- I. Minerals: the building blocks of rocks
 - A. Definition of mineral
 - 1.Naturally occurring
 - 2.Inorganic
 - 3.Solid
 - 4. Possess an orderly internal structure of atoms
 - 5. Have a definite chemical composition
 - B. Rocks are aggregates (mixtures) of minerals or mineral-like material—coal is a rock
- II. Composition and structure of minerals
 - A. Elements
 - 1.Basic building blocks of minerals
 - 2.More than 100 are known
 - 3.eight most common elements in Earth's crust: oxygen, silicon, aluminum, iron, calcium, sodium, potassium, magnesium
 - B. Atoms
 - 1.Smallest particles of matter
 - 2. Have all the characteristics of an element
- III. Structure of atoms
 - A. Nucleus contains
 - 1.Protons—positive electrical charge
 - 2.Neutrons —electrically neutral
 - B. Energy levels, or shells of electrons
 - 1. Surround nucleus
 - 2.negative electrical charge
 - C. Atomic number, the number of protons in an atom's nucleus, identifies element
 - D. Bonding of atoms
 - 1.Compounds are formed from two or more elements
 - 2. Ions are atoms that have gained or lost electrons
 - E. Isotopes
 - 1. Vary in the number of neutrons—same number of protons
 - 2. Have different mass numbers—the sum of the neutrons plus protons
 - 3.Radioactive isotopes
 - a. Unstable
 - b. emit energy and particles

- IV. Minerals
 - A. Properties of minerals
 - 1.Crystal form—growth surfaces, external expression of internal arrangement
 - 2.Luster-reflection of light: ALL minerals have a luster!
 - 3.Color—may be created by minor impurities
 - 4.Streak—more diagnostic in identifcation
 - 5.Hardness—resistance to scratching, may be affected by alteration
 - 6.Cleavage—parallel planes of breakage, determined by strength of internal bonds, there may be intersecting sets in some minerals
 - 7. Fracture—description of breakage when there is no cleavage
 - 8.Specific gravity-comparison to an equal volume of water, heft
 - 9. Other properties
 - a. Taste
 - b. Smell
 - c. Elasticity
 - d. Malleability
 - e. Feel
 - f. Magnetism
 - g. Double refraction
 - h. Reaction to hydrochloric acid
 - B. About 25 minerals are called the *rock-forming minerals*
 - 1.Feldspars, quartz, micas, pyroxenes, amphiboles, olivine, calcite, gypsum, dolomite, iron oxides, pyrite, garnet
 - The eight elements that compose most rock-forming minerals are oxygen (O), silicon (Si), aluminum (Al), iron (Fe), calcium (Ca), sodium (Na), potassium (K), and magnesium (Mg)
 - 3. The most abundant atoms in Earth's crust are
 - a. Oxygen (46.6% by weight)
 - b. Silicon (27.7% by weight)
 - C. Mineral groups
 - 1.Silicates
 - a. Most common mineral group: because O & Si most common
 - b. Contain the silicon–oxygen tetrahedron
 - 1) Four oxygens surrounding a much smaller silicon atom
 - 2) The silica tetrahedra join together in a variety of ways
 - a) Framework
 - b) Sheet
 - c) Chains: single chains and double chains
 - c. Feldspars are the most plentiful group: framework silicate
 - d. Most silicate minerals crystallize from magma as it cools

- 2.Non-silicate minerals
 - a. Major groups
 - 1) Oxides
 - 2) Sulfides
 - 3) Sulfates
 - 4) Halides
 - 5) Carbonates
 - 6) "Native" elements
 - b. Carbonates
 - 1) Major rock-forming group
 - 2) Found in limestone and marble
 - c. Halite and gypsum—found in sedimentary rocks
 - d. Many have economic value
- V. The rock cycle
 - A. Inter-relationship of parts of Earth system
 - 1. Three types
 - a. Igneous—crystallized from magma
 - b. Sedimentary—deposited by deposition or precipitation
 - c. Metamorphic—changed in the solid state
 - 2. cycle discussion can start at any position
 - a. usually at the molten magma
 - 1) magma mostly Si, O
 - 2) minor amounts of AI, Fe, Ca, Na, K, Mg
 - b. crystallizes to form silicate minerals: igneous rocks
 - 1) intrusive—cooling slowly below surface=coarse grained
 - 2) extrusive—cooling quickly at or near surface=fine grained
 - c. exposure at surface results in weathering
 - 1) breaks down minerals chemically and physically
 - a) different temperature and pressure than formed
 - b) action of water, a universal solvent
 - 2) becomes sediment that is deposited
 - d. sediment is lithified by compression and cementation
 - e. addition of heat and pressure can cause atoms to reform into different minerals, or different grain sizes,
 - 1) without melting
 - 2) metamorphism, metamorphic rock is formed
 - f. other paths exist across the 'cycle'
 - 1) igneous or metamorphic rocks can be metamorphosed
 - 2) sedimentary or metamorphic rocks can be weathered
 - 3) if there is melting, the only route is magma \rightarrow igneous

- II. Sedimentary rocks
 - A. Formed of particles transported by, or crystallization from, water
 - 1. two major classification: detrital (or clastic), and chemical
 - 2. detrital sedimentary rocks from particles of pre-existing rocks
 - a. classified by particle size
 - 1) gravel—conglomerate or breccia
 - 2) sand—sandstone
 - 3) mud—shale or siltstone
 - b. range of size of particles implies environment of formation
 - 3. chemical sedimentary rocks
 - a. limestone composed of calcite
 - 1) calcite often precipitated by organisms as shell or 'test'
 - some directly from concentrated solution—especially in caves or from hot springs
 - b. silica can form from solution in deep sea, and in hot springs
 - c. evaporation of surface water leads to 'evaporite' deposits
 - 1) halite most common—Na, CI in high in sea water
 - 2) gypsum also from sea-water: Ca, SO₄
 - 4. third 'oddball' classification is "organic"
 - a. coal is organic sedimentary rock
 - b. some limestones may be classified here too
 - 5. sedimentary rocks can preserve Earth-surface features
 - a. evidence of past life on Earth—fossils
 - b. on deposition surface showing environment of formation
 - 1) desiccation cracks
 - 2) ripple marks
- III. Metamorphic rocks
 - A. Change in the solid state by heat and pressure
 - 1. change of grain size or shape
 - 2. rearrangement of atoms into different minerals
 - 3. parent rock, and various amounts of heat and amounts of pressure result in wide variety of metamorphic rocks
 - a. slate, schist, gneiss
 - b. quartzite, marble

B. high pressure, temperature allows rock to flow from directed stress IV. Tectonic setting of rocks

- A. Convergent plate boundaries create directed pressure and intermediate and felsic magma
 - 1. metamorphic rocks grades depend on depth/lateral position
 - 2. andesite volcanic rocks and granite intrusive rocks
- B. divergent plate boundaries create basalt, gabbro, ultramafic rocks
- C. where continental-to-oceanic lithosphere is not on an active plate boundary, there is a great amount of time to deposit sediment over wide areas of continental shelf