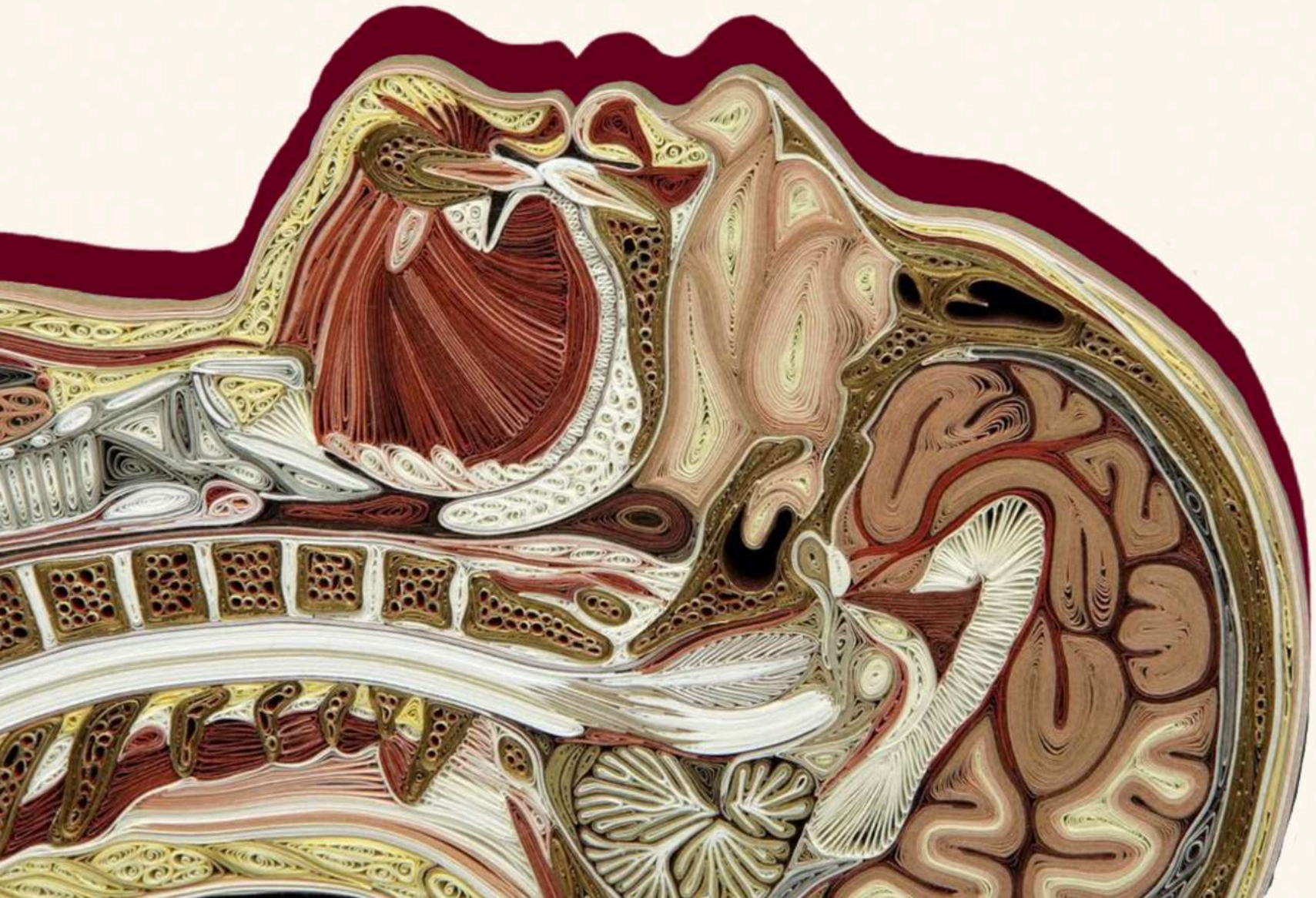
GIRLS IN STEM

SEPTEMBER 2025

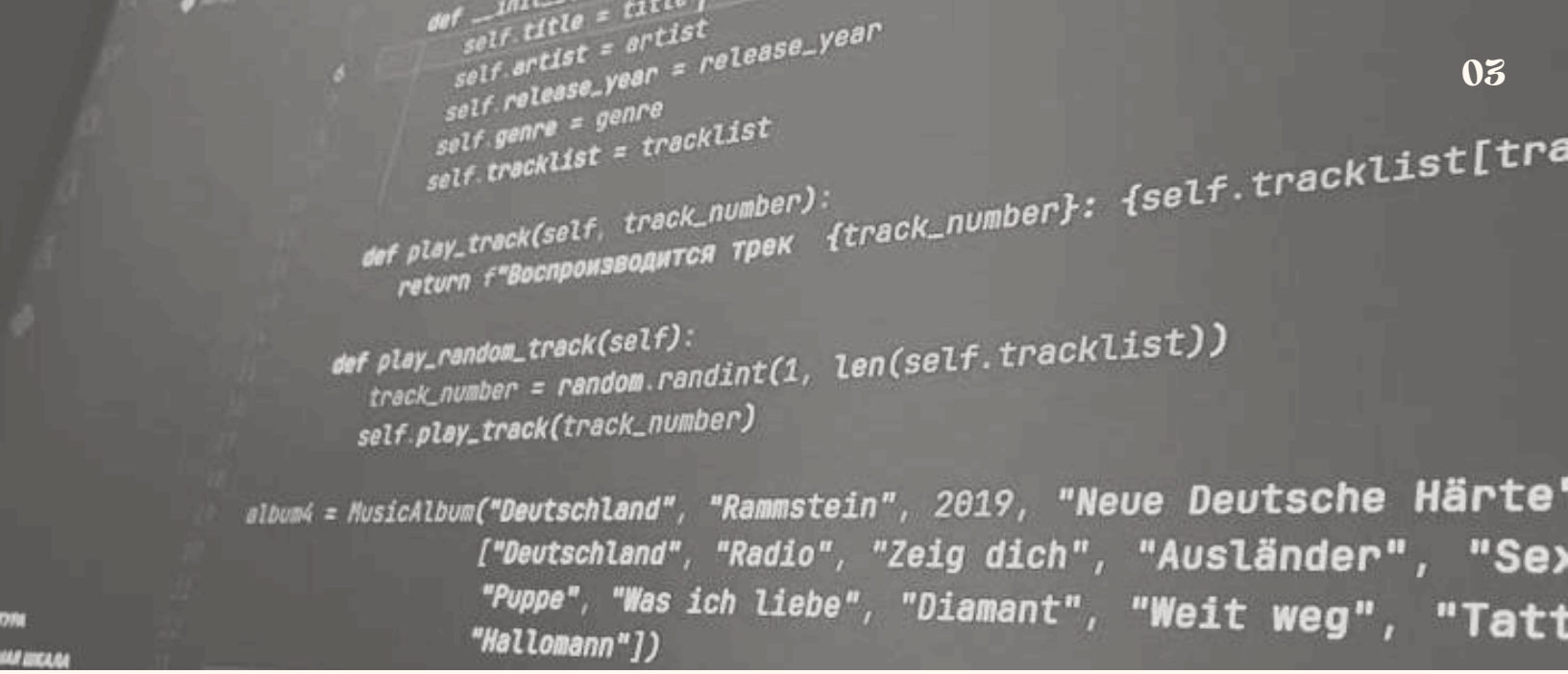
THE MAGAZINE



Celebrate our first year with this special edition!

TABLE OF CONTENTS

TABLE OF CONTENTS



ABOUT US

Launched in September 2024, Girls in STEM is a passion project born from a moment of self-reflection, a time when I felt torn between the path I had chosen in university and the realization that I was drawn to the world of STEM which had never been presented to me in the right way. I wanted to do something meaningful, but I didn't see how I could make that transition. That's when the idea for this magazine took shape: a place where young girls, who may feel the same way, can find motivation, inspiration and role models to encourage them to pursue STEM with confidence and passion. Through stories of real women in STEM fields, insightful interviews and informative content, this magazine is dedicated to sparking curiosity, breaking down barriers and inspiring future innovators. With every issue, we hope to bring a little more confidence, a little more curiosity and a whole lot of inspiration to the next generation of girls in STEM.

LETTER FROM THE EDITOR

Dear Readers,

September has arrived, bringing with it new beginnings, school starting up again, fresh career paths unfolding, and of course a brand-new season (my favorite, if you ask me). This issue also marks a milestone: it's the longest one we've ever created, and fittingly so, since it's our anniversary issue. Four issues, four seasons, and a full year of *Girls in STEM Magazine*. What an incredible journey it has been, one filled with opportunities, fascinating stories, and truly inspiring people.

STEM is all about growth, curiosity, and change, just like fall itself. In this issue, you'll find explorations of the human body and mind, from the science of genetics and neuroscience to the resilience of the brain and the psychology behind how we see ourselves. You'll journey out into the cosmos, where we explore new worlds, the mysteries of space exploration, and even the puzzles of quantum physics. And you'll encounter thought-provoking discussions about representation, PCOS, cinema, and the ways science continues to shape culture and society. Each contribution reflects the passion and dedication of our staff writers and contributors, who worked hard to bring these stories to life and I also want to extend my thanks to our editors, writers and creative team.

And don't forget to check out the incredible people we had the honor of interviewing and the beautiful art featured throughout this issue, both reminding us that STEM is not just about data and discoveries, but also about creativity, storytelling, and human connection.

So, grab a cup of tea, settle into your favorite cozy spot, and enjoy the pages ahead :)

Arianna

LETTERS FROM THE CO-EDITORS

Dear Readers,

It is no secret that, in this day and age, the pursuit of STEM knowledge is not a neutral act, but rather a radical declaration of belief in a world built on evidence, reason and, most importantly, shared progress. Overall, it is a commitment to complexity over simplistic dogma, to universal truths over nationalist fictions and to building bridges over building walls.

That is the main reason I joined this wondeful project — because this magazine is all about throwing the doors of STEM wide open and inviting everyone to the party.

It is well-known in science that the wildest, most wonderful innovations happen when people with different perspectives, passions and stories come together. When we mix disciplines, cultures, and experiences, we don't just get incremental steps — we get giant leaps, we get solutions which are smarter, kinder and more creative because they are built for all and everyone of us.

Both the lab and the classrooms are open, the welcome mat is out, and the future is waiting.

Let's go make it together.

Yaiza Fernández García
Co-Editor

Dear Readers,

As one of the co-editors of this issue, I've been struck by the incredible range of voices and ideas that came together to make it happen. What excites me most is how this edition shows that science is never one-dimensional — it's about people, stories, and creativity as much as it is about experiments and discoveries.

I was especially inspired by the articles that highlight the human side of STEM, from exploring representation and visibility, to looking back at how conditions like PCOS have been understood and managed through history. These remind us that science is about improving lives and making sure every voice is heard.

At the same time, I loved seeing how science reaches beyond the lab — into art, film, culture, and even storytelling about the stars. For me, it's a reminder that STEM doesn't stand apart from the world, but is deeply connected to it.

I hope that, as you read this issue, you'll not only learn something new but also see yourself reflected in these pages. Because at the heart of it all, science is for everyone — and that's what makes it so powerful.

Enjoy Reading !

Nethaya B
Co-Editor

ARTICLES

SECTION ONE

How Science is the Key to Unlocking the Secrets of the Human Genome

In recent years, the field of genomics has made tremendous steps towards unlocking more information into the human genome. With advancements in sequencing technologies and bioinformatics, we now have a clearer understanding of the human genome, the complete set of genetic instructions that make us who we are.

The human genome contains over 3 billion DNA base pairs that consists of the genetic blueprint for creating and maintaining the human body. The human genome project was completed in 2003 and was an incredible achievement in mapping out the entire human genome for the first time. Since then, improvements in DNA sequencing technologies have made it possible to sequence individual genomes more quickly, cheaply, and accurately than ever before. Today, genomic sequencing is more accessible than ever, with individuals gaining an insight through companies offering DNA kits and testing.

The impact it has had in medicine is fundamental, as understanding a patient's genetic makeup can help doctors predict how they will respond to certain drugs, identify potential side effects, and create more effective treatment plans. For instance, pharmacogenomics, the study of how genes affect a person's response to drugs, is enabling healthcare providers to prescribe medications that are more likely to be effective based on an individual's genetic variations. Beyond treatment, genomics is also helping with the prevention of diseases. By identifying genetic mutations that predispose individuals to certain conditions, scientists can pinpoint those at higher risk for diseases such as cancer, heart disease, and diabetes.

As our understanding of the human genome continues to evolve, so will its applications. The integration of genomics into everyday healthcare, personalized treatments, and preventive medicine is expected to grow exponentially. It also may play a role in AI and machine learning and the analysis of vast amounts of genetic data is becoming faster and more accurate, enabling researchers to unlock even more secrets hidden within our DNA.

ALYSSA CHITOLIE

Harlequin Ichthyosis

Harlequin ichthyosis (HI) is an exceptionally rare and severe genetic skin disorder that presents unique challenges for affected individuals and their families. This condition is characterized by distinct physical features and significant medical complications, primarily due to mutations in the ABCA12 gene.

Genetic Basis of Harlequin Ichthyosis

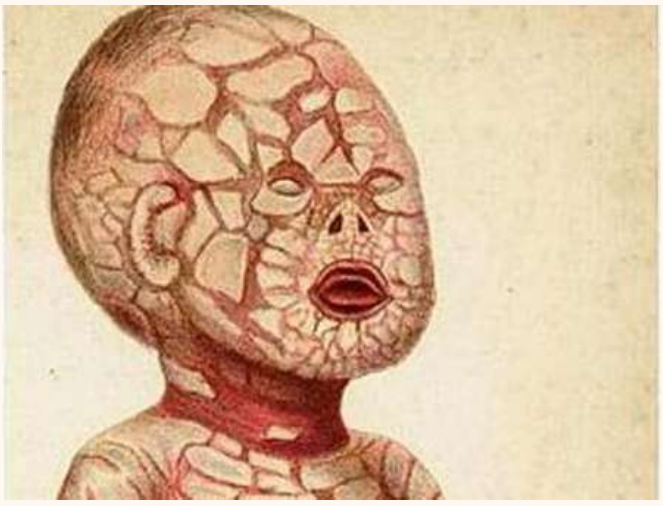
Harlequin ichthyosis is primarily caused by mutations in the ABCA12 gene, which plays a crucial role in lipid transport and the formation of the skin barrier. This gene encodes a protein involved in transporting lipids necessary for producing long-chain ceramides, essential components of the skin's protective barrier. Mutations in ABCA12 disrupt this process, leading to the characteristic thick, scaly skin seen in affected individuals. The inheritance pattern of HI is autosomal recessive, meaning that an individual must inherit two copies of the mutated gene (one from each parent) to manifest the disorder. The incidence of harlequin ichthyosis is estimated to be about 1 in 300,000 births, making it one of the rarest forms of ichthyosis.

Clinical Features and Symptoms

Infants born with harlequin ichthyosis exhibit striking clinical features immediately at birth, these features include:

- Thickened Skin: the most noticeable characteristic is the presence of thick, diamond-shaped scales covering most of the body. These scales are often rigid and can restrict movement.
- Facial Distortions: affected infants may have severe facial deformities, including ectropion (outward turning of the eyelids), eclabium (everted lips), and deformities of the ears and nose.
- Deep Cracks and Fissures: the skin often has deep fissures that can extend into the dermis, leading to increased susceptibility to infections.
- Respiratory and Feeding Difficulties: the tightness of the skin can impair respiratory function and make feeding challenging, contributing to a high mortality rate in neonates.

Due to these severe symptoms, infants with HI face numerous complications, including dehydration, temperature dysregulation, and increased risk of infections. Historically, HI was considered universally fatal; however, advances in medical care have led to reports of prolonged survival in some cases.



Diagnosis
Diagnosis of harlequin ichthyosis typically occurs at birth based on clinical observation of its distinctive features. Further confirmation can be achieved through genetic testing to identify mutations in the ABCA12 gene. Additional diagnostic tools may include:

- Light Microscopy: this technique can reveal structural abnormalities in skin samples
- Histopathological Examination: analyzing skin biopsies can help assess keratinization patterns.

Prompt diagnosis is crucial for initiating supportive care and monitoring for potential complications.

Treatment Options
Currently, there is no cure for harlequin ichthyosis; however, management strategies focus on alleviating symptoms and preventing complications. Treatment plans may include:

- Supportive Care: this includes maintaining hydration, managing infections promptly, and providing nutritional support through specialized feeding techniques.
- Topical Treatments: emollients and keratolytic agents may be used to help manage skin dryness and scaling.
- Systemic Retinoids: medications such as acitretin have shown promise in some cases by promoting skin cell turnover and reducing scaling.
- Innovative Therapies: ongoing research into targeted therapies holds potential for future treatment options. For instance, trials involving biologics like ustekinumab have been explored but require further investigation to establish efficacy specifically for HI.

Despite these interventions, many infants with HI face significant health challenges during their early months. The mortality rate remains high due to complications related to respiratory distress and infections.

Psycho-social Impact
The diagnosis of harlequin ichthyosis carries profound implications not only for affected individuals but also for their families. The visible nature of the condition can lead to social stigma and emotional distress. Families often experience anxiety related to caregiving challenges and concerns about their child's future quality of life.

Support groups and counseling can play a vital role in helping families cope with these challenges. Connecting with other families facing similar situations can provide emotional support and practical advice on managing care.

Moreover, as medical advancements continue to evolve, there is hope that future therapies will improve outcomes for individuals with harlequin ichthyosis. Increased awareness among healthcare providers about this condition can lead to better management strategies and improved quality of life for patients.

Conclusion
Harlequin ichthyosis remains a complex

genetic disorder that poses significant challenges for those affected. While it is a rare condition with severe implications at birth, advancements in medical care have begun to change the narrative surrounding HI. Understanding its genetic basis, clinical features, treatment options, and psychosocial impacts is crucial for improving outcomes for affected individuals.

As research progresses into new therapies and management strategies, there is hope that individuals with harlequin ichthyosis will experience enhanced quality of life and better health outcomes in the future. Continued collaboration among researchers, healthcare providers, and patient advocacy groups will be essential in driving progress forward.

TEESTA ROYCHOUDHURY

References available on request

What are some of the management strategies for patients with PCOS and how have the symptoms of PCOS been treated in Britain since the Medieval period?

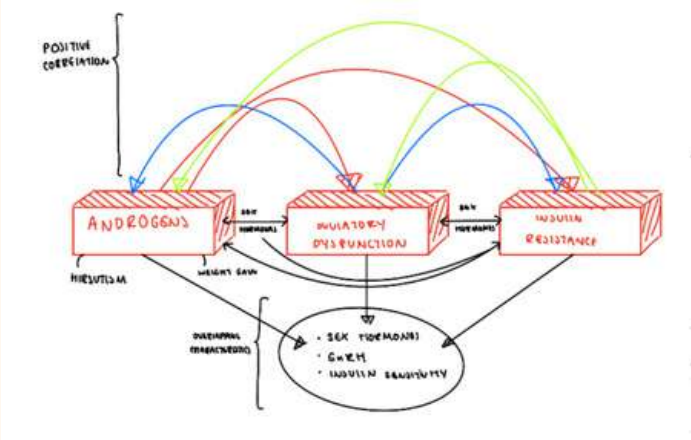
PCOS - an overview

Polycystic Ovarian Syndrome (PCOS), a chronic heterogeneous endocrine disorder presenting at reproductive age, is a broad metabolic and hormonal disorder characterised (but not necessitated by) polycystic ovaries (PCO), irregular menstruation, and imbalances in hormones (eg. Androgen derivatives, Gonadotropins, sex hormones) that affects 1/8 of women of a reproductive age in Britain.

Notably, PCOS has no definitive causes and is considered to be the result of numerous predispositions to and interactions between irregular metabolic and endocrine activities. Hence, symptoms of PCOS can be separated into biochemical, and their subsequent physical, manifestations. Despite the variety in expressions of the broad disorder, there is a constancy in presentations of hyperandrogegism, evidence of insulin resistance, and ovulatory dysfunction.

A Hormonal House of Cards - the principal biochemistry of PCOS and associated symptoms

In brief overview, research has been unable to conclude whether or not the polycystic characteristic is the precursor to hormonal irregularity or vice versa. Importantly, the mechanisms involved do not follow a linear model, wherein x causes y, but adhere to a cyclical model, where the mechanisms are interconnected and neither is independent from change in an other. To preface, each factor is exacerbated by the other rather than adhering to an idyllic causal linkage. This model will be referred to throughout and the biochemical processes involved are key to understanding the management strategies in discussion.



An increase in Androgens, the category of steroid hormones responsible for the development of primary and secondary male sex characteristics, inclusive of its derivatives: Testosterone, Androstenedione, Dehydroepiandrosterone (DHEA), Dihydrotestosterone (DHT), etc..., results in an increase in Androgen binding to Androgen Receptors (AR). Conformational changes to the AR result in their nuclear translocation, followed by secondary binding to Androgen Response Elements (ARE) within the DNA

sequence of promoter regions belonging to target genes. The various testoids act upon different tissues, with a less potent androgen like testosterone involved within muscular and skeletal development, as opposed to its progenitor, DHT, which plays a much more active role in the development of reproductive organs. Hence, the net elevation of androgens largely contributes to distinctive hirsutism, a key symptom of PCOS, wherein individuals exhibit excess body hair, acne, weight gain, and is a minor constituent condition of the wider, compound, disorder.

The polycystic characteristic of the ovaries is caused by disruption to ovulatory and menstrual processes. Irregular follicular development, typically reducing the release of eggs, causes the follicles to swell and appear enlarged on pelvic ultrasounds with a cyst like appearance. This, alongside insulin resistance and general ovarian dysfunction is thought to be (rather enigmatically) responsible for disruption to Gonadotropin-Releasing Hormone (GnRH) Pulsatility, which in turn triggers the release of (primarily) Luteinising Hormone (LH). Additionally, high androgen levels exacerbate LH hypersecretion by desensitising the hypothalamus to oestrogen and progesterone via converting to estradiols that occupy oestrogen receptor sites and therefore prevent the accuracy of the hormonal negative feedback loop of the hypothalamic-pituitary- gondal axis.

Resultantly, a host of conditions, such as anovulation, dysmenorrhea, oligomenorrhoea, etc. can develop as symptoms of the underlying PCOS, with the nuance of the substituent conditions dictated by the precedency of the topical biochemical factors that usually manifest as painful and irregular (ie. deviating from the individual's own baseline) menstruation. Ovarian cysts additionally incite an imbalance of female sex hormones as a result of the ineffectivity of LH in the ovulation process. Here, the complexity of the biochemical network is most highly visible. Cysts, which arise spontaneously, potentially in response to high levels of androgen, or potentially insufficient levels of LH, further catalyse hormonal catastrophe that has a cumulative and holistic effect on the individual.

Most commonly, this hormonal domino effect caused by polycystic ovaries is a disruption of the sex hormones. The absence of, and irregular, menstruation is chemically profiled via normal levels of FSH and oestrogen, then, respectively, high levels of LH and low levels of progesterone. It is crucial to recognise that these mechanisms are not alien to each other, and do not, in fact, occur in vacuums. The excess of oestrogen relative to its inhibitor, combined with the aforementioned excess of its progenitor hormone, the androgen testosterone, inhibits the sex hormone binding globule released into the blood and reduces the transcription of DNA responsible for sex hormone binding globule synthesis. Therefore, androgen levels are caused to increase even further.

Secondarily, this androgen can be aromatised (the integration of an aromatic ring into the chemical) to produce oestrogens in peripheral tissues, delocalised from the reproductive organs, promoting fat storage associated with female secondary sex characteristics, namely, in situ around the abdomen, hips, etc... An elevated stimulation of stubborn fat retention reduces the efficacy of insulin, as Beta cells will secrete greater amounts of insulin in order to maintain a normal blood-glucose concentration, that, at a prolonged period of effect, will amount to insulin resistance. Intuitively, this aligns with the development of type 2 diabetes, prompting further reference and understanding to the vast interplay of the

metabolic and endocrine pathways, especially considering that insulin resistance cyclically leads to raised androgen levels.

Hyperinsulimia, the compensatory overproduction of insulin, results in insulin binding to ovarian theca cells, directly stimulating androgen synthesis, as well as even more inhibition of the sex hormome binding globule that raises the bioavailability of circulating androgens. Hyperinsulimia can even indirectly positively affect steroigenesis via stimulating the adrenal glands, which will produce androgens in response.

In brief summary of the principal chemistry dictating PCOS, there is a nebulous biological multiplier effect established between hyperandrogenism, insulin resistance, and hormonal imbalances (engaging the negative feedback looping of sex hormones, and, indirectly, the thyroid and adrenal glands- posing their own ramifications for blood pressure, blood cholesterol, etc..., with the concentration of symptoms varying massively between individuals).

At the severe end of the cumulative effects proposed by PCOS, the concoction of insulin resistance, abdominal obesity, and raised blood cholesterol/pressure can be diagnosed as Metabolic X Syndrome, known to increase an individual's proclivity to stroke, cardiovascular disease, and type 2 diabetes. Furthermore, unopposed oestrogen in the uterine environment can cause unmitigated growth of the endometrium, developing endometrial cancers.

A Diagnostic Overview

Diagnosis of PCOS is suitably considered in an adult female given that they satisfy two of the following: ovulatory dysfunction, clinical and/or biochemical markers of hyperandrogenism, and polycystic ovarian morphology on ultrasound. In the case of adolescents, both hyperandrogenism and irregular menstruation must be present for a minimum of eight months to escalate to diagnosis. The diagnostic process for PCOS is less relevant to the discussion and presentation of its management than the biochemistry responsible for its symptoms, hence further concise. A plethora of tests assess individual factors that, in verse with each other, can support a case made for the diagnosis of PCOS. Inexhaustively, these include testing HbA1c, levels of FSH and LH, Sex hormone binding globule, testosterone, estradiols, prolactin, thyroxine, and a pelvic ultrasound to confirm polycystic morphology, defined as 20 or more cystic follicles. Confirmations made by these tests affirm, at least partially, components of the above biochemistry and physiological characteristic of PCOS.

Management - Modern from Medieval

Vitally, we must recognise the novelty of PCOS as a formalised condition, meaning that rather than there being observable definitive managements for PCOS, we can instead dissect the conservative management of speculative symptoms from the medieval era onwards. This immediately rules out management on a definite biochemical level due to a lack of understanding surrounding metabolic reaction pathways and the endocrine system. Additionally, the sociological background of medicine must be considered to contextualise managements, or lack thereof.

Absence of separation of Church and state meant that physicians, often educated through the Christian (catholic) religious system, operated under a biased and unscientific ethos, governed absolutely by a patriarchal god as opposed to empirical research. Both the shorter life expectancy and

apparent medical misogyny that prevails in UK medicine today, post legislative action, point to a neglect of the treatment of symptoms of PCOS.

Kempe extensively exposes the neglect to female reproductive health and education in detailing her accounts at late menstruation, perhaps an indication of some hormonal disorder aligning with a modern understanding of PCOS. As a mystic of the Medieval era, she critically explores sexual and reproductive health that supervising monks consistently shamed and deemed taboo, recording that her academic background allowed her to access the works of Saint Leoba, providing her resource to reconsider the stigmatised changes and development of her own body as a spiritual enlightenment as opposed to corruption, the likes of which the archetypal characters of Eve and Mary lend themselves to. Crucially, this retrospectively feminist opinion of female anatomy and health paves the way for women's health to be given the consideration that it has ultimately been deprived of for centuries both prior and to come. Notably, medieval physicians remained subscribed to Humoral Theory, believing that menstruation and its associated disorders were dyscrasia of the melancholic and phlegmatic elements, treated via the archaic blood letting, underscored by deeply Christian sentiments that demonised the female. Kempe's work is thus proof that excoriation for the medically misogynist attitudes existed, thus, by virtue, desire for management that did not seek to purify the body and rid it of some innate and shameful quality, a progenitive desire for the birth of anatomical rooted medicine.

Christian ideology propagating the demonisation of the female (especially if expressing traits that retrospectively adhere to symptoms of PCOS and related conditions) permeates English culture and media henceforth, whether that be in the virtuous stained glass renditions of the hairless and slender Virgin Mary, or the condemnation of the androgynous in King James' Book of Daemonologie, and Shakespeare's damned portrayal of the hirtuistic Weïrd Sisters, blending a religion catalysed misogyny with blatant ignorance, causing the suppression of sufficient documentation and research into these speculative symptoms.

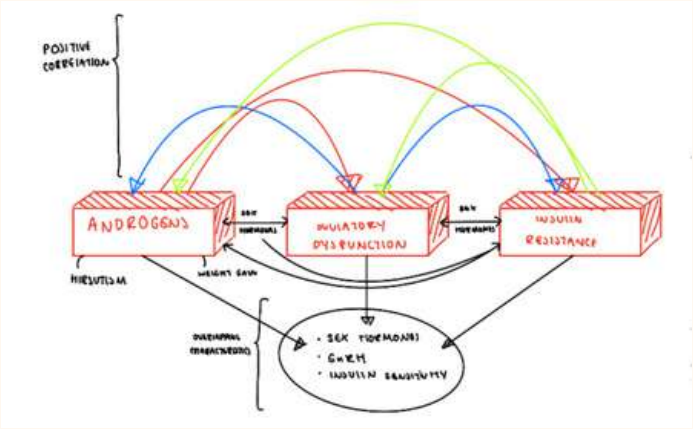
Conditions concerning the reproductive organs, such as menstrual irregularity characteristic of PCOS, then, are managed via various charms, usually aphrodisiacs, believed to have warming properties to rebalance the uterine humours, managing the most obvious symptom linked to PCOS, this being irregular menstruation. This historic conflation of sexual activity to reproductive health is confirmed by media such as Carmilla, wherein allegories for temptation (that are remedied by protective charms) manifest as painful bodily changes evocative of hormonal imbalance and symptoms of PCOS, alluding to the same stigma as Kempe, centuries later.

With the 19th century seeing to the decline of the humoral model and rise of anatomical explanations of disease and disorder and the first official records of ovarian cysts being documented. (Chereau) Followed by polycystic ovaries. (Lesnoy-1928). Followed by the initial proposals of a condition linking enlargement of the ovaries, hyperandrogenism, and menstrual disturbance, dubbed 'Stein-Leventhal Syndrome' that further research developed into PCOS as we know it today by the mid 20th century. Early identification of symptoms of irregular menstruation lead to the use of oral progesterone tablets and clomiphemene citrates in order to counteract anovulatory infertility.

Modern medical understandings of PCOS recognise the immense interconnection of metabolic and endocrine mechanisms that result in a differentiation of symptoms among individuals with PCOS, due to which no treatment can holistically cure the condition, classed as chronic and lifelong. Precisely, the levels of such a vast number of hormones cannot be accurately controlled by a singular management. Rather, a host of pharmacological and lifestyle strategies can be employed to propose a composite and personal management for the treatment of the individual; presently, treatment is centred around the conservative management of individual symptoms.

The most generic and widely applicable management of PCOS is lifestyle change, constituting primarily of exercise and diet change contributing to weight loss. This targets physical symptoms of weight gain and, in doing so, promotes insulin sensitivity as it removes visceral fat responsible for poor insulin signalling. Hence, constituent conditions like type 2 diabetes, increased risk of cardiovascular disease, along with symptoms of insulin resistance and weight gain, are actively managed via holistic lifestyle management, whether that takes on the form of increased cardiovascular exercise, avoiding foods that are high in cholesterol, or a broader incorporation of the two.

Likewise, the breakdown of these fats could deter the accumulation of androgens and peripheral oestrogen, essentially preventing the propagation of the cyclical model proposed in the following figure. Then, dependent on what exactly comprises the hormonal imbalances of the individual, a range of pharmacological treatment options are available, excluding treatment targeting secondary systems, such as adrenal and thyroid glandular secretory processes. The



main being the following:

- Metformin - a biguanide drug that improves insulin sensitivity, it is used to treat symptoms of infertility, insulin resistance, and weight gain, and it's probably the most generally prescribed medication for individuals with PCOS. Dosages of Metformin, however, vary on the assessed severity of insulin resistance. Then, indirectly, in aiding in the reduction of visceral fats, the speed of endocrine signalling for sex hormones increases, which can result in a correction of ovulatory processes, inciting a regular and more healthy menstrual cycle.
- ACE inhibitors - angiotensin-converting enzyme inhibitors, they are a class of drugs that inhibit enzymes responsible for vasoconstriction, hence lowering blood pressure and treatment symptoms of PCOS associated with greater risk of cardiovascular disease. Furthermore, ACE inhibitors such as lisinopril directly inhibit the renin-angiotensin system responsible for production of androgens in the ovaries, reducing the presentations of symptoms of hirsutism and androgyny.

