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Sense N' Science

To Infinity And Beyond

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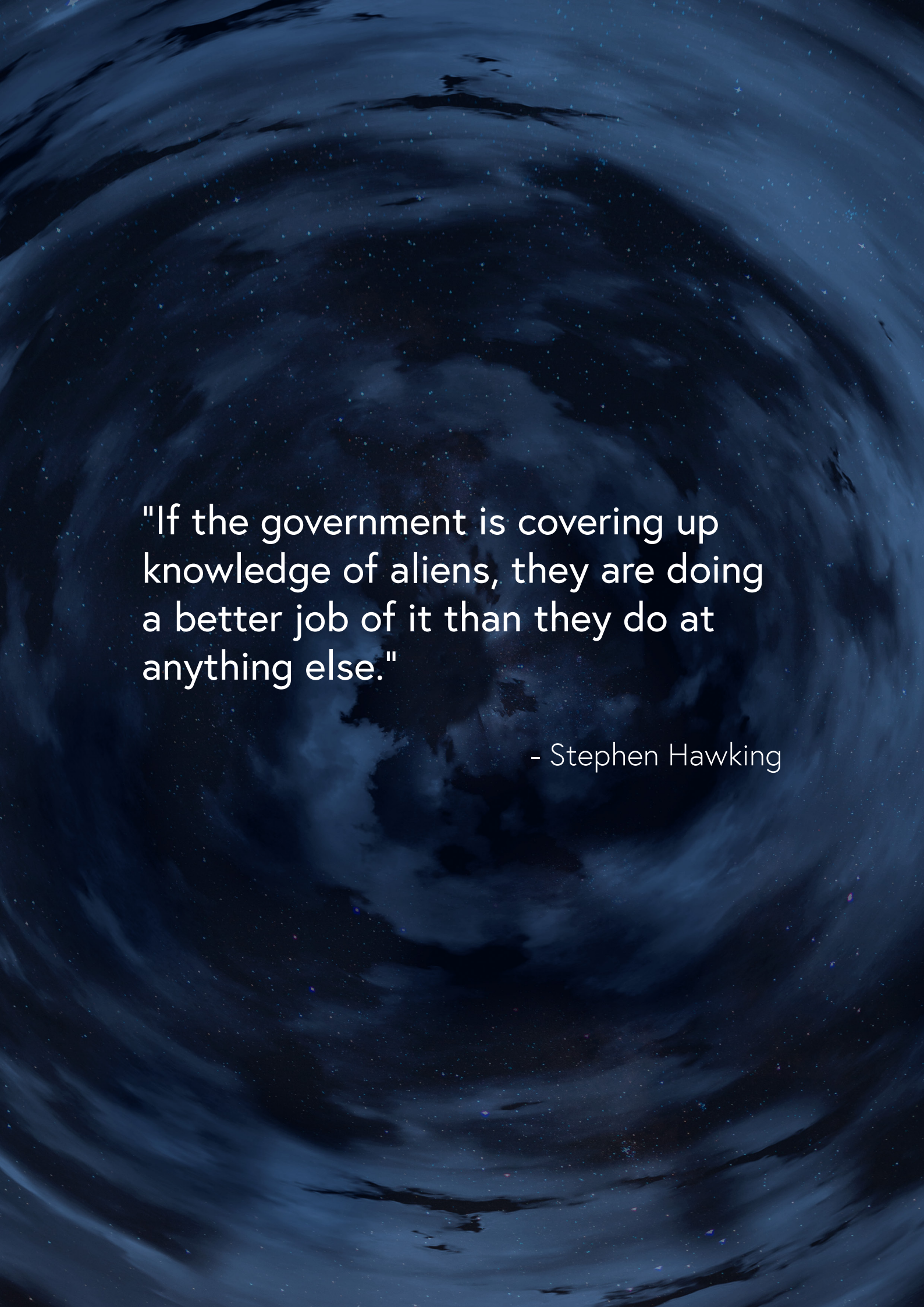
The Fermi Paradox & Searching For Extraterrestrial Life

By Trisha Saini
Page 5


"If the government is covering up knowledge of aliens, they are doing a better job of it than they do at anything else."
- Stephen Hawking

Editor's Note

Forget the stars,
today I'm gonna look at the space
between them and stare deep at all
the things which my eyes simply
cannot perceive

- Rebekka Kaur

The vastness of space is a concept that has fascinated humanity for millennia. Millions of people look to the stars and wander what it is like in the great beyond. We wander what mysteries lie beyond our solar system. From the first man on the moon to the first picture of a black hole, we have made tremendous advancements in our understanding of space but still, so much is left to discover. We are proud to present the 6th Edition of Sense N' Science and show you the wonders of the universe.

