A REVIEW STUDY ON ALTERNATE HABITAT IN SOLAR SYSTEM

PROJECT REPORT

Submitted in partial fulfillment of requirements for the award of the degree of

BACHELOR OF SCIENCE IN PHYSICS
(Model 1)

Submitted by

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DEPARTMENT OF PHYSICS

BHARATA MATA COLLEGE

THRIKKAKARA, KOCHI- 21

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Affiliated to Mahatma Gandhi University, Kottayam

CERTIFICATE

This is to certify that the project entitled “A REVIEW STUDY ON ALTERNATE HABITAT IN SOLAR SYSTEM” carried out and submitted by Mr. Anandu Dinesan, Mr. Gowtham Krishna R, Miss. Ganga Sajan in partial fulfillment requirement of B.Sc Degree in Physics, Model 1, is a bonafide record of the studies undertaken by them under my supervision at the Department of Physics, Bharata Mata College, Thrikkakara during the academic year 2021-24. This dissertation has not been submitted for any other degree elsewhere.

Place: Thrikkakara

Date:

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External Examiner:

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DECLARATION

We hereby declare that this project entitled 'A REVIEW STUDY ON ALTERNATE HABITAT IN SOLAR SYSTEM' is a bonafide record of work done by us under the guidance of Dr. Manesh Michael, Assistant Professor, Department of Physics, Bharata Mata College, Thrikkakara and the work has not previously formed the basis for the award of any academic qualification, fellowship or other similar title of any other University or Board.

Place: Thrikkakara

Date:

Anandu Dinesan

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ACKNOWLEDGEMENT

We would like to express our sincere thanks to **Dr. MANESH MICHAEL,** Assistant Professor, Department of Physics, Bharata Mata College, Thrikkakara whose guidance helped us to complete this project work and we are also thankful for his helping attitude and valuable advice.

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Place: Thrikkakara

Date:

Anandu Dinesan

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ABSTRACT

Title: A review study on alternate habitat in solar system.

Human curiosity and need to secure survival of the human race beyond our planet are the major reasons why we seek alternative homes within the Solar System. This article summarises the findings of recent studies and missions on possible life-supporting areas beyond our own earth.This study gives an in-depth analysis of the many potential homes for humans in space, like Mars, the moons of gas giants, and the creation of artificial living spaces in space.

Due to its likeness and record of water, Mars is one of the main places that astronauts might visit in years to come or even be inhabited. Understandings about the features of this planet's surface including rocks that make up its soil based on new investigation studies from different countries are however necessary for mankind if we intend to make any progress regarding where people could live there someday.

Moons orbiting gas giants, such as Europa and Enceladus, are good candidates for extraterrestrial life given their sub-surface oceans and geothermal processes. The mission is to explore these icy worlds and investigate their habitability using flyby missions as well as proposed lander missions.

The exploration of other habitats within the Solar System is an important step for people in space. The purpose of this essay is to gather information from available sources that can help us understand what has happened to date so as inform where we are going to and keep up with what is still being done about man's place among stars from his own perspective.

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A REVIEW STUDY ON ALTERNATE HABITAT IN SOLAR SYSTEM

CHAPTER 1

Indroduction:

Earth is the only known astronomical object to support life and is located third from the Sun. It is the home of many different types of ecosystems, including deserts, arctic regions, forests, and oceans. Nitrogen and oxygen make up the majority of Earth's atmosphere and are essential to life as we know it. There are many different types of climates and topography on the world, such as plains, mountains, and bodies of water. For thousands of years, human civilization has developed on Earth, with cultures changing and influencing the planet's environment in diverse ways.
Earth, along with eight other planets, moons, asteroids, and comets, is a component of the solar system and is thought to be around 4.5 billion years old. Oceans and continents make up its surface, with plate tectonics causing the continents to move constantly. The Earth is shielded from dangerous solar radiation and cosmic rays by its magnetic field.
The ecosystem on Earth has been significantly impacted by humans, who have changed the way things look, contaminated the air and water, and wiped out entire species. The combustion of fossil fuels and deforestation are the main human-caused causes of climate change, which presents serious difficulties for the future of the world.

Issues that force us to depart from Earth:

1. Natural Disasters:

Natural catastrophes, such as earthquakes, volcanic eruptions, storms, and asteroid strikes, are a permanent threat to Earth and can result in extensive destruction and fatalities. Humanity could be protected from potential cosmic threats and given resistance against Earth-based disasters by establishing communities on other celestial bodies.
There are severe weather events in Earth’s atmosphere, for example hurricanes, tornadoes, floods and cyclones although at a greater cost in terms of life loss. Climate change intensifies these atmospheric turbulences hence leading to increased disaster proneness thus necessitating urgent proactive adjustment strategies.Settling on other planets that are turned into habitable spacecrafts or living in underground houses can save people from fierce Earth’s winds and support their existence at the same time.

The Earth's atmosphere gives rise to extreme weather conditions such as hurricanes, tornadoes, cyclones and floods that destroy many lives across the continents’ societies with substantial losses. Climate change has made these climatic disturbances worse and requires immediate steps to adjust.

Earthquakes and volcanic outbreaks, phenomena which are influenced by tectonic patterns, poses notable dangers to both human populations and infrastructure. In certain parts of the world, more lives are at stake as a result of disastrous trembling of the ground.

2. <u>Resource Depletion</u>:

When vital resources such as arable land, freshwater, or fossil fuels run out, society may collapse and people may have to migrate to other planets in order to survive.

Human survival and agricultural productivity depend on the presence of enough fresh water. However, there already exist regions where water is scarce or its availability is inadequate. This problem is compounded by over-exploitation of groundwater resources, land pollution as well as global warming effects.

Water potential is the possibility of securing a sustainable water supply for human settlements by colonizing other celestial bodies such as the moon which have ice deposits or Mars which possesses subterranean aquifer.

The transition to renewable energy sources and obtaining enough energy to meet the demands of a growing population are challenging. Due to their exhaustion, natural resources like coal, gas, and oil contribute to pollution and climate change.Transferring human habitation to other planets will reduce reliance on Earth and open up opportunities to harness renewable energy sources such as solar, nuclear, or helium-3 from lunar mining for fusion.

Resources that aren't renewable include metals, minerals used in building, and other resources that the electronics industry uses. As a result, there is concern about future shortages and unresolved supply chain issues.Exploiting the mineral-rich regolith of the Moon and other celestial bodies, or mining asteroids, offers a practical way to augment terrestrial resources and guarantee a steady supply of essential elements for economic development and scientific improvement.

Earth is at risk from plastic pollution among others indisciplined waste such as e-waste, spoiled industrial items and the like which may contain harmful substances to humanity as well as other living creatures. To save the environment from resource exhaustion as well as pollutants it is important to come up with methods that can be used sustainably like recycling or making manure together with energy production from refuse.

3. **<u>Pandemics</u>:**

Global pandemics may pose serious risks to human life on Earth, particularly if they have large death rates or long-term health effects. As a result, off-world colonies may need to be established in order to ensure the survival of the species.

Whenever pandemics arise, they are disasters travelling all over the Universe with a capacity to overpower healthcare systems, consume all that concerns medicine, bring about so much human suffering that it leads to death. The quick expansion of diseases caused by infections is required for being handled by human nations with great care as a result of being so widespread due largely to globalization and dependence among societies.Creating separated settlements on other planets or in stations in space is something that can give where patients are kept in quarantine avoiding them from spreading infections and thus keeping people living outside earth healthy as well as the quality of life.

Outbreaks affect global production chains, trade structures, and economic matters by delivering general retrenchments, monetary inconstancy, and economic decline. This stresses how dependent on surface economies are and, at the same time, shows the need for conducting businesses elsewhere than in space.The investment in space exploration and colonization could inspire so many innovations, create fresh sectors while still providing tough economic chances that would help to deal with pandemics and other crises on earth.

4. <u>Technological Catastrophe</u>:

The unintended consequences of advanced technologies, such rogue AI or cataclysmic nuclear war, could endanger human existence and force the construction of self-sustaining colonies abroad.

Fears about Artificial Intelligence's (AI) capability to fail, exhibit unplanned behavior, or be abused for harmful intents are on the rise as the technology evolves and becomes more autonomous. This might lead into worst case scenarios such us; Using deadly weapons without any human supervision and Programming superintelligent software mistakenly released that is highly unsafe.

The ongoing dangers of nuclear power stems from the widespread adoption of nuclear weapons and nuclear power facilities. Governments must establish definitive nuclear safety regimes and work to reduce hazards by furthering nuclear weapons disemergence.The necessity surrounding the preservation of human life after a possible nuclear disaster calls for better rules and regulations concerning radioactivity leakages and terms of disarmament.

In biotechnology, the CRISPR-Cas9 gene editing techniques may revolutionize someday. Even though we hope that this coming soon is impossible, we still worry about it in relation to accidents and intentions for the release of genetically engineered organisms (GMOs) but unexpected outcomes. Global pandemics or ecological disasters could follow some worst nuclear accidents and/or deliberate bioweapon development, like creating an extremely infectious human-killing disease or making bio-weapons out of previously unknown viruses.

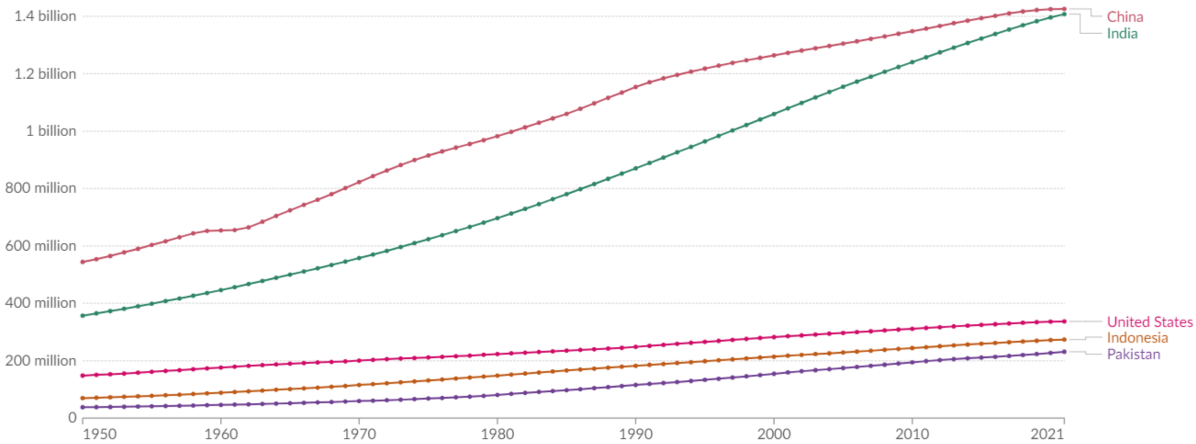
The ultimate risk preparedness in case of biotechnological disaster to protect human health and environmental integrity is to develop separate living areas with proper provisions for keeping life-weapons.

5. <u>Overpopulation</u>:

The population of Earth is expected to keep increasing, placing a tremendous amount of demand on limited resources including energy, arable land, and water. Problems like poverty, social unrest, and urban overcrowding are made worse by overpopulation. Other planets or moons could offer more area for habitation and access to resources needed to support human civilization if they are explored and colonized.

The earth bears a great strain of overpopulation due to its finite resources such as freshwater, arable land, and energy. Whenever world population grows, more of these resources are required leading to their exhaustion, pollution, as well as ecosystem failure. However, should mankind start living in outer space colonies then some pressure will be relieved from our planet while still broadening access routes for other resources which will ensure human civilization survives for long.

Social services, infrastructure and economic systems get overloaded because of overpopulation. This makes our towns crowded, poor and results in social uprising. In overcrowded areas there is unfairness, as people fight for meager resources.Exploring new planets it’s a way to reduce the density of populations, reduce socioeconomic tensions, and support even growth, thus improving the ability of a society to recover as a whole and increasing the quality of human life.



6. <u>Climate Change</u>:

Deforestation, pollution, and greenhouse gas emissions are examples of human actions that have exacerbated environmental degradation and contributed to climate change. Rising sea levels are endangering coastal towns and infrastructure due to erosion and flooding brought on by melting ice caps and glaciers.Significant obstacles to human civilization include sea level rise, harsh weather, rising global temperatures, and biodiversity loss. Humanity may be able to find refuge on other planets or moons in the event that environmental degradation renders Earth uninhabitable.

Global warming is a direct result of a rise in the levels of greenhouse gases like carbon dioxide, methane, nitrogen oxides which in turn causes events such as change in sea levels, melting ice near poles as well as more extreme weather conditions occurring often. In terms of people’s livelihoods and the earth’s species range it is a clear danger because it can make food scarce in some places while in other parts there might be no rainfalls hence no water or uncontrollable flooding all due to changes in climates hence affecting these aforementioned communities.

By colonizing other extraterrestrial objects, human beings can reduce the pressure on Earth's delicate ecosystems, thus helping to cut down on the effects of climate change that threaten its long-term habitability while diversifying global living spaces.

The polar caps of ice are melting and seas warmning causes the sea-level rise, directly endangering coastal communities, low-lying islands, as well as vital infrastructure; it also aggravates coastal erosion, inundation and salt-water intrusion resulting in the loss of territory, destruction of wildlife habitats, and mass displacement of inhabitants.

Extremely hot days, dry spells, strong tropical cyclones, and catastrophic flash floods are just a few of the uncommon weather phenomena that are intensifying due to global warming and have a significant impact on both the environment and the economy. These actions have the potential to devastate farming systems, have a detrimental impact on the amount of water that can be used, disrupt societal structures, and force the majority of the population to relocate from their original settlements, which worsens poverty, starvation, and mayhem, occasionally resulting in civil unrest.

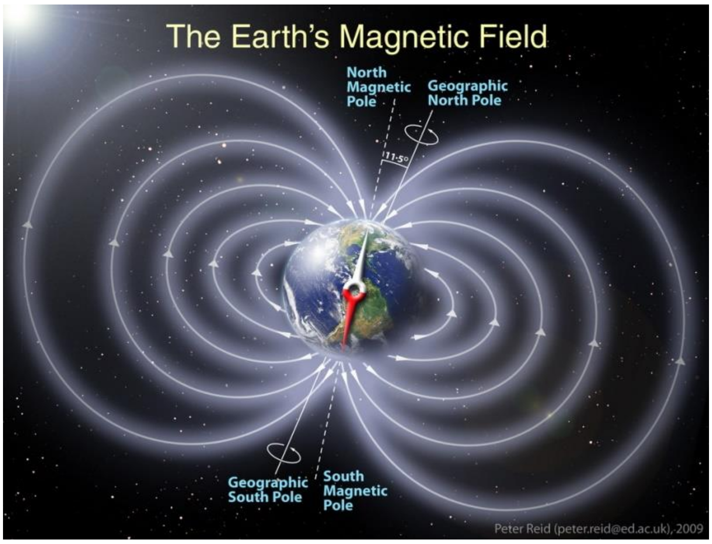
7. **Geomagnetic Reversal**:

A reversal of Earth's magnetic field is an uncommon occurrence, but it might have serious repercussions, such as increased solar radiation exposure and interference with electrical and communication systems. It's unlikely to render Earth entirely uninhabitable, but during the transitional time, it might be necessary to find safer regions off-planet.

Magnetic reversal is thought to be caused by complex mechanisms in the Earth's outer core, where molten iron and nickel create the earth's magnetic field by the geodynamo process. When its flow patterns change, it can cause instabilities in this molten material leading to changes in the magnetic field possibly ending in a reversal of polarity(Point). As it stands currently, exact mechanisms behind these changes remain largely unknown awaiting continuous scientific investigations.

The consequences of geomagnetic reversal for life on Earth are not fully understood. While the reversal itself is a gradual process that can take thousands of years to complete, during the transitional period, Earth's magnetic field may weaken, leading to increased exposure to cosmic radiation and potential disruptions to technological systems such as satellites and power grids. The extent of these effects and their impact on human society remain subjects of ongoing scientific investigation.

Magnetic minerals in rocks record call for geomagnetic reversals. When the rock cools and turn to solid state, The magnetic minerals in it naturally get their charge from magnetic fields of the earth. This is why geologist can tell when earth's magnetic field was flipped in terms of its polarity using those rocks . Besides that, there are other natural records like clay layers and old pottery which may provide proofs about reverse going on in geomagnetic field.



8. Exploration and Expansion:

Opportunities for scientific advancement, technological innovation, and cultural enrichment are presented by space exploration. We can learn more about the universe, the beginnings of life, and the possibility of extraterrestrial habitats by investigating other planets, moons, and celestial bodies. Aside from that, space exploration encourages international cooperation, motivates the next generation, and advances science, engineering, and technology. And one of the main thing is to make human beings a multiplanetary species.

Humans are naturally inquisitive about the unknown and always long for more information through exploration; having been part and parcel of human nature. Explorers had always gone to places where no one had gone before with an intention of making sense out of them thereby demystifying himself in relation to those surroundings throughout the ages. Nothing demonstrates this intrinsic aspect of humanity better than leaving our planet because we want nothing less than traversing through space looking for its hidden answers while at the same time unraveling universal enigmas.

Researchers explore The world and the universe broadening our comprehension in science. Men can give explanations on gravels on different planets and satellites, interstellar gas and dust, life beyond Earth among others by going into space and investigating other heavenly bodies. Going far from this planet makes groundbreaking studies be carried out new things discovered human knowledge advanced and therefore innovation happens in terms of intellectual increase.

Exploration provides chances for utilization of resources more than beyond Earth(confines), getting into the vast store (wealth) of space-related resources. Space rocks filled with precious metals and moon soil with valuable minerals are some examples of celestial bodies where materials at human disposal might be found sufficient enough to support settlements or feed into future industries.

9. The Kardashev Scale:

In 1964, Soviet astronomer Nikolai Kardashev created the Kardashev scale as a model to measure how technologically advancedn a civilization is by looking at the amount of power they use.

The scale is broken down as follows:

- **Type I Civilization**

All of the energy on its home planet is accessible for this civilization to harness and exploit. They control the elements, including the weather, earthquakes, and volcanoes. But we're not quite there yet; mankind is more akin to a Type 0 civilization.

- **Type II Civilization**

With devices like Dyson spheres or swarms, this civilization is able to capture the energy output of its entire star. They can make use of all the energy that their star radiates, which makes it possible for amazing advances in energy and technology.

- **Type III Civilization**

This society is able to use the energy of a whole galaxy. They would be able to travel between stars and combine the energy of several star clusters and individual stars.

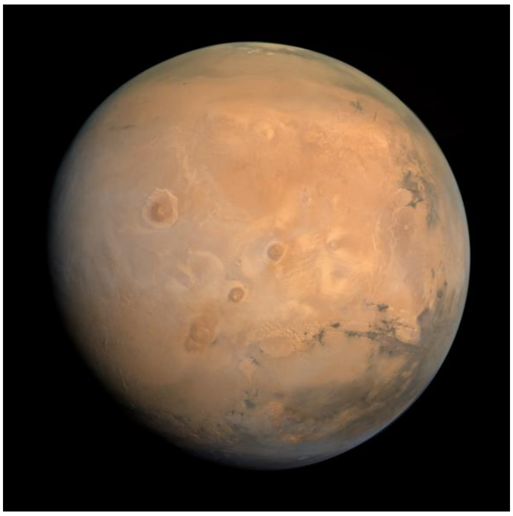
Based on their energy use and technological progress, civilizations can be categorised using the Kardashev scale. It's an intriguing idea that in our consideration of the possible future paths taken by sentient life throughout the universe.

- Our aim is to take human species to Type III civilization and to make human species a non-extinct species.

CHAPTER 2

MARS

In our solar system, Mars is the planet that is fourth from the Sun.Because of its crimson hue, it is known as the "Red planet."The iron oxide (dust) on its surface is what gives it its red hue. Because of its potential as a destination for human exploration and the potential for life, Mars has long captivated scientists and space enthusiasts.In the solar system, it is the second-smallest planet.

