

Earth History
GEOL 206 & GEOL 206L

Lectures: T & Th 11:00AM-12:15 PM, MSEC 105

Labs: W 2:00-5:00 PM, MSEC 241

Instructor contact info

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Course overview: The origin of life was one of the most important events in the geologic history of our planet. The evolution of life has affected the chemical composition of the atmosphere and ocean, changed the nature and rate of geological processes such as weathering and sedimentation, and fundamentally altered global elemental cycles. Throughout this course, we will explore the history of the Earth and its life, and consider the many interactions between biological and geological processes over Earth's 4.6 billion year history. Topics will include the geologic timescale, the formation and chemical evolution of Earth, tectonic evolution of continents, early evidence for life on Earth, and long-term interactions between the geosphere, atmosphere, and biosphere. We will explore the diversity of life over geologic time and the patterns and processes that contributed to that diversity, including some of evolution's greatest hits like the Cambrian explosion, the origin of the major lineages of modern animals, and mass extinctions that nearly wiped out animal life on Earth. Laboratory exercises will allow students to delve deeper into concepts and methods in paleobiology, including sedimentology and stratigraphy, the Phanerozoic fossil record, phylogenetic analysis, and preservational biases and their impact on the fossil record.

Place in curriculum: This course is a required course for most undergraduate degrees offered in the Earth and Environmental Science Department.

Course learning outcomes: Upon successful completion of this course, students will be able to:

- Describe some of the major events that shaped our planet's life, landscape, and climate.
- Describe the formation and tectonic evolution of the Earth.
- Explain important feedbacks in the Earth system, and some of the linkages between plate tectonics, life, and climate.
- Reproduce the geological timescale, and explain how it has been developed and refined.
- Describe relative versus absolute dating and explain how geologists determine the ages of rocks, fossils, and the Earth.

- Describe the process of natural selection and evolution.
- Recognize and identify common marine invertebrate fossils from the Phanerozoic.
- Discuss how preservational and other biases impact our interpretation of the fossil record.
- Recognize or explain some of the major mass extinctions recorded in the fossil record and discuss their potential causes and effects.
- Recognize and explain major changes in Earth's climate during the Cenozoic, and how humans have and currently are impacting Earth's climate.
- Access scientific literature through library resources and online databases, and explain the difference between popular and scholarly material.
- Interpret and synthesize material from the primary literature in class discussions and writing assignments.

Program learning outcomes: Learning outcomes for undergraduate and graduate degrees in Earth and Environmental Science: <https://nmt.edu/academics/ees/Outcomes.php>

Prerequisites: Either GEOL 1110 (Physical Geology) or GEOL 1190 (Geology of the National Parks) and their accompanying laboratories (GEOL 1110L or GEOL 1190L) are prerequisites for this course. If you have not yet taken one of these courses and have arranged to take the course anyway, you should expect to work harder than usual to catch up on material that would have been covered in the prerequisite. You may find it useful to pick up an introductory geology textbook and to develop working collaborations with other students to help you get up to speed.

Lab: Enrollment in the accompanying lab section (GEOL 206L) is required for this course.

Mode of instruction: Face-to-face lectures and labs. Some lectures may be recorded, but attending remotely is not an option unless under exceptional circumstances.

Field trips: We will have at least three mandatory field trips during the course, one of which will be on a weekend and the others during lab. Details will be provided in lecture, and if you need an accommodation for any reason, please discuss with your instructor and teaching assistant.

Course website: Canvas course website, <http://learn.nmt.edu>

Readings:

Required texts:

- *Earth System History (4th ed.)*, by Stanley and Luczaj (2014, W.H. Freeman, ISBN 978-1429255264). *Earth System History* is the main text for this course. If you don't want to purchase it, a copy is on reserve at the Skeen Library, and used copies of the 3rd edition are available. If you choose to use an older version or the alternative text (below), you will need to translate the page numbers for reading assignments.

Other required readings: Additional readings will be taken from the scientific literature or other sources. Electronic versions will be made available through the course webpage.

Alternative text: As an alternative to *Earth System History*, you may instead use *The Evolving Earth*, by Prothero (2020, Oxford University Press, ISBN 978-0190605629). If you choose to use this text, you will need to translate the page numbers for reading assignments.

Optional reading: *T. Rex and the Crater of Doom*, by Walter Alvarez. This is a popular science book on the end Cretaceous extinction that provides a fascinating perspective on that event, as well as many other topics covered in this course. This book was required reading in past years, but is not this year. However, I encourage you to read it for interest and a different and accessible perspective on many class topics. An electronic copy is available, and hard copies are on reserve at the Skeen Library.

Skeen Library reserve: The following references are placed on reserve at the Skeen Library. You may check them out for up to 2 weeks at a time, with the option to renew.

- *Earth System History*, by Stanley and Luczaj. A copy of both the 4th and 3rd editions are on reserve. (These are personal copies, so please treat them with care!)
- *Evolution of the Earth (7th ed.)*, by Prothero and Dott (2004). This is an older version of another popular Earth History textbook that provides useful background on Earth history topics.
- *T. Rex and the Crater of Doom*, by Walter Alvarez. An electronic copy is available (link provided on Canvas), and two hard copies are on reserve. (Again, these are personal copies, so please try not to spill too much coffee on them!)
- *Night Comes to the Cretaceous*, by Powell (1998). This is another book on the end Cretaceous extinction that is written for a general audience, and provides interesting background on this famous debate in an accessible way.

Grading: For this course, I am using a philosophy of assessment called “specifications grading,” which has been shown to reduce some of the negative impacts of grades on the learning process. Students are provided a guide to the work required to achieve a particular grade. Grades are directly tied to learning objectives through satisfactory achievement of assignments, often with opportunities to revise the assignments to achieve a satisfactory score. If you’re curious to learn more about this grading philosophy, see *Specifications Grading* by Linda Nilson (2015), or short pieces such as those by Johannesen et al. 2022 (<https://doi.org/10.1130/abs/2022AM-382375>) or Bayraktar 2020 (<https://higheredpraxis.substack.com/p/tip-specs-grading>).

Grades will be assigned based on the following criteria:

		<u>Earn C</u>	<u>Earn B</u>	<u>Earn A</u>
Labs (out of 12)	Meet expectations for at least	8	10	11
Timescale quizzes (out of 4)	Meet expectations for at least	2	2	3
Exams (out of 3)	Meet expectations for at least	1	2	2 (E on 1)
Review paper**		M*	M	E
Attendance and participation		M	M	E

*Students may earn a grade of C by completing a shorter review paper (6 pages instead of 10).

**In order to achieve a score of M or better on the review paper, students MUST complete all review paper deadlines including the paper topic statement, draft outline/bibliography, and partial draft

Scoring system

For most assignments, grades will be assigned based on the following categories:

- Excellent (E): Complete understanding of the material is evident, and errors are trivial.
- Meets Expectations (M): Complete understanding of the material is evident without the need for further revision. May include some errors that warrant revisions but are covered by comments.

- Needs Revision (R): Limited understanding of the material is evident. Exhibits many errors or one or more major errors that necessitate revision.
- Not Completed (N): Not completed to a degree where understanding is evident or can be assessed.

Different assignments or projects may use a specific rubric or have different criteria for achieving a score of R, M, or E. For points-based assignments and exams, a score of M is usually $\geq 75\%$ of possible points, and E is usually $\geq 90\%$ of points. Assignment-specific details will be provided in class.

Resubmitting substandard or incomplete work: Labs and other assignments that do not meet expectations (score of M or better) may be resubmitted within a week of receiving your score. This does not apply to scheduled exams/quizzes or the review paper, but for those items, there will be opportunities for feedback and to prepare in advance including practice exams, review sessions, and rough draft submissions.

+/- letter grade criteria

- A grade of B+ would mean achieving B criteria, but meeting A criteria in at least 2 categories; likewise for C+ versus C.
- A grade of B- would mean achieving B criteria in all except one category; likewise for A- versus A and C- versus C.

D/F grades: These grades indicate that most learning objectives were not met, and therefore a fundamental breakdown of expectations. A grade of D represents a meaningful but unsuccessful attempt at earning a C or above (earning C criteria most but not all categories). An “F” represents a lack of evidence of meaningful progress (not meeting C criteria in most categories).

Late work: You have the option to turn in three assignments up to one week late. You might think of this as having three “tokens” that allow you a free pass to submit late work. Otherwise, no credit will be given for late assignments.

No extra credit is available outside of designated assignments. We will look over any exam or homework questions you think are not graded correctly and adjust your score as appropriate, but we will otherwise not negotiate your final grade. If you are having trouble in class for academic or any other reasons and are concerned about your grade, please see me early on so we can discuss how you can improve your understanding and performance.

Exams: We will have three exams during the semester that will cover lecture and reading material. If you achieve satisfactory or high quality on the first two exams, you do not have to take the final, per the grading outline above.

Timescale quizzes: You will be quizzed on the geologic timescale at least four times over the term. Quizzes will be administered in lab, at the start of the lab period.

