Unit #4 ES 100 lecture outline and related internet links.

For this unit read chapters 11 and 12. Start with the chapter summaries. Learn the key terms and answer the review questions. The readings are required before class. The lectures and films augment and clarify the readings. The ends of chapter questions are in order of the material presented in the text. The CD Rom at the back of the book has additional material to help you.

Films:
Please view the Earth Revealed videos before class.

10. Geologic Time (unit 4)
To illustrate the immensity of geologic time, the entire span of Earth's existence is compressed down to a year. The timeline of major geologic events is superimposed onto the year for a condensed view of Earth's evolution. A relationship between this timeline and that of life on Earth is established, with fossils and radiocarbon dating playing a major role in the discovery.

Read the questions first. Then answer them while watching this episode of "Earth Revealed".

1. What was the original Biblical estimate of when the earth was formed?
2. What is one of the most difficult aspects of understanding any study of the earth?
3. What important question intrigued Hutton?
4. What did he observe which helped answer his dilemma?
5. What did he reason about unconformities, and what did they indicate to him?
6. Describe the Principal of Uniformity and how it relates to the timing of geological events.
7. Describe the Principle of Superposition and how it helps to unravel earth's history.
8. Describe the Principle of Original Horizontality.
9. Describe the Principle of Cross-cutting Relationships.
10. How do geologists use relative age dating?
11. What are fossils, and how do they help geologists locate themselves in time?
12. What is paleontology?
13. How have geologists established the Relative Geologic Time Scale?
14. What did Rutherford determine in 1905?
15. How does radioactive dating work?
16. What is half-life? What is the half-life of Carbon-14?
17. Why is Carbon-14 age dating only good for materials less than 50,000 years old?
18. How do geologists date older materials?

19. What is the correlation between absolute and relative age dating, and how do they work together to establish a chronology of earth history?

11. Evolution Through Time (unit 4)
The fossil record reveals much about the diversity and development of species. This program examines the traces left by early plants, animals, and single-celled organisms and follows the progression of life forms over time. Connections are drawn between atmospheric gases, climate change, rock formation, biological functions, and mass extinctions.

Read the questions first. Then answer them while watching this episode of "Earth Revealed".

1. What does the fossil record suggest about early life on earth?
2. Describe the ways fossils can be formed.
3. Summarize why the preservation of life is skewed towards marine organisms.
4. What are prokaryotic cells?
5. What are eukaryotic cells, and what makes them more advanced?
6. How did the advent of eukaryotes fuel evolutionary change?
7. What is the significance of the Cambrian Explosion, and what does it represent?
8. Describe the early Paleozoic.
9. What happened in the mid-Paleozoic?
10. How did the increase in free oxygen contribute to the expansion of life on land?
11. What happened to the carbon dioxide in the atmosphere?
12. Discuss mass extinctions.
13. What new life forms appeared in the Mesozoic?
14. How have paleontologists changed their theories about dinosaurs?
15. What may have caused the mass extinction at the end of the Mesozoic?
16. How did tectonics affect evolution at the beginning of the Cenozoic?
17. What was preserved at Rancho La Brea?
18. Why are microfossils important to the understanding of ancient environments?
19. Discuss Darwin's theory of evolution.
20. What is punctuated equilibrium?
21. What effect are humans having on the earth's biosphere?

17. Sedimentary Rocks: The Key to Past Environments (Unit #1 and #4)
This program returns to the Grand Canyon: its exposed layers of sedimentary rock allow scientists to peer into the geologic past. The movement of sediment and its deposition are covered, and the processes of lithification, compaction, and cementation that produce sedimentary rocks are explained. Organic components of rock are also discussed.

Read the questions first. Then answer them while watching this episode of "Earth Revealed".

1. How many years of earth history are represented in the Grand Canyon?
2. What are sedimentary rocks?
3. How are sediments formed?
4. How do weathering and erosion influence the composition of sediments?
5. Describe mechanical weathering and the formation of clastic sediments.
6. Describe chemical weathering and the formation of solutions.
7. How can sediments be transported?
8. How does energy relate to the transportation and deposition of sediments?
9. Why do you usually find sand at the beach?
10. What is sorting?
11. What are "facies changes" and how do they relate to sedimentary rocks?
12. Describe the process of lithification.
13. Describe chemical sedimentation, and how it takes place in the ocean.
14. What are sedimentary structures, and why are they important?
15. What is a bedding plane, and what do they represent?
16. How is cross-bedding used by geologists to interpret geologic history?
17. Describe the formation of symmetrical and asymmetrical ripple marks.
18. How are sedimentary rocks important to economics?
19. Summarize the geologic history of the Grand Canyon.

## Chapter Outlines:

Chapter #11

Objectives: Geologic Time

After reading, studying, and discussing Chapter 11, you should be able to:

- Describe the doctrine of uniformitarianism.
- Explain the difference between numerical and relative dating.
- List the laws and principles used in relative dating.
- Discuss unconformities.
- Explain correlation of rock layers.
- Describe fossils, fossilization, and the uses of fossils.
- Explain radioactivity and radiometric dating.
- Describe the geologic time scale.

### Geologic Time

I. Historical notes
  A. Catastrophism
    1. Landscape developed by catastrophes
    2. James Ussher, mid-1600s, concluded Earth was only a few thousand years old
  B. Modern geology
    1. Uniformitarianism
      a. Fundamental principle of geology
      b. "The present is the key to the past"
    2. James Hutton
      a. *Theory of the Earth*
      b. Late 1700s

II. Relative dating
  A. Placing rocks and events in sequence
  B. Principles and rules of
    1. Law of superposition – oldest rocks are on the bottom
    2. Principle of original horizontality – sediment is deposited horizontally
    3. Principle of cross-cutting relationships – younger feature cuts through an older feature
    4. Inclusions – one rock contained with in another – rock containing the inclusions is younger
    5. Unconformities
      a. An unconformity is a break in the rock record
      b. Types of unconformities
        1. Angular unconformity – tilted rocks are overlain by flat-lying rocks
        2. Disconformity – strata on either side are parallel
        3. Nonconformity
          a. Metamorphic or igneous rocks below
          b. Younger sedimentary rocks above

III. Correlation of rock layers
  A. Matching rocks of similar age in different regions
  B. Often relies upon fossils

IV. Fossils: evidence of past life
  A. Remains or traces of prehistoric life
  B. Types of fossils
    1. Petrified – cavities and pores are filled with precipitated mineral matter
    2. Formed by replacement – cell material is removed and replaced with mineral matter
    3. Mold – shell or other structure is buried and then dissolved by underground water
    4. Cast – hollow space of a mold is filled with mineral matter
    5. Carbonization – organic matter becomes a thin residue of carbon
    6. Impression – replica of the fossil's surface preserved in fine-grained sediment
    7. Preservation in amber – hardened resin of ancient trees surrounds an organism
    8. Indirect evidence includes
      a. Tracks
      b. Burrows
      c. Coprolites – fossil dung and stomach contents
      d. Gastroliths – stomach stones used to grind food by some extinct reptiles
  C. Conditions favoring preservation
    1. Rapid burial
    2. Possession of hard parts
  D. Fossils and correlation
    1. Principle of fossil succession
      a. Fossils succeed one another in a definite and determinable order
      b. Proposed by William Smith – late 1700s and early 1800s
    2. Index fossils
      a. Widespread geographically
      b. Existed for a short range of geologic time
V. Radioactivity and radiometric dating
  A. Atomic structure reviewed
    1. Nucleus
      a. Protons – positively charged
      b. Neutrons
        1. Neutral charge
        2. Protons and electrons combined
    2. Orbiting the nucleus are electrons – negative electrical charges
    3. Atomic number
      a. An element's identifying number
      b. Number of protons in the atom's nucleus
    4. Mass number
      a. Number of protons plus (added to) the number of neutrons in an atom's nucleus
      b. Isotope
        1. Variant of the same parent atom
        2. Different number of neutrons
        3. Different mass number than the parent atom
  B. Radioactivity
    1. Spontaneous breaking apart (decay) of atomic nuclei
    2. Radioactive decay
      a. Parent – an unstable isotope
      b. Daughter products – isotopes formed from the decay of a parent
      c. Types of radioactive decay
        1. Alpha emission
        2. Beta emission
        3. Electron capture

C. Radiometric dating
    1. Half-life – the time for one-half of the radioactive nuclei to decay
    2. Requires a closed system
    3. Cross-checks are used for accuracy
    4. Complex procedure
    5. Yields numerical dates
D. Carbon-14 dating
    1. Half-life of only 5730 years
    2. Used to date very recent events
    3. Carbon-14 produced in upper atmosphere
        a. Incorporated into carbon dioxide
        b. Absorbed by living matter
        4. Useful tool for anthropologists, archeologists, historians, and geologists who study very recent Earth history
E. Importance of radiometric dating
    1. Radiometric dating is a complex procedure that requires precise measurement
    2. Rocks from several localities have been dated at more than 3 billion years
    3. Confirms the idea that geologic time is immense

VI. Geologic time scale
A. Divides geologic history into units
B. Originally created using relative dates
C. Subdivisions
    1. Eon
        a. Greatest expanse of time
        b. Four eons
            1. Phanerozoic ("visible life") – the most recent eon
            2. Proterozoic
            3. Archean
            4. Hadean – the oldest eon
    2. Era
        a. Subdivision of an eon
        b. Eras of the Phanerozoic eon
            1. Cenozoic ("recent life")
            2. Mesozoic ("middle life")
            3. Paleozoic ("ancient life")
    3. Eras are subdivided into periods
    4. Periods are subdivided into epochs
D. Difficulties in dating the time scale
    1. Not all rocks are datable (sedimentary ages are rarely reliable)
    2. Materials are often used to bracket events and arrive at ages

Chapter #12
Earth's History: A Brief Summary
Objectives :

After reading, studying, and discussing Chapter 11, you should be able to:

- List the principal geologic and biologic events for each era of geologic time.