Another year spent in our homes led us to looking outwards for inspiration. The limited confinements of our room are the opposite of what we imagine when we look up at the universe. We use science to explain the world around us. Now, we will look into how we use science to explain the mysteries of the space above us. We thank all the teachers and students who helped us with the newest issue of Sense N' Science. In this issue of our magazine, we will delve deeper into topics that explore the area beyond our home planet and much more.

Teacher In Charge
Meenu Gupta

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Fermi Paradox

Trisha Saini
IBDP-2B

The Fermi paradox is the contradiction between the lack of proof for the existence of extraterrestrial life and the high probability of their existence. It begs the question - where are all the aliens? The Fermi paradox is based on the fact that there are billions of stars in the Milky Way similar to the Sun and a very high probability that these stars have Earth-like planets: that is a planet where conditions are such that life can exist. Our sun and thus the Earth are relatively young in the life of the universe. This means there must be far older stars and hence planets on which intelligent life developed long ago leading to more advanced civilizations than ours. Some of these should have developed interstellar travel and since many of the stars are billions of years older than the Earth, we should have been visited by extraterrestrial life or their probes by now. Yet, we have no convincing evidence that this has occurred. So where is everybody?

This paradox has been discussed by scientists for many years with many arguments and possible explanations exploring it coming up. These can be divided into arguments that fall under believing there are no higher civilizations in existence or that there are but there are logical reasons we have not heard from them. The people who believe in the former point out that if there are thousands of higher civilizations, any argument put forth to explain why they haven't visited us should have an exception. If there is a theory that applies to 99.9% of extraterrestrial civilizations, there should be the .01% that behaves differently and proves the existence of aliens to us. Thus these people believe that there are no more advanced civilizations but as the math suggests that there is a probability of the existence of thousands of civilizations, something must be stopping them.

This something is believed to be the Great Filter. This theory believes that there is a stage or event that all life hits in the evolutionary process that is impossible to go beyond. This leads to the next questions - When does the Great Filter occur? Some believe that we are rare, that the great filter is behind us and in a fluke biological event, we somehow surpassed it. Some believe that we are one of the first intelligent life in the universe and that conditions were just perfect recently which allowed us to develop. This could mean that we are on our way to superintelligence. Others believe that the great filter is ahead of us and this is not particularly good news as it would mean our extinction.

Another group of people believe that intelligent civilizations are out there but there is a reason we have not heard from them yet. It could be that they visited Earth before we were here or we were just not able to understand/notice. Our technology could be too primitive to establish contact or the government is not informing people about it. Higher civilizations could be observing us or visiting us physically might be too backwards for advanced beings. It could be that there are predators that wait for other civilizations like ours to reach a particular moment before exterminating us or are smart enough to not let us know of their existence.

https://en.wikipedia.org/wiki/Fermi_paradox, https://waitbutwhy.com/2014/05/fermi-paradox.html

How Do Bones Age In Space?

Khushi Patel
IBDP-2A

Life within the microgravity environment of space brings numerous changes to the human body. The misfortune of bone and muscle mass, alter in cardiac execution, variety in behaviour, and body-wide changes started by a changing apprehensive system are a few of the negative impacts of microgravity.

Changes to bone are especially discernible since they influence an astronaut's capacity to move and walk upon return to Earth's gravity.

A few of the forms and functions of bones alter after the space explorer has lived in microgravity for a few days. In space, the sum of weight that bones must back is diminished to nearly zero. At the same time, numerous bones that help in development are now not subjected to the same stresses that they are subjected to on earth. Over time, calcium ordinarily put away within the bones is broken down and discharged into the circulation system. The high level of calcium found in astronaut's blood amid spaceflight reflects the decrease in bone thickness, or bone mass. This drop in thickness, known as neglect osteoporosis, clears out bone powerlessness and is less able to bolster the body's weight and development upon return to the earth , putting the space traveler at a better chance of fracture.

Bone loss occurs in a span of the first few days present in space. The most serious misfortune happens between the second and fifth months in space, in spite of the fact that the method proceeds all through the complete time spent in microgravity. Expanded remains on Mir have come about in losses of bone mass of as much as 20%. Space explorers recapture most of their bone mass within the months after their return from space, but not all of it.

Fair as space explorers eat a cautious diet and get plenty of uncommon exercise in space to anticipate neglect osteoporosis, steps can be taken to anticipate osteoporosis on Soil. A balanced diet wealthy in calcium and vitamin D, work out, a way of life free of smoking and liquor, bone thickness testing, and pharmaceutical all avoid or ease osteoporosis.

https://www.nasa.gov/audience/foreducators/postsecondary/features/F_Bones_in_Space.html

Where Is The Missing Matter?

Arohi Nawab
IBDP-1

Going into space, we are greeted by matter in the form of stars, galaxies and nebulae. The universe consists of three types of substance- 'dark matter', 'dark energy', and normal 'baryonic' matter. This matter includes the protons and neutrons that make up all our elements and are present in almost everything around us. Baryonic matter takes up 5% of the universe- or at least, it should.

According to scientists, half the baryonic matter in the universe was missing. They predicted that dark matter would take up 85% of the total matter in the universe according to the basic ratio of hydrogen to deuterium (an element formed soon after the Big Bang). There are 26 deuterium nuclei to every million hydrogen nuclei. This ratio was used to find the ratio of photons (the basic unit of all light) to baryons, and thus predict the approximate mass of baryons in the universe. In 1997 a census of all the planets, stars and gases around conducted by a group of scientists found only half the predicted mass of baryonic matter. This left scientists around the world confused as to where this extra matter was hiding, or whether it ever existed at all.

Early in 2020, a group of scientists took a new census of ordinary matter in the universe by examining how bright flashes of radio waves from other galaxies, called fast radio bursts, are distorted by particles on their way to Earth. This analysis showed that about half of the universe's ordinary matter, which has eluded detection for decades, is lurking in intergalactic space. The missing baryons exist as hot strands between galaxy pairs. Twenty years of speculation and confusion have finally been put to rest with this confusion, but there remain many mysteries in the world of astrophysics.

https://news.ucsc.edu/2020/05/missing-matter.html

RIDDLES

1. What is the life sustaining zone around a star called?

2. Who was the first man in space (Hint: Not Neil Armstrong)

3. What is the large violent storm on Jupiter called?

4. What was the name of India's Mars mission?

5. What is the similarity between Europa, Io and Ganymede?

6. Which belt lies between Mars and Jupiter?

1. Goldilock's Zone, 2. Yuri Gagarin, 3. Great Red Spot,
4. Mangalyaan, 5. Jupiter's Moons, Asteroid Belt

Wormholes

Aryan Singh
IBDP-2B

Almost everyone on this planet is familiar with what black holes are, especially since we were able to capture the first photograph of one. However, very few people are aware of the existence of wormholes and their exact function despite being arguably much more interesting than black holes.

So, what are wormholes exactly? In short, it is a path through which we can travel from point A in space to point B, regardless of the distance in very short times. In more complicated terms, it is a method of folding the space-time continuum on top of each other in order to connect 2 arbitrary points in space together. This would help shorten the distance between them and allow you to pass easily and quickly between them. In practical terms, think of folding a paper in half and stabbing a hole through it with a pencil. That is in essence, what a wormhole is. For this, we can thank Einstein and his theory of how gravity isn't simply a force that attracts matter but an actual warping of spacetime. If we fold the continuum enough, we can have 2 points with the same physical location! However, wormholes aren't just used for travelling from one place to another. Theoretically, they can also be used for time travel! Since we are travelling through space-time, we can travel backwards through time if we travel fast enough at the speed of light due to the effects of time-dilation. This is the fantasy of every science-fiction lover.

In theory, these wormholes can solve the issue of interstellar travel which has plagued humanity for centuries and can allow us to time-travel to the back. However, the biggest question arises: are they real? Sadly, according to all laws of physics, it is almost impossible to create such wormholes. One of the major problems with it is that they are unstable and cannot be travelled through. Think about it. Wormholes are essentially 2 black holes connected to each other and each black hole is surrounded by an event horizon. When an object travels past the event horizon, it becomes impossible for it to escape. If by some miracle, you are able to get into the wormhole, the presence of your mass will cause it to distort and snap together. You will not survive it. One possible workaround is by using a material with negative mass. But by the laws of physics, it is impossible for there to be an object with negative mass since it would violate nearly all the laws of physics. All we can do is wait for a new theory to come across or to get some sort of confirmation about the existence of these phenomena.

However, not all hope is lost. There are still a plethora of things we do not know about the universe. Perhaps, the universe has already created wormholes and we just haven't discovered it. If there are wormholes out there, we can finally solve the problem of intergalactic travel and fulfill the dreams of every science fiction lover.

https://phys.org/news/2015-12-wormholes.html, https://www.scientificamerican.com/article/follow-up-what-exactly-is/

What Could Aliens Be Made Up Of?

Garvit Agarwal
A Level

All the forms of life we see around us, plants, animals and even we, humans are considered as carbon based life forms. This is because chains of carbon atoms provide the chemical structure over which our body is built. In fact, 12% of the atoms in our body are carbon atoms. However, is carbon the only element which can serve as the backbone of life? Sadly, we do not have a definitive answer since earth is the only known planet to support life and we have only found carbon based organisms.

