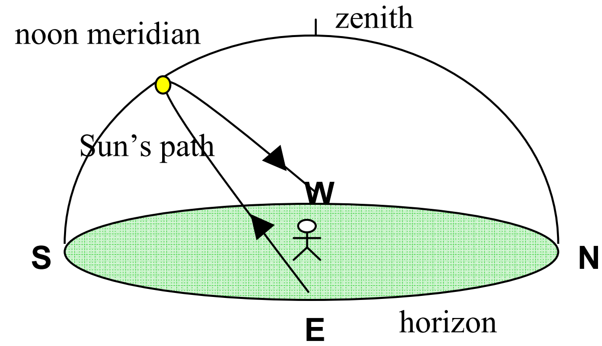
Regents Earth Science – Unit 6: Celestial Motions

Celestial Sphere



Celestial Object – any object outside Earth's atmosphere (in space)

– ex.: moon, Sun, planets, stars

Celestial Sphere – a model used to represent the real sky with the Earth at the center of the model

- used to help visualize the position and movement of the Sun, moon and stars

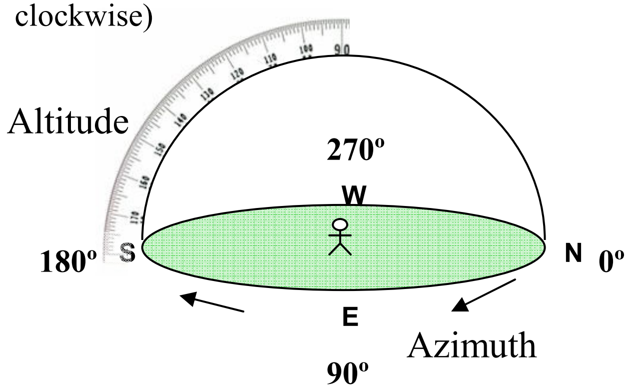
Horizon – boundary between the sky and Earth

Zenith – highest point in the sky; point directly above an observer on Earth (90º altitude)

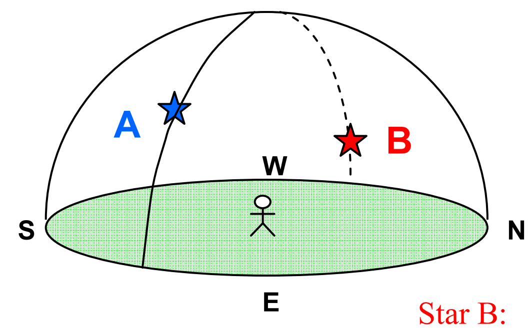
Noon Meridian – meridian the Sun is on at noon

Altitude - angular distance above the horizon (measured in degrees)

Azimuth - angular distance along the horizon (measured from North clockwise)



Example: What is the altitude and azimuth of star A and star B?



Star A:

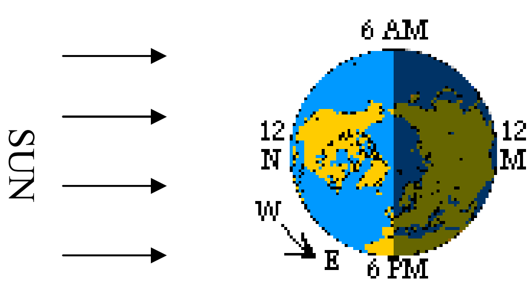
altitude = 45º, azimuth = 120º

Star B:

altitude = 15º, azimuth = 310º

Earth's Rotation

Rotation – the spinning of a celestial object (such as Earth) on an imaginary line called an **axis**



- Earth rotates counterclockwise once every 24 hours
- rate of rotation:

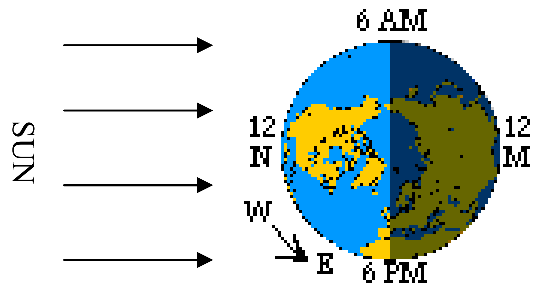
$$R = \frac{360^\circ}{24 \text{ hours}}$$

$$R = 15^\circ/\text{hour}$$

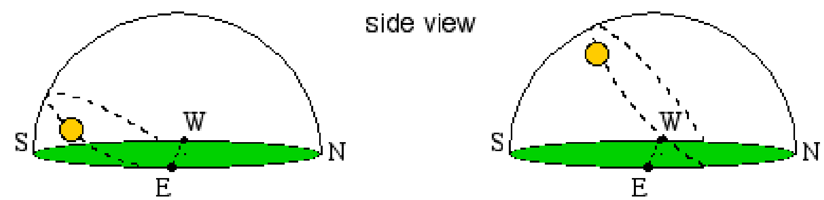
Earth's Rotation

Effects of Earth's Rotation:

