EARTH'S MOTION RELATIVE TO THE SUN (Earth-sun Relations)

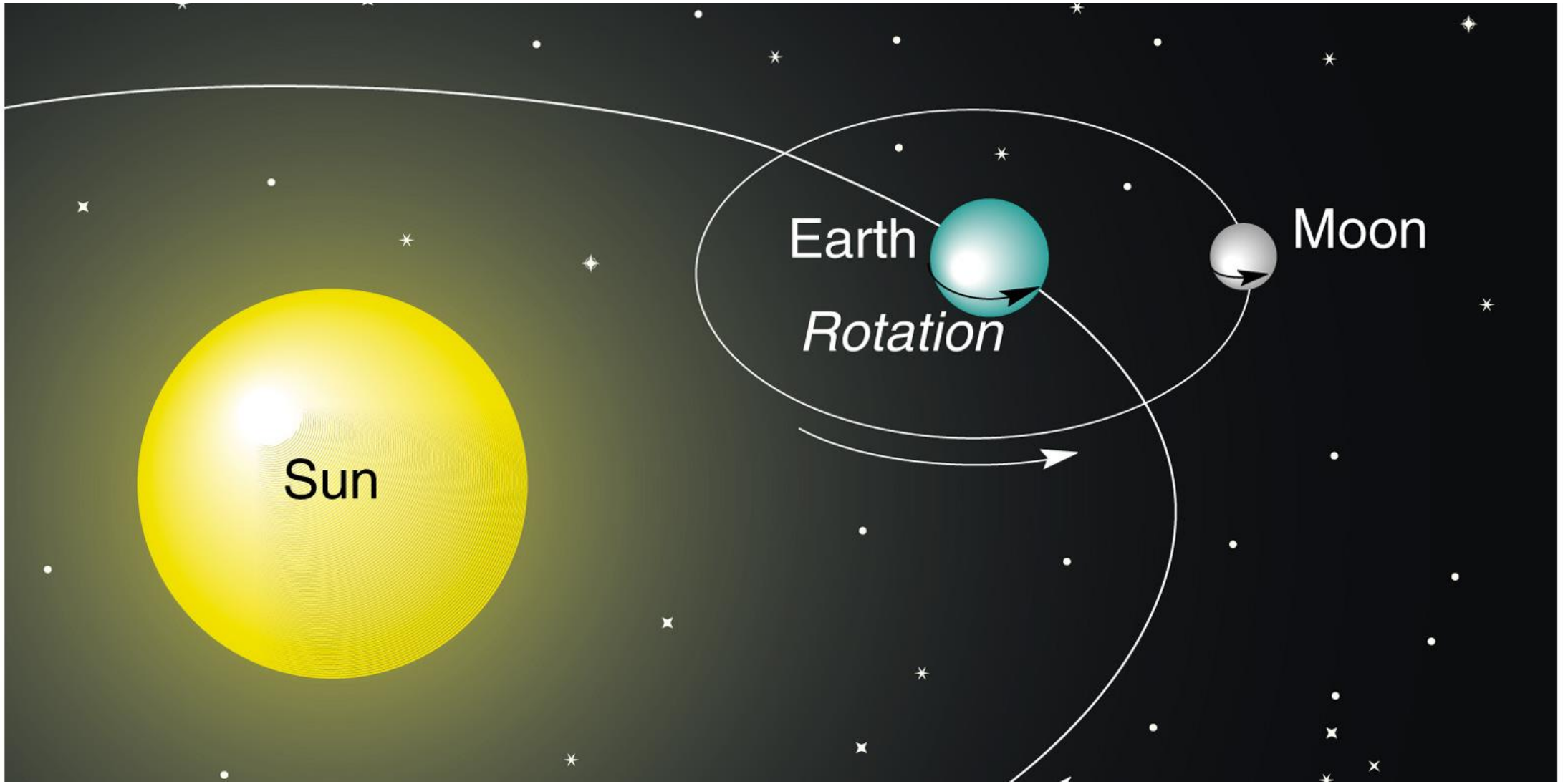
June 7th, 2021

Earth's Motions

•The functional relationship between Earth and the Sun is vital because life on Earth is dependent on solar energy.