Laboratory exercises: Most laboratory write-ups will be due at the start of the following lab period, although the deliverables for most lab activities can be completed during the lab period.

You will have the opportunity to revise lab assignments that don't meet expectations, usually within 1 week of receiving your score.

Participation and Attendance: Everyone is expected to attend class and participate in discussions, field trips, and other activities. A score of S means no more than 6 *unexcused* absences, completing at least two learning reflections and participation inventories, and participating in the weekend fieldtrip. In order to earn a score of E, you must have no more than 2 *unexcused* absences and complete at least three learning reflections/participation inventories. We recognize that life happens, and we will make reasonable accommodations for medical absences and for students that contact us in advance about unavoidable absences. This includes absences for COVID-19 and other illnesses; please consult NMT's COVID-19 information page (<https://www.nmt.edu/covid19/>) for up-to-date guidelines.

Tracking participation: You will be asked to track and reflect on your participation through periodic "participation inventories," typically as part of your learning reflections (see below).

Reflections: Assessing your own learning process (metacognition) is a critical skill for lifelong learners. Three times over the course of the semester, you will be asked to reflect on your learning journey in this course. Details will be provided during the semester.

Review paper: The final paper for the class will be a scientific review paper on an Earth history topic of your choice. The text of your paper should be 10 pages in length (12 point font, Times New Roman, 1 inch margins, double-spaced), with figures and references on subsequent pages. You are encouraged to incorporate original figures that you have drafted yourself. You should expect to cite a minimum of 10 articles from the primary or secondary literature. Details will be provided in lecture.

Please note the due dates for the paper topic, abstract, outline and bibliography, and partial draft. **You are also welcome to turn in a rough draft at any point up until two weeks before the final paper is due.** If you choose to do this (and I highly recommend it!), do not expect to receive immediate feedback, but within 3-4 days is reasonable. Drafts must be reasonably well written and not contain egregious spelling errors and typos.

Effective communication to both a broad audience and to your scientific peers is paramount for a successful career. **You are STRONGLY encouraged to take advantage of the resources available at the Writing and Communication Lab**, which offers qualified tutors for graduate and undergraduate students to improve writing skills (<https://www.nmt.edu/academics/class/center.php>).

For your review paper, please select from one of the topics on this list. (You may also come up with your own topic, but please discuss with me first.)

- Preservational biases in the fossil record and their impact on diversity over time
- Causes of the PETM
- The Younger Dryas period
- Hypotheses and evidence for the P-T extinction event
- Hypotheses and evidence for the end Ordovician extinction
- Hypotheses and evidence for the late Devonian extinction
- The fossil record of eukaryotic microorganisms

- Biogenicity of the Apex Chert microfossils
- New developments in the universal tree of life
- Huronian glaciations
- Diversity and lifestyles of the Ediacaran biota
- The Great Oxidation Event
- The cause(s) of Cenozoic global cooling and glaciation
- Assembly and breakup of Columbia/Nuna or other early supercontinents
- The India-Asia collision

NMT Policies and Resources

Academic Honesty: New Mexico Tech’s Academic Honesty Policy for undergraduate and graduate students is found in the catalog, which can be found at: <https://www.nmt.edu/registrar/catalogs.php/>. Further information about academic honesty can be found on the Associate Vice President for Academic Affairs website: https://www.nmt.edu/academicaffairs/avpaa/academic_honesty.php
You are responsible for knowing, understanding, and following this policy.

Student Resources: Wondering where to go for help? Please see the offices below or visit the “[Where NMT Students Should Go for Help](#)” website.

Student Success: New Mexico Tech offers numerous peer tutoring services for students who are struggling in their courses, or who just wish to receive friendly advice, including the Office of Student Learning (Skeen Library, <https://www.nmt.edu/osl/>), Math Helproom (<https://www.nmt.edu/academics/math/ugrad/mathhelproom.php>), the Writing and Communication Lab (Skeen Library, <https://www.nmt.edu/academics/class/center.php>), and numerous department-run centers. These services are free of charge to students! Students may also consult the Dean for Student Success Initiatives, Elaine Debrine Howell (Fidel, rm. 237; 575-835-5208; elaine.debrinehowell@nmt.edu) or may receive emails from her if they are struggling in class.

