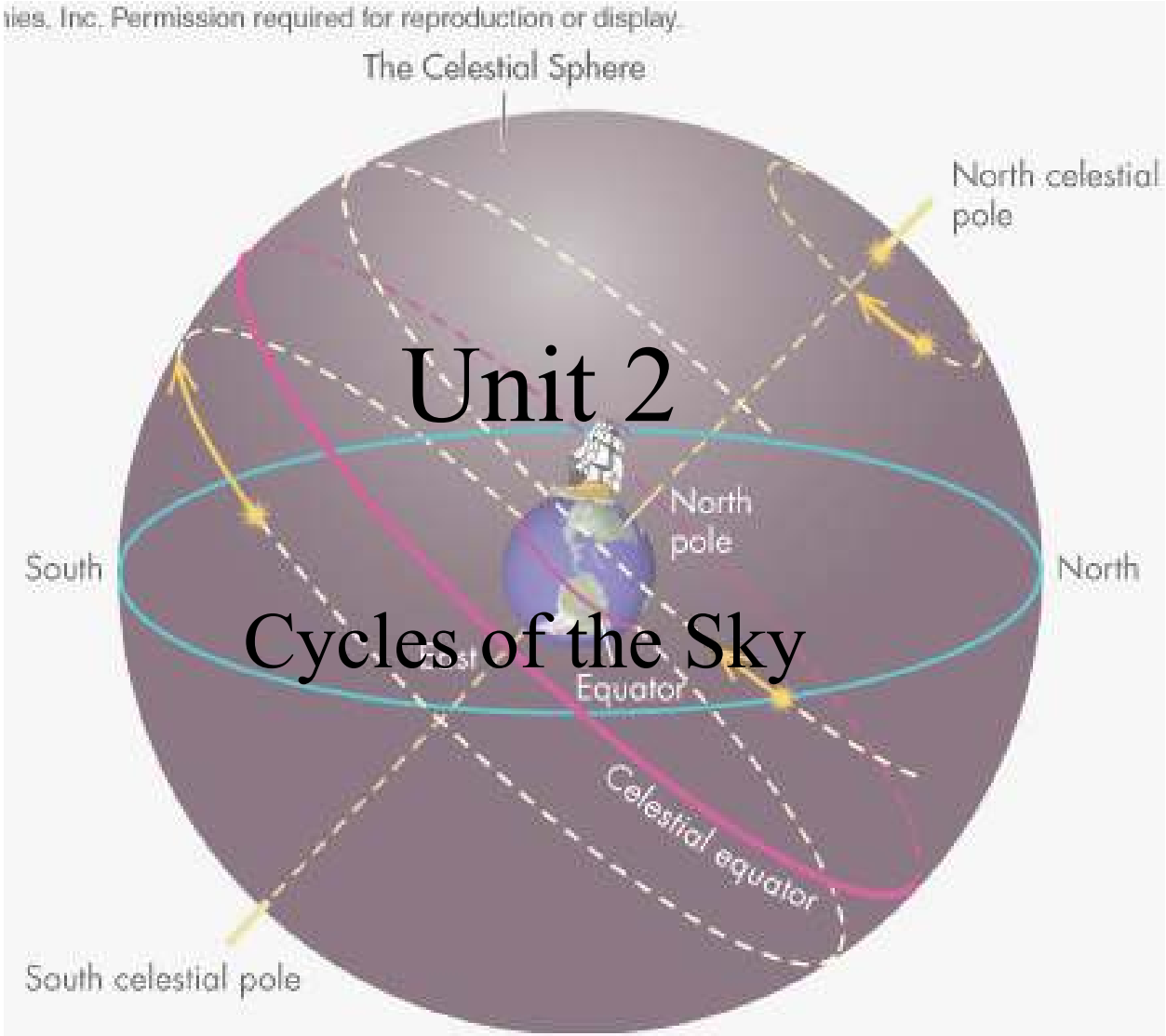
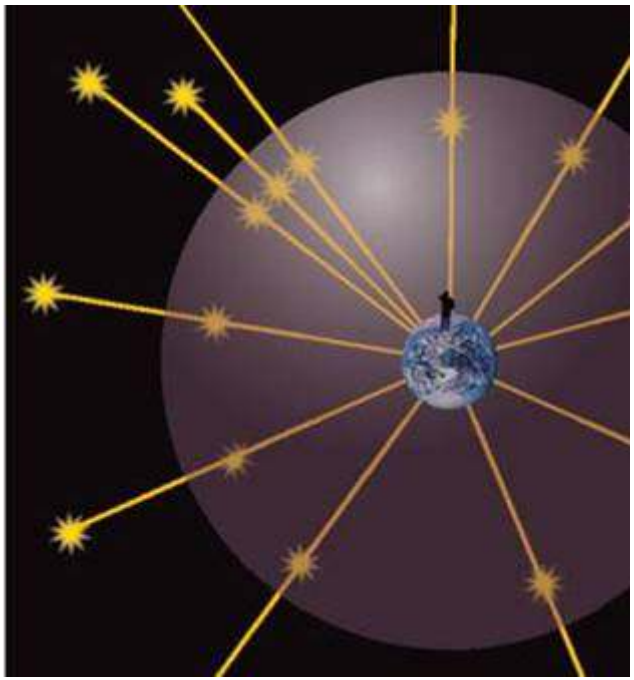
Unit 2

