105 Chapter 9 Review Notes

- **Meteorites** are pieces of extraterrestrial (from beyond Earth) material that fall to Earth from outer space and survive as solid materials that reach Earth's surface
    - **Meteoroids** are small bits of material in space
    - **Meteors** are the streaks of light produced as meteoroids streak through Earth's atmosphere heating their surfaces and the surrounding air to white-hot due to the friction produced by the atmospheric drag on the decelerating projectile
        - Most meteors are produced by dust to sand grain-sized meteoroids that vaporize completely in Earth's upper atmosphere
- If a meteorite is collected upon having been seen (or felt!) falling to Earth, it is called a meteorite **fall** (rare)
- All other meteorites collected without their arrival having been witnessed (and recorded) by humans are known as meteorite **finds** (more common)
- Meteorites range in size from submicroscopic dust up to large boulders (Hoba, the largest known, has a mass of 55 metric tons!)
- Known sources of meteorites include:
    - Asteroids (most common)
    - Comets (primarily for dust-sized particles)
    - The Moon
    - Mars
- Meteorites can be broadly divided into 3 main groups:
    - Stony – primarily silicate minerals (often in spheroidal "chondrules") with tiny bits of iron metal; may also include carbon compounds and hydrated (water-containing) minerals
    - Irons – crystalline metallic iron with small amounts of nickel
    - Stony Irons – combination of silicate minerals in an iron metal matrix
- Irons are most easily found (they're really heavy and easily detectable with metal detectors), but not nearly as common overall. Percentages for all meteorites (estimated from collection in Antarctica and from observed falls):
    - Stony – 93-94%
    - Iron – 5%
    - Stony Iron – 1%
- Fall age for a meteorite (how long it's been on Earth) can be estimated by looking for radioactive decay of short-lived isotopes from on surface of meteoroids in space (cosmic ray-induced)
- Best places to find meteorites are places where dark (typical **fusion crust** color) rocks would really stand out, as in areas covered by light sand or snow/ice (e.g., the Sahara Desert, and Antarctica)
- Observed fall meteor paths recorded on video have been used to calculate orbits, tracing the meteorites' orbits back to the asteroid belt
- To date, at least 4 people (and 1 dog) have been recorded to be hit by falling meteorites, as well as a Chevy Malibu!
- Micrometeorites are common in terrestrial dust and deep sea sediments (we each probably get "hit" by them at least weekly)

- The ages of minerals in meteorites (except for those few meteorites that originated on Mars or the Moon) are all greater than about 4.55 Ga, but range in age over a period of about 13 Ma, from about 4.57 Ga to slightly less than 4.56 Ga.
- The most primitive materials in meteorites are the refractory CAIs (Calcium-Aluminum-rich Inclusions), which formed at the earliest times in the nebula and survived the reheating during the early stages of the Sun's T-Tauri phase. These have ages of about 4.57 Ga.
- Chondrules formed over the next few million years from recondensed nebular dust (after initially remelting from T-Tauri heating), followed by more differentiated materials (like igneous mineral grains in achondrites and segregated metals in irons and stony irons)
- A few meteorites appear (based on ages and Oxygen isotope info) to have originated on the Moon and Mars. These are primarily basaltic in composition, with brecciated samples being common as samples ejected from the lunar surface (fragments of impact crater ejecta that got compacted into a rock). Anorthosistic fragments (an intrusive igneous rock that forms the brighter highland areas of the moon) are also common in lunar meteorites.
- One Mars meteorite, ALH84001, contains microscopic mineral grain arrangements that are similar (both in shape and mineral composition) to structures produced by very primitive bacteria on Earth. However, the grains are smaller than typical Earth bacteria and could have been produced by non-biological processes.
- Primitive terrestrial bacteria, known as *Archaea*, have been found in a variety of different extreme environments on Earth, including:
    - Extremely salty water (halophiles)
    - Extremely acidic water (pH between 0 and 1) – (acidophiles)
    - Extremely hot water (up to 120° C!) – (hyperthermophiles)
    - Wet fractures in rocks several kilometers beneath the ground
- These types of conditions are thought to be similar to those that prevailed in the early history of the Earth, and may currently exist beneath the surface of Mars (or on the bottom of any ocean existing beneath an icy shell – e.g., Europa)
- It may have been *only* these types of bacteria that were able to survive the waning stages of the *heavy bombardment* that effectively obliterated the surface of all the terrestrial planets over and over again during the first 600 Ma or so of the solar system's history.