OCN 637 - Aquatic Microbial Geochemistry - Introduction

Appreciation for the synergy that exists between geochemical cycling and microbial ecology has grown at a rapid pace in recent years. Microbes have co-evolved with the planet's biogeochemical cycles and continue to shape important geochemical and geological processes today. How has life evolved to colonize such a wide variety of environments? What are the limits and extents for life on this planet or elsewhere? What are the biotic and abiotic controls of sources, sinks, and transformations for varying geochemical materials in varying habitats, and how have these changed through geologic time scales? How are anthropogenic activities influencing the relationships between microbes and the environment on local and global scales? These are some areas of microbial geochemistry that are being actively explored and developed further by UH Oceanography faculty and collaborators.

OCN 637 is offered at the graduate level, in response to growing demand, interest, and support from Oceanography Department faculty and graduate students alike. Although SOEST is a leader in the fields of biogeochemistry and microbial ecology, there is not presently a course that provides upper-level graduate students with advanced concepts of aquatic chemistry (including thermodynamics and kinetics) as applied to natural systems (including consideration of microbial processes).

The course content is the result of a confluence of my own research interests and teaching activities in upper-level undergraduate *Biogeochemical Systems (OCN 401)* and introductory-level graduate *Chemical Oceanography (OCN 623)*. *OCN 637* is well aligned with the existing Department Curriculum, filling a void in advanced interdisciplinary topics, while building upon concepts introduced or omitted within the core curriculum. Fundamental topics to be covered in greater depth than in existing courses include advanced thermodynamics, kinetics, biomineralization, anaerobic microbial metabolisms, and spatial/temporal cycling of key biogeochemical processes from micro to global spatial scales on short to geologic time scales. The course contributes to the Student Learning Outcomes of the Oceanography Graduate Program, including:

> *Comprehensively synthesize, evaluate, and interpret the fundamental knowledge in their subdiscipline and how it relates to the other subdisciplines*
>
> *Critically analyze and synthesize the results of their research to derive conclusions which advance the field and are of a quality suitable for publication in the peer-reviewed literature*
>
> *Evaluate the hypotheses, methods, results and conclusions of published scientific literature and apply conclusions to their own work*

OCN 637 aims to help graduate students attain these objectives by increasing the depth of their understanding of fundamental aquatic chemical processes within the context of

natural systems, and with consideration of microbial influences. The course is structured as a blend of lectures and discussion sessions, with weekly critiques of a journal article (relevant to the lecture material) led by a student. This structure helps to further convey the concepts covered during lecture with real-world applicability, as well as help develop students' critical assessment skills with regard for both the literature and each other during peer evaluation of the discussion sessions (see evaluation rubric attached to syllabus). Comments from students who took the initial course offering in 2009 included:

> *"I learned how to read, analyze, and apply what we learned in class to understand a scientific paper better"*
>
> *"The idea of the course was fantastic--tie together chemical oceanography and microbiology"*
>
> *"Great course, but still requires some work to get fully running"*
>
> *"The idea of a biogeochemistry course like this one is fantastic, and a necessity for many students in the department"*

It is the expectation that this course will most strongly appeal to senior graduate students within the Marine Geology and Geochemistry Division in the Department of Oceanography, however students from the Biological Oceanography Division and other Departments (Geology and Geophysics, Microbiology) are likely to also become interested as the course becomes more established and more widely advertised. In order to maximize the efficiency of discussion sessions and interactive lectures, enrollment for the course would be limited to eight.

OCN 637 - Aquatic Microbial Geochemistry - Syllabus (subject to change)

Course instructor: Brian Glazer
Office: Marine Science Building 227 Phone: 956-6658 E mail: glazer@hawaii.edu
Office Hrs: by appointment
Class location and time:

Course description
The general objective of the course is to provide a one semester, comprehensive overview of the synergy between the biogeochemistry of element cycling and the (microbial) organisms involved. Within the discipline of microbial ecology, biogeochemistry is often given only cursory attention; with biogeochemistry, organisms are frequently viewed as mere catalysts. The aim of this course is to interface across these disciplines, from the perspective of a practical blend of aquatic chemistry, microbial ecology, biogeochemistry, and molecular biology. We will cover a large amount of material through lectures, readings, and student-led discussions.

Prerequisites
OCN 623 or consent from instructor

Student learning outcomes
Upon successful completion of the course, students will be able to:
--identify aquatic chemical and microbial processes as they pertain to their own areas of oceanographic interest
--discuss details of Gibbs Free Energy, chemical equilibrium, and chemical kinetics in natural waters
--discuss contemporary biogeochemical cycles of oxygen, carbon, nitrogen, phosphorus, sulfur, iron, and manganese
--discuss the coevolution of microbes and biogeochemical cycles through geologic time
--critically evaluate and discuss current scientific research literature

Grading

--1 exam (final)	35%
--Research paper critiques (written review and lead class discussion)	35%
--Participation	15%
--Homework	15%

Materials

The required textbook is Canfield (2005). Serious geochemistry students should also have a copy of Stumm (1996). We will also draw heavily upon current literature.

