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Edition 12

Editing the Human Genome

Nikhil Srinivas investigates the future of base editing and the problems it may pose

The Search for the 'Theory of Everything'

Arjun Kotecha discusses the hunt for a solution to physics' greatest problem

Type II Diabetes

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Welcome Back!

Edition 12, Lent 2023

A message from the YSJ Team:

"We are delighted to bring you the first post-COVID edition of the LGS Young Scientists' Journal! The YSJ aims to foster a passion for the fields of science, technology, engineering and maths for pupils throughout the school, as well as providing a platform for students to showcase their interest and excitement through research in their respective fields. This term's edition includes articles ranging from genome editing to science in the Qur'an, to the 'Theory of Everything'.

We're so pleased to have seen so many enthusiastic contributions across different year groups and have thoroughly enjoyed reading them. We would love to see more people get involved in the next edition, so feel free to drop us an email with your ideas!"

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We would like to thank everyone who has written an article for this edition of the YSJ, as well as Mr. Reeves for technical help with the journal.

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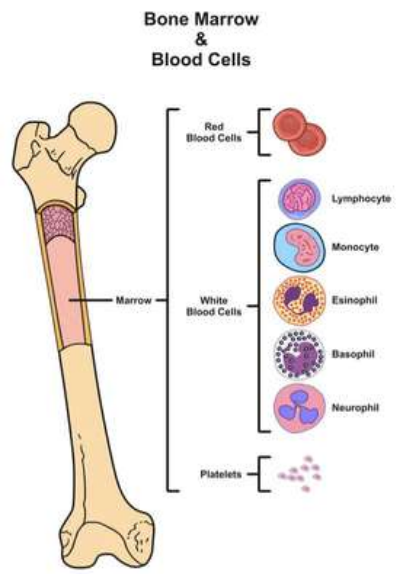
Inside this edition

Editing the Human Genome: A promise or a problem?

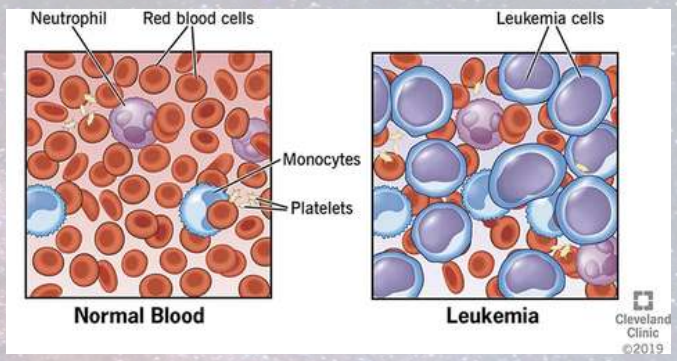
Nikhil Srinivas

Whilst skimming through BBC news in early December, an interesting article about a revolutionary treatment caught my attention. This may be a scientific breakthrough. A young 13-year-old girl from Leicester, Alyssa, was suffering from leukaemia, which had failed all other treatments. (Gallagher, 2022, online)



Leukaemia is a form of blood cancer where the white cells in the blood multiply in an uncontrolled manner. Abnormal white blood cells produced do not function properly. This can lead to a range of symptoms including the body's inability to fight infections which are more frequent and severe. There are several types of white blood cells in the human body. Doctors classify leukaemia based on the type of cells involved and how quickly the disease progresses. (Mayo Clinic, 2022, online). It usually is a disease that affects adults over the age of 55, but it is also the most common cancer in children younger than

15. (National Cancer Institute, n.d.)



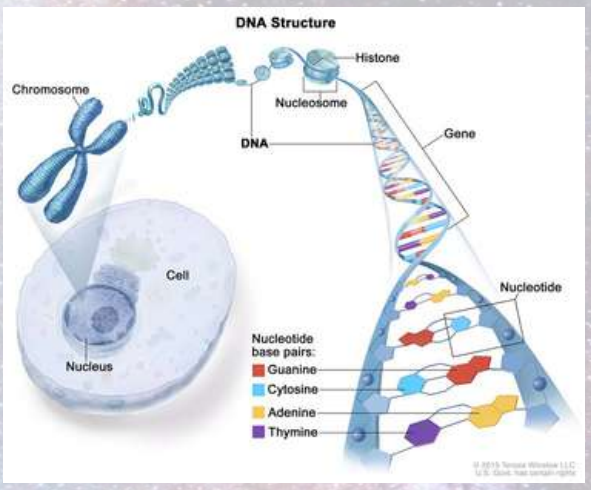
Alyssa was diagnosed with T-cell acute lymphoblastic leukaemia in May last year. Her T-cells, a critical part of the immune system which target specific foreign particles (antigens) (Ryding, 2021, online), were growing out of control, making her cancer aggressive and resistant to treatment with chemotherapy and bone marrow transplant.

This is where the team at Great Ormond Street Hospital used this revolutionary technology called base editing, a novel advance in genetic engineering, to help patients like Alyssa.

This is where the team at Great Ormond Street Hospital used this revolutionary technology called base editing, a novel advance in genetic engineering, to help patients like Alyssa.

Genes, present on DNA strands within the cell nucleus, are instruction manuals for making proteins. All cancers begin when one or more genes in a cell change (mutation) (Cancer.net, 2018, online). Hence, an incorrect/abnormal protein is formed. This

can cause cells to multiply uncontrollably, causing cancer (Cancer Research UK, 2020, online).



As seen on the illustration above, a gene is made of a string of the four base nucleotides (Adenine – A, Thymine – T, Cytosine – C, Guanine – G) (Susman, 2014, online). In base editing, scientists alter the structure of one base, thereby changing it to another, which results in the changing of the genetic instructions (Gallagher, 2022, online).

In Alyssa's case, scientists used this technology to create a new type of T-cell which had the ability to kill the cancerous T-cells. The entire process was done in 4 stages:

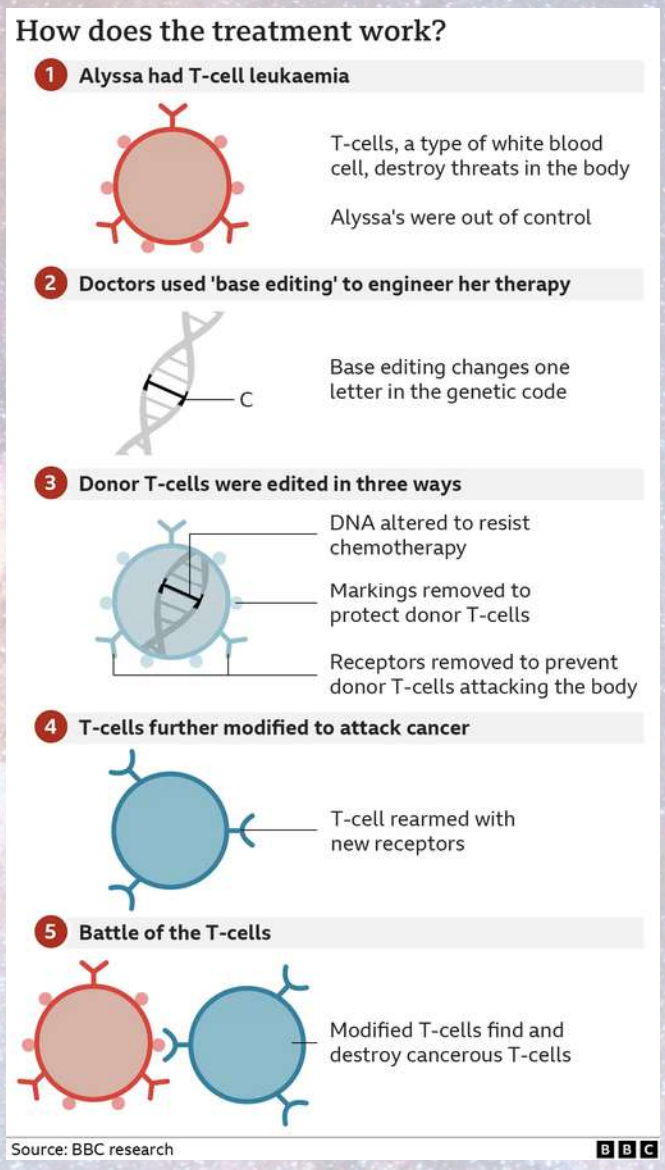
- Firstly, they obtained healthy T-cells from a volunteer (donor). These were then modified using a base editing technology which changed them so that they would not attack Alyssa's body.

- Every T-cell has a natural chemical tag on it, known as CD7. The donor T-cells' CD7 marker was removed (for the reason explained in the fourth step).

- The donor cells were then given a protective armour to prevent them from being killed by chemotherapy drugs.

- Finally, the donor T-cells were genetically modified to instruct them to kill all T-cells which had the CD7 chemical marker on them. This would result in all of Alyssa's T-cells being killed including her non-cancerous ones. The CD7 marker was removed from the donor cells to prevent them from killing themselves.

It was hoped that Alyssa's immune system would be rebuilt, with a new bone-marrow transplant, if the above treatment was successful.



Fortunately, Alyssa decided to undertake this experimental therapy in May this year and is now disease-free (in remission). This is brilliant news for the scientific community as the treatment could benefit many patients with this condition - imagine the exciting possibilities from here on.

However, gene editing has not always had expected and desired results. In November 2018, 2 twin girls with an HIV carrier father had been born with modified genes to make them immune to the virus. HIV is the Human Immunodeficiency Virus that damages cells in your immune system and weakens the body's ability to fight infections (NHS, 2021).

This experiment raised the eyebrows of the scientific community as the targeted gene was also related to major brain functions. It was questioned that the scientist who performed this experiment may have engineered human enhancement by creating super intelligent humans, with better IQ and memory. Furthermore, the particular gene targeted put the twins at an increased risk of other viruses. Gene editing in one of the two babies was incomplete, raising issues for the child's future health. Moreover, the genetic editing will mean that alterations will be inherited. Questions have also been raised about precision of the technique (Raposo, 2019, online).

Genetic engineering in rabbits appear to have been a misadventure, whereby an aim of producing leaner rabbits produced an unusual characteristic of them possessing enlarged tongues. Experiments to create meatier pigs led some to develop an extra vertebra. Calves which were genetically edited died prematurely in Brazil and New Zealand (Wei, n.d., online).

In Minnesota, a gene editing company which made hornless cattle, found that the genome sequence of the edited animals contained a stretch of bacterial DNA that included a gene coding for antibiotic resistance. This was an unintended outcome. A person who consumes this beef could take up this antibiotic resistant gene, leading to fatal consequences. (Regalado, 2019)

In conclusion, this new technology opens fascinating opportunities in health care science. However, it is still in its early stages. Does gene editing present humanity with a new set of ethical and medical challenges? The scientific community has raised ethical concerns previously, as stated above. Will this technology lead humans to becoming a more superior race? Are we embarking on an uncertain road of new, inherited conditions which could eliminate mankind? Only time will tell if this is the future or not.

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Are EVs the Future of the Transport Industry?

Hasan Khwaja

The automobile industry is currently going through a significant transformation with the rise of electric vehicles (EVs). With their potential to reduce emissions, improve air quality, and increase energy security, EVs are being hailed as the future of the industry. In this article, I will explore the benefits of EVs and their potential to transform the automobile industry.

The global EV outlook in 2021 shows us that EVs are a major factor in the transport industry. There are currently over 330,000 Battery Electric Vehicles in use across the UK. This growth has also been witnessed globally, with 10 million electric cars reportedly on the world's roads by the end of 2020. A considerable proportion (3 million) of these vehicles were registered in 2020 alone, showing that the pace of growth has picked up significantly over the last couple of years. The overall landscape of the Electric Vehicle market is vastly different to that of 2011, not only encompassing electric cars but also electric buses and heavy-duty vehicles. As the EV sector is growing exponentially, expert knowledge regarding trends and technology enhances the career of professionals in the sector.

One of the primary benefits of EVs is their reduced environmental impact. EVs emit zero tailpipe emissions, unlike traditional gasoline-powered vehicles that emit harmful pollutants such as carbon dioxide, nitrogen oxides, and particulate matter. This means that EVs can significantly reduce air pollution and help combat climate change.

Additionally, the electricity used to power EVs can be generated from renewable sources such as wind or solar power, further reducing their carbon footprint. Another advantage of EVs is their reduced operating costs. EVs have fewer moving parts than traditional vehicles, making them less prone to breakdowns and requiring less maintenance. Additionally, EVs have lower fuel costs as electricity is cheaper than gasoline in most parts of the world. EVs are also more energy-efficient, with some models achieving over 100 miles per gallon or equivalent (MPGe).

