EESC 3501: Mass Extinctions: Death and Rebirth in the Fossil Record

Lectures: T/Tr 2:40 – 3:55, Schermerhorn 603

3 Credits

Instructor Information:

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Instructor Bio: I am a PhD candidate at Columbia University's Lamont-Doherty Earth Observatory (LDEO), where I study dinosaur footprints, the End Triassic Extinction (202 million years ago), and global environmental change through the Mesozoic (252-65 million years ago). As an indigenous scientist, I am also keenly focused on environmental justice and am a part of ongoing collaborations between Columbia University and Navajo Nation community partners to understand the distribution of geogenic groundwater contaminants in the Nation's water supply. I consider myself a storyteller above all else and think that paleontology provides our best framework for navigating an increasingly volatile future. Through my career as a scientist and educator, I hope to inspire people to see the intrinsic sense of wonder gained through careful observation of any natural system, such that they carry that wonder with them into a more beautiful world.

Commented [BS1]: One of my goals as an instructor is to create a rapport with my students. I believe that by sharing a bio, they can get a better sense of who I am and my intentions in the classroom.

Course Description: Mass Extinctions are caused by catastrophic shifts in the earth's climate, solid earth, and life systems. These major inflection points in the history of life leave lasting impacts and require study across a variety of disciplines. In this course we will use these 'system breakdowns' to take a bird's eye view of the history of life. We'll study what happens when vast magmatic provinces spew gases into a darkened sky and try to pick up the pieces as asteroid impacts desecrate the world around them. Along the way, we'll consider how our own actions have the potential to shape the world around us, and the nature of our relationship with an ever-changing earth system. Over the course of the semester students will practice integrating paleontological data from a variety of sources to study both evolutionary hypotheses and the causes of climate change in deep time. We will incorporate foundational ideas from geochronology and stratigraphy as a group, to place fossils into a broader geologic context. Students from all backgrounds who have taken at least one of the three "Systems" courses or Dinosaurs and the History of Life are welcome.

Commented [BS2]: Here, my aim was to create an evocative image to help pull students in and engage them from a place of excitement.

Prerequisites: One or more of: EESC 2200 The Solid Earth System, EESC 2300 The Life System, EESC 2100 The Climate System, EESC 1000/1400 Dinosaurs and the History of Life

Objectives: By the end of the semester, students will be able to:

1. Describe the biotic effects of a changing climate in geologic time and use it to make predictions about extinction survivability
2. Hypothesize an animal's ecological context based on a fossil's geologic and biologic context
3. Create an evolutionary hypothesis based on observable anatomical differences
4. Draw a schematic of a fossil / rock formation to highlight important features
5. Create a unified timescale integrating multiple lines of evidence
6. Reflect on and describe their place in the earth system as a whole

Commented [BS3]: In designing the class, I tried to curate verbs across multiple levels of Bloom's taxonomy and drawing on a mutltidiscipenary approach that allows students from different backgrounds to succeed.

Course Structure: The course is split into six approximately two-week units. These start with a unit on toolsets and perspectives, then move chronologically through life's major mass extinction events. In the last unit, we will focus on the debate surrounding the ongoing sixth mass extinction, and work to understand what it might mean to live through such an important event. More thorough unit descriptions are listed below.