Cycles of the Sky



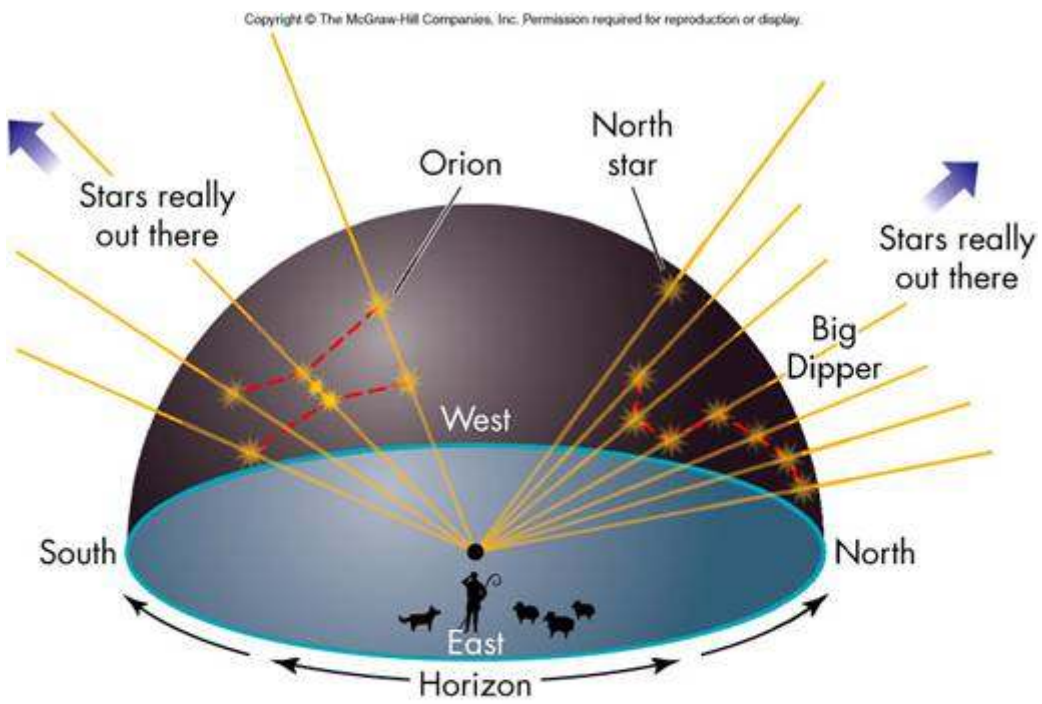
The Celestial Sphere



- 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

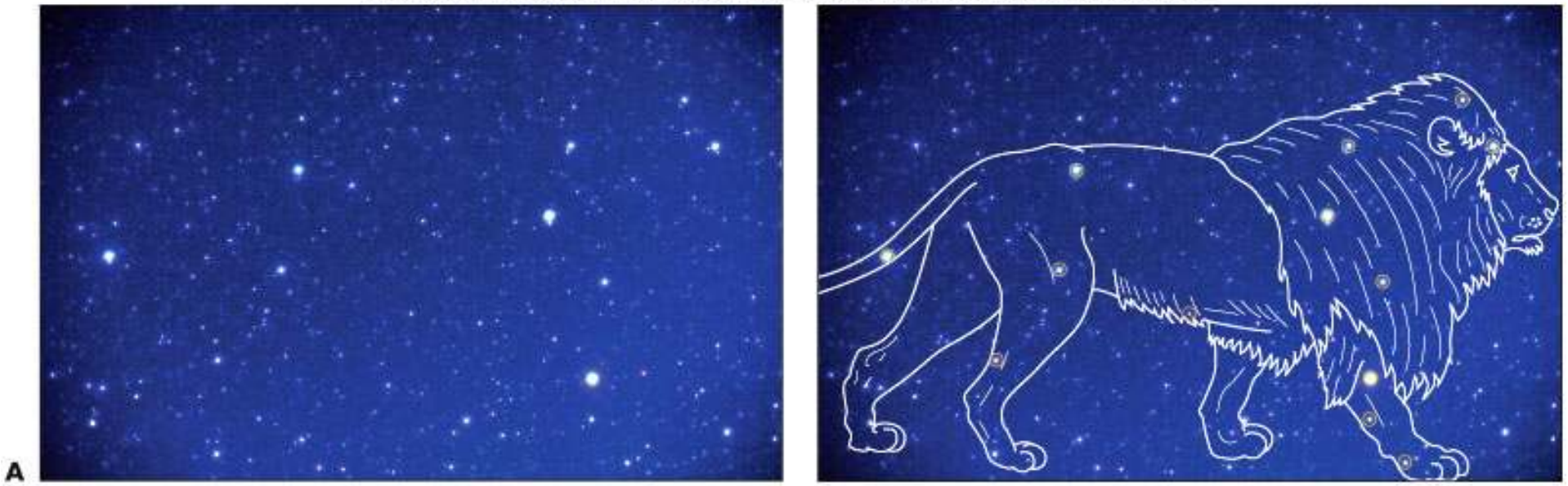


Our Experience of the Celestial Sphere.

B

Constellations

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



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

Constellations

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

- 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

Circumpolar Constellations

Ursa Major, Ursa Minor, Draco, Cassieopeia and Cepheus

Autumn Constellations

Andromeda, Pegasus, Perseus, Triangulum, Aries, Cassieopeia and Cepheus

Winter Constellations

Perseus, Auriga, Taurus, Orion, Canis Major, Canis Minor, Gemini, and Cancer

Spring Constellations

Cancer, Ursa Major, Leo, Virgo, Bootes, Corona Borealis, Canes Venatici, and Coma Berenices

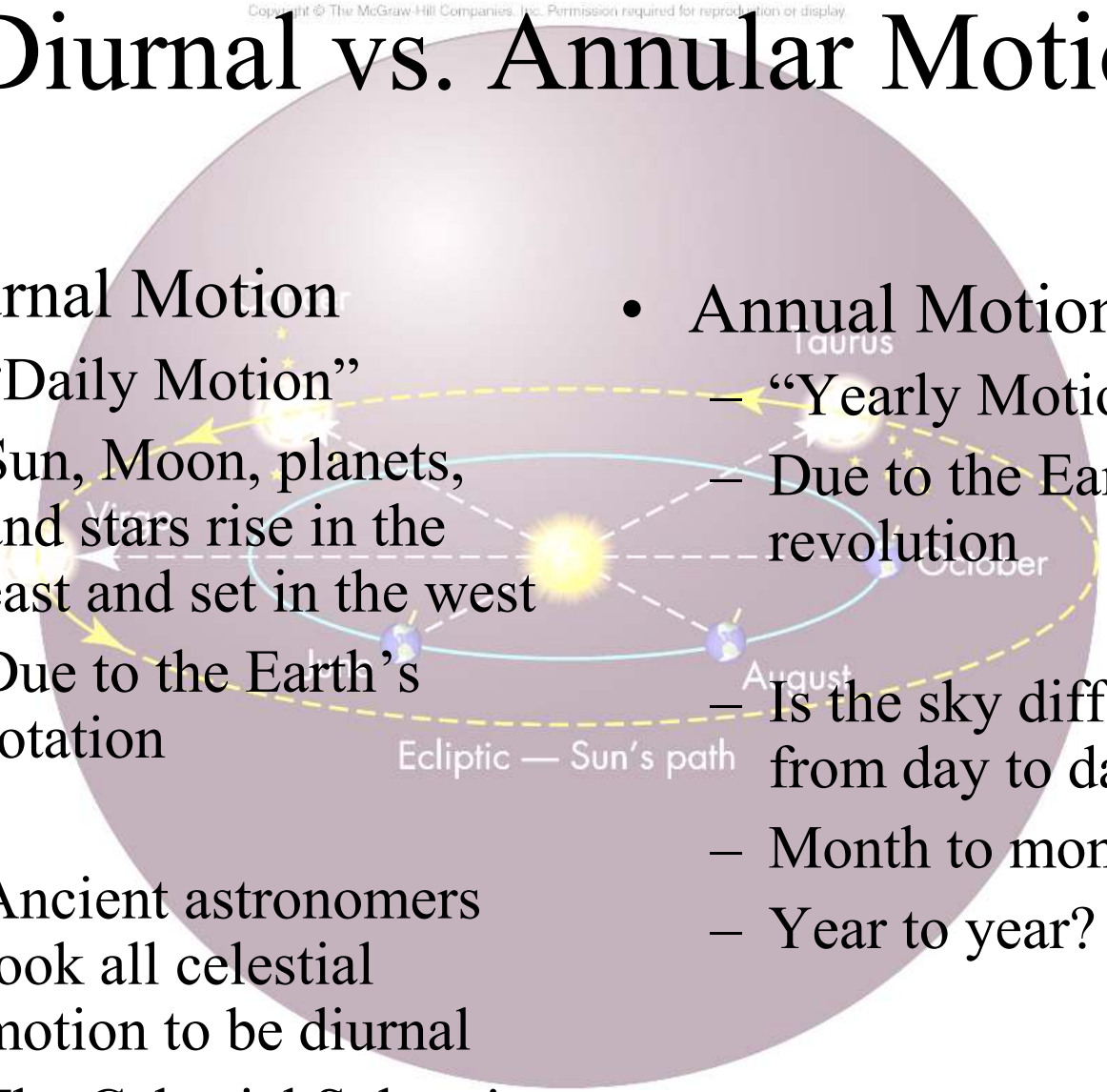
Summer Constellations

Corona Borealis, Hercules, Scorpius, Sagittarius, Lyra, Cygnus and Aquila

Diurnal vs. Annular Motion

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

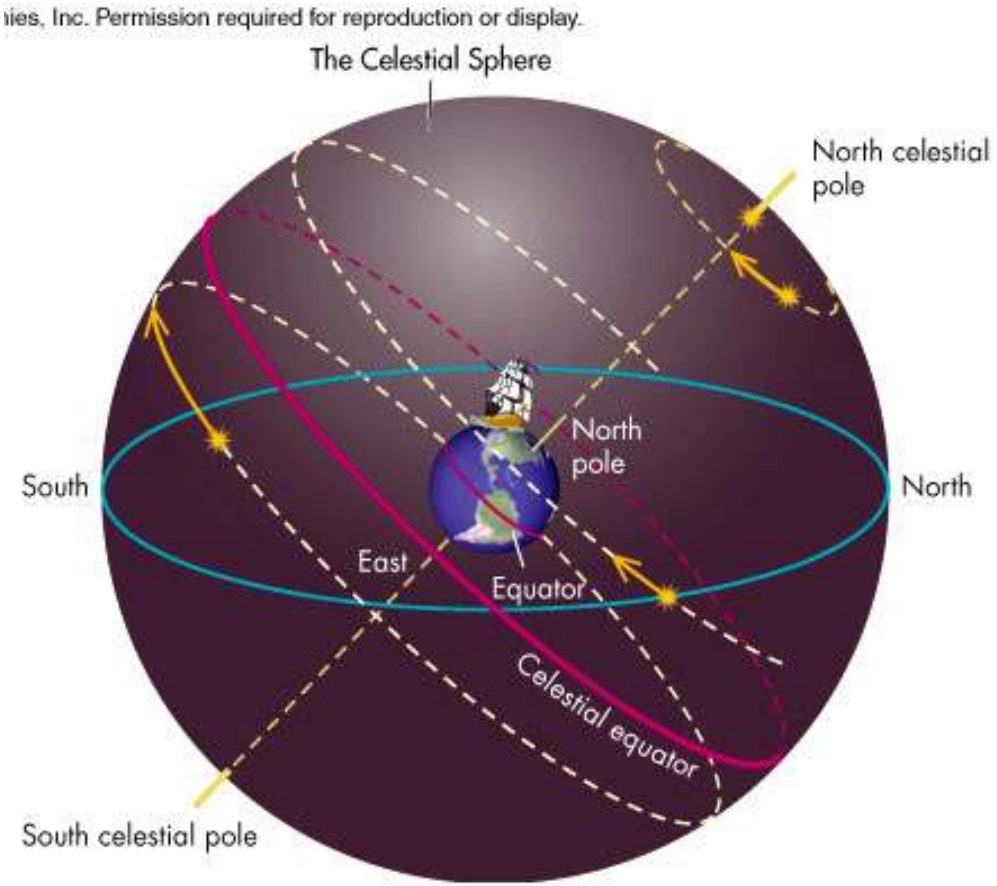
- Diurnal Motion
  - "Daily Motion"
  - Sun, Moon, planets, and stars rise in the east and set in the west
  - Due to the Earth's rotation
  - Ancient astronomers took all celestial motion to be diurnal
  - The Celestial Sphere!



