Importance of Solar System Objects discussed thus far

- **Sun**: Major source of heat for the surfaces of planets
- **Asteroids**: Provide possible insight to the composition of the inner early solar system
- **Comets**: Provide possible insight to the composition of the outer early solar system
- **Moon**: Provides insight to the early accretion phase of the solar system
The Terrestrial Planets

Mercury

Venus

Earth

Mars
<table>
<thead>
<tr>
<th></th>
<th>Radius (R\text{Earth})</th>
<th>Mass (M\text{Earth})</th>
<th>Avg Density (g/cm³)</th>
<th>Surface Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>0.38</td>
<td>0.055</td>
<td>5.43</td>
<td>0.38</td>
</tr>
<tr>
<td>Venus</td>
<td>0.949</td>
<td>0.815</td>
<td>5.25</td>
<td>0.91</td>
</tr>
<tr>
<td>Earth</td>
<td>1.00</td>
<td>1.00</td>
<td>5.52</td>
<td>1.00</td>
</tr>
<tr>
<td>Mars</td>
<td>0.533</td>
<td>0.107</td>
<td>3.93</td>
<td>0.38</td>
</tr>
<tr>
<td>Sun</td>
<td>1.09</td>
<td>333,000</td>
<td>1.41</td>
<td>27.5</td>
</tr>
</tbody>
</table>

Distance from Sun (AU):  
- Mercury: 0.38
- Venus: 0.72
- Earth: 1.00
- Mars: 1.52
- Sun: —

Orbital Period (years):  
- Mercury: 0.24
- Venus: 0.61
- Earth: 1.00
- Mars: 1.88
- Sun: —

Rotation Period (days):  
- Mercury: 58.6
- Venus: 243
- Earth: 0.00
- Mars: 1.026
- Sun: 25.4

\[R_{\text{Earth}} = 6,378 \text{ km} \quad M_{\text{Earth}} = 5.97 \times 10^{24} \text{ kg}\]
\[g_{\text{Earth}} = 9.8 \text{ m/s}^2\]
The Interior Structure/Composition of the Terrestrial Planets

- **Core**: center of planet composed of dense metals (iron, nickel)
- **Mantle**: Layer above the core composed of silicates (i.e., oxides comprised of silicon, aluminum, magnesium)
- **Crust**: Low density, light silicates
Rock Strength

- **Lithosphere**: outer layer of rigid rock
- solid rock below the lithosphere is at higher temperatures, and thus deforms & flows more easily
- Thus, the lithosphere “floats” on the soft rock below
- The thickness of the lithosphere is dependent on temperature
  → The higher the temperature, the softer the rock
  → More massive planets have thinner lithospheres
Cores & Mantles

• The relative Core/Mantle sizes depend on the planet’s composition
  → Composition of Solar Nebula
  → Composition of Impactors

• Cores may be molten: Dependent on internal temperature & pressure
Figure 9.6 Interior structure of the terrestrial worlds, in order of size
How do we know about the inner structure of planets?

- **Average density** determinations (discussed previously)
- **Local gravity variations** as measured with artificial satellites
- **Magnetic fields**: molten core/convection
- **Lava flow**: internal composition
- **Earthquakes**: internal structure
Internal vs. External Heat

- The Earth receives ~ 1000 W / m² from the Sun

\[
\frac{\text{Energy} \times \text{Time}}{\text{Area}} \sim \frac{1}{R^2}
\]

- Distance between Sun & planet

- About 0.05 W / m² leaks from the center of the Earth
Planetary Cores & Magnetic Fields

- **Magnetic Fields** are generated in some planets via the motion of molten material
  - → Convection
  - → Planetary rotation

- Mercury: yes (molten rock)
- Venus: no
- Earth: yes (molten rock, cooled off)
- Mars: no

Why? molten rock cooled off
Three principle interior energy sources

• **Accretion**: (discussed earlier) kinetic energy from impactor → heat

• **Differentiation**: (discussed earlier) gravitational potential energy → heat

• **Radioactivity**: radioactive decay of uranium, potassium, etc.

  → resultant kinetic energy of decay product creates heat through collisions with neighboring particles

• **Tidal Heating**: (discussed later) Not important for terrestrial planets
How do the interior regions cool off?

- **Conduction**: heat transfer via the macroscopic jiggling of molecules *(important in the lithosphere)*

- **Convection**: hot materials expands & rises, cool material contracts & falls

- **Eruption**: transfer of heat to the surface by depositing lava on the surface
The cooling of the interior regions of Terrestrial Planets

- The lithosphere thus gets thicker with time (as the planets cool).
- Cooling time is dependent on the size of the planet.
Shaping Planetary Surfaces

- **Impact Cratering**: the excavation of bowl-shaped depressions by asteroids or comets striking the planet’s surface

- **Volcanism**: the eruption of molten rock, or lava, from a planet’s interior onto its surface
  
  → Magma rises because it is light weight, or through tectonic stresses
  
  → Volcanism is occurring on all terrestrial planets & some of the outer solar system satellites
Shaping Planet’s Surfaces (cont)

- **Tectonics**: the disruption of a planet’s surface by internal stresses
  - stress of convective currents
  - stress from temperature changes due to radioactive decay
  - stress from compression of lithosphere as the planet cools
Shaping Planet’s Surfaces (cont)

• **Erosion**: the wearing down or building up of a planet’s geological feature by wind, water, ice, etc…
  → The thicker the atmosphere the greater the erosion
  → The faster the planet rotates under its atmosphere, the greater the erosion