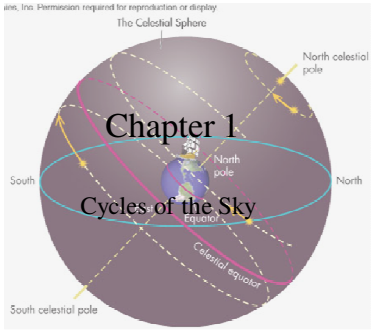

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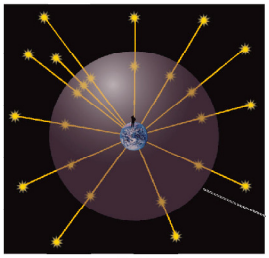
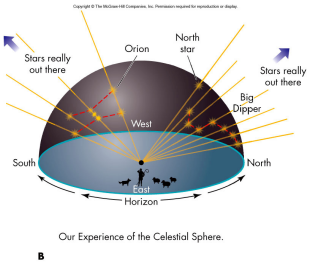
The Celestial Sphere



- Vast distances to stars prevent us from sensing their true 3-D arrangement
- Naked eye observations treat all stars at the same distance, on a giant ***celestial sphere*** with the Earth at its center

Models and Science

- The celestial sphere is a ***model,*** which does not necessarily match physical reality
- Models provide a means to enhance our understanding of nature



Our Experience of the Celestial Sphere.

B

Constellations

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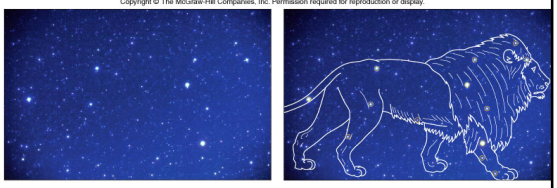

A

- ***Constellations*** are fixed arrangements of stars that resemble animals, objects, and mythological figures
- Stars in a constellation are not physically related

Constellations

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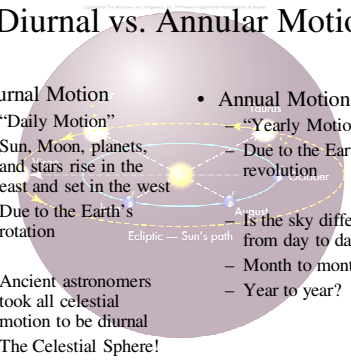
B

- Positions of stars change very slowly; constellations will look the same for thousands of years
- Origin of the ancient constellations is unknown although they probably served as mnemonic tools for tracking seasons and navigation

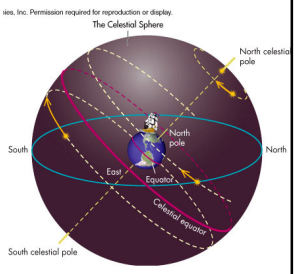
Diurnal vs. Annular Motion



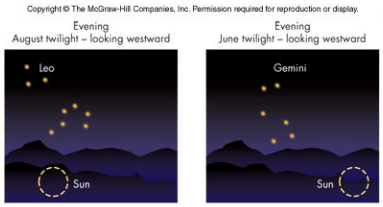
- Diurnal Motion
  - "Daily Motion"
  - Sun, Moon, planets, and stars rise in the east and set in the west
  - Due to the Earth's rotation
  - Ancient astronomers took all celestial motion to be diurnal
  - The Celestial Sphere!
- Annual Motion
  - "Yearly Motion"
  - Due to the Earth's revolution
  - Is the sky different from day to day?
  - Month to month?
  - Year to year?

Diurnal Motion

- Daily motion can be explained by the rotation of the celestial sphere about the north and south ***celestial poles*** located directly above the Earth's north and south poles
- The ***celestial equator,*** which lies directly above the Earth's equator, provides another astronomical reference marker



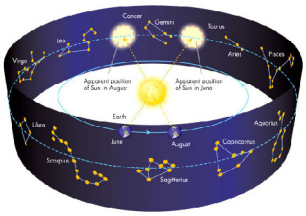
Annual Motion



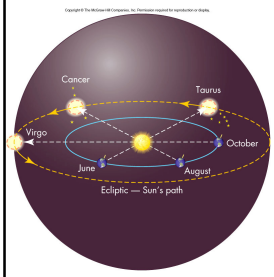
- For a given time (say 10:00 PM), as the months proceed, constellations do not appear in the same part of the sky

Annual Motion

- A given star rises 3 minutes 56 seconds earlier each night
- This annual motion is caused by the Earth's motion around the Sun, the result of projection
- The ancients used the periodic annual motion to mark the seasons

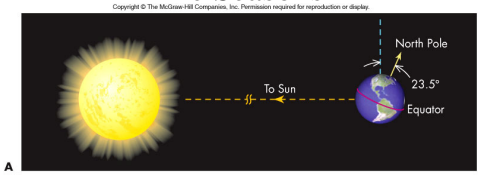


The Ecliptic



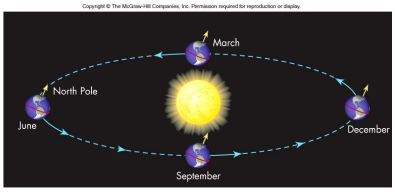
- The path of the Sun through the stars on the celestial sphere is called the ***ecliptic***
- The ecliptic is a projection of the Earth's orbit onto the celestial sphere and is tipped relative to the celestial equator

The Seasons



- The Earth is closest to the Sun in January, which is winter in the northern hemisphere
- Therefore, the seasons cannot be caused by the Sun's proximity to the Earth
- The Earth's ***rotation axis*** is tilted 23.5° from a line perpendicular to the Earth's orbital plane

The Seasons



- The rotation axis of the Earth maintains nearly the same tilt and direction from year to year
- The northern and southern hemispheres alternate receiving (on a yearly cycle) the majority of direct light from the Sun
- This leads to the seasons!

The Seasons

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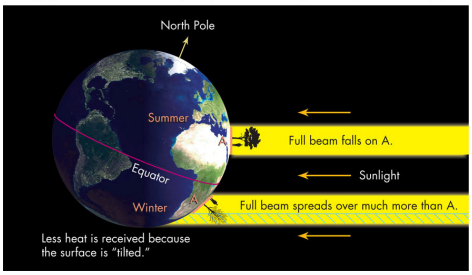

Seasons and The Ecliptic

- The tilt of the Earth's rotation axis causes the ecliptic not to be aligned with the celestial equator
- Sun is above celestial equator in June when the Northern Hemisphere is tipped toward the Sun, and is below the equator in December when tipped away
- Tilting explains seasonal ***altitude*** of Sun at noon, highest in summer and lowest in winter

The Ecliptic's Tilt

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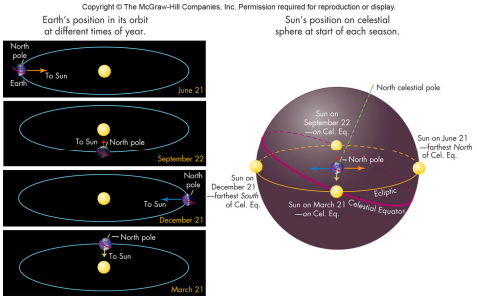

Solstices and Equinoxes

- Points on horizon where Sun rises and sets changes periodically throughout year
- In summer months of Northern hemisphere, the Sun rises north of east and sets north of west
- In winter months of Northern hemisphere, the Sun rises south of east and sets south of west
- The ***solstices*** (about June 21 and December 21) are when the Sun rises at the most extreme north and south points
- The ***equinoxes*** (equal day and night and about March 21 and September 23) are when the Sun rises directly east
- Ancients marked position of Sun rising and setting to determine the seasons (e.g., Stonehenge)

A

Solstices and Equinoxes

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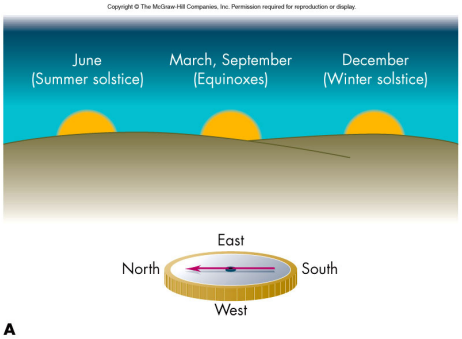

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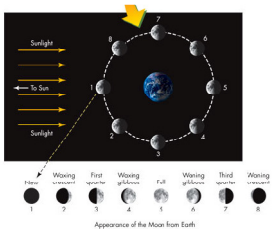
The Moon