1. What is a Mass Extinction? - To begin the course on the same page, we'll start with an introduction to the fossil record and the diversity of life. We'll focus on the introduction of tools and methods of learning, which we'll return to with increasing complexity again and again throughout the semester. Key concepts in the first unit include: cladistics, stratigraphy, biodiversity, and the nature of the fossil record.
2. Early Mass Extinctions - We'll discuss the evolution of complex life, and the extinction of the Precambrian fauna, and then transition into the 'big five' mass extinctions, where we will remain for the rest of the course. We'll use the End Ordovician and the End Devonian mass extinctions as a vehicle to introduce several key concepts, including an association between geographic and biological diversity, the Signor-Lipps effect, Biostratigraphy, and making inferences in deep time.
3. The Great Dying - Earth's deadliest mass extinction provides an exceptional case study in climate perturbation. We'll examine the climatic effects of Large Igneous Provinces, considering the effects of intrusion into a variety of different rocks, as well as consider how the competing forcing effects of different climate levers would play out and leave evidence in the fossil record. We'll also examine the pacing of mass extinctions, with a special focus on their lasting impact, the existence of disaster taxa, and the timing of ecosystem recovery.
4. The End Triassic Extinction - The End Triassic provides a good jumping off point for examining major life history trends going into the rest of the age of the dinosaurs, as well as the development of many modern fauna. We'll use the Newark Supergroup to talk about cyclical climatic change, geochronology, and climatic change. We'll spend a class period doing an extended deep dive into hypothesis testing with regards to kill mechanisms at the ETE. We'll also look at the uses and limitations of trace fossils in the fossil record.
5. K/Pg Boundary - Key questions for this unit include: how did the asteroid actually kill the dinosaurs? How do we know there was a bolide impact? What traces can single events leave in the fossil record? How do we distinguish between competing forces in a prolonged climate catastrophe? We'll also look at the exceptional Tanis site and consider ethical issues relating to paleontologists and the media.
6. Where do we go from here? - In the final unit, we'll consider the proposed sixth mass extinction, discuss the meaning of the Anthropocene, and attempt to consider what mass extinctions would mean to us as a species. We'll discuss views of nature using selected passages from literary sources as well as scientific texts and consider the nature of our responsibility as self-aware actors in a changing earth system. We'll also work on collating problem sets and reflections from the semester into a single portfolio for the end of term.

Classroom Materials and Unique Resources: There is no required textbook for purchase in this class. Selected readings will be provided at the start of each unit from the academic literature, and we will spend time in class discussing how to read them. One chapter will be provided from Benton and Harper's *Paleobiology and the Fossil Record*. Two class periods will be spent on self-guided visits to the American Museum of Natural History, and we will use a variety of fossil materials from the department's teaching collection as well. Students are expected to have access to a computer with a word processing software, as well as a pen and paper for drawing.

Commented [BS4]: The learning objectives listed above are non-sequential. In order to engage with each multiple times throughout the semester I decided it would be better to use them to guide the activities. However, to give a compelling narrative to the course, I provided this chronological list, and chronological pathway, for making sense of the fossil record.

Commented [BS5R4]: Additionally, as we know more and more about events that are closer to the present, this structures allows for a class arc that builds in complexity, and ensures students will have the tools necessary to decide what the class means to them by the time we engage fully in understanding the present in the last unit of the course.

Assessment: Final grades in this class will be based on Attendance and Participation (10%), our two museum visits (10%), six problem sets (60%), and the final portfolio assignment (20%). Rubrics will be provided for all assignments beforehand. Apart from the portfolio assignment, students may re-submit assignments with annotated changes to earn up to 50% of points lost back. Examples will be provided after PSET 1. Work is expected to be turned in on time, and a 10% penalty will be added for any late work. This is to encourage students to submit on time, ensuring prompt feedback and helping students stay on top of assignments.

The Portfolio Assignment: Each problem set will contain one final question that must be completed individually. These questions tie the course material into the broader world, and will ask students to think creatively, beyond the scope of material we have explicitly covered in class. For the final assignment, students will annotate and reflect on these previous final questions, collating them into a portfolio, and constructing for themselves a meta-narrative about what they've learned in the class and the way their thinking has evolved over the course of the semester. We will devote lecture time to discussing this before the end of the semester. You are not being asked to change any of your previous work, nor will you be graded again on the same questions, rather, the portfolio asks you to put your own work in conversation with the world beyond the classroom.

Commented [BS6]: I made this decision based on a desire to have a relatively consistent workload, and to discourage the use of unhealthy study strategies based on rote memorization. My goal in having a consistent workload be the primary source of assessment was also based on the belief that real learning happens s students work with and utilize material.

Commented [BS7]: I want to encourage students to engage critically with the feedback I provide, the goal here then is to provide them the means of doing so, without making the initial effort seem trivial.

Commented [BS8]: I think the construction of an active metacognition of the learning process is vital to understanding one's place in the world and seeing the impact a class makes in real time. Too often, science classes can feel like they're only useful in service of later learning more advanced material. My goal here was to create the space for students to see the tangible impacts of classroom material, and treat themselves seriously as people with ideas worth sharing.