The availability of EV-charging infrastructure has been a significant concern in the past. However, this is rapidly changing, with more and more charging stations being installed worldwide. In 2019, there were only about 500,000 public charging stations worldwide. By 2025, this is expected to increase to over

seven million. This will make it much easier for people to own an electric car as their primary vehicle. Additionally, governments are also providing incentives for EV owners, such as tax credits and rebates, to encourage the adoption of EVs.

One of the main challenges facing the EV industry is the high upfront cost of EVs compared to traditional vehicles. However, this is expected to change as battery technology advances, making EVs more affordable. The production of batteries is also expected to become more efficient, further reducing costs. As the demand for EVs increases, economies of scale will come into play, reducing the cost of production. Furthermore, in 2021, the discussions centered on the termination of internal combustion engine (ICE) vehicle sales. New regulatory targets in the European Union and the United States now aim for an EV share of at least 50 percent by 2030, and several countries have announced accelerated timelines for ICE sale bans in 2030 or 2035. This shows us how governments are opening their doors towards EVs and how they know its crucial to make changes as soon as possible to save the environment.

EVs also have the potential to transform the energy industry. EVs can be used as energy storage devices, helping to balance the grid and increase the use of renewable energy. By charging during off-peak hours and discharging during peak hours, EVs can help utilities to manage demand, reduce the need for expensive peaker plants, and increase grid stability. Another advancement within this industry is the possible use of hydrogen-powered vehicles. Hydrogen cars use similar fuel cell technology as EVs to convert chemical energy into electricity. With hydrogen powered cars, the fuel cells convert the mix of hydrogen and oxygen taken from ambient air, into the energy that drives the motor, activates and powers the wheels.

Moreover, the driving range of hydrogen cars is still extremely varied. However, estimates highlight that the car has the capability to cover over at least 300 miles. General estimates are that hydrogen fuel cell cars can reach at least 300 miles, though it will be interesting to see how model development proceeds in the next few years. Another benefit for Hydrogen cars would be that because they have no tailpipe emissions, hydrogen cars also qualify for the same type of government grants that are available for electric cars which would make it appealing for the general public.

Recapping the UK government's UK Hydrogen Strategy, there is a clear focus on making progress over the next few years. The government's goal is to produce 5GW of clean hydrogen by 2030. Even though hydrogen is the cleanest fuel available, and the most abundant resource on earth, there are challenges in harnessing it for use in cars. Processing it takes time as hydrogen gas is extracted, compressed, then mixed with oxygen to turn it into the electricity needed to run a car. This process isn't as efficient as simply charging an EV to power up the lithium-ion battery. The infrastructure currently held in the UK is also currently significantly smaller than it needs to be for mass endorsement of driving hydrogen cars. There are very few functioning hydrogen filling stations in the country. According to the UKH2 mobility website, there are only 12 Hydrogen Refueling Stations (HRS) in England and Scotland and these are widely spread out with some regions – including the south, south-west and east, as well as Wales – having no HRS at all. Evidently, this number must rapidly progress otherwise hydrogen cars will not have a realistic future within this country.

BMW has been developing a hydrogen car, the SUV BMW iX5 Hydrogen. After intensive research and development, BMW has more than doubled the fuel cell's continuous output in the BMW iX5 Hydrogen's second-generation fuel cell. Weight and size have decreased 'dramatically' BMW say. Two hydrogen tanks, fuel cell and an electric engine have been integrated into the BMW X5's existing architecture.

In conclusion, EVs have the potential to transform the automobile industry by reducing emissions, improving air quality, and increasing energy security. The industry has attracted more than $400 billion in investments over the last decade—with about $100 billion of that coming since the beginning of 2020, indicating the huge potential of EVs within the industry. While there are still some challenges to overcome, such as the high upfront cost of EVs, the availability of charging infrastructure, and the need for more efficient battery technology, the benefits of EVs far outweigh these challenges. As the world continues to shift towards a more sustainable future, EVs are likely to play a significant role in the transportation sector.

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The Science of Happiness: Where does it truly come from?

Meerub Iqbal

To begin, I have inserted a quote by an American neurosurgeon Wilder Penfield, which will give some insight on what I will be talking more about. He said:

"The brain is the organ of destiny. It holds within its humming mechanism secrets that will determine the future of the human race."

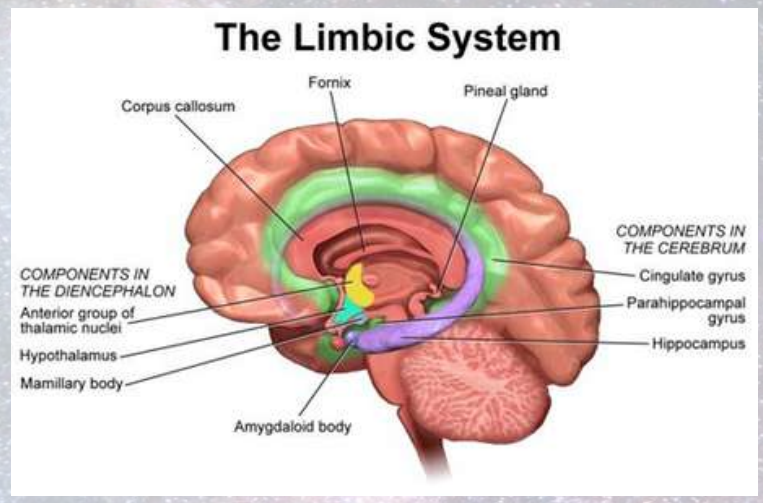
As humans, we tend to forget the extent of our ability to change the way we think and create happiness for ourselves. You may have heard that happiness comes from what you surround yourself with, your achievements or life circumstances. These factors are true to an extent, but, as with all emotions, there has to be an authentic source which can explain all of these feelings that can sometimes be so overwhelming and consuming. A 2022 Ipsos survey shows that two in three adults consider themselves as "happy", with Netherlands and Australia being listed among the happiest countries. Have you ever thought about the scientific side to happiness, and if there is any truth to the things you commonly hear? Let's take a deeper look into the brain, and see what actually happens in this three-pound organ. Among many other functions, the brain is responsible for the ability of your muscles to contract and relax, your ability to breathe in and out, and your ability to feel an array of emotions.

The Brain? The Mind? What are they?

Happiness may seem like a relatively simple emotion to feel, yet there is a certain complexity to the emotion that tends to go unnoticed by many. The mind and the brain are terms often used interchangeably and can be confused with each other. The brain is the physical component of the human body, whereas the mind is mental and refers to what we feel and think.

Fear, anger and happiness are just some of the emotions that the amygdala in the brain is responsible for. The amygdala is a small structure which is part of the limbic system in the brain, and is located in a region called the temporal lobe. If the amygdala interprets a situation as threatening, it will send a chemical message to the hypothalamus - which is responsible for the release of the hormone adrenaline. This will prepare you for the 'fight or flight' reaction. In other words, the fear we would feel if we were to come in contact with a hungry bear would be interpreted by the amygdala which then causes us to respond to this emotion... by running away! Similarly, this small structure also interprets things that make us happy. The limbic system helps us establish emotional states and facilitates memory storage of these emotions.

Although the mind is a separate concept to the brain, they are, in some ways, inseparable. You could say they go hand in hand with each other. Over time, scientists



have learned that we cannot consciously experience something without the brain, but these experiences are not caused by the brain alone, rather the mind and brain working together to achieve feelings and emotions about a certain experience.

Dopamine and Serotonin

Happiness is constantly competing with periods of sadness, anxiety and stress. In order to further understand the complexity of happiness, scientists have investigated the effects of dopamine and serotonin on the brain. For many hundreds of years, happiness was thought to have two components that made up the emotion. The first aspect was hedonia (well-being, happiness) with the second being eudaimonia (highest human good). Both dopamine and serotonin are neurotransmitters, which are chemical messengers used by the nervous system, and thought to be the chemicals that make up the two components of happiness. In other words, hedonia comes from serotonin, whilst eudaimonia comes from dopamine. Dopamine is characterised by the feeling of satisfaction which comes after achieving something, causing you to feel happy. Before more advanced research, experts thought that low levels of dopamine and serotonin caused depression, although that has since been proven to be not completely true.

Serotonin is an excitatory neurotransmitter that makes you feel good and can actually be increased. For example, increasing serotonin levels is as simple as visualising something that's makes you happy.

How can this feeling of 'happiness' truly be achieved?

For years people have been searching endlessly for the answer to the question 'How can happiness be achieved?'. The truth is that, by training your brain and mind simultaneously through meditation, exercise and other mindful activities, you allow yourself to reconnect to your mind which can trigger awareness of your own sensations and feelings. Over time, we fall victim to the rapid pace of life and forget the importance of taking care of our mind and brain. Nowadays, in a world consumed by social media and economic gain, we fail to remember that we cannot succeed in finding and maintaining happiness without taking time to replenish our mind.

Taking a look at the brain once again, the insula (triangular in shape), which is also located in the temporal lobe, tracks the internal state of the body and is involved in sensing emotions that we are experiencing. Scientists believe that this way of 'strengthening' your insula and amygdala will lead to an overall increase in happiness. You can trigger your insula to pick up on happy sensations in your body whilst completing day-to-day activities – by paying attention to these sensations, being mindful and thus becoming more in touch with yourself.

The truth is, happiness really does start within you, and you can be responsible for your ability to feel and take control of it.

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Editing the Human Genome; Science and Ethics

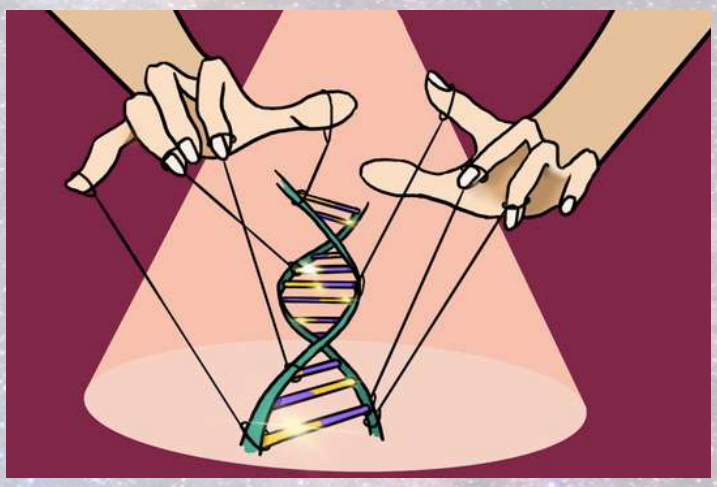
Sonia Naidu

Human Genome Editing, to put it simply, is a method of making precise alterations to the DNA of an organism or a cell. It involves adding, removing, or altering the DNA sequence in the genome (the entire set of genetic material in an organism). There are 3 types of cells genome editing can be used for: somatic cells (non-heritable), germline cells (to be used for reproduction) and germline cells (not to be used for reproduction). Over the past few years, recent scientific advances have allowed genome editing to be used to improve human health. However, with human genome editing comes many scientific, ethical, social, and legal challenges.

A well-known system of genome editing called CRISPR-Cas9 has allowed a fast, cheap, accurate and efficient method of editing the genome. CRISPR-Cas9 was adapted from a naturally occurring genome editing system that bacteria use as an immune defense mechanism. It has been used to treat and prevent disease. The use of somatic (non-heritable) genome editing has already been undertaken, such as through addressing HIV and sickle cell disease, and in vivo editing (gene therapy). Although well-established and regulated, somatic gene editing still poses many concerns. These include the need for inclusivity that considers the diversity of the human population; medical travel; and the reporting of illegal, unregistered, unethical or unsafe research. This also includes various safety concerns throughout the process, such as the risk of mutations and the development of cancerous cells.

However, by far the most ethical concerns are flagged from heritable human genome editing. This refers to the editing of nuclear DNA such that it is heritable across generations. It is currently a subject of intense debate due to its possible consequences for the offspring and society, which is why it poses greater safety and ethical issues compared to somatic human genome editing. The idea of informed consent is a big issue, as many feel that it is impossible to obtain informed consent for germline therapy from those involved - because the embryo and future generations are also affected. Additionally, there is an intense argument surrounding the idea of justice and equity where, as with many new technologies, only the wealthy can access it. This could create a class of individuals defined by the quality of their engineered genome. Given the use of embryos, many people have moral and religious objections as embryos will be created or destroyed in the research process. As a result, some countries have allowed the research of gene editing on the condition that it is used for non-reproductive reasons, and used on nonviable embryos left over from IVF treatment. Some countries do allow the use

of genome editing research on viable embryos, but this is a minority. The WHO Director-General made a policy statement in June 2019 clarifying that 'it would be irresponsible for anyone to proceed with clinical applications of human germline genome editing'.