•Two basic **Earth** movements are critical for continuously changing the geometric perspective between the Earth and the Sun:

- **Earth's annual revolution around the Sun**
- **Earth's daily rotation on its axis**


Earth
Moon
Rotation
Sun

Rotation

- Earth rotates toward the **east** on its axis, with one complete rotation taking 24 hours = 1 day
- This eastward spin creates an illusion that the celestial bodies are rising in the east and setting in the west.
- Although the speed of rotation varies from place to place, it is constant in any given place, so humans do not experience a sense of motion.
- This rotation has several striking effects on the physical characteristics of Earth's surface:
  - There is an apparent deflection in the flow path of both air and water; called the **Coriolis effect**, it deflects to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.
  - There is a **diurnal** (**daily**) alternation of light and darkness, which in turn influences local temperatures, humidity, and wind movements.

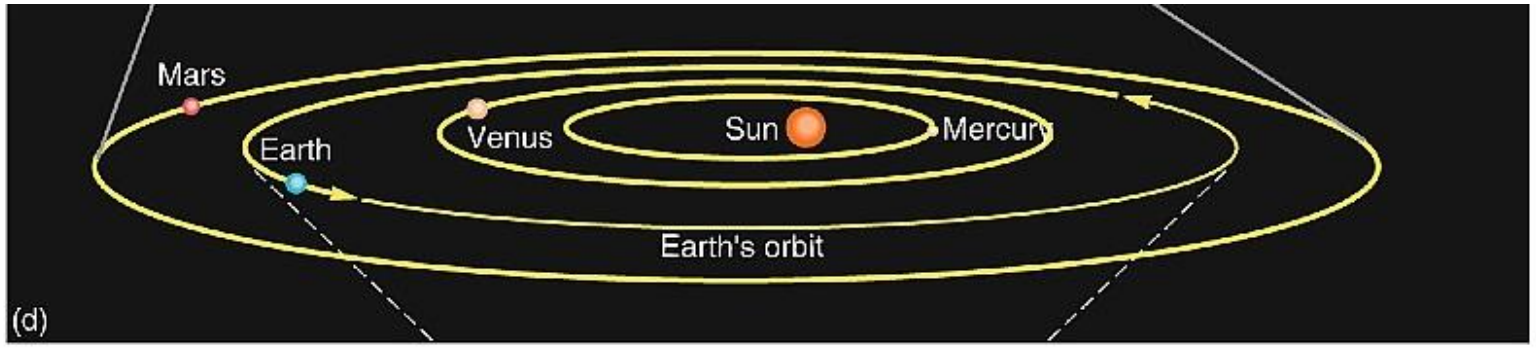
Revolution

Tropical Year: time it takes Earth to complete one revolution around the Sun = 365.25 days.

Earth's revolution is an ellipse, which varies the Earth–Sun distance (i.e. the orbit is not a perfect circle).

The varying distance between Earth and the Sun is NOT an important determinant of seasonal temperature fluctuations, but for climate.

- **PERIHELION**: the point in an orbit that takes a planet nearest to the Sun (for Earth, it is 147,166,480 kilometers or 91,455,000 miles, on January 3).
- **APHELION**: the point in an orbit that takes a planet furthest away from the Sun (for Earth, it is 152,171,500 kilometers or 94,555,000 miles, on July 4).

