EPS 187/287 BIOGEOCHEMICAL PROCESSES – SPRING 2024

Prof. Ann Pearson (pearson@eps.harvard.edu)

This course is based loosely on the original Biogeochemistry lecture course taught by the late John Hayes, which debuted 25 years ago. After several generations of updates, the current version emphasizes the global carbon cycle and biogeochemical processes through a combination of lecture, primary literature, and short written assignments. We will spend considerable time studying the formation, processing, and preservation of organic carbon (and its connection to the other bio-elements N, S, and O), with emphasis on paleoenvironmental applications and the co-evolution of life and Earth. The class is intended for students who have some familiarity with *light stable isotope geochemistry*; if you do not know what this means, you must talk to Prof. Pearson before enrolling (prior enrollment in EPS 53 or its equivalent is recommended). **The only difference between enrolling in 187 or 287 is that students in 287 must also make a final presentation (detailed below). All other requirements, including a final exam, are required for all students in both 187/287.**

Schedule: TuTh, 9:00-10:15, first meeting in GeoMuseum 365, January 23, 2024.

Section: Time TBD. TF, Ruth Tweedy (rtweedy@g.harvard.edu)

Web: https://canvas.harvard.edu/courses/128762

GRADING

187 – Final Exam 30%	287 – Final Exam 25%
187 – Midterm Exam 30%	287 – Midterm Exam 25%
187 – Problem Sets 30%	287 – Problem Sets 25%
	287 – Final Presentation 15%

Both – Participation, Preparation, and Attendance (class and section) 10%

READING

There is no specific textbook. Required readings will consist of chapters of selected texts, plus original research papers, and will be posted on the course web site. All students are expected to check the web site after every class meeting to download the readings, lecture notes, and slides.

REFERENCE TEXTS

The following textbooks may be helpful reference guides. The Pearson lab owns many of these books (most also can be found in Cabot library). You are welcome to come and study from them any time. The books are not to be removed from the lab, however, and please remember that our conference room/library is a quiet study space. Conversations and problem set working-groups should relocate to Hoffman 4th floor.

Sarmiento and Gruber (2006) *Ocean Biogeochemical Dynamics*
Schlesinger (1997) *Biogeochemistry, Second Edition: An Analysis of Global Change*
Killops & Killops (2005) *An Introduction to Organic Geochemistry*
Hoefs (any year) *Stable Isotope Geochemistry*
Fry (2006) *Stable Isotope Ecology*
Madigan et al. (any year) *Brock Biology of Microorganisms*
Jacobson, Charlson, Rodhe, Orians (2000) *Earth System Science*
Canfield et al. (2005) *Aquatic Geomicrobiology*
Knoll et al. (2012) *Fundamentals of Geobiology*

ASSIGNMENTS

Requirements: The course consists of 2.5 hours per week of lecture and 1 hour of section. In-person attendance at lectures and sections is required unless you have a valid excused absence (e.g., medical, athletic). All lecture slides will be posted after class for re-review or for absent students. Lectures will not be streamed or recorded.

Note – during mid-terms week we will have labs instead of lectures and section.

Problem Sets: There will be eight problem sets spaced throughout the semester. These p-sets will draw on your skills in scientific reading and writing, incorporate relatively easy quantitative exercises, and use skills from general chemistry and basic bio/organic chemistry.

Late Work: All students will receive 5 "free" late days (unexcused delays, taken no more than 2 per assignment) without penalty. Late work beyond this quota will require a valid petition/excuse to be granted. Unexcused late work will receive a 10% penalty per day.

Midterm Exam: There will be a take-home written essay exam, open book, for all students.

Final Exam: There will be a standard (3-hr) closed-book final exam of quantitative and qualitative problems for all students.

EPS 287 Students: Graduate students (anyone enrolled in the 287 version) will do an oral presentation during the last week of class. This is an additional assignment, not in lieu of any other work.

Collaboration policy

Discussion and the exchange of ideas are essential to doing academic work. For assignments in this course, you are encouraged to consult with your classmates as you work on problem sets, laboratories, and writing assignments. After discussions with peers, however, make sure that you can work through the problem yourself and ensure that any answers you submit for evaluation are the result of your own efforts. Written work you submit must be the result of your own research and written by you, reflecting your own approach to the topic. In addition, you must formally cite any books, articles, websites, lectures, or other material that you have used in your submitted work.