Reasonable Accommodations: New Mexico Tech is committed to protecting the rights of individuals with disabilities and providing access and full participation in the educational experience. Students with disabilities who require reasonable accommodations are invited to make their needs known to the Office for Student Access Services (SAS) as soon as possible. Accommodations are not retroactive and may take some time to implement. The process for requesting accommodations can be found at their website https://nmt.edu/ds/for_students.php

You can contact SAS in person at the Fidel Center Room 245, call 575-835-6209, email access@nmt.edu or book through the link on our [website](#).

Counseling Services: The Counseling Center is very excited to announce that Tech has partnered up with the Virtual Care Group (VCG), to offer free supplemental healthcare services to our degree-seeking students. This virtual healthcare includes unlimited Tele-medical and

unlimited Tele-therapy/counseling sessions available 24/7, as well as life coaching. Both in-person sessions on campus and this virtual healthcare are available for those degree-seeking students currently enrolled for Fall classes. Download The Virtual Care Group app from your app store. For questions about the platform, please email VCG's Care Team at care@virtualcaregroup.com. For more information on services at NMT, please call 835-6619, email counseling@nmt.edu or check out our website at <https://www.nmt.edu/cds/>.

Respect Statement: New Mexico Tech supports freedom of expression within the parameters of a respectful learning environment. As stated in the *New Mexico Tech Guide to Conduct and Citizenship* (Student Handbook): “New Mexico Tech’s primary purpose is education, which includes teaching, research, discussion, learning, and service. An atmosphere of free and open inquiry is essential to the pursuit of education. Tech seeks to protect academic freedom and build on individual responsibility to create and maintain an academic atmosphere that is a purposeful, just, open, disciplined, and caring community.”

Title IX Reporting: Sexual misconduct, sexual violence, and other forms of sexual misconduct and gender-based discrimination are contrary to the University’s mission and core values, violate university policies, and may also violate state and federal law (Title IX). Faculty members are considered “Responsible Employees” and are required to report incidents of these prohibited behaviors. Any such reports should be directed to Tech’s Title IX Coordinator (Dr. Peter Phaijah, 238 Fidel Student Center, 575-835-5953 (O), 575-322-0001 (C), titleixcoordinator@nmt.edu) or reports can be filed online to [Tech’s Title IX & Sexual Misconduct Report](#). Please visit [Tech’s Title IX Website \(www.nmt.edu/titleix\)](#) for additional information and resources.

Land Acknowledgement: We acknowledge that the New Mexico Institute of Mining and Technology campus stands on the unceded ancestral lands of the Pueblo and Apache peoples. These lands were taken by Congress in the Indian land Cession 689 on October 1, 1886, and the people forcibly moved to reservations. These injustices were accomplished under false white-supremacist ideologies such as manifest destiny and the doctrine of discovery. As visitors to these lands we appreciate their millennia of stewardship to the land, water, animals and plants, and the opportunity to live and learn here. Please visit <https://indianpueblo.org/new-mexicos-19-pueblos/> to learn more about these Native nations, their cultures, and sovereignty.

Language on New Mexico Tech policies from <https://www.nmt.edu/academicaffairs/policies.php>, and courtesy of Dr. Steve Simpson.

Language on learning reflections, tracking participation, and some grading topics courtesy of Dr. Katherine Mattaini, Tufts University, Dr. Kathleen Hershberger, Grinnell College, and Dr. David Clark, Grand Valley State University.

Land acknowledgement text courtesy of Anne Gray, Chris ChoGlueck, Michael Schaefer, and the EES Diversity, Equity, and Inclusion (DEI) committee.

GEOL 206: Earth History

Spring 2024

Course schedule

ESH is the textbook, Earth System History by Stanley & Luczaj

Module 1: Geologic Time

Week 1: Introductory week and geologic time

T 16 Jan Course overview and geologic time
Th 18 Jan Age of the Earth and introduction to the geologic timescale
ESH: Ch. 1 Earth as a System
No lab

Week 2: Geologic time

T 23 Jan Relative and absolute dating
Th 25 Jan Relative and absolute dating
ESH: Ch. 6 Correlation and Dating (with Ch. 2 and 5 as background)
Lab 1: Field trip: Stratigraphy and relative dating

Module 2: The Hadean and Archean Eons

Week 3: Origin of Earth and Early Earth

T 30 Jan The Big Bang, stellar evolution, origin of solar system
Th 1 Feb Hadean Earth
ESH: Ch. 11 The Hadean and Archean Eons of Precambrian Time (with Ch. 2 as background)
Lab 2: Dating and stratigraphy

Week 4: Tectonic evolution

T 6 Feb Cratons, continents, and Archean rocks
Th 8 Feb Evolution of plate tectonics
ESH: Ch. 11 The Hadean and Archean Eons of Precambrian Time, Ch. 8 The Theory of Plate Tectonics
Lab 3: Paleogeography and tectonics **Timescale quiz 1 (in lab)**

