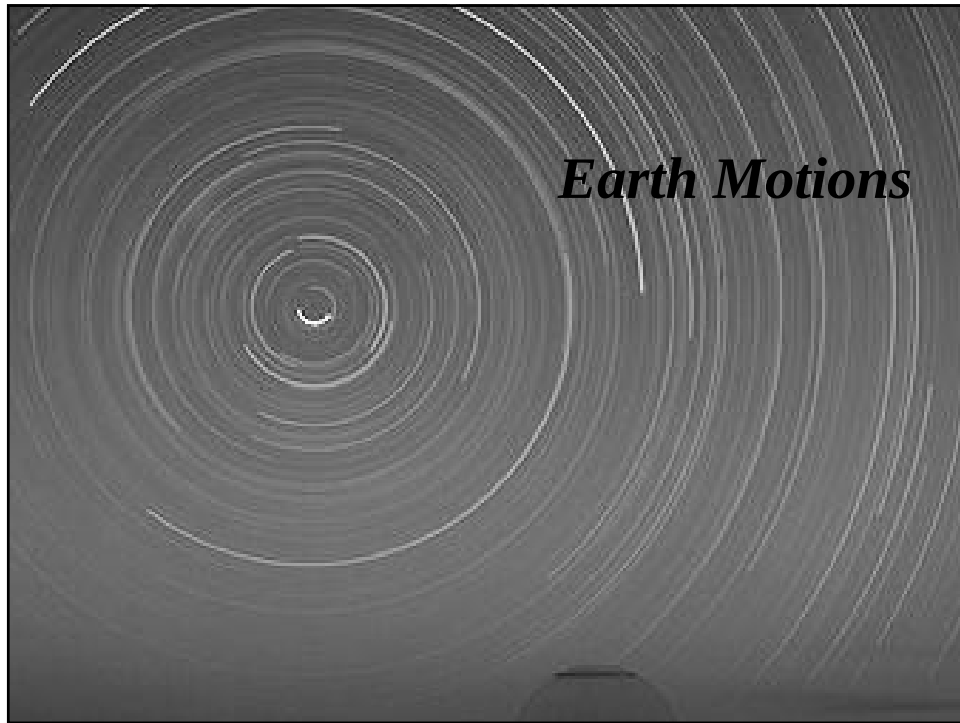




Earth's Rotation

Mean Solar Day
VS
Sidereal Day

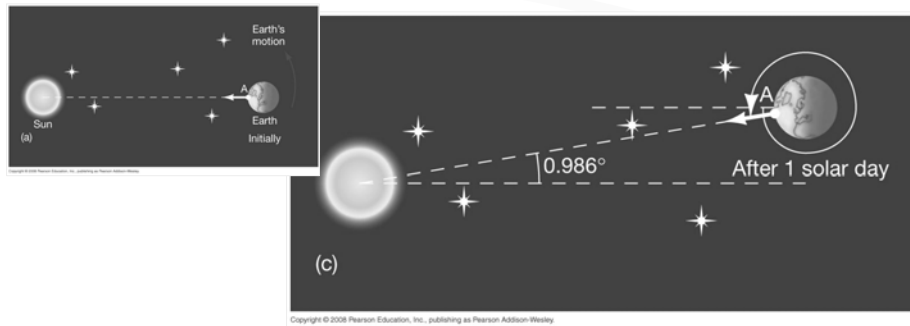
The diagram consists of two parts. The top part shows a sphere representing Earth with a vertical line labeled "Meridian" and a horizontal line labeled "Horizon". The top of the sphere is labeled "Zenith". The sphere is divided into four quadrants labeled "W" (West), "E" (East), "S" (South), and "N" (North). A curved arrow on the right side of the sphere indicates the direction of rotation. The bottom part shows a diagram of the Sun and Earth. The Sun is on the left, labeled "Sun (a)". A dashed line connects the Sun to the Earth, which is on the right, labeled "Earth Initially". A curved arrow labeled "Earth's motion" indicates the Earth's orbit around the Sun. A point "A" is marked on the Earth's surface.

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Earth's Rotation

Mean Solar Day

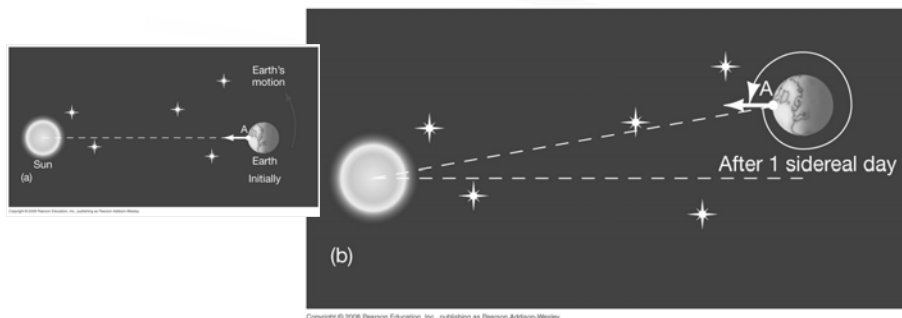
- time interval from one noon to the next (24 hours)
- noon: Sun is at zenith (highest point)



Earth's Rotation

Sidereal Day

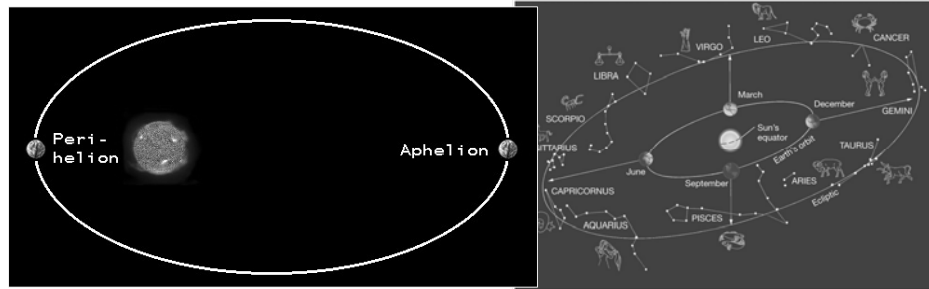
- time interval for Earth to make one rotation with respect to a particular star (23 hours, 56 minutes, 4 seconds)



Earth's Revolution

Revolution

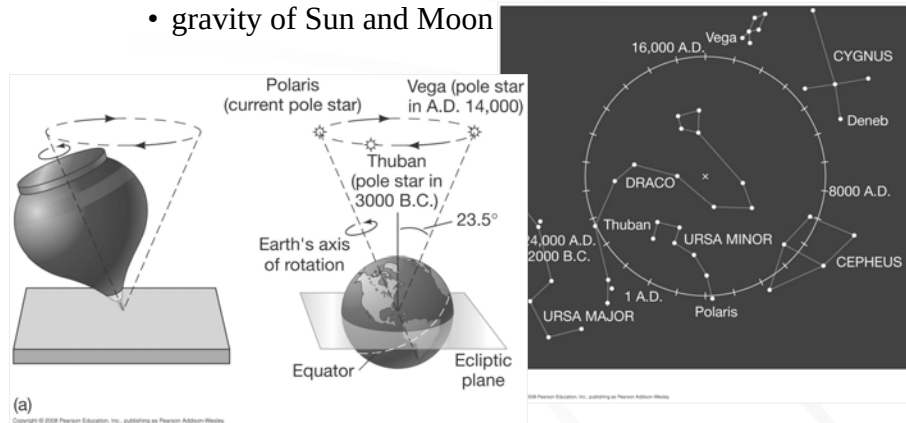
- motion of body around some point in space (> 107,000 km/hr)
 - **Perihelion:** closest to Sun (January 3rd ~147 million km)
 - **Aphelion:** farthest from Sun (July 4th ~153 million km)



Earth's Precession

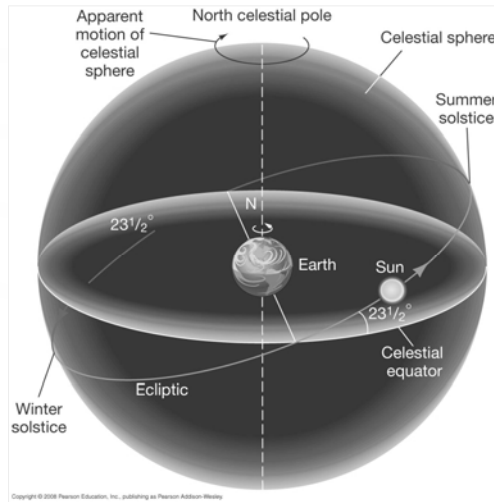
Precession

- very slow shifting of direction of Earth's axis
 - "wobbles" (traces circle every 26,000 yrs)
 - gravity of Sun and Moon



