

GEOMICROBIOLOGY FALL 2004

Objectives: The objective of this course is to describe interactions between microorganisms and Earth to bridge the gap between geochemistry and environmental microbiology. Fundamental processes will be discussed, including microbial diversity, metabolism and bioenergetics, geochemical controls on microbial diversity and activity, microbiological controls on geochemical reaction networks. Biogeochemical cycles of matter and energy and evolution of Earth and microbes will be studied. This course will also provide students with hands-on experience in some of the most important tools in geomicrobiology: light microscopy, lipid analysis and ribosomal DNA sequencing.

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Prerequisites: Prerequisites for the course are one introductory biology course and one introductory geology course.

Lectures:

Labs:

TA:

Course Material: Course material is based on class notes, handouts, and assigned readings. There are no specific textbook associated with this course, but the following will be used regularly:

- T. Fenchel; G. M. King; T. H. Blackburn. 2000. Bacterial Biogeochemistry: the ecophysiology of mineral cycling. Academic Press.
- J. F. Banfield; K. H. Nealson. 1997. Geomicrobiology: interactions between microbes and minerals. Reviews in Mineralogy Vol. 35. Mineralogical Society of America.
- M.T. Madigan; J.M. Martinko; J. Parker. 2000. Brock Biology of Microorganisms. 9th edition, Prentice Hall.

Useful References

Books:

- F. J. Stevenson; M. A. Cole. 1999. Cycles of Soils: Carbon, Nitrogen, Phosphorus, Sulfur, Micronutrients, 2nd Edition. Wiley.
- E. A. Paul; F. E. Clark. 2000. Soil Microbiology and Biochemistry. Academic Press.

Journals:

- Geomicrobiology
- Applied and Environmental Microbiology
- Environmental Microbiology
- Global Biogeochemical Cycles
- Nature
- Science
- Microbial Ecology
- Trends in Microbiology
- Virtual Journal of Geobiology (a collection of geobiology-related articles from Elsevier journals)

Organization of the Course

The course will consist of introductory lectures given by the instructors followed by class discussion. Every student registered for the class is expected to read each assigned paper carefully and have at least three questions to be addressed in class.

A term paper will be required from each group (no more than three students). This paper should be written based on results from the group lab projects.

Grading: Your semester grade will be determined based on the following:

Group lab project (paper: 30%, presentation: 10%)

Mid-term exam (25%)

Final exam (25%)

Reading and discussion (10%)

Statement on accommodations for disabilities: Iowa State University complies with the American with Disabilities Act and Section 504 of the Rehabilitation Act. Any student who may require an accommodation under such provisions should contact me as soon as possible and no later than the end of the first week of class or as soon as you become aware. No retroactive accommodations will be provided in this class. Those seeking accommodations based on disabilities should obtain a Student Academic Accommodation Request (SAAR) form from the Disability Resources (DR) office (515-294-6624). DR is located on the main floor of the Student Services Building, Room 1076.

The following is a sequence of the course topics

1. INTRODUCTION AND HISTORICAL CONTEXT

Wk 1 Aug 23 Introduction and overview of geomicrobiology
 Aug 25 **Lab 1 – Lab overview, lab safety, and lab basics**
 Aug 27 Microbial evolution and Earth history

Wk2 Aug 30 Geological and microbial benchmarks of microbes-Earth interactions
 Sept 1 Geological and microbial benchmarks of microbes-Earth interactions (cont'd)

2. MICROBIOLOGY

 Sept 3 **Lab 2 – Field trip to and sampling at Capital Beach Lake, Lincoln, Nebraska**
 Project outlines due

Wk3 Sept 6 *Labor Day, no class*
 Sept 8 **Lab 3 – Light microscopy**
 Sept 10 Microbial diversity
 Detailed project plan due

Wk4 Sept 13 Cell structure and function
 Sept 15 **Lab 4 – Lipid isolation**
 Sept 17 Microbial growth

Wk5 Sept 20 Microbial metabolism
 Sept 22 **Lab 5 – Lipid preparation**
 Sept 24 Bioenergetics of microbial metabolism

Wk6 Sept 27 Bioenergetics and the structure of microbial communities

3. MOLECULAR MICROBIOLOGY AND ECOLOGY

 Sept 29 **Lab 6 – Lipid identification and interpretation**
 Oct 1 Biochemical methods

Wk7	Oct 4	Biochemical methods (cont'd)
	Oct 6	Phylogenetic methods
	Oct 8	Phylogenetic methods (cont'd)

4. CARBON FIXATION AND OXIDATION

Wk8	Oct 11	Cyanobacteria and photosynthesis revisited
	Oct 13	Lab 7 – DNA isolation
	Oct 15	Rise of oxygen: Banded iron formations

Wk9	Oct 18	Chemosynthesis
	Oct 20	Stromatolites and microbial mats
	Oct 22	Stromatolites and microbial mats (cont'd)

Wk10	Oct 25	Mineralization of organic matter
	Oct 27	Gas hydrates and methane oxidation
	Oct 29	<i>Mid-Term Exam</i>

5. MICROBES-EARTH INTERACTIONS

Wk11	Nov 1	Microbial habitats of geomicrobial importance
	Nov 3	Lab 8 – PCR
	Nov 5	The role of microbes in mineral formation and transformations

Wk12	Nov 8	Geomicrobiology of carbonates
	Nov 10	Lab 9 – DGGE
	Nov 12	Geomicrobiology of silicon (silicates)

Wk13	Nov 15	Geomicrobiology of iron and manganese
	Nov 17	Lab 10 – Ribosomal DNA sequencing
	Nov 19	Geomicrobiology of sulfur and microbial diversity in the sulfur cycle

Wk14	Nov 22	Geomicrobiology of extremophiles
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6. GEOMICROBIOLOGY AND ENVIRONMENTAL STATISTICS

	Nov 24	Multivariate ecological statistics
	Nov 26	Multivariate ecological statistics (cont'd)

Wk15	Nov 29	Statistical DNA analyses
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7. SCIENTIFIC PRESENTATIONS

	Dec 1	Statistical DNA analyses (cont'd) <i>Student paper due</i>
	Dec 3	Reading and writing geomicrobiology articles
Wk16	Dec 6	How to prepare a geomicrobiology presentation

8. STUDENT PROJECT PRESENTATION

	Dec 8	Student presentations
	Dec 10	Student presentations
Wk17	Dec 13	Student presentations
	Dec 10	Student presentations
	Dec 15	Final Exam

Group Lab Project:

The overall goal of the group project is to give you hands-on experience with some of the most important tools of geomicrobiology, including microscopy, lipid analysis, and ribosomal DNA sequencing. The idea is that this will make you better prepared to explore the geomicrobiology and biogeochemistry and empower you with enough expertise to begin to follow your own curiosity in geomicrobiology in the future if you decide to.

- (i) Proposal outlines – due Sept 3rd.
- (ii) Detailed project plan – due Sept 10th.
- (iii) Paper – due December 1st. Write a comprehensive report on your group's project (one paper per group) in the form of a scientific paper. The format of the journal Applied and Environmental Microbiology is recommended.
- (iv) Oral presentation (20 min, 15 min for presentation and 5 min for questions). The goal of the oral presentations is to communicate your findings to the class.