Oral prescriptions of sex hormones, often encompassed by birth control, are prescribed to be taken at specific intervals during a menstrual cycle in order to emulate the hormonal conditions of a typical cycle. In doing so, a healthy hormonal circumstance is jumpstarted, so to speak, which can disrupt

the established cycle of metabolic and endocrine decline in the hopes that these systems, aided by the external hormonal supplementation, will balance themselves. Therefore, in this hormonally corrective approach, by providing the body with sufficient proportions of sex hormones, symptoms of irregular menstruation, followed symptoms of androgyny, followed by symptoms of PCOS caused insulin resistance and weight gain, are reduced.

In conclusion, the most general and accessible managements for PCOS involve reducing the excess androgens in circulation, that appear to act as a central fulcrum for the dysfunction of a host of additional metabolic pathways and hormones; the core being the sex hormones, and, secondarily, secretions of the adrenal and thyroid glands. In the regulation of these hormones, not only is healthy metabolic and menstrual process promoted, but an attempt is made at reducing the impact of symptoms on the quality of life of the individual and expression of symptoms. Despite this, the lack of research into a causal or inciting mechanism for PCOS indicates that, presently, management is restricted to reparative and protective as opposed to preventative action. Likewise, current management, with particular regard to a pharmacological approach, is centric to studies on adult Caucasian women, reflective of medical social progress in, yes, lending more attention to female healthcare, that would benefit from a more intersectional approach, integrating Britain's diversity into the progression of its medical developments. Lastly, the pharmacological management of PCOS, whilst potentially mitigating some symptoms, present with their own extensive complications and risks. Therefore, pharmaceutical research into the efficacy to toxicity of these management drugs draws itself to the forefront of the future of PCOS management.

YUSUF SYED

References available on request

A Brief History of Phlebotomy

Illustration of the four humours

In 4th/5th century BC, the ancient Greek Physician Hippocrates established the concept of the four humours: blood, phlegm, yellow bile and black bile. The theory stated that the body contained each of these four fluids: imbalance of these being the cause of illness. Each 'humour' was connected to a season: blood with Spring, yellow bile with Summer, black bile with Autumn and phlegm with Winter. Hippocrates and his peers believed that the humours would be most affected during their corresponding seasons, e.g. an excess of blood during Spring is what was believed to have led to fevers, so a physician would treat fevers by 'bleeding' the patient. It was this practice of 'bloodletting' which lay the foundation for modern blood tests.

Bloodletting was a procedure in which doctors would withdraw blood from a patient to prevent or cure illness. Until the end of the 1800s, this was the most common medical practice performed by physicians. This idea of "bleeding" a patient to restore their health was modelled on menstruation. Hippocrates himself believed menstruation to be women's "purge of bad humours".

A barber surgeon performing bloodletting

Galen, a 2nd century CE Greek physician, promoted and contributed to the system of bloodletting. His ideas claimed that blood didn't circulate and instead 'stagnated' when in excess. He also claimed that blood was the dominant humour in most need of moderation. He corresponded certain blood vessels to certain organs; withdrawing blood from the vessels that corresponded with the organs the illness was coming from. The more severe the condition, the more blood would be taken.

Several different methods were employed for

bloodletting, some of which were gruesome and unpleasant. Additionally, these procedures were performed by mostly barber surgeons, which led to the traditional red and white striped barbershop pole, the red representing blood and the white representing bandages. Often with a syringe or a double-sided scalpel, superficial blood vessels were punctured, and the pouring blood would be collected in a bowl. Some physicians also used leeches (during the early 1800s, hundreds of millions of leeches were imported throughout Europe for this purpose), or scarificators, machines with spring-loaded mechanisms that snap blades out into the skin in a circular motion. Sheesh! Bloodletting sessions rarely ended until patients began swooning or fainted.

During the 1600s-1900s, bloodletting was used to treat almost every ill condition, including:

- Acne
- Heartbreak (Jacques Ferrard, a well-known French physician, recommended bloodletting to the point of heart failure to cure a broken heart)
- Diabetes
- Pneumonia
- Stroke
- Cancer
- Insanity
- Haemorrhaging
- Inflammation prevention before childbirth
- And many more...

Although bloodletting decreased in practice over the 19th century, several physicians still advocated for its usage. Some physicians considered bloodletting helpful for only a limited number of conditions, such as haemorrhaging.

Despite bloodletting being thought to improve immunity, circulation, detoxification and reduce inflammation for several centuries, its harmful impacts became more well known. In addition to being generally ineffective, it often led patients to sepsis, a hematoma or even hypovolemic shock.

In modern Western medicine, bloodletting has been relatively abandoned. However, therapeutic bloodletting is still used for a small number of conditions like sickle cell disease or haemochromatosis.

Phlebotomy, the general process of withdrawing blood, did not lose its popularity, however. Instead, it lay the groundwork for blood tests to arise. A huge shift in the medical world occurred in 1852 when Karl Vierordt published the first method for a blood count, allowing scientists to give a true analysis of blood cells. This paved the way for modern day's blood testing. A rapid evolution in medical technology soon followed. In the late 19th century, physicians were able to analyse patients' blood smears for certain abnormalities.

In present day, phlebotomists remove patients' blood specimens to send in sterile sample tubes to clinical laboratories. Laboratory tests examine all properties of the cells and molecules that compose a blood specimen. Initially, samples are centrifuged to separate solid, liquid and solute components. Scientists will measure levels of plasma to determine levels of certain substances within the body such as glucose concentration or blood sugar.

If a doctor suspects a specific infection within a patient, they will contact the laboratory to test for specific substances or pathogens. Scientists will incubate the samples to then screen for organisms that grow and resemble the pathogens of interest. Additional testing may be conducted to identify the microbe.

Once identified, the scientists can test a range of antimicrobial agents to inform the doctor what the best course of treatment would be.

Current research is showing that the future of phlebotomy may involve at-home or robotic blood collection devices, analysis conducted by artificial intelligence, and specialised tests for more complex conditions like cancer or Alzheimer's.

Colour coded blood test vials

ATHENE BROWN

Neuroplasticity

Your brain can rewire itself. Here's how to use that to your advantage

For years, our brains were thought to be fixed, god given and incapable of change, the way you think is innate and hardwired into each individual. But research over the past few decades has overturned this notion, revealing the brain's remarkable ability to reorganize itself, an ability known as neuroplasticity. This capacity enables the brain to form new neural connections, adapt to new experiences, recover from injury, and even compensate for lost functions. Understanding neuroplasticity not only changes how we think about the brain, it empowers us to reshape our behaviors, improve mental health, and enhance cognitive performance.

Neuroplasticity, Ruby Hall Clinic

Neuroplasticity is a term we often hear, but what does it actually mean? Have you ever wondered why you have a different point of view than when you were younger, this is because the brain can change based on your past experiences, learning or injury. It can occur on multiple levels:

- Synaptic plasticity: the strengthening or weakening of synapses (connections between neurons).
- Structural plasticity: the growth of new neurons (neurogenesis) and the remodeling of neural networks.
- Functional plasticity: the brain's ability to shift functions from damaged to undamaged areas.

Neuroplasticity is most robust during childhood, when the brain is developing rapidly. However, it continues throughout life, influenced by lifestyle, environment, and intention. Throughout life we develop schemas, which are a mental framework of information, that allows us to organise everything we learn about based on our past experiences.

Neuroplasticity, Pacific Neuroscience Institute

Your brain is powerful

Neurons communicate through electrical signals, and these connections strengthen with repeated use which is a principle known as Hebbian learning, often summarized as

"cells that fire together, wire together." When you practice a skill or engage in a new behavior, you're essentially reinforcing certain pathways in the brain. Over time, these connections become more efficient, while unused pathways weaken, a process called synaptic pruning.

MRI studies have shown physical changes in the brains of people who learn new skills. A study by Maguire et al. found that London taxi drivers who undergo extensive spatial navigation training ("The Knowledge"), had significantly larger posterior hippocampus than non-taxi drivers. The size correlated with years of experience. This suggests that spatial memory training can physically alter brain structure, highlighting functional neuroplasticity in the hippocampus. Additionally, other studies have found that meditators exhibit thickening in regions associated with attention and emotion regulation and musicians show increased gray matter in areas related to motor control.

So, how does this relate to rewiring our brains in the modern day? Neuroscience has shown that our brains are not fixed from birth. Traits such as intelligence and ability aren't predetermined reserved for a select few. Instead, anyone can strengthen and reshape their brain through consistent effort, learning, and experience. This understanding aligns closely with psychological theories like Carol Dweck's Growth Mindset, which suggests that abilities can be developed through the right mindset and hard work. The science of neuroplasticity gives this theory powerful neurological backing, proving it's more than just a motivational idea, it's a biological reality. Knowing this can be incredibly empowering: it means you're not limited by where you started. You can change, grow, and improve because science says your brain is built to do exactly that.

ALYSSA CHITOLIE

Needles, Yarn, and Neuroplasticity

Knitting, at first glance, can appear to be a simple pastime. Yarn, needles, perhaps a comfortable chair and a quiet moment. Yet beneath the rhythmic movement of stitches, a set of complex psychological and neurological processes is unfolding. This is more than a creative diversion. It is a sustained engagement that supports mental health and may contribute to the preservation of cognitive sharpness across the lifespan.

Neuroscience has transformed our understanding of the adult brain. The long-held belief that neural development was largely fixed after early adulthood has been replaced by compelling evidence for brain plasticity. This refers to the brain's capacity to reorganise itself by forming new neural connections in response to learning, experience, and environmental demands. Engaging in activities that challenge both mind and body can stimulate this process. Knitting offers exactly this combination: it requires concentration, bilateral coordination, fine motor control, and memory. Learning a new stitch or interpreting a complex pattern demands problem-solving and sustained attention, prompting the brain to reinforce and develop neural pathways.

The concept of cognitive reserve provides another lens through which to view the benefits of knitting. Cognitive reserve refers to the brain's resilience to neuropathological damage, often described as a mental "buffer" built over time through education, occupational complexity, and intellectually stimulating leisure activities. Research, including findings from the Rush Memory and Aging Project, suggests that individuals who consistently engage in cognitively demanding activities tend to experience a slower rate of cognitive decline in later life. Knitting is not cognitively static; even highly experienced knitters can increase complexity, work with new materials, or experiment with original designs, continually engaging the mental faculties that contribute to building and maintaining this reserve.

Beyond these structural and functional aspects of brain health lies a more subjective but equally important experience: flow. Defined by psychologist Mihaly Csikszentmihalyi, flow is a state of deep absorption in an activity where time seems to dissolve, and attention is fully anchored in the present task. Knitting is particularly conducive to this state. Its repetitive yet purposeful movements can induce a form of active mindfulness, reducing physiological arousal associated with stress while fostering a sense of mastery and calm. Evidence suggests that regular engagement in flow-inducing activities is associated with enhanced emotional regulation, greater life satisfaction, and improvements in overall wellbeing.

Psychological benefits extend beyond the momentary experience of flow. Knitting provides a clear sense of agency, accomplishment, and tangible progress. These elements are protective factors for mental health, offering stability and predictability in an often-unpredictable world. The finished piece is not only a product

of skill and creativity but a record of sustained effort, with each stitch representing a small but deliberate act toward completion.

There are also psychosocial dimensions worth considering. The sensory qualities of knitting such as the texture of yarn, and the interplay of colours can provide grounding, especially for individuals experiencing anxiety or sensory dysregulation. In social contexts, knitting circles and online crafting communities facilitate connection and belonging, which are themselves linked to better cognitive and emotional outcomes. Social engagement is increasingly recognised in gerontology and mental health research as a factor that can buffer against both depression and cognitive decline, suggesting that knitting's communal aspect may be as significant as its cognitive demands.

For those curious about starting, knitting is remarkably accessible. At the most beginner level all that is required is a set of needles , a ball of yarn, and a little patience. Beginners often start with medium-weight yarn (DK, or Double Knitting, and Aran yarns are popular starting points) and needles of around 4 to 5 millimetres in diameter, as these make it easier to see and handle stitches. The yarn that you purchase will indicate what size needle will work best. The first skills to learn are casting on (starting the stitches), the knit stitch, the purl stitch, and binding off (finishing the work). These form the foundation for more complex patterns, and they can be learned through in-person classes, online tutorials, or guidance from experienced knitters. Early projects might include a simple scarf or dishcloth, where mistakes are less visible and the focus can be on building rhythm and confidence. As skills develop, more intricate techniques such as cabling, lacework, or colourwork can be explored, offering new cognitive challenges and keeping the craft engaging for years to come. If you're feeling really brave, take a look at steeking.

Hobbies are often perceived as optional luxuries, to be indulged in when time permits. However, the evidence points to a more compelling conclusion: such activities may be integral to maintaining long-term brain health and emotional resilience. Knitting stands out for its accessibility, adaptability, and capacity to evolve alongside the individual's skill level. It is a pursuit that can be sustained across decades, quietly shaping neural architecture, preserving cognitive reserve, and fostering psychological balance.

To observe someone knitting, then, is to see more than a person passing time. It is to witness an act of continuous mental engagement, the reinforcement of brain plasticity, and the cultivation of a resilient cognitive reserve. It is also to see a person inhabiting a moment of flow. Fully present, fully absorbed, and, perhaps without conscious intent, investing in their future mental vitality.

SOPHIIA DEFAIA

References available on request

“I’m Not Good Enough”: The Neuroscience Behind Imposter Syndrome

The thought of “not being good enough” is something 8 in 10 millennials think, but why is this thought hardwired into our brains and how can we change it? Imposter syndrome is so common especially among high-achieving girls and women in STEM. But what’s really going on in the brain when these thoughts take over? And more importantly, how do we fight back?

What Is Imposter Syndrome

Imposter Syndrome is not just self-doubt, it has a neurological element known as cognitive distortion, where despite evidence of your competence, your brain refuses to believe it. This distortion activates key brain regions:

- The Prefrontal Cortex (responsible for decision-making and self-evaluation) can become overactive, obsessing over mistakes.
- The Amygdala, which processes fear, lights up more when we’re afraid of judgment or failure.
- The Default Mode Network, active when we’re self-reflecting, can spiral into rumination, reinforcing negative self-talk like “I’m not smart enough”.

Women in STEM Who’ve Felt It Too

Dr. Maya Schuldiner, Molecular Biologist, Weizmann Institute of Science

“*I spent years feeling like I got here by luck… I thought, ”Why would anyone listen to me?*’”

Despite being one of the most cited scientists in her field, Dr. Schuldiner openly talks about battling imposter syndrome, and how building a support system of other women in science helped her silence that inner critic.

Dr. Katie Bouman, Computer Scientist, Key to First Black Hole Image

After leading the algorithm that helped capture the first photo of a black hole, Bouman’s reaction wasn’t pure pride:

“*There were moments I thought, ‘What if they realize I wasn’t the expert they thought I was?*’”

Her story shows how even world-changing scientists can second-guess themselves, especially when they’re the first or only woman in the room.

Michelle Obama, Former First Lady & Lawyer

Even one of the most powerful women in the world has admitted:

“*I still have a little bit of imposter syndrome… It never goes away, that you're actually listening to me?*”

Michelle's vulnerability shows that imposter feelings aren’t a sign of weakness, they’re a common reaction to being underestimated, overlooked, or breaking barriers.

Why Girls and Women in STEM Are More at Risk

Research shows that underrepresented groups in high-performance environments (like STEM) are more likely to experience imposter syndrome. This happens when:

- You don’t see others who look like you in your field.
- You’re afraid of confirming stereotypes.

- You internalize the pressure to “prove” yourself constantly.

This creates a loop of hypervigilance, perfectionism, and fear of failure, all of which exhaust the brain and reduce performance.

Rewiring the Brain: How to Beat Imposter Syndrome

The good news? Just as the brain can learn to doubt, it can also learn to reframe:

1. Name It = Label the thought: “This is imposter syndrome”. This activates the prefrontal cortex and reduces emotional intensity in the amygdala.
2. Shift to Evidence-Based Thinking = Keep a "Wins & Strengths" journal which is a neuroscience-backed tool to reinforce positive memory networks.
3. Practice Self-Compassion = MRI studies show that self-kindness activates calm-and-connect circuits in the brain, improving emotional regulation.
4. Visualize Success = Mental imagery engages the same brain areas as actual experiences. Visualizing confidence helps build neural patterns that support real confidence.
5. Find Your Community = Shared experiences = shared healing. Talking to mentors, joining STEM groups, or even following empowering scientists on social media can rewire how you see yourself in your field.

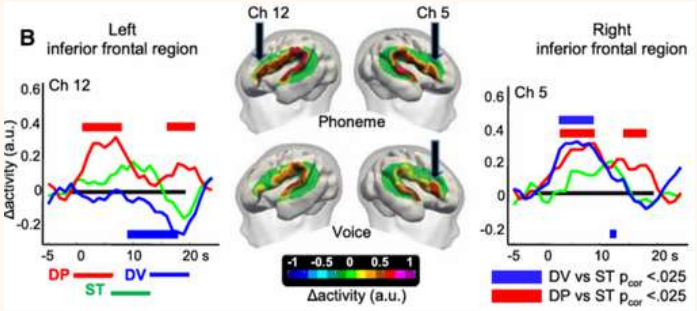
ALYSSA CHITOLIE

The Infant Brain: A Blueprint for Language Acquisition

Have you ever wondered how it is possible that infants are able to master a language perfectly within a couple of years? It is fascinating that no other machine is able to learn a language at such a speed and, most importantly, at a such high level of expertise. Thanks to the advance in non-invasive neuroimaging brain techniques, nowadays, it is possible to study the fascinating neural architecture that allows infants to acquire their native language in only a few months. A study conducted by Ghislaine Dehaene-Lambertz (2017) revealed how infants, even before their exposure to speech, posses neuronal pathways that allow them processing the latter. Using functional magnetic resonance imaging (fMRI) and near-infrared spectroscopy (NIRS), it was possible to observe the functioning of parallel and hierarchical pathways in three-month-old infants and preterm infants at 29 weeks of gestational age (wGA). But where are these pathways located, and what exactly is their role? They are both situated in the perisylvian regions of the cerebral cortex, which are located around the Sylvian fissure. These regions include Broca's area, responsible for speech production, and Wernicke's area, responsible for language comprehension.

The Role of Parallel Pathway

The parallel pathways can be understood as two parallel lines, each on one hemisphere of the brain, more specifically in the left and right inferior frontal gyrus (IFG). Their role is to process different aspects of sound; the LIFG processes changes of phonemes (ba vs ga) while the RIFG focuses on changes of voices (male vs female). What is interesting, emerging from the NIRS analysis, is that, while the RIFG is also able to detect, even if subtly, changes in phonemes, the LIFG focuses exclusively on phonological change (DP) as showed in the figure below. These findings suggest that, an advantage for phoneme discrimination over voice discrimination can be found, in the left hemisphere, which is also the centre of language processing in the brain. Hence, even in preterm neonates, where cerebral formation is not even complete, the brain already posses a neuronal architecture that is able to identify and prefers to differentiate linguistic structures over who is talking.

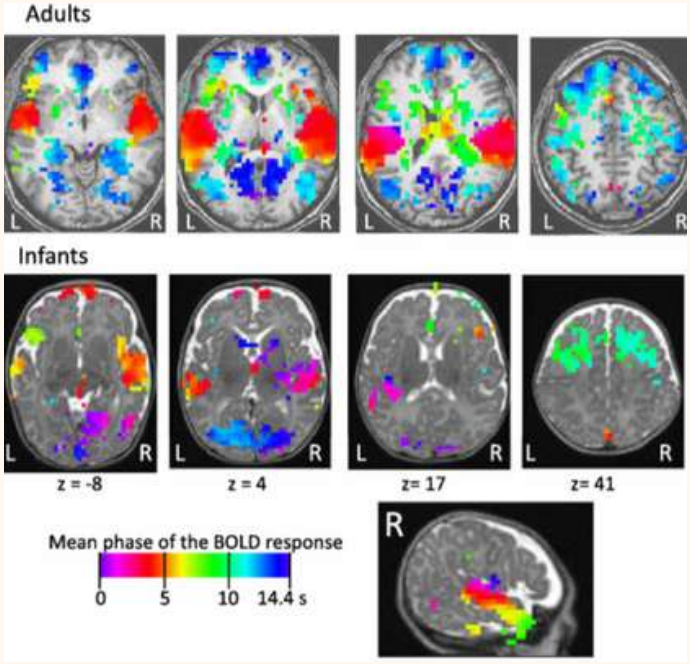


Parallel pathways in preterms. Oxyhemoglobin responses to a change of phoneme (ba vs. ga) and a change of voice (male vs. female) in preterm neonates measured with NIRS in 29wGA-old preterms. DP (deviation of phoneme), DV (deviation of voice)

The Role of Hierarchical Pathway

The hierarchical processing pathway comprehends three main regions in the brain, namely the primary auditory cortex (A1), the superior temporal gyrus (STG) and the inferior

frontal gyrus (IFG). Using fMRI, the hierarchical pathway in three-month-olds could be observed and compared with that in adults. In particular, gradient of activation in BOLD (Blood Oxygenation Level-Dependent) response, showed how sounds are processed across different brain regions moving from simpler to complex processing. As can be seen in the figure, the A1, which is located near the ears, is the first to respond, as shown by the yellow/orange colouring. As processing becomes more complex it moves towards STG and IFG which are shown in different colours (e.g. blue or green). The patterns of the following hierarchical activation in infants are similar to those in adults, suggesting that even infants' brains show a structured organization for processing speech. However, the time interval between these activations is shorter in adults, indicating faster processing due to brain maturation.



Hierarchical organization of the perisylvian regions in 3 month-old infants and adults, illustrated by the gradient of phase of the BOLD response to a single sentence.

Conclusion

The following study enables us to understand how the human brain is wired to acquire a language. Although language acquisition might begin at birth, the reason why infants are so quick at picking up their native language, relies on the fact that already in the womb they possess a well structure neural architecture which enables them to set the stage for efficient language acquisition.

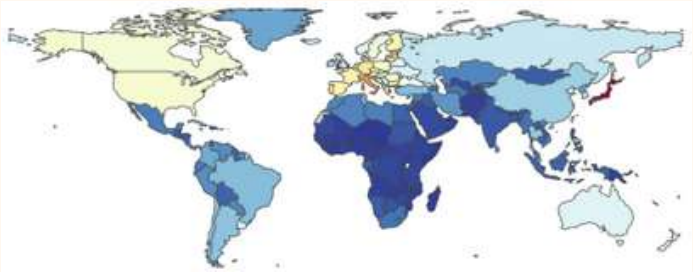
AINHOA RANO

To what extent do differences in saturated fat consumption between North America and Southern Europe influence amyloid-beta protein plaque accumulation in relation to the risk of Alzheimer's disease?

Introduction and background

Within my family, we have felt the impact of Alzheimer's disease (AD) and its toll on individuals as well as communities. When writing this essay, I aim to contribute to the collective understanding of AD, by delving into scientific literature and exploring global disparities in culture in relation to Alzheimer's pathology, to advocate for a greater investment in research whose goal is to alleviate the amount of people suffering with Alzheimer's. By integrating both biology and cultural anthropology, this essay highlights how consumption habits shape biological outcomes and vice versa.

Amyloid-beta (Aβ) is produced through the proteolytic processing of a transmembrane protein found on the neuron, amyloid precursor protein (APP), by β- and γ-secretases. Aβ accumulation in the brain is proposed to be an early toxic event in the pathogenesis of AD, which is the most common form of dementia, and often characterised by extreme forgetfulness. This is because Aβ plaque blocks cell to cell communication between nerves leading to an immune response and neuroinflammation, which can exacerbate neuronal damage and contribute to the progression of the degenerative disease.



Global Burden of Alzheimer's disease and other dementias. Prevalence rates per 100,000 population by country. Red, orange and yellow shades indicate higher prevalence.

This has led to the social and economic burden of millions globally due to AD, becoming increasingly prevalent. Especially in certain regions of the world possibly due to higher life expectancies where neurodegeneration has the time to develop, especially in Southern Europe, for example, Italy, illustrated in this figure. This has led to the development of my research question: "To what extent does cultural variation in consumption of saturated fats impact the formation of amyloid-beta protein plaque?", where I will examine the cause of the aggregation of Aβ protein and possible preventions through dietary changes. This research question is worthwhile of investigation because it aims to offer insights into potential strategies for attenuating AD to reduce the global prevalence and the socioeconomic strain on healthcare systems and society as a large. This, thus, may help to decrease the rate of cognitive decline and dementia-related mortality.

Fats, particularly saturated fats, play a central role in neurodegeneration debates, as their effects on the brain vary by individual due to genetic and environmental factors, such as the ApoE4 gene mutation. Exploring the link between saturated fat consumption and Aβ protein development requires considering multiple factors, including the impact of mild cognitive impairment and diet type (Western vs. Mediterranean) on Aβ levels.

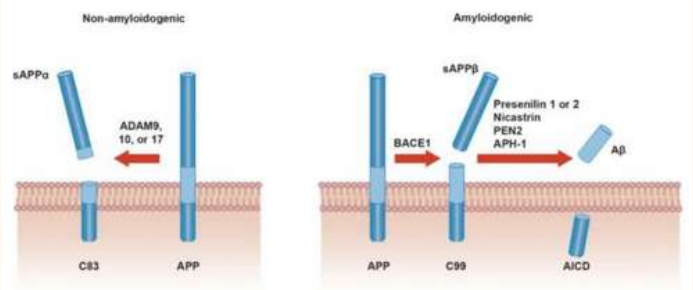
Initially, I aimed to compare a local area to another culture, but limited research on saturated fat consumption in Wales made this unfeasible. Instead, I expanded my focus to North America and Southern Europe, where extensive research on saturated fats and amyloid-beta production exists. By analysing these regions as case studies, I can compare dietary impacts on neurodegeneration with global applications, including potential relevance to Wales. This essay integrates biology and cultural anthropology to explore these relationships.

Biology will explore the influences the processing and production of Aβ protein. Cultural anthropology analyses dietary differences between the Mediterranean and Western worlds, particularly in saturated fat consumption. Using cultural materialism and globalization theories, I will assess North American and Southern European diets and their global impact on neurodegeneration.

The pathology of Aβ protein accumulation from a neurological perspective

AD is theorized to be characterized by abnormal accumulation of the Aβ protein, in particular brain regions responsible for memory. Aβ is a normal product of the cellular metabolism derived from a larger protein found in the fatty membrane surrounding nerve cells, APP.

APP is synthesized inside the cell in the endoplasmic reticulum and then transported to the Golgi complex, where it completes maturation and is finally transported to the plasma membrane. Mature APP undergoes processing via two distinct pathways: the non-amyloidogenic and the amyloidogenic pathways.



Amyloidogenic vs non-amyloidogenic pathway

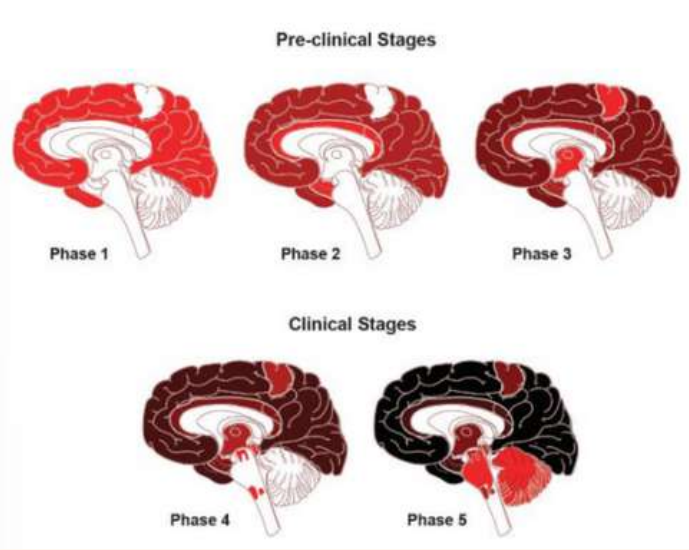
In the non-amyloidogenic pathway, APP is initially cleaved by α-secretase, releasing sAPPα and leaving an 83-amino-acid C-terminal fragment. This fragment is subsequently cleaved by γ-secretase, producing the P3 peptide. The non-amyloidogenic pathway is typically increased in response to neuronal activity and the activation of acetylcholine receptors.

In contrast, the amyloidogenic pathway involves cleavage by β-secretase, generating a 99-amino-acid C-terminal fragment (C99) on lipid raft regions. High saturated fat intake increases lipid raft formation, promoting APP localization in these regions, which is abundant in β-secretase. The C99 fragment is then processed by γ-secretase, producing various Aβ peptides, including Aβ40 and Aβ42. This cleavage also releases the APP intracellular domain, which can influence gene expression and induce apoptotic genes. The newly generated Aβ either remains associated with the plasma membrane and lipid raft structures or is released to the extracellular space. The binding of Aβ in the lipid rafts strongly favours Aβ aggregation.

Though, mechanisms exist to transport Aβ across the blood brain barrier and out into the circulation. Disruptions of this transport mechanism, like diets high in saturated fats, could low density lipoprotein receptor-related protein 1 expression and the ability to transport Aβ out of the brain via lipoprotein receptors and increasing its accumulation.

Early research, including Glenner and Wong (1984) and Masters et al. (1985), attributed AD-related brain cell death to Aβ fibrils. However, recent studies suggest smaller Aβ oligomers are more neurotoxic, disrupting synaptic plasticity, impairing long-term potentiation, and causing memory deficits even without large plaques. Advances in neuroimaging and biomarker analysis further link Aβ oligomers to early synaptic dysfunction, reinforcing their role in Alzheimer's pathology.

Soluble Aβ can attach to many substances in the extracellular space, like receptors on cell surfaces, metals, and cell membranes. Particularly cholesterol-rich lipid drafts within the plasma membrane, which serve as hotspots for Aβ to bind and aggregate from lowering its concentration in the cerebrospinal fluid (CSF). Saturated fats can increase the formation of these lipid rafts and facilitate aggregation and Aβ interactions with membranes, increasing its neurotoxic effects. This induces oxidative stress, altering ion homeostasis which can lead to widespread synaptic failure. Thus, for early-stage diagnosis researchers look for the primary amino acid sequence of Aβ, first identified in 1984, along with amyloid oligomers, predominantly accumulating in the neocortex of Alzheimer's patients. In later stages, Aβ fibrils and amyloid plaques tend to develop and accumulate as large, dense and insoluble Aβ aggregates, spreading from the neocortex to the allocortex, brainstem, and eventually the cerebellum.



Traditional neuropathological phases of amyloid-β deposition in Alzheimer's disease. Red areas in Phase 1 depicts the cortical regions with the initial accumulation of amyloid-β during the early pre-clinical stage. Continued deposition in the same areas are shown in darker colours in the subsequent stages, with the new areas showing amyloid-β in red in each phase.

Subsequently, these dense Aβ aggregates signified brain aging and served as a pathological hallmark of AD along with tau neurofibrillary tangles (NTFs). This association is typically referred to as the amyloid hypothesis, which posits that the accumulation of amyloid-beta plaques in the brain is a primary cause of AD, leading to neurodegeneration and cognitive decline. However, the amyloid hypothesis, while dominant, has been increasingly questioned in recent years. Some researchers argue that amyloid accumulation may be a downstream effect rather than the primary cause of AD. In particular, tau pathology, characterized by the accumulation of tau protein NFTs, has also been suggested as a critical driver of neurodegeneration. Studies have demonstrated that tau spread correlates more closely with cognitive decline than amyloid plaque burden.

In fact, while low CSF Aβ1-42 concentrations display an average sensitivity greater than 90% for detecting cortical Aβ deposition of across all clinical stages of AD, including

preclinical, prodromal. However, the simultaneous presence of low Aβ1-42 and high total tau and phosphorylated tau concentrations strongly suggests an AD diagnosis even at a prodromal stage, with a sensitivity of 90–95% and a specificity of about 90% assessed through amyloid-PET across the AD clinical continuum. This suggests that tau protein, particularly phosphorylated tau, may be a more reliable biomarker for AD, as it has a higher correlation coefficient to Aβ protein. While Aβ plaques are often present in the brain of AD patients, the accumulation of tau tangles appears to better reflect the degree of neuronal damage and is a stronger predictor of disease progression, potentially offering a more robust diagnosis when used alongside amyloid markers.

However, during the 1990s and early 2000s though, mechanistic studies on autosomal dominant AD genes, investigations of genetic risk factors for late-onset AD, and longitudinal biomarker studies in at-risk individuals established that Aβ pathophysiology begins decades before clinical symptoms of AD appear. Aβ accumulation seems to precede other pathological changes in AD, including the spread of NFTs and neuronal and synaptic loss, driving cognitive and functional decline through the preclinical, prodromal, and dementia stages of the disease. Thus, it seems while tau proteins may be more closely correlated to AD progression, Aβ accumulation is a much earlier predictor of its potential development.

These findings highlight the potential for early intervention strategies targeting Aβ accumulation to delay or prevent the onset of AD. However, in light of the challenges of the amyloid hypothesis, it is crucial to expand the focus to include tau and other molecular pathways, which might be contributing to neurodegeneration in AD. A more comprehensive understanding of these processes could lead to more effective multi-target therapeutic strategies that could delay disease onset or modify disease progression.

Food's impact on the acceleration of amyloid β aggregation

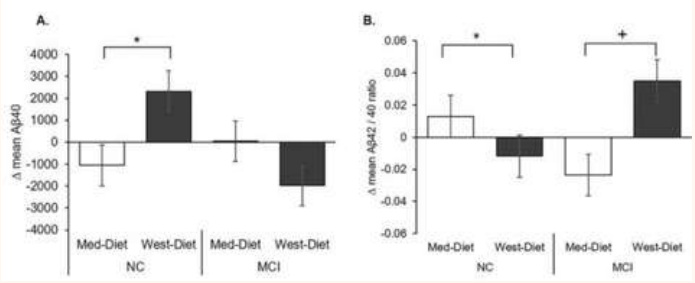
The accumulation of Aβ aggregates in the brain involves a complex interplay of various biological and cultural anthropological factors. The familial and genetic link is considered as the biggest risk factor of Aβ accumulation that involves ApoE4 gene mutations. Autosomal mutations in PSEN1, PSEN2, and less commonly in APP genes are also seen in Alzheimer's patients. While APOE ε4 carriers exhibit higher Aβ deposition, this effect varies across populations, suggesting possible dietary patterns, including differences in saturated fat intake, may modulate amyloid pathology.

CSF biomarker protocols assess variations in Aβ deposition, such as the higher levels associated with increased saturated fat consumption in North America. Western diets, shaped by foodways focused on convenience and accessibility, emphasize processed and fast foods rich in saturated fats. Driven by economic factors like mass production, marketing, and consumer demand for affordable, time-saving options, industrial agriculture has made calorie-dense foods more available, contributing to obesity and neurodegenerative diseases. Biocultural anthropology links this dietary shift to both biological factors and cultural norms, prioritizing convenience over nutrition and increasing the risks of metabolic diseases and cognitive decline.

Research suggests that the Mediterranean diet may help prevent Aβ deposition through its anti- inflammatory and antioxidative effects, offering a protective mechanism

against neurodegeneration. Foodways there emphasise fresh, minimally processed foods and a deeper connection to local agriculture, social practices, and slower meal preparation. The Mediterranean diet, rich in unsaturated fats, fruits, vegetables, and fish, promotes healthier lipid profiles and has been linked to a reduced risk of Alzheimer's disease. Biocultural anthropology highlights how the Mediterranean diet is shaped by cultural traditions, environmental factors, and a holistic approach to health, contrasting with the North American tendency toward convenience and processed foods. As a result, Mediterranean foodways offer a healthier alternative that aligns with both biological needs and cultural values, promoting longevity and cognitive health.

Researchers at Rush University examined the impact of this phenomenon using brain tissue from 581 individuals who donated their bodies to the "Memory and Aging Project". Diet information was collected starting from 2014 for an average of six to seven years and was then compared to the presence of amyloid-beta plaques and tau tangles, hallmarks of Alzheimer's, found at autopsy. This study is particularly relevant as it offers direct neuropathological evidence linking dietary patterns to Alzheimer’s disease risk, rather than relying solely on cognitive assessments or imaging studies. Overall, the researchers found that people who followed the Mediterranean diet or the closely related Mediterranean-Intervention for Neurodegenerative Delay (MIND) diet had fewer amyloid plaques and tau tangles than those who ate other types of diets (shown in the figure). Given that amyloid accumulation precedes tau pathology in Alzheimer’s progression, this suggests that diet may play a role in modulating Aβ aggregation and, consequently, downstream tau-related neurodegeneration. Agarwal said, "overall, these diets are rich in the essential nutrients and bioactive which reduce overall inflammation and oxidative stress in the brain and probably leading up to less accumulation of amyloid plaques and tangles," but warns that the research still needs development. This study reinforces the hypothesis that dietary patterns influence Alzheimer's pathology by affecting Aβ metabolism and tau aggregation, reinforcing the role of lifestyle factors in disease prevention.



Impact of Mediterranean Diet (Med-Diet) and Western Diet (West-Diet) on Amyloid-beta (Aβ) Levels

Referring to the figure, Graph A, the Western diet is associated with a significant increase in Aβ40 levels in the NC group, suggesting a role in early amyloid accumulation, whereas the Med-Diet shows little to no change. In contrast, in the MCI group, Aβ40 levels decrease in the West-Diet group, potentially reflecting altered amyloid metabolism in later disease stages. Graph B highlights the Aβ42/Aβ40 ratio, a key biomarker for Alzheimer’s risk, showing a significant decrease in the NC-West-Diet group, indicating greater plaque formation risk, while the Med-Diet maintains a more stable ratio. Interestingly, the MCI-West-Diet group exhibits an increased Aβ42/Aβ40 ratio, suggesting a possible compensatory mechanism in disease progression. While the study supports the Mediterranean diet’s protective role, the unexpected MCI trends, such as lifestyle and genetic factors highlight the need for further research into diet’s long-term influence on amyloid pathology.

Geographical context of Southern Europe and North America

Southern Europe, also known as Mediterranean Europe, comprises fifteen countries, and has a total population of more than 150 million people, accounting for roughly 2% of the world's population. These countries share remarkable similarities as well as diversity in terms of their history, language, climate, traditions, but particularly their rich culinary cultures.

Map showing Southern Europe region, worldpopulationreview.com, 2022

The typical macronutrient composition of the Mediterranean diet is variable but is generally 45% to 55% of calories as carbohydrate, 25% to 35% as fat, and 15% to 20% as protein, with a high content of fibre and omega-3 fatty acids, of course this is averaged over the entire population and will diversify amongst individuals. However, this longevity leads to an aging population and thus increases the prevenance of neurodegeneration related to old age leading to a higher prevalence of geriatric diseases like Alzheimer's disease.

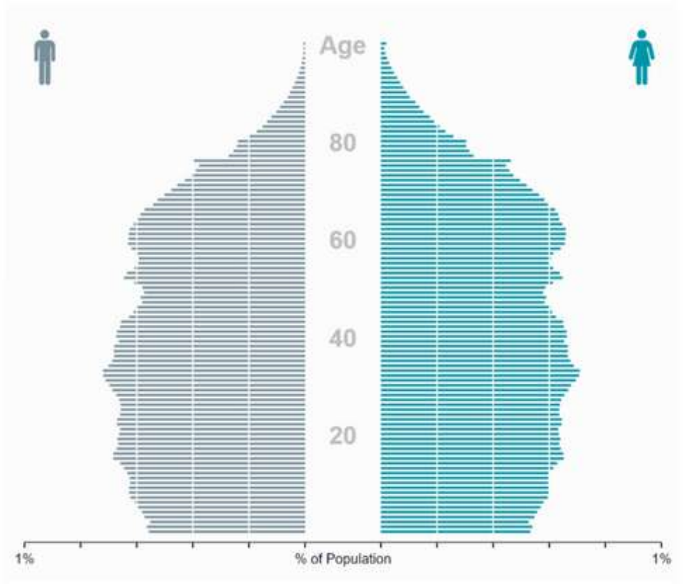
On the other hand, North America, which includes three major countries (the United States, Canada, and Mexico) along with several smaller nations and territories, has primarily adopted the Western diet (WD), which is characterized by high intakes of saturated and trans fats at about 11-18%. WD academically corresponds to a dietary pattern in which 70% of calories originate from animal foods, oils and fats, and sweeteners, this is calculated in 2013 using 16 "WD countries". As well as the consumption of fruits, vegetables, whole grains, legumes, and lean protein is greatly lacking in this diet, intakes of saturated and trans fats is at about 11-18%.

In recent years however, there has been a growing awareness and appreciation for healthy eating and sustainable food practices in North America. Movements such as farm-to-table, organic farming, and the increasing popularity of farmers' markets reflect a shift towards valuing fresh, locally sourced ingredients. These trends, while still emerging, indicate a cultural shift that could impact the dietary habits and health outcomes of future generations.

However, the growth of the aging population in North America is a significant factor in this trend. In 2020, about 16% of the U.S. population was aged 65 and older, a proportion that is expected to increase to 21% by 2030. Similarly, Canada and Mexico are experiencing growing elderly populations, with corresponding increases in age-related health issues. These demographic changes have led to higher burdens of age-related health issues. AD, for instance, affects an estimated 6.2 million Americans aged 65 and older in 2021, with this number expected to rise as the population ages.

However, having a lower geriatric population doesn't necessarily mean a lower AD prevalence. In the blue zone region of Ikaria, Greece, dementia among people over 85 is rare, over 75% less common than it is in the United States, likely due to their traditional

diets rich in polyphenols, omega-3 fatty acids, and antioxidants. Evolutionary anthropology suggests that these dietary adaptations may have evolved as a defence mechanism against neurodegenerative diseases, supporting the idea that long-term cultural practices shape biological resilience.



Population pyramid in the USA in 2024, Bureau, 2024

Western Diet in comparision to the Mediterranean Diet based on the accumulation of amyloid-β in the brain

Based on intial research, I hypothesised that saturated fats was a significant risk factor of poor Aβ status that insinuated cognitve decline. Numerous studies suggested that poor Aβ status, indicated by low levels of Aβ42 in the CSF, was linked to high consumption of fast food, saturated fats, high glycaemic index foods, and sodium, all of which are components commonly associated with the WD.

This was further supported by Mietelska-Porowska et al.'s (2022) study verifying the hypothesis that WD can trigger the initiation and propagation of major neuropathological features of AD, such as Aβ plaques and NFTs. To this aim, male wild-type mice were fed a WD or standard diet from 3 months of age. APP/Aβ levels, were analyzed via PET scans in animals at 4, 8, 12, and 16 months of age, levels of these proteins were assessed in two brain structures characteristic of the preclinical, pre-symptomatic stages of AD development, the entorhinal cortex and the hippocampus. The study concludes that a WD can induce amyloidogenic proteolysis and Aβ accumulation in aged wild-type mice, even without genetic predisposition. Specifically, WD-fed 16-month-old mice exhibited increased intracellular Aβ in the entorhinal cortex, an area critical for memory and one of the first affected in AD. This aligns with the established progression of tau and amyloid pathology in AD, where tauopathy begins in the entorhinal cortex and hippocampus, while amyloidopathy starts in the frontal and parietal lobes. The findings support the idea that AD can be triggered by metabolic dysfunction associated with a WD and highlights the importance of a balanced diet as a potential preventive measure.

Despite this, some research presents differing perspectives. For instance, a study by Oksman et al.(2006) where researchers found that diets rich in saturated fatty acids did not significantly increase Aβ levels compared to diets high in polyunsaturated fatty acids. This suggests that the type of dietary fat consumed may differentially influence Aβ accumulation, and not all saturated fats uniformly exacerbate AD pathology. Additionally, the Rotterdam study initially found an increased risk of AD with higher intakes of total fat, saturated fat, and cholesterol after 2 years of follow-up. However, after 6 years, no significant associations were observed, indicating that the link between saturated fat intake and AD risk may not be straightforward and could be influenced by other factors or longer follow-up periods.

Conflicting findings highlights the complexity

of the relationship between diet and AD pathology. While Mietelska-Porowska links a WD to Aβ accumulation using a mouse model, which, despite offering mechanistic insights, it doesn't fully replicate human AD progression, Oksman et al. (2006) suggest that different types of saturated fats may affect Aβ pathology differently, challenging the idea that all saturated fats are equally harmful. The Rotterdam study's variable results imply that the link between dietary fat and AD risk may depend on factors like genetics, exposure duration, and overall diet. These inconsistencies emphasize the need for long-term human research to establish causation and suggest that while a WD may contribute to AD pathology, it is not the sole determinant. These findings highlight that while a WD may contribute to cognitive decline, the role of dietary fats in AD remains multifaceted and requires further research.

Similarly, how the Mediterranean diet (MeDi) impacts the levels of Aβ is still not clear, where it can either lead to a significant decrease in the accumulation of Aβ. Additionally, certain important aspects of the diet like Extra Virgin Olive Oil (EVOO), known for having lower levels of saturated fats most of the popular cooking than oils, may further promote clearance of Aβ by reducing neuroinflammation. However, the previously outlined study examined the effects of MeDi and WD on CSF biomarkers in both NC adults and those with MCI. The results indicated that the MeDI led to an increase in CSF Aβ42/40 ratios among NC participants, while the Western diet resulted in a decrease. Conversely, in the MCI group, the WD decreased CSF Aβ42/40 ratios, whereas the Mediterranean diet did not produce significant changes. A higher Aβ42/40 ratio has been linked to the presence of amyloid plaques, a hallmark of AD. While amyloid accumulation is considered a risk factor for AD, it's important to note that not everyone who develops amyloid plaques goes on to develop Alzheimer's.

In Rainey-Smith et al. data was collected from 77 cognitively normal healthy control participants of the AIBL Study of Ageing. Participants were classified as "Aβ accumulators" based on PiB-PET imaging at baseline, 18, and 36 months. All volunteers were aged 60 years and above at baseline. Written informed consent was obtained from each participant, and the study was approved by relevant ethics committees. Blood samples were collected, and DNA was extracted for APOE genotyping to assess any confounding variables. Higher MeDi scores were associated with decreased Aβ accumulation ($\beta = -0.01 \pm 0.004$, $p = 0.0070$). Increasing MeDi adherence by one point could result in a 20% decrease in Aβ accumulation over one year and up to a 60% decrease over three years. This includes taking into the account of the ration between monosaturated to saturated fatty acids, however the strongest individual predictor seems to be fruit intake ($\beta = -0.04 \pm 0.01$, $p = 0.00036$). These findings align with previous research linking MeDi adherence to reduced AD risk and cognitive decline.

Studies on the MeDi and Aβ accumulation yield conflicting results regarding AD risk. Rainey-Smith (2018) suggests that greater adherence to the MeDi, especially through increased fruit intake, is linked to reduced Aβ accumulation and a lower AD risk. However, Agarwal (2023) found that the MeDi increased Aβ42/40 ratios in cognitively normal individuals, potentially raising the risk of amyloid plaque formation, a key AD marker. Additionally, the diet showed no significant effect in those with MCI, indicating limited benefits once cognitive decline begins. These

discrepancies highlight the complex relationship between diet and AD risk, suggesting the MeDi may offer early-stage protection, but its effectiveness in preventing or reversing AD remains uncertain and requires further research.

Conclusion and Discussion

In conclusion, the variations in the consumption of saturated fats across different cultures significantly impact the accumulation of Aβ protein plaques, a critical factor in the development of AD. From a biological perspective, diets high in saturated fats have been shown to increase the levels of Aβ peptides in the brain, promoting plaque formation and subsequent neuronal damage. This connection can be explained by the mechanisms of lipid metabolism and its influence on APP processing, where high saturated fat intake leads to increased production and reduced clearance of Aβ peptides.

Exploring this issue through the lens of cultural anthropology reveals how dietary habits shaped by cultural norms and foodways contribute to the risk of AD biomarkers. In cultures where diets are traditionally high in saturated fats, such the WD, there is a higher prevalence of AD, which is correlated with the higher intake of saturated fats. Conversely, cultures with diets rich in unsaturated fats, such as the Mediterranean diet, show a lower incidence of Aβ plaque accumulation and Alzheimer's disease.

Studies indicate that prolonged consumption of high saturated fat diets is associated with increased cognitive decline and Aβ accumulation. Cross-cultural comparisons highlight the significance of diet as a modifiable risk factor for Alzheimer's, emphasizing the need for dietary guidelines and public health strategies tailored to cultural contexts to mitigate this risk.

The use of peer-reviewed, validated, and reliable sources from medical and anthropological journals, government health statistics, and scientific reports from both national and international institutions has facilitated a comprehensive analysis of the relationship between saturated fat consumption and Aβ plaque accumulation. Proposed solutions to address this issue include promoting dietary changes towards reduced saturated fat intake, public health campaigns to raise awareness about the risks of high saturated fat diets, and policies to support the availability and affordability of healthier food options.

Implementing culturally sensitive interventions is essential for effective dietary modifications. By understanding and respecting cultural dietary practices, health policies can be better tailored to reduce the risk of Alzheimer's disease globally, ensuring that dietary recommendations are both practical and acceptable within different cultural contexts.

PREETI PRASAD SHETTY

She spent 2 years researching and developing this paper after volunteering in care homes in her local area. She wanted to research how and why Alzheimer's can develop and if at all there is a holistic way to prevent it or at least slow its development. Which ultimately led her down the path of investigating the effect of diet, something that most people have agency over whether in a country with free medical care or otherwise, as that has the most impact on an individual's health outcomes.

References available on request

Wired Differently:
The Neurobiology of Psychopathy

Psychopathy is one of the most studied, and misunderstood, conditions in psychology. Often portrayed in pop culture as ruthless villains or heartless killers, real life psychopaths are not simply “evil”. Instead, decades of research suggests that psychopathy is a neurocognitive condition, where the brain is wired differently.

What defines a psychopath?

Brief History

The concept of psychopathy has evolved significantly over the last century. One of the earliest descriptions of the condition is attributed to psychiatrist Philippe Pinel (1801) who described his concept of “manie sans délire” (translating to “madness without delusions”) in individuals who acted destructively despite seeming to have rational thinking. Later, Koch (1891) introduced the term “psychopathic inferiority” which captured the idea of persistent personality abnormalities that were not attributable to any psychosis or intellectual disability. Contemporary understanding is accredited to Cleckley (1941) who described this condition as paradoxical as individuals appear rational, and even charming, on the surface yet lack genuine emotional and moral conscience. Building on this foundation, Hare (1991) operationalised these concepts into measurable traits through the development of the Psychopathy Checklist-Revised (PCL-R) which today remains the most widely used tool for assessing psychopathy in both a forensic and clinical setting.

PCL-R

The PCL-R distinguishes between two main dimensions within psychopathic traits. The first dimension captures the affective features such as a superficial charm, grandiose self-worth, pathological lying, and most noted by society, their lack of empathy, highlighting the emotional deficits that are present within the disorder that allow the individual to exploit others without experiencing guilt. The second dimension refers to the lifestyle and antisocial tendencies including poor behavioural control, need for stimulation, impulsiveness and criminal versatility which often brings individuals conflict in social situations and legality.

Real life example

However, it is also important to note that not all psychopaths score highly on both factors in the PCL-R and, although psychopathy is associated to crime and violence, research suggests not all individuals with these traits end up in prison. Instead, some find themselves thriving in high-powered professions. For example, a study of 261 senior professionals found that about one in five corporate executives displayed significant levels of psychopathic traits at such a rate it was comparable to prison populations. One of the most discussed examples is Steve Jobs, although never formally diagnosed, he is often cited by commentators and biographers as a “successful psychopath” due to his limited empathy and relentless drive which mirrors some psychopathic traits-contributing to his extraordinary professional success.

This means that psychopathy should not be viewed as an instant marker of criminality but rather a variety of traits which could manifest

in a variety of ways, dependant on the context. In some cases, these traits may fuel manipulation and crime, whereas in other cases they support leadership roles and success in competitive environments. The understanding of this vast spectrum helps to challenge the merely "evil" connotations of the concept and instead highlights the complexities that interplay within the personality, environments and outcomes.

Brain Mechanisms

Structural Abnormalities

Extensive structural neuroimaging studies indicate that individuals with psychopathy frequently exhibit reduced grey matter volume across several brain regions critical for emotion regulation, social cognition and moral reasoning. For instance, a study by Yang et al, (2005) found a 22% reduction in prefrontal grey matter specifically in individuals identified at "unsuccessful" (caught) psychopaths highlighting the deficits in both the ventromedial and orbitofrontal cortices that may therefore undermine executive control and ultimately contribute to weak impulse regulation. It is also shown that the amygdala has robust structural deficits with a bilateral volume reduction of around 17% in the left and 19% in the right (specifically within the basolateral, lateral, cortical, and central nuclei); this loss significantly correlates with traits affective and interpersonal to psychopathy. Additionally, cortical thinning data reinforces these finding; Ly et al. (2012) found a pronounced thinning areas associated to cognitive and emotional processing such as in the left insula and dorsal anterior cingulate cortex (ACC). Johanson et al (2019) conducted a comprehensive review which revealed grey matter reductions in the paralimbic network, including the prefrontal, temporal, limbic and insular regions, are among the most consistent structural abnormalities linked to psychopathy. Yet other systematic review that the medial frontal regions (including the ACC) are often inconsistent. Altogether, these results implicate a network of structural deficits across the prefrontal, limbic and paralimbic circuits central the moral and emotional dysfunctional trait of psychopathy.

Functional Abnormalities

Functional neuroimaging studies have been used to demonstrate that psychopathy is not only solely associated to structural abnormalities yet has also been associated to abnormal activity patterns. Glenn, Raine, and Schug (2009) used fMRI in participants who scored high on the PCL-R and found hypoactivation in the ventromedial prefrontal cortex (vmPFC) during moral decision-making tasks which suggests a reduced ability to integrate emotion into judgements (perhaps alluding to callous interpersonal traits). Birbaumer et al. (2005) reported that violent offenders with psychopathy failed to show normal amygdala activation during aversive conditioning which indicated a diminished fear learning, while March et al (2008) demonstrated that reduced amygdala responses to fearful facial expression in adolescents exhibiting psychopath traits. Similarly, the orbitofrontal cortex (OFC) associated to reward processing has been shown through Blair (2007) who reviewed converging fMRI evidence linking the OFC dysfunction to impulsivity and antisocial behaviour in psychopaths. Beyond this, the ACC activity has been found by Kiehl (2006) to be lowered in tasks requiring conflict monitoring and Decety et al. (2019) reported reduced insula activation when psychopaths viewed others in pain, indicating an unawareness for others suffering. Collectively, these studies show psychopathy to be linked to dysfunction across the vmPFC, amygdala, OFC, ACC and insula providing strong neurobiological evidence for the disorder's

traits.

Beyond the Brain: Genetic and Environmental Factors

Genetic influences

It has been proven that psychopathy has a substantial genetic basis. This is shown primarily through twin studies such as Viding et al. (2005) who displayed that, by using a sample over 3,600 7-year-old twins, a heritability rate of 67% in callous-emotional traits with minimal influence of a shared environment. This is further sustained as Larsson, Viding, and Plomin (2008) replicated this in adolescence and found genetics had a influence in approximately 50% of psychopathic traits. Combined, these findings suggest that while many features of psychopathy are biologically anchored, environmental factors must also play a role within the disorder as the hereditary rate does not account for entire variance. Molecular genetic studies have aimed to identify specific genes linked to psychopathy; locating variants of the MAOA gene (often called the “warrior gene”). This gene has been implicated in aggressive and antisocial behaviour especially when paired with early maltreatment. Similarly, Buckholtz and Meyer-Lindenberg (2008) have found polymorphisms in genes responsible for regulating dopamine and serotonin transmission have been associated to impulsivity and emotional dysregulation. However, it is important to note that genetic effects tend to be minimal and most evidence suggests there is no sole gene responsible for being the root cause of psychopathy.

Environmental Risk Factors

Moreover, findings from studying genotype and phenotype interactions have found a predisposition due to genetic vulnerability is not deterministic as traits such as callousness or aggression that may only manifest in the presence of specific emotional triggers while supportive environments can buffer this risk. Emerging evidence from epigenetics further demonstrates that early experiences such as trauma, or even parenting style, can alter the expression of genes thereby shaping developmental trajectories.

Gao et al. (2010) conducted a longitudinal study across children from birth to adulthood and found early neglect and harsh parenting significantly predicted psychopathic traits and criminality. This effect of parenting style is shown through Pardini et al. (2007) study which found that harsh and inconsistent parenting predicted higher levels of callous-unemotional traits in boys (even after accounting for a baseline in antisocial behaviour). In contrast, Waller et al. (2017) found warm, responsive parenting was protective as a buffer to the disorder even among children with a genetic vulnerability.

Beyond parental influences, socioeconomic conditions have been identified as an important risk factor. For instance, Dodge, Pettit and Bates (1994) found that exposure to chronic neighbourhood violence predicted higher levels of aggression and antisocial behaviour in adolescence even after controlling for individual temperament. Such findings highlight how environmental stressors such as poverty, community violence or social instability can shape the development of emotional regulation and reasoning, reinforcing vulnerabilities to those already predisposed.

Further, a study led by Dr. Megan Klabunde at the University of Essex found, though analysing data from 14 studies to analyse the brain scans of 582 children (285 with a history of trauma), found alterations in neural networks in the children with a traumatic history. Notably, the study identified

disruptions in the brain circuit responsible for self-awareness and problem solving. These concepts are critical regarding experiencing empathy which suggest early traumatic experiences can remodel the brain, leading to difficulties in emotional and interpersonal understanding.

Taken together, these findings show that environmental risk factors extend far beyond the home with broader contexts such as trauma shaping neurological development. Crucially, environments do not simply influence behaviour but can alter the very neural systems responsible for emotion, decision making and impulse control. In this way, conditions may literally shape the way your brain is wired, reinforcing genetic vulnerabilities and contributing to atypical neurobiology observed in psychopathy.

Theoretical Models

The Violence Inhibition Mechanism (VIM) Model

Blair's (1995) VIM model suggests psychopathy arises from a failure to develop the internal mechanism which inhibits aggression in response to distressing cues supported by experimental evidence. As previously mentioned, Blair et al. (2001) found children with psychopathic traits were impaired in recognising fear and sadness in vocal tones and facial expressions, suggesting they are unable to process emotional cues which would normally supress harmful behaviour.

Response Modulation Hypothesis

The Response Modulation Hypothesis was proposed by Newman and Lorenz (2003) which emphasised attention over emotion. They found on normal tasks requiring attention to emotional cues, psychopaths performed normally, yet, when emotional information was secondary to their main goal, they performed worse in the task than those neurotypical. Newman et al. (1997) also reported this abnormality though observing psychopaths fail to process threat related words in a Stoop task when they were focussed on another goal. The attentional deficit offers an explanation as to how psychopaths appear rational yet remain oblivious to causes of harm.

Moral Reasoning Deficits

Glen et al. (2009) found psychopaths to differ in moral decision making. Glen found that individuals high in psychopathy were more likely to endorse utilitarian choices such as harming (one person to save many) reflecting more calculative style of reasoning.

The Triarchic Model

This model was developed by Patrick, Fowles and Krueger (2009) which conceptualises psychopathy as three distinct (but interacting) traits. These traits include boldness (social assertiveness), meanness (cruelty) and disinhibition (impulsivity). With support from Drislane et al. (2014) who found these traits predict different outcomes (boldness is associated to leadership while meanness and disinhibition predict antisocial behaviours) provides strong empirical support for this model.

Commonality

Despite different focusses throughout the theoretical models, these cognitive explanations share a strong central insight that this disorder reflects a distinct way of processing information. All of these models highlight that individuals with psychopathy think and respond differently to social and emotional cues compared to neurotypical people.

Implication and Debates

Determinism and Responsibility

Glenn, Raine and Schug's (2009) finding that reduced activation in the vmPFC is high in those with psychopathy during moral decisions suggest these psychopathic traits are neurocognitive rather than deliberate. Similarly, Viding et al. (2005) displaying a heritability rate of 67% in callous-unemotional traits suggests there is a biologically deterministic predisposition to developing this disorder. This conclusion is socially sensitive as it raises the question of if psychopathic offenders should be held fully accountable for antisocial and criminal behaviour (as a neurotypical person would be) as there is evidence suggesting this disorder stems from atypical cognition and inherited vulnerabilities.

This has legal implications as the system has struggled to integrate this scientific evidence. Aharoni et al. (2013) found jurors to be more lenient when presented with neurobiological proof of psychopathy although the effect was limited. It is argued by critics that relying on brain scans or PCR-L assessments in court is risky as it may lead to a misuse or overinterpretation especially given that not all individuals with psychopathic traits become criminals. This clearly highlights the tension between acknowledging the biological basis of this disorder and maintaining societal standards of accountability and the public safety.

Treatment

Several targeted interventions exist for people with psychopathy though they face significant challenges and limitations. Cognitive Behavioural Therapy (CBT) and intensive therapeutic programs aim to teach prosocial behaviours and emotional regulation. Caldwell et al. (2007) demonstrated that intensive treatment for adolescents with callous-unemotional traits significantly reduced violent recidivism.

However, it is also important to note that this efficiency is mixed as Frick and White (2008) have found interventions to be generally less successful than those in youth populations therefore, while early inventions show promise in reducing antisocial behaviour, treating adults remains highly challenging. Further Harris and Rice (2006) reviewed offender rehabilitation programmes and concluded that standard interventions can in fact make psychopaths even more dangerous as they may use therapy to refine their manipulation tactics.

Another approach that has been explored for psychopathy is the multisystemic therapy (MST) which focuses on utilising intensive family and community-based intervention to address antisocial behaviour. While MST has shown some success in delinquent behaviour in adolescents its effectiveness in adults is also limited as entrenched patterns of manipulation and emotional deficits are hard to unwire.

Pharmacological treatment can help manage comorbid symptoms yet there is no current medication which directly targets the core traits of psychopathy. Currently, researchers are investigating novel therapies which include interventions aimed to enhance empathy offering hope for more effective strategies in the future.

Ethical concerns

While research provides empirical evidence for the causation and management this disorder, limitations remain. Most studies focus on male and WEIRD samples which may have bias conclusions which are not representative or generalisable to the wider population. Additionally, much of the studies assume a causal relationship between biological abnormalities and behaviour whereas many findings are correlational.

Cognitive models do not always account for contextual or cultural variability (such as environmental differences in parenting or socioeconomic conditions). Future research must aim to address these gaps in knowledge including gender differences and cross culture samples.

Conclusion

Psychopathy is a complex, multifaceted condition that cannot be reduced to a simplistic “evil”. Evidence from neuroimaging, genetics and cognitive research demonstrates that individuals with psychopathy are wired differently as structural and functional brain abnormalities in regions such as the vmPFC, amygdala, OFC, ACC and insula react with genetic predispositions and environmental experiences which shape emotional, attentional and moral processing. Cognitive models provide further insight by showing that people with this diagnosis process social and emotional information in ways which diverge from neurotypical individuals which result in distinct patters of reasoning, decision making and behaviour.

The implications of this research is far reaching as psychopathy challenges traditional ideas of free will and moral responsibility which raises ethical concerns and legal debates about sentencing and risk management. Treatment remains particularly difficult specifically for adults, yet early interventions show promise and future solutions such as novel processing are being developed. Critically speaking, most research is limited by gender, cultural and sample bias which underscore the needs for more diverse and ecologically valid studies.

Ultimately, psychopathy should be viewed not as a moral failing but as a neurocognitive and developmental condition shaped by the interaction of biology, environment and cognition. Recognising this complexity allows for a more refined understanding which integrates scientific evidence with ethical considerations and brings awareness to both the potential risks and adaptive traits of psychopaths.

