



2. Radiofrequency (RF) Field

To actually convert the magnetic signals given off by the nuclei into usable electrical signals, electromagnetic pulses are sent at a certain 'flip angle' (α) to the direction of the B0 field (many pulses are sent at a range of flip angles to obtain different patterns which are ultimately used to build up the final image).

This knocks the hydrogen nuclei out of longitudinal alignment with the main magnetic field – the nuclei then recover to longitudinal alignment exponentially but, before they reach full alignment again a second 90° pulse is sent through which translates the magnetism at that point in time to the 'xy' plane; this is vital because the spins of the hydrogen atoms are now in sync and also not in line with the main field so, via Faraday's laws, the changing magnetic field generates a voltage which can be measured. By measuring the magnetisation level of nuclei after different amounts of time, a graph of magnetisation against time can be plotted which complex machine learning algorithms can link to characteristics of different body tissues and hence tell us the anatomy of the body.

This sequence will happen over 10,000 times times in one scan as each layer of the image is formed and errors and uncertainties are taken into account. The actual method of going from magnetisation uses very complex concepts like k-space and Fourier transforms which are beyond this article but essentially it stores all the amplitude and frequency from the scans and combines them to produce the final image.

3. GRADIENT MAGNETIC FIELD

So we know the RF field excites hydrogen nuclei and measures their recovery but how does the scanner know where in the body each signal is coming from? If every hydrogen atom experienced the same magnetic field, they would all resonate at the same frequency and the scanner would have no way of distinguishing a signal from your liver from one originating in your spine. This is the problem that gradient magnetic fields solve.

A gradient magnetic field varies in strength across space in a controlled, linear way. Three sets of gradient coils, one for each spatial axis (x, y, z), are layered on top of the main B0 field. Because the resonant frequency of a hydrogen nucleus depends directly on the local field strength it experiences (described by the Larmor equation: $\omega_0 = \gamma B_0$, where γ a constant that varies atom-by-atom and describes how much it reacts to a given magnetic field strength), nuclei at different positions along each axis resonate at subtly different frequencies. The scanner can then decode which frequency corresponds to which location, effectively giving every point in the body a unique magnetic location.

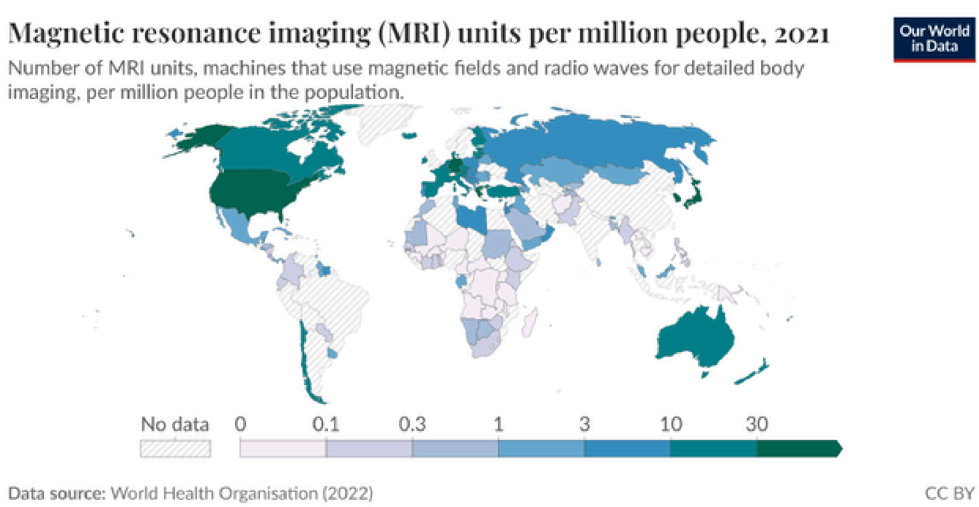
This process happens in three stages: slice selection, frequency encoding, and phase encoding; working along each axis in turn. Together, they allow the thousands of RF pulses sent during a scan to be precisely mapped to a 3D coordinate, which is then fed into the k-space framework to reconstruct the final anatomical image.

Without gradient fields, MRI would produce nothing more than a single, meaningless average signal from the entire body reducing our remarkable anatomy to useless noise.

CURRENT LIMITATIONS

MRI is undoubtedly one of the most powerful analytical tools in modern medicine but it is far from perfect. Understanding its current limitations is just as important as appreciating its achievements and some of the most exciting research in medical physics right now is working towards MRI improvement.
The most immediate practical limitation is scan duration. As described earlier, a single scan requires thousands of RF pulse sequences, each one encoding a different slice of k-space. This process simply takes time (typically 20 minutes but can sometimes even be up to over an hour) and any patient movement between pulses introduces phase errors into the signal that corrupt the final reconstructed image. This is not merely an inconvenience; prolonged stillness is genuinely difficult for claustrophobic patients, young children, and those in acute pain meaning sedation is sometimes required therefore adding clinical risk and cost.

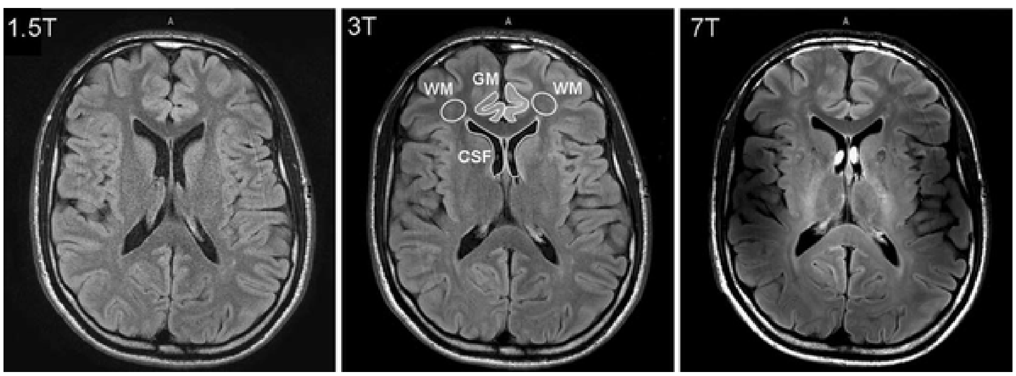
Closely related is the issue of accessibility. The superconducting coils that generate the B0 field must be maintained at approximately 4 Kelvin, almost absolute zero, using liquid helium, which is both limited in supply and increasingly expensive. This extreme cooling requirement makes scanners incredibly costly to run and effectively limits MRI to well-funded hospitals, creating significant healthcare inequality globally and contributing to growing waiting lists in systems like the NHS and the image below really shows how much cheaper and more accessible solutions are needed for lower income countries.



There are also fundamental signal-to-noise constraints on image resolution. The voltage induced in the receiver coils by precessing hydrogen nuclei is vanishingly small and increasing resolution means detecting signals from ever-smaller tissue volumes containing fewer nuclei, reducing signal strength further still. Pushing resolution below roughly 1mm therefore requires either stronger B0 fields increase nuclear alignment, longer averaging times, or both.

FUTURE IMPROVEMENTS

However, the future of MRI is genuinely exciting. Ultra-high-field scanners operating at 7T are already used in research settings; a stronger B0 directly increases the population difference between parallel and anti-parallel nuclear states, producing a stronger net signal and dramatically improving resolution, potentially transforming early cancer detection and neurological imaging. AI-assisted reconstruction attacks the scan duration problem from a different angle entirely: rather than acquiring every point in k-space sequentially, machine learning algorithms can reconstruct a full diagnostic image from a partial dataset, with early results suggesting scan times could be halved without sacrificing image quality.



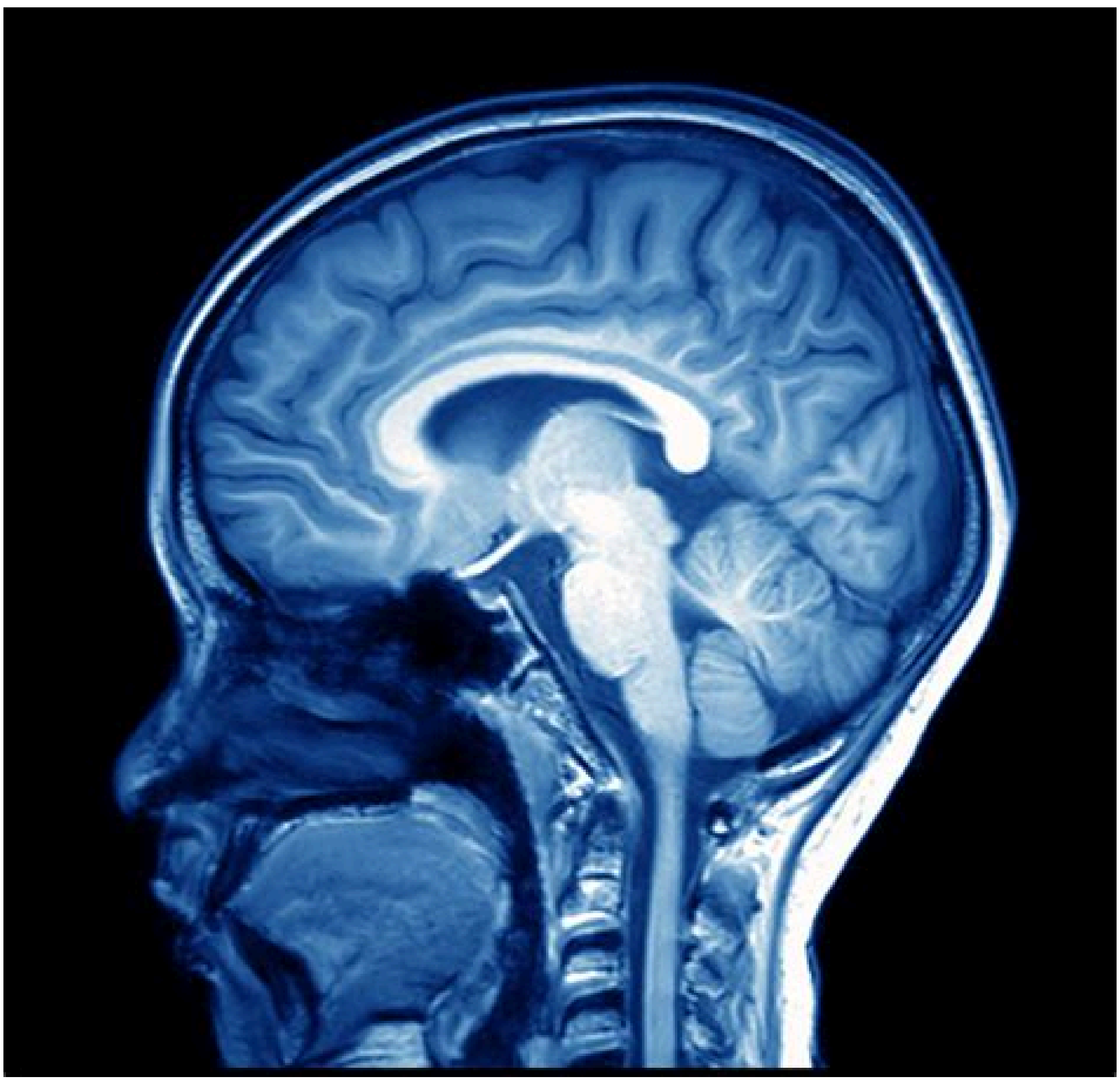
Perhaps most transformatively, research into low-field portable MRI using permanent magnets rather than superconducting coils is advancing rapidly. While a weaker B0 reduces signal strength and resolution as the nuclei feel the magnetic effects less so rotate and spin less aggressively, modern AI reconstruction techniques are increasingly able to compensate, potentially enabling deployment in rural clinics, ambulances, or areas where liquid helium infrastructure simply does not exist.

CONCLUSION

The three components explored in this article: the main magnetic field, the radiofrequency pulses, and the gradient fields do not work in isolation. They are a precisely choreographed sequence, each one building on the last: B0 aligns the nuclei, the RF field disturbs and listens to them, and the gradient fields ensure every signal can be pinned to an exact location in the body. The result is a detailed anatomical image produced without a single X-ray, incision, or injection of contrast agent in most cases.

