Earth: The Physical Environment

Geosciences 225

General Information

Professors: F.A. Dahlen (Lecturer), Room 321-C Guyot Hall, extension 8-4130, fad@princeton.edu; Laurel Goodell (Laboratory Manager), Room 15 Guyot Hall, extension 8-1043, laurel@princeton.edu; Karin Sigloch (Laboratory Instructor), sigloch@princeton.edu; Mark Davidson (Homework Grader), markd@princeton.edu.

Textbook: *Understanding Earth* by Frank Press, Raymond Siever, John Grotzinger and Thomas H. Jordan

Organization: The lecture and laboratory segments of the course are divided into four quasi-independent units:

- First quarter: Earth materials, rocks and minerals, and geologic time
- Second quarter: surface geological processes, modes and rates of erosion
- Third quarter: the Earth's interior, earthquakes, and plate tectonics
- Fourth quarter: energy and resources, man's impact on the environment

Each of these units will be studied for a three-week period. The textbook offers a broad but qualitative perspective upon the topics studied, as well as an introduction to the vocabulary of geology. The lectures will address a few specific topics of interest in more quantitative detail. The laboratory exercises have been integrated as well as possible into the above four-quarter organizational structure.

Homework: One homework problem set will be assigned each quarter. The problems will deal with topics introduced in the lectures, and will typically involve both estimation and simple numerical calculation. A hand calculator will be useful. Student collaboration in solving the problems is encouraged. No math beyond high-school pre-calculus is required.

Hour Exams: Each of the above four units will be studied for a three-week period. There is no midterm or comprehensive final examination. Rather, at the end of each three-week quarter, there will be a one-hour, in-class exam. The one-hour exams will include problems similar to those in the homework sets, as well as questions intended to test your assimilation of the vocabulary and concepts discussed in the textbook. The exams will be closed book, but you will be allowed to bring a one-page, two-sided personal study sheet. A collection of sample problems and questions designed to assist you in studying will be handed out prior to each exam. The exam dates are:

- First quarter: Friday, October 1, 2004
- Second quarter: Friday, October 22, 2004
- Third quarter: Friday, November 19, 2004
- Fourth quarter: Friday, December 10, 2004

Anyone with a bona fide reason for missing one these exams (sports team trip, etc.) should apply to take it well in advance. There will be no opportunity to take a makeup exam after the scheduled date.

Laboratory: All students must complete the three-hour weekly laboratory sessions. The purpose of the labs is to introduce you to geology as an observational science, and to give you hands-on experience in collecting, analyzing and interpreting geologic and other data. The labs include field trips to local sites of interest, as well as one full-day weekend trip to the Delaware Water Gap in northern New Jersey on Sunday, October 17, 2004. Students who are unable to attend this trip because of a sports or other conflict should speak with either Professors Dahlen or Goodell, to plan makeup arrangements well in advance. Most of the three-hour labs require completion of assigned exercises prior to attendance. The lowest weekly lab grade will be dropped in assigning an overall lab grade.

Research Paper: All students will write a scientific or technical paper approximately ten pages long, on a topic of their own choosing. Topics and a preliminary bibliography are to be submitted for approval on Wednesday, November 24, 2004. *Every paper must include at least two references to an original publication in a scientific journal (not an introductory textbook or internet site).* The paper should be handed in to the Geosciences Departmental Office, Room 110 Guyot Hall on or before the Dean's Date, Tuesday, January 11, 2005. No paper will be accepted after this date without written approval from the Dean's Office. Late papers will be reduced in grade. See "Choosing a Topic for the Research Paper" for more information.

Final Grade: The relative weights of the various elements in the course are listed below:

Homework	10%
Four one-hour exams	40%
Research paper	25%
Laboratory	25%
	100%

Students using Geo 225 to satisfy the ST Distribution Requirement must receive a passing grade in the laboratory portion of the course in order to pass the course.

Geosciences 225 Fall 2004

Lecture and Lab Schedule

First quarter: Read chapters 1–4, 7–8 & 10 of *Understanding Earth*

Week 1 The Earth as a planet

Mon	Sept 13	Earth dimensions — third rock from the Sun
Wed	15	Earth chemistry — clues from meteorites
Fri	17	Nucleosynthesis — origin of the elements

Lab 1: Rock-forming minerals

Week 2 Rock-forming minerals

Mon	20	Minerals, crystal structures, X-ray diffraction
Wed	22	Silicate minerals & diamonds — phase diagrams
Fri	24	Joly's Na clock — why is the sea salty?

Lab 2: Classification and identification of rocks and campus building stones

Week 3 Radioactive age dating

Mon	27	Radioactive decay — ^{14}C dating
Wed	29	K-Ar & Rb-Sr dating — age of the Earth
Fri	Oct 1	First one-hour exam

Lab 3: Local geology field trip

Second quarter: Read chapters 12–15 & 18 of *Understanding Earth*

Week 4 The hydrological cycle

Mon	4	H_2O on Earth & in the Solar System
Wed	6	Reservoirs & fluxes of H_2O — box models
Fri	8	Water transport & streamflow

Lab 4: Stony Brook field trip, floodplain and measurement of discharge

Week 5 Erosion — exponential decay of the landscape

Mon	11	Mass transport — streams as conveyers of sediment
Wed	13	Erosion rates — what are the controlling factors?
Fri	15	Two case studies — Taiwan & the Huanghe River

Lab 5: Flood hazard evaluation using on-line USGS discharge data

Lab 6: All-day field trip to Delaware Water Gap – Sunday October 17

Week 6 Surface geologic processes & sedimentary environments

Mon	18	Landslides — the slippery slope
Wed	20	Deltas — the sediment graveyard
Fri	22	Second one-hour exam

Third quarter: Re-read chapter 2, read chapters 5–6, 17 & 19–21 of *Understanding Earth*