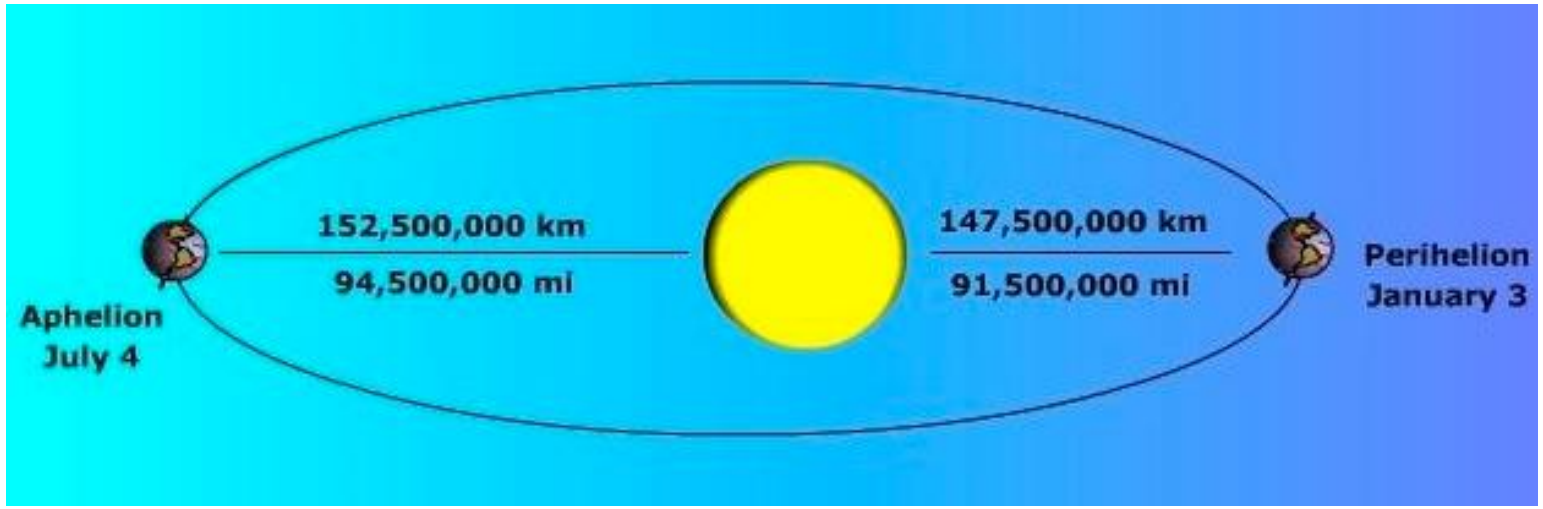


Farthest from Sun—aphelion, July 4
152,083,000 km
(94,500,000 mi)

Sun

Focus of Earth's elliptical orbit

Closest to Sun—perihelion, January 3
147,255,000 km
(91,500,000 mi)



