

NYU
A 12.0001
EARTH SYSTEM SCIENCE
Fall 1993

Sarvey
NYU ESS
PROF. RAMPINO
Dept. of Earth System Science

Class meets Tuesday and Thursday, 9:55-11:10 in Room 520 Main Hall.

Lectures: Prof. Michael R. Rampino (Department of Earth System Science, formerly the Department of Applied Science). Office—Rm. 501, Barney Bldg., 34 Stuyvesant St. (near the corner of 9th St. and 3rd Ave.); Phone: Office: 998-8995; Fax: 995-3820; Home Phone: 242-0929; Home Fax: 255-2739).

Special Lectures: Prof. Tyler Volk (Department of Earth System Science).

REQUIRED READING:

Healing Gaia, James E. Lovelock (Harmony Books, 1991, \$25).

The History of Earth, W. Hartmann and R. Miller (Workman, 1991, paper, \$19.95).

Planet Under Stress, C. Mungai and D. McLaren, eds. (Oxford, 1991, paper, \$24.95)

I will hand out Fact Sheets and Study Guides to help you keep up with the facts and concepts of the course.

OPTIONAL READING:

The Nemesis Affair, David Raup (Norton, New York, 1986, paper, \$7.95).

Earth System Science is a basic course that examines our current view of the Earth, in its cosmic setting, as a system involving interactions among the atmosphere, oceans, solid earth, and life. Emphasis is placed on the dynamics and evolution of these systems over time, and predictions for the future. The subject matter includes new observations from space; geophysics and plate tectonics; the circulation of the oceans and atmosphere; cycles of elements essential for life; the co-evolution of climate and life on earth over the past 4,500 million years; and will emphasize current problems, e.g. the greenhouse effect from increasing atmospheric carbon dioxide, deforestation, and depletion of the ozone layer.

COURSE OBJECTIVES: The aim of the course is to give students a new view of the Earth as an integrated system. This requires a survey of the dynamic interactions of the atmosphere, oceans, solid earth, and living things. Global observations, new technologies, and quantitative computer simulations have just recently given us the capability to probe these processes. At the same time, greater knowledge of the history of the Earth and other planets provides evidence for the long-term co-evolution of physical and "biogeochemical" systems.

The course material includes up-to-the-minute studies that attempt to forecast the global changes that will occur in the coming decades, both naturally and in response to large-scale human activity. The subject matter ranges, therefore, from cosmic questions such as why the Earth is suitable for life, and why the dinosaurs became extinct, to timely problems such as the global environmental effects of our everyday activities. As you will see, these issues are not unrelated.

COURSE REQUIREMENTS: The grading in the course will be based on performance in three exams. Homework problem sets will also be assigned. Note that a

great deal of factual information, and a number of new concepts will be introduced in this course; it is essential to keep up in the readings.

POLICY ON ATTENDANCE & MAKEUP EXAMS.: Students are expected to attend the class, as some class material will not be covered completely in the readings. Make-up exams must be scheduled **in advance** for students with a valid excuse (illness, family emergencies) for missing an exam.

Note exam dates now: 10/12, 11/16, and Final (week of Dec. 15-22).

SYLLABUS

9/9 and 9/14

Intro: The Cosmic Setting of the Earth. Scientific evidence relating to the Earth's place in the Universe. The origin and early history of the Earth and its Moon. The Faint Young Sun Problem.

Reading: Fact Sheet 1; Hartmann, p. 1-33;

9/16

Goldilocks. A comparison of the Earth, Mars & Venus. Why is the Earth comfortable, Mars too cold, and Venus too warm? Habitable zones around stars. Geologic activity on the terrestrial planets. The origin of atmospheres and oceans.

Reading: Lovelock, p. 9-34. Fact Sheet 2

9/21

Inside the Earth. The basic composition and structure of the Earth. The core, mantle, and crust. Volcanism, and the internal workings of the Earth. Convection currents in the earth's interior. Continental drift.

Reading: Hartmann, p. 35-57. Lovelock, p. 47-49; Mungal, Chap. 1.

9/23

Moving Continents. The opening and closing of ocean basins. The theory of plate tectonics. History of plate motion. The great geological cycles.

Reading: Hartmann, p. 60-71, 128-139. Fact Sheet 3

9/28—Prof. Volk

Cycles of Important Elements: Carbon and Oxygen: Elements important for life. The biogeochemical cycles of carbon and oxygen.

Reading: Hartmann, p. 96-109, Lovelock, p. 89-132. Fact Sheet 4.

9/30—Prof. Volk

Cycles of Important Elements: Nitrogen, Phosphorus, Sulfur: The nitrogen, phosphorus, and sulfur cycles. Ocean chemistry of nitrate and phosphate as major nutrients.

Reading: Handouts

10/5 and 10/7—Prof. Volk

Gaia: Does Life Regulate Conditions on the Earth? The Gaia Hypothesis of Lovelock and Margulis. Cybernetics, homeostasis, and the principle of feedback. Daisy World models. Food for thought.

Reading: Hartmann, p. 140-157; Lovelock, p. 50-88. Fact Sheet 5. Handouts.

10/12 First Exam

10/14 and 10/19

Air. The composition and dynamics of the atmosphere. The heat budget of the Earth. The hydrologic cycle. The Earth's present climate.

Reading: Lovelock, p. 35-46. Mungal, Chap 2; Fact Sheet 6.

10/21 and 10/26

Water. The composition and dynamics of the oceans. Basic ocean chemistry. The basic wind-driven and thermohaline circulations of the ocean.

Reading: Lovelock, p. 35-46. Mungal, Chap. 6; Fact Sheet 7.

10/28 and 11/2

Life. What is life? The origin of life, and how it evolved. Basic life processes. The composition of the biosphere. Global ecosystems.

Reading: Hartmann, p. 72-95 and Lovelock, p. 89-132. Fact Sheet 8.

11/4 and 11/9

How Climate and Life Co-Evolved. Long-term climate changes. Highlights in the history of life and the Earth's environment. The effects of continental drift on climate and life. Feedbacks between biology and the atmosphere.

Reading: Hartmann, p. 112-127; Lovelock, p. 133-152. Mungal, Chap. 3 & 4. Fact Sheet 9.

11/11

4,500 Million Years of the Earth System. Models of geochemical cycles over long timescales. Computer simulations of the Earth's climate system.

Reading: Lovelock, p. 57-72. Fact Sheet 10.

Optional Reading: Raup, The Nemesis Affair, Chap. 1-3.

Second Exam 11/16

11/18 and 11/23

Extraterrestrial Factors in the Earth's Evolution. External vs. internal causes of geologic changes: A current debate. The meaning of "deep time". Mass extinctions of life. Comet and asteroid impacts and the geologic record. The Shiva theory.

Reading: Hartmann, p. 158-195. Fact Sheet 11.

Optional Reading: Raup, Nemesis Affair, Chap. 4-8.

11/30

Natural Disasters and Human History. Volcanoes, earthquakes, tidal waves, floods, severe storms, impacts: What are the risks? The Atlantis Legend. The "year without a summer". Volcanic winter. The Tunguska event of 1908.

Reading: Hartmann, p. 196-209.

12/2 and 12/7

The Human Perturbation. Population growth, energy use, and the carbon dioxide greenhouse effect. The effects of other trace gases (e.g., methane, cfc's) on climate and the ozone layer. Land use changes and deforestation of the tropical rainforests.

Reading: Hartmann, p. 212-229; Lovelock, Chap. 8. Mungal, Chaps. 8, 9, 11.

12/9 and 12/14

The Next Hundred Years: What Can We Do? The climate of the last few centuries. Detecting the greenhouse warming in climate records. The next 100 years. Policy decisions: What can we do to mitigate natural and human-induced change?

Reading: Hartmann, p. 230-241. Lovelock, Conclusion. Mungal, Chaps. 10, 14, 16.

Final Exam (Week of Dec. 15 to 22)