Nevertheless, we can speculate what other elements could possibly serve as the framework of intelligent life. A well discussed theory is that silicon could be an alternative. Silicon sits just below carbon in the periodic table and has similar chemical properties. Deoxyribonucleic acid or DNA which encodes the instructions for life also has a carbon chain. Silicon too has the ability to form long chains thereby allowing us to theorize a silicon based structure which can encode biological information and instructions.

Even in the unfathomable reaches of outer space, 92 different molecules have been identified. Out of these 84 are carbon based while 8 are silicon based. This does provide some evidence that silicon based molecules are out there and could potentially be the cause of extraterrestrial life. Unfortunately, there are a few caveats. Out of the 8 silicon centric molecules, 4 of them still have carbon.

Moreover, silicon may be able to form long chains, but it does not have the versatility of carbon atoms. Silicon cannot form bonds with as many types of atoms as carbon can and are unable to form double bonds. On the other hand carbon double bonds are an essential part to many life giving molecules. Silanes, which are compounds of silicon and hydrogen which could be compared to organic hydrocarbons are highly reactive with water and can undergo spontaneous decomposition, making it unfit to be part of any biological system.

Another element which does appear to share similar characteristics is sulphur which can also form long chain molecules but shares the same issues as silanes. Boranes are also considered as a probable candidate and can be stable in a reducing atmosphere (an atmosphere with abundance of reducing gases such as hydrogen or carbon monoxide). But the relative rarity of boron atoms and compounds lowers its probability of being a life base.

Therefore, it would be scientifically flawed to ascertain with confidence what other forms of life may be made up of, but in the vastness of the universe we live in, we may discover aliens who have a very different composition.

https://www.wikiwand.com/en/Hypothetical_types_of_biochemistry, https://www.wikiwand.com/en/Carbon-based_life

There is no atmosphere in space, which means that sound has no medium or way to travel to be heard.

Just as colors are made more dramatic in sunsets on Earth, sunsets on Mars, according to NASA, would appear bluish to human observers watching from the red planet. Fine dust makes the blue near the Sun's part of the sky much more visibilke, while normal daylight makes the Red Planet's familiar rusty dust color the most perceptible to the human eye.

Scientists estimate there are about 500,000 pieces of space junk today, including fragments from rockets and satellites, and everyday items like spanners dropped during construction of the International Space Station!

There's a planet made of diamonds twice the size of earth The "super earth," aka 55 Cancri e, is most likely covered in graphite and diamond. Paying a visit to that planet would probably pay for the $12 million dollar space suit needed to get there

The Sun accounts for 99.86% of the mass in our solar system with a mass of around 330,000 times that of Earth. Did you know that the Sun is made up of mostly hydrogen (three quarters worth) with the rest of its mass attributed to helium.

The Apollo astronauts' footprints on the moon will probably stay there for at least 100 million years

SPACE FACTS

https://www.natgeokids.com/uk/discover/science/space/ten-facts-about-space/, https://childwellbeing.asu.edu/SpaceFacts

Space & Maths

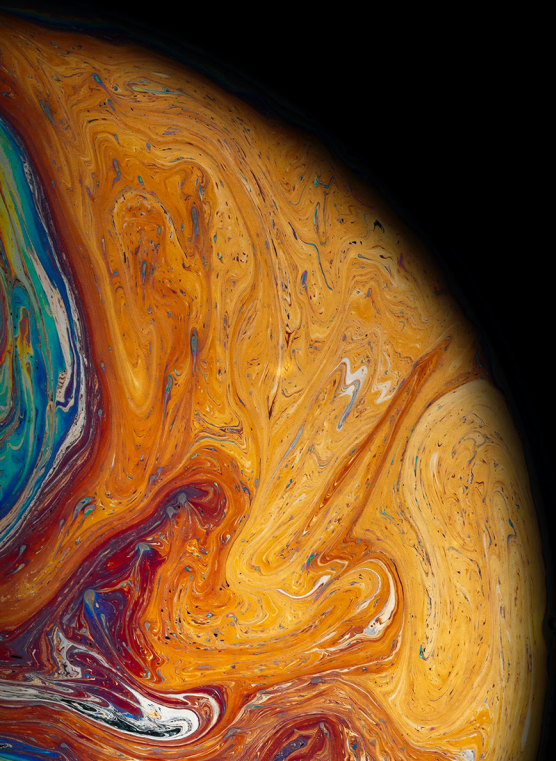
Anay Shah
8A IGCSE

Maths is used in the world of space in many different ways. Many astronomers use maths in space for different purposes. For example, calculate when to take off. The engineers must know when to take off or they might not reach at the correct time.

