ES 105 Geologic Time
I.   Principles of relative dating
     a. Original horizontality
     b. Lateral continuity
     c. Superposition: NOTE only applies to sedimentary rocks, intrusions could come up from below!!
     d. Inclusion
     e. Crosscutting relationships
          i. Intrusions
          ii. Faults
          iii. Unconformities
               1. •An unconformity is a break in the rock record
               2. •Types of unconformities
                    a. •Angular unconformity –
                         i. tilted rocks are overlain by flat-lying rocks
                         ii. tilting event, erosion, deposition
                    b. •Nonconformity –look for inclusions!!
                         i. •Metamorphic or igneous rocks below
                         ii. •Younger sedimentary rocks above
                    c. •Disconformity – hardest to recognize
                         i. strata on either side are parallel
                         ii. lack of sedimentation, or actually erosion
     f. Faunal succession

II. Fossils—evidence of past life
     a. Types of fossilization
          i. petrified—
          ii. formed by replacement—microscopic details may be preserved
          iii. mold—
               1. perfected when original material dissolves
               2. only shows shape and surface markings
          iv. cast—space in mold filled with mineral material
          v. carbonization—
          vi. Impression when carbon is lost
          vii. Preservation in amber—
          viii. Trace evidence includes
               1. Tracks—footprints in soft sediment: Tuba City AZ
               2. Burrows—worms, mammals, some clams
               3. Coprolites—dung, stomach contents Gastroliths—gizzard or stomach stones
     b. Preservation of evidence of past life actually not common
          i. Rapid burial of the organism, or its trace
          ii. Possession of hard parts—soft parts very uncommon fossils

III. Fossils and correlation
  a. Principle of faunal succession
      i. fossils in beds of differing ages have distinctly different fossils, and the order of occurrence is definite and determinable
          1. William Smith: canals in England in the late 1700s
          2. Beds in widely separated areas could be predicted by noting the fossils in beds above compared to the same fossils in another area
      ii. Fossils organisms succeed one another in a definite and determinable order, and therefore any time period can be recognized by this fossil content
          1. Age of trilobites, age of fishes, age of reptiles, age of mammals
          2. Recognition of fossils as time indicators became a very useful means of correlation of rock units

IV. Geologic Time Scale
  a. Subdivides 4.5 billion years (4500 million years)
  b. Eons based on large changes in the fossil record
      i. Hadean—hidden life
      ii. Archean—primitive life: cyanobacteria is a plant-like single-celled organism
      iii. Proterozoic—early multi-cellular organisms without hard parts
      iv. Phanerozoic—life that can be seen: beginning of hard parts
  c. The first three Eons are collectively known as the preCambrian (Cambrian is the first Period of the first Era of the Phanerozoic Eon)

d. Eras—divisions of the Phanerozoic
   i. Paleozoic—Ancient Life: nearly all major groups of life (phyla) evolve in this era
      1. Arthropods—dominant early
      2. fishes—significant in the middle
      3. land plants
      4. insects
      5. amphibians—abundant later
      6. reptiles
      7. mammals—only minor presence
      8. Paleozoic ended with the greatest mass extinction in geologic record
         a. 90+% of marine species die out, 70% of terrestrial vertebrates
         b. Fungus dominant life form on land
   ii. Mesozoic Era—Middle Life: reptiles rise to prominence
      1. Dinosaurs rule Earth
      2. Birds evolve from dinosaurs
      3. mammals evolve
      4. Flowering plants appear
      5. Ends with another great extinction—50% of all genera, including non-avian dinosaurs
   iii. Cenozoic Era—Recent Life: rise of mammals
   iv. Each Era is divided into Periods, distinguished by less-pronounced changes in life
      1. Periods divided into Epochs—each of which may be several million years long
      2. Periods are tens to hundreds of millions of years long
      3. Eras may be several hundred million years
      4. Eons hundreds to thousands of millions of years
e. Actual numeric dates of the subdivisions of the geologic time scale determined by radiometric age dating of igneous rocks
   i. Ash layers within sedimentary sequence
   ii. Crosscutting relationships of intrusive rocks
   iii. Thousands of instances give consistent results of age
   iv. Methods such as these have allowed precise correlation of rock units in the Colorado Plateau area