IB-113L: Paleobiological Perspectives on Ecology and Evolution

Course format: Two lectures (1 hr 20 min ea)/wk; one 3 hr laboratory/wk (4 units)

Instructor: TBD

GSIs: TBD

Description: What do the fossil and geologic records have to tell us about the nature of ecological and evolutionary processes? What do they teach us that cannot be learnt from the living world alone? In answering these questions, this course provides an introduction to the analysis of key problems in paleobiology, with an emphasis on how evolutionary and ecological processes operate on geologic timescales. Topics include: the evolution of ecosystems; dissecting biodiversity dynamics; determining times of origin and extinction; assessing the absolute completeness of the rock and fossil records; stratigraphy and phylogeny reconstruction; theoretical and functional morphology; major events in the history of life, including Precambrian evolution, the Cambrian explosion, and the mass extinctions.

Labs: Scientific understanding flows from raw data, in our case from the morphologies, ecological associations, environments and ages of fossils. The labs will engage students in these empirical aspects of the fossil record. Each lab will have a formal assignment that will be assessed as part of each student's final grade.

Reading: There is no text adequate for this course; instead weekly readings (see syllabus) will be made available via bCourses.

Prerequisites: Prior biology experience or permission of instructor. No paleontological or geological background required.

Assessment

	% of Final Grade
Weekly lab exercises	20%
Participation in weekly labs	5%
Mid-semester Exam (Th., March 1st)	25%
Lab Exam (Wed, April 25th)	20%
Final Exam (Mon. May 7th, 11:30–2:30)	30%
	100%

Syllabus

(the **readings** will be most useful if read before lecture, the **references** may be most useful if you at least skim them after lecture)

Jan 16 1) Introduction to the course
Jan 17 **No LAB this week**
Jan 18 2) Fossils, the fossil record, and its completeness
Reading: Foote, M.J. & A.I. Miller. 2007. Chapter 1: "Nature of the Fossil Record" in *Principles of Paleontology*. Pp. 1–30.

Jan 23 3) Exceptional preservation; Geological time
Jan 24 **LAB 1**: Intro to Fossils; Tour of the UCMP Collections
Jan 25 4) Continental drift and plate tectonics
Reading: Stanley, S. M. 1999. Ch. 1: "Earth as a system" in *Earth System History*. Pp. 1–27.
Reference: Stanley, S. M. 1999. Ch. 6: "Correlation and dating of the rock record" in *Earth System History*. Pp. 151–178.

Jan 30 5) An overview of the history of the Earth and life
Jan 31 **LAB 2**: Fossilization
Feb 1 6) Major transitions: origin of life
Reading: Knoll, A.H. & R.K. Bambach. 2000. Directionality in the history of life: diffusion from the left wall or repeated scaling of the right? *Paleobiology* **26**: (Supplement): 1–14.
Reading: Luisi, P.L. & Y. Kuruma. 2014. Open questions on the origin of life (OQOL)–Introduction to the Special Issue. *Orig. Life Evol. Biosph*. **44**: 267-268.

Feb 6 7) Time in the rock record
Feb 7 **LAB 3**: Nature of the Rock Record
Feb 8 8) Major transitions: Cambrian explosion; invasion of land; origins of the modern California biotas
Reference: Coe A.L., et al. 2003. Ch. 4: "Sequence Stratigraphy" in *Sedimentary Record of Sea-Level Change*. Pp. 57–95.
Reading: Marshall, C.R. 2003. Nomothetism and understanding the Cambrian "explosion". PALAIOS 18: 195–196.
Reference: Marshall, C.R. 2006. Explaining the Cambrian "explosion" of animals. *Annual Review of Earth and Planetary Sciences* **34**: 355–384.

Feb 13 9) How species richness has changed with time
Feb 14 **LAB 4**: Diversity Dynamics – DNA vs. The Fossil Record
Feb 15 10) Extinction: background vs mass extinctions; the death of the dinosaurs
Reading: Sepkoski, J.J.Jr. 1997. Biodiversity: past, present, and future. *Journal of Paleontology* **71**: 533-539.
Reference: Marshall, C.R. 2010. Using confidence intervals to quantify the uncertainty in the end-points of stratigraphic ranges. In: *Quantitative Methods in Paleobiology*, J. Alroy & G. Hunt (eds). The Paleontological Society Papers 16: 291–316.

Feb 20 11) The emergence and evolution of plants (Guest Lecturer: Dr. Duijnstee)
Feb 21 **LAB 5**: Fossil plants
Feb 22 12) Extinction: the other two greatest mass extinctions and their legacy
Reference: Taylor T.N et al., 2009. Ch. 1: Introduction into paleobotany, how fossil plants are formed. In: *Paleobotany - the biology and evolution of fossil plants*. Academic Press, Pp 1-42.

Feb 27 13) Diversity dynamics – what drives species richness change?
Feb 28 **No LAB this week**
March 1 **MIDTERM**
Reading: None

March 6 14) Systematics and the fossil record (Guest Lecturer: Dr. Finnegan)
March 7 **LAB 6**: Dinosaurs and some of their Relatives
March 8 15) Stratigraphic data, phylogeny reconstruction, and ancestors
Reading: Smith A.B. 1994. Ch. 6 "The construction of evolutionary trees" in: *Systematics and the Fossil Record*. Pp. 125–141.
Reference: Marshall, C.R. 1999. "Missing links in the history of life." In: *Evolution: Facts and Fallacies* (J.W. Schopf, ed.). Pp.37-69.

March 13 16) Punctuated equilibrium and rates of evolution
March 14 **LAB 7**: Dinosaurs in Motion
March 15 17) Macro-evolution (in contrast to micro-evolution)
Reading: Sheldon, P.R. 2001. Punctuated equilibrium and phyletic gradualism. Encyclopedia of Life Sciences, pp 1-6.
Reference: Foote, M.J. and A.I. Miller. 2007. p.190–210 in: *Principles of Paleontology*.

March 20 18) The evolution of Marine ecosystems
March 21 **LAB 8**: Early life and Sepkoski's Cambrian and Paleozoic faunas
March 22 19) Diversity change versus disparity change; why is there complexity?
Reference: Bush et al. 2007. Changes in theoretical ecospace utilization in marine fossil assemblages between the mid-Paleozoic and late Cenozoic. *Paleobiology* **33**: 76-97.
Reference: Foote, M.J. and A.I. Miller. 2007. p.243–248 in: *Principles of Paleontology*.

SPRING BREAK

April 3 20) Theoretical morphology and the filling of morphospace
April 4 **LAB 9**: The Paleozoic fauna (continued)
April 5 21) Insights from fossil molecules: stable isotopes and biomarkers
Reference: Foote, M.J. and A.I. Miller. 2007. p.135–148 in: *Principles of Paleontology*.
Reference: Koch P.L. 2007. Isotopic study of the biology of modern and fossil vertebrates. In: Michener R, Lajtha K (eds) *Stable Isotopes in Ecology and Environmental Science*, 2nd Ed. Pp. 99-154.

April 10 22) Life in moving fluids; Molecular clocks
April 11 **LAB 10**: Sepkoski's Modern Fauna
April 12 23) Calibrating time trees; Ancient DNA
Reference: Vogel, S. 1981. *Life in Moving Fluids*. rinceton Univ. Press. Pp. 25–33; 41–43; 50–51; 61-81; 127–129; 141–143; 152–157; 241–243.
Reference: Smith, A.B. and K.J. Peterson. 2002. Dating the time of origin of major clades: molecular clocks and the fossil record. *Annu. Rev. Earth Planet. Sci.* **30**: 65-88.
Reference: Holmes R.D.M. & E.C. Holmes. 1998. Ch. 7 "Models of molecular evolution" in *Molecular evolution. A phylogenetic approach*. Pp. 228–279.
Reading: Slatkin, M. & F. Racimo. 2016. Ancient DNA and human history. *Proceedings of the National Academy of Sciences, USA*, **113**: 6380–6387.

April 17 24) The carbon cycle and climate change over geologic timescales
April 18 **LAB 11**: Ecology through time: Evolutionary escalation
April 19 25) The evolution of our humanness
Reference: DePaolo D.J. 2015. Sustainable carbon emissions: the geologic perspective. *MRS Energy & Sustainibility* **2**: e1-e16.

April 24 26) *Homo sapiens* as a geologic force
April 25 **LAB 12**: **LAB FINAL EXAM**
April 26 27) How has paleontology changed our view of the present?
Reading: Waters et al. 2016. The Anthropocene is functionally and stratigraphically distinct from the Holocene: Review summary. *Science* **351**: 137.
Reference: Waters et al. 2016. The Anthropocene is functionally and stratigraphically distinct from the Holocene. *Science* **351**: 138-148.

Background Texts

Text: Principles

Foote, M.J. and A.I. Miller. 2007. *Principles of Paleontology*. W.H. Freeman, New York, 354 pp.

Texts: Principles and taxonomy of fossil groups

Prothero, D.R. 2004*. Bringing Fossils to Life: an Introduction to Paleobiology*. 2nd Ed. McGraw-Hill, Dubuque, Iowa, 503 pp.

Benton, M.J. and D.A.T. Harper. 1997. *Basic Palaeontology*. Prentice Hall, London, 360 pp.

Texts: Morphology and taxonomy of fossil groups

Benton, M.J. 2005. *Vertebrate Palaeontology*, 3rd Ed. Blackwell Science, Oxford, 455 pp.

Clarkson, E.N.K. 1993. *Invertebrate Palaeontology and Evolution*. 3rd Ed. Chapman and Hall, London, 434 pp.