The safety of the astronaut is also very important. In case of emergency several systems are automated to ensure that the pilots survive. Maths plays an important role in programming these systems so things can operate smoothly even if a pilot is unable to control the craft or there's technical issues. Maths is also used to calculate speed, velocity and other quantities to create a flight plan for the spacecraft and determine how astronauts can reach their destination and satellites can operate in such a way that they are able to accomplish their goal of collecting data and transmitting back to earth .

They even use it to calculate the area of a planet. They need to know the calculation of the planet as to when in future if people visit they might need to know how many people will fit in the planet. To make better machines they also need maths. They need to make the machines better in the future so they can research the planet better and know more about the planet. We can even get to know how much distance there is between two planets or the distance from a specific planet to the sun. These are some ways maths and space are related.

Not only going to space requires maths but making space objects also requires maths. Like making telescopes ,different cameras and lenses to view properly. These instruments have to be made very precisely. If even something little goes wrong you won't be able to see properly through it. Hence I conclude that without maths, going to space or making anything useful to go to space will almost be impossible.



First Oxygen Extracted From Mars

Shlok Shah
IBDP-2A

NASA's Perseverance Mars rover has turned part of the Red Planet's thin, carbon dioxide-rich atmosphere into oxygen for the first time, according to the US space agency.

On April 20, the Mars Oxygen In-Situ Resource Utilisation Experiment (MOXIE), a toaster-size, six-wheeled robot aboard Perseverance, completed the mission.

MOXIE produced roughly 5 grammes of oxygen in this initial operation, which is about 10 minutes' supply of breathing oxygen for an astronaut. MOXIE is capable of producing up to ten grammes of oxygen per hour.

MOXIE operates by extracting oxygen atoms from carbon dioxide molecules (one carbon atom plus two oxygen atoms). Carbon monoxide, a waste product, is released into the Martian atmosphere.

To achieve a temperature of roughly 1,470 degrees Fahrenheit, the conversion process necessitates a lot of heat (800 Celsius). The MOXIE unit is built of heat-tolerant materials to handle this, including 3D-printed nickel alloy components that heat and cool the gases moving through it, as well as a lightweight aerogel that helps keep the heat in. The exterior of MOXIE has a thin gold coating that reflects infrared heat, preventing it from spreading outside and potentially harming other components of Perseverance.

Over the course of a Martian year, MOXIE is expected to collect oxygen at least nine additional times (nearly two years on Earth).

There will be three stages to these oxygen-production runs. The first phase will test and characterise the instrument's functionality, while the second will put it through its paces in various atmospheric circumstances, such as different times of day and seasons. In the third phase, MOXIE's principal investigator, Michael Hecht of the Massachusetts Institute of Technology's Haystack Observatory, said, "we'll push the envelope" by trying new operating modes or introducing "new wrinkles, such as a run where we compare operations at three or more different temperatures."

The Mars 2020 Perseverance mission is part of NASA's Moon to Mars exploration strategy, which includes Artemis lunar missions to assist prepare for human exploration of Mars.

https://indianexpress.com/article/explained/explained-nasas-perseverance-mission-extracted-oxygen-mars-why-big-deal-7284595/

Dehydrated Life On The Moon

Khushi Patel
IBDP-2A

An Israeli lunar lander conveying the minuscule creatures collided with the moon in April, and presently researchers are attempting to decide whether the animals are as yet alive. They might've been gotten dried out life on the moon. In April, a lunar lander conveying small and astoundingly tough creatures called tardigrades collided with the moon. Presently, mission control specialists are attempting to decide whether the tardigrades endure the effect.

The little creatures were dried out and put away in gum or stuck on tape and bundled in a "lunar library," a little holder loaded up with a minuscule document of mankind's set of experiences, human DNA, and the tardigrades. The objective of sending the material to the moon was to store a "back-up" of human information and Earth's science on the off chance that a daily existence finishing occasion occurred for the planet. The reinforcement was to sit on the moon inside Beresheet, a secretly financed Israeli lunar lander. Yet, the accident may have showered its payload across the outside of the moon—essentially that is the thing that it looks likes from film of prior and then afterward the effect.

Since the tardigrades are dried out, they are in a lethargic state. That implies on the of chance that they made it, they are in a minuscule ball, with their heads and legs withdrew internal and their digestion at 0.01 percent of their typical rate, BBC reports. It's not likely they'll colonise the moon like that; they'd need water to vivify. Yet, "What it implies is the purported 'flawless climate' of the moon has been broken," Monica Grady, a teacher of planetary and space sciences at Open University in the UK, tells BBC. (It was broken before when Apollo space traveler set foot on the moon, with their microorganisms, and furthermore when they left 100 sacks of defecation there).