Week 7	Interior of the Earth		
	Mon	Nov 1	Heat flow & volcanism
	Wed	3	Mid-ocean ridges & seafloor bathymetry
	Fri	5	Interior properties & constitution of the Earth
	Lab 7: Introduction to GIS, spatial distribution of earthquakes		
Week 8	Earthquakes		
	Mon	8	Earthquake sizes & numbers
	Wed	10	Earthquake locations
	Fri	12	Earthquake mechanisms — beachballs
	Lab 8: Earthquake location and focal mechanism		
Week 9	Plate tectonics		
	Mon	15	Fit of the continents & seafloor magnetic anomalies
	Wed	17	Plate boundaries & velocities
	Fri	19	Third one-hour exam
	Lab 9: Tracking tectonic plates		

Fourth quarter: Read chapters 22, 23 & 16 of *Understanding Earth*

Week 10	Population and food supply		
	Mon	22	Population — growth rates & projections
	Wed	24	Food supply & carbon cycle — paper topic due
	No lab or Friday class this week — THANKSGIVING RECESS		
Week 11	Energy resources		
	Mon	29	Fossil fuels — geologic sources
	Wed	Dec 1	Fossil fuels — supply & demand
	Fri	3	Solar radiation & the greenhouse effect
	Lab 10: Jelloea		
Week 12	Global climate change		
	Mon	6	CO_2 emissions — sources and sinks
	Wed	8	Global warming — proxy observations & projections
	Fri	10	Fourth one-hour exam
	Lab 11: Records of climate change in ODP sediment & Vostok ice cores		

Research paper due Tuesday, January 11, 2005 (Dean's Date)

Please write NEATLY

Name _____

What do you prefer to be called? _____

Class ('05, '06, '07, '08, etc.) _____

Major or possible major _____

Campus phone _____

E-mail _____

Where are you from?

Where have you traveled?

Why are you taking this course? Are you enrolled or still "shopping"?

What math/physics/chemistry/geoscience courses have you taken here or in high school?

Characterize your computer experience in the following areas:

	Neophyte (never heard of it)				Expert (could write the manual)
Word processing	0	1	2	3	4
Spreadsheet use (e.g., EXCEL)	0	1	2	3	4
Graphing data	0	1	2	3	4
GIS	0	1	2	3	4

Is there anything else that you would like us to know about you?
(e.g., extra-curricular interests; sports; allergies we should know about for field trips; any first-aid certification; possible interest in a geoscience major . . .)

Earth: The Physical Environment

Geosciences 225

Choosing a Topic for the Research Paper

You are required to write a research paper approximately ten pages long (seven superbly written pages would be even better). The objective of this requirement is for you learn more about an area of the geosciences that you find particularly interesting. It is important to select a topic that is of an appropriate scope to be treated meaningfully within the ten-page guideline. Avoid topics that are too broad or general. Choose something that is relatively narrowly focused, something on which you can become an expert with a week's worth of research in the Geosciences Library. The boxed features (*Earth Issues* and *Earth Policy*) in the text by Press, Siever, Grotzinger and Jordan are a good source of possible topics. The *New York Times* or other newspapers may also provide you with ideas. Here is another shopping list of possible topics, by no means complete. It is intended only to give you an idea of the ideal scale of a topic, rather than to be all-inclusive.

Strictly scientific topics:

Greenland and Antarctic ice cores: a record of paleoclimate
Origin of oxygen in the atmosphere
Geomagnetic reversals: does the field turn or decay and re-grow?
Geologic evidence for the "Snowball Earth" 600–800 million years ago
Blind thrust faults in the Los Angeles Basin
Tidal heating and volcanism on Io
Precision (sub-centimeter) GPS geodesy, or SAR interferometry
Geomorphic evidence of water on Mars
Impact origin of the Moon
Is there a global liquid ocean on Europa?
Astronomical evidence for planets around other stars
Stability of the West Antarctic ice sheet
Uplift history of the Himalaya
Post-glacial rebound
Geologic causes of recent sea-level rise

More policy-oriented:

Radon: the geologic perspective
Asbestos: is it a real danger?
Yucca Mountain nuclear waste disposal site
Ozone in the stratosphere
Mineral resource availability: choose an element or material
Carbon sequestration strategies
Drought prediction: El Niño
Land-use planning for coastal areas in your home state or region
Earthquake, landslide or flood hazard in your home state or region
Insurance implications of natural hazards
Politics and economics of reducing CO_2 emissions
Legal or economic aspects of water allocation: choose a region,
say the Colorado River, the Tigris & Euphrates, or the Middle East

Format for the Paper

A working title, bibliography listing several pertinent references you have consulted so far, and a brief description of your paper topic must be turned in on Wednesday, November 24, 2004. These will be reviewed for their appropriateness, in particular with regard to the scale of the topic, and the nature of the references. At least two references to original papers published in a refereed scientific journal must be included in every bibliographical list.

For many, this may be the first scientific or technical research paper you have written. It should be written in the style of a research paper in a scientific or technical journal (which differs from expository writing in the humanities). Consult any professional geosciences journal such the *Bulletin of the Geological Society of America* or the *Journal of Geophysical Research* of the American Geophysical Union for the proper format. Every paper should be preceded by an abstract, which summarizes the principal findings or conclusions in a few pithy sentences.

References to anyone else's ideas or data (which are unavoidable in a library-research paper such as this) must be cited in the text. This should be done using either of the two following citation formats:

> Song & Richards (1996) have recently shown that the inner core of the Earth is rotating one degree per year more rapidly than the mantle and crust.
>
> The rotation rate of the Earth's inner core has recently been shown to be one degree per year greater than that of the mantle and crust (Song & Richards 1996).

Every paper should have a *References Cited* section at the end. All books and journal articles cited in the text should be listed alphabetically (by last name of first author). The above-cited paper would be included in this list as follows:

> Song, X. & Richards, P. G., 1996. Seismological evidence for differential rotation of the Earth's inner core, *Nature*, vol. 382, pp. 221-224.

References to material found in books often include explicit page numbers, to assist the reader who may wish to find the same information:

> The solid inner core of the Earth was first discovered by the Danish seismologist Inge Lehman (Press, Siever, Grotzinger & Jordan 2003, pp. 486 & 491).

Books listed in the *References Cited* section should indicate the publisher and date:

> Press, F., Siever, R., Grotzinger, J. & Jordan, T.H., 2003. *Understanding Earth*, Fourth Edition, W. H. Freeman, New York.

References which you may have consulted but which are not cited explicitly in the text are not listed at the end of the paper. Do not use footnotes, as you might in a literature or humanities paper. It is also rare to use direct quotes in scientific or technical writing.

The protocol for citing material found on the internet is not as well standardized. Authorship of web pages is frequently unspecified, so it is difficult to know where to place such citations alphabetically. Be as complete and explicit as possible. The point is to make it easy for the reader to look up the cited information, if he or she wants to.

The inclusion of illustrations, graphs, photos and maps to help you illustrate your points is strongly encouraged. These can either be scanned or photocopied from the original sources. Maps are especially important in any regional geological or policy study. All illustrations, graphs, photos and maps should be called Figures and numbered in sequence as discussed. All tables are called Tables and numbered sequentially. Each figure or table should have a caption, in which, among other things, you cite the original source. Generally, it is better to place smaller figures on the text page; larger figures should be placed on a separate page following the first place they are discussed in the text. Your paper should be printed on standard $8.5'' \times 11''$ paper; any figures larger than that can be folded. As a general rule, the more figures the better; if you must exceed the ten-page guideline, do so by including an abundance of pertinent figures — suitably woven into the discussion in the text.

Every paper is to be independently written and researched. Items that will be considered in grading include:

1. suitability of topic (not too broad, sufficiently technical)
2. understanding of scientific and technical issues involved
3. clarity and style of technical writing
4. level of sophistication in quantitative analysis
5. resolution of ideas and issues
6. appropriateness of recommendations (in a policy-oriented paper)
7. proper handling of citations and references
8. effective use (and proper citation) of figures, graphs, tables, etc.
9. quality of abstract: make it informative

Remember, it's supposed to be a scientific or technical paper. You are required to read at least two scientific articles in the course of doing research on your paper. Try to emulate their style. Don't write a *Newsweek* or *Economist* style article.

The research paper is due on the Dean's Date, Tuesday, January 11, 2005. It should be turned in to the Geosciences Departmental Office, Room 110, Guyot Hall.

The paper and all lab reports and homework (unless clearly stated by the instructor) are considered to be independent assignments, requiring the written and signed statement:

This paper represents my own work in accordance with University regulations.

Geo225 Laboratory Information and Policies

Our goal in the labs is to give you hands-on experience with and supplement the topics you are covering in lecture and in the textbook, and to show you a bit about how geoscientists work.

1. BE PREPARED. Be on time for lab, as a courtesy to your lab instructor and fellow students as well as for your own benefit. You are expected to be in lab the whole time, and must schedule other activities around this. Bring to every lab session: a scientific calculator, pencils with erasers, and your completed pre-lab homework assignment (if applicable).

2. FIELD TRIPS. Labs 3 and 4 are local field trips; evening labs will need to be rescheduled for those weeks. Lab 5 is an all day field trip to the Delaware Water Gap on Sunday, October 13.

3. MISSED LABS/MAKE-UP LABS. We assume you will attend all of your scheduled lab sessions and do not offer make-up labs. If you have significant one-time conflicts with the lab schedule (sports, performing groups, etc.), it is your responsibility at the beginning of the semester to reconcile your schedule with the lab schedule, and discuss the situation with the lab manager (Laurel Goodell). Your lowest lab grade is dropped when your lab average is determined, so in effect you may miss one lab without penalty. If you miss more than 1 lab you will get 0's for any additional missed labs.

   EXCEPTION: you may not drop Lab 5, the all-day field trip to the Delaware Water Gap. If you are not able to go on that trip, you may replace it with an all-day field trip that the GEO206 class is taking on Tuesday, January 7, 2003. Likewise, you should not skip Lab 6: Intro to GIS on November 5, because several subsequent labs are based on GIS. Extraordinary circumstances should be discussed with the lab manager (Laurel Goodell).

4. GRADING LABORATORY ASSIGNMENTS. In order to pass GEO225, you must pass the lab portion of the course; "passing" the lab is defined as having an average on lab assignments of 2.0 on the 0-5 point Laboratory Grading Scale. Generally, labs are due at the end of the laboratory period, but this may be modified at the discretion of the instructor.

5. LABORATORY HOMEWORK. Most labs have homework due at the beginning of lab that is part of the lab grade for that week. Homework assignments are posted on Blackboard and are meant to prepare you for lab and to allow you to work on introductory material at your own pace. This allows us to do more interesting things in the lab session itself. If your homework assignment is not done or is done in a cursory or incomplete manner, 1 point will be deducted from your lab grade for that week.

6. RETURNING OF GRADED LABS. Graded labs will be returned the following week. Keep graded labs until the end of the term.

7. CONTRIBUTE TO THE LAB. Ask questions; discuss things with your instructors and classmates. The instructors can only do so much; you as an individual and your lab section as a group of interacting individuals, are also responsible for the success of the lab.

8. WORKING TOGETHER. You are permitted to work together and help each other; this will even be required for some labs. You are encouraged to discuss approaches and compare results. But, after your work takes shape, you must separately and independently write up your answers. Do not produce identical prose or equations. Your lab instructor can give further advice on what is permissible.

GEO225 Lab Schedule
Fall 2002

Lab 1	Sept 17	Physical properties of minerals
Lab 2	Sept 24	Rocks and campus building stones
Lab 3	Oct 1	Local geology field trip
Lab 4	Oct 8	Stony Brook field trip
Lab 5	**Sunday, Oct 13**	All-day field trip to Delaware Water Gap
Lab 6	Oct 22	Flood hazard evaluation of hometown stream using on-line USGS discharge data
	Midterm Break	
Lab 6	Nov 5	Introduction to GIS
Lab 7	Nov 12	Earthquake location and focal mechanism
Lab 8	Nov 19	Tracking tectonic plate movements using GIS
Lab 9	Nov 26	GIS analysis of population trends
Lab 10	Dec 3	Oil production data — when will we run out?
Lab 12	Dec 10	Gelatin volcanos and Hawaiian volcanism

Laboratory Grading Scale for GEO225

The following scale is used by laboratory instructors to evaluate laboratory work. The edu-jargon describing standards reminds you that we are not grading the labs at so many points per question, but are looking at the overall quality of the work. In order to pass Geo206b, you must pass the lab section of the course; in order to pass the lab, you must have a lab average of 2.0. (Note that we do not evaluate lab grades in terms of letter grades until the end of the semester. However, as a quideline, getting consistent 3's on labs means your overall lab work would be evaluated as some kind of B.)

5	Superior	Completion of all assigned tasks, including homework. It exhibits independent, consistent, and precise work. It is correct, complete, appropriate, and well written. It is neat and legible. Qualitative and quantitative data analysis are effectively and correctly used. It contains elaboration, extension, and/or evidence of higher-order thinking as well as using prior knowledge effectively. No major misconceptions. No major and only a few minor inaccuracies.
4		Given at instructor's discretion.
3	Satisfactory	Completion of most or all assigned tasks. It exhibits independent, consistent work. It is generally correct, complete and appropriate, although minor inaccuracies may appear. Qualitative and quantitative data analysis are used, but may be flawed. There may be evidence of elaboration, extension and/or evidence of higher-order thinking and use of relevant prior knowledge
2		Given at instructor's discretion.
1	Unsatisfactory	Completion of some assigned tasks. While it may contain some elements of an adequate assignment, significant portions may be inaccurate, incomplete, inappropriate, messy, and/or illegible. There may be little evidence of independent thinking, elaboration, higher-order thinking and/or relevant prior knowledge. There may be evidence of misconceptions.
0		Missed or illegible lab.

New reserve book list.

Princeton University Library
Reserves/General Periodicals Services

The Online Reserves Request Service

- **Geosciences 225: Earth: The Physical Environment**
- **Enrollment:**
- **Dahlen Jr., Francis A, Geosciences, 321C Guyot Hall, 609 258-4130**

NOTE: After you review your list, you may add, delete or accept the list as is, but you **MUST** click on the ***Approve Your Course List*** button at the bottom of the page in order for your list to be recorded by the Reserve Department staff. Lists not ***approved*** will not be received and processed.

Book/Coursepacks **Journal Articles/Book Chapters** **Video/Other Items**

Books/Coursepacks
Remove or **Edit** by clicking on title
Add additional books
Remove all books by clicking **here**
List of books:

- Broecker, Wallace S., How To Build a Habitable Planet , QB631 .B76, Optional
- Consolmagno, Guy, Worlds apart : a textbook in planetary sciences , QB601 .C66 1994, Optional
- Davidson, Jon P., Exploring Earth: an introduction to physical geology , QE28.2.D375 1997, Optional
- Graedel, T.E., Atmospheric Change: an earth system perspective , QC981.8.C5 G69 1993, Optional
- Holland, Heinrich D., Living dangerously : the earth, its resources, and the environment , QE28 .H74 1995, Optional
- Judson, Sheldon, Earth : an introduction to geologic change , QE28.J83 1995, Optional
- Lunine, Jonathan Irving, Earth: evolution of a habitable world , QB631.L836 1999, Optional
- McElroy, Michael B., The Atmospheric Environment: effects of human activity , QC861.3.M34 2002, Optional
- Pipkin, Bernard W., Geology and the environment , QE38 .P48 1994, Optional
- Turco, Richard P., Earth under siege: from air pollution to global change , TD883.T85 2002, Optional

Journal Articles/Book Chapters
(Electronic reserves are submitted here.)
Remove or **Edit** by clicking on title
Add additional articles/chapters
Remove all articles/chapters by clicking **here**
List of articles/chapters:

Video/Other items, such as sample exams, sample papers, lecture notes, etc.
Remove or **Edit** by clicking on title
Add additional items
Remove all items by clicking **here**
List of items:

Add Books/Coursepacks


Laurel
version

Earth: The Physical Environment

Geosciences 225

General Information

Professors:
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Laurel Goodell (Lab Instructor), Rm 15 Guyot Hall, ext 8-1043, laurel@princeton.edu

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- First quarter: Friday, October 3, 2003
- Second quarter: Friday, October 24, 2003
- Third quarter: Friday, November 21, 2003
- Fourth quarter: Final exam date, January, 2004

Anyone with a bona fide reason for missing one these exams (sports team trip, etc.) should apply to take it well in advance. There will be no opportunity to take a makeup exam after the scheduled date.

Laboratory: All students must complete the three-hour weekly laboratory sessions. The purpose of the labs is to introduce you to geology as an observational science, and to give you hands-on experience in collecting, analyzing and interpreting geologic and other data. The labs include field trips to local sites of interest, as well as one full-day weekend trip to the Delaware Water Gap in northern New Jersey on Sunday, October 19, 2002. Students who are unable to attend this trip because of a sports or other conflict should speak with either Professors Dahlen or Goodell, to plan makeup arrangements well in advance. Most of the three-hour labs require completion of assigned exercises prior to attendance. The lowest weekly lab grade will be dropped in assigning an overall lab grade.

Research Paper: All students will write a scientific or technical paper approximately ten pages long, on a topic of their own choosing. Topics and a preliminary bibliography are to be submitted for approval on Wednesday, November 26, 2002. Every paper must include at least two references to an original publication in a scientific journal (not an introductory textbook or internet site). The paper should be handed in to the Geosciences Departmental Office, Room 110 Guyot Hall on or before the Dean's Date, Tuesday, January 13, 2004. No paper will be accepted after this date without written approval from the Dean's Office. Late papers will be reduced in grade. See "Choosing a Topic for the Research Paper and Research Paper Guidelines" for more information.

Final Grade: The relative weights of the various elements in the course are listed below:

Homework	10%
Four one-hour exams	40%
Research paper	25%
Laboratory	25%
	100%

Students using Geo 225 to satisfy the ST Distribution Requirement must receive a passing grade in the laboratory portion of the course in order to pass the course.

Geosciences 225

Lecture and Lab Schedule

First quarter: Read chapters 1–4, 7–8 & 10 of *Understanding Earth*

Week 1	The Earth as a planet		
	Mon	Sept 15	Earth dimensions — third rock from the Sun
	Wed	17	Earth chemistry — clues from meteorites
	Fri	19	Nucleosynthesis — origin of the elements
	Lab 1: Physical properties of minerals		
Week 2	Rock-forming minerals		
	Mon	22	Minerals, crystal structures, X-ray diffraction
	Wed	24	Silicate minerals & diamonds — phase diagrams
	Fri	26	Joly's Na clock — why is the sea salty?
	Lab 2: Classification and identification of rocks/campus building stones		
Week 3	Radioactive age dating		
	Mon	29	Radioactive decay — ^{14}C dating
	Wed	Oct 1	K-Ar & Rb-Sr dating — age of the Earth
	Fri	3	First one-hour exam
	Lab 3: Field trip to local geological outcrops		

Second quarter: Read chapters 12–15 & 18 of *Understanding Earth*

Week 4	The hydrological cycle		
	Mon	6	H_2O on Earth & in the Solar System
	Wed	8	Reservoirs & fluxes of H_2O — box models
	Fri	10	Water transport & streamflow
	Lab 4: Stony Brook field trip, floodplain and measurement of discharge		
Week 5	Erosion — exponential decay of the landscape		
	Mon	13	Mass transport — streams as conveyers of sediment
	Wed	15	Erosion rates — what are the controlling factors?
	Fri	17	Two case studies — Taiwan & the Huanghe River
	Lab 5: Flood hazard evaluation using on-line USGS discharge data		
	Daylong field trip to northern NJ, Sunday Oct 19 (counts as Lab 6)		
Week 6	Surface geologic processes & sedimentary environments		
	Mon	20	Landslides — the slippery slope
	Wed	22	Deltas — the sediment graveyard
	Fri	24	Second one-hour exam

Third quarter: Read chapter 2 (again) and chapters 5–6, 17 & 19–21 of *Understanding Earth*

Week 7	Interior of the Earth		
	Mon	Nov 3	Heat flow & volcanism
	Wed	5	Mid-ocean ridges & seafloor bathymetry
	Fri	7	Interior properties & constitution of the Earth
	Lab 7: Introduction to GIS, spatial distribution of earthquakes		
Week 8	Earthquakes		
	Mon	10	Earthquake sizes & numbers
	Wed	12	Earthquake locations
	Fri	14	Earthquake mechanisms — beachballs
	Lab 8: Earthquake location and focal mechanism		
Week 9	Plate tectonics		
	Mon	17	Fit of the continents & seafloor magnetic anomalies
	Wed	19	Plate boundaries & velocities
	Fri	21	Third one-hour exam
	Lab 9: Comparison of geological and VLBI plate velocities, using GIS		

Fourth quarter: Read chapters 22, 23 & 16 of *Understanding Earth*

Week 10	Population and food supply		
	Mon	25	Population — growth rates & projections
	Wed	27	Food supply & carbon cycle — paper topic due
	No lab or Friday class this week — THANKSGIVING RECESS		
Week 11	Energy resources		
	Mon	Dec 2	Fossil fuels — geologic sources
	Wed	4	Fossil fuels — supply & demand
	Fri	6	No class until Monday, January 5 (reading period)
	Lab 10: Oil production data — when will we run out?		
Week 12	Global climate change		
	Last Lab 11: Records of climate change in ODP sediment & Vostok ice cores		
Week 13	First week of reading period — Global climate change (continued)		
	Mon	Jan 5	Solar radiation & the greenhouse effect
	Wed	7	CO_2 emissions — sources and sinks
	Fri	9	Global warming — proxy observations/projections
	Fourth one-hour exam given in lieu of final exam		

Research paper due Tuesday, January 13, 2004 (Dean's Date)

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Geosciences 225

Choosing a Topic for the Research Paper

You are required to write a research paper approximately ten pages long (seven superbly written pages would be even better). The objective of this requirement is for you learn more about an area of the geosciences that you find particularly interesting. It is important to select a topic that is of an appropriate scope to be treated meaningfully within the ten-page guideline. Avoid topics that are too broad or general. Choose something that is relatively narrowly focused, something on which you can become an expert with a week's worth of research in the Geosciences Library.

The boxed features (*Earth Issues* and *Earth Policy*) in the text by Press, Siever, Grotzinger and Jordan are a good source of possible topics. The *New York Times* or other newspapers may also provide you with ideas. Here is another shopping list of possible topics, by no means complete. It is intended only to give you an idea of the ideal scale of a topic, rather than to be all-inclusive.

Strictly scientific topics:	More policy-oriented:
Greenland and Antarctic ice cores: a record of paleoclimate	Radon: the geologic perspective
Origin of oxygen in the atmosphere	Asbestos: is it a real danger?
Geomagnetic reversals: does the field turn or decay and re-grow?	Yucca Mountain nuclear waste disposal site
Blind thrust faults in the Los Angeles Basin	Ozone in the stratosphere
Geologic evidence for the "Snowball Earth" 600–800 million years ago	Mineral resource availability: choose an element or material
Tidal heating and volcanism on Io	Carbon sequestration strategies
Stability of the West Antarctic ice sheet	Drought prediction: El Niño
Geomorphic evidence of water on Mars	Land-use planning for coastal areas in your home state or region
Impact origin of the Moon	Earthquake, landslide or flood hazard in your home state or region
Is there a global liquid ocean on Europa?	Insurance implications of natural hazards
Astronomical evidence for planets around other stars	Politics and economics of reducing CO_2 emissions
Precision (sub-centimeter) GPS geodesy, or SAR interferometry	Legal or economic aspects of water allocation: choose a region, say the Colorado River, the Tigris & Euphrates, or the Middle East
Uplift history of the Himalaya	
Post-glacial rebound	
Geologic causes of recent sea-level rise	

Format for the Paper

A working title, bibliography listing several pertinent references you have consulted so far, and a brief description of your paper topic must be turned in on Wednesday, November 26, 2003. These will be reviewed for their appropriateness, in particular with regard to the scale of the topic, and the nature of the references. At least two references to original papers published in a refereed scientific journal must be included in every bibliographical list.

For many, this may be the first scientific or technical research paper you have written. It should be written in the style of a research paper in a scientific or technical journal (which differs from expository writing in the humanities). Consult any professional geosciences journal such the *Bulletin of the Geological Society of America* or the *Journal of Geophysical Research* of the American Geophysical Union for the proper format. Every paper should be preceded by an abstract, which summarizes the principal findings or conclusions in a few pithy sentences.

References to anyone else's ideas or data (which are unavoidable in a library-research paper such as this) must be cited in the text. This should be done using either of the two following citation formats:

> Song & Richards (1996) have recently shown that the inner core of the Earth is rotating one degree per year more rapidly than the mantle and crust.
>
> The rotation rate of the Earth's inner core has recently been shown to be one degree per year greater than that of the mantle and crust (Song & Richards 1996).

Every paper should have a *References Cited* section at the end. All books and journal articles cited in the text should be listed alphabetically (by last name of first author). The above-cited paper would be included in this list as follows:

> Song, X. & Richards, P. G., 1996. Seismological evidence for differential rotation of the Earth's inner core, *Nature*, vol. 382, pp. 221-224.

References to material found in books often include explicit page numbers, to assist the reader who may wish to find the same information:

> The solid inner core of the Earth was first discovered by the Danish seismologist Inge Lehman (Press, Siever, Grotzinger & Jordan 2003, pp. 486 & 491).

Books listed in the *References Cited* section should indicate the publisher and date:

> Press, F., Siever, R., Grotzinger, J. & Jordan, T.H., 2003. *Understanding Earth*, Fourth Edition, W. H. Freeman, New York.

References which you may have consulted but which are not cited explicitly in the text are not listed at the end of the paper. Do not use footnotes, as you might in a literature or humanities paper. It is also rare to use direct quotes in scientific or technical writing.

The protocol for citing material found on the internet is not as well standardized. Authorship of web pages is frequently unspecified, so it is difficult to know where to place such citations alphabetically. Be as complete and explicit as possible. The point is to make it easy for the reader to look up the cited information, if he or she wants to.

The inclusion of illustrations, graphs, photos and maps to help you illustrate your points is strongly encouraged. These can either be scanned or photocopied from the original sources. Maps are especially important in any regional geological or policy study. All illustrations, graphs, photos and maps should be called Figures and numbered in sequence as discussed. All tables are called Tables and numbered sequentially. Each figure or table should have a caption, in which, among other things, you cite the original source. Generally, it is better to place smaller figures on the text page; larger figures should be placed on a separate page following the first place they are discussed in the text. Your paper should be printed on standard $8.5'' \times 11''$ paper; any figures larger than that can be folded. As a general rule, the more figures the better; if you must exceed the ten-page guideline, do so by including an abundance of pertinent figures — suitably woven into the discussion in the text.

Every paper is to be independently written and researched. Items that will be considered in grading include:

1. suitability of topic (not too broad, sufficiently technical)
2. understanding of scientific and technical issues involved
3. clarity and style of technical writing
4. level of sophistication in quantitative analysis
5. resolution of ideas and issues
6. appropriateness of recommendations (in a policy-oriented paper)
7. proper handling of citations and references
8. effective use (and proper citation) of figures, graphs, tables, etc.
9. quality of abstract: make it informative

Remember, it's supposed to be a scientific or technical paper. You are required to read at least two scientific articles in the course of doing research on your paper. Try to emulate their style. Don't write a *Newsweek* or *Economist* style article.

The research paper is due on the Dean's Date, Tuesday, January 13, 2004. It should be turned in to the Geosciences Departmental Office, Room 110, Guyot Hall.

The paper and all lab reports and homework (unless clearly stated by the instructor) are considered to be independent assignments, requiring the written and signed statement:

This paper represents my own work in accordance with University regulations.

Geosciences 225

Professors:

- Tony Dahlen — Lecturer
- Laurel Goodell — Laboratory Manager
- Karin Sigloch — Laboratory Instructor
- Mark Davidson — Homework Grader

Textbook:

- *Understanding Earth*, Fourth Edition, 2003
  Press, Siever, Grotzinger & Jordan
- Useful for vocabulary
- Excellent photos and illustrations
- Not very quantitative
- To be thought of as a third segment of the course (in addition to lectures and labs)

Syllabus:

- first quarter — elements, rocks and time
- second quarter — water and mud
- third quarter — heat and earthquakes
- fourth quarter — the earth as man's abode

Geosciences 225

Homework — 10% of grade

- one problem set every quarter

Exams — 40% of grade

- four closed-book in-class exams — 10% each
- no comprehensive final exam

Laboratories — 25% of grade

- one three-hour lab every week
- one daylong field trip Sunday, October 17

Term Paper: — 25% of grade

- scientific or technical research paper
- no assigned topic — it's your choice
- due on Dean's Date, January 11

Size (km)	Orders of Magnitude Larger Than Earth	Significant Distances
10^{23}	19	Diameter of Universe
10^{22}	18	
10^{21}	17	
10^{20}	16	
10^{19}	15	Distance to Nearest Galaxy Like Ours
10^{18}	14	
10^{17}	13	Diameter of Our Galaxy
10^{16}	12	
10^{15}	11	
10^{14}	10	
10^{13}	9	Distance to Nearest Star
10^{12}	8	
10^{11}	7	
10^{10}	6	Diameter of Solar System
10^{9}	5	
10^{8}	4	Astronomical Unit
10^{7}	3	
10^{6}	2	Diameter of Sun
10^{5}	1	Diameter of Jupiter
10^{4}	0	Diameter of Earth
10^{-3}	7	Child 1 m
10^{-8}	12	Cell
10^{-13}	17	Atom 10^{-10} m
10^{-16}	20	Nucleus
10^{-20}	24	Electron

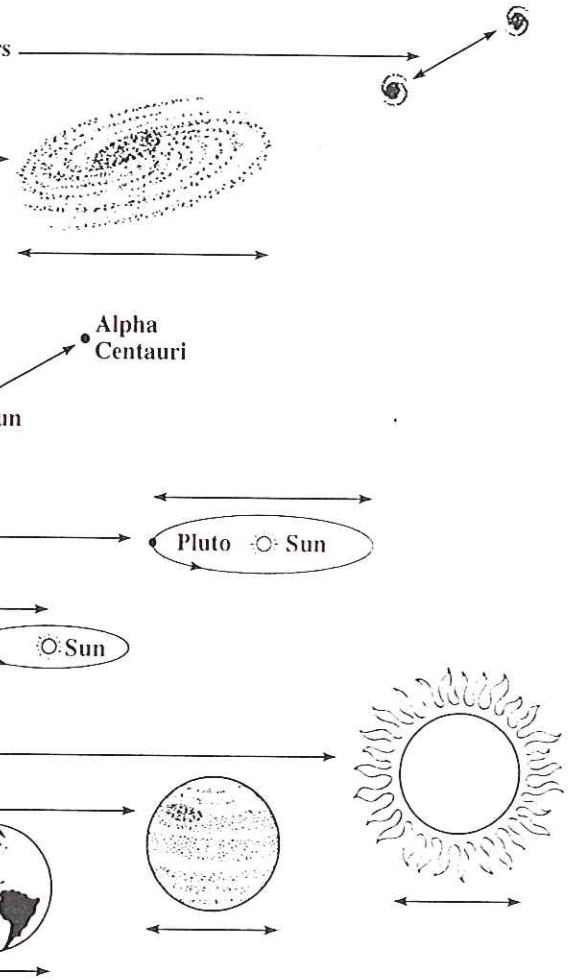


Figure 2.1. Sizes of various objects over the enormous range that the natural world encompasses. From Robbins and Jeffreys (1988) by permission of John Wiley and Sons.

First Class — Friday — Organization

GEO 225 has three ingredients:

- book by ~~J & R~~ Press & Sievert — presents an overview of topic — good for vocabulary & qualitative descriptions

- lectures — pick a few topics, cover in more detail than book — pick topics that lend themselves to simple quantitative analysis

- labs — also quasi-independent, though timing is ~ tied to class

Basis of grading

~~Exams~~ Learn-by-Teaching project in lieu of term paper

One day field trip to Delaware Water Gap and Northern New Jersey

Level of math required — only pre-calculus, no calculus

Fig. 2.1 Lunine shows tremendous range of scales studied in geology & astronomy.

Note — we <u>will</u> use power-of-ten (aka "scientific") notation

Question — how many atoms in a person?

Size of atom $\sim 10^{-10}$ m = 1 Å angstrom

Size of person ~ 1 m

Answer not simply 10^{10} because volumes are involved

Volume of an atom

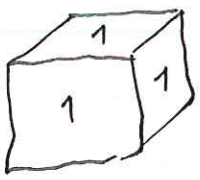
$$V_{atom} \approx \frac{4}{3}\pi (10^{-10}\ m)^3$$

$$\approx 4 \cdot 10^{-30}\ m^3$$

before the age of sex, drugs, rock & roll

Telephone booth packing — undisputed champ of 1950's

Volume of a person — ask how many fit in a $1\ m^3$ box?



Answer — between 10 and 20

[10 100 kg or 20 50 kg people]

$V_{person} \sim$ [redacted] $\frac{1}{20}\ m^3$ ← small people (50 kg each)

$$\#\ atoms = \frac{1/20\ [redacted]\ m^3}{4 \cdot 10^{-30}\ m^3}$$

$$\#\ atoms \cong [redacted]\ 10^{28}$$

More accurate answer — since not all atoms same size & difficult to estimate people's volumes —

Use mass instead

Ask — what are elements in a person?
Show periodic table

Answer : CH_2O C : H : O = 1 : 2 : 1

C : 12 gm/mole
H : 1 gm/mole
O : 16 gm/mole

$12 + (2 \times 1) + 16 = 30$

↓ a cox not a stoke

moles CH_2O in a 60 kg person

$$= \frac{60\ kg \times 10^3\ gm/kg}{30\ [redacted]\ gm/mole} = [redacted]\ 2000\ moles\ CH_2O$$

1 mole = Avogadro's number of "molecules"

$N = 6 \cdot 10^{23}$ molecules/mole

CH_2O = $(6 \cdot 10^{23})$ (2000)

= [illegible] 10^{27}

Thus a 60 kg person consists of

- 10^{27} C atoms
- $2 \cdot 10^{27}$ H atoms
- 10^{27} O atoms

$4 \cdot 10^{27}$ atoms

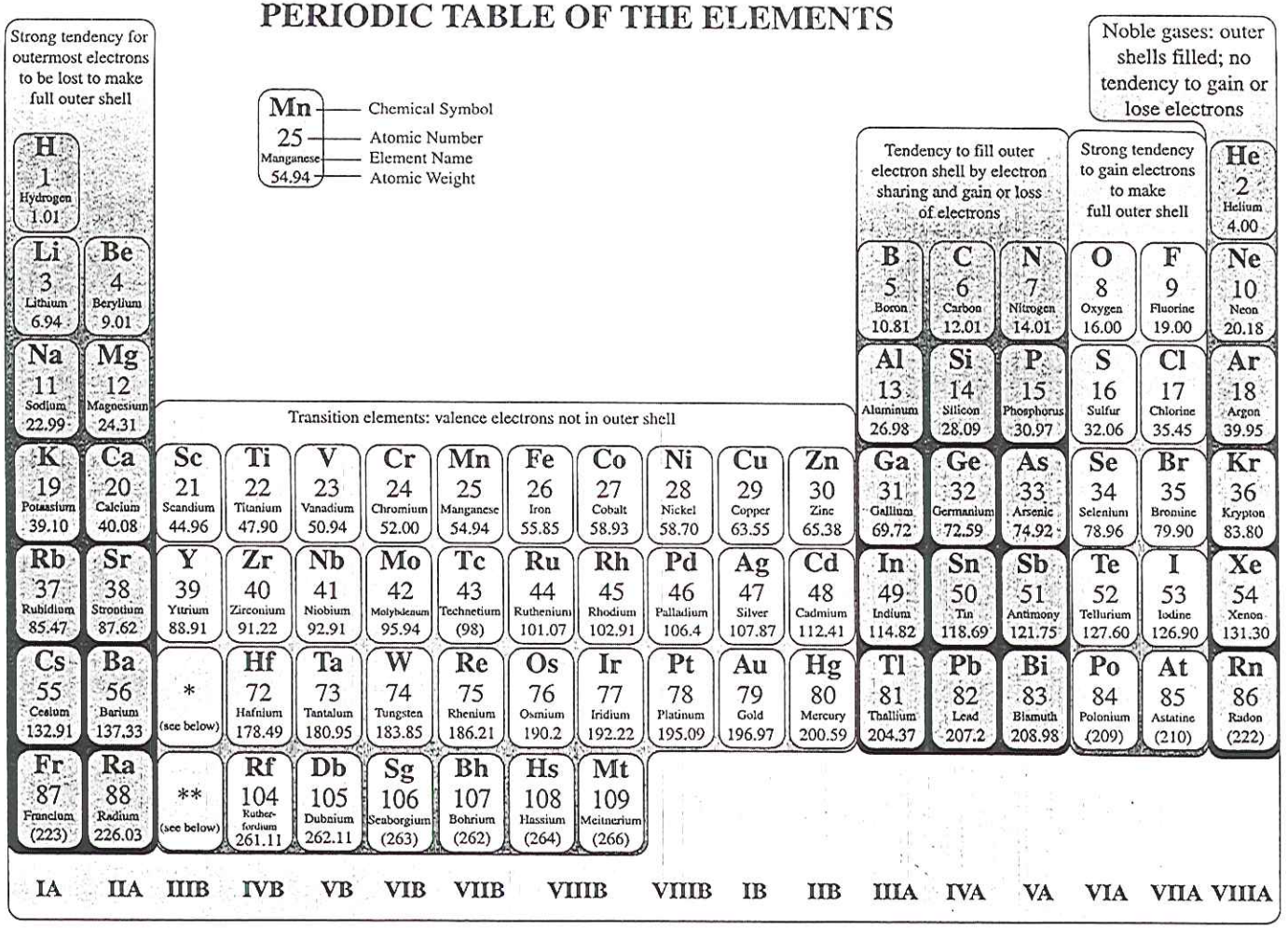
Question — which we shall address next time

What are the principal elements in the Earth? What are their relative proportions?

Just as for a person we need to begin with [illegible] $V_\oplus$ and $M_\oplus$ — next time.


TELEPHONE

PERIODIC TABLE OF THE ELEMENTS



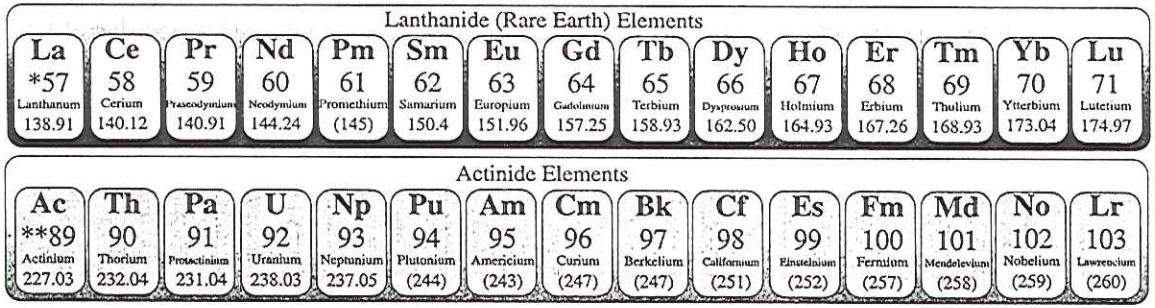


Table 5.1. Average Chemical Composition of Organic Matter

	Percentage Composition by Weight		
Element	*Carbohydrates*	*Fats*	*Proteins*
O	49.38	17.90	22.4
C	44.44	69.05	51.3
H	6.18	10.00	6.9
P		2.13	0.7
N		0.61	17.8
S		0.31	0.8
Fe			0.1
Total	100.00	100.00	100.00

Source: Rankama and Sahama 1950.