GEOL/ESS 2000: Geochemical Cycles and the Earth System
Syllabus, Fall 2017

This course introduces the Earth system, bringing together elements of the solid Earth, hydrosphere, biosphere and atmosphere to achieve a more integrated view of the Earth's major interacting parts – in other words, the Earth as a system. First, we explore the origins of the elements, the solar system, and the Earth. We then cover systems concepts in the context of Earth science. We examine the interactions between the components of the Earth system, along with their major past changes, recognizing that rocks provide a record of past conditions and are key to understanding how the Earth system works over the long term. This helps us understand where our resources come from, and the effects of utilizing them. Understanding the Earth system helps us understand today's global issues such as resource availability (water, food, materials, and energy), global climate change, and decreasing biodiversity. An understanding of Earth's past changes helps us understand Earth's present – and future - changes.

Instructor:

Carrick M. Eggleston, ESB 3020 or, more likely, Geol 122/124, 307-223-1027, carrick@uwyo.edu. Office hours: Mon. 2:10-3:00, Thur. 12:30-2:30, other times by appointment. *I am happy to talk with you at any time I am in my offices, unless I have another meeting or some other prior commitment.*

TAs:

Alero Gure, ESB 3022, agure@uwyo.edu Office hours: Monday, Thursday 12-1 pm

A. Kacy Patrick: GEOL 225, apatric2@uwyo.edu Office hours: Wednesday, Thursday 2-3 pm

Class meeting times:

Lectures: MWF 9:00 to 9:50 Room 216 SH Knight Geology

Labs:Tues., 1:10 to 3:00 (section 10), 3:10 to 5:00 (section 12), 5:10-7:00 (section 11);
Wed., 3:10 to 5:00 (section 13), Room ESB 1004 or ESB 1006 (check schedule)

Labs: Bring calculator and text to lab; computers will be available for the labs that need them. You can probably use your own laptop sometimes, but some of the labs use specialized software installed on the UW computers. We are considering making changes, however.

Required textbook: The Earth System, 3rd edition, by Kump, Kasting and Crane, Pearson Prentice-Hall, 2010. We will also hand out (or post on the website) supplements covering subjects that the textbook does not cover. You are expected to read all chapters that are covered in class along with the supplements. In addition, you will be assigned problems from the book, usually from the "Critical Thinking Problems" at the end of each chapter. In some cases, I will add parts to these problems! In other cases, I will write my own problems and give them to you in class (and post on the website).

Prerequisites: A 4-credit 1000-level science course with lab; for geology majors this must be a 1000-level geology lab course. For ESS majors this is be a 1000-level lab course that meets ESS requirements. CHEM 1020 must be taken prior to, or concurrently with, this course.

Format: GEOL/ESS 2000 consists of 3 lectures per week, a laboratory exercise on all but the first and last weeks of class, and homework problems handed out or assigned from the book every Monday and due every Friday (in class, including exam weeks) except the first and last weeks of class. There is a "practice" problem set the first week of class that must be turned in (it will not be graded formally, but credit will be lost from the subjective evaluation as noted below if it is not turned in).

Note Taking: Taking notes is an important skill. It helps your mind to go over new information, to pick the most important points from a lecture, to remember more of the content later, and to develop writing skills. It is therefore expected that you will bring to the class a means of taking notes on each lecture. Do not hesitate to stop us, to ask questions, to slow us down so that you have time to take in what you need to take in!! If we are not stopped, we will forge ahead! We will sometimes provide materials that are not in the textbook, but whether we are working from the text or from written materials that we provide you are expected to take your own notes in whatever fashion is most useful to you. The lecture materials are available on the web (see below), and you can print them to take notes on if you wish.

Website: This course has a simple and unsophisticated website that I maintain personally (http://geofaculty.uwyo.edu/eggleston/FOG-1/GEOL2000/GEOL2000.html). The website has things like syllabus, problems that are assigned (including problem materials for those not from the book), review sheets prior to exams, lecture materials if you wish to print them out for note-taking, etc. I will announce the posting of various materials in class as well.

