

Earth, Life & Time

(CORE-UA 312.001)

Fall 2021

Class Meets Tuesdays and Thursdays 2:00 to 3:15 PM

Silver 207

Lectures: Professor Michael R. Rampino

Departments of Biology and Environmental Studies

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Why Take This Science Course?

Science is not merely a "subject", it is a way of empirically examining and understanding the amazing world we live in and how it works. Science relies on careful observations, controlled experiments, cause-and-effect relationships, and rational thinking.

Around 250 thousand years ago, a new species, Homo sapiens, appeared in southern Africa, with an oversize brain (~1,400 cubic cm in volume), and a rudimentary technology. Human technology improved enormously over time, and this young species went on to invent art, religion, agriculture, politics and

civilization as they spread across the planet. There are now about 7 billion of us on all of the continents.

In 1610, the Italian scholar Galileo pointed his newly constructed telescope at the night sky and began a new way of looking at the World-- the "Scientific Revolution" that continues to this day. We first discovered that we were not the center of the Universe. Later, Darwin showed how humans had evolved naturally from other organisms over geologic time, and had not been the result of a special creation. The scientific discoveries that we will discuss in this course shattered our assumptions of our favored place in the Cosmos, and gave us a new perspective on our position in the Universe that we are still coping with today.

We have found that the Universe is strictly governed by the laws of physics and probability, and Science is our way of addressing the Cosmos objectively and rationally to discover the nature of reality. It provides naturalistic cause-and-effect explanations for all events, and rejects any supernatural, magical, astrological, paranormal, mythical or theistic causes.

One of the most beautiful things about modern science is the fact that all of the sciences are "consilient", that is, they all --physics, chemistry, astronomy, geology, biology--fit together seamlessly in their explanation of the Universe. Of course, science is always evolving as we develop improved understanding of the Universe, with new, more sophisticated tools, and as that understanding leads to further and deeper questions.

In just the last century, we have discovered that the Universe is nearly 14 billion years old, originating in a cosmic "explosion" -- the hot Big Bang. Over the lifetime of the Universe, the chemical elements necessary to build planets and living things were forged inside stars and distributed across the galaxies by stellar explosions. The Sun and planets were formed from those materials 4.6 billion years ago. Life on Earth, originating from non-living chemistry some 4 billion years ago, has evolved from simple cells to complex creatures with large brains in response to environmental changes, sometimes catastrophic, on our planet.

The course examines the history of the intimate relationships between the Earth's changing environments and the evolution of life. It is also clear that major evolutionary innovations have led to transformations of the

Earth's atmosphere, oceans and climate that have affected its habitability. This long-term perspective provides a background for current issues such as climate change, habitat destruction and loss of biodiversity, animal intelligence, and the new field of Astrobiology—involving the search for other habitable planets, life and intelligence elsewhere in the Cosmos, and addressing the overarching question--Are we alone in the Universe?

I enjoy teaching this class because I believe that such a course, which presents our best current scientific answers to fundamental questions about the nature of the Universe and our place in it, provides a necessary foundation for thinking about the human condition. Surveys show that more people believe in extraterrestrial visitations, ghosts, evil spirits and angels than in evolution by natural selection as the process whereby humans and other organisms developed on the Earth. In the USA, polls show that only about 40% of the population accepts that we are natural products of evolution. This is a lower percentage than 30 European countries plus Cyprus and Japan. Clearly, courses like the present one serve an important purpose.

Required Reading: (1) *Origins of Life in the Universe (OLU)*, R. Jastrow & M. Rampino, 2008 (Cambridge University Press, paperback). (2) *Cataclysms: A New Geology for the 21st Century (CAT)*, M. R. Rampino, 2017 (Columbia University Press). (3) *The Laboratory Manual* for the course will be available from the NYU Bookstore.

Recommended Readings: If you are interested in exploring these topics more deeply, you might pick up the following recent books; (1) *The Little Book of Cosmology*, L. Page, 2020 (Princeton Univ. Press); (2) *A Brief History of the Earth*, A. Knoll, 2021 (Custom House); or (3) *The Rise and Fall of the Dinosaurs*, S. Brusatte, 2018 (William Morrow).

LABS: All students must register for a Lab section. If you are not in a Lab, you are not in the course. The lab rooms are on the 2nd Floor of the Silver Center, room 203.

Be sure to read the labs *beforehand*. Each Lab starts with an on-line Quiz to be completed before the Lab session. Labs will count for 20% of the final grade.

Lab Instructor Information:

Lab Instructor	Lab Section	Email
Ifeoluwa Bamidele	002: Monday 9:30am-10:45am 003: Monday 11:00am-12:15pm	Igb8014@nyu.edu
Meng Gao	004: Monday 12:30pm-1:45pm 005: Monday 2:00pm-3:15pm	Mg6622@nyu.edu
Yulia Ji	006: Monday 3:30pm-4:45pm 007: Monday 4:55pm-6:10pm	Yj1550@nyu.edu

LECTURES: For the Lecture part of the course, there will be two exams during the semester, and a final exam (each covering a third of the semester); each accounting for 25% of your final grade (total 75%). Exams will be objective, with T/F, Multiple Choice, and Matching questions.

HOMEWORK: Homework is comprised of the questions at the ends of the chapters in the OLU textbook. HW counts for 5% of your grade. HW will be submitted to the Lab Instructors by email.

Students are urged to attend the lectures, as some material discussed or emphasized in the lectures might not be covered in the readings. This especially applies to new information and discoveries made subsequent to the publication of the textbook.

WEEK	LECTURES	LABS
Week 1.	Lect. 1: 9/2 <i>The Discovery of Deep Time</i> Reading: <i>OLU, Chapter 1</i> <i>CAT, Introduction & Chapters 1 & 2</i>	
Week 2.	Lect. 2: 9/7 <i>The Discovery of Deep Space</i> Reading: <i>OLU, Chapter 1</i> Lect. 3: 9/9 <i>The Universe: its Origin & Fate</i> Reading: <i>OLU, Chapter 2</i> Homework: Questions Chapters 1 & 2	<i>09/06: No Lab - Labor Day</i>
Week 3.	Lect. 4: 9/14 <i>Evolution of Stars and Creation of the Elements</i> Reading: <i>OLU, Chapter 3</i>	<i>09/13: Lab - Cosmic Distance Ladder</i>

Lect. 5: 9/16 The Solar System: The Sun & Planets

Reading: *OLU, Chapter 4*

Homework: Questions Chapters 3 & 4

Week 4.

09/20: Lab - Simulating Planetary Motion

Lect. 6: 9/21 Fossils & the Geologic Timescale

Reading: *Handout*

Lect. 7: 9/23 Earth-Moon Origins and Dating of Rocks

Reading: *OLU, Chapter 5*

Homework: Questions Chapter 5

Week 5.

09/27: Lab - Fossils and Geological Time

Lect. 8: 9/28 Asteroids, Comets & What We Learned from Meteorites

Reading: *Handout*

Lect. 9: 9/30 Mars, Venus & the Search for Life

Reading: *OLU, Chapters 6 & 7*

Week 6.

10/04: Lab - Review for Exam 1

Lect. 10: 10/5 Habitable Planets Around Other Stars

Reading: *Handout*

Homework: Questions Chapters 6 & 7

10/7 Exam 1 - Covering OLU Chapters 1 through 7

Week 7.

10/12: Lab - Impact Craters and Catastrophes

****No lab Monday 10/11. Lab is running on TUESDAY 10/12****

10/12 **No Class.**

Lect. 11: 10/14 The Inner Earth: Earthquakes and Volcanism

Reading: *OLU, Chapter 8*

CAT, Chapter 7

Week 8.

10/18: Lab - Sea-floor Spreading

Lect. 12: 10/19 A Crazy Idea? Continental Drift

Reading: *OLU, Chapter 9*

Lect. 13: 10/21 The Plate Tectonics Paradigm

Reading: *OLU, Chapter 9*

CAT, Chapter 9

Homework: Questions Chapters 8 & 9

Week 9.

10/25: Lab - Dances with the Earth I

Lect. 14: 10/26 Climate Change & its Causes

Reading: *OLU, Chapter 10*

Lect. 15: 10/28 Another Crazy Idea? Astronomical Cycles & the Earth

Reading: *OLU, Chapter 10*

Homework: Questions Chapter 10

Week 10.

11/01: Lab - Dances with the Earth II

Lect. 16: 11/2 What is Life? Life's Chemistry & Origins
Reading: OLU, Chapter 11

Lect. 17: 11/4 Evolution by Natural Selection
Reading: OLU, Chapter 11
CAT, Chapter 6
Homework: Questions Chapter 11

Week 11.

11/08: Lab - Evidence of Evolution

Lect. 18: 11/9 The Early Co-Evolution of Life & the Earth
Reading: OLU, Chapter 12

Lect. 19: 11/11 From Cambrian Explosion to Vertebrate Success
Reading: OLU Chapter 12
Homework: Questions Chapter 12

Week 12.

11/15: Lab - Review for Exam 2

Lect. 20: 11/16 The Age of Reptiles & the Origins of Birds
Reading: OLU, Chapter 13
CAT, Chapter 8

11/18 Exam 2 - Covering OLU Chaps. 8 through 11

Week 13.

11/22 - 12/07: Lab AMNH Dinosaur Exhibit

Lect. 21: 11/23 Mass Extinctions and the History of Life
Reading: OLU, Chapter 13
CAT, Chapters 3 & 4

11/25 THANKSGIVING

Week 14.

11/29: Lab - 10. Growth of the Brain

Lect. 22: 11/30 The Explosive Evolution of the Mammals
Reading: OLU, Chapter 14
Homework: Questions Chapters 13 & 14

Lect. 23: 12/2 Human Evolution & Growth of the Brain
Reading: OLU, Chapter 15

Week 15.

12/06: Lab - Review for Final Exam

Lect. 24: 12/7 Extraterrestrial Life & the Drake Equation
Reading: OLU, Chapter 16
Homework: Questions Chapters 15 & 16

Lect. 25: 12/9 Cosmic Evolution: Our Place in the Universe
Reading: CAT, Chapters 11, 12 & Epilogue

Week 16.

12/14 Final Exam: Covering OLU Chapters 12 through 16
