TIME

UNDER THE MICROSCOPE

Editors note

Stop all the clocks…

Issue #10 of Under the Microscope, your favourite school magazine, is out!

'Time' is a concept that affects us all - from dreams about time travel to the number of lates at school. In this issue, we explore 'time' from a whole host of angles. These cover topics such as Einstein's Twin Paradox to ancient medical practices, all written by our budding STEM enthusiasts. This theme ties in with British Science Week 2024.

Our team is comprised of 21 writers, ranging from students, across years 7 through 12, to teachers - all of whom have pitched in with their timely ideas. Efforts were made way past our bedtimes, we stayed ahead of the clock, and deadlines were met in the nick of time.

The new editorial team had great fun and pleasure reading, editing, and piecing this issue together. Please do feel free to share this with anyone who may be interested. If you have any further suggestions or queries, do get in touch (email s.kamide@put.gdst.net). We would love to hear from you!

Thank you to all our writers, the editors and Dr. Dixon. We hope you enjoy reading our magazine!

Meet the team:

Features Editors: Ashmita and Maia - Gets fun and original content for the magazine! See this edition's book reviews and word search :)

Commissioning and Development editor: Rubani - helps get as many articles from across the school as possible ranging from year 7 to sixth form (including teachers as well!)

Copy editors: Juliana and Ysaline - reads through each article to catch any slips in meaning or spelling and grammar and ensures scientific accuracy.

Creative editor: Jasmine - puts all the articles into a cohesive and exciting format as well as designing a fantastic front cover!

Editor in Chief: Sora - helps to organise the team to make sure everything goes to plan.

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The influence of Ancient Medicine on Modern Medicine

By Lucy Greenhalgh

Looking back, ancient medicine practices seem bizarre, such as leech therapy (which was used to treat infections, skin diseases, dental issues, and more). After centuries of research, modern medicine has evolved from these early techniques - but how many of these seemingly horrific and painful practices do we still use today? Do modern physicians still use techniques stemming from ancient societies?

Ancient India

The earliest concepts of ancient Indian medicine are set out in the sacred writings known as the Vedas, which date back as far as the second millennium BCE. According to a later writer, the system of medicine that the ancient Indians used, known as Ayurveda, was received from the god Brahma. The techniques used for the treatment of diseases were rich in ‘magical practices’, such as charms that would expel disease-causing ‘demons’. These diseases had symptoms including fevers, coughs, diarrhoea, seizures, tumours, and skin diseases. These methods were later replaced with comprehensive medical texts known as the Charaka-samhita and Sushruta-samhita. All later writings on Indian medicine were based upon these treatises.

In diagnosis, the Hindu physicians used all five senses. For example, hearing was used to determine the nature of a patient’s breathing, if there were alterations in their voice, and whether there were any grinding noises produced by the rubbing together of broken bone fragments. These methods show both good clinical sense and understanding. Modern physicians, when performing an examination, still use their senses to discover the issue.

In addition to this, some of the medicines used in ancient India are still used in modern medicine. The medicine consisted mainly of vegetable drugs from indigenous plants, such as cardamom and cinnamon, which are still used today. However, animal remedies like milk and bones as well as minerals such as arsenic, lead, copper sulphate and gold were also used.

The ancient Indians also had renowned surgical methods. Bladder stones were removed via lateral lithotomy: an incision is made into the bladder behind the prostate. This operation is still used today. Plastic surgery was used in certain circumstances. For example, if the individual committed adultery, then their nose would be cut off. This was then repaired by cutting a piece of tissue from the patient’s cheek or forehead and applying it to the stump of the nose.

Hippocrates and Ancient Greece

Hippocrates is known to most as the father of modern medicine. Born around the year 460 BCE, not much is known regarding his life. Hippocrates evolved theocratic medicine (a form of medicine based on a specific religion) into modern medicine and introduced 'physis' (a tissue that, together with the metaphysis, is responsible for longitudinal bone growth). Many of the professional standards and ethical practices which he formulated are valid even today. An example of this is the Hippocratic Oath, which serves as both a moral and ethical code for modern medical practitioners.

Ancient Greeks are said to have believed in the harmony of the mind and body - this produced the phrase 'healthy mind in a healthy body'. Research has proven that this concept rings true. Recent studies have shown that "maintaining a level of physical fitness and a balanced diet during your time at university will prove to be hugely beneficial to both your physical and mental health". Moreover, the Greeks treated mental illnesses the same as physical diseases. Hippocrates, for example, classified several mental disorders, such as insanity, paranoia, panic, epilepsy, melancholy, and hysteria. Some of these terms are still used today.

This form of medicine was evidence-based knowledge; Greek physicians intended to give an in-depth medical history of patients. To give diagnoses, they would record information like geographical location, age, gender, habits, diet, menstrual changes, appetite, sleep duration and mood swings. In the physical analysis, paralysis, respiration, fever, sputum, urine, and vomit were examined. Following this, a diagnosis would be given, based on the results of said observations, and a treatment plan would be formulated. This is very similar to current research protocol in modern medicine.

Ancient Egypt

Egypt had bountiful knowledge of medicine, ranging from treating and diagnosing diseases to treating wounds. However, the most interesting aspect of their treatment of ailments was the ingredients used. Egyptians sourced the ingredients from a plethora of plants, animals, and minerals. Many of these ingredients are still used today. For example, in ancient Egypt, vitiligo was treated using the juice from the Ammi majus, also known as Queen Anne's lace flower. Today, scientists extract 8-methoxypsoralen from the juice to treat vitiligo and psoriasis.

Moreover, the Egyptians had a vast knowledge of anatomy - they performed bone setting, stitched up wounds, fixed dislocated shoulders using a method like the one we use today (the Kocher method), and opened boils (to drain them) using linen cloth. Remains of ancient Egyptians have also been discovered which show that amputations and brain surgery were performed, and some even had prosthetic limbs.

The tools used to perform these surgeries are very similar to those used today - metal scalpels, linen bandages, catheters, and clamps for stopping blood flow have been discovered among others.

Ancient China

The system of Chinese medicine is still widely practised. The ancient Chinese believed in the dualistic cosmic theory of the yin-yang, in which yin (the female part) is passive and dark whereas yang (the male part) is active and light. The great aim of ancient Chinese medicine is to control the proportions of yin-yang in the body.

To diagnose a patient, detailed questions are asked about both the history of the illness and the patient's taste, smell, and dreams. Then, the quality of voice, colour of face and tongue are assessed. These practices are very similar to the techniques used in both ancient Greek and ancient Egyptian medicines, in addition to the diagnosing of modern patients.

The ancient Chinese medical treatments are very extensive and consist usually of vegetable, animal, and mineral remedies. The herb mahuang, also known as Ephedra Vulgaris, has been used for 4,000 years in Chinese medicine. In modern medicine, the alkaloid ephedrine has been isolated from it, which is used in the treatment of asthma. Moreover, the Chinese plant Rauwolfia contains the alkaloid reserpine, which can be used to treat high blood pressure, in addition to some mental conditions since it causes the blood vessels to slow and the heartbeat to relax.

Undeniably, the most famous form of ancient Chinese medicine which is used today is acupuncture. This consists of the insertion of needles into the skin and tissues. The reasoning behind this practice is the needle affects the distribution of the yin and the yang in the body. Research suggests that the treatment triggers the brain to release endorphins, which are hormones that reduce the feeling of pain. The site of the insertion is specific to organs. This is still widely used to treat many diseases and for pain relief.

Conclusion

From the chemicals in the herbs to the extraordinary surgical techniques to the ethical oaths, it is undeniably clear that ancient medicine has made a significant impact on the methods and treatments used today. Without the trials and tests done by ancient civilisations, where would modern medicine be today? The roots of diagnosis and prognosis go back to ancient Greece, pain relief goes back to China, and plastic surgery to India. Modern medicine owes its success to the physicians of the ancient world.

Our understanding of CAR-T cells over time…

By Sora Kamide

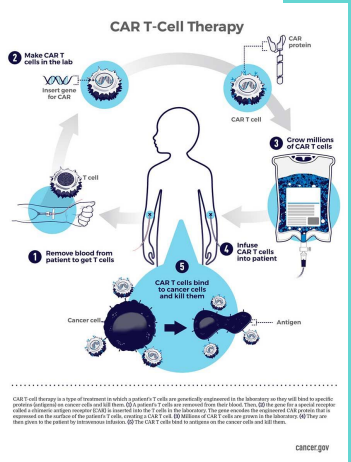
Chimeric antigen receptor T cells (CAR-T cells) are genetically engineered cells, with a new receptor enabling them to bind to cancer cells and kill them.

Such cells are made by harvesting immune cells called T cells from patients with a disease. The cells are then modified in a lab to produce proteins called chimeric antigen receptors (CARs), enabling them to take on a target of choice (e.g., a cancer cell). When CAR-T cells are re-infused back into the patient, they seek out and destroy their target.

Since 2017, six CAR-T cell therapies have been approved by the Food and Drug Administration (FDA). All of these are approved for the treatment of blood cancers, including lymphomas, some forms of leukemia and multiple myeloma.

Initially, CAR-T cells were developed to destroy B cells, a type of immune cell, that grow out of control in blood cancers. In treatment for some leukemias and lymphomas, CAR-T cells are designed to recognize a protein called CD 19, present on the surface of most B cells. The attachment of a CAR-T cell to a B cell kills the normal B cells as well as cancerous B cells. This either reduces the number of B cells or destroys all of them. This unfortunately makes the patient vulnerable to infections.

Nonetheless, CAR-T cell therapy has shown significant success in patients with B-cell acute lymphoblastic leukemia (B-ALL), with complete response rates between 70% and 94% across distinct trials. However, despite such a high rate of durable complete responses, some patients still relapse. Furthermore, a 2023 study published in April in Nature Reviews Clinical Oncology reported on trials that showed complete response rates of 40% to 54% for relapsed and/or refractory aggressive B-cell lymphomas, 67% in patients with mantle cell lymphoma, and 69% to 74% in patients with indolent B-cell lymphoma.



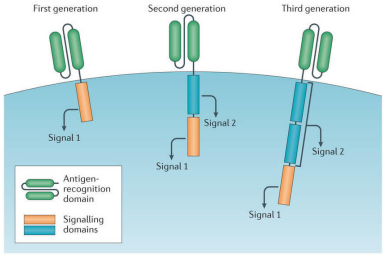
CAR T-cell therapy is a type of treatment in which a patient's T cells are genetically engineered in the laboratory so they will bind to specific proteins (antigens) on cancer cells and kill them. (1) A patient's T cells are removed from their blood. Then, (2) the gene for a special receptor called a chimeric antigen receptor (CAR) is inserted into the T cells in the laboratory. The gene encodes the engineered CAR protein that is expressed on the surface of the patient's T cells, creating a CAR T cell. (3) Millions of CAR T cells are grown in the laboratory. (4) They are then given to the patient by intravenous infusion. (5) The CAR T cells bind to antigens on the cancer cells and kill them.

Hence, CAR-T cells have displayed their efficaciousness, making them a popular candidate to treat other diseases, such as autoimmune diseases.

An autoimmune disease is when the body's immune system attacks and destroys healthy body tissue by mistake. A primary feature of autoimmune diseases is the loss of B cell tolerance and the inappropriate production of antibodies. Therefore, there have been speculations for the potential of CAR-T cell therapy in treating autoimmune diseases, such as multiple sclerosis (MS).

On 22 February 2024, Nature published an article stating CAR-T therapy for multiple sclerosis was entering US trials for the first time.

