Biogeochemistry (BIO/EOS 272)
Fall 2006, Tu/Th 10:05 AM, LSRC 247
Drs. Emily S. Bernhardt and William H. Schlesinger

Date	Lecturer	Topic	Chapter Readings
August 29	ESB	Introduction	Chapter 1
August 31	WHS	Origins of the Elements and the Earth	Chapter 2
September 5	WHS	Origins of Metabolism and Life	Chapter 2
September 7	WHS	Biogeochemistry on Neighboring Planets	Chapter 2
September 12	ESB	Free Energy & Nonequilibrium Thermodynamics	
September 14	WHS	Earth's Atmosphere	Chapter 3
September 19	WHS	Tropospheric Gas Reactions	Chapter 3
September 21	WHS	Stratospheric Gas Reactions	Chapter 3
September 26	ESB	Rock Weathering: Processes	Chapter 4
September 28	WHS	Rock Weathering: Global patterns and rates	Chapter 4
October 3	WHS	Net Primary Production	Chapter 5
October 5	WHS	Detritus	Chapter 5
October 10		FALL BREAK	
October 12	ESB	Terrestrial Biogeochemistry	Chapter 6
October 17	ESB	Terrestrial Biogeochemistry	Chapter 6
October 19	WHS & ESB	Oxidation - Reduction Reactions	
October 24	ESB	Wetland Biogeochemistry	Chapter 7
October 26	ESB	Freshwater Bigeochemistry: Lakes	Chapter 7
October 31	ESB	Freshwater Biogeochemistry: Rivers	Chapter 8
November 2	ESB	The Oceans	Chapter 9
November 7	ESB	Marine Biogeochemistry NPP	Chapter 9
November 9	ESB	Marine Biogeochemistry	Chapter 9
November 14	ESB	The Global Water Cycle	Chapter 10
November 16	WHS	The Global Carbon Cycle	Chapter 11
November 21	WHS	The Global N and P Cycles	Chapter 12
November 23		Thanksgiving Break	
November 28	WHS	The Global S Cycle	Chapter 13
November 30	WHS	GAIA, Perspectives on the Future	Chapter 14

Contact Information for Course Instructors:

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Office hours available by appointment

Grading:

Semester grades will be based on:

25% A take-home final exam
handed out on last day of class & due back by December 7th

25% A research paper focusing on a biogeochemical process or budget of your choice
due in class on November 21st

40% A series of problem sets (5 assigned, 4 highest scores included at ~10% each)
Problem Set 1 due in class on September 21st
Problem Set 2 due in class on October 5th
Problem Set 3 due in class on October 24th
Problem Set 4 due in class on November 7th
Problem Set 5 due in class on November 28th -- Seminar based paper

10% Participation in discussions of the assigned papers

Reading Assignments:

Unless otherwise indicated, all chapter readings are from:

Schlesinger, W.H. 1997. Biogeochemistry an Analysis of Global Change. Academic Press (Elsevier), San Diego.

Discussion Readings:

August 29: Introduction to Biogeochemistry

Gorham, E. 1991. Biogeochemistry: its origins and development. Biogeochemistry 13:199-239.

August 31: Origins of the Elements and Earth

Cowan, J.J. and C. Sneden. 2006. Heavy element synthesis in the oldest stars and the early University. Nature 440: 1151-1156.

Klekociuk, A.R. et al. 2005. Meteoritic dust from the atmospheric disintegration of a large meteoroid. Nature 436: 1132-1135

September 5: Origins of Metabolism and Life

Tian, F., O.B. Toon, A.P. Pavlov, and H. De Sterck. 2005. A hydrogen-rich early Earth atmosphere. Science 308: 1014-1017.

Busemann, H. et al. 2006. Interstellar chemistry recorded in organic matter from primitive meteorites. Science 312: 727-730.

September 7: Biogeochemistry on Neighboring Planets

Kennedy, M., M. et al. 2006. Late Precambrian oxygenation: Inception of the clay mineral factory. Science 311: 1446-1449

Rouxel, O.J., A. Bekker, and K.J. Edwards. 2005. Iron isotope constraints on the Archean and Paleoproterozoic ocean redox state. Science 307: 1088-1091.

September 12: Free Energy & Thermodynamics:

Libes, S. 1992. The importance of oxygen. pp. 107-128, in S. Libes, ed. An Introduction of Marine Biogeochemistry. Wiley & Sons [****posted on course blackboard site*]

Jackson, B. E., and M. J. McInerney. 2002. Anaerobic microbial metabolism can proceed close to thermodynamic limits. Nature 415: 454.

September 14 Earth's Atmosphere

Richter, A. et al. 2005. Increase in tropospheric nitrogen dioxide over China observed from space. Nature 437: 129-132.

Kaufman, Y.J. and I. Koren. 2006. Smoke and pollution aerosol effect on cloud cover. Science 313: 655-658.

September 19: Tropospheric Gas Reactions

Reimann, S., et al. 2005. Low European methyl chloroform emissions inferred from long-term atmospheric measurements. Nature 433: 506-508.

Brown, S.S. et al. 2006. Variability in nocturnal nitrogen oxide processing and its role in regional air quality. Science 311: 67-70

September 21: Stratospheric Gas Reactions

Weatherhead, E.C. and S.B. Andersen. 2006. The search for signs of recovery of the ozone layer. Nature 441: 39-45

Rohrer, F. and H. Berresheim. 2006. Strong correlation between levels of tropospheric hydroxyl radicals and solar ultraviolet radiation. Nature 442: 184-187.

September 26: The Crust, Rock Weathering. I. Processes

Derry LA, et al. 2005. Biological control of terrestrial silica cycling and export fluxes to watersheds. Nature 433: 728-731.

Dietrich, W. E., and J. T. Perron. 2006. The search for a topographic signature of life. Nature **439**:411-418.

September 28: Rock Weathering II. Patterns

Raymond, P. A. and J. J. Cole. 2003. Increase in the export of alkalinity from North America's largest river. Science 301: 88-91.

Syvitski, J.P.M. et al, 2005. Impact of humans on the flux of terrestrial sediment to the global coastal ocean. Science 308: 376-380.

October 3: Net Primary Production

Ciais, P. et al. 2005. Europe-wide reduction in primary productivity caused by the heat and drought in 2003. Nature 437: 529-533.

Keppler, F. et al. 2006. Methane emissions from terrestrial plants under aerobic conditions. Nature 439: 187-191.

October 5: Detritus

Austin, A.T. and L. Vivanco. 2006. Plant litter decomposition in a semi-arid ecosystem controlled by photodegradation. Nature 442: 555-558.

Bellamy, P.H. et al. 2005. Carbon losses from all soils across England and Wales 1978-2003. Nature 437: 245-248

October 12: Terrestrial Biogeochemistry I

Wardle DA, L.R. Walker LR, and R.D. Bardgett. 2004. Ecosystem properties and forest decline in contrasting long-term chronosequences. Science 305: 509-513.

October 17: Terrestrial Biogeochemistry II

Croll DA et al. Introduced predators transform subarctic islands from grassland to tundra Science 307: 1959-1961.

October 19: Redox

Hedin, L. O., J. C. von Fischer, N. E. Ostrom, B. P. Kennedy, M. G. Brown, and G. P. Robertson. 1998. Thermodynamic constraints on the biogeochemical structure and transformation of nitrogen at terrestrial-lotic interfaces. Ecology 79: 684-703.

October 24: Wetlands

Raghoebarsing, A. A. et al. 2005. Methanotrophic symbionts provide carbon for photosynthesis in peat bogs. Nature **436**:1153-1156.

Freeman, C., N. et al. 2004. Export of dissolved organic carbon from peatlands under elevated carbon dioxide levels. Nature **430**:195-198.

October 26: Lakes

Pace, M. L. et al. (2004). Whole-lake carbon-13 additions reveal terrestrial support of aquatic food webs. Nature 427(6971): 240-243.

Blomqvist, S, A Gunnars, and R Elmgren. 2004. Why the limiting nutrient differs between temperate coastal seas and freshwater lakes: A matter of salt. Limnology & Oceanography. 49:2236-2241.

October 31: Rivers

Mayorga, E. et al. (2005). Young organic matter as a source of carbon dioxide outgassing from Amazonian rivers. Nature 436(7050): 538-541.

Taylor, B. W., A. S. Flecker, and R. O. Hall. 2006. Loss of a harvested fish species disrupts carbon flow in a diverse tropical river. Science 313: 833-836.

November 2: Oceans

Curry, R. and C. Mauritzen (2005). Dilution of the northern North Atlantic Ocean in recent decades. Science **308**(5729): 1772-1774.

Orr, J. C., et al. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature 437: 681.

November 7 – Marine Net Primary Production

Jickells T.D. et al. 2005. Global iron connections between desert dust, ocean biogeochemistry, and climate. Science 308: 67-71.

Boyd, P. W. et al. 2004. The decline and fate of an iron-induced subarctic phytoplankton bloom. Nature **428**:549-553.

November 9- Marine Biogeochemistry

Arrigo, K. R. 2005. Marine microorganisms and global nutrient cycles. Nature **437**:349-355.

Hopkinson, C. S., and J. J. Vallino. 2005. Efficient export of carbon to the deep ocean through dissolved organic matter. Nature **433**:142-145.

November 14: The Global Water Cycle

Oki, T., and S. Kanae. 2006. Global Hydrological Cycles and World Water Resources. Science 313: 1068-1072.

November 16: The Global Carbon Cycle

Sabine, C.L. et al. 2004. The oceanic sink for anthropogenic CO_2. Science 305: 367-371.

Sowers, T. 2006. Late Quaternary atmospheric CH_4 isotope record suggests marine clathrates are stable. Science 311: 838-840.

November 21: The Global Nitrogen & Phosphorus Cycles

Sowers, T., R.B. Alley, and J. Jubenville. 2003. Ice core records of atmospheric N_2O covering the last 106,000 years. Science 301: 945-948.

Schulz, H.N and N.D. Schulz. 2005. Large sulfur bacteria and the formation of phosphorite. Science 307: 416-418.

November 28: The Global Sulfur Cycle

Johnston, D.T. et al. 2005. Active microbial sulfur disproportionation in the Mesoproterozoic. Science 310: 1477-1479

November 30: GAIA, Perspectives on the future

Imhoff, M.L. et al. 2004. Global patterns in human consumption of net primary production. Nature 429: 870-873

Schlesinger, W.H. 2006. Global change science. Trends in Ecology and Evolution 21: 348-351.

Research Paper Assignment:

As you will learn over the course of the semester, one of the most challenging tasks for biogeochemists is scaling up from small scale field measurements to plot, watershed, continental and global estimates of biogeochemical pools and fluxes. To help you better understand the difficulties and challenges inherent in this type of effort, we expect you to examine the controls on rates of a biogeochemical process or to put together a biogeochemical budget. With either effort your challenge is to frame an interesting question that is neither overly ambitious or so specific that there is insufficient published data to answer the question.

Because this is a challenging assignment we will provide feedback at several points through the semester.

By **September 19th** you must select and articulate your question, write a one or two paragraph description of your proposed approach to addressing it, and provide a list of relevant citations from which you will acquire the necessary data. Course instructors will help you to refine your question and approach based on this initial proposal.

By **October 19th** you must hand in a data compilation that should include most of the relevant data available in the literature for addressing your question. For example, if you are building a global budget for Boron (e.g. Park & Schlesinger 2002) you will want to make it clear what pools and flux data you have found, and what is missing in the literature. Alternatively, if you are looking at how an environmental variable affects an important biogeochemical rate (e.g. how does K affect plant growth, Tripler et al. 2006) you will want to provide synthesized data in tables or graphs to describe the patterns you see. We will provide feedback to improve your dataset and to suggest approaches to data synthesis and analysis.

Final papers are due on **November 21st.** These papers need not be lengthy, we expect that you will present your question and justify your effort by describing the importance of understanding this process/budget. You will then present the data as clearly as possible, and discuss the implications.

If you feel extremely confident in your approach, you need not hand in interim materials on October 19th and can wait until November 21 to hand in your finished work. However, we strongly encourage to take advantage of the earlier deadlines, this assignment cannot be done well as a last minute effort.

This paper will be worth 25% of your final grade and is equivalent to the final exam in its weighting.

Park, H., and WH Schlesinger, Global biogeochemical cycle of boron, Global Biogeochemical Cycles, 16(4), 1072

Tripler, C. E., S. S. Kaushal, G. E. Likens, and M. T. Walter. 2006. Patterns in potassium dynamics in forest ecosystems. Ecology Letters 9: 451-466.

Problem Set #5
Biogeochemistry 272, Fall 2006
Due in class on November 28th

Over the course of the semester there are a number of opportunities to attend seminars on active areas of biogeochemical research. We hope you will attend many, but you are required to attend at least one over the course of the semester. Following the seminar, you should prepare a 3-5 page report (double spaced with 1" margins) summarizing the content of the seminar and placing the research presented in the context of the speaker's work and in the general field of research (~cite relevant literature).

Possibilities:
Many other appropriate seminars may be scheduled – We will announce relevant seminars in class. please ask a TA if you would like to write your report on a seminar other than those listed below or advertised in class.

Sept 15th — Nigel Roulet, McGill University, "*Northern Peatlands, Carbon Cycling and Climate Change*" Seminar 1:15-2:30 in LSRC A247

October 17th — Wallace Broecker, Columbia University, UNC Ecology seminar series, 4:00pm, location TBA

October 27th — Todd Dawson, Berkeley, "*The manner and magnitude by which trees impact the hydrological cycle*" Seminar 1:15-2:30 in LSRC A247