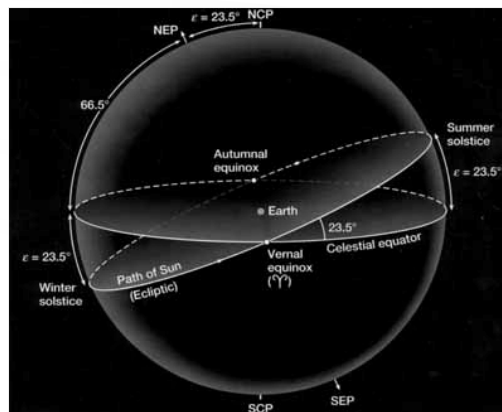
Earth's Seasons

- **Seasons:** tilt of Earth's axis (23.5°)



Earth's Seasons

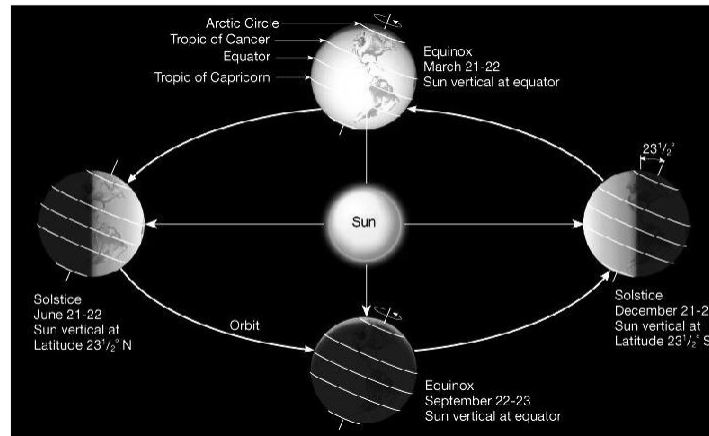
- **Seasons:** tilt of Earth's axis (23.5°)



Earth's Seasons

Equinox: equal day and equal night

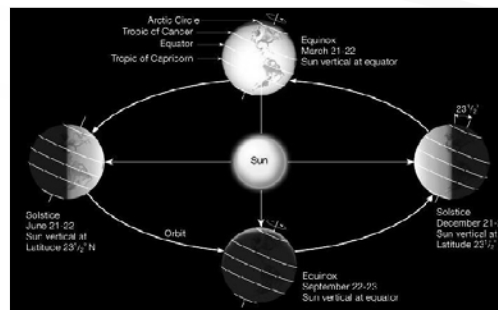
– Sun directly overhead equator



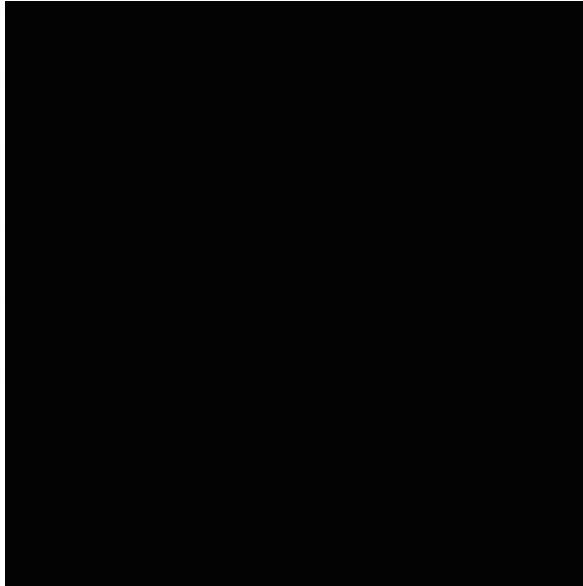
Earth's Seasons

Solstice: longest day and night

- marks edge of Arctic Circle
- *Winter solstice:* Sun is directly overhead *Tropic of Capricorn* (shortest day)
- *Summer solstice:* Sun is directly overhead the *Tropic of Cancer* (longest day)