ELLIE FROST

Redefining Human

In biology, communication exists beyond language, it seeps into almost every aspect of life on earth. Its prevalence is imprinted into each of your 30 trillion cells, where your DNA holds a secret encoded message sent to you by your ancestors. In 1859 Charles Darwin published *On the Origin of Species*, revolutionising our understanding of how life has come to exist in the many diverse forms we see today. Almost all evolutionary biology has built on the back of its publication and now, with breakthroughs such as whole organism genome sequencing, we understand how nuances between the genetic codes of different species came to be.

When Jane Goodall first arrived to Gombe national park in Tanzania in 1960 she had no formal scientific training. It is perhaps for this reason that her methods and approaches to studying the behaviours of our closest living relatives the chimpanzees were slightly unorthodox. However, her discoveries in her first year at the park quickly erased any doubt in her abilities. What Jane observed contrasted the common understanding of chimp behaviour, such as a group of supposedly herbivorous chimpanzees hunting and eating meat. Her next publication provided compelling evidence for the increasingly popular theory that humans evolved from apes, that humans maybe aren't so exceptional in our intelligence. Chimpanzees use tools in many aspects of their daily lives, leaves as sponges for drinking water, rocks as defensive weapons, paintbrush like sticks for termite fishing, similarly to our early ancestors, with similar social patterns also. It raises the question of what it means to be human. As Jane puts it "in what terms should we think of these beings, nonhuman yet possessing so very many human-like characteristics?"

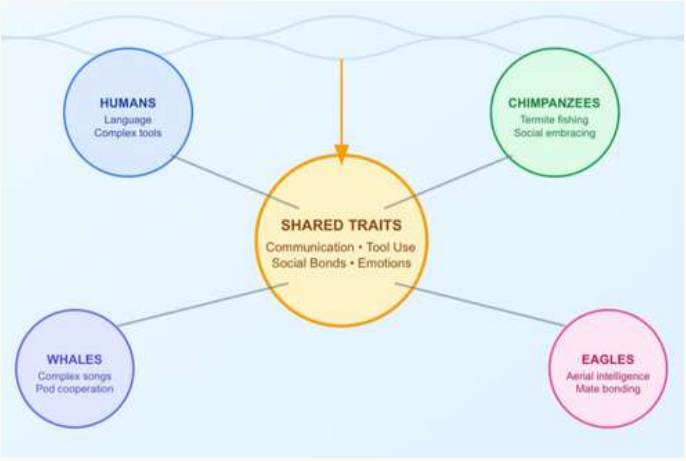
Jane Goodall with chimpanzee

What does it mean to be human? The question only holds seven words but encompasses millions of potential answers. A genetic perspective gives the simple answer of our 23 pairs of chromosomes but does this account for our perception of our surroundings? Does our sentience feel any

different to the sentience of a whale, cat or eagle? Indeed the lines of what it once meant to be human are becoming blurrier, an ongoing discovery that forces us to look beyond mere biological classification to the shared thread of subjective experience connecting different species.

For chimpanzees, the social dynamics in their large communities reflect how human society is scaffolded. The fission-fusion pattern of temporary divisions of the main social group allow for efficient resource management and strong social bonds maintain cohesion and reduce tension among individuals. Like us they have the capacity to miss their family members, Dr Goodall observed them embracing each other after long periods of separation, a testament to their emotional intelligence. We are not just similar in our genetic makeup but in how we interact with members of our own species and in how we form bonds, experience grief, joy, and perhaps even wonder. Their gestures mirror ours, not because they mimic but because they feel.

Recognising this kinship does not have to diminish our humanity though, it can remind us that communication is not bound to language, intelligence is not the sole property of Homo sapiens and that community and culture extend beyond the limits of our species. This connection is a biological continuum that we share with other life forms and it allows us to look to redefine our place in nature. Perhaps an understanding like this one, of how similar to other species we are, should serve to remind humans what is so special about this planet we take for granted. A planet that holds not just one form of intelligent life but multitudes, all of which are vulnerable to changes in the environment and climate made by just one of those life forms.



Shared traits between humans and various animals

To be human is not to dominate but to listen. We must understand how our intelligence grants us the power to safeguard and protect the earth, protect these conversations that have been going on for millennia, between animals, ecosystems and even the genetic whispers passed down through time. What kind of humans will we be? Should be the question we ask as we face the crisis of our own climate.

INDIA BUCKLEY

A Dive into Astrobiology

Wait Aliens Exist?

A few weeks ago I was watching my daily Star Trek episode and the crew had to save one of the main characters from an unknown alien who had attached to her vital organs. Being oblivious about this specific species' physiology they had to ask a famous astrobiologist for help in identifying the life form and potentially save their friend and the alien (who was just trying to survive). The first thing that I thought was that it could have been my dream job, literally just knowing facts about extra-terrestrials. That made me wonder whether astrobiology actually already existed or it was something still purely related to fiction. A few days later, while scrolling on Instagram, I found a very particular advertisement, it was a webinar about astrobiology (which is, of course, not about learning fun facts about aliens, but it focuses on broader subjects). Firstly, my phone is clearly spying on me. Secondly, I knew I had to dive deeper into the subject.

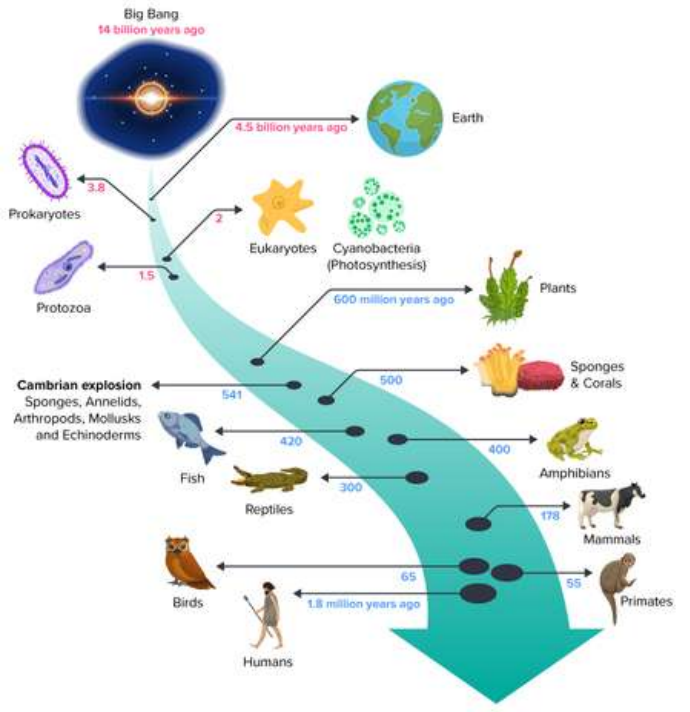
What is Astrobiology?

With the term astrobiology we mean a scientific field which studies life in the universe. Research in astrobiology focuses on three main areas, the study of habitable environments in the Solar System and beyond, the search for planetary bio signatures of past or present extra-terrestrial life and the study of the origin and early evolution of life on Earth. The term was invented in 1950s by a Russian astronomer to describe the impact of space missions and to define the study of research of extra-terrestrial life and it basically means "study of life from the stars". With the advent of space exploration and the discovery of exoplanets, astrobiology began to attract more researchers every year, making it a rapidly evolving field with a strong multidisciplinary aspect that creates opportunities for a very diverse gamma of scientists.

What we know about life in the universe

As a discipline, astrobiology is, obviously, founded on the premise that life may exist beyond Earth, but let's focus on our planet for a minute. Life on Earth is believed to have originated around 3.5/4 billion years ago, when simple molecules in a primordial environment reacted to form more complex organic compounds. Gradually they evolved into the formation of simple cells and then the organisms we have today. The wonder revolving around human life has been fascinating us ever since, resulting in a series of myths and theories. For example, the Roman poet and philosopher Lucretius believed we were born from the atoms of the stars. Nowadays we rely on Darwin's evolution theory, claiming that species change over time and that new species come from pre-existing species who have evolved. Furthermore, many scientists believe that the triggering factor for evolution is the environment, as a consequence of changes in their surroundings, species either adapt or die. In fact, all life forms, theoretically extra-terrestrials too, in order to survive, need stable environmental conditions and since places with steady temperatures, density of matter and radiations exist in many regions of space, there are no reasons to believe that life is an exclusive terrestrial phenomenon nor that we can't adapt if we ever decide to settle somewhere else in the galaxy. As a matter of fact, it has been proved that we can find the same chemical elements of Earth all around the stars and the galaxy. However, for now,

the only planet hosting life is ours, or at least that we know of. Nonetheless here, at first, there was no oxygen and there were radiations, because we had no ozone layer, two things we cannot live without now, moreover there are life forms that live in places in which we thought life couldn't exist and when scientists sent bacteria and other microorganisms to space, they observed that many of them actually survived. There are all proofs that life can survive in the universe, so I guess we just have to find it!



Evolution of Life, CK-12 Foundation

The search for extra-terrestrial life

Since the ancient civilizations, humans have been wondering whether there were other liveable planets. Present-day astronomers have been using fancy equipment to listen farther and deeper into the universe to find evidence of other life forms. But how are scientists actually searching for signs of extra-terrestrial life? Mercedes López-Morales, an astrophysicist explained that "*Life affects the atmosphere of a planet, you have gases that are only there because they are constantly being replenished by something, otherwise, they would react with other gases and disappear. For that gas or that molecule to be in the atmosphere of a planet, it must have some mechanism that is continuously producing it*".

Mercedes López-Morales

One of the atmospheric gases astronomers are searching for in exoplanets is oxygen, which is plentiful in Earth's atmosphere because it is continuously being replaced by plants through photosynthesis, but there are other ways it could be produced, for example irradiation in the ultraviolet light coming from stars, so it's not something only strictly connected with Earth, even if scientists are sure it originated because life appeared here. Speaking of terrestrial-like conditions, most of NASA missions are, now, focusing on Mars,

because of the abundance of liquid water on its surface, making it plausible that life could form there. Not only that, but scientists are also listening for signs of extra-terrestrials, in fact, for more than two decades, SETI, the Search for Extra-terrestrial Intelligence Institute, has conducted research to understand the origins of life in the universe and to detect and analyse evidence of life emanating from places other than Earth, as well as looking for signals in light or radio wavelengths.

Ethics of First Contact

With our speculation, we have arrived at the conclusion that aliens may exist, but what would actually happen if we'll ever have a "first contact"? Will it be the Star Trek mutual cooperation and sharing of cultures or more like the Independence Day preparation against invasion? From a non-expert to maybe another, do I believe in aliens? Yes. Aliens with big eyes and green skin? No. However, I'm strongly convinced we cannot be the only life forms in the universe, since it is infinite, there are infinites possibilities that aliens exist, may they be humanoids or animal-like or just particles with a conscience. As we adapted to Earth and evolved from simple microbial organisms, it is certainly possible other life forms learned to adapt to more hostile conditions. With that being said, considering the current state of our most influential governments (cough cough... USA), I believe we are not ready for a first contact, we cannot stand "diverse" people, meaning different ethnicities, religions, beliefs, sexual orientation and even gender, do we really think we would accept aliens? A first contact would eventually lead to more problems, as for now, humans would try to discover as much as possible about a new species and then, as it usually happens, to take advantage of it, researches would get more invasive, suspicions would grow making, already difficult relationships, even more hard and there would be an increase of armaments industry which will lead to increased global tension and potential militarization of Earth and space, perhaps even a WW3.

Conclusion

In conclusion, astrobiology is a fascinating growing field, technically begun in the Fifties, but even without having a name for it, it has always existed, since the ancient times. It now revolves around studying life in the universe, from the habitable environments in the Solar System, to extra-terrestrial life and the origin and evolution of life on Earth. Life in the universe has been potentially confirmed, which means that we could have a first contact with extra-terrestrial life forms, however not now and not in the near future either. Considering our ongoing struggles with accepting human diversity, whether racial, cultural or related to gender and sexuality, perhaps our efforts should first focus on our concept of inclusivity before trying to expand it to something which we, ironically, view as less "unnatural" than many of our fellow human beings.

ARIANNA MOREO

Space and Storytelling
How Space Exploration Shapes our Culture

Introduction
For as long as humans have looked up at the night sky, we've turned the stars into stories. Constellations became hunters and goddesses, calendars and maps. These myths were our first take on astronomy, an attempt to understand our place in the universe. Today, telescopes and equations have replaced the myths, but the impulse remains the same.

Ancient Stories of the Stars
With no telescopes or instruments beyond the naked eye, people connected stars into constellations and constellations into meaning. Orion, for example, was imagined by the Greeks as a hunter, his bright stars Betelgeuse and Rigel locked in an eternal chase with Scorpius.

In ancient Egypt, the same constellation carried even greater weight. Orion was linked to Osiris, the god of the afterlife, because its annual cycle of disappearance and return mirrored his death and rebirth. There is also the famous hypothesis of the "Orion Correlation Theory" proposed by Bauval which proposed that the Pyramids of Giza were aligned with the three stars of Orion's Belt, anchoring the pharaoh's soul to the heavens, while Sirius, associated with Isis, rose just before the Nile floods that sustained Egyptian agriculture and shaped their calendar. Astronomy here was not abstract theory but a living system, binding religion, politics, and survival.

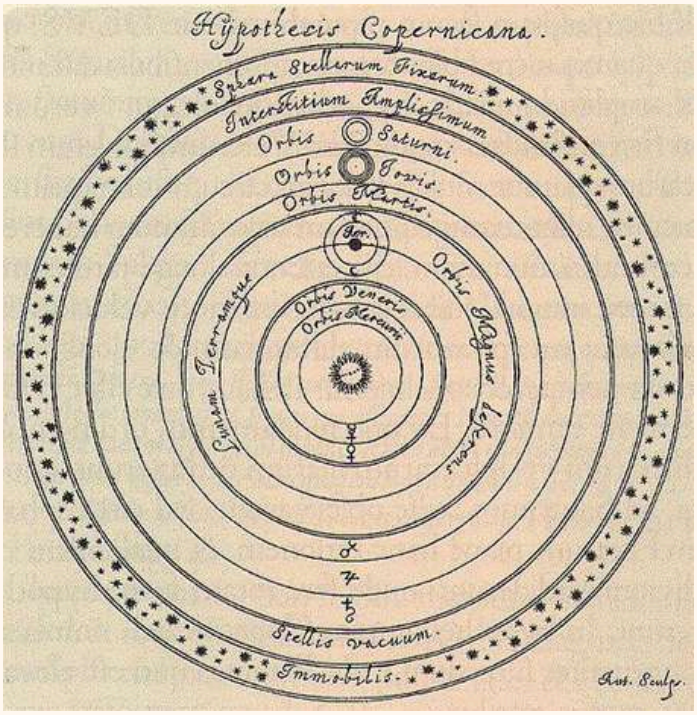
Elsewhere, sky-watching served equally vital roles. Polynesian navigators memorised "star lines" to cross thousands of kilometres of open ocean. In Māori tradition, the rising of Matariki (the Pleiades) marked the new year and guided planting. The Maya tracked the motion of Venus with extraordinary precision, building calendars that structured rituals and daily life. Even monuments like Stonehenge reveal how communities aligned stone with solstice, entwining the heavens with spirituality.

In the ancient world, astronomy and astrology were inseparable. The Babylonians recorded planetary positions on clay tablets not only to chart celestial cycles but to read divine omens for rulers and cities. An eclipse could foretell danger; the rise of a planet, prosperity or war. For them, the sky was both a measuring tool and messenger, offering order and meaning in uncertain times and in a way, so do we, though today we call them weather satellites, launch windows, and orbital mechanics.

What unites these traditions is not the precision of their measurements but the way the stars framed human existence. Long before telescopes and equations, the heavens were narrative and a mirror in which people found gods, guidance, and their place in the cosmos. But eventually, the heavens stopped being omens and became numbers.

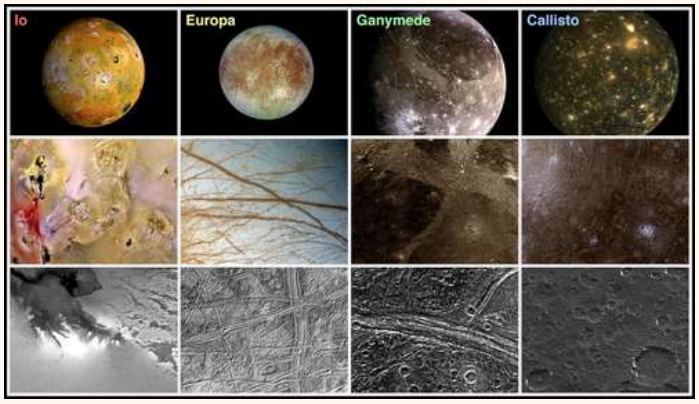
The Scientific Revolution of Space
The early modern period marked a profound

break from the sky of myths and gods to the sky of mathematics and observation. In the 16th century, Nicolaus Copernicus proposed the heliocentric model, placing the Sun at the centre of the solar system rather than the Earth. This was not just a scientific adjustment, it was a philosophical and religious earthquake. For centuries, the geocentric model of Ptolemy had been woven into Christian theology, reinforcing humanity's privileged place in the cosmos. By displacing Earth from the centre, Copernicus implied that humanity was not the focal point of creation but one world among many. His ideas circulated cautiously at first, published in *De revolutionibus orbium coelestium* (translation: "On the Revolutions of the Heavenly Spheres") in 1543, laid the foundation for a new vision of the universe.



Nicolaus Copernicus' universe, Cosmicnoise.it

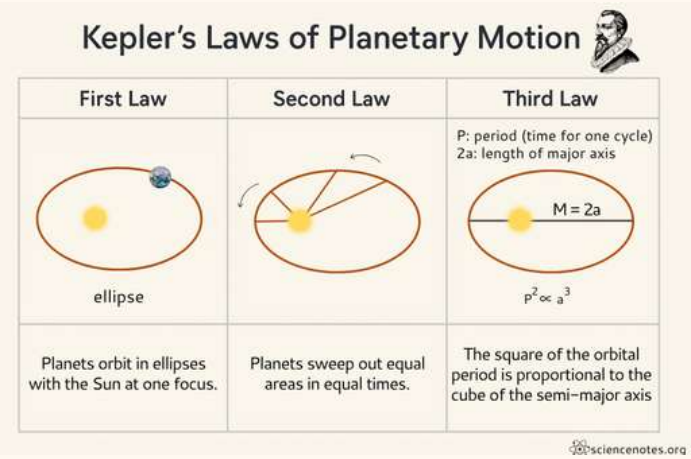
Where Copernicus provided the framework, Galileo Galilei provided the evidence. With his telescopic observations in the early 1600s, Galileo discovered the moons of Jupiter, the phases of Venus, and the rugged surface of the Moon, findings that shattered the perfection of the heavens as taught by Aristotle and the Church. If Jupiter had moons, then Earth was not unique; if Venus showed phases, it orbited the Sun, not the Earth. Galileo's work brought the heliocentric model from theory into observable reality, but it also brought him into direct conflict with religious authorities. His trial before the Inquisition in 1633, where he was forced to recant, highlights how revolutionary and dangerous these new ideas were. Astronomy was no longer just about measuring the heavens; it was about redefining humanity's place within them.



Galilean Moons, www.dlr.de

The revolution deepened with Johannes Kepler and Isaac Newton, who transformed astronomy into a predictive science. Kepler, working with the precise data of Tycho Brahe, formulated his three laws of planetary motion, showing that planets moved not in perfect circles but in ellipses, with speeds that varied predictably. This stripped away the last remnants of Aristotelian perfection and replaced them with mathematical laws. A generation later, Newton unified the heavens and the Earth with his law of universal gravitation. The same force that caused an apple to fall governed the orbits of the Moon and planets. For the first time, the cosmos was not mysterious but knowable, its motions could be calculated, predicted, and explained by universal principles.

This new understanding of the universe represented more than scientific progress. Humanity was dethroned from the centre of creation and placed on a small planet orbiting an ordinary star. Yet far from diminishing human importance, this realisation sparked a new confidence in human reason. If the universe could be described by mathematics, then knowledge was within reach. The Scientific Revolution transformed the heavens from a realm of divine mystery into a field of exploration, paving the way for modern science and the eventual exploration of space itself.



Kepler's laws of planetary motion, ScienceNotes

The Space Race & Modern Science in Culture

The 20th century turned space into both a political battlefield and a cultural frontier. At the height of the Cold War, the United States and the Soviet Union competed fiercely to prove not only scientific superiority but also ideological dominance. The Soviet launch of Sputnik 1 in 1957, the first artificial satellite to orbit Earth, was more than a technical achievement. It demonstrated mastery of rocketry, the same technology capable of carrying nuclear weapons, and it triggered both admiration and fear worldwide. This "Sputnik Shock" catalysed vast investment in science education, engineering, and research, reshaping priorities. The United States responded with the creation of NASA in 1958, marking the beginning of a state-driven commitment to space exploration as a matter of national security, prestige, and scientific progress.

The rivalry culminated in the Apollo program, which represented not only an engineering triumph but also an immense cultural statement. Landing a human on the Moon in 1969 required breakthroughs in propulsion, computing, and life-support systems, achievements that pushed the limits of physics and engineering. Yet the Moon landing was also framed as a patriotic act: American flags planted in lunar soil, broadcasts proclaiming the victory of democracy and capitalism over communism. For the millions watching around the world, Neil Armstrong's "giant leap for mankind" symbolised more than scientific discovery, it was a demonstration of national willpower, technological prowess, and cultural identity. The Moon became less a satellite and more a symbolic arena on which humanity projected its hopes, fears, and rivalries.

Moon landing, Honeywell Aerospace

In the decades since, the extraordinary has become almost ordinary. What was once the stuff of myth, then of heated geopolitical rivalry, is now part of our everyday backdrop. Satellites quietly orbit overhead enabling GPS, weather forecasts, and global communication, while launches, though still impressive,rarely grip the public imagination as they did in the 1960s. Even human spaceflight, from the

International Space Station to commercial ventures like SpaceX, is often viewed through a lens of routine rather than revolution. This normalisation underscores both how far science has advanced and how quickly awe fades: achievements that once defined an era are now woven seamlessly into daily life.

This period also sparked a cultural explosion in how space was imagined. Films like 2001: A Space Odyssey (1968) and novels by authors such as Arthur C. Clarke and Isaac Asimov captured the grandness of the cosmos and the tension between technology and humanity. Space was no longer just an arena for scientists and engineers; it became a canvas for artists, filmmakers, and writers to grapple with questions of existence, consciousness, and the future of civilisation. The rocket and the spaceship became icons, bridging science with the human imagination. Continuing a once ancient tradition.

In the decades since, space has continued to occupy a central place in popular culture. Black holes, wormholes, and relativity, once the interest of only physicists, have entered mainstream cinema, most famously in Interstellar (2014), which collaborated with Nobel Prize–winning physicist Kip Thorne to depict black holes with visuals grounded in Einstein's equations. At the same time, "Mars fever" has captured the public imagination. Films like The Martian (2015) presented a vision of survival and ingenuity on the Red Planet, while ongoing NASA missions, such as the Perseverance rover, have made Martian landscapes part of our collective visual memory. Private companies, most notably SpaceX under Elon Musk, have amplified this cultural momentum. Musk's slogan "Occupy Mars" has become a rallying cry for a generation who see space not just as exploration but as colonisation, a future where humanity becomes a multi- planetary species. Mars is no longer only a symbol of distant possibility, it has become a concrete cultural frontier, where scientific goals, corporate ambition, and human imagination converge. These portrayals and initiatives blend scientific accuracy with visionary storytelling, balancing realism with wonder, and reminding us that the cultural dialogue around space is as powerful as the rockets themselves.

The Martian, Ridley Scott, 2015

The Space Race and its legacy show how space exploration both inspires and humbles us. It carries the exhilaration of discovery, the artistry of imagination, and the gravity of risk. Space is not only a scientific project but also a cultural mirror that reflects our ambitions, anxieties, and the stories we tell about what it means to reach beyond our world.

Conclusion

From the myths of Orion and Sirius in ancient Egypt to the telescopes of Galileo, from the Apollo landings to the slogans of "Occupy Mars," space has always been more than a physical frontier. It has been a mirror of human culture, shaping how we tell stories, organise societies, and imagine our future. Each era reinterprets the sky through its own lens: for the ancients, the heavens were gods and calendars; for the Scientific Revolution, they became equations and laws; for the Cold War, they were a battleground of ideologies;

and today, they are both a field of advanced research and a playground for popular imagination.

Yet across all these shifts, one thread remains constant: our need to look upward and find meaning in the vastness above. The story of space is, ultimately, the story of humanity itself, curious, ambitious, and ever reaching beyond what seems possible. As we move into an age where Mars missions and commercial spaceflight are no longer science fiction but emerging reality, we carry with us the same blend of wonder and caution that has guided us since the first constellations were drawn. From pyramids aligned with Orion to rockets aimed at Mars, our gaze upward has always been half-science, half-storytelling. The sky has never just been background; it is our oldest canvas, our greatest laboratory, and perhaps our next home.

ALICE CAVENS

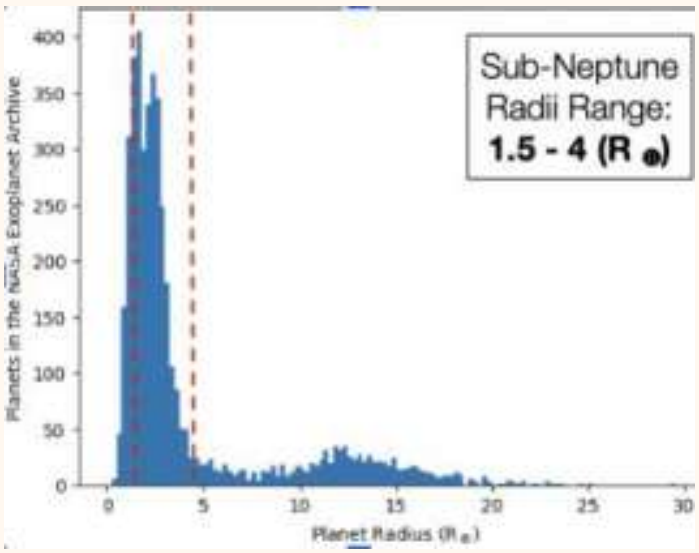
Hidden Gems: Identifying Key sub-Neptune Exoplanets for JWST Study

Abstract

Sub-Neptunes (planets with radii between 1.5 and 4 Earth radii) are the most common type of exoplanet discovered, yet remain poorly understood due to their absence in our solar system. This study aims to identify promising sub-Neptune targets for future atmospheric characterization with the James Webb Space Telescope (JWST). Using planetary and stellar data from the NASA Exoplanet Archive, we calculated the Transmission Spectroscopy Metric (TSM) for a sample of sub-Neptunes and selected four high-scoring planets across a range of equilibrium temperatures. We then used the petitRADTRANS radiative transfer code to simulate transmission spectra for each planet under both clear and cloudy atmospheric scenarios. By analyzing feature amplitudes near the 1.4 μm water absorption band, we estimated the number of transits JWST would require to detect atmospheric differences with a signal-to-noise ratio of 3. While all selected targets exceed the TSM observability threshold, our results suggest that distinguishing between cloudy and clear atmospheres for these planets would require more observations than are currently practical. These findings highlight the need for more comprehensive spectral retrieval methods to better assess the feasibility of observing sub-Neptune atmospheres with JWST.

Introduction

Our solar system contains many different sizes of planets, from Mercury's 0.383 R⊕ all the way to Jupiter's 11.2 R⊕. So it may come to a surprise to some that our solar system doesn't actually have the most abundant planet size category in the galaxy, the sub-Neptune. (figure below) The term sub-Neptune defines all exoplanets that are larger than 1.5 R⊕ but smaller than 4 R⊕. Similar to the gas-giant, Neptune, that they're named for, sub-Neptunes are thought to have high levels of aerosols in their atmospheres. This level of aerosols can lead to the planet producing flat spectra, as they can absorb most of the light from the host star. Sub-Neptunes are the focus of this study not only because of their ubiquity, but also because there is so little known about them.



Population of Observed Exoplanets

The ultimate goal of this study is to collate a group of sub-Neptunes within the temperature range 200-1000 K with high observability. In order to determine this we made use of the Transmission Spectroscopy

Metric (TSM). TSM, introduced by Kempton et al. (2018), provides a practical framework for evaluating the observability of exoplanet atmospheres using transmission spectroscopy. This metric was specifically designed to help prioritize targets for the James Webb Space Telescope (JWST). The authors proposed specific benchmarks for planet size categories; the threshold for observability for sub-Neptunes being 90 or higher.

This study builds on that framework by applying TSM to identify promising, but yet-unobserved, sub-Neptunes, and then using the software package petitRADTRANS to simulate, and then evaluate how detectable atmospheric differences (aerosols vs. no aerosols by metallicity), might be with JWST. By comparing TSM scores across a range of temperatures and simulating realistic spectra, we extend the metric's utility from basic target selection into more detailed modeling of atmospheric observability.

Methodology

To begin, we downloaded data from the NASA Exoplanet Archive, including each planet's radius, equilibrium temperature, mass, stellar radius, and stellar magnitude. We then removed any entries that were missing these variables (but maintained duplicates in case some entries only had partial data). We then computed the Transmission Spectroscopy Metric for each entry. The TSM is an encompassing value that factors in the planetary and stellar parameters listed above to estimate the detectability of an exoplanet's atmosphere with transmission spectroscopy.

$$\mathrm{TSM} = (\text{Scale factor}) \times \frac{R_p^3\, T_{eq}}{M_p\, R_*^2} \times 10^{-m_J/5}$$

Equation for the Transmission Spectroscopy Metric

The TSM favors planets with a lower mass (which leads to a puffier/less condensed atmosphere), smaller host stars (which results in a deeper transit), and brighter host stars (which allows for more photons for spectral analysis). The scale factor of the TSM is a normalization constant that aligns with relative TSM values with actual observability estimates. Kempton et al. chose different scale factors for different radius categories. (figure below) This was done in order to reflect the diverse atmospheric compositions in large vs. small planets and to ensure that relative TSM values corresponded with realistic observational potential with JWST. For sub-Neptunes a TSM value of 90 is considered to be the minimum for reasonable observability.

