Extraterrestrial Institute

# Extraterrestrial Activity Special Overview

Teaser

www.extraterrestrial.institute

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From year to year, interest in extraterrestrial activity is growing and gaining more weight. **Extraterrestrial Institute** analysed the extraterrestrial activity's scientific and fictional bases in order to define the future of research and development on this topic.

The special overview is the first step in separating truth from fiction in humanity's attempt to find intelligent life beyond our planet by **bringing together in one organization** the latest discoveries, trends, and developments in the field of extraterrestrial activity research. Extraterrestrial Institute created a **framework** in order to provide the interested parties with an advanced definition of extraterrestrial activity research, which will provide the niche with a huge leap forward in terms of newfangled R&D.

No conclusive evidence of alien life has been found despite ongoing research. Thus, Extraterrestrial Institute created a **sophisticated analytical system**, which will be improved in the process of iterative updating and increasing functionality, turning it into a big data analytical system that will be able to show humanity the real state of things in the field of SETI.

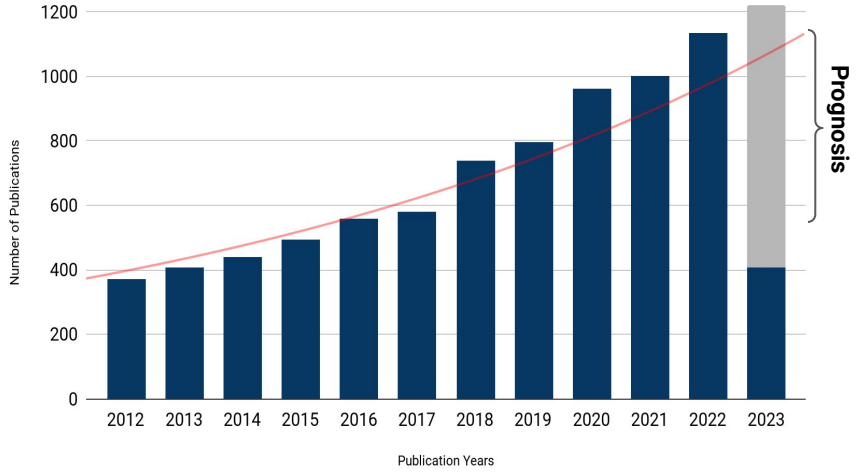
As a result, the brand-new reality implies a need to define and elaborate on relevant policies and technologies of **extraterrestrial interactions**. Extraterrestrial Institute discusses the current and future developments and makes a few projections concerning the future social impacts of discovering extraterrestrial forms of life.

# Scientific Interest is Only Starting to Ignite

**Extraterrestrial Activity Special Overview 2023** aims to review extensive and thoughtful landscape of mainstream scientific theories regarding extraterrestrial life. While space exploration is experiencing its second birth and our sight is sharper than ever, sciences like astrophysics and biology strive to look even further and answer the essential question of whether we are alone in this universe. Can there be other forms of life, even intelligent ones? What conditions are sufficient to even suspect presence of life?

According to the Web of Science search by tags **'extraterrestrial life', or 'exoplanets', or 'technosignatures',** there is an obvious increase in scientific interest. The progressive growth of research literature on the specified themes is linked to the emergence of increasingly technologically modern satellite data. The 2023 publishing forecast is tied to James Webb Space Telescope data collecting.

**Dynamics of Scientific Publications on Extraterrestrial Life**

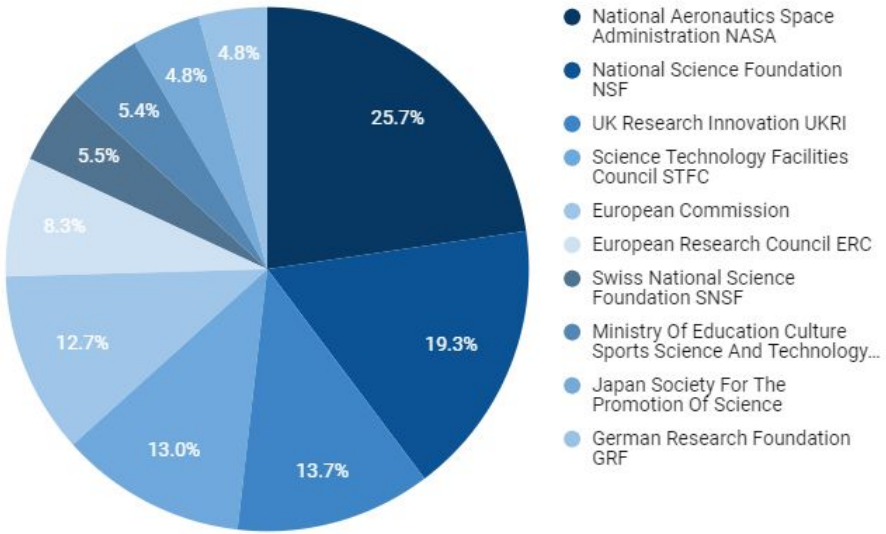



**The report is arranged as follows:** first, we present the **objects of research** in order to give a helicopter view on the studied fields. Then, current **investigational programmes** and their newest updates are covered. Then we review the cutting edge **research methods**. And finally, **locations** of special interest are put for your consideration.