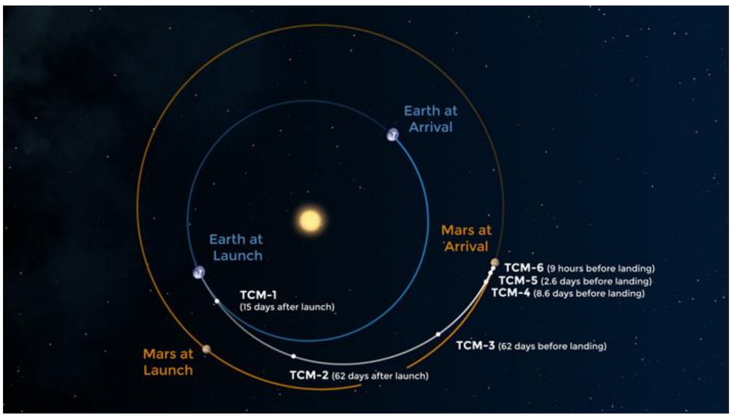


Comparison Between Earth and Mars:

1)Size and Mass:

The dimensions of Earth and Mars are as follows: Earth is approximately 12,742 kilometers (7,918 miles) in diameter and 5.97×10^{24} kilograms in mass, whereas Mars is approximately 6,779 kilometers (4,212 miles) in diameter and 6.42×10^{23} kilograms in mass.With a mass 10.7% that of Earth, Mars is about half the size of Earth.

2)Orbit and Rotation:



The axis tilts of Earth and Mars are similar. Mars takes around 687 Earth days to complete one circle of the Sun, with an average distance of about 228 million kilometers.Mars completes a full rotation in roughly 24 hours and 40 minutes, compared to Earth's precise 23 hours, 56 minutes, and 4 seconds. That is, a day on Mars is roughly equivalent to a day on Earth.

3)Atmosphere:

The majority of the gases in Earth's thick atmosphere are nitrogen (approximately 78%) and oxygen (about 21%), with trace amounts of other gases. The atmosphere of Mars is somewhat thinner and primarily made up of carbon dioxide (approximately 95.3%), with smaller amounts of argon, nitrogen, and other gases. As a result, the average temperature on Earth and Mars differs significantly.

4)Temperature:

The average surface temperature of the Earth is estimated to be around 15°C (59°F). Since temperatures largely vary based on latitude, altitude, and proximity to large bodies of water, these numbers can provide only a general idea. The range is extreme from below freezing in polar regions to extreme heat in deserts. Mars conversely has an average surface temperature of about -63°C (-81°F). This can be attributed to the long distance it is from the Sun alongside having an atmosphere that is too thin.While night time of -73°C (-100°F) are common in the equatorial regions during the summer months, daytime temperatures could soar as high as 20°C (68°F). It can be colder in the polar regions where temperature sometimes falls as low as -143°C (-225°F) in winter.

5)Gravity:

On Earth, gravity is much stronger than on Mars. Earth's surface gravity is around $9.8 m/s^2$, whereas Mars' surface gravity is only about $3.7 m/s^2$, roughly 38% of Earth's. This variation in gravity has an impact on the weight of objects on each planet, with objects weighing less on Mars compared to Earth.

6)Magnetic feild:

The Earth's magnetic field shields it from dangerous solar radiation and cosmic rays, thanks to the molten iron-nickel core that generates it. Unlike Earth, Mars currently lacks a magnetic field. However, studies suggest that evidence of a magnetic field was present on Mars four billion years ago.

7)Surface features:

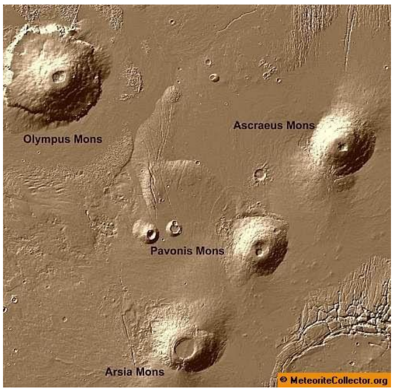
On Earth, you will find various surface features such as continents, oceans, mountains, and valleys. Similarly, Mars displays diverse characteristics like volcanoes, canyons, and impact craters.

Some important surface features of Mars are:

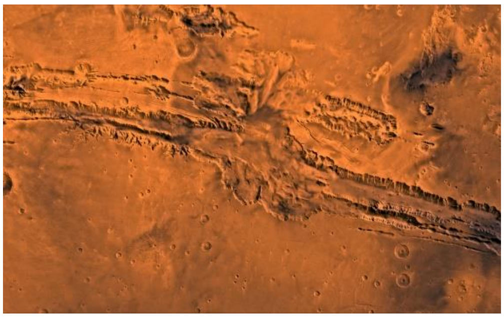
- **Olympus Mons:**One of the most famous sights on Mars is Olympus Mons, the tallest volcano in the solar system. At roughly 21.9 kilometers (13.6 miles) in elevation, it is three times higher than Mount Everest.

- **Polar Ice Caps:** There are ice caps on both Earth and Mars, despite the fact that the ice constituents are different. While polar ice contains only water on earth, martian ice comprises dry ice alongside water ice.

- **Tharsis Region:** Olympus Mons and other sizable volcanoes can be found in the Tharsis region, a vast volcanic plateau on Mars.



- **Valles Marineris:** Valles Marineris is a massive system of valleys located on Mars. In its size, it surpasses 4000 kilometers in length which is more than 600 km in width on average and reaches as low as 7 kilometers into the ground which means that it's even wider than it's deep; it's even more deep than it's wide. It is bigger than earth's Grand Canyon and the largest canyon system within our solar system.

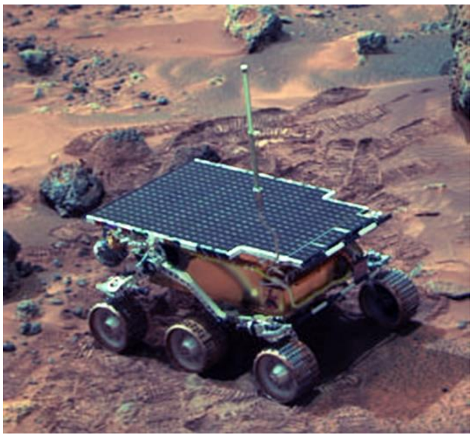


8)Moons:

Earth contains only one natural satellite,one large moon. While Mars has 2 small moons, Phobos and Deimos. Earth's moon is approximately 3,474 kilometers (2,159 miles) in diameter and has a nearly spherical shape. On the other hand, Phobos and Deimos are much smaller and have an irregular, potato-like shape due to their low mass preventing gravity from forming them into spheres.

MARS PATHFINDER MISSIONS:

1)SOJOURNER:



Sojourner was the very first Mars rover created by NASA, as a component of the Mars Pathfinder mission. Its main purpose was to show that it was possible to explore and perform experiments on the surface of Mars. The rover was given the name Sojourner, in honor of Sojourner Truth, a notable African American abolitionist and advocate for women's rights.

The Mars Pathfinder spacecraft successfully landed Sojourner on Mars on July 4, 1997. Sojourner exceeded its mission duration of seven sols and operated on the Martian surface for about 83 sols. Throughout its mission, Sojourner covered approximately 100 meters (330 feet) and gathered essential data on the Martian environment, including soil, rocks, and atmosphere.

Sojourner, with its scientific tools like cameras, a spectrometer, and an alpha proton X-ray spectrometer, gave us important information about the makeup and structure of the Martian land. It also carried out tests to learn more about the weather and atmosphere of the planet.

Sojourner's mission on Mars was a success, leading the way for future rovers like Spirit, Opportunity, Curiosity, and Perseverance. Its accomplishments showed the possibilities of robotic exploration on Mars and motivated advancements in planetary exploration technology.

Mission objective:

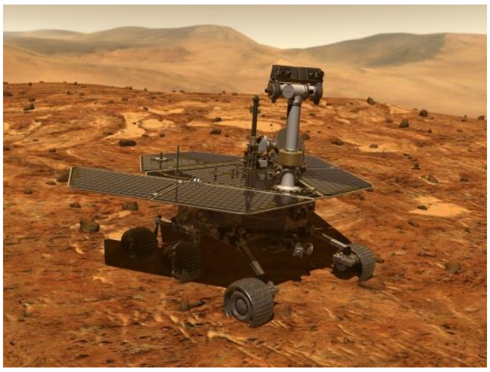
- To demonstrate that it is possible to explore the Martian surface.
- Carry out scientific research to learn more about Mars' weather, geology, and composition.
- Evaluate the autonomy and mobility of rovers in a genuine Martian environment.
- Serve as a technology demonstration for future Mars missions.

Major discoveries:

- Characterizing the composition and texture of Martian rocks and soil.

- Studying the effects of wind and weather on the Martian surface.
- Providing valuable engineering data for the design of future Mars rovers.
- Capturing iconic images of the Martian landscape, including panoramic views and close-up images of rocks and soil.

2)<u>SPIRIT</u>:



NASA’s first Mars Exploration Rovers program, Spirit, was launched in 2003. As part of that program, the rover Opportunity’s twin, it was designed to explore Mars too. In the Gusev Crater, it landed on 4th January and has been undertaking studies on it since then. Ever since then it has concentrated on trying to understand whether there was water there before or not. Geology and history of the Martian environment is the key concern in the analysis.

Spirit surpassed its 90 Martian day (sols) mission duration, operating for over six years until communication was lost in March 2010. Throughout its extended mission, Spirit made several important discoveries, uncovering evidence of past water activity and revealing a diverse geological history on Mars.

The discovery of silica deposits, which raises the possibility that hot springs or steam vents formerly existed in Gusev Crater, was one of the mission's most memorable events. Important information regarding Martian dust storms, soil composition, and the planet's past temperature was also supplied by the rover. Eventually, Spirit was unable to continue its wandering after being lodged in the soft Martian soil.

<u>Mission Objectives</u>:

Spirit and its twin rover Opportunity's main objectives were to explore the Martian surface, learn about its geology, and look for evidence of previous water activity. The mission's goal was to collect information that would enable researchers to assess whether or not microbial life had ever existed on Mars.

<u>Landing Site</u>:

Gusev Crater is where the Spirit rover, which is a component of NASA's Mars Exploration Rover mission, made its landing. Located close to the Martian equator, Gusev Crater is an ancient impact crater with a diameter of roughly 160 kilometers (100 miles). The region was picked because it is thought to have formerly housed a lake or other body of water, which makes it a good place to look for traces of historical water activity and possibly even traces of ancient Martian life. On January 4, 2004, Spirit touched down on Mars and set about investigating the planet by analyzing its minerals and geology.

Scientific instruments:

Many scientific tools were available to Spirit so that it could investigate the Martian atmosphere and surface. These tools comprised environmental sensors, spectrometers, a rock abrasion tool (RAT), and panoramic and navigational cameras. They made it possible for Spirit to measure the atmospheric conditions, take pictures of its surroundings, and examine the makeup of rocks and dirt.

Major discoveries:

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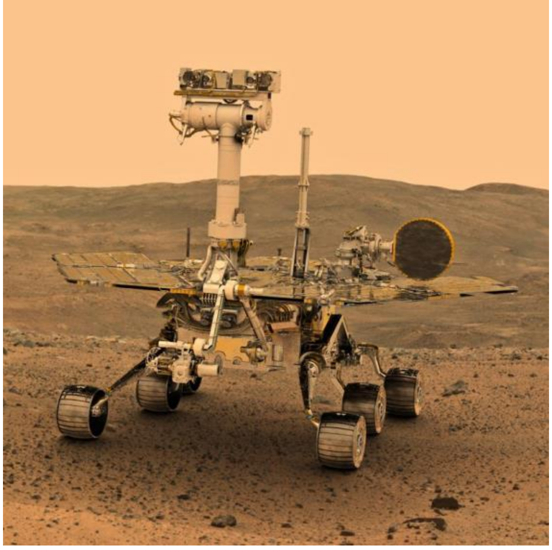
3)OPPORTUNITY:



The Opportunity rover was a robot vehicle that explored Mars from January 2004 to June 2018 as part of NASA's Mars Exploration Rover mission. The mission aimed to investigate the planet's surface and geology to uncover any evidence of past water on Mars and to look for indications of ancient or current life.

The Opportunity rover was initially designed to travel a mere 600 meters, but it far exceeded this expectation by covering over 28 miles (45 kilometers) during its mission. Originally scheduled for a 90-day lifespan, it operated for almost 15 years, making it the longest-lasting Mars rover. Throughout its time on Mars, Opportunity made many important findings, such as confirming the existence of standing water on the planet for extended periods, discovering minerals like hematite and gypsum that indicate water presence, and identifying traces of ancient hydrothermal systems.

Opportunity showed that it could successfully drive a rover on Mars for over ten years, despite facing technical challenges along the way. It covered a total distance of 28.06 miles (45.16 km) before its mission came to an end, which is equivalent to running a marathon.

The rover Opportunity's mission came to an end in June 2018 after a worldwide dust storm swept across Mars, blocking sunlight from reaching its solar panels, which prevented Opportunity from operating. NASA declared the rover dead in February 2019 after multiple attempts to reestablish communication, but not before leaving behind a substantial scientific legacy that continues to influence the work of NASA's current Curiosity rover.

Mission Objectives:

As part of NASA's Mars Exploration Rover mission, Opportunity was dispatched on July 7, 2003. To look for evidence of water on Mars and ascertain if it could support life are its main objectives. The focus of Opportunity's mission was to examine a variety of geological formations, test rocks and soils, and observe the habitat of Mars.

Landing Site:

On the 25th of January, 2004, Opportunity safely lofted down to Mars in the equatorial Meridiani Planum section. Satellite observations that showed the existence of hematite, a mineral connected to water-related activities, led to the selection of the landing site. There were excellent prospects to learn about the prehistoric past of Mars at that site.

Scientific Instruments:

Opportunity had onboard various scientific devices for analysis of Martian surface as well as atmosphere. They comprised panoramic and navigation cameras, spectrometers, a rock abrasion tool (RAT), among other environmental sensors. Through these instruments, Opportunity was able to observe rocks and soil composition, take pictures around her vicinity, and determine weather conditions.

Major discoveries:

- **Water on Mars**:
  The small hematite spheres, aptly named "blueberries" by scientists, that are normally created when there is some water flow were found on earth by rover.

- **Blueberries**:
  Small, round, blue-gray concretions of the mineral hematite were found at the landing site of the rover, providing evidence of ancient water activity on Mars.

- **Ancient Acidic Lakes**:
  Evidence of ancient acidic lakes on Mars, which could have been habitable for microbial life, was discovered by the rover.

- **Dust Devils**:
  Opportunity observed dust devils on Mars which has actually helped a lot of scientists to gain a better understanding in matters relating to the atmospheric dynamics of the planet as well as how wind moves dust and sand around in the extremely thin atmosphere that exists on Mars.

- **Ancient hydrothermal system**:
  Opportunity discovered proof of a historical hydrothermal system on Mars, which suggested that water had been interacting with magma.

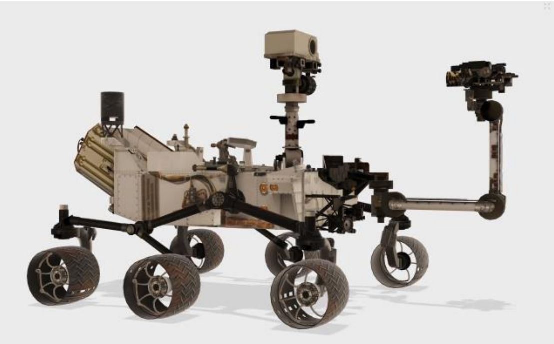
- **Ferric Sulfates**:
  Ferric sulfates were found by the rover at the Troy, Husband Hill, Gusev Crater, indicating that rock surfaces on Mars had been modified by contemporary waters.

- **Iron-magnesium carbonates**:
  Opportunity discovered iron-magnesium carbonates at the Comanche outcrop in Gusev Crater’s Husband Hill. The finding implied that water had mixed with magma on Mars.

Mission Duration:

Its mission duration was much longer than the original expected lifespan of the Opportunity rover. Opportunity was supposed to last for around 90 Martian days (also called sols), which is about 92 days on Earth more or less. Nevertheless, this robot managed to keep working on Mars for more than 14 years during which NASA lost touch with it due to a serious dust storm over the whole planet. The official closure date was February 13, 2019 when the contact was permanently cut off by NASA after the latter could no longer recover anything from this piece of equipment.

4)CURIOSITY:



The Mars Rover Curiosity is a car-sized rover on Mars that is part of NASA's Mars Science Lab Project (MSL). It was sent out of Cape Canaveral on November 26, 2011, and landed inside Gale crater, Mars on August 6, 2012. Research has been centered on the planet's weather conditions, rocks, soils, and whether any places within Gale have ever presented an environment conducive for microorganisms growth.It is also supposed to give insights into how humans exploring other planets could survive there.

Curiosity rover comes equipped with several gadgets to serve its scientific purposes which include cameras, spectrometers and a drill for taking rock and soil samples. The car is powered by a Multi Mission Radioisotope Thermoelectric Generator (MMRTG) turning heat released by the radioactive decay of Plutonium-238 to electricity.

Mars Curiosity Rover has discovered many things since it landed on Mars. It has discovered many traces that show there was once liquid water on the surface of Mars; there were clays and sedimentary rocks showing that rocks had been interacting with water for long time. What is more, it has seen organic molecules that are essential for life in soil and rocks.

Mission Objectives:

The Curiosity rover was primarily tasked with examining the habitability of Mars, and in line with this, it has four mission objectives:

- Determine the type of organic carbon compounds and the quantity of each compound available.
- Take stock of the basic chemicals that constitute life (including carbon, hydrogen, nitrogen, oxygen, phosphorus, sulfur).
- Recognize the features that could be due to biological procedures.
- Examine the chemical, isotopic and mineralogical compositions of the Martian surface and near-surface geological materials.

Landing Site:

Curiosity safely touched down on Mars on the 6th of August in the year 2012 within the Gale Crater located near the equator of Mars. This site was selected because of its diverse geology including a mountain that has various layers known as Mount Sharp from which we may be able deduce some information concerning past weather patterns on the red planet.

Scientific Instruments:

Curiosity has been endowed with a state-of-the-art combination of scientific instruments which comprises spectrometers, cameras and chemistry and mineralogy analyzer (CheMin) -analyzing X-ray diffraction-(XRD), as well as a sample analysis at Mars (SAM) instrument suite. This enables Curiosity to examine the composition of Mars rocks and dirt, as well as to scrutinize gaseous substances in the atmosphere and look for carbon-based compounds.

Major discoveries:

- **Habitable Environment:**

  Evidence of a habitable environment on Mars has been found by Curiosity, making it possible to have life since it contains key chemical ingredients such as sulphur, nitrogen, hydrogen, oxygen, phosphorus and carbon. The discovery of clay minerals and a neutral environment with pH close to 7 may hint at some ancient aqueous environment, possibly a lake which was not so brackish.

- **Organic Compounds:**

  In rock samples from Mars' Gale crater, Curiosity found organic compounds that can be seen as building materials and "food" for life. This implies that life might have existed on the planet sometime in the past.

- **Rock Formation and Exposure Age:**

  For the first time, Curiosity has established the formation and exposure ages of a rock on the surface of another planet, revealing details about Mars's geological past.

- **Radiation Levels:**

  Curiosity has been studying the environment of Martian radiation. This is helping the researchers learn about the risks that radiation could present for the possible native microbes and human visitors.

- **Ancient Streambed:**

  Curiosity has discovered proof that an ancient river used to flow on very long term time scales at about knee depth, suggesting mars might have been partially habitable at some point in the past many billions of years back.