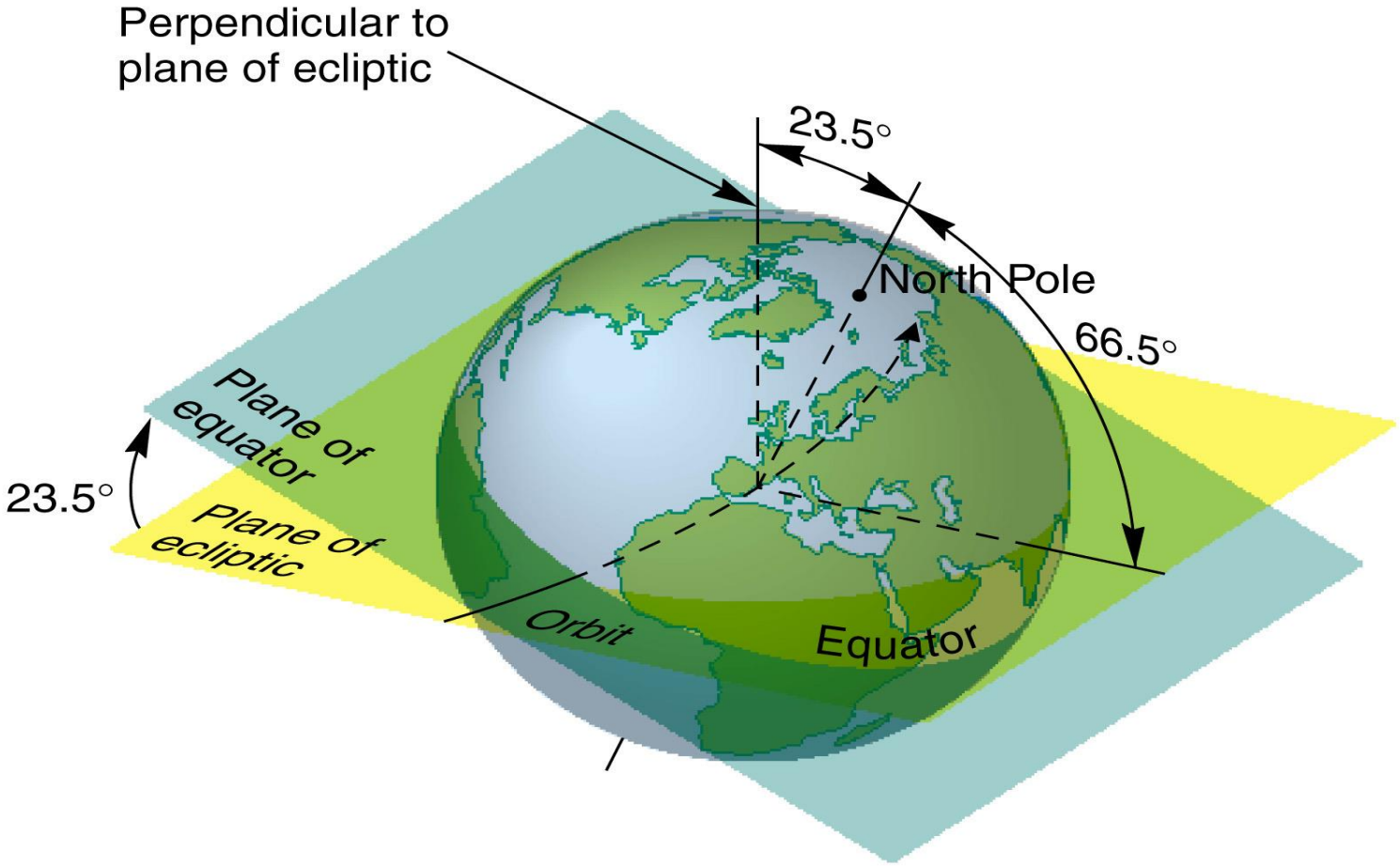
Inclination of Earth's Axis

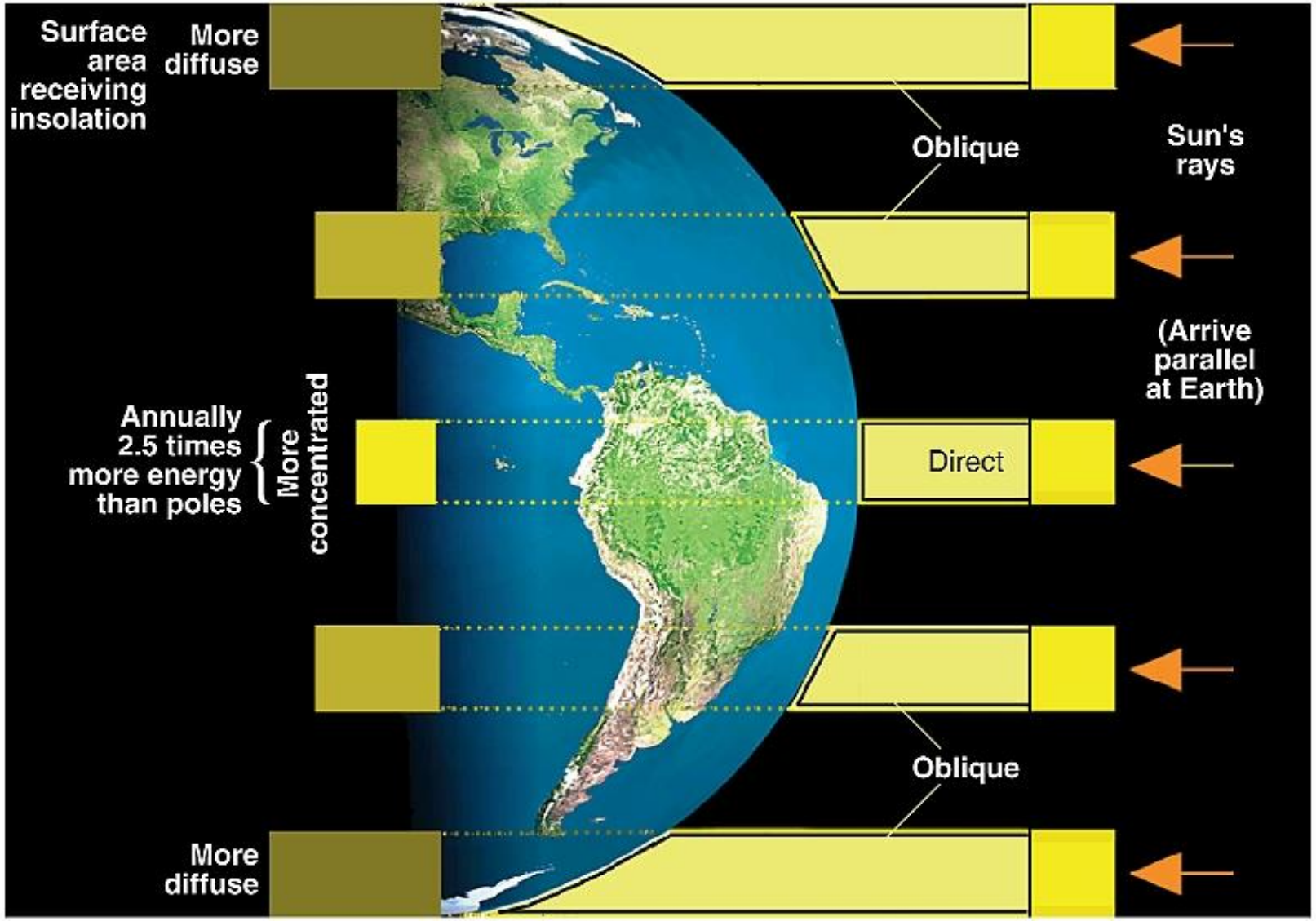