- Annual Motion
  - "Yearly Motion"
  - Due to the Earth's revolution
  - Is the sky different from day to day?
  - Month to month?
  - Year to year?

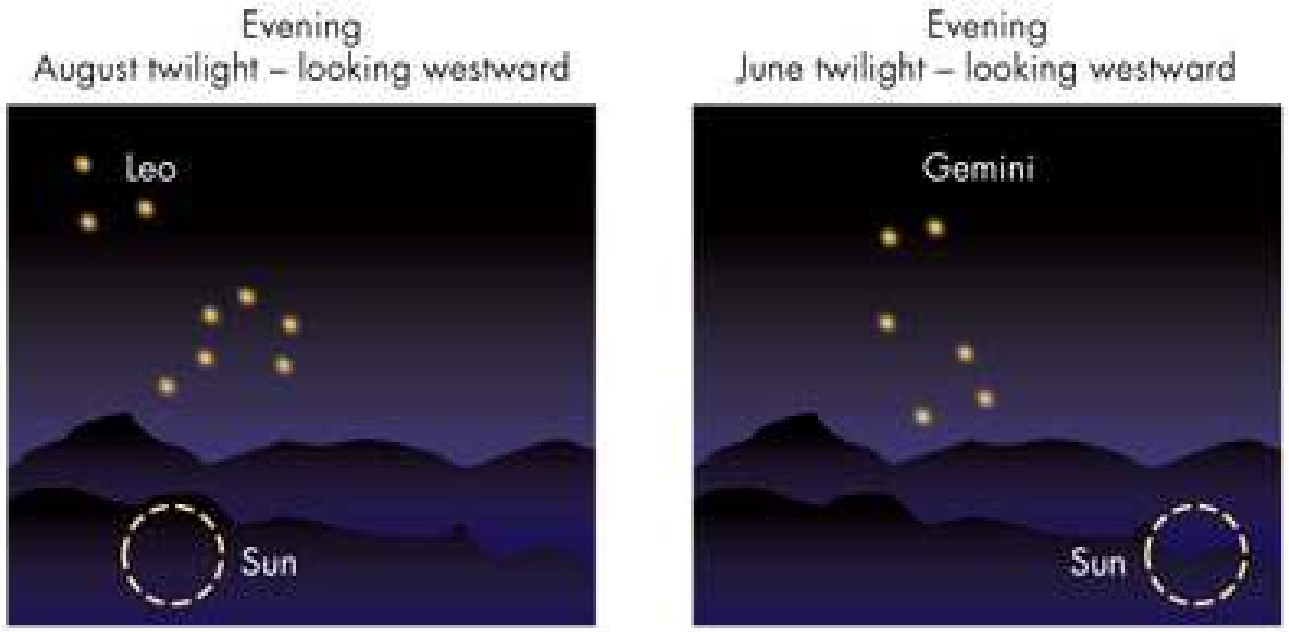
Diurnal Motion

- 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

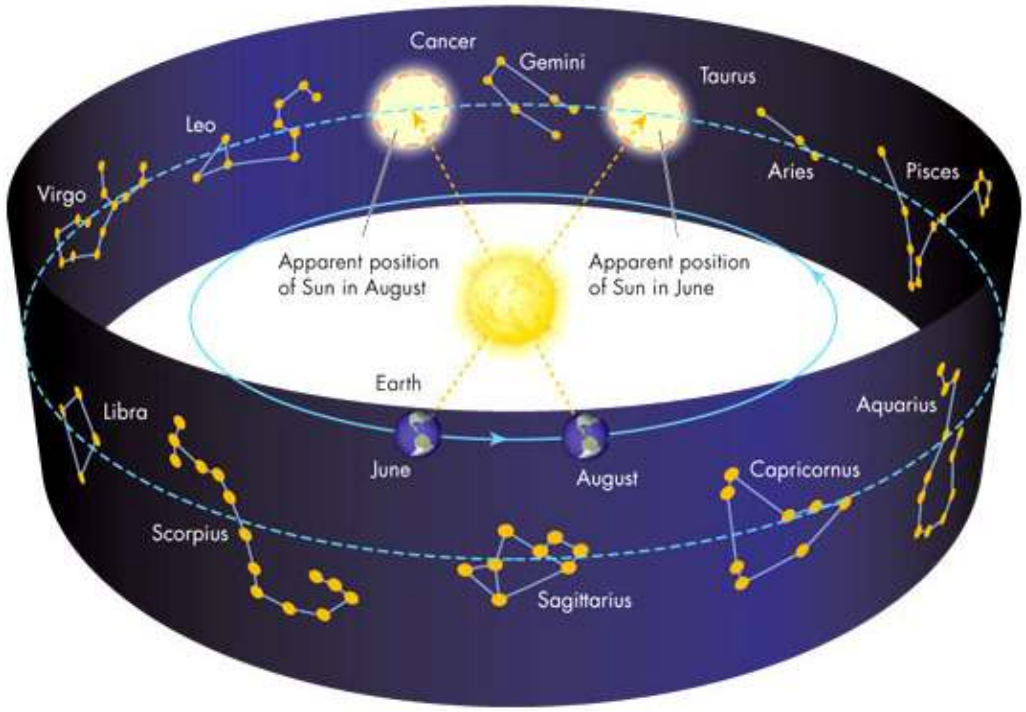
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



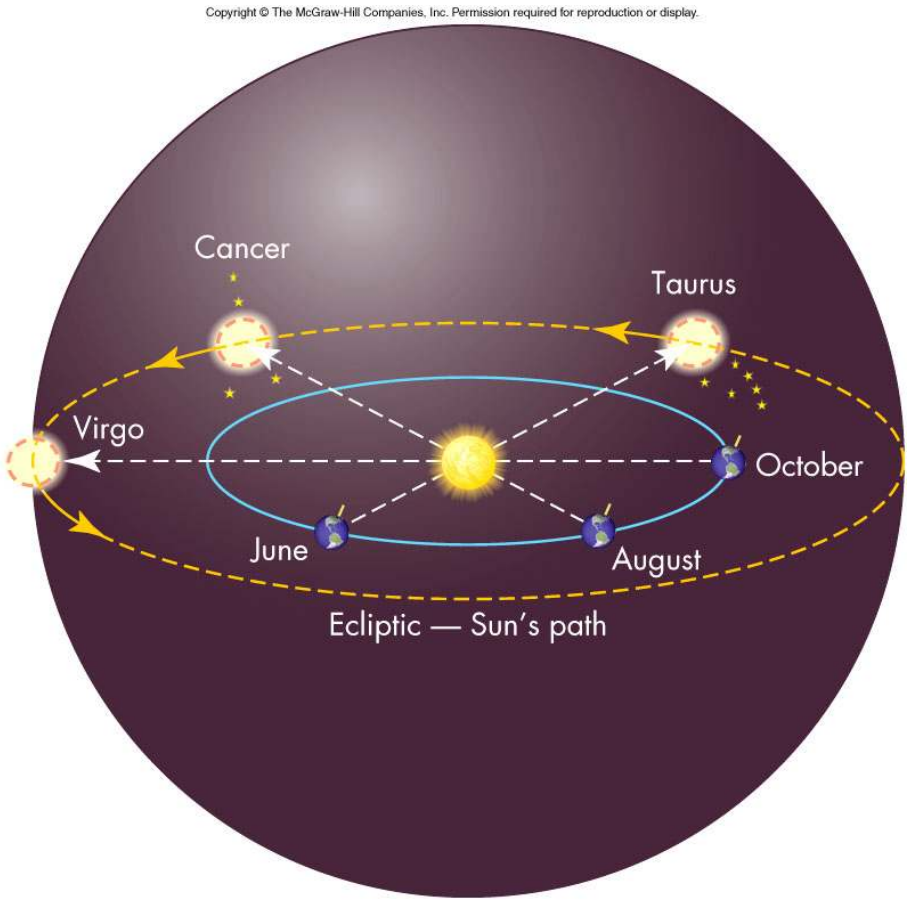
- For a given time (say 10:00 PM), as the months proceed, constellations do not appear in the same part of the sky

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



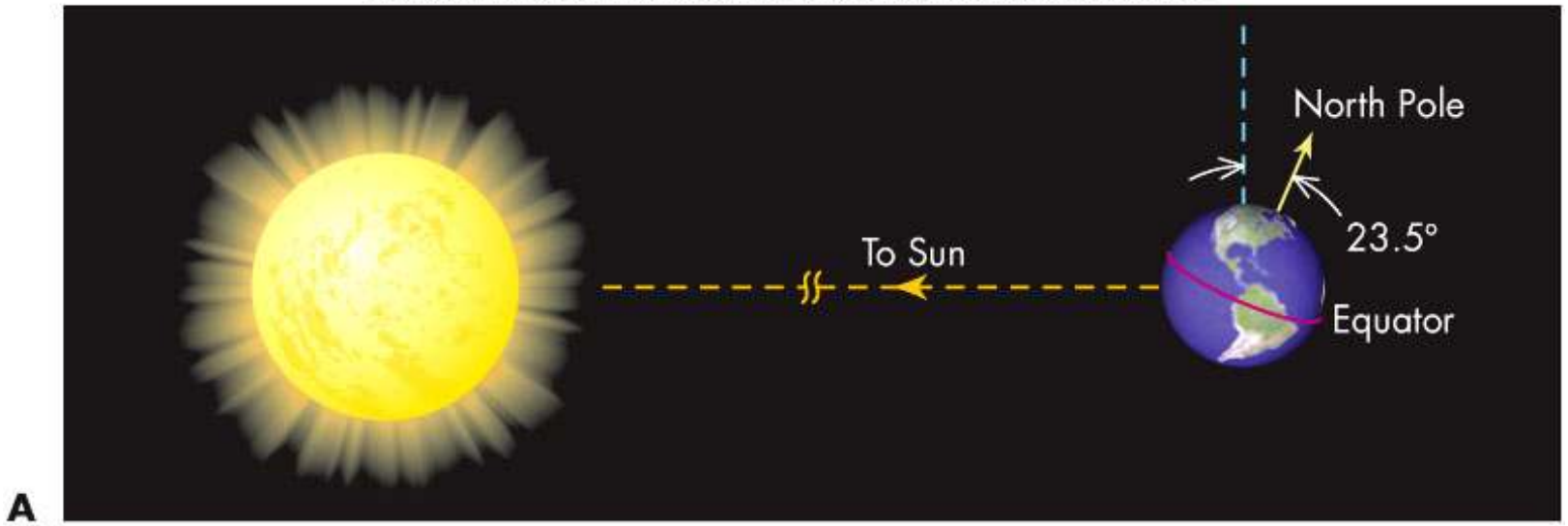
The Ecliptic



- 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

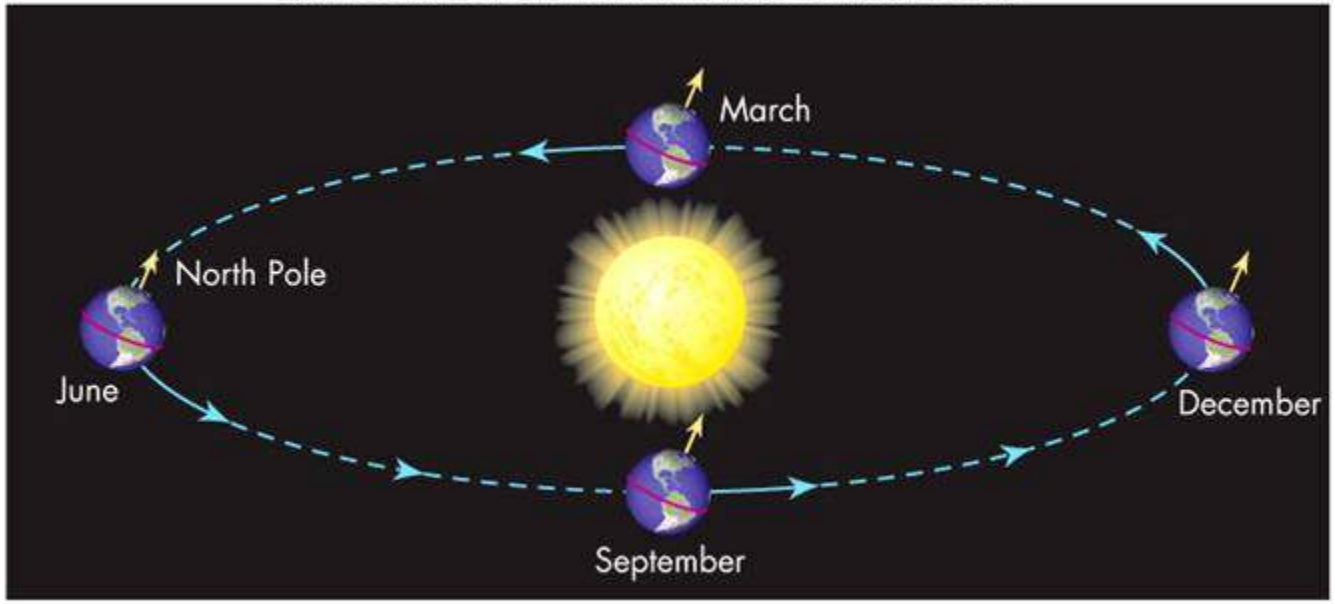
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



- 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 23.5º from a line perpendicular to the Earth's orbital plane

The Seasons

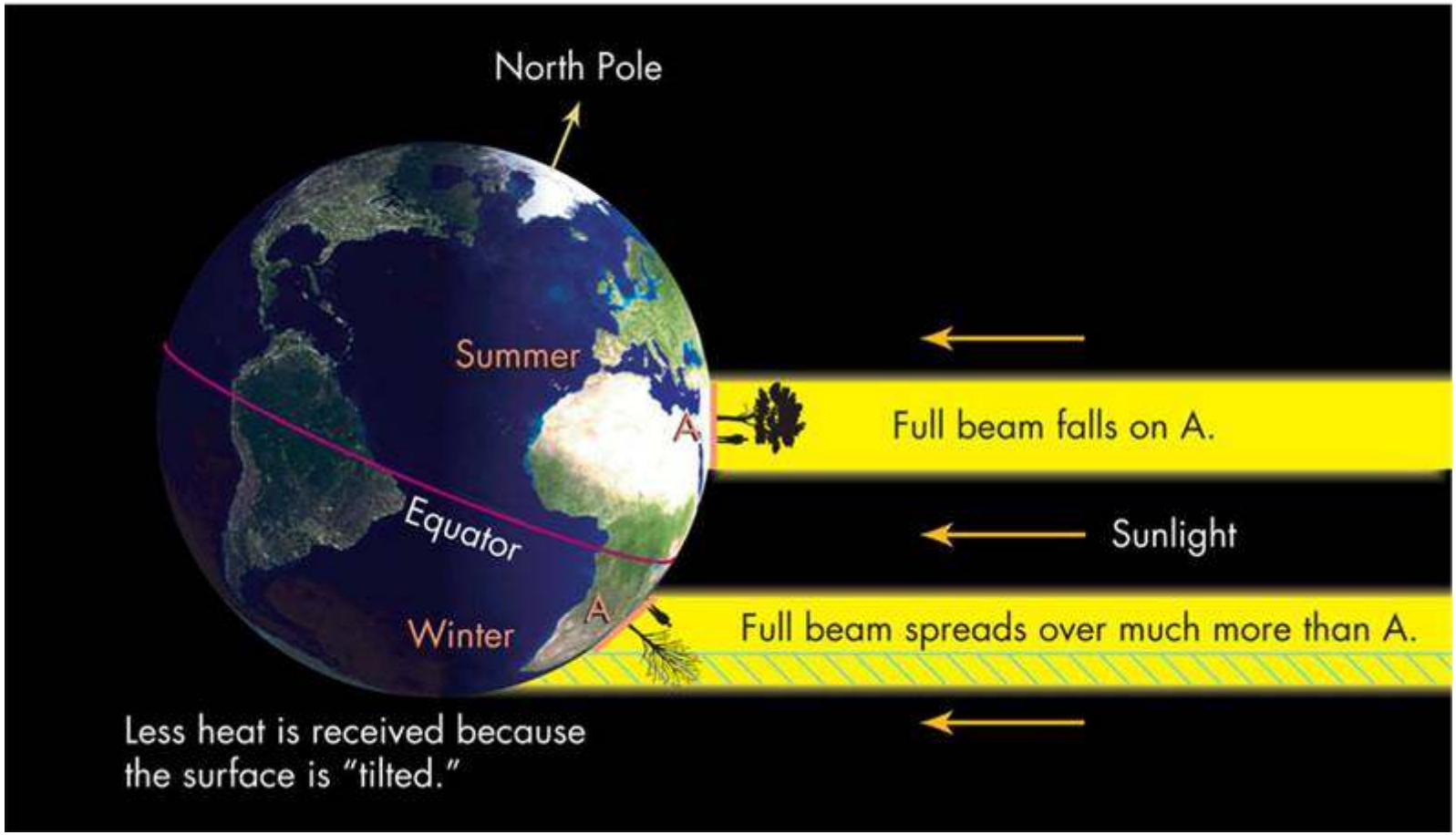
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



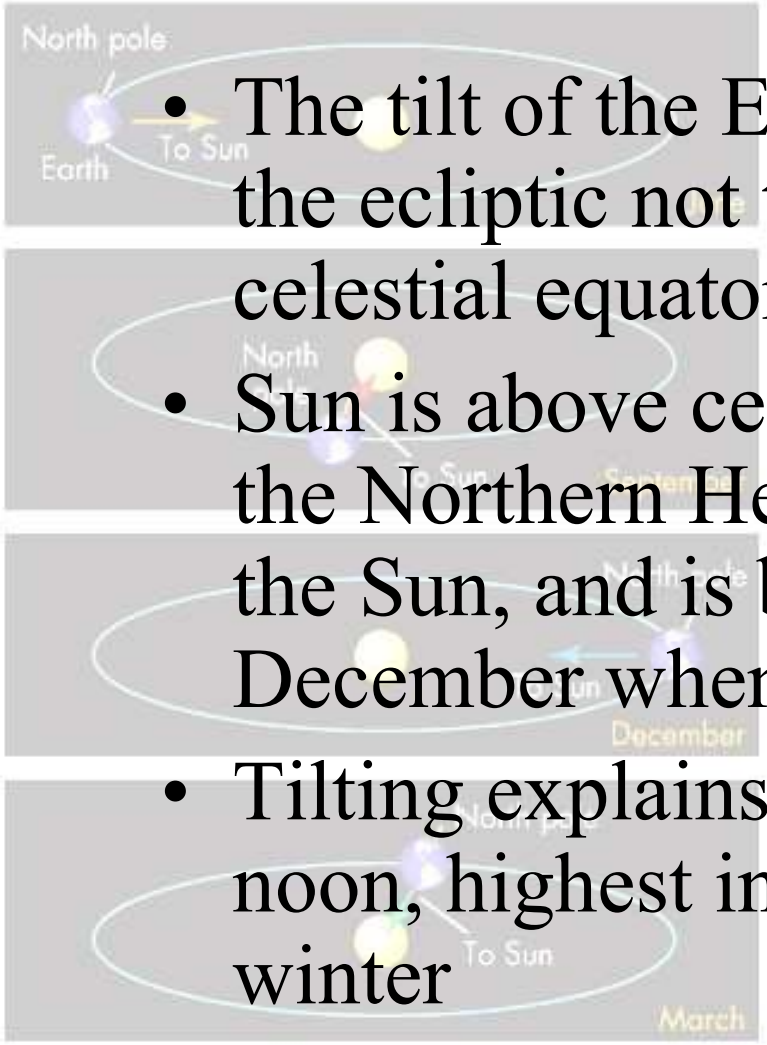
- The rotation axis of the Earth maintains nearly the same tilt and direction from year to year
- The northern and southern hemispheres alternate receiving (on a yearly cycle) the majority of direct light from the Sun
- This leads to the seasons!