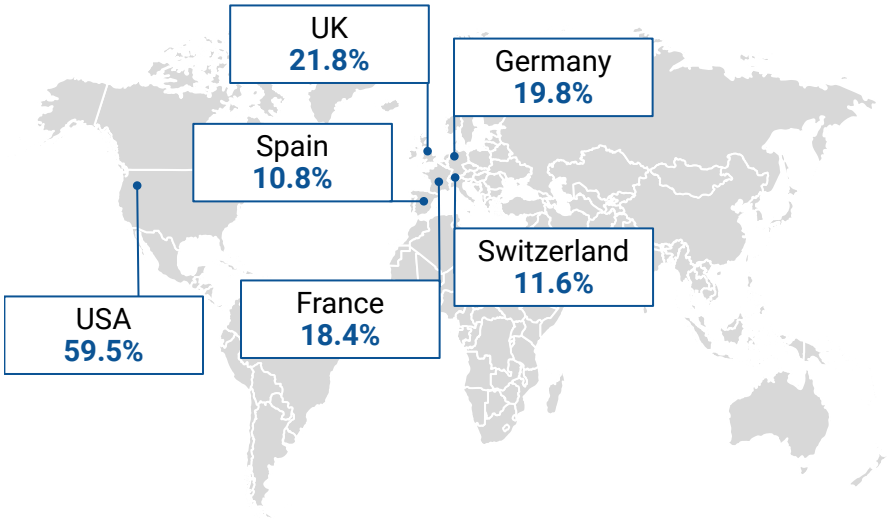
Sources: Web of Science

# Research Competition in Finding Extraterrestrial Intelligence

### Top 10 Agencies That Fund Astrophysics Research




### Top 5 Countries by the Number of Publications on the Topic of Extraterrestrial Life




By the number of publications related to the extraterrestrial life research, the USA takes the first place having slightly more than a half of all published scientific papers. It correlates well with the fact that top two agencies that fund astrophysics research are both US organisations: NASA and NSF. Other four leaders by the number of selected scientific publications are located in Europe where the UK accounts 21.8% of all publications. It is not a surprise since the British organisations take 3rd and 4th places in the list of funding agencies: UKRI and STFC (parent organisation: UKRI).

Sources Open Source Research by Extraterrestrial Institute:

# Study of Extraterrestrial Activity Framework

The framework is created to depict the most important sectors within the study of extraterrestrial activity. Scientists start building assumptions and find technosignatures, based on what they already know in terms of planetary science, moving on to the habitability and biosignatures of our Solar System. When it comes to objects located far from the Milky Way, the researchers tend to use extraterrestrial chemistry and astrobiology  methods in order to prove the basis of the first given assumptions.

## Object

- Intelligent Life Forms
- Primitive Life Forms
- Active
- Tracks
- Messages
- Organic or Life Signatures
- Tech Signatures
- Suitable Worlds Discovery
- Megastructures
- Alternative Life Forms
- Laws of Physics Obstruction

## Research Method

- Measurement
- Modeling
- Radiolocation
- Alternative life Forms
- Optical
- Megastructures Signatures
- Spectroscopy
- Biomarkers Signatures
- Gravitational Waves Measuring
- Planetary Conditions

## Location

- Atmosphere
- Near-Earth Orbit
- Our Solar System
- The Milky Way
- Observable Universe

# Hypothetical Types of Biochemistry

Biochemical forms that have been deemed scientifically plausible but are not yet verified to exist are known as hypothetical types. All currently recognised types of living things on Earth rely on carbon molecules for fundamental structural and metabolic processes, water as a solvent, and DNA or RNA to define and regulate their form.

Although it is also possible that there are organisms with very different chemistries such as those involving other classes of carbon compounds, compounds of another element, or another solvent in place of water, it is possible that if life exists on other planets or moons, it is chemically similar.

A current scientific debate on the feasibility of 'alternative' biochemistries underpinning life-forms is being influenced by knowledge of extraterrestrial settings, as well as the chemical behaviour of various elements and compounds.


Sources: Scispace

# Astrobiology Is a Key To Define Extraterrestrial Life

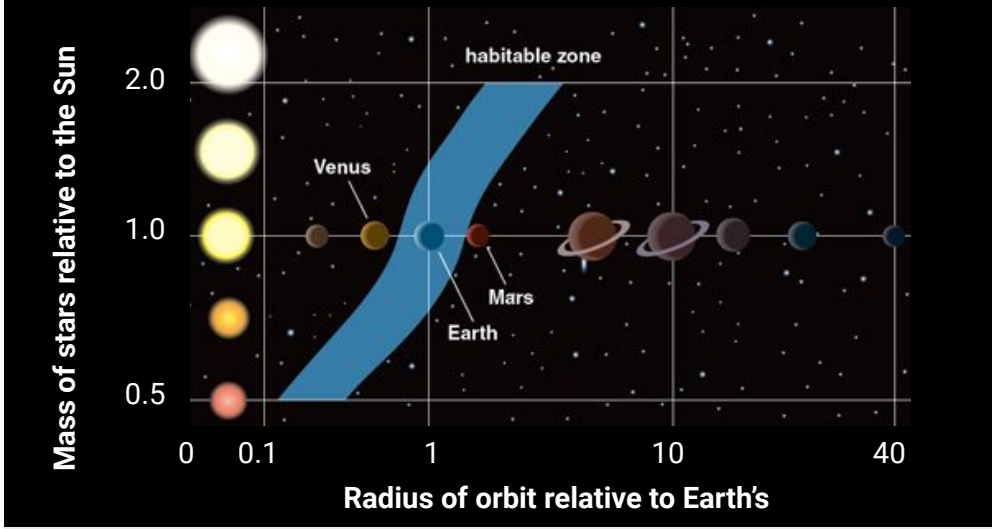
Astrobiology is quickly becoming a topic with active scientific and technical research. There has been a lot of interest in the numerous recent space missions to asteroids, comets, and other celestial bodies in search of alien primitive life. Several additional spacecraft thereafter followed the Viking landings on Mars. It was discovered by the Cassini Probe to Saturn and the Galileo Mission to Jupiter that several of these big planets' moons might have enormous amounts of water beneath their surfaces.

