Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

The sections shown on this interface are based on the templates UG OBTL+ or PG OBTL+
If you are revising/duplicating an existing course and do not see the pre-filled contents you expect in the subsequent sections e.g. Course Aims, Intended Learning Outcomes etc. please refer to Data Transformation Status for more information.

Expected Implementation in Academic Year	
Semester/Trimester/Others (specify approx. Start/End date)	
Course Author * Faculty proposing/revising the course	Janelle Thompson (Assoc Prof);#1119
Course Author Email	Janelle.thompson@ntu.edu.sg
Course Title	Emergent Life
Course Code	ES5002
Academic Units	0
Contact Hours	39
Research Experience Components	

Course Requisites (if applicable)

Pre-requisites	Nil
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

This course will provide an introduction to the search for Life in our solar system and beyond, and how biological processes shape the environment of Earth, and possibly of other worlds. You will consider the various interpretations of what it means to be "alive", the known factors that limit habitability on our modern world and the diversity of organisms that have adapted to thrive across conditions, including in "extreme" environments such as hydrothermal vents, acid pools, and high deserts. You will also learn about how biology has played a role in shaping earth's environment in the geological past and in modern times. You will learn about the search for life on other worlds, creation of new lifeforms through synthetic biology, and the interplay of scientific and cultural theories on the origin of life from abiotic conditions (i.e. abiogenesis). You will also carry out group-based projects in concert with the second half of the course, to investigate trajectories of non-human life in the solar system, within the context of earth's geologic past, current scientific and technological advances, sustainability under scenarios of global change, and socio-cultural considerations. This multidisciplinary course contributes to the NTU mission to provide education "…founded on science and technology, nurturing leaders through research and a broad education in diverse disciplines."

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Articulately describe the modalities of life expected to occur in different environments on earth and across the solar system. (LO1)
ILO 2	Identify the major resources required to support carbon-based life. (LO2)
ILO 3	Describe the impact of biological processes on planetary scale features such as atmosphere and ocean composition (LO3).
ILO 4	Critically discuss topics in popular science (e.g. astrobiology and synthetic biology) within the context of their recent scientific advances, potential future developments, and socio-cultural considerations. (LO4)

Course Content

The course content covers three major areas: 1) Emergence and early life on earth, 2) Factors governing the habitability of planetary bodies, 3) Application of the scientific method to the search for life in the Universe. Course readings and discussions will include knowledge and theory as well as socio-cultural perspectives.

Reading and References (if applicable)

Primary References (students encouraged to purchase): Primary Reference (students encouraged to purchase): Jeffrey O. Bennett and Seth Shostak. Life in the Universe (4th Edition). Pearson eBook ISBN: 9780134080352 Secondary References (on reserve at library) David A. Rothery (Editor), Iain Gilmour (Editor), Mark A. Sephton (Editor). An Introduction to Astrobiology (3rd Edition) ISBN-13: 978-1108430838 (cost $52 USD) Falkowski, P.G. Life's Engines: How Microbes Made Earth Habitable. ISBN-13: 978-0691173351 ($15 USD) Church, G. and E. Regis. Regenesis: How Synthetic Biology Will Reinvent Nature and Ourselves. ISBN-13: 978-0465075706 (cost $15 USD)

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Introduction & Foundations of Life (as we know it) How do biology, astronomy and planetary science help us to understand the possibilities of extraterrestrial life? What are the general properties of Life on earth? What are extremophiles and what do they tell us about the conditions where life might survive in the universe?	LO1, LO2, LO4	Chapter 1 (p. 2-11) 1.1 The possibility of life beyond earth p. 2-4 1.2 The scientific context of the search p. 4-8 1.3 Places to search p. 8-10 1.4 The new science of astrobiology p. 10-11 Chapter 5 (p 154-176 & 183-188) 5.1 Defining Life p. 154-165 5.2 Cells: The Basic Units of Life p. 165-172 5.3 Metabolism: The chemistry of Life p. 172-176 5.5 Life at the Extreme p. 183-188 Note: skip 5.4 and 5.6	In-person	
2	Structure & Energy in the Universe What are matter and energy? How big is the Universe and what structures are apparent? What features are in Earth's cosmic neighborhood?	LO1, LO2, LO4	Chapter 3 (p. 50-80) 3.1 The Universe and life p. 50-51 3.2 The structure, scale and History of the Universe p. 51-69 3.3 A Universe of Matter and Energy p.69-80 (Chemistry and Physics Review)	In-person	