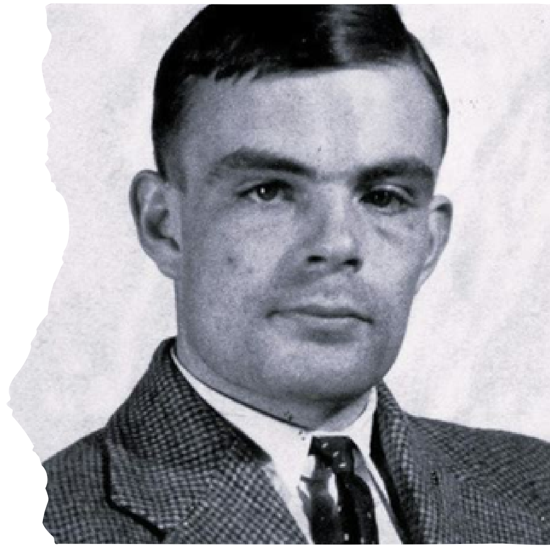
It is worth pausing to appreciate just how extraordinary this is. The signals MRI detects are vanishingly small, tiny voltages induced by the wobbling of hydrogen nuclei in your soft tissue. Yet from those whispers of magnetism, clinicians can identify a 2mm tumour, map the connections of a living brain, or diagnose a torn ligament with confidence that would have been unimaginable to that early physician making their educated guess.

MRI is perhaps the finest example of fundamental physics: quantum mechanics, electromagnetism, signal processing - converging into a single machine that saves lives every day. The science behind the scanner is as remarkable as the images it produces.



By Maria Matias

Alan Turing - The father of modern computing



Alan Turing was born in 1912 in England and since he was a child, he showed a deep understanding and fascination with mathematics.

Alan Turing's most foundational contribution was the theoretical concept of the Turing Machine, introduced in his landmark 1936 paper. This abstract computational model described a device that could read and write symbols on a tape according to a set of rules, capable of simulating any algorithm or computation.

He also made enormous practical contributions during World War II, leading the effort at Bletchley Park to crack the German Enigma cipher. His design of the Bombe machine, which mechanically tested thousands of possible Enigma settings, gave the Allies a critical intelligence advantage and is widely credited with shortening the war by several years.
After the war he worked in several other scientific projects, mainly in biology, studying how natural patterns like spots, petal and stripes developed, linking them to chemical processes.

He was arrested in 1952, after an affair with an young man, as all male homossexuality was illegal until 1967 in Britain. He accepted probation with hormonal treatment which was equivelent to chemical castration. He escaped Britain, leaving in Greece and Norway. Nonetheless, he was harrassed by police surveilance and ended his life, through cyanide poisoning in 1954. He remains one of the most important scientist in history and his works in Computer Science remain the basis of all AI and computational development.

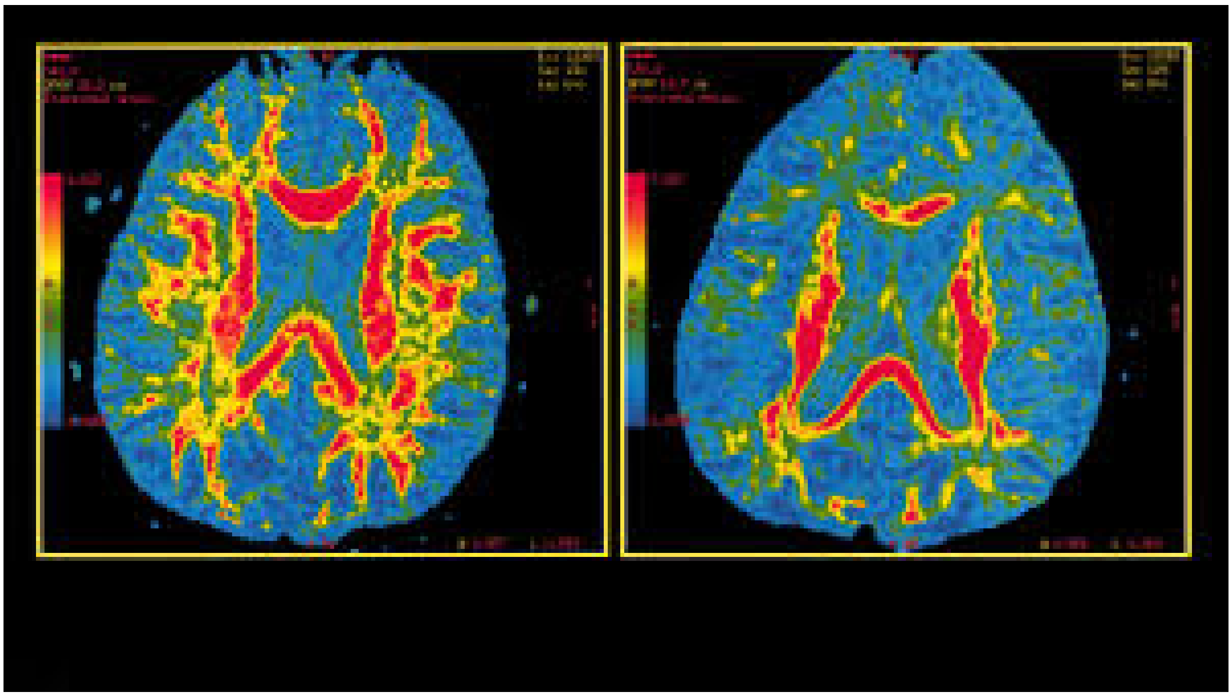
MIND OVER MISTERY: THE NEW ERA OF NEUROMEDICINE

BY DEBORAH COLLIER

What causes psychiatric and neurological illness? Can we fully repair brains damaged by traumatic injury? In this article I will delve into recent attempts to answer these burning queries.

INTRODUCTION

Despite ground-breaking neurological discoveries, including the first visualisation of Parkinson's triggers, novel live brain tissue research for Alzheimer's, and even AI-driven detection of epilepsy, one would be ignorant to assume a nuanced understanding of the brain. Our knowledge is limited, akin to the 1% of the ocean discovered-where the vast depths of the neural chambers remain uncharted. This ambiguity caused us to question: What causes psychiatric and neurological illness? Can we fully repair brains damaged by traumatic injury? In this article I will delve into recent attempts to answer these burning queries.



What causes psychiatric and neurological illness?-As of April 2026, studies indicate that 47.7% of adults in England are living with a common mental health condition, over a 20% increase since 2007. The main cause of this drastic increase links to living in deprived areas; individuals in the most deprived areas are 64% more likely to experience a common mental disorder compared to the least deprived. At the same time, studies at McGill University (April 2026) show that specific brain cells are damaged at different rates based on temperature, with glutamatergic neurons (memory/learning) and GABAergic neurons (mood/sleep) being highly vulnerable.

The longer the tissue is left before collection, the more its genetic profile diverges from what it looked like in a living brain. Researchers confirmed that even a 6-hour postmortem interval caused significant changes in gene activity compared to freshly extracted tissue. To separate the effects of time and temperature, the team stored fresh tissue at either room temperature (20°C) or in a fridge (4°C) for 6, 24, and 36 hours. Tissue kept at 4°C for 6 hours showed no changes, while just 6 hours at room temperature was enough to trigger them. At 24 hours, oligodendrocytes, which allow signals to travel efficiently became the most affected, followed by microglia, the brain's immune cells.

This deterioration of neurons can alter what an individual perceives as reality, leading to symptoms of schizophrenia. Ethical implications of this study include consent from the post-mortem individuals (PMIs), before death, to use brain tissue for scientific study.

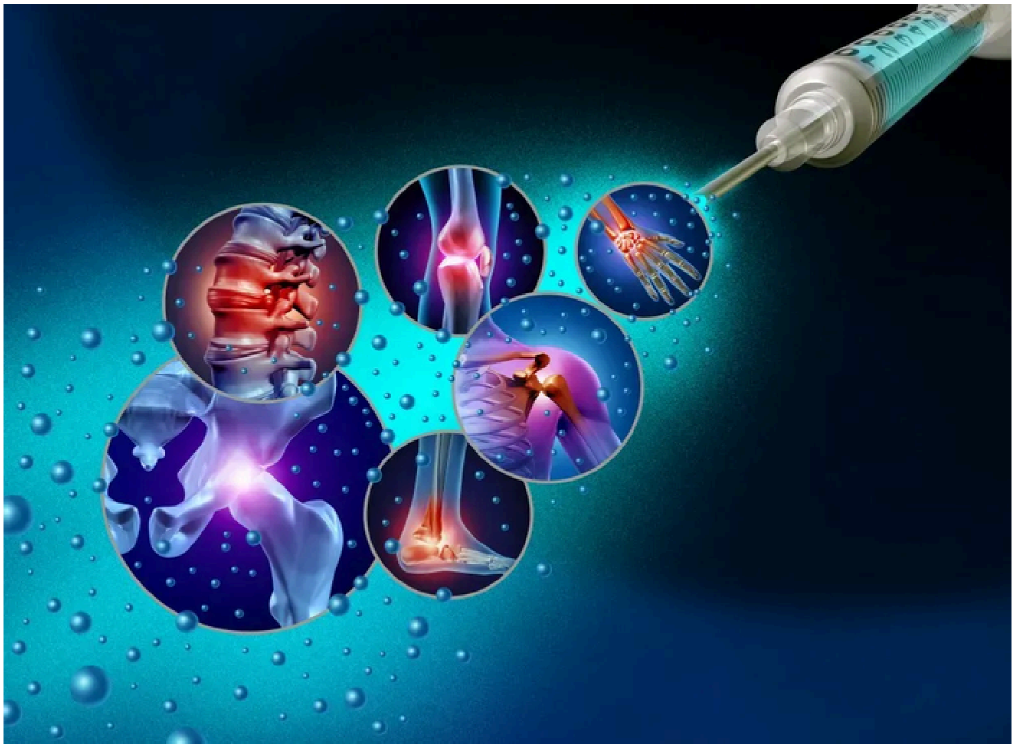
Can we fully repair brain damage? - SELETHERM 2 was conceived by the Clinical Neuroscience team at the University of Cambridge, designed to reduce the metabolic demand, inflammation, and secondary injury caused by traumatic brain injuries. Beginning in February 2026, the study assessed the device on 20 patients over a 12-month period, where half of the individuals will be randomly selected to receive brain cooling with the collar for 72 hours, while the other half will receive standard current therapies. This study follows on from SELETHERM1, which focused of the effects of delivering selective brain temperature management. The device is portable and includes a carrying pack and quick-fitting collar, enabling the use outside of the hospital. However, there are systemic effects including immune suppression or even chest infections, which delay the recovery process. Fortunately, CB240 Aurora was developed in partnership with Neuron Guard, a Small and Medium-Sized Enterprise (SME) set up in 2013, to minimise the side effects of conventional, whole-body cooling, such as immune suppression or pneumonia. Primarily, the goal is maintaining intercranial pressure below 20 mm Hg serving as a crucial measure of safety, then assessing the brain-to-core temperature management. Although this method reduces the effects of brain injury, it does not address the root cause.

Likewise, researchers at Northwestern University developed an injectable regenerative therapy using supramolecular therapeutic peptides (STPs), otherwise, referred to as "dancing molecules" - nanofiber assemblies that can cross the blood-brain barrier.

These molecules find and engage cellular receptors, sending signals to encourage nerve cells to repair themselves. In a 2026 study, this therapy significantly reduced brain tissue damage after stroke and prompted the repair of neural networks.

The therapy is injected as a liquid and immediately gels into a complex network of nanofibers. This get mimics the natural environment around the spinal cord. Molecules withing the nanofibers move, or 'dance' to engage with the cell receptors, which are constantly in motion. The scientists found that the more the molecules moved, the more successful the therapy was in reversing severe injuries. The dynamic nature of the therapeutic peptides could reverse paralysis and repair tissue in mice after a single injection at the site of severe spinal cord injury, hence the nickname "dancing molecules."

This new study found scientists can administer similar dynamic assemblies of molecules intravenously. This therapy is a significant advance that could also be useful in treating traumatic brain injuries and neurodegenerative diseases such as ALS. Key ethical challenges include informed consent, the exploitation of vulnerable patients through unproven treatments, and the sourcing of cells. Prohibitive costs of regenerative therapies may limit access to only affluent populations. Furthermore, this method involved the testing of the injection on animals, which can be considered animal cruelty, especially if they had severely adverse effects.



Ultimately, these advances in neuroscience demonstrate that although humanity has made remarkable progress in understanding the brain, we remain far from fully comprehending its immense complexity. From selective brain cooling devices to regenerative "dancing molecules," modern research offers promising possibilities for reducing neurological damage and restoring lost function. Simultaneously, studies into psychiatric illness reveal how both biological vulnerability and environmental deprivation can shaoe mental health, emphasising that neurological disorders cannot be explained through a single lens.However, these breakthroughs are accompanied by significant ethical and practical challenges, including informed consent, accessibility and affordability of treatment, and the reliability of translating animal research into human therapies.

By Ritisha Agarwal

Katharine Johnson - Architect of Space Trajectories

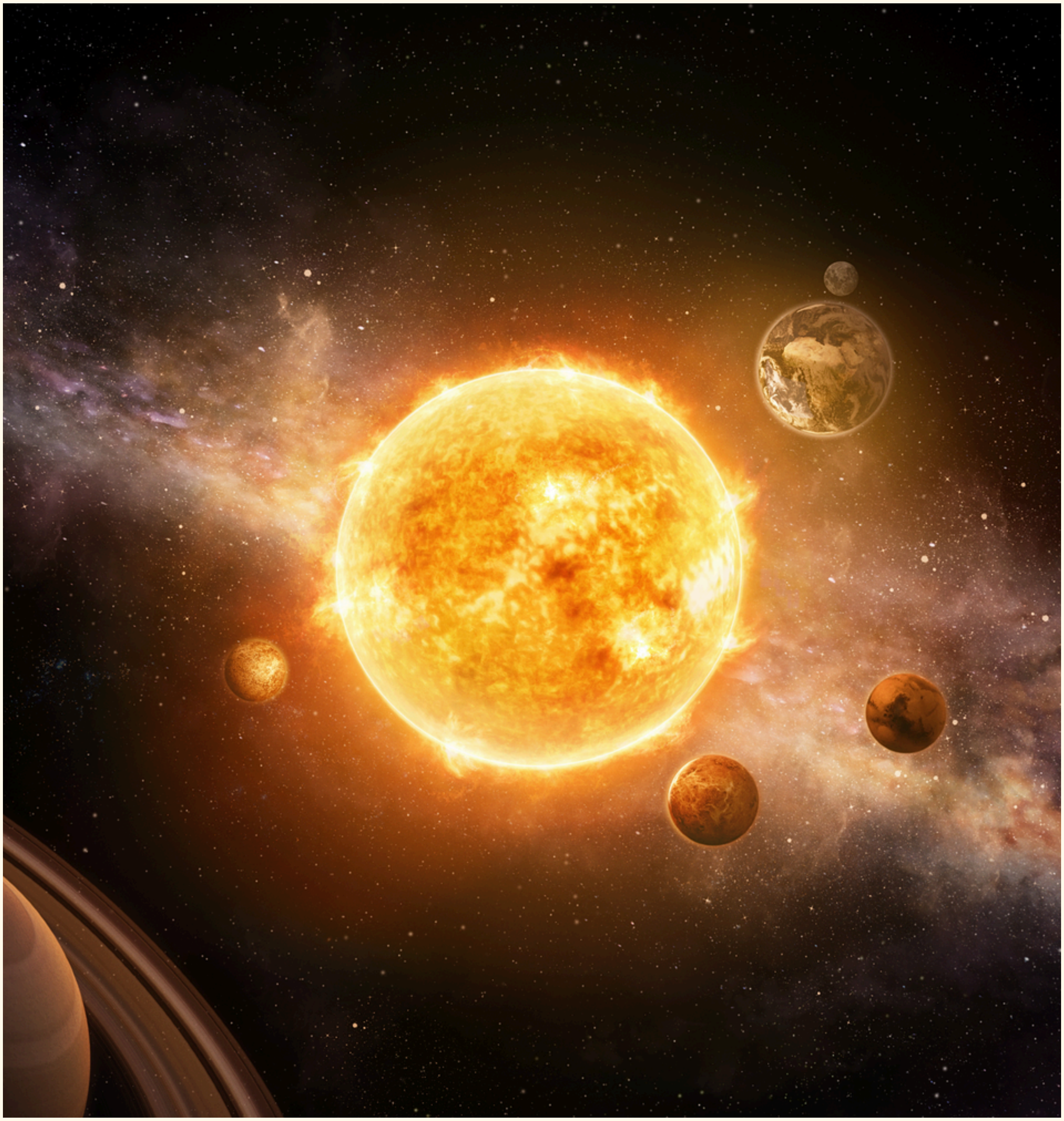
Katherine Johnson was born in 1918 in West Virginia and showed exceptional mathematical talent from a young age. After studying Mathematics at college, she joined NACA, which later became NASA, where she worked as a mathematician. Johnson calculated flight paths and trajectories for several important space missions, including the first American crewed spaceflight and the Apollo Moon missions. In 1962, astronaut John Glenn specifically requested that she check the computer's calculations before his orbital flight.

Despite her vital contributions, Johnson faced discrimination because she was both African American and a woman. During her early career, NASA's workplaces were segregated, and women were often excluded from important meetings and recognition. As a result, her achievements remained largely unknown for many years. However, her work was eventually recognised, and in 2015 she received the Presidential Medal of Freedom. Today, she is celebrated as one of the key figures behind America's early successes in space exploration.

MEASURING THE UNIVERSE

BY IBRAHIM CHISHTI

From the moment we are born our world is constantly expanding. Your world expands from your mother's womb, to the hospital bed you are born in, then onwards to your local area. Maybe as you get older you will travel and your world will expand further to the entire planet. Today we will discuss the methods used to expand our world even further to understand and measure our Solar System, as well as setting us up to understand what could lie beyond.



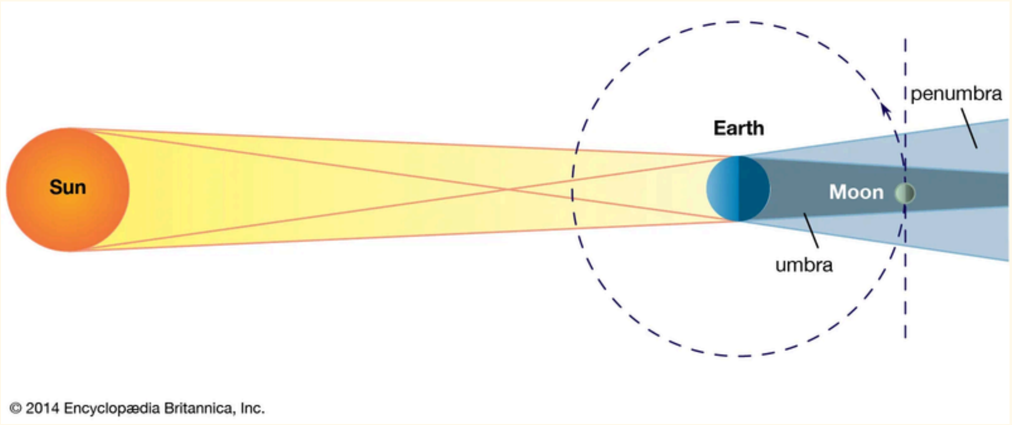
INTRODUCTION

Orion was a hunter from Greek mythology. The gods were so impressed with his skills that they put him and his dogs amongst the stars. Even today we still refer to the constellations as Orion, Canis Major and Canis Minor (Latin for "Great dog" and "Little dog" respectively). For as long as people have had stories, we have used the night sky to tell them.

As a result of contributions from many different peoples, at many different times, we can put numbers to the night sky and truly understand the universe in which we live in.

RUNG 1: THE SHAPE OF THE EARTH

The Ancient Greeks were the first to deduce the shape of the Earth by considering lunar eclipses.



During a lunar eclipse, the moon will pass through the Earth's shadow. At first this seems to be of little use but by looking at the moon as it passes into the shadow, we can get a cross-sectional view of the Earth. Think of it as using the Moon as a backdrop to project the Earth's shape. Furthermore, there is no shortage of data when it comes to eclipses, nearly every eclipse since the invention of writing has been written down one way or another.

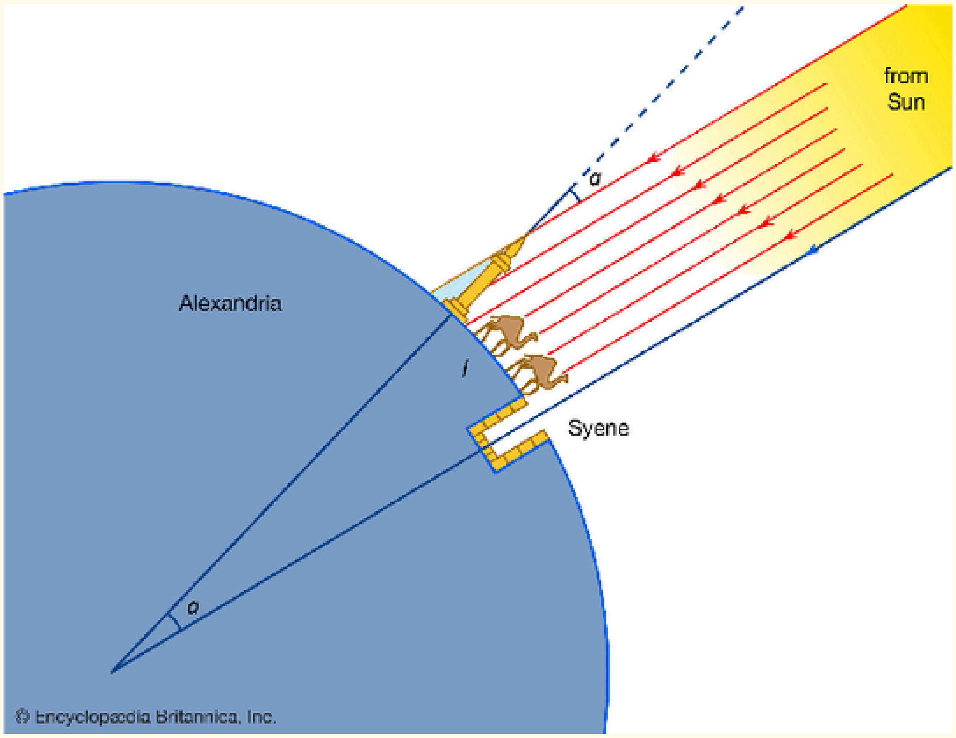
Note that in every recorded eclipse, the Moon appears to look like the following, with a circular cutout of the Moon cloaked in shadow:

Since an eclipse is independent of the Earth's orientation (the Moon doesn't care which way the Earth is facing), we can see that the Earth's cross-section appears to be circular from all orientations. The only way for this to be the case is for the Earth itself to be spherical as opposed to a flat disc.

Determining the size of this sphere is a different story.

THE CIRCUMFERENCE OF EARTH

Eratosthenes was the first to measure the Earths circumference. He knew that on the summer solstice every year in Syene, you could look into a well and see the reflection of the Sun at the bottom. That is to say that the Sun was directly overhead. Eratosthenes decided to try to do the same experiment in his hometown of Alexandria. This ultimately led to failure but unveiled a great realization. What if the Sun was directly over head in Syene but not in Alexandria because of the curvature of Earth.



Eratosthenes measured the angle of the shadow cast at Alexandria to be 7°. From this he concluded that the distance between Alexandria and Syene to be 7/360 of the Earth's Circumference.

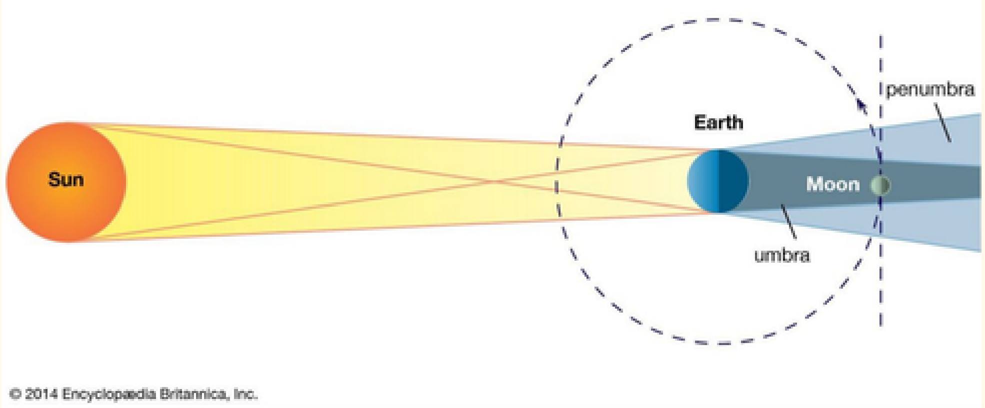
The method of which Eratosthenes measured the distance from Alexandria to Syene is still unknown, it is believed that he hired people to pace the entire distance and count how many steps it takes. This seems very dull now but in Ancient Greece it was a well-known profession. He may have also asked merchants who regularly travelled the distance. However he did it, Eratosthenes found the distance from Alexandria to Syene to be 5000 stadia (or 740 km in today's units). From this he concluded that the Circumference of Earth was 250,000 stadia or 38,000 km. We now know that the true value is 40,000 km. Very close for two thousand years ago!

RUNG 2: MEASURING THE RADIUS OF THE MOON

With the knowledge of the Earth's radius, we can now calculate the radius of the Moon using an indirect measurement.

Indirect measurements are those that allow us to express one length in terms of another. Due to the lack of measuring tapes that can measure distances this big, we must resort to indirect methods of determining distance.

Consider again a lunar eclipse:



We can approximate the diameter of Earth's shadow to be twice the Earth's radius. The Moon travelling through this shadow is enough to deduce the Moon's size relative to the Earth. For example, we can model an eclipse viewed from Earth as the Moon passing through the center of Earth's shadow at constant speed. With this being said, we can do 2 measurements in time to find the ratio of our distances.

Assuming the Moon travels from right to left, we can measure the time it takes for the Moon to travel from A to B and compare it to the time it takes the moon to travel from A to C.

Using the July 2018 Eclipse, the time from A to B was 1 hour 5 mins 48 secs, while the time from A to C was 4 hours 48 mins 45 secs. These times are in the ratio of about 1:4.4, implying that the Moon is 4.4 times smaller than the Earth. This is in the right ballpark but is slightly off, with the Moon actually being 3.7 times smaller than Earth.

There are many sources of error for this measurement, for example

- The Earth's shadow is conical, not cylindrical
- The Moon may not pass the center of Earth's shadow
- The Moon does not move at constant speed

MEASURING THE DISTANCE TO THE MOON

Aristarchus was the first to measure the distance to the Moon around 2000 years ago.
Unlike the Measurements above, we can calculate the distance to the Moon without some chance alignment. This can be attributed to all the work we have done thus far. By timing a Moonset to be about 2 minutes and comparing this to the time from Moonset to Moonset (approximately 24 hours due to Earth's rotation).
Let's think about what this means, the Moon appears to travel a circle with the same radius as distance to the Moon in a day, and it appears to travel through its own diameter once every 2 minutes. Since 2 minutes is 1/720th of a day, we can show that:

$$2 \times \pi \times R = 720 \times 2 \times r$$

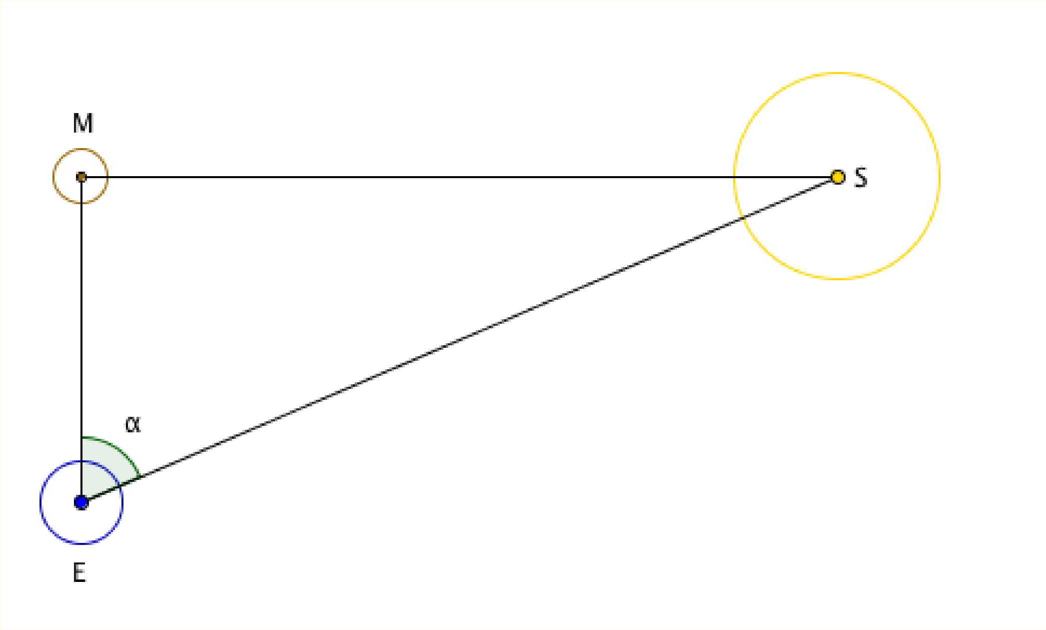
Where R is the distance to the Moon and r is its radius.
We've calculated r above to be 3.7 times smaller than Earth's radius. Solving for R gives us a final value of 398000 km. This is surprisingly accurate, we know now that the distance to the moon varies between 360000 km and 410000 km, so this is right in the middle of the range.
Something to note is that Aristarchus did this investigation before an accurate value of pi had been calculated. He assumed that $\pi = 3$.

RUNG 3: MEASURING THE DISTANCE TO THE SUN

Unfortunately, this is where the Ancient Greeks fall short. Ultimately their lack of technology (most notably a telescope) causes their undoing here.

The distance to the Sun can be measured using another indirect measurement, using the distance to the moon as reference. By observing the angle between the Sun and the moon during an exact half-moon, we can find the distance to the Sun.

Once again Aristarchus was the first to carry out this observation



By measuring the angle between the Sun and Moon (shown in the bottom-right corner), we can use trigonometry to find the ratio of the distances between the Sun and Moon.

Aristarchus measured this angle to be 86 degrees, implying that the Sun was 20 times further than the Moon.

Also we should note that the Sun and Moon appear about the same size in the sky, (beautifully illustrated during a solar eclipse)

By similar triangles, we can also show that the Sun is also 20 times larger than the Moon, making it about 7 times further than the Earth.

This is also the first mention of a Heliocentric model. Aristarchus reasoned that if the Sun is so much larger than the Earth, it would be absurd for the sun to move around Earth and instead the Earth must move around the Sun. At first the Ancients rejected this out of hand, under the pretence that since parallax effects weren't visibly affecting the constellations, the Earth must be stationary in relation to the distant stars. The only scenario that the distant Stars would appear constant and the Heliocentric model was true was if the stars were ridiculously far away and that is just absurd (it was later found that the stars were, in fact, ridiculously far away).

While all the above is mathematically accurate, there was one major flaw, Aristarchus was unable to accurately measure the angle (at no fault of his own). Aristarchus used a Sextant which has a precision of about 1 degree. The true angle was a mere 0.25 degrees off the vertical, a measurement that Aristarchus would be unable to accurately determine. The first reasonably accurate measurement of the distance to the Sun came from Copernicus, who used the ratios of planetary orbits to give a much more accurate value.

CONCLUSION

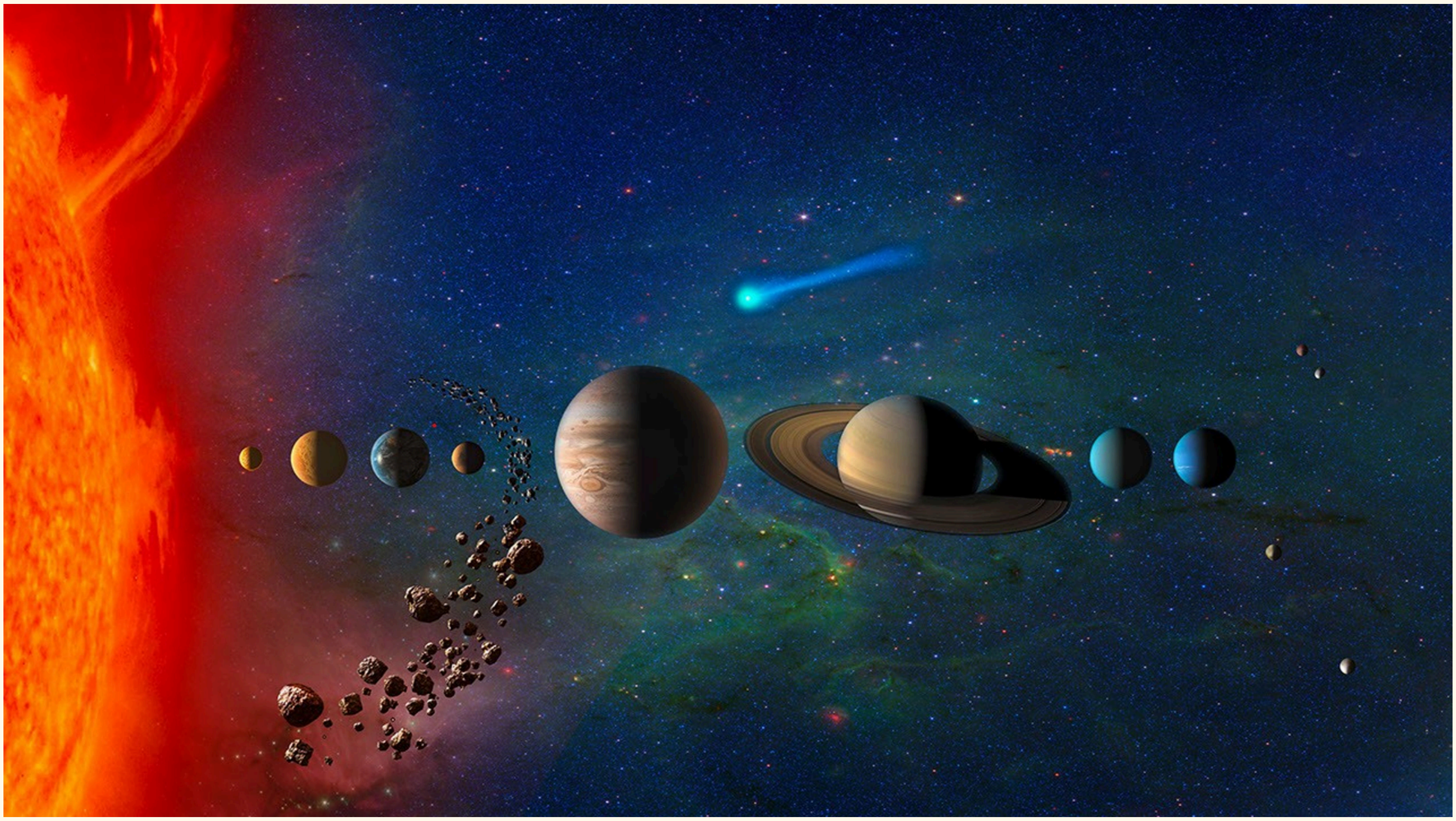
Today we have only discussed the first 3 Rungs of the Cosmological Distance Ladder. The Distance Ladder continues, allowing us to measure other stars, the milky way, and ultimately continuing to the entire Universe. The field of Astrometry is fascinating and its refinements over thousands of years have helped mankind understand the cosmos and, for the case of the Moon at least, use these measurements to travel there ourselves.

One final note I want to leave you with is this image taken by Bill Anders on the Apollo 8 mission; the first-time people went to orbit the moon:

We showed today that the circumference of Earth to be 40,000 km, but that is a very large number and a very difficult number to get your head around. It feels so vast that it may as well be infinite.

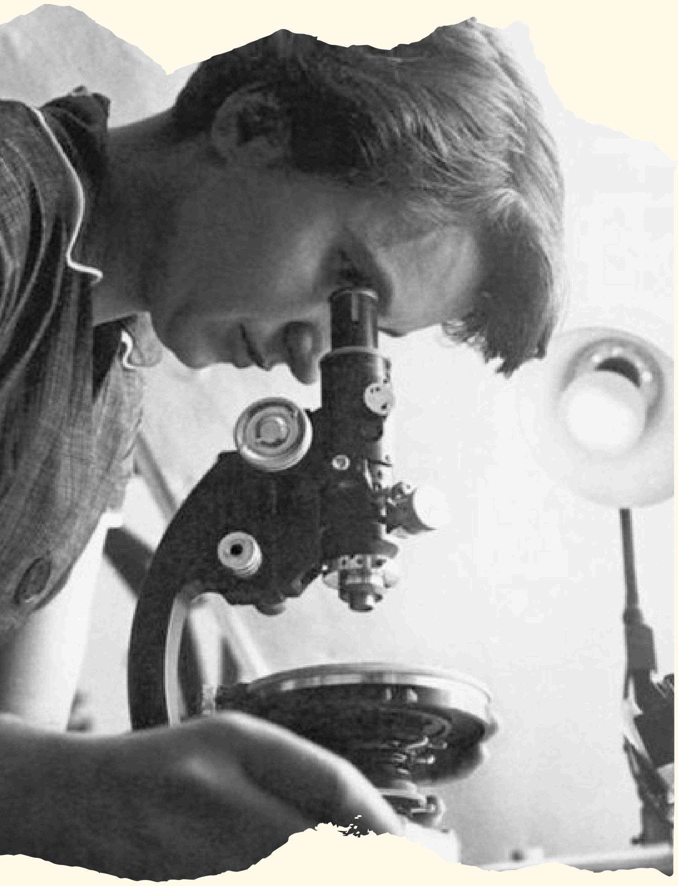
It's not.

The Earth appears to be quite small in relation to the cosmos, the numbers may have told us this earlier, they are that way by logical necessity after all, but the journeys those numbers took us on made us truly realise the scale of the universe we live in.



HIGHLIGHT #4

Rosalind Franklin: The First Lady of DNA



Rosalind Franklin (also none for manya aliases like the "wronged heroine") is one of the most brilliant bioquimists cristalography expert of all times. During the 1950's she was a researcher at the King's College in London, studying DNA structure and composition.

During the 1950's she was studying the structure of DNA using X-ray radiation to photograph DNA fibres. She used her expertise in X-ray deffraction to study more and prove the helix structure that today, we associate with DNA.

Her co-worker, Maurice Wilkins, began the study of DNA photographs using X-ray deffration, but it was only with Rosalind's expertise that significant, high quality results were available to their research.

Due to professional and personal differences, in 1953, Wilkins shared one of Franklin's photographs, (which took on average more than 100 hours to reveal) to a competing DNA researcher - James Watson.

James Watson and Francis Crick used her photograph - the famous *Photograph 51* - as a foundation to develop their three-dimensional double-helix model of the DNA molecule, which awarded them the Nobel Prize in Phisiolagy or Medicine in 1962, in spite of accessing Franklin's data and work with neither her knowledge nor consent. It was not long after her death that her immense contributions to biochemistry and our knowledge of DNA structures were finally recognized by the scientific community,

After studying DNA, Rosalind dedicated herself to other areas. We owe her a lot of ground-breaking discoveries about the dissemination of viral infections by studying the RNA structure in the tobacco mosaic virus and the virus of polio.

For all of her amazing contributions to science she is seen as one of the most important biologists of the 20th century.
And so much more that just the "wronged heroine"...

THE FIGHT FOR HAND-WASHING

Germ theory, infectious diseases and the history of medical hygiene

BY MARIA MATIAS

INTRODUCTION

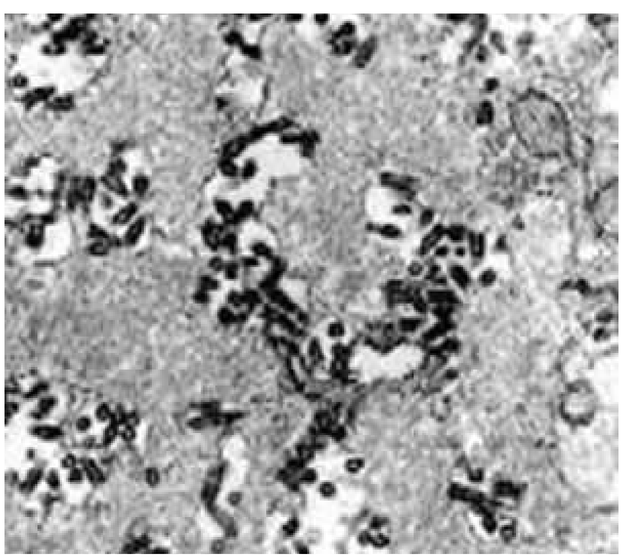
As intuitive as it may seem to us today, the idea that diseases can be caused by micro-organisms that travel through the air, food, beverages, surfaces or even animal vectors is fairly recent in scientific history, and it wasn't until the 19th century that it became a hypothesis, and not without a lot of scepticism from both scientists and medical professionals.

Here we explore what germ theory is, how it arose in the scientific context, the history of medical hygiene since then, and the crucial role it plays in our modern world!

Most of our medical, public health, and day-to-day practices revolve around the idea that we can become sick. When we go to the canteen, we expect that whoever is serving our meal is wearing a pair of gloves. In the doctor's office, you probably patiently wait until they have disinfected their hands to do whatever examination you need. Your community probably expects its water to be passed through a water treatment station before it surges in their faucets. It seems intuitive, almost essential for survival, but the truth is that throughout most of our history, we were completely unaware of the power (and even the existence) of microorganisms in all the activities the human being partakes in, from eating to working to simply breathing. This discovery, like most of those in the scientific process, was made gradually, with a lot of scepticism and with the contribution of several different actors, to whom we owe a lot of our development in public health. But let's start from the beginning...

WHAT IS GERM THEORY?

The germ theory of disease, or simply germ theory, is the currently accepted scientific principle that explains the cause of contagious diseases. At its core it is mainly based in two ideas: one is that contagious diseases like cholera, smallpox or influenza are caused by microorganisms or germs, which are too small to be detected by the human eye, but which are capable of evading animals, plants and even bacteria and whose growth and reproduction within their host can cause disease. Furthermore, these microorganisms can be passed from one organism to another, causing further disease. This theory was finally proven by Louis Pasteur, the inventor of the pasteurisation method, in the 1850's, but its principles date back hundreds of years...



THE DEVELOPMENT OF GERM THEORY

This theory was rather revolutionary several times throughout history. In fact. It is important to understand that, before the 19th Century, the accepted theory of disease was the miasma theory. It states that disease is caused by a substance - miasma - that emanates from rotting organisms. This miasma is a form of "bad air" and it is not transmissible among living organisms. Infection and disease would only occur through contact with environmental factors containing these miasma particles. So, in light of this theory, it is difficult to accept that disease is caused by living things; quite the contrary, miasma is born out of dead organisms, which pollute the air. This theory makes much more sense when we put it in perspective with the few. diseases that were understood at the time: cholera, which is transmitted by faeces, was extremely associated with foul smell, hence the explanation of transmission by "polluted" air.

A depiction of miasma, the polluted air, dated from the 18th century

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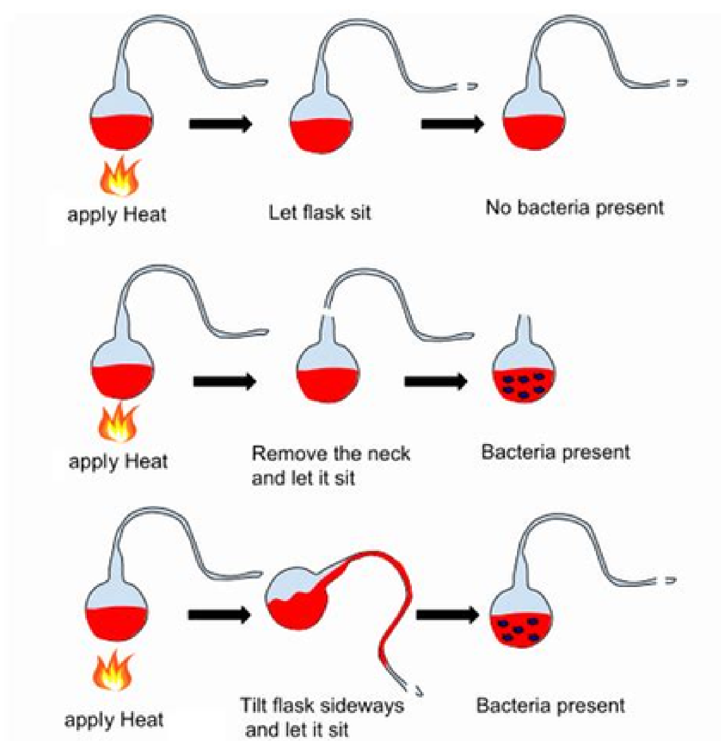
SPONTANEOUS GENERATION

Another widespread belief before Louis Pasteur was the idea of spontaneous generation, that is, that living organisms could rise from nonliving matter. This idea has long been disproven and even given origin to Cell Theory, but that's beyond the point. Although this may again seem absolutely impossible to imagine to us today, what people before the 19th century predominantly saw was that if you left a piece of cheese or bread in a dark corner of a room, maggots or even mice would eventually appear. They thus thought that these living beings would actually rise from food, for example.

Therefore, even with the idea that diseases were caused by microorganisms, one did not necessarily accept that they would be transmitted by one individual to another. If microorganisms can be generated spontaneously, they could surge in virtually any space. Louis Pasteur, however, came to disprove this theory in one of his most famous experiments: in a nutshell, he boiled a meat broth in a flask whose neck curved downward, so as not to allow any particles to enter the flask while allowing the free flow of air. He then allowed the meat broth to cool, thus sterilising the food in a process now known as pasteurisation. On those flasks whose necks were not downward, which allowed particles to come, the broth showed signs of spoilage and the presence of bacteria within days, whereas those that were only in contact with air flow did not show signs of these.

These results showed that the living organisms couldn't have risen from the broth alone: they must have been transported through the spores in the air, rather than spontaneously generated within that food itself. Although we have to keep in mind that Pasteur's discovery was the culmination of many scientists' work, his experiment provided a definitive answer to the question of how organisms are generated and opened the path for many, many more advancements in public health and epidemiology.



HAND WASHING - EARLY DISCOVERIES

Curiously enough, many had already postulated the transmissible nature of diseases before some of the conclusions we discussed earlier. These pioneers shared a common factor of being connected to the medical activity, where they came in close contact with how diseases seemed to jump from one patient to another, and how mortality rates seemed to follow a distinctive pattern among their hospitals and clinics.

Even more worrisome, some of these pioneers realised that death rates resulting from fevers and similar perils seemed to follow doctors themselves. In fact, during the 19th century, conditions within the health care facilities were so precarious that people saw them as “real houses of death” rather than infrastructures where one could go to seek treatment. And most of these rather chilling tales are owed to the extremely unhygienic procedures taking place within these hospitals. One of the areas where this problem was most quickly identified was in gynecology. In fact, transmissibility of disease to mothers was almost simultaneously identified by two of the most prominent figures in hygiene: Oliver Holes and Ignaz Simmelweiss.

Semmelweiss and cadaveric particles

The story of this great physician is rather tragic and deserving of a full article in itself. He is awarded the first to statistically prove the transmissibility of disease, although his results remain unpublished, used only for his clinical setting.

Imagine this: it is the year 1848 in Vienna. Ignaz Semmelweiss was working as a physician in Vienna’s general hospital. During this time, it was rather common for women to deliver their children at home, although some, due to complications, lack of resources or other personal preferences, went to the hospital to deliver their children, where they were faced with a 20 to 30% maternal death rate, mostly due to puerperal infection incurred from very poor conditions in the clinical setting. Semmelweis’s hospital was no different in these challenges, and it faced a mortality rate as large as 20%. However, Vienna’s hospital had an interesting peculiarity: its maternity was divided into two distinct delivery rooms: in one of these, procedures were carried out by medical students, whilst in the second, it was mostly run by midwifery students. Asides from this, they were identical in condition and resources. But Ignaz Semmelweiss noticed something intriguing: maternal mortality seemed to follow medical students much more closely than midwives. So much so that, in the first division, the mortality rate was as high as 18.75%, while the second showed a significantly smaller representation of only 3%. After noticing this extreme discrepancy in mortality, Semmeleweiss started questioning what could cause such astounding differences. He realised that, in the first division, medical students would perform autopsies in the morning and, later in the day, would go to the maternity ward, while midwife students did not. He then hypothesised that medical students would carry some sort of ‘cadaveric particles’ from the autopsies in their hands which would cause puerperal infections in the mothers later on.

To test this idea he ordered a strict hand-sanitizing policy: before students and physicians entered the labor room they were required to wash their hands in chlorine water until the cadaveric smell was gone and their hands did not show signs of any previous particles. They were also required to brush under their fingernails. These measures were astonishingly effective: one year after the implementation of this policy death rates from mothers in the first division of the maternity ward fell to 2.4%, even smaller than the second division. In spite of the impressive results, Semmelweiss' theory was met with extreme skepticism. In fact, he really couldn't find a satisfactory explanation of this result. We must remember that this was pre-germ theory, what to us now looks intuitively as bacterial agents transferring from cadavers to physician's hands and from these to the mother's open wounds, causing infection, was definitely a far fetch in 1847. To his superiors, Semmelweiss' theory was unfounded and incoherent. Moreover, for these experienced doctors, it was hard to imagine 'unholy death particles' being transferred from the hands of 'holy' doctors.

Dr. Ignaz Semmelweiss

His theories were very violently received by his peers. He suffered from a lot of mental health issues as a result, characterized by bouts of depression, paranoia and rage. He died in 1865 in a mental asylum.
His contributions wouldn't be recognized until 20 years later, with the development of germ theory and antisepsis by Joseph Lister.

Oliver Holmes and his hand-washing defense

Oliver Holmes's story is very similar to our previous one, but this time we get to see the reaction of the scientific community on the other side of the Atlantic, presenting the first theories of medical disease transmissibility in the United States of America. Oliver Holmes was an influential physician, anatomist and poet (under the pseudonym "the Autocrat of the Breakfast Table", if you're curious).

He became interested in gynaecological care, specifically childbed fever, in 1842 after attending a lecture on the topic. He quickly began a thorough investigation, which resulted in a paper, "The contagiousness of puerperal fever", which he read before the Boston Society for Medical Improvement. In this paper, published in the New England Quarterly Journal of Medicine and Surgery, he argued that the cause of puerperal fever in mothers was the lack of hand sanitation of the doctors who provided them with care. He made remarkably radical recommendations, including but not limited to washing their hands before and after every surgical procedure or autopsy, and to burn the clothes they wore if one of their patients died of puerperal fever after a delivery performed by them.

Because the above-mentioned journal in which the paper was published ended shortly after its release, his findings did not get the traction which they could have. Only 12 years later, in 1855 when it was republished as a booklet did it gain widespread attention. Even then, similarly to his European counterpart, Holmes' work was met with a lot of criticism from his peers and the medical community.

LISTER, PASTEUR AND THE RISE OF CONTEMPORARY HYGIENE

As we have mentioned, maybe too many times throughout this article, Pasteur's theory of disease completely revolutionised the world's view of hygiene. Before his work, there wasn't an unifiable proof of disease transmission and microbial action. As a consequence, there was no practice of sterilised medicine, treatment or tools for medical practice. Needless to say, post-surgical infections and complications were beyond common.

Pasteurisation, that is, the heating of a structure or substance to a high enough temperature to kill microorganisms, followed by its cooling to sterilise it, was beyond revolutionary for the beginning of hygienasation.

Pasteur's work heavily inspired another brilliant scientist: Joseph Lister. Joseph Lister was born in 1827 in Essex. He studied medicine in the Royal Infirmary in Edinburgh, where he developed his talents for scientific research. In 1865, he was introduced to Pasteur's work. Lister began to think there might be a correlation between airborne microorganisms described by Pasteur and hospital sepsis he encountered in his profession. We must remember that, by this time, surgeons worked with mortality rates as high as 40% from procedures such as amputations.

And if these infections are caused by living organisms, then they can also be killed.

He quickly began a series of experiments using carbolic acid as an antiseptic with an impressive success rate for the time: from the 13 serious patients he treated, only two succumbed to infection. He finally released an article in the British Medical Journal showing his findings.
Not without scepticism was his hypothesis accepted, but the use of antiseptic acid during the Franco-Prussian wars by the Prussians led to the success of Lister's method. By the 1870's, antiseptic surgery was widespread and the hospital's cleanliness became essential for practice.

CONCLUSION

So, what can we learn from this long, difficult path towards hygienesation?

Development is not a linear path. The process of acquiring new knowledge, better, more secure procedures and breaking the status quo is always met with scepticism and resistance. But this is how science works. We have to keep asking questions, we have to think and refuse what has been settled as absolute. Imagine how our world would look like if Lister had not questioned the idea that infections were a necessary, unavoidable part of surgeries? Even something as simple as washing your hands was extremely hard to accept, over 150 years later, feels only natural to us.

So maybe next time you go and wash your hands, with a good amount of soap and water, remember the enourmus amount of scientists that enabled that habit.

HIGHLIGHT #5

By Ritisha Agarwal

Mildred Dresselhaus

The Queen of Carbon Science

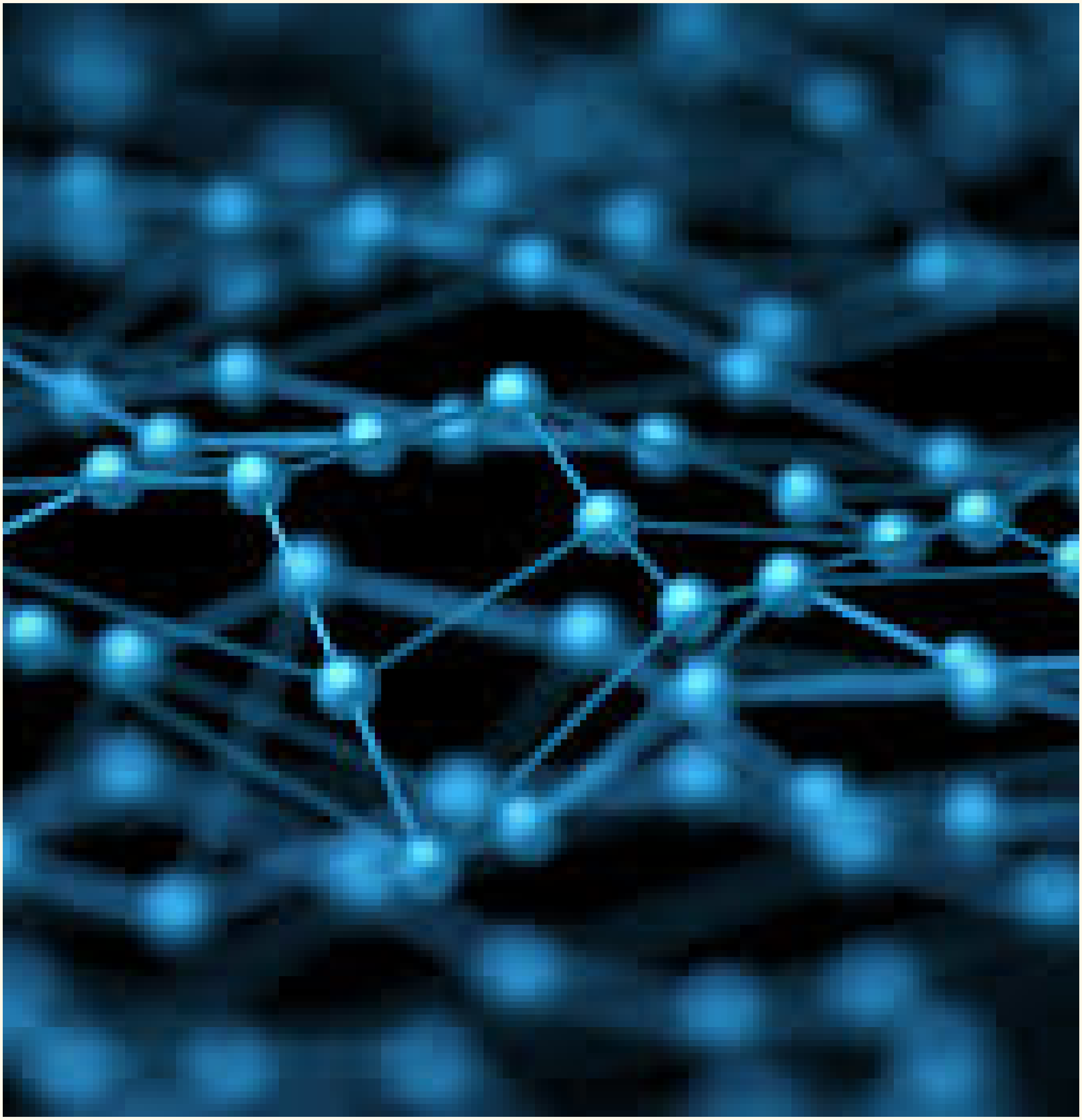
Mildred Dresselhaus was born in 1930 in New York City and developed a passion for science and mathematics from an early age. After studying physics, she became a professor at the Massachusetts Institute of Technology (MIT) and carried out pioneering research in condensed matter physics. Her work focused on the properties of carbon materials, including graphite, carbon fibres, and carbon nanotubes, helping to lay the foundations for modern nanotechnology and advanced electronic materials.

Despite her significant contributions, Dresselhaus worked in a field where women were heavily underrepresented and often overlooked. Throughout much of her career, female physicists received less recognition than their male counterparts, and many of her achievements were not fully appreciated outside the scientific community. Nevertheless, she became known as the “Queen of Carbon Science” and received numerous prestigious awards. Today, she is recognised as one of the most influential condensed matter physicists of the twentieth century.

GRAVITY AS MATTER

What if we could describe gravity as the behaviour of a material? How condensed matter physics is helping us test one of the biggest questions in science.

BY ERIN GALLEGO



A single water molecule is not wet, and a single iron atom is not magnetic, but huge numbers of them, arranged in the right way, produce these familiar properties. The idea that collective behaviour arises from simple underlying rules turns out to be useful when thinking about gravity.

WHAT IS CONDENSED MATTER PHYSICS?

Condensed matter physics is the study of how large groups of particles behave together. Covering solids, liquids, and more exotic states of matter where particles are packed closely enough together to interact strongly with each other. In many ways, it is the physics of everyday things: metals, magnets, superconductors, and the strange quantum fluids that exist near absolute zero. What makes the field fascinating is a concept called emergent behaviour. When enough particles come together, the system can start doing things that none of the individual particles could do alone. A single water molecule is not wet, and a single iron atom is not magnetic, but huge numbers of them, arranged in the right way, produce these familiar properties. The idea that collective behaviour arises from simple underlying rules turns out to be useful when thinking about gravity.

THE PROBLEM GRAVITY POSES

Gravity is described by Einstein's general theory of relativity, in which mass curves space and time, and what we feel as gravity is simply objects following the path set by that curved geometry. The theory works with extraordinary precision at large scales, correctly predicting the orbits of planets, the bending of light around stars, and the existence of black holes. The problem arises when you try to combine it with quantum mechanics, the theory that governing very small systems. Other fundamental forces: electromagnetism, the strong nuclear force, the weak nuclear force have been successfully described within the framework of quantum field theory, a synthesis confirmed by decades of particle physics experiments. Gravity has not. At the scales where quantum effects and gravity both matters simultaneously, for example inside a black hole, or at the Big Bang, our current theories produce nonsensical infinities and simply break down. Finding a quantum theory of gravity is widely regarded as one of the deepest unsolved problems in all of physics, and it is this gap that analogue gravity aims to probe.

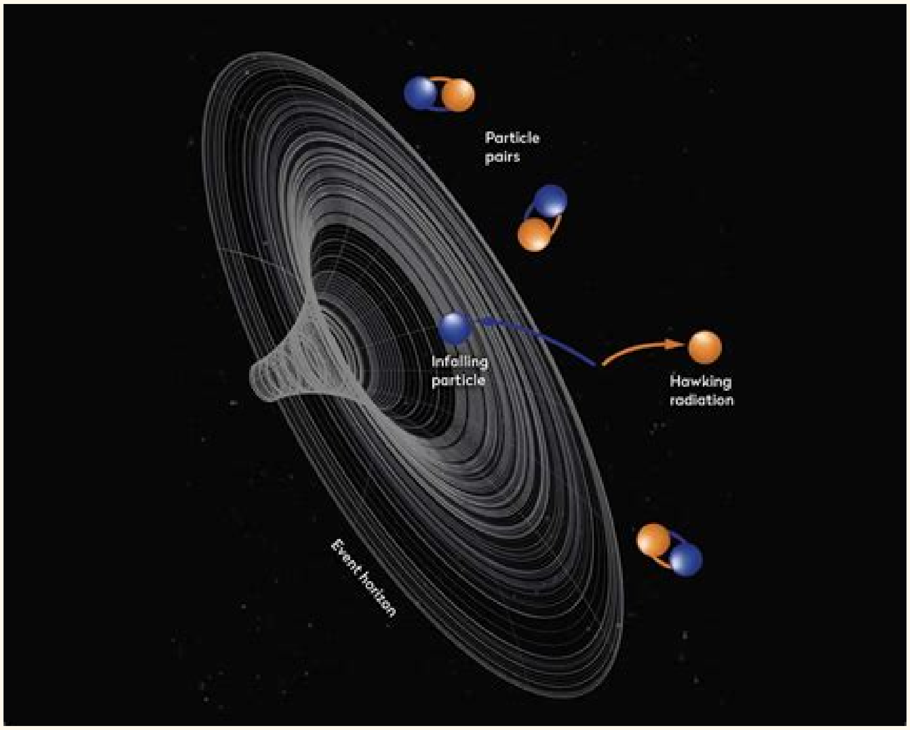
ANALOGUE GRAVITY

In the 1980s, physicist Bill Unruh noticed something striking: sound waves moving through a flowing fluid obey equations that are mathematically structured in almost similarly to light waves moving through curved spacetime. If a fluid flows faster than the local speed of sound, then sound waves propagating against that flow can no longer escape upstream. They get swept along by the current and become permanently trapped.