The Seasons

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



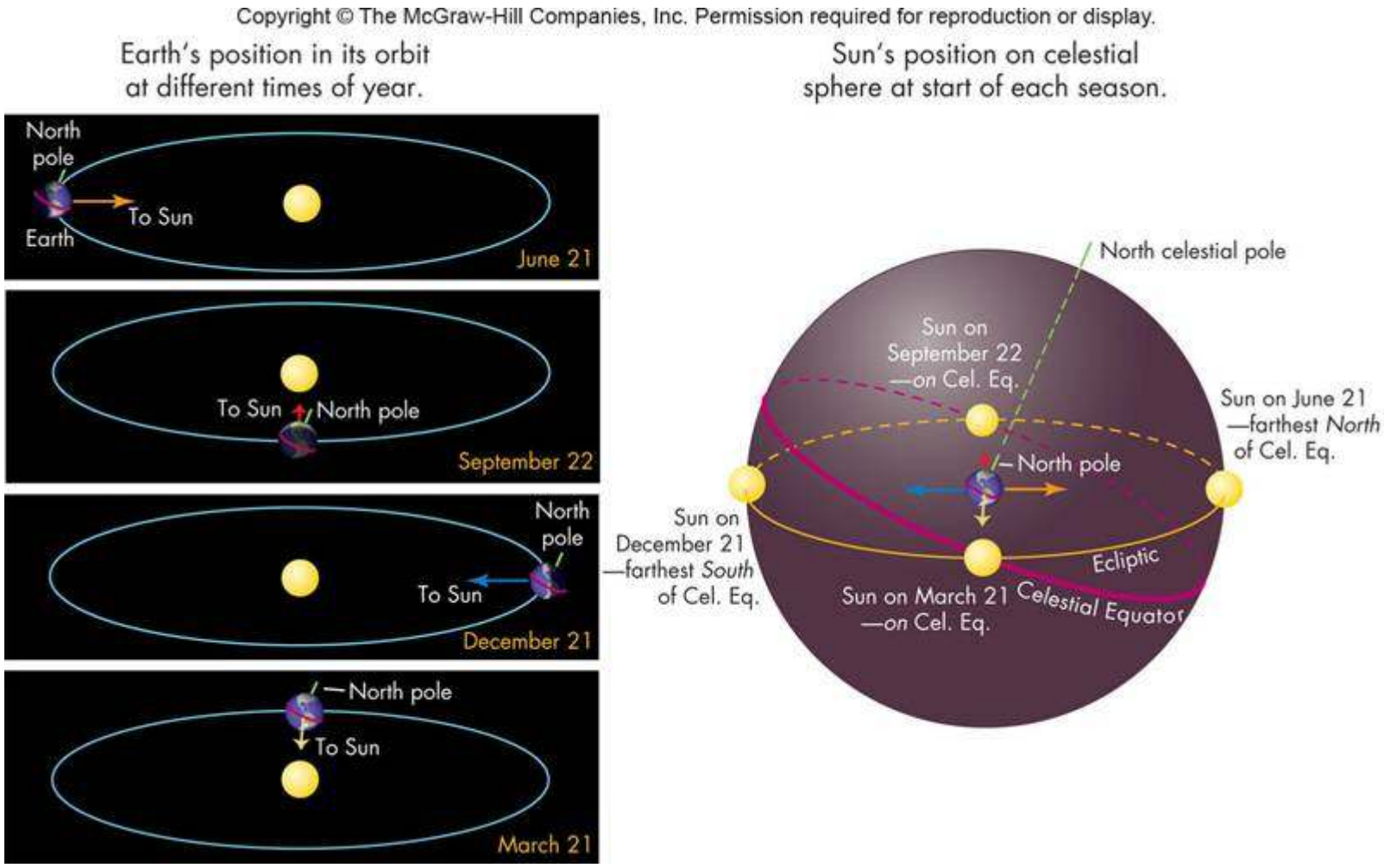
Seasons and The Ecliptic



- 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

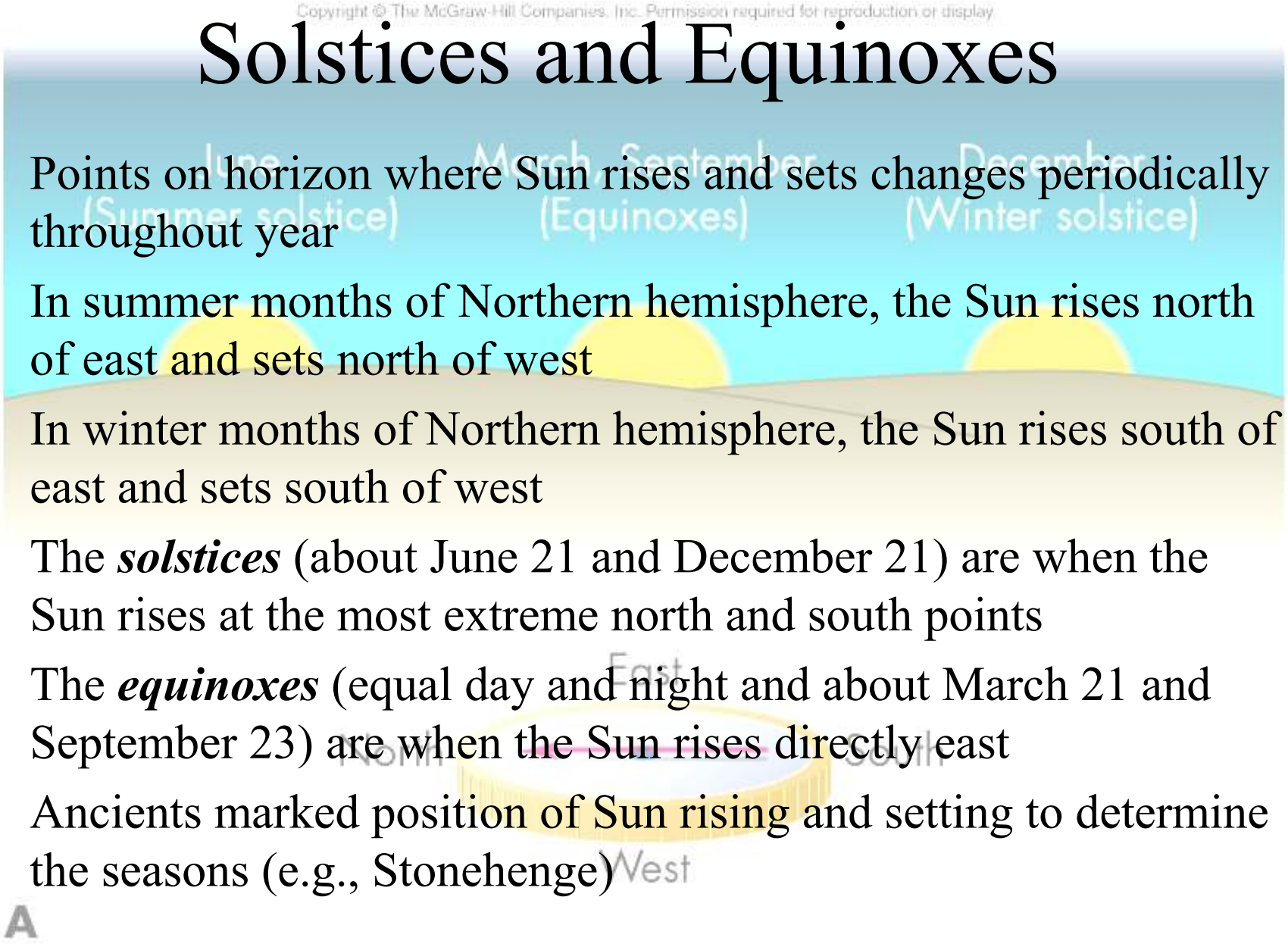
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

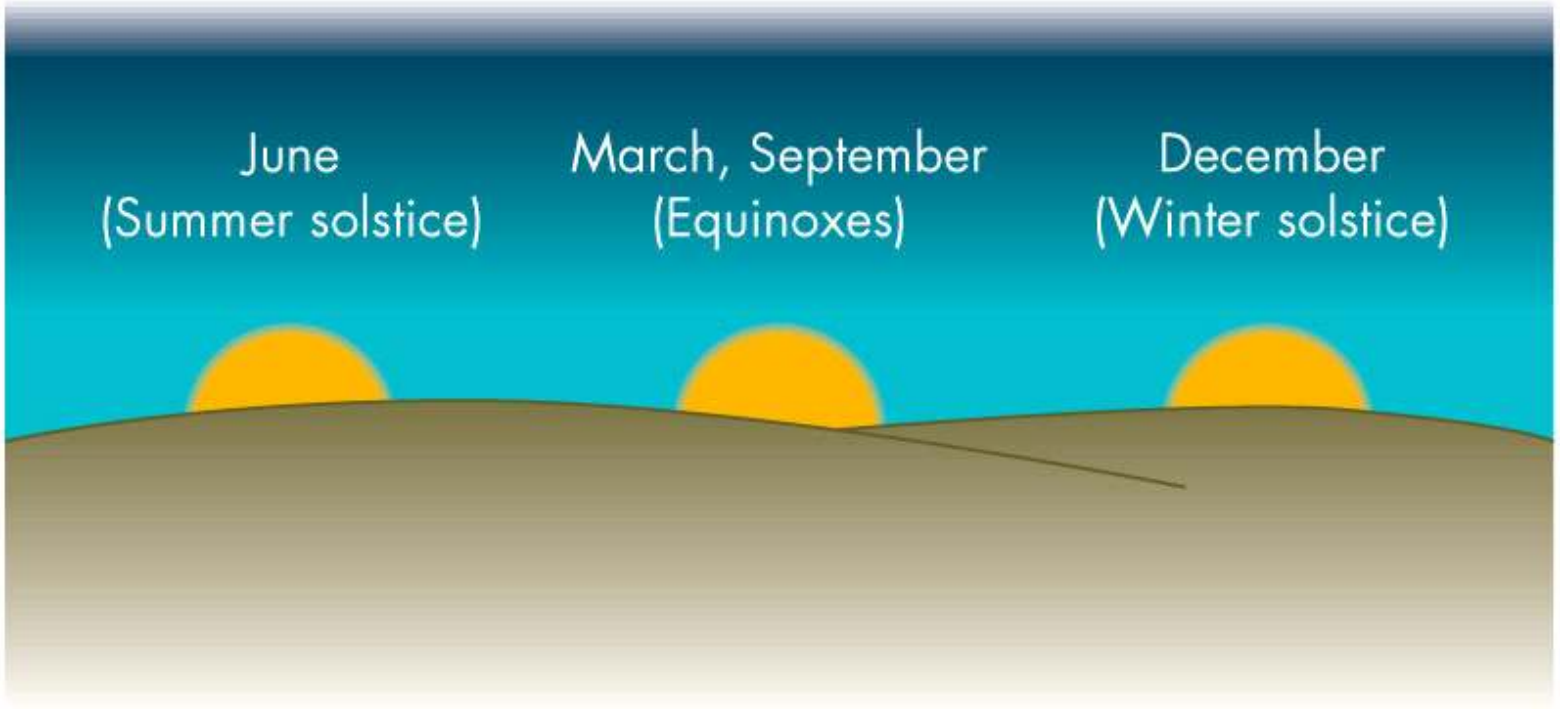
Solstices and Equinoxes

- 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)



Solstices and Equinoxes

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



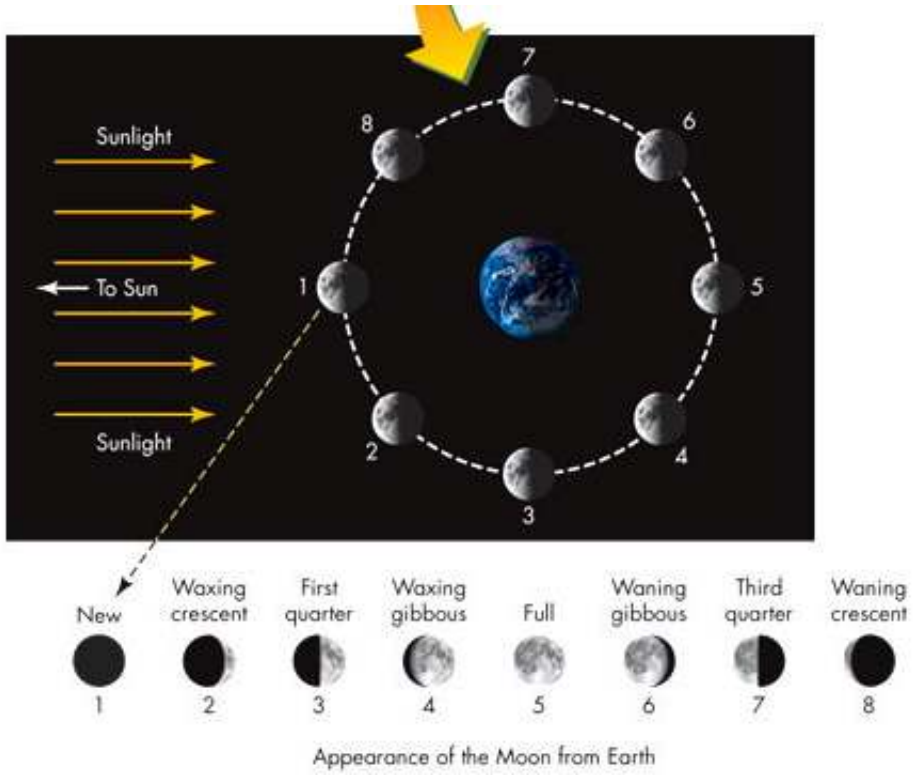
A

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)


Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

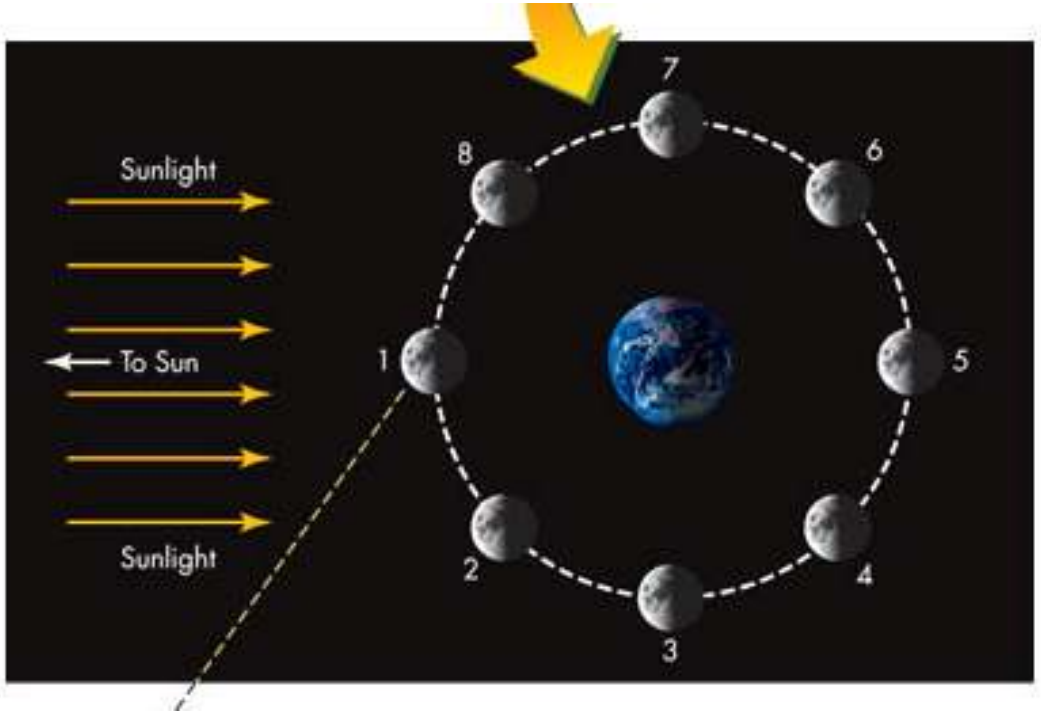
The Phases of the Moon



Appearance of the Moon from Earth

- 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

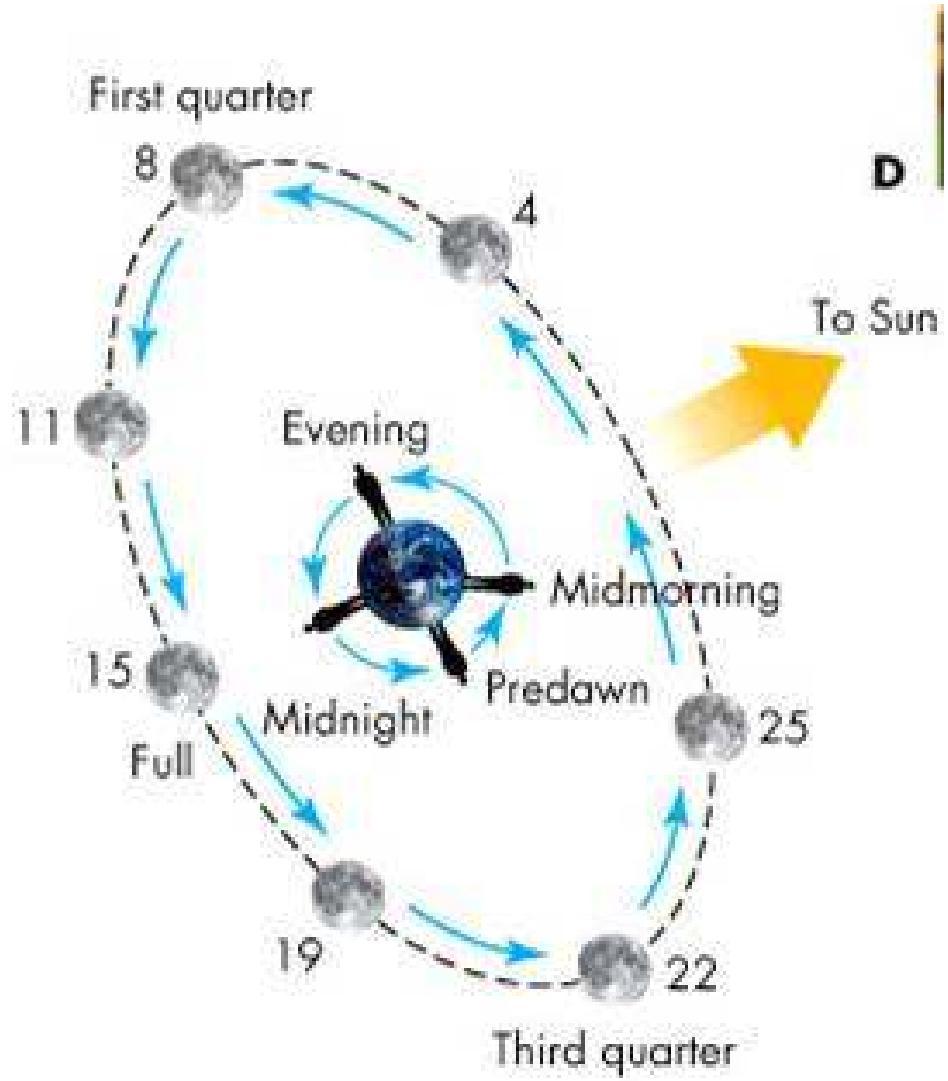
The Phases of the Moon



- 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

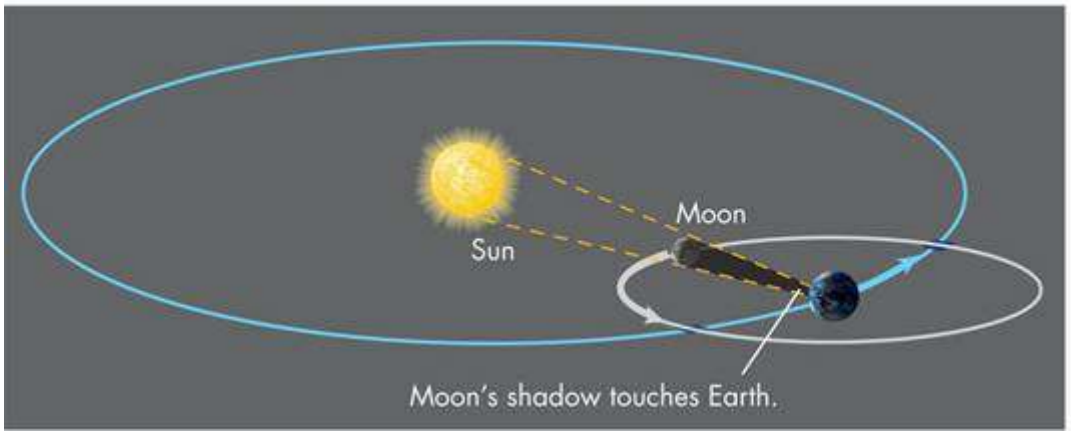
Lunar Rise and Set Times

- The Moon rises roughly 50 minutes later each day



Eclipses

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



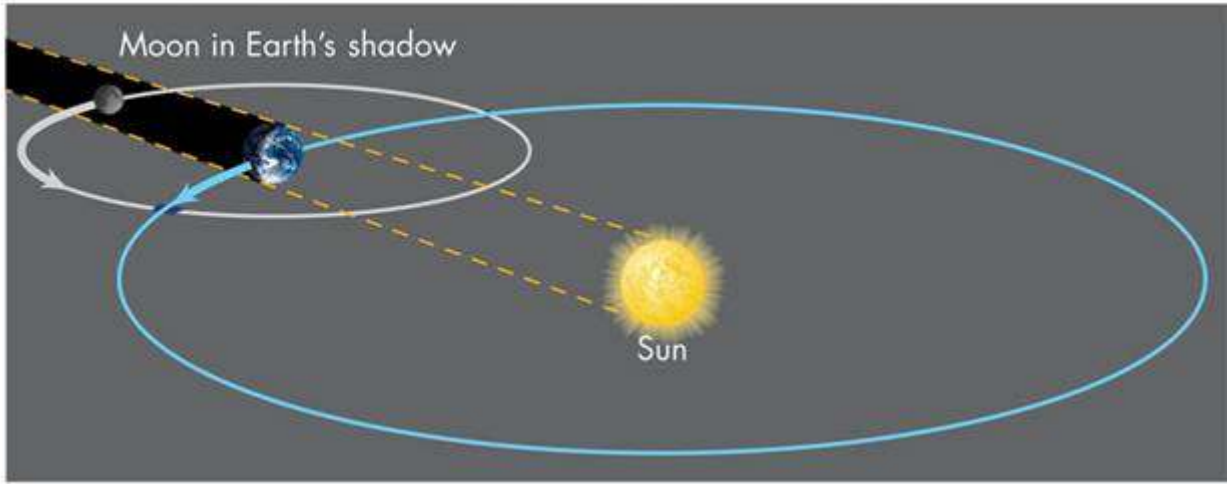
- An ***eclipse*** occurs when the Sun, Earth, and Moon are directly in line with each other
- A ***solar eclipse*** occurs when the Moon passes between the Sun and Earth, with the Moon casting its shadow on the Earth causing a midday sky to become dark as night for a few minutes