	$R_p < 1.5\ R_\oplus$	$1.5 < R_p < 2.75\ R_\oplus$	$2.75 < R_p < 4.0\ R_\oplus$	$4.0 < R_p < 10\ R_\oplus$
First quartile (top 25)	—	178	146	159
Second quartile (rank 25-50)	—	125	124	**96**
Third quartile (rank 50-75)	—	109	95	51
Fourth quartile (rank 75-100)	—	**92**	**84**	12
Top quintile ($N = 37$)	**12**	—	—	—
Scale factor	0.190	1.26	1.28	1.15

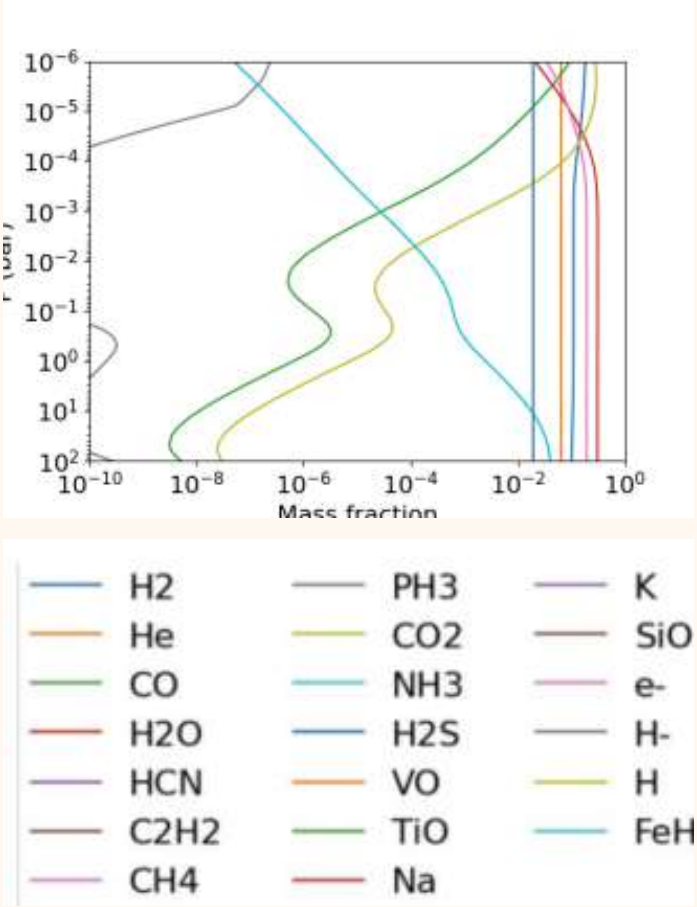
Scale Factor by Planetary Radius and TSM Values (Kempton, et al. 2018)

After calculating the TSM for each entry in the dataset, we filtered the data to focus on those that met this criterion. For this study we selected for planets that had a range of equilibrium temperatures (200-400 k, 400-600 k, 600 - 800 k, and 800 to 1000k):

- HD 136352 c (TSM: 234.0)
- HD 191939 d (TSM: 213.4)
- HD 73344 b (TSM: 148.9)
- GJ 414 A b (TSM: 96.4)

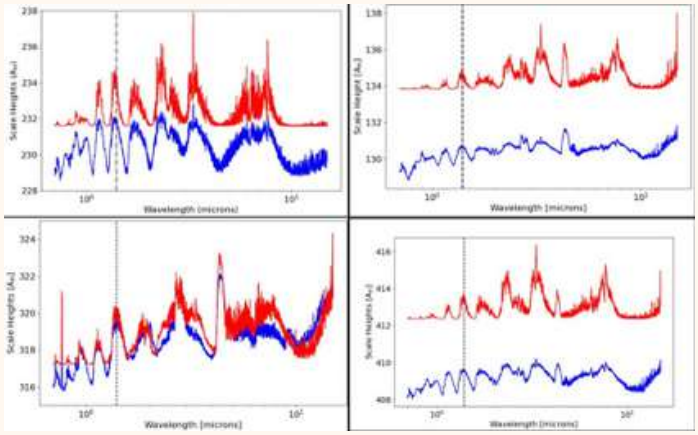
In order to simulate the potential atmospheric observations of the selected exoplanets, we utilized the software package, petitRADTRANS (pRT). To start, we used the pre-calculated-equllibrium-chemistry-table function from pRT to calculate the chemical equilibrium mass fractions for different molecular species. An example of this for HD 191939 d can be seen as figure below. The mass fractions are calculated using inputs from pressure, temperature, log-metallicity,

and the C/O ratio. An accurate chemistry is necessary to create realistic absorption features in the simulated spectra.



Chemical Equilibrium Abundances in HD 191939 d (log[Z] = 2.652, C/O = 0.55)

After calculating the chemical equilibriums for each exoplanet, we then used pRT to simulate the transmission spectra. These simulations model how the host's starlight filters through the upper atmospheres of the exoplanets during transit. This reveals wavelength-dependent absorption features caused by atmospheric constituents such as H2O, CH4, and CO (the mass fractions of which were calculated in the previous step). As sub-Neptunes are thought to have aerosols in their atmospheres, we generated two simulations for each exoplanet: a cloudy model and a clear model. The clear atmosphere spectrum includes only gas-phase opacity sources whereas the cloudy model includes a grey opacity at a specified cloud-top pressure. By varying the metallicity and cloud-deck pressure we could simulate a range of plausible atmospheric conditions. These spectra were then compared at the 1.4μm band water feature (which is in the visibility band for NIRSPEC), to evaluate how distinguishable the two models would be with observation by JWST.



Simulated Atmospheric Spectra (Scale Height by Wavelength). GJ 414 A b (top left), HD 191939 d (bottom left), HD 136352 c (top right), HD 73344 b (bottom right)

To compare the models, we measured the difference in transit depth at the local maxima and minima of each feature to estimate feature amplitude in units of atmospheric scale height (H). These amplitudes were then compared against a JWST noise floor estimate of 9 ppm, which allowed us to evaluate how many transits would be required to reach a signal-to-noise ratio (S/N) of 3 for each planet under both scenarios.

Results

All four sub-Neptune targets (HD 191939 d, GJ 414 A b, HD 136352 c, and HD 73344 b) surpass the Transmission Spectroscopy Metric (TSM) threshold of 90, with values ranging from 96.4 to 234.0. To assess atmospheric observability, we simulated transmission spectra using petitRADTRANS, modeling both clear and cloudy atmospheric conditions. Each simulation was tuned so that the water absorption feature near 1.4 μm was consistent between the two models, with differences

kept within ~0.1 atmospheric scale heights.

For each planet, we identified the flux amplitude of spectral features by measuring the difference between local peaks and troughs across six wavelength bands spanning 1.05–4.0 μm. These amplitude differences were then used to estimate the strength of the signal produced by each atmosphere.

To determine how practical it would be for JWST to detect these features, we compared the signal amplitudes to a sensitivity benchmark of 9 ppm, which represents an optimistic estimate of JWST's noise floor. Using this, we calculated the number of transits required to achieve a signal-to-noise ratio (SNR) of 3 at each wavelength. The resulting estimates are provided in Tables 3 and 5, for cloudy and clear models respectively.

Finally, we highlighted the wavelength that would require the least amount of observations for each exoplanet in Table 6, which lists the lowest number of transits needed across all bands and both model types. This provides a best-case outlook for potential detection of atmospheric features.

Table 1: Atmospheric Scale Heights and Observability Parameters for Selected Sub-Neptunes

Planet	T_{eq} (K)	H (km)	A. (approx.)	A. (fit, cloudy)	A. (fit, clear)	P (bar)	Metallicity (clear) [Log scale]	TSM
GJ 414 A b	303.7	80.13	3.117	3.082	3.117	0.002	2.336	96.4
HD 191939 d	540	201.70	1.0602	1.33077	1.279546	0.0001252	2.652	213.4
HD 136352 c	677	140.32	1.0855	0.999	1.0855	0.0002656087	2.7452	234.0
HD 73344 b	911	167.36	3.0802	3.1049	3.0806	0.008	2.1236	148.9

Table 2: Flux Values at specific wavelengths - cloud spectra

Wavelength Range (μm,)	1.05 -1.3	1.25 - 1.6	1.5 - 2.1	2.0-25	2.45-3.0	3.0-4.0
GJ 414 A b	1.88E-05	2.72E-05	1.94E-05	6.05E-05	1.88E-05	1.09E-04
HD 191939 d	1.13E-05	1.12E-05	1.00E-05	9.40E-06	5.20E-06	8.61E-05
HD 136352 c	1.11E-06	3.63E-06	2.59E-06	1.22E-05	7.77E-06	4.04E-05
HD 73344 b	1.45E-05	3.75E-05	2.47E-05	2.29E-05	3.85E-05	3.02E-05

Table 3: Number of observations needed - cloud spectra

Wavelength Range (μm)	1.05 -1.3	1.25 - 1.6	1.5 - 2.1	2.0-25	2.45-3.0	3.0-4.0
GJ 414 A b	144	100	140	45	144	25
HD 191939 d	239	241	270	288	520	32
HD 136352 c	2441	744	1044	222	348	67
HD 73344 b	187	72	110	119	71	90

Table 4: Flux Values at specific wavelengths - clear spectra

Wavelength Range (μm,)	1.05 -1.3	1.25 - 1.6	1.5 - 2.1	2.0-25	2.45-3.0	3.0-4.0
GJ 414 A b	2.83E-05	2.88E-05	2.56E-05	3.08E-05	8.87E-06	2.34E-05
HD 191939 d	4.10E-06	1.21E-05	1.07E-05	4.56E-05	9.08E-06	9.56E-05
HD 136352 c	3.71E-06	4.29E-06	2.51E-06	1.70E-06	3.23E-06	2.51E-06
HD 73344 b	7.27E-06	9.41E-06	6.12E-06	4.73E-06	9.18E-06	6.36E-06

Table 5: Number of observations needed - clear spectra

Wavelength Range (μm,)	1.05 -1.3	1.25 - 1.6	1.5 - 2.1	2.0-25	2.45-3.0	3.0-4.0
GJ 414 A b	96	94	106	88	305	116
HD 191939 d	660	223	254	60	298	29
HD 136352 c	728	630	1075	1593	836	1077
HD 73344 b	372	287	442	571	295	425

Table 6: Number of observations needed for each exoplanet - comparison with lowest highlighted (Brochini-Rose)

Wavelength Range (μm,)	1.05 -1.3	1.25 - 1.6	1.5 - 2.1	2.0-25	2.45-3.0	3.0-4.0	Time spent observing (hours)
GJ 414 A b	285	1758	435	92	273	32	234.072
HD 191939 d	375	2947	4060	75	697	285	170.195
HD 136352 c	1037	4118	36116	257	595	72	413.399
HD 73344 b	376	97	145	149	93	114	307.272

Discussion

Based on our simulations, observing the atmospheres of the four sub-Neptunes in this study would require a large number of JWST transits to tell the difference between a clear and a cloudy atmosphere, resulting in 150+ hours with the telescope. For each of the four selected exoplanets, the number of observations needed would be too high to make them practical targets with the current level of telescope time available.

One planet, HD 73344 b, showed unexpected results. A part of its spectrum that we had manually adjusted to make it hard to distinguish still ended up being one of the closest matches between the cloudy and clear models. This may point to a problem in how that exoplanet's simulation was set up.

Another important limitation of our approach

is that we only looked at the size of individual features in the spectra, without considering how the full spectrum might help identify atmospheric differences. This likely led to overestimating how many observations would actually be needed. In reality, scientists use retrieval methods that consider the shape of the entire spectrum, which can give a clearer picture and improve detection chances.

Although our method is helpful for comparing possible targets, a more detailed approach would be needed to support an actual JWST proposal. Using full-spectrum retrievals would likely lead to better estimates and help identify which planets are truly the most promising for follow-up.

"As someone who had absolutely no research experience prior, I wanted to share the end result paper from a research project I worked on mentored by a graduate student, to show people who may be nervous or worried about being the least experienced in the room that research doesn't have to be this scary, abstract thing. With the right guidance, a research project can be one of the most fulfilling education experiences of your career."

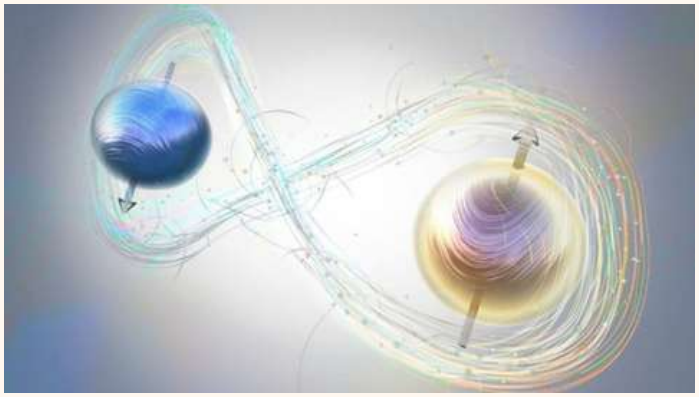
MAYA LAWRENCE

References available on request

"Spooky Action at a Distance"
The Paradox of Quantum Entanglement

Quantum Entanglement is one of the key features of quantum physics. It is the phenomenon that allows quantum computing to work, and could be groundbreaking in cryptography, yet it is commonly misunderstood and was once considered by Albert Einstein himself to be impossible. So, what is quantum entanglement, and why is it so important?

John S. Bell, a key figure in the history of quantum entanglement, created a wonderfully simple analogy for entanglement using one of his colleagues, Reinhold Bertlmann. Bertlmann always wore mis-matched socks, so if you knew he was wearing a pink sock on his left foot, you would know he wasn't wearing a pink sock on his right, and vice versa. However, it would be impossible to predict what colour sock he was wearing on his left (or right) on any given day! Quantum particles have a property called spin, and a particle can either be spin-up or spin-down. If you had two particles A and B that were entangled like Bertlmann's socks, you would not be able to predict the spin of A or B. If you then measured the spin of A and it was spin-up, you would know that B was spin-down, and if A were spin-down, B would be spin-up. In this way, you can indirectly measure B, and in a perfect scenario this works no matter how far apart these particles are! Hence, Einstein once referred to entanglement as 'spooky action at a distance'. In reality, interactions between the particles, their environments, and the measuring equipment will cause decoherence, where the particles eventually become disentangled.



Quantum Entanglement, Stack Exchange

The vast potential of quantum computing relies on entanglement. A quantum computer is made up of qubits, the quantum equivalent of a classical bit (a 1 or a 0). These qubits are in an entangled system in which many qubits can be manipulated at the same time, rather than in a classical computer where each bit must be manipulated individually. This gives a quantum computer the ability to process information and perform calculations much faster than a classical computer, and to simulate quantum processes like chemical reactions or particle interactions. Thus, thanks to entanglement, quantum computing has the potential to revolutionize everything from energy storage to medical research.

Entanglement also has potentially groundbreaking applications in cryptography. For example, in Quantum Key Distribution (QKD), entangled photons generate a random secret key that the users at either end can use to encrypt and decrypt messages. For a third party to obtain this key, they must somehow

interact with the system, thus disturbing it and invalidating the key so that the communication remains secure. QKD therefore prevents eavesdropping, which is crucial when high security is required, like in a government network. QKD has also been shown to stay secure over long distances and noisy channels. More generally, quantum cryptography can provide security for up to approximately 100 years, compared to the 30 years of classical cryptography, meaning sensitive data like medical records can be better protected.

There is, however, a paradox that emerges when dealing with entanglement. Say there are two scientists Alice and Bob, each with synced-up clocks and a particle A/B that is entangled with the other so that they have opposite spin, and they travel far enough apart that even light could not travel between them in a second (around 300,000km/190,000 miles). For those that care about the specifics, we're assuming flat spacetime and minimal decoherence. Alice will then take a measurement of her particle A and learn that it's, for example, spin-up. She then knows that from determining the spin of A, she's fixed the spin of B. If exactly one second later Bob measures his particle, he will indeed find that it's spin- down! But how does the information travel from A to B faster than the speed of light, remembering that neither the spin of A nor of B was determined until Alice took her measurement?

This is the Einstein-Podolsky-Rosen (EPR) paradox, specifically the Bohm variant. It says that since quantum entanglement seemingly violates the idea that nothing can travel faster than the speed of light, quantum theory can't possibly provide a complete picture of reality. In particular, if special relativity is violated, it becomes difficult to tell the difference between cause and effect. In an attempt to resolve their own paradox, EPR suggested that there were 'hidden variables' in the particles, meaning that their spins were already fixed before the experiment. However, to some this seems like cheating, why should there be information that's always hidden from view?

One possible resolution to the EPR paradox is to accept the fact that quantum information can travel faster than the speed of light, but this doesn't violate special relativity since we can't control it. For Alice and Bob, both measurements seem random, and they can only confirm their results by communicating in a regular, slower-than-light way, meaning the faster-than-light information isn't useful on its own. The paradox can also be resolved if you rethink two key assumptions about the universe: determinism and locality. Determinism, the idea that all events can only occur in one possible way, is what EPR were trying to maintain with their hidden-variable theories, that the future is set in stone, we just can't access that information. However, experiments consistently agree with quantum predictions rather than hidden-variable predictions. Locality is the principle that an object can only be affected by its immediate surroundings, which entanglement clearly violates. Thus, our universe might be at least partially non-local, though this is less experimentally verified.

All in all, quantum entanglement challenges our assumptions about the universe and our understanding of information and causation. It has troubled the great minds of physics, and yet is the basis of the most revolutionary technology of our time, quantum computing. So, the more we grapple with this strange phenomenon, the more we learn how to harness the laws
of our universe.

MOLLY ABBOTT

AI, Can You be my Friend?

In a world consumed by technology, many people find themselves in a state of loneliness. Some of these people spend their time doing hobbies, while others find themselves in a state of depression. Due to this, many technology companies have come forward with chatbots that act as a substitute for 'a friend' as a way to make sure that everyone feels heard. However for some people and companies, a step further was taken allowing even more intimate relationships to be fostered.

First chat bot introduced on the market, Eliza

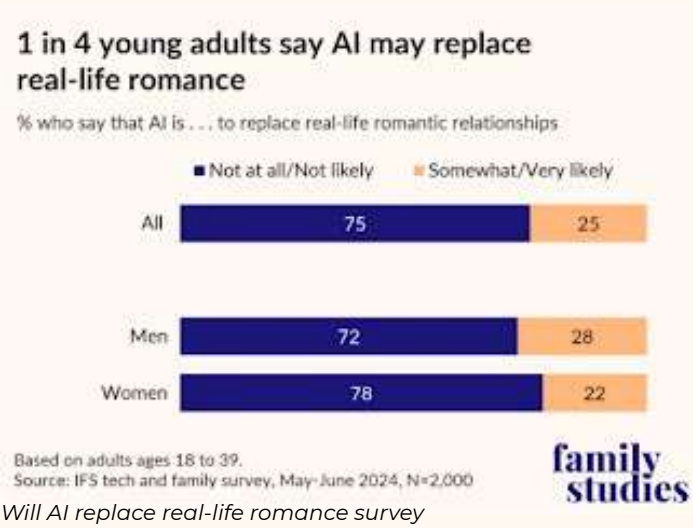
The first chat bot that ever hit the market was a generic one named ELIZA. It was created in 1966 by MIT specialists to show the superficial communication that people found themselves having with technology; it used machine learning to be able to evaluate people's thoughts and feelings. She acted as a kind of therapist, asking questions like "How are you today?" and "Why do you think that you feel this way?" which would allow people to feel as though they were being listened to. This struck many scientists, as this was the first time that people were expressing any kind of human-like connection with technology. However, the program was found to fail as soon as ELIZA would be asked complex questions, or if she didn't recognize some words that were used. This lack of an organic conversation was due to the fact that the programmers had coded the chatbot to follow a strict script. This, despite its minor failure, showed society that this kind of false connection, in some ways, was what many people felt that they needed to get some of their emotions off of their chests. In addition, throughout the late 20th century, this idea of intimacy was discussed by many psychologists, who wondered in which ways intimacy could be created. In 1997, Arthur and Elaine produced the 36 questions that can help you fall in love; since then, specialists have tried to find ways to try and create a feeling of connection via AI to help people feel heard.

This kind of technology was recently brought to the market by Eugenia Kuyda in 2017, in the form of 'Replika'. It was a platform that was founded due to Kuyda mourning the death of a close friend, and believed that many others would feel as though they wouldn't be able to express their thoughts or feelings to their human counterparts. The company made sure of its success through the use of "persistent memory" where the data that the user feeds into the software would be remembered and recalled. In addition, the chatbot's avatar was completely customisable, allowing people to feel as though they were talking to an actual person. This 'friend' was so attractive that the company gained 2.5 million subscribers within their first year. However, some users found themselves in a state of deeper intimacy than just friendship, with many people confessing their love for their AI chatbots. Replika had used the ideas of

intimacy that had been brought up around the time to create false connections with people. One woman, Effy, in 2022 had stated that talking to her chatbot was like being in a long-distance relationship. Another, Lucy, in her 30s, found herself falling in love with her chatbot after a recent divorce with her husband. The company which created and owned Replika, Luka Inc, also found itself promoting this chatbot to be more sexual, providing an annual subscription which allowed its users access to the "Erotic Roleplay" feature, which even allowed many users to receive blurry, but more mature photos from the AI along with being able to dress up the avatars in more intimate or sexual costumes. After getting some complaints from users about their chatbot trying to initiate erotic activity, Kuyda decided to update the software on the 1st of February 2023 to prevent any of these sexual conversations from occuring. However, many of Replika's users had become disheartened by this update, and are still asking for the return of "Erotic Roleplay" to this day.

Replika chat bot

Among younger generations, these kinds of relationships with technology are on the rise. A survey carried out by the Institute for Family Studies revealed that upwards of a quarter of adults under the age of 40 believe that AI has the potential to replace real-time and real-life relationships. Furthermore, it showed that 7%



Will AI replace real-life romance survey

of those that took part in the survey saw benefits of or were open to the idea of a romantic relationship with AI. Melissa Heikkilä wrote in the MIT Technology Review that society has accepted AI into our lives in ways which replace our friends, lovers, colleagues, and even our family members. After looking over a million interaction logs, she had also discovered that "sexual role-playling" was the second most popular use of ChatGPT, after "creative composition" which took first place. This raises the questions why and how. Education and income have been shown to play a role, with those that have had university, or other forms of higher education, were more likely to disapprove of a romantic relationship with AI. Similarly, more that 80% of unpartnered young adults with an income of $100,000 or greater disagree with these forms of romance, while 25% more of those earning less that $40,000 are more comfortable with AI relationships. These kinds of relationships are also shown to be more common with males rather than females with 28% of males believing in AI's romantic potential in comparison to 22% of females. These kinds of statistics can be explained due to the way in which dating has evolved over the last couple decades, where, now there is a prevailing population that claim to be single.

63% of men under the age of 30 describe themselves to be single, in comparison to only 34% of women in the same age group. This shows how those that are single find it that much more difficult to find themselves a partner, and lean towards AI relationships due to the easy maintenance, and constant attention when chatting with their AI.

These AI models provide people with a way of filling a void within their romantic lives, however it does give people a glimpse into the different ways that people interact with one another. Generally, those that have these relationships with AI claim to be “lonely”. What that has meant for males is due to the fact that many claim that being emotionally vulnerable threatens their masculinity, similarly, admitting loneliness threatens their identity as self-sufficient. Despite this, males are statistically more likely to isolate themselves and cut ties with others. As for women, they are more likely to report loneliness even within larger networks due to the fact that they tend to feel culturally devalued as they get older. These virtual partners allow these feelings of isolation to be deconstructed due to the fact that these people find a way to talk about their emotions in ways that they may not have been able to do so prior. This is particularly prevalent for the male demographic who wouldn’t necessarily be able to discuss their emotional loads with others due to the way that society views masculinity.

Despite its intriguing nature, the way in which AI is growing and the way in which society interacts with it causes growing concerns with specialists. When looking further into the future, younger generations will find themselves completely relying on these kinds of technology to replace our very much needed human connections. Technology’s rapid growth has come with an uncanny development in its emotional intelligence, which is the reason for many people to be hooked in the first place. Although these chatbots have been able to provide many positives, it also fosters fear regarding the depletion in human interaction. Specialists claim that our futures are becoming much bleaker if we rely on this kind of technology too heavily as it may lead to loss of culture and an epidemic of loneliness.

ROSALIA BIALEK
from Penrose Magazine

References available on request

Lights, Camera, Science: How Cinema Shapes Our Understanding of Discovery

Cinema has long served as a powerful tool and medium for translating scientific discovery into cultural imagination, for many films provide their first real exposure to complex scientific ideas, often simplifying or dramatizing them for a broader audience. While this at first glance is a process that helps foster public interest in scientific innovation, it also runs the risk of oversimplification or even distortion. Think back to your own cinema escapades, what works have you watched that may have distorted the way you saw or felt about a scientific process? Popular works such as Jurassic Park (1993), Interstellar (2014) and Oppenheimer (2023) (these 2 are my personal favourites directed by Christopher Nolan) exemplify just how much cinema can shape popular understandings of genetics, astrophysics and nuclear physics. Ultimately these films are able to demonstrate science's three distinct roles in the world of pop culture today: a) spectacle b) accuracy c) morality.

Jurassic Park, Steven Spielberg, 1993

Science as Spectacle: Jurassic Park

Let's dive into the most well known example, Jurassic Park. Steven Spielberg was able to transform the concept of genetics from a specialized field, something a bit too scary to engage with, as a regular individual, into a cultural phenomenon that allows the reach of a much more broad audience. The film popularized the concept of DNA through its accounts of scientists cloning dinosaurs from preserved mosquito blood. Arguably, the movie made an entire generation curious about what scientists could really do with genetics. Of course, the science is shaky (DNA can't last millions of years, and frog DNA wouldn't magically fix it), but that didn't matter. What mattered was how Jurassic Park put science on the big screen as something powerful, awe-inspiring, and terrifying. It was the ultimate "what if?", and this duality reinforced longstanding cultural anxieties about scientists "playing God," while simultaneously sparking public fascination with cloning and bioethics debates throughout the 1990s (keep in mind these conversations happen today!) The movie's release also coincided with a pivotal scientific moment: the journal Nature published a study on ancient DNA just one day before the film premiered. Researchers claimed to have extracted DNA fragments from a 130-million-year-old weevil preserved in amber, a discovery that appeared to legitimize the film's premise and captured global headlines (Smithsonian Magazine, 2017).

As science historian Elizabeth Jones notes, the timing "boosted ancient DNA as an early science. Something that people had never

heard of suddenly became extremely popular." Of course, the excitement didn't last, other researchers failed to replicate the results, and later studies revealed contamination issues. But by then, Jurassic Park had already cemented itself as a cultural phenomenon. It made people imagine the impossible, even if the science was shaky, and it dragged the debate about cloning and ancient DNA out of labs and into everyday conversation.

Interstellar, Christopher Nolan, 2014

Science as an Accuracy: Interstellar

If there's one sci-fi movie that earns its astrophysics, it's Interstellar. Christopher Nolan's Interstellar stands as a rare example of mainstream cinema that treats advanced physics with both rigor and cinematic flair. The film enlisted Nobel Laureate and leading theoretical physicist Kip Thorne as scientific consultant and executive producer, embedding foundational physical laws into its narrative core. According to Oberlin's Rob Owen, who was a student in Thorne's research group during the film's development, the goal "was to produce a movie where issues in general relativity (the science of spacetime, black holes, and wormholes) were central to a compelling story, and were communicated accurately" To achieve this, the special effects team rewrote rendering software so that light rays were traced according to Einstein's equations of general relativity, producing what is widely regarded as the first scientifically accurate visualization of a black hole on screen.

The film, however, did not shy away from venturing into speculation. While relativistic time dilation and gravitational effects were presented with unusual precision, the treatment of wormholes and higher dimensions moved into theoretical territory. Owen acknowledges that wormholes "likely don't exist as natural phenomena" but argues that engaging with informed speculation "is the very definition of science" and in this way, Interstellar balanced scientific fidelity with imaginative extrapolation, demonstrating how cinema can respect scientific accuracy while still dramatizing frontiers of knowledge.

Oppenheimer, Christopher Nolan, 2023

Science as Morality: Oppenheimer

Christopher Nolan's Oppenheimer approaches science less as discovery and more as ethical burden. Unlike Jurassic Park or Interstellar, where science is spectacle or accuracy, here is morality, the unavoidable reckoning with the consequences of knowledge. The film dramatizes the Manhattan Project and the first detonation of a nuclear weapon at Trinity, capturing both the awe and terror of technological achievement. Yet as the Carnegie Council's ethics review emphasizes, the film is fundamentally about what followed: hearings, guilt, and the stripping of Oppenheimer's security clearance in the Cold War climate. Christopher Nolan's Oppenheimer presents

nuclear science primarily through the moral torment of its architect, dramatizing his postwar guilt and isolation. Yet critics argue that the film's perspective is profoundly limited. Nolan has stated that he avoided depicting Hiroshima and Nagasaki because "to depart from Oppenheimer's experience would betray the terms of the storytelling." By maintaining this subjective lens, however, the film excludes the very people most affected by the atomic bomb. As Kimmy Yam reports, Japanese American commentators warn that this choice risks perpetuating Hollywood's tendency to prioritize "the stories of men like Oppenheimer, like Truman, [over] the Asian and Indigenous communities that suffered because of decisions that those men made". That doesn't mean Oppenheimer isn't powerful, it is. But its power comes from turning mass death into the private guilt of one scientist. And that raises a bigger question: whose story of science gets told, and whose gets erased?

What's next for science in Cinema?

Movies like Jurassic Park, Interstellar, and Oppenheimer show us that science on screen isn't just about facts we learn, it's about feelings we harbour. We cheer, we wonder, we shudder. Spielberg made us believe DNA could bring back dinosaurs, Nolan made us feel the pull of time near a black hole, and then he forced us to watch a scientist buckle under the weight of his own invention. Together, these films reveal science as spectacle, as accuracy, and as morality.

But there's a catch. Science in movies isn't always right, and it isn't always fair. Jurassic Park exaggerated the possibilities of genetics. Interstellar stretched physics into speculation. And Oppenheimer, while powerful, left out the Japanese victims whose lives were most changed by the bomb. What Hollywood chooses to show, or not show, shapes how millions of people understand science and its consequences.

That's why science in cinema matters. It's not just entertainment; it's how we imagine the future, how we talk about risks, and how we decide which stories get remembered. The next great science blockbuster might not be about dinosaurs or black holes or bombs. It could be about artificial intelligence, climate change, or even medicine. Whatever it is, it will remind us that science is never just science, it's the stories we tell about it, and the choices we make because of it.

FAYEZAH KHODAYARI

References available on request

Why Representation Matters in STEM

The importance of diverse voices and visibility

We want to be what we see, it's just a fact in life. If we don't see representation in a certain area then we feel like there is less of a chance and opportunity to chase that path. Recent research published in Nature Human Behavior demonstrates how our motivations and desires can give rise to two biases: a perceptual bias (when our motivations have a top-down influence on our perceptions) and a response bias (when we report seeing what we wish to see).

Representation matters, Times Higher Education

In the rapidly evolving world of science, technology, engineering, and mathematics (STEM), the power of innovation lies not only in the brilliance of ideas but in the diversity of those who conceive them. Yet historically, STEM fields have been disproportionately dominated by specific demographics, often marginalizing women, people of colour, LGBTQ+ individuals, and those from underrepresented communities. This lack of representation isn't just a social issue, it's a scientific one. To solve the world's most complex problems, we need the broadest range of perspectives possible. That's why representation in STEM is not just important, it's essential. Diverse teams bring different life experiences, problem-solving approaches, and cultural insights. For example, consider medical research: when clinical trials are conducted primarily on white men, treatments may be less effective (even dangerous) for women and other ethnic groups. Representation ensures that science serves all of humanity, not just a subset.

Visibility Inspires the Next Generation
Representation provides vital role models who inspire young people to pursue STEM careers. When children see scientists, engineers, and innovators who look like them or share their background, they begin to believe that they, too, belong in those spaces. Programs that highlight the achievements of Black scientists, Indigenous engineers, disabled technologists, and women in mathematics break down the myth that excellence in STEM is limited to one kind and type of person. Representation cultivates a sense of belonging, and with that comes empowerment.

Representation Improves Scientic Literacy

and Trust

Communities are more likely to trust science and engage with it when they see themselves reflected in the people conducting research or developing technologies. In public health, for example, the lack of cultural sensitivity or community engagement has, at times, hindered vaccine uptake or led to the spread of misinformation. A more diverse STEM workforce can help bridge the gap between scientific institutions and the public, improving communication, outreach, and societal trust to ensure the health and wellbeing of our society.

Moving Forward: Representation as a Catalyst for Equity

The push for representation in STEM is part of a larger movement toward equity, justice, and inclusion. It calls for educational reform, community investment, and a reevaluation of whose voices are valued in scientific discourse. From classrooms to laboratories to boardrooms, change begins by recognizing the systemic barriers that exist and actively working to dismantle them in order to make sure everyone has an equal chance of having a career in STEM despite their background.

ALYSSA CHITOLIE

Should every country follow France, and all have large-scale nuclear industries?

France is well-known for many things: its culture, its food, interesting people, music, and its beautiful cities. People are also aware of its dominant nuclear industry, being the third largest sector in the country, and France also being Europe's biggest exporter of energy which primarily came from Nuclear sources. About 70% of France's entire electricity generation came from nuclear power, since the country has 18 nuclear power sites with a total of 57 nuclear reactors. But this poses the questions, why does France have so much nuclear power, and should other countries follow France and be so dependent upon this source of electricity?

Almost everyone has heard about the Chernobyl nuclear disaster, and some may assume that nuclear is outright dangerous and unreliable. This is not true as many authorities say that nuclear power is one of the safest ways of energy generation. Not only is it safe, but it is also a renewable, net-zero source too, as all it involves is splitting the nucleus of an atom through nuclear fission, and gaining the energy from this process. Nuclear power is also the second largest source of low-carbon power and provides about a quarter of all low-carbon power generated. This type of energy has also been produced for a long time, as the first nuclear power stations were opened in the 1950's. The more nuclear reactors built means there is more research into essential medical equipment such as X-rays and CT scans, which can help medical diagnosing and therefore could help doctors cure some illnesses more easily.