Earth revolves along **Plane of the ecliptic**—the imaginary plane that passes through the Sun and through every point of Earth's orbit around the Sun.

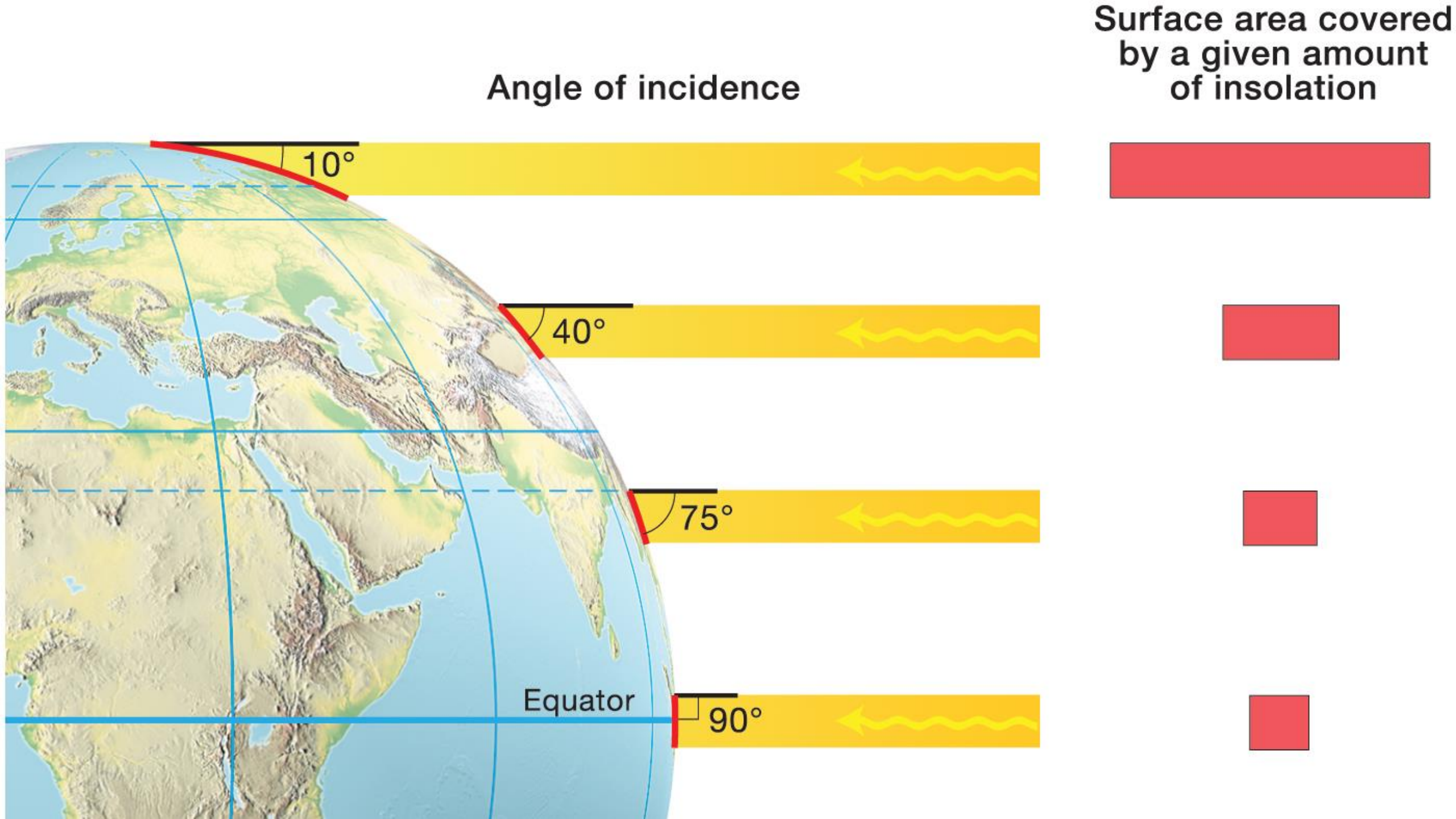
It is not perpendicular to Earth's rotation axis, which allows for seasons to occur.