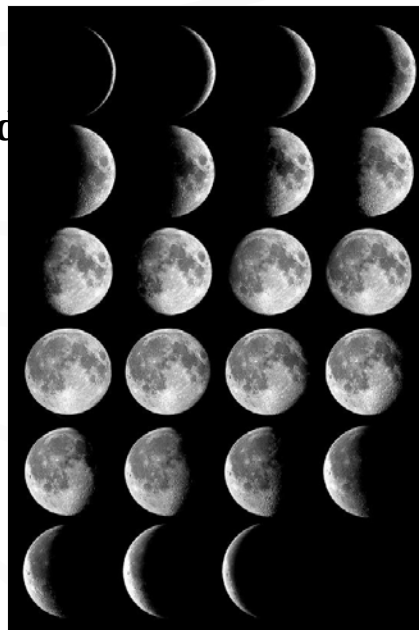


Phases of the Moon



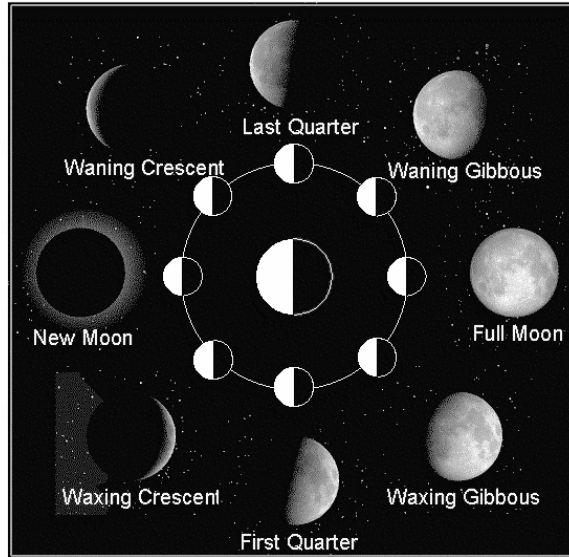
Phases of the Moon

- Reflected sunlight (albedo)



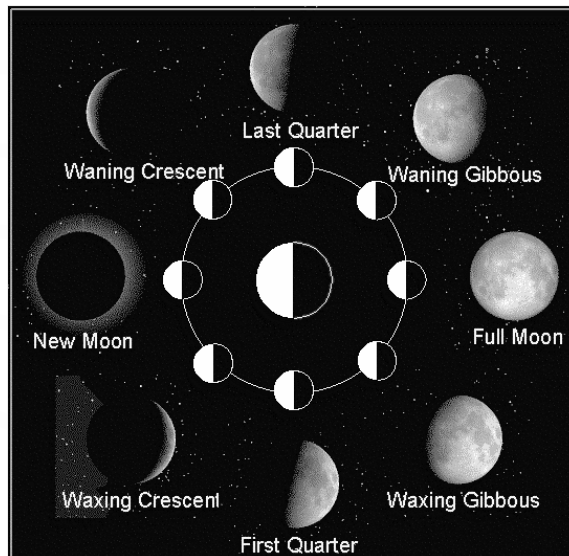
Phases of the Moon

- *During the first two weeks:*
 - waxing increasing illumination
 - new moon/waxing crescent/first quarter/waxing gibbous/full moon



Phases of the Moon

- *During the second two weeks:*
 - waning: decreasing illumination
 - full moon/waning gibbous/third quarter/waning crescent/new moon



Phases of the Moon

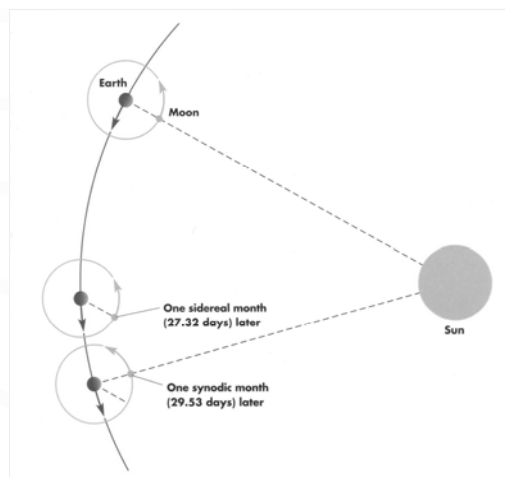
- *Note:* same features on the Moon's surface are observed throughout month