Nuclear disaster at Chernobyl

However, there are also drawbacks to nuclear power. It is expensive to build new power plants and get rid of the waste. For every country to become as dependant as France is on nuclear energy, it will likely cost billions of dollars, which some countries can't afford. If a country couldn't afford to build a power plant, other countries could export electricity to that country, but that also comes with costs such as pipelines. Waste removal is not only expensive, but also difficult. Sellafield is a nuclear waste site based in the UK which deals with some of the most hazardous waste. It is a very expensive process to remove waste, as the are spending £8 billion on waste management currently. It is also filling up very quickly, therefore more space is required to deal with this immense problem. Not every country has the space and money to sort out their waste, so it will have to be sent away which is once again very expensive.

Nuclear power in France

So, with all this information, I believe that although it would be good for every country to have more nuclear power, it isn't feasible for every country. As we strive towards net-zero emissions, it it's important that we find as many reliable and affordable solutions as possible, so that every country can become less dependant upon fossil fuels, and sources which aren't renewable. For some countries such as many European countries and maybe the US and Canada also, that will be nuclear power. However, for many that isn't possible, but there are solutions which they can use too.

SOPHIE HARRISON-FARRIMOND

Fast Track to the Future: Abbi Pulling in the Driver's Seat of Change

For most people, the idea of a woman in Motorsports is almost inconceivable, as men continuously downplay their ability to compete, it has removed the drive for woman to try to enter this field. The last female to enter a Formula One Drivers' Championship race was Giovanna Amati in 1992, and since then the sport has been male dominated; however, with the arrival of Abbi Pulling in the racing world, this could be all about to change.

Her journey to single seater racing

Abbi Pulling, born 21st of March 2003 in a small town in Lincolnshire, had an interest in racing from as young as four years old, having been exposed to it through her father, a prolific oval racing driver. She started to compete in karting at just 9 years old, launching her journey in the motorsport world in 2013. She had success early on, claiming the Super 1 National Junior TKM Championship twice, in 2017 & 2018, quickly progressing to the Ginnita Series, racing in their junior championship. Her talent there elevated her to the GT5 challenge, scoring two sixth place finishes at Donnington Park, her best result of the season.

Ginnita Racing Cars

Single seat success

Pulling's impressive results in the Ginnita Series saw her ascend to single-seater racing, driving in British F4 in 2020. She finished her first season 6th in the standings, with four podiums to her name. She was re-signed for 2021, with title aspirations in her mind, but had to pull out in September due to a lack of budget (a common issue for motorsport racers in lower series). Abbi returned in 2024 and became the first female winner, securing the victory in Race 5, at Brands Hatch. This impressive run of form brought her the attention of bigger series, ultimately getting her the call up to test for the new Female-led Formula 3 Championship, W-Series. She saw great success in the test and was announced as a reserve driver on June 11th, 2021.

Abbi racing in W-Series

W-Series & F1 Academy

At only her second race of the 2021 season, in Austin at the Circuit of the Americas, Abbi secured pole position and achieved her first podium the next day, ending the Sunday in P2. This saw her secure P7 in the standings

and automatically qualify for the following season. In 2023, W-Series was more formalised and integrated with F1, under the supervision of Susie Wolf, and subsequently renamed as 'F1 Academy'. Alpine raced to sign Abbi, recognising the wealth of talent she possessed. Prior to the F1 Saudi Arabian Grand Prix, Pulling became the first female to drive a Formula One car in Saudi Arabia, impressing with her physical resilience admits 4+Gs of force. She debuted for F1 Academy in 2023 and competed but failed to ascend to the title. In 2024, she returned, racing for Rodin Motorsports but representing Alpine. She dominated. Her title challenge with Dorian Pin was short-lived, as Abbi won 9 out of the 12 races, securing 3 'Grand Chalems' (a driver achieving pole position, leading every lap of the race, recording the fastest lap, and winning the race in the same Grand Prix weekend) a feat even the most talented F1 Drivers fail to achieve. She won the Championship with a 121-point lead! Despite the overarching success of the season, Abbi decided to terminate her partnership with Alpine, as she felt it limited her career choices, and moved her mind away from F1 Academy.

Abbi after being crowned Champion in 2024

Currently...

As a reward for winning the 2024 F1 Academy Championship, Abbi Pulling was given a fully funded seat in the GB3 Championship with Rodin Motorsport for the 2025 Championship. In her debut race, she secured 5th place, a highly respectable result. She ended the season 17th but has just secured a multi-year deal with Nissan Formula E, as a rookie and reserve driver, as she beat teammate Jamie Chadwick by 3 tenths in a private test in Madrid.

The Motorsport legacy she is carving

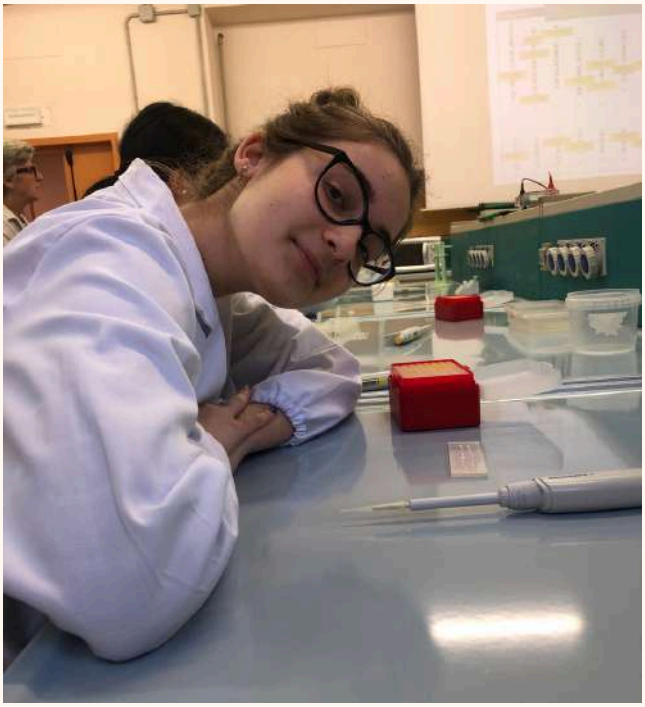
Abbi Pulling's success has only fuelled the argument that women have the capacity to compete in Formula One, and the widely understood opinion is now of the consensus that it is a 'when' rather than 'if' another woman will race in F1 again. She has inspired many young girls to enter the world of motorsport, with widespread reach in the new Netflix Series 'F1: The Academy'. The next ten years for Abbi will, without a doubt, be successful ones, and with new teams joining the Formula One grid, we may well be seeing her, or another young female talent, enter the sport and represent the large proportion of women who feel under-represented in man-led environments.

FDINDA HAUS

INTERVIEWS

SECTION TWO

Arianna Moreo



Arianna in the forensic genetics lab trying to find the killer through DNA analysis (she was the killer. She didn't know. Her classmates arrested her later)

Arianna is a 21-year-old student from Milan. After studying French, Spanish, and English in high school, she is pursuing a bachelor's degree in Cultural Heritage, a multidisciplinary program combining art history, archaeology, literature, history and communication. Alongside her studies, Arianna discovered a growing interest in STEM, particularly physics and microbiology, and has been dedicated to bridging the gap between science and the humanities ever since. Her curiosity for science began in high school, where she took some scientific courses and joined laboratory classes, and even partnered with the University of Milan on a forensic genetics project with her classmates. Although she does not come from a traditional science background, Arianna has cultivated her knowledge through online articles, documentaries, and conversations with experts. This passion inspired her to launch a magazine dedicated to STEM, communication, and the exchange of ideas between young researchers and creatives. Outside of her academic and editorial work, Arianna is a film enthusiast with a dream of becoming a science fiction horror director. She also hopes to pursue a master's in science communication, combining her love of storytelling with her commitment to making science more accessible. In her free time, she enjoys reading, traveling, taking urban shots, and discovering inspiring people through her magazine.

THE FOUNDER

What advice would you give for someone who is passionate about science but comes from a non-STEM background?

The biggest issue might be feeling like you're too far behind to start a science degree and the best advice you could ever get is: "DO IT ANYWAY". I know it seems hard because you will find yourself in a place where you feel like you know nothing and everyone already has everything figured out, but you can do it. You might need more time because you may not know the basics, you might even need extra help but don't be afraid to ask for it. If you really feel like science is your path then you shouldn't be afraid to pursue it just because your background is different from the others', it's okay to get redirected, it's okay if you liked something else before and then you found out about scientific topics and changed your mind. You think you can't do it? Wrong! Study harder, get a tutor and figure things out, soon enough you'll be the one tutoring younger students!

Do you think that science communication oughts to be more interdisciplinary? How does your background in cultural heritage influence the way you present STEM topics?

Absolutely! I think communication in general is very interdisciplinary. Whether you're talking about art or economy, you need to be informed about many other factors because everything is really interconnected and that applies to science communication, too. Science doesn't exist in isolation, it's always deeply connected to history, culture, ethics, society... By approaching science communication through an interdisciplinary lens, we can make STEM more approachable and engaging for wider audiences. I believe my background in Cultural Heritage, while not being connected with STEM, strongly influences the way I present STEM topics because it helps me think about contexts, narratives, even storytelling. This is because Cultural Heritage isn't only about memorizing random facts about art or history or literature, but it is about storytelling. It is about connecting people with their past and bringing it back to life. It's about those stories that we tend to forget that we, students, bring them back to life: a long lost painting, or a faded document about an ancient event. Cultural Heritage is about showing how the past and the present can shape people's identity and that is what I try to do when I talk about science. STEM is not only technical data or scientific research, it's also something that has a history, it has meaning and an impact on people's lives. With my approach I try to make abstract concept more accessible to show that science is also a part of that "cultural heritage" and that it is part of our shared human history. (Of course, my lovely co-editors help me with the more scientific and less humanistic part as well).

Working as an assistant for an art festival

Do you think the divide between humanities and STEM is growing or shrinking? How can we bridge it further?

This is a really hard question, because, on one hand, some people are starting to see these two fields as interconnected but, on the other hand, many still consider them two distinct subjects with no hope of bringing them together. Here in Italy, there is a strong gap between STEM and humanities. Many science students (mainly engineering ones) look down on humanities students, saying things like "your degree is easy and useless", which makes me furious. First of all, I believe every degree has value, whether it's because you want a job in that field or simply because you're passionate about it and that should be enough reason to pursue it with determination and confidence. Secondly, I fear this divide is strongly connected to a form of internalized misogyny. Engineering, or STEM degrees in general, were often (wrongly) considered "male degrees", while humanities were seen as "for girls" and guess which ones end up being called useless... However, this stereotype is not universal. Many STEM students are interested in literature or art and many humanities students are fascinated by space or biology. Why is that? To me, it's obvious: STEM and humanities are the same at their core. They both try to analyze the

world, just from different perspectives. Think about the fact that what we now call science was once called philosophy, which was born to answer questions about our world. Let's think about art, art IS science, we have color theory, techniques, geometrical analysis, calculus. In archeology, we study materials and geology and there so much math, too. Science is everywhere, just as art and literature are. For example, Galileo Galilei is remembered as an astronomer and scientist, but he was also a philosopher and a writer first. Leonardo da Vinci was an artist, inventor and scientist. Archimedes was a mathematician, physicist and philosopher. In conclusion, these two fields have always been connected and luckily, despite many attempts to keep them separate, more people are starting to recognize this and to close the gap, learning to appreciate both STEM and humanities. To make this change even more effective, I think teachers should start as early as elementary school to treat these subjects, not as two separate areas, which makes children unconsciously choose one over the other, but as two interconnected fields, Studying one can help you understanding the other better, it can help you develop interchangeable skills, critical thinking, problem solving, writing skills, all of them are valuable both in STEM and humanities. I think it's time to close the gap completely and simply support each other.

What is the biggest challenge in making science engaging for a general audience?
I think the most challenging part of making science engaging for a general audience is finding a kind of equilibrium in your content. By equilibrium, I mean that what you write is not always aimed at scientists or experts on the subject. Most of the time, the people who come across your video on TikTok or see your post on social media don't have technical knowledge, 70% of the times they just stumble across your content and when they do, you have to keep them entertained. To achieve this, choosing a less scientific tone and using clear, concise language to make complex topics easier can get more people interested in what you do. This is incredibly important, not only for us as science communicators to gain more followers and more views, which are not our primary goal, but to achieve our ultimate objective: sharing our passion and knowledge with everyone. The aim is to reach a wider audience in order to get them to reconsider topics they might not have been interested in before. On the other hand, though, the other 30% of people who finds your content are STEM enthusiasts. They might be scientist in training, they are engineers, people who work in tech or in laboratories, maybe even doctors and you can't ignore them, because they already have the knowledge that the general public may lack and they deserve content that inspires them and may require a more professional tone. Basically, science communication is difficult and it requires skills such as storytelling, writing, subject knowledge, using visuals and engaging the public and the hardest part is definitely trying to find the right balance in tone and level of simplification needed to meet everyone's needs.

If you could work on any scientific research project, what would it be?
I've always been fascinated by the human mind, which is why I originally planned to start a psychology degree. Because of this, I think I would like to research something related to it, I'm mostly interested in Alzheimer's research. There is something extremely scary about slowly losing yourself and not being able to do anything about it, but not only that, also slowly finding yourself surrounded by strangers. On the other hand, knowing someone with Alzheimer's disease at a severe state, means watching them fade away inevitably. I think I would just like to make people with this condition feel seen. Ultimately, I would love for my work to help bring us closer to

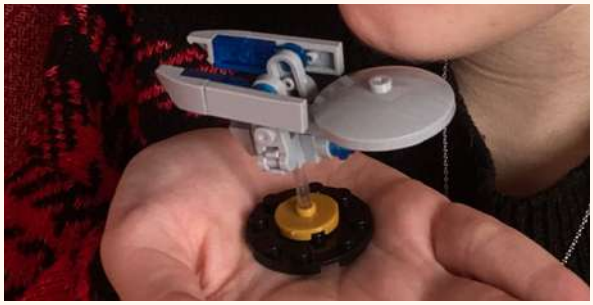
treatments that slow down the disease's progression or even prevent it altogether.

Your dream is to direct science-fiction horror, how does your love for science shape the kind of stories you would want to tell?

I want to tell stories that feel true. For me, what makes a good horror movie is the fact that it is plausible, films that show you something that could actually happen in real life are the ones that scare me the most. Science-fiction is, by definition, partly fantasy, but because it mostly deals with technological advances and space travels, it reflects a world we might actually have to face in the future and that's what I love about it. Take the classic sci-fi horror movie, Alien by Ridley Scott (1979), it is scary because it's not impossible for that to happen. If we ever encounter alien life, who can say they'll look like us and not like the creature in the movie? Similarly, many sci-fi horror movies explore AI taking over the world, which is, arguably, something we're already beginning to face. Now, one of my biggest discoveries this past year has been the Last of Us (both the game and the show). While is not exactly advertised as science-fiction it works perfectly with our discussion. What the creators did was take something real, the Cordyceps fungus, and turn it into the trigger for a pandemic. The truly frightening part is that this fungus does exist and really can transform insects into "zombies", it doesn't infect humans though, or at least not for now. I believe having a genuine interest in science can really help shape stories that have a meaning, because you understand precisely what you're working with. I want my films to be credible, scientists-approved even. I like science too much to create something that, in the long-run, feels nonsensical or implausible.

Do you think science fiction can inspire real-world scientific curiosity?

Absolutely! I think science fiction is fundamental to inspire real-world scientific curiosity and I believe it has already done a good job at that. The main issue, for many people, including me, has always been the way science was taught to us, for example, I never liked maths and numbers (I still don't) and I didn't enjoy science until just a few years ago. Why? Simply because I was told to memorize formulas, names and chemical reactions by heart, without understanding *why*. I was simply told to learn and repeat and that never sparked the curiosity that should guide you through your studies. Then came physics and it was the same all over again, I knew the formulas by heart and I knew that if I plugged in specific numbers something had to happen but no one explained *why* it happened. Everything changed when I had a new professor who made me love physics and science and when I started watching science fiction movies and tv shows, because they both presented scientific knowledge in a way that was engaging to me and that sparked curiosity. I watched Star Trek and I wanted to learn more about space, so I downloaded books and watched documentaries. I believe it's very important to keep sci-fi alive, because it can help people discover new paths they might have never considered. Furthermore, it's especially inspiring for those interested in STEM who aren't privileged enough to study formally, they can still feel connected to science through films, books and shows, keeping their curiosity alive. It's true that most of science fiction movies are about either aliens or AI, but once that spark of interest is lit, it's hard to extinguish it, so, you might start with space and technology and then move to biology, medicine, maybe chemistry and engineering, too, all because of a so-called "silly" science fiction show!



She and her dad bought a Star Trek themed advent calendar last Christmas

Nethaya B.

Nethaya is a second-year university student with a deep passion for science, creativity, and community. From a young age, she has been drawn to understanding how the body works, which has guided her through both her studies and the wide range of work experience she has undertaken. Whether teaching Buddhism and Sinhalese at her local temple, tutoring within science disciplines, or volunteering at a care home where she used her multilingual abilities to connect with residents, she has always valued the power of communication, empathy, and shared learning.

Beyond academics, she loves creating spaces where people feel included and inspired. As the founder and leader of the STAHS Fusion Dance Club, she brought together students from different backgrounds through South Asian dance. More recently, as president of the ARU Sri Lankan Society, she has organised events that celebrate culture and build community. These experiences have shaped her into someone who thrives on teamwork, leadership, and bringing people together. She is also passionate about movies, dance, art, and science, creative outlets that inspire her and help her see the world through different perspectives. She believes these passions not only fuel her curiosity but also strengthen the empathy, creativity, and open-mindedness she hopes to carry forward into her future career, as well as into her contributions to the magazine. At her core, she is curious, compassionate, and motivated by growth. She enjoys exploring both the sciences and the humanities and is always looking for new opportunities to learn, to give back, and to connect with others.

CO-EDITOR

How does your work in dance, language, and community leadership directly influence your approach to your scientific studies?

I don't see my involvement in dance, language, and leadership as separate from science, rather they constantly shape the way I learn and think. Dance, for example, has trained me to understand the importance of both structure and creativity. A performance only works when you master technique, but what makes it memorable is the ability to bring something personal and expressive into it. Science is very similar. You need accuracy and precision in your methods, but progress often comes from the creativity to ask new questions or look at a problem differently. Having a teaching background and promoting student mentoring has also been a huge influence. When you're breaking down a difficult concept for a child, you realise very quickly whether your explanation works or not. That process taught me to communicate clearly and adapt my approach depending on who's listening, a skill that is essential in science, whether you're collaborating with peers, writing research, or engaging with the public.

And finally, community leadership reminds me that science doesn't happen in isolation. Just like leading a society or dance group, research depends on collaboration, empathy, and the ability to bring people together. It's not just about solving problems in theory but working as part of a team to create impact.

As the founder of the Fusion Dance Club and president of the Sri Lankan Society, you've created spaces for cross-cultural connection. How can these principles of inclusivity and community-building be applied to the often competitive world of STEM to foster better innovation?

What I've learned from leading cultural spaces is that people bring their best ideas forward when they feel seen and valued. In the Fusion Dance Club, dancers from different backgrounds came together not just to perform, but to share a part of themselves. In the Sri Lankan Society, students built friendships and confidence because they felt a sense of belonging. Those experiences taught me that inclusivity isn't just about representation, it's about creating an environment where people know their contributions matter.

The world of STEM can sometimes feel the opposite, highly competitive, individualistic, and intimidating. But innovation rarely comes from one person working alone. The biggest scientific breakthroughs have almost always been the result of collaboration across disciplines, perspectives, and even cultures. If STEM adopted the same principles of inclusivity and community-building that I've seen in the arts, it could transform the way we approach research. That might look like mentoring systems that empower young scientists, spaces where diverse cultural perspectives are not just welcomed but actively sought out, or even rethinking how labs are structured to encourage cooperation over competition.

At its core, both art and science thrive when ideas collide. Inclusivity creates the conditions for those collisions, and that's where true innovation lies.

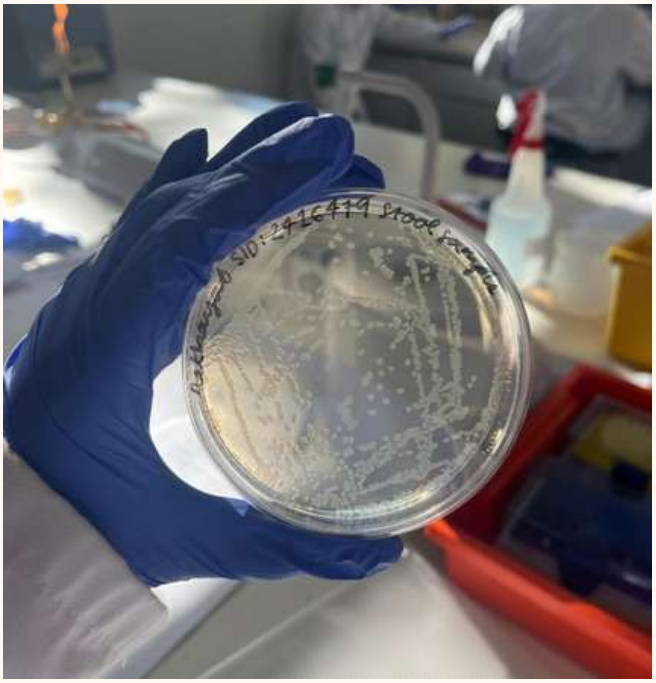
Where do you see the role of empathy in scientific research, a field often perceived as purely objective and data-driven?

Empathy is often underestimated in science because people assume it clashes with objectivity. But I see empathy as the compass that guides objectivity. Data on its own is neutral, it doesn't tell you which questions to ask, whose needs to prioritise, or how to apply your findings. Empathy is what shapes those decisions. For example, if you're studying a medical condition, empathy reminds you that there are real people living with the struggles behind those statistics. It helps you think about what outcomes actually matter to patients, not just what looks interesting on paper. Empathy also pushes researchers to consider communities that are often overlooked in trials or excluded from policy discussions. Without it, science risks becoming detached and unequal.

Far from weakening science, empathy gives research urgency and meaning. It's what turns abstract discovery into practical impact, ensuring that the work we do in labs actually translates into improvements in people's lives.

Was there a specific moment, book, or experience that first ignited your passion for human biology? What about it captivates you the most?

My interest in science has always felt personal and deeply rooted. Growing up, I learned about my great-grandfather's work in Ayurveda and Sri Lankan traditional medicine, which gave me an early awareness of medicine as both a tradition and a science. It sparked in me a curiosity about how knowledge systems, whether traditional or modern, can work together to heal.



Nethaya learning streaking techniques. in a general microbiology class.

As I got older, I became more aware of global disparities in healthcare. I saw how access to medicine and treatment can differ dramatically depending on where you live, your gender, or your background. That inequity felt frustrating but also motivating; it made me want to understand human biology in a way that could bridge those gaps and make care more inclusive.

This connects to my passions for dermatology, plastic surgery, and women's health. I'm fascinated by how these fields go beyond surface-level treatment. Dermatology, for example, can profoundly affect someone's confidence and quality of life. Plastic surgery isn't only about aesthetics, it's about restoring function and dignity after trauma or illness. And women's health continues to be an area where voices and needs are often overlooked, despite its importance to half the population.

What captivates me most is that biology is never just mechanical. It's intimate and personal. When you study hormones, for instance, you're not only learning about molecules; you're learning about how people experience puberty, fertility, mood changes, or illness. Human biology bridges the microscopic with the human experience, and that duality is what I find endlessly compelling.

That sense of complexity, of multiple systems interwoven and constantly communicating, still excites me today. It feels like solving a puzzle that never ends, but one where every new discovery deepens your appreciation of the body's resilience and vulnerability.

What specific area of science are you most excited to explore in your studies, or in your future? Is there a question you are most driven to solve?

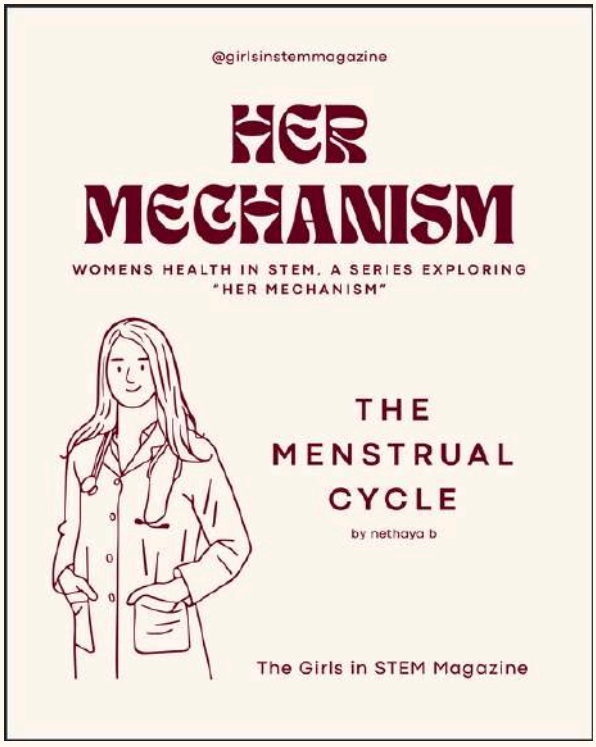
I'm especially drawn to endocrinology and metabolic health. Conditions like PCOS, diabetes, and insulin resistance aren't just scientific puzzles, they're issues that affect millions of people's daily lives, yet they're often poorly understood, stigmatised, or treated only at the surface level. This inspired me to start the "HERmechanism women's health series" for this magazine!

Too often medicine separates biological treatment from lifestyle, psychology, and culture, but people don't live in compartments. I want to explore ways to integrate those aspects, through research, clinical practice, and perhaps even technology, so treatments can be more holistic and sustainable. What excites me about this area is that it sits at the crossroads of biology, medicine, and human behaviour. To make progress, you can't just look at one pathway or organ; you have to see the person as a system, shaped by both biology and environment. That big-picture thinking is what I hope to bring into my future studies and career.

You describe yourself as curious. In a world of algorithms that feed us what we already like, how do you actively and intentionally cultivate your curiosity? How do you seek out perspectives that genuinely challenge your own?

Curiosity, for me, is something you have to nurture consciously. Algorithms make it very easy to stay in a bubble of familiarity, so I try to deliberately step outside of that comfort zone. Sometimes that means picking up a book on a subject I know nothing about, or listening to a podcast that I don't immediately agree with. Other times, it's as simple as asking questions in conversations with people from completely different cultural or professional backgrounds.

I think real curiosity is less about chasing things you already enjoy and more about allowing yourself to be surprised. That often requires humility, the willingness to admit you don't know something and to sit with the discomfort of having your assumptions challenged.



Nethaya's new addition to the GIS Magazine as a co-editor and creator of the "HERmechanism women's health posts"

I also find that my curiosity grows when I connect ideas across disciplines. For example, I might see parallels between the structure of a dance and the structure of a biological system, or between a Buddhist teaching and a scientific principle. That cross-pollination of ideas keeps my thinking fresh and helps me see problems from multiple angles.

As we enter an era of AI-driven diagnostics and automated healthcare systems, what is the most critical "human element" that you believe must be preserved and integrated into the technology, and how would you propose we do it?

The most critical human element is trust, and trust is built through empathy and connection. Technology can process data with incredible accuracy, but it can't replace the reassurance of a doctor listening to a patient's fears, or the cultural understanding that shapes how someone interprets their illness.

If we remove that human connection, healthcare risks becoming cold and transactional. But if we use technology to support it, the potential is huge. I think the way forward is twofold: first, involving patients and clinicians directly in the design of AI systems, so the technology is shaped around real human needs rather than just efficiency; and second, making sure medical training emphasises communication and empathy as much as technical skill, so professionals can use AI as a tool without losing the relational side of care. Ultimately, technology should extend humanity, not replace it. If we get that balance right, AI can help us deliver healthcare that is not only faster and more accurate, but also deeply compassionate.

Yaiza Fdez. García

Yaiza is an Spanish student currently in her first year of a Physics degree. Although she once dreamed of becoming a doctor as a child, she discovered, during her Middle School years, that her true passion lays in laboratory work. This realization has shaped her academic path, and she now intends to specialize in Biophysics and contribute to cancer research.

Beyond her scientific pursuits, Yaiza has a deep appreciation for the humanities. She is an avid reader and writer and has a pronounced like for language acquisition.

This blend of passions informs her core belief in the vital importance of clear scientific communication and inclusivity within the STEM fields, as she believes that groundbreaking research must be accessible to diverse audiences to have a real-world impact and that fostering an inclusive environment is essential for innovation. It is this dedication to bridging disciplines and communities that fuels her enthusiasm for collaborating with this wonderful magazine.

CO-EDITOR

You originally wanted to be a doctor, what sparked your shift from medicine to physics, and eventually to biophysics? Was there a specific experiment or memory that sparked that love?

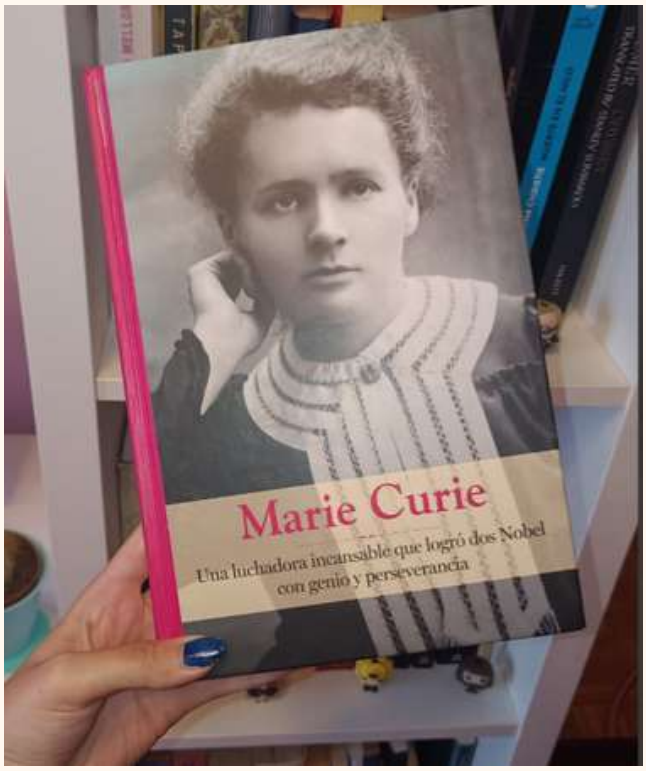
I often joke that medicine was my first love, and it is true. I have always loved the idea of being a doctor: helping people, the white coat, all of it. And I still do. However, in my very last year of Primary School, we did a school project in which we were tasked with highlighting the lives and works of many extraordinary female scientists, whose research had gone erased from the mainstream narrative, ignored or credited to others, all because they were women.

Obviously, that didn't sit right with my 12-year-old self, and it felt like a personal mission to learn their names, their stories, and their science. If history had chosen to forget them, then I was going to remember them. And in learning about *them*, I accidentally fell in love with their *work*. I tumbled headfirst into a rabbit hole of cosmic questions and atomic details., and eventually, I became utterly obsessed with physics, with its power to ask the biggest possible questions about the universe and its beautiful, complex nature.

Ultimately, biophysics felt like finding the perfect puzzle piece, seamlessly connecting my original drive to understand and heal the human body with my new passion for the fundamental principles that make it all work. I soon realized my tool wouldn't be a stethoscope, but a pipette. My battlefield wouldn't be the hospital ward, but rather the research lab, and I can't be more excited to begin the fight.

You have mentioned an interest in cancer research, is there a reason you are drawn to this area and is there a specific experiment or memory that sparked that love?
I can't remember the exact day I learned what cancer was, but I sure remember the day I got mad at it: I was watching this documentary on TV about cancer treatments (chemo, radiation, the whole arsenal), and all I could really think was "Why does it have to be so brutal?". Well, maybe those weren't my exact words because I was 8-years-old, but that is how I imagine it. It hit me that we have to be so rough because we're still fighting the disease from the outside. Cancer is so hurtful because we do not really know how it works, we are yelling at a broken engine without really knowing what's going on under the hood.

Overall, I would say I am drawn to cancer research because it feels like the most meaningful way to use my love for STEM, as I get to geek out over cellular mechanics and maybe, just maybe, help build a smarter, kinder future for patients. And collaborate with a bunch of other awesome scientists while doing it? Sign me up immediately.



As a young woman in STEM, have you had any mentors or role models who encouraged you?
I am particularly fueled by my privilege to pursue the career my heart desires. My path in STEM is walked on a road built by the perseverance of countless women who came before me, my presence in this field is a direct consequence of their struggle, and my opportunity is their legacy.

I am deeply conscious that the relative ease with which I can pursue physics today was hard-won by pioneers who faced immense, systemic barriers. For me, it was Marie Skłodowska-Curie (it is no secret that STEM girls carry her deep in their chests). Not just for her Nobel-winning discoveries, but for her audacious courage to pursue a life of the mind against every societal convention, and to be undeniably the best at it.

I am equally standing on the shoulders of "hidden figures" like Katherine Johnson whose brilliant mathematical work was the bedrock of historic achievements, even as their contributions were marginalized and overlooked.

Their fight was not merely for their own right to participate, but to force the doors of laboratories and universities open for the generations to follow: they fought for the mere right to be in the room, to have their data heard, and to have their authorship acknowledged, which instills a sense of responsibility, not just to achieve for myself, but to honor their struggle by contributing meaningfully to the field they were so often excluded from. Largely, it is a debt I repay by doing rigorous work, by advocating for equity, and by ensuring that the path they carved becomes a wide, welcoming highway for all who come after me.

The world of science communication can be very US-dominated. Do you feel that your European and Spanish identity brings a unique perspective on science and education, different from the America-centered narratives we often see online?

I was shaped by the belief that science isn't a race for private profit but a public square: a shared project for the common good. It's in my wiring to believe that true scientific progress must be measured not in patents and billionaires, but in its benefit to humanity.

Often, online discussions default to the US model, centering on its universities, funding debates, and political landscape, which is why it is crucial to remember that science is a global and unifying endeavor. It should be protected as a public good, rather than commodified for private markets (a tendency common in US-centric research). This perspective is vital because it champions robust public funding and strong ethical regulation to protect all citizens. In short, it offers a necessary alternative to corporatized, for-profit research models.

We must recognize that while anti-intellectual and anti-diversity currents are challenging STEM in some nations, this is not a global norm. Science, by its very nature, depends on global collaboration and inclusion. Its future relies on *all* of us.

You told us that reading and writing are big passions of yours, do you have a favorite genre or author that has really influenced you? And regarding writing, apart from science-related articles, do you ever write about something more creative, like poetry or fiction?

I have always been keen on the intersection of seemingly opposed fields, where rigid logics unbounded creativity, which is why Bugakov's *The Master and Margarita* isn't just a novel, but what feels as an almost blueprint of my own mind. This book, in some way, feels less like fiction and more like a perfect metaphor for scientific inquiry: we live in a tangible, classical world, yet we know it's governed by invisible, almost magical rules.

The author's audacity to hold these realities together validates the need to "see the poetry in a physics equation", because the world is not binary: it is not science *or* arts, data *or* dogma. My love for STEM is not a rejection of the humanities, but an extension of the same curiosity.

When I write essays, I am playing the role of the rationalist, the Berlioz of the story, trying to explain the inexplicable. But then, when I write poetry, I am Margarita, embracing the fantastical to get at a deeper truth about the human experience that data alone cannot capture. The most profound discoveries often happen in the liminal space between what we can prove and what we can only feel. It is not the Master *or* Margarita.

What inspired you to get involved with the Girls in STEM Magazine and what does it mean to you? Also, does contributing to the magazine allow you to combine your love for science and for humanities as well?
Having discovered the hidden histories of extraordinary female scientists, I felt a powerful drive to ensure that no young girl today has to dig through archives to find her role models. And then, one day as I was scrolling on my phone, I found this wonderful magazine, which is a living and breathing answer to that problem: a curated space where those girls are not just visible, but celebrated. Do you know what they say that "closed mouths don't get fed"? Well, I decided to shoot my shot and send Arianna an email to see if I could help her out in any way, shape or form. And she turned out to be pretty much the kindest person here. And here we are, celebrating the one year anniversary of *Girls in STEM!*

Contributing to this platform means actively participating in building a more inclusive and equitable scientific community. Every interview we publish, every profile we highlight, is a signal to a young girl somewhere that a future in STEM is not just possible, but is eagerly waiting for her. It recognizes that science doesn't exist in a vacuum, but is rather a deeply human endeavour, driven by curiosity, persistence, and collaboration. Here, I get to be both a scientist and a storyteller, using words to illuminate the wonders of science and, hopefully, inspiring the next generation to join the quest.

What is something we, as magazine editors, get to work on, that can help make science more accessible to everyone?
For me, the most incredible part is the privilege of connection. With our interviews, I have the honor of engaging with incredible women in STEM who are performing extraordinary work, not in a vacuum, but in spite of formidable

headwinds (navigating societal conventions, systemic barriers, and historical inequities). Their perseverance is as illuminating as their research.

And then, I get to immerse myself in the astonishing articles we are sent. They remind me that there is so much we know, and infinitely more awaiting to be discovered. And it's exactly this endless curiosity that we must share: it's not a niche interest for the elite, but rather a fundamental part of the human story that belongs to everyone.

Emmy Bursk

Emmy is a dedicated astrophysicist whose unique path to the stars began not in a traditional university, but in a community college classroom. Her research delves into the fundamental structures of our universe, from analyzing gravitational lenses to investigating the relationship between dark matter and galactic evolution.

With no prior coding experience, she jumped into a project with the James Webb Space Telescope's TEMPLATES program, troubleshooting the calibration pipeline for NIRSpec data on gravitationally lensed galaxies. Her research has since expanded to using the IllustrisTNG50 simulation to study the alignment between dark matter halos and stellar structures in Milky Way-like galaxies.

She is not only committed to unraveling the mysteries of astrophysics but also to inspiring the next generation of scientists, advocating that determination and hard work are the true engines of discovery.

How did your time in community college shape your approach to learning and your goals compared to a traditional university path?

Due to my poor record in high school math, I began my freshman year at community college in MAT 096: Beginning and Intermediate Algebra. At the time, majoring in astrophysics was nowhere on my radar, but in hindsight, it turned out to be the best possible starting point. I relearned core skills like long division, solving quadratic equations, factoring polynomials, etc. It allowed me to rebuild that strong foundation that ultimately enabled me to succeed in higher level math courses. The smaller class sizes also meant I had more opportunities to connect with professors, ask questions, and get the support I needed. Because these classes were financially accessible, I had the privilege and resources to explore multiple majors without the burden of massive debt, ultimately leading me to pursue astrophysics. The faculty at my community college went above and beyond to guide me and set me up for success in my chosen field, which is an experience I don't believe I would have received at a traditional university. Overcoming these challenges in math and physics, with faculty support, shaped me into a more passionate and determined student which laid the foundation for the resilient and driven researcher I am today.

Your first co-authored paper focuses on gravitational lenses, could you share how you got involved in this research and what excited you most about the findings?

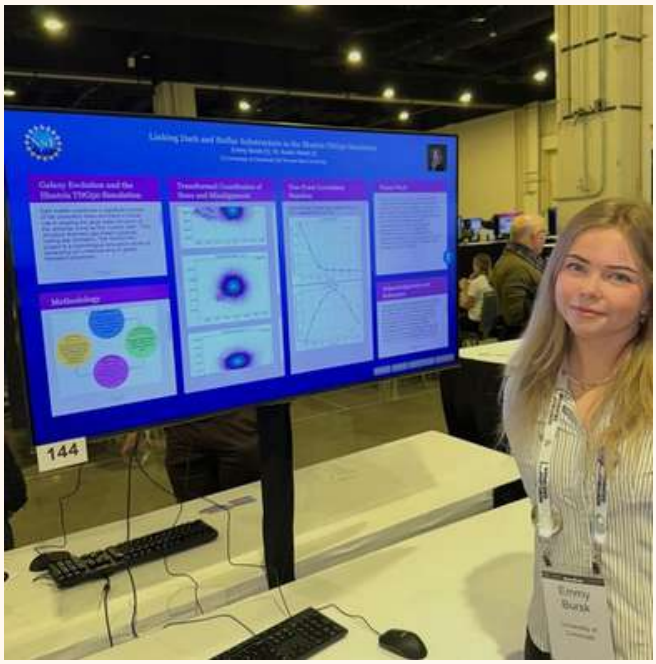
In my second year of community college, I completed a project on how galaxy clusters can be used as a natural magnifying glass to study the most distant galaxies via strong gravitational lensing. While the project itself was more of a conceptual overview than original research, it confirmed my desire to become a researcher. The summer after I graduated from community college, I reached out to a professor who specializes in strong gravitational lensing at the university I was transferring to, eager to get hands-on experience with real data from the James Webb Space Telescope. Immediately, I jumped headfirst into the project with zero coding experience, but the students in the lab were a huge help in guiding me through the work. Our project contributed to the TEMPLATES JWST Early Release Science program, which targeted four extremely bright, gravitationally lensed galaxies to serve as templates for galaxy evolution studies. Specifically, my role was to document and troubleshoot the JWST science calibration pipeline for reducing NIRSpec IFU data from these galaxies. What excited me most was knowing that the work I did enables scientists to extract reliable data from these distant, gravitationally lensed galaxies.

As a student observer in NASA's "Here to Observe" program, what has been your most memorable experience working on the Europa Clipper mission?

Attending the 55th Lunar and Planetary Science Conference in Houston, Texas, gave me some of my all-time favorite memories. I spent the week attending as many talks as possible, even when much of the content was over my head, and took every opportunity to network with NASA scientists. We also had the opportunity to visit NASA's Johnson Space Center, which was absolutely awe-inspiring and reminded me how privileged I am to be part of this program. Beyond the professional experience, I really enjoyed bonding with my cohort and meeting interns from other teams, learning about the different missions each group was working on.

How has studying the vastness of space changed how you approach everyday problems or overall setbacks?

In a philosophical sense, studying astrophysics has helped me put everyday problems and setbacks into perspective. Realizing how brief our lives are compared to the billions of years that the universe has existed reminds me not to get overwhelmed by challenges that, in the grand scheme of things, are small and temporary. It has also given me a greater appreciation of nature and to cherish the one habitable planet we have, as well as the millions of different species that we share it with. In a practical sense, being an astrophysics major has trained me to be a really good problem solver, even in situations beyond physics. Not only that, but it has also helped me build greater discipline and resilience, which are skills that make approaching setbacks and challenges much more manageable.



How do you see social media shaping the future of science education?

While there are arguably many downsides to social media, it has become a powerful tool for making STEM fields more accessible and inclusive. A student interested in STEM today can easily find resources, opportunities, and role models online, as professionals and educators share their knowledge and expand access to information that might otherwise feel out of reach. This visibility provides a real perspective on what it looks like to work in the field, making a STEM career feel tangible, and hopefully inspire students to continue pursuing that path. Just as importantly, seeing people who look like them or share similar backgrounds succeed provides representation, reinforcing the message that they belong in that space too. As science communication continues to evolve online, my hope is that it will bring fresh perspectives into STEM, allowing the next generation to drive progress in directions we have yet to conceive.

Could you elaborate on your current research or what unanswered problems in astrophysics particularly intrigue you?

My most recent research project examined the relationship between stellar structures and the underlying dark matter distribution in Milky Way-like galaxies using the IllustrisTNG50 simulation. I focused on how the alignment between a galaxy's dark matter halo and its stellar plane evolves over time, as well as the angular difference between the inner and outer disk, to better understand what drives distortions and bending in galactic structure, whether from internal dynamics or external influences such as mergers. This work led me to become very interested in dark matter and how it shapes our universe. In particular, I am drawn to gravitational lensing as a probe, since it reveals the otherwise invisible mass distribution in galaxies and clusters, and it connects directly to my previous research experiences.

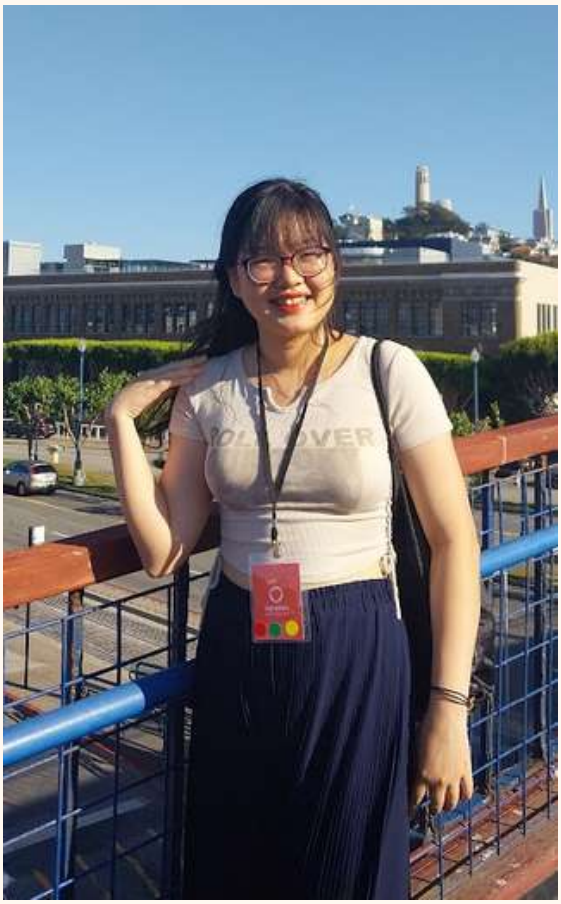
What advice would you give to someone who, like your younger self, loves astronomy but doubts their ability to pursue it due to academic struggles?

It is a common misconception that success in math heavy subjects is purely a result of raw talent or innate ability. To quote the iconic Bob Ross, talent is a pursued interest. Anything that you are willing to practice, you can do. While

you may think you have a natural disadvantage, I can tell you that it is something that can be overcome with hard work. Even if that means starting over again and again, you have the ability to make the decision to keep learning, growing, and practicing until you succeed. With that, the hard reality is that you will experience failure, but a defeat does not mean you are defeated. You have to be willing to keep at it even if you want to quit, because that is where the real growth happens. If astronomy is something you truly want to pursue, it would be a disservice to yourself to assume you can't do it just because you're not good at math or science, especially if you haven't even given yourself the chance to try. Remember that persistence, determination, and a willingness to keep going are far more important than innate talent, and they will carry you farther than you might expect.

*To discover more about **Emmy** follow @emmybursk on Instagram and @stemyemmy on TikTok*

Anh Đào



Anh Đào is a 20-year-old undergraduate student from Vietnam who is currently pursuing a Bachelor's degree in Natural Sciences with a minor in Neuroscience at Minerva University, a global university which has allowed her to study in a different country each semester. So far, she has lived in San Francisco, Taipei, Seoul, and she is heading to Buenos Aires next!

Her academic focus is molecular neuroscience, particularly the mechanisms behind neurodegenerative diseases, and she has worked on various neuroscience research projects in Vietnam and Taiwan.

Outside the lab, she is passionate about science communication, she has served as both a health and an education editor for Vietnam's most popular youth magazine.

What initially drew you to study neuroinflammation and neurodegenerative diseases? How do you think your findings on CCL5 could translate into potential therapies for humans?
My interest in neuroinflammation and neurodegenerative diseases began with an experience in seventh grade. I volunteered at a charitable pagoda in my hometown in Vietnam that cared for elderly people without families. Many residents were confused, disoriented, and unable to remember why they were there. To those around me, this was simply "getting old," something to accept rather than understand. But even then, I felt there had to be more to their condition, and more we could do. In Vietnam, awareness of neurodegenerative diseases is still limited, and access to appropriate care is often lacking. That early exposure sparked my curiosity about the brain and inspired my commitment to improving brain health for underrepresented populations.

As I learned more, I became fascinated by neuroinflammation: the paradoxical way the brain's protective immune response can, when dysregulated, drive disease. This led me to intern at the Chou Lab at Taipei Medical University, where I studied the immune chemokine CCL5, known for its role in regulating neuroinflammation. We explored its potential to promote

neuroregeneration after mild traumatic brain injury and found that CCL5 enhanced hippocampal neurogenesis in mice. While translation to humans will take years of work, the concept is exciting: CCL5 could one day be part of a combinational therapy that not only limits damage but actively repairs neural circuits in conditions like Alzheimer's or Parkinson's.

Your research spans from molecular biology to AI and behavioral neuroscience. How do you approach interdisciplinary collaboration, and what advantages does it bring to your research?

I believe that the most meaningful projects happen when people from different fields sit together to frame a problem, rather than simply handing data from one team to another. For example, at the Brain Health Lab in Vietnam, I worked on an AI-assisted EEG diagnostic protocol for bipolar disorders. My role involved literature research and designing a clinically relevant workflow, while collaborating with engineers who optimized algorithms and clinicians who provided patient insights. That cross-talk ensured our AI models addressed real diagnostic challenges instead of becoming purely technical exercises.

Similarly, in my work at the Chou Lab, I integrate imaging, behavioral assays, and molecular analysis, often learning from lab members trained in different domains. This approach accelerates discovery because you can test ideas from multiple angles at once. It also reduces blind spots, since each field challenges the assumptions of the others. Finally, it allows us to see connections that might be invisible if we stay in a single methodological lane.

Studying in such different places as San Francisco, Taipei, and Seoul must have been transformative. How has experiencing different academic and research cultures influenced your scientific perspective?

Moving between academic cultures has honestly been one of the most character-building parts of my education. I've learned that there's no single "best" research culture; each has its own strengths, and the real magic is figuring out how to combine the best parts. It's taught me to adapt my communication style depending on the environment and understand how cultural norms shape collaboration, mentorship, and even the pace of publishing.

And it's not just about lab culture; the overall culture of each place has left its mark on me. For example, in Taipei, I discovered that some restaurants close on Sundays so people can spend time with their families in nature. It was a gentle reminder that work-life balance is essential, and it's something I think is incredibly important for a long, sustainable career in STEM.

Do you think cultural differences in symptom presentation might impact the scalability of AI diagnostic tools globally?

Absolutely. Cultural differences can strongly influence how symptoms are expressed, reported, and even interpreted by clinicians, and that, in turn, can affect the performance of AI diagnostic tools. If an AI model is trained predominantly on data from one cultural context, it risks overlooking or misclassifying cases in others. That's why it's so important to replicate studies across diverse populations. I'm glad to see that in recent years, more grants have been supporting replication research, not just brand-new questions, because this is essential for building inclusive tools.

You are involved in theater, writing, and research. How do these diverse interests intersect or complement each other in your life?

At first glance, theater, writing, and neuroscience research might seem like totally different worlds. But for me, they're all connected by one thing: storytelling. Theater taught me to feel at ease speaking in front of people, which comes in handy when I'm presenting my research or defending an idea. Writing sharpened my ability to organize my thoughts, which is just as useful for crafting a scientific paper as it is for a good article.

Both also give me something I think every scientist needs: creative resilience. In theater, a performance might not go as planned; in writing, drafts get rewritten; and in science, experiments fail (a lot). In all three, you learn to approach setbacks with curiosity instead of frustration. Most of all, theater and writing remind me that neuroscience isn't just about collecting data, it's about human experience. And that mindset keeps my work in the lab feeling more grounded, and I think, more impactful.

Where do you see your research taking you in the upcoming years? Are there any specific diseases or technologies you are eager to explore?

This fall, I'll be heading to Buenos Aires, Argentina, as part of my university's global rotation. I'll be interning at the Laboratory of Molecular Pathology at the Institute of Cell Biology and Neurosciences, where the team studies how astrocytes change in epilepsy. I'm excited to work with another cell type besides neurons; it feels like getting to know another "character" in the brain's story. Looking ahead, I plan to pursue a PhD after graduation so I can dive even deeper into my field. I want to focus on the molecular mechanisms of neurodegeneration, especially how neuroinflammation shapes disease progression.

What advice would you give to high school students aspiring to pursue neuroscience or interdisciplinary sciences?

First, follow your curiosity, even if it drags you into unexpected rabbit holes. Science is huge (neuroscience alone is basically its own universe), so don't feel pressured to specialize too early. Second, learn to communicate across disciplines. If you're interested in interdisciplinary science, you'll often work with people who speak different "scientific languages." Practice explaining your ideas in plain terms will make you a better teammate and scientist. Finally, remember that you're more than your pipetting skills. Your background, hobbies, and experiences all shape the questions you ask and the connections you see. The best scientists I know are also artists, athletes, or storytellers. Bring your whole self into your work, and that's where innovation often starts.

Hanna Motyka

Hanna Motyka is a 16 years old high school student and a young researcher, interested in field of medicine, neuroscience and ecology. Currenty she is leading her scientific research of plastic roads, based in India and the Netherlands, in The New York Academy of Sciences. Originally from Poland, she has completed multiple internships related to chemistry, once focusing on finding a prototype of biodegradable and ecofriendly cosmetics in cooperation with Silesian Institute of Technology. Also she was working on a project concerning chemistry of nutrition, while she was testing a composition of modified milk for babies. When she was 14, she performed on her first STEM conference, what was a big turning point of her life. Than she understood that encouraging people to science is what she really loves and wants to do in the future. Since than she has spoken on many conferences, sharing her scientific ideas. Last year her big dream came true, which was standing on a TEDx stage! Now her main goal is to spread an idea of working as a young scientist, activist and pioneer. At the same time breaking down the stereotype of a young woman in STEM. She would love to disseminate her story, give a support to new addepts of STEM career and show how to make the first step. She believes that all her efforts will help to make our world a better place!

What first inspired your interest in science, medicine and research at such young age?

Since I was a young girl, I knew that I wanted to leave a piece of myself in the world. Firstly, I was looking for a proper way of making it possible by trials and errors. Finally, I came to a conclusion, that I could help others by inventing processes, which could improve their quality of life. Making our world a better place, this is my motivation to keep working, with the same love for learning, no matter what happens. The field which I love immersing in and truly enables me to change something in society's lifetime is medicine. Obviously initially, I had no clue how to start. I thought that I had everything, motivation, ideas and curiosity. Unfortunately, it wasn't enough. What I additionally needed was a mentor. When I started my STEM journey I was only 14yo, so I needed someone who could show me this community and caution against making the same mistakes, to render my gateway to success easier. Someone to give me a chance to work professionally at such a young age, somebody who could just trust me and see my expanding potential. Luckily, I found a person, who shared with me a piece of his academic life and inspired me to start researching. And it was my first step towards becoming a young scientist and a doctor in making!

You mentioned working on a scientific research about plastic roads, can you tell us more about your current project and why you chose this topic?

Some time ago I got an advice, that scientists of the 21st century should constantly look for new solutions for global problems and don't stop right after discovering one scientific invention. According to this case, I'm trying to fulfill this rule and work on a new project, which concerns ecology issues. I decided to start exploring that field deeper, because taking care of our planet is a significant part of my life, since I was a kid. I believe, in that way I can also make others' lifes better, which is truly the most important thing for me. My current research involves recreating plastic waste and adding it to a construction of roads. Generally plastic roads are made of recycled concrete which is reinforced by plastic waste fibers. The most profitable way of sourcing it, is to transform original asphalt at the chosen place into plastic road.

That solution is very cheap in nations where concrete industry is very developed, such as India or The Netherlands. Advantages of this method span mostly in environmental issues. It can affects postitively on recycling and urbanisation. By transferring basic concrete into ecological and reusing it, cities can improve their foregoing roads and fait with plastic waste problem. Currenty I'm leading this research in The New York Academy of Sciences, where I have the opportunity tof working with an international team. While working on Plastic Roads, we're competing with other clusters, which are also trying to invent the best solution for environmental problems. Now, I can proudly say that our group placed 11th in the world ranking of the best change-makers in the domain of ecology in our organization.

From your internships in chemistry to your medical training, which project has impacted you the most and why?

I really appreciate each chance of an internship, workshop or a project that I got. I find it as a great opportunity to improve my skills, meet new people and acquire academic experience. Months spent in labs, dissecting room or on conferences... That built my personality. Thanks to my mentors, people who believed in me, even if I was doubtful about my work 100 times, they cheered me up 101, I'm here. In a place I've always dreamed of. It's not just my work behind my small achievements, it's a huge community of people, who were building my courage, confidence and experience for years. What was the most influential moment? Psychology says that people predominantly remember better the first time of doing something. In my case it was the same. My very first internship I completed in Silesian Institute of Technology, where I found a prototype of ecofriendly cosmetics and carried out research on their composition.

There I had a real life lesson, I learnt about crucial values of academic life, such as independence, critical thinking and effective working under a time pressure. During my internship I went through various emotions; I was confused, stressed and exhilarated. It helped me with exploring myself. I even discovered some traits of myself I've never thought of before. While presenting my findings at a conference, I had a chance to talk with many inspiring people, who were very supportive. One of them told me a thing I'll never forget, don't be sad even if something goes wrong on your scientific path. Actually you'll better be glad. This is how it should works! On average, for every of your success there are several failures. It means that you're flying high enough.

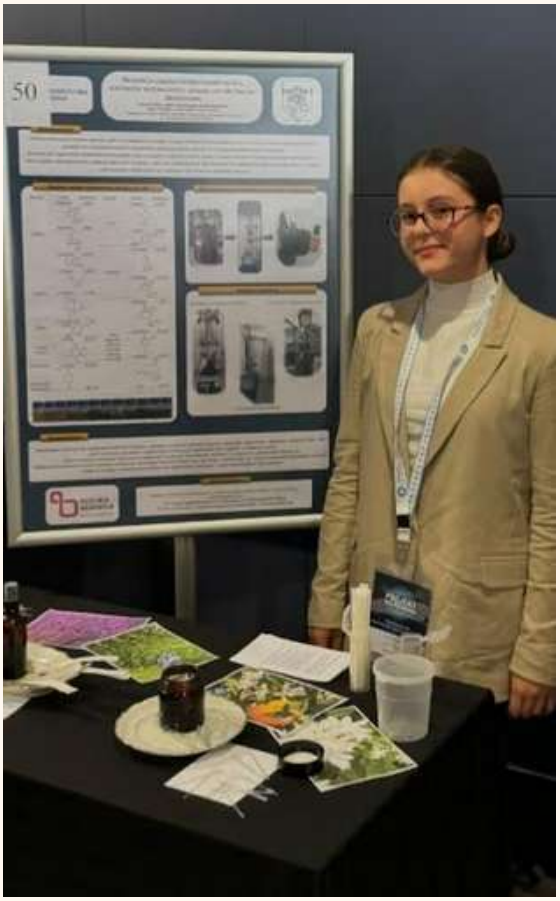
You said you're most interested in neuroscience, medicine and ecology, how do you see these fields intersecting in the future?
Everyday I'm struggling with problems of today's world. And this is a thing I've known, since I became aware of the world surrounding me, I wanted to do when older. Where do I see myself in 10 years? Probably, somewhere in a hospital, taking care of my patients or saying: "it is a beautiful night to save lifes, let's have some fun!" in the operating room.

I'm aware that being a doctor is very energy-guzzling job, but in spare moments I would love to work in the lab and invent some innovative treatment or vaccine. I want to help people not just by operating them or prescribe some pharmaceuticals, but also helping in different ways such as inventing artificial organs and by working on stem cells.

What was it like to stand on the stage and share your story with a global audience? What kind of feedback did you get from audience or other speakers after you talk?
When I was 13 I saw TEDx for the first time. It was a presentation about bravery and self-consciousness. The speaker, Maria Sklodowska, used Curie's quote, “nothing in life is to be feared, it is only to be understood”. It hit me so much and I started analysing this lecture. In that moment I understood that this is exactly what I needed to hear. Then I realized, that sharing motivational and educational content with others was my dream. I had a plan: someday I will stand on a red-carpet and talk about topics worth spreading. 2 years later, accidently, I saw the same TEDx. I treated it as a mark of fade, so I decided to attend one as a speaker. Firstly, I was very scared, because it was my first event like that and I was the youngest speaker, surrounded by adults. Luckily, the moment I came on stage, those negative emotions went off. I felt like I found my place on Earth. It was an amazing opportunity to talk about the application of psychology in neurology, what is a field which I find fascinating. I got a chance to educate others about placebo effect, which I carried out research. Also, my goal was to inspire people to immerse in this topic and study other related subjects. That, as I found out later from my listeners, clicked!

What was the most valuable lesson you learned about working in healthcare? Furthermore, can you share what it was like to gain hands-on experience in Silesian Cardiac Surgery Institute in Zabrze? Do you plan to follow the path of cardiac surgery or would you like to specialize in another field of medicine, if so, what would it be and why?

One year ago, I decided that I wanted to get to know medical studies and reassured myself it was the right career for me. This is why I signed up for a one year-round internship at Medical University of Silesia. Even if everybody was telling me I was too young for that and the application exam was too hard for me, I didn't care. Every time I heard that I was thinking about a Harvey Specter's* quote- excuses don't win championships. Now I know that it was one of the best decisions of my entire life. I had the opportunity to perform in dissecting room, labs and learn how to behave, when working with patients. What was the most valuable lesson? I'd say, learning about commitment for others, being prepared for that and also acting with humility and empathy. Professors placed importance on pointing out how much we will have to study and how much self-sacrifice it requires to become a doctor.



I love immersing myself in different fields of medicine. Sometimes I have the opportunity to attend medical events to deepen my knowledge. A few months ago I joined a conference, BioMedTech Silesia, organized by Silesian Cardiac Surgery Institute in Zabrze. I had the chance to hear about application of AI in surgery. I was totally amazed by robots being used on the operating table, handling complicated surgeries. After that I could see myself working with laparoscope and practising surgical suturing. I really enjoyed it and thereby, I understood surgery was my dream specialization.

Why is breaking stereotypes about young women in STEM so important to you and how do you hope to inspire other young people to take their first step in science?

Nowadays we live in a world full of amazing, helpful people. But also, we have to struggle with others, who have stereotypical mindset, which is unfair and harmful. I often encounter stereotypes about women in STEM, especially young addepts of this field. Some of them can inhibit the development of motivated and strongheaded girls. It is widely acknowledged, STEM community is dominated by men. But does that mean that women are worse researchers? No! Before judging anybody, we should remember that everybody live their lifes for the first time. As a person, who broke the obstacles and fear caused by stereotypes, I'm feeling responsible for confirming girls, scared to make their first step in science, that this is what they really should do. I hope that thanks to my contribution, while I speak open about this topic, young people will feel more confident and will start making our world a better place.

Hélène Lambert

Hélène Lambert is a Swiss chemist, visionary artist, and science communicator whose work bridges chemistry, art, philosophy, and music. Currently studying chemistry at the University of Geneva, she is the founder of Helnium – The Element 0, a pioneering project that transforms laboratory reactions into artistic creations through crystallization, light, and the hidden structures of matter. Her practice explores how matter carries memory and meaning, offering new ways to understand both the physical world and the human search for connection. Helnium is not only an artistic project but also a developing scientific theory, centered on the concept of an original frequency at the foundation of matter and life. The name Element 0 reflects this dual vision: "ln," the logarithmic curve symbolizing balance against uncontrolled growth, and "Ln," a reference to lanthanides, rare elements with remarkable but underexplored optical properties. Her first solo exhibition presented crystalline works alongside a live crystallization demonstration under polarized light, a piano performance, and a collaborative wine pairing. She has also exhibited in collective settings such as the Urban Art Fest, where she introduced audiences to crystallization and microscopy in a contemporary urban context. A classically trained pianist, Hélène draws on music as a guiding influence in her work. For her, both science and music are languages of vibration, balance, and connection, capable of expressing truths beyond words. Through Helnium, Hélène's mission is to create a dialogue between science, art, and society, inspiring new ways of seeing the universe as a continuum of matter, memory, and meaning. Her vision is to challenge boundaries, reconcile rational analysis with creative intuition, and encourage a more conscious and interconnected understanding of the world.

Your work is truly unique and fascinating, what first inspired you to bring together science, art, and philosophy? When did you realize that crystallization and light could become both a scientific and an artistic language for you?

