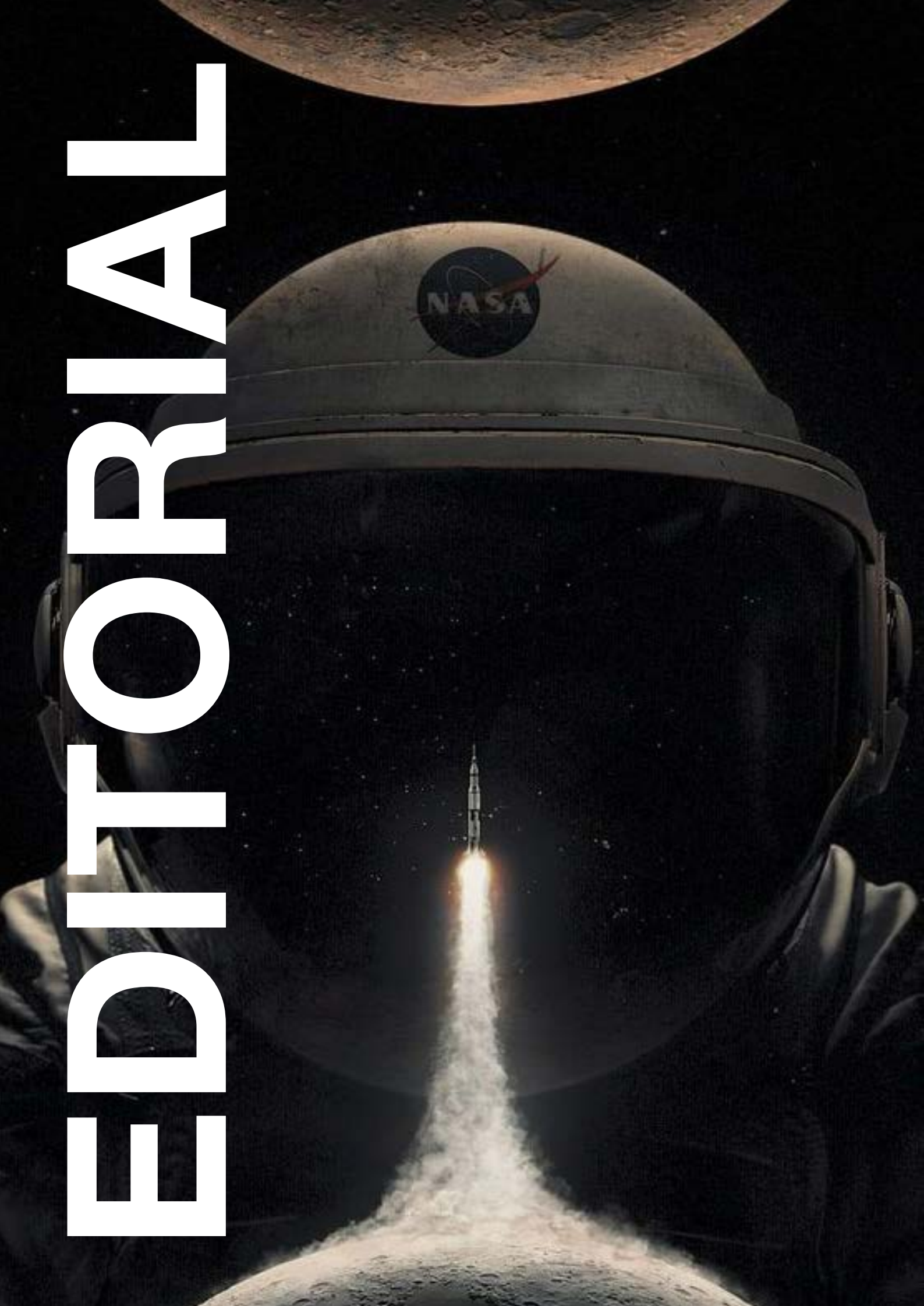
THE ECHO

SPRING ISSUE 2024

EDITORIAL



Editorial Board

A clear bubble of air rises from the muck, floating to the surface, where it joins a group of bubbles. Another bubble, meanwhile, pops. Theories in science come and go but each leaves its own impact and remains in its own niche. The Echo strives to capture these changes as they happen and as new theories are made.

This Spring's edition of the echo explores some of the latest discoveries in the field of science. From Nanotechnology to Cancer detecting tests, each page of this publication attempts to convey the breadth and the depths of the discoveries that are happening almost every day in science. You might be interested to learn more about the new developments regarding hydrogen fuel or understand how humans are copying nature's mechanisms.

The special section of this issue pays homage to the world above our heads in Developments in the space industry, talking about the major advancements in the space industry. From electron rockets to Apollo 13's "Houston, we have a problem", this section creates a comprehensive picture of space advancements.

Finally, I'd like to thank all the editors, writers and designers for their tireless efforts in creating this issue of The Echo. Their efforts have been captured within these pages and I hope that you enjoy reading this issue.

Happy Reading,

Aradhya Jain

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THE ECHO

HYDROGEN FUELS

Rafay Habibullah aims to evaluate the potential of hydrogen fuel as a sustainable and efficient alternative to fossil fuels while acknowledging its current limitations and future possibilities.

With climate anxiety rising and councils being held worldwide, we must reevaluate the fuel sources we rely on for our daily lives. Fossil fuels make up the majority of our fuel sources, and to truly fulfil the plan of zero carbon dioxide emissions, we must look at alternate fuel sources. At this moment, hydrogen testing is occurring all over our planet to test what looks to be both a sustainable and efficient fuel. With the rising interest surrounding it, we must question whether it is as good as it appears. Well, the answer to that is not clear enough, so for now, the answer is too unclear to be sure.

Hydrogen fuel can be created without any carbon dioxide emissions whatsoever. The waste it produces when creating energy is water vapour, making it seem like a breakthrough in the eyes of most, but as best put by Professor Alessandro Abbotto, a well-known and respected lecturer of Organic Chemistry, "96% of hydrogen production is derived from non-renewable sources, effectively cancelling out its green properties." Therefore, we must understand that to properly harness the power of green hydrogen, it must be produced in a renewable way. To explain, the vast majority of hydrogen is created through fossil resources, specifically natural gases like methane, which are both low-cost and large-scale. The major downside brought about by this is that we are effectively still keeping fossil fuels on the grid, therefore continuing carbon emissions and

“Before entering the realm of entirely green hydrogen, I would like to explore the grey area, the second biggest hydrogen production method”

holding onto our non-renewable fueling ways. The alternate forms are more expensive but also more environmentally friendly.

Before entering the realm of entirely green hydrogen, I would like to explore the grey area, the second biggest hydrogen production method, though less used, ‘power to gas,’ which is using electrolysis to break hydrogen and oxygen from water. According to the US Energy Information Administration, though the electrolysis process has no byproducts or emissions except for hydrogen and oxygen, the electricity required can come from both renewable and non-renewable sources. If an effort were made, this process could be the future of production for truly green hydrogen, using green energy to create the electricity that goes into this process. However, the reason why ‘power to gas’ is not used for the generation of hydrogen in a green way is due to the drawbacks that come with each renewable source of energy. The damming of water for hydroelectric power leads to flooding, destroying ecosystems and inhabitants. At the same time, biomass and biofuels are also renewable, but they release similar amounts of carbon emissions as fossil fuels while taking up huge amounts of land.

Finally, green hydrogen can only be created by fully environmentally friendly energy, which is performed by separating hydrogen from water using renewable sources such as solar power. However, this method is still being tested, making this energy-efficient method inaccessible to us at the moment. Now green hydrogen, in this day and age, is created using solar technology and

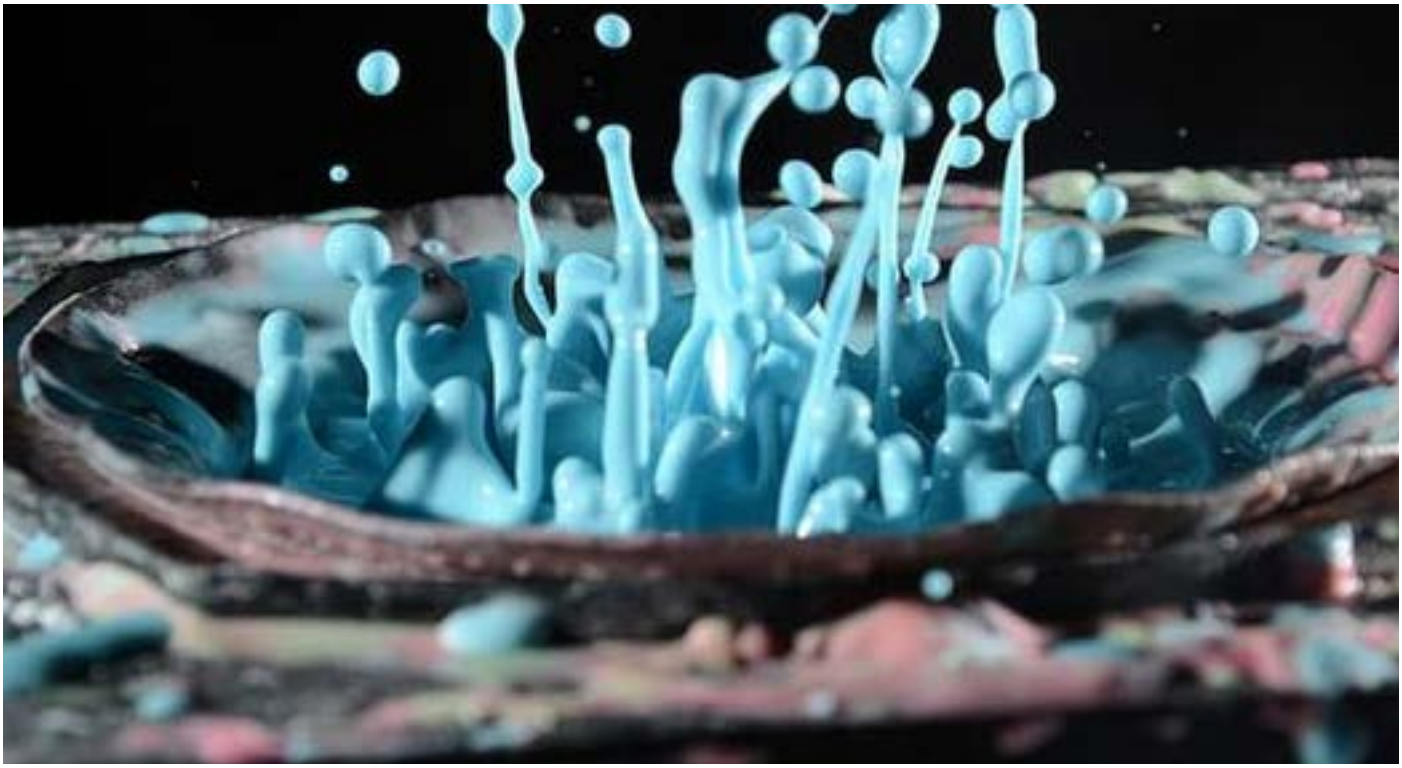
methods. The main problem with these production methods is that the amount of hydrogen created is less in a specific amount of time as compared to other methods. This problem is prevalent whenever solar energy is brought up since the fact that solar energy can charge throughout the day also comes with a drawback: one solar panel only generates 2 kW of power in a day, which is just enough to run a small air conditioner for around 5 hours, creating quite a conundrum for this green fuel. In short, this method has a drastic drawback: efficiency.

Even with their efficiency problems, hydrogen fuels still have a fighting chance in the debate between them and natural gases. With all the drawbacks, being their high flammability, the fact that they need to be compressed considerably, and their low efficiency when produced in a fully green way, Viscofan has implemented hydrogen fuels and has conducted an on-site test by using Bergen Engines running on natural gases and hydrogen fuels, concluding in what could be described as a clear win for both hydrogen fuels and Viscofan, Viscofan potentially losing eight thousand metric tons of carbon emissions a year and confirming that hydrogen fuels can indeed work regularly in a work environment. This proof that hydrogen fuel does indeed have the potential to be the fuel of the future not only cuts down on carbon emissions around the globe but also pushes the world into a more sustainable era — the era of hydrogen fuels.

The Paris Agreement in 2015 led to 196 countries agreeing to use cleaner forms of fuel to cut down on carbon emissions, and while there might be alternative fuel sources to hydrogen fuels, they all have their drawbacks as well. In conclusion, hydrogen fuel might only be in the experimental stages right now, but with the results it has already shown us, it seems to have a real opportunity to grow in our world and hopefully, with the continuation of its current trend, become the world’s first truly green fuel source.

Non-Newtonian Fluids in Next Generation Speed Bumps

Shaaktam aims to highlight the potential of non-Newtonian fluid-based speed bumps as an innovative solution to improve road safety and enhance traffic management.



We constantly require our roads to be safer, subsequently mitigate accidents and enhance traffic control. Humanity is already moving towards traffic police robots and various devices to work towards this goal but now we have achieved a new breakthrough in the line of innovations - the incorporation of non-Newtonian fluids into the design of speed bumps. These remarkable fluids, renowned for their adaptive flow properties in response to applied forces, offer an approach which is a paradigm shift from traditional speed bump design, that aims to revolutionise modern road safety to superlative standards.

What are non-Newtonian fluids? Essentially, such fluids defy the conventional viscosity behaviour observed in Newtonian fluids or conventional fluids, like water or oil. While their Newtonian counterparts maintain a constant viscosity, or thickness, irrespective of any form of external forces, non-Newtonian fluids exhibit variable viscosity under different conditions. Upon variations or changes in shear and stress rate, these fluids change their viscosity, which helps us use them to the optimum. If the shear rate increases, the viscosity of non-Newtonian fluids may either decrease or increase. Those whose viscosity decreases are called shear-thinning fluids and those whose viscosity increases are called shear-thickening fluids. These distinct properties make such fluids the ideal candidates for applications where controlled resistance to deformation is desired, such as in speed bump design.

Since time immemorial, traditional speed bumps have long been criticised for their abruptness, which are responsible for causing discomfort to drivers and passengers while exerting significant wear and tear on vehicles. The integration of non-Newtonian fluids into speed bump construction offers a compelling alternative. The fundamental principle behind non-Newtonian fluid-based speed bumps lies in their ability to dynamically adjust viscosity based on the speed and weight of approaching vehicles.

When we travel under normal driving conditions, like an average trip to a mall on a Sunday - you expect a crowd but you're still able to drive through fairly fast enough - the fluid maintains a low-viscosity state, enabling vehicles to traverse the speed bump smoothly with minimal discomfort. Upon a circumstance in which vehicles exceed the prescribed speed limit (if you're

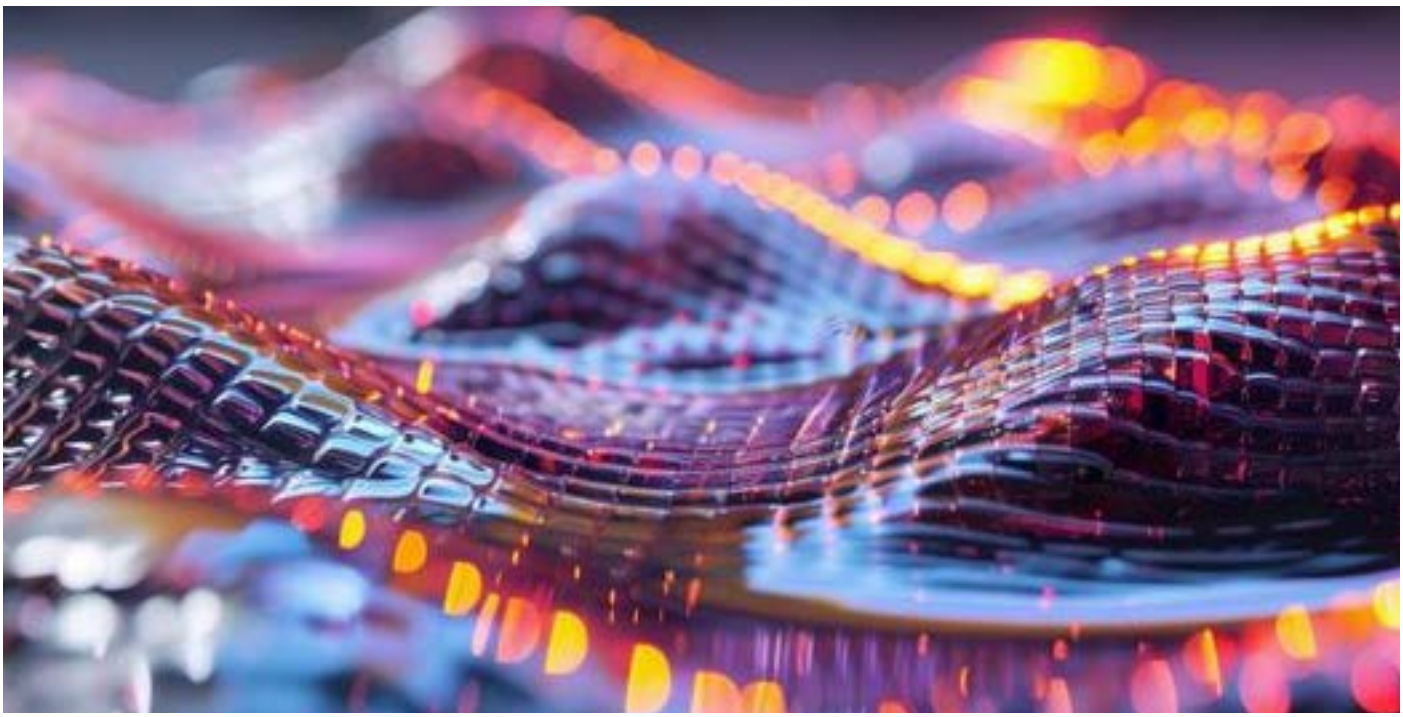
driving on a highway) or surpass a designated weight threshold (if you're aboard a 36-wheel loaded truck), the shear rate acting on the non-Newtonian fluid becomes intensified. In response to this change, the fluid undergoes a rapid transition to a state of higher viscosity. This makes the speed bump a formidable obstacle. The sudden increase in resistance makes the vehicle decelerate, promoting safer driving practices without subjecting occupants to any and every form of undue discomfort.

Non-Newtonian fluid-based speed bumps effectively reduce speeding incidents and enhance overall road safety by adjusting their resistance to vehicle motion. Unlike traditional speed bumps which subject vehicles to abrupt jolts and detrimental impacts, non-Newtonian fluid-based speed bumps offer a smoother and more gradual deceleration. This also helps in minimising any kind of wear and tear on vehicle components, be it an average scooter or Max Verstappen's RB19. The characteristics of non-Newtonian fluids can be tailored to suit specific road conditions and traffic requirements, thus offering flexibility in the design and placement of speed bumps. Non-Newtonian fluid-based speed bumps also have been proven to reduce fuel consumption and emissions, steering our efforts towards environmental sustainability.

With municipalities and transportation authorities seeking innovative solutions to improve road safety, non-Newtonian fluid-based speed bumps have gained traction in various parts of the world. Cities like Tokyo, Singapore, and London have implemented many a pilot program, so as to implement these into their road networks. The results are promising. These initiatives demonstrate the global potential of fluid technology in enhancing traffic management and reducing accidents on urban roads.

Integrating non-Newtonian fluids into speed bump design represents a significant leap forward in road safety engineering. Engineers have created speed bumps that adapt to changing traffic conditions, effectively slowing down vehicles and promoting safer driving practices. Non-Newtonian fluid-based speed bumps successfully offer a promising avenue for enhancing traffic management and improving overall road safety standards.

"Since time immemorial, traditional speed bumps have long been criticised for their abruptness, which are responsible for causing discomfort to drivers and passengers while exerting significant wear and tear on vehicles."



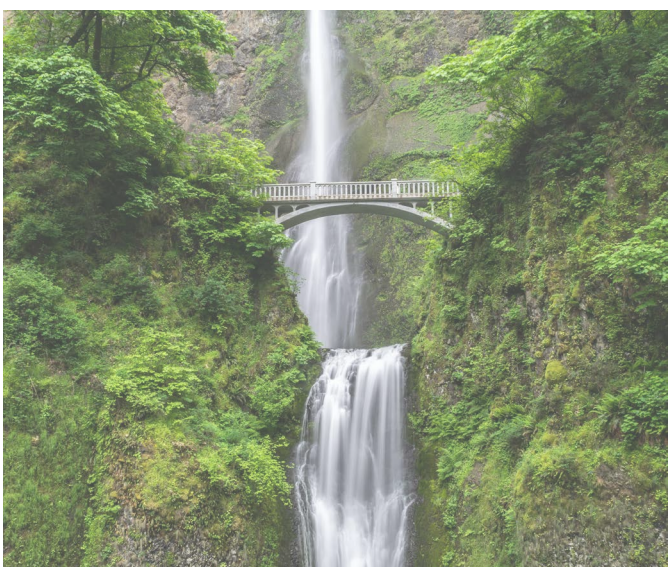
Biomimicry

Vir Sandhu explores biomimicry, by analysing past examples of incorporating nature's genius into human activities.

Have you ever thought of using nature's cleverness to tackle human challenges that seem hardly unsolvable? Believe me, you can do that: Today, we are about to examine an unexpected wonder – Biomimicry. It is the way of overcoming people's issues by following examples set by birds, animals or insects in our environment including even plants too. This approach involves drawing on natural systems for designing new things which are not only innovative but also environmentally friendly designs on things like revolutionising energy systems.

Leonardo Da Vinci, the renowned painter is known to be the founder of biomimicry since he showed great interest in various functional activities of nature, and the symmetry between birds and fish. Janine Benyus, a well-known biologist is considered to be a front-runner in this area having done extensive studies regarding it among other diverse uses of biomimicry. "Biomimicry: Innovation Inspired by Nature" published in 1997 was her book that talked more about biomimicry.

One of the most famous examples would be the 'Velcro'. During a walk, a Swiss engineer George de Mestral noticed that the burdock plant seeds adhered to his dog and his socks. He looked into it and discovered that the "bur" seed had tiny hooks on the tips that clung to soft fur or cloth. De Mestral was inspired and used this idea to create an applicable product called loops, tiny, powerful hooks that cling to softer fabric. Since the late 1950s, it has been utilised globally in an extensive range of applications under the name Velcro.



Next, we have the bullet train - When early Japanese high-speed trains came out of tunnels, the air pressure inside the tunnel increased and caused sonic booms and loud air bursts, which agitated the locals. The technical department's general manager, Eiji Nakatsu, loved to observe birds. He noticed how their beaks are shaped and observed that kingfishers hardly make a splash when they dive into the water to capture prey. Upon testing several different "bullet" designs, the one that most closely resembled the kingfisher's beak was considered to be the most effective. The train's continuously expanding diameter design increased its aerodynamics, which decreased air pressure during tunnel transit, and reduced noise pollution at the tunnel's exit. This allowed the train to travel 10% faster using 15% less electricity, reducing emissions and making the train more energy-efficient.

Another beautiful example that I would consider would be the Darkling Beetles, which are renowned for "drinking water from air". These beetles live in one of the driest habitats in the world, but some species of darkling beetle get the water they need from dew and ocean fog, using their very own body surfaces. The hardened forewings of the beetle have micro-sized bumps/grooves that assist in condensing and transporting water into the beetle's waiting mouth. These structures also have a combination of hydrophilic and hydrophobic regions that boost the efficiency of fog and dew accumulation and this method was fabricated in the Warka Tower in Ethiopia. The tower is constructed of a polyester mesh cloth supported by a bamboo frame. Like a darkling beetle gathering water from fog, atmospheric water vapour (from rain, fog, or dew) condenses on the cool surface of the mesh to produce droplets of liquid water that flow down into a storage tank located at the bottom of the structure. To stop the collected water from evaporating, a cloth canopy covers the bottom portions of the tower. It is simple and cost-effective to construct.

Architecture has also been influenced by bee hives for hundreds of years. Hexagonal constructions are not only visually appealing but also structurally sound. Hexagonal constructions offer high compression strength and a hexagonal honeycomb is the way to fit the most area with the least perimeter, according to Thomas Hales' famous book, "Honeycomb Conjecture". The Duo Towers in Singapore, designed by Büro Ole Scheeren, are a contemporary example. They have an eye-catching exterior made of a metal

honeycomb framework. The hexagons that round the tower symbolise the hub of activity within the structure and offer shelter from the sun, lowering interior temperatures without obstructing city views. It is a swarm of activity, with residences, offices, a hotel, and a retail gallery all located there. Closer home, in Surat, a sustainable family home called 'Hive Home' replicates a Purdue research based on the same.

By mimicking the systems and processes of nature, this discipline of science has led to research and innovations that include creating green structures, efficiently using water and electricity, promoting architectural wonders in the middle of deserts to cutting costs, pollution, carbon emissions, and minimising waste. Still in its nascent stage, Biomimicry has an enormous futuristic scope to give the world a sustainable and wonderful life.

"This approach involves drawing on natural systems for designing new things which are not only innovative but also environmentally friendly"

What is common between a Mario speedrunner's character glitching, a plane's flight control malfunctioning, and a candidate receiving extra votes in Belgium in 2003? A single, negligent ionising particle, sparked by cosmic rays from space, caused it all. Cosmic rays are highly energetic particles travelling through space near the speed of light. When cosmic rays enter the atmosphere, they collide with atoms and molecules, stripping away electrons and creating charged particles called ions. This ionisation process occurs at altitudes ranging from the ground level up to approximately 60 km. The resulting ions and free electrons are called ionising particles. They play a crucial role in the electrical properties of the atmosphere, influencing cloud and thundercloud formation as well as the global electric circuit.

Look at computers. Their fundamental operation manipulates binary data through transistors, represented as high and low signals, or 1's and 0's. Controlling electronic transitions that occur in the transistors of a computer makes them reliable. Suppose an ionising particle like an alpha particle strikes just the right spot. In that case, it can generate many free charge carriers, allowing electrons to fill the positive side of the transistors and flip a 0 to a 1. This is known as a single-event upset (SEU). Let's take Marie Moe, a heart patient who experienced an SEU, as an example. She was on a flight to Amsterdam with only 20 minutes left until landing when she started feeling a repeated muscle twitch in her chest. She felt something was amiss with her pacemaker and suspected a loose wire. Marie immediately informed the crew, and as soon as the plane landed, she was taken to a hospital, where a pacemaker technician quickly identified the problem. The issue was within the processor unit, which had become corrupted. This was linked to a single-event upset because an ionising particle caused a disturbance in the electronic system.

Another SEU occurred on May 18, 2003, when a computerised voting system was used in Brussels's municipality, Schaerbeek (Belgium). Each voter has to insert a magnetic card into the system and make their choices on the screen. Their vote was stored on both the computer and a magnetic card, which they kept in a box for backup. During the vote count, an election official spotted an error with the results from Schaerbeek. Maria Vindevogel, an unknown candidate from her party, received more

votes than is mathematically achievable. They retrieved the magnetic cards and conducted a recount. The vote totals for all candidates remained unchanged, except for Maria Vindevogel. In this case, the stated number of votes was 4,096 less than the original. The number 4096 is significant because it equals 2^12, which aligns with how bits are counted in powers of two. So, an energetic particle must have hit the 13th bit that stored Maria's vote count, flipping a 0 into a 1 and giving her 4,096 more votes. These events are still highly improbable, and you might never even witness one.

The mystery and discovery of cosmic rays came as a surprise to everyone. Theodore Wolf went to the top of the Eiffel Tower with his electrometer in 1910. Because radioactivity exists in the Earth's soil and rocks, he predicted that the radiation 300 meters above ground would be only a fraction of that at ground level. To his surprise, he found only a marginal decrease instead.

Austrian physicist Victor Hess chose to do experiments with ionising particles in 1911.

He installed electric scopes within the hydrogen balloon's basket. During his first two flights, he saw similar phenomena to Wolf's observations. Up to a height of 1.1 kilometres, both visits demonstrated no significant variation in radiation from ground-level levels. But the next year, he sailed seven balloons to a height of 5.2 kilometres. He made an incredible discovery. While radiation decreased for the first few hundred meters, it increased above one-kilometre altitude. At the peak altitude, the radiation level was significantly higher than on the ground, several times more intense. The radiation appeared to come from the sky rather than the Earth. Hess planned one of his balloon flights around a solar eclipse. And as the moon passed before the sun, he paid close attention to his instruments. But the readings remained unaffected. Even with half of the sun covered, the level of radiation remained constant. Hess scheduled one of his balloon trips around a solar eclipse. And as the moon crossed in front of the sun, he focused on his instruments. But the readings were unaltered. Even with half of the sun hidden, radiation levels remained steady. Since no eclipse effect on the penetrating radiation was observed, he concluded that even if some of the radiation is of cosmic origin, it is unlikely to emanate from the sun.

Victor Hess's groundbreaking discovery of cosmic rays, high-energy particles originating from space, has profound implications for advancing our understanding of cosmic phenomena. Both Marie's pacemaker issues and the vote recount in Belgium were attributed to the effects of cosmic rays, highlighting the far-reaching influence of these high-energy particles.

What is common between a Mario speedrunner's character glitching, a plane's flight control malfunctioning, and a candidate receiving extra votes in Belgium in 2003? A single, negligent ionising particle, sparked by cosmic rays from space, caused it all.

How **Cosmic Rays** Silently Shake Our World

Tanay Chowdhry

ARNAV TIWARI

QUANTUM COMPUTING

IS IT A YES?

Quantum mechanics has transformed the way we view powerful machines and so, scientists and engineers alike are on a quest to unravel this technology. Nowadays, at the forefront of computational science, quantum computing has offered various alternatives to existing classical options, guaranteeing exponential growth in the field. More recently, the advent of quantum computing has propelled our technological facilities, breaking the boundaries of theoretical speculation and forming more practical forms of absolute computing. Overall, we can say that quantum computing is seeing an augmented rate of progress, from rudimentary principles to recent breakthroughs. What is more compelling is the abilities that quantum computing offers, making it way more efficient than its predecessors, and reducing the number of algorithmic operations required to arrive at a desired result. This transformation of quantum computing from mere theoretics to more probable practical applications is as riveting as it is surreal, making these emergent traits all the more relevant in the fast-paced world today. We may solve complex problems as well as redefine our approach to mastering the world around us. Quantum computing stands as an entrancing avenue, ready to be explored and delved deep into unimaginable possibilities.

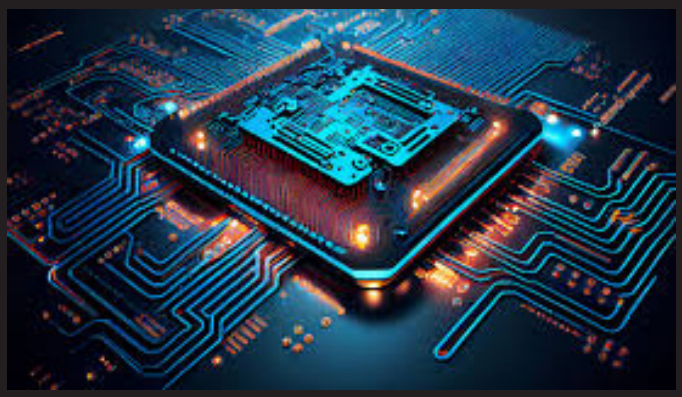
First, let's understand the principles behind such an intricate technology. At its core, lies the qubit, which exists in superposition states–referring to the ability of the quantum system to exist in several states at a time, until a measurement is made. Think of it as a bit that is continuously changing its values, existing as 1 and 0 at the same time, till the point where it is measured and a value is sought after. Isn't it fascinating? As a result, it is possible to store more than one value at the same time, in a quantum bit or qubit! In practice, rather than enhancing efficiency speed, a combination of qubits exponentially decreases the steps required to arrive at the desired solution of a computation. But how do you read or write information from such a derivation? To name a few, scientists have utilised the polarizations of a photon, the spin states of an electron, and the energy levels of an ion to harness the superposition states of qubits. Specifically, the spin of the electron, which may exist as spin up or down, can be used to attain a superposition state. Similarly, the polarization of an ion (left-handed and right-handed circular polarisation) extends to provide four states: 00, 01, 10, or 11. What's more interesting is the specific capability of quantum computing. Rather than increasing the speed of computation, quantum computing will be more relevant in solving complex problems. "Problems that classical computers or supercomputers can't solve or can't solve quickly enough," as per computer scientists from International Business Machines (IBM).

Another fundamental concept known as quantum entanglement allows quantum computers to simulate multiple qubits in a single operation rather than manipulating single units as seen in classical computers. In such entangled combinations, qubits become correlated in ways that classical bits cannot, facilitating complex computations. Computations that cannot be derived from standard measures, such as finding an odd perfect number, remain a several-century-long problem; algorithm. However, with Shor's algorithm, the problem can be approached through quantum computing. Mathematically, the formula: No. of positions of a qubit = 2N, where N is the number of qubits used, conveys the exponential capability of qubits. So, quantum gates can execute quantum algorithms with tremendous power.

> **"Problems that classical computers or supercomputers can't solve or can't solve quickly enough,"**

This can prove to be useful across scientific fields, from solving equations concerning black holes to decoding genetic expressions for tackling cancer. There are more and more possibilities.

Quantum hardware has certainly witnessed significant advancements, including superconducting circuits, trapped ions, and photonic qubits. Companies like IBM, Google, and Rigetti are racing to build larger, seemingly more stable quantum processors, all within the confines of research laboratories. To effectively build such systems and ensure qubit coherence and reliability, methods such as cryogenic cooling and error correction techniques are being used, bringing practical quantum computing closer to reality.



In 2019, Google's Sycamore processor came as a significant milestone in the field, with its supposition that Google had achieved quantum supremacy. Quantum supremacy refers to the idea of quantum systems achieving dominance over classical computers). The processor used just 53 qubits to solve specialised problems way more efficiently and faster than classical computers. What's more interesting is the fact that Sycamore successfully completed a specific task in few seconds which would take the Frontier (the world's fastest supercomputer) over 47 years to fulfill. This served as evidence of the hypothesis that specialised problems could be solved exponentially faster with such systems. Worldwide, renewed interest has been sparked, with several companies and individuals investing in the field of quantum computing to build such power systems. On the other hand, however, the path to creating these advanced technologies faces formidable challenges. Quantum computing systems are susceptible to noise and errors, getting affected by unwanted disturbances that influence computation, being detrimental to the system's performance. Another factor lies in the scaling up of quantum processors while maintaining qubit coherence, which till date remains a significant obstacle, not to mention the exorbitant cost of manufacturing such particles. Furthermore, designing these quantum algorithms is non-trivial, with the need for advanced approaches to build such systems.

The notion of quantum supremacy brings forth bewilderment in the scientific community, with the ultimate goal being to leverage quantum computing for practical applications. The field of quantum computing holds the potential to revolutionize existing fields such as cryptography yet also poses the threatening possibility of decrypting the most difficult of encryption algorithms, with looming danger over existing security methods. Pharmaceutical companies may illuminate drug discovery through quantum simulations. The buzzword of today's generation, 'AI', may be significantly enhanced with the advent of complex neural networks that may simulate human intelligence in a more precise manner. With all the challenges in the system, from scaling up systems to mitigating errors, the transformative potential of such a system is undeniable. Nevertheless, quantum computing appears to serve as a double-edged sword, leaving us with the choice to leverage the sharp blade for the better. So, I leave it for you to contemplate, dear reader; is it a yes?

NANOTECHNOLOGY

Ayaan Gupta

We've evolved so much, and yet, cancer is still one of the most devastating challenges in modern medicine, affecting millions of lives. Despite the significant advancements in cancer treatments, the complexity and diversity of cancer cells make modern conventional cancer therapies ineffective or result in severe side effects such as bone density loss, bleeding, heart damage, and memory problems. These problems have resulted in the use of nanotechnology in cancer. By harnessing the unique properties of nanomaterials, scientists can find many ways to revolutionise cancer therapy.

Nanotechnology involves the manipulation of matter at a very minute scale, equivalent to about 1 to 100 nanometers. At this scale, the materials exhibit different properties than their bigger counterparts because, at this scale, their physicochemical properties change. The changes in properties include the surface area, increased reactivity and different optical and magnetic properties, which make nanomaterials perfect for drug delivery, imaging and diagnosis of tumours in cancer treatments.

One of the most promising results of nanomaterials is that they can help in targeted drug delivery. If not achieved, results in the drugs given will be toxic for the patient due to the uneven concentration of substances, which can deteriorate the patient's organs. The uneven concentration can also lead the tumour to develop drug resistance. This is where nanocarriers such as liposomes, polymeric nanoparticles and dendrimers provide a solution by precisely deploying drugs in a sustained concentration in the tumour. This helps in reducing the concentration of the drug and making it safer for the patient consuming it.

These nanocarriers can be engineered to carry chemotherapeutic drugs and can be equipped with targeting ligands that can find the overexpressed receptors in cancer cells. This method helps in the increase of concentration of the drug near the cancer

site which will help in destroying cancer cells, while also decreasing the concentration of these toxic drugs in the other parts of the body.

Nanotechnology can also help in cancer diagnosis by monitoring it through advanced imaging. Nanoparticle-based contrast agents allow superior imaging capabilities than the traditional contrast agents which allow doctors to detect the tumour early and being able to characterise it in a better way. Strong signal intensity and the ability to be functionalised to target particular biomarkers make quantum dots, gold nanoparticles, and iron oxide nanoparticles useful for accurate imaging of tumour morphology, angiogenesis, and metastasis.

Nanoparticles combine diagnostic and theranostic functions within a single platform which allows for real-life monitoring of the treatment given to a patient. Theranostic nanoparticles enable personalised treatment strategies that are tailored to the specific needs of each patient by combining therapeutic interventions with imaging modalities like fluorescence imaging, computed tomography (CT), and magnetic resonance imaging (MRI).

Multidrug resistance (MDR) poses a significant challenge in cancer therapy, limiting the efficacy of chemotherapy agents. Cancer cells develop resistance mechanisms, such as overexpression of drug efflux pumps and alterations in drug targets, rendering them insensitive to multiple drugs. Nanotechnology offers innovative solutions to overcome MDR by circumventing cellular defence mechanisms and enhancing drug accumulation within resistant tumours.

Due to their small size and surface modifications, nanoparticles can enter tumour tissues deeply and evade drug efflux pumps. Additionally, resistance pathways can be circumvented and combinatorial effects can be produced against resistant cancer cells by co-delivering synergistic drug combinations within a single nanocarrier. Moreover, the progress of stimuli-responsive drug delivery systems is possible because of nanotechnology which allows therapeutic payloads to be released so that they can respond to some cues which are found in the region of the tumour, which increases the efficiency of the tumour and reduces the unneeded effects.

Although there are promising advancements, several challenges must be addressed to translate nanotechnology-based cancer therapies from a lab to a hospital bed. Safety concerns regarding the long-term biocompatibility and potential toxicity of nanomaterials remain important. Intensive preclinical studies and thorough toxicity assessments are essential to evaluate the safety of nanocarriers and ensure their clinical applications.

“Although there are promising advancements, several challenges must be addressed to translate nanotechnology-based cancer therapies from a lab to a hospital bed.”

Furthermore, scalability and reproducibility in manufacturing are essential for the broad use of medicines based on nanotechnology. Large-scale clinical trials and commercialization require formulation techniques to be optimised and production processes streamlined.

In the future, there is a huge possibility for progress in cancer treatment due to the merging of nanotechnology with other fields like gene therapy, immunotherapy, and artificial intelligence. We can accelerate the development of the next generation of nanomedicines which will eventually provide us with new hope to cancer patients globally, by fostering collaborations across industries and medical agencies. One of nanotechnology’s main advantages is its ability to precisely locate cancer cells while protecting healthy tissues, reducing side effects and improving patient results. Additionally, due to their multifunctionality, therapeutic and imaging agents can be delivered at the same time, allowing real-time monitoring of the progress of a disease and the efficiency of a treatment.

In conclusion, an enormous change in the battle against this terrible disease is represented by the application of nanotechnology in cancer therapy. Nanotechnology provides fascinating potential for more accurate and successful cancer treatment through targeted use of drugs, better imaging instruments, and creative nano-sized delivery equipment.

Unravelling the Mysteries of Sleep

by Devansh Mondal

Sleep is an essential aspect of human life. Beyond its important role in physical recovery and rejuvenation, sleep holds a vital connection to our consciousness and intellectual well-being. In this article, we will understand the complicated intersection of neuroscience, focus, and high-quality sleep, exploring the profound implications of this relationship with the mysteries of thoughts and the importance of relaxation for cognitive function and general well-being.

When we sleep, our brains are very busy, but the preparation begins earlier. Melatonin, also known as the 'sleep hormone', is produced by the pineal gland when no light passes through your retina. It helps regulate your sleep cycle. Melatonin levels typically rise in the evening, signalling that it is time to sleep, and decrease in the morning, causing increased wakefulness. There are stages of sleep, such as deep sleep and dream sleep. Each hemisphere has its own specific pattern of brain activity. Some chemicals in our brain, such as serotonin and dopamine, help us sleep and stay awake. During sleep, cortisol levels also decrease to facilitate relaxation and restorative processes, as it is also known as the stress hormone. There are specific parts of the brain, like the hypothalamus and brainstem, that ensure everything runs smoothly while we sleep. When we sleep deeply, our brain slows down, allowing us to relax. This is when our brain organises memories and eliminates unnecessary things. So, if you want to remember what you read for a long time, you need to get enough sleep. When we dream, our brain is very active, almost like when we are awake. This is called REM sleep. Our brains do this cool thing where our body is paralysed (kind of), so we don't act out our dreams. Overall, studying how our brains work during sleep helps us understand why we need sleep and how to sleep better.

The connections between neuroscience, attention, and excellent sleep hold profound implications for our well-being and cognitive characteristics. Adequate sleep, characterised by enough period, continuity, and depth, plays a vital role in strengthening memory, learning, and decision-making, promoting cognitive growth. As we further understand the realm of sleep, let's relax and tap into the endless capabilities of our minds.

When we sleep, different parts of our brain are constantly at work. For example, the thalamus helps process what we sense, and the prefrontal cortex helps us think. Connections between multiple different parts of the brain help balance our thoughts and our cognitive function. Understanding these brain parts helps us

understand what happens when we sleep.

Our consciousness continuously goes through thrilling changes as we move through the degrees of sleep. In REM sleep, the mind is as active as we are at some stage in the day. We dream of some things that might seem irrational to us but always have a specific reason behind them. Yet even during non-REM sleep, our body is still conscious.

Non-REM sleep is divided into three stages, which are N1, N2, and N3. Well, N1 (Phase 1) is the shortest stage of sleep, where you just drift off. Your muscles begin to relax, and your brain generates slow brain waves. N2 (Phase 2) is considered deep sleep, in which your brain begins to fire rapid brain waves called sleep spindles and produces large waves called K-complexes. Your body temperature drops, and your heart rate and breathing normalise. N3 (Phase 3), also known as deep sleep or slow sleep, is the deepest stage of non-REM sleep. Brain activity slows dramatically, and your body performs vital functions such as nerve repair, immune boosting, and memory strengthening.

REM (rapid eye movements) is basically when you sleep, but it is like being conscious. During REM sleep, your muscle tissues become briefly paralyzed (muscle atonia) to prevent you from acting out your goals. This is managed by the brainstem. REM sleep is thought to be important for emotional processing, reminiscence consolidation, and creativity because all that you dream is emotionally, mentally, or physically connected to your body or mind.

These ranges cycle throughout the night in roughly 90-minute intervals, with REM sleep turning into longer cycles as you sleep. This alternate processing between REM and non-REM sleep is vital for restorative sleep and standard health.

Determining how long to sleep varies with the aid of man or woman and relies upon age, lifestyle, and normal fitness. Most adults require 7-9 hours per night for top-quality functioning, while babies want 14–17 hours, and teens typically want 8–10 hours. Assessing non-public desires and understanding the way you sense through the day can help determine your ideal sleep period. Adjustments may be essential, primarily based on lifestyle adjustments or fitness situations, but it depends on you, and you need to display and know the way you have to sleep, as this becomes only a manual so that it will apprehend the entirety. You have to put it in force properly.

“The connections between neuroscience, attention, and excellent sleep hold profound implications for our well-being and cognitive characteristics. Adequate sleep, characterised by enough period, continuity, and depth, plays a vital role in strengthening memory, learning, and decision-making, promoting cognitive growth.”

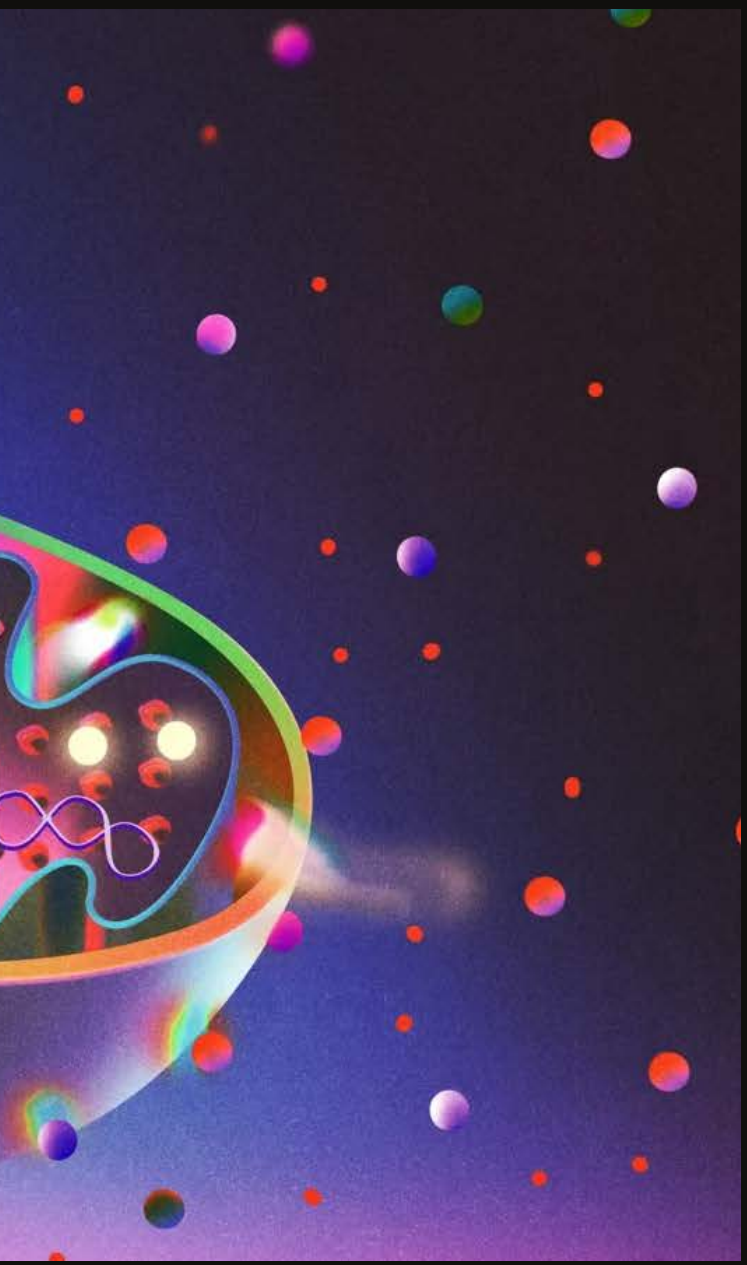
Grail Galleri's Test

Harshil Makin

"Our mission is to detect cancer early, when it can be cured. We are working to change the trajectory of cancer mortality and bring stakeholders together to adopt innovative, safe and effective technologies that can transform cancer care." -Grail

As written on their website, Grail is exactly what it claims to be, a novel and much awaited breakthrough in the field of cancer research, that helps in early detection of cancer cells using its new Galleri Tests. This groundbreaking technology promises to redefine cancer screening by offering a non-invasive, highly accurate, and comprehensive approach to detecting multiple types of cancer at an early stage. Having been incorporated in their plans by various medical institutions and insurance companies, many have put their faith in Grail, but how does it work, and what makes it unique?

The Galleri test is a blood test that has the potential of detecting multiple types of cancer. It does this by looking for DNA found in the blood, called cell-



free DNA (cfDNA), that's shed by both tumour cells and healthy cells into the bloodstream. Galleri uses artificial intelligence and advanced genetic sequencing technologies to search for patterns of chemical changes in the cfDNA that come from cancer cells but aren't seen in healthy cells, allowing it to only detect cfDNA that indicates the existence of cancer. After this, if a cancer-related signal is detected, further tests can be undertaken to further confirm the diagnosis and help the patient as soon as possible.

Grail can detect more than 50 types of cancer just from this simple blood test, including some of the most common types of cancer including breast, lung, prostate, colon and rectum cancer. Apart from that, other much rarer and unusual forms of cancer that doctors do not typically screen for are also tested for in this test, which includes ampullary cancer and certain types of soft-tissue sarcoma. Research revealed that the specificity of the Galleri test was 99.5%. This indicates that false-positive findings were extremely improbable because it was very accurate at identifying cases in which a person's sample did not include signals connected to cancer. The test's overall sensitivity was 51.5%, although it varied significantly depending on the type of malignancy. This indicates that slightly more than half of the individuals in their sample who had cancer-related signals were appropriately identified.

For the remainder of the population, the test failed to pick up on signs associated with cancer. This indicates that a false-negative result was obtained for these people. As the cancer stage advanced, so did the Galleri test's sensitivity. This indicates that in patients with more advanced carcinomas, it was more likely to detect signals associated with cancer. Lastly, in individuals who received a positive result and had cancer, the Galleri test correctly identified the origin site of the cancer in 88.7% of people.

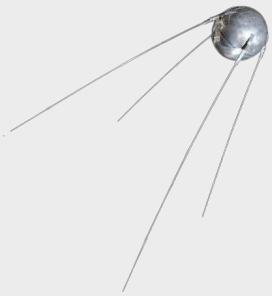
However, some of the biggest unknowns about this test are whether it would be able to improve people's lives and whether it would affect the impact cancer has on them by being involved in the screening process. Multiple clinical trials are underway to find out whether it can save lives or not. The largest one was held by the NHS in the United Kingdom with the help of King's College London. A little over 140,000 adults who never had cancer in the past three years volunteered to be part of the study. Throughout the course of this study, over a two-year period, each trial participant will undergo three blood tests and Galleri will be used to analyse the samples of half of these participants. The efficacy of MCED (Multi Cancer Early Detection) tests, like Galleri, in reducing cancer-related fatalities is being investigated by the National Cancer Institute (NCI). It plans to begin recruiting 24,000 healthy individuals for a pilot study in 2024. A more extensive study including up to 225,000 participants will be established if MCED tests prove to be helpful.

Being FDA and ACS approved, Grail should be able to further improve on the probability of cancer being detected in its early stages and helping people improve their chances of living. People trust it and that can be seen in its increased popularity in the recent years with the help of Grail helping take it to the people with the help of its company. This accessibility of the Galleri test now, might just help save people's lives and is what was needed, a simple yet effective test that people can use to get security. While it may not be perfect right now, research in Galleri is going on and in the next few years, we might just perfect it and help save people further.

DEVELOPMENTS IN THE SPACE INDUSTRY

1957

On October 4th, 1957, The Soviet Union launched the first spacecraft. Known as Sputnik 1, this mission marked the beginning of the space age.



1961

On April 12, 1961, Soviet cosmonaut Yuri Gagarin orbited the Earth aboard the Vostok 1 spacecraft, becoming the first human in space. His 108-minute flight was a major milestone in the Cold War space race between the Soviet Union and United States. Gagarin's cramped Vostok capsule was launched atop a modified Soviet R-7 intercontinental ballistic missile. His successful mission paved the way for future space exploration.

196

"THE DREAM IS ALIVE"

- John Young

“Houston, we have a problem”

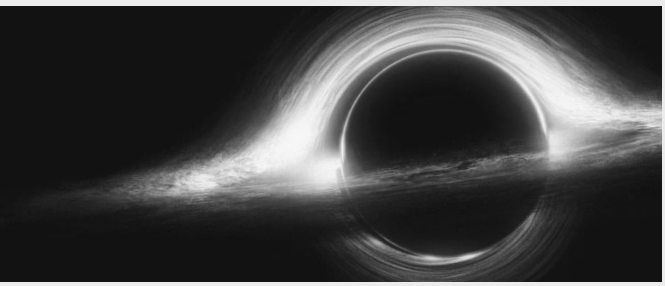
- Apollo 13

1965

On March 18, 1965, Soviet cosmonaut Alexei Leonov became the first person to walk in space when he exited the Voskhod 2 spacecraft for a 12-minute spacewalk. But his space suit inflated in vacuum, making it difficult to re-enter the airlock. After having to depressurize the suit, he was able to barely squeeze back inside. Leonov’s pioneering spacewalk provided valuable experience for future extravehicular activities.