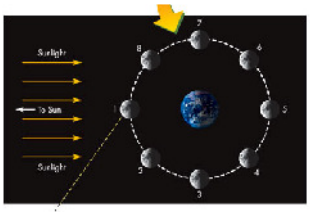
- Rises in the east and sets in the west
- Like the planets and Sun, the Moon moves from west to east relative to the stars (roughly the width of the Moon in one hour)

The Phases of the Moon



- During a period of about 30 days, the Moon goes through a complete set of ***phases:*** new, waxing crescent, first quarter, waxing gibbous, full, waning gibbous, third quarter, waning crescent

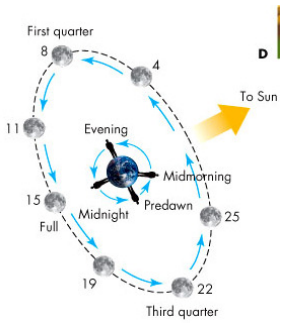
The Phases of the Moon



- The phase cycle is the origin of the month (derived from the word moon) as a time period
- The phases of the Moon are caused by the relative positions of the Sun, Earth, and Moon

Lunar Rise and Set Times

- The Moon rises roughly 50 minutes later each day



Eclipses

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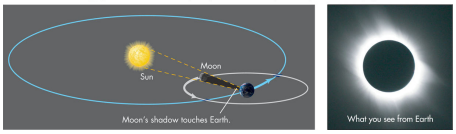

- An ***eclipse*** occurs when the Sun, Earth, and Moon are directly in line with each other
- A ***solar eclipse*** occurs when the Moon passes between the Sun and Earth, with the Moon casting its shadow on the Earth causing a midday sky to become dark as night for a few minutes

Solar Eclipse from Space

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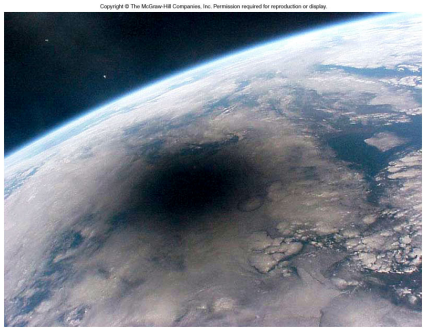

Lunar Eclipses

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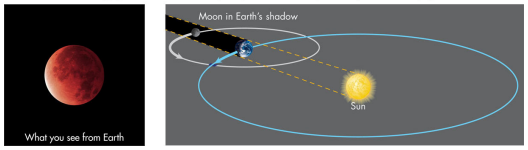

- A ***lunar eclipse*** occurs when the Earth passes between the Sun and Moon, with the Earth casting its shadow on the Moon giving it a dull red color

Rarity of Eclipses

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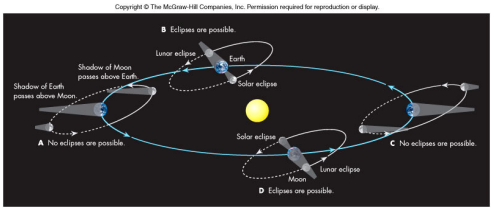

- Because of the Moon's tilt relative to the ecliptic, eclipses will not occur at every new and full Moon
- Twice a year the Moon's orbit will pass through the Sun giving the possibility of an eclipse – these times are called ***eclipse seasons***

Eclipse Seasons

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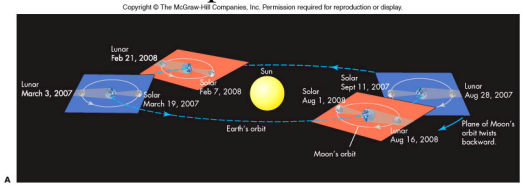

- Since the Moon's orbit tilts nearly in the same direction through the year, twice a year the Moon's orbit will pass through the Sun giving the possibility of an eclipse – these times are called ***eclipse seasons***
- When a solar eclipse occurs at new Moon, conditions are right for a lunar eclipse to occur at the full Moon either before or after the solar eclipse

Eclipse Periods

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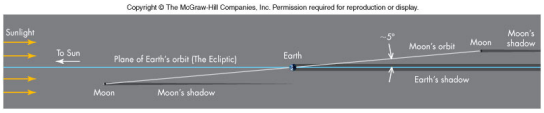

- Eclipses do not occur every 30 days since the Moon's orbit is tipped relative to the Earth's orbit
- The tipped orbit allows the shadow of the Earth (Moon) to miss the Moon (Earth)

Recent and Upcoming Solar Eclipses

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