**Main Trends in Astrobiology**

- Exobiology
- Life on Other Planets
- Extrasolar planets
- Astronautics
- Origin of Life
- Outer Space Exploration

**Rare Earth Hypothesis**

According to this hypothesis, life on Earth is possible because of a conjunction of the right circumstances (galaxy and location within it, Solar System, star, orbit, or atmosphere, etc.)




The location of the habitable zone, the range of distances from a star where temperatures allow water to be liquid, varies depending on the mass and age of the star. If a habitable zone is too close to its star, any planet located there may become tidally locked, with one side perpetually facing the star.

Sources: Stanford

# Detection of Extraterrestrial Forms of Life

The mixture of gases in the atmospheres of Earth-sized exoplanets could be seen for the first time by the James Webb Space Telescope, which was launched in 2021. The Webb or a future spacecraft of a comparable design might be able to detect oxygen, carbon dioxide, and methane, which are components of our own atmosphere, a strong cue that life might exist.

The conversion of light into chemical energy by plants is known as photosynthesis. Future telescopes may also detect gases or chemicals that indicate the presence of biological life. However, the discovery of an exoplanet with, say, a 95% possibility of life would be a historic turning point.

Some 300 million light-years from Earth, four of the galaxies in a group called Stephan's Quintet are interacting, transferring gas and dust between them. Credit: NASA images from James Webb Telescope

## Where Should We Look?

Exoplanets, or planets that orbit other stars, have been counted at about 4,900 in our galaxy, but there are undoubtedly trillions more. The idea of the 'livable zone' is one of the best resources scientists have to start focusing their search for habitable planets. It is the distance from a star at which temperatures would permit liquid water to occur on the surface of a planet. A steady star that is not prone to erupting in sterilising flares would also be necessary, along with a planet of the right size and atmosphere. Really, the habitable zone is only a way to narrow the field and focus on the planets most likely to have favourable circumstances for life.

## Tools for Detection of Extraterrestrial Forms of Life

- Advanced Spaceships
- Telescopes
- Scanning Drones
- Orbital Observatories

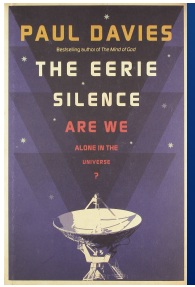


Sources: NASA

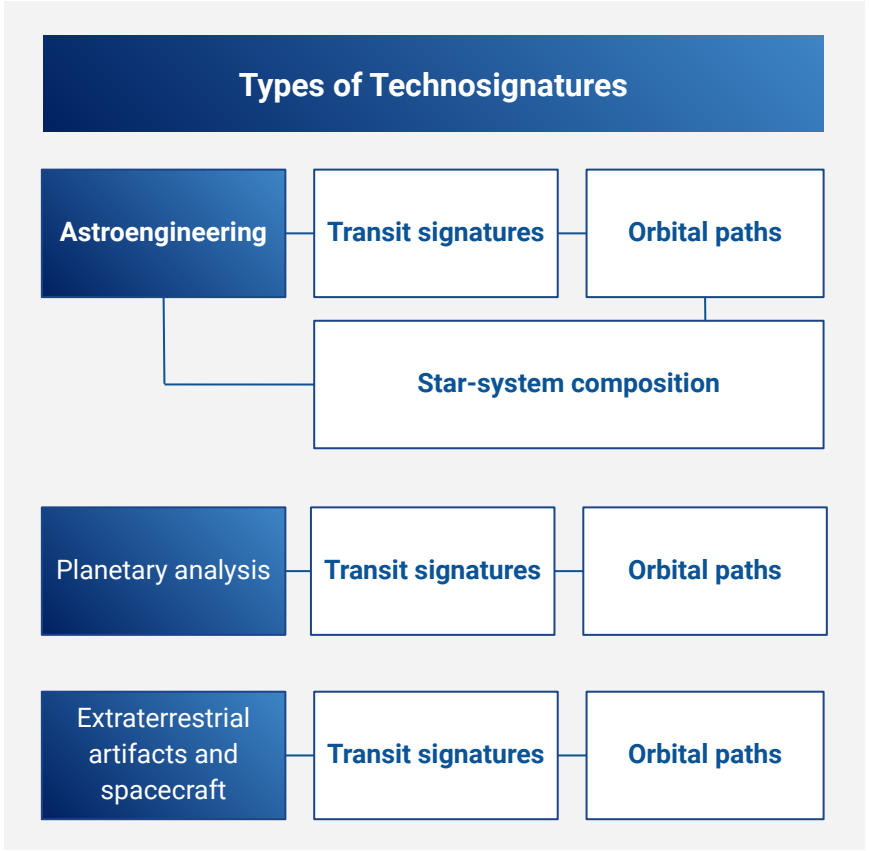
# What Are Technosignatures?

Any quantifiable characteristic or result that offers objective proof of previous or contemporary technology is referred to as a **technomarker** or **technosignature**. Similar to biosignatures, which indicate the presence of life, whether sentient or not, technosignatures indicate the presence of intelligent life capable of advanced technology. Radio broadcasts are sometimes left out of definitions by authors; however this limited usage is not common.

**Jill Tarter** (American astronomer) has proposed that the search for extraterrestrial intelligence (SETI) be renamed into **'the search for technosignatures'.**




Some examples of technosignatures are described in **Paul Davies**'s 2010 book ***The Eerie Silence*** although the terms 'technosignature' and 'technomarker' do not appear in the book.




Sources: NASA

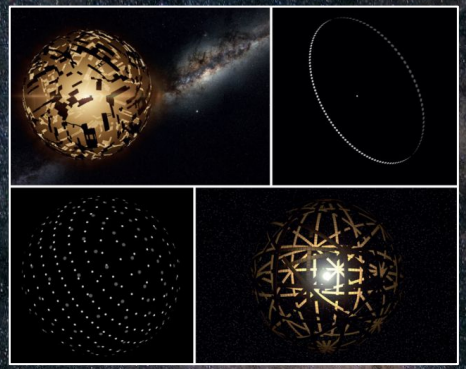
# Picking Up Pollution and Alien Megastructures

Another technosignature could be the pollution that aliens in the early stages of technological development are pumping into the atmosphere of the planets they inhabit. Indeed, atmospheric chemical pollutants could be identified in the same way as biosignatures like oxygen and methane by looking at the spectral data. Spectral templates will come from running climate models that depend on the planet's features.

A notable technosignature would be the detection of a Dyson sphere – a hypothetical megastructure first proposed by Freeman Dyson in *Science* magazine in 1960. Originally conceived as a hollow shell that an advanced exocivilisation might construct surrounding its host star, the sphere would capture all of the star's energy – in our case, two billion times more energy than falls on Earth's upper atmosphere.

SETI has traditionally focused on looking for signs of life by scanning the skies for **electromagnetic radiation**.

Image: *A false-color view constructed using infrared data from the Spitzer Space Telescope of the Orion Nebula.*



**Energy harvester**
The classic Dyson sphere is a 'shell' (top left) that completely surrounds a star. This would be mechanically unstable, but other Dyson megastructures that are more likely to work include the ring (top right), bubble (bottom left), and swarm (bottom right).

Another suggested technosignature pollutant is nitrogen dioxide, $NO_2$, which is found here on Earth as a byproduct of combustion from vehicles and fossil-fuelled power plants.

Solar collectors on these structures could beam microwaves down to the planet's surface for power, which could drastically modify the star's spectrum, creating an infrared blackbody.



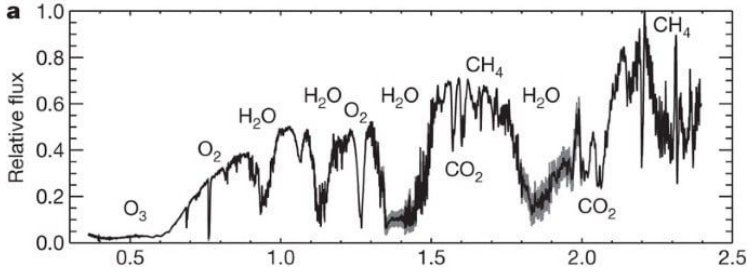
Sources: MotherJones, NewScientist

# Spectroscopy

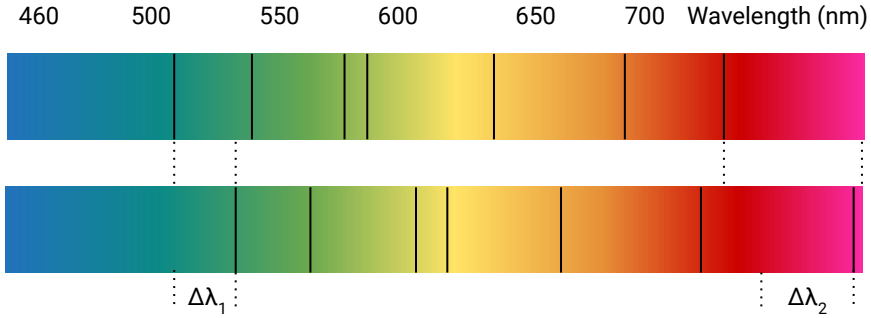
Spectroscopy is one of the main methods of exploring stars, galaxies, quasars, and planets by measuring their response to different frequencies of radiation. Different celestial objects produce different types of spectra what is an output information of matter and materials of the object.

| Continuum spectrum | Absorption spectrum | Emission spectrum |
|---|---|---|

By comparing spectrums the chemical composition of objects can be determined. This provides the scientists with wide markers that can prove or disprove existence of parameters needed for life. Complex molecules like oxygen, carbon, and hydrogen are the basis of life on Earth.




Earth's transmission spectrum




**The Doppler Effect is used to discover extrasolar planets through change of frequency on spectrum. The precision what we need to discover a Jupiter-like planet is 28.4 m per second. In comparison we need a 9 cm per second to detect an Earth-like planet. For this purpose spectroscopists are using high-precision radial-velocity spectrographs.**

ESPRESSO – third-generation echelle spectrograph

# Gravitational Waves Measuring by LIGO (1/2)

**Although one seldom hears 'extraterrestrial intelligence' and 'space-time continuum' in the same breath, there is a perceived connection between the two subjects.**

The method suggests that the extraterrestrials use a more avant-garde communication mode: gravity waves compared to simple radio signals or laser flashes. There are some significant reasons why aliens should choose gravity waves for communication. Unlike laser light, gravity waves can pass unimpeded through the dusty substance that permeates interstellar space. And unlike radio waves, the ionised plasma that litters the cosmos does not alter or scatter gravity waves.

## What Are Gravitational Waves?

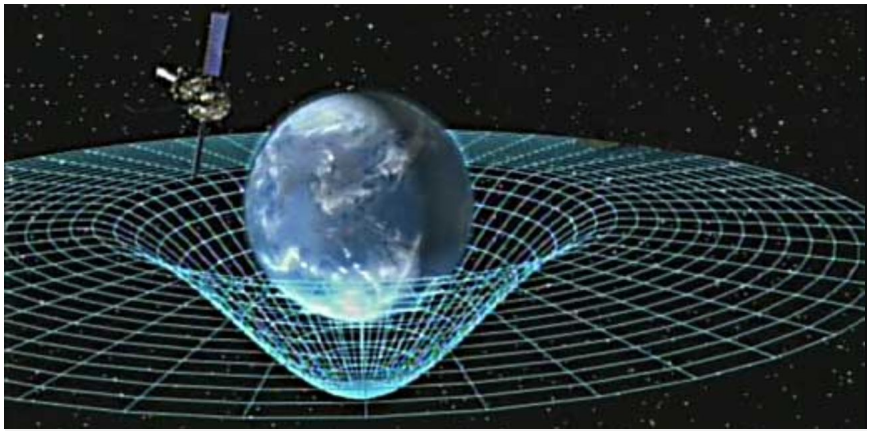
Gravitational waves are ripples in space-time (the fabled 'fabric' of the universe) caused by massive objects moving with extreme accelerations. In outer space, this means objects like neutron stars or black holes orbiting around each other at ever-increasing rates, or stars that blow themselves.

*The Laser Interferometer Gravitational-Wave Observatory(LIGO) Supported by National Science Foundation (USA) Operated by Caltech and MIT*

LIGO

CALIFORNIA INSTITUTE OF TECHNOLOGY 1891

Caltech



**Two-dimensional illustration of how mass in the universe distorts space-time**



Sources: LIGO, Caltech, SETI

# Big Data ML-Modelling for Extraterrestrial Research (1/4)

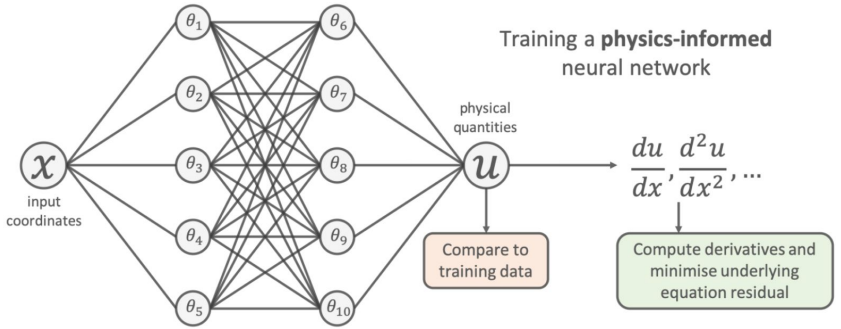
SETI Institute spin-off Frontier Development Lab (FDL) applies AI technology to advance the frontiers of study and develop new tools to resolve some of humanity's most significant concerns. These include the effects of climate change, the prediction of space weather, the improvement of disaster response, and the identification of meteorites that may hold the key to understanding the history of our universe. FDL is a public-private partnership between NASA, DOE, the SETI Institute, Trillium Technologies, the ESA, and leaders in commercial AI, space exploration, and Earth science, including Google Cloud, NVIDIA, Intel, IBM and Microsoft.

## Planet Poles Exploration

FDL in partnership with Luxembourg Space Agency investigate whether Physics-Informed Neural Networks (PINNs) could replace conventional lunar mapping techniques to facilitate rover traverses and human operations at the lunar or any other planet poles.

**The PINNs underlying concept is to add the known differential equations directly into the loss function when training the neural network.**

**Whilst we focused on a specific physics problem here, physics-informed neural networks can be easily applied also to many other types of differential equations and are a general-purpose tool for incorporating physics into Machine Learning (ML).**




**Schematic of Physics-Informed Neural Network**

Sources: Ben Moseley

# Habitability of Planets in the Solar System

**Mercury**

The spacecraft MESSENGER found evidence of water ice on Mercury.

**Saturn**

Like Jupiter, Saturn is not likely to host life. However, Titan and Enceladus have been speculated to have possible habitats supportive of life.

**Mars**

Current studies on Mars by the Curiosity and Opportunity rovers are searching for evidence of ancient life, including a biosphere based on autotrophic, chemotrophic, chemolithoautotrophic microorganisms, as well as ancient water.

**The Moon**

3.5 to 4 billion years ago, the Moon could have had a magnetic field, an atmosphere, and liquid water sufficient to sustain life on its surface.

**Jupiter system**

Scientists have indications that heated subsurface oceans of liquid water may exist deep under the crusts of the three outer Galilean moons: Europa, Ganymede, and Callisto. The EJSM/Laplace mission was planned to determine the habitability of these environments; however, due to lack of funding, the programme was not continued. Similar missions like ESA's JUICE and NASA's Europa Clipper are currently in development and are slated for launch in 2023 and 2024, respectively.

