Integrative Biology 113L
(Class #17834), 4 units
Paleobiological Perspectives on Ecology and Evolution

Instructor Prof. Charles Marshall (crmarshall@berkeley.edu)
Office Hours: [1] Mondays 12:10 pm to 1 pm
[2] Wednesday 1:10 pm to 2 pm
[3] By appointment (e-mail me to find a time).

GSIs Tanner Frank (tanner_frank@berkeley.edu)
Office Hours: [1] Thursdays 10 am to 11 am
[2] By appointment

Kat Magoulick (kmagoulick@berkeley.edu)
Office Hours: [1] Tuesdays, 2 to 3 pm
[2] By appointment

Prerequisites: Some background in organismal biology preferred (if you have doubts contact the Instructor). *No paleontological or geological background knowledge is assumed.*

Lectures: Tuesdays and Thursdays, 11:10 am–12:30 pm, Wheeler 204. Course capture will be deployed.

Lecture Slides: PDF versions of the PowerPoint presentations will (typically) be posted on bCourses the evening before the lecture.

Lab sections: Wednesdays, either 9-noon or 3-6 pm, **Valley Life Sciences Building 3003**. *You can only switch sections with the explicit agreement of both GSIs.*

Course goals: Our goals for the course is to help you discover what the fossil and geologic records tell us about the history of life on Earth and the nature of the environmental, ecological and evolutionary processes that have shaped it. The course emphasizes what cannot be learned from the living world alone. In the labs your GSI will help you learn how to 'read' fossils and the fossil and rock records. You will work in groups, learning from each other as well as from your GSI (and the fossils and other materials presented).

Textbook: There is no adequate textbook available for this course. Weekly readings (see syllabus below) that provide background information will be made available via bCourses (under the appropriate week under 'Files'). *Exam questions will not be drawn from the readings.*

Grading: I recently participated in a program to improve my teaching (called FLOSS, Faculty Learning Optimizes Student Success program). As a consequence, I have redesigned several elements of the course to try and reduce stress, be as fair as possible, and enhance your

learning experience. Since these are new approaches, let me know your thoughts on what might improve your learning experience. Your grade will be determined by:

In-class participation	(5%)
Homework (exit tickets)	(10%)
Midterm exam	(20%)
Final exam	(25%)
Weekly lab exercises	(25%)
End-semester lab presentation	(15%)

In-class participation will be recorded via your participation in the Poll Everywhere questions in lecture. This is part of your formative evaluation, so you will receive full credit for participation.

Homework (exit tickets, via "Quizzes" on bCourses) after each lecture. These are also part of your formative evaluation, so just providing an answer will be sufficient for full credit. Some questions will be so we can learn about you and what works for you, some will be to help you prepare for the exams (including practice questions). None will be arduous.

Midterm exam (open book) will be on Thursday Feb 29th during the normal lecture time in the lecture room (Wheeler 204).

Final exam (open book) is really a 2nd mid-term; it will cover the material since the midterm (given the its foundation on material before the midterm). The campus has assigned us an exam time of Monday, May 9th, 11:30 am to 2:30 pm.

Grading scale: Grades will be based on an absolute scale. The letter standard cutoff will be:

A 93.33%
A- 90%
B+ 86.66%
B 83.33%
B- 80%
C+ 76.66%
C 73.33%
C- 70%
D+ 66.66%
D 60%
F <60%

If you all get >90% you will all get at least an A-; that is, there is no limit on the number of students who can get a given grade. However, even though unlikely, if we feel the absolute scale is too high given the rubric given below, we will lower the cut-offs between the grades. Under no circumstances will we raise the cut-offs to make it more difficult to get a given grade.

Grading rubric: Grading is not curved but based upon your individual mastery of the course material, using the following rubric:

A: Excellent command of the material. Demonstrates an often-nuanced understanding of most of the important as well as many of the subsidiary ideas, concepts, tools, and data presented.

B: Good command of the material. Demonstrates a solid understanding of the most important and some of the subsidiary ideas, concepts, tools, and data presented, but with not infrequent lapses in understanding.

C: Fair command of the material. Demonstrates some understanding of the majority of the important ideas, concepts, tools, and data presented, but with frequent lapses in understanding.

D: Minimal command of the material. Demonstrates only a limited understanding of some of the most important ideas, concepts, tools, and data presented.