Everyone will, undoubtedly, be familiar with the term 'natural section' coined by Charles Darwin, in which alleles are slowly passed down more frequently over generations due to greater survival rates that the alleles allowed for. Now, consider 'artificial selection'. Artificial selection is not new to humans, in which we consciously select for or against features in organisms. However, we only see this in animals or plants. For example, choosing which species to focus efforts on conserving, or breeding from one generation to the next. But now imagine doing that to our own human race. It is quite a frightening idea: humans themselves could consciously control which alleles, and thus characteristics, are passed on. Critics of this technology have drawn parallels to Adolf Hitler's ideologies of a 'super Aryan race'. It would only take one crazy human manic to take advantage of human genome editing to attempt the creation of a 'master race', which is an incredibly scary thought.

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Medical Innovations that could Change Everything

Abhiram Varanasi

Solutions. Ever since the dawn of humanity, humans have been obsessed with finding solutions to problems that faced them, to achieve what our ancestors all so dearly wanted. A long, joyful life and offspring to carry their legacy. However, their understanding of the human body was not as advanced as it is today, leading to the wrong conclusions being made and incorrect advice given. Yet, over centuries of development, ideas, and inventions, we are now lucky enough to live in a society where we have access to high quality medical care and technology, though this is not the case all over the world. This technology however, as all things, will not last forever. Countless biomedical scientists work around the clock to find the solutions to tomorrow's problems. It is these solutions that this article will be based on.

Xenotransplantation

The most extraordinary of the latest innovations according to some was the xenotransplantation, (the transplantation of organs between species), of a pig's heart into a 57-year-old man named David Bennet on January 7th, 2022, in Baltimore, Maryland in the USA. Bennet would have otherwise died, so doctors at the University of Maryland Medical Center sought special permission from the American medical regulator to use a pig's heart for the transplant. The pig had to be genetically modified, so that Bennet's body would not reject it immediately. Although the higher risk, there are multiple advantages to xenotransplantation. According to the U.S. Department of Health and Human Services, 18 people die every day whilst waiting for an organ transplant in America. This is because of the lack of organ donors across the country, as well as the world. The fact is that human organ donation can be extremely time consuming and there is simply not enough availability, but using organs from distinct species could be a game changer in the field of transplantation. However, there are many controversies around this method of solving organ scarcity. The elevated risk and unclear survivability of such procedures brings doubt to some, whilst others are concerned about implications on animal rights and whether certain religions would agree with such transplants, especially from a pig, which Jews and Muslims have strict laws about. David Bennet unfortunately passed away on March 8th, 2022, suggesting that scientists need slightly longer to make xenotransplantation safer and more successful.

Figure 1: Bennet in hospital with surgeon Bartley P Griffith at the University of Maryland Medical Center

3D Printing

Transplantation is an immense problem in the field of medicine and xenotransplantation is not the only way to deal with it. Medical 3D printing was discovered by Russian scientists who printed a thyroid gland. This body part was chosen because of its simplicity and the increasing prevalence of thyroid cancer. If 3D printing were to succeed in terms of safety and function, as well as availability across the world, transplantation would be transformed into a much less complicated system, with a reduced number of humans for donations needed and the influence of technology escalating exponentially.

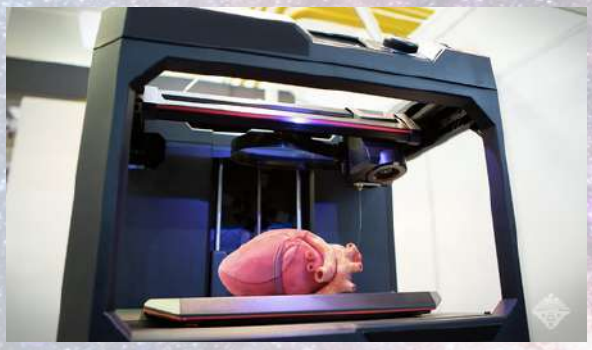

Figure 2: What 3D printing organs would look like in practice, in this case a human heart.

Additionally, advantages of 3D printing organs may include the ability to customise and personalise prosthetics and implants in such a way that a human donor cannot offer, providing the patient with an organ which is better suited to them and their needs. It would also be far more cost-effective, the cost of custom printing being especially low for dental or spinal implants, which need smaller parts. This is principally because of the rapid growth of 3D printing, and materials and technology prices declining steadily. Scientists across the world can share their discoveries and progress using open databases, enabling a discovery in New Zealand for example, to be used in the United Kingdom the very next day.

Yet, 3D printing is still an unknown concept for our bio-medical scientists, so it would be wrong to expect any huge breakthroughs soon.

Blood Replacements

Blood is vital for our bodies, and when accidents or injuries occur a replacement or replenishment may be required. Unfortunately, this does not mean using a random batch of blood which is available, as there are several types of it, such as A, B, AB, and O, each with positive and negative sides. A blood cannot be transfused into someone who has the B type blood, and vice versa. Certain patients are unable to get access to blood for this reason. However, if a 'blood substitute' was ever successfully manufactured, if there could be litres upon litres of all the distinct blood types sitting in fridges, ready to be used, transfusions would become effortless. When a transfusion with real blood takes place, it must be tested to make sure there are no pathogens in the blood, which can easily raise the price, as well as the time used. However, there are a few drawbacks for artificial blood. It can be quite expensive to manufacture, does not always mix well with blood, may cause unpleasant side effects, and does not carry as much oxygen.

Figure 3: An animation of what blood production would look like.

RNA Vaccinations

The most beneficial implementation of medical research in the recent past has been the creation and deployment of the COVID – 19 RNA vaccines, which had never been used before that point. RNA is an abbreviation for ribonucleic acid and is defined by the Oxford Dictionary as a messenger carrying instructions from DNA. An RNA vaccine takes small fragments of the pathogen's genetic code to start manufacturing itself inside the human body, which then recognises it as a foreign entity and attacks it with antibodies, destroying the threat. If the person happened to encounter the pathogen at a later point, their immune system would promptly send antibodies and T-Cells to take care of the danger. However, it is not only COVID that can be combated through the ribonucleic acid vaccine, as latest research by Moderna and MSD indicates that even cancer could be treated with this technology. Their personalised cancer vaccine is designed to locate and annihilate cancerous cells, with doctors believing this could be effective against skin, bowel, and other types of cancer. According to Moderna's chief medical officer Paul Burton, the vaccine has shown a "44% reduction in the risk of dying of cancer or having your cancer progress." Although this has yet to be scrutinised by independent regulators or experts, signs show that this could be extremely efficacious in the future.

Figure 4: A COVID RNA vaccine

Science is a fascinating field. Many believe that scientists and researchers are just learning about how this universe became what it is today, how our bodies work, or even how long we have left on this planet. However, scientists are problem solvers. They use what their understanding about the past and the present, to improve our future. The problems that faced us a few centuries ago are not bothering us today, and the problems troubling us today will hopefully not bother those in the future. Scientists, inventors, and innovators make this possible. This has been the case throughout history, and they will continue to do so.

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Science in the Holy Qur'an

Yahya Musa

A common misconception amongst the public is that there is a total divide between religion and science – many even proclaim that the two fields are opposites. However, it is often the case that they both prove each other correct. As a Muslim, the Holy Qur'an is a book of guidance, miracles, and endless knowledge. Modern science has 'discovered' a great number of advancements, none of which are contrary to the verses of the Qur'an. Despite its revelation being over fourteen centuries ago, the Qur'an has remained unchanged.

Though we live in a *progressive* society, an ironically debatable title to give the modern world in some aspects, the Qur'an's innumerable lessons are still practiced, propagated, and studied. The Qur'an is not a book of science, yet it talks about a range of scientific topics, from the expanding universe to embryology – it even mentions the spherical shape of the Earth, which was only confirmed by Europeans in the Middle Ages.

In the Qur'an, mention has been made to seas and rivers. Modern science has discovered that when two different seas meet, a metaphorical 'barrier' is made between them. Different water bodies around the world have unique features that make them unique, such as salinity, density and even temperature. [1]

An example of this phenomenon is the meeting of the Atlantic Ocean and the Mediterranean Sea, at the Strait of Gibraltar (Figure 1). The Mediterranean Sea is warmer, more saline, and less dense when compared to the water of the Atlantic. When Mediterranean water enters the Atlantic over the Gibraltar sill, it moves several hundred kilometres into the Atlantic at a depth of about 1000 metres with its own characteristics (as mentioned above). The Mediterranean water stabilises at this depth. [2]

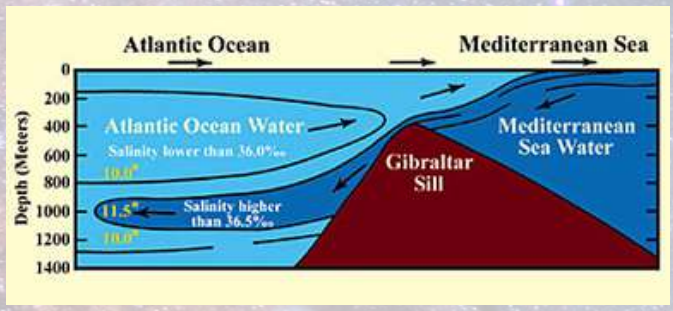

Figure 1: The Mediterranean Sea water as it enters the Atlantic over the Gibraltar sill with its own warm, saline, and less dense characteristics, because of the barrier that distinguishes between them. Temperatures are in degrees Celsius. [3]

An upper layer of Atlantic water flows eastward into the sea over a lower layer of saltier and heavier Mediterranean water flowing westward into the ocean, known as the Mediterranean Outflow water. [4]

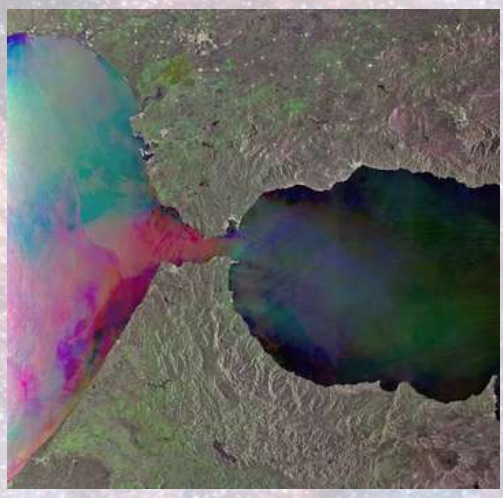

Figure 2: The Strait of Gibraltar, which lies between the southern coast of Spain and the northern coast of Morocco, is the only place where water from the Atlantic Ocean mixes with water from the Mediterranean Sea. [5]

As the Mediterranean Outflow water leaves the sea (Figure 2), it flows over a sudden rise in the sea floor, generating a series of internal waves, which can be seen in this image from radar instruments aboard the European Space Agency's Envisat satellite. The images were taken August 12th, 2010, October 1st, 2009, and August 27th, 2009, over the same area. The colours are the result of changes in the surface between photographs. [6]
Despite the fact that both bodies of water have large waves and very strong currents, because of this 'barrier', they do not mix. The Holy Qur'an has explicitly mentioned this barrier in the following verse:

مَرَجَ ٱلْبَحْرَيْنِ يَلْتَقِيَانِ
بَيْنَهُمَا بَرْزَخٌ لَّا يَبْغِيَانِ

"He released the two seas, meeting [side by side]; Between them is a barrier [so] neither of them transgresses." [7]

In another verse, when the Qur'an mentions the divider between fresh and salt water, God talks about the existence of a 'forbidding partition' with the barrier:

وَهُوَ ٱلَّذِى مَرَجَ ٱلْبَحْرَيْنِ هَـٰذَا عَذْبٌ فُرَاتٌ وَهَـٰذَا مِلْحٌ أُجَاجٌ
وَجَعَلَ بَيْنَهُمَا بَرْزَخًا وَحِجْرًا مَّحْجُورًا

"And it is He who has released [simultaneously] the two seas, one fresh and sweet and one salty and bitter, and He placed between them a barrier and a prohibiting partition." [8]

The Qur'an mentions the partition when speaking about the divider between fresh and salt water, though it did not mention it when speaking about the divider between the two seas. Modern science has discovered that in estuaries, where fresh (sweet) and saltwater meet, the situation is different from what is found in places where two seas meet. It has been discovered that what distinguishes fresh water from salt water in estuaries is a 'pycnocline zone' with a marked density discontinuity separating the two layers. [9]

Only recently has this information been discovered, using modern advanced technology to measure water features such as temperature, salinity and density. The naked human eye cannot see the difference between the two seas as, to the viewer, the seas appear to meet consistently.