Chapter 12: **Earth's History**

I. Precambrian era
  A. 4.5 billion to 540 million years ago
  B. 88% of Earth's history
  C. Only sketchy knowledge
  D. Most Precambrian rocks are devoid of fossils
  E. Precambrian rocks
    1. Most are buried from view
    2. Each continent has a "core area" of Precambrian rocks called a shield
    3. Extensive iron ore deposits
    4. Absent are fossil fuels
  F. Earth's atmosphere
    1. Primitive atmosphere formed from volcanic gases
      a. A process called outgassing
      b. Water vapor, carbon dioxide, nitrogen, and several trace gases
      c. Very little free oxygen
    2. Water vapor condenses and forms primitive oceans as Earth cools
    3. Bacteria evolve
    4. Plants evolve and photosynthesis produces oxygen
    5. Oxygen content in the atmosphere increases
      6. By about 4 billion years after Earth formed, abundant ocean-dwelling organisms that require oxygen existed
  G. Precambrian fossils
    1. Most common are stromatolites
      a. Material deposited by algae
      b. Common about 2 billion years ago
    2. Microfossils of bacteria and algae have been found in chert
      a. Southern Africa (3.1 billion years of age)
      b. Lake Superior area (1.7 billion years of age)
    3. Plant fossils date from the middle Precambrian
    4. Animal fossils date from the late Precambrian
    5. Diverse and multicelled organisms exist by the close of the Precambrian

II. Paleozoic era
  A. 540 million years ago to about 248 million years ago
  B. First life forms with hard parts
  C. Abundant Paleozoic fossils
  D. Early Paleozoic history
    1. Southern continent of Gondwanaland exists
    2. North America
      a. A barren lowland
      b. Seas move inland and recede several times and shallow marine basins evaporate leaving rock salt and gypsumdeposits
      c. Taconic orogeny, a mountain building event, affects eastern North America

E. Early Paleozoic life
1. Restricted to seas
2. Vertebrates had not yet evolved
3. Life consisted of several invertebrate groups
a. Trilobites
b. Brachiopods
c. Cephalopods
4. First organisms with hard parts, such as shells – perhaps for protection

F. Late Paleozoic history
1. Supercontinent of Pangaea forms
2. Several mountain belts formed during the movements of the continents
3. World's climate becomes very seasonal, causing the dramatic extinction of many species

G. Late Paleozoic life
1. Organisms diversified dramatically
2. Land plants
3. Fishes evolve into two groups of bony fish
a. Lung fish
b. Lobe-finned fish which become the amphibians
4. Insects invade the land
5. Amphibians diversify rapidly
6. Extensive coal swamps develop

III. Mesozoic era

A. 248 million years ago to about 65 million years ago

B. Often called the "age of dinosaurs"

C. Mesozoic history
1. Begins with much of the world's land above sea level
2. Seas invade western North America
3. Breakup of Pangaea begins forming the Atlantic ocean
4. North American plate began to override the Pacific plate
5. Mountains of western North America began forming

D. Mesozoic life
1. Survivors of the great Paleozoic extinction
2. Gymnosperms become the dominant trees
3. Reptiles (first true terrestrial animals) readily adapt to the dry Mesozoic climate
4. Reptiles have shell-covered eggs that can be laid on the land
5. Dinosaurs dominate
6. One group of reptiles led to the birds
7. Many reptile groups, along with many other animal groups, become extinct at the close of the Mesozoic
a. One hypothesis is that a large asteroid or comet struck Earth
b. Another possibility is extensive volcanism

IV. Cenozoic era

A. 65 million years ago to the present

B. Often called the "age of mammals"

C. Smaller fraction of geologic time than either the Paleozoic or the Mesozoic

D. North America
1. Most of the continent was above sea level throughout the Cenozoic era
2. Many events of mountain building, volcanism, and earthquakes in the West
3. Eastern North America
a. Stable with abundant marine sedimentation
b. Eroded Appalachians were raised by isostatic adjustments

4. Western North America
    a. Building of the Rocky Mountains was coming to an end
    b. Large region is uplifted
        1. Basin and Range Province formed
        2. Re-elevates the Rockies
        3. Rivers erode and form gorges (e.g., Grand Canyon and Black Canyon)
    c. Volcanic activity is common
        1. Fissure eruptions form the Columbia Plateau
        2. Volcanoes form from northern California to the Canadian border
    d. Coast Ranges form
    e. Sierra Nevada become faultblock mountains

E. Cenozoic life
1. Mammals replace reptiles as the dominant land animals
2. Angiosperms (flowering plants with covered seeds) dominate the plant world
    a. Strongly influenced the evolution of both birds and mammals
    b. Food source for both birds and mammals
3. Two groups of mammals evolve after the reptilian extinctions at the close of the Mesozoic
    a. Marsupials
    b. Placentals
4. Mammals diversify quite rapidly and some groups become very large
    a. e.g., Hornless rhinoceros, which stood nearly 16 feet high
    b. Many large animals became extinct
5. Humans evolve