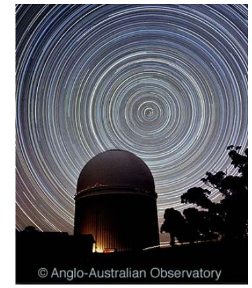
1. Day and Night



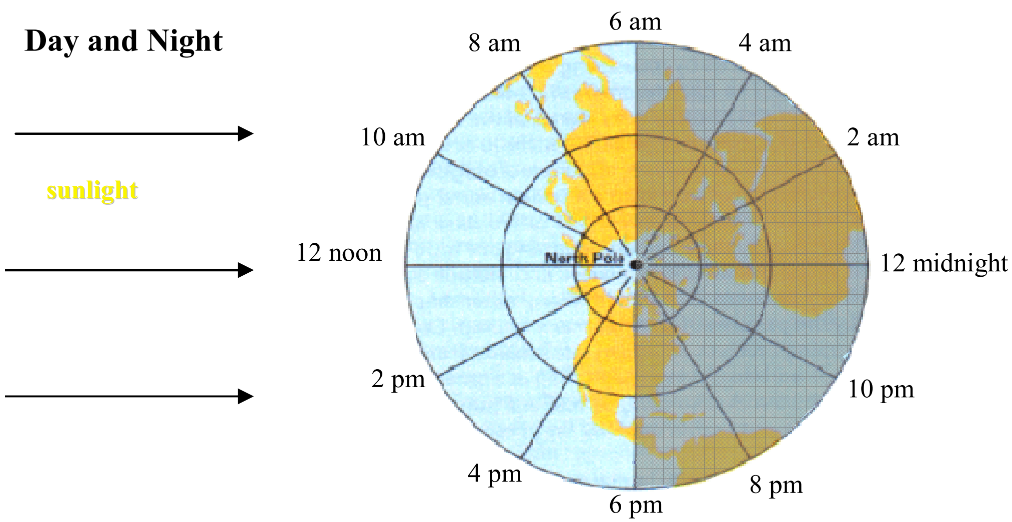
2. Apparent Motion of the Sun



3. Apparent Motion of the Stars



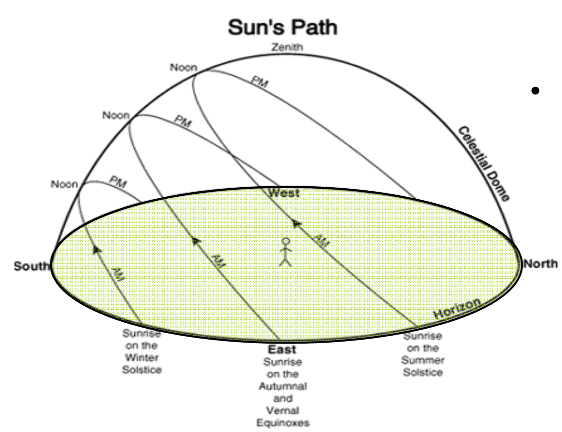
Day and Night



- the rotation of the Earth causes half the Earth to be "lit-up" by the Sun, the other half is in shadow

Apparent Motion of the Sun – the Sun appears to rise in the eastern part of the sky and moves up an arc in the south sky to its highest point in the sky at noon

- Sun's path in the sky is called the **ecliptic**
- the Sun then moves in an arc down towards the western horizon where it sets
- the sun appears to move at a rate of 15º/hour on its path in the sky during every season

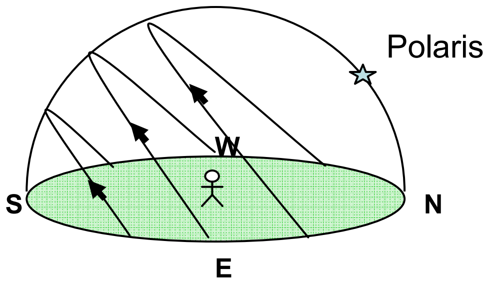


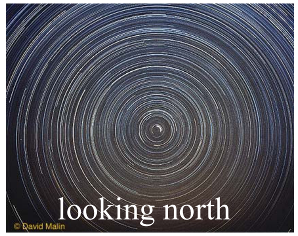
- the tilt of the Earth on its axis causes the Sun's rising and setting positions to change during different seasons

the sun is **NEVER** directly overhead in NYS - it is **ALWAYS** due south at solar noon

Earth's Rotation

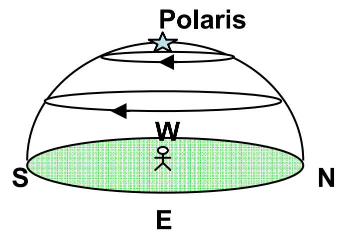
Apparent Motion of the Stars – the paths of stars ("star trails") appears different when looking at different parts of the sky



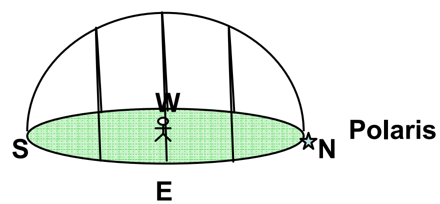


The apparent **daily motion** (motion of celestial objects during the course of a day) changes with the observer's latitude:

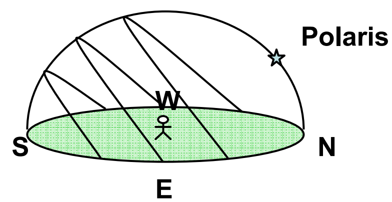
- 90º N (north pole):



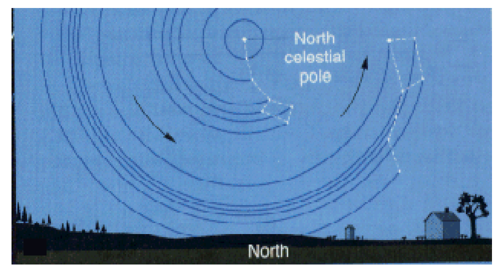
- 0º (equator)

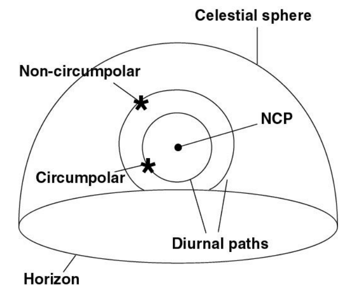


- 43ºN (New York)



Circumpolar Stars – stars that never rise or set; stars that are always above the horizon



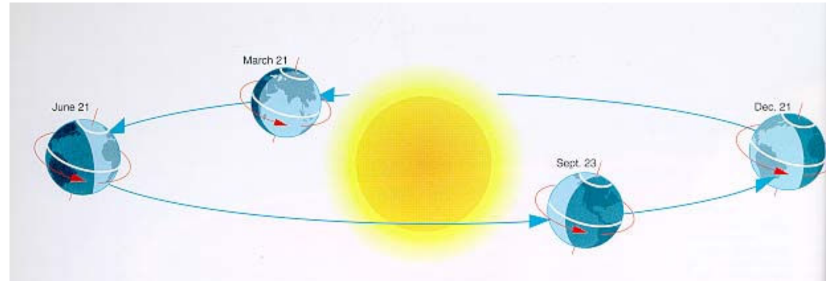


- in NYS, only the stars seen circling the North Star are circumpolar
- at the equator, no stars are circumpolar
- at the poles, all stars are circumpolar

Earth's Revolution

Revolution – the orbiting of one celestial object (Earth) around another celestial object (Sun)

- Rate of Earth's Revolution around Sun:
  one complete orbit (circle) = 360º
  365 day in one Earth year