Synchronous orbit:
rotation = revolution

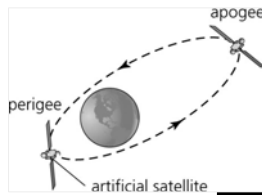


Phases of the Moon

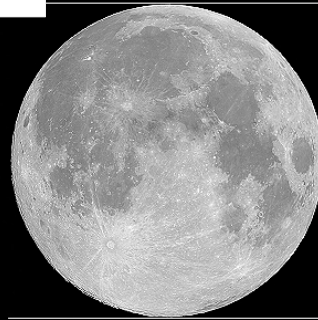
- **Synodic (Lunar) Month:** relative to Sun (29.5 Earth days for 1 Moon day)
- **Sidereal Month:** relative to distant stars (27.3 Earth days)
- **Moon's orbital period (revolution) = 27.3 days**



Phases of the Moon

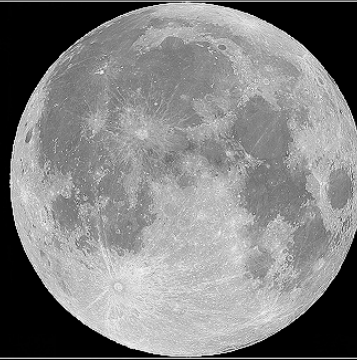


Apogee



2006-02-13
405,978 km
29.87 arc-mins
Altitude @ 69.17°

Perigee



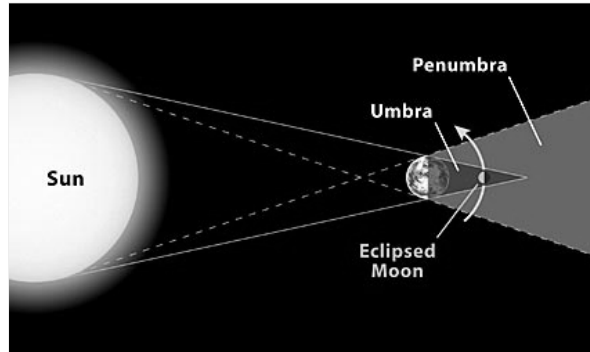
2006-09-08
357,210 km
33.89 arc-mins
Altitude @ 45.36°

Eclipses: Solar and Lunar



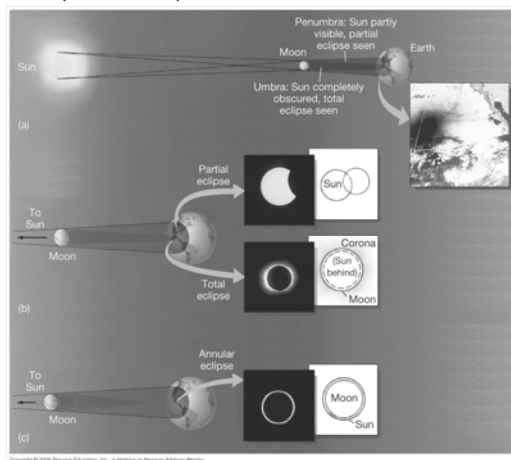
Eclipses: Solar and Lunar

- **Geometry of eclipses**
 - *umbra*: complete shadow
 - *penumbra*: partial shadow



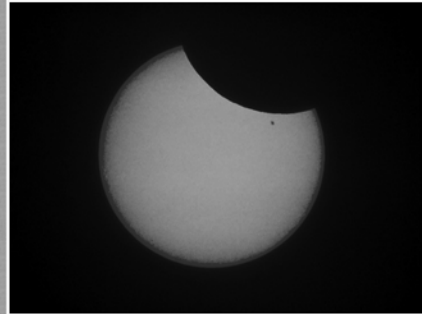
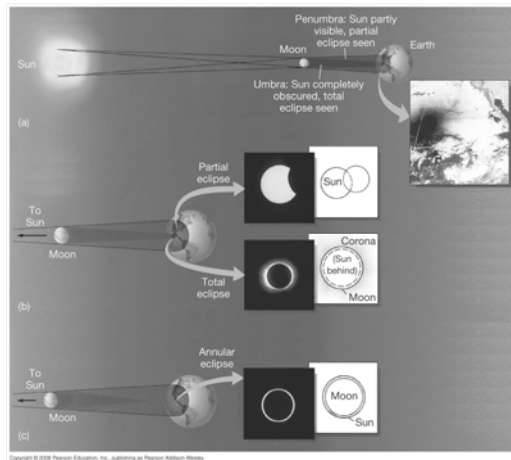
Solar Eclipses (S-M-E)