Week 5: Introduction to life

T 13 Feb Chemical characteristics of life and the universal tree of life
Th 15 Feb Life in the Archean
ESH: Ch. 10 Major Geochemical Cycles, Ch. 11 The Hadean and Archean Eons of Precambrian Time (with Ch. 5 as background)
Lab 4: Library and reference lab **Timescale quiz 2 (in lab)**

Module 3: Evolution of the Biosphere in the Proterozoic

Week 6: The Proterozoic Eon

T 20 Feb Exam 1 (in class, covers material from weeks 1-5) **Exam 1**
Th 22 Feb Evolution of the atmosphere and the Great Oxidation Event
ESH: Ch. 10 Major Chemical Cycles, Ch. 12 The Proterozoic Eon of Precambrian Time
Lab 5: Paleozoic marine invertebrates

S 24 Feb Saturday field trip: Depositional environments and marine fossils

Week 7: The Proterozoic Eon

T 27 Feb Snowball Earth
Th 29 Feb Early eukaryotes and the Ediacaran fauna **Paper topic due Th, Feb 29**
ESH: Ch. 10 Major Chemical Cycles, Ch. 12 The Proterozoic Eon of Precambrian Time
Lab 6: Primary literature discussion 1 (and continue Lab 5: Paleozoic marine invertebrates)

Week 8: Evolution

T 5 Mar Evolution 1
Th 7 Mar Evolution 2
ESH: Ch. 7 Evolution and the Fossil Record (with Ch. 3, 4, and 5 as background)
Lab 7: Phylogeny and tree-thinking

Module 4: Life in the Paleozoic

Week 9: Cambrian Explosion

T 12 Mar The Cambrian Explosion
Th 14 Mar Finish Cambrian Explosion, start Phanerozoic diversity
ESH: Ch. 12 The Proterozoic Eon of Precambrian Time, Ch. 13 The Early Paleozoic World
Lab 8: Primary literature discussion 2 (and finish Lab 5: Paleozoic marine inverts) **Draft abstract, outline, bibliography due Th, Mar 14**

Week 10: Spring Break (The Boring Billion)

T 19 Mar No class (Spring Break)
Th 21 Mar No class (Spring Break)
No lab

Week 11: The Paleozoic Era

T 26 Mar Phanerozoic diversity of marine life
Th 28 Mar Permo-Triassic extinction
ESH: Ch. 13 The Early Paleozoic World, Ch. 15 The Late Paleozoic World (with Ch. 14 as background)
Lab 9: Field trip: Late Paleozoic stratigraphy **Partial paper draft due F, Mar 29**

Module 5: Mass Extinctions

Week 12: Mass Extinctions

T 2 Apr K-Pg extinction 1
Th 4 Apr K-Pg extinction 2
ESH: Ch. 17 The Cretaceous World, Ch. 18 The Paleogene World (with Ch. 16 as background)
Lab 10: Field trip: Late Paleozoic terrestrial deposits

Week 13: Mass Extinctions

T 9 Apr Finish mass extinctions
Th 11 Apr Exam 2 (covers material from weeks 6-12) **Exam 2**
ESH: Ch. 17 The Cretaceous World, Ch. 18 The Paleogene World (with Ch. 16 as background)
Lab 11: Diversity and biases in the fossil record

Module 6: Climate in the Cenozoic

Week 14: Into the Cenozoic

T 16 Apr Theories, hypothesis and the scientific method T, 18 Apr: last day to turn in a full rough draft for instructor feedback
Th 18 Apr Cordilleran tectonics
ESH: Ch. 17 The Cretaceous World; Ch. 18 The Paleogene World
Lab 12: Primary literature discussion 3 (reading TBA) **Timescale quiz 3 (in lab)**

Week 15: Cenozoic and Climate

T 23 Apr PETM
Th 25 Apr Ice ages and modern climate change
ESH: Ch. 18 The Paleogene World, Ch. 19 The Late Cenozoic World Before the Holocene
Lab 13: Presentations **Timescale quiz 4 (in lab)**

Week 16: Humans and the future of life

T 30 Apr The future and life elsewhere **Final paper due: M Apr 29, 5:00PM**
ESH: Ch. 20 The Retreat of Glaciers and the Holocene
No lab

Final exam period, date TBA

Exam 3 (final exam, comprehensive with emphasis on material from weeks 13-16) **Exam 3**