Geology 315: Paleoclimatology and Paleoceanography
Spring 2011

Instructor:

Dr. Kira Lawrence
102 Van Wickle Hall
lawrenck@lafayette.edu
610-330-5194

Office Hours: Monday 1pm-3pm or by appointment
Course Website: http://moodle.lafayette.edu

Lectures: Tuesday, Thursday 9:30 to 10:45am 15 Van Wickle Hall
Laboratory: Thursday 1:10 to 4 pm in 15 Van Wickle Hall

Course Reading:

- *The Earth System* (Third Edition) by Kump, Kasting, and Crane (2010), Pearson Education. (Required)
- *Interpreting Pre-Quarternary Climate from the Geologic Record* (First Edition) by Judith Totman Parrish (1998), Columbia University Press. (on Reserve)
- Literature articles listed in the "Course Literature" section below will be made available by the instructor.

Some of the "Course Literature" articles are derived from popular science magazines (e.g. Discover, Scientific American). These articles offer accessible distillations of important scientific advances in a format that is entertaining and meant to be read from start to finish. Enjoy these!

Also in the "Course Literature" section are research articles from primary scientific journals, which are intended to be read primarily by other scientists. These articles provide detailed information about the scientific investigation undertaken and what important conclusions resulted from that investigation. At first, you will probably find reading these articles challenging because they are full of specific information. I do not expect you to understand every aspect of these articles. But, as you will learn, it is usually possible to understand the important overall contribution ("the essence") of the study without having to understand every detail.

Course Description:

Understanding Earth's climate system and predicting future climatic change requires both the study of the climatic processes that operate within the Earth system as well as detailed studies of climate changes in the past. Direct human observations of climate have captured only a very small fraction of the potential range of Earth's climatic variability. In contrast, the geologic record provides a rich archive of past variations in climate. In this course, we will explore the processes that control Earth's climate, investigate and interpret the geologic record of past climatic changes, and examine methods used to reconstruct past climates. Prerequisties: GEOL 115, 130 or 205 or written permission of the instructor. Preference given to Geology Majors, Minors and Environmental Science Minors.

Course Objectives:

1) Students gain a deep understanding of Earth's climatic history
2) Students learn to think like scientists
3) Students learn about analytical techniques used to probe Earth's climatic history
4) Students improve critical thinking, reading, writing, and presentation skills

Course Outcomes:

At the conclusion of this course, you should be able to:

1) Identify key components of scientific studies in primary scientific literature;
2) Distill and communicate effectively in both oral and written format the essence of scientific papers from the primary paleoclimate literature;
3) Analyze and interpret basic paleoclimate data;
4) Provide a concise account of climatic change through Earth history;
5) Describe key climatic forcing factors and responses and be able to assess which were likely at play during different intervals in Earth's history;
6) Synthesize data and conclusions from multiple sources;
7) Use library resources to carry out effective research on a topic of interest.

Exam:

There will be one mid-term this semester, which will be taken during lab period. The exam will test your knowledge of fundamental concepts in climate science and paleoclimate investigations. The exam will entail short-answers or essay questions, which may involve the sketching of graphs and diagrams, and/or calculations. I expect you to think critically and actively about the course material, you will be required to demonstrate your reasoning as well as your recall of facts.

Laboratories and Field Trips:

Lab activities will involve examination of paleoclimate data from a variety of sources. Labs provide an opportunity for the hands-on experiences that illustrate the concepts and ideas discussed during class. In addition, they provide a chance for small-group collaborative work and individualized help from the instructor. ***Thus attendance at and completion of all labs is mandatory to receive course credit***. At the conclusion of each lab exercise to help you synthesis and concisely articulate what you have just learned, you will be required to complete a concluding summary or write a scientific abstract (<1 single-spaced page) about the investigation you undertook.

During the semester we will take one weekend field trip to collect paleoclimate data and examine evidence for climatic change in the geologic record. The tentative dates and destination are provided in the course schedule. More information will be provided as the date for the trip approaches.

Critical Reviews:

Critical evaluation of the scientific literature and clear, concise written communication of scientific ideas are two essential skills of scientific investigation. To help you learn these important skills, three critical reviews of recent primary scientific literature will be assigned. You are expected to read carefully through the papers when they are assigned making notes and outlining the key components of each paper in anticipation of a class discussion on the assigned papers. In a subsequent class session, we will explore the geologic evidence or theory presented and discuss the scientific contribution of each paper. After some of these sessions, you will be required to produce a paper of 4 pages (double spaced), placing the scientific investigation undertaken in the paper in a broader context, highlighting the nature of the investigation, identifying any assumptions or short comings of the work, and summarizing the significant scientific advancement made by the paper reviewed. You will have an opportunity to provide and receive feedback on each critical review through the process of peer review.

Participation:

Class discussions will be an integral part of this course. Because a significant portion of this course will be discussion based, the extent to which you prepare for and participate in class will directly affect not only how much you learn, but also how much your peers learn. You are expected to come to class prepared to actively engage in discussing the course readings and assignments.

Final Project:

For your final project you are to select one of the paleoclimatic topics/time periods we have examined during the course and explore the depth and complexity of that topic. This is a research project, which means that you will draw upon the knowledge you have acquired through taking this course as well as additional information you obtain through your own literature search. You will be required to make a poster to present your topic and the results of your research to your peers and the instructor. Poster presentations will take place during our scheduled final exam time. In addition, you will be required to submit a synthesis critical review of your topic with references and figures. Synthesis critical reviews are to be 8-10 pages in length (double spaced) not including figures and references. Synthesis critical reviews will be due during exam period. ***Your approach to exploring your chosen topic must be approved by the instructor.***

Geology 315 a "W" Course:

Geology 315 meets the specifications of a "Writing Course" designation by requiring at least twenty pages of reviewed out-of-class writing and providing instructive commentary on your writing throughout the semester. Satisfaction of these requirement is achieved in a number of ways. One of the principal means of evaluation is through "critical reviews" of primary paleoclimate literature which are short (four pages, double spaced) reader friendly synopses of scientific papers akin to *Nature Magazine* "News & Views" and *Science Magazine* "Perspectives" articles. Critical reviews build upon individual examination of primary literature and in class discussion and analysis of scientific papers. You will obtain feedback on drafts of these critical reviews through a peer review process in which you will read and provide constructive criticism on each other's drafts. Critical reviews build a foundation for your final research project, which entails selecting one of the topics we will explore during the semester and developing a synthesis critical review of that topic (8-10 pages, double spaced). For your final project you will use library resources to gather additional primary literature for your chosen topic. On the way to producing your final critical review you will receive feedback on a preliminary final project proposal in additional to feedback from both your peers and the instructor about the accuracy, organization, clarity, and completeness of your poster presentations. These forms of feedback should enable you to iteratively revise your thinking and more robustly develop of your final critical review.

Course Grading:

Mid-Term Exam	15%
Labs and Field Trips	25%
Critical Reviews	15%
Participation	25%
Final Project	20%

Grading and Lateness:

Assignments not turned in by the due date will be penalized by 10% of the score for each day they are late. I can accommodate for truly extenuating circumstances, yet I need to know in advance why a deadline will not be met. Any requests for assignment extensions that occur after an assignment deadline, including extensions requested because of illness, must be accompanied by a Dean's excuse.

Academic Honesty:

You are responsible for reading and abiding by the College's "Principles of Intellectual Honesty," (Student Handbook p. 7):

"To maintain the scholarly standards of the College and equally important, the personal ethical standards of our students, it is essential that written assignments be a student's own work, just as is expected in examinations and class participation. A student who commits academic dishonesty is subject to a range of penalties, including suspension or expulsion. Finally, the underlying principle is one of intellectual honesty. If a person is to have self-respect and the respect of others, all work must be his/her own."

Electronic Devices:

Please make sure your cell phones, iPods, and other electronic devices are turned off before the start of class! Students who inappropriately use these devices during class time will be promptly dismissed from that class meeting, earning no credit for assignments or activities occurring during that class meeting.

COURSE LITERATURE

Long-Term Climate Change

Appenzeller, T., 1992. What Drives Climate? Discover, 66-73.
Hoffman, P.F. and D.P. Schrag, Snowball Earth, Scientific American, 1999, 68-75.
Hoffman, P.F. and D.P. Schrag, 1998. A Neoproterozoic Snowball Earth. Science, 281, 1342-1346.

Cenozoic Cooling

Zachos, J. C., M. Pagani, L. C. Sloan, E. Thomas and K. Billups, 2001. Trends, Rhythms, and Aberrations in Global Climate 65 Ma to Present. Science 292, 686-693.

Lear, C.H., H. Elderfield, and P.A. Wilson, 2000. Cenozoic Deep-Sea Temperatures and Global Ice Volumes from Mg/Ca in Benthic Foraminiferal Calcite, Science, 287, 269-272.

Paleocene-Eocene Thermal Maximum

Suess, E., Bohrmann, G., Greinert, J., and Lausch, E. 1999. Flammable Ice. Scientific American, 76-83.

Zimmer, C. 1997. Their Game is Mud. Discover, 28-29.

Thomas, D., Zachos, J., Bralower, T., Thomas, E., and Boharty, S. 2002. Warming the fuel for the fire: evidence for the thermal dissociation of methane hydrate during the Paleocene-Eocene Thermal Maximum. Geology 30, 1067-1070.

Wing, S.L. et al. 2005, Transient Floral Change and Rapid Global Warming at the Paleocene-Eocene Boundary. Science, 310, 993-996.

Zachos, JZ. Et al. 2005. Rapid Acidification of the Ocean During the Paleocene-Eocene Thermal Maximum, Science, 308, 1611-1615.

Bowen, G. and Zachos, J.Z., 2010. Rapid carbon sequestration at the Palaeocene-Eocene Thermal Maximum, Nature Geoscience, 3, 866-869.

Archer, D. 2010. How it went down last time, Nature Geoscience, 3, 819-820.

Jaramillo, C. et al. 2010. Effects of Rapid Global Warming at the Paleocene-Eocene Boundary on Neotropical Vegetation, Science, 330, 957-961.

Orbital Variations in Climate

Olsen, P.E. 1986. A 40-Million-Year Lake Record of Early Mesozoic Orbital Climatic Forcing, Science, 234, 842-848.

Olsen, P.E. and D.V. Kent, 1996. Milankovtich climate forcing in the tropics of Pangaea during the Late Trassic, Palaeoceanography, Palaeclimatology, Palaeoecology, 122, 1-26.

Glaciation of the Northern Hemisphere

Cane, M. A., and P. Molnar (2001), Late Cenozoic Closing of the Indonesian Seaway as the Missing Link between the Pacific and East African Aridification, *Nature*, *411*, 157-162.

deMenocal, P. (2004), African climate change and faunal evolution during the Pliocene Pleistocene, *Earth and Planetary Science Letters*, *220*, 3-24.

Driscoll, N. W., and G. Haug (1998), A Short Circuit in Thermohaline Circulation: A Cause for Northern Hemisphere Glaciation, *Science*, *282*, 436-438.

Herbert, T.D. et al. Tropical Ocean Temperatures Over the Past 3.5 Million Years, Science, 328, 1530, 2010.

Ravelo, A. C., et al. (2007), Onto the Ice Ages: Proxy evidence for the onset of Northern Hemisphere Glaciation, in *Deep Time Perspectives on Climate Change*, edited by M. Williams, et al., pp. 563-574, The Micropalaeontological Society.

Glacial Cycles/ Last Glacial Maximum/ Younger Dryas

Broecker, W. and G.H. Denton, 1990. What Drives Glacial Cycles? Scientific American, 49-56.

Petit, J.R. and others. 1999. Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica. Nature v. 399, p 429-436.

McManus, J.F. 2004. A great grand-daddy of ice cores, Nature 429, 611.

EPICA, 2004. Eight Glacial Cycles from an Antarctic ice core, Nature 429, 623-628.

Millennial Scale Climate Change

Alley, R.B. and M.L. Bender, 1998. Greenland Ice Cores: Frozen in Time. Scientific American, 80-85.

Dansgaard, W. et al. 1993. Evidence for general instability of past climate from a 250-kyr ice-core record, Nature, 364, 218-220.

Grootes, P.M. et al. 1993. Comparison of oxygen isotope records from GISP2 and GRIP Greenland ice cores, Nature, 366, 552-554.

McManus, J.F. et al. 1994. High-resolution climate records from the North Atlantic during the last interglacial, Nature, 371, 326-329.

Blunier, T. and Brook, E.J. 2001. Timing of Millennial-Scale Climate Change in Antarctica and Greenland During the last Glacial Period, Science, 291, 109-111.

Bond, G. C., and R. Lotti (1995), Iceberg Discharges into the North-Atlantic on Millennial Time Scales During the Last Glaciation, *Science*, *267*, 1005-1010.

Holocene Climate Change

Svitil, K.A.1997, The Greenland Viking Mystery, Discover, 28-29.

Svitil, K.A. 1999, Burning Man, Discover, 1-3.

Kunzig, R., 2000, Exit from Eden. Discover, 84-91.

Claussen, M., C. Kubatzki, V. Brovkin, and A. Ganopolski, 1999. Simulation of an abrupt change in Saharan vegetation in the mid-Holocene, Geophysical Research Letters, 26, 2037-2040.

Hodell, D.A., Curtis, J.A. and Brenner, M., 1995. Possible role of climate in the collapse of the Classic Maya civilization *Nature*, *375*, 391-394.

Haug, G. H., et al. 2003, Climate and the collapse of Maya civilization, *Science*, *299*, 1731-1735.

Humans and Climate

Ruddiman, W.F., 2003. The Anthropogenic Greenhouse Era Began Thousands of Years Ago. Climate Change, 61, 261-293.

Intergovernmental Panel on Climate Change Working Group 1 Fourth Assessment Report, Summary For Policymakers (web release Feb. 2, 2007 at (www.ipcc.ch)

Lacis, A.A. et al. 2010. Atmospheric CO_2: Principle Knob Governing Earth's Temperature, Science, 330, 356-359.

Geology 315 Paleoclimatology and Paleoceanography
Tentative Schedule
Spring 2011

Kump, Kasting & Crane = K,K&C

Week	Dates	Topics & Assignments	Reading
1	Jan 25th, 27th	Fundamentals of the Climate System	K,K&C Chp 3, 4
		Climate Processes: Radiation Budget, Greenhouse Effect	
		NO LAB	
2	Feb 1st, 3rd	Fundamentals of the Climate System	K,K & C Chp 5,6
		Climate Processes: Circulation of the Atmosphere and Ocean	
		Lab 1: Distribution of Climates on Earth - Field Trip	
3	Feb 8th, 10th	Fundamentals of the Climate System	K,K & C Chp 8
		Climate Processes: The Carbon Cycle	Parrish Chp 1
		Paleoclimate Indicators	optional:
		Lab 2: Controls on Planetary Temperature	K,K & C Chp 7
4	Feb 15th, 17th	Fundamentals of the Climate System	Sample Scientific Paper
		Climate Processes: The Carbon Cycle	Sample Critical Review
		Climate Archives	
		Reading Primary Scientific Literature	
		Lab 3: Biostratigraphy	
5	Feb 22nd, 24th	Long-Term Climate Change	K,K&C Chp 11 & 12
		Snowball Earth	Supplemental Articles
		Terrestrial Indicators of Paleoclimate	Refer to:
		Mid-Term Exam During Lab Period	Parrish Chp 4, 5
6	Mar 1st, 3rd	Long-Term Climate Change	Supplemental Articles
		Cenozoic Cooling	
		Marine Indicators of Paleoclimate	Refer to:
		Lab 4: Cenozoic Climate Change	Parrish Chp 2
7	Mar 8th, 10th	Cenozoic Cooling	Supplemental Articles
		Marine Indicators of Paleoclimate	
		First Critical Review Due to Instructor	Refer to:
		Lab 5: Magnetostratigraphy	Parrish Chp 3
		March 12th-20th SPRING BREAK	
8	Mar 22nd, 24th	Paleocene-Eocene Thermal Maximum	Supplemental Articles
		Marine Indicators of Paleoclimate	
		Lab 6: PETM	
Mar 26th-27th Lab 7: FIELD TRIP #1 Hartford Basin (CT) Rift Sediments and Cyclostratigraphy			
9	Mar 29th, 31st	Glaciation of the Northern Hemisphere	Supplemental Articles
		Lab 8: Paleoclimate Research/Paper Review	
10	Apr 5th, 7th	Glacial Cycles/ Last Glacial Maximum	K, K,& C Chp 14
		Second Critical Review Due to Instructor	Supplemental Articles
		Lab 9: Ocean Gateways	
11	Apr 12th, 14th	Millennial Scale Climate Change	Supplemental Articles
		Final Project Topic Selection	
		Lab 10: Oxygen Isotope Stratigraphy	
12	Apr 19th, 21st	Holocene Climate Change	K,K &C Chp 15
			Supplemental Articles
		Lab 11: Final Project Research	
13	Apr 26th, 28th	Humans and Climate	K,K&C Chp 16
		Third Critical Review Due to Instructor	Supplemental Articles
		Lab 12: Future Greenhouse Gas Emissions Scenarios	
14	May 3rd, 5th	**Work on Final Projects**	
		NO LAB	
FINAL PRESENTATIONS/ SYNTHESIS CRITICAL REVIEWS DUE DURING FINAL EXAM WEEK			