Advances in Marine Biology vol. 48: Aquatic Geomicrobiology by DE Canfield, B Thamdrup, and E Kristensen, Elsevier Academic Press, 2005.

Aquatic Chemistry: Chemical equilibria and rates in natural waters by W Stumm and JJ Morgan (3rd edition), John Wiley & Sons, Inc., 1996.

OCN 637 - Aquatic Microbial Geochemistry - Syllabus (subject to change)

Performance expectations of an upper-level graduate course

Leading research paper critiques accounts for 35% of final grade

This is meant to develop and reinforce critical literature evaluation and communication skills within the field of aquatic microbial geochemistry. Each student will lead two critical discussions of a primary literature research article relevant to timely lecture material as scheduled. Discussion leaders will be responsible for selecting a paper, submitting a written review, and leading class discussion of the article. Evaluation will be based upon:

A) Providing an accurate and complete overview of the study
- -relevant introduction, study design, analytical technique, data handling components
- -relevant statistics, results, figures, tables, authors' conclusions

B) Providing an accurate and complete analysis and critique of the study
- -introduction: journal quality, authors, affiliations, abstract, background, scientific rationale
- -methods: study design, samples, experimental treatments, positive/negative controls, data handling, statistics
- -results: figure quality, presentation of study results, confounding variables,
- -discussion/conclusion: interpretation of results, identification of limitations, comparison to other studies, consideration for future studies, suggestions for study improvement

C) Degree of preparation
- -knowledge of background context, study details, and applicability to course material
- -response to discussion points and questions

D) Quality of presentation skills
- -speaking style, clarity, volume, cadence, timing, distracters, eye contact

Participation in discussions accounts for 15% of final grade

This is meant to develop and reinforce critical literature evaluation and communication skills within the field of aquatic geomicrobiology. Each student will be expected to intelligently participate in weekly critical discussions, and evaluated on the same criteria listed A, B, C, D above.

Performance expectations of an upper-level graduate course (*continued*)

Homework problem sets account for 15% of final grade

This is meant to evaluate retention and application of material covered in course lectures and readings through performing problem solving and relevant calculations. Each student will complete a total of 6 take-home problem sets relevant to timely lecture material as scheduled.

Final exam accounts for 35% of final grade

This is meant to evaluate retention of material covered in the course through connection and interpretation of relevant course material within the context of individual research projects, and is meant to serve as preparation for PQE/Comprehensive –style examinations. Each student will receive a custom, take-home final exam question relevant to their own research within the context of course content, to be completed in an extended essay format (3-page max).

Aquatic Microbial Geochemistry Literature Review – Student Presentation Evaluation Rubric

I. Study Overview			**2 points**	**1 point**	**Score**
Introduction • Authors • Affiliation • Study Objectives • Rationale			Accurately and completely reported ALL relevant introduction, rationale, & objective components	Accurately and completely reported MOST relevant introduction, rationale, & objective components	
Methods - Design • Sampling • Analyses • Experiments • Controls • Statistics			Accurately and completely reported ALL relevant methodological & analytical components	Accurately and completely reported MOST relevant methodological & analytical components	
Results • Results of each Method • Confidence Intervals • p-values • Plots & Tables			Accurately and completely reported ALL relevant statistics, results, & plots/tables	Accurately and completely reported MOST relevant statistics, results, & plots/tables	
Conclusions • Authors' interpretation & conclusion			Accurately and completely reported ALL relevant interpretations & conclusions	Accurately and completely reported MOST relevant interpretations & conclusions	
Comments:					
II. Study Critique	**4 points**	**3 points**	**2 points**	**1 point**	**Score**
Analyzed all parts of study (see reference sheet for guidance)	All parts appropriately critiqued, with ALL relevant questions accurately addressed with strengths, weaknesses, & impact described	Missed only 1 or 2 considerations or relevant questions in critique, with rest appropriately addressed with strengths, weaknesses, & their impact described	MOST parts appropriately critiqued; some relevant questions with strengths, weaknesses, & their impact overlooked or inaccurate	Only SOME parts appropriately critiqued; most relevant questions with strengths, weaknesses & their impact overlooked or inaccurate	2x score multiplier for this <u>category only</u>
Comments:					
III. Study Critique Conclusion	**4 points**	**3 points**	**2 points**	**1 point**	**Score**
Clear, concise conclusion stated	Conclusion summarized accurately & completely stating ALL of: key points to be taken home, study limitations, role in relevance/significance to the field, AND need for further research	Conclusion did not summarize accurately & completely one of the following: the key points to be taken, role in relevance-significance, need for further research	Conclusion did not summarize accurately & completely two of the following: the key points to be taken, role in relevance-significance, need for further research	Failed to give conclusion OR conclusion completely inaccurate	
Comments:					

Aquatic Microbial Geochemistry Literature Review – Student Presentation Evaluation Rubric

IV. Preparedness		**3 points**	**2 points**	**1 point**	**Score**
Knowledge of study details			Well prepared, thoroughly explained ALL details of study	Thoroughly explained only some study details	
Response to questions		Correctly answered ALL questions in a confident manner	Correctly answered ALL questions in a non-confident manner OR correctly answered MOST questions in a confident manner	Correctly answered MOST questions in a non-confident manner OR correctly answered only SOME questions	
Comments:					
V. Presentation	**4 points**	**3 points**	**2 points**	**1 point**	**Score**
Speaking style			Spoke clearly, easy to hear & understand	Difficult to hear or understand	
Use of visual aids				Used whiteboard or slides appropriately	
Distractors ("uhs, uhms," etc., OR distracting mannerisms			Used few (or no) distractors or distracting mannerisms	Used several distractors or distracting mannerisms	
Comments:					
Additional Comments:				**Total Score**	

Study analysis and critique reference sheet: Important considerations for each section

Journal/Authorship/Abstract/Introduction
Is this a publication from a high-quality journal? Are there potential conflicts of interest or obvious biases that would influence the study's objective, methods, or conclusion? Does the abstract accurately summarize the highlights of the study? Was an appropriate rationale given for conducting the study? Is there adequate scientific background information to elucidate the significance? Is the objective or hypothesis consistent with the research question that needed to be addressed?

Methods
Were the overall field sampling strategies, study designs, and/or experiments appropriate to fulfill the objective? Optimal? Were there potential biases in sampling? How was sampling location, size, duration, etc. determined? Were controls used? Were all appropriate analytical techniques used correctly? Was it clear how many samples were used for which analyses? Were appropriate statistical tests used for all primary results? Secondary results?

Results
Were results reported for each measure described? Were measures of variability addressed in figures and tables? Were results statistically significant? Are there any confounding variables that could influence the results reported? Were they reported and/or controlled for in the study? Should results have been plotted or analyzed in additional ways?

Discussion/Conclusion
Were results interpreted appropriately by the authors? Did the authors adequately explain key limitations and any discrepancies from other similar studies? Were authors' conclusions consistent with the results and study limitations and extrapolated appropriately?

References
Are the references adequate for the scope and length of the study? Are the references up-to-date? Is there an unjustified amount of author self-citation? Are references missing?

OCN 637 – Aquatic Microbial Geochemistry - Topic Schedule – ***(Subject to Change)***

week	topic	reading (*source*)chapter
1	course overview and introduction	syllabus
	The earth as microbial habitat - early earth & 'origins'	*Ehrlich 1, 2, 3 & Konhauser 7*
	PAPER CRITIQUE #1	*handout*
2	microbial systematics & phylogeny	Canfield 1
	microbial structure, properties, & growth - Part I	Canfield 2, Ehrlich 6, Konhauser 1
	PAPER CRITIQUE #2	*handout*
3	microbial structure, properties, & growth - Part II	Canfield 1
	Mass transfer, diffusion & flow...questions of scales	*Zhang 3*
	PAPER CRITIQUE #3	*handout*
4	mineral-microbe interactions, mineral-microbial weathering	Konhauser 5,
	chemical thermodynamics…& a little kinetics - Part I	Stumm 2, Walther 3, 13
	PAPER CRITIQUE #4	*handout*
5	chemical thermodynamics…& a little kinetics - Part II	Stumm 2, Walther 3, 13
	acids & bases	Stumm 3
	PAPER CRITIQUE #5	*handout*
6	coordination chemistry & speciation - Part I	Stumm 6
	coordination chemistry & speciation - Part II	Stumm 6
	PAPER CRITIQUE #6	*handout*
7	oxidation & reduction	Stumm 8
	the solid-solution interface	Stumm 9
	PAPER CRITIQUE #7	*handout*
8	trace metals - Part I	Stumm 10
	trace metals - Part II	handout
	PAPER CRITIQUE #8	*handout*
9	kinetics & the solid-water interface	Stumm 11 & 13
	kinetics of redox processes	Stumm 11 & 13
	PAPER CRITIQUE #9	*handout*
10	microbial metabolism intro, cell surface reactivity	Canfield 3, Konhauser 2, 3
	biomineralization	Konhauser 4
	PAPER CRITIQUE #10	*handout*
11	microbial carbon fixation - Part I	Canfield 4
	microbial carbon fixation - Part II	Canfield 4
	PAPER CRITIQUE #11	*handout*
12	oxygen - Part I	Canfield 6
	oxygen - Part II	handout
	PAPER CRITIQUE #12	*handout*
13	nitrogen, phosphorus, silicon - Part I	Canfield 7, 11, 12, Ehrlich 12, 11, 9
	nitrogen, phosphorus, silicon - Part II	Canfield 7, 11, 12, Ehrlich 12, 11, 9
	PAPER CRITIQUE #13	*handout*
14	iron	Canfield 8, Ehrlich 15
	manganese	Ehrlich 16
	PAPER CRITIQUE #14	*handout*
15	sulfur	Canfield 9, 10
	methane and hydrogen	handout
	PAPER CRITIQUE #15	*handout*
16	real world waters	Stumm 15
	layered microbial ecosystems	Canfield 13
	PAPER CRITIQUE #16	*handout*