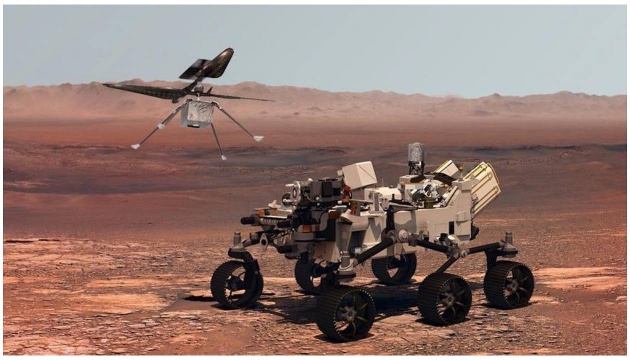
- **Possible Signs of Life:**

  Significant evidence has been obtained by the Curiosity Rover regarding the existence of life on Mars through the identification of possible biosignatures in ancient stones alongside finding mud cracks which might have constituted the various habitats during the formation period of life.

Mission Duration:

At the beginning, curiosity had been planned to last for a single year on Mars which equals to 687 days on Earth. But because of its durable construction and longer service duration, it has gone beyond the planned period of its main work. As per the latest information I have, Curious is still working and exploring the surface of planet Mars.

5)**PERSEVERANCE**:



As part of NASA's Mars 2020 project, Perseverance, often referred to as Percy, is a car-sized Mars rover built to investigate the Jezero crater on the planet. On July 30, 2020, it was launched, and on February 18, 2021, it made a successful landing on Mars. Since landing, the rover has completed 1,129 sols, or 1,160 Earth days, or three years, two months, and five days of operation. In order to prepare for future crewed missions, Perseverance's mission objectives include identifying ancient Martian environments that could support life, looking for evidence of past microbial life, gathering rock and soil samples for analysis in the future, and testing oxygen production from the Martian atmosphere.

Nineteen cameras, two microphones, and seven primary payload instruments are carried by the rover in addition to the mini-helicopter Ingenuity, which on April 19, 2021, accomplished the first powered aircraft flight on another planet. The existence of igneous rocks that imply a dynamic and habitable environment billions of years ago, as well as indications of past water activity, are only two of the important findings about Mars' ancient history that Perseverance has made.

Mission Objectives:

• Investigating the possibility of life on Mars in the past and searching for its traces in soil.

• Collecting soil and rock samples for in-depth analysis by specialists on Earth.

• Trying out new technologies like MOXIE device capable of extracting oxygen from Martian air or helicopter Ingenuity, that are planned for usage during manned flights to Mars.

• Research on habitability of Mars.

• Searching for past microbial life.

Landing Site:

Jezero Crater, a forty-five kilometers widen (28 miles wide) impact basin located just north of the Martian equator is the place where Perseverance successfully landed on Mars on February 18, 2021. Investigating Jezero Crater is thought to have held some form of lake, making it an interesting point at which to look out for possible evidences related to ancient life.

Scientific Instruments:

- **Mastcam-Z**:Advanced camera system to obtain high-resolution images and videos.
- **SuperCam**: A laser-firing device for investigating the mineralogy and chemistry of rocks and soil.
- **SHERLOC**:Spectrometer to find minerals and chemical substances that might indicate the presence of previous microbiological life.
- **RIMFAX**: Ground-penetrating radar to examine the Martian subsurface's geologic structure.
- **MOXIE:** An experimental device designed to generate oxygen from the carbon dioxide atmosphere of Mars.

Mars Helicopter(Ingenuity):

- The Perseverance rover and the small, autonomous helicopter Ingenuity were both a component of the Mars 2020 project.
- During launch and landing on Mars, the Perseverance rover's bottom was equipped with Ingenuity. After that, it was set up and started to fly independently of the rover.
- The main objective of Ingenuity was to demonstrate technology by demonstrating that powered, controlled flight is feasible in the thin Martian environment. On April 19, 2021, it accomplished this first trip and made history by becoming the first object to fly powered and controlled beyond space.
- It served as the Perseverance rover's aerial scout. It aided in route planning for the rover, mapping the topography, and identifying possible science targets.
- Ingenuity accomplished 72 flights over almost three years, covering approximately 17 kilometers on Mars, significantly exceeding its original planned goal. This significantly increased our knowledge of and capacity for using aerial vehicles to assist rover operations on other planets.
- On January 18, 2024, Ingenuity made its last flight before being permanently grounded due to a rotor blade failure during landing.
- Ingenuity collaborated closely with the Perseverance rover over its entire operation, offering insightful analysis and useful aerial reconnaissance to aid in the rover's primary science goal of looking for evidence of prehistoric microbial life on Mars.

Major discoveries:

- **Ancient River Delta:**

  Perseverance discovered proof that other time Jezero crater contained an ancient river delta, thus pointing to a possible habitat on Mars in its by gone eras. The mobile laboratory in fact identified igneous rocks as well as mineral sediments suggesting that billions of years ago there existed liquid water bodies within which some forms of life could have thrived.

- **Organic Compounds:**

  Iron phosphate, a necessary component for life on Earth, was found by Perseverance, suggesting that phosphorus was present on Mars in a form that would have been accessible to possible extinct life forms.In the rocks and sediments it has examined, the rover's instruments have found organic molecules and other possible biosignatures.

- **Detailed Geological Characterization:**

  Perseverance, with advanced technology such as the SuperCam, has brought forward hitherto unseen detailed images coupled with geological and mineralogical analysis from the area around Jezero Crater. 12 rocks to be brought back here for further study were recently collected by a robot as a precursor to forthcoming missions on Mars aimed at returning some samples to our planet.

- **Ingenuity Helicopter Flight:**

  Accompanying Perseverance, the Ingenuity helicopter achieved the first powered, controlled flight on a different planet, showcasing airborne vehicles' potential to aid in future Mars exploration.

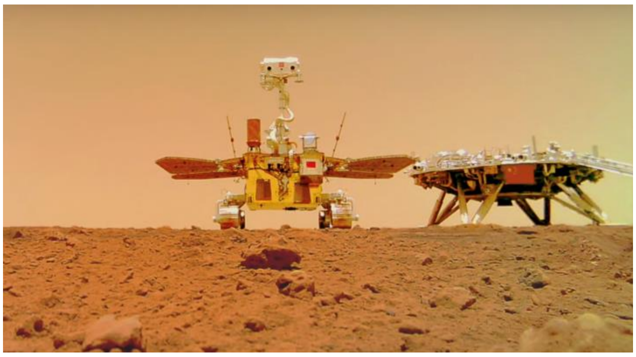
- **Advanced Technology:**

  In order to prepare the path for future human exploration of Mars, perseverance has tested and proved advanced technology such as the MOXIE equipment, which can synthesize oxygen from the Martian atmosphere.

Mission Duration:

The Perseverance rover has its mission duration planned to last for a minimum of one Martian year, which is equivalent to about 687 days on Earth. Nevertheless, the rover has been specifically developed for long-term operations and its Lifetime will depend on health and availability of resources; currently, it still functions on Mars Investigating variously located physical terrains within Jezero Crater while doing research studies.

6)<u>ZHURONG</u>:



As part of the Tianwen-1 mission, Zhurong, a Chinese rover, touched down on the Martian surface in May 2021, making China the second nation to accomplish this feat.The Chinese mythological character connected to fire and light is the inspiration behind the name of the Zhurong rover. It was intended to last for ninety Martian sols, or ninety-three Earth days.

Either Zhurong is able to talk straight to Earth or it can use its Tianwen-1 orbiter to carry data at very high speed. The orbiter also has its own science tools particularly designed for studying the red planet with one of them being a high resolution camera that is expected to yield amazing pictures.

Similar to NASA's Curiosity and Perseverance rovers, Zhurong is equipped with cameras, geology and climate study tools, and even a device to zap rocks and record the chemical traces that occur. By launching radio waves into the surface and timing their reflections, the rover radar enables Earth scientists to piece together a three-dimensional map of what is below the surface.

<u>Mission Objectives</u>:

- Learn about the composition of the rock and soil on Mars' surface to gain insight into the planet's geological past.
- Examine surface characteristics and sedimentary deposits for indications of prehistoric microbial life.
- To learn more about the dynamics of Mars climate, measure the temperature, pressure, humidity, and wind patterns in the atmosphere.
- Examine the mineralogy and chemical makeup of Martian rocks and soil to learn more about the planet's geological processes.
- Technology Demonstration: By successfully landing and operating a rover on Mars, China will demonstrate its prowess in deep-space exploration and open the door for future missions.
- Determine whether water ice and other resources exist on Mars and investigate them.

Landing Site:

The Zhurong rover touched down in Utopia Planitia, a large plain in Mars' northern hemisphere. The comparatively level surface of Utopia Planitia, one of Mars' biggest impact basins, makes it a perfect landing spot for the rover. Following an extensive remote sensing investigation conducted by the Tianwen-1 orbiter, the landing site was chosen.The area is a promising field for scientific investigation since it may have historically held water and is thought to feature historic river channels. The chance to investigate the geological past and possible habitability of this Martian region is presented by Zhurong's landing in Utopia Planitia.

Scientific Instruments:

- **Navigation and Panoramic Cameras:** High-resolution photographs of the rover's surroundings are captured by these cameras, which help with navigation and offer detailed views of the Martian terrain.

- **Multispectral Camera:**This device records images at various light wavelengths.Scientists can examine the mineralogy and composition of rocks and soil using these informations.

- **Magnetic Field Detector:** By measuring the magnetic characteristics of Martian rocks, this equipment offers valuable insights about the planet's geological processes and magnetic history**.**

- **Ground Penetrating Radar(GPR):**Geological characteristics such as buried rocks, ice, and water can be studied by scientists using the GPR device, which shoots radar pulses into the Martian subsurface and counts the echoes bounced back.

- **Mars Surface Composition Detector(MSCD):**Using X-ray fluorescence spectroscopy, this device examines the chemical makeup of rocks and soil to reveal information on the elements that are present on the surface of Mars.

- **Meterological Station:**Zhurong has sensors to measure wind speed, humidity, temperature, pressure, and other atmospheric parameters. These measurements aid in the understanding of the weather and climate dynamics on Mars by scientists.

- **Surface Spectrometer:**This device measures the amount of light that the Martian surface reflects back, which helps researchers learn more about the water-bearing minerals and surface mineralogy.

Major discoveries:

- **Detection of Recent Water Activities**:

  Zhurong discovered signs of recent water activity on Mars, including liquid water on low-latitude sand dunes, suggesting that certain regions of the Red Planet might support life.

- **Identification of Hydrated Minerals**:

  Using its equipment, the rover discovered that the dune's surface layer, where water activity was found, was rich in hydrated silica, hydrated sulfates, iron oxide minerals, and perhaps chlorides. This information provided important new information about the geological makeup of Mars.

- **Exploration of Geomorphologic Features**:

  Zhurong investigated and researched a range of geomorphologic characteristics close to its landing location, such as ridges, troughs, rampart craters, and cones. These features help us comprehend the geological history of Mars and the history of water and ice activities in the area.

- **Detection of Buried Polygonal Wedge Structures**:

  Discovery of buried polygonal wedge structures around 35 meters below the surface in the Utopia Planitia region. These characteristics imply previous freeze-thaw cycles and temperature fluctuations on prehistoric Mars, offering hints about the planet's past habitability.

- **Measurement of Magnetic Field**:

  The Utopia Planitia region has a comparatively weak magnetic field when compared to other sections of the planet, which could have consequences for understanding the planet's geological history and evolution. Zhurong's surface magnetic field detector detected the magnetic field on the Martian surface.

- **Characterization of Dust Storm**:

  The severity, duration, and effects of the dust storms on the surrounding environment were all described by the rover's meteorological equipment, providing important information for comprehending the climate and weather patterns of Mars.

Mission Duration:

Zhurong had a planned endurance period of 90 Martian solar days (or 93 Earth days), but ended up lasting for 358 Earth days (or 347 Mars sols) in place of the initially estimated 90 sols indicating the toughness of the rover’s design. Starting May 20th this year, the planet’s approaching winter season and anticipated dust storms forced it to enter sleep mode until it naturally wakes up within favourable temperature and light conditions.The main design engineer of the rover explained that it was anticipated for Zhurong to become active again by December 2022 but this was never the case due to dense dust build-up.

<u>MARS SATELLITE MISSIONS</u>:

1)<u>MANGALYAAN</u>:

The ISRO dispatched its maiden spacecraft to the crimson globe on 5 November 2013 for probing the red planet and checking out vital technologies needed for surveying the inner solar system — an achievement known as Mangalyaan or the "Mars craft." By September 23, 2014 India had reached Martian orbit with its Mangalyaan spacecraft hence becoming the fourth space agency globally under ISRO to accomplish this mission.India's foray into the exploration of Mars comes after the US, the USSR, and the European Space Agency (ESA) but before others. Initially, it was intended by ISRO to launch Mangalyaan using GSLV instead of PSLV even if it meant a loss of about half its capacity.

Mangalyaan could only be launched into an extremely elliptical Earth orbit by the PSLV. Over the course of the next few weeks, the spacecraft would need to fire its engines multiple times at specific locations in each orbit to establish itself on a route to Mars, failing which it would miss the planet entirely. Although the trajectory plan was somewhat atypical for a Mars mission, it was successful. About 300 days after reaching the Red Planet, the spacecraft restarted its engines and was able to enter Mars orbit.

<u>Mission Objectives</u>:

- **<u>Orbital Exploration</u>:** Study the surface, atmosphere, and mineral composition of Mars by orbiting it.
- **<u>Atmospheric Studies</u>:** Learn about the dynamics and composition of Mars' atmosphere by conducting research.
- **<u>Surface imaging</u>**: Take detailed pictures of Mars' surface for geological study.
- **<u>Mineralogy Analysis</u>**: Employing infrared spectroscopy, investigate the mineral composition of Mars' surface.
- **<u>Methane Detection</u>**: Look for the presence of methane in the Mars atmosphere as a possible sign of geological or biological activity.
- **<u>Technology Demonstration</u>**: Demonstrate India's competence in precise orbital maneuvers and interplanetary missions.

Launch:

The Polar Satellite Launch Vehicle (PSLV) is what was used to launch Mangalyaan from Sriharikota, India's Satish Dhawan Space Centre on November 5, 2013. It was a major turning point in the country's space program since India had never before sent a spacecraft to another planet.

Orbital Insertion:

On September 24, 2014, Mangalyaan entered Mars' orbit after traveling for around 300 days. The spacecraft demonstrated India's capacity to carry out interplanetary missions by executing a series of orbital maneuvers to accomplish Mars capture.
The spacecraft's engines were fired at exact times and angles during the orbital insertion maneuver in order to reduce its velocity in relation to Mars. In order to keep Mangalyaan in the intended orbit and prevent it from colliding with the planet or escaping back into space, this maneuver was essential.

Scientific Instruments:

Five scientific tools were available for Mangalyaan to research Mars:

- **Lyman Alpha Photometer(LAP**):This instrument measures the amount of deuterium and hydrogen in the upper atmosphere of Mars.

- **Mars Exospheric Neutral Composition Analyzer(MENCA):**The purpose of the Mars Exospheric Neutral Composition Analyzer (MENCA) is to investigate the exospheric composition of Mars.

- **Mars Color Camera(MCC**): Images of the Martian surface were taken by the Mars Color Camera (MCC) in order to understand its topography and geological features.

- **Thermal Infrared Imaging Spectrometer (TIS):**It is a tool used to investigate the mineral composition and surface temperature of Mars.

- **Mars Orbiter Mission Methane Sensor (MOMMS**): The purpose of this device is to find methane in the planet's atmosphere, which may be a sign of geological or biological activity.

Major discoveries:

- **Methane Detection:**

  Methane in the Martian atmosphere was to be found by Mangalyaan's Methane Sensor for Mars (MSM) instrument. The data offered important insights into the distribution and behavior of methane on Mars, which has consequences for comprehending the planet's geological and biological processes, even though the results did not definitely prove the planet's methane presence.

- **Atmospheric Dynamics**:

  Mangalyaan's observations contributed to our growing knowledge of the seasonal fluctuations, dust storms, and gas behavior of Mars' atmosphere. These discoveries advance our understanding of the climate and weather of Mars.

- **Surface Imaging**:

  High-resolution photos of the Martian surface were taken by Mangalyaan's Mars Color Camera (MCC), which is a useful tool for geological research and surface feature analysis. Although these photographs are not as detailed as those from previous Mars missions, they have helped us comprehend the geography and surface morphology of Mars.

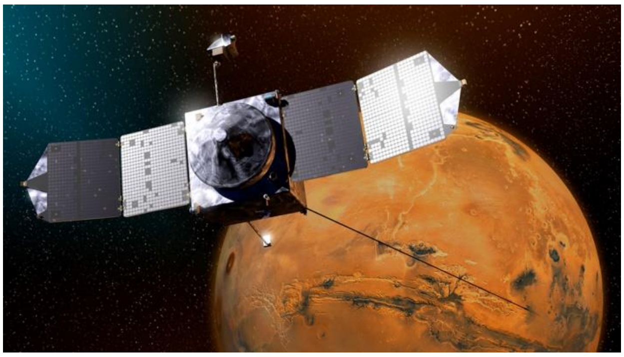
- **Measurements of Escape Velocity**:

  In order to comprehend Mars' capacity to hold onto its atmosphere over geological time scales, Mangalyaan carried out measurements of the planet's escape velocity. The atmospheric evolution and loss mechanisms of Mars are better understood thanks to these measurements.

Mission Duration:

Though the Mangalyaan project was only supposed to last six to ten months, it ended up operating for more than eight years, completing thousands of orbits around Mars and significantly longer than expected.
Mangalyaan was out of touch with ISRO in April 2022 after spending a considerable amount of time in Mars' shadow. According to officials, the spacecraft most likely ran out of propellant and was unable to correctly align its solar panels in order to collect power. The mission's estimated six-month duration was greatly exceeded.

2)MAVEN(Mars Atmosphere and Volatile EvolutioN):



NASA created the spacecraft MAVEN (Mars Atmosphere and Volatile Evolution) with the goal of researching Mars' atmosphere. On November 18, 2013, it was launched, and on September 21, 2014, it entered Mars' orbit. Investigating the planet's upper atmosphere, ionosphere, and interactions with the solar wind and Sun is the mission's main objective. Three sets of equipment are carried by MAVEN to investigate different facets of Mars' atmosphere and the planet's atmospheric loss history. After losing its magnetic field, the probe discovered that Mars lost almost two thirds of its early atmosphere to space as a result of encounters with the solar wind. Every 3.5 hours, MAVEN circles Mars, reaching a maximum distance of 150 km (90 miles) from the planet's surface.

Mission Objectives:

- **Atmospheric Loss**: Learn about the gradual loss of Mars' atmosphere.
- **Climate Changes**: Examine how the climate is changing and how that affects Mars' habitability.
- **Solar Wind Interaction**: Examine the effects of the solar wind on the upper atmosphere of Mars.
- **Atmoshperic Composition**: Give an account of the gases found in the atmosphere of Mars.
- **Atmospheric Escape Processes**: Examine the processes by which gases from the atmosphere escape into space.
- **Martian Climate History**: Reconstruct the climate history of Mars in order to understand its former habitability.

Launch:

NASA's Mars Atmosphere and Volatile Evolution mission (MAVEN) successfully launched its debut flight on November 18, 2013 in Cape Canaveral Air Force Station Florida aboard the Atlas V launcher. It aimed at exploring the atmosphere of Mars and its connection with the solar wind. It was the primary step towards apprehending how the atmosphere of Mars and its weather patterns have changed over the years.It was also a major milestone for NASA in its ongoing efforts to unravel Mars' atmospheric history and evolutionaries.

Orbital Insertion:

The spaceship MAVEN successfully reached orbit around Mars on September 21, 2014, marking the beginning of the mission. In order for the spacecraft to enter a stable orbit for scientific studies, it was necessary to slow it down so that it could be grabbed by Mars' gravity. An important step forward for the project was MAVEN's orbital insertion, which allowed it to start studying Mars' atmosphere and how it interacts with the sun.

Scientific Instruments:

A variety of scientific instruments are carried by MAVEN. The primary scientific tools on board MAVEN are as follows:

- **Neutral Gas and Ion Mass Spectroneter (NGIMS):** Determines the neutral gas composition of Mars upper atmosphere and ion composition, isotopic ratios, and temperatures.

- **Solar Wind Ion Analyzer (SWIA):** Determines solar particles composition, density and velocity on Mars atmosphere by the solar wind.

- **Solar Wind Electron Analyzer (SWEA):**Examines the characteristics of solar wind electrons to learn more about how they interact with Mars' upper atmosphere.

- **Solar Energetic Particle (SEP) instrument suite:** Determines the flow, energy, and composition of solar energetic particles in order to assess their influence on the atmosphere of Mars.

- **Magnetometer (MAG):** Measures Mars's magnetic field to learn how it interacts with the solar wind and how that affects atmosphere loss.

- **Langmuir Probe and Waves (LPW):** Measures the temperatures, velocities, and densities of plasma as well as plasma waves to study the ionosphere of Mars.

- **Imaging Ultraviolet Spectrograph (IUVS):** Studies the composition and structure of Mars' ionosphere and upper atmosphere by taking ultraviolet photographs of the planet.

Major discoveries:

- **Atmospheric Loss Confirmation:** MAVEN verified Mars' atmosphere is currently losing a considerable amount of mass to space. The study discovered that the solar wind is continuously removing atmospheric particles, which eventually causes Mars' atmosphere to decrease.

- **Solar Wind Interaction:** MAVEN offered comprehensive insights into how the solar wind and Mars' upper atmosphere interact. It was discovered that Mars' atmosphere is directly impacted by the solar wind, which causes atmospheric gases like oxygen and hydrogen to escape.

- **Seasonal Variations:** Seasonal fluctuations in temperature, density, and composition were observed in Mars' upper atmosphere by MAVEN. These fluctuations add to the dynamic aspect of Mars' atmosphere and are impacted by elements like solar radiation and dust storms.

- **Magnetic Field Variability:** MAVEN verified that Mars' magnetic field is very changeable and impacted by the solar wind. The processes leading to atmosphere loss are influenced by this interaction between the solar wind and Mars' magnetic field.

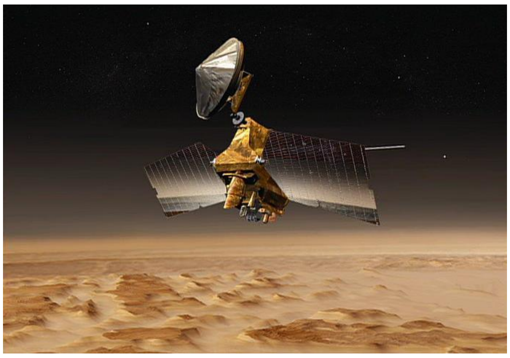
- **Water Vapour Loss:** According to MAVEN's findings,Water vapor on Mars is being lost to space at a faster rate than previously believed. This discovery has ramifications for both the possibility of liquid water existing on Mars' surface and the planet's historical climate.

- **Auroras on Mars:** Mars auroras were seen by MAVEN and were brought about by interactions between solar particles and the planet's atmosphere. These auroras reveal details on the makeup and dynamics of Mars' upper atmosphere and occur at far lower altitudes than those seen on Earth.

Mission Duration:

MAVEN's (Mars Atmosphere and Volatile Evolution) primary mission lasted one Earth year, starting on September 21, 2014, when it arrived at Mars. Nonetheless, because of MAVEN's achievements and ongoing scientific output, its mission has been extended several times. MAVEN is still in use and is still researching the Martian atmosphere and how it interacts with the solar wind.

3)MARS RECONNAISSANCE ORBITER:



NASA tried to use the Mars Reconnaissance Orbiter in an attempt to prove that there had been water on Mars for a long time. Although the earlier Mars missions evidence suggested there had been water on the surface of the planet before, it is not yet known whether it existed there long enough to be able to nurture any form of life on that barren celestial body.

The Mars Reconnaissance Orbiter started using its research instruments to look for evidence of past water on Mars after a seven-month journey to the planet and six months of aerobraking to get to its science orbit. The devices measure the amount of dust and water dispersed in the atmosphere, examine minerals, search for subterranean water, take extremely close-up photos of the Martian surface, and track the daily weather patterns worldwide.These investigations involve looking for signs of ancient seashores and lakeshores, detecting mineral deposits that may have originated in water over long periods of time, and examining deposits that have been deposited in layers over time by flowing water.

Mission Objectives:

- **High-Resolution Imaging:** In order to investigate the Martian surface's morphology, geology, and surface characteristics at a resolution greater than that of earlier missions, MRO seeks to take precise pictures of the surface.
- **Mineral Mapping:** Using its instruments, the spacecraft maps the surface of Mars' mineral composition, detecting important minerals like sulfates and clays that suggest possible habitability and historical water activity.
- **Atmospheric Studies:** MRO studies the dynamics, composition, and seasonal variations of Mars' atmosphere through observation, including dust storms, cloud forms, and atmospheric temperatures.
- **Search for Water:** In order to comprehend the planet's historical and present water cycle, one of MRO's main goals is to look for signs of water on Mars, such as the existence of hydrated minerals, water ice, and liquid water flows.
- **Landing Site Selection:** Detailed photos and information about possible landing sites, such as their accessibility, safety, and scientific worth, are provided by MRO to help in the selection of landing sites for upcoming Mars missions.
- **Climate Monitoring:** The mission of the spacecraft is to study the climate history and possible habitability of Mars by tracking changes in temperature, atmospheric pressure, and seasonal fluctuations.

Launch:

On August 12, 2005, an Atlas V-401 rocket assisted in the launch of the Mars Reconnaissance Orbiter (MRO). It lifted out from Cape Canaveral Air Force Station Space Launch Complex 41 in Florida, USA. The journey to Mars commenced with the launch of the Atlas V rocket, powered by United Launch Alliance, into space.MRO's journey to learn more about Mars has started with this deployment. These include its topographical features, atmosphere from both the past and now, and possible habitability from either the past or present.

Orbital Insertion:

On Mars 10, March 2006; the Mars Reconnaissance Orbiter (MRO) managed to successfully enter orbit around the planet, Mars. This is so because, at this crucial point precise engine burns were vital to desist the spacecraft from moving fast and allow Mars’ gravity to capture it. Upon its entrance to the orbit, MRO applied aerobraking mechanisms that enabled the alteration of its course hence beginning detailed surveillance of the planet’s topography, weather conditions and climate like never before.

Scientific Instruments:

A variety of scientific equipment are carried by the Mars Reconnaissance Orbiter (MRO) to investigate different facets of the planet's surface, atmosphere, and temperature. The primary scientific tools on board MRO are as follows:

- **HiRISE (High-Resolution Imaging Science Experiment):** With the use of HiRISE, a high-resolution camera, scientists will be able to examine Martian surface features, geological formations, and possible landing places for upcoming missions.
- **CRISM (Compact Reconnaissance Imaging Spectrometer for Mars[1]**]): CRISM is a spectrometer that uses sunlight reflection to determine the mineral content of the Martian surface. It provides information on previous water activity and possible habitability by identifying minerals including carbonates, sulfates, and clays.
- **CTX (Context Camera):**CTX is a wide-angle camera that helps scientists discover areas of interest for additional instruments to explore in greater detail by providing background photos of the surface of Mars.
- **MARCI (Mars Color Imager):** MARCI is a wide-angle camera that takes daily, worldwide pictures of the planet in various wavelengths to track the weather and environment on Mars.
- **SHARAD (Shallow Radar):** SHARAD studies underlying phenomena including buried ice, silt layers, and geological structures by penetrating the Martian surface using radar pulses.
- **CRISM-Map (CRISM Mapping Spectrometer):** Detailed mapping of the mineralogy over the Martian surface is made possible by CRISM-Map, an enhanced version of CRISM with better spectral and spatial resolution.
- **RS (Radio Science):** RS gathers data on the gravity field and atmospheric density of Mars by measuring changes in the Doppler shift of radio signals sent from the orbiter to Earth.

Major discoveries:

- **Evidence of Water:**
  Images taken by MRO's HiRISE camera reveal evidence of ancient lake basins, deltas, and river systems on Mars, as well as other features associated with previous water activity. These results imply that water flowed across the surface of Mars when it was a warmer, wetter world.

- **Seasonal Flows**:
  Dark streaks on Martian slopes termed as "recurring slope lineae" (RSL) have been identified by MRO observations. These streaks appear annually. These RSL are thought to be brought on by the flow of briny water, which suggests that liquid water is still present on the surface today.

- **Mineral Mapping**:
  With the help of MRO's CRISM sensor, the distribution of minerals on Mars' surface has been mapped. Hydrated minerals, like sulfates and clays, are indicative of previous water activity. These mineral deposits shed important light on the possible habitability and geological past of Mars.

- **Impact Craters**:
  MRO has found and investigated a large number of impact craters on Mars, offering information about the geology and impact history of the planet. High-resolution photos taken by the spacecraft have provided information on impact processes, ejecta patterns, and crater shape.

- **Polar Ice Caps**:
  The polar ice caps of Mars have been measured in great detail by MRO, including their size, composition, and seasonal fluctuations. Scientists can better comprehend Mars' atmospheric dynamics and climate thanks to these data.

- **Active Geology**:
  MRO has found signs of recent landslides, lava flows, and dust devils, among other geological processes and volcanic activity on Mars. Mars's surface is being shaped by continuous processes, suggesting that the planet is continuously experiencing geological activity.

- **Martian Moons**:
  MRO acquired high-resolution images of Phobos and Deimos, two of Mars' moons, which allowed for the extraction of important information on their geological properties.

Mission Duration:

The Mars Reconnaissance Orbiter (MRO) was initially intended to be in operation for two Earth years. However, its mission has been extended several times as a result of its successful operations and ongoing scientific productivity. MRO is still in use and is still orbiting Mars, gathering important information about the climate, atmosphere, and surface of the planet. The spacecraft's durability and the importance of its findings in deepening our understanding of Mars are highlighted by its prolonged mission lifetime.

Why do we choose Mars as next Home:

- **Similarities to Earth:**
  When it comes to day length and axial tilt, Mars is the closest planet in our solar system to Earth, which makes it a more hospitable place for human habitation than other planets or moons.

- **Water Presence:**
  Although Mars is currently dry and barren, there is evidence that liquid water once covered its surface. Since water is necessary for life, its existence on Mars may help future human settlements that attempt to colonize or harvest resources.

- **Potential for Terraforming:**
  One of Mars' long-term objectives is to "terraform," or alter a planet's atmosphere to make it more resemble Earth. Mankind might be able to make Mars more livable by changing its temperature and atmosphere.

- **Interplanetary Expansion:**
  A major step in extending humankind beyond Earth and guaranteeing the long-term survival of our species is the establishment of a human presence on Mars. Humans can explore new horizons in space travel and lessen the risks of being limited to a single planet by building cities on Mars.

- **Technological Developments:**
  The difficulties of settling Mars, including creating habitable environments, methods for extracting resources, and life support systems, spur technological innovation and developments that can help both Earthly life and space exploration.

How will life be sustained on Mars?

- **Robotic Exploration:**
  Deploying advanced robotic rovers to thoroughly examine Mars. These probes would evaluate possible landing locations for human missions, carry out geological surveys, examine the Martian atmosphere, and look for water and other resources.

- **Human Missions:**
  Deploy crewed missions to Mars to perform brief stays, evaluate technologies, and acquire information in order to get ready for long-term settlement. The goal of these expeditions would be to build spacecraft that could carry occupants to and from Mars safely.

- **<u>Resource Identification</u>:**
  Finding and evaluating local resources that could be utilized to support infrastructure development and human settlement, including as minerals, water ice, and regolith (Martian soil), is known as resource identification.

- **<u>Recycling and Reusing Resources</u>:** Recycling and Reusing Resources: In order to minimize the need for replenishment from Earth, Martian communities will need to recycle and reuse as much as possible of their basic resources, including as water, air, and waste products.

- **<u>Technology development</u>:**
  Developing creating and testing the tools necessary for human living on Mars, including power generation, resource exploitation techniques, habitat construction, and life support systems.

- **<u>Communication Infrastructure</u>:**
  Building a dependable communication network between Earth and Mars will enable data transfer, remote control of robotic equipment, and mission planning for next expeditions.

- **<u>Habitats</u>:**
  Building sturdy homes that can protect occupants from the hostile Martian environment, including as intense heat, radiation, and dust storms, is important. These habitats would offer a secure and cozy place to live that is furnished with communication tools, power generating, and life support systems.

- **<u>Life support system</u>**:
  The creation of advanced life support systems that will give astronauts access to food, water, and oxygen. These systems would produce food through indoor farming or other sustainable techniques, recycle and purify water, and produce oxygen through electrolysis or other means.

- **<u>Food production</u>:**
  Setting up soilless farming methods such as aeroponics, hydroponics, or other sustainable systems to grow vegetables indoors. This would augment astronauts' diets with wholesome, locally farmed food and supply them with fresh produce.
- **<u>Sustainable Infrastructure</u>:**
  Build sustainable infrastructure on Mars, such as waste management facilities, communication networks, power generation, and transportation systems. Long-term human habitation would be made possible by this infrastructure, which would meet the needs of the Martian colony.

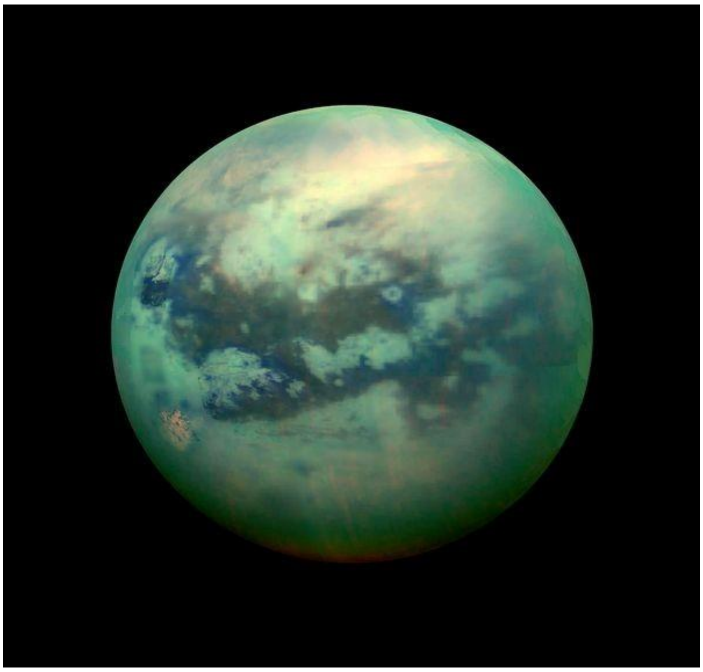
- **Energy Generation:**
  Producing electricity for research instruments, life support systems, and housing on Mars. Mars receives a lot of sunlight, making solar power a viable alternative. However, other energy sources, like nuclear power, might also be taken into consideration.

- **Healthcare and Well-Being:**
  Providing Martian residents with access to support networks and medical facilities to address their physical and emotional health. This covers medical treatment, psychological counseling, and steps to lessen the negative health consequences of extended space flight and the Martian environment on humans.

- **Governance and Management:**
  The establishment of management and governance frameworks is necessary to guarantee the smooth running of Martian colonies and their long-term growth. This includes rules, laws, and policies that control conduct, settle conflicts, and advance the general welfare.

TITAN

Titan, the largest moon associated with Saturn, is an extraordinary world. It is the only moon in our solar system with a significant atmosphere in more than 150 known moons. Besides, the only place within the solar system apart from earth that has liquids in form of rivers, lakes and seas is Titan.



Titan is our solar system's second largest moon ,larger even than mercury.
Similar to Earth, Titan has an atmosphere primarily composed of nitrogen, although Titan's surface pressure is 50% more than Earth's. Titan is home to methane and ethane-filled liquid hydrocarbon seas, rivers, lakes, and clouds.

The biggest oceans span hundreds of miles and are hundreds of feet deep.
Titan has a more liquid ocean beneath its thick layer of water ice, not a methane ocean.
Subterranean water on Titan may support life as we know it, whereas liquid hydrocarbon lakes and seas on the surface may support life with a distinct chemistry.

Distance from earth: 746 million miles, or 1.2 billion kilometers.

Comparison of Earth and Titan

1. Size

Titan is much smaller than Earth.

- **diameter:**

Planet Earth:around 12,742 kilometres (7,918 miles)

Titan: around 5,151 km, or 3,200 miles

The diameter of Earth is around 2.5 times that of Titan.

- **Surface Area:**

Earth: around 196.9 million square miles, or 510.1 million square kilometres

Titan: About 83.5 million square kilometres (32.1 million square miles) is Titan.

2.Shape

Because of their composition and the pull of gravity, Titan and Earth have different forms.

Earth: Earth is roughly an oblate spheroid, which means that although it rotates, it is primarily spherical but is slightly flattened in the poles and bulges at the equator. Gravitational forces and the rotation of the Earth combined to create this shape.

Titan: However, Titan's surface features such as mountains and valleys give it a more diversified appearance than Earth's, while having a same general spherical form. Titan differs from Earth's more pronounced landforms and oceans in that its low gravity and dense atmosphere also have an impact on its general shape and surface features.

3.Gravity

Because of these differences in their masses and radii, Titan and Earth have notably different surface gravities.

Earth: Earth's surface gravity is approximately 9.81 m/s^2

The surface acceleration of Earth is approximately 9.81 m/s^2. This indicates that Earth has a reasonably strong gravitational pull.

Earth's higher mass (around 5.97×10^{24} kilogrammes) and comparatively compact radius (about 6,371 km) contribute to its strong gravity.

Titan: Titan's surface gravity is roughly 1.352 m/s^2 which is one-seventh of Earth's gravity.

Titan has a surface acceleration of roughly 1.352 m/s^2, which is significantly less than Earth's gravity.

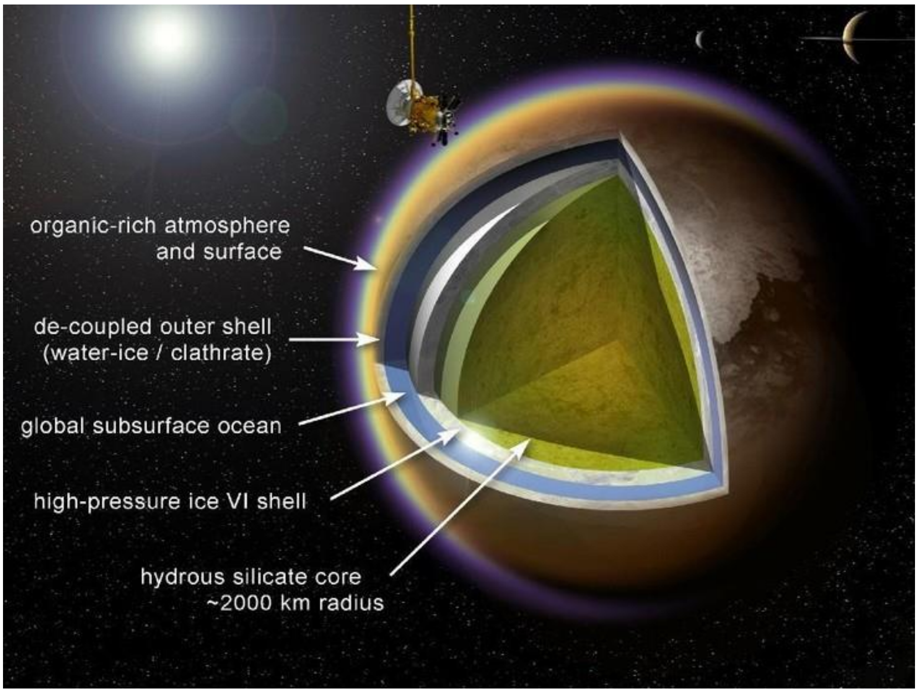
Titan has a smaller mass (around 1.35×10^{23} kilogrammes) and a lower density than the Moon, which makes its gravitational pull weaker even though it is larger than the Moon.

