

Indian Institute of Technology, Kanpur

Proposal for a New Course

1. **Course No:** SPA633
2. **Course Title:** Introduction to Astrobiology
3. **Hours per week:** 2 lectures (L), 0 tutorial (T), 1 laboratory (P), 0 Additional hours (A). Credits: $2*L+0*T+1*P+0*A = 7$.

Duration of Course: Full Semester

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 introduces students to the foundational and emerging concepts in astrobiology, with a focus on their relevance to planetary exploration. It examines the origin and limits of life on Earth and extends this understanding to assess habitability and biosignature potential on other planetary bodies. Emphasis is placed on planetary processes shape habitable environments and guide life-detection strategies. Through case studies, remote sensing, analog field sites, and mission design, students will gain interdisciplinary skills applicable to planetary science, astrobiology, and space exploration, with a special focus on upcoming Indian missions to the Moon, Mars, and Venus.
- b. **Contents** (preferably in the form of 5 to 10 broad titles):
 - i. Isotope Cosmochemistry and Early Solar System Processes (4 lectures): Stellar nucleosynthesis; radionuclide systems; condensation sequence; accretion of planetesimals; thermal evolution of planetary bodies; meteorite classification (stony, iron, stony-iron) and dating;
 - ii. Planetary Geology and Surface Processes relevant for the facilitation of biological life (2 lectures): Planetary differentiation; internal structure; volcanism; tectonics; impact cratering; hydrothermal systems; weathering; erosion; sedimentation; geological timescales;
 - iii. Planetary Mineralogy and Remote Sensing Techniques relevant for biosignature detection (3 lectures): Brief introduction to biosignatures; Clays; sulfates; carbonates; Raman spectroscopy; XRD; LIBS; infrared spectroscopy; hyperspectral imaging; remote mineral mapping;
 - iv. Origin and Evolution of Life on Earth (5 lectures): Prebiotic chemistry; organic synthesis; RNA/DNA world; protocells; early metabolism; microbial ecosystems; oxygenic photosynthesis;
 - v. Life in Extreme and Analog Environments (3 lectures): Extremophiles; high salinity; acidity; radiation; pressure; desiccation; hydrothermal vents; hypersaline lakes; polar deserts; deep subsurface ecosystems; planetary analog simulations;
 - vi. Detailed investigation of biosignatures (5 lectures): Types, Preservation, and Detection: Molecular biosignatures; isotopic signatures; morphological biosignatures; stromatolites; microbial mats; biominerals; preservation processes; diagenesis; false positives. Detection of biosignatures on exoplanets.
 - vii. Analog Field Studies and Mission Case Studies (3 lectures): Lonar Crater; Rann of Kutch; Ladakh; Deccan Traps; Atacama Desert; Pilbara; Dallol; Iceland; planetary field geology; sample collection; ISRO and international missions;

viii. Space Instrumentation (3 lectures): Life-detection instruments; sample handling; contamination control; CubeSats; ISS; balloons; Perseverance; ExoMars; Dragonfly; Gaganyaan, Bharatiya Antariksha Station; Chandrayaan-4/5 (sample return, lunar lander); Venus Orbiter Mission (VOM); Mangalyaan-2 (Mars mission);

- c. **Pre-requisites, if any:** There are no formal prerequisites. Prior knowledge of basic physics, biology, chemistry, geology, maths and physics, and an open mind to learn, will be useful but not absolutely essential. Quantitative skills and scientific reasoning will be emphasized throughout the course, and supplemental resources will be provided where necessary.
- d. **Short summary for inclusion in the Courses of Study Booklet:** This course introduces students to astrobiology (and astrogeology as relevant for biological life/biosignatures), through the lens of cosmic and planetary processes. Topics span the formation of the universe, stellar nucleosynthesis, early Solar System chronology, and isotopic evidence from chondrites for water and organics. Students explore the origin of life on Earth, extremophiles, and biosignature preservation across geologic time. The course covers life-detection techniques, remote sensing, and mission instrumentation. Special focus is given to planetary analogs and the astrobiological potential of Indian space missions to the Moon, Mars, Venus, and low-Earth orbit within a global exploration framework.

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

- **Fundamentals of Geobiology;** Andrew H Knoll, Donald E. Canfield, and Kurt O. Konhauser; ISBN: 978-1405187527
- **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

8. **Any other remarks:** N/A

Dated:

Proposer:

Dated:

DUGC/DPGC Convener:

The course is approved/not approved

Chairman, SUGC/SPGC

Dated: