12.007 GEOBIOLOGY

Instructor:  Roger Summons (E34-246, rsummons@mit.edu)

Guest Lecturers:  Julian Sachs (E34-254, jsachs@mit.edu),
Yanan Shen (yshen@oeb.harvard.edu),
John Hayes (jhayes@whoi.edu)
Charles Marshall (cmarshall@oeb.harvard.edu)

Lectures:  Tues. & Thurs. 11-12:30 in 54-317

Course Description:
The interactive Earth system: biology in geologic, environmental and
climate change throughout Earth history.
Since life began it has continually shaped and re-shaped the atmosphere,
hydrosphere, cryosphere and the solid earth. This course introduces the
concept of ‘life as a geological agent’ and examines the interaction between
biology and the earth system during the roughly 4 billion years since life first
appeared.

Grading:  30% Problem Sets/Assignments; 8 for the course
20% Final Paper & Oral Presentation
20% Midterm Exam
30% Final Exam

Textbook:  Earth System History, Steven M. Stanley (W.H. Freeman & Co.,
New York, 1999). Available at The MIT COOP and on reserve in Lindgren
Library.

Recommended Reading
The Spark of Life, Christopher Wills & Jeffrey Bada (Perseus, Cambridge, MA,
2000).
The Earth System, Lee R. Kump, James F. Kasting & Robert G. Crane Prentice
Planet Earth: Cosmology, Geology and the Evolution of Life and Environment
Cesare Emiliani, Cambridge University Press, 1992
How to Build a Habitable Planet, Wallace S. Broecker, Eldigio Press, Lamont

More readings are provided at each lecture.

Tentative Lecture Schedule
1. **Tue 2/3**: Overview of course; Time scales; The Big Bang; Origin and compositions of the Solar System, Earth and Moon; Creation and distribution of the chemical elements; Earth segregation; Formation & composition of early atmosphere  
   **Reading**: Stanley, Chap. 1 & pp. 289-302 (RES)

2. **Thur 2/5**: Characteristics of the ‘habitable zone’; Basics of geology (RES)  

3. **Tue 2/10**: Theories about the origin of life; Geologic Evidence for antiquity of life (RES)  
   **Reading**: Stanley, pp. Stanley, pp. 306-311, 320-323

4. **Thur 2/12**: More about Early Life (RES)

5. **Tue 2/18**: No Class (Monday Schedule)

6. **Thur 2/19**: Anaerobic metabolism, energy yields, deep biosphere (RES)

7. **Tue 2/24**: Oxygenic photosynthesis; the rise of atmospheric O₂ (RES)  
   **Reading**: Stanley, pp. 257-269 & 323-325

8. **Thur 2/26**: Biogeochemical tracers #1: biominerals, fractionated isotopes and trace elements (Guest Lecturer: Yanan Shen)

9. **Tue 3/2**: Biogeochemical carbon cycle (Guest Lecturer: John Hayes)  
   **Reading**: Kump et al., Chap. 7

10. **Thur 3/4**: Long-Term Climate Cycles #1: Faint Young Sun Paradox; CO₂ -Climate connection; Snowball Earth (JS)  
    **Reading**: Stanley, pp. 269-282 & 325-329

11. **Tue 3/9**: Long-Term Climate Cycles #2: Permian glaciations, Mesozoic warmth, Cenozoic cooling (JS)

12. **Thur 3/11**: Life’s three domains; fossil and biogeochemical evidence for their presence and evolution through geological time (RES)

13. **Tue 3/16**: Evolution of algae & vascular plants; impact on biogeochemical carbon cycle (RES)

14. **Thur 3/18**: **Mid-term Exam**
15. **Tue 3/23:** Spring Break

16. **Thur 3/25:** Spring Break

17. **Tue 3/30:** Mass extinctions and re-radiation #1 PC-C boundary, P-T boundary (RES)  
**Reading:** Stanley, Chap. 7 & pp. 341-360, 369-386

18. **Tue 4/1:** Evolution and radiation of metazoans (Guest Lecturer: Charles Marshall)

19. **Thur 4/6:** Mass extinctions and re-radiation #2; K-T boundary, LPTM. Volcanism, carbon cycle perturbation or impact? (RES)  
**Reading:** Stanley, Chap. 7 & pp. 341-360, 369-386

20. **Tue 4/8** Biogeochemical Tracers #2 Lipid Biomarkers (RES)

21. **Thur 4/13:** Biogeochemical tracers #3: Sedimentary records of life an environment (RES)

22. **Tue 4/15:** Biogeochemical tracers #4 Fate of buried organic carbon; Petroleum and natural gas occurrence and distribution (RES)

23. **Tue 4/20:** Patriot’s Day Holiday

24. **Thur 4/22:** Methane hydrates; formation, distribution, potential role in C-cycling and subsurface ecosystems dependent upon them (RES)

25. **Tue 4/27:** Pleistocene glaciations (JS)  
**Reading:** Kump et al., Chap. 11; Stanley, pp. 526-536

26. **Thur 4/29:** Holocene climate; Abrupt climate change; Anthropogenic forcing of climate (JS)  
**Reading:** Stanley, Chap. 20

27. **Tue 5/4:** Student Presentations

28. **Thur 5/6:** Student Presentations

29. **Tue 5/11:** The ‘Sulfidic Ocean’ Hypothesis. (Guest Lecturer: Yanan Shen)

30. **Thur 5/13:** Exam review