How could the Prophet Muhammad (peace be upon him) have known all this? He could neither read nor write, and he lived in the barren deserts of Arabia. Personally, I believe that the Qur'an is the word of God, so I cannot see any coincidence that this recently discovered scientific information was mentioned in the Qur'an, over fourteen centuries ago, in an era that lacked both technology and scientific advancements.

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Could AI Replace Doctors?

Gargi Nisal

Prior to the rise of the COVID-19 pandemic, the question of AI potentially replacing doctors was discussed and often cast aside as nothing more than fantastical drivel, but the pandemic has shaped our lives in ways we could not imagine. From online learning to over-the-phone consultations, the virus has demonstrated that the vast capability of technology has no limits, with the increasing impact of AI leaving many professionals, including doctors, wondering whether robots could take over their jobs.

The opening of this century has already seen a gargantuan development in medical practices, with some of the more recent developments including "A lab on a chip" [1] from Stanford University researchers, which solves the problem of delays in samples reaching labs and can produce a test result within 30 minutes. Wearable continuous glucose monitors [2] have also been developed, eliminating the need for intermittent glucose testing for diabetes patients and enabling them to keep track of their blood sugar levels in real-time. Even brain-computer interfaces [3], computer chips which, by sending electrical impulses, can give a blind person sight or a deaf person hearing, have been developed. The marvels of AI in technology have already given hope to so many that would have suffered had they been born even five years previously; why should we stop there?

Figure 1: A Lab on A Chip

On the most basic level, doctors complete three tasks; diagnosis, treatment, and prognosis; all tasks which are steadily being consumed by AI. AI has one significant advantage that humans fail to possess; it gets more and more accurate on a daily basis [4], through the process of machine learning and natural language processing. Intelligent algorithms which utilise the patient's input and match it against a vast database of medical conditions can factor in their lifestyle, habits, current state of health, and recent activities. They are learning and adapting on a day-to-day basis and are a conceivable reality in today's fast-paced world. They have the advantage of never getting tired; the recent move towards GPs working longer hours to compensate for lost time during the COVID-19 pandemic, (with some being forced to work up to 11 hours a day [5]) creates a problem that AI will never face; tiredness can lead to human error, but robots will always remain just as accurate no matter how long they are running.

On the other hand, diagnosis is not linear. The immense variety of factors and facts doctors are required to consider whilst diagnosing an issue is a massive hurdle for intelligent algorithms. Some facts which may come into light later on, through passing comments and experiences of patients that can only be gleaned by doctors asking the right questions, questions which an algorithm wouldn't necessarily have the capabilities or logic to ask, can lead to fatal mistakes in diagnosis and therefore threaten the life of the patient. Take the example of autonomous vehicles, which operate on similar principles and technology (including intelligent algorithms, LiDAR, and

RADAR sensing technology). Despite their programmed ability to learn and adapt to the road, there are still 9.1 self-driving car incidents per million miles, compared to just 4.1 crashes for regular cars [6], demonstrating how unreliable AI can really be; implementing this technology in its current state could be catastrophic.

Yet the world could have no choice but to resort to AI in the future. Across the developing world, the divide between the most skilled doctors and the poorest individuals is obscene; in sub-Saharan Africa, there is 1 MRI machine for 25 million people, whereas, in the West, there are 25 MRI machines per 1 million people [7]. AI, increasingly cheaper, faster, and more accessible than skilled doctors, could be the way to solve the healthcare crisis, where millions of individuals are denied treatment each month simply because they are unable to access it – through either poverty or simply a lack of trained individuals in the area. AI is a pragmatic and feasible way of delivering help to those who need it, the main aim of doctors practicing centuries ago, today, and in the future.

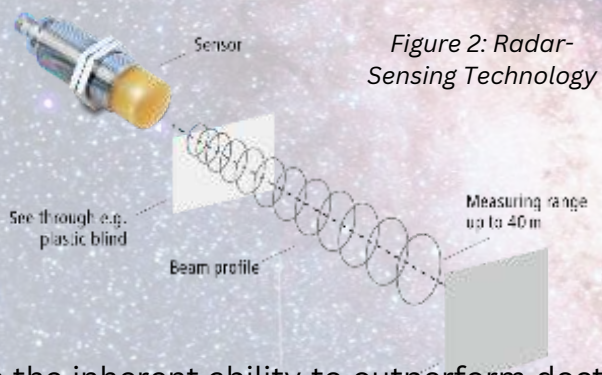

Figure 2: Radar-Sensing Technology

AI has the inherent ability to outperform doctors. However, there is one key element of healthcare that AI is simply not able to provide, and may never be able to provide: empathy [8]. A man dying of cancer doesn't want to hear his diagnosis from a computer screen; building trust, empathy, and compassion between the patient and the doctor is vital, as it materializes hope. This sort of belief can work miracles, and cannot be instilled by robots or technology, but only by the human touch. AI eliminates a sort of humanity within the patient and reduces their well-being to the inputs of an algorithm. Empathy can make all the difference.

Whilst the extraordinary capabilities of AI are undeniable and will continue to shape our lives in the future, I do not think AI will ever be able to replace a job so sensitive as being a doctor or a nurse. I believe it will be necessary to implement healthcare technology to eliminate the social inequalities in the world of medical care, but the trust between a doctor and a patient is something that no computer will ever be able to mimic or replace. The development of technology is vital to the future of medicine and whilst it will continue to aid and improve patient healthcare, it will never replace healthcare professionals. Rather, it could change what their job looks like: with the elimination of menial tasks such as admin and the addition of new tasks surrounding the operation of new technology. The future of medicine is a vision where both humans and AI co-exist in harmony.

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The Search for the 'Theory of Everything'

Arjun Kotecha

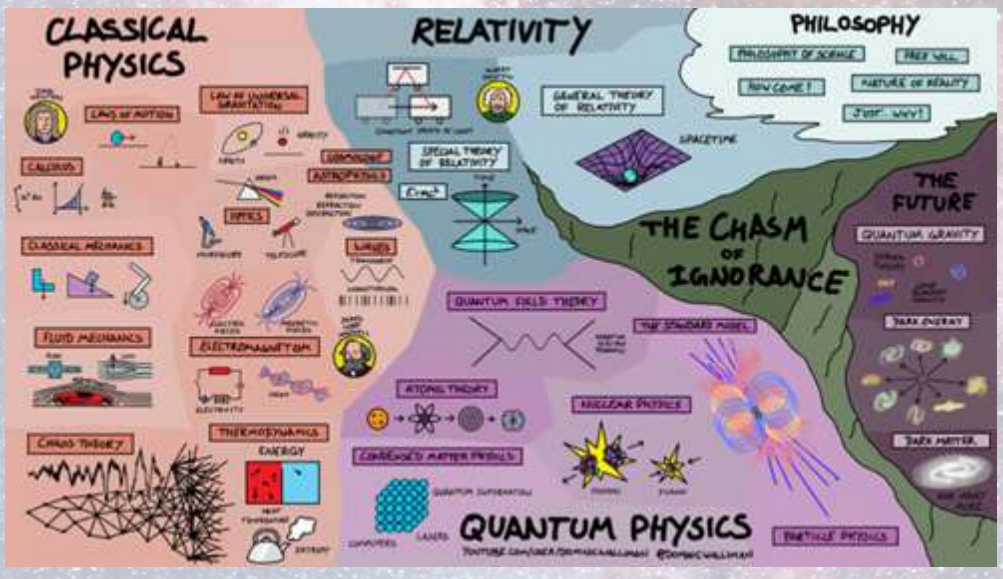
Humans as a species are curious about how 'the world' around them works. During our history, we have expanded our knowledge, developed technologies and built tools such as telescopes, to peer into the vast expanse that is our universe, and particle colliders (such as the Large Hadron Collider in CERN) to understand what actually makes up the matter of the universe. However, we still haven't quite worked out how *everything* fits together in the universe like it does, nor *why* the universe exists! [1]

The Problem

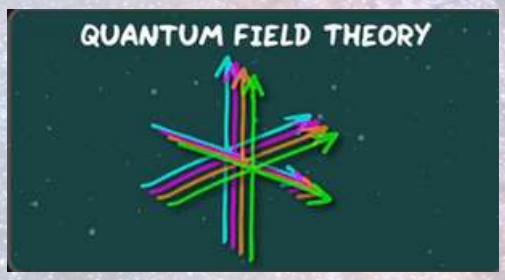
The problem that challenges theoretical physicists around the world today is bridging the giant 'chasm of ignorance' between two fundamental theories in physics: Quantum Field Theory and Einstein's Theory of General Relativity, both of which have been tested experimentally countless times to incredible precision and are the best descriptions (so far) of the universe ...except they don't fit together!

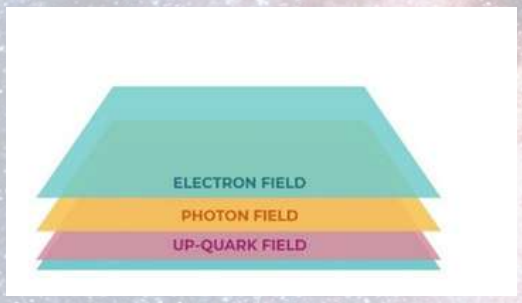
If the so-called theory of *"Quantum Gravity"* can be found, we will have an explanation for all of physics (at least, at the moment, we think so!). [2]

Quantum Field Theory (QFT), pioneered by physicists such as Erwin Schrödinger, Richard Feynman and Paul Dirac in the 20th Century, describes how the fundamental particles work and interact with each other, encompassing areas such as electromagnetism, the nuclear strong force and the nuclear weak force. The term 'quantum' means any description of the science of the very little things in the universe, i.e. QFT explains the universe with respect to subatomic particles. In ordinary space, there are 'wave functions' or 'fields' everywhere for all known subatomic particles (think of a sheet of paper representing a field). Particles are just 'excitations', or localised vibrations in those fields. In addition, when particles interact, the different fields interact, and energy is transferred to create vibrations in each of those fields – more 'excitations' are produced. [3]



There is also an element of probability involved in QFT: we can use the wave functions for each subatomic particle to calculate the *probability* that its position, mass, energy etc. is a given value – nothing is ever known for certain, these properties are only predicted. However, when the subatomic particle is measured, it appears in a given position as a particle, and not as a wave function. There is a 'quantum realm' where wave functions exist and nothing is certain, but as soon as a property is measured in 'our world', this collapses the wave function, and we see a particle. The wave function is the quantum representation of a particle in 'our world'. [4]





On the other hand, General Relativity describes how different objects at a large-scale (depending on their mass, position and energy) interact with each other due to the curvature they make in spacetime. [1, 5]. The term 'spacetime' is used to describe a mathematical model which joins together the ideas of the three dimensions of space and the one dimension of time into a single four-dimensional manifold [8]. Albert Einstein came up with this 'theory of gravity' in 1916 and published his findings in the German physics journal *Annalen der Physik*.

The main idea behind the theory is that, instead of gravity being an invisible force that attracts objects to one another due to their mass, it is essentially the curving of space. This means that that the more massive an object, the more it warps the space around it. When we think of two objects being attracted to each other due to their masses, according to General Relativity, what actually happens is that the object with less mass 'falls' into the pocket of warped spacetime created by the object with more mass to meet it. [6]

So why care about unifying these theories?

There are two extreme scenarios where Quantum Mechanics and Relativity meet, i.e. black holes and the Big Bang, and to explain these great mysteries we need a theory of *"Quantum Gravity"*. Currently, General Relativity breaks down when trying to describe the infinite curvature of spacetime inside black holes (due to how massive black holes are). Quantum Gravity may be able to answer the wild questions that physicists have about black holes: are there other universes on the other side of black holes and so do they act as wormholes? Also, Quantum Gravity could give us some ideas on the origins of our universe and what happened before the Big Bang.

Looking at the bigger picture, every fundamental change in our understanding of physics has led to new technologies being discovered, ultimately leading to advances in our societies. For example, the understanding of Quantum Mechanics led to the invention of computers and the whole information age! In order to find a 'theory of everything', a fundamental law of physics will inevitably have to be abandoned, but this would open new avenues to things that we don't even know exist now. [1]

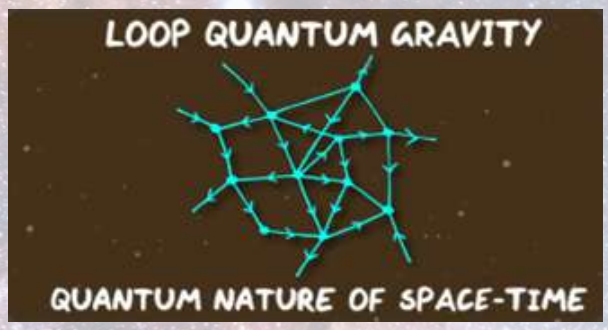
What are the contenders for this 'Theory of Everything'?

The current main contenders for the theory of *"Quantum Gravity"* are String Theory and Loop Quantum Gravity.

Quantum Field Theory, as previously mentioned, postulates that we have a field for each of the fundamental particles, and the particles themselves are 'excitations' of those fields. Similarly, String Theory treats spacetime (from General Relativity) as another quantum field, thus unifying gravity with all of the other forces in one framework. The theory proposes that 'all fundamental constituents of the universe' and all of their properties 'are one dimensional "strings" rather than point-like particles' (and the vibrations in loops of string are what we perceive as particles). What really is mind-boggling is that String Theory requires six or seven extra dimensions of space on top of the four or five already described for the fundamental 'particles' – so *eleven* dimensions of spacetime! One set of vibrations in the strings correspond to the 'graviton' – the particle hypothesised to represent gravity. So, String Theory attempts to condense all the particles down to a single entity – a string. Despite the theoretical success of String Theory, it has been criticised for not actually describing the real world. [1, 7]

On the other hand, Loop Quantum Gravity doesn't try to unify gravity with the other forces, like String Theory does. It attempts to separately work out the quantum nature of spacetime itself, and thus links with the theory of General Relativity, at the very short lengths of the Planck length (1.616255(18)×10^−35 m) which, according to Quantum Mechanics, we cannot measure anything smaller than. The theory, pioneered by many theoretical physicists including Carlo Rovelli and Lee Smolin, implies that there is a minimum possible distance, 'like a spacetime pixel' which the universe and the spacetime fabric is made of. These are the 'loops' of Loop Quantum Gravity and they are theorised to be able to represent any kind of geometry in 3D space. [1, 5] *(Loop Quantum Gravity does try to solve the problem of 'background independence' – if you'd like to know more, see [5], but do so at your own risk!)*

It is important to note that in addition to these theories, there are other contenders for the theory of Quantum Gravity. Despite all the successes of String Theory and Loop Quantum Gravity in an abstract/theoretical sense, the main limitation for both is the fact that neither theory has experimental observations that can back up the maths behind them and that can prove a prediction to be true that isn't already covered in QFT or General Relativity.



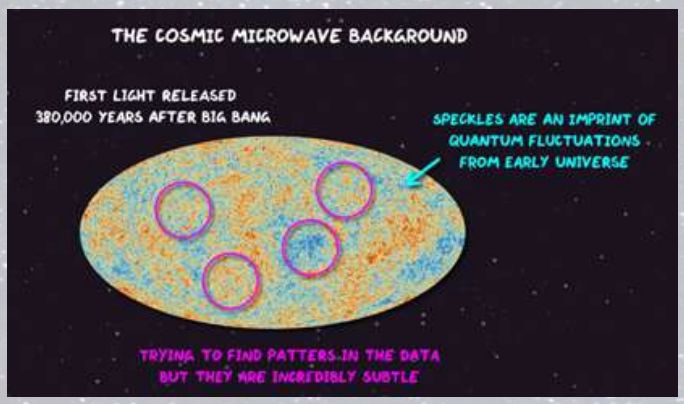
Why is this the case?

The short answer is that the 'force' of gravity (from General Relativity) is much weaker than the other forces in the universe (from QFT), which means that creating an experiment where an object feels all of these forces simultaneously is very difficult, or even impossible. Gravity only becomes strong if you are dealing with very massive objects (gravitational field strength increases with the mass of an object), e.g. it takes the whole mass of the Earth to keep you on the ground. For objects this large, the quantum effects are sadly not noticeable! On the

other hand, at the scale of atoms and subatomic particles, these quantum effects are much more noticeable, yet the 'force' of gravity isn't, since all subatomic particles have negligible mass! For example, two electrons that are brought together would feel a strong electrostatic repulsion due to their (negative) electric charge and an attractive force due to their mutual gravity. However, the repulsive force is *10^42 times* stronger than the gravitational force – so the effect of gravity is completely lost!

So, the only way you can experimentally test the theories of Quantum Gravity are situations where you have a very large mass in a very small volume - very high-energy situations such as in black holes or at the Big Bang. Unfortunately, we cannot simulate these situations given our current technology – we would need a particle accelerator, like CERN, but the size of the solar system and detectors the size of Jupiter, to get the correct amounts of energy. This experiment would probably turn into a black hole, thereby sucking us all into the abyss in the process! The best we can do at the moment is observe the workings and collisions of black holes very far away from us (and analyse what we see using *Gravitational Wave Astronomy* – seeing if there is a departure from General Relativity).

If there is a theory of Quantum Gravity, there must be a 'graviton' particle (i.e., a small packet of gravity), that we should be able to detect. Except... we can't (at the moment) with our gravitational wave detectors LIGO and Virgo. They could actually be impossible to detect, because we would need to detect changes smaller than the Planck length, which is impossible according to Quantum Mechanics. Also, we are only studying the effects of the Big Bang that we can still detect today. For instance, we observe CMBR (Cosmic Microwave Background Radiation), which we can use to detect quantum fluctuations in the first light released after the Big Bang and try to find patterns in it. [1]



Conclusion

To summarise, we have theories which describe our universe at the large-scale and at the very small-scale - General Relativity and Quantum Field Theory respectively. Theoretical physicists are trying to relate the two somehow, in a supposed theory of *"Quantum Gravity"*. If successful, we would, in effect, have a 'theory of everything' that we would be able to use to try and explain weird and wonderful things such as Black Holes and where the universe came from.

Wouldn't it be great for humans to be able to explain everything in the universe? I don't think we will ever come close to explaining *absolutely* everything...

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Image Credit: Domain of Science/Dominic Walliman, PBS Space Time, The Online Blackboard, New Scientist

The Science Behind Autism

Alice Hawkins

For those of you who may be unsure as to what autism (formally autism spectrum disorder - ASD) is, it is described as 'a lifelong developmental disability which affects how people communicate and interact with the world' [1]. And, as someone who has had the condition my whole life, I often ask the question, "Why do I have autism? What is the science behind it?". I will hopefully answer this question now.

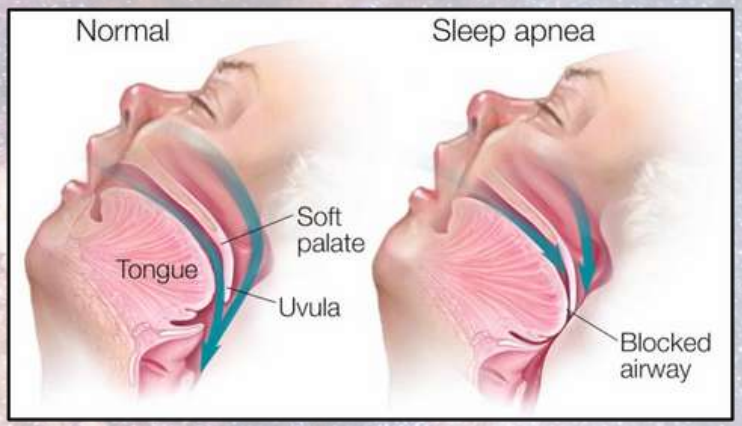
Scientists are still not fully sure of what the full causes for ASD are, however, there are a few theories. Scientists are, however, sure that the main cause for ASD is genetic, and are thus certain that ASD runs in families, with studies showing that heritability is at 83% [2]. Researchers have tallied about 100 genes that contribute to autism when mutated [3]. Sometimes, ASD is caused when mutations from two parents combine.

Still focusing on genes, even though there is a strong heritability surrounding ASD, *de novo* mutations (mutations that are present for the first time in one family member [4]) in the father's sperm or mother's egg could also be a factor. Also, autism could be more likely in older parents as *de novo* mutations in sperm and eggs often occur due to age.

Still focusing on genes, even though there is a strong heritability surrounding ASD, de novo mutations (mutations that are present for the first time in one family member [4]) in the father's sperm or mother's egg could also be a factor. Also, autism could be more likely in older parents as de novo mutations in sperm and eggs often occur due to age.

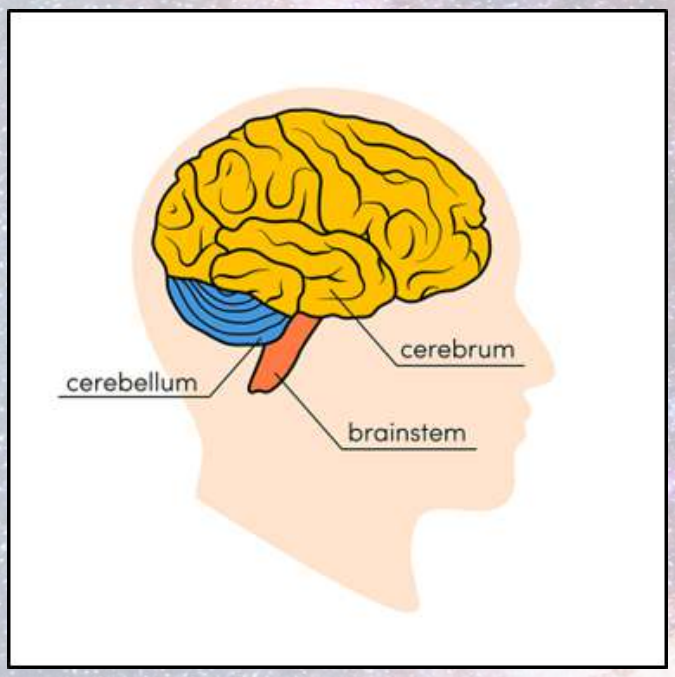
Moving on, another cause for autism could be due to aspects of the prenatal environment. Pregnant mothers who experience *sleep apnea* (a condition where breathing stops more often than normal during sleep) could result in the unborn child developing ASD. Viral infections, such as rubella, could also be a contributor.

Disruptions in normal brain growth in foetal development could also result in ASD. This could be the result of how the genes control how the brain (and, in particular, the cerebellum) grows as it has been proven that autistic people often have less tissue in that part of the brain. The cerebellum helps play a role in cognition and social interaction (a major symptom of autism is lack of social intelligence).



Extreme prematurity (born before 26 weeks of gestation) can also relate to autism. There is also a myth that autism is caused by vaccines as a child, yet this has since been proven to be false (but is still talked about by anti-vaccination activists).

Overall, I have summarised the main suspected causes for autism, and it has truly been enlightening finding out about them.



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What makes Type II Diabetes so prevalent among South Asians?

Meghna Rao

It is common knowledge amongst South Asians that type 2 diabetes is incredibly prevalent in most families and communities of our ethnicity. This is also echoed in various pieces of research - “Asian Indians are up to four times more likely than white Europeans to develop young onset type 2 diabetes whilst having a normal BMI” (University of Dundee, 2022) and “Nearly half of all adults with type 2 diabetes mellitus (T2DM) live in India and China” (Nature Reviews Endocrinology, 2022, p413-432). Evidently, the line we are all fed in GCSE Biology that “type 2 diabetes is a lifestyle disease” does not necessarily always ring true; but what is it about South Asian genetics that make this disease so much easier to develop?

Lifestyle Factors

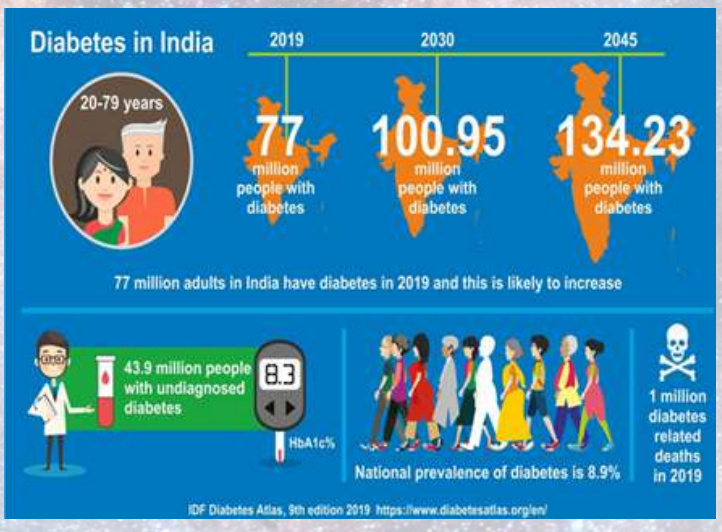
It can be argued that this is, in some way, accredited to lifestyle choices and environmental factors. For example, Indians historically were accustomed to the vigorous lifestyle that came with farming work and copious amounts of walking. Thus, in modern life, it can be said that our bodies do not cope with the relative inactivity of a more urbanised lifestyle.

Again, obesity and high BMI (Body Mass Index) numbers can result in impaired glucose tolerance. The so-called “Asian Indian Phenotype” tends to have a higher central fat distribution and larger waist circumference, associated with an increased risk of developing impaired glucose tolerance (IGT), which could then progress to diabetes.

Cultural and social customs are the most attributed reason for this spike in diabetes amongst South Asians. Traditional dietary patterns are morphing as South Asian countries increasingly conform to the Western workday and meal timings, which historical colonisation and famines have rendered unsuitable for the way Indian bodies have had to evolve as a result of these past circumstances. Moreover, increased amounts of processed foods (heavy in wheat and rice, which are central to the Indian diet) lead to an increased fat intake and higher calorie intake, all of which can result in IGT.

Genetic Factors

Type 2 diabetes consists of two main issues: the pancreatic cells not secreting enough of the hormone insulin, and cells responding poorly to insulin, thus intaking less glucose (Mayo Clinic, 2022). Insulin is a hormone stored within pancreatic β-cells in dense granules. Typically, these β-cells can sense



changes in the glucose concentration within blood plasma and respond by releasing the correct amounts of insulin. Upon sensing a change, insulin is secreted as granules within the β-cells fuse with the plasma membrane, releasing the insulin contained within these granules in a process called exocytosis. Insulin then regulates the amount of glucose in the blood by taking up more into the body cells and thus decreasing glucose in the bloodstream.

Insulin resistance, as the name suggests, is when a person's body does not respond well to insulin (i.e. is 'resistant' to the effects of). This is not the same medical condition as prediabetes or diabetes (when the pancreatic β-cells do not produce enough insulin to maintain adequate levels of glucose in the blood). Mayo College researchers did find that Indians were more likely to be insulin resistant than Europeans (American Diabetes Association, 2008) in an extensive study conducted in 2008. Insulin resistance is typically prevalent amongst those with type 2 diabetes and recognised as a major pathophysiological feature of type 2 diabetes since it leads to hyperglycaemia (elevated blood sugar levels) and thus, in time, type 2 diabetes.

β-cell dysfunction is when these pancreatic β-cells cannot properly sense blood glucose and thus cannot stimulate insulin secretion when necessary; this leads to constant hyperglycaemia. South Asian people have far lower β-cell function than necessary and, as mentioned, this amplifies the pathogenesis of type 2 diabetes.

These "genetic burdens" (University of Dundee, 2022) are impossible to get rid of completely and lead to an increased likelihood of developing type 2 diabetes; this is known as a genetic predisposition. Due to the multiple genetic variants that cause South Asians to be

this likely to be hyperglycaemic and consequentially diabetic, it can be said that their genotype shows evidence of a genetic predisposition to this disease.

Conclusion

Whilst some may argue that the evidence that this prevalence is genetic is purely circumstantial, I would say that a further delve proves quite the contrary. Insulin levels across all Asian Indians, diabetic or not, were higher than their European counterparts (Journal of the Association of Physicians of India, 2004), with the study concluding that this association was independent of all other lifestyle factors. This study predicts that "by 2045, an estimated 151 million South Asians will have diabetes".

Understanding why certain people are more susceptible is vital to early detection and implementation of adequate control measures, to prevent the serious consequences of type 2 diabetes. However, more holistically, your GCSE textbook did not tell you the complete truth about diabetes; the likelihood of having type 2 diabetes can be exacerbated by one's lifestyle of course, but there are indeed genetic factors that contribute concurrently.

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Cardiac Arrests & Heart Attacks

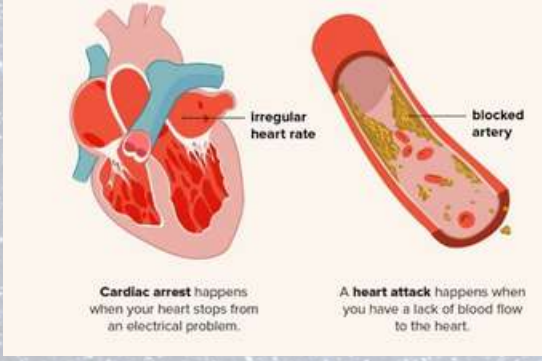
Kaarthik & Kaushik Santosh

Most of us are not aware of the difference between cardiac arrest and heart attack. People often use these terms interchangeably, but they're not the same. We've all heard the terms, and each one signifies a health crisis involving the heart so we should understand more about each. Both are medical emergencies, but they are two different problems with radically different causes and treatments.

A cardiac arrest happens when a person's heart stops pumping, which prevents the supply of oxygen around the entire body, including the brain. As a result, the person's breathing stops as there is no supply of oxygen. A heart attack occurs when a blocked artery prevents oxygen-rich blood from reaching a section of the heart. If the blocked artery is not reopened quickly, the part of the heart normally nourished by that artery begins to die. The longer a person goes without treatment, the greater the damage.

Symptoms

In some cases of cardiac arrest, there may be no symptoms at all. However, you may experience these symptoms prior to cardiac arrest or heart attack:



- Fatigue
- Dizziness
- Shortness of breath
- Nausea
- Chest pain
- Heart palpitations (fast or pounding heartbeat)
- Loss of consciousness

Causes of Cardiac Arrest & Heart Attack

If a person is in cardiac arrest, this means that they will faint suddenly, and will be unresponsive. Call 999 if you suspect this is a cardiac arrest and if trained, perform CPR. However, there are different ways a cardiac arrest may happen. Let us look at some of the ways.:

- Ventricular fibrillation
- Cardiomyopathy
- Congenital heart disease
- Heart valve disease

One of the ways cardiac arrest happens is through erratic heart rhythms in which the electrical system in the heart functions rapidly (*arrhythmia*). This causes the heart to stop, and the person dies. This whole process is called *ventricular fibrillation*.

In simple terms, *cardiomyopathy* causes inflammation of the heart, leading to scar tissue formation and forcing ventricular fibrillation. The process of cardiomyopathy is also called myocarditis. This occurs due to infections such as from cancer, and contagious bacterial diseases. Some people with autoimmune system disorders also

develop giant myocarditis, but treatment can be completed successfully.

CHD (congenital heart disease) runs genetically in families and is carried out from birth. CHD happens if there is a hole in the heart, or lesser-formed heart sections. Some born with less critical CHD can live their whole life as normal. Some CHD cases are temporary - the heart condition can change at any time, and could lead to a healthy heart eventually.

Heart valve disease happens when the valves in the heart do not work properly. The heart has four valves, so if one valve does not work properly, the blood flow through your heart can be disrupted. This can lead to cardiac arrest.

The main cause of heart attacks is coronary heart disease. This happens due to sudden contraction of the coronary heart artery which stops the flow of blood to cardiac muscle, and can be caused by:

- smoking.
- a high-fat diet.
- diabetes.
- high cholesterol.
- high blood pressure (hypertension)
- being overweight or obese.

Precautions for Cardiac Arrest & Heart Attack

If someone near you is in a cardiac arrest, call 999 immediately, perform CPR if possible, and use a defibrillator to slow the irregular beating. Follow instructions from the 999 operator until emergency services take over. Starting immediate CPR is vital as it keeps blood and oxygen moving to the brain and around the body.

We need to follow the below precautions in the event of a heart attack:

- Call 911. Drive the person with the heart attack to the nearest hospital.
- Give the patient an aspirin to chew and swallow. It helps the person keep his/her blood from clotting and reduces the amount of heart damage.
- Take nitro-glycerine, if previously prescribed by health care professionals.
- Begin CPR, if the person isn't breathing, so the blood flow does not stop. Push hard and fast in a rapid manner. This can be about 100-120 compressions a minute.
- Use an automated external defibrillator (AED). Follow the instruction to maintain the device's effectiveness.

Avoiding Heart Problems

Below are a few of the common things which we need to be aware of:

- Always remember to eat a healthy and balanced diet that has the correct amount of roughage/fibre and nutrients required.
- Be more physically active. Exercise is always essential to keep your body fit and healthy. The more active you are, the more fit you will be. Also, activity reduces weight if you are obese, which can be a major heart attack red flag.
- Give up smoking and drinking alcohol, since smoking causes cancer and smoking kills. The smoke, when inhaled, may be a threat to the heart. Furthermore, liquor drinking is linked to heart problems.

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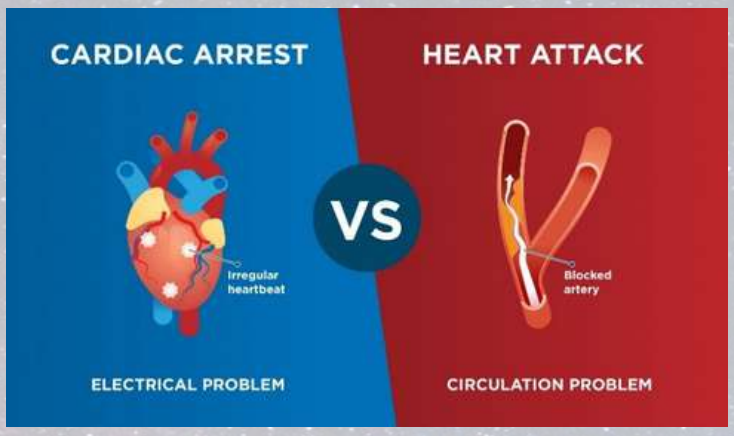
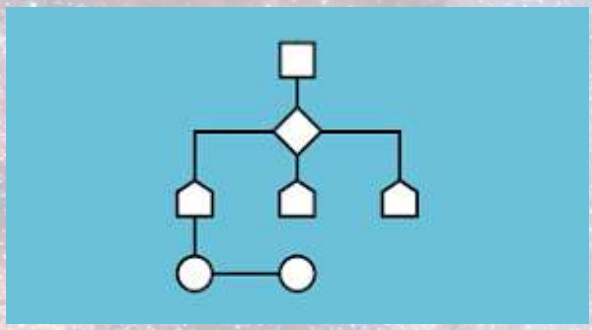


How algorithms can be used to make optimal decisions in everyday life

Ved Patel

Algorithms are defined as a set of instructions that can be completed in a finite amount of time. We are constantly using algorithms in our life, such as you reading this article right now: you clicked on a link; scrolled to this article; read the title; decided whether you would like to read this article or not; moved to reading the first line of the article; saw at some point that there were not any more words on the same line; moved to the line underneath. This is an example of a simple algorithm that we follow subconsciously.

We can enhance our lives by using established mathematical and computational algorithms to pick the optimal choice when forced to make a decision. Should you stay at home or go to a restaurant? Should you go to your favourite restaurant or the new one that everyone is talking about? Should you go with your best friend or one of your newer friends? Decisions like this come up in life, and we are forced to make a decision. A strategy that computer scientists have made is known as “explore or exploit”. Exploration is gathering information and exploitation is using that information in order to obtain the best result. Exploiting will almost guarantee a good result every time, but seldom is it that you must gather information as, if you are deciding between your favourite restaurant and one you have never been to before, there is a chance the new restaurant becomes your new favourite. In the mind of a child, if you have a limited number of game credits and you want to get the biggest prize by getting the most tickets, you will play a game that you already know will give you a lot of tickets. As you spend your limited credits and keep winning tickets, by getting a large number of tickets (e.g.) 60% of the time, you realise that you might just run out of credits before gathering the number of tickets you require to get the biggest prize. If you continue playing the game that has a 60% success rate, you might not reach your goal, but you might try a different game which either has a chance of a lower or a higher success rate. This could be the key to getting you to the number of tickets you want before you run out of credits. Decisions like these can be made easier by using an established, optimised algorithm. The optimal decision in the situation is to ‘explore’ different options when time (or in this case credits) are more abundant, and ‘exploit’ when credits are about to run out, to get the optimal result.



