

# Our Barren Moon

## Chapter Ten



# Introduction To Modern Astronomy I: Solar System

Introducing Astronomy  
(chap. 1-6)

Planets and Moons  
(chap. 7-15)

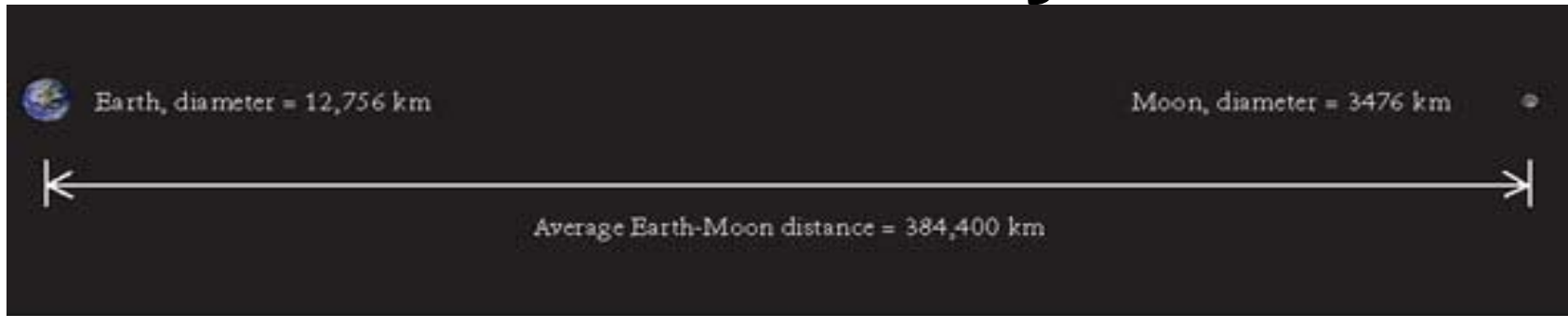
Chap. 16:  
Chap. 28:

Ch7: Comparative Planetology I  
Ch8: Comparative Planetology II  
Ch9: The Living Earth

**Ch10: Our Barren Moon**

Ch11: Earthlike Planets  
Ch12: Jupiter and Saturn  
Ch13: Satellites of Jupiter & Saturn  
Ch14: Uranus, Neptune and Beyond  
Ch15: Vagabonds of Solar System

# Earth-Moon System



(a) The Earth-Moon system

- Diameter: 3476 km, or 27% of Earth
- Mass: 1.23% of Earth Mass
- Density: 3344 kg/m<sup>3</sup>
- Average distance: 384,400 km, or ~ 30 Earth diameter
  - Round-trip of light: 2.6 sec
  - Spacecraft at 10 km/s: 10 hours
  - Car at 60 mi/hr: 167 days
- Elliptical orbit: eccentricity 0.05
- Inclination of orbit to ecliptic: 5°
- Inclination of lunar equator to orbit: 7°

# Earth-Moon System

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- **Liberation:**
  - The **synchronous rotation** of Moon is not perfect.
  - It wobbles slightly, rocking back and forth around its north-south axis and nodding up and down in a north-south direction.
  - The liberation permits us to view 59% of the Moon's surface
  - The liberation is caused by the Moon's non-circular orbit and the inclination angle
- Earth and Moon both orbit around a point between their centers called the **center of mass**
  - The center of mass is very close to the Earth's center

# Moon's Atmosphere

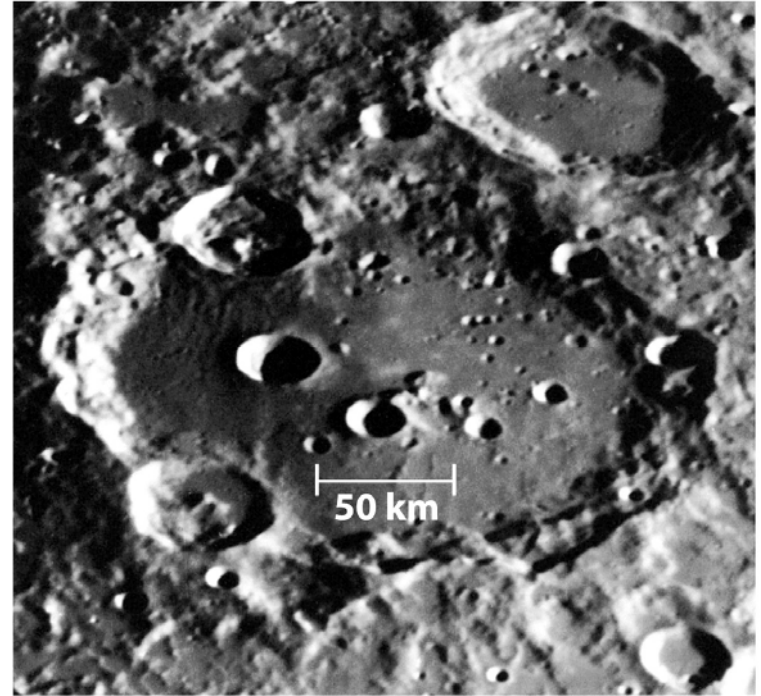
- None
  - The gravity is too weak to retain any atmosphere



(b) The Earth and Moon to scale, shown 10 times larger than in part (a)

# Moon's Surface

- Extremely old surface
  - Covered with numerous **craters**, e.g, 30,000 craters larger than 1 km/s
  - These are impact craters.
  - no plate tectonic activity on the Moon
    - Moon is too small to retain internal heat
    - The entire crust is a single plate



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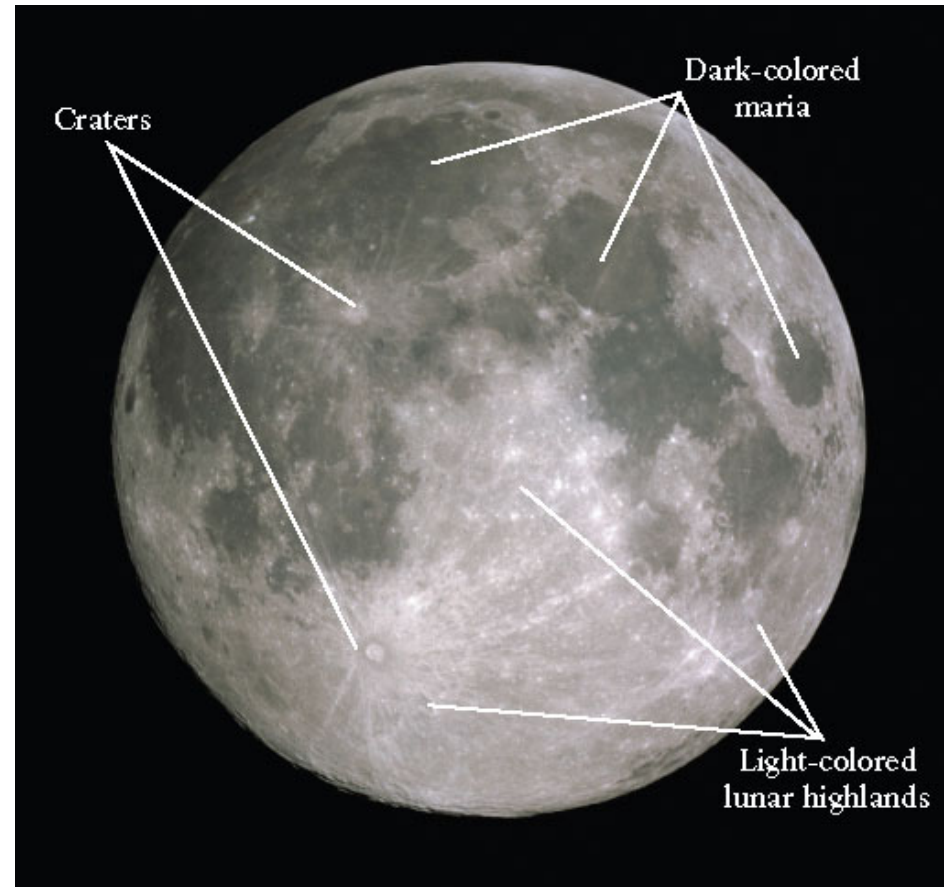
# Moon's Surface

## 1. Maria (mean “sea”)

- the dark area
- low-lying plains
- 15% of surface

## 2. Highlands

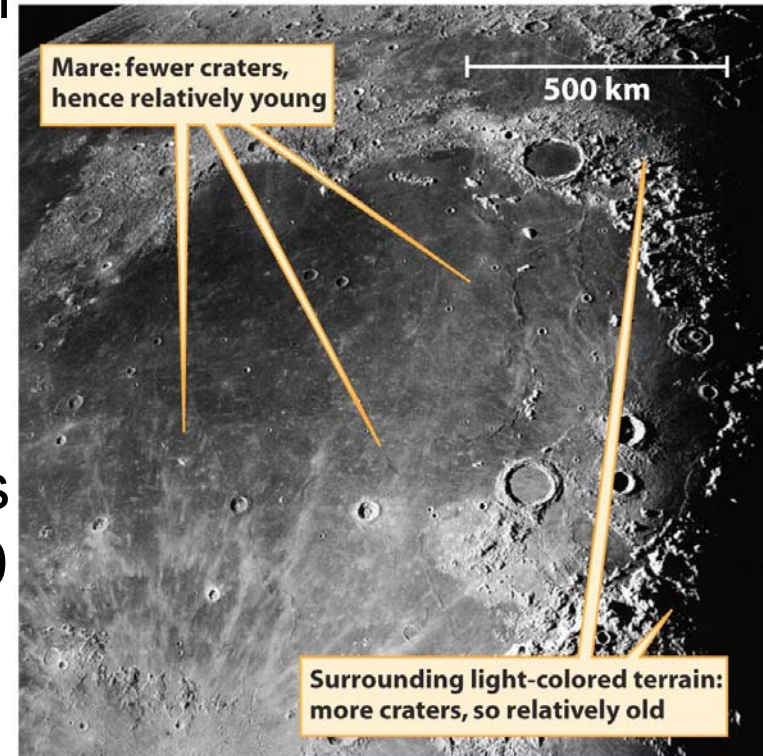
- the light-colored area
- highlands on the Moon
- 85% of surface



# Moon's Surface

- **Maria**

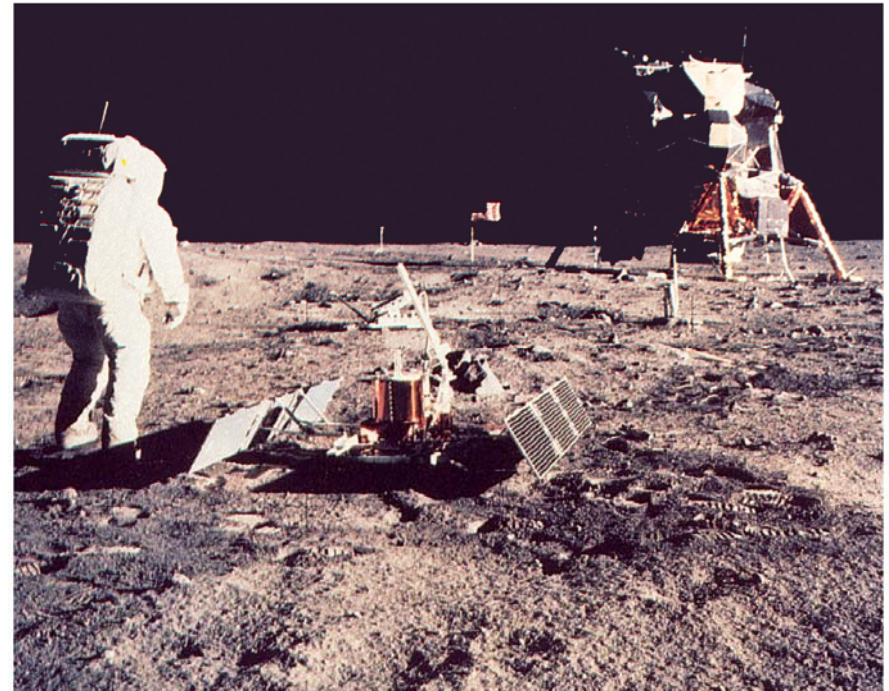
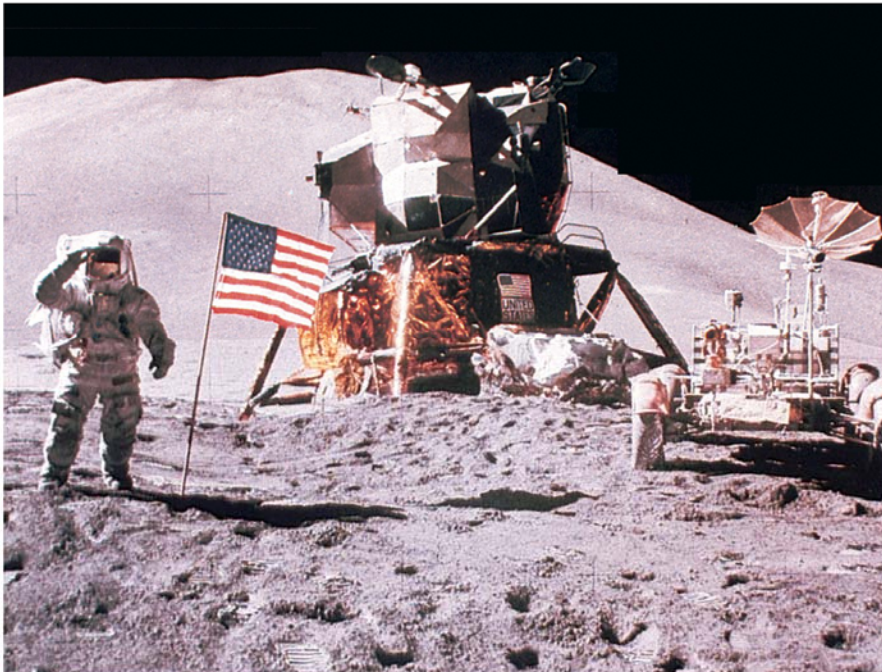
- Maria have relatively less denser craters
- **Maria (~ 4.0 billion years) are relatively younger than highlands (~ 4.5 billion years).**
- Mare basin was caused by impacts of very large meteoroids or asteroids at a later time (~ 4.0 billion years ago)
- Lunar crust is cracked by the large impact, causing lava flooding the basin
- dark color is due to solidified lava