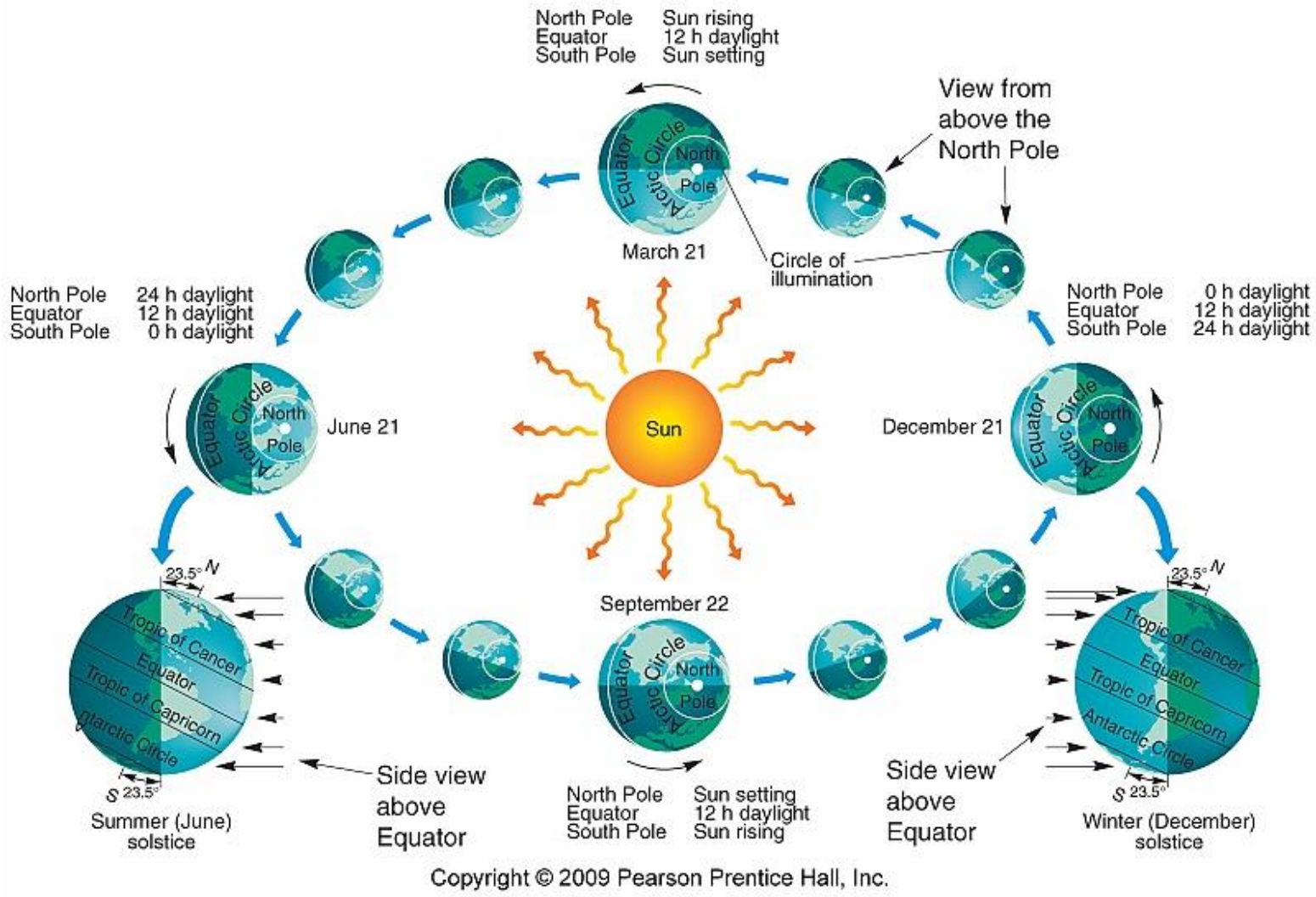
Inclination of Earth's axis—the degree to which Earth's rotation axis is tilted (about **23.5°** away from the perpendicular).