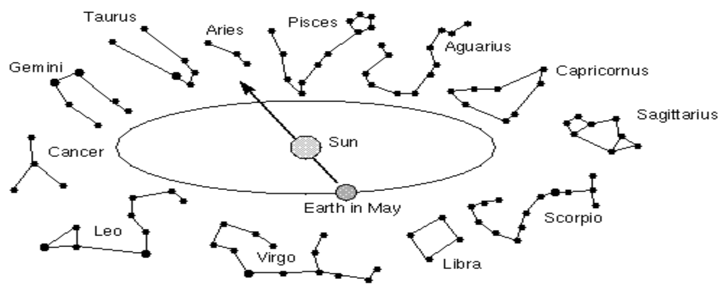


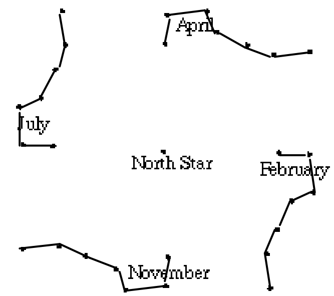
$$R = \frac{360^\circ}{365 \text{ days}}$$

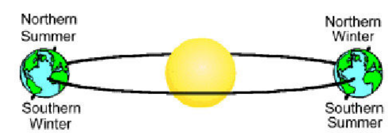
$$R = 1^\circ/\text{day around the Sun}$$

Effects of Earth's Revolution around the Sun:

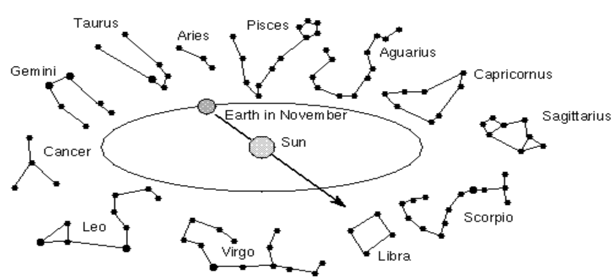
1. Constellations seen at night change in a yearly cycle
2. Position of the Big Dipper changes in a yearly cycle
3. Seasons

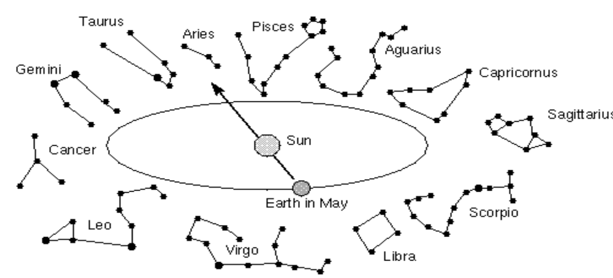






Constellations seen at night change in a yearly cycle – as earth revolves around the Sun, the nighttime side of the Earth faces different constellations at different seasons

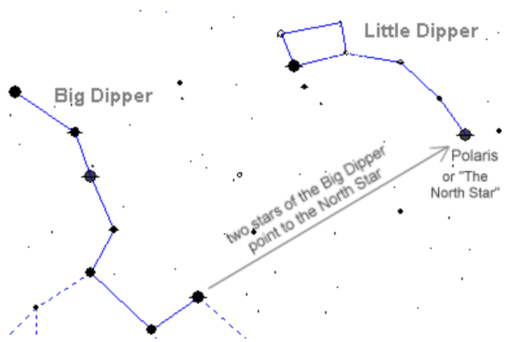




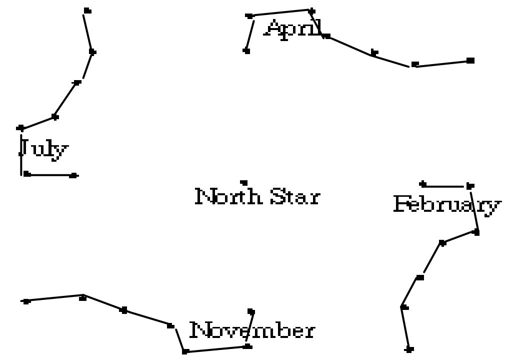
Earth's Revolution

Position of the Big Dipper changes in a yearly cycle – the Big Dipper circles around the North Star (Polaris)

- the Big Dipper is a circumpolar constellation – it never rises or sets – its always above the horizon as seen in NYS

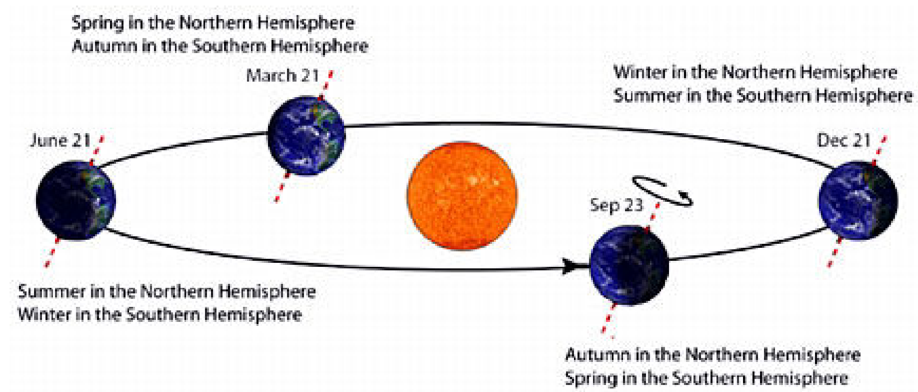


- at 9 pm at the start of each season, the position of the Big Dipper changes



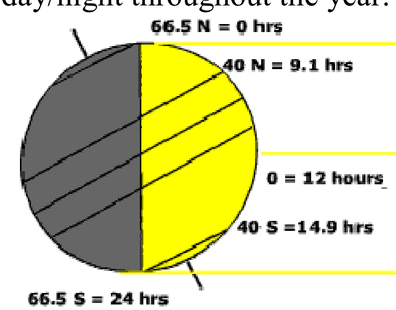
Seasons – the cyclic changes in the Earth's climate as the Earth revolves around the Sun

- yearly cycle: spring, summer fall, winter
- Causes of the Seasons:
  1. Earth's revolution around the Sun
  2. Earth is tilted on its axis of rotation
  3. Earth's axis always points to the same direction in space (parallelism of the Earth's axis)

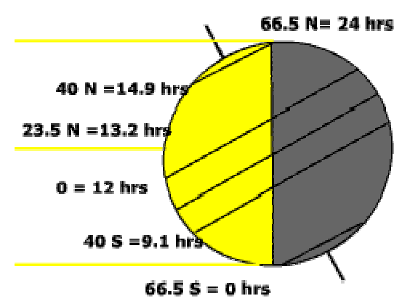


Because the Earth is tilted on its axis by 23 ½ º, as the Earth revolves around the Sun, a direct ray of sunlight will strike the surface of the Earth at different locations depending upon the season of the year