- *Total Solar Eclipse*: similar angular diameters (umbra)



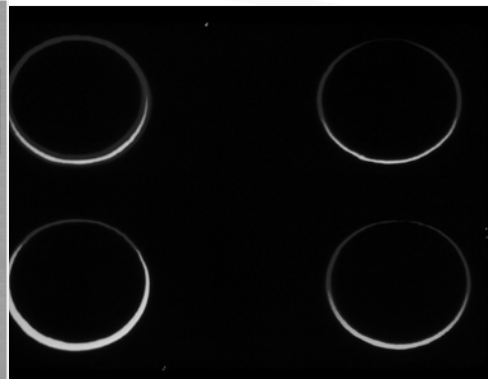
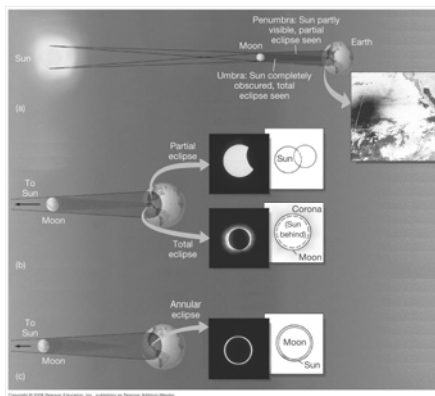
Solar Eclipses (S-M-E)

- *Partial Solar Eclipse*: partial shadow (penumbra)



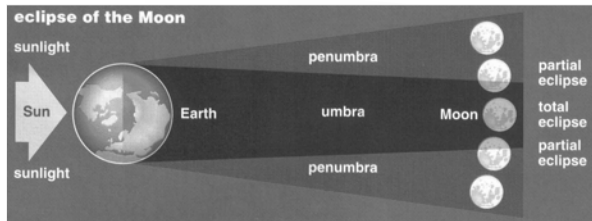
Solar Eclipses (S-M-E)

- *Annular Eclipse*: umbra does not reach surface
 - elliptical path: eclipse occurs at apogee



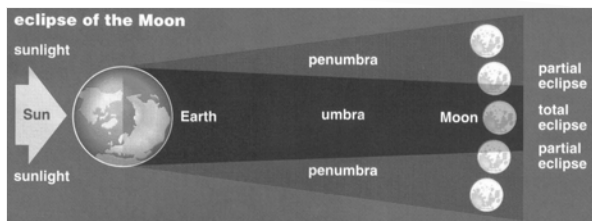
Lunar Eclipses (S-E-M)

- *Total Lunar Eclipse*: passes completely through umbra



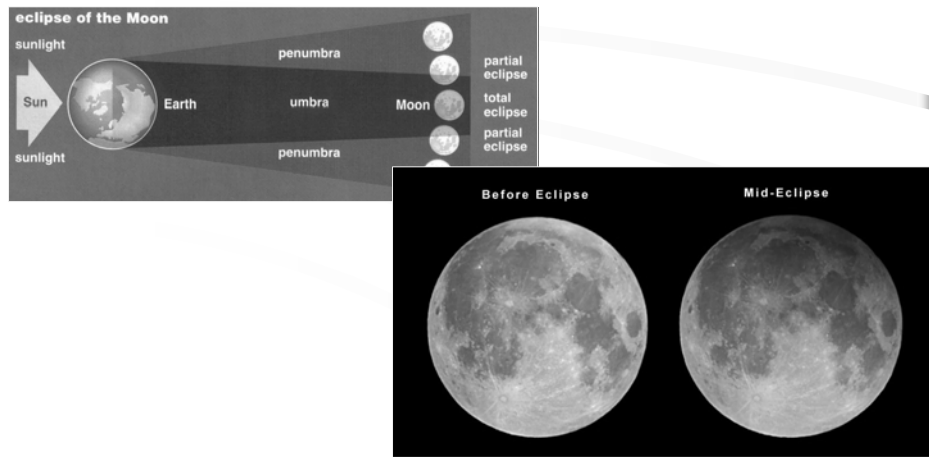
Lunar Eclipses (S-E-M)