- **Effects of gravity**

  Earth: In several different manners is geology and life affected by the force that holds things down onto the surface of our planet; it has influence on landscape forming, brings about atmospheric pressure differences, supports bulky air columns and also enables movements such as jogging or even parkour.

Titan: Drops in Titan’s gravity have a lot of impact on the atmosphere and geology of Titan. Without leading to their falling apart from heaviness, it makes possible presence of high mountains and buildings. This implies how gases including the lighter ones either run out of or remain in the atmosphere.

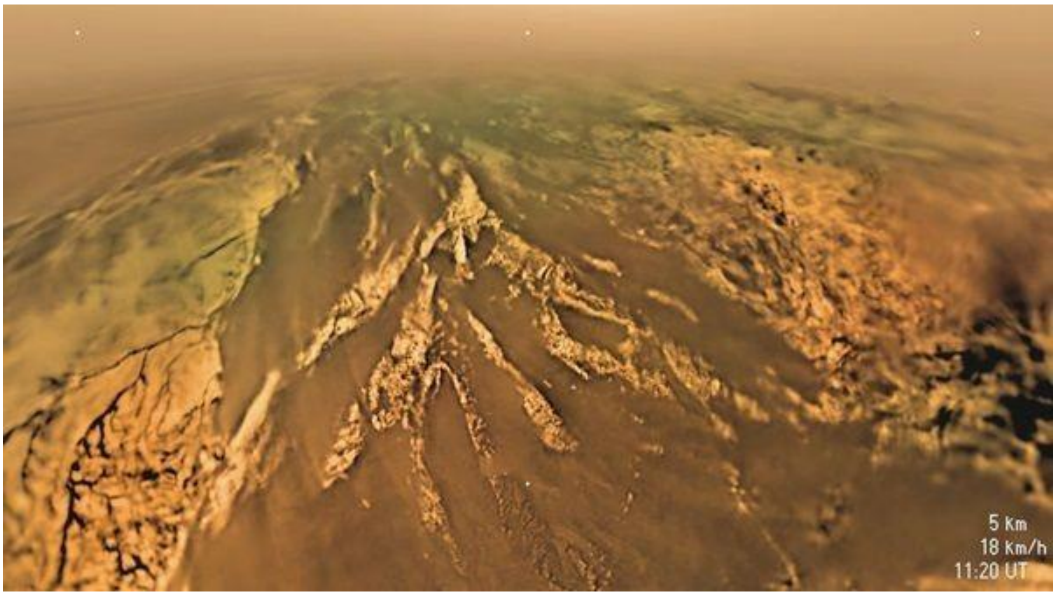
4.Internal structure



Earth: The internal structure of Earth have an exterior solid crust made of silicates, a solid mantle and very viscous asthenosphere, a liquid outer core that produces the Earth’s magnetic field, and a solid inner core.

Titan: Although Titan’s internal structure is unknown, one concept based on Cassini-Huygens mission data implies Titan has five main layers. A core of rock, namely silicate rock that contains water, approximately 2,500 miles (4,000 km) in diameter makes up the innermost layer. An outer layer of water ice, known as ice-VI, which is exclusive to extremely high pressures, envelops the core. A layer of briny liquid water encircles the high-pressure ice, and an outer crust of water ice rests over it. Organic molecules that have fallen or otherwise settled out of the atmosphere and taken the shape of liquids and sands cover this surface. A thick atmosphere envelops the surface.

5.Surface features



Due to differences in their compositions, atmospheres, and geological processes, Titan and Earth exhibit remarkably diverse surface features.

Earth: The continents, seas, mountains, valleys, forests, deserts, and many geological formations make up the planet's surface features.

Plate tectonics, erosion (by wind, water, and ice), volcanic activity, and impact cratering all shape the surface.

The atmosphere of Earth is dynamic and contains weather systems, such as clouds, precipitation, storms, and climate zones.

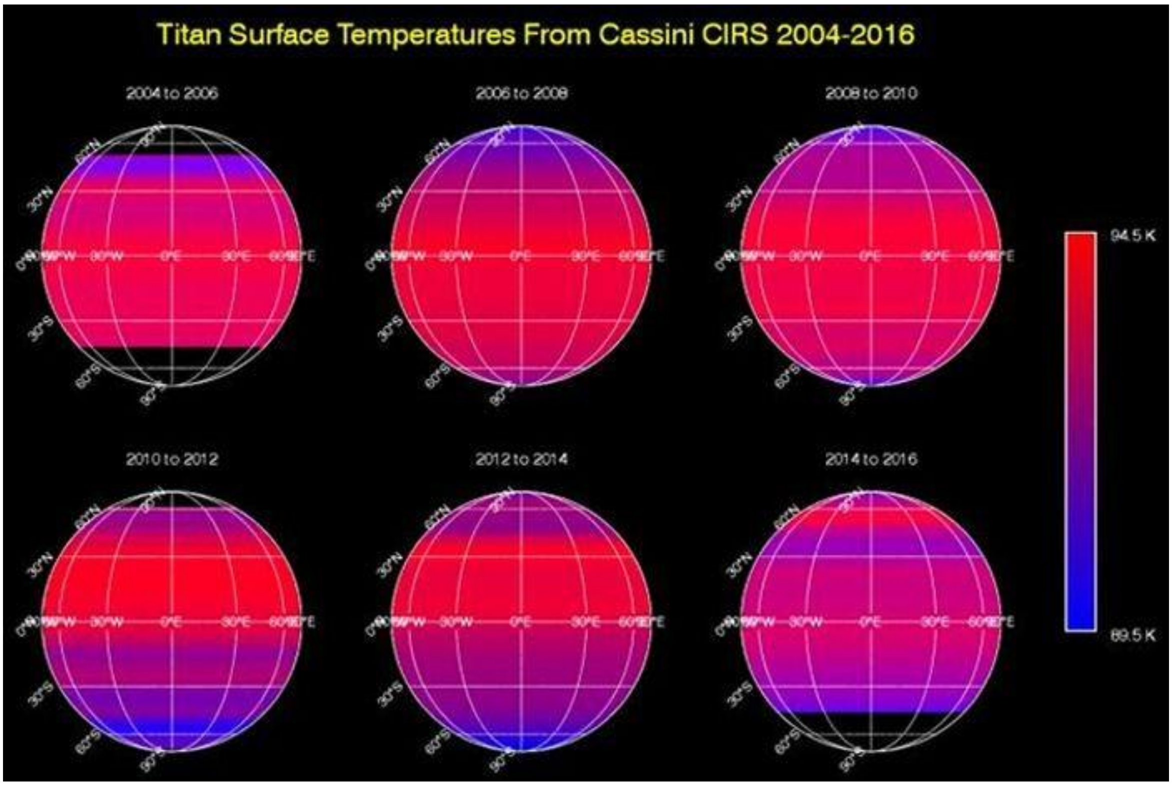
Titan: Large plains, sand dunes, lakes, and river valleys make up the majority of Titan's surface features.

Titan's hydrocarbon lakes and seas, primarily made up of liquid ethane and methane, are its most notable features.

There are vast dune fields composed of biological sand particles (tholins) and frozen mountains on Titan's surface.

6.Temperature

Because of differences in their surface characteristics, atmospheric compositions, and separations from the Sun, Earth and Titan have radically different temperatures.



Earth: The mean surface temperature of Earth is roughly 15°C (59°F).

The temperature of Earth varies greatly between distinct climate zones, from extremely hot in equatorial parts to below freezing in polar regions.

Ocean currents, surface albedo (reflectivity), sunshine, and atmospheric composition, which includes greenhouse gases, all have an impact on Earth's temperature.

Through the greenhouse effect, gases found in Earth's atmosphere, such as nitrogen, oxygen, carbon dioxide, and water vapour, significantly affect the planet's temperature.

Titan: The average temperature is around -179°C (-290°F) which is about the same as that on Titan. Titan orbits the sun roughly 1.4 billion kilometers (886 million miles) away hence explaining its extremely chilly surface.

Nitrogen is the primary constituent of its thick air, with traces of methane and other hydrocarbons making up the rest. Its atmosphere is quite efficient at retaining warmth because of these qualities and as such it mimics earth's greenhouse effect.

Titan's surface is more stable and warmer than predicted based on the amount of solar energy it receives, despite its distance from the Sun, thanks to its thick atmosphere and greenhouse gases.

7.Atmosphere

- **Composition**

Earth: With trace amounts of other gases including argon, carbon dioxide, and water vapour, the atmosphere of Earth is mainly made up of nitrogen (78%) and oxygen (21%).

Titan: The atmosphere of Titan is primarily made up of nitrogen (98.4%), with a notable proportion of methane (1.4%) and other trace gases such as ethane, hydrogen, and other hydrocarbons.

- **pressure**

Earth: Earth's atmospheric pressure at sea level is roughly equal to one atmosphere (atm), or 1013 millibars (mb).

Titan: Because of its thicker atmosphere and lower gravity, Titan has a surface atmospheric pressure that is approximately 1.5 bars (1.47 atm) higher than Earth's.

- **Weather and clouds**

Earth: Earth's atmosphere is responsible for a multitude of weather events, such as clouds, rain, snow, storms, and atmospheric circulation patterns that are influenced by Earth's rotation and solar heating.

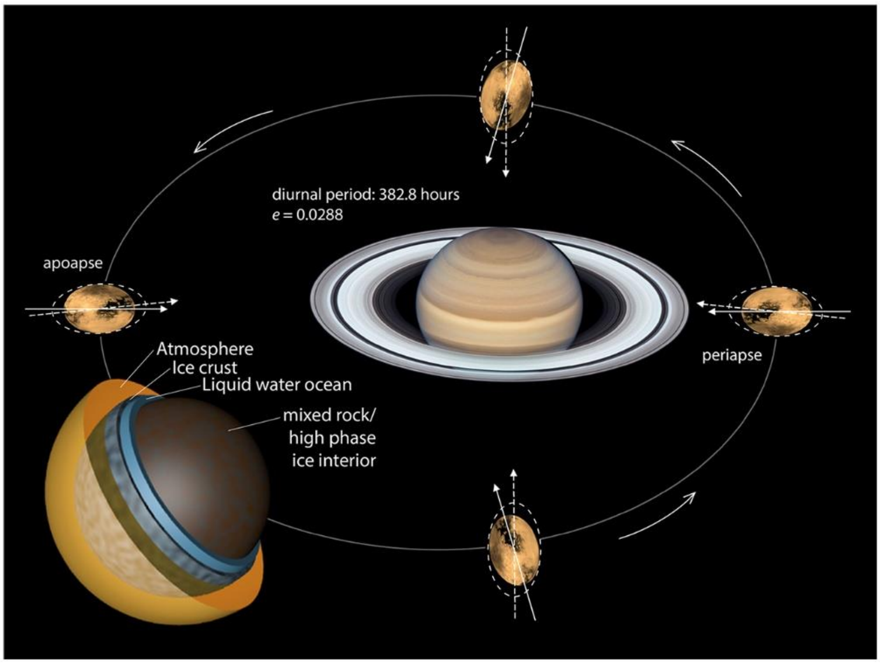
Titan: Seasonal variations, cloud formation, and the precipitation of ethane and methane are all features of Titan's dynamic weather patterns. Methane and ethane make up the majority of Titan's clouds, which result in rain and surface lakes.

- **Greenhouse effect**

  Earth: Gases like carbon dioxide and water vapour that cause heat retention and help to maintain suitable temperature range required for life on Earth make up the atmosphere of Earth.

  Titan: Methane and other hydrocarbons in the atmosphere of Titan cause a greenhouse effect that traps heat and increases surface temperatures that surpass what anyone might predict based on being situated on this moon alone.

- **8.Orbit and Rotation**

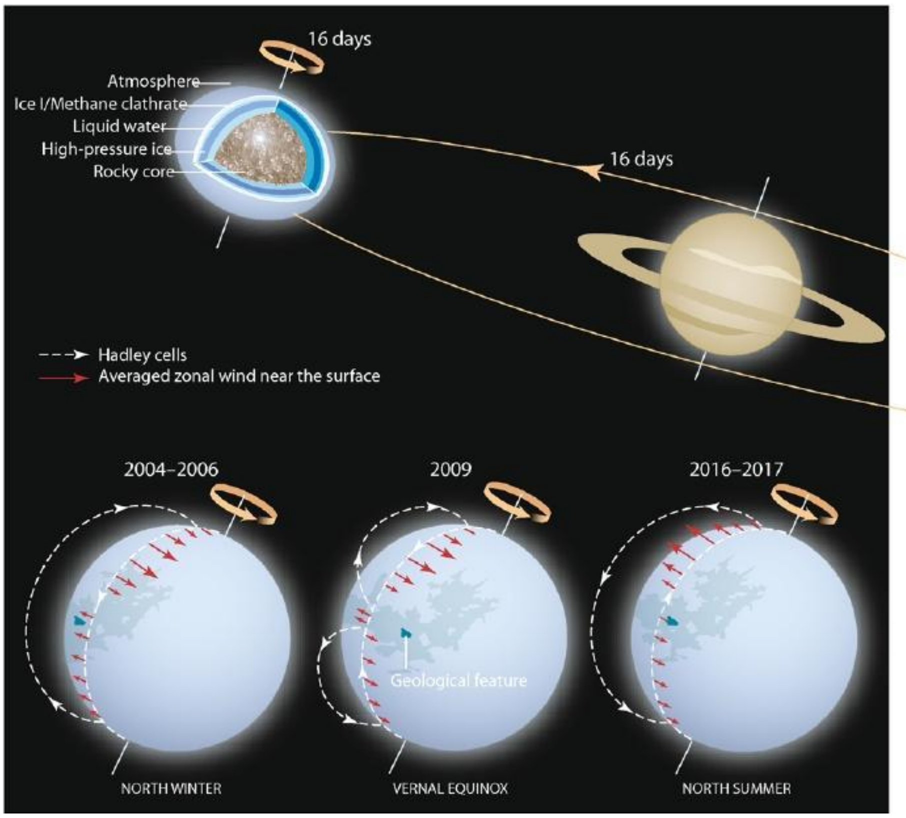


Earth and Titan have different rotational and orbital properties, which affect their seasons, climates, and geology.

- **Orbit**

Earth: Earth travels in an elliptical orbit around the Sun, covering a distance of roughly 149.6 million kilometres (92.96 million miles) on average every 365.25 days. One Earth year is defined by this period.

Titan: Titan's typical orbital radius around its parent planet, Saturn, is around 1.2 million kilometres (746,000 miles). A Titanian year is defined as one orbit around Saturn that takes around 29.5 Earth years to complete.



- **Rotation**

Earth: The planet revolves around its axis, with one full rotation taking place about every twenty-four hours, or one Earth day. In addition to influencing patterns of atmospheric and oceanic circulation, this rotation time establishes cycles of day and night.

Titan: Titan exhibits synchronous rotation, which is the rotation of Titan on its axis at a period synchronised with its orbit around Saturn. This implies that, like the Moon's synchronous rotation with Earth, one side of Titan is constantly facing Saturn. Its orbital period around Saturn is equivalent to one Titanian day, or roughly fifteen Earth days.

- **Impact on climate and seasons**

Earth: Seasonal changes occur in the two hemispheres due to Earth's axial tilt, which is around 23.5 degrees relative to its orbit around the Sun. The Earth's seasons and climatic patterns are shaped in part by this tilt.

Titan: Due to its synchronous rotation and unique orbit, Titan has lengthy seasons that extend beyond several Earth years. Because of its much lesser axial tilt (approximately 0.3 degrees) than Earth's, seasonal fluctuations are less noticeable.

- **Geological and surface impacts**

Earth: Geological formations, oceans, and continents are all influenced by the planet's orbit and spin. The dynamics of Earth's orbit and rotation promote tectonic activity, erosion, and weathering.

Titan: The synchronous rotation of Titan has an impact on its climatic patterns and surface features. Because of its slow rotation and far-off orbit from the Sun, it suffers cryovolcanism, river-like features, and dunes sculpted by winds and surface processes.

9.Minerals

Earth : Mica, olivine, quartz, feldspar, and other silicate minerals make up the majority of the Earth's crust.

The building blocks of the rocks and minerals that make up the Earth's crust, mantle, and core are silicate minerals, which are widely distributed on the planet.

Other minerals that can be found on Earth are oxides (like hematite), carbonates (like calcite), sulphides (like pyrite), and other metal ores (including iron, copper, and aluminium).

Titan : Rather than silicate minerals, the majority of Titan's surface is made of water ice and hydrocarbon molecules.

Titan has a lot of water ice, which may be found in many different forms, such as water ice grains in the atmosphere and water ice bedrock.

Titan is reddish-brown in colour because of other organic molecules, such as tholins, which are complex chemical compounds made from simple molecules under ultraviolet light.

In conclusion, silicate-based minerals make up the majority of Earth's material composition, whereas organic molecules, hydrocarbon compounds, and water ice dominate Titan's surface. The variations in mineral makeup are a reflection of the unique geological

10.Water content

As we know the water content in earth let's discuss about Titan

It is known that Titan, Saturn's largest moon, has a sizable amount of water in it in different forms. It is important to note, though, that liquid water is rare on Titan's surface because of the extremely low temperatures, and the majority of Titan's water content is found in the form of ice.

Water Ice: Water ice, which can be found in a variety of forms, including icy plains, ice volcanoes (also known as cryovolcanoes), and water ice bedrock, makes up Titan's surface.

Titan has a lot of water ice, which is essential to the formation of the planet's mountains, valleys, and impact craters.

Spacecraft missions like Cassini, which found water ice on Titan's surface and in its atmosphere, provide evidence for the existence of water ice.

Liquid Water: Titan's surface is extremely cold, averaging -179°C or -290°F. As a result, liquid water is scarce there, however some scientists theorise that liquid water may exist in underground oceans or aquifers beneath Titan's icy crust.

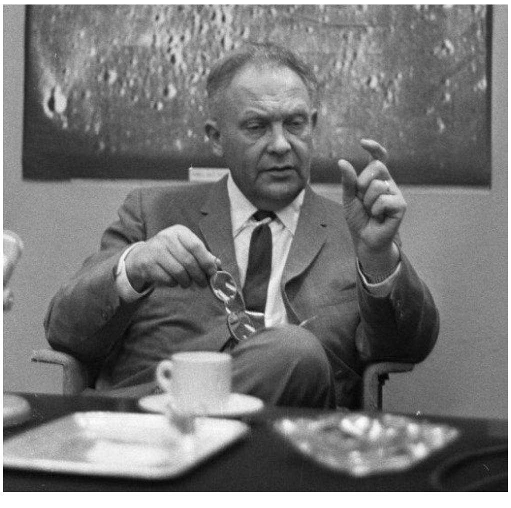
Geological features and processes seen on Titan, such as methane-ethane lakes and seas, which may interact with subsurface water reservoirs, imply the existence of liquid water beneath the surface.

Lakes and Seas of Hydrocarbons: Titan is well-known for its rivers, lakes, and seas that are made of liquid ethane and methane rather than water.

Projects and Studies based on Titan

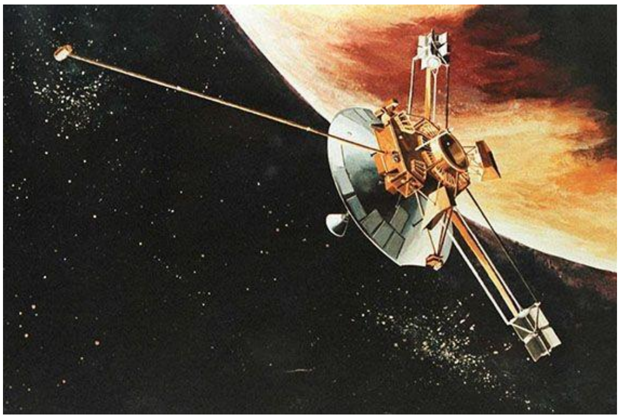
1.Who found Titan?