Boardman, R.S., A.H. Cheetham, and A.J. Rowell (eds.). 1987*. Fossil Invertebrates*. Blackwell Science, Oxford, 713 pp. [*An advanced text too hard for most introductory classes*]

Text: The evolution of life in the context of our evolving planet

Stanley, S. M. 1999. *Earth System History*. W.H. Freeman and Company, New York, 615 pp.

Text: Paleoecology (an underdeveloped field; there are no great texts)

Brenchley, P.J., and D.A.T. Harper. 1998. *Palaeoecology: Ecosystems, environments and evolution.* Chapman and Hall, London, 402 pp.

Flessa, K.W. et al. 2005. *The Geological Record of Ecological Dynamics.* National Research Council of the National Academies, National Academies Press, Washington, DC, 2000 pp. [*A report, not a textbook*]

Concise Syntheses

Briggs, D.E.G. and P.R. Crowther (eds.). 1990*. Paleobiology: A Synthesis.* Blackwell Scientific, Oxford, 583 pp. [*Some 100 topics covered, 3-8 pages each, with about 110 authors*]

Briggs, D.E.G. and P.R. Crowther (eds.). 2001. *Paleobiology II.* Blackwell Scientific, Oxford, 583 pp. [*Similar the volume above, with contributions from 170 authors*]

Laggerstätten

Bottjer, D.J., Etter, W., Hagadorn J.W. and C.M. Tang (eds.). 2002. *Exceptional Fossil Preservation: A unique view on the evolution of marine life.* Columbia University Press, New York, 403 pp.

Muller, K.J. and D. Walossek. 1987. *Morphology, Ontogeny, and the Life Habit of Agnostus pisiformis from the Upper Cambrian of Sweden.* Universitetsforlaget, Oslo, 125 pp.

Briggs, E.G., Erwin, D.H. and F.J. Collier. 1994. *The Fossils of the Burgess Shale.* Smithsonian Institution Press, Washington, London, 238 pp.

Xian-Guang, H., Aldridge, R.J., Bergstrom, J., Silveter, David.J., Silveter Derek J. and F. Xiang-Hong. 2004. *The Cambrian Fossils of Chengjiang, China.* Blackwell Science, Oxford, 233 pp.

You can even download many of these for free (as entire books), thanks to Berkeley's subscriptions: http://www.lib.berkeley.edu/BIOS/ebooks.html

Academic Expectations

You are among the top students in the world, and will be treated accordingly. Being a student at UC Berkeley is a great privilege, and you have worked hard to get here. But the hard work is not over. Berkeley produces great graduates by consistently challenging its students to become better, and this class will be no different. The concepts covered in lectures are ones that I believe you will be able to understand, but that understanding won't always come easily. The GSIs and I will work hard to help you understand them, but we also expect you to work hard and to rise to the challenge. If you are having difficulty understanding something in class, please speak out! I guarantee that you will not be the only one who is confused.

The student community at UC Berkeley has adopted the following Honor Code: "As a member of the UC Berkeley community, I act with honesty, integrity, and respect for others." The hope and expectation is that you will adhere to this code.

Collaboration and Independence: Reviewing lecture and reading materials, and studying for exams can be an enjoyable and enriching thing to do with fellow students. This is recommended. However, exams and assignments are to be completed independently.

Cheating: Anyone caught cheating on a quiz or exam in this course will receive a failing grade in the course and will also be reported to the University Center for Student Conduct. In order to guarantee that you are not suspected of cheating, please keep your eyes on your own materials and do not converse with others during the quizzes and exams.

Plagiarism: To copy text or ideas from another source without appropriate reference is plagiarism and will result in a failing grade for your assignment and usually further disciplinary action. For additional information on plagiarism and how to avoid it, see, for example: http://www.lib.berkeley.edu/instruct/guides/citations.html#Plagiarism, or http://gsi.berkeley.edu/teachingguide/misconduct/prevent-plag.html.

Academic Integrity and Ethics: Cheating on exams and plagiarism are two common examples of dishonest, unethical behavior. Honesty and integrity are of great importance in all facets of life. They help to build a sense of self-confidence, and are key to building trust within relationships, whether personal or professional. There is no tolerance for dishonesty in the academic world, for it undermines what we are dedicated to doing – furthering knowledge for the benefit of humanity. Your experience as a student at UC Berkeley is hopefully fueled by passion for learning and replete with fulfilling activities. Nonetheless, we appreciate that being a student can be stressful. There may be times when there is temptation to engage in some kind of cheating in order to improve a grade or otherwise advance your career. This could be as blatant as having someone else sit for you in an exam, or submitting a written assignment that has been copied from another source. Or it could be as subtle as glancing at a fellow student's exam when you are unsure of an answer to a question and are looking for some confirmation. One might do any of these things and potentially not get caught. However, if you cheat, no matter how much you may have learned in this class, you will have failed to learn perhaps the most important lesson of all, the value of personal integrity and self-respect.