CHAPTER ZERO

What is life?

The Astrobiologist's Dilemma

Astrobiologists constantly grapple with a fundamental question: How did life originate on Earth? This question is intriguing for two reasons. First, because no one knows the definitive answer, and second, because it sparks infinite speculation. Did life truly originate on Earth, or did it arrive here from another planet? These possibilities open the door to exploring not only the origins of life but also the nature of life itself. Before delving into these ideas, let us first ask: What is life? And more importantly, how do we define it scientifically and philosophically?

The story of Stuxnet

In the year 2010, a 500-kilobyte computer virus (worm) was discovered infecting Microsoft Windows system machines and networks. It was targeting industrial control systems of

centrifuges (specialized machines designed for the separation of components in a liquid or slurry mixture) inside a nuclear power plant in Iran. Once the virus gained access to the system, it searched for a specific type of control system known as a Programmable Logic Controller (PLC). In nuclear programs, the centrifuges were used to enrich Uranium. After the virus recognized a PLC, it manipulated the system, causing the centrifuges to spin at a faster rate, ultimately leading to the self-destruction of the system. This occurred due to a previously existing vulnerability in the software used to control the centrifuges.

Although no one claims to be the author of the virus, leaks suggest that the United States and Israel created it under the project name "Operation Olympic Games." Its intention was to slow down the nuclear power plant in Iran.

This serves as an example of how a self-replicating computer worm harmed a nuclear power plant. Notably, it wasn't a Polymorphic Virus. Stuxnet possessed all the characteristics that are considered part of living beings, except evolving only by natural or artificial selection. However, a similar effect can be achieved by a polymorphic virus, which can change its underlying code to avoid detection. Depending on the environment, the polymorphic virus can be considered equivalent to natural selection in that specific virus. Stephen Hawking once said that “I think computer viruses should count as a life.” People can argue that his perspective is more philosophical than a scientific fact and they are right, we just do not know what is really a difference between living and non-living philosophically, and we do not know what a perfect definition for a living creature must be.

The Evolution of the Question

Are we alone in the universe? Many of us have likely heard this question before, but are we the first to ask it? Is it simply because science has advanced that we now start thinking about alien life and communication with extraterrestrials? If not, who were the people who pondered this question before our generation, and what answers did they find? Throughout history, many great individuals have asked, "Are we alone in the universe?" Some were brave enough to risk their lives for this question—and ultimately, some lost their lives in pursuit of it.

Giordano Bruno's life and death are a powerful testament to the courage of questioning established beliefs and envisioning a universe far larger than what was imagined in his time. Born in 1548 in Nola, Italy, Bruno was a Dominican friar, philosopher, mathematician, and one of the boldest thinkers of the Renaissance. He dared to dream of an infinite cosmos, filled with countless worlds, potentially teeming with life—a vision that would cost him dearly.

The Revolutionary Idea

In an era dominated by the geocentric view of the universe, with Earth firmly at the center of God’s creation, Bruno proposed something radically different. Inspired by the ideas of Copernicus,

Bruno took the heliocentric model further. He suggested that the Sun was just one of countless stars, and that each star could have its own planets, possibly harboring intelligent beings. He argued that the universe was infinite, boundless, and teeming with life—an idea not grounded in empirical evidence, but in the philosophical conviction that the Creator's magnificence would not be confined to a single world or a single species.

This vision was outlined in his 1584 work, On the Infinite Universe and Worlds, where he rejected the concept of a finite, closed universe. For Bruno, the vastness of the cosmos reflected the boundlessness of God. His ideas were deeply spiritual, yet they defied the rigid orthodoxy of the Catholic Church, which held the Earth and humanity as the centerpiece of divine creation.

The Conflict

Bruno’s ideas were as provocative as they were visionary. He questioned the authority of the Church, not only with his cosmology but also with his theological beliefs. He denied the doctrine of transubstantiation, the virgin birth, and the divinity of Christ. For the Church, his heresies were too dangerous to ignore.

In 1592, Bruno was betrayed by a noble patron in Venice and handed over to the Roman Inquisition.

Over the course of seven years, he was imprisoned, interrogated, and pressured to recant his views. Bruno refused to abandon his vision of the universe. His defiance wasn't just intellectual—it was deeply moral. He believed that truth, no matter how uncomfortable or dangerous, was worth defending.

The Martyrdom

In 1600, Bruno was declared a heretic. The Church condemned him for his blasphemous ideas and his refusal to submit to its authority. On February 17, 1600, he was burned at the stake in the Campo de' Fiori in Rome. Witnesses recorded that he faced his execution with unflinching courage, reportedly telling his judges, "Perhaps you pronounce this sentence against me with greater fear than I receive it."

Bruno's death marked him as a martyr for free thought and the pursuit of knowledge. His ideas about the infinite universe and extraterrestrial life were centuries ahead of their time, influencing later scientific pioneers like Galileo, Kepler, and even modern astronomers who continue to explore the cosmos.

Today, Bruno stands as a symbol of intellectual courage and the unyielding pursuit of truth. His life reminds us that progress often comes at great personal cost, and that the questions he dared to

ask—about life beyond Earth and humanity's place in the universe—remain as compelling as ever. Bruno’s dream of an infinite cosmos inspires us to look to the stars and wonder: Are we truly alone? Or are there others, somewhere out there, asking the same questions?

Early Speculations Gone Awry

It’s the late 18th century, and astronomer William Herschel peers through his telescope. The Moon’s surface, pockmarked with craters and valleys, seems alive with activity. Herschel is convinced he’s glimpsed “towns,” perhaps even bustling civilizations. Word spreads quickly, fueling public imagination. Could humanity have neighbors so close? The excitement is palpable, but time reveals the truth—optical illusions misinterpreted as evidence of life.

Fast-forward to the late 19th century. In a sprawling observatory in Arizona, Percival Lowell obsessively maps Mars, his pencil sketching intricate networks of “canals.” To Lowell, these are signs of intelligent life, Martian engineers constructing waterways to survive a dying world. His theories captivate the public and inspire generations of science fiction. Yet, as telescope technology improves, Lowell’s canals vanish. They were never there, mere tricks of the eye that

taught humanity an important lesson: the desire to find life can sometimes cloud our vision.

These missteps are not failures but stepping stones in our understanding of the cosmos. They reveal a timeless truth about human nature: our unrelenting hope to find ourselves less alone in the universe.

Blurring Life's Definition

The sterile hum of a laboratory in the 1980s provides the setting for a discovery that would upend biology. Stanley Prusiner, a biochemist, examines a peculiar class of proteins known as prions. Unlike any life form known, prions lack DNA or RNA, yet they replicate and wreak havoc in the brains of their hosts. How could something so simple blur the line between life and non-life? Prusiner's discovery earned him a Nobel Prize, but it left science with a puzzle: what does it mean to be alive?

In another corner of the intellectual world, Stephen Hawking ponders this same question. Speaking through his synthesized voice, he muses on viruses, entities that defy simple classification. "Viruses straddle the boundary between life and non-life," he says. They replicate and evolve, yet rely entirely on other organisms to do so. Are they alive? Hawking's musings echo Prusiner's discovery, challenging us to rethink biology's oldest question.

The deeper we delve into life’s mysteries, the more blurred its definition becomes. From rogue proteins to parasitic viruses, the lines that separate the living from the inanimate grow increasingly indistinct.

The Living

Maybe for some of you the answer to this question may seem very simple, because in the conventional education system we have learned how to differentiate between a living and non-living thing, but the answer to the question is not as simple as categorizing life in one of those two categories. Here are the characteristics of life according to conventional definition .

- It is complex and exhibits complex behavior
- It grows
- It Replicates (divides)
- It metabolizes
- It contains a system for storing information
- It evolves not only by natural but also artificial selection

You can see most of these characteristics in a computer virus too, for example Stuxnet.

Sentience and Life

Sentience - A lot of us may think that being alive and being sentient is the same thing but it's not sentience or

sometimes interchangeably used as consciousness refers to the feeling of sensations like pain or to experience emotions such as grief. It is also linked to the feeling of self awareness of being alive.

Living - Life is a little broader concept than sentience, life refers to a state characterized by the capacity to grow, reproduce and exhibit complex behaviors, basically the characteristics that were listed above in this book.

It will not be wrong if I say that all sentient beings are living but not all living beings are sentient as we have seen so far.

The Black Swan

In the year 1697 a Dutch explorer Willem de Vlamingh made the first European claim of sighting a black swan when he sailed into, and named, the Swan River on the western coast of New Holland, which is now known as Australia. Before the discovery of the black swan european believed that all swans are white so much so that "All Swan are white" a phrase was often used to describe a well-known truth. Now the black swan event is referred to as a metaphor which signifies that just because something has not been discovered doesn't mean that it will not occur in future.

Willem de Vlamingh

This term was later used and popularized by Economist and author Nassim Taleb; he said there are three describing attributes for a Black Swan event.

1. An event that is unpredictable.
2. A black swan event results in severe and widespread consequences.

3. After the occurrence of a black swan event, people will rationalize the event as having been predictable (known as hindsight bias).

The term black swan will frequently appear later in the book to explore the unexpected and challenge preexisting thought processes about life beyond our planet. Much like a black swan event, discovering extraterrestrial life requires us to consider that just because we haven't encountered something doesn't mean it cannot exist. I would also like to delve into this topic and talk about if AI could be that black swan.

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