Axial Tilt and Parallelism



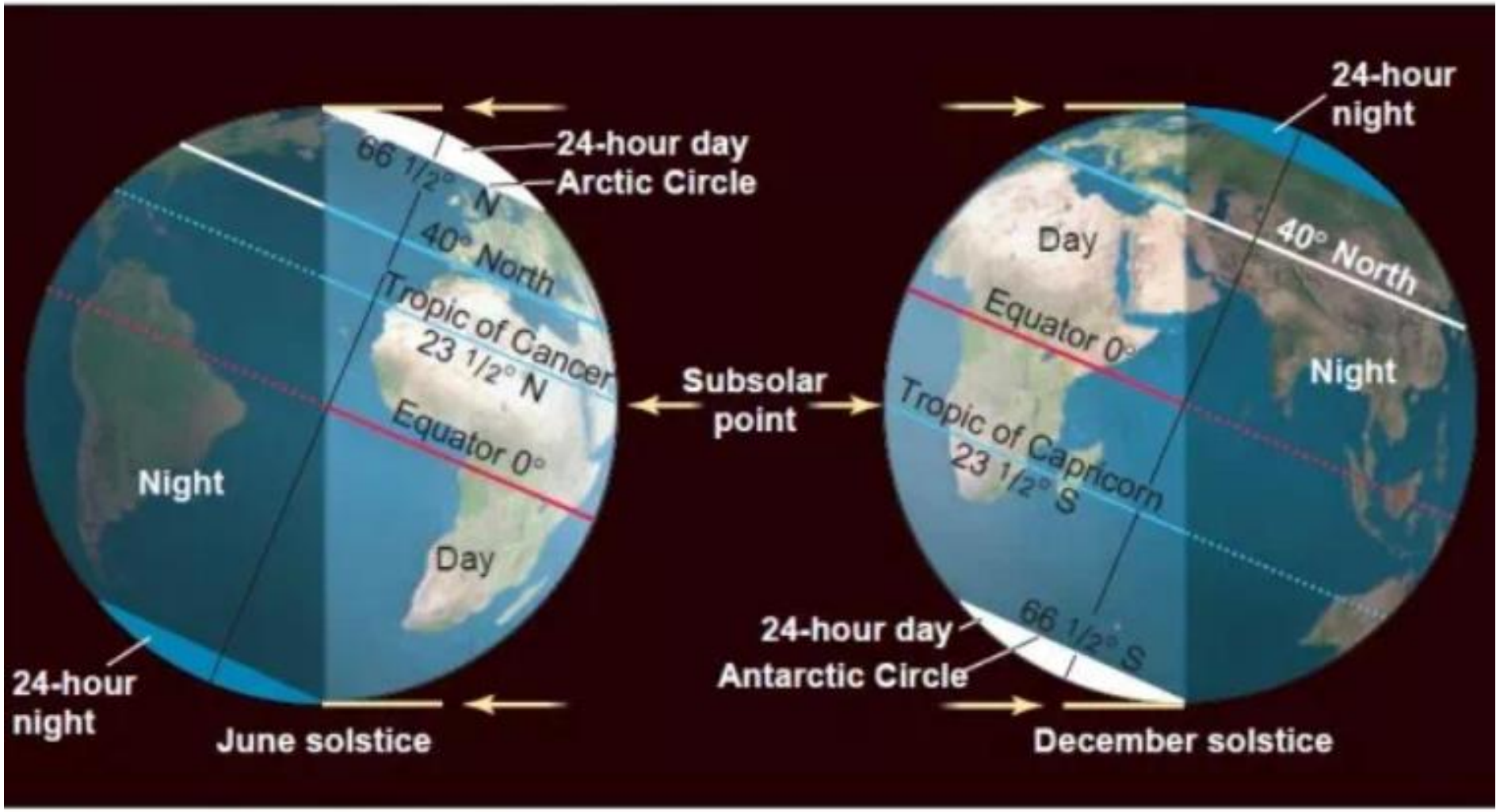



Angle of incidence
Surface area covered by a given amount of insolation
10°
40°
75°
90°
Equator



June Solstice or Summer Solstice

- **June solstice**—On or about June 21, the North Pole is oriented most directly toward the Sun.
- On this day the direct rays of the Sun at noon strike perpendicular to the surface of the **Tropic of Cancer (23.5º N).**
- The length of day is longer in the Northern Hemisphere on this day, and day lengths are shorter in the Southern Hemisphere.
- Day length is equal on the equator because the **circle of illumination** (the line dividing between half daylight and nighttime on Earth) bisects the equator evenly.
- **Arctic Circle—the parallel of 66.5° north latitude; experiences 24 hours of** light on this day.
- **Antarctic Circle—the parallel of 66.5° south latitude; experiences 24 hours** of darkness on this day.


24-hour day
Arctic Circle
66 1/2° N
40° North
Tropic of Cancer
23 1/2° N
Equator 0°
Night
Day
24-hour night
June solstice
Subsolar point
24-hour night
Day
40° North
Equator 0°
Night
Tropic of Capricorn
23 1/2° S
24-hour day
Antarctic Circle
66 1/2° S
December solstice

December Solstice

On or about December 21, the South Pole is oriented most directly towards the Sun.

On this day the direct rays of the Sun at noon strike perpendicular to the surface of the **Tropic of Capricorn (23.5º S).**

The day lengths are longer in the Southern Hemisphere on this day, and day lengths are shorter in the Northern Hemisphere.

Day length is equal on the equator because the circle of illumination (the line dividing between half day light and nighttime on Earth) bisects the equator evenly.

Arctic Circle—the parallel of 66.5° north latitude; experiences 24 hours of darkness on this day.

Antarctic Circle—the parallel of 66.5° south latitude; experiences 24 hours of light on this day.

Equinoxes

September Equinox (AKA autumnal equinox)

•Occurs on or about September 22 and all latitudes experience 12 hours of day and 12 hours of night.

- This is because all latitudes are bisected evenly by the circle of illumination.

•The equinoxes represent the midpoints in the shifting of direct rays of the Sun between the Tropic of Cancer and the Tropic of Capricorn.

March Equinox (AKA vernal equinox)

