*Course title:* **Biogeochemical Cycles**

*Course number:* EAS 6122 (graduate) / 4602 (undergraduate)

*Term:* Spring 2014
*Credits:* 3
*Lecture:* 3
*Lab:* 0

*Time & location:* 9-10am, MWF, L1116

*Instructor:* Taka Ito (EST 1102), Jennifer Glass (EST 1234)
*Email:* taka.ito@eas.gatech.edu; jennifer.glass@eas.gatech.edu

*Short description:* Physical, chemical, and biological mechanisms that control atmospheric carbon dioxide, and global biogeochemical cycles of nitrogen, phosphorus, sulfur and oxygen

*Long description:* The goal of this course is to prepare advanced undergraduate and graduate students for research in a variety of scientific fields that incorporate aspects of chemical oceanography and biogeochemical cycles. Lectures will provide a theoretical framework on fundamental and advanced aspects of chemical cycling. Relevant physical and biogeochemical processes, including seawater composition, carbonate chemistry, air-sea gas transfer, photosynthesis, respiration, geochemical mass balance and anthropogenic perturbations will be discussed in a quantitative manner. Particular emphasis will be placed on the global carbon cycle and the present and past fate of $CO_2$ in the ocean. Current topics including ocean acidification, iron fertilization and controls on the atmospheric content of major greenhouses gasses will be discussed in detail. Students are expected to spend significant time and effort outside of the classroom on background reading and homework assignments. Homework will include modeling and data analysis exercises that are complementary to the lectures. Current journal articles on research subjects that reflect the interests of participating students will be incorporated into class discussions.

*Evaluation:* Homework 40%; Midterm exam 20%; Final exam 40%

*Texts:*
**Emerson S. and J. Hedges (EH)**, *Chemical oceanography and the marine carbon cycle*, Cambridge University Press, pp. 468
**Schlesinger, W.H. and E. S. Bernhardt (SB)**, *Biogeochemistry: An Analysis of Global Change*, Third Edition, 2013, Academic Press

Recommended reference:
**Sarmiento, J. L. and N. Gruber**, *Ocean Biogeochemical Dynamics*, Princeton University Press, pp. 526

| *Week, dates* | *Topic* | *Reading* | *Homework* |
|---|---|---|---|
| 1 (1/6-10) | Introduction and overview<br>• Course objectives and scientific questions<br>• Observed carbon distributions: present and past<br>• Atmospheric and ocean tracer transport<br>• The "carbon pumps" in the oceans | EH chap 1 | |
| *Part I: The Global Carbon Cycle* | | | |
| 2 (1/13-17) | Solubility pump<br>• Solubility<br>• Carbonate equilibrium<br>• 2 box ocean-atmosphere model | EH chap 4<br>+1 journal article | HW#1 |
| 3 (1/20-24) | Air-sea gas transfer<br>• Diffusive flux<br>• Bubble-mediated flux<br>• Observational data<br>• 3 box model<br>• Mechanics of the numerical solution<br>• Anthropogenic perturbations and ocean acidification | EH chap 10 | HW#2 |
| 4 (1/27-1/31) | Biological pump<br>• Photosynthesis and respiration<br>• "Redfield" Stoichiometric ratio<br>• Soft tissue (organic) pump<br>• Hard shell (carbonate) pump | EH chap 6 | |
| 5 (2/10-14) | Interactions: the global cycling<br>• "Harvinton-Bear" 4 box model<br>• Nutrient cycle<br>• Carbon cycle<br>• Analytic and numerical solutions | EH chap 11 | HW#3 |
| 6 (2/17-21) | Steady-state carbon cycle<br>• High latitude surface nutrient<br>• The "preformed" concept<br>• A theory for equilibrium atmospheric $CO_2$<br>• Glacial-interglacial $CO_2$ change | Journal articles | HW#4 |
| 7 (2/24-2/26) | River sources and sediment sinks<br>• Carbonate and silicate weathering<br>• Diagenesis of $CaCO_3$<br>• Lysocline and carbonate compensation | EH chap 2.1 and 12 | |

**2/28 Midterm exam (in-class)**

8 (3/3-3/7) Iron Fertilization and $CO_2$ Journal articles

- Iron speciation
- Biological requirements
- Iron fertilization controversy

9 (3/10-14) The Terrestrial Carbon Cycle

- Photosynthesis and decomposition SB chap 5, 11 + HW #5
- Methane
- Land use changes
- Climate change impacts

**3/17-21 Spring break**

*Part II: Global Nitrogen, Phosphorus, Sulfur and Oxygen Cycles*

10 (3/24-28) The Global Nitrogen Cycle, Part I SB chap 7, 12

- Redox transformations
- Microbial cycling: land and sea
- Nitrous oxide: sources and sinks

11 (3/31-4/4) The Global Nitrogen Cycle, Part II Journal article + HW#6

- Anthropogenic perturbations
- Global budgets

12 (4/7-4/11) The Global Phosphorus Cycle SB chap 12 +Journal article

- Coupling to the rock cycle
- Controls on primary productivity over geologic time
- Global budgets

13 (4/14-18) The Global Sulfur & Mercury Cycle SB chap 9, 13 + HW #7

- Redox transformations
- Microbial cycling: land and sea
- Anthropogenic perturbations
- Global budgets

14 (4/21-25) The Stability of Atmospheric Oxygen SB chap 11 +Journal article

- Global budgets
- Oxygen minimum zones
- Controls on atmospheric oxygen over geologic time

**4/28-5/2 Final exam**