Another problem that has been solved by computer scientists and mathematicians is the “secretary problem”. This problem can be described as hiring the best secretary with a twist: if you do not pick the secretary you are interviewing and want to see if there are better options, you miss out on hiring that secretary. This is given that, if you accept the secretary you are

interviewing, they will definitely join. The question in this scenario is this: when should you stop looking at candidates before you pick one? If you pick too early (the second candidate, for instance) you only know if the candidate chosen is better than the first candidate, while there could be somebody much better that you will never interview. Alternatively, if you are too choosy, then you risk losing the best candidate in the pool. After many years of this problem being passed around the mathematical and computational community, it was featured in the February 1960 issue of The Scientific American among several other puzzles for recreational mathematics. After a hunt to trace back who first made the discovery to the solution, a man by the name of Merill Flood was found to have produced the original solution. His influence on computer science was impossible to ignore, after his solving and popularisation of solutions to problems such as this (he also may have coined the word “software”!). The solution to the “secretary problem” is now very popularly known as the “37% rule”. This suggests not accepting a single candidate out of the first 37 candidates (assuming there are 100 in the pool), no matter how impressive they may be. After going through the first 37%, hire the next secretary that is better than the best in the first 37 that were interviewed. This rule, derived from a more complex probability formula, can be applied in many situations, such as choosing a spouse - which was the case for Michael Trick, professor of operations research at Carnegie Mellon, who decided to use the 37% rule on women in the age range of 18-40 to find the perfect partner for himself. The rule can also be obeyed while looking for apartments in an area where there are a lot of customers, and where the house would be out of your hands forever if you do not make an immediate offer.

The purpose of this article was for you to realise how mathematical or computational thinking, and calculations can influence your future decisions for whether you want to hire a secretary for your company to what film you would want to watch on a particular day. You use simple algorithms every day, so adding some algorithms like the ones stated in this article to your arsenal will definitely help you make the optimal decision in all aspects of life.

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The Secret World of Entomology

Kumari-Shanaye Lad

What is entomology and what do entomologists do?

Entomology is the scientific study of insects [10] [17]. There are two types of entomologists: professional and amateur. The professional entomologist works on investigating how to stop insects from spreading illnesses to livestock and crops [17]. The amateur entomologist conducts research on these hidden creatures because of their beauty and differences [17].

Entomologists review the positive and negative effects insects have on the world and their relationship with humans and other living organisms. They also protect, classify, educate and preserve insects [6].
The professionals spend time in laboratories, in conservation or spend their time outdoors with different species of insects. Entomologists collect samples of different species of insects, which are brought back to study [10].

Although not all species are taken back to the laboratory, some are studied in their natural habitat. The importance of studying insects in their natural habitat helps to understand their normal behaviour, because if they are in an unfamiliar place they will not behave as they usually would. For example, a Common Sexton Beetle (Nicrophorus Vespilloides), also known as the American Burying Beetle (Nicrophorus Americanus), bury corpses of dead animals and lay their eggs inside, as it provides a food supply for the larvae as well as shelter to keep them safe [15]. This plays a part in the

(a)

ecosystem by recycling the corpse for nutrients, vegetation and prevents the spread of diseases produced by the decaying matter [15].

Why do we need to study entomology?

Entomological research is used in different fields of pest control, molecular science, and the production of food, robotics and pharmaceuticals [17].

One aspect of entomology is that it enhances our knowledge on diseases that can be transmitted to humans, plants or animals as insects are the largest group of living organisms on the planet [4] [5] [13]. If we learn about the diseases spread by insects, we can then create cures. A brilliant example of insects that cause disease is a Savannah Tsetse Fly (Glossina), which causes elephantiasis and sleeping sickness once infected [4] [5].Species of insects that latch on to its host for survival are called parasitic

insects as this causes infections to its living host [2] [12]. Common examples of parasitic insects are: Ticks (Ixodida), Fleas (Siphonaptera), Mosquitoes (Culicidae) and Lice (Phthiraptera).

Another use of entomological research is understanding biodiversity, as biodiverse organisms create the foundations for all life on earth [14]. Entomology is used in ecology because we are able to understand insects' habitat in-depth and explore why the insects live in those particular biomes. By researching the insects habitat and lifestyle, we can further maintain their habitat so that the can continue to generate major terrestrial ecosystems (land-based communities), making insects one of the most vital living organisms on the planet [11].

Related Definitions

Biodiversity	The range of life in a particular habitat
Ecology	The study of living organisms and their connection with their surrounding habitat
Agriculture	The science of farming products humans needs to survive, crops and breeding livestock.
Terrestrial	The study of the life that lives on land instead of the sea, air or trees.
Ecosystem	All the organisms in a biome.

So... what actually are insects?

The mini beasts take up 90% of all living things on earth [10]. There are two main groups of the bug kingdom: Arthropods (Arthropoda) and insects (Insecta). Arthropods have a hard exoskeleton (protective shell), segmented legs and their head and thorax are fused meaning they only have a head and an abdomen. Some arthropods you will have heard about include Spiders (Araneae), Scorpions (Scorpiones), Lobsters (Nephropidae), Millipedes (Diplopoda), Centipedes (Chilopoda) and Mantises (Mantodea) [5]. Insects, on the other hand, have three pairs of legs, no exoskeleton and a head, thorax and abdomen. Some insects you will have heard of are Butterflies (Lepidoptera), Moths (Lepidoptera), Bees (Anthophila) and Ants (Formicidae) [5]. Both Insects and Arthropods are found in all biomes, even in the water. Aquatic insects take up 6% of all insect species [7]. Some of these include the Water Spider (Argyroneta Aquatica), Water Scorpion (Nepidae) and Pond Skaters (Gerridae).

Evolution of Insects

Insects evolved from a barely-discovered group of poisonous Crustaceans called Remipedes. 300 million years ago, during the Paleozoic period, insects (Insecta) were much larger than what they are now [16]. Dragonflies (Anisoptera) had the largest wingspan of around two and a half feet long, yet the workers of the miniscule ants we see today were 1-3cm long and the queens were 5.5cm long. When birds arrived into the world, flying insects needed the advantage of speed and so the evolution brought them to a smaller size [1].

(b)

Fields of Entomology

Fields of Study	*Insects that are studied in this field*
Entomology	All Bugs (Insecta)
Apiology	Bees (Anthophila)
Dipterology	Flies (Diptera)
Coleopterology	Beetles (Coleoptera)
Myrmecology	Ants (Formicidae)
Acarology	Ticks (Ixodida) and mites (Acari)
Arachnology	Spiders (Aranaeae), scorpions (Scorpiones) and related species
Parasitology	Parasites (Parasitus)

Fantastic features of favourite insects

All insects have many different features which make them extremely fascinating. Some of the most interesting features are vision, camouflage, feeding and intelligence.

Vision

The Praying Mantises (Mantodea) eyes' have countless lenses that make up one single compound eye. This allows them to act quickly to the smallest movement. The Praying Mantises (Mantodea) may also nod or tilt its head, as it calculates the distance between the itself and the prey [5].

(c)

Intelligence

In a single Ant (Formicidae) brain, there are around 250,000 brain cells. Humans have 10,000 million brain cells. That means that a colony of 40,000 ants have the same total brain cells as a human being! Considering the birth rate of Ants (800 eggs per day) 40,000 is not a big number [5].

Camouflage

Walking Leaf Mantises (Phylliidae) are one my favourite insects as they camouflage unusually well into the leaves of their habitat, so well that others of the same species think it is a juicy, edible leaf. To add to their disguises, Walking Leaf Mantises (Phylliidae) sway with the wind as it makes it harder for predators to spot them [4].

(d)

(e)

Feeding

The Dragonfly Nymph (Anisoptera) has a hidden mouth piece called Labium. When its' prey is close enough, it shoots out the Labium, grabs and pulls the prey towards itself so it can eat. Impressively, the Labium shoots out at 10 milliseconds. That is 140 milliseconds faster than an average human blink [5].

Recent Discoveries:

In 2021, an accidental squishing of a Bush Cricket (Tettigoniidae) brought attention to a new discovery of Worm (Annelida) called the 'Horse Hair Worm' (Acutogordius Olivetti) found inside the Cricket. As the Horse Hair Worm sensed its host was about to die, it left the body, only to be collected by researchers. It was soon found to be a male and measured 165mm in length and 0.95 in width [3].

Another gripping discovery in 2021, was a Japanese Centipede (Scolopendra Alcyona) which has a length of 20cm long and 2cm width, making it roughly the same length as a rat [3]. The Japanese Centipede (Scolopendra Alcyona) is the third amphibious centipede species ever recorded!

Greta Spiders (Thunberga) (found in 2021) are named after the environmental activist Greta Thumberg. This single species continued to grow to make 25 other species. The 25 species have been named after other inspiring young people, such as Malala Yousafzai [3].

Interesting facts:

- Out of all the life forms existing on earth, insects out numbers them all! [13] [10]
- Out of all the identified insects, only 5 % are pests, however 20% of the worlds crops are consumed by them! [9] [13]
- Without insects our world would be covered with waste and diseases!
- The first group of insects appeared around 479 million years ago in the Early Devonian Period. This makes insects around 249 million years older than dinosaurs! [1]
- The word Entomology comes from the Greek language!
- Entomology is a branch of zoology!

Further Reading

If you wish to find out more about bugs, I would recommend reading: DK Pocket Eyewitness Insects, DK Eyewitness Insects, My First Big Book of Nature and The Ultimate Bug-opedia.

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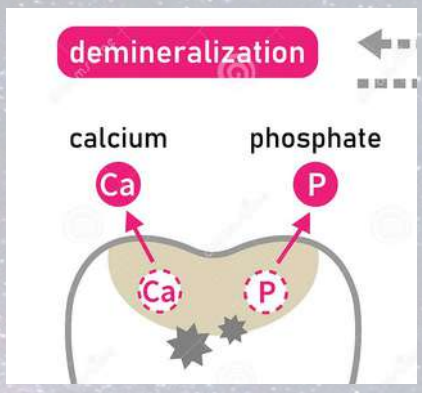
The Science Behind Tooth Decay

Aaryan Singh

You've probably been told at some point in your life that 'if you eat too many sweets, your teeth will rot', but has anyone ever explained why? Has anyone explained what can actually happen if your teeth rot and moreover, what takes place in the mouth during the formation of dental caries? Tooth decay or 'rotten teeth', come about mainly due to poor oral hygiene and our diet (Sandhya, 2022). In some ways, this is good as it tells us that it is in our hands to maintain a healthy mouth, free of decay. But to be able to understand what we need to do to protect our teeth, and what foods we need to avoid, we must understand the science behind decay.

Our mouths are hosts for millions and millions of different bacteria, and while many of these are beneficial bacteria that keep our mouths healthy, some are not beneficial for our oral health and are actually cariogenic. Cariogenic bacteria are bacteria that cause caries (cavities) (Decho, 2017), such as Streptococcus Mutans. These harmful bacteria metabolise the carbohydrates from the sugary and starchy foods we eat. In fact, they feed on the sugars in foods - in the same way we might feed on that packet (or packets) of Haribo's, or that Dairy Milk bar - and, in the process, produce acids which enable demineralisation. Demineralisation is when acid attacks our enamel, which is the hard, protective (not to mention shiny and white) outer coating of our teeth, stripping it of its minerals (Brown, 2013). Minerals are responsible for strengthening the enamel and so, when demineralisation occurs, the enamel becomes softer and more prone to dental erosion. Our bodies do have a secret weapon to reverse the detrimental effects that demineralisation has on our teeth... saliva!



Now you're probably wondering how saliva became the enamel's saviour against demineralisation. Saliva contains many minerals including calcium and phosphate, both of which are lost during acid attack and demineralisation. The saliva can restore the minerals in the enamel, somewhat reversing the effects of acid attack (Brown, 2013). Saliva is only able to promote re-mineralisation once the pH of the mouth returns to its neutral state, thus if you eat sugary foods frequently, the saliva is not able to remineralise the teeth as the pH of the mouth is constantly low (due to sustained exposure to sugar and consequently, an acid attack). This results in mineral loss over time, a weakened, eroded enamel and, consequently, a cavity. Although cavities are a definite cause for concern, we cannot overlook damage done to the enamel. Cavities can be easily treated via fillings, when caught in the early stages. However, enamel cannot regenerate or be 'fixed' when it's lost, and so when it's gone... it's really gone (Bauer, 2022).

While saliva is great for re-mineralising the teeth, it doesn't work alone: its 'sidekick' happens to be tap water. While it may not be the most exciting partner in crime, tap water (in the UK) is fluoridated. There is 1mg of fluoride per litre of

water so, while the water you drink may not be teeming with fluoride, there is enough to provide some protection against decay. But what is fluoride and why is it so good at preventing decay?

Fluoride is a naturally occurring mineral found in water, however, in some regions of the UK, the water contains less natural fluoride so additional fluoride is added to the water supplies. Fluoride is absorbed into the enamel when it becomes softened following acid attack, working to attract calcium ions from the saliva and bring these together with phosphate ions for the purpose of remineralisation. Some fluoride also remains on the surface of the enamel, which strengthens the enamel and makes for a more acid resistant surface (Bauer, 2022).