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
3	Formation of habitats around stars How do we distinguish science from non-science? How did attempts of ancient civilizations to understand the sky start us on the road to modern science? How does modern science explain the features of our Solar system? What is gravity and does life require it?	LO1, LO4	Chapter 2 (p. 24-44) 2.1 (OPTIONAL-The Ancient Debate about Life Beyond Earth p. 16-24) 2.2 Copernican Revolution (Keppler's Laws) p.24-32 2.3 The Nature of Modern Science p.32-40 2.4 The fact and theory of gravity p. 40-44 Chapter 3 (p. 80-98) 3.4 Our Solar System p 80-92 3.5 Ongoing development of Nebular Theory p. 92-98	In-person	
4	Geology and habitability of early earth What can we learn about early life from rocks and fossils? How does Earth's geology contribute to its habitability? How has Earth's climate changed over prolonged periods of time?	LO1, LO2, LO3, LO4	Chapter 4 (p. 105 -148) 4.1 Geology and Life p. 105-107 4.2 Reconstructing the History of Earth and Life p. 107-121 4.3 The Hadean Earth and the Dawn of Life p 121-125 4.4 Geology and Habitability p. 125-136 4.5 Climate regulation and change p. 137-143 4.6 Formation of the moon p. 144-148	In-person	

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
5	A multidisciplinary scientific foundation for astrobiology How have our learnings from the fields of biology, astronomy, chemistry, physics and geology prepared us to consider where life may occur on Earth, in the Solar System, and elsewhere in the Universe?	LO1, LO2, LO3, LO4	Review and discussion of material from weeks 1-4. No new content assigned. Midterm Exam 1 (1 hr) To be completed during the week	In-person	

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
6	Origin(s) of life & Searching for Life in a Solar System What are the major theories regarding the origin of life on Earth? What major events have marked the diversification of life on Earth? What is the state of current research and ethical considerations regarding the creation of artificial life? What are the prospects for life to exist or survive elsewhere in our Solar system?	LO1, LO2, LO3, LO4	Chapter 6 (p. 198-228) 6.1 Searching for life's origins 6.2 The origin of life 6.3 The evolution of life 6.4 Impacts and extinctions Skip 6.5 6.6: Artificial life Chapter 7 (p. 244-263) 7.1: Environmental Requirements for Life 7.2: A Biological Tour of the Solar System: The inner solar system 7.3: A Biological Tour of the solar system: The outer solar system 7.4: Space craft exploration of the solar system.	In-person	

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
7	The search for life on Mars What are the major features of Mars today? How has Mars climate and potential habitability changed since the birth of the Solar System? What principals govern the modern-day search for life on Mars?	LO1, LO2, LO3, LO4	Chapter 8 (p. 268-298) 8.1: Fantasies of Martian Civilization 8.2: A Modern portrait of Mars 8.3: The Climate History of Mars 8.4: Searching for life on Mars 8.5: Martian meteorites	In-person	
8	The search for life on the Jovian moons What are the general characteristics of the Jovian Moons? Do Ice World Oceans contain sufficient building blocks for life? What is Lyfe? And why do scientists think Titan is a good candidate to support Lyfe?	LO1, LO2, LO3, LO4	Chapter 9 (pp. 303-331) 9.1: The Moons of the Outer Solar System 9.2: Life on Jupiter's Galilean Moons 9.3: Life Around Saturn, and Beyond 9.4: Chemical Energy for Life	In-person	

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
9	Habitability in our solar system and the search for habitable extrasolar planets How do we find planets in Star systems beyond Earth? How are stellar properties used to infer the habitable zones of star systems? How do we characterize physical, chemical, (and possibly biological) properties of exoplanets? What are the general properties of the exoplanets that have been discovered so far?	LO1, LO2, LO3, LO4	Chapter 10 (pp. 336-365) 10.1: The Concept of a Habitable Zone 10.2: Venus: An Example in Potential Habitability 10.3: Surface Habitability Factors and the Habitable Zone 10.4: The future of life on Earth 10.5: Global Warming Chapter 11 (pp. 370-416) 11.1: Distant Suns 11.2: Discovering Extrasolar Planets 11.3: The Nature of Extrasolar planets 11.4: The Habitability of Extrasolar planets 11.5: Classifying Stars	In-person	

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
10	The search for intelligent life What factors have influenced the emergence of intelligence on Earth? What is a civilization and how is the Drake equation used to estimate their frequency in the Galaxy? What are the prevailing theories explaining the lack of recognized techno-signatures in the universe? How does the research agenda of initiatives like Breakthrough listen address these theories?	LO1, LO3, LO4	Chapter 6 (229-238) 6.5: Human evolution Chapter 12 (pp. 422-456) 12.1: The Drake Equation 12.2: The Question of Intelligence 12.3: Searching for Intelligence 12.4: UFOs and Aliens on Earth Chapter 13 13.3: Fermi paradox (p. 479-489)	In-person	
11	The Search for life in the Universe What major recent discoveries and current research directions are advancing the search for habitable planets and niches in our solar system and beyond?	LO1, LO2, LO3, LO4	Monday meeting, review and discussion of weeks 6-10. No new content assigned. Midterm Exam 2 (75 mins)	In-person	