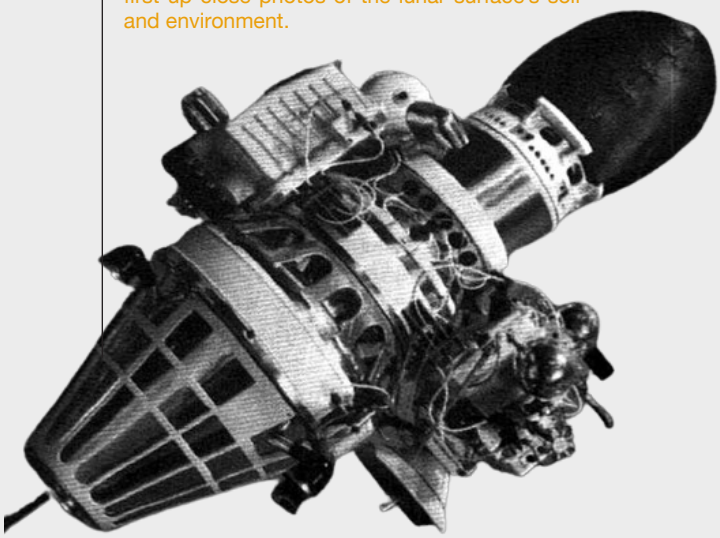
62

NASA’s Mariner 2 spacecraft conducted the first successful planetary encounter on December 14, 1962 when it flew by Venus, scanning the cloud-shrouded planet with infrared and microwave radiometers. Its readings helped characterize Venus’s hot, harsh climate and mapped areas of its surface through the thick atmosphere for the first time. Mariner 2 was the first of many NASA missions exploring the inner solar system.



1966

The Soviet Union scored another first on February 3, 1966 when the robotic Luna 9 spacecraft made a successful soft landing on the Moon - the first manmade craft to achieve a controlled landing on another celestial body. Though its communications only lasted a few days, Luna 9 took the first up-close photos of the lunar surface's soil and environment.

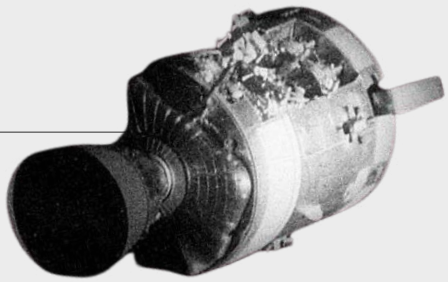


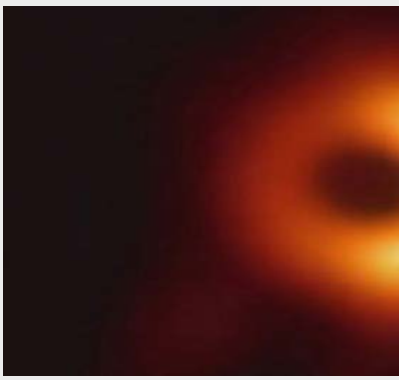
1976

NASA's Viking 1 and Viking 2 missions extensively studied the M surface and environment after to down in 1976. Conducting soil experi the Viking landers were the first ded search for potential biosignatur organic compounds on Mars. Thou results were inconclusive about lif Viking missions provided the first resolution color images and charact the Red Planet's atmosphere, weathe geology in detail.

1969

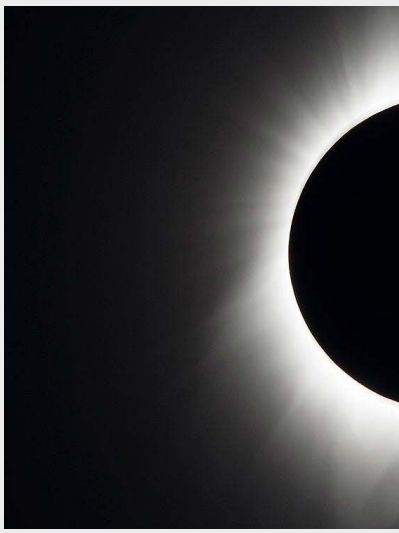
On July 20, 1969, NASA's Apollo 11 mission achieved the historic first crewed landing on the Moon in the Sea of Tranquility. Astronauts Neil Armstrong and Buzz Aldrin spent 21 hours on the lunar surface, conducting experiments and taking photographs, while Michael Collins orbited above in the command module. Armstrong's first step onto the lunar soil was watched by over 500 million viewers on television. Their return marked an unprecedented technological accomplishment for the United States.





"That's one small step for man, one giant leap for mankind."

- Neil Armstrong



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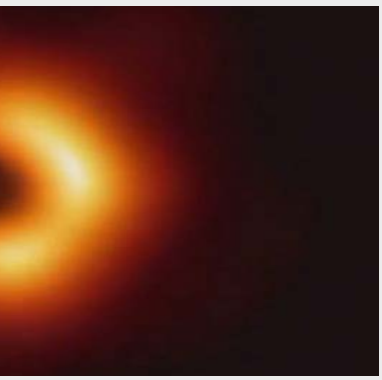
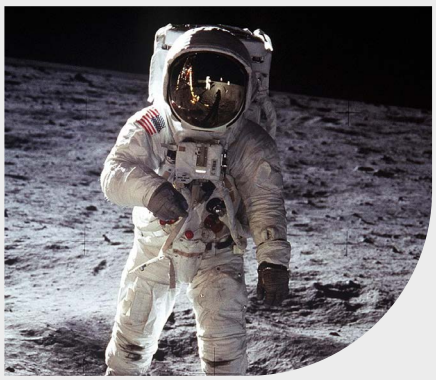
1986

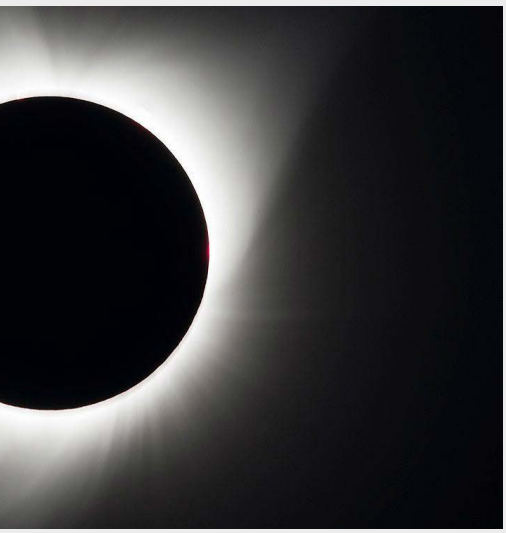
The Challenger space shuttle disaster occurred on January 28, 1986 when the shuttle broke apart just 73 seconds after launch due to the failure of an O-ring seal in one of its solid rocket boosters. The tragedy that killed all seven crew members aboard was a major setback for NASA as scrutiny intensified over the risks of human spaceflight. An investigation uncovered critical management and communication failures that enabled the launch despite concerns about cold temperatures.

1981

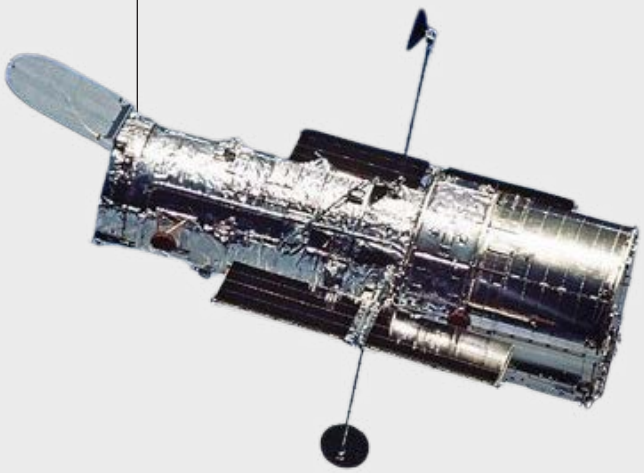
On April 12, 1981, NASA's Space Shuttle Columbia inaugurated the era of reusable spacecraft with its maiden launch from Florida. Columbia circled the Earth 36 times on this first test flight, paving the way for the Space Shuttle program's three decades of service in low Earth orbit. The world's first operational winged, reusable spacecraft was a major technological achievement.







1990 NASA's Hubble Space Telescope was launched aboard the Space Shuttle Discovery on April 24, 1990. Once deployed into orbit around the Earth, Hubble's unprecedented optical capabilities allowed it to observe some of the most distant galaxies in the universe and gather transformative astronomical data across the electromagnetic spectrum thanks to its position above Earth's atmosphere. Despite an initially flawed main mirror requiring in-space repairs, Hubble revolutionized observational astronomy.



1993 **December:** STS-61, the first servicing mission of the Hubble Space telescope takes flight.

1994 **February:** Sergei Krikalev becomes the first cosmonaut to fly on both the Space Shuttle and the Mir space station.
July: Comet Shoemaker-Levy 9 collides with Jupiter

1995 **December:** The Galileo spacecraft enters Jovian Orbit.
The ETS-VI mission establishes the first laser communication from space.

1996 **February:** NASA launches the NEAR Shoemaker spacecraft, the first ever mission dedicated to studying an asteroid.

1997 **July:** The Mars Pathfinder touches down on Mars, deploying the Sojourner rover - the first mobile rover to explore another planet.

1998 **February:** NEAR Shoemaker enters the orbit of the asteroid 433 Eros, becoming the first spacecraft to successfully orbit an asteroid.
November: The first component of the International Space Station is launched.

1999 **November:** Launch of the Cassini-Huygens spacecraft, a joint mission by NASA and ESA to explore Saturn and its moon, Titan.

2000 **May:** Launch of the New Millennium Program Deep Space 1 spacecraft, which becomes the first mission to include ion propulsion technology for deep space travel.
The International Space Station (ISS) welcomes its first crew, marking the beginning of continuous human presence in space.

2001 NASA's Mars Odyssey spacecraft reaches the Red Planet and begins mapping its surface and studying its climate.

2003 China becomes the third country to send humans into space with the launch of the Shenzhou 5 spacecraft, carrying astronaut Yang Liwei.

2004 NASA's Spirit and Opportunity rovers land on Mars, providing valuable insights into the planet's geology and potential for past life.

2005 The European Space Agency's Huygens probe successfully lands on Saturn's moon, Titan, providing the first-ever images of its surface.

2006 NASA's New Horizons spacecraft is launched towards Pluto, embarking on a mission to gather information about this distant world.

2007 China launches its first lunar probe, Chang'e 1, kicking off a series of successful lunar missions in the coming years.

2008 NASA's Phoenix Mars Lander successfully touches down on Mars, uncovering evidence of water ice near the planet's north pole.

2009 The Lunar Reconnaissance Orbiter (LRO) is launched by NASA, mapping the lunar surface in unprecedented detail and paving the way for future manned missions.

2010 SpaceX's Falcon 9 rocket becomes the first privately-developed spacecraft to reach orbit, marking a significant milestone in commercial spaceflight.
Space X launched the Falcon 9 rocket to resupply cargo in the International Space Station (ISS). Minotaur IV carried hypersonic test vehicles to the ISS.

2011 China launched its first space station module Tiangong-1. New satellite spacecrafts such as Zenit-3F made their maiden flights.

2012 The Dragon spacecraft was launched and carried passengers to the ISS for the very first time. NASA's Curiosity Rover landed on Mars to study the planet's geology and past habitability. Voyager 1 made history by becoming the first human-made object in interstellar space.

2013 India launched it's Mars Orbiter Mission. Companies like Space X, Blue Origin and Virgin Galactic made significant strides in commercial spacecraft and reduced costs of space missions.

2014 India began the first nation to reach and orbit Mars on its first attempt. The European Space Agency (ESA)'s Rosetta spacecraft became the first object to successfully land on a comet.

2015 China's launch vehicles Long March 6 and 11 made their first spaceflight. India launched AstroSat, its first multi-wavelength telescope.

2016 ESA and Roscosmos launched the ExoMars Trace Gas Orbiter to study the Martian atmosphere and search for signs of life.

2017 The first suborbital test for Rocket Lab's Electron Rocket took place. India launched its orbiter LVM3.
The Cassini space probe was deliberately destroyed by plunging into Saturn's atmosphere, on 15 September 2017.

2018 The NASA InSight seismology probe was launched in May 2018 and landed on Mars in November

2019 The Chinese probe Chang'e 4 made humanity's first soft landing on the far side of the Moon on 3 January and released its Yutu 2 rover to explore the lunar surface on the far side for the first time in human history.

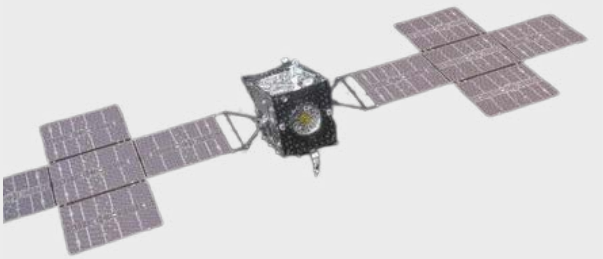
2020 In 2020, NASA made significant progress on America's Moon to Mars exploration strategy, met mission objectives for the Artemis program, achieved significant scientific advancements to benefit humanity, and returned human spaceflight capabilities to the United States.

2021 NASA's Lucy mission launched in 2021 to explore asteroids that share Jupiter's orbit

2022 NASA's CAPSTONE lunar orbiter launched on June 28 and arrived in lunar orbit on 14 November 2022. Artemis 1, the first flight of NASA's Space Launch System (SLS) and the first lunar mission for Orion, was launched on November 16, 2022.

2023 NASA launched the Psyche spacecraft on 13 October 2023, an orbiter mission that will explore the origin of planetary cores by studying the metallic asteroid 16 Psyche, on a Falcon Heavy launch vehicle. On November 1, NASA's Lucy probe performed a flyby of asteroid 152830 Dinkinesh, revealing it to be a binary pair. The heaviest payload to date was launched with the launch of the falcon heavy.

2024 ASA's Advanced Composite Solar Sail System, or ACS3, is scheduled to launch into Earth orbit during the first half of 2024 aboard a Rocket Lab Electron launch vehicle. ACS3 will test out materials that could enable the development of much larger solar sails.



STARSHIP

Mankind's Ticket to the Cosmos

Taarak Harjai aims to capture the importance of Starship in humanity's road ahead.

A giant hunk of steel penetrates the atmosphere, a blazing meteor in the Texas night. Centuries ago, our ancestors would not have dared to imagine that a 191m long hull of stainless steel would be so detrimental to the future of their species. Times have changed, and so has humanity's understanding of themselves, and their planet. Elon Musk's goals to make humanity a lasting and multi planetary species led him to his pursuits of manufacturing a rapidly reusable launch system.

Now, why is Elon doing all of this in the first place? What's the point of spending so much on such a large rocket when there are already so many problems on Earth? These are questions I cannot do justice to even through a full article, but in a nutshell, what Elon believes is that humanity as a species is too fragile. NASA believes that a deadly asteroid strike takes place every 600,000 years, just like the strike which killed the dinosaurs. Pandemics and similar threats have caused 99% of the species that have ever existed on Earth to go extinct. Newly developed dangers such as nuclear wars have also emerged, and the odds of humanity ending up like Earth's previous inhabitants have skyrocketed. The only way to prevent these problems is to expand to different planets, and make humanity a multiplanetary species, and much less prone to extinction.

SpaceX launched their first rocket in 2006, but it took them 10 more years to land and make their rockets reusable, which they achieved through the Falcon 9 . Elon Musk recognized the inherent need for reusable rockets as it would heavily reduce costs; a factor which led to the abolishment of the previous major US launch vehicle - the space shuttle. However, the Falcon 9 was not strong enough to deliver large payloads to Mars; hence, Elon decided to look towards developing a stronger launch vehicle.

Starship is a two stage rocket; the first stage is called the booster or Super Heavy, and lands back on Earth after separating, whilst the second stage called Starship or ship contains the payload, and journeys all the way to the destination. Both the stages use Raptor engines, using liquid methane and oxygen as their fuels. Raptor engines are known to have one of the highest specific impulses compared to other engines, improving Starship's performance. Initial prototypes were made out of carbon fibres, a very expensive choice compared to the stainless steel which is currently used. The low mass and strong engines come together and create humanity's strongest rocket boasting a huge thrust of 22,000 Kilonewtons.

After much development, Starship was finally ready for launch in April of 2023. It rose from Starbase Facility, Texas, as its roars rattled nearby windows and the immense force shattered parts of its own launch pad. However, four minutes into the flight, stage separation failed, which led to the mission being abandoned, and the first prototype exploding into pieces. SpaceX was immediately struck by over 60 FAA warnings regarding their vehicle. This time, they used a hot staging technique, where the second stage

fires its engines to separate from the first stage. A water spewing system was also installed in the launch pad, to prevent heavy damage like in the first launch. This time, the ship was able to successfully separate, however the lower stage exploded during its boostback burn, whilst signals were lost with the second stage. SpaceX was also struck with only 17 warnings, compared to the previous 62, which shows their hard work and progress, towards one major goal

The ship took flight once on the 14th of March 2023 (Pi Day), where the first stage crash landed onto the launch pad after failing to adequately slow down, whilst the second stage was able to successfully reach orbit and attempt reentry, when it stopped sending signals. With every attempt, SpaceX is gathering more data, and progressing further towards their goal of a rapidly reusable rocket.

Remember, this is unlike anything any human has ever attempted before. Launching 11 million pounds, and landing some of it back isn't a piece of cake, hence SpaceX's rate of progress is truly commendable, and Starship is destined to be successful. Conducting such a large scale mission, hurdles are to be expected, but overcoming them is to be expected as well. Whilst not many people realise it, we are witnessing history. Starship is the best option mankind will have to take heavy payloads up till 1000 tonnes to Mars, to stay. We are witnessing the creation of the strongest rocket ever, the rocket which will take the first humans to Mars and beyond in our lifetime, the rocket which will make humans the first interplanetary species to ever live on Earth... or as far as we know.

"We are witnessing the creation of the strongest rocket ever, the rocket which will take the first humans to Mars and beyond in our lifetime..."

Consciousness

The driving factor behind us all

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