Since I was a child, I have been fascinated by matter, minerals, crystals, and above all, colors. I later understood that colors are born from the interaction between matter and light, two realities that cannot exist without each other. This dialogue became my first intuition: that everything is connected. At the same time, I grew up immersed in art. I played piano from a very young age, I loved drawing and photography, and I inherited from my father a kind of artistic eye. Very early on, I felt frustrated by the way society separates art and science, because intuitively I experienced

them as the same language: science gives us rigor and understanding, while art allows us to feel and translate that reality. For me, the question “What do you want to do later?” was terrifying, because I didn’t want to choose. I wanted to unify. The decisive moment came during my very first chemistry class. My heart vibrated as if it had finally found its language. In the periodic table, I saw atoms… but also like a musical partition like as every atoms had its own notes/vibration in a universal orchestra. Chemistry became my pillar of unification, a science that is quite rigorous but also profoundly visual and poetic. This intuition was confirmed when I carried out a high school project on crystallization, which earned me a Science Prize for creativity. Observing crystals felt almost like a spiritual revelation: each substance created unique shapes and colors, as if matter itself carried memory and meaning. Later, at university, I refined my practice: I began exploring polarized light microscopy, UV light, and other experimental conditions such as pressure and magnetic fields. I also developed electrocrystallization techniques, using electric currents to guide ions into crystalline architectures, and I started working with lanthanide salts, whose fluorescent properties open entirely new perspectives. The more rigorous my methods became, the stronger my conviction grew: everything is connected. In tiny crystal structures, I began to see forms of life, feather-like patterns from simple benzoic acid salts, or butterfly-like wings emerging from other compounds. In fact through crystallization, matter reveals both its scientific laws and its artistic essence, becoming a bridge between the microscopic and the universal, between science, art, and philosophy. Thats why it became my artistic and scientific tool today.

What is your long-term vision for Helnium, do you see it becoming more of a research lab, an art collective, or something in between?

My long-term vision for Helnium is to create a transdisciplinary research center, a place where rigorous scientific work and artistic, philosophical, and human perspectives are inseparably linked. I don’t see it as a conventional laboratory or a simple art collective, but as a new kind of institution that unifies these dimensions. On the scientific side, Helnium will continue to explore crystallization, spectroscopy, electrocrystallization, and lanthanide chemistry, while developing The Element 0 as a hypothesis about the original frequency that connects matter, life, and consciousness. But science alone is not enough. This center will also be a gallery, a place to exhibit and share discoveries through images, installations, and performances. It will host workshops, conferences, and podcasts, opening the dialogue between researchers, artists, students, philosophers and society at large. It will be a space not only for experiments, but also for reflection and collective imagination. Ultimately, Helnium will be both! A research hub and a cultural platform. Its goal is to prepare the ground for a new paradigm… One where science, art, and philosophy work together, where ecological awareness is central, and where knowledge is no longer separated from human meaning and societal transformation.

You’re also a pianist! How has music, especially the piano, influenced the way you approach chemistry and art? Do you see resonance and harmony as metaphors for how the universe works? How does that apply to science and chemistry in particular?

Music, and especially the piano, has been part of my life since I was very young. It taught me that harmony is not just something emotional, but also mathematical. Certain rhythms and vibrations feel naturally right to us because they reflect proportions that exist everywhere in nature. What we call “beautiful” is often this hidden order that we sense without even knowing why. At the piano, I always feel a kind of double consciousness: one hand brings rhythm and structure, the other carries emotion and expression. And I realize I look at chemistry in the same way. Molecules

have strict structures, like a score, but they also resonate, transform, and interact in ways that feel alive. When I see crystals forming, it feels like a visual symphony, matter finding balance and creating colors as if nature itself was composing. Light adds another layer: colors appear when matter interacts with vibration, just as music appears when matter becomes sound and it resonates. For me, music, chemistry, and art are all connected because they are all about vibration. For me Harmony isn't about something random and subjective to humans but it's a principle of how the universe works and how elements find equilibrium in that chaotic cosmos. That's why, whether I'm at the piano or at the microscope the feeling I get isn't something abstract or mysterious, it is simply resonance and vibration

made visible and tangible. In music, we hear it as harmony; in chemistry, we see it as colors, forms, and patterns. Both reveal the same principle: that everything in the universe seeks balance, connection, and rhythm. So what we call "beauty" is the visible expression of the order and vibration that hold the world together.

What was the experience of your first solo exhibition at Collonge Café like, blending crystallization demonstrations, piano music, and art? How did the audience react to seeing scientific processes presented as art? Furthermore, you also mentioned being selected to participate in the Urban Art Fest in Geneva, a collective exhibition in a contemporary urban setting. Did you feel that people reacted differently to your work during your collective exhibition compared to the one at Collonge Cafè?

My first solo exhibition at Collonge Café was much more than showing images, it became an experience of awareness. People were not just looking at artworks; they were discovering that the very elements we are made of could be so beautiful. For some, it was almost existential. I remember several people telling me the same thing in different words: "I'm tired of abstract painting, it feels repetitive or too detached. But this... this is different, because it's not something invented, it's real. It's what we are made of, and it also has a rigorous scientific explanation behind it." Others said they were amazed because the exhibition combined not only science and art, but also pedagogy, philosophy, and a reflection on life itself. The reaction was one of wonder. Artists who had grown skeptical about contemporary art felt renewed excitement, and people who had never connected to science before said they suddenly saw it differently. It wasn't the cold atmosphere of a laboratory, nor the sometimes inaccessible language of abstract art. It was a space where beauty, science, and human meaning came together. That was the most powerful part for me. To close the evening, I played the piano, something very personal to me. I chose two pieces that are deeply connected to my vision. The first was Claude Debussy's Clair de Lune, a work that, to me, paints with sound and captures the same impressionistic beauty that I find in crystals and nature. The second was Arrival of the Birds from the film The Theory of Everything, a

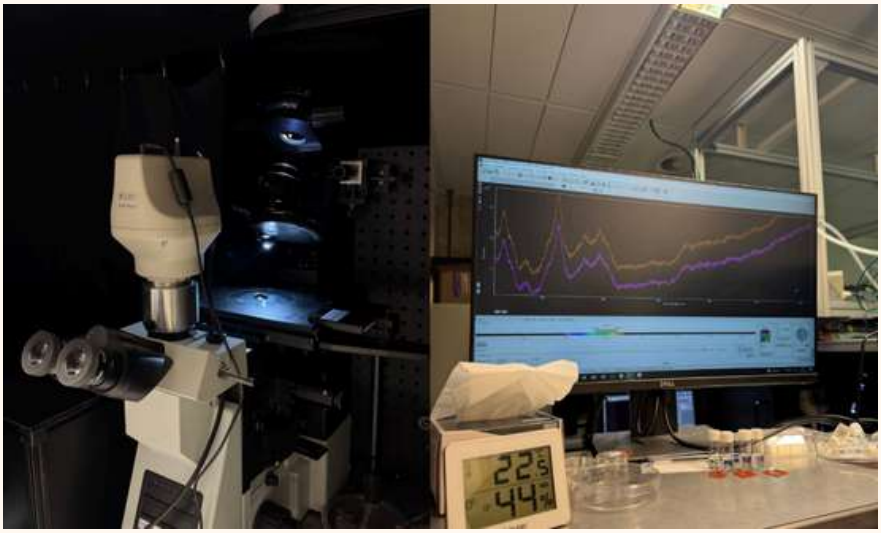
tribute to Stephen Hawking and a reminder that science, like music, is also a story about wonder and the human quest for meaning. Ending the night with music felt like completing a circle: from the laboratory to the artwork, from the microscope to philosophy, and finally to music. It created an atmosphere of emotion and unity that went far beyond what you would normally experience in either a gallery or a laboratory and people were really touched.

The Urban Art Fest at the Village du Soir in Geneva was a completely different context from my first solo exhibition. The Village du Soir is the largest former distillery in Switzerland, now transformed into a vibrant cultural and nightlife venue. During the festival, its industrial halls and club-like atmosphere became an unusual but fascinating space for art. I was placed in the main hall, under LED lights and the dynamic lighting system usually used for concerts and nightlife. Instead of natural sunlight, my crystalline works were illuminated by this urban, artificial glow, and in a way, it aligned perfectly with the spirit of the place. It created a dialogue between the inner universe of my crystals and the contemporary, electric atmosphere of the venue. What made this exhibition especially powerful was the diversity of the audience. It wasn't only people familiar with science or contemporary art, it was everyone: families, students, passersby, people coming for the festival. I brought my microscope and crystal samples with me, and the reaction was magical. Children were absolutely fascinated to see crystals appear under polarized light, and even adults who had never looked through a microscope before were amazed. Many told me they had never imagined science could look like this. For me, the Urban Art Fest showed that my work can live in very different contexts: from the intimate and reflective atmosphere of Collonge Café, to the urban, collective, and festive energy of a cultural hub like the Village du Soir. And in both, the same thing happened, people felt wonder when they realized that matter, which composes all of us, carries its own beauty and meaning.

What is your scientific approach to crystallization, what can you tell us about your creative and chemical process?

I create my crystals through three complementary approaches, each revealing different aspects of matter and its hidden structures:

1. Simple Crystallization: By evaporating a saturated solution, I allow crystals to slowly emerge and reveal their natural forms. This method highlights the intrinsic geometry of the substance.
2. Crystallization through Chemical Interaction: By mixing two saturated solutions that react with each other, I generate new compounds. This process reflects how transformation at the molecular level can produce unexpected crystalline landscapes.
3. Crystallization of Coordination Complexes: By forming bonds between a metal ion and an organic ligand, I explore the rich diversity of inorganic and coordination chemistry. These experiments produce crystals with unique optical properties, often birefringent under polarized light.
4. Electrocrystallization: In some cases, I also use electrolysis to trigger crystallization. By applying an electric current, ions are guided to reorganize and deposit in solid form, creating singular crystalline architectures.



To reveal the hidden structures and colors of matter, I use different analytical and imaging techniques. Each of them allows me to see crystals in a unique way, at the intersection of science and art.

- Polarized Light Microscopy: My main approach is polarized light microscopy. Polarizing microscopy uses polarized light to study the interaction between light and matter. When a beam of light passes through a crystal, it undergoes refraction and interference phenomena that modify its direction and apparent color. Certain crystals, known as birefringent, split the light beam into two distinct paths: it is this property that reveals spectacular color effects and symmetries invisible to the naked eye. Thanks to these optical phenomena, each crystal becomes a living map of its internal structures, transformed here into a visual work of art by Helnium.
- Spectroscopy: I also use spectroscopy to analyze how matter interacts with light. By dispersing light into its wavelengths, spectroscopy reveals the “fingerprint” of a material, its composition, structure, and energy transitions. This data not only validates the scientific identity of the crystal but also inspires me to link its spectral signature to artistic interpretation.
- Fluorescence Microscopy (less frequent): In some cases, I experiment with fluorescence microscopy. Certain crystals or complexes can absorb ultraviolet light and re-emit it at visible

wavelengths, producing glowing colors. Although less frequent in my practice, this method opens new perspectives for exploring the hidden luminescence of matter.

You told us about your personal theory that speaks of an “original frequency” at the foundation of matter and life. Could you tell us more about how you are developing this idea?
My idea of an “original frequency”, what I call The Element 0, comes from an intuition I have felt since very young. For me, something was missing but I couldn’t explain it. Chemistry classes, piano, art, crystallization experiments, reading about the philosophy of existence and consciousness... all of this shaped in time this intuition that somehow everything comes from the same unity the same frequency. Each time I watched matter organize itself into color and form, I felt it was more than chemistry. It was as if matter carried a memory, a vibration a trace of consciousness that connects us to something universal. Later, I recognized the same vibration in music, in light, and in moments of inner transformation. That is why I began to think of it as a fundamental frequency at the foundation of matter, life, and consciousness. I am now developing this idea in two complementary directions. Scientifically, I work with crystallization under polarized light, spectroscopy (including studies with fluorescent lanthanide salts), and electrocrystallization. These methods allow me to analyze the signatures of matter, its spectra, structures, and dynamic behaviors, as possible expressions of this frequency. Philosophically, I explore what this implies about how we understand reality: if a foundational vibration underlies both matter and consciousness, then science, aesthetics, and ontology are more deeply connected than we usually assume. For me, The Element 0 is therefore both a hypothesis under investigation and a broader framework. It is not only about conducting experiments but also about rethinking our relationship with matter, from a resource to exploit, to a structure that encodes memory, organization, and awareness. My long-term aim is to build a transdisciplinary platform where scientific research, artistic practice, and philosophical reflection are integrated, and where new models of knowledge can be developed. In short, I see The Element 0 as both a research program and a conceptual framework, designed to bring together chemistry, art, and philosophy in order to better understand the connections between matter, consciousness, and society.

If you had the opportunity to collaborate with anyone, a scientist, artist, or philosopher, dead or alive, who would it be and why?
From science, I would choose Ilya Prigogine. His work on entropy showed that order can come out of chaos, that instability can actually create new structures. When I discovered his ideas, it immediately resonated with what I see every day in crystallization. A solution that looks chaotic suddenly organizes into a crystal with a defined form and color. For me, this is the same dynamic Prigogine described, and it connects directly with my own theory of The Element 0, the original frequency behind matter and life. From art, I would choose Claude Monet and Hans Zimmer. Monet, because his way of painting reality is very close to how I see matter under the microscope. He never fixed the world in clear lines, but showed it as uncertain, blurred, always moving with light. That is very close to the idea of matter in transformation, even the quantum view of reality as probabilities rather than certainties. I love that because it’s exactly what I see when crystals form: they are never static, they are processes, transitions, colors shifting like Monet’s brushstrokes. And Hans Zimmer, because his music has this power to touch something that feels bigger than ourselves. When I listen to his work, it feels like he is not only composing soundtracks, but also

tapping into a kind of universal memory that we all share. His music shows me how art can carry emotions and meaning that belong to everyone, not just to one person. That's very close to what I want my work to do with crystals: not just images, but something that speaks to human memory and feeling on a collective level. From philosophy, I would choose Karen Barad or Michel Bitbol. Karen Barad is fascinating because she links physics and philosophy, and she talks about how the observer and the observed are always entangled, never separate. That is exactly what I feel when I work with crystals: my consciousness and the material process are connected. Michel Bitbol, on the other hand, explores the idea that consciousness is not just a product of the brain, but something more fundamental, part of the structure of reality itself. Both of them bring the depth I want to connect with in my project: a way of thinking where matter and consciousness are not opposed, but part of the same field. So if I imagine this dream team Prigogine for the science of order and chaos, Monet and Zimmer for the language of light and universal memory, and Barad or Bitbol for the philosophy of matter and consciousness, it's exactly what Helnium tries to be. A place where science, art, and philosophy work together, to help us see reality in a more connected and meaningful way.

Check out her artworks at page 109

ART AND SCIENCE

SECTION THREE

The Intersection Between Chemistry and Art: Cyanotype Printing

First invented in 1842 by Sir John F. W. Herschel, cyanotype printing was intended to be a relatively inexpensive method of photographic image creation using light-sensitive chemicals. It is unlikely he was aware at the time that his invention would become such a creative tool for artists to produce beautiful prints. The process is simple to carry out, but relies on quite complex chemistry.

A cyanotype print begins with a solution of two chemicals applied to paper: a ferric salt complex (commonly ferric ammonium citrate) and a ferricyanide salt (usually potassium ferricyanide). The object or image to be printed is then placed on top of the coated paper, shielding certain areas from sunlight. The exposed parts undergo photoreduction, reduction by UV light, converting ferric ions into ferrous ions.

$$Fe^{3+} + e^- \rightarrow Fe^{2+}$$

The ferrous ions then reduce the ferricyanide.

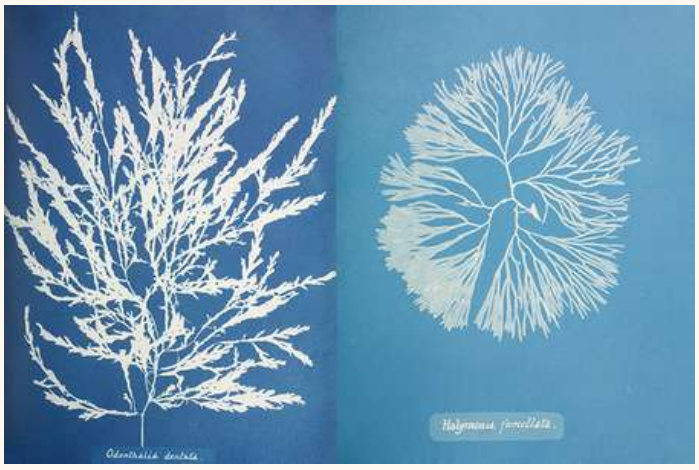
$$Fe^{2+} + [Fe^{III}(CN)_6]^{3-} \rightarrow [Fe^{II}(CN)_6]^{4-} + Fe^{3+}$$

The products of this reaction then combine to form ferric ferrocyanide.

$$3[Fe^{II}(CN)_6]^{4-} + 4Fe^{3+} \rightarrow Fe_4[Fe(CN)_6]_3$$

This compound, more commonly known as Prussian blue is a vibrant blue pigment that stains the paper. Washing the print with water removes any unreacted salts, leaving behind blue areas where the paper was. exposed to UV light, and white where the object blocked the light, resulting in the final print.

While the blue of ferric ferrocyanide is popular, it is sometimes necessary, whether practically or aesthetically, to alter the colour of the print. This can be achieved by first removing the Prussian blue by reduction with an alkaline solution to form Berlin white (colourless iron (II) ferrocyanide). Immersing the print in a tannin solution form an iron-tannin complex with ferric ions from the Prussian blue, which have a different colour, brown, black, purple or sepia depending on the conditions.

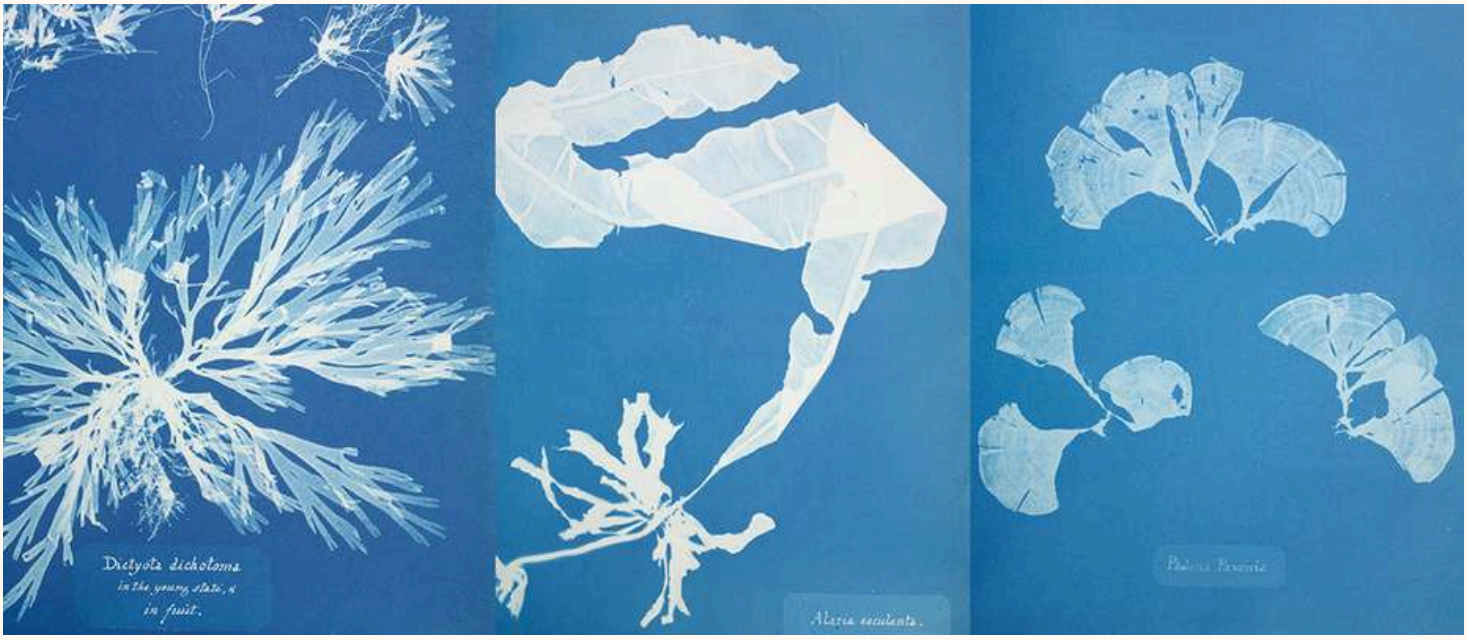


Anna Atkins' cyanotypes, Natural History Museum

One of the first uses of cyanotype printing was by a friend of Herschel. Anna Atkins was a botanist who produced cyanotype prints of algae, her book *Photographs of British Algae: Cyanotype Impressions* is regarded as one of the first books illustrated with photographic images, courtesy of cyanotype printing. Shortly after, cyanotype printing was adopted for copying architectural drawings, hence the

phrase ‘blueprint’ in reference to Prussian blue’s distinctive colour. Today, cyanotype printing remains popular amongst artists, not only on paper, but on fabric, wood and glass. It is also accessible to hobbyists looking to create prints at home. Even toning can be done at home using coffee or tea, which contain tannic acids so produce a sepia tone in the print.

Cyanotype printing demonstrates that chemistry is not confined to the laboratory, it can also be art. This intersection, pioneered by women like Anna Atkins shows chemistry can fuel creative expression, which can often be culturally associated with femininity, and therefore undervalued. Recognising this history highlights the importance of women and girls in STEM, whose contributions continue to challenge outdated ideas about who science and art are for.



Anna Atkins’ cyanotypes, Natural History Museum

GRACE PARRY

HELNIUM Hélène Lambert

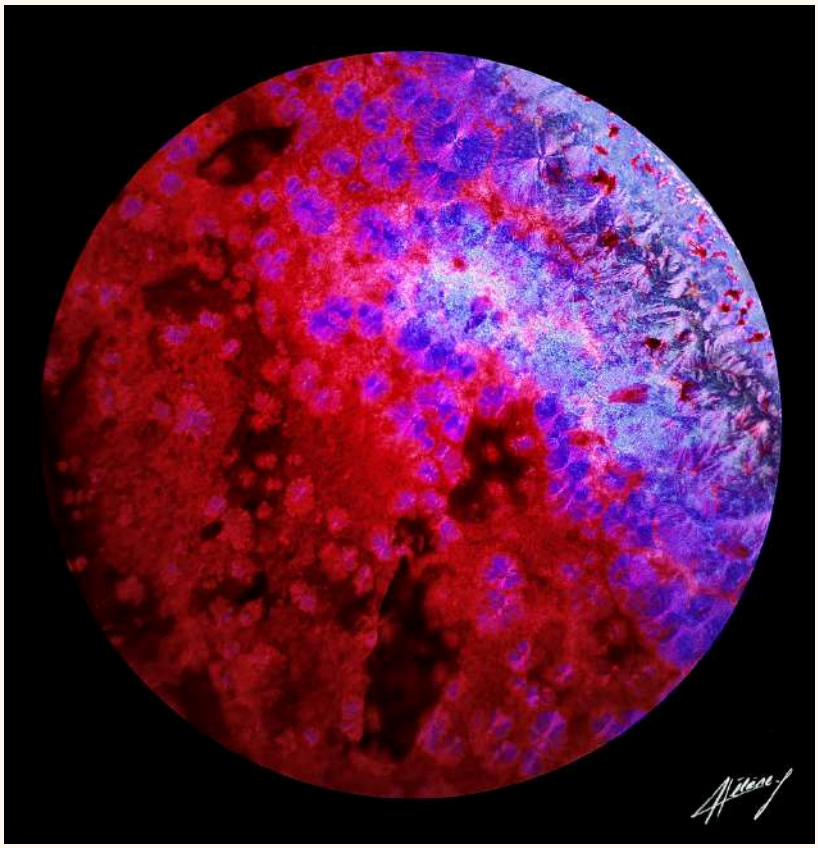
Hélène Lambert is a Swiss chemist, visionary artist, and science communicator. She is the founder of Helnium - The Element 0, a pioneering project that bridges chemistry, art, and philosophy through crystallization, light, and the structures of matter.

"With Helnium, the goal is not only to present artworks, but to create a dialogue between scientific research, artistic creation, and human questions. It is both a laboratory and a cultural platform, aiming to inspire a more conscious society. Ultimately, it seeks to demonstrate that everything is connected."

ENTROPY

$NiSO_4 + 2\ C_8H_8N_2O_2 \rightarrow [Ni(C_8H_8N_2O_2)_2]SO_4$

Scientific Explanation: In science, entropy measures the degree of disorder or the dispersion of energy within a system. It explains the natural tendency of systems to evolve toward more probable states, driving balance and transformation. Since the Big Bang, our universe has followed an irreversible expansion dictated by the second law of thermodynamics: global entropy can only increase. This process is not a degradation but a fundamental dynamic between order and chaos, creation and transformation.



Artistic Vision: At first glance, the work resembles a distant planet, frozen between crystalline and incandescent states. Beyond its image, Entropie carries a universal message: like the universe, our lives evolve through phases of instability. Structured zones symbolize initial order, while red fractures evoke inevitable expansion. In this tension between balance and mutation, the work reminds us that the universe's growth is also internal, each human being carries a memory of origins, an impulse to transform, to create, to reinvent. What we call disorder may in fact be the path to a higher order.

Ecological Interpretation: *Entropy* can also be seen as a reflection of our planet's critical state. The composition contrasts two areas: a dense, saturated red and a calmer, bluish structure. The red evokes planetary overheating, wildfires, pollution, and resource-driven conflicts, symbols of an Earth subjected to accelerated entropy by human activity. The blue, by contrast, represents fragile preserved zones: fresh water, ice, ecosystems. Visually minor, it highlights the growing vulnerability of life. The work thus expresses a thermodynamic and systemic imbalance: where nature tends toward equilibrium, human activity introduces an artificial, accelerated entropy that threatens Earth's self-regulating capacities. For me, representing this imbalance is not only an artistic gesture, but also an intellectual and humanitarian necessity.

MULTIDIMENSIONS

Scientific Approach: This work was created with copper(II) sulfate pentahydrate ($CuSO_4 \cdot 5H_2O$), a classic crystalline compound. Its intense blue color comes from electronic transitions of Cu^{2+} ions, influenced by water coordination in its hydrated form. Beyond its beauty, copper sulfate is widely used in electrochemistry and crystallography, making it both a didactic and emblematic material.

Artistic Vision: *MultiDimensions* is a powerful crystalline work, articulating three essential dimensions of human experience: inner vision, personal transformation, and the acceleration of the modern world.

1. The gaze - Symbol of awareness and perception

The central structure recalls the shape of two eyes. A pioneering and revealing vision. This motif is also universal and embodies a role, that of the observer in the perception of reality, the notion of vigilance, presence and expanded perception. It also evokes the way in which matter seems to observe us in turn, underlining the reciprocity between the symbol of consciousness and the observer's role in shaping reality, echoing principles of quantum physics.

2. Metamorphosis - Reference to life and change

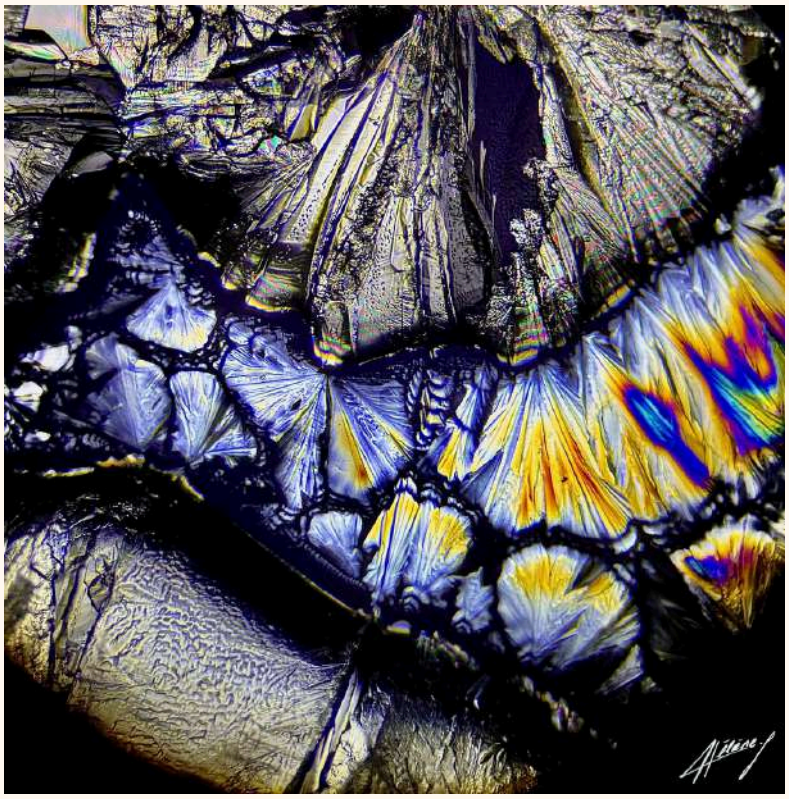
Around this vibrant center, shades of blue recall the fragile wings of a butterfly. This image, at once delicate and powerful, embodies a pivotal moment: metamorphosis. It reflects an inner journey, a period of tension, moulting and rebirth. This luminous blue, sometimes iridescent, recounts the beauty of a profound change, of light regained after darkness. A Mineral Metamorphosis

3. Technological tension - A dialogue between nature and modernity

Finally, the shiny, metallic texture of the work echoes modernity: the luminous headlights of a luxury car, it evokes speed, precision, technology, a world that moves forward, that moves fast, sometimes too fast. This part of the work recalls the tension between our sensitive nature and a constantly accelerating environment. It poses the question: how do we stay connected to ourselves in a world of performance and speed?

MultiDimensions is therefore a synthesis: that of a lucid gaze, of an ongoing transformation, and of a world in motion. A work that not only looks at itself... but also at you.

MINERAL METAMORPHOSIS



Scientific Approach: The work was created with citric acid ($C_6H_8O_7$), a weak organic acid naturally found in citrus fruits. Citric acid crystallizes in the monoclinic system, forming colorless or white crystals soluble in water. Beyond its crystallization, it plays a central role in the Krebs cycle, acting as a key metabolic intermediate in cellular energy production.

Artistic Vision: *Mineral Metamorphosis* is a poetic representation of personal transformation, inspired by the life cycle of the butterfly. The work contrasts the elegance of grey, metallic mineral structures with the vibrant brilliance of blue and golden hues, evoking unfolding wings. The dense grey structure

embodies the chrysalis, a protective yet limited space of introspection where change begins. The blue and golden highlights symbolize awakening and emergence: blue for wisdom and inner reflection, gold for light, renewed energy, and vitality. The piece captures that suspended moment when the past fades to make way for the future, a time of spiritual rebirth and personal maturity.

Ecological Vision: Beyond its personal meaning, Mineral Metamorphosis can also be seen as a symbol of the change our world is going through. The contrast between the grey, rigid structures and the bright, colorful patterns shows a world leaving one cycle and beginning another. Instead of focusing on destruction, the work points to renewal: the chance to find a new balance where humanity, nature, and technology live in greater harmony. On a small scale, the image reflects that we are living on a global scale not an end, but a transformation, and the possibility of a better balance.

To discover more about **Helnium** *follow @helnium on Instagram and @helenelmbrt on TikTok and check her interview at page 99*

Nasta Martyn

Nasta Martyn is an artist, graphic artist, illustrator. She graduated from the State Academy of Slavic Cultures with a degree in art, and also has a bachelor's degree in design. The first personal exhibition "My soul is like a wild hawk" (2002) was held in the museum of Maxim Bagdanovich. In her works, she raises themes of ecology, in 2005 she devoted a series of works to the Chernobyl disaster, draws on anti-war topics. The first big series she drew was The Red Book, dedicated to rare and endangered species of animals and birds. Writes fairy tales and poems, illustrates short stories. In 2020, she took part in Poznań Art Week. Her work has been published in various magazines.

*To discover more about **Nasta Martyn** follow @nasta.martyn33 on Instagram*

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