

Guiding Questions

- 1. Is the Moon completely covered with craters?
- 2. Has there been any exploration of the Moon since the *Apollo* program in the 1970s?
- 3. Does the Moon's interior have a similar structure to the interior of the Earth?
- 4. How do Moon rocks compare to rocks found on the Earth?
- 5. How did the Moon form?

table 10-1 | Moon Data

Distance from Earth (center to center):

Eccentricity of orbit: Average orbital speed: Sidereal period (relative to fixed stars): Synodic period (new moon to new moon): Inclination of lunar equator to orbit: Inclination of orbit to ecliptic: Diameter (equatorial):

Mass:

Average density: Escape speed: Surface gravity (Earth = 1): Albedo: Average surface temperatures:

Atmosphere:

Average: 384,400 km = 238,900 mi Maximum (apogee): 405,500 km Minimum (perigee): 363,300 km 0.0549 3680 km/h 27.322 days 29.531 days 6.68° 5.15° 3476 km = 2160 mi = 0.272 Earth diameter

 $\begin{array}{l} \textbf{7.349} \times \textbf{10}^{22} \text{ kg} \\ = \textbf{0.0123} \text{ Earth mass} \end{array}$

3344 kg/m³ 2.4 km/s

0.17

0.11

Day: $130^{\circ}C = 266^{\circ}F = 403 \text{ K}$ Night: $-180^{\circ}C = -292^{\circ}F = 93 \text{ K}$ Essentially none



The Moon's Orbit

This Picture Distorts the Earth-Moon Distance

- The Moon and Earth both orbit around a point between their centers called the center of mass of the Earth-Moon system
- The center of mass then follows an elliptical orbit around the Sun



An Everyday Example of Center of Mass Motion



Motion of the Earth-Moon Center of Mass



Moon

<u>Major Regions</u>	<u>Appearance</u>	Process Formed
Highlands	Bright	meteor impact
Age? old	Heavily cratered	
Mare Basins	Dark	asteroid impact
Age? young		lava flows

See transparency of lunar surface.

The Moon's airless, dry surface is covered with plains and craters



- The Earth-facing side of the Moon displays light-colored, heavily cratered highlands and dark-colored, smooth-surfaced maria
- The Moon's far side has almost no maria

Another View of the Moon



The Moon's Surface – Close up



- Virtually all lunar craters were caused by space debris striking the surface
- There is no evidence of plate tectonic activity on the Moon

The maria formed after the surrounding light-colored terrain, so they have not been exposed to meteoritic bombardment for as long and have fewer craters



Human exploration of the lunar surface







Much of our knowledge about the Moon has come from human exploration in the 1960s and early 1970s and from more recent observations by unmanned spacecraft

The Lunar Surface Provides Clues about its Structure and Formation





Meteoroid impacts have been the only significant erosion agent on the Moon

The Moon's regolith, or surface layer of powdered and fractured rock, was formed by meteoritic action

All of the lunar rock samples are igneous rocks formed largely of minerals found in terrestrial rocks





- The lunar rocks contain no water
- They differ from terrestrial rocks in being relatively enriched in the refractory elements and depleted in the volatile elements





Highlands anorthosite

Impact breccia

Lunar rocks reveal a geologic history quite unlike that of Earth

- The anorthositic crust exposed in the highlands was formed between 4.0 and 4.3 billion years ago
- The mare basalts solidified between 3.1 and 3.8 billion years ago
- The Moon's surface has undergone very little change over the past 3 billion years



The Moon has no global magnetic field but has a small core beneath a thick mantle



The Formation of the Moon

- The collisional-ejection theory
 - Successfully explains most properties of the Moon
 - Hypothesizes that the proto-Earth was struck by a Mars-sized protoplanet and that debris from this collision coalesced to form the Moon
- The Moon was molten in its early stages, and the anorthositic crust solidified from low-density magma that floated to the lunar surface
- The mare basins were created later by the impact of planetesimals and filled with lava from the lunar interior
- Other alternate theories that fail in areas
 - Co-creation (sister), fission, capture

Origin of the Moon See P. VII - 6

1. Fission Theory - Moon split off from spinning Earth.



Prediction: chemical composition of Moon, same as Earth or different?

Do Apollo results favor this theory?



Prediction: chemical composition of Moon, same as Earth or different?

Do Apollo results favor this theory?



4. Large impact theory..

1. Impact of large Mars-sized object ejects huge amount of material which forms Moon.

2. Impact heated materials & drove off volatiles like water.

3. Material later condensed to form the Moon.

Prediction: chemical composition of Moon, same as Earth or different?

Do Apollo results favor this theory?

Most widely accepted theory.



Tidal interactions between the Earth and Moon are slowing the Earth's rotation and causing the Moon to move away from the Earth



1. The Moon's tidal forces elongate Earth's oceans along an Earth-Moon line. 2. Friction between the spinning Earth and its oceans drags the tidal bulge about 10° ahead of alignment with the moon.

Moon

10°

3. Friction between Earth and its oceans also makes the Earth rotate more slowly, increasing the length of the day. 4. The tidal bulge on the side nearest the Moon exerts a small forward force on the Moon, making it spiral slowly away from Earth. Lunar Colonies: Why would it be difficult to live on the Moon?

1. No atmosphere

Large temperature variation:

Daytime: $T = 100 \circ C$ boiling pt. of H_2O

Night time: $T = -173^{\circ} C$

Cosmic rays hit surface. Must live 11 ft below ground.

2. No water (maybe)

3. Gravity 6 x weaker than Earth. Bones lose calcium.

Why it is better to live on Moon?

1. No Moonquakes

2. Gravity weaker - easier to build large structures. (Although need to protect from meteors.)

3. No atmosphere. Better for astronomers.

4. No radio or TV stations. Better for radio astronomers.



2. Lunar soil can be used for shielding space colony.

3. No atmosphere better for telescopes.

Key Words

- anorthosite
- capture theory
- center of mass
- co-creation theory
- collisional ejection theory crater
- far side (of the Moon)
- fission theory
- impact breccia
- impact crater
- libration

- lunar highlands
- mare (plural maria)
- mare basalt
- moonquake
- refractory element
- regolith
- synchronous rotation
- terminator
- terrae
- volatile element