Generative AI/ChatGPT

Use of AI/ML tools generally is not permitted in this class (and in most cases wouldn't be helpful anyway). The only allowed exception is for the proofreading/final editing of written answers; you may use AI/ML to improve your grammar and syntax in your written answers. This can be especially helpful to students for whom English is not their first language.

Integrity Policy

SCHEDULE

Background

L1: January 23 (Tu) – Organizational meeting; introduction to biogeochemistry; review of redox chemistry; review of thermodynamics

L2: January 25 (Th) – Introduction to paleoecology; review of stable isotope fractionation, closed and open systems; global cycles, conservation of mass, and box models

Biomass Production (Carbon Fixation, Primary Production)

L3: January 30 (Tu) – Photoautotrophy, terrestrial – Part I, systematics

L4: February 1 (Th) – Photoautotrophy, terrestrial – Part II, modern applications

L5: February 6 (Tu) – Photoautotrophy, aquatic – Part I, systematics

L6: February 8 (Th) – Photoautotrophy, aquatic – Part II, systematics (continued); modern applications

L7: February 13 (Tu) – Photoautotrophy – paleo pCO_2 – 50:50 class (guest lecture, Kelsey?)

L8: February 15 (Th) – Photoautotrophy – anoxygenic photosynthesis, microbial primary production

L9: February 20 (Tu) – Redfield ratios; master variables and feedbacks: Van Cappellen & Ingall feedback (C/N/P/Fe/S/O); the N vs. P debate; marine N-cycle

Biomass Consumption (Remineralization)

L10: February 22 (Th) – Coupling of O_2 and CO_2 (Keeling); aerobic heterotrophy, you are what you eat

L11: February 27 (Tu) – Re-oxidation and chemoautotrophy; review redox series, sediment diagenesis; what is a heterotrophic microbe?

L12: February 29(!) (Th) – Preservation of sedimentary organic carbon; evolution of land plants and soils and associated changes in C-cycle

Lab / Midterm Week

Lab 1: March 5 (Tu) – Laboratory I – isotopic analysis of honey (in lab)

Lab 2: March 7 (Th) – Laboratory II – isotopic analysis of fingernails (in lab)

Biomass Consumption (Remineralization), continued

L13: March 19 (Tu) – C_1 metabolism, methanogenesis; terrestrial methane cycle, aerobic methanotrophy

L14: March 21 (Th) – Marine methane cycle, anaerobic methanotrophy; S cycle

Biomarkers and Organic Geochemistry

L15: March 26 (Tu) – Synthesis of major biochemicals

L16: March 28 (Th) – Stable isotope properties of biomarkers

L17: April 2 (Tu) – Biomarkers – Part I, modern processes & recent paleoclimate

L18: April 4 (Th) – Biomarkers – Part II, ancient processes & ancient records

Early Earth – Precambrian Biogeochemistry

Lxx: April 9 (Tu) – *NO CLASS TODAY*

L19: April 11 (Th) – Redox environment in the Archean and Proterozoic; Miller-Urey experiments & origin of biomolecular precursors; molecular, fossil, isotopic records of early life

L20: April 16 (Tu) – Eukaryotic evolution; extremophiles and microbial diversity; astro/exobiology

EPS 287 Lecture Presentations

April 18 (Th) – TBD

April 23 (Tu) – TBD

EPS 287 FINAL ASSIGNMENT

During the last two meetings of class, students enrolled in EPS 287 will be given the responsibility of preparing and teaching a lecture on a subject we did not cover during the term. Students will be actively mentored through the process of developing a lecture outline; putting together slides, notes, handouts, and readings; and teaching the lecture for 30 minutes (half a class). The hypothetical scenario for 5 students in the EPS 287 version is as follows. If more/fewer students, we will adjust the schedule for the last weeks of class as necessary.

Grad student presentations - potential subjects:

1) Marine DOC budget and potential changes over time
2) Using the oxygen triple isotope system to constrain global productivity
3) Arctic biogeochemistry
4) Evolution of oxygenic photosynthesis and aerobic respiration
5) The marine nitrogen cycle in modern and ancient oceans