Fluoride can be found in your toothpaste and is often a key ingredient to look for, especially in children's toothpaste. As a child, it is likely that, if you have been keeping up with your 6-monthly dental check-ups, you have routinely had a fluoride varnish applied to your teeth by your dentist. What's special about these varnishes is that the fluoride can be retained by the hard tissues of the teeth, and released over time into the saliva to aid and promote remineralisation. Dental plaque is also able to retain fluoride - which is great news for your teeth. This is because fluoride has been shown to decrease the ability of plaque-causing bacteria to produce acid, and therefore limits decay.

Dental plaque is the slippery film on your teeth (which can be scratched off) - known as a 'biofilm'. The biofilm is made up of many different bacteria along with a sticky polymer that allows these microorganisms to adhere to your teeth and populate, forming entire colonies (yes, colonies!) of bacteria. Plaque forms throughout the day and is not uncommon. However, it can prove to be very harmful for your teeth if not removed by brushing and flossing. The bacteria that release acids are in the plaque on our teeth, and the stickiness of the plaque means that, in the same way popcorn kernels can get stuck in your teeth, the acid released by cariogenic bacteria sticks to your enamel and exacerbates the effects of acid attack (Cochran, 2023).

While dental erosion (wearing away and loss of enamel) is a big problem, it can get worse. Eventually, as the enamel erodes, it will reveal the dentin, a layer of the tooth that protects the pulp and, unlike enamel, has nerves and blood vessels. This means that as the decay progresses and reaches the dentin, not only will it cause sensitivity but could lead to a hole in the tooth, more commonly known as a cavity (Brown, 2013). When the decay is at more advanced stage, it can begin to affect the pulp of the tooth and infect this bundle of nerves and blood vessels. At this stage, you will most likely experience a lot of pain and, consequently, a root canal treatment may be suggested by your dentist to remove the infected pulp. While every effort will be made to preserve the tooth, complications can follow root canals and so a tooth extraction may become necessary. This type of treatment is often only necessary in the later stages of decay, and therefore, if you are able to spot decay early on the treatment is much simpler and less uncomfortable.

Both root canal treatments and extractions come under the NHS band 2 and cost £65.20, as well as being uncomfortable procedures. If decay is caught in its initial stage by your dentist (such as during your biannual routine dental check-up) it can be treated more easily by an amalgam or composite filling. Fillings are procedures that come under band 1 and are significantly cheaper than band 2 treatment options, such as extractions and root canals. During this procedure, the dentist will clear out the decay using a drill, and subsequently prep

and fill the tooth with the chosen filling material. So fillings are not only much cheaper, but they are also less uncomfortable procedures, well... aside from not being able to eat in the few hours following (Bauer, 2022).

Maybe next time you see that packet of Haribos or that Dairy Milk, you'll think back to the colony of Streptococcus Mutans having a blast in your mouth... or maybe, you'll still take that bite!

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Discussing the debate over the legalisation of active euthanasia

Riana Pathmanathan

The debate over the legalisation of active euthanasia in the United Kingdom is considered to be one of the most polarising medical debates currently. The British Medical Journal (BMJ) states: 'proponents and opponents of assisted dying do not all agree on the terminology used to describe the process' (BMJ, 2021). The BMJ website defines the commonly used terms as follows: 'Assisted dying – proponents of the Assisted Dying Bill 2015 in England and Wales argue that this term best describes prescribing life ending drugs for terminally ill, mentally competent adults to administer themselves after meeting strict legal safeguards.' Assisted dying, as defined like this, is legal and regulated in the US states of California, Colorado, Hawaii, Montana, Oregon, Vermont, and Washington, and in Washington, DC.

In 2017, similar legislation was passed in Victoria, Australia. Assisted suicide describes giving assistance to people with long term progressive conditions/terminal illnesses, and other people who are not fatally ill, enabling them to pass away. The drugs are self-administered. Some opponents to assisted dying do not accept that it is different from assisted suicide. Assisted suicide, as defined like this, is permitted in Switzerland. The term voluntary euthanasia describes a doctor directly administering life ending drugs to a patient who has given consent. Voluntary euthanasia is permitted in Belgium, Luxembourg, and the Netherlands. In 2016, Canada legalised both voluntary euthanasia and assisted dying for people whose death is "reasonably foreseeable," in what it calls "medical assistance in dying." (BMJ, 2021) [1]

Under section two of the Suicide Act 1961, as amended by the Coroners and Justice Act 2009, any person deemed to be of assistance in the suicide or attempted suicide of another person could be imprisoned for up to fourteen years. [2] In October 2012, there was a speech made at the Oxford Union, which opposed the legalisation of euthanasia and assisted killing of patients. The speaker discussed how Parliamentarians have asked the question of whether allowing euthanasia for a few without putting many others at risk is possible – they have concluded that this is not feasible. The speech noted that 95% of Palliative Medicine Specialists – the people who look after dying patients everyday – are opposed to a change in the law. Does this make them all cold and dispassionate? There must be a logical reason as to why these specialists, who care for people at their most vulnerable and dependent, do not want active euthanasia to be legalised.

The saying 'dying with dignity' is often utilised by those who are in favour of a change in the law, but this phrase does not necessarily warrant said change. Palliative care workers,

hospices and nurses all work exceptionally hard to deliver compassionate care to those in need of it in their final weeks. When those with terminal illnesses die, what determines whether they have died with dignity or not? When the physical, psychosocial, and spiritual needs of the patient are met, requests for euthanasia are extremely rare. Dr Robert Twycross, Emeritus Clinical Reader in Palliative Medicine, Oxford University insisted 'euthanasia must never become part of normal medical practice' and that 'society must safeguard the right to life'. Dr Twycross went on to say, 'if we kill voluntarily, we will eventually offer involuntary euthanasia'. One of the caveats that the legalisation of active euthanasia could lead us down is the danger of the 'right to die' becoming a 'duty to die' – patient safety could become compromised; doctors may be required to actively kill patients and those with disabilities or terminal illnesses will be led to believe they would be better off dead. Baroness Warnock, the philosopher, stated that due to the care they need, sick people are 'wasting people's lives': 'If you're demented, you're wasting people's lives – your family's lives – and you're wasting the resources of the National Health Service.'. Suggesting that we have a 'duty to die', she said, 'I think that's the way the future will go, putting it rather brutally, you'd be licensing people to put others down.' Evidently, his shocking way of thinking does not consider how valuable human life is. Moreover, one in eight cases of elder abuse involves financial abuse by relatives. A change in the law, legalising active euthanasia, would inevitably increase this further, presenting us with yet another issue. The speech at Oxford Union notes that care and kill cannot be synonymous – in a large proportion of medical cases, killing someone who is elderly, disabled or suffering from a terminal illness would be malicious, for both the patients and their relatives. [3]

However, it is impossible to ignore how many people are in favour of a change in the law. In 2021, Baroness Meacher introduced the private member's Assisted Dying Bill in the House of Lords. Her reasons were as follows: 'My bill would allow terminally ill, mentally capable adults to have the option of accelerating their deaths with medical assistance. It is based on assisted dying laws that have been in place in the US State of Oregon for almost 25 years. Too many dying people suffer against their wishes at the end of life in this country, and our current laws fail to protect dying people who often feel they have no option but to seek help overseas or take matters into their own hands at home. Dozens of our citizens travel every year to Switzerland to make use of its assisted dying laws, at great emotional and financial cost. Many hundreds of terminally ill people take their own lives in this country in distressing circumstances. Even with the very best care, thousands of people in the UK every year will die without adequate pain relief or with unmanageable and distressing symptoms, despite the very best palliative care. This law would help a small but significant number of dying people avoid unwanted suffering at the end of life, but would also provide protection and reassurance to those living with a terminal illness that this option will be available to them if the worst should happen; assisted dying would not be a substitute for palliative care, but an additional option alongside it. 'Dying people need excellent palliative care and the option of assisted dying in the event that they find their suffering unbearable.' (Meacher, 2021) [1]

Furthermore, the statistics are chilling – it is currently believed that 1 in 7 suicides may be

elated to terminal and serious illness. One evident problem with the euthanasia debate is that it is led by opinion rather than fact. There are many compelling reasons which explain why a change in the law should not even be debated over. In the past 15 years, the number of Britons who travelled overseas for assisted death has increased six-fold to at least one per week. In addition, nine out of ten members of the public now support legalising the right to die – a right that 150 million people already have worldwide. [5] In the cases of people such as Debbie Purdy, Diane Pretty and Tony Bland, it is impossible to ignore how the lack of the right to death affects patients, and their relatives too. The euthanasia debate forces the 'right to life' onto society, but one should surely be able to die with the same dignity they have lived with – to say otherwise is nonsensical. To force a person to live in excruciating, incurable agony for a prolonged amount of time is undoubtedly inhumane and cruel.

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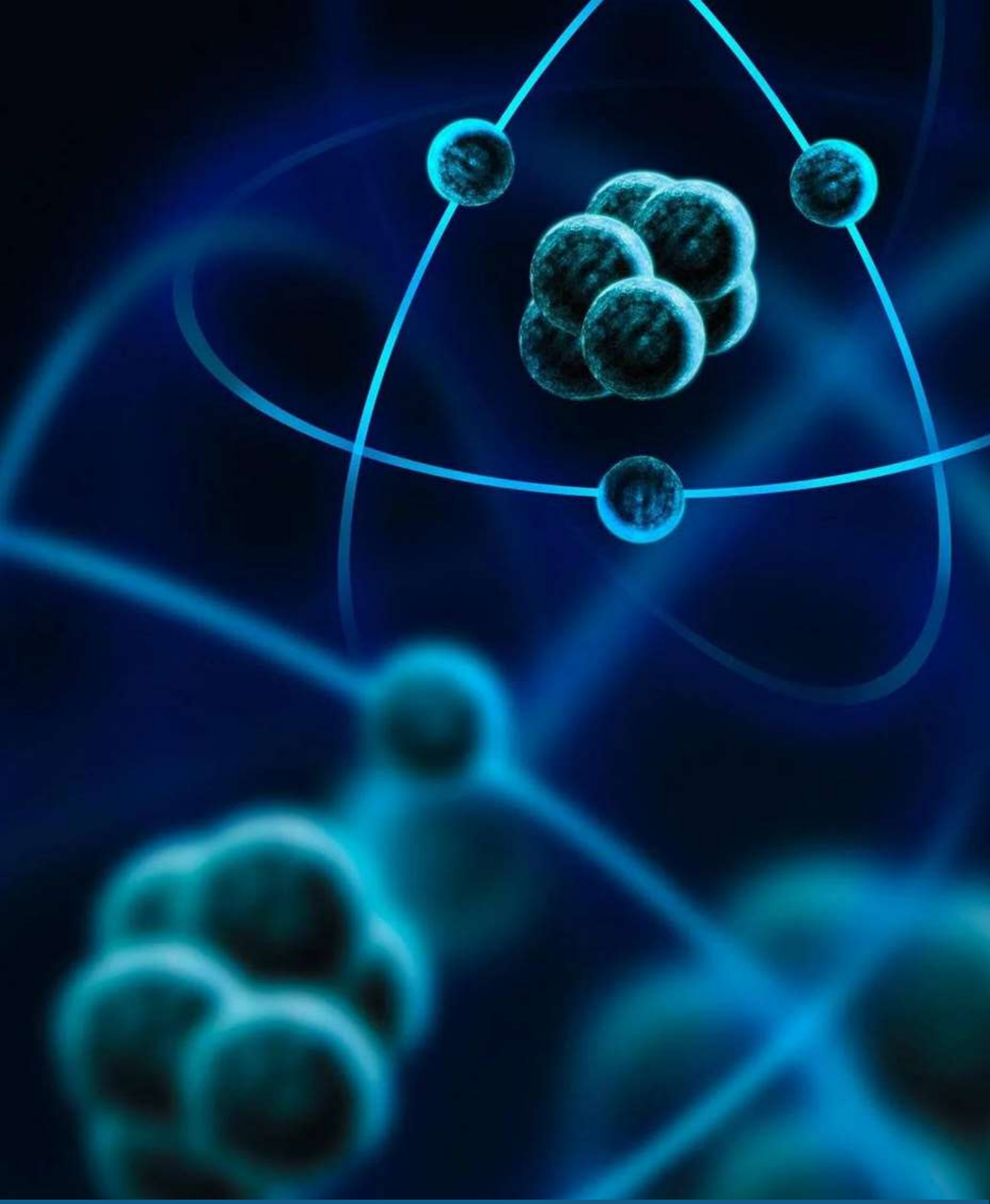

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