Shuttle should comply with the Outer Space Treaty, which means they will not debase their current circumstance. "I don't figure anyone would have authorisation to appropriate dried out tardigrades over the outside of the moon," Grady says. "So it's not great."

NASA's Office of Planetary Protection, in any case, isn't really rigid with regard to heaving DNA and organisms on places thought to be drained of some other kinds of life, like the moon, contrasted and doing likewise on places that may have their own local microorganisms, like Mars or Enceladus, as per Wired. The Arch Mission Foundation presumably will not be sending Earth back-ups to those spots any time soon however it intends to dispatch future missions to the moon with more DNA and other material.

https://www.inverse.com/science/tardigrades-may-have-taken-over-the-moon, https://www.nasa.gov/press-release/nasa-s-sofia-discovers-water-on-sunlit-surface-of-moon

JOKES!

What does space-time and apples have in common?

A wormhole.

If you aren't impressed with the picture of the first Black Hole you clearly don't understand the gravity of the situation.

What do a bag of Lay's potato chips and the Milky Way have in common?

They're both mostly empty space.

What's a light year? The same as a regular year, but with less calories.

Usually, the speed of light is faster than the speed of sound. On the road, it's the other way around. You can hear the car horn before the light turns green.

https://upjoke.com/wormhole-jokes, https://upjoke.com/black-hole-jokes

Life In The Solar System: An Overview

Meesha Chotai
IBDP-2A

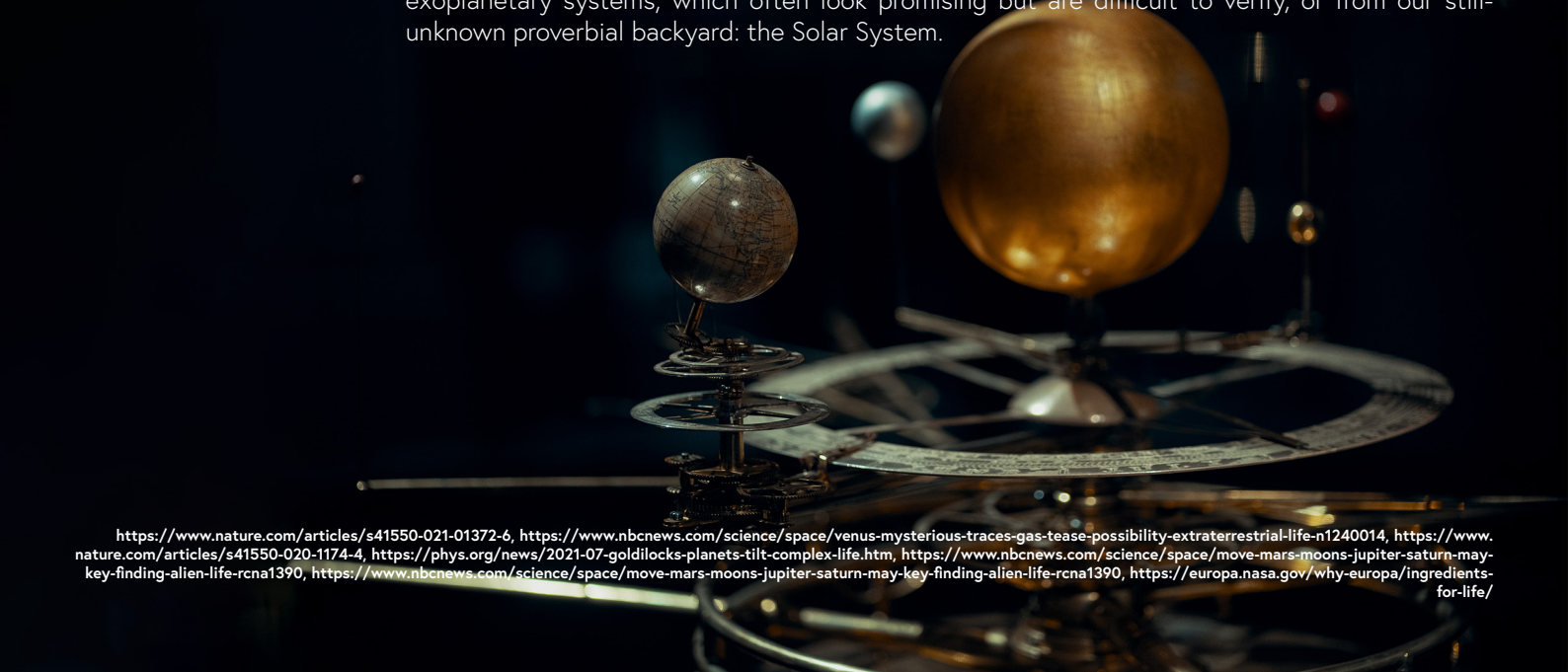
Finding life in space - apart from on Earth, of course - has long been a goal of scientists who study planets in the solar system. Initial discoveries of ice caps on Mars' poles had given rise to speculation about life, but progress in the area has since stagnated. Instead, the focus has moved elsewhere, to more promising prospects - but as always, the search takes two steps forward, one step back. Here are some of the newest developments in the field:

Enceladus is one of Saturn's ice-covered moons. Much like Europa (a moon of Jupiter that is a candidate for the existence of subterranean life), it was initially dismissed as too cold to support life, and therefore never investigated. Observations from NASA's Cassini, however, show that Enceladus has an internal liquid ocean - one with hydrothermal vents. An analysis of the composition of a plume of ocean material from one of the vents revealed abnormally high amounts of methane and hydrogen, suggesting the presence of an organism similar to methanogenic archaea on Earth. This is even more promising than the evidence for Europa, which merely suggested that it would be able to support life, not that life existed already.

Last September, a research paper discussed the presence of phosphine (PH_3) gas in Venus' atmosphere. Phosphorus should, according to the researchers, only exist in oxidised form in the atmosphere of Venus, and the compound phosphine tends to be associated with microorganisms that break down organic matter on Earth, with very few other possibilities for constant production as is suggested by the Venus atmosphere. This discovery sparked further research until recently separate studies were published that both questioned the validity of the initial research due to data errors, and suggested alternative explanations for phosphine - such as volcanoes - that imply life is still unlikely to exist on Venus after all.

Scientists have long ago identified most of the factors creating the 'Goldilocks zone' - the space relative to a central star, mass, density, and other requirements for a planet to potentially support life. Within the Goldilocks zone, though, another potential differentiator in regards to complex life has been identified: planetary tilts. Tilts of planets through the Solar System have been observed to cement this hypothesis. The Earth's axis has a tilt of 23.5o, which is highly significant in the way our climate works and the cyclical nature of the seasons. It appears that this tilt is important in more than one way, though - the self-regulating nature of our planet may have arisen from it. Research is still ongoing, but seems to suggest that complex life is more likely to arise on planets with moderate tilts - for example, a 98o tilt like that of Uranus is much too large.

All in all, there are constant developments in the search for life. They may come from far-off exoplanetary systems, which often look promising but are difficult to verify, or from our still-unknown proverbial backyard: the Solar System.



https://www.nature.com/articles/s41550-021-01372-6, https://www.nbcnews.com/science/space/venus-mysterious-traces-gas-tease-possibility-extraterrestrial-life-n1240014, https://www.nature.com/articles/s41550-020-1174-4, https://phys.org/news/2021-07-goldilocks-planets-tilt-complex-life.htm, https://www.nbcnews.com/science/space/move-mars-moons-jupiter-saturn-may-key-finding-alien-life-rcna1390, https://www.nbcnews.com/science/space/move-mars-moons-jupiter-saturn-may-key-finding-alien-life-rcna1390, https://europa.nasa.gov/why-europa/ingredients-for-life/

Shape Of The Universe

Anaaya Agrawal
10B IGCSE

The state of the universe, in actual cosmology, is the neighbourhood and worldwide calculation of the universe. The nearby highlights of the math of the universe are essentially depicted by its bend, though the geography of the universe portrays general worldwide properties of its shape starting at a consistent item. Expecting the cosmological standard, the discernible universe is comparable from all contemporary vantage focuses, which permits cosmologists to examine properties of the whole universe with just data from considering their recognizable universe.

A few expected topological or mathematical characteristics of the universe interest might be talked about. A portion of these are:

1. Boundedness (regardless of whether the universe is limited or endless)

2. Level (zero ebb and flow), exaggerated (negative shape), or round (positive curve)

3. Availability: how the universe is assembled, i.e., basically associated space or duplicate associated space.

There are sure consistent associations among these properties. For instance, a universe with positive shape is essentially finite.] Although it is generally expected in the writing that a level or contrarily bended universe is endless, this need not be the situation if the geography isn't the unimportant one: for instance, a three-torus is level however limited.

The detectable universe can be considered as a circle that broadens outwards from any perception point for 46.5 billion light-years, going farther back on schedule and more red shifted the more far off away one looks. Preferably, one can keep on thinking back right to the Big Bang. Trial examinations show that the noticeable universe is exceptionally near isotropic and homogeneous.