Solar Eclipse from Space

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

Lunar Eclipses

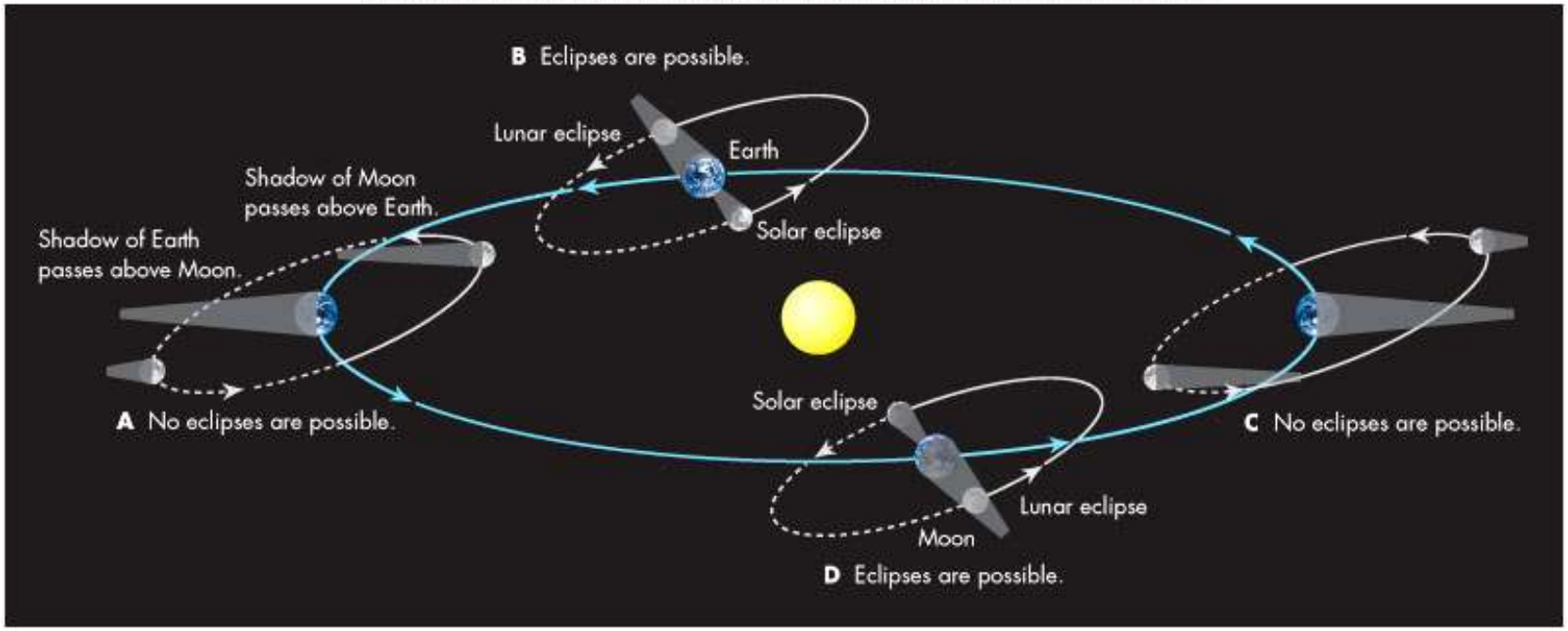
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



- 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

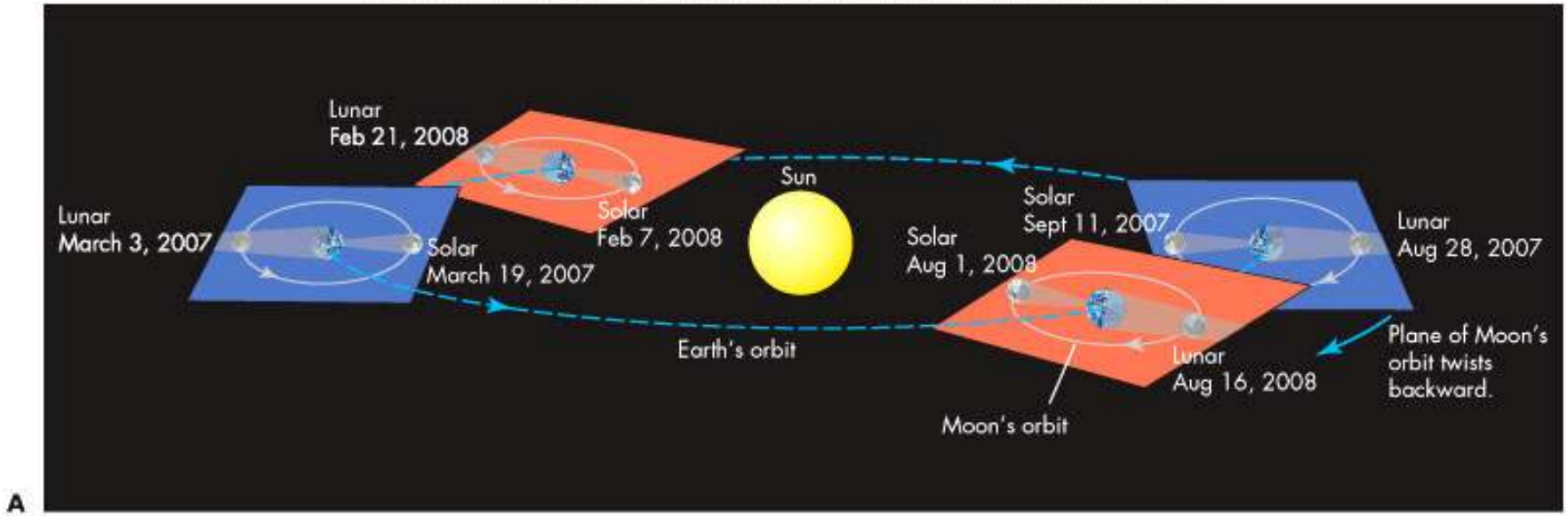
Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



- 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

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

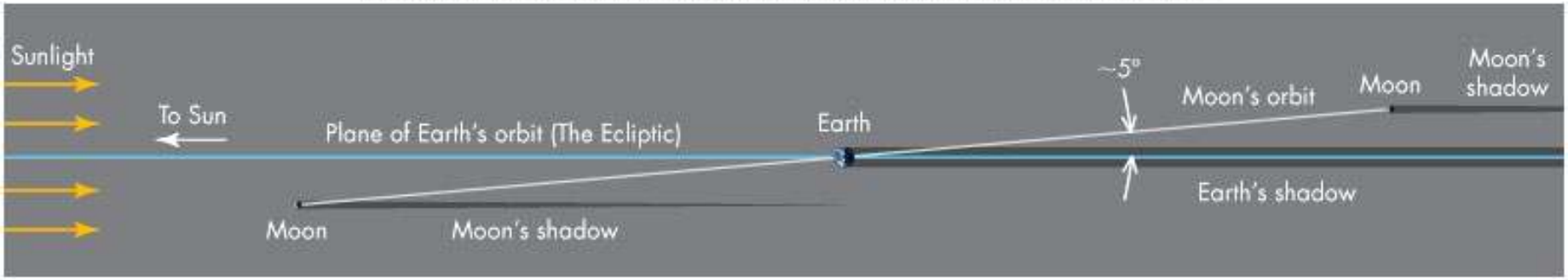


- Since the Moon's orbit tilts nearly in the same direction through the year, twice a year the Moon's orbit will pass through the Sun giving the possibility of an eclipse – these times are called ***eclipse seasons***

- 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

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



- 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

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.