

Indian Institute of Technology, Kanpur

Proposal for a New Course

1. **Course No:** SPA698X
2. **Course Title:** Key concepts in Astrobiology and Space Biology
3. **Lectures per week:** 3 (L), Tutorial: 0 (T), Laboratory: 0 (P), Additional hours: (0-2): 0 (A), Credits (3*L+0*T+0*P+0*A): 5,

Duration of Course: Half Semester Modular Course

4. **Proposing Department:** Space, Planetary and Astronomical Sciences and Engineering (SPASE)
5. **Proposing Instructor:** Yamini Jangir and Kunal Mooley
6. **Course Description:**

- a. **Objectives:** This course provides an in-depth understanding of astrobiology and space biology with a focus on future ISRO missions, including Chandrayaan-4, Chandrayaan-5, the Bharatiya Antariksha station, planned Venus and Mars missions. Students will explore key principles of life sciences in space, focusing on biosignature detection and microbial survival in extreme environments. The course will examine the biological challenges of human spaceflight, planetary protection protocols, and contributions to global astrobiology research by NASA, ESA, and ISRO, preparing students to contribute to upcoming space missions and advance life sciences research in space exploration contexts.
- b. **Contents** (preferably in the form of 5 to 10 broad titles):
 - i. **Life on Earth** [4 lectures]: the formation of organic molecules in primordial conditions, the role of hydrothermal vents; the significance of RNA in the hypothesis of the first self-replicating systems; the emergence of cellular life; the development of metabolic pathways; and the rise of oxygenic photosynthesis.
 - ii. **Earth Life in Space Environments** [5 lectures]: microbial adaptations to space physical extremes, such as temperature, radiation, pressure, gravity, and geochemical extremes (e.g., desiccation, salinity, pH, depletion of oxygen or extreme redox potential).; simulating the lunar and martial environment on Earth.
 - iii. **Biosignatures of Life in Space** [5 lectures]: definition of life; seeking for life as we know it; seeking for life as we don't know it; potential biosignatures of life in space; molecular, isotopic, and morphological biosignatures, such as specific organic molecules, isotopic ratios, and microfossil structures; understanding the limitations of current detection methods and discussing the implications of potential discoveries for our understanding of life in the universe; identifying potential biosignatures in spectral data
 - iv. **Space Instrumentation for Life Studies** [5 lectures]: approaches to in-situ life detection and monitoring life in space; mission science to flight hardware; planetary protection and contamination control; sample handling and fluidics; thermal environment and regulation; radiation resistance; virtual prototyping; platform for instrument validation (lab, ballon, rocket, cubesat, ISS, AUVs. etc).
 - v. **Astrobiology and Space Biology in the context of Indian space missions [2 lectures].** Gaganyaan and human spaceflight. Chandrayaan-4, Chandrayaan-5, Bharatiya Antariksha station, Venus and Mars missions (detection of biosignatures).
- c. Pre-requisites, if any: N/A
- d. Short summary for inclusion in the Courses of Study Booklet:

This course delves into the exciting field of astrobiology and space biology. We will examine the beginning, diversity, and resilience of life on Earth, understanding the fundamental conditions necessary for its existence. Next, we explore the challenges and possibilities of Earth life surviving in the harsh conditions of space, providing a basis for considering extraterrestrial life. The core of the course focuses on identifying potential biosignatures—chemical or physical

traces of life—that could be detected on distant planets. We will explore various types of biosignatures and discuss their potential as indicators of extraterrestrial life. We will also examine the advanced instrumentation used in space missions to detect and analyze these biosignatures, providing insights into the technological frontiers for astrobiology and space biology. Finally, we will delve into Astrobiology and Space Biology in the context of Indian space missions planned for low-Earth orbit, Moon, Venus and Mars.

7. Recommended Books: The teaching material will be taken from the books mentioned below. Handouts will be provided regularly as the course progresses.

- ***Astrobiology: An Introduction***; Kevin W. Plaxco and Michael Gross; ISBN: 978-1421441290
- ***Life Everywhere: The New Science of Astrobiology***; David Darling; ISBN: 978-0465015641
- ***Planetary Astrobiology***; Victoria Meadows; ISBN: 978-0816540068
- ***Fundamentals of Space Biology: Research on Cells, Animals, and Plants in Space***; Gilles Clément, Klaus Slenzka; ISBN: 978-0387331133

8. Any other remarks:

Dated: Proposer:

Dated: DUGC/DPGC Convener:

The course is approved/not approved

Chairman, SUGC/SPGC

Dated: