

# Emergent Life: Introduction to Astrobiology

## NTU ES9002

### Fall 2021

- Instructor: Prof. Janelle Thompson, Asian School of the Environment  
Office: N2-01c-68  
Email: Janelle.thompson@ntu.edu.sg
- Class Meeting: Monday 2:30 – 4:00 pm, Online (i.e. Blackboard Collab.)  
Video Lectures: Monday 4:00 – 5:30pm (or preferred alternate time) view weekly pre-recorded lectures at NTULearn (.mov or .pptx format)
- Prof. Office hours: Weekly Thursday 11 am-12 pm; BB collaborate  
TA Office hours: Weekly (Day and time to be Confirmed)  
Physical location: Meeting room and online.
- Content: This course will provide an introduction to the search for Life in our Universe. You will consider the various interpretations of what it means to be “alive” and the factors that are thought to constrain habitability in our solar system and beyond. You will also consider the diversity of organisms that have adapted to thrive across conditions on Earth, including in “extreme” environments such as hydrothermal vents, acid pools, and high deserts. You will learn about how biology has played a role in shaping earth’s environment in the geological past and in modern times. You will also learn about the ongoing work to search for life elsewhere in our solar system, and develop hypotheses for modalities of life that might occur in these environments, considering availability of key resources such as energy, liquids (e.g. water), and molecules from which to build living material. In concert with the second half of the course, you will carry out group-based projects to explore these hypotheses within the context of current and future scientific and technological advances.
- Homework: Seven weekly or biweekly homework assignments will be distributed on the course website. Problem sets are due before the Monday meeting (by noon). Homework should be submitted online via NTULearn. Your two lowest homework scores will be dropped from your final grade such that a total of 5 of the 7 homeworks are considered for your final grade. **In general extensions on homework will not be granted since we will discuss answers during our Monday meetings.** Students who cannot complete at least 5 homeworks by the deadline may opt to be graded by a model that excludes the homework component, however this is not recommended (see grading Models A and B). Collaboration on homework is allowed; however, each student is responsible for submitting an individual assignment.
- Exams: Exams will be distributed via NTULearn at 4pm (i.e. after class) on the day they are assigned. The exams will be due before class, the next week (by noon). The exam will be posted in the same format as the problem sets. The exam can be taken at any time during the week. Be sure to secure your e-textbook copy prior to the exam if using the library’s e-book. No collaboration is permitted on the exam and the exam will be timed (60 mins for exam 1 and 75 mins for exam 2, to be completed in a single sitting).

The first midterm exam will cover the first four weeks of the course, and the second mid-term exam will cover the entire course up to and including week 11. Both exams will be open book, open notes, and open internet. However, collaboration on the exams is strictly prohibited.

**Group Report:** The final report and presentation will be done in groups. Teams of 5 or 6 will be assigned semi-randomly in Week 4 to distribute classmates from different schools across different groups. A single set of assignments will be due from each group, along with peer evaluation for group work.

Please refer to the Group Report assignment description for details on the assignment and assessment.

**Grading:** Your final grade will be determined by two models (with and without your homework score) and the model with the highest grade taken as your final grade. Model A tends to give higher overall grade for students who are able to submit at least 5 homework assignments on time for grading. Model B is provided as an alternative for students who cannot, or choose not, to submit at least 5 homeworks by the grading deadline.

**Model A:** 35% homework; 20% midterm-1 exam; 25% midterm-2 exam; 20% class report and presentation.

**Model B:** 0% homework; 31% midterm-1 exam; 38% midterm-2 exam; 31% class report and presentation

**Web site:** This syllabus, video lectures, homework assignments, supplemental readings, and other information will be made available on the NTULearn website.

**Reading:** Required readings will draw from the textbook below. A physical copy of the 4<sup>th</sup> edition text is on reserve at Lee Wee Nam Library (QH327.B471 2017), in addition, several copies of the e-book are accessible for short-term loan through NTU Libraries, and individual copies of the e-book can be purchased with NTU discount at BookLink @ NorthSpine. Equivalent readings may be found in the 3<sup>rd</sup> edition of the textbook, although with some differences and omissions. A 3<sup>rd</sup> edition reading list is posted to the class website as an additional resource.

**Required Textbook:**

Bennett and Shostak, 2017. Life in the Universe, 4<sup>th</sup> Edition. Pearson. ISBN-13 9780134080352. E-book.

## **Course Policies and Student Responsibilities**

### **(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 meetings you have missed or that are provided in an online-only format.*

### **(2) Online Assignments**

*You are required to submit online assignments on due dates for them to be graded, since class discussion may include references to the problem sets. While multiple attempts are permitted before the due date, the latest score (not the best 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.*

### **(4) Academic Integrity**

*Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.*

*As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the [academic integrity website](#) for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.*

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Date	Lecture Topics and Readings <i>All Readings from Bennet and Shostak, Life in the Universe, 4<sup>th</sup> edition.</i>
Aug. 16 – Monday	<p><b>Week 1: Introduction &amp; Foundations of Life (as we know it)</b></p> <p>Chapter 1 (p. 2-11)</p> <p>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</p> <p>Chapter 5 (p 154-176 &amp; 183-188)</p> <p>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  <i>Note: skip 5.4 and 5.6</i></p> <p><i>Pset #1 (Week 1) due Monday Aug. 23, noon</i></p>
Aug. 23 – Monday	<p><b>Week 2: Structure &amp; Energy in the Universe</b></p> <p>Chapter 3 (p. 50-80)</p> <p>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)</p> <p><i>Pset #2 (Week 2) due Monday Aug. 30, noon</i></p>
Aug. 30 – Monday	<p><b>Week 3: Formation of habitats around stars</b></p> <p>Chapter 2 (p. 24-44)</p> <p>2.1 (OPTIONAL-The Ancient Debate about Life Beyond Earth p. 16-24)            2.2 Copernican Revolution (Kepler'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</p> <p>Chapter 3 (p. 80-98)</p> <p>3.4 Our Solar System p 80-92            3.5 Ongoing development of Nebular Theory p. 92-98</p> <p><i>Pset #3 (Week 3) due Monday Sept. 6, noon</i></p>

Sept. 6 – Monday	<p><b>Week 4: Geology and habitability of early earth</b>  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</p> <p><i>Pset #4 (Week 4) due Monday Sept. 13, noon</i></p>
Sept. 13 - Monday	<p><b>Week 5: A multidisciplinary scientific foundation for astrobiology</b>  Monday meeting, review and discussion of weeks 1-4.</p> <p><i>Midterm Exam 1 (1 hr)</i>  <i>To be completed during the week. Due Monday Sept. 20, noon</i></p>
Sept. 20 – Monday	<p><b>Week 6: Origin(s) of life &amp; Searching for Life in a Solar System</b></p> <p>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</p> <p>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.</p> <p><i>Pset #5 (Weeks 5 &amp; 6) due Monday Oct. 4, noon</i></p>
Sept. 27 – Monday	<p>Recess Week (No class)</p>
Oct. 4 – Monday	<p><b>Week 7: The search for life on Mars</b>  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</p>

Oct. 11 – Monday	<p><b>Week 8: The search for life on the Jovian moons</b>  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</p> <p><i>Report Outlines Due Monday, Oct. 11, noon</i>  <i>Pset #6 assigned (Weeks 7 &amp; 8) due Monday Oct. 18, noon</i></p>
Oct. 18 – Monday	<p><b>Week 9: Habitability in our solar system and the search for habitable extrasolar planets</b>  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</p> <p>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</p> <p><i>No assignments due</i></p>
Oct. 25 – Monday	<p><b>Week 10: The search for intelligent life</b>  Chapter 6 (229-238)  6.5: Human evolution</p> <p>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</p> <p>Chapter 13  13.3: Fermi paradox (p. 479-489)</p> <p><i>Pset #7 (Weeks 9 &amp; 10) due Monday Nov. 1, noon</i></p>
Nov. 1 – Monday	<p><b>Week 11: The Search for life in the Universe</b>  Monday meeting, review and discussion of weeks 6-10.</p> <p><i>Midterm Exam 2 (75 mins)</i>  <i>To be completed during the week. Due Monday Nov. 8, noon</i></p>

Nov. 8 – Monday	<p><b>Week 12: Astrobiology Group Presentations</b></p> <p>Note: This final Monday meeting will be the full 3 hours (2:30-5:30 pm with one 15-minute break)</p> <p><i>Please plan to attend for the full duration to present, discuss and evaluate presentations. If you have an unavoidable conflict, email Prof. Thompson to obtain an excused absence by October 25.</i></p>
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