- *Partial Lunar Eclipse*: passes through only part of the umbra

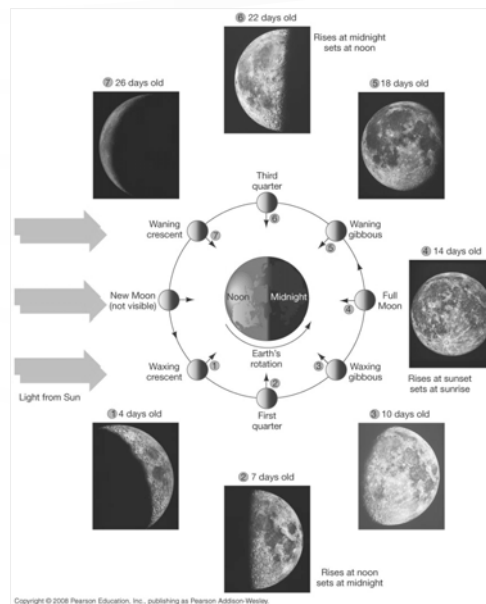


Lunar Eclipses (S-E-M)

- *Penumbral Lunar Eclipse*: passes through penumbra only

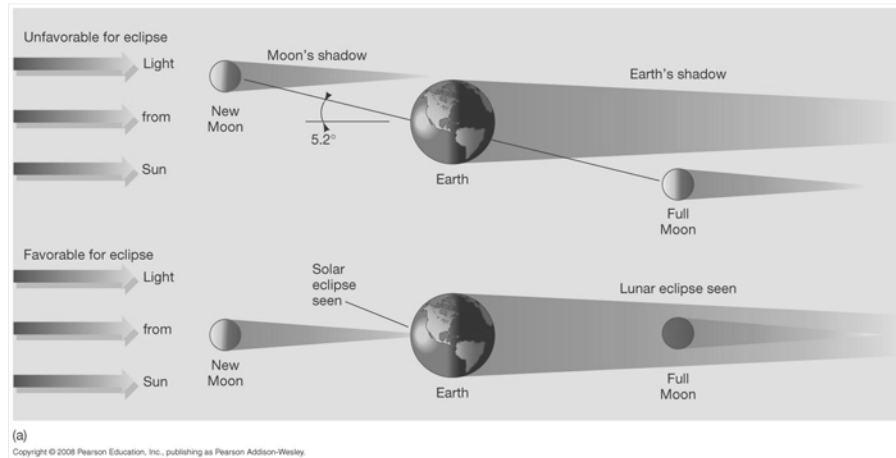


Eclipses & Phases of the Moon



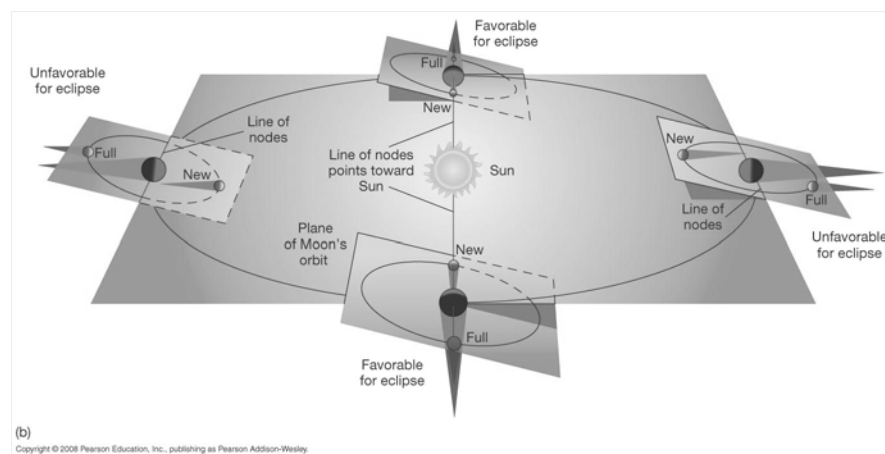
Monthly Eclipses?

- Moon's orbital plane is inclined about 5° from Earth's orbital plane



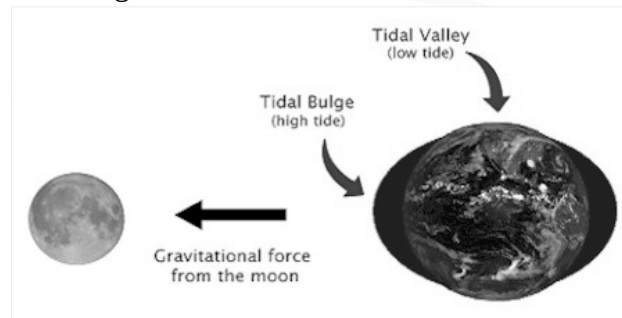
Monthly Eclipses?

- eclipse: same plane as Earth's (**line of nodes**)



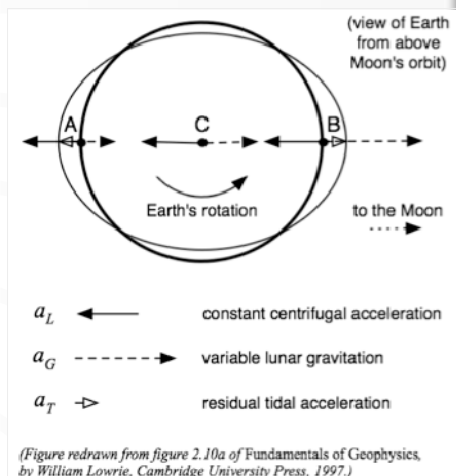
Earth Tides

- **Tides:** periodic change in elevation of the ocean surface because it is flexible
- **Effect of Moon**
 - **Cause:** gravitational effects



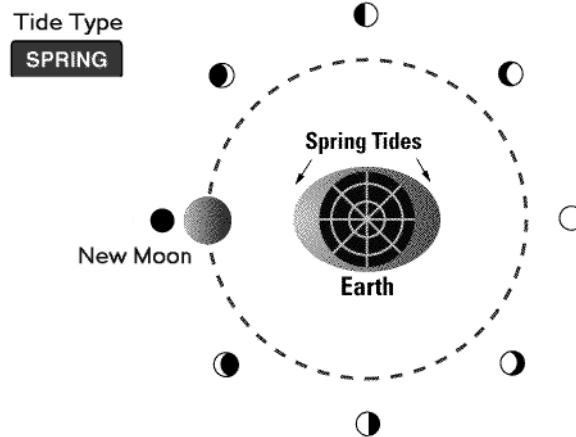
Earth Tides

- **Process**
 - oceans: flexible
 - gravitational force
 - average: center of body
 - greatest on side nearest Moon
 - weakest on farthest side
 - Centrifugal force
 - Earth rotation: solid Earth



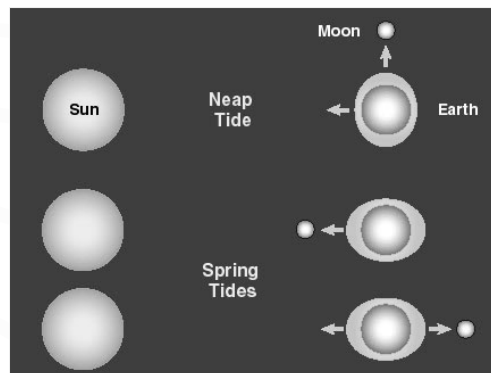
Earth Tides

- **Result:** Earth continuously experiences 2 high and 2 low tides



Earth Tides: Effects of Sun

- Sun has greater mass, but farther away than Moon ($<1/2$ Moon)
 - **Spring Tides:** Sun and Moon are aligned; higher than normal high tides
 - **Neap Tides:** Sun and Moon are not aligned; lower than normal, high tides



Earth Tides: Additional Effects

- forward bulge exerts force on Moon: orbital diameter increasing
- friction slows rotation - longer days
- tidal deformation (up to 60 cm)