	Student Calendar									
Date	2-Sep	4-Sep	9-Sep	11-Sep	16-Sep	18-Sep	23-Sep	25-Sep	29-Sep	2-Oct
Class	1	2	3	4	5	6	7	8	9	10
Topic	**What is a mass extinction?**			**Early Mass Extinctions**			**The Great Dying**			
Assignment	PSET 1				PSET 2				PSET 3	
Returns						PSET 1				PSET 2
Date	7-Oct	9-Oct	14-Oct	16-Oct	21-Oct	23-Oct	28-Oct	30-Oct	4-Nov	**6-Nov**
Class	11	12	13	14	15	16	17	18	N/A	**19**
Topic	**The End Triassic**				**AMNH 1**		**K/Pg Boundary**			
Assignment	PSET 3			PSET 4				PSET 5		
Returns				PSET 3				PSET 4		
Date	**6-Nov**	11-Nov	13-Nov	18-Nov	20-Nov	24-Nov	27-Nov	2-Dec	4-Dec	12-Dec
Class	**19**	21	22	23	24	25	N/A	26	27	28
Topic	**K/Pg Boundary**	**AMNH 2**		**Where do we go from here?**					**Review**	**Final**
Assignment	PSET 5			PSET 6					Portfolio	
Returns					PSET 5				PSET 6	

Assignments are due at the beginning of the last class listed. For example, PSET 1 is due Sep 11th, at class time. If a due date is an impossibility for you, please let me know as far in advance as possible and we can discuss alternatives.

Resources and Support: I encourage all students to actively seek support from each other and from me wherever needed. Additionally, the Columbia Writing Center has a wealth of resources and personnel who can aid you in writing, whether you need feedback or just accountability. Struggle is an important part of the learning process, but it does not have to be futile. Please ask for help if you need it!

Accommodations: If you feel a certain aspect of the course may present an accessibility concern to you, please reach out, as I am happy to make accommodations. If you have a letter from Disability Services please find a time to meet with me so we can make sure your needs are met.

Use of Technology: While some classroom activities may require the use of a laptop or other word processor, I encourage students to use pen and paper wherever possible. Some exercises will require students to sketch material on paper they can later turn in. When using laptops or other electronic devices, please be mindful of the effect distraction can have not just on your own learning, but on that of your peers, and limit your activity to that immediately related to classroom materials.

Absences and Participation: Classroom participation is vital to making sure you stay on top of course material. Some portion of every class will be spent tackling problems from that unit's problem set, and it can be easy to fall behind if you miss class. I will not be recording lectures. I recognize that various things come up. Students can take two excused absences with no questions asked, but beyond that I would ask you to please be in touch so we can ensure you are receiving the support you need to still learn and have productive classroom experiences. I also recognize that classroom participation looks different for every student. During the first class period, we will spend time discussing a variety of ways for students to demonstrate engagement with the course and material, both inside and outside the classroom.

Academic Integrity: I am confident that every student can succeed in this course based on their own hard work. I also recognize the lure of shortcuts. I would encourage all students to reach out to me if they are struggling with an assignment rather than taking another way around. I expect that students turning in work with their name on it are asserting that it is representative of their original work, without the use of AI tools to write, research, or re-word. Most importantly, academic integrity is vital to ensuring authentic learning happens.

Students are expected to do their own work where indicated on all assignments for this class and act in accordance with the Faculty Statement on Academic Integrity and Honor Code established by the students of Columbia College and the School of General Studies. Because any academic integrity violation undermines our intellectual community, students found to have cheated, plagiarized, or committed any other act of academic dishonesty can expect to be referred to the Dean's Discipline process.

A Further Note on Assessments: The bulk of the grade in this class is made up of six problem sets. Each problem set grade will be 50% group work, and 50% individual. Questions where group work is permitted will be explicitly indicated, as will the individual questions. A rubric will be provided with each assignment to help identify areas for improvement and provide feedback. I am a strong believer in the value of peer learning but recognize that individual work is vital to ensuring students accurately understand their own capabilities and I can best meet the needs of the class. PSET questions will be more advanced versions of exercises practiced in class, with each PSET containing a last prompt that asks students to write two pages (double-spaced) responding to a prompt. The two-page responses will help you chart the course of your own thinking over the course of the semester and provide the material on which you will base your portfolio reflection at the end of the semester. The goal here is both to help you discover what you're interested in, and to relate the activities in the classroom to the broader world, and I hope the reflective process you start here will continue well beyond the course itself.

Commented [BS9]: Here I took a page from a CTL podcast episode on rigor. I think it's important both to acknowledge that classroom material can be difficult, and to emphasize that I believe all students can excel in the class.

Commented [BS10]: My aim was to affect a non-punitive relationship here. I want to explain to students the reasoning behind a certain course of action without coming across as a disciplinarian.