

## **The Privileged Planet**

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The mystery of the earth's significance in the universe has challenged philosophy and science for more than 2,000 years. The early perceptions were shaped by Greek scholars Aristotle and Ptolemy. They taught that the earth sat motionless in the center of the heavens, while the moon, sun and other stars and planets revolved around it. This geocentric view was the foundation of Western cosmology for 18 centuries. Then in 1543, the Polish astronomer Nicholas Copernicus argued that the earth was not stationary, but instead orbited with the other planets around the sun.

This proper view of the mechanics and structure of the solar system opened the door for the mathematical study of the planetary system and laid the cornerstone for modern astronomy.

Four hundred years after his discovery the empirical fact that the earth was not the center of the solar system had evolved into what is now known as the Copernican Principle – the idea that the earth occupies no preferred place in the universe. This principle had developed in the 20<sup>th</sup> century as the Principle of Mediocrity – the earth location and status in the universe is mediocre and unexceptional.

This principle of mediocrity was popularized in the 1970s and 1980s by Astronomer Carl Sagan. In his bestselling book, *Pale Blue Dot*, Sagan wrote “Because of the reflection of sunlight the Earth seems to be sitting in a beam of light, as if there were some special significance to this small world, but it is just an accident of geometry and optics ... 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.”

One reason for the widespread acceptance of the Copernican Principle can be traced to a discovery made at Mount Wilson Observatory in California in the 1920's by Edwin Hubble. He discovered that there are millions of galaxies. The Milky Way Galaxy encompassing more than 100 billion stars including our sun was one of many millions of other galaxies.

Robert Jastrow, an American astronomer, physicist, cosmologist and a leading NASA scientist stated “The universe is populated by innumerable Earths and, perhaps, innumerable forms of life.”

An outgrowth of the Copernican Principle is the belief that habitable planets and complex life are abundant throughout our galaxy and the rest of the cosmos. This belief has led to the establishment of a research program called SETI – Search for Extraterrestrial Intelligence. The purpose of SETI is to try to discover if intelligent life exists beyond planet earth.

The thinking is that unless there is something very, very special, miraculous if you will about our solar system, about our planet earth, then what happened here on earth must have happened many times in the history of the universe. This has led to a new science called astrobiology—which is the search for evidence of living organisms past and present on other planets. Are habitable planets rare or common in the universe? What are the conditions necessary for life here on earth and to search elsewhere in the universe and see if those conditions are met anywhere else.

Many research scientists hold the presupposition that there must be other civilizations out there and that the galaxy must be teeming with life.

In addition to the large number of stars that are in the universe, the other significant fact is that there are a number of factors necessary to have a habitable planet in a planetary system. Scientists know that there are certain unchanging physical and chemical laws that apply not only to the planet earth but to the entire universe. The factors necessary for complex life on earth are also the best parameters in the search for complex life on habitable planets elsewhere in the universe.

The primary prerequisite for complex life is liquid water. The chemical properties of water are exquisitely suited for carbon based life. These properties include water's ability to dissolve and transport the chemical nutrients vital to all living organisms and its unmatched capacity to absorb heat from the sun, a process critical for regulating the earth's surface temperature. In liquid form water is an extraordinary substance and its existence hinges upon another factor essential to complex life, a planet's distance from its home star.

The right distance between the planet and its sun (habitable zone) is necessary to have liquid water. Too close and water will boil away, too far away and water freezes out. Within our solar system the habitable zone is relatively narrow. If the earth were just 5% closer to the sun, it would be subject to the same fate as Venus, a runaway greenhouse effect with temperatures rising to nearly 900 degrees Fahrenheit. Conversely, if the earth were 20% farther from the sun, carbon dioxide clouds would form in the atmosphere initiating the cycle of ice and cold that has sterilized Mars.

The presence of liquid water is a necessary condition for life but it's not a sufficient condition. Following are some of the necessary conditions:

Within Galactic Habitable Zone	Orbited by large moon
Orbiting main sequence G2 dwarf star	Magnetic field
Protected by gas giant planets	Plate Tectonics
Within circumstellar habitable zone	Ratio of liquid water and continents
Nearly circular orbit	Terrestrial planet
Oxygen-rich atmosphere	Moderate rate of rotation
Correct mass	

These conditions must all be present at one place and time in the galaxy if you are going to have a planet as habitable as the earth. What is the probability of attaining this combination of factors simultaneously? A thousandth of a trillion. This leads to the conclusion that the earth is a rare planet, a privileged planet in the galaxy, a unique planet that can sustain complex life.

### **Solar Eclipse and Scientific Discovery**

The sun and moon appear the same size in Earth's sky because the sun's diameter is about 400 times greater – but the sun is also about 400 times farther away. So the sun and moon appear nearly the same size as seen from Earth. And that's why we on Earth can sometimes witness that most amazing of spectacles, a total eclipse of the sun. The perfect eclipse of the sun is not only compelling to observe but it also opens the portal onto the physics and chemistry of the entire universe.

Eclipses allow us to observe the outer part of the sun's atmosphere that is critical towards understanding how its light is produced. The eclipse of 1870 led to an understanding of the structure of the sun and the discovery of helium, the second most abundant element in the universe. This led to the understanding of how the spectrums of distant stars are produced. This discovery allowed us to understand how other stars work, because distant stars are in fact other suns.

The only reason scientists here on earth were able to discover this fascinating cosmic reality is that the size of the sun, the size of the moon and the distance between these three spheres is perfectly spaced in order to create a total eclipse of the sun which allows for the scientific discovery of the sun's atmosphere. The best place in the entire solar system to view solar eclipses is from the surface of the earth.

Researchers recognize a fascinating connection between the factors necessary for complex life and scientific observation. What if those things that make a planet habitable also make that planet the best place for making scientific discoveries? The same narrow circumstances that allow us to exist also provide us with the best overall setting for making scientific discoveries. Only the earth's atmosphere can sustain complex life and only the earth's atmosphere is transparent, which allows us to view the stars.

It is a remarkable coincidence that the kind of atmosphere needed to sustain complex life, does not preclude that life from observing the distant universe. Not only is our location within our solar system important to sustain complex life, so also is our location within the Milky Way Galaxy. Our position in the galaxy is not only critical for sustaining life but it is also surprisingly important for making scientific discoveries.

"The most incomprehensible thing about the universe is that it is comprehensible." Albert Einstein

What you have is not only a universe that is finely tuned that life can occur but also has a beautiful, elegant mathematical structure and a structure such that we can discover that structure. Most scientists take for granted that the world is both ordered and intelligible. The universe is ordered in a way that human beings are capable of understanding it.

Nicholas Copernicus stated, "The mechanism of the universe, wrought for us by a supremely good and orderly Creator.... the system the best and most orderly artist of all framed for our sake.

Modern scientific discoveries lead to the conclusion that the earth is far different than a pale blue dot lost in a cosmic sea.