I. Factors that determine structural damage
   A. Intensity of the earthquake
      1. Duration of the vibrations
      2. Nature of the material upon which the structure rests
      3. The design of the structure
   B. Destruction from
      1. Ground shaking
      2. Liquefaction of the ground
         a. Saturated material turns fluid
         b. Underground objects may float to surface
      3. Tsunami, or seismic sea waves
      4. Landslides and ground subsidence
      5. Fires: San Francisco, 1906—Jack London's account
         http://london.sonoma.edu/Writings/Journalism/sfearthquake.html
   C. Examples of destructive earthquakes
      1. Alaska 1964
         a. Moment magnitude 9.2, Richter magnitude 8.7
         b. Duration of shaking: 3-4 minutes
         c. Damage
            1) on 'quick-clay' that was subject to liquefaction
            2) from tsunami, especially in Resurrection Bay
      2. New Madrid, Missouri, 1811-1812
         a. Series of earthquakes
            1) 5 of Magnitude 7 to 8
            2) Shaking lasted between 30 seconds and two minutes
            3) As many as 200 greater than 4.3
         b. Subsidence and uplift 3-5 meters widespread
      3. Loma Prieta, 1989
         a. Moment magnitude 7.2
         b. Duration 7 to 15 seconds
         c. Movement about 1.5 meters
         d. Structural collapse
      4. Northridge, 1994
         a. Magnitude 6.9
         b. Duration 10 to 20 seconds
         c. Landslides in surrounding mountains, absence of liquefaction
      5. Kobe, Japan, 1995
         a. Magnitude 6.9 (Mw), 7.2 (Ms)
         b. Duration 20 seconds
         c. Damage from building collapse, gas leaks, lack of water, wood-paper construction with charcoal heating in older parts of city

6. Niigata, Japan 1964
    a. Magnitude 7.5
    b. Liquefaction
        1) tilted buildings as much as 80^{o}
        2) building designed to resist earthquake damage
            a) people climbed out of upper story windows
            b) building jacked up to vertical and rehabitated

II. Earthquake prediction
A. Short-range – no reliable method yet devised for short-range predictions
B. Long-range forecasts
1. Premise is that earthquakes are repetitive
2. Region is given a probability of a quake

III. Earth's layered structure
A. Most of our knowledge of Earth's interior
1. comes from the study of P and S earthquake waves:
2. we've only drilled to about 12 km—0.2% to center
B. Travel times of P and S waves through Earth vary depending on the properties of the materials
1. travel faster at depth—
    a. due to increased pressure enhancing elastic properties of rock
    b. results in curved paths of seismic waves through Earth
2. abrupt velocity changes of waves at particular depths—causes refraction of waves
    a. S waves travel only through solids
    b. allows us to model Earth's interior based on seismic wave behavior

C. Layers defined by composition
1. Crust
    a. Thin, rocky outer layer
    b. Two types. Varies in thickness
        1) Oceanic crust—does not extend below entire continental crust!
            a) Roughly 7 km (5 miles) in oceanic regions
            b) Basaltic composition--relatively homogeneous
            c) Density about 3.0 g/cm^3
            d) Younger (180 million years or less) than the continental crust
        2) Continental crust
            a) Continental crust averages 35-40 km (25 miles)
            b) Exceeds 70 km (40 miles) in some mountainous regions
            c) Upper crust composed of granitic rocks
            d) Lower crust is more like basalt
            e) Average density is about 2.7 g/cm^3

f) Up to 4 billion years old

2. Mantle—over 82% of Earth's volume
    a. Below crust to a depth of 2900 kilometers (1800 miles)
    b. Composition of the uppermost mantle is the igneous rock peridotite (changes at greater depths)
    c. average density 3.3 gm/cm^3
3. Core
    a. Below mantle
    b. A sphere having a radius of 3486 km (2161 miles)
    c. Composed of an iron-nickel alloy
    d. Average density of nearly 11 g/cm^3

D. Layers defined by physical properties
1. Lithosphere
    a. Crust and uppermost mantle (about 100 km thick)
    b. Cool, rigid, solid
    c. Two types: continental and oceanic
2. Asthenosphere
    a. Beneath the lithosphere
    b. Upper mantle
    c. To a depth of about 660 kilometers
    d. Soft, weak layer
    e. Easily deformed
3. Lower mantle
    a. 660-2900 km
    b. More rigid layer
    c. Rocks are very hot and capable of gradual flow
4. Outer core
    a. Liquid layer
    b. 2270 km (1410 miles) thick
    c. Convective flow of metallic iron generates Earth's magnetic field
5. Inner core
    a. Sphere with a radius of 1216 km (754 miles)
    b. Behaves like a solid

E. Discovering Earth's major layers
1. Discovered using changes in seismic wave velocity
2. Mohorovičić discontinuity (Moho)
    a. Velocity of seismic waves increases abruptly below 50 km of depth
    b. Separates crust from underlying mantle
3. Shadow zone
    a. Absence of P waves from about 105 degrees to 140 degrees around the globe from an earthquake
    b. Explained if Earth contained a core composed of materials unlike the overlying mantle