- this leads to the differing amount of day/night throughout the year:



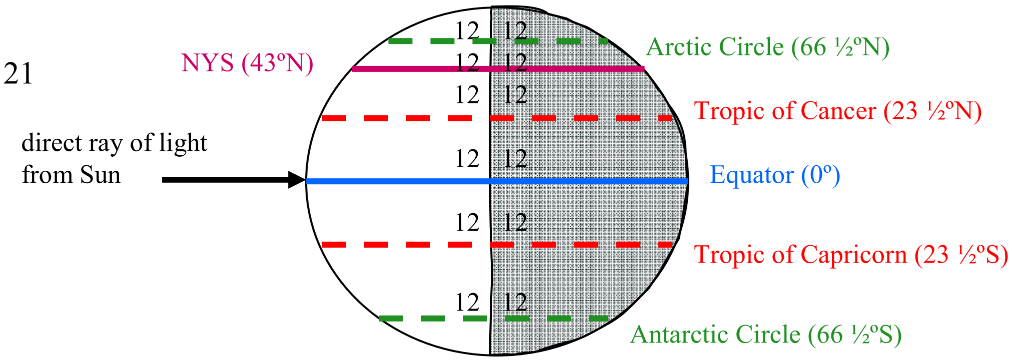
December Solstice



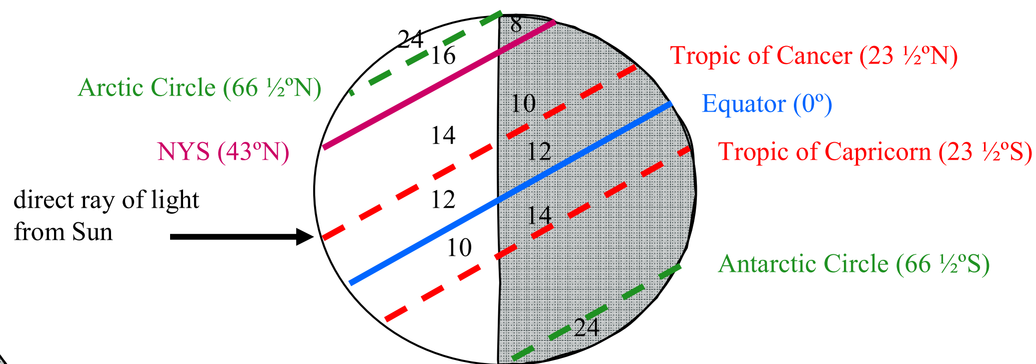
June Solstice

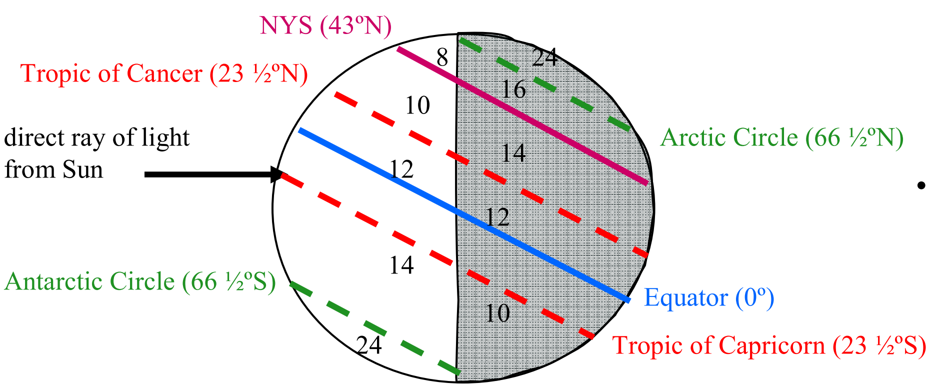
Seasons

- when a direct ray of sunlight strikes the Earth at the Equator (0º), everyone on Earth has 12 hours of day and 12 hours of night
- this occurs twice a year on an **equinox** (**equinox** – equal day/night length)
  - **Vernal** (Spring) **Equinox** – March 21
  - **Autumnal** (Fall) **Equinox** – September 21



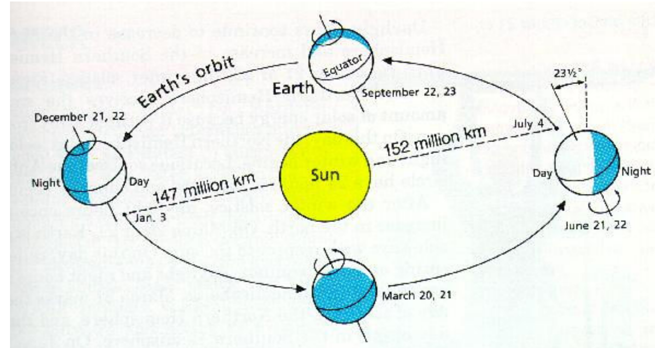
- when a direct ray of sunlight strikes at its highest point in the northern hemisphere, people living at mid to high latitudes in the northern hemisphere will have long days/short nights; in the southern hemisphere, they will have short days/long nights
  - **Summer Solstice** - June 21 — direct rays from the Sun are at their most northern point (23 ½ ºN of the equator)





- when a direct ray of sunlight strikes at its lowest point in the southern hemisphere, people living at mid to high latitudes in the northern hemisphere will have short days/long nights; in the southern hemisphere, they will have long days/short nights
  - **Winter Solstice** - December 21 – direct rays from the Sun are at their most southern point (23 ½ ºS of the equator)

Seasons



The seasons are **NOT** caused by the Earth's distance to the Sun

- the Earth is closer to the Sun in the wintertime in the northern hemisphere (Jan. 3)
- the Earth is further to the Sun in the summertime in the northern hemisphere (July 4)

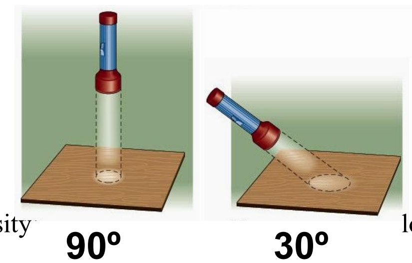
Insolation

Insolation – **IN**coming **SOL**ar radi**ATION** – light from the sun that reaches the Earth

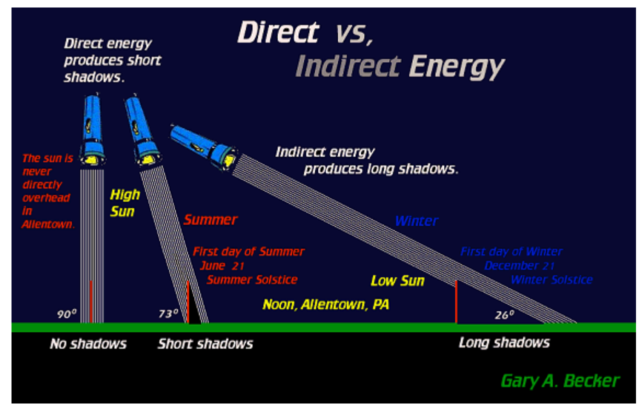
Angle of Insolation – the angle sunlight strikes the surface of the Earth

- as the angle of insolation increases, the intensity of insolation increases:

high angle = high intensity

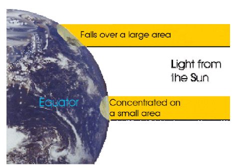


low angle = low intensity

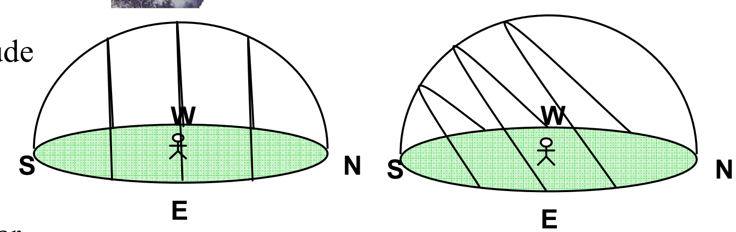


Factors that Effect Intensity of Insolation:

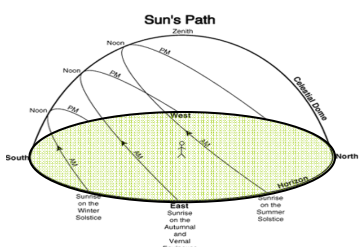
1. Shape of the Earth



2. Observer's Latitude



3. Season of the Year



4. Time of Day

Insolation

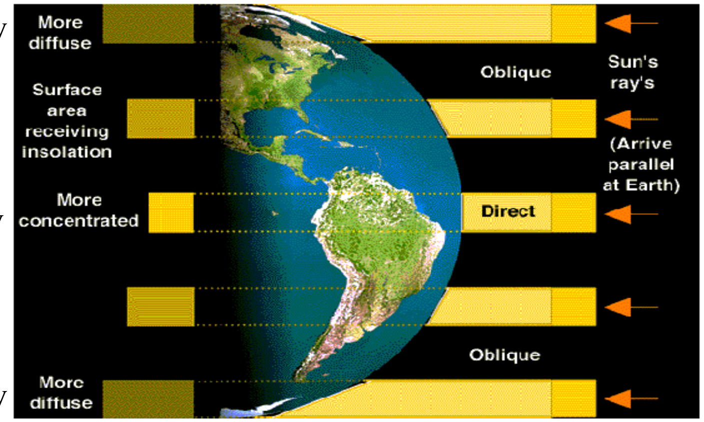
Shape of the Earth – the Earth is spherical – light from the Sun will hit the Earth at different angles depending on the latitude of the observer

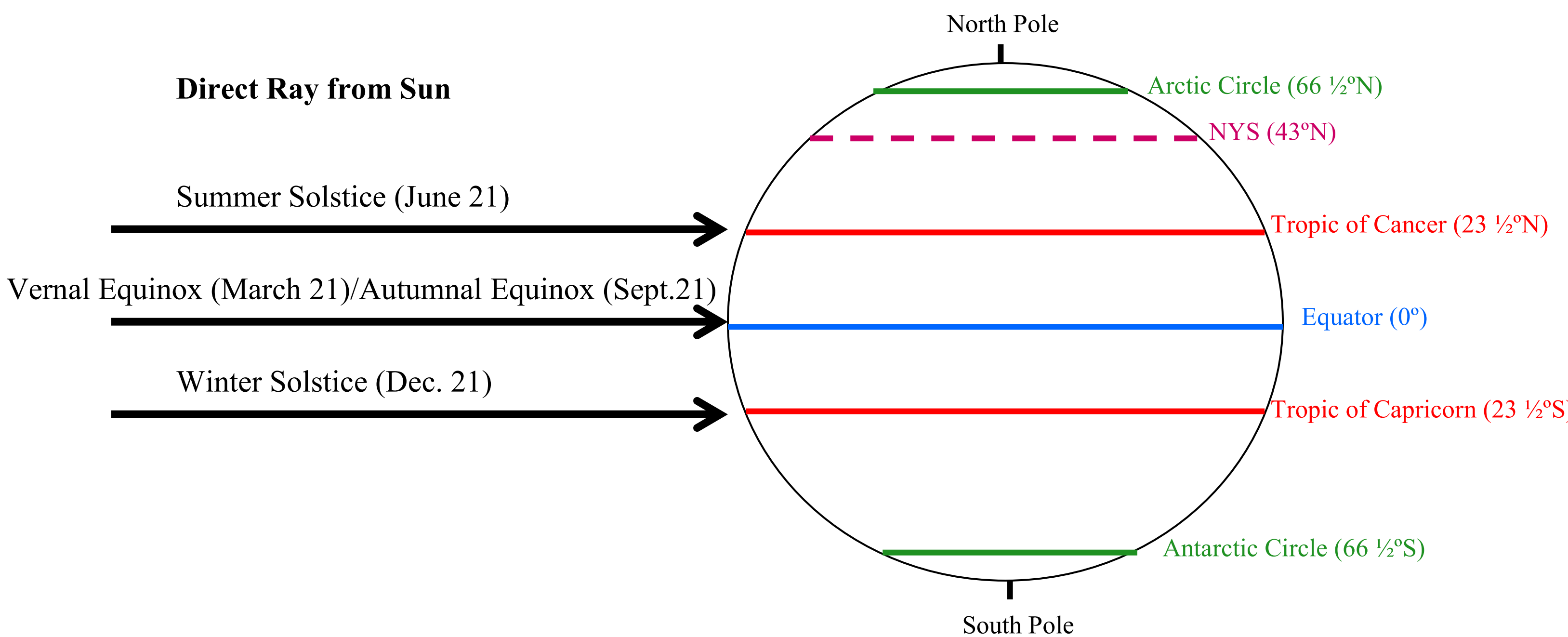
- as latitude increases, the angle of insolation decreases, and the intensity of insolation decreases