Other Expectations: While almost all of you already know and understand this last point, we find it useful to point out that expectations in a college course are different from those that may have been the norm in some peoples' K-12 experience. We find that in some cases, people have grown used to "having their hands held" through even fairly simple problems and complexities and have come out at this end unaccustomed to having to figure things out independently, without a step-by-step procedure provided. This may seem obvious, but we are not doing you a favor by holding your hand so tightly that you don't have to think your way through a problem independently. Struggle is not a bad thing – it is a way to get your brain working. Struggle teaches, and one of the more important things it teaches is self-reliance and the fact that you can do it, something that is almost impossible to teach any other way. Embrace struggle, and work through it! True independent thinking and problem solving are learned skills – and you should seize the opportunity to practice whenever possible. We are happy to answer questions – but you should grapple with each problem yourself first in order to ask the most useful questions. Forming good questions is also an important learned skill. I have a few other more specific expectations of you in this course:

1) I assume that you are here to learn and will behave accordingly. If you are not here to learn, be elsewhere.
2) I assume that you have learned basic algebra. I also assume that you know a bit about chemistry, chemical elements, what a mole is, and basic chemical equations. You will need to use these skills.
3) I assume that you have sufficient self-motivation to apply your skills to the problems, studying, and labs in this course. By this, I mean that you will (a) read what you need to read, (b) not simply read a problem and throw up your hands in frustration without trying (remember that struggle is part of learning). I assume instead that you will take the problem as far as you can without help.
4) I assume that you are a grown-up, not a child. This is nothing like high school. What comes with this is the expectation that you will apply yourself to your studies without a teacher "making you". For most of you this is obvious, but a few of you may never have thought of the world in this way yet. It's time to start.

5) Don't sell yourself short. I very, very rarely encounter people who are not perfectly smart. You're all as smart as the Harvard students, and that means that you can do this. Usually, difficulties in courses like these come from lack of attention or lack of the needed background, not lack of brains. You've got 'em, and you can use 'em. Wyoming taxpayers generously support the only 4-year university in the state. They do not do so to have a second-rate institution. Despite the many headwinds that universities in small places like Wyoming endure, UW is ranked among the top 400 universities in the world out of thousands. The Geology and Geophysics department Ph.D. programs have ranked as high as 12th in the nation (on a list that had Harvard at 13th). You get access to this expertise at a small fraction of the cost of places like Harvard. Take full advantage of such opportunity. I have lived and worked internationally, hold a PhD from Stanford, and know what it is like to compete on a global stage. I don't want to hear "but I'm just a Wyoming student" and neither do Wyoming taxpayers. We all want and need you to succeed – and success will only come with work. There's no secret to it.

Evaluation/Grading:

The basis for grading will be 3 in-class hour exams, a final exam, lab performance, and homework performance. In addition, there is a subjective evaluation that we call, in general terms, "professionalism".

Hour Exams:	Friday Sept. 22	
	Friday Oct. 20	
	Friday Nov. 17	(all hour exams in classroom)
Final Exam:	Friday Dec. 15, 8:00 am to 10:00 am (in classroom)	

Hour Exams:	100 points each	300	(30%)
Final Exam:	200 points	200	(20%)
Homeworks	200 points total	200	(20%)
Labs	250 points total	250	(25%)
Professionalism:	50 points total	50	(5%)
TOTAL POINTS AVAILABLE:		**1000**	

Note that content from the labs is in part meant to reinforce material introduced in class and therefore may – possibly - be included on the tests. Lab subject material is also meant sometimes to familiarize you with material *not* covered in class, i.e., to supplement class.

Please note there are no scheduled make-up tests. If you have to miss a test for a medical or other emergency let the instructor know ***prior*** to the test date to make alternative arrangements. Such arrangements ***cannot be made after the test***.

Lab write-ups are due at the following lab session. Late labs will receive a 10% automatic reduction in grade. Labs more than one week late will receive no credit. If you will need to miss a lab for a very good reason, contact the TA to make ***prior*** alternate arrangements. I have asked the TAs ***not to do any make-up labs*** unless students have made ***appropriate*** prior arrangements. If you have a problem with this policy, see me, not the TAs.

Homework problems that are up to one week late will also receive a 10% reduction. Homework problems more than one week late will receive no credit.

Other Policies:

1) Cheating. University Regulation 802, revision 2, defines academic dishonesty as "an act attempted or performed which misrepresents one's involvement in an academic task in any way, or permits another student to misrepresent the latter's involvement in an academic task by assisting the misrepresentation." There is a well-defined procedure to judge such cases, and serious penalties may be assessed. In this class, your exams are expected to be your work ONLY. You may work together on problems and labs, provided that the work you turn in represents your own thinking on the subject. We should point out that it is painfully obvious when a bunch of students all make the same mistakes and get the same wrong answer, even using the same symbols! We do notice this.
2) Conduct. University Regulation 29, change 1, states that the instructor can "establish reasonable standards of conduct for each class which should be made known at the outset." In this class I expect engagement and participation, including regular attendance, and that we all treat each other with courtesy and respect. This does not mean we have to agree with each other- but professionalism and civility are an expectation.
3) College of Arts and Sciences document, **A&S - Students and Teachers Working Together**. A 5-page document is available at: http://www.uwyo.edu/as/current-students/ After getting to this site, click on "Students and Teachers Working Together"
This document lays out the guidelines for the course syllabus, attendance, classroom etiquette (no sleeping or cell phone use!), phone and email protocol, office hours and how to make appointments outside of office hours. Good stuff.
4) Disabilities. If you have a physical, learning, or psychological disability and require accommodations, please let the instructor know immediately. You will need to register with, and provide documentation of your disability to University Disability Support Services (UDSS) (in "Student Educational Opportunity"), 109 Knight Hall, Phone: 307 766-6189, Fax: 307 766-4010, Email: udss@uwyo.edu

Generalized Class Outline:

NOTE: This is an approximation for information purposes. I reserve the right to change materials at any time. There are many reasons why the schedule may change, including simply the number of questions in class! This outline should therefore not be used for assignments – attend class for definitive news about assignments!!! This is intended only as a rough guide.

Week 1: Introduction, origin of universe, elements, solar system

Wed. Aug. 30: Introduction, Initial Logistics

Fri. Sept. 1: Atoms, Fundamental Forces, Atomic Decay

Read supplementary material (No lab or graded homework, but look at Problem 1)

Week 2: Origins continued, with radiometric dating

Mon. Sept. 4: Holiday, no class

NOTE: No labs this week!!

Wed. Sept. 6: Radiometric Dating

Fri. Sept. 8: Big Bang, Stars, Origin of the Solar System

Problem 1 due

Week 3: Systems Introduction

Mon. Sept. 11: Origin of Elements

Wed. Sept. 13: Chapter 1, Global Change

Fri. Sept. 15: Chapter 2, Systems

Read supplementary material; read Chapter 1, start Chapter 2

Lab 1: Radiometric age dating and meteorites

Problem 2: Exponential Decay (handout)

Week 4: Energy Balance

Mon. Sept. 18: Chapter 3, Energy Balance

Wed. Sept. 20: Chapter 3, Continued

Fri. Sept. 22: Exam 1

Read Chapter 3

Lab 2: Rocks and Minerals Review

Problem 3: Steady State (handout), Critical Thinking Problem #4, page 35

Week 5: Atmospheric Circulation, Ocean Circulation

Mon. Sept. 25: Chapter 3, Continued

Wed. Sept. 27: Chapter 4, Atmospheric Circulation

Fri. Sept. 29: Chapter 4, Continued

Finish Chapter 3, Read chapter 4

Lab 3: Daisyworld – A Systems Model in STELLA or InsightMaker

Problem 4: Radiating temperatures of terrestrial planets (handout), and Critical Thinking Problem #6, page 56

Week 6: Cryosphere, Plate Tectonics

Mon. Oct. 2: Chapter 5, Ocean Circulation

Wed. Oct. 4: Chapter 5, Continued

Fri. Oct. 6: Chapter 6, Cryosphere

Read Chapters 5 and 6

Lab 4: Light Intensity, Energy Balance

Problem 5: Relative Humidity and Dewpoint (handout)

Week 7: Plate Tectonics, A Review

Mon. Oct. 9: Chapter 7, Circulation of the Solid Earth.
Wed. Oct. 11: Chapter 7, Continued
Fri. Oct. 13: Chapter 8, The Carbon Cycle
Read Chapter 7, start 8
Lab 5: Thermal Steady State, using STELLA to model thermal steady state
Problem 6: Critical Thinking Problem #1, page 148 (use Excel to do this, turn in printed graph with correct profile, horizontal axis in kilometers, not time!)

Week 8: The Carbon Cycle

Mon. Oct. 16: Chapter 8, Continued
Wed. Oct. 18: Chapter 8, Continued
Fri. Oct. 20: Exam II
Read remaining part of Chapter 8
Lab 6: Thermohaline circulation and water density
Problem 7: Critical Thinking Problem #4, page 174

Week 9: The Biosphere

Mon. Oct. 23: Chapter 9, The Biosphere
Wed. Oct. 25: Chapter 9, Continued
Fri. Oct. 27: Chapter 10, Early Life
Read Chapters 9, 10
Lab 7: Weathering
Problem 8: Rainwater pH (handout)

Week 10: The Effects of Life on Earth

Mon. Oct. 30: Chapter 11, Effect of Life on Earth
Wed. Nov. 1: Chapter 11, Continued
Fri. Nov. 3: Chapter 12, Long-Term Climate Regulation
Read Chapters 11, 12
Lab. 8: Life Lab
Problem 9: #1, Critical Thinking Problems, page 174

Week 11: Climate Regulation

Mon. Nov. 6: Chapter 12, Continued
Wed. Nov. 8: Chapter 13, Biodiversity Through Earth History
Fri. Nov. 10: Chapter 13, Continued
Read Chapter 13
Lab. 9: STELLA or InsightMaker and population dynamics
Problem 10: #1, Critical Thinking Problems, page 232

Week 12: Biodiversity

Mon. Nov. 13: Chapter 14, Pleistocene Glaciations
Wed. Nov. 15: Chapter 14, Continued
Fri. Nov. 17: Exam III
Read up to Chapter 14 and study!
Lab 10: Iron solubility
Problem 11: #1, Critical Thinking Problems, page 253 (all parts!)

Week 13: Glaciations

Mon. Nov. 20: Chapter 14, continued
Wed. Nov. 22: NO CLASS
Fri. Nov. 24: NO CLASS

Week 14: Global Warming

Mon. Nov. 27: Chapter 15, Global Warming Part I
Wed. Nov. 29: Chapter 15 continued
Fri. Dec. 1: Chapter 16, Global Warming Part II
- Read Chapter 15
- Lab. 11: Exponential growth
- Problem 12: Critical Thinking Problem #2, page 271

Week 15: Where are we headed?

Mon. Dec. 4: Chapter 16, continued
Wed. Dec. 6: Supplementary Material: Energy Resources
Friday. Dec. 8: Wrap-up example: Water supply in an Alpine Village
- Read Chapter 16 and supplementary material
- Lab 12: Laramie Water Supply, Exponential Growth
- Problem 13: Critical Thinking Problem #3, page 319

"Week" 16: Wrap-up

Mon. Dec. 11: Scotland, Battle of Prestonpans, Energy and Environment

Final Exam: Friday, Dec. 15, 8-10 am, in the classroom (GE 216)

University Studies:

GEOL/ESS 2000 carries an "SE" designation under the older University Studies Program requirements, but does not carry a "PN" designation. As such it contains significant content addressing the Earth-sun relationship and astronomy (in the form of thinking about where our universe, solar system, and elements came from as well as the role of Earth-sun relations in modulating Earth's climate through Milankovitch cycles), and geological features and principles as applied to understanding the components, linkages, and feedback loops in the Earth System. We look at and interpret maps, we include large course segments that deal with the atmosphere and climate systems, we look at ocean circulation and nutrient systems, and we cover the role of soils, vegetation, and microorganisms in the Earth system.

The course goes beyond the basics of Earth science, taking a more quantitative approach than in 1000-level introductory courses. The subject is an excellent one for showing how present-day scientific thinking is the result of adjusting to new evidence as that evidence has been uncovered. The laboratory exercises and lecture content provide extensive familiarization with the scope and limitations of the scientific method, and the subject of climate in particular amply demonstrates relationships between scientific research and contemporary society. The laboratory exercises provide you with an opportunity to work with aspects of the Earth system in quantitative fashion, as well as to make measurements that allow us to derive simple quantitative relationships.

Expected Outcomes:

By the end of this course, you should be able to:

1) Explain to others the origins of the universe, the elements, the solar system, and the Earth on a sound scientific basis including an understanding of the structure of atoms, isotopes, nucleosynthesis, radioactive decay, neutron capture, and other processes.
2) Mathematically describe exponential decay as applied to radiometric dating of rocks and other materials.
3) Understand and quantitatively apply the concept of steady state in many different contexts.
4) Understand the difference between perturbations and forcings, interactions between the parts of a system, positive and negative linkages between system parts, and positive and negative feedback in systems of interacting parts.
5) Understand and construct computer models of simple systems.
6) Explain to others the Earth's energy balance between the total input of energy to the planet from the sun and total output of energy from the planet in the form of radiation, including the application of steady state concepts to this balance (see number 3 above).
7) Explain to others how a system of interacting parts can be self-regulating, such as in the Daisyworld model.
8) Understand the major factors in atmospheric circulation on Earth, including heat and mass transport, pressure gradients, geostrophic winds, etc.
9) Understand the major factors in ocean circulation on Earth, including gyres, thermohaline circulation, convergent and divergent circulation, etc.
10) Understand the major components of the Earth's cryosphere.
11) Explain to others the circulation of the solid Earth (plate tectonics).
12) Understand the major components of the Earth's carbon cycle, including the difference between organic and inorganic carbon, major carbon reservoirs, and the flux of carbon between reservoirs.
13) Understand the basics of how carbon dioxide dissolves in water to create carbonic acid.
14) Understand the basics of energy flow through biological systems, including the ability to recognize photosynthesis and respiration; understand the necessities of life such as sources of carbon, of water, and of energy.
15) Understand the basics of the genomic tree of life and a few basic relationships among the different major branches of living things.
16) Understand the properties of the earliest life forms, their basic chemical requirements, and their impact on the global environment over long periods of time.
17) Understand the difference between oxidizing and reducing conditions, the oxygen cycle on Earth, and the rise of oxygen in Earth's atmosphere due largely to biological activity.
18) Understand and explain the major outlines of Earth's climate regulation systems.

19) Understand what is meant by basic biological terms such as taxonomy, extinction, natural selection, evolution, adaptation – and understand major events in the history of biology and biodiversity on Earth and their relationship to climate changes and major events such as asteroid impact events.

20) Understand the major outlines of Earth's climate history, including major glaciation events.

21) Understand the Earth's orbital parameters and their influence on solar energy input to Earth (Milankovich cycles).

22) Understand current thinking with regard to the origins and feedbacks affecting ice ages during the last ~800,000 years of Earth's history.

23) Understand the scientific reasoning behind climate change and global warming on Earth now and in the future, with reference to past climate events that affected people profoundly.

24) Understand how large the anthropogenic carbon, nitrogen, and other fluxes are compared to natural fluxes (flows of energy or material between reservoirs in a system).

25) Understand the limits of exponential growth and ideas concerning the carrying capacity of Earth with regard to its human and other populations.

26) Understand the basics of Laramie's municipal water supply with regard to local geological structures.

27) Be able to solve quantitative problems with regard to exponential decay, exponential growth, steady state, the interaction of a system's parts, atmospheric concentrations and masses, energy input and output, matter and energy fluxes, mineral formulae and their meaning, and atmospheric processes.