Would math be able to clarify everything? In his numerical universe theory, he suggests that math is in fact a human revelation and that the universe is basically one immense numerical article. At the end of the day, arithmetic no more depicts the universe than iotas portray the articles they form; rather math is the universe.

https://www.quantamagazine.org/what-shape-is-the-universe-closed-or-flat-20191104/, https://en.wikipedia.org/wiki/Shape_of_the_universe

The Fight For The First Flight

Kush Agarwal
A Level

The famous space race between the United States and the Soviet Union saw the greatest technological advancements of our time. Humans landed on the moon, something which may have not even been a part of the wildest dreams before the space race. A 115 billion USD space station orbits the earth while satellites help us provide internet connectivity, GPS and many more services. Space exploration has majorly served a constructive purpose, such as improving communications, remote sensing and imaging etc. However, with the introduction of commercial players such as Virgin Galactic, SpaceX and Blue Origin space exploration has been largely redefined.

Space no longer remains a domain only accessible by the government, private individuals have also expanded into this unchartered territory. Similarly space exploration has also expanded from having a constructive purpose to a more recreational one. Arguably the first such recreational flight was done by Richard Branson's Virgin Galactic. The space plane, Unity 22 took off on July 11 and reached an altitude of 88km. The United States defines the start of space at 80km, the minimum altitude where an artificial satellite can sustain an elliptical orbit. However, some define the start of space at 100km, the Kármán line. One of the major critics was Jeff Bezos, founder of Blue Origin. Infat it was Jeff Bezos who had announced his mission to space first, which prompted Richard Branson to advance his launch as to claim the title of the first space tourist flight.

Jeff Bezos is set to launch on his Blue Oirigin Shepard rocket and be accompanied by his brother Mark, an 18 year old physics students (the youngest person to travel to space) and an 82 year old female pilot. This all civillian crew would reach an altitude about the Kármán line, the internationally recognised boundary of space. This race between Branson and Bezos has been dubbed the Billionare Space Race.

https://www.bloomberg.com/news/articles/2021-07-16/billionaire-space-race-between-bezos-branson-and-musk-is-just-the-beginning

Ion Thrusters

Hargobind Khurana
A Level

Ion thrusters are being designed for a wide variety of missions—from keeping communications satellites in the proper position (station-keeping) to propelling spacecraft throughout our solar system. These thrusters have high specific impulses—ratio of thrust to the rate of propellant consumption, so they require significantly less propellant for a given mission than would be needed with chemical propulsion. Ion propulsion is even considered to be mission enabling for some cases where sufficient chemical propellant cannot be carried on the spacecraft to accomplish the desired mission.

An ion thruster ionizes propellant by adding or removing electrons to produce ions. Most thrusters ionize propellant by electron bombardment: a high-energy electron (negative charge) collides with a propellant atom (neutral charge), releasing electrons from the propellant atom and resulting in a positively charged ion. The gas produced consists of positive ions and negative electrons in proportions that result in no over-all electric charge. This is called a plasma. Plasma has some of the properties of a gas, but it is affected by electric and magnetic fields. Common examples are lightning and the substance inside fluorescent light bulbs.

The most common propellant used in ion propulsion is xenon, which is easily ionized and has a high atomic mass, thus generating a desirable level of thrust when ions are accelerated. It also is inert and has a high storage density; therefore, it is well suited for storing on spacecraft. In most ion thrusters, electrons are generated with the discharge hollow cathode by a process called thermionic emission.

Electrons produced by the discharge cathode are attracted to the dis- charge chamber walls, which are charged to a high positive potential by the voltage applied by the thruster's discharge power supply. Neutral propellant is injected into the discharge chamber, where the electrons bombard the propellant to produce positively charged ions and release more electrons. High-strength magnets prevent electrons from freely reaching the discharge channel walls. This lengthens the time that electrons reside in the discharge chamber and increases the probability of an ionizing event.

The positively charged ions migrate toward grids that contain thousands of very precisely aligned holes (apertures) at the aft end of the ion thruster. The first grid is the positively charged electrode (screen grid). A very high positive voltage is applied to the screen grid, but it is configured to force the discharge plasma to reside at a high voltage. As ions pass between the grids, they are accelerated toward a negatively charged electrode (the accelerator grid) to very high speeds (up to 90,000 mph).

The positively charged ions are accelerated out of the thruster as an ion beam, which produces thrust. The neutralizer, another hollow cathode, expels an equal amount of electrons to make the total charge of the exhaust beam neutral. Without a neutralizer, the spacecraft would build up a negative charge and eventually ions would be drawn back to the spacecraft, reducing thrust and causing spacecraft erosion.

https://www.nasa.gov/centers/glenn/technology/Ion_Propulsion1.html, https://en.wikipedia.org/wiki/Ion_thruster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