High Latitudes = low angle, low intensity

Low Latitudes = high angle, high intensity

High Latitudes = low angle, low intensity

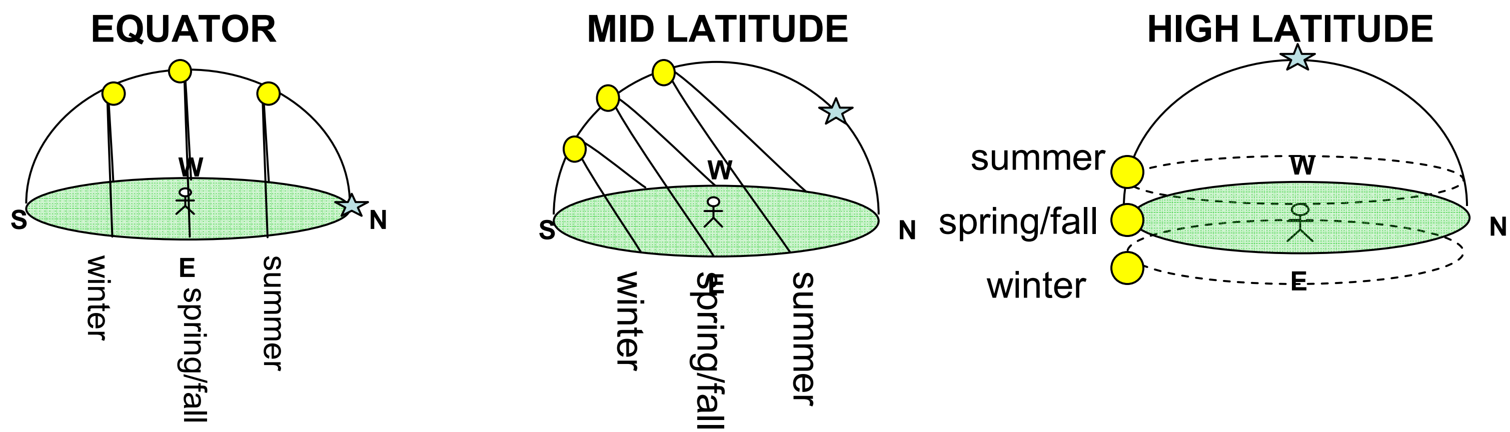




Insolation

Observer's Latitude – the path the Sun takes in the sky depends upon the observer's latitude

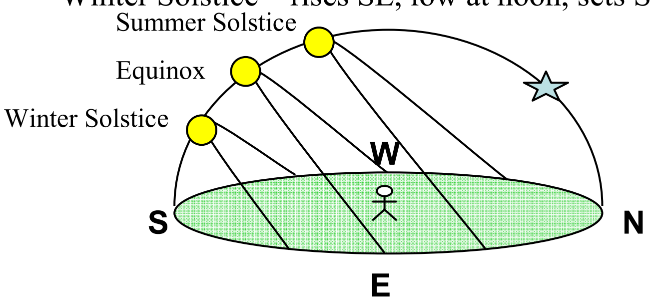
- at low latitudes, the Sun is always high in the sky year round
- at mid latitudes, the Sun is high in the sky in the summer (never overhead) and low in the sky in the winter
- at high latitudes, the Sun is always low in the sky year round

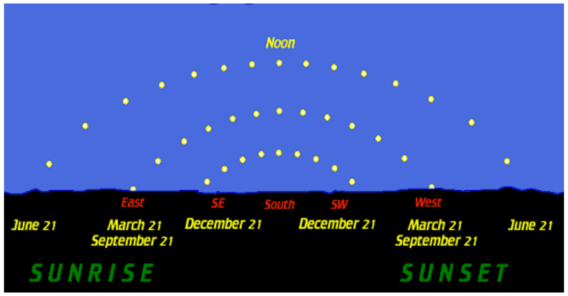


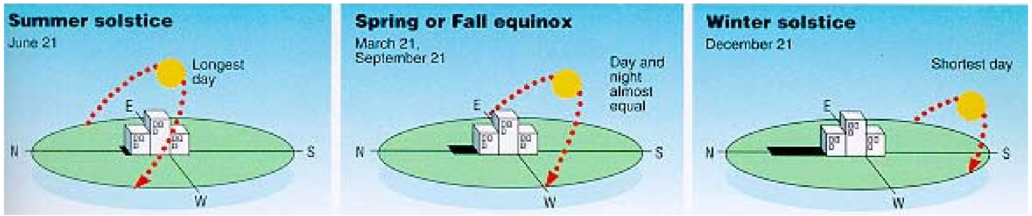
Season of the Year – direct rays of light from the Sun migrate from the Tropic of Cancer (June 21) to the Tropic of Capricorn (Dec. 21) and back again

- this changes the apparent path the sun takes during the year:

- Summer Solstice - rises NE, high at noon, sets NW
- Equinoxes – rises due E, mid-height at noon, sets due W
- Winter Solstice – rises SE, low at noon, sets SW





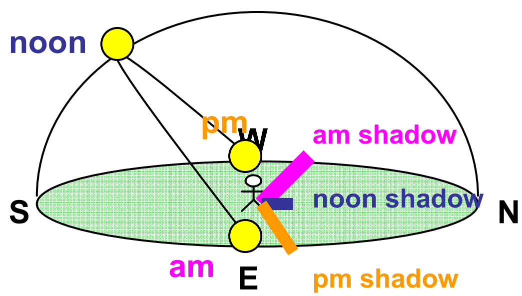


- the Sun is at its highest point during the day at noon
- the noon Sun is highest on the Summer Solstice (shadows are short) and lowest on the Winter Solstice (shadows are long)

Insolation

Time of Day – the Sun is low in the sky in the morning and evening (low angle of insolation, low intensity)

- at noon, the Sun is at its highest point of the day (highest angle of insolation, highest intensity)