F: Fail.

For P/NP grades, following campus practice, a grade of C– or better will be assigned a Pass.

Policy on exams, lecture, and design assignments due dates. There are due dates for all assignments. *However, if you do find yourself facing an unforeseen circumstance, please contact us as soon as possible to let us know so we can work out how best proceed.*

Policy on DSP students. DSP students please make sure that your letter from the Disabled Students Program is sent to us as soon as possible, and that you contact us so we can help you succeed in the course. See http://dsp.berkeley.edu.

Policy on recording lectures or selling slides or notes. Posting or selling video recordings are expressly prohibited by University of California policy. Lectures are comprised of copyrighted intellectual material, and the recording and sharing of that material without express permission is a violation of copyright and personal privacy. Note, it is a violation of copyright to sell notes, assignments or exams to on-line companies.

Academic Expectations. You are among the top students in the world. Being a student at UC Berkeley is a great privilege. You have worked hard to get here, but the hard work is not over – Berkeley produces great graduates by consistently challenging you to become better. I believe you will be able to understand the concepts covered in lectures, but that understanding may not always come easily. The GSIs and I will work hard to help you, but we also expect you to work hard and rise to the challenge. If you are having difficulty understanding something in class, please speak up! I guarantee that you will not be the only one who is confused. And make use of office hours!

Honor Code: The student community at UC Berkeley has adopted the following Honor CodeLinks to an external site.: "*As a member of the UC Berkeley community, I act with honesty, integrity, and respect for others*." Thank you for adhering to this code.

Policy on UC Berkeley's Code of Student Conduct. All students are expected to follow the University of California at Berkeley's Campus Code of Student Conduct, as is published at http://sa.berkeley.edu/uga/codeofconduct. Cheating, plagiarism, or any other form of academic dishonesty will not be tolerated (102.01).

Collaboration and Independence: Reviewing lecture and reading materials and studying for exams with fellow is highly recommended. Nonetheless, exams and assignments are to be completed independently.

Encountering non-academic problems. We imagine that some of you will have serious non-academic challenges during the semester. For myself, my younger brother and I were in foster homes by my sophomore in High School, and as an undergraduate I sometimes did not have enough money to make ends meet. Please do not hesitate to alert us to any issues beyond the course that you might have with housing or food security, physical and mental health, safety, etc. You may feel embarrassed to ask for help (I was mortified), but we are here to help. There are also a wide range of resources available on campus:

SUPPORT

Here is the link to the various forms of support offered by the campus: **https://bcourses.berkeley.edu/courses/1526802/pages/support-resources.**

- Basic Needs Support Links to an external site.– food, housing, financial assistance, & COVID-19 support
- Sexual Violence & Sexual Harassment Support & Prevention: http://survivorsupport.berkeley.edu/
- Counseling and Support Groups: https://uhs.berkeley.edu/counseling/social-services/counseling
- Mental Health Concerns: https://uhs.berkeley.edu/counseling/urgent
- UHS Emergencies & Crises: https://uhs.berkeley.edu/emergency
- When the University Health Service is closed: https://uhs.berkeley.edu/after-hours
- Student to Student Peer Counseling: https://sspc.berkeley.edu/about/
- Covid-19 Information and Resources: https://uhs.berkeley.edu/coronavirus-covid-19-information
- Undocumented Student Support: https://undocu.berkeley.edu/

Policy on accommodation of religious holidays and other scheduling conflicts (for example, athletic events, job interviews): In compliance with Education code, Section 92640(a), it is the official policy of the University of California at Berkeley to permit any student to undergo a test or examination, without penalty, at a time when that activity would not violate the student's religious creed, unless administering the examination at an alternative time would impose an undue hardship which could not reasonably have been avoided. All deadlines are noted on this syllabus. It is your responsibility to note any conflicts with the exam and due dates and let the instructor and GSIs know in a timely fashion. If you have other scheduling conflicts, please see the guidelines at: https://teaching.berkeley.edu/academic-calendarand-student-accommodations-campus-policies-and-guidelines.

Course Schedule

(Note: the **readings** provide background information only and will not be examined directly)

Week 1:

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.

Week 2:

Jan 23 3) Exceptional preservation; Geological time
Jan 24 **LAB 1**: Intro to Fossils, tour of the Museum of Paleontology with Prof. Marshall
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.
Reading: Stanley, S. M. 1999. Ch. 6: "Correlation and dating of the rock record" in *Earth System History*. Pp. 151–178.

Week 3:

Jan 30 5) An overview of the history of the Earth and life
Jan 31 **LAB 2**: Fossilization
Feb 1 6) Major transitions: Origins of the living California biotas; 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: Brunk, C.F., & C.R. Marshall. 2021. 'Whole organism', systems biology , and top-down criteria for evaluating scenarios for the origin of life. *Life* 11:690–715.

Week 4:

Feb 6 7) Time in the rock record
Feb 7 **LAB 3**: Nature of the Rock Record
Feb 8 8) Major transitions: Cambrian explosion and the invasion of land

Reading: 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.
Reading: Marshall, C.R. 2006. Explaining the Cambrian "explosion" of animals. *Annual Review of Earth and Planetary Sciences* **34**: 355–384.

Week 5:

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.

Week 6:

Feb 20 11) The emergence and evolution of plants (Guest Lecturer: Dr. Looy)
Feb 21 **LAB 5**: Fossil plants
Feb 22 12) Mass Extinctions (continued) and their evolutionary legacy

Reading: 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.
Reading: 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.

Week 7:

Feb 27 13) Diversity dynamics – what drives species richness change?
Feb 28 **LAB 6**: Lab presentation preparation instructions and tips
Feb 29 **MIDTERM**

Week 8:

Mar 5 14) Systematics and the fossil record
Mar 6 **LAB 7**: Dinosaurs and some of their Relatives
Mar 7 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.
Reading: Marshall, C.R. 1999. "Missing links in the history of life." In: *Evolution: Facts and Fallacies* (J.W. Schopf, ed.). Pp.37-69.

Week 9:

Mar 12 16) Punctuated equilibrium and rates of evolution
Mar 13 **LAB 8**: Dinosaurs in Motion
Mar 14 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.
Reading: Foote, M.J. and A.I. Miller. 2007. p.190–210 in: *Principles of Paleontology*.

Week 10:

Mar 19 18) The evolution of Marine ecosystems
Mar 20 **LAB 9**: Early life and Sepkoski's Cambrian and Paleozoic faunas
Mar 21 19) Diversity change versus disparity change; why is there complexity?

Reading: Bush et al. 2007. Changes in theoretical ecospace utilization in marine fossil assemblages between the mid-Paleozoic and late Cenozoic. *Paleobiology* **33**: 76-97.

Reading: Foote, M.J. and A.I. Miller. 2007. p.243–248 in: *Principles of Paleontology*.

SPRING RECESS

Week 11:

Apr 2 20) Theoretical morphology
Apr 3 **LAB 20**: The Paleozoic fauna (continued)
Apr 4 21) Fossil molecules: stable isotopes; biomarkers

Reading: Foote, M.J. and A.I. Miller. 2007. p.135–148 in: *Principles of Paleontology*.

Reading: 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.

Week 12:

Apr 9 22) Life in moving fluids; Molecular clocks
Apr 10 **LAB 11**: Sepkoski's Modern Fauna
Apr 11 23) Calibrating time trees; Ancient DNA

Reading: 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.

Reading: 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.

Reading: 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.

Week 13:

Apr 16 24) The carbon cycle and climate change over geologic timescales
Apr 17 **LAB 12**: Ecology through time: Evolutionary escalation
Apr 18 25) The evolution of our humanness

Reading: DePaolo D.J. 2015. Sustainable carbon emissions: the geologic perspective. *MRS Energy & Sustainibility* **2**: e1-e16.

Week 14:

Apr 23 26) *Homo sapiens* as a geologic force
Apr 24 **LAB 13:** Project presentations
Apr 25 27) How has paleontology changed our view of the present?

Reading: Ripple t al. 2019. World scientists' warning of a climate emergency. *BioScience*.
Reading: Waters et al. 2016. The Anthropocene is functionally and stratigraphically distinct from the Holocene: Review summary. *Science* **351**: 137.
Reading: Waters et al. 2016. The Anthropocene is functionally and stratigraphically distinct from the Holocene. *Science* **351**: 138-148.

Background Texts

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

Principles

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

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.

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*]

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.

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.