MS is where the immune system (erroneous T cells and B cells) attacks the brain and spinal cord, affecting function in cognitive, emotional, motor, sensory or visual areas as a result. Over 1.8 million people have this condition worldwide and there is no cure for this autoimmune disease. Instead, neurologists have treated this disease with antibodies that target CD20, a protein which is a marker of B cells. These antibodies kill the B cells, keeping the immune system in check. However, such treatments only prevent the disease, they do not cure it. Autologous hematopoietic stem cell transplantation (AHSTC) has also been used as a treatment for MS. This is a procedure that aims to reset the immune system, by having the patient with MS receive high doses of chemotherapy and monoclonal antibody treatments to kill off all their immune cells. This is then followed by an infusion of their own stem cells to repopulate their immune system. Despite promising results, AHTSC has a high risk, such as an increase in severe infections, effects on fertility and increased likelihood of cancers.



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Given that CAR-T cells kill target B cells that contribute to the disease, this may be a safer and more effective treatment than chemotherapy, which kills all the T and B cells of the person's immune system.

Nevertheless, there are still risks with use of CAR-T cells. These include cytokine-release syndrome (CRS) and neurotoxicity. CRS occurs due to the production and secretion of large amounts of cytokines and inflammatory molecules from CAR-T cells, which can trigger multiorgan failure. As for neurotoxicity, since the brains or patients with MS are already inflamed, CAR-T cell therapy may only exacerbate the problem. Therefore, this method of treatment may not be the 'answer'… yet.

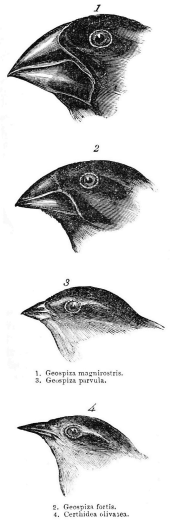
With sustained efforts in the development of drugs and medicine globally, CAR-T cells hold much promise in treatment of MS and other autoimmune diseases.

By Ysaline Pauwels

Vampire finches: how the little birds in the Galapagos evolves to drink blood over time

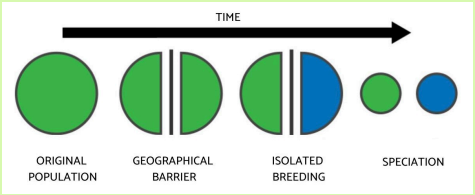
For millions of years, the Galápagos Islands were one of the world's natural secrets, evolving into the home of the most fascinating plants and animals of all time. These islands were eventually discovered by pirates, scientists, the first resident of the Galapagos and best known of all, Charles Darwin, revealing their secrets. The islands are a remote volcanic archipelago located about 600 miles off the coast of Ecuador and they are a biodiversity hotspot due to their isolation. Organisms that somehow make it to the islands must adapt to the harsh conditions or they go extinct…

Charles Darwin visited the islands in 1835, on his famous voyage aboard the HMS Beagle, and studied its flora and fauna for 19 days. Featuring in these discoveries was the finch, known for helping Darwin understand that the process of evolution happens by natural selection. Having arrived as a flock 2 million years ago, these birds searched for food such as seeds and insects. They then reproduced and became established as a population on the island. Mutations occurred, producing a variety of different genotypes within the population, making some finches more successful survivors than others. Over time, the single species of finch discovered by Darwin evolved into 13 more from their common ancestor as a result of adaptive radiation (when one species gradually spreads into various subspecies over an empty ecospace). These finches became known as the Darwin finches. Each species has evolved a different beak size and shape, allowing them to exploit different food items. For example, the cactus finch has a long thin beak which allows it to consume nectar from cactus flowers. But where did the blood-feeding come from?



Author's note: Perfect Planet, the series narrated by David Attenborough for the BBC shows the vampire finches in their element on the islands. Do give it a watch!!!

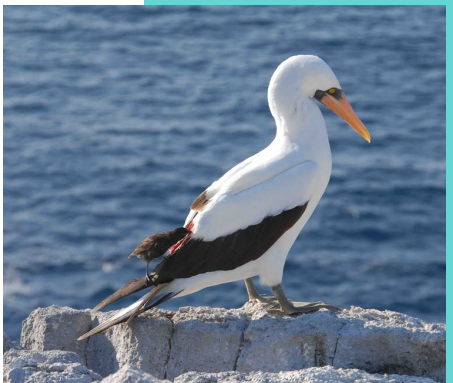
At some point in the last half-million years, finches arrived on Wolf and Darwin (the two northernmost islands of the archipelago) and began to co-exist with large seabirds which nest on the islands, such as red-footed and Nazca boobies. It is said that they were blown onto the islands by a process known as allopatric speciation (where a species population becomes separated by a geographic barrier, whereby reproductive isolation evolves producing two different species). Both islands are tiny, each less than a square mile, and are separated from the larger islands by 100 miles of open ocean. Freshwater is extremely rare, and some food can disappear entirely during the dry season.



The first vampire ground finch (Geospiza septentrionalis) was spotted in 1964, piercing its steak-knife beak into a Nazca booby. This evolution had occurred over the long period of time they had spent on the isolated Galapagos islands where conditions are harsh and seeds and insects, their normal food source, are extremely scarce. However, blood wasn't their first intention. At first, the finches had evolved to eat parasites found in the feathers and on the skin of the boobies. This was a 'mutual relationship' as the boobies benefited from the parasite removal, and the finches benefited by finding nutrition in the lice as opposed to their usual diet.

Nevertheless, the removal of parasites led to open skin wounds on the boobies, allowing the finches to consume their first taste of their blood. There was no going back…

The finches learned to pierce skin at the base of young feathers to access the blood directly, no longer needing the insect parasites anymore. Consequently, the finches made the most of the alternative food resource, blood from the boobies, and earned their nickname 'Vampire finches'. For the boobies, the whole experience is very similar to a human being attacked by mosquitoes.



It's hard to know exactly how much of the finch's diet is made up of this blood, but unpublished data from the Galapagos Conservation Trust suggests it's about a tenth. Natural selection appears to have adjusted the vampire finch beak for skin-piercing and blood-sucking, as the birds have evolved particularly long and pointy beaks compared to non-blood-feeding populations on other islands. When the microbes found in these vampire finches' guts were studied for adaptations, a microbiome different from any other species of Darwin's finches was found, presumably caused by the blood diet.

By Annissa Cheng

Einstein's Twin Paradox

Albert Einstein's theory of relativity, first presented in 1905, revolutionized our understanding of how gravity affects the fabric of space-time. Special relativity argued that space and time are inextricably connected, but that theory didn't acknowledge the existence of gravity. Among the intriguing consequences of this ground-breaking theory was the Twin Paradox, an apparent anomaly that challenges our conventional notions of time. The Twin Paradox explores the effects of time dilation on two identical twins, one of which who embarks on a journey through space at a significant fraction of the speed of light. This paradoxical scenario has profound implications for our understanding of time, space, and the nature of the universe.

Suppose that the Twin Paradox begins with two identical twins, one of whom stays on Earth (the 'stationary twin'), while the other flies off into space at nearly the speed of light (the 'travelling twin'). According to Einstein's theory of special relativity, time is not an absolute concept but is relative and can vary depending on the observer's motion. As the travelling twin accelerates to a high velocity and experiences constant motion, time dilation occurs.

Time dilation, a consequence of special relativity, states that time moves more slowly for an observer in motion relative to a stationary observer. The faster an object moves, the slower the time progresses for that object. This phenomenon becomes increasingly significant as the object approaches the speed of light. According to relativity, the travelling twin, moving at a substantial fraction of the speed of light, experiences time dilation during the journey, as time passes more slowly on the spacecraft than it does on Earth.

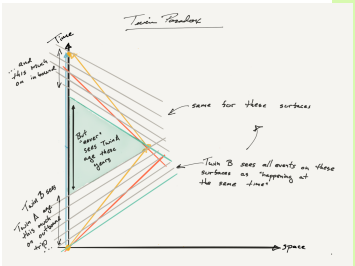
Time dilation, in the theory of special relativity, is the 'slowing down' of a clock as determined by an observer who is in relative motion with respect to that clock. As a result of time dilation, when the travelling twin returns to Earth after the space journey, they find that less time has passed for them than their Earth-bound twin. The travelling twin has effectively aged more slowly than the stationary twin and will be younger. However, what one twin sees as happening to the second one, the second one sees as happening to the first one. To the 'travelling twin', time moves more slowly on Earth than it does on their spacecraft, yet when this twin returns, their stationary counterpart is younger. However, this is puzzling since each twin sees the other twin as moving. Consequently, due to an incorrect application of time dilation and the principle of relativity, each twin should paradoxically find the other to have aged less. This intriguing aspect of the Twin Paradox challenges our intuitive understanding of time as a constant, universally ticking entity.

This paradox is only apparent, because the situation is not appropriately treated by special relativity. The travelling twin's trajectory involves two different inertial frames, one for the outbound journey and one for the inbound journey. The rocket must change direction to return to Earth, which violates the fundamental principle of special relativity - steady straight-line motion. Since the travelling twin is undergoing acceleration, they can be considered a non-inertial observer. General relativity, which demonstrates that there would be an asymmetrical change in time between the two twins, is necessary for a comprehensive treatment. Therefore, the twin paradox is not actually a paradox in the sense of a logical contradiction. There is still debate as to the resolution of the twin paradox as of today.

In Einstein's famous paper on special relativity in 1905, he deduced that for two stationary and synchronous clocks placed at points A and B, if the clock at A is moved along the line AB and stops at B, the clock that moved from A would lag behind the clock at B. He stated that this result would also apply if the path from A to B was polygonal or circular; Einstein considered this to be a natural consequence of special relativity, not a paradox, as some suggested. Additionally, Einstein didn't see the story of the twins as constituting a challenge to the self-consistency of relative physics. This theory was proved by an experiment carried out in 1971 by physicists Joseph Hafele and Richard Keating, who put atomic clocks onboard jet aircrafts and sent them flying around the world. Upon their return, the clocks were out of sync with a ground-based clock by exactly the amount predicted by special relativity.

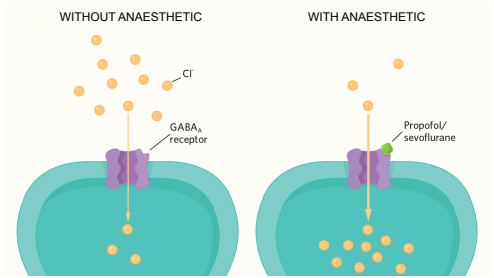
While the Twin Paradox might seem like a purely theoretical concept, its principles find practical applications in modern technology. For example, the Global Positioning System (GPS) relies on both special and general relativity to account for the time dilation effects experienced by satellites in orbit around Earth. It takes into consideration the decrease or increase of time inside the satellites due to relativity. Without the corrections derived from these relativistic principles, GPS systems would gradually accumulate errors, giving wrong coordinates and rendering them unreliable.

Einstein's Twin Paradox, while initially perplexing, ultimately serves as a testament to the complexities of Einstein's theory of relativity. This contradiction, rooted in the effects of time dilation, highlights for the need for a broader perspective beyond special relativity. This paradox, though not a true logical contradiction, challenges our intuitive understanding of time and space and emphasises the interconnected nature of these fundamental concepts. As debates persist regarding its resolution, the practical applications of relativity, exemplified by technologies like the Global Positioning System, continue to demonstrate the tangible impact of Einstein's theories on our understanding of the universe and modern technology.



By Juliana Cotton

From ancient civilisations to the modern day–how have general anaesthetics developed over time



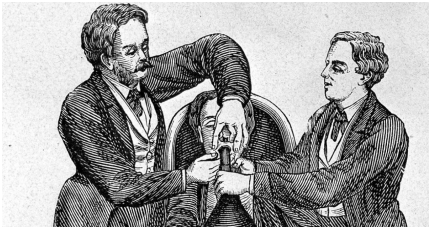
Anaesthesia is the method of using chemical substances known as anaesthetics to prevent or reduce feelings of pain during medical procedures and surgical operations, existing in various forms that create different levels of 'insensibility', or unconsciousness.

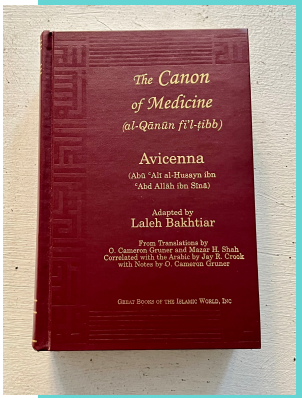
For example, general anaesthetics are used for major surgeries where it is required for the patient to remain in a controlled state of unconsciousness for a prolonged period. Local or regional anaesthetics on the other hand, such as childbirth epidurals, are used to numb specific parts of the body, when a patient may need to remain conscious during a major procedure. They do this by essentially creating an electrical barricade against impulses that would travel through the nervous system to the brain, blocking feelings of pain from a particular region.

Sedatives may also be used to relax patients and reduce discomfort during minor procedures or while in intensive care. Analgesia is more similar to pain relief than anaesthesia, although the two often involve the same drugs and are frequently used together.

However, anaesthesia has not always been as developed and safe as it is today and has a long history, dating back thousands of years, of ancient herbal remedies, medieval 'potions', poisonous plants, and even recreational drugs (before its medicinal utility was finally understood). In fact, attempts at producing functional general anaesthetics, through ancient writings and texts, can be traced back to early Sumerian, Egyptian, Indian, and Chinese civilisations (to name but a few). Many of these trials likely consisted of herbal remedies derived from plants with mind-altering properties, while alcohol is the oldest known sedative used in ancient Mesopotamia.

During this time, alcohol functioned as a solvent in sedative potions, of which opium, cultivated and harvested from the opium poppy, was another common ingredient at the time. Several more variations of a similar concept have also emerged over time. For example, 'mafeisan', a mixture of herbal extracts and plants such as monkshood (belonging to the genus Aconitum), is one of the earliest examples of sedative potions and was created by the 2nd century Chinese surgeon Hua Tao. The Egyptians may have also prepared crude analgesics and sedatives from extracts of the mandrake fruit.





In the Middle Ages, even more new anaesthetic and sedative mixtures emerged, such as the "soporific sponge" circa 1020. Created by Ibn Sīnā (an Islamic physician) and documented in his medical encyclopaedia, 'The Canon of Medicine'. It is described as a sponge imbued with aromatics and narcotics that was to be placed under a patient's nose as a form of sedative inhalation.

Between 1200 and 1500 AD, a potion called 'dwale' was used as an anaesthetic in England, as sedative mixtures began to standardise around a particular group of plants. However, dwale's ingredients (including bile, opium, hemlock, and lettuce), could appear somewhat odd and concerning from a modern perspective.

Significant progress in anaesthetic techniques and synthesis was finally made throughout the mid- 18th and early 19th centuries, as scientists began to investigate the pain-reducing effects of several gases. During the Enlightenment, for instance, carbon dioxide, oxygen and nitrous oxide were investigated for their therapeutic potential as 'pneumatic medicine'. There had already been early reports of their pain-relieving effects and ability to render users' unconscious, although such anaesthetic properties were not applied clinically until long after their initial observation.

For example, the anaesthetic properties of nitrous oxide were originally discovered in 1799 by the British chemist, Sir Humphrey Davy. Upon inhaling the gas, he noted its euphoric and analgesic effects, subsequently coining the term 'laughing gas'. Yet, the implications of his research for surgery were largely ignored and instead caught the public eye, thus increasing the recreational use of the substance at events like 'laughing gas parties'. Despite this, Davy continued his research at the Royal Institution of London, eventually meeting Michael Faraday in 1813. Together they studied the impacts of inhaling ether (diethyl ether)– a volatile liquid with sedative and analgesic properties. Faraday produced a paper on anaesthetics properties in 1818, although just as with nitrous oxide, it was valued more for its intoxicating effects at so-called 'ether frolics' and public demonstrations. At the time, it was even sold as an alternative to alcohol in pubs across the UK.

In the 1840s, ether and nitrous oxide gradually made their way to the United States, where several young doctors and dentists independently experimented with them to dull the pain of minor operations and tooth extractions. The first proper surgical use of these anaesthetics is accredited to the Boston dentist William Morton: the first person to successfully demonstrate the use of ether as a general anaesthetic in public, henceforth revolutionising global surgical practice.

Meanwhile in Edinburgh, Professor of Midwifery, James Young Simpson enthusiastically advocated for and pioneered the use of anaesthesia on women during childbirth. He additionally discovered chloroform as a sweet-smelling alternative to ether, receiving royal approval when it was administered to Queen Victoria during the birth of two of her children. Although of course, in the tradition of the ether frolic, Simpson and his acquaintances first tested the chloroform on themselves.

Whether it was chloroform or ether, by the late 19th century, general anaesthetics had become much more widely accepted. However, that is not to say that these early anaesthetics were a perfect solution, as they often had uncomfortable side effects (such as vomiting upon recovery) and were generally somewhat hazardous. This was largely because the devices used to administer them (e.g. metal containers or ether/chloroform-soaked sponges) allowed for little to no control over their dosage.

Thus, with the increased usage of anaesthesia, came the reports of anaesthetic deaths and inquiries into their safety. Many speculated that chloroform deaths were caused by respiratory or cardiac failure. Therefore, modern inhalation anaesthetics (like halothane and trichloroethylene) now have a much wider safety margin and when administered, are mixed with both oxygen and nitrous oxide. Modern day anaesthetists can now safely and precisely control the flow, composition, and dosage of gas mixtures directly into patients, whilst simultaneously being able to artificially maintain respiration via mechanical means. These inhalational anaesthetics can also now be supplemented with intravenous anaesthesia such as the sedative propofol (that induces unconsciousness) and opioids like fentanyl (that reduce pain).

In conclusion, anaesthesia has taken massive strides since it was first discovered and is now an essential part of the fabric of medicine. Aided by advances in chemistry and pharmacology, it is now much more effective and brings about fewer, less-severe side effects than in the past, allowing for not only a painless surgery experience for patients, but also the improvement of surgical techniques during intensive operations like c-sections or organ transplants. Modern medical drugs can still sometimes have serious side effects, so it is still highly important that anaesthesiologists balance the right quantity of anaesthetics, so that patients do not feel any discomfort, whilst also monitoring their vital signs and adjusting drug administration as required.

TU YOUYOU: The Brave Scientist Who Battled Against Malaria

Malaria is a major threat to global public health. In 2021, a distressing number of 247 million people were diagnosed and treated for malaria. Malaria is caused by a single-cell parasite that causes severe fever. The global efforts to eradicate malaria via a relevant vaccine were not very successful, as the parasite's resistance responds very quickly to new anti-malarial drugs. For instance, in the 1990s, African malaria parasites had become resistant to standard treatments such as chloroquine, and malaria deaths in Uganda doubled in a decade!

The good news is that over the last years, very significant progress has been achieved in reducing the rate of death of patients with malaria. One of the heroes in this field is a Chinese scientist who, after 40 years in obscurity, has been recognized with a Nobel Prize for her contribution in medicine.

This is the story of Tu Youyou, a scientist whose unusual discovery continues to save more than 100,000 lives each year.

Tu Youyou is a Chinese pharmaceutical chemist and pharmacologist who was born in 1930 and became known for the discovery of artemisinin, a drug that has become a key component in the treatment of malaria. Tu got her name from an ancient Chinese poem that translates as 'deer call ("youyou") when they are happily eating the plant Qinghao in the wild.' In a way her name was prophetic as this is exactly how things happened in her life.

In the 1970s, during the Vietnam War, North Vietnam requested China's help in dealing with a malaria epidemic affecting its soldiers. Tu Youyou became the lead of a secret military project which aimed to find a cure for malaria. Tu had a huge interest in traditional Chinese medicine and she and her team turned to traditional Chinese medicine texts for inspiration. She screened thousands of traditional herbal remedies and performed multiple experiments. Finally, Tu Youyou managed to identify a compound from the sweet wormwood plant, Artemisia annua. This compound proved to be highly effective against malaria parasites. Initially Tu proved that the plant could treat malaria in mice and monkeys. To prove that the effect could be achieved on humans, Youyou and two of her colleagues volunteered to test the drug on themselves.

Artemisia is a plant that has been used for centuries in traditional Chinese medicine. Given that Artemisia is easy to grow, it is the perfect solution for the African continent since it is ravaged by malaria and faces very limited access to healthcare and medicine. After performing long term studies on the effect of the plant, Artemisinin-based therapies are now widely used as a treatment for malaria, saving lives around the world.

Initially, Tu Youyou's work was kept confidential. Since the project was very secretive, Tu did not receive public recognition for many years. However, in 2015, Tu Youyou was awarded the Nobel Prize in Physiology or Medicine for her remarkable contributions to the discovery of artemisinin. She became the first Chinese woman to be awarded a Nobel Prize in a scientific category.

By Beatrice Crachilova 10JLE

Units of Time

By Mr Oliver

My early education was filled with memorising complicated, non-metric systems of measurement. For example, the units of length we had to know about were inches, feet, yards, chains, furlongs, and miles (in order of size). Non-metric systems were used for most things, including money, where there were 12 pennies in a shilling and 20 shillings in a pound. Thankfully, we have now moved to metric systems for virtually everything, but there is one non-metric system which has remained untouched and that is how we measure time.

The units of time only become metric on a very large scale, for units greater than a year, where we have decades, centuries, millennia and, on geological and cosmological timescales, millions, and billions of years. Time is also measured on a metric scale at the other end of the spectrum, for units below seconds, where we use tenths, hundredths, and thousandths of a second.

In between these two extremes, we have a real mish-mash of units that come to us for historical, geographic and religious reasons. Two ineluctable measures provide us with the day and the year - the time taken for the Earth to fully rotate on its axis and the time taken for the Earth to perform a complete rotation of the Sun. The patterns of everyday life for humans, night and day, and the cycle of the seasons, have been governed by these two measures for the whole of human existence.

The relationship between these two is problematic, as the year is not an exact multiple of the day. Instead, there are 365.242 days in a year. This is almost 365 and a quarter days which accounts for the need for an additional day to be introduced into the calendar every fourth year. However, this overcounts the shortfall slightly, so every 100 years (the year 1900 was an example) what would have been a leap year reverts to being a normal year. This, in turn, requires adjustment and so every 400 years the 100th year flips back to being a leap year (as in the year 2000). This system was introduced by Pope Gregory XIII back in the 16th century and it keeps our years and days aligned pretty well. Nevertheless, I estimate that every 400 years we would overshoot by about 3 ten-thousandths of a day. This means that after about 3,000 such cycles we would need to take away one of these leap years.

Whilst the importance of the day and the year are obvious, the need for the month is less so. In most non-metric systems of measurement, there are many intermediate levels of measurement. Whilst we could simply keep track of 365 days, it is difficult to do so, especially for pre-literate cultures. Instead, it is much easier to keep track of lunar cycles and link these to both the year and the day. Again, we encounter the problem of linking these units together. The lunar month is approximately 29.5 days. Twelve of these is 351 days and thirteen is 380.5.

Different cultures have addressed this problem in different ways. The Ethiopian calendar has 12 months of 30 days each and then adds an additional 5 or 6 days at the end of the year. The Bahai calendar has 19 months of 19 days each, with 4 or 5 days added. All of these solutions aim to keep the months aligned with the seasons of the year. This inevitably means that calendar months are not kept aligned with the lunar cycle.

The current system used by the global community is a legacy of the Romans, and in particular, Julius Caesar. The Roman calendar, prior to the reforms enacted by Caesar in 46 BC, was complicated and inaccurate. The Romans tried to avoid even numbers, so they had 4 months of 31 days and 8 of 29 days. They had to add an additional month of about 22 days every other year to stop the months processing. Julius Caesar's reforms included making up the shortfall of days by bumping up the 29-day months to 30 and 31 days (ignoring the superstition about even numbers) and changing the start/end of the year to December/January instead of February/March. The names of the months were left largely unchanged, although the fifth month was renamed after him (and later, the sixth month after Augustus). This provides us with the answer to two puzzles. Firstly, the names given to the months from September to December seem to be out by two, but that is because they were indeed the seventh to the tenth months in the pre-Julian calendar. Likewise, adding a leap day to February seems odd, but it was previously the end of the year which made it the obvious month to adjust.

An even less obvious unit of time is the week. An obvious theory for this is rooted in scripture. Jewish culture revolved around the seven-day cycle, with one of the commandments being to keep the Sabbath day holy - corresponding to the day of rest in the story of creation. However, it appears that the 7-day week has even deeper historical roots which can be traced back to at least the Babylonians and possibly as far as the Sumerians, the earliest civilisations. The Babylonian astronomer priests venerated the number 7, possibly because of the number of celestial bodies that they observed in the solar system. These ancient civilisations appear to have seeded the cycle of seven days, which was propagated throughout influential cultures in the near and middle East such as Persian, Jewish, and Hellenic. Over time this cycle found its way into the Islamic and Christian world view, as well as India and China, possibly as a result of Hellenic and Persian influence.

MS 2781
The Middle Babylonian almanac. Babylonia, ca. 1100-800 BC

Other variations of a week have existed over time. After the French Revolution, the Republican calendar was introduced, with twelve 30-day months, each comprising of three 10-day weeks (with 5 or 6 days added). This was not entirely new, as this was in fact the exact system used in ancient Egypt. What was new, however, was the attempt to decimalise the measurements of time within the day. Each day was divided into 10 hours and each hour into 100 minutes which were subdivided into 10 seconds. Each Republican hour was therefore 2.4 hours. Each Republican minute was 86.4 seconds and each Republican second 0.84 standard seconds. This experiment lasted only from 1793 to 1806, when it was abandoned.

The units used for time on a scale smaller than a day have their roots in ancient history. Many ancient civilisations used base 12 in their counting systems. Having numbers with many factors was desirable in a world where computation was hard. The Babylonians used a turbo-charged version of base 12, the sexagesimal system, which used base 60 instead. The bases used by these ancient cultures are the reason we use the sexagesimal system in our measurement of seconds and minutes and base 12 for the number of hours in a day. The reason for 24 hours is that originally, day and night were both divided into 12 hours each - the hours were not of equal length but varied according to the time of year. Interestingly, the use of base 60 for time seems to have come via the other leftover of the sexagesimal system–the number of degrees in a circle. The Greek polymath, Eratosthenes, used the Babylonian system to subdivide the circle into 360 parts or degrees. Each degree was further divided into 60 smaller parts, known as pars minuta prima (or first small part) and each of these were divided into 60 even smaller parts, known as the pars minuta seconda. These are the origins of the words minute and second.

It seems strange that the metric system has obliterated all previous systems of measurement on the global stage, yet the way we measure time has remained unchanged throughout the millennia. It seems to me, that measuring time is integrated into our lives in a way that nothing else can match. Furthermore, a common understanding of time is essential to the way in which we interact and cooperate. Whilst it would theoretically be possible to change the units which we use measure time, in the same way as the decimal system replaced old money in the UK, in practice, it would require global coordination on an unprecedented scale for marginal benefit. In my view, the legacy of the Babylonians is safe for a while yet.

A brief exploration of how our understanding of the brain has changed over time

335 BC

Back in 335 BC, Greek philosopher Aristotle believed that the brain was a radiator. He also believed that the sole job of the brain was to prevent the very important heart from overheating.

16th Century

In the 16th century the first nervous system sketch was drawn. Belgian anatomist Andreas Vesalius created a highly detailed map of the nervous system. This opposed the idea of ventricles as the site of brain function - which we now know is correct. (Rather than being the site of brain function, the ventricles are filled with cerebrospinal fluid. This fluid helps cushion the brain against physical impact and nourishes brain cells.)

1848

Phineas Gage (an American railroad worker) had an iron rod pierce his head, passing through his left frontal lobe. After the event, despite surviving, his personality had changed. This suggested that specific brain regions had different and independent functions.

Early 1900s

During this time period many anatomists were interested in using microscopes and new staining methods to investigate the smaller parts of the brain. Due to this, neuroanatomists Santiago Ramón y Cajal and Camilo Golgi were awarded the Nobel prize (1906) for identifying that neurones are the 'building blocks' of the brain as well as showing that there are many different types of neurones.

1963

In 1963, Alan Hodgkin, Andrew Huxley and Sir John Eccles won a noble prize. This prize was awarded for their research which showed how neurones communicate via electrical and chemical signalling.

170 AD

In 170 AD the brain's 4-ventricle structure was suggested by Roman physician Galen. He believed that the brain was the seat of complex thought which determined one's bodily function and personality. He was one of the first to propose that the brain was where our personality, memory and thinking stems from.

1791

Luigi Galvani showed that applying electricity to the nerves causes the muscles contract. This helped to form the suggestion that electrical impulses are important in the nervous system.

1860-70s

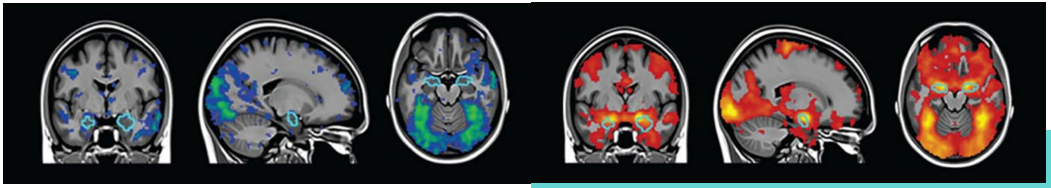
The idea of the brain having separate regions was further cemented by physicians Paul Broca and Carl Wernicke as their studies showed that specific parts of the brain were dedicated to different components of speech.

Early 1932

After proposing the concept of synapses (junctions between neurones), Sir Charles Sherrington and Edgar Adrian won the Nobel prize. This helped advance the understanding of the central nervous system.

1960-present

From the 1960s to the present day there has been a great expansion of neuroscience research due to developments in technology. This has led to greater understanding of the brain through detailed imaging and mapping of networks in the brain (done via fMRI scans, PET scans etc.)

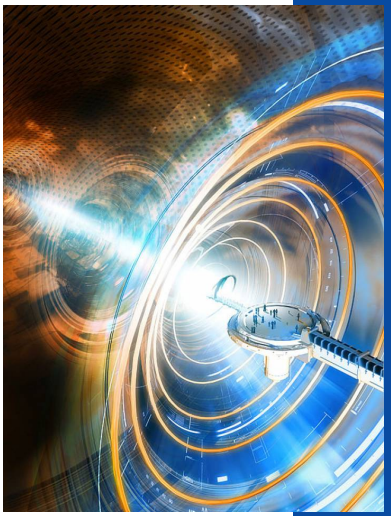


By Jasmine Yu

The right use of time travel?

By L

Time travel has always fascinated humans and inspired countless stories across different mediums. The use of time travel has always been dubious. The DC universe, especially the Flashpoint Paradox movie, uses time travel to create complex plot developments that explore the consequences of altering history. In the Flashpoint universe, the Flash's desire to save his mother leads him to change the past, causing a ripple effect. This essay will examine how the "Justice League: Flashpoint Paradox" movie uses time travel effectively. However, first we must explore how he manages to change the past.



There are different ways to travel through time, such as using futuristic technology (used by characters Booster Gold and Rip Hunter), magical artefacts (Dr. Fate), or tapping into the 'Speed Force'– a dimension that enables temporal manipulation. However, most characters follow a strict rule of not interfering with time. There is actually a comic where Booster Gold interferes with the time stream in order to save someone, only to have to let said someone die.

In the Flashpoint universe, the Flash doesn't follow this single rule of not messing with time. He doesn't accept the past, and so he therefore decides to alter it. However, changing the past had dire consequences in terms of reshaping the present and also potentially jeopardising the fabric of reality itself. His desire to save his mother leads to a domino effect where the heroes that we knew don't become the heroes that we thought they would. This new universe is set to be a dark alternative, where the atmosphere is bleak and hopeless. Bruce Wayne is no longer Batman (and is dead). Hal Jordan is no longer the Green Lantern (and is also dead). Clark Kent is not Superman (but also a shell of his former self). Wonder Woman and Aquaman are the antagonists. This contrasts with the beginning of the story, where we could see the heroes fighting together and showing kindness and courage.

One of the most compelling aspects of "Justice League: The Flashpoint Paradox" is its exploration of the moral and ethical implications of time travel. Barry (the Flash) is forced to confront the consequences of his actions, realising that his attempt to save his mother has caused widespread suffering and chaos. This one act of selfishness has caused humanity to suffer. His need to save his "mummy" drove him to change reality as he knew it. This adds depth to Barry's character and raises thought-provoking questions about responsibility and the unforeseen consequences of choices.

The film excels in its portrayal of alternate timelines and parallel universes. As Barry navigates this new reality, he encounters alternate versions of his friends and allies, each with unique backstories and motivations because, as mentioned before, the Justice League is no longer the Justice League that we once knew. They are no longer unified. This allows for fascinating character exploration, as it allows us to see an alternate world with their different decisions. Time travel is used as a device to further develop the characters that we know, and it adds layers of complexity to the storyline.

Flashpoint Paradox is not just a superhero action film, where the fight scenes are made to overshadow the plot; it is an emotional journey for our protagonist. Barry was told at the beginning to accept the past and he doesn't. In the end, his quest is to set things right and restore the timeline. He is driven by a desire to save the world, in contrast to his earlier motivation to undo his own personal tragedies. He accepts the lack of agency he has in his mother's death, while the audience is forced to watch him tackle his past self in order to save the present. Humans often want to rewrite the times that they felt inadequate or made a mistake. However, it is those mistakes that make us the people we are today and no matter how small a change to the past is, it could have a massive domino effect on today. Like Reverse Flash said, Barry didn't save anyone significant and didn't kill any dictators, he only saved his mother (which in the big scheme of things is rather insignificant). The emotional weight of the narrative is what carries the story and not time travel.

The time travelling aspect is not what makes or breaks a film. I believe that time travel can be used as a story device and should never be at the heart of a story. It shouldn't be the focal point of what happens. The movie leaves you with a message about moving on, rather than the dangers of time travel.

By Yvie Apps

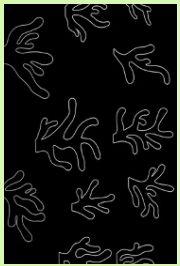
The effects of climate change on coral reefs over time

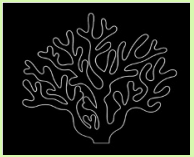
What is coral?

Corals are made up of soft invertebrates, known as polyps, which are protected by a hard skeleton around them, growing at a rate of around 0.3 to 2 centimetres per year. Corals are known as sessile animals meaning they cannot move. There are also microscopic algae that live within the tissue of the coral polyps which use sunlight to make sugar for energy. Coral reefs have been evolving for millions of years and create intricate structures that provide a habitat for over 25% of marine species. Despite not having a brain, they can grow 6 feet tall and live up to 5,000 years.

Corals reproduce to form large coral reefs which are essential in protecting coastlines from storms, erosion, and they also act as a barrier against strong waves. This is done naturally through asexual reproduction processes, known as budding or fragmentation. Through budding, new polyps 'bud' off from the parent polyps to form new colonies, while fragmentation involves the entire colony branching off and forming a new one. These processes repeat and form newer and larger colonies across the ocean.

However, with increasing climate change, coral reefs are struggling to survive. The rising sea temperatures associated with climate change can cause coral bleaching. This is where the coral is forced to expel the algae from within its tissue resulting in the corals to appear white, or pale. Therefore, the coral is more susceptible to diseases and early mortality. As well as this, the increased levels of carbon dioxide in the seawater results in ocean acidification. This hinders the corals' ability to build their calcium carbonate skeleton, which makes them weaker, more vulnerable to erosion and also inhibits reef growth. The effects of climate change have resulted in almost 50% of coral reef loss in the past 30 years and this is expected to rise to 90% by 2050.





What is being done to solve this?

Out of many other organisations, Coral Vita is attempting to regenerate the ocean's coral reefs. Coral Vita is run by 2 entrepreneurs in Grand Bahama and uses coral farming to reverse the effects of habitat destruction, overfishing, pollution, and climate change on the health of the coral reefs.

Coral farming is done in 2 ways. Micro-fragmenting, done by Coral Vita workers, collects healthy coral species and cut off small pieces for them to grow in their farm. By cutting up the pieces of coral and placing them near each other, it triggers a natural healing process which forces the corals to fuse back together, much like scar tissue. In the wild this would take decades or centuries, but Coral Vita has been able to engineer this process to take only months or years, speeding up growth rates by up to 50x faster than in the wild, whilst also vastly expanding the diversity of species for restoration.

They also use a process of assisted evolution to ensure that only the coral that have the ability to survive climate change are planted back into the wild. The pieces of coral are placed in land-based water tanks where temperature and acidity can be manipulated to purposefully stress the coral and build its tolerance to harsh environments. When the coral pieces are grown and strong, they are placed onto 'coral cookies' and placed back into the wild, where they can expand into coral reefs. A healthy reef is able to limit the negative impacts of storms, as well as create jobs for local communities through fishing and tourism, develop drugs for cancer, arthritis, and viruses, and much more.

Natural growth of coral can take decades, but the engineering done at Coral Vita enhances the corals resilience and is able to restore the dying population of coral reefs in just a couple of months. It is essential that we protect coral reefs from the climbing rates of climate change and the first step towards this is supporting or spreading awareness about the issue before it is too late.

By Dr Dixon

Deep Time

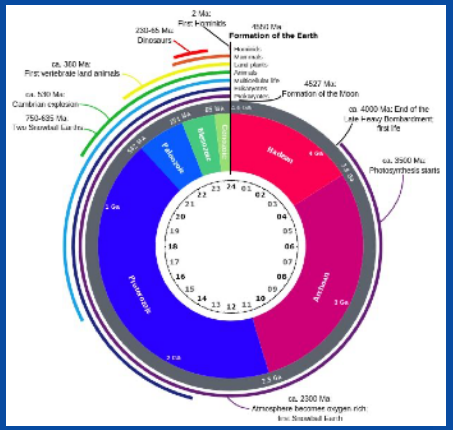
Arabesque by Debussy, has a time signature of andantino. In Italian this literally means "a little walk" and many of the time signatures used in Classical music relate to our everyday life, from "allegro" meaning cheerful to rubato meaning "stolen" to describe a slower passage of time. This interplay between time and our existence tells us much about how we view the world. We perceive time at different ages– to a young child a year is too long to possibly wait, so the quarter years until the next birthday are eagerly counted, whereas as the years advance adults begin to measure age in decades, with an emphasis on the beginning– so I am definitely in my forties rather than approaching 50.

But the reality is that there are universalities beyond our own conception of time. A year merely represents the time it takes for the Earth to orbit the sun. This fact spawns other facts, with the average speed of the Earth on this journey being 66000 miles per hour. That is the equivalent of running a marathon in less than two seconds. Such immense speeds are difficult for our brains to comprehend, and we rely on technology to aid us in our understanding. Slow motion photography assists us with this.

But the other end of the scale confronts us when we consider the age of the Earth. Johannes Kepler, author of the laws of planetary motion and one of the first to accurately describe how planets orbit the sun in the solar system, in collaboration with Galileo, suggested that the Earth was created 3992 years before the birth of Christ. Subsequent academics revised this date to 4004 BC.

Whilst 6000 years to a human feel like an eternity, a paradox arose when 18th century geologists such as James Hutton and Charles Lyell started to describe how the rocks that we know today as igneous, metamorphic, and sedimentary were formed in the rock cycle. Whilst volcanoes erupted in a matter of seconds, the subsequent process of weathering, erosion, deposition, mineralisation, and compaction occurred at such a slow rate that it was inconceivable that the layers and types of rocks found across the globe could possibly have occurred within the time frame apparently available. In the words of Charles Lyell, author of Principles of Geology: "the imagination was first fatigued and then overpowered by endeavouring to conceive the immensity of time required for the annihilation of whole continents by so insensible a process". After grappling with the overwhelming evidence behind his theories, Lyell proposed the concept of "deep time", breaking the assumption that the Earth had been created. In his 1788 book Theory of the Earth, geologist James Hutton wrote the famous phrase "[In geology] we find no vestige of a beginning, no prospect of an end."

Between the sedimentary rock layers, palaeontologists, such as Mary Anning in the Isle of Wight, uncovered fossils of immense prehistoric sea creatures, but perhaps more importantly discovered the transitional forms that appeared to show links between currents forms, such as between rays and sharks. The combination of fossil evidence and a paradigm shift in how the age of the earth was viewed paved the way for a young Charles Darwin to develop his own theories to explain the wonderful diversity of life on earth. Charles Darwin wrote in his 1859 work On the Origin of Species: "there is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved."



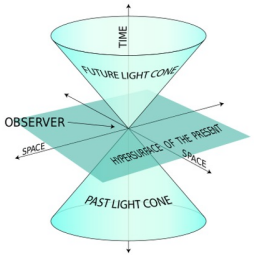
Three years after the publication of this book, in 1862, the physicist Lord Kelvin attempted to put an age on the Earth by reasoning that the solid world we live on today must once have been liquid magma. With a known volume of the Earth, and extrapolation of its density from rock samples, combined with the specific heat capacity formula, he calculated that the Earth was 400 million years old. Whilst this was a good first estimate, improved understanding of radioactive decay has allowed us to recalibrate our estimates of the age of the Earth to 4.5 billion years. To help us comprehend the place of humans in this history, the American Museum of Natural History has a display showing all the events of the Earth's history over the 24 hours of a day. If the Earth formed at midnight, the first animals emerged at 5am, in what geologists refer to as the Precambrian era. It took until 8pm for the first animals with backbones– vertebrates – to evolve and the first dinosaurs walked the Earth at 10.41, reigning for half an hour before their subsequent extinction at 11.14 and 27 seconds. But what about human life on Earth? We evolved less than a second before midnight at the end of the day. Our fleeting existence and the uncertainty of our future brings to mind the advice of Horace from his Odes, published over 2000 years ago, "Carpe diem". Seize the day. What fewer people know is how the poem continues– "now [is] the time to dance footloose upon the Earth."

Distance, space, time and relativity

By Isabelle McGrail - 10JLE

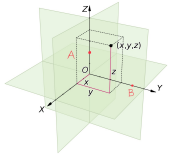
When travelling on Earth, we really only need to think about it in two dimensions: how far north or south, and how far east or west. This is shown through our everyday use of maps. You could interpret two-dimensional travel like riding a bike. You can move forwards or backwards and left or right.

However, this is not the case for pilots. They have to also consider latitude when flying in the Earth's atmosphere. This is three dimensional as you have height, width, and length. This differs from travelling in space. In space it's not enough to know where something is but you also need to know when in time it is, meaning in space there is a four-dimensional space-time (longitude, latitude, altitude, and time). This is shown through the four-dimensional Minkowski Space, which is a combination of the three-dimensional Euclidean Space and time.

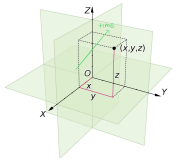


Minkowski Space

The Minkowski Space model is named after the German mathematician Hermann Mikowski and published in 1907. To help understand how it works you can look at the Euclidean Space which shows three axes of height (x), width (y) and length (z) (as shown below). These form an equation: $D^2 = X^2 + Y^2 + Z^2$ where D is distance. All observers can agree on the distance between points A and B. This is because the distance is represented by the equation. No matter how much the spatial axes are rotated, the equation for distance gives the same answer.



Euclidean Space



Space-time interval

In Einstein's Theory of Relativity - in which the time axis is added - this is no longer true. Observers will now agree on a new parameter which is known as the "space-time interval" (see left) which is represented through a different equation. This equation is $S^2 = X^2 + Y^2 + Z^2 - (Ct)^2$ where 'S' is the space-time interval, 'C' is the speed of light and 't' is the distance between A and B.

According to the Theory of Relativity, observers will disagree on the distance between two things, and will also disagree on the time at which the two things occur. They will agree on the space-time interval. Another factor that is agreed on is the speed of light. This is a result of light moving along paths at a space-time interval of zero between every two points along a graph. The model provides an explanation of Einstein's Theory of Relativity and an understanding of the connections between Space and time.

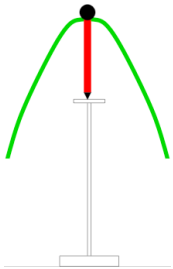
Is it conceptually possible for the "arrow of time" to be slowed or reversed completely in the quantum system & is time travel possible?

By Jess Vick

Time is a measurable and observable phenomenon used by humans to quantify the duration of events and give structure to our daily routines. Although time lacks any physical properties to directly measure it by, it is the intervals separating various events that we keep track of. The concept of the passing of time intricately links to the concept of the "arrow of time" which proposes the "one-way direction" or "asymmetry" of time which restricts us from revisiting our past.

It is possible to determine the direction of this "arrow of time" through the study of the organisation of atoms and molecules. At a macroscopic level there is always an obvious direction of time and systems will not show symmetry under time reversal. This is due to the second law of thermodynamics which establishes why scientists have only thought of time as an entity that travels in one direction. It states that in an isolated system, on average, entropy always increases with time, with the lowest state of entropy occurring at the Big Bang. Entropy can be defined as the degree of disorder or uncertainty in a thermodynamic system. This means that the process of entropy isn't reversible. For instance, if you drop an egg on the floor it will break, creating disorder of the original object as well as increased entropy. Since it is impossible for the reverse of this event to occur where the broken egg spontaneously fixes itself, this is an example of how systems get more disordered as time progresses. Therefore, giving time a seemingly irreversible direction; known as the arrow of time.

The symmetry of time, as mentioned before, can be referred to as T-symmetry and is the theoretical symmetry of physical laws under the transformation of time reversal. If time were to be perfectly symmetrical, a video of any event would appear realistic whether it was played forwards or backwards. An example of this is gravity, whereby a ball that is thrown directly upwards will fall back down in a symmetrical manner. A recording of this would look equally realistic whether it is played forwards or backwards, therefore making this action reversible and making weight a time-reversible force in this example.

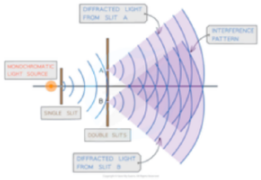


Taking this idea into account, there are other processes that are also time-reversible. Since increasing entropy is linked to both the passing of time and forward direction of the "arrow of time", then would there be a way to switch our temporal direction and create a decrease in entropy to reverse the arrow of time? When considering this theory, we have to look into microscopic systems as opposed to macroscopic ones. This is because physical processes on a microscopic level are mostly believed to be time-symmetric, where if the direction of time was reversed, these processes would remain true. Therefore, it is possible for the system to naturally evolve towards situations of lower entropy and return to a prior state. To understand this concept, take into consideration a vessel with gas inside that occupies half of the space available, confined by a valve in the middle. If we remove this valve, the gas is now free to diffuse throughout the entire container and will eventually occupy the whole vessel. Now, consider the probability that all the gas particles return to their original positions occupying only half of the vessel. In principle, this will be a non-zero probability, however, the likelihood gets smaller and smaller as the number of particles in the gas increases. It would then be logical to presume that with an extremely small number of gas particles in the vessel, such as three, the probability that these particles simultaneously return to their original side of the vessel is reasonably large, due to their random motion. This is just one simple example of how systems can naturally evolve to their previous situations, almost as if they have gone back in time.

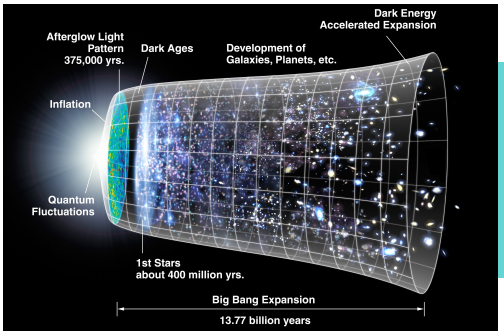
Another idea that could be used to decrease entropy is to consider a non-isolated system. The entropy of isolated systems can never decrease, but when a system isn't isolated and is instead in contact with its surrounding, the entropy of this open system may decrease, with an increase in the entropy of the surroundings compensating for it. Considering this theoretically, if the past is linked to a decreasing entropy, this theory could be applied in time-reversal experiments.

According to the discovery from the double slit experiment, otherwise known as the principle of quantum superposition, individual units in a quantum system can exist in multiple states at the same time. For example, this experiment proved the wave-particle duality of electrons. This remains true until the system is observed. A team of scientists carried out time reversal experiments and looked at the quantum superposition of a state that can evolve both forwards and backwards in time. The measurements they recorded showed that most of the time, the system ended up moving forward in time. However, for small entropy changes, it was possible for the system to evolve both forward and backward in time, as previously represented by the model of gas particles in a vessel. Using this model, researchers have discovered that it's possible to speed up, slow down, or reverse the flow of time in a quantum system.

Although this proves that a microscopic system has the possibility of evolving backwards in time, unfortunately it's not applicable to macroscopic systems such as humans as we cannot perceive these micro phenomenons at the quantum level. Even then, since the number of forward evolutions in a microscopic system would always far exceed the number of backwards ones, it would never have an effect on the direction of macroscopic evolutions - on average everything would still move forwards.

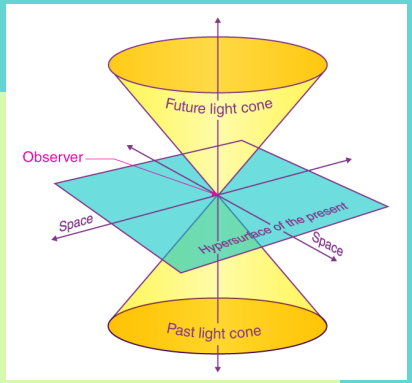


The laws controlling the macroscopic and microscopic worlds are simply different manifestations of the same underlying principles. It is thought that the world is constructed from quantum systems with two temporal dimensions, with "arrows of time" moving in opposite directions relative to one another - both forwards and backwards simultaneously. It is possible for our experience of time passing and our concept of the present to arise from our consciousness oscillating between these two arrows. Where events become memories, stored in an increasing past. However, due to our inherently limited perception of the world, we are constrained to only experience time as moving forward since its direction is subjective and relative to the observer. Even if we could oscillate between these two arrows, we would still experience that arrow as moving forward, as relative to us, the other one would now move backwards.



Moving onto a different theory of how time could be reversed, as mentioned before, the lowest state of entropy experienced by our universe occurred at the Big Bang. The universe now entered an inflationary state, the theory of exponential expansion of space in the early universe. This is associated with the arrow of time pointing forward. If the universe was to ever enter a deflationary state, this could theoretically be affiliated with the arrow of time pointing backwards, therefore giving scope for time-reversal. At the moment, the universe is constantly expanding at an accelerating rate, with galaxies moving further and further apart. Although some studies predict that this expansion will continue forever, other research suggests that the expansion may begin to slow down as dark energy may enter a phase in its cycle where it decays, causing its repellent forces to diminish. This may cause the expansion of the universe to smoothly transition to a phase of slow contraction. If this occurs, it could theoretically provide an opportunity for the arrow of time to be reversed, although we can never know for certain what will happen if our universe ever reaches this point. One suggested consequence of this contraction happening, is that the universe reaches its eventual death and could possibly be reborn in the form of another Big Bang. If this were true, it would provide evidence that our universe could follow a cyclical process of expansion and contraction, almost as if time has been 'reset' after every repeat of this cycle. Our universe would be one of many that have ever occurred, and in between each cycle it theoretically could be compared to going back in time, where the universe always returns to how it was before.

All concepts previously mentioned have little scope for making a large impact on the way humans perceive the passing of time in our lifetime. However, there is one more theory that can be used to manipulate the passing of time: Einstein's theory of special relativity. He published this theorem in 1905, which deals with the structure of space-time, stating that time and space are relative, and the rate that time passes depends on the motion of the observer. This can be seen where a person moving at extremely high speeds will experience time passing more slowly compared to the point of view of a stationary person. However, you would need to start approaching the speed of light in order for the effect to be significant. This idea gives rise to the twin paradox, in which one twin travels around space, close to the speed of light, and returns home to find that the twin who remained on Earth had aged more. One twin has now travelled into the future whilst remaining in their more youthful body. Likewise, time passes more slowly if you are surrounded by an intense gravitational field. It has been suggested that even on Earth your head would age quicker than your feet. This is due to Earth's gravitational field which gets stronger the closer you are to the Earth's core. As the difference between the gravity experienced at your head and at your feet is so minuscule, any difference in aging would be virtually unnoticeable. This effect becomes more noticeable when considering a black hole. If you managed to spend a relatively short amount of time in one without being crushed to infinite density from the intense forces, you would find that decades or centuries may have passed on Earth and in the rest of the universe.



Therefore, there is a future possibility for travelling into the future. However, it would take a long time to develop the technology needed.

Is the Gregorian Calendar the most scientifically correct?

By Amelia Schutt

Out of the worlds 195 countries 168 of them follow the incredibly popular Gregorian calendar, but what about the others?

There are around 40 different calendars in use today including the Jewish, Islamic and Hindu amongst many others. Some countries such as North Korea and Japan start their calendars on the day their leader or monarch was born or elected, while others base it around the birth of Christ or lunar/solar patterns.

In the UK, since 1752 we have solely used the Gregorian calendar. This is a calendar created in 1582 by Pope Gregory XIII. It states that each year consists of 365.2425 days, a direct correlation to the Earth's path around the sun. However, as we can't have quarter days, each year is only 365 days with every fourth year as a leap year with 366 days. This Calendar was initially only followed by Spain, Portugal, Poland, and most of Italy (the mainly Catholic, Christian countries), although due to ease and to simplify communication between countries, others soon followed.

Ethiopia is one of the few countries that hasn't adapted to the Gregorian calendar as they follow their own calendar called the Ge'ez calendar, which has 12 identical months of 30 days and then a 13th month called Pagume (this comes from the Greek word epagomene meaning 'days forgotten when a year is calculated') is added so that they align with the Earth's path around the sun. The reason it is only 2017 in the Ge'ez calendar is because they disagree on the year Jesus was thought to have been born. The man who calculated the year Jesus was born, Dionysius Exiguus, was thought to be 6-8 years too late, leading to the Ethiopian calendar actually being the more scientifically correct one.

Additionally, in Iran and Afghanistan they use the Solar Hijri calendar. This calendar is one of the oldest in the world, as well as the most accurate solar calendar in use today. It is a calendar in which the first 6 months have 31 days, the following 5 months have 30 days, and the last month is a leap month with either 29 or 30 days–similar to February in the Gregorian calendar. This calendar considers new year to be on the March equinox, the time when the sun crosses the equator, moving from south to north, between the 19th and 21st of March. In the Solar Hijri calendar, the year is currently 1402CE, as Solar Hijri year count starts with the year of the journey of the Islamic prophet Muhammad from Mecca to Medina in 622CE.

In conclusion, there are numerous different calendars used all over the globe and although the Gregorian calendar is the most widely used, it may not be the most accurate or the most correct.

How our perception of mental health/ illnesses have changed over time

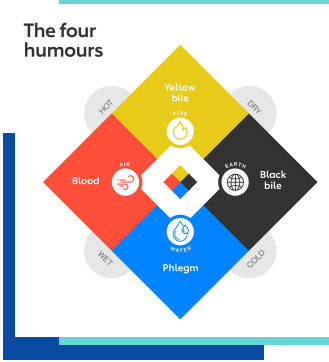
By Rubani Pandya

Throughout history, our perception of mental health has undergone drastic transformations which have been shaped by scientific, social, cultural, and philosophical influences. From ancient beliefs in supernatural causes to modern understanding derived from scientific research, the everchanging understanding of mental health reflects humanity's evolving comprehension of the human brain and all of it's intricacies.

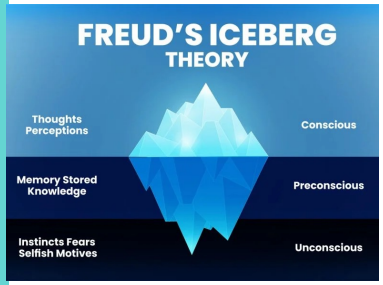
Mental health is a subject which we, as young adults, hear a lot about nowadays. In the UK, approximately 1 in 4 people will experience a mental health problem each year. A study carried out in 2017, approximated that 10.7% of the global population (792 million people) were living and struggling with some sort of mental health issue. But when did mental health become such a pertinent topic?

In ancient civilizations, mental health issues were often linked to supernatural causes, such as divine punishment and possession by the devil. During neolithic times (4300BC - 2000BC) a procedure known as 'trephining' occurred to those who showed signs of suffering from mental illnesses. The procedure involved using a sharp stone instrument to create a hole in the skull of the patient - this would allow the supernatural being residing in the patients head to escape, in turn curing the patient. This procedure was also carried out on those who experienced migraines or had undergone trauma to their skull. Although this procedure evolved to be more successful over time, initially the survival rate was around 40%. In contrast to this, the ancient Egyptians seemed to adopt a much more effective and civil approach. Those who required treatment for mental problems would be encouraged to engage in recreational activities like singing and dancing to achieve a state of 'normalcy'. Practices such as exorcisms and prayer rituals were also commonly used to try and cure those who ancient civilisations believed were possessed or were facing trial from God.

The first signs of any scientific link to mental health problems emerged when the Greek philosopher Hippocrates developed his theory of the 'Four Humors', which consisted of blood, yellow bile, black bile and phlegm and how these particular substances affected the function of the human body. Hippocrates believed that a build-up of black bile in the body would lead to 'melancholy' which was described and documented similarly to the mental health issue we now classify as depression. The treatment used for cases of 'melancholy' was to provide the patient with laxatives. Hippocrates was the first to conclude that mental illnesses were not caused by supernatural interference, but by natural occurrences in the human body. From the years 1200 to the 1700's, people who showed symptoms of mental illnesses were committed to insane asylums and were banished from society as they didn't fit into societal standards. At this time there was a heavy religious influence which affected the treatment that people received as there was still belief that mental illnesses were caused by supernatural occurrences. The majority of the people admitted were women who were said to be 'hysterical'.



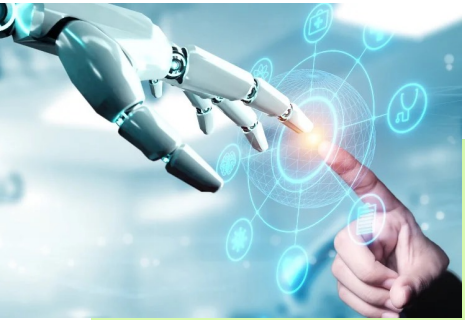
During the 20th century the Freudian approach was adopted. A man from Czechia named Sigmund Freud proposed the psychodynamic approach which assumes that we can understand mental health better by looking at childhood experiences and unconscious mental forces which people are unaware of, which drive actions and various emotions. He believed that the way to cure mental problems was to experiment with methods of open dialogue with the patient, creating the basis of what we know as therapy. American psychologist John B. Watson also introduced the theory of behaviourism around about the same time. This theory explained how psychopathology was closely related to behavioural conditioning during the patient's childhood, and the way to treat this was to use methods of adaptive reconditioning. This period saw significant advances in biological psychiatry and what we know now as 'mental health' was finally realized by medical practitioners. Methods of treatment in this time period included psychoanalysis, hypnosis, and dream analysis to try and understand the unconscious mind to a higher degree.



Now, in the 21st century, people recognise mental health as a multifaceted topic which can be caused by psychological, environmental, and biological factors. Negative beliefs have been debunked due to multiple campaigns on the topic and new scientific evidence about the human brain. The use of medication administered by physicians, and treatments such as psychotherapy have helped to adopt more of a holistic approach to mental health.

How Artificial Intelligence (AI) has changed medicine over time: AI assistance in diagnostics

By Ashmita Suppiah

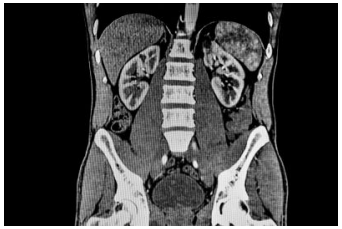


In the medical field, getting the right diagnosis is the most fundamental aspect of healthcare, as it provides information about the patient's medical condition through analysing symptoms, test results and medical history. This allows subsequent medical decisions to be made that provide effective treatment. Even now, early diagnosis is considered an issue due to the lack of ability to understand the complexity behind diseases. Artificial intelligence (AI) is an emerging aspect of medicine, that is transforming healthcare drastically, with the promise of revolutionising diagnostics.

Over time, AI systems have been able to analyse data regarding demographic information, medical history, test results, bio-signals (e.g. ECG, EEG) or even vital signs (e.g. pulse, respiration rate, blood pressure and body temperature). These tools can help enhance the accuracy and precision of medical diagnostics, whilst being more time efficient. Healthcare providers are better enabled to make informed decisions about patients (allowing them to obtain an in depth understanding of the patient's health and symptoms), subsequently helping them decide on the correct medical treatment.

Improving accuracy has been a key role in changing diagnostics through the use of AI. AI has helped to reduce the chance of misdiagnosis, and it provides more accurate results in significantly less time. A study published in the UK regarding the usage of AI in interpreting mammograms showed that there was a significant decrease in the number of false positives (by around 5.7%) and false negatives (by around 9.4%). Additionally, advanced AI programmes were utilised in detecting pneumonia from chest radiography with a sensitivity of around 94%, in comparison to radiologists with a sensitivity of approximately 50%. Furthermore, a study was completed showing how AI affects diagnosing acute appendicitis, in order to identify early if there is a need for appendix surgery. The results showed that an algorithm accurately predicted 83.75% of cases, which meant that it could be implemented in some hospitals to assist healthcare professionals in diagnosing acute appendicitis. Overall, AI has greatly improved the accuracy of medical diagnosis through enhanced pattern recognition, reduced diagnostic errors, and improved speed and efficiency.

X-ray



CT scan

In conclusion, the assistance of AI in medical diagnostics has benefitted medicine in numerous ways, and this pioneering aspect of medicine will ensure the increased accuracy of diagnostics. In the future, AI will completely revolutionise diagnostics, providing speed, efficiency and accuracy that has not been possible before.

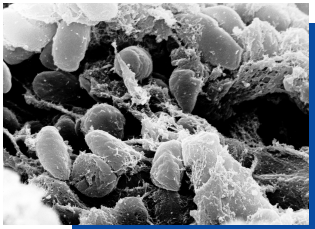
How will AI technology provide help to clinicians in the future? AI technology is rapidly growing and will be able to help clinicians by giving them deeper insights and live assistance with patients. Scientists are continuing to research how AI can be used to study medical images (e.g. X-rays, MRIs, and CT scans) as well as identify abnormalities (e.g. fractures, tumours, or conditions). Laboratory efficiency and precision have also improved greatly due to the implementation of AI. Automated techniques have improved laboratory efficiency in areas such as blood cultures, molecular platforms, and susceptibility testing. This has enabled results to come through within 24-48 hours, which helps in choosing (antibiotic) treatments and it also expedites the treatment process.

The Department of Health and Social Care (NHS England) stated in March 2023 that 'Nine of the most promising artificial intelligence healthcare technologies [are] to receive nearly £16 million in government funding to accelerate research'. Some of the funding is dedicated to diagnosing rare diseases. AI has the potential to change the process of diagnostics in the NHS substantially, by recognising signs more quickly and accurately and detecting symptoms of undiagnosed diseases.

MRI scan

Snapshots in time: how paleomicrobiology and aDNA have helped us track the evolution and spread of the plague

By Jahnvi Sodha



The evolution of microorganisms and pathogens is not easily tracked, and fossils of these microbes are not easily identifiable. Paleomicrobiology is the study of ancient microorganisms, and the analysis of ancient DNA (aDNA) that can give us a brief insight into the evolution and virulence of pathogens such as the plague.

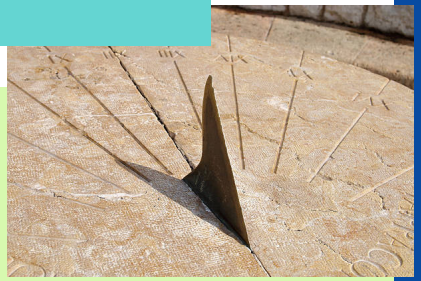
Microbial aDNA can be obtained from a variety of sources, ranging from permafrost to the dental pulp inside teeth, with the latter being a concentrated source of microbial aDNA for blood borne infections. Despite this, isolating and analysing aDNA can come with challenges, especially regarding the degradation of aDNA over time. This results in the aDNA being of a lower quality than modern DNA, which highly restricts the number of samples that can be successfully analysed and also means that it is harder to analyse older samples. Additionally, aDNA is highly susceptible to contamination, thus affecting reliability and further decreasing the number of successful samples taken. The limitations of analysing aDNA mean that only brief snapshots of a microorganism's history can be seen. However, this is still enough to gain valuable insight into the evolution of pathogens and their virulence, as different lineages of pathogens can be identified along with any adaptations that may have changed how pathogens affect humans.

This has been seen during studies on Yersinia pestis, the bacterium that causes plague. The earliest known cases of plague in the human population occurred around 5000 years ago, during the late Neolithic period in Sweden. However, this ancient Y. pestis lineage was identified as not having been adapted for transmission via a flea vector, which was how the bacterium was spread during the outbreak in the 14th century. Whilst it is unclear how this ancient lineage may have affected the human population, the difference in transmission methods may have resulted in significant differences in the virulence of the disease, which may have been a contributing factor in the development of a highly contagious and deadly disease that emerged later on. However, another lineage of plague dating back to the Bronze Age in Russia was identified as having adapted to flea transmission, suggesting that both variations of the Y. pestis bacterium existed at similar times, and were both present in Eurasia. While this was the first strain of Y. pestis identified as being capable of causing bubonic plague, this form of the bacterium was also found in Spain, around the Iberian Peninsula, and was dated to be around 500 years younger than the initial flea-adapted sample. This suggests that this form of Y. pestis was widespread across Europe during the Bronze Age. The presence of Y. pestis found in dental pulp aDNA has also suggested a high concentration in the bloodstream, indicating that it could have been deadly. This evidence is consistent with an earlier plague outbreak, thousands of years before the Black Death swept across Europe.

How has technology affected time and how we perceive time?

By Isobel Jefferies

The first attempts to track the passage of time were made with lunar calendars by the Mayans and Babylonians, while the first sundials were created by the Egyptians. This indicates that between approximately 4000 to 1500 BC, the most commonly used measures of time were the month, day, and hour, varying with how advanced the civilisation was. The lunar calendar had many flaws and versions, with the Babylonians using 12 months with 28 days which was often corrected by a leap month to account for the correct timings of solstices. This certainly compared to the later calendars and the need for them to be so precise in today's world. The Egyptians were the first civilisation to create the 'hour'. This started with sundials which marked out every hour depending on the direction of the sun. The Egyptians also invented the first division of the hour which was later named the 'minute'; however, they didn't have a use for this 'minute' as their life was not like our rushed, fast paced life. This meant that the 'minute' didn't resurface until the 14th century when clocks were invented.



As time passed, technology advanced and there was a need for a precise calendar which actually tracked the full year, being 365.2425 days. In 46 BC Julius Caesar proposed a new calendar with 365 days and a leap day every 4 years. In theory this would sound like a good calendar, however, in the 16th century a problem was noticed when it was observed in 1582: the solstices of that year were 10 days off, causing an imbalance in the Catholic Church's calculation of Easter. When proposing this calendar, there was a leap error which caused the year to actually be 365.25 days long. While this may not seem like a big deal, it made the year slower by 11 minutes every year which summed up over time and meant a new calendar was needed. The Gregorian reform of the Julian calendar brought about the current calendar used today by most countries. The change to the calendar introduced the leap year rule, which stipulated that every year exactly divisible by 4 is a leap year, except for years divisible by 100. However, centurial years divisible by 400 are still considered leap years. This adjustment reduced the mean year time from 365 ¼ days to 365 and 97/400 days. This change reflected advancements in the world and technology, highlighting the need for a precise clock to accommodate people's reliance on accurate time measurements.

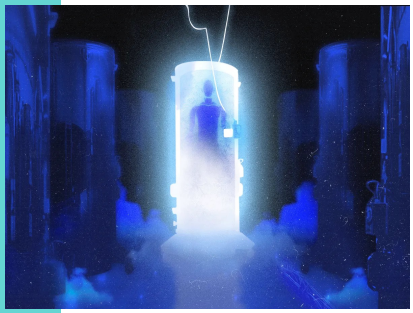
While Calendars were useful, humans needed to tell the time of the day in increasingly smaller increments. As previously mentioned, the sundial was the earliest and main way of telling the time, whilst there was also a water clock. These were mainly used from the early AD to the 1600s, as they were more accurate than the sundials and could even be used when the sun was down. This further illustrates that as our technology and understanding of time advanced, we actively sought newer ways of telling the time in a more reliable way. Mechanical clocks were the next step to telling the hours of the day. They were primarily used in the early 14th century to indicate the start of each new hour, satisfying people's timekeeping needs for an extended period. The 14th century also saw the introduction of spring and pendulum clocks, which featured minute hands. Since the invention of the minute, this marked the first time people started using it to tell the time. Over time, the minute proved to be too short, leading to the introduction of the second in spring-driven clocks. However, initially, it wasn't commonly used to tell the time. This innovation was revolutionary as people could tell the time more accurately, and by the 17th century, it had become increasingly accessible. With the development of electrical clocks, scientists wanted the most precise way to measure the second, leading to the creation of the caesium standard in 1955. This is what scientists classify as a second and it was used to create the atomic clock in 2013, which remains the most accurate way to tell the time to this day.

These developments over time in methods of telling the time, tailored to suit the needs of the people using them, demonstrate how we have evolved alongside time and how our perception of time differs from that of the past. In earlier time periods, people were happy with knowing only the days and the months passing, which contrasts drastically with today's world where even a 0.0004th of a second can change so much over time.

For example, the World Trade Centre (WTC) in New York connected underground wires to the WTC in Chicago to shave off that 0.0004th of a second in communication. This cost millions of dollars. However, after completion they gained 12 billion dollars in revenue because of the time difference. This shows that our current world perceive time much faster than past generations. These trends may suggest that in the future, we may be using even shorter increments of time in everyday life.

Aldehyde Stabilised cryonics

By Katie Say



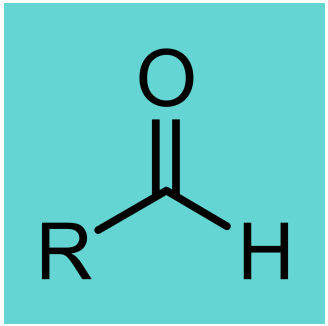
Introduction

Cryonics is the freezing of human remains (typically to around -195°C) with the speculative hope of resurrection at some future date. This practice is generally viewed as pseudoscience within the scientific community as the likelihood of science progressing to the extent that of reversing death itself is extremely low. Keeping these remains at low temperatures prevents tissue decay but introduces further damage to cells (which are already irreversibly damaged from a lack of oxygen and nutrients from death) through the formation of ice crystals.

Despite the lack of sufficient evidence supporting the viability of cryonics, many companies already offer the banking of human remains for future revival as an expensive service. The most famous example is 'Alcor Life Extension Foundation,' an American non-profit organisation charging $100,000 for neural preservation and $220,000 for whole body preservation. As of October 31, 2023, Alcor had 1,927 members, including 222 who have died and whose corpses have been subject to cryonic processes; 116 bodies had only their head preserved. Alcor also applies its cryonic process to the bodies of pets. As of February 13, 2009, there were 33 animal bodies preserved.

Another organisation associated with cryonics is 'The Brain Preservation Foundation' which funds research into technical services development in the field of whole brain preservation. They focus specifically on preserving the ultrastructure of the brain with the hope that at some future date this can be interpreted using AI or other means and then translated into a computerised replica of the mind. This foundation funded the first and only successful experiment using aldehyde-stabilised cryopreservation in 2015, in which numerous rabbit and pig brains were fixed with glutaraldehyde and then injected with ethylene glycol (a cryoprotectant) before being stored at around -135°C for at least one week. Slices of these brains were examined under electron and light microscopy and showed excellent preservation of the brain on a microscopic level. The rest of this article will delve into the specifics of how these brains were preserved as well as the potential this study may hold for future human cryopreservation.

Aldehyde Fixation



Typically, when someone dies the ultrastructure of the brain is not only lost through decay but through the physical process of death itself.

Neurones degrade without a supply of oxygen and nutrients; this causes synaptic disruption. In the absence of ongoing neural activity and maintenance processes, synaptic connections quickly deteriorate after death. Neurotransmitter release, synaptic vesicle recycling, and other synaptic functions cease, leading to the disruption and breakdown of synaptic structures. Cellular swelling and autolysis also occur in the initial stages after death. Cells may undergo swelling due to disturbances in ion gradients and metabolic imbalances and enzymes regulation ceases to occur, so enzymes begin to breakdown cells. This is also exacerbated by pH changes after death: an early study reported a pH change from 7.0 to 5.5 in cardiac blood 20 hours post-mortem. These processes further contribute to the destruction of cellular structures, including dendrites, axons, and synaptic terminals, which are essential for maintaining the details of the connectome.

To avoid the degradation caused after death, the aldehyde must be injected whilst the specimen is still alive. It prevents degradation of cellular morphology cross-linking proteins and fixing them, and the cells around them, in place. They also cross link enzyme active sites, halting biochemical reactions.

Formaldehyde is another common aldehyde used for preserving specimen for research and for embalming. However, glutaraldehyde is used as a fixative here instead as it has a higher cross-linking efficiency, and it penetrates tissues more deeply and evenly.

Cryopreservation

Aldehyde fixation is not sufficient in preserving the ultrastructure of the brain alone as it fails to sufficiently preserve the integrity of cellular membranes, leading to changes in membrane permeability and leakage of cellular contents over time. This is why cryopreservation is the second necessary step.

The specimen was lowered to a temperature of around -135°C very quickly and then injected with cryopreservatives. Ordinarily, if the cells were to be lowered to such low temperatures, ice crystals would form. The water molecules would arrange themselves in a regular lattice structure held in place by strong hydrogen bonds. This structure is less dense than liquid water, causing the water to expand, as the ice crystals expand inside the cell, they would damage the plasma membrane. If ice crystals form outside, the cell can also lead to cellular dehydration as the water potential outside the cell is lowered, causing water to move out of the cell through osmosis.

To avoid the water forming crystals, a cryoprotectant is injected: ethylene glycol. This causes the water to vitrify instead, with water molecules moving closer together and vibrating around fixed positions. The vitrified water holds the cell's membrane and organelles in place. Ethylene glycol has the ability to penetrate to the cell membrane rapidly than any other cryoprotectant, this is because the molecular weight is so small (62.07 g/mol).

Results

The specimen was observed under both light and electron microscopes showing excellent preservation of their molecular structure. Quote from the study:

'The absence of ''dark'' neurons, indicates proper fixation and the lack of mechanical disruption to brain tissue. Nuclear envelopes are clearly defined and display no discontinuities. Intracellular organelles are also well preserved: rough endoplasmic reticulum is clear and compact, and the mitochondria appear normal, with cristae clearly visible even at the relatively low magnification of the image. There are no visible examples of exploded and vacuolated (or ''popcorned'') mitochondria. The few darkly-stained myelinated transverse processes seen are well-preserved, with tight myelin sheaths.'

Future application

Although the results of the experiment showed an impressive preservation of the rabbit and pig brains, it's unlikely this research will ever be used to prolong or conserve human life. While known physical elements of the connectome were well preserved there are many connections within our brains that are understood only through statistical rather than physical connection and we therefore lack the knowledge to conserve these elements. Furthermore, while some hope that nanotechnology may become far more advanced in the future, even to the extent of being able to reverse damage caused by aldehyde fixation, its highly unlikely brains preserved in this way will ever regain physical functionality. The only viable option appears to be mapping the connectome into a computer which might them simulate the dead person although this appears equally unlikely and ethically questionable.

Word search

S M G C R J L L Q N G C C A N Y M E A S
E M I A G E X P A R A D O X G D K Y H C
C M X R N Z D C S E A S O N D L K B Q T
O W I Q E T I M E L I N E U Y D C Z D C
N Q W C X L Z F M N I M X V P U R Q W W
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C F Q V W S C U I M T T R P Y N H E O K
I C P G D V A R N V T E H Y R X E R A J
T N D S E U I E C I I A M C I S R I M N
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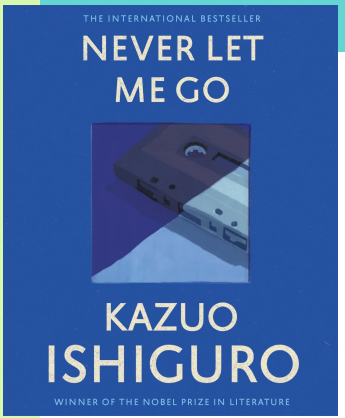
Y O A V U V Q U Z N M O M E N T E O L T
N L L N M P O R J A G L A F T A S J X A

Chronology
Interval
Calendar
Paradox
Second
Season
Week
Future
Millennium
Timeline
Temporal
Decade
Period
Moment
Month
Relativity
Duration
Century
Present
Minute
Clock
Epoch
Hour
Day
Past
Age
Year
Era

(Answers are on the last page!)



By Maia Akhtar

‘Never Let Me Go’ is a heartbreaking yet compelling novel by Kazuo Ishiguro, a world-renowned author and winner of the Nobel Prize in Literature. The story is set in a dystopian, imaginary world in which human cloning is possible, and accepted in society to cure human diseases through the inevitable organ donation from clones. It follows Kathy H, a clone herself who reminisces in the past about her life at Hailsham, the school she attended. Throughout her time there, Kathy becomes increasingly aware of her place in society, and how she and the students at Hailsham are completely hidden from the rest of the world. Only in her late teenage years does she come to realise, that she is not human, but rather a clone, and one day will donate her organs and ‘complete’.

Book Review – Never Let Me Go by Kazuo Ishiguro

As the novel progresses, the reader learns about her life at the ‘Cottages’, where Kathy and her closest friends, Ruth and Tommy live after their education. It is then, when the three grow distant, before Kathy returns to the present to describe her life as a ‘carer’, who looks after those who have begun donations are nearing the end of their lives. Although by the end of the story Kathy is left alone without any true meaning in life, she promises herself that she will carry the memories of her friends forever.

I feel as if the novel reminds you what it feels like to be human, whilst you read the story of young girls and boys who thought they were for most of their lives, before understanding they were only an experiment to benefit humanity. The novel emphasizes the question of possibility, as human cloning is a topic that has been researched and talked upon in the scientific industry. In the future, the novel’s events could easily happen with the rapid rate of scientific discovery and theories.

The novel explores the theme of identity, time, and friendship, as most of the story is set in the past, describing memories, both good and bad of Kathy and her closest friends. In the opening pages of the book, Kathy introduces herself and openly dives into a memory of Hailsham whilst driving through the countryside. Throughout the novel, it is easy to get lost in the mystery and bittersweet friendship between the characters.

Overall, it was a thrilling read, which made me think a lot about the world we live in today and the possibilities of time, science, and technology, and how it may impact our lives in the future.

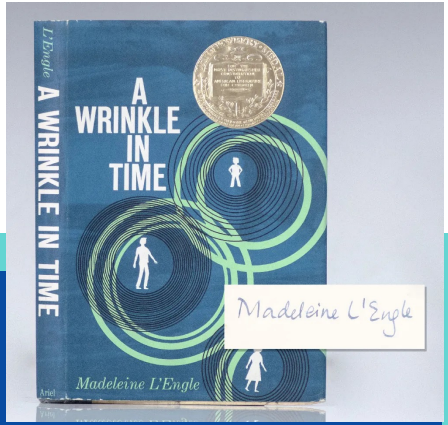
Book review of A Wrinkle in Time

By Hannah Lam (7RA)

“It was a dark and stormy night,” is one of the most famous quotes in literature, and the starting sentence of ‘A Wrinkle in Time’, the first book in a science fiction quintet written by Madeleine L’Engel. The book is about three children who fight a brain called IT that has complete control over everyone on the planet Camazotz.

Most of the book is told in third person, and focuses on Meg, one of the three children. Her full name is Margaret Murry, and she is the oldest of the four children in her family: Meg, the twins, Sandy and Dennys, and Charles Wallace. She has mouse-brown hair, wears glasses that she cannot see without, and has braces. Although she is very clever and can do any math problem faster than any of her peers, she does not fit in at school, is unable to get adequate grades, and is disliked by her teachers mostly because she never pays attention in class and occasionally causes irritable distractions for her classmates.

Eccentric, enigmatic and somewhat alarming, Mrs Whatsit, Mrs Who and Mrs Which play key roles in the plot. They are extra-terrestrial creatures who guide the children on their journey to Camazotz to fight IT and save Mr Murry, a physicist who was trapped on Camazotz by reasons unexplained in the book. Mrs Whatsit, Mrs Who and Mrs Which can ‘tesser’ meaning they can travel anywhere in space and time, otherwise known as the fifth dimension. This is explained by Charles Wallace as: “the fifth dimension is a tesseract. You add that to the other four dimensions, and you can travel through space without having to go the long way around.” (Page 75). This could be very useful to humans in the field of space exploration and would allow us to change events from the past, enhancing the future and possibly even prevent disaster.



In conclusion, A Wrinkle in Time is an excellent science fiction series with many examples of new technologies that may be achieved by Homo sapiens in the near future and I highly recommend it.

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V Z V X M R R E P L W T A P T Y A O B G
X D Y R I N U A W A O F Y E O K U D P I
K E I W L W C F T O S C H O U R M S F G
M C N Y L E P C V I N T K I G G A C S V
Y A T E E P U C H R O N O L O G Y L Y G
H D E A N O Z K X S B N G U B Y W E E K
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Year
Era

Thanks for reading!