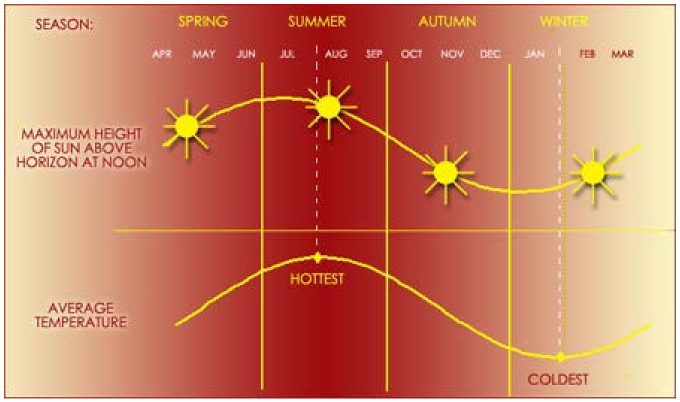
- shadows are longest when the Sun is lowest in the sky
- shadows are shortest when the Sun is highest in the sky

Duration of Insolation – how long the Sun is above the horizon

- in summer, the Sun is high in the sky and the days are long (long duration of insolation); the Earth receives energy from the Sun for a long period of time
- long days + Sun high in sky = WARM DAYS
- in winter, the Sun is low in the sky and the days are short (short duration of insolation); the Earth receives energy from the Sun for a short period of time
- short days + Sun low in sky = COLD DAYS
- when the Sun is above the horizon, the Earth's surface heats up – the higher and longer the Sun is in the sky, the greater the intensity and amount of insolation

Temperature Lag – the maximum temperatures occur *after* greatest intensity of insolation – the minimum temperatures occur *after* minimum intensity of insolation

- this lag between the Sun's strength and the actual temperatures experienced is caused by the time needed to heat (or cool) the Earth's surface
- temperature increases when the amount of energy received is greater than the amount of energy lost
- temperature decreases when the amount of energy received is less than the amount of energy lost
  - the warmest part of a day is in the late afternoon (max. insolation occurs at noon)
  - the coldest part of the day is in the early morning (min. insolation occurs at midnight)
  - the warmest days of the year are in July (max. insolation occurs June 21)
  - the coldest days of the year occur in January (min. insolation occurs Dec. 21)



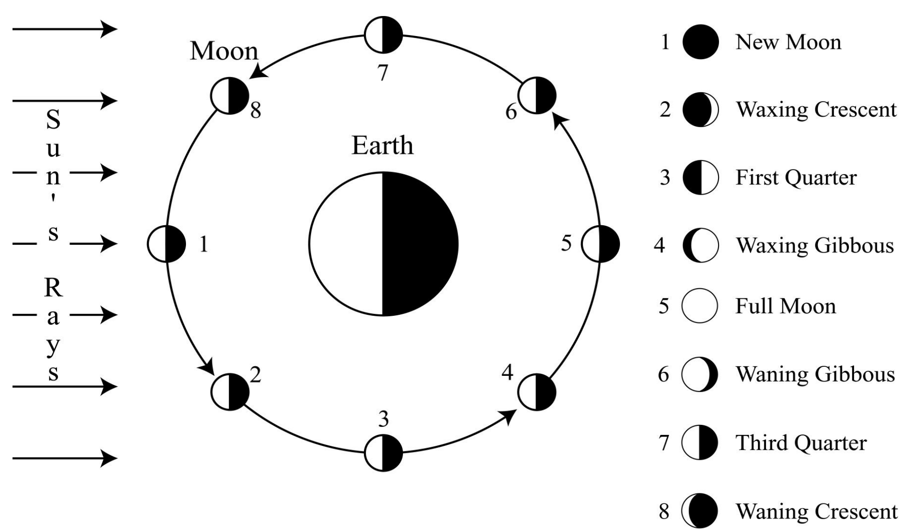
Seasons - Summary

Season	Sunrise	Sunset	Noon Sun Altitude	Angle of Insolation	Insolation Intensity	Length of day	Vertical Ray
Mar 21 Vernal Equinox	Due E	Due W	midway 47°	medium	moderate	Equal 12 day 12 night	Equator
June 21 Summer Solstice	NE	NW	high 71°	high	high	Long 15 day 9 night	Tropic of Cancer
Sept. 21 Autumnal Equinox	Due E	Due W	midway 47°	medium	moderate	Equal 12 day 12 night	Equator
Dec. 21 Winter Solstice	SE	SW	Low 23°	medium	moderate	Short 9 day 15 night	Tropic of Capricorn

Phases of the Moon

Phases of the Moon – caused by the moon's **revolution** (orbit) around the Earth

- the moon gives off no light of its own – it reflects the Sun's light off its surface
- we see the changing illuminated part of the moon's surface that is facing the Earth as the moon moves around the Earth



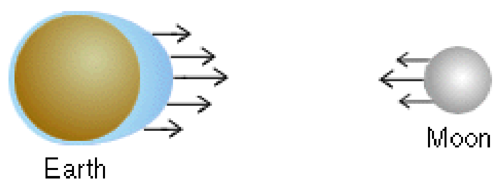
Tides

Tides – the cyclic changing height of the ocean caused by the moon's gravitational pull as it revolves around the Earth

Bay of Fundy – Nova Scotia, Canada

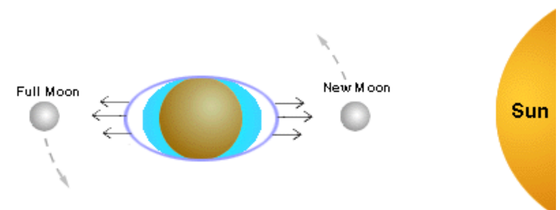
- if there were no moon (or Sun) the ocean waters would all be at the same height everywhere on earth at all times

- but there is a moon and its gravity pulls on the Earth causing the ocean waters (liquid) to rise or bulge in the direction of the moon – this bulge also occurs on the opposite side of the Earth from the moon (due to centrifugal force)



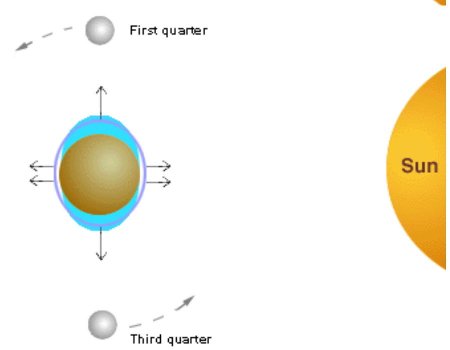
Spring Tides – occurs at New Moon and Full Moon

- these are the highest high tides and the lowest low tides due to the influence of the Sun's gravitational pull in the same direction as the moon's gravity



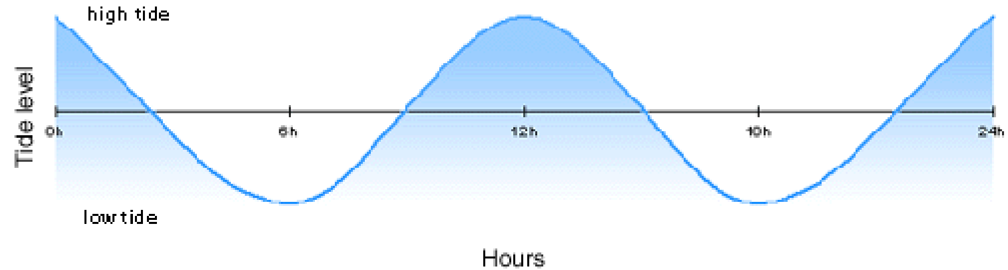
Neap Tides – occurs at 1st Quarter Moon and 3rd Quarter Moon

- these are the lowest high tides and the highest low tides due to the influence of the Sun's gravitational pull at a right angle to the moon's gravity



Tides

- a given place on will experience two high and two low tides a day – due to the gravitational bulge of the ocean towards the moon and the centrifugal bulge on the opposite side
- the tides are cyclic – to go from high tide to low tide back to high tide takes 12 hours 25 minutes
- tides are predictable



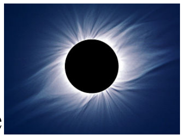
Eclipses

Eclipse – the blocking of one celestial body by another celestial body

- Types of Eclipses:

1. Lunar Eclipse

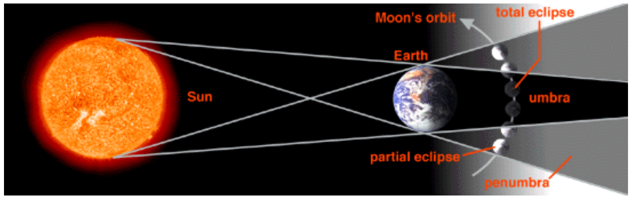
2. Total Solar Eclipse



3. Annular Solar Eclipse

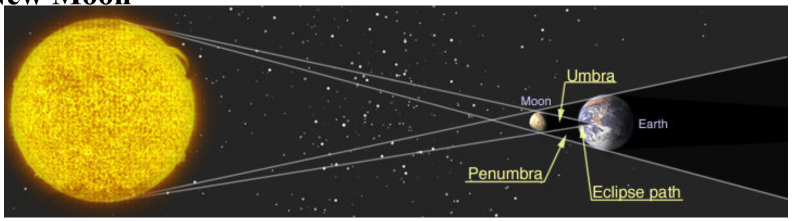
Lunar Eclipse – the Earth blocks the Sun's light to the moon

- two types of shadow are produced in an eclipse:
  - **umbra** - the eclipse is total
  - **penumbra** - where the eclipse is partial
- when the moon enters the Earth's umbra, we see the shadow of the Earth on the moon
- during a total lunar eclipse, the moon will look a deep red
- occurs only during a **Full Moon**

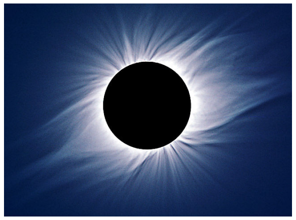


Total Solar Eclipse – the moon completely blocks the Sun's light to the Earth

- the moon by coincidence happens to be the same angular size in the sky as the Sun – it can completely block the entire face of the Sun
- occurs when the moon is near its closest from the Earth and at a **New Moon**



- a total solar eclipse is only seen in a very small region where the umbra shadow hits the Earth
- the Sun's outer atmosphere (**corona**) can be seen

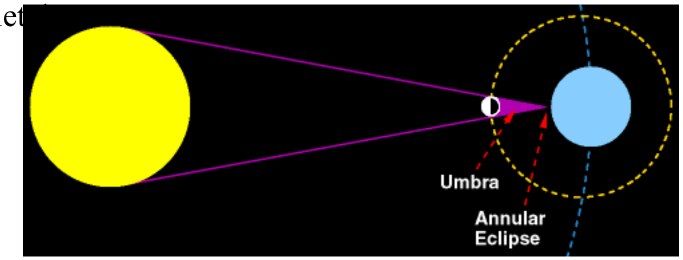


Partial Solar Eclipse is seen in a larger region where the penumbra shadow hits the Earth

Eclipses

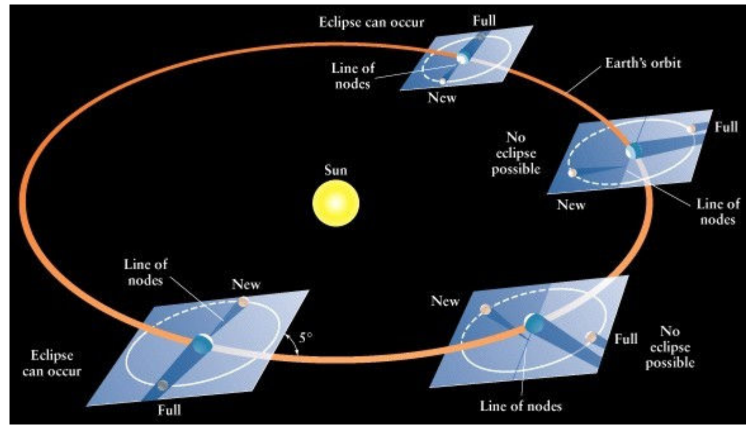
Annular Solar Eclipse – the moon is too far from Earth during a New Moon to complet
block the Sun

- the umbra shadow never reaches the Earth
- the moon is too small as seen from Earth to completely block the Sun so the Sun is seen as a ring



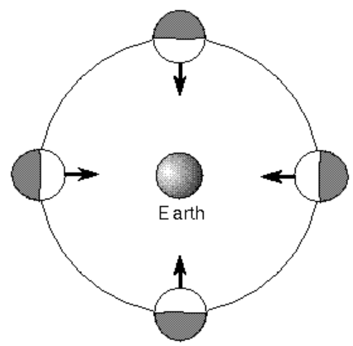
Not every New Moon or Full Moon will produce an eclipse

- the moon orbits the Earth at a angle of 5º
- the shadow produced during an eclipse is usually above or below the Earth during a New Moon or the above or below the moon during a Full Moon



The moon's rate of rotation is the same as its rate of revolution (orbit) around the Earth – 27 1/3 days

- this means that on Earth, the same side of the moon faces us at all times



Moon's rotation period = its orbital period. It keeps one side facing the Earth
We never see far side of Moon (shaded).