# Human Exploration

- From 1969 to 1972, 12 astronauts walked on the Moon, through 6 successful manned landings
- July 21, 1969, 2:56 UTC, Armstrong put his left foot on the surface, and spoke
  - *That's one small step for (a) man, one giant leap for mankind.*



# Human Exploration

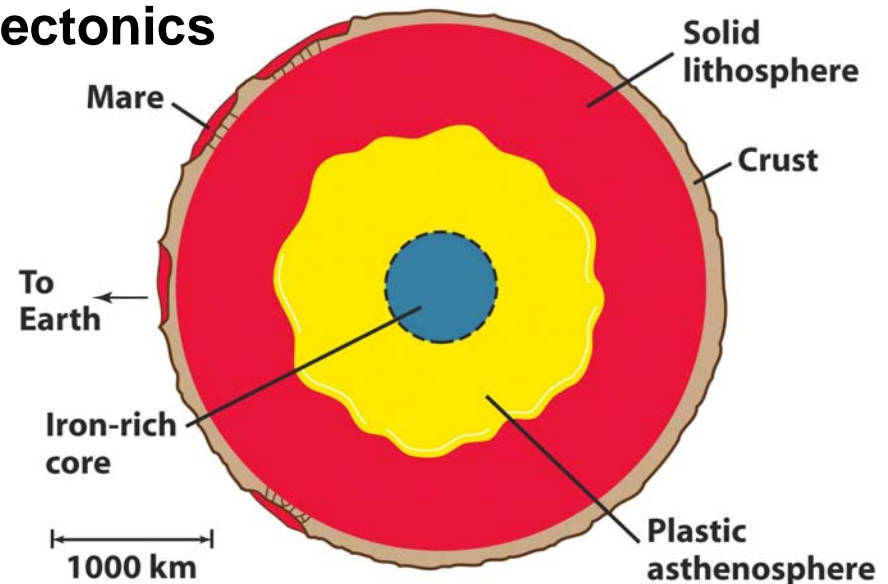
- About 400 kg of lunar materials have been brought back by Apollo astronauts
- Seismic equipment have been put on the Moon to detect moonquakes and deduce the structure of the moon's interior
- Mirrors have been put on the Moon to measure the accurate Earth-Moon distance using Laser light: moon spiraling away at 3.8 cm/year

# Human Exploration

- The second race to the Moon
  - Aim to set up large and permanent bases
  - NASA's **Constellation Project**
    - Send astronauts back to Moon in 2018
    - Build a large scale Moon base in the next 25 years
  - China's **Chang'e project**
    - Chang'e 1 launched on Oct. 24, 2007
  - Japan's moon project
    - Kaguya spacecraft launched on Sep. 14, 2007

# Internal Structure

- Like the Earth, the Moon has **crust, mantle, and core**
- **Core:**
  - ~700 km in diameter, relatively small
  - iron rich, partially liquid
  - **not producing global magnetic field**
- Moon's solid lithosphere is about 800 km thick
  - In contrast, the Earth's lithosphere is only 50 km thick
  - Therefore, Moon has **no plate tectonics**



# Moonquake

- Moonquakes are measured by seismometer set up by astronauts
- Moonquakes are rare in frequency and small in scale
- Originate 800 km below the surface, marking the boundary between solid lithosphere and plastic asthenosphere
- The moonquakes are caused by the Earth's tidal force
  - Tidal force deforms the solid body of the Moon
  - The force is greatest when the moon at perigee (most frequent quakes are observed)
  - The force is weakest when the moon at apogee

# Formation of the Moon

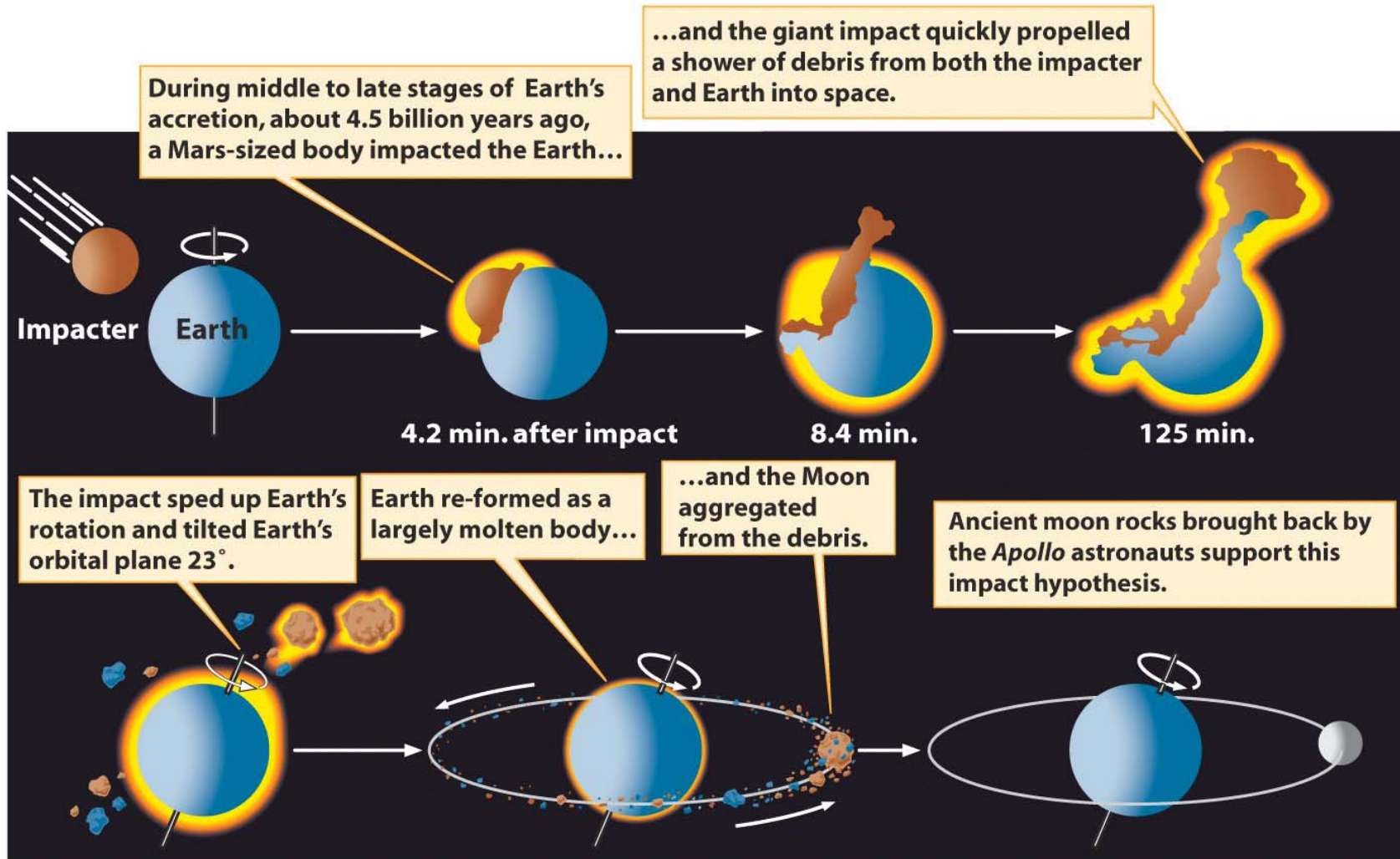
- **Collisional-ejection theory:**
  - the proto-Earth was struck by a Mars-sized protoplanet
  - debris from this collision coalesced to form the Moon
- This theory explains
  - Low density of Moon
  - Small core of Moon
  - Because the Earth's iron has sunk to its center due to chemical differentiation, little iron would have been ejected from the surface

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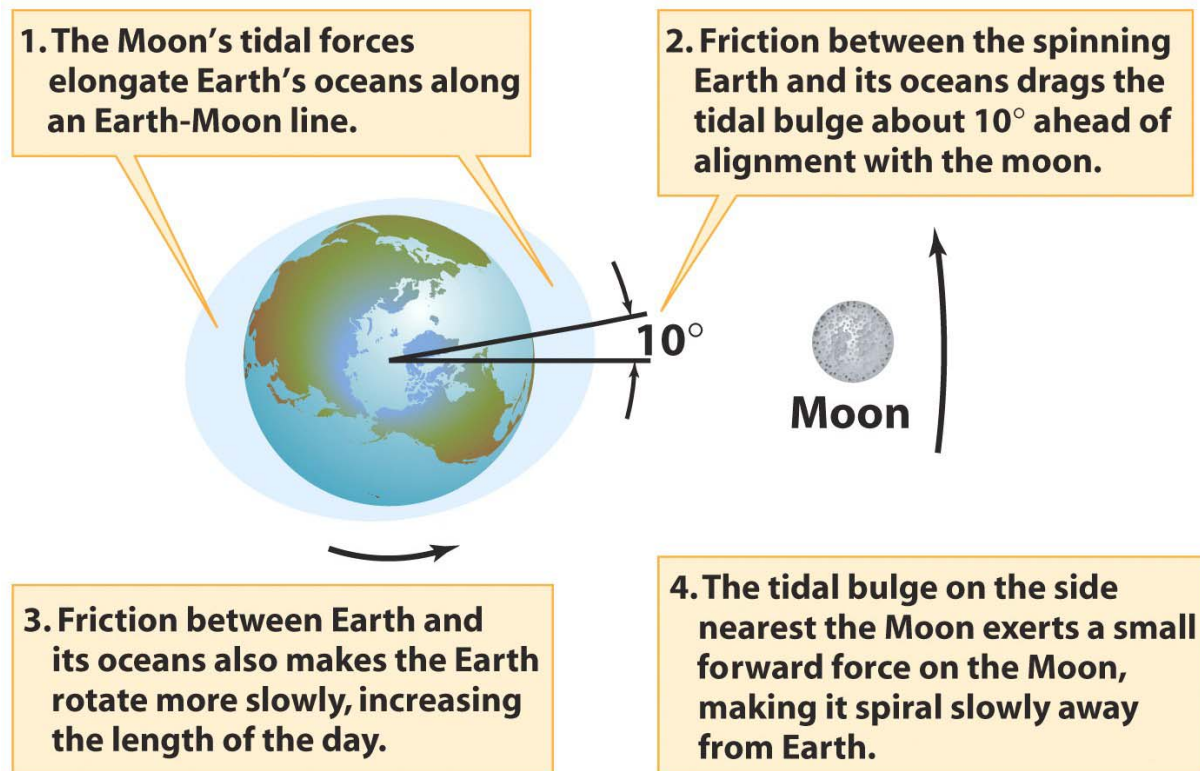
# Formation of the Moon

- **Collisional-ejection theory:**



# Tidal Forces

- The Earth's tidal force on the Moon produces the synchronous rotation of the Moon
- The Moon's tidal force on the Earth slows down the Earth's rotation, through the friction between Earth and its bulged oceans; 0.002 sec per century





# Final Notes on Chap. 10

- There are 5 sections in total
- Section 10-4 (on Moon rocks) is not covered