Earth, the Lively* Planet

* not counting the life on the planet!
What We Will Learn Today

- What are planet Earth’s features?
- What processes shape planetary surfaces?
- How does Earth’s surface move?
- How did the continents form?
- How is Earth’s geology unique in the solar system?
## Planet Earth Details

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-major axis</td>
<td>149.6 million km (1.00 AU)</td>
</tr>
<tr>
<td>Size (radius)</td>
<td>6,378 km (1.00 (R_{\text{Earth}}))</td>
</tr>
<tr>
<td>Mass</td>
<td>(5.97 \times 10^{24}) kg (1.00 (M_{\text{Earth}}))</td>
</tr>
<tr>
<td>Average density</td>
<td>5.52 g/cc</td>
</tr>
<tr>
<td>Composition</td>
<td>Rocks, metals</td>
</tr>
<tr>
<td>Average surface temperature</td>
<td>290 K</td>
</tr>
<tr>
<td>Moons</td>
<td>1</td>
</tr>
<tr>
<td>Orbital period</td>
<td>365.242 days (tropical)</td>
</tr>
<tr>
<td>Rotation period (sidereal)</td>
<td>23h, 56m (sidereal)</td>
</tr>
<tr>
<td>Axis tilt</td>
<td>23.5°</td>
</tr>
<tr>
<td>Orbital inclination</td>
<td>0.00°</td>
</tr>
<tr>
<td>Orbital eccentricity</td>
<td>0.007</td>
</tr>
</tbody>
</table>

Largest terrestrial: Liquid water on surface! Densest in Solar System Largest moon/planet size Fastest terrestrial
Shaping Planetary Surfaces

• Mostly flat
  – Tallest mountains are like grains on sand on a typical globe

• Shaped by
  – Impacts
  – Volcanism
  – Tectonics
  – Erosion

• All four are significant on Earth
Impacting Meteorites

- Remember, speed of Earth around the Sun is 30 km/s (over 65,000 mph!)
- Typical rocks (asteroids) have similar speeds
- Collisions at these speeds are very eventful
  - Typical impact speeds are 10 – 70 km/s!
  - Obliterate the impacter
  - Leave scar marks on Earth
  - Could wipe out all humans!
- A planetary scar
  - Size of crater ~ 10 times impacter
  - Depth of crater ~ 10 – 20% size
- Meteoroid
  - Piece of rock floating in space
- Meteor
  - Visible event when rock enters atmosphere
- Meteorite
  - Piece of space-rock on Earth’s surface
Past Impacts on Earth

Meteor Crater (AZ)
- Created 50,000 years ago
- Asteroid was about 50 m across
- Crater is over 1 km wide
- About 200 m deep

Manicouagan Crater (Canada)
- Created 200 million years ago
- “Crater” is over 70 km wide
- Mostly eroded away
- Picture taken from Shuttle Colombia
Volcanism

- Molten rock in upper mantle finds its way to the surface
- Thin, cracked lithosphere helps
- Only small pockets of the mantle are molten (magma)
  - Less dense than solid rock
  - Squeezed out walls of chamber
  - Trapped gases help rise & explosion

- Types of volcanic features
  - Volcanic plains
    - Runniest lava, flattens out
  - Shield volcanoes
    - Thicker lava
    - Tall mountains, but not steep (Hawaii)
  - Stratovolcanoes
    - Thickest lava – tall, steep mountains (Fuji, Rainier)
    - Unique to Earth

Mount Fuji
Mount Rainier
Tectonics

- Mantle convection driven
  - Compression features
  - Spreading cracks & valleys
- New mountain bends & cracks lithosphere
- Rising plume bulges lithosphere
- Fracture of lithosphere into distinct plates (Plate tectonics)
- Unique to Earth
Plate Tectonics

- Continental plates
  - Fractured pieces of the lithosphere
  - Move few cm per year

![Map of Plate Tectonics](image)
Continental Motion

- South America and Africa fit like puzzle pieces
- Similar rocks and fossils found in eastern South America and western Africa
- Mid Atlantic Ridge is moving Europe and Americas farther apart
- Two types of crust
  - Seafloor crust: Thinner, denser (basalt), younger (200 million years old)
  - Continental crust: Thicker, less dense (granite), older (up to 4 billion years old)
Shaping of Earth’s Surface

- Seafloor recycling
  - Mid Atlantic Ridge covers up 2 km$^2$ every year
  - Will recycle entire ocean floor in 200 million years
  - Eventually bumps into continental plate and goes below it: *subduction zone*
  - Returns crust material into the mantle at deep ocean trenches
  - Leads to stratovolcanoes unique to Earth
Volcanoes & Earthquakes

- Rifts: Plates moving apart
- Faults: Plates sliding sideways
  - Sliding plates move in jerks
    - Stress builds up over time
    - When friction gives up to building stresses, an earthquake occurs
  - In 20 million years, LA and SFO will be together

- Hot Spots
  - Plume of hot mantle erupt periodically to create a chain of islands (Hawaii)
  - Islands form, move with the plate, erode over time
The Ever-Changing Landscape

- 2 cm per year = 2,000 km in 100 million years
- Had a single continent 200 million years ago
  - Pangaea
- Over billions of years drastic changes occur
  - Studies based on magnetized rocks and fossils
  - Central Africa was once at the South pole
  - Antarctica was once at the equator

Fig 9.45
Erosion

Driven by wind & water
- Breaks down mountains
- Builds river deltas, sedimentary rocks, sand dunes
Key Drivers of a Planet’s Geology

The Role of Planetary Size

Small Terrestrial Planets
- Interior cools rapidly.
- Surface is too hot for rain, snow, or ice, so little erosion occurs.
- High atmospheric temperature allows gas to escape more easily.

Large Terrestrial Planets
- Warm interior causes mantle convection leading to ongoing tectonic and volcanic activity; most ancient craters have been erased.
- Orogeny produces an atmosphere and strong gravity fields it so that erosion is possible.
- Core may be molten, producing a magnetic field if rotation is fast enough.

The Role of Distance from the Sun

Planets Close to the Sun
- Surface is too hot for rain, snow, or ice, so little erosion occurs.

Planets at Intermediate Distances from the Sun
- Moderate surface temperatures can allow for water, rain, snow, and ice, leading to substantial erosion.
- Gravity can more easily hold atmospheric gases.

Planets Far from the Sun
- Lower surface temperatures can allow for ice and snow, but no rain or clouds, leading to erosion.
- Atmosphere may exist, but gases can more easily condense to make surface ice.

The Role of Planetary Rotation

Slow Rotation
- Less wind and weather means less erosion, even with a substantial atmosphere.

Rapid Rotation
- More wind and weather means more erosion.
- Rapid rotation is necessary for a global magnetic field.
Unique Features of Earth’s Geology

• Largest terrestrial planet
• Densest planet in the Solar System
• Liquid water on surface
• Plate tectonics
  – Earthquakes
  – Continental drift
• Stratovolcanoes: steep high mountains
• Constant erosion
  – Youngest surface among terrestrial planets