This creates what Unruh called a "dumb hole", a play on the word mute, since sound cannot speak from within it, which is the acoustic equivalent of a black hole's event horizon, the boundary beyond which even light cannot escape. As Barceló, Liberati and Visser established in their detailed review of the field, these condensed matter systems provide experimentally accessible models of curved-space quantum field theory, mimicking the kinematic aspects of general relativity (how things move in curved spacetime) even though they do not reproduce its dynamics .Analogue gravity is therefore not claiming that gravity is a fluid. It is saying that some of the mathematical machinery used to describe gravity also describes certain materials, and that this overlap can be used to test ideas that would otherwise be completely untestable.

HAWKING RADIATION

IA key application of condensed matter physics involves Hawking radiation. Stephen Hawking predicted, in 1974, that black holes emit radiation due to quantum effects occurring at the event horizon. A challenge is that this radiation is almost quite faint. Physicist Silke Weinfurtner noted, the Hawking temperature is inversely proportional to the mass of the black hole, and for the smallest observed black holes, those with a mass comparable to the Sun, this temperature is around 60 nanokelvins, producing a signal so small that direct astronomical detection cannot pick up. However, condensed matter physics offers a potential way around this. By cooling rubidium atoms to around a few billionths of a degree above absolute zero, physicists can create a Bose-Einstein condensate, a quantum state in which atoms behave collectively as a single entity. When this condensate flows, it forms an acoustic black hole that traps sound (phonons) instead of light (photons), and the mathematics governing phonons at its horizon is the same as that governing light at a real black hole's horizon.

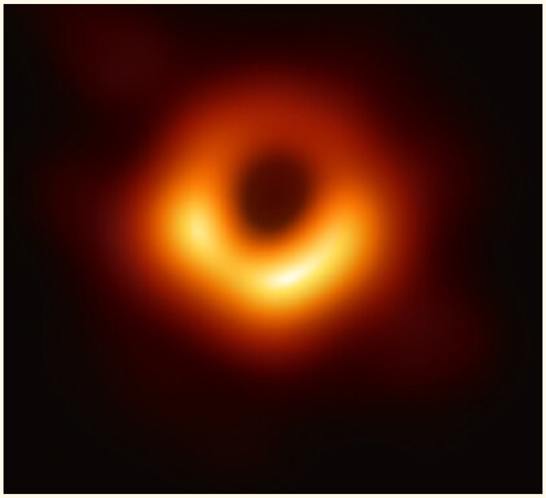


In 2016, Jeff Steinhauer at the Technion–Israel Institute of Technology ran one of these experiments continuously for six days, demonstrating that phonons escaping from the acoustic horizon were quantum-entangled with those falling inward, and observing a thermal distribution of radiation consistent with Hawking's predictions. Separately, Weinfurtner and colleagues measured surface waves in flowing water near an acoustic horizon and showed, using Einstein's relation between stimulated and spontaneous emission, that the spontaneous quantum emission from that horizon would also be thermal. Neither experiment proves that real astrophysical black holes emit Hawking radiation, but both demonstrate that the quantum field theory underpinning Hawking's calculation produces real, measurable effects in systems that share the same mathematical structure, which is precisely the kind of indirect confirmation the field has been working towards.

FROM BLACK HOLES TO THE EXPANDING UNIVERSE

The reach of analogue gravity extends beyond black holes. In 2018, experiments with a rapidly expanding ring-shaped Bose-Einstein condensate showed that sound waves within it exhibit cosmological redshift and Hubble friction. The same effects that cause light from distant galaxies to shift towards the red end of the spectrum as the universe expands. Confirming a predicted connection between acoustic systems and cosmological spacetimes.

A year later, a controlled rapid change in the trapping parameters of an ion chain produced phonon pairs analogous to particle creation in an expanding universe, a quantum effect predicted by cosmological theory but never previously observed in isolation. As Weinfurtner and colleagues noted in a 2020 Royal Society review of the field, a coupled two-component Bose-Einstein condensate can even be used to mimic a first-order relativistic phase transition akin to the false vacuum decay, which is thought to relate to how the vacuum state of the early universe evolved. Taken together, these results show that a table-top experiment in a physics laboratory can reproduce both mathematically and physically phenomena that are normally only expected to occur at the scale of the entire observable universe.

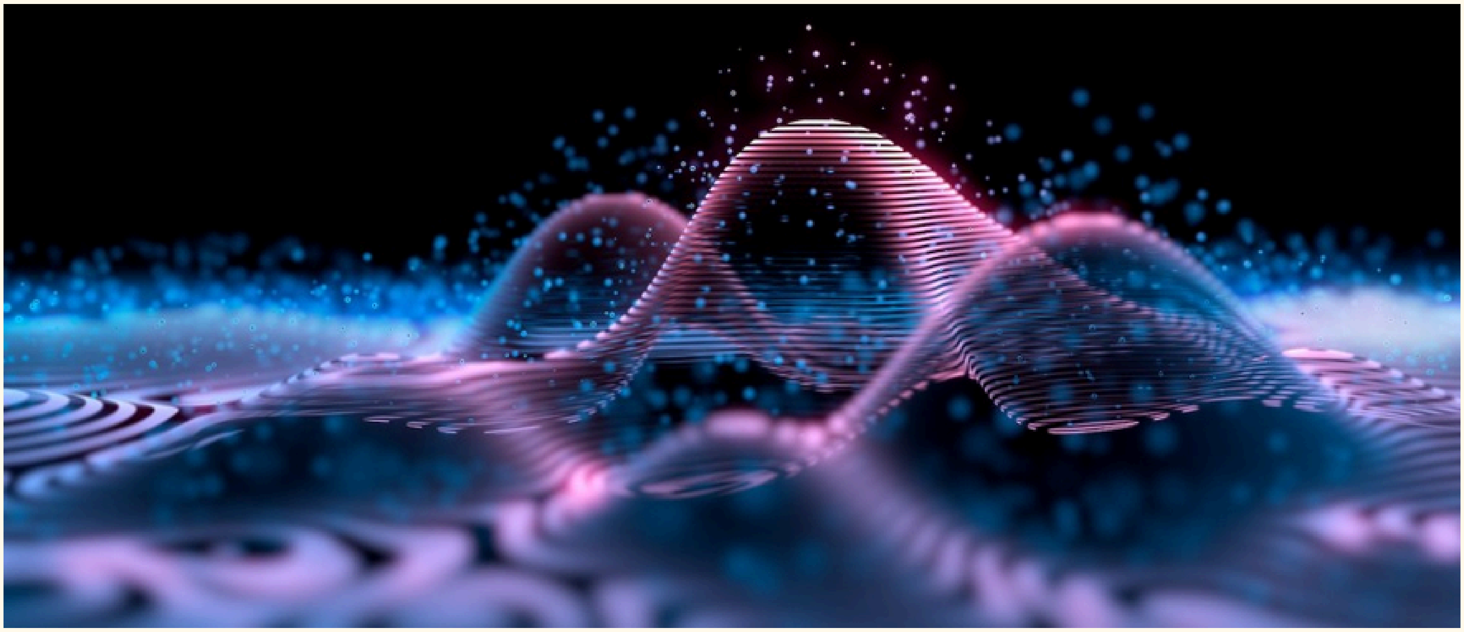


SO, WHAT DOES THIS TELL US?

The honest conclusion is that analogue gravity does not prove gravity is truly made of some kind of condensed matter. What it establishes is that if there is a perturbation in the right kind of condensed matter system, the equations of motion governing that perturbation take the same mathematical form as those describing quantum fields in curved spacetime.

As Shahbazi's 2023 analysis of the field argues, the observation of phenomena in these condensed matter simulators can serve as genuine empirical confirmation of the underlying theoretical structures, via the shared mathematical architecture of both systems. This has a deeper implication: the fact that such different physical systems share the same equations suggests that features we associate with gravity: horizons, thermal radiation, the relationship between geometry and wave propagation, may themselves be emergent phenomena, arising from more fundamental laws in the same way that magnetism emerges from the collective behaviour of atoms.

Whether or not gravity ultimately turns out to be emergent in this sense, analogue gravity has already established itself as a genuine experimental tool for testing ideas in curved-space quantum field theory that would otherwise remain purely theoretical, bringing some of the most extreme physics in the universe within reach of a laboratory bench.



HIGHLIGHT #6

By Ritisha Agarwal

Theodore Lawless

Pioneer of Infectious Skin Disease Research

Theodore K. Lawless was born in 1892 in Louisiana and became one of the first prominent African American dermatologists in the United States. After studying medicine, he specialised in dermatology at a time when the field was still developing many of its modern treatments. His research focused mainly on skin diseases such as syphilitic skin conditions, leprosy (Hansen's disease), and other chronic infectious and inflammatory disorders that disproportionately affected poorer communities. He also studied skin pigmentation disorders and worked on improving treatments for conditions caused by prolonged exposure to sunlight and chemical irritation.

Lawless made important contributions to both clinical dermatology and public health, particularly in improving diagnosis and treatment approaches for infectious skin diseases. He also helped advance the use of early chemotherapy treatments for skin-related infections and supported research into more effective therapeutic methods. Despite his significant work, he faced severe racial discrimination throughout his career, which limited his access to certain academic and hospital positions and meant his achievements were often under-recognised in mainstream medical circles. Today, he is remembered as a pioneer who advanced dermatological research while breaking barriers for Black physicians in medicine.

THE DEATH OF DIVERSITY IN DERMATOLOGY

BY KEZIAH DAVID

Skin conditions affect nearly one-third of the human population. However, despite individuals with skin of colour representing the vast majority of humanity, there are still significant discrepancies between accurate diagnoses and treatment of dermatological conditions across diverse skin tones. This article aims to explore the main reasons these discrepancies exist and how we could tackle them by promoting diversity in medical education, raising awareness of dermatological diseases, and using artificial intelligence to improve the precision and efficiency of diagnoses.

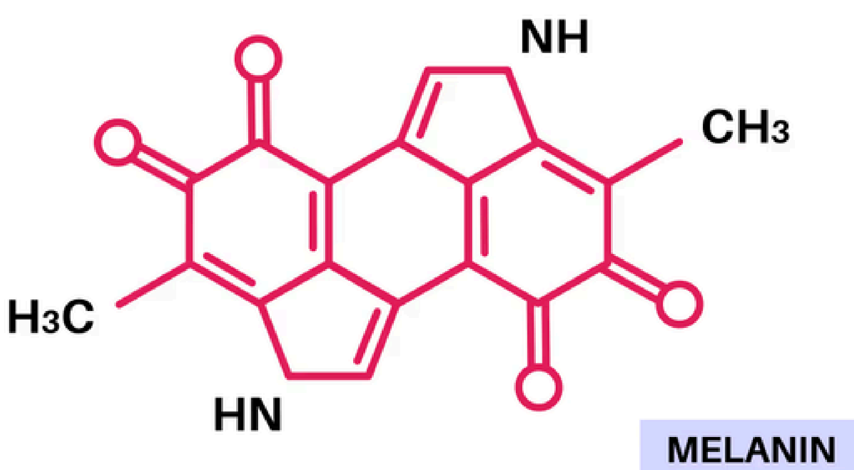
INTRODUCTION TO SKIN TONES

Human skin tones exist on a continuous spectrum, ranging from the darkest brown to the lightest hues. Each unique skin tone results from variation in pigmentation, influenced by factors such as genetics, exposure to ultraviolet radiation (UVR), and/or disorders.

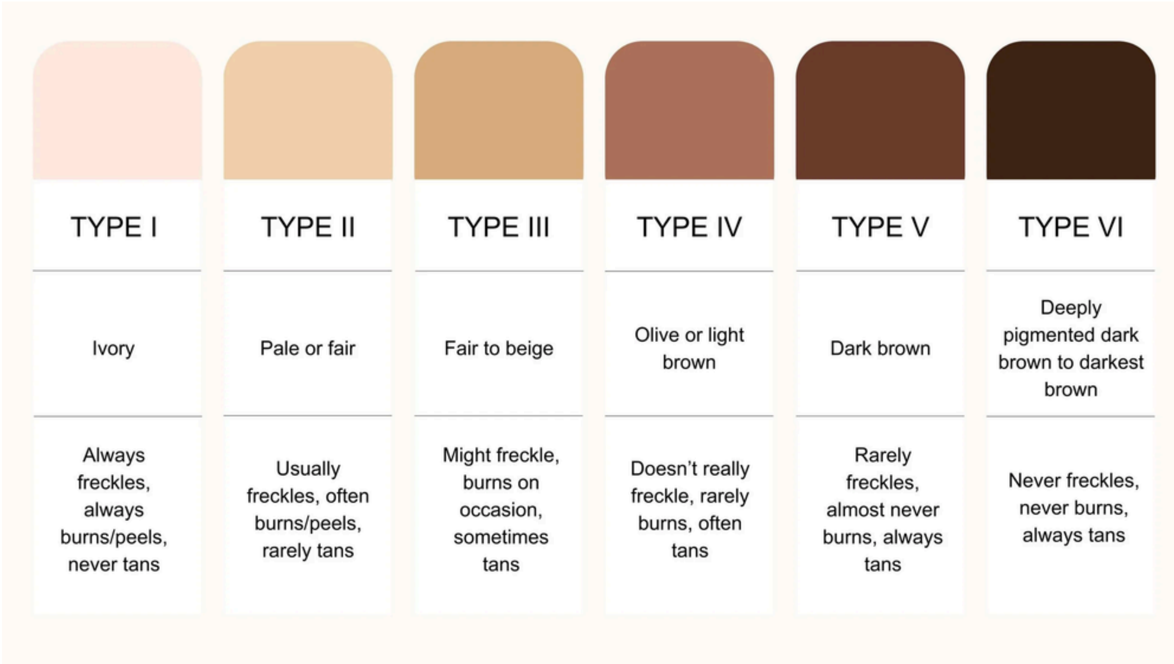
There is a direct correlation between the geographic distribution of UVR and the distribution of skin pigmentation around the world; regions that receive higher amounts of UVR - typically located near the equator or at higher altitudes - tend to have darker-skinned populations. And regions far from the tropics and closer to the poles of the earth - thus receiving lower UVR - tend to have lighter-skinned populations. Interestingly, natural skin colour can be changed due to processes such as tanning, which causes the skin to darken (facultative pigmentation). Thus, the leading theory is that human skin pigmentation is an adaptation to UVR: a cause of skin aging, immune suppression, and more prominently, skin cancer.

THE ROLE OF MELANIN

Our skin has evolved to defend itself against harmful UVR from the sun, and the sole defender is a minuscule yet complex molecule - melanin.



Melanin is a protein that provides pigmentation to your eyes, hair, and skin, and it is produced by specialised cells called melanocytes that are present in the deepest layer of the epidermis. Different subtypes of melanin exist, and the ones of particular interest are eumelanin, responsible for dark colours like black and brown, and pheomelanin, responsible for reddish-yellow colours. Higher levels of eumelanin result in darker skin tones, whereas higher levels of pheomelanin result in paler skin tones. People across all skin tones have a fairly consistent number of melanocytes - it is the amount and proportion of the different types of melanin produced by melanocytes that causes variation in skin pigmentation.

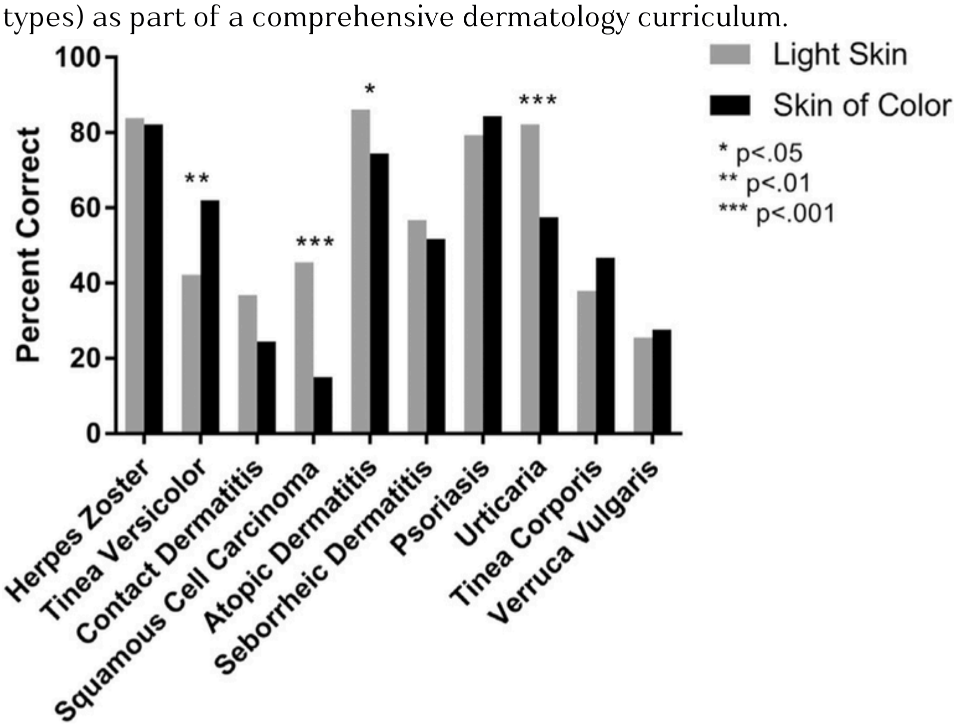


WHERE DOES THE ISSUE LIE?

Despite many skin conditions in Type I skin presenting differently from Type III skin, medical training is conspicuously centered around Type I-II skin. This is a result of medical curricula that inadequately equip students with dermatological knowledge, as well as the lack of representation and diversity in skin studies.

1. Adressing Deficits in Medical Curricula

A recently conducted study highlighted the stark differences in medical students' ability and confidence in correctly identifying skin conditions in individuals with light skin compared to individuals with dark skin. The inaccuracy of identification across the different skin conditions speaks volumes, considering the fact that the students in the study previously underwent dermatology coursework. The issue appears to lie not with the students themselves, but with the structure and content of the medical curriculum, as even the findings of the study persuade the need to present all dermatologic conditions in both light skin and skin of colour (in other words, all FST types) as part of a comprehensive dermatology curriculum.



2. Lack of Diversity in Skin Studies

Psoriasis is a skin disease that affects 1-3% of the global population, with its prevalence varying across different genetic ancestries. In the United States, psoriasis is present in 1.3% of African Americans and 2.5% in European Americans. However, it was recently noted that most participants in phase II psoriasis clinical trials in the United States identified as "White" in terms of ethnicity, with only 3.09% identifying as "Black".

This is not a one-off situation, as research has shown that when participant data from dermatology trials completed in the United States were compared with prevalence rates for the most underrepresented racial group, certain minority groups were underrepresented in dermatology trials, with Black/African Americans being the most underrepresented, even when accounting for prevalence rates. Insufficient research on dermatological conditions on melanin-rich skin has resulted in healthcare providers' inadequate awareness and understanding, which may lead to delayed diagnoses and misdiagnoses.

EFFECTS OF MISDIAGNOSIS AND DELAYED DIAGNOSIS

Linking back to the aforementioned skin disease, psoriasis is a chronic skin disease that causes painful, itchy, and scaly patches on various parts of the body. Type VI skin has a significantly higher eumelanin content than Type I skin; thus, the presentation of the psoriasis patches will differ: In Type I skin, psoriasis presents as red patches with silvery-white scales, whereas in Type VI skin, the patches are violaceous with gray scales. These features can often overlap with other papulosquamous disorders or erythema (an inflammatory condition). This ultimately affects how the disease is diagnosed.

Misdiagnosis or delayed diagnosis of skin diseases can often result in the excessive usage of topical steroids, a common treatment for eczema and psoriasis. Prolonged use of topical steroids leads to many side effects, such as skin thinning, stretch marks, hyperpigmentation (in those with eumelanin-rich/ER skin), and even an increased susceptibility to infections.

Additionally, it was illustrated that even after correctly ordering a biopsy for patients, physicians commonly failed to diagnose patients with skin of color with the correct etiology. Such a discrepancy between diagnosis and treatment will ultimately lead to lower survival rates, as shown by the five-year survival rate in the US for Black patients being 66% whereas for non-Hispanic White patients, it was 90%.

Overall, the insufficient training of healthcare providers on skin conditions affecting melanin-rich individuals perpetuates racial and ethnic disparities in healthcare. Patients with melanin-rich skin may face language or financial barriers, and the shortcomings of healthcare providers in such cases can lead to the distrust of said healthcare providers.

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WHAT CAN BE DONE ABOUT THIS?

Research is absolutely vital in the development of dermatology treatments, yet, as I've explored earlier, there has been a historical lack of diversity in clinical trials, and so, seeking out patients of a variety of skin tones and representing them in clinical trials is necessary. This will enable the dispensing of proper dermatology treatments, thus significantly improving patient satisfaction. Accurate severity assessments can also be made as a result of diverse clinical trials, allowing patients to access the right treatment.

In regard to medical curricula, more research with diverse clinical trials can help expand medical training by including more images and case studies of people with skin of colour. Using these resources, medical institutions should allocate more time towards teaching students about dermatological conditions on the variety of FST Types.

Dermatology's unique nature of identifying diseases by observing visible features means that AI, which is especially helpful in image recognition, can be used to diagnose diseases with a greater level of accuracy and efficiency than before. With larger datasets provided by diverse clinical trials and research, the risk of misdiagnosis can be decreased. However, this must be carried out with caution, as AI systems trained on biased datasets can, of course, perpetuate the aforementioned disparities if not developed carefully.

Cultural factors play a role in the awareness, knowledge, and/or susceptibility to certain dermatological conditions. For example, some communities use henna, black hair dyes, or traditional home remedies that may cause skin reactions. Furthermore, many people with darker skin do not receive enough or clear guidance on the importance of sun protection, perhaps due to common misconceptions about melanin and its overestimated ability to protect the body from UVR. Hence, raising awareness on the importance of taking care of your skin and disputing misconceptions is necessary too.

CONCLUSION

Significant disparities in the diagnosis and treatment of dermatological conditions persist to this day because medical education and research have historically underrepresented people with skin of colour. Addressing these inequities requires more diverse clinical trials, improved dermatology curricula that represent all skin types, greater public awareness, and the responsible use of artificial intelligence to enhance diagnostic accuracy. By prioritising inclusivity in both research and healthcare, we can reduce misdiagnoses, improve patient outcomes, and create a more equitable dermatological care system for all.

THE WATCHLIST

Media pieces you might be interested in if you enjoyed "On The Margin"

HIDDEN FIGURES – THEODORE MELFI

Hidden figures is a movie telling the true story of three African-American women, Katherine Johnson, Mary Jackson and Dorothy Vaughan, who work at NASA as mathematicians, and their essential part in John Glen's launch while dealing with racial and gender discrimination. It is both an heartwrenching and inspiring movie, with a fantastic storyline and even better representation of the science community in the 1960's.

THE IMITATION GAME – MORTEN TYLDUM

The Imitation Game is a biographical movie narrating the life and genius of Alan Turing – and his mission to crack the Nazi's Enigma code, while developing the bases of cryptoanalysis and computer science. The movie makes an extraordinary work in showing the parallel between Turing's work and his ultimate downfall as his homosexuality is revealed in a 1940's highly conservative Britain.

PODCAST – QUEER SCIENCE!

A podcast exploring the intersection of science, society, and queerness. Intertwining personal interviews and audio storytelling, this podcast aims to challenge the current discourse of diversity in STEM to empower marginalized voices and think critically about the ways in which science is done. We highly recommend it for fantastic speakers and a critical overview of several scientific topics!

FURTHER READING AND BIBLIOGRAPHY

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THE EXECUTIVE TEAM

TERESA PAN

RITISHA AGARWAL

MARIA MATIAS

PRISHA GOSWAMI

YUVANSH JAIN

LEO VAN JAARSVELD

XINYUE YING

SPRIHA PRADEEP

ANISH ALAPATI

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