**Other bodies**

Models of heat retention and heating via radioactive decay in smaller icy Solar System bodies suggest that Rhea, Titania, Oberon, Triton, Pluto, Eris, Sedna, and Orcus may have oceans underneath solid icy crusts approximately 100 km thick.

**Small Solar System bodies**

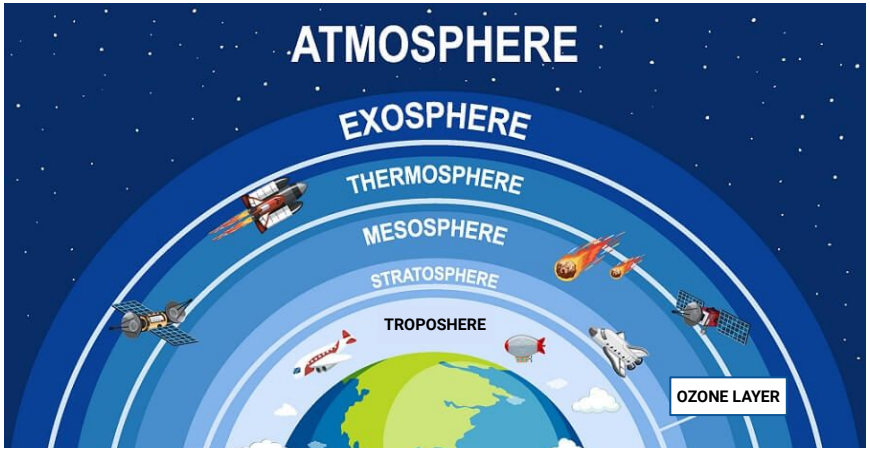
Small Solar System bodies have also been speculated to host habitats for extremophiles. Fred Hoyle and Chandra Wickramasinghe have proposed that microbial life might exist on comets and asteroids.



Sources: Open Source Research by Extraterrestrial Institute

# Low Earth Orbit Has Plenty of Room for Near Research

An orbit having a period of 128 min or less (making at least 11.25 orbits per day) and an eccentricity of less than 0.25 is referred to as a low Earth orbit (LEO). The majority of man-made satellites are in LEO, never rising above an altitude of about one-third of the radius of Earth. The region of space below 2,000 km, or roughly one-third of Earth's radius, is also referred to as the LEO region. Even if they are suborbital or have an apogee further out, objects on orbits that pass through this zone are closely monitored because they pose a risk of colliding with the numerous LEO satellites.



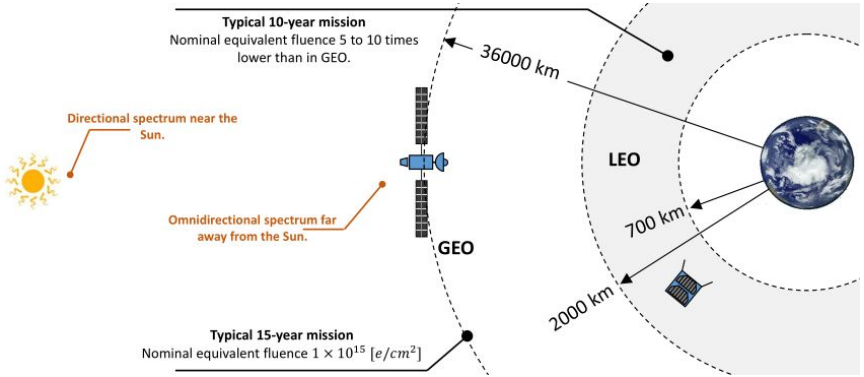




**Illustration of the low earth orbit (LEO) and geostationary earth orbit (GEO) with typical equivalent fluences**

## Examples

- The International Space Station is in a LEO about 400 km (250 mi) to 420 km (260 mi) above Earth's surface and needs reboosting a few times a year due to orbital decay.
- The Iridium telecom satellites orbit at about 780 km (480 mi).
- The Hubble Space Telescope orbits at about 540 km (340 mi) above Earth.
- The Chinese Tiangong space station was launched in April 2021 and currently orbits between about 340 km (210 mi) and 450 km (280 mi).



Sources: Space.com

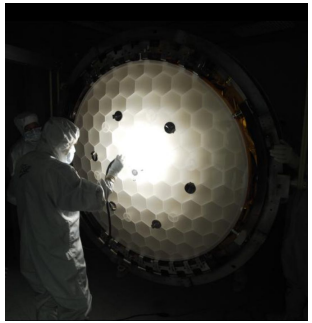
# Precise Kepler Research in the Borders of the Milky Way

## A Brief Summary of the Kepler mission

Kepler was NASA's first mission devoted to the search for exoplanets via the transit technique. The idea was to put a telescope in space, above Earth's atmosphere, in order to make very, very precise measurements of stellar brightness -- because only measurements at the level of 0.01 percent or better can show evidence for Earth-size planets orbiting Sun-size stars. Kepler's camera contained 42 CCD chips, covering an area of on the sky of about 16x16 degrees -- inside of which might be tens of thousands of stars.

**1** Kepler's mirror was relatively small: about 1.4 meters in diameter.

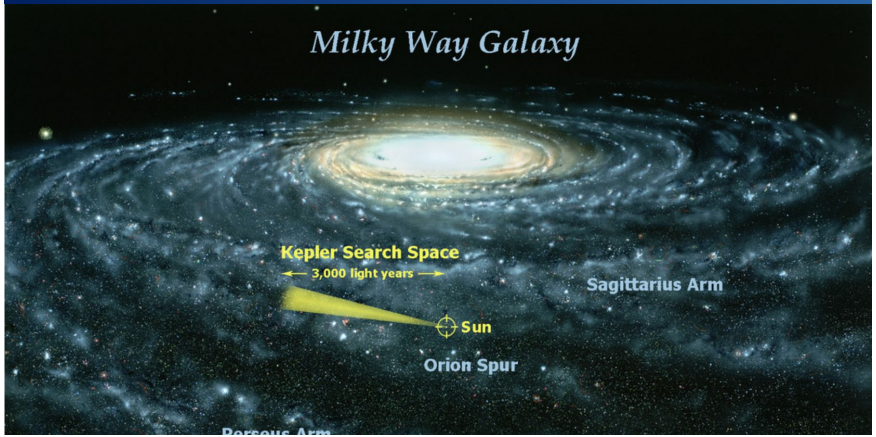
**2** The entire package was part of a satellite about the size of a truck.



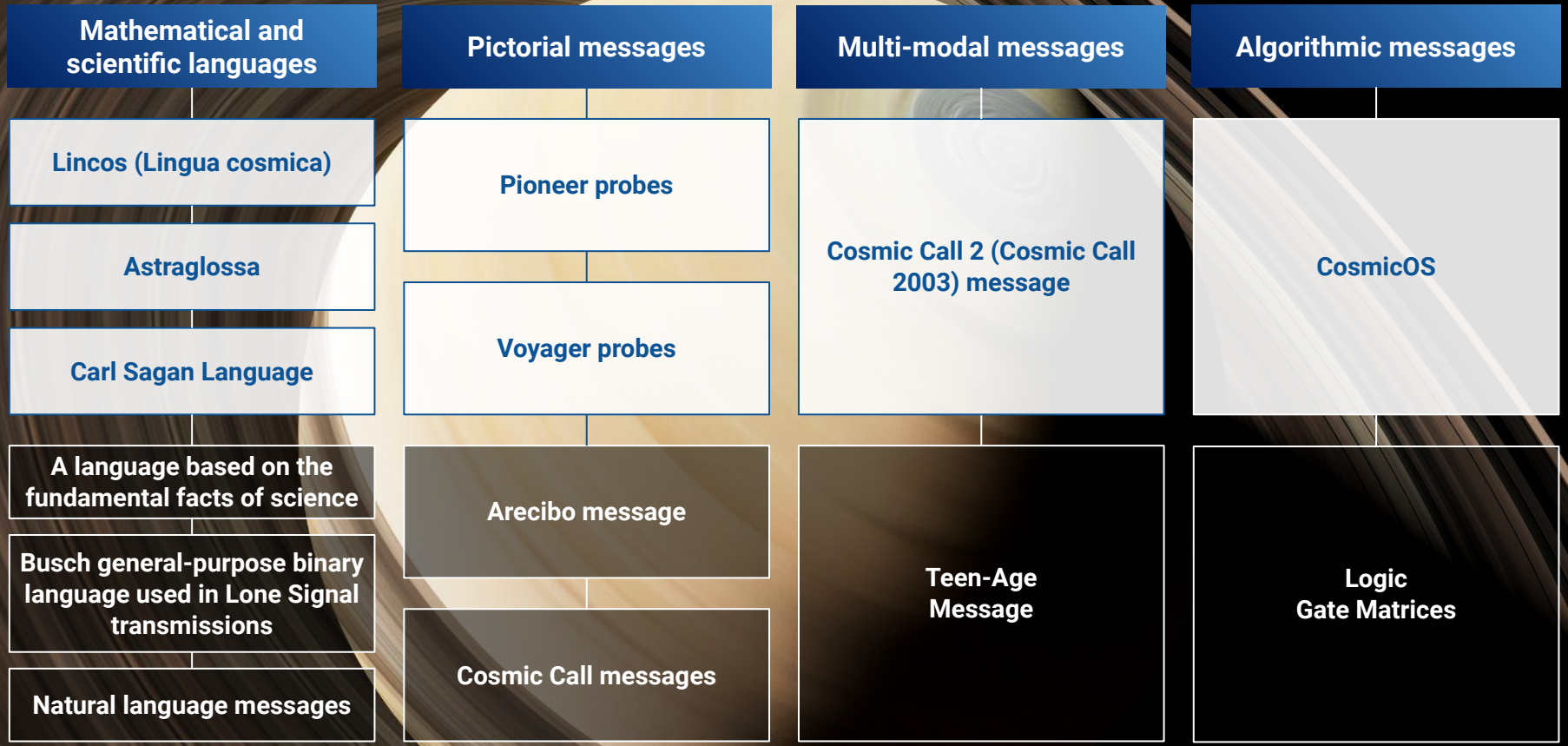
**Before Kepler was launched, the number of transiting exoplanets was relatively small; not a single planet as small as Earth had been found by this method**

**When the Kepler satellite was decommissioned in Oct, 2018, the final count of planets (or planetary candidates) discovered by the mission was somewhere above 5,000.**

**In order to maximize the number of planets found over the course of its mission, Kepler pointed at a region which contained lots of stars: a section of the sky close to the Milky Way.**



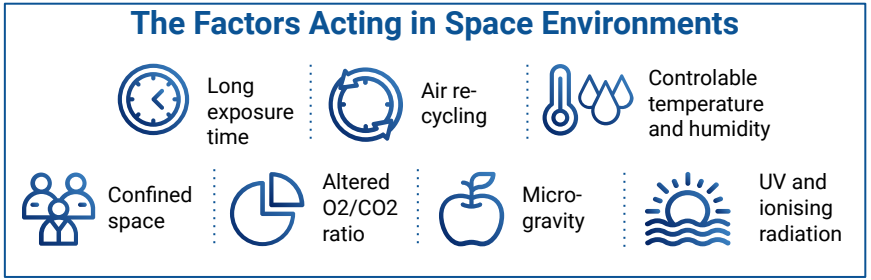
# Extraterrestrial Communication Framework



# Biological Viruses in Space

On 11 October 1968, an astronaut caught a cold and infected the whole crew on Apollo 7. Without gravity, mucous collected, creating pain. The astronaut did not even wear helmets while landing because they feared Earth's atmosphere could damage their sinuses or eardrums. Since NASA opted to confine all astronauts for two weeks before flight, there have been no viral breakouts in space.

### The Factors Acting in Space Environments

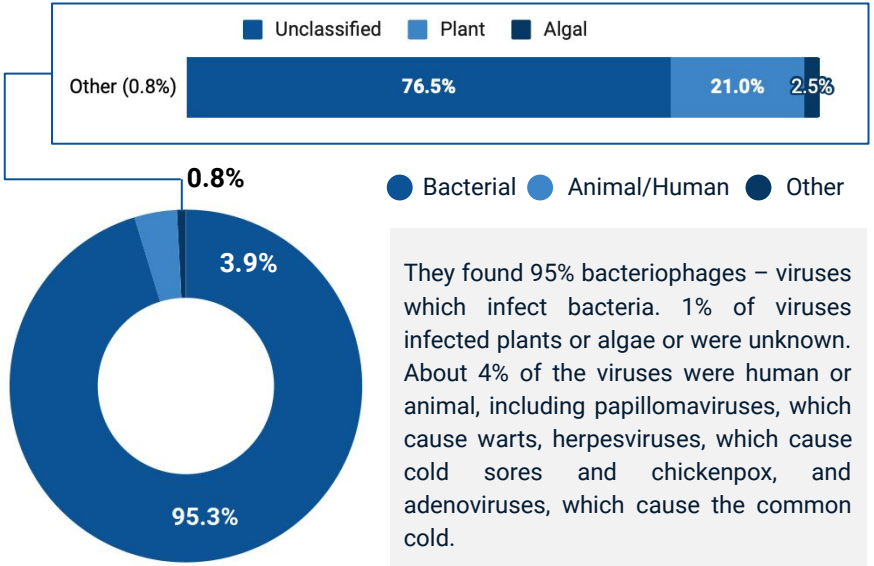



## Reactivated Viruses

Some dormant viruses in astronauts' bodies may reactivate in space, causing symptoms or replication. Herpesviruses like varicella zoster cause chickenpox and shingles in adults when reactivated. Ultraviolet radiation exposure has been shown to reactivate viruses in rodents and suppresses the immune system of humans and animals. Differences in humidity, gravity, dehydration, and sleep deprivation could also influence virus reactivation in space (see picture above).

## Microbiome of the ISS Surfaces

Only one analysis of viruses in space has been done so far. It examined viruses aboard the International Space Station (ISS) and was published in the journal *Nature Communications* in 2019. In that study, researchers sequenced viral genomes and identified various viruses using swabs taken from surfaces on the space station.




They found 95% bacteriophages – viruses which infect bacteria. 1% of viruses infected plants or algae or were unknown. About 4% of the viruses were human or animal, including papillomaviruses, which cause warts, herpesviruses, which cause cold sores and chickenpox, and adenoviruses, which cause the common cold.



Source: Astrobiology Journal

# Scientific Communities Focused on Extraterrestrial Life (1/2)

## The Galileo Project

www.projects.iq.harvard.edu/galileo

The goal of the *Galileo Project* is to bring the search for extraterrestrial technological signatures of Extraterrestrial Technological Civilisations (ETCs) from accidental or anecdotal observations and legends to the mainstream of transparent, validated, and systematic scientific research.

## Berkeley SETI

www.seti.berkeley.edu

*Berkeley SETI Research Center* searches for electromagnetic signatures of intelligent extraterrestrial civilisations, spanning wavelengths from radio to visible light. They take part in the new Breakthrough Listen initiative to use the Green Bank, Parkes, and Automated Planet Finder telescopes.

## Astrobiology Society of the University of Manchester

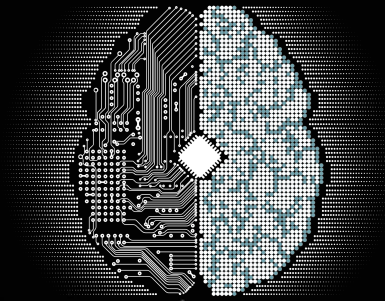
www.astrobiologysociety.com

Created in 2020, the organisation delivers world-class education and science exchange, creates high-quality events to enrich and promulgate astrobiology, and along the way. It is a nonprofit organisation registered within the University of Manchester.

## Extraterrestrial Materials Analysis Group


www.lpi.usra.edu/exmag

Community-based, interdisciplinary group providing a forum for discussion and analysis of matters concerning the collection, curation, and analysis of extraterrestrial samples, including planning future sample return missions.

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