Titan, Saturn's largest moon, was found by Dutch astronomer Christiaan Huygens on March 25, 1655. About 300 years later, in 1944, Dutch-American astronomer Gerard Kuiper made a significant



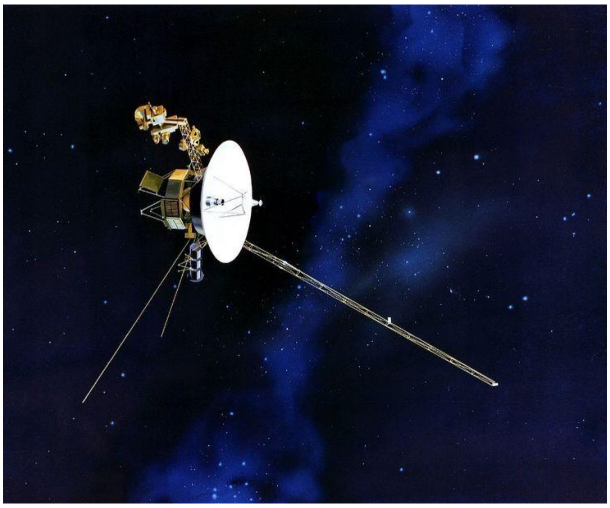
discovery that would distinguish Titan with a fact that, this distant moon does, in fact, contain an atmosphere. Kuiper made the discovery by shining sunlight reflected from Titan through a spectrometer, which he used to identify methane. Titan's atmosphere was shown to be dense and hazy by additional observations made with Earth-based telescopes.

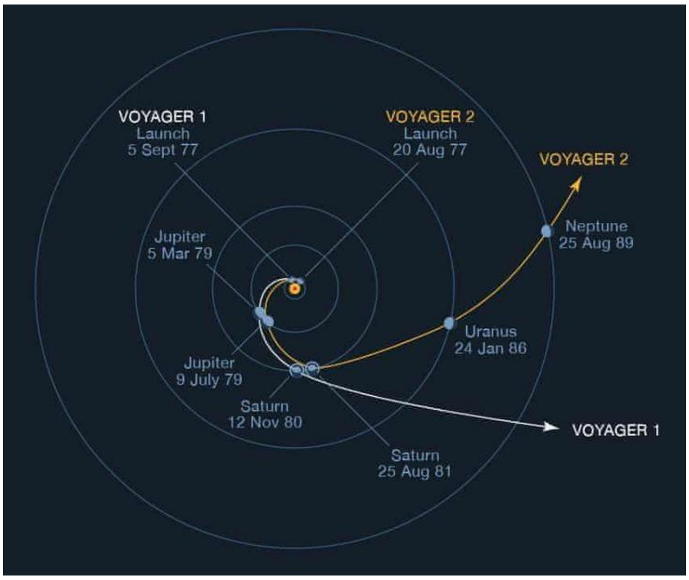
2.Pioneer 11



The Pioneer 11, which was the initial spacecraft to study Titan, his Saturn system on the 1st of September in 1979. While the information of Titan's mass and temp had been established by human observers, also a trend that was shown to be accurate using Pioneer 11. At that time, researchers had erroneously thought that Titan could be the biggest moon in the whole solar system because its atmosphere was long and impenetrable. Titan's upper atmosphere was also partially visible to Pioneer 11, and scientists anticipated the Voyager spacecraft would be able to observe this bluish haze. And it takes some pictures of titan too.

3.Voyager 1 and Voyager 2



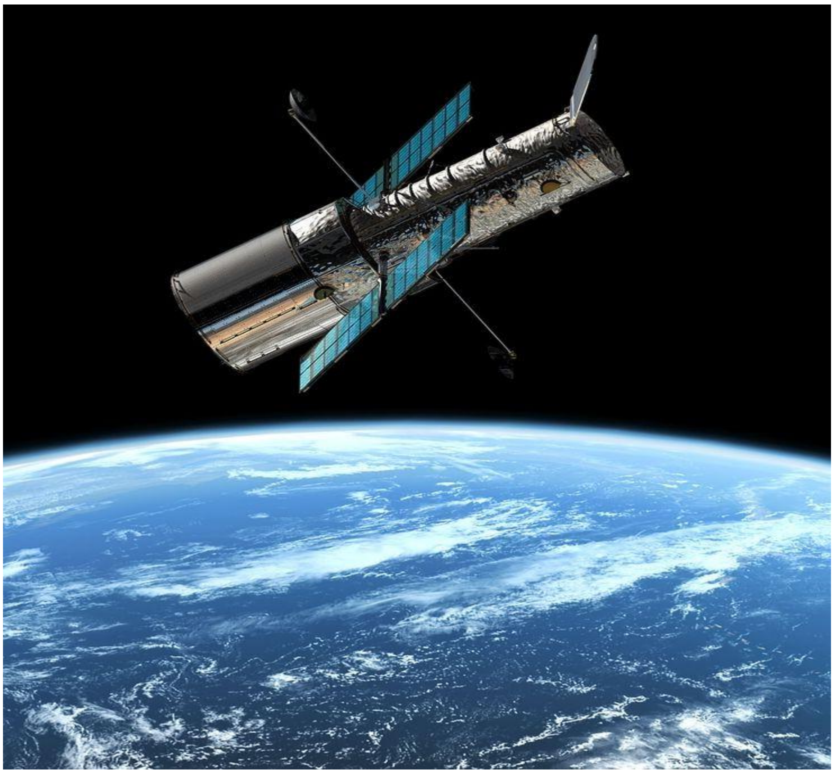


Titan's atmosphere made it impossible for the Voyager 1 and 2 spacecraft to observe its surface during their passage through the Saturn system in 1980 and 1981; instead, photographs from that voyage rev ealed an orange world devoid of features. However, the blue haze was visible to them as a layer of Tit an's upper atmosphere that appeared to be unattached.
A few scientists conjectured that Titan might have oceans of liquid hydrocarbons prior to Voyager 1's arrival in the Saturn system because of the moon's frigid temperatures and methane content.
However, Titan's thick atmosphere prevented the Voyager spacecrafts' cameras from penetrating it lon g enough to obtain a good picture of the surface.
Nonetheless, Voyager did discover that Titan's atmosphere was mostly nitrogen and that it contained t races of acetylene, ethane, and propane in addition to other organic compounds.

Titan’s surface temperature, air pressure, and radius were all ultimately measured by Voyager 1, and the results showed that Titan is actually the second-biggest moon in the solar system the largest being Jupiter’s Ganymede rather than the largest, which is Mercury. Together with this, the explorers noticed a noticeable shift in brightness from north to south, which was initially thought to be the result of seasonal variations and subsequently verified.

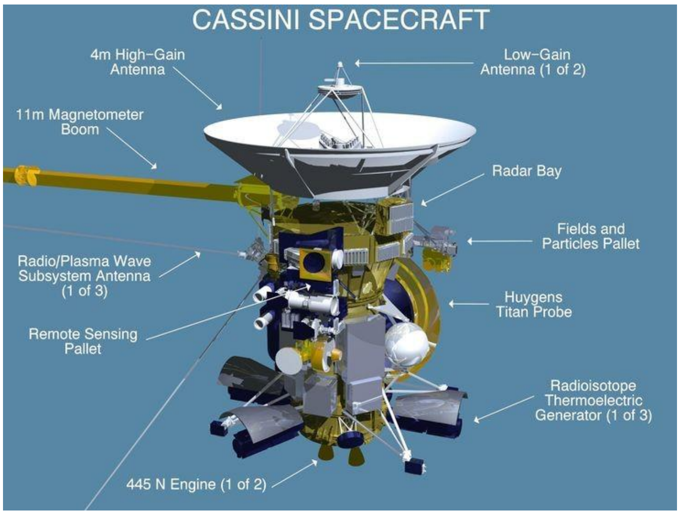
4.Hubble Space Telescope

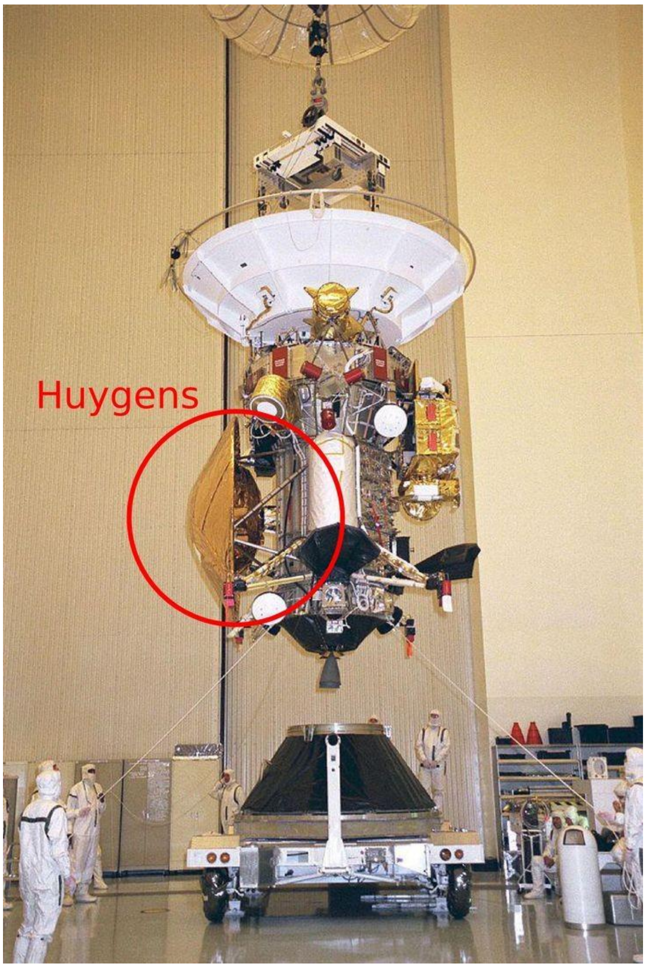
Using specific colours of infrared light that might cut through the haze, NASA’s Hubble Space Telescope took images of Titan in 1994. Huge regions of light and dark were visible in the Hubble



photos, one of which was the size of Australia. However, the existence of liquid oceans was not established by the Hubble data, and until 2004, it was unknown what lay beneath Titan’s haze.

5.Cassini-Huygens Mission





In 2004, the Huygens probe from the European Space Agency was joined to the Cassini spacecraft, making it the first object created by humans to orbit Saturn. Cassini saw Titan for the first time almost immediately, looking through the haze. On January 14, 2005, the Huygens probe made history by becoming the first spacecraft to land on Earth when it broke free from Cassini and parachuted through Titan’s atmosphere. Huygens took pictures and measured atmospheric parameters both from the surface and during its descent. It then sent the information to Cassini, which then sent it back to Earth. Using a variety of equipment, like as radar and infrared instruments, Cassini conducted 127 close flybys of Titan over the course of 13 years in order to finally provide scientists with a thorough image of the planet. And it gave scientists detailed information about the moon’s surface and complex atmosphere .

Polar winds, which pull nitrogen and methane (charged by interactions with light) out of Saturn’s atmosphere and along its magnetic field, have been observed by the Cassini mission. It is thought that our own magnetic field on Earth goes through a similar process.

Cassini-Huygens' exploration of Titan's surface features revealed lakes and rivers of liquid hydrocarbons on the top, but under the surface, an ocean of liquid saltwater beneath clouds pouring down.

NASA's Jet Propulsion Laboratory website states that Cassini and Huygens discovered the largest moon of Saturn, Europa, which is one of the planets most similar to Earth. These discoveries included new meteorological, climatic, and geological patterns that will aid in our understanding of how our planet functions.

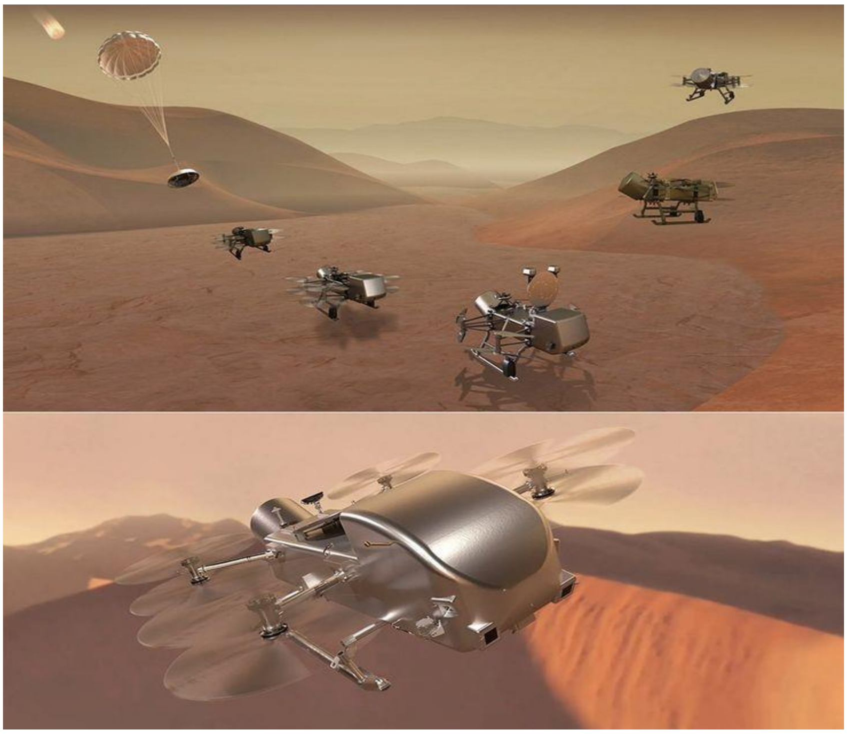
- **<u>About Huygens probe</u>**

A distinctive and sophisticated spacecraft, the European Space Agency's Huygens Probe played a vital role in the larger Cassini mission to study Saturn. The probe weighed approximately 700 pounds (318 kilogrammes) and measured about 9 feet diameter (2.7 metres). It was constructed similarly to a mussel, with a hard shell shielding its delicate innards from intense heat as it descended through Titan, Saturn's massive moon, for two hours and twenty-seven minutes.

There are two parts to the probe: the Entry Assembly Module and the Descent Module. The Entry Assembly Module consisted of a heat shield acting as both a brake and protective device, as well as mechanisms for controlling Huygens once it separated from Cassini. The Descent Module contained scientific instruments plus three different types of parachutes used one after another to control Huygens' descend to Titan's surface.

6.Conformed Future Missions

- **<u>Dragonfly Mission</u>**



Titan will be visited by a robotic rotorcraft as part of the Dragonfly NASA spacecraft project. The launch window is set for July 2028, with an arrival date of 2034. The goal of this first aircraft on Titan is to explore prebiotic chemistry and alien habitability by conducting the first powered, fully controlled atmospheric flight on any moon. Next, it would transport itself between exploration areas using its vertical takeoffs and landings (VTOL) capability.

Why we choose Titan ?

- As we know Titan is the best known place to harbour life after Earth. And it the most Earth like world we have ever seen on our solar system. Scientists are looking forward for further studies about sustaining life on Titan. As part of humanity's larger space exploration and hunt for habitable planets beyond Earth, Titan is being investigated for possible colonisation.
- Despite its strange name, Titan is actually one of the solar system's friendliest planets. Titan's nitrogen atmosphere is so dense that walking the surface would not require a pressure suit for humans. But given that Titan's surface is about minus 290 degrees Fahrenheit (minus 179 degrees Celsius), he or she would also require an oxygen mask and protection from the cold.

  Because of the thick atmosphere, Titan's surface is less affected by the radiations. Titan's dense atmosphere, which is mostly nitrogen with some methane, acts as a barrier against micrometeoroids and cosmic radiation It is possible to utilise this atmosphere for a number of purposes, including the creation of fuel or the provision of breathable air for humans.

- Rainfall on Titan would occur more slowly than on Earth due to its dense atmosphere and gravity, which is about the same as that of the Moon. Rainfall on Titan is estimated by scientists to occur at a rate of roughly 3.5 miles per hour (1.6 metres per second), which is roughly six times slower than rainfall on Earth, which occurs at a rate of about 20 miles per hour (9.2 metres per second). Titan is known for his enormous rains. Raindrops on Earth can only have a maximum diameter of 0.25 inches (6.5 millimetres), but raindrops on Titan can have a maximum diameter of 0.37 inches (9.5 millimetres), which is approximately 50% larger than an Earthly raindrop. However, hydrocarbons make up these raindrops.

  The only known celestial body with stable liquid surfaces, aside from Earth, is Titan. But instead of water, these are liquid hydrocarbons, such as ethane and methane. These could be used as a possible fuel source

- Evidence points to the possibility of subterranean water ice on Titan, which may be harvested and utilised for agriculture, drinking water, and other necessities for human settlers.

- Studying Titan's intricate organic chemistry could shed light on possible primordial chemistry that existed on Earth before life first appeared

- Because Titan has a gravity that is roughly one-seventh that of Earth, building and moving around may be simpler for human residents.

- Titan's surface is smooth and icy, which may present prospects for landing and infrastructure development.

- Titan offers a distinctive research facility for investigating organic chemistry, prebiotic environments, and putative biosignatures.

On Titan, establishing dwellings or research stations would facilitate further scientific investigation and discovery.

- Titan colonisation could be a means of planetary defence, guaranteeing human survival in the case of major world disasters

- The creation of sustainable methods and technology for surviving in harsh conditions may find use both on Earth and in upcoming space exploration projects.

- Building human settlements on Titan is consistent with the long-term goal of humankind becoming a multiplanetary species and extending its reach beyond Earth.

- It might promote cross-national cooperation, technical developments, and commercial prospects in space travel and settlement.

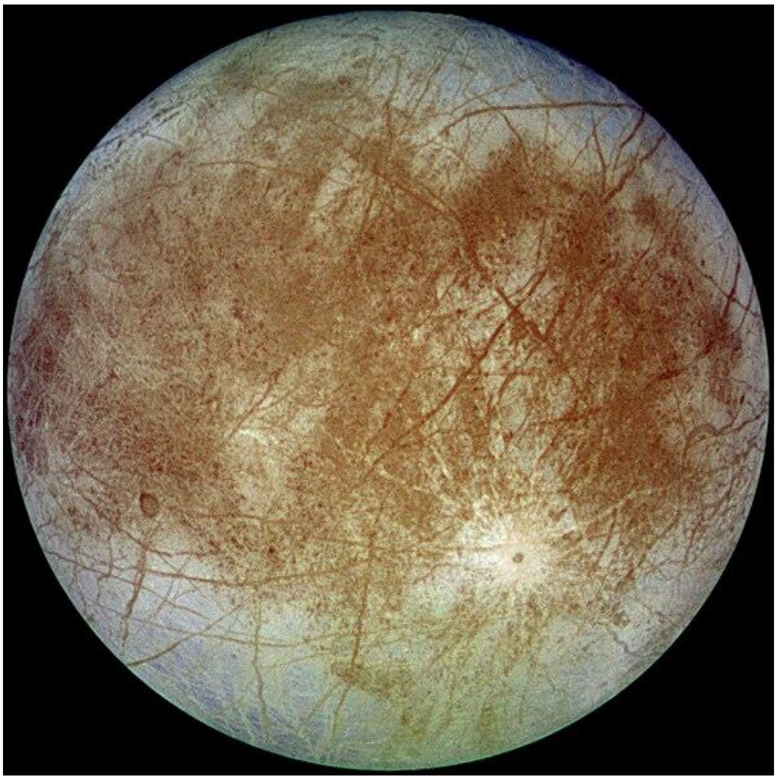
- And one of the main things is that when the sun becomes a red giant, the habitable zone shifts to the positions where Jupiter and Saturn are situated, making it easier to protect humans from extinction.

- Chances of formation of life like microorganisms are high in the water below the ice crust.

It is important to remember, though, that colonising Titan is still a theoretical idea with many obstacles to overcome, including as extremely low temperatures, a dearth of breathable air, little sunlight, and the requirement for self-sustaining infrastructure and dwellings. In the far future, serious consideration of such an endeavour would involve extensive research, technological innovation, and international cooperation.

EUROPA

Europa is governed by Jupiter and happens to be the smallest among the quartet of Galilean moons as well. Moreover, the satellite is the sixth biggest within our solar system though comparatively smaller than Earth's own moon; this makes it a scientific marvel to cosmologists everywhere. With a silicate rock composition, Europa has both an outer crust largely comprised of water ice plus an inner nickel-iron core. Although the spheroid has little air surrounding it compared to earth's atmosphere, what little there is contains mostly oxygen interspersed with some water vapor.Some models suggest that because of the heat from the tidal flexing causes the results the ocean to remain liquid. Europa is the smoothest known object in the Solar System.



COMPARISON BETWEEN EARTH AND EUROPA:

1. **SIZE**

   Europa: Europa's diameter is about 3100 kilometers that is about 1940 miles.

   Earth: Earth's diameter is about 12,756 kilometers (7926 miles).

2. SHAPE

Europa: When the Europa comes a lit bit nearer to the planet Jupiter, Jupiter's gravitational force increases resulting the Europa to elongate towards and away from it.
And when the Europa moves away from the Jupiter, Jupiter's gravitational attraction decreases and hence Europa relaxes back to its spherical shape.
And this creates tides in its subsurface oceans which makes the ocean to remain in the liquid state.

Earth:
The shape of the Earth could be described almost like an oblate spheroid or an oblate ellipsoid for that matter which means it is bulged at the equator and flattened at the poles; this bulge is due to Earth's rotation.

3. TEMPERATURE

Europa: Europa's surface temperature is about 50K (-220 degree Celsius) at the poles and 110K (-160 degree Celsius) at the equator.

And this makes the Europa's crust so hard.

Earth: Earth's surface temperature is about 15 degree Celsius (59 degree Fahrenheit).

There are some reasons which affects the planet in making such a temperature. One such reason is Green house effect.

As a result the gases in the Earth's atmosphere naturally affects the Earth's temperature which increases the Earth's temperature.

And the other reason is the human activities which makes the change in the Earth's temperature.

4. ATMOSPHERE

Europa: Europa has a very thin atmosphere and it consists mostly of oxygen while containing traces of water vapor. However, the oxygen is not produced organically. On Europa, frosty ground makes it extremely cold, so when being irradiated with solar ultraviolet light sources, as well as charged particles (electrons, ions) from Jupiter's magnetosphere, steam turns into hydrogen and oxygen almost in the same time.

The hydrogen is light enough to continue traveling through the atmosphere's surface gravity, leaving just oxygen in its wake. Through the process of radiolysis, or the dissociation of molecules by radiation, the surface-bounded atmosphere is created.

Earth: Atmosphere of Earth is mainly made up of gases like Nitrogen (78%), Oxygen (21%), Argon (0.9%), 0.1 percentage of other gases. The 0.1 percent include the traces of Carbon dioxide, Methane, Neon, etc.

5. WEATHER

Europa: Europa’s weather is extremely cold. Europa lacks the characteristics like wind, precipitation, colour in the sky.

Earth: Earth have weather like wind, cloud, rain, snow, fog, and storms. It can be caused due to the solar radiation, large oceans in the Earth, different types of landscapes.

6. MINERALS

Europa: The composition of the reddish-brown material covering fissures and other young geological structures on the surface of Europa.

Spectrographically, these reddish streaks on Europa’s surface may be enriched in salts like Magnesium Sulfate. Sulfuric acid hydrate is also observed.

Presence of abiotic organic compounds like Tholins are observed. And these may bring some implications like prebiotic chemistry and abiogenesis.

It has been observed that sodium chloride is present in Europa’s subsurface sea. In the internal ocean of Europa, carbon was observed in the form of carbon dioxide on the surface ice, and was noted as being a component of the subterranean oceans.

Earth: 98% percent of Earth’s crust is made up of Oxygen, Iron, Silicon, Sodium, Potassium, Aluminium, and Magnesium.
And rest by Phosphorus, Manganese, Sulphur, Hydrogen, Carbon, Nickel, Titanium and others.
More than 2000 minerals constitute Earth’s crust but the most plentiful minerals are Quartz, Pyroxenes, Feldspar, Amphiboles, Olivine and Mica.

7. WATER CONTENT

Europa: Below Europa's surface is a layer of liquid water. The heat generated by the tidal flexing keeps the subsurface ocean to continue to exist as liquid.

Because of its normal surface temperature, which is just 50 K (−220 °C; −370 °F) in the poles and 110 K (−160 °C; −260 °F) at the equator, Europa's icy crust persist as hard as granite.

Theoretical concerns of tidal heating provided the first indications of a subsurface ocean.

Based on study of Voyager and Galileo photos, members of the Galileo imaging team argue in favour of the presence of a subterranean ocean. The most striking example is "chaos terrain," a surface feature that is widespread to Europa and which some scholars interpret as a location where the ice crust has melted to reveal the deep ocean.

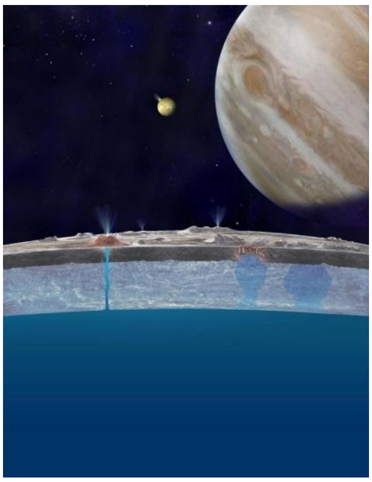
This interpretation is debatable. The majority of geologists who have researched Europa support the "thick ice" theory, according to which the ocean has hardly ever, if at all, directly impacted the current surface.

When the massive craters on Europa are examined, they provide the most solid proof for the thick-ice hypothesis. It has been calculated that the ice-covered outer shell is composed of solid ice, plus a soft "warm ice" layer, 10-30 kilometers (6-20 mi) deep beneath it. This may therefore mean that liquid water ocean under the ice sheet is probably approximately 60 miles (100 kilometers) deep.

Ice has filled the central peak ring structures of the largest impact basins and seems to be made of fairly smooth relatively young. These data are based on the energy produced by tidal forces within Europa. As a result, the volume of water in these oceans is 3×1018m3, 2 times more than twice as much as in Earth’s oceans.

Earth: Water covers around 71% of the Earth's surface, with the seas containing 96.5 percent of the planet's total water. Aquifers, rivers, lakes, icecaps, glaciers, the earth's soil, and water vapor in the air are among the other places where water can be found.

8. SURFACE FEATURES

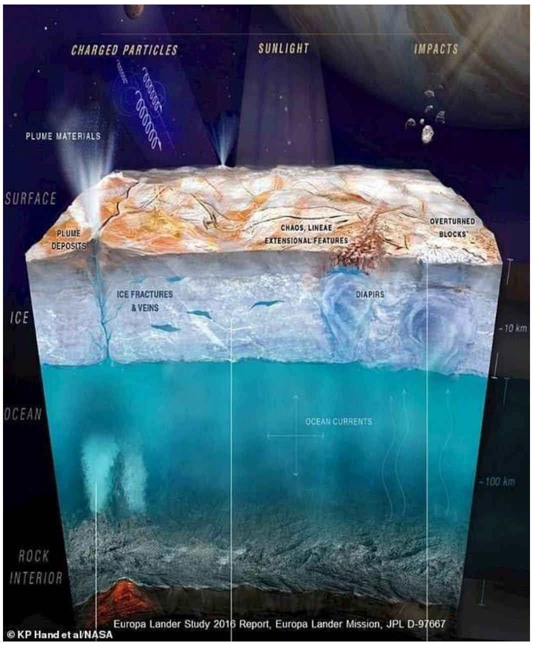


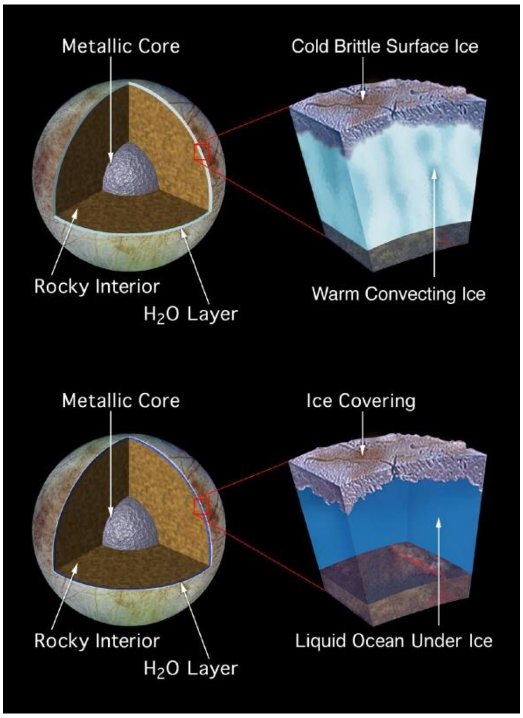
Europa: Europa does not have any large scale features such as Mountains, Craters. Due to the fact that direct sunlight reaches Europa's equator ice sublimes hence forming vertical fissures with resultant frozen spikes called penitentes that may rise up to 15m high.

Albedo characteristics that highlight low terrain believed to be the primary cause of the noticeable marks that crisscross Europa.

Earth: The barrier separating the solid Earth, the oceans, and the atmosphere is the Earth's surface.
Earth’s surface features include Mountain ranges, forests, seas, oceans, valleys, deserts, volcanoes, subduction trenches, tectonic plates and mid-ocean ridges.

9. INTERNAL STRUCTURES





Europa: Around 100 kilometers of water make up Europa's outer layer, which is divided into two sections: a liquid ocean beneath the ice and a portion of frozen crust. There may be a subsurface conductive layer on Europa since recent magnetic-field measurements from the Galileo satellite revealed that the planet interacts with Jupiter to produce an induced magnetic field.

This layer most likely consists of an ocean of salted liquid water. Roughly 80° of rotation is thought to have occurred in some parts of the crust, almost toppling over, which is improbable if the ice were firmly affixed to the mantle.

Europa most likely has a metallic iron core.

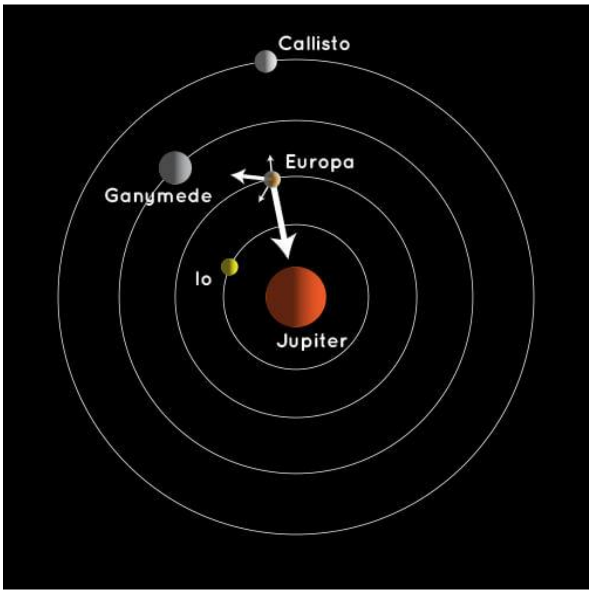
Earth:
Substratum: An outer layer of chemically distinct silicate solid crust rests atop an extremely viscous solid mantle.

The crust and the cold, hard top of the upper mantle make up the lithosphere, which is made up of tectonic plates that move apart from one another.

The layer that sits below the lithosphere is called the asthenosphere, and it is less viscous than the lithosphere.

Beneath the mantle is a solid inner core and a liquid outer core with extremely low viscosity.

10. ORBIT AND ROTATION



Europa: The same side of the moon is constantly facing Jupiter because Europa is linked to the planet by gravity and orbits it every 3.5 days.

Because Jupiter rotates almost completely on its axis, neither the planet nor any of its other moons, like Europa, have seasons like those on Earth. Jupiter is orbited by Europa twice.

Europa's eccentric orbit causes variations in its distance from Jupiter, with the near side of the moon experiencing Jupiter's gravity more intensely than the far side.

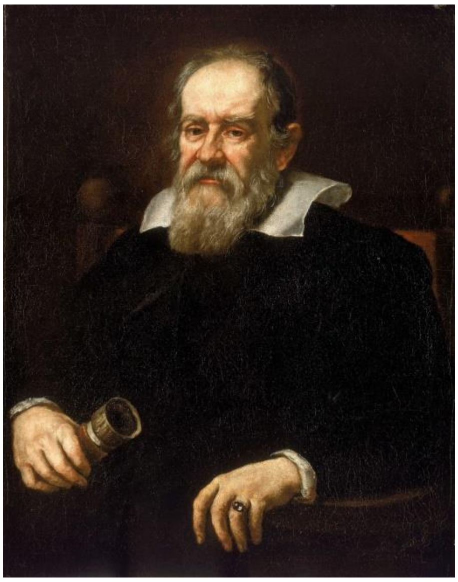
As Europa orbits, the amount of this difference varies, causing tides that stretch and relax the moon's surface.

Earth: Earth is a planet in the inner Solar System and the third closest planet to the Sun due to its orbit around the Sun.

The average orbital distance of Earth is around 150 million km, or 380 times the distance from Earth to the Moon.

In one sidereal year, or 365.2564 mean solar days, Earth completes one orbit around the Sun.

WHO FOUND EUROPA?



On January 8, 1610, Galileo Galilei made the discovery of Europa, along with that of Jupiter's other three major moons, Io, Ganymede, and Callisto. Simon Marius may have made the discovery on his own. Galileo had used a 20×-magnification refracting telescope at the University of Padua to examine Io and Europa jointly on January 7, but the inadequate resolution was unable to distinguish the two objects. He initially observed Io and Europa as distinct bodies the same evening.

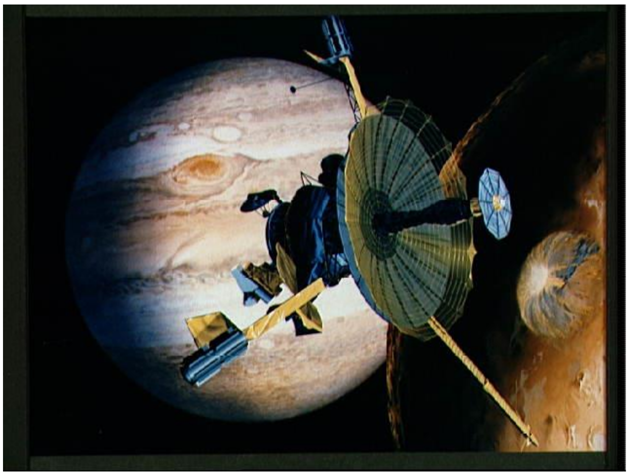
STUDIES RELATED TO EUROPA

1. PIONEER 10 AND 11

Pioneer 10, a NASA spacecraft, successfully completed the first mission to reach Jupiter in 1972. And Pioneer 11 is a robotic space probe operated by NASA that was launched on April 5, 1973, with the goal of studying the solar wind, cosmic rays, the asteroid belt, and the region surrounding Jupiter and Saturn.

Pioneer 10 and 11's flybys of Jupiter in 1973 and 1974, respectively, marked the start of Europa exploration. The resolution of the initial close-up images was lower than that of subsequent missions. In 1979, saw the passage of the two Voyager spacecraft through the Jovian system, giving scientists a better understanding of the ice surface of Europa. Numerous experts conjectured about the likelihood of a liquid ocean beneath the photos.

2. GALILEO SPACE PROBE



Galileo was a robotic spacecraft built by the United States that investigated the asteroids Gaspra and Ida, as well as the planet Jupiter and its moons. It had an orbiter and an entrance probe, and it was named for the Italian astronomer Galileo Galilei.

The Galileo space probe, which launched in 1995 and orbited Jupiter for eight years until 2003, offered the most thorough analysis of the Galilean moons to that point. Several close flybys of Europa were conducted as part of the "Galileo Europa Mission" and "Galileo Millennium Mission."

3. JUNO SPACECRAFT

A NASA spacecraft named Juno is orbiting Jupiter. Lockheed Martin built it, and NASA's Jet Propulsion Laboratory runs it.

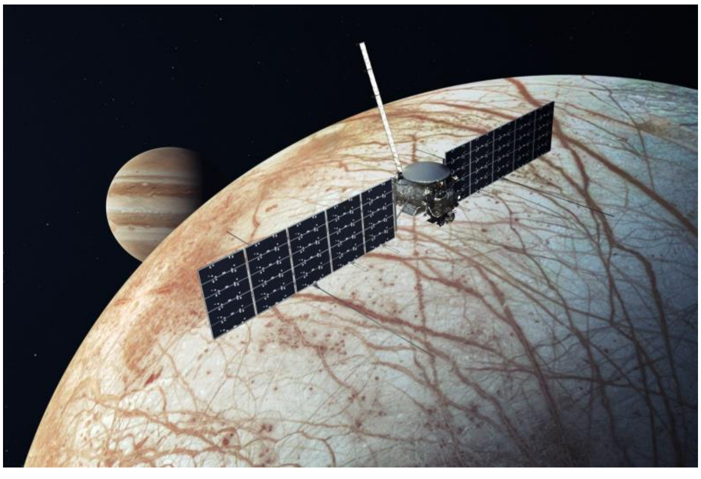
The Juno orbiter passed over Europa in 2022 at a distance of 352 km.

4. JUPITER ICY MOONS EXPLORER (JUICE)

The goal of the interplanetary spacecraft Jupiter Icy Moons Explorer is to orbit and investigate Ganymede, Europa, and Callisto, three of Jupiter's icy moons.
The European Space Agency (ESA) decided to proceed with the Jupiter Icy Moons Explorer (JUICE) mission in 2012. Although two flybys of Europa are part of the project, Ganymede is the main focus. After eight years of journey and four gravity assistance, the spacecraft was launched in 2023 and is predicted to arrive at Jupiter in July of 2031.

UPCOMING MISSIONS FOR EUROPA

1. EUROPA CLIPPER:

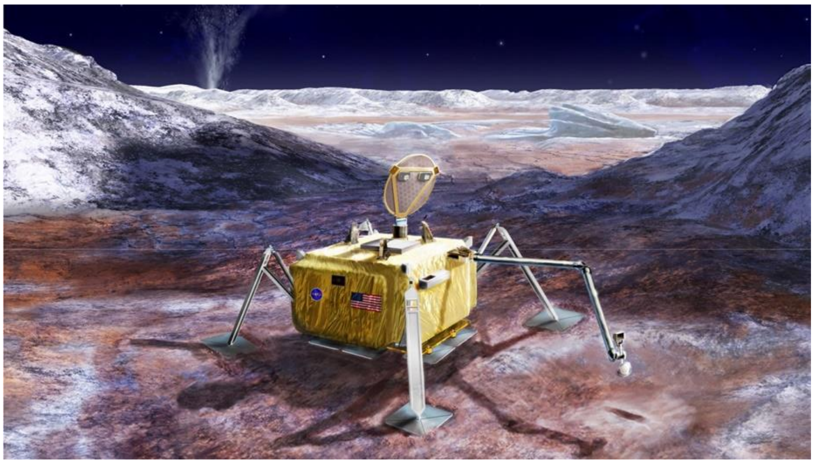


NASA is developing a space probe named Europa Clipper, which was originally known as Europa Multiple Flyby Mission. In July 2013, The Jet Propulsion Laboratory as well as the Applied Physics Laboratory revealed an enhanced flyby mission concept for Europa which was christened Europa Clipper.

NASA disclosed the instruments to be used in the Europa Clipper mission in May 2015, along with an announcement that the mission has been approved for development. The mission of Europa Clipper is to survey the continent to determine whether it is habitable and to help choose landing sites for a future lander.

In October 2024, a Falcon Heavy is expected to launch the mission.

2. **EUROPA LANDER:**



NASA has suggested an astrobiology mission proposal called Europa Lander, which aims to deploy a lander to Europa, Jupiter's frozen moon.

A new NASA concept mission called Europa Lander is being investigated. According to studies conducted in 2018, Europa might be covered in tall, jagged ice spikes that would complicate any attempt to land on the planet's surface.

WHY DO WE CHOOSE EUROPA?

Life on Europa is a topic that has not been fully understood at least as of now, despite being considered as one of the leading candidate sites within our solar system where living organisms may exist due mainly to its capability of supporting a variety conditions and nutrients necessary for living beings. It can be argued that life may occur within its subsurface ocean much similar to deep sea hydrothermal vents existing on our planet.

In 2015 it came to the attention of researchers that some geological spots on Europa’s surface might be covered by salts sourced from an undersea ocean beneath it, indicating an interaction between the ocean and the seabed. Whether or not this hints at a habitable environment is an open question. The growing interest is to send a spacecraft that will see whether or not there is liquid water in touch with Europa’s silicate rocks.

Liquid water, some chemical elements, and an energy source are apparently the three ingredients that life apparently needs. In addition, it evidently needs time. If Europa's ocean has existed for the full 4 billion years of our solar system's history, that might be time enough for life to have developed.

Water and the right chemical elements are found on Europa, such as carbon, hydrogen, nitrogen, oxygen, phosphorous and sulfur which are part of existence- researchers claim this assertion- but astrobiologists (researchers in the origins, development and fate of life anywhere in the universe).

Energy is the third essence of life. Every thing that is alive has its source of power. Earth uses Sun majorly as the energy origin. For instance, plants grow well because photosynthesis changes sunlight into energy which they use. By eating plants, people together with other living organisms get the same energy that plants use.

But the life that might exist on Europa would not be driven by photosynthesis but strictly by chemical reactions because any life that might have existed on Europa would be under the ice cap, and photosynthesis cannot take place by living organism.

If we ever discover some kind of life on Europa it will be microorganisms or perhaps something more sophisticated. Life may have even originated independently on two planets around the same star, and on such grounds, one might well be prepared to take the view that life is formed easily in the universe once the right ingredients are provided, and life may thus turn up all over our galaxy and the universe.

Chances of formation of life like microorganisms are high in the water below the ice crust

MOON

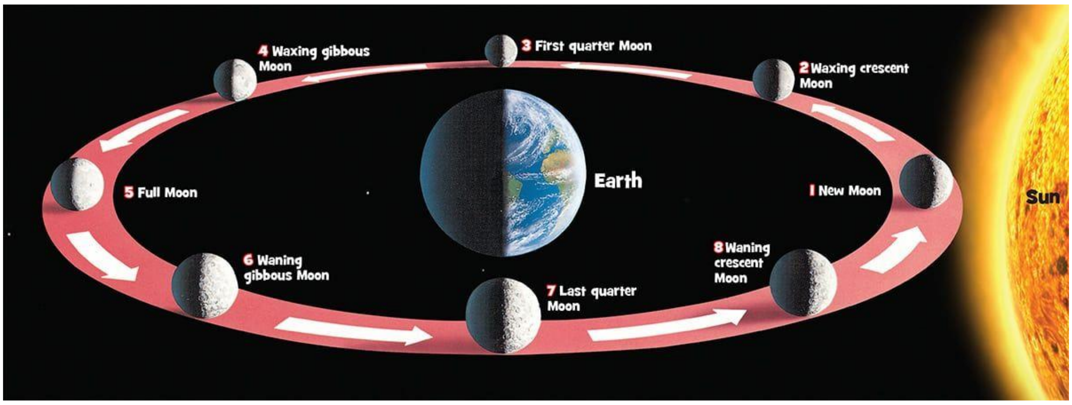
The Moon circles the planet at an average distance of 384,400 kilometers, or roughly 30 times Earth's diameter.The stabilization of Earth's axial tilt, which results in a comparatively steady climate, is largely dependent on the Moon. On Earth, it also creates tides.After an object the size of Mars collided with the early Earth billions of years ago, the Moon most likely formed.
Over its lengthy history, asteroids and comets have left behind craters on its surface. The Moon lacks weather and erosion processes that alter its surface features since it has no atmosphere at all. This implies that astronauts' traces from the Apollo missions, which took place more than 50 years ago, can still be seen today.
Over the course of its orbit around Earth, the Moon travels through several phases, changing from the New Moon to the Full Moon and back again in around 29.5 days. Different areas of the Moon's surface are lighted during these phases due to variations in the angles of the Sun, Earth, and Moon.

Comparison Between Earth and Moon:

1)Size and Mass:

Roughly 27% the size of Earth, the moon has a diameter of 3,474 km, in relation to Earth's circumference of 12,742 km. The mass of the moon is about seven point thirty five ten to the power of twenty two kilograms, which is a bit less than one point two percent that of Earth. This means that the earth is about eighty one times heavier compared to the moon.

2)Orbit and Rotation:



The Moon, which circles the planet in around 29 days, is the only natural satellite of Earth. In turn, Earth completes one orbit of the Sun every 365 days. Synchronous rotations result from the Moon's revolution around the Earth and Earth's orbit around the Sun.

3)Atmosphere:

The earth's strong atmosphere that exists in several layers with plenty of oxygen and water is one reason why the atmosphere is suitable for living thing. On the other hand, it is not possible for any living thing to be supported on the moon due to its lack of a notable amount of air around it. Anyone from the earth who could wish to explore the moon will have to carry some oxygen tanks for him/her to survive on its empty ground.

4)Temperature:

The Moon's lack of atmosphere and sluggish rotation cause it to have much higher temperatures than Earth. In locations that get darkness, like deep craters near the poles, temperatures can drop to as low as -173°C (-280°F) during the lunar night. At the equator, temperatures can surge to approximately 127°C (260°F) during the lunar day. On the other hand, the average surface temperature of Earth is far milder, ranging from roughly -50°C (-58°F) in Antarctica to 50°C (122°F) in scorching desert regions. Compared to the harsh and uninhabitable circumstances on the Moon, Earth's atmosphere helps regulate temperatures by trapping heat, creating a more favorable habitat for life.

5)Gravity:

The gravitational pull of Earth is approximately six times that of the Moon. Each body's capacity to jump and its weight are impacted by this variation in gravitational attraction. A person on the moon might jump six times higher with the same amount of energy and weigh only one-sixth of what they do on Earth.

6)Magnetic feild:

The Earth's magnetic field shields it from dangerous solar radiation and cosmic rays, thanks to the molten iron-nickel core that generates it. Unlike Earth, Mars currently lacks a magnetic field. However, studies suggest that evidence of a magnetic field was present on Mars four billion years ago.

7)Water and Resources:

Large lakes, rivers, and seas cover a large portion of the surface of the water-rich Earth. There is no liquid water on the surface of the dry, barren Moon.
Water ice, on the other hand, may exist in permanently shadowed craters close to the lunar poles, according to recent data, and this could be an important resource for habitation and exploration of the moon in the future.

8)Surface Features:

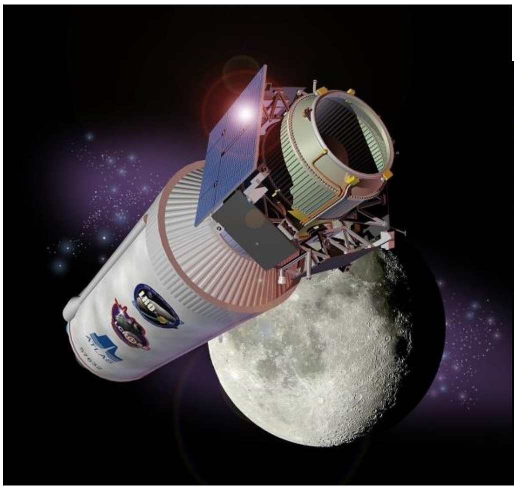
Mountains, volcanoes, rivers, and tectonic plates are just a few of the Earth's many geological characteristics. On the other hand, there are no active geological processes on the Moon's surface, which is mostly cratered.
Due to historical volcanic activity, the lunar surface is covered in mountains, impact craters, and black basaltic plains called maria. The terrain has been altered by erosion and plate tectonics, indicating a greater geological activity on Earth's surface.

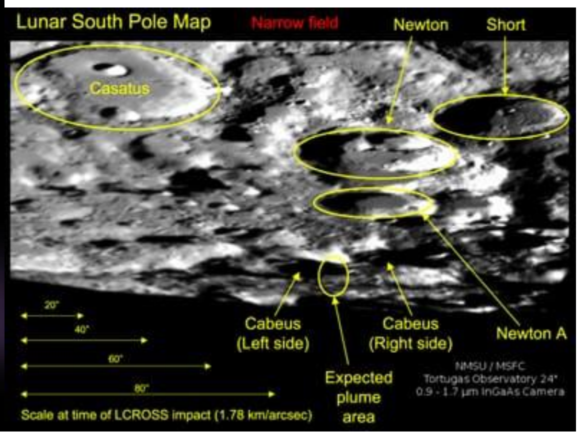
9)Habitability:

Only Earth is known to be able to sustain sophisticated, multicellular life on any planet in the cosmos. Due to the absence of an atmosphere, water, and protection from the hostile space environment, the Moon is entirely uninhabitable for life as we know it.

MOON MISSIONS:

1)LUNAR CRATER OBSERVATION AND SENSING SATELLITES (LCROSS):





- On the moon, water ice was found during the LCROSS mission. It identified a plume of material, mostly crystalline frozen water, rising from the lunar surface in craters at the moon's south pole that were constantly shaded.
- The LCROSS impact showed that the soil of the Moon's Cabeus crater contained higher concentrations of important elements, including as mercury, magnesium, calcium, silver, and sodium, besides water ice.

- Based on the LCROSS data, the Moon is chemically active and has a water cycle such that water is transported as well as deposited in regions that always receive lack of sunlight.
- The mission provided important findings into the physical and chemical features of the moon’s surface and subsurface, such as temperature disparities as well as seismic movements.

2)LUNAR PROSPECTOR:

- The Lunar Prospector Mission provided the initial on-ground confirmation of water ice deposits in permanent shadowed craters near the lunar poles. These regions high in hydrogen and possibly containing the frozen liquid were identified.
- Lunar Prospector mapped the variations in the Moon's gravity and magnetic fields which were revealing a lot about its internal structure and composition. This data aided scientists in getting useful information about the geophysical properties of the Moon as well as its past volcanic activity and the development of the crust.
- Lunar Prospector discovered proof of repeated emissions of volatile elements such as radon, polonium out of the lunar atmosphere and that improved our comprehension about dynamic exosphere together with probable interior processes of the moon because it was able to study its rarefied air.

3)<u>CLEMENTINE</u>:

- Clementine made the Moon's first detailed map by taking images that were finer and covered more area than any before These maps supplied important information concerning the moon's surface geology and topography and other features.
- Mineral compositions and surface materials across different regions were identified by Clementine through an analysis of the spectral characteristics of the lunar surface, which provided scientists with valuable information about how minerals, rocks as well as regolith were distributed on the Moon.
- Clementine discovered water ice was found in the regions on the Moon that do not often get light, such as certain craters. The value of this discovery included being able to know more about the different gases and other substances that exist on our sidekick as well as possibilities of making good use of them later.
- Clementine reported variations in gravitational strength and surface elevation on the Moon using exact measurements. These data served as a key to the mysteries about the Moon's internal structure, mass distribution, and geological evolution.

4)<u>APOLLO MISSION(1994-1999)</u>:

- The Apollo missions were important because they were the first time people traveled to other.
- In addition to revealing that it contains basalt, anorthosite, and other rocks, the lunar samples taken by the Apollo astronauts provided the foremost actual proof of the geological composition of the Moon. This information made it possible for the scientists to know more about the internal configuration and development of the Moon.
- Upon analysing dust and soil on the Moon, the scientists found certain unique properties of it, such as its powdery form that is fine enough and absence of any signs of weathering which helps explain the lack of air around this celestial body.
- Moonquakes were detected by Apollo missions' instruments left on the lunar surface; they permitted precise measurements of the Moon's gravitational field thereby revealing its internal dynamics.
- The Apollo system led to the production of a large number of innovative technologies which included the Lunar Roving Vehicle, life support systems, and the first live television broadcasts from space, thus transforming the capability of space exploration.

WHY DO WE CHOOSE MOON

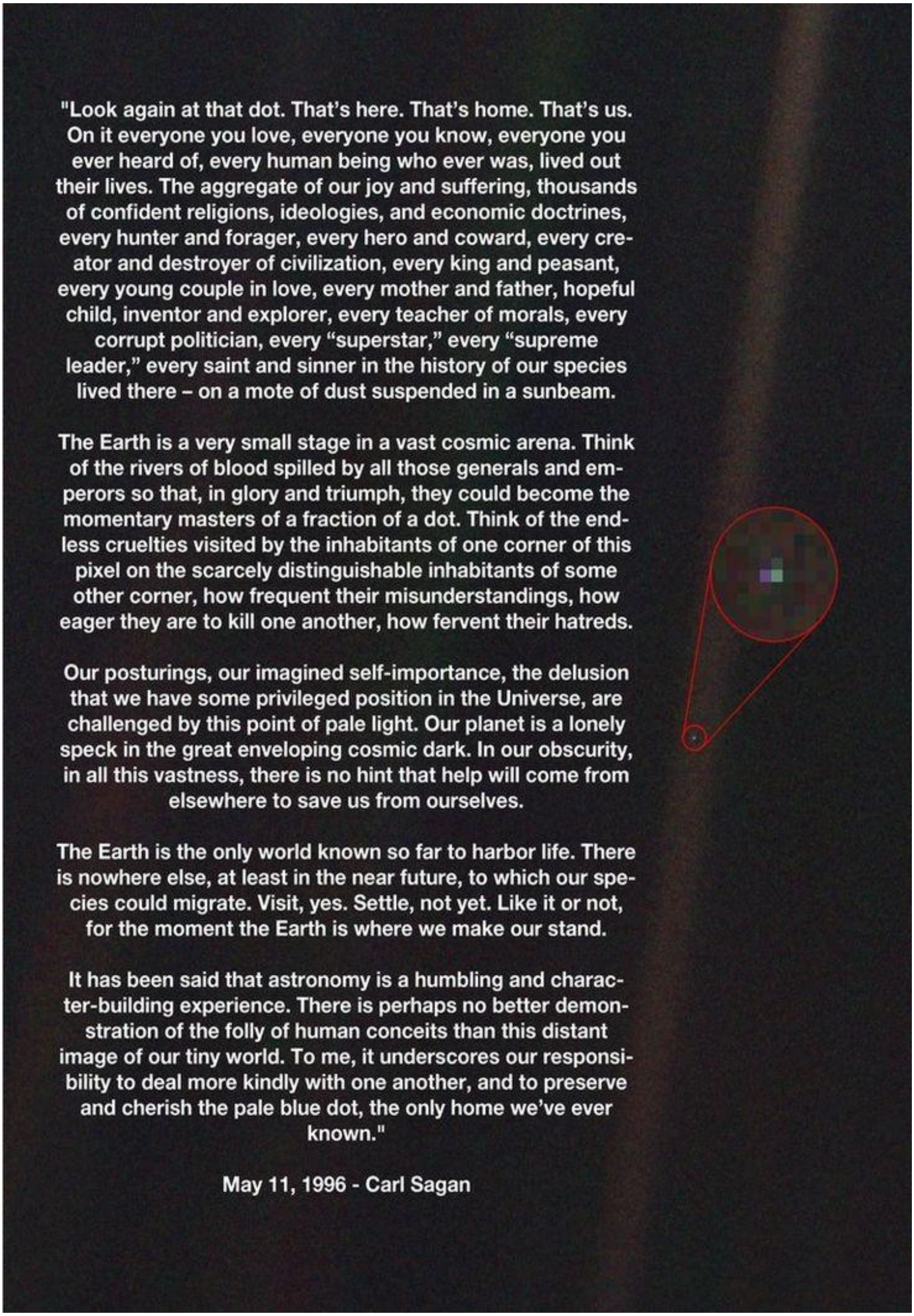
- Our moon is very close to our planet and this makes it a very reasonable and reachable target to explore. Our knowledge how about the way by which the formation and growth of the universe has occurred was changed totally by this mission through earth.
- Early studies of the Moon have shown that our understanding of the origin and evolution of planets is deeply rooted in the collision between solid objects, which we now know is an essential occurrence. This information was obtained by examining its surface and features from impacts.
- The Moon's surface keeps detailed records of asteroid impacts that have occurred around the Earth and its neighboring planets. These records can help us understand how life began or ended here on Earth. By studying its features, we can learn more about what has happened during natural history down here below its surface across time with greater clarity.
- Lunar exploration provides a way for humans to move into other parts of the solar system besides serving as an essential first step. We will be able send people to even outside Mars once we master living and working on our closest neighbor in space.
- . Opportunities for economic growth could be derived from extracting and utilizing the resources on the Moon. Like water, the Moon is rich in valuable minerals like helium-3 that can be used for nuclear fusion energy production. Thus, these resources could be employed as the basis for future space-based industries and commerce.

CONCLUSION

Although we are finding a new planet or an astronomical object for future exploration or for restoring a habitat, for now, Earth is where we make our stand. And it is more important to protect our planet, the most beautiful place we could ever see in our whole universe. In the vastness of the endless universe, a rock that is suspended by some star dust , a small planet named Earth is our home. So in all this research for humans to get to a multiplanetary species, we should never forget our home, Earth .

And we remember a moment when the Voyager space probe exited our solar system, and then NASA gave it a command to take a picture of Earth from there.

And we also remember famous astronomer Carl Sagan’s speech about the picture of our home.


"Look again at that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives. The aggregate of our joy and suffering, thousands of confident religions, ideologies, and economic doctrines, every hunter and forager, every hero and coward, every creator and destroyer of civilization, every king and peasant, every young couple in love, every mother and father, hopeful child, inventor and explorer, every teacher of morals, every corrupt politician, every "superstar," every "supreme leader," every saint and sinner in the history of our species lived there – on a mote of dust suspended in a sunbeam.
The Earth is a very small stage in a vast cosmic arena. Think of the rivers of blood spilled by all those generals and emperors so that, in glory and triumph, they could become the momentary masters of a fraction of a dot. Think of the endless cruelties visited by the inhabitants of one corner of this pixel on the scarcely distinguishable inhabitants of some other corner, how frequent their misunderstandings, how eager they are to kill one another, how fervent their hatreds.
Our posturings, our imagined self-importance, the delusion that we have some privileged position in the Universe, are challenged by this point of pale light. Our planet is a lonely speck in the great enveloping cosmic dark. In our obscurity, in all this vastness, there is no hint that help will come from elsewhere to save us from ourselves.
The Earth is the only world known so far to harbor life. There is nowhere else, at least in the near future, to which our species could migrate. Visit, yes. Settle, not yet. Like it or not, for the moment the Earth is where we make our stand.
It has been said that astronomy is a humbling and character-building experience. There is perhaps no better demonstration of the folly of human conceits than this distant image of our tiny world. To me, it underscores our responsibility to deal more kindly with one another, and to preserve and cherish the pale blue dot, the only home we've ever known."
May 11, 1996 - Carl Sagan

REFERENCE:

1) https://www.nasa.gov/
2) https://www.space.com/
3) https://www.isro.gov.in/
4) Tyson, Neil deGrasse. *Astrophysics for People in a Hurry*. WW Norton & Company, 2017.
5) Sagan, Carl, and Ann Druyan. *Pale blue dot: A vision of the human future in space*. Ballantine books, 2011.
6) Hawking, Stephen. *The theory of everything*. Jaico Publishing House, 2006.