EARTH 101: INVERTEBRATE PALEOBIOLOGY

The fossil record contains the history of life on Earth. It is impossible to understand the evolution of modern animals and their ecosystems without information from the fossil record. Fossils are also invaluable in many aspects of geology: they are used to subdivide Earth history into the geological timescale, they carry important information for reconstructing ancient environments, and much more. Finally, there is just something exhilarating about finding the remains of an organism that lived tens or hundreds of millions of years ago!

This course will provide an introduction to the use of fossil data in solving evolutionary, environmental, and ecological problems. My own research uses ancient mass extinctions – caused by ocean warming, acidification, and deoxygenation – to understand the physiological and/or ecological characteristics that help organisms survive these crises. In this class, we will do a lot of problem-solving activities, working with real data to practice making well-supported arguments. The labs will give you opportunities to work with real fossils from all types of invertebrates.

2018 Course Summary:

Instructor and Contact Info: Matthew Clapham: mclapham@ucsc.edu, EMS A208, 459-1276.

Office Hours: Official times are Tuesdays from 2-3 or Wednesdays from 10-11. I have an open door policy, so you are welcome to drop by at other times if I am in my office. You can also contact me to schedule a meeting. I am here to support your learning and to help you succeed, so please take advantage!

Lectures: MWF 12:00-1:05, EMS D226

Course Website: At Canvas (https://canvas.ucsc.edu, log in with your UCSC user name and Gold password). Handouts and assignments will be posted there and you will also need to log in to submit papers.

Course Learning Objectives: By the end of this class, you should be able to:

1) Identify important fossil groups.

2) Use fossils to create and test hypotheses about geological and biological problems.

3) Write clearly and concisely to create strong arguments supported by evidence.

Clear, concise, and accurate written communication is the most important skill for almost all careers. The writing assignments will heavily focus on structuring papers to create a compelling story, using supporting evidence to build strong arguments, and writing sentences and paragraphs that flow. You will also learn to critically examine quantitative claims; many of the lecture and lab exercises will involve thinking analytically and using data to test hypotheses. A good sense of quantitative intuition (i.e., whether claims are reasonable or not) and skeptical assessment of apparent patterns (are they real or simply random fluctuations?) are valuable tools for a scientist.

Class Structure and Assignments

This course is roughly divided into three sections. The first three weeks focus on "big ideas" in paleobiology: mass extinctions, macroecology, morphometrics, evolutionary pattern and process, heterochrony, biogeography, and speciation via vicariance or dispersal. Paleobiology is an extremely broad area of study, so this part of the course will only give you a taste of some of the topics. We'll go into more detail on some of them during the remainder of the quarter.

This part of the class will use active learning, where you will work individually or in small groups on hands-on exercises to make interpretations from data. The in-class exercises are designed to challenge you and push you outside of your comfort zone. You may feel confused at times but that is actually good; you learn more when

trying to solve a problem, especially if you haven't already been taught the solution. The background information and terminology are explained in short (10-15 minute) videos from the YouTube playlist, and you should watch them prior to coming to class, taking notes to understand the key concepts. If the explanation of a concept still isn't clear after the video, please come to see me so I can try to explain the idea in a different way. You will get the most out of the in-class exercises if you are familiar with the terminology from the video and come prepared to use it to solve problems.

The next two weeks will focus on developing research ideas and writing a short research proposal. Each one of you will develop an idea for a research project that incorporates some of the "big ideas" from the first part of the course, identifying a question to be answered and proposing an approach to answer that question. This might sound intimidating, but you will work on it in stages and get a lot of feedback and guidance, including working on it in class, before the final product is due.

The remainder of the course will be spent actually doing the research. As a class, you will select one proposal to actually undertake, collecting the data as a group and then interpreting it and individually writing up your findings as a research paper. Each of you will write your own paper, but you'll all be working on the same project because you'll need to work together on the data collection so that we can get enough data in the short time available during the quarter. The paper will also be written in sections so that you can get feedback and guidance.

Research proposal: The proposal will be written in stages. First, you will submit an "elevator pitch" (**Oct 23**) – just a few sentences with the broad idea of the question you want to answer. In preparation for that, you're also welcome to bounce ideas off of me during the first few weeks of the quarter as you're learning about the various "big ideas." You aren't expected to have a perfect research idea immediately; we'll have some back and forth to help refine the plan. Next, you'll submit an outline (**Oct 28**) that contains some more detail about the research question, how it fills a gap in existing knowledge, and the type of data necessary and methods required to answer the question. You'll submit the full proposal draft (**Nov 1**) and then incorporate feedback to complete the final proposal (**Nov 6**).

Research paper: Like the proposal, the paper will be written in stages and there will be multiple opportunities in and outside of class for guidance and feedback. You will submit an introduction outline (**Nov 13**) and a draft of the introduction and methods (**Nov 18**), followed by an outline of the results and discussion (**Nov 22**) and a draft of the results and discussion (**Dec 2**). With the feedback on all of those, you will complete the final report by the Thursday of exam week (**Dec 12**).

Late Policy

The due dates (all assignments due before 11:59 PM on the date) are chosen so that you can receive timely feedback to be applied to your next assignment. There should be sufficient time to complete the papers, but I recognize that deadlines from other courses can occasionally all occur at the same time. Because of that, if you have circumstances that you feel prevent you from completing your best work, please contact me or meet with me **before the deadline**. I am happy to arrange a no-penalty extension if you propose a timeline for completing the work.

Grading Philosophy

Most of the assignments are formative (not graded and intended to provide feedback for improvement); only the final submission of the research proposal and the research paper are summative (intended to evaluate mastery of the learning outcomes). The process of assigning grades may actually hinder learning, so we're going to try something a bit radical for grading. After submission of the research proposal, and at the end of the quarter after submitting the research paper, you will answer some questions to reflect on your achievement of the learning objectives and we will meet to discuss your learning progress.

In my view, an A grade is achieved for *excellent mastery* of the course learning objectives. To earn an A, students will be able to apply material from the class in creative ways to solve novel problems and will write clearly, in detail, and with sophisticated interpretations. Grades in the B range indicate *good mastery* of the learning

objectives, such as the ability to solve problems similar to previously-encountered questions. Writing that receives a B will contain interpretations supported by the data but may lack detail or nuance. A C grade indicates only *adequate mastery* of the learning objectives. This means that a student may only be able to solve some problems or the writing may lack clarity or have limited interpretation without clear support from the data.

Writing and Plagiarism

The scientific method builds upon previous results, but it is extremely important to give credit whenever you are using ideas from other sources and always to rephrase those ideas in your own words. Rewriting and proper citation is important not only because it is ethical, but also because plagiarism hinders you from achieving a deeper understanding of concepts and prevents you from practicing important skills like writing. We will discuss scientific citation in more detail before the second paper. Because academic dishonesty circumvents the learning process, I have a zero-tolerance policy for plagiarism. The penalty for academic dishonesty is, at a minimum, zero on the assignment and may also include a formal filing with your college for particularly serious cases.

You are encouraged to work in groups during the labs and on in-class assignments so you can learn from each other, and I also encourage you to discuss proposal ideas, data interpretations, and give each other feedback on writing, but your papers must be original.

Disability Accommodation

UC Santa Cruz is committed to creating an academic environment that supports its diverse student body, as am I. If you require accommodations to achieve equal access in this course, please stop by my office with your letter from the Disability Resource Center (DRC), preferably within the first two weeks of the quarter, so we can discuss ways to ensure your full participation in the course. I encourage all students who may benefit from learning more about DRC services to contact DRC by phone at 831-459-2089 or by email at drc@ucsc.edu.

Textbooks: There are no required textbooks. The writing exercises will be based on chapters from the book "*Writing Science*" by Joshua Schimel; this book is available as a pdf at the Canvas site.

Labs: TA Stephanie Bosch (A201, sbosch@ucsc.edu). Labs will be held most weeks (Tuesday 5 PM-8 PM, Thursday 1:30 PM-4:30 PM) in D258. Lab exercises will involve a combination of in-class examination of specimens, focusing on important aspects of morphology and classification, and exercises on topics like biogeography and evolution. Lab grades will be separate from lecture grades.

Field Trip: We have a field trip from Friday October 11 (8 AM) to Sunday October 13. You will gain valuable expertise in observing fossils and collecting data to test hypotheses. Field trip attendance is extremely important; if you cannot reschedule conflicts and are unable to participate, please come talk to me as soon as possible so we can discuss alternative options.

Class Schedule – Fall 2019

Schedule is subject to change, depending on the requirements of the research project

Date	Topic	Pre-Lecture Video/Reading	Due Dates
Sept 27	Introduction; taphonomy (preservation); environmental preferences	Environmental prefs/marine org	
Sept 30	Diversity: extinction and origination	Extinction and origination	
Oct 2	Macroecology: guilds/evolutionary faunas	Guilds and evolutionary faunas	
Oct 4	Evolution: species concepts/morphometrics	Species concepts and classification	
Oct 7	Evolution: classification and phylogenetics	Phenetics and cladistics	
Oct 9	Evolution: pattern and process	Evolutionary pattern and process Evolutionary trends vs random walks	
Oct 11	*No class (field trip)*		
Oct 11-13	**Field trip (fossil reefs of Nevada)**		
Oct 14	Evolution: ontogeny and heterochrony	Ontogeny and heterochrony	
Oct 16	Biogeography	Biogeography	
Oct 18	Biogeography: vicariance and dispersal	Biogeography: vicariance/dispersal	
Oct 21	What's in a research proposal?		
Oct 23	Refining research ideas	*Schimel chapter 2*	"Elevator pitch"
Oct 25	Functional morphology: suspension-feeding	Morphology of suspension feeders	
Oct 28	Working on research proposal drafts	*Schimel chapter 11*	Outline
Oct 30	Functional morphology: reef-builders	Functional morphology: reefbuilding	
Nov 1	Project selection / logistical planning		Full proposal
Nov 4	Collecting the data		
Nov 6	Collecting the data		Revised full proposal
Nov 8	Previous work and the "knowledge gap"	*Schimel chapters 3 and 4*	
Nov 11	*No class (Veterans Day)*		
Nov 13	Finding the story	*Schimel chapters 4 and 5*	Intro outline
Nov 15	Collecting and/or interpreting the data		
Nov 18	Refining the opening	*Schimel chapters 6 and 7*	Intro/methods draft
Nov 20	Interpreting the data		
Nov 22	Interpreting the data: identifying key points	*Schimel chapters 8 and 9*	Results/discussion outline
Nov 25	Functional morphology: substrate	Substrate adaptations	
Nov 27	Interpreting the data / draft writing		
Nov 29	*No class (Thanksgiving)*		
Dec 2	Creating a strong argument	*Schimel chapter 10*	Results/discussion draft
Dec 4	Biostratigraphy	Biostratigraphy	
Dec 6	Building a compelling narrative	*Schimel chapters 12 and 13*	
Dec 12	**PAPER DUE**		Revised full paper