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
12	Astrobiology Group Presentations Building upon knowledge gained this term, develop a testable hypothesis for the existence of an organism (life or lyfe) in an extraterrestrial environment. Design a research strategy to test for its existence leveraging a) current or b) blue sky technologies.	LO1, LO2, LO3, LO4		In-person	Presentations will be online (oral) or in person (poster) based on prevailing public health guidance.
13	As the class is offered on Monday, there are only 12 scheduled classes in the NTU academic term. Thus, each week the teaching content is targeted to cover 3.25 hours for equivalency with a 13 week course.	Not Applicable	Not Applicable	In-person	

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Lecture	Lectures will effectively convey information on fundamental theories and key concepts (Course LO1-4) and will mix use of lecture slides, video, and in-class problem solving.
Peer to Peer Learning	Sessions convened during lecture presentations will provide you with opportunities for questioning and critique of lecture content via small group discussion (e.g. "Pair Share" or "Breakout group") format. Discussion-based learning will help develop critical thinking and verbal communication skills and your ability to articulate convincing arguments (LO2).
Team Based Learning/Group work	Independent research and presentation will help you analyse, formulate, and communicate a deep understanding of topics that are fundamental to astrobiology and the emergence and trajectory of life on Earth and potentially on other worlds.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Others([quiz/test])	1-4	Knowledge (PLO 1); intellectual flexibility and critical thinking (PLO 2); passion and communication (PLO3); interdisciplinary (PLO 7)	20			
2	Continuous Assessment (CA): Others([quiz/test])	1-4	Knowledge (PLO 1); intellectual flexibility and critical thinking (PLO 2); passion and communication (PLO3); interdisciplinary (PLO 7)	25			
3	Continuous Assessment (CA): Others([assignments (e.g. term paper, essay)] Weekly/Biweekly problem sets. (7 total: keep best 5 grades))	1-4	Knowledge (PLO 1); intellectual flexibility and critical thinking (PLO 2); passion and communication (PLO3); interdisciplinary (PLO 7)	35			
4	Continuous Assessment (CA): Others([group or individual projects/evaluations] Term Project: Abstract & Workplan)	1-4	Knowledge (PLO 1); intellectual flexibility and critical thinking (PLO 2); passion and communication (PLO3); interdisciplinary (PLO 7)	4			

No.	Component	ILO	Related PLO or Accreditation	Weightage	Team/Individual	Rubrics	Level of Understanding
5	Continuous Assessment (CA): Others([group or individual projects/evaluations] Term Project: Poster/Report & Peer Assessment)	1-4	Knowledge (PLO 1); intellectual flexibility and critical thinking (PLO 2); passion and communication (PLO3); interdisciplinary (PLO 7)	11			
6	Continuous Assessment (CA): Others([presentations] Term Project: Presentation)	1-4	Knowledge (PLO 1); intellectual flexibility and critical thinking (PLO 2); passion and communication (PLO3); interdisciplinary (PLO 7)	5			

Description of Assessment Components (if applicable)

Formative Feedback

You will receive solutions and be able work through the correct answers for problem set component 3. For component 4 (poster) you will receive written feedback on the 1-page abstract of their topic, due 4-5 weeks before the report due date and will receive oral feedback from peers and evaluators during the presentation at the 13th week.

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level

Course Policy

Policy (Academic Integrity)

Policy (General)

(1) General

You are expected to complete all assigned readings and activities and take all scheduled assignments and tests by due dates. You are expected to attend lectures where possible and participate in-class discussions and activities. You are also expected to take responsibility to follow up with recorded content, course notes, assignments, and course related announcements for lecture sessions that you have missed or lectures that are provided in an online-only format.

Policy (Absenteeism)

0

Policy (Others, if applicable)

(2) Online Compulsory Assignments

You are required to submit online compulsory assignments on due dates. The latest score will be considered in the course assessment.

(3) ASE Diversity and Inclusion policy
Integrating a diverse set of experiences is important for a more comprehensive understanding of science. It is our goal to create an inclusive and collaborative learning environment that supports a diversity of thoughts, perspectives, and experiences, and that honours your identities (including ethnicity race, gender, socioeconomic status class, sexual orientation, religion or, ability., etc.).
To help accomplish this:

- If you feel like your performance in the class is being impacted by your experiences outside of class, please don't hesitate to come and talk with one of the instructors or an ASE faculty member. We want to be a resource for you.
- Your classmates and instructors (like many people) are still in the process of learning about diverse perspectives and identities. If something was said in class (by anyone) that made you feel uncomfortable, please talk to the instructors or an ASE faculty member about it.
- As a participant in course discussions, you should also strive to honour the diversity of your classmates. You can do this by: (e.g., using preferred pronouns and names; being respectful of others opinions and actively, making sure all voices are being heard; and refraining from the use of derogatory or demeaning speech or actions., etc.).

We expect all members of the class to adhere to the NTU Anti-harassment policy (https://ts.ntu.edu.sg/sites/policyportal/new/Documents/msrf%20included%20NIE%20staff/Anti-Harassment%20Policy.pdf), if you witness something that goes against this or have any other concerns, please speak to your instructors or an ASE faculty member.

Last Updated Date: 26-05-2025 06:39:43

Last Updated By: Janelle Thompson (Assoc Prof)