



Workshop “Life in the Cosmos - Beyond the blind spots”

November 18, 2024, to November 20, 2024, Villa Galileo and INAF-Osservatorio Astrofisico di Arcetri

Organisers: Paolo Tozzi (INAF-Osservatorio Astrofisico di Arcetri, Italy), Amedeo Balbi (Università Tor Vergata, Italy), John Brucato (INAF-Osservatorio Astrofisico di Arcetri, Italy), Adam Frank (University of Rochester, USA), Lisa Kaltenegger (Cornell University, USA), Manasvi Lingam (Florida Tech, USA), **LOC:** Patrizia Braschi (INAF-Osservatorio Astrofisico di Arcetri), John Brucato (INAF-Osservatorio Astrofisico di Arcetri), Paolo Tozzi (INAF-Osservatorio Astrofisico di Arcetri)

Abstract. Astrobiology has made remarkable progress in the last 30 years. From the discovery of exoplanets to the development of atmospheric characterisation techniques and relevant in situ missions to objects in the solar system, there has been an explosion in studies of where, when and how life might form (and thrive) in the Universe. However, by its nature, Astrobiology is a new kind of wildly interdisciplinary (or even transdisciplinary) science requiring extensive collaborations across fields as diverse as geology, planetary science, biology, ecology and even anthropology and history. In this workshop (perhaps the first in a series), we focus on progress in the field with a focus on the “blind spots” that currently exist. Given the progress being made, we ask what kinds of perspectives are needed and how these blind spots might be addressed. The organisers aim to build new, interdisciplinary networks of collaboration to address the most exciting and challenging issues surrounding life in the cosmos.

Keywords: astrobiology, life sciences, exoplanets.

Scientific rationale

Life in the Cosmos – Beyond the Blind Spots was a transdisciplinary conference exploring the frontiers of astrobiology, evolution, planetary science and the physics of life. Bringing together expertise from geology, planetary science, biology, ecology, anthropology and history allowed us to address some of the blind spots often associated with the astrophysical framework that underpins astrobiology. The aim of the workshop was to gather about twenty-five researchers active in the field of astrobiology to discuss the latest results and potential future developments. The conference was held at Villa Galileo, the last residence of Galileo Galilei, and in the library of the Arcetri Observatory, where the Einstein piano is

conserved, ideally bridging two historical places with the most visionary research topics in astronomy and life sciences.

The approach of the workshop was instrumental in engaging the diversified audience, given the wide range of backgrounds represented among those who attended. Starting with foundational questions – *What is astrobiology?* and *What's universal about life?* – the programme brings different perspectives together to probe the general principles that may underlie biology beyond Earth. Talks addressed the boundaries of evolution, the thermodynamic constraints shaping life and the provocative idea that life as we know it might represent not just a successful path, but the only possible one. Philosophical and sociological dimensions including why we may be the only humans in the universe and what that means for our future as a species were also explored.

The conference linked conceptual frameworks with observational strategies, from modelling planetary climates and assessing exoplanet habitability to the search for biosignatures and techno-signatures. Contributions ranged from discussions on Martian biosignatures and cyanobacteria-based experiments to high-resolution observations with next-generation instruments like ANDES on the Extremely Large Telescope. Emerging paradigms, such as Hycean worlds and the role of transition metals in life detection, were critically examined. Lastly, novel approaches – including the use of natural language processing and information theory in the hunt for techno-signatures – challenged participants to re-frame long-standing assumptions and illuminate the blind spots in our quest to understand life in the Universe.

This conference, possibly the first in a series, marked a significant first step towards fostering a truly transdisciplinary approach to astrobiology. The final goal is to understand how universal terrestrial biology is and how well it adapts to space. We are convinced that continuing along this path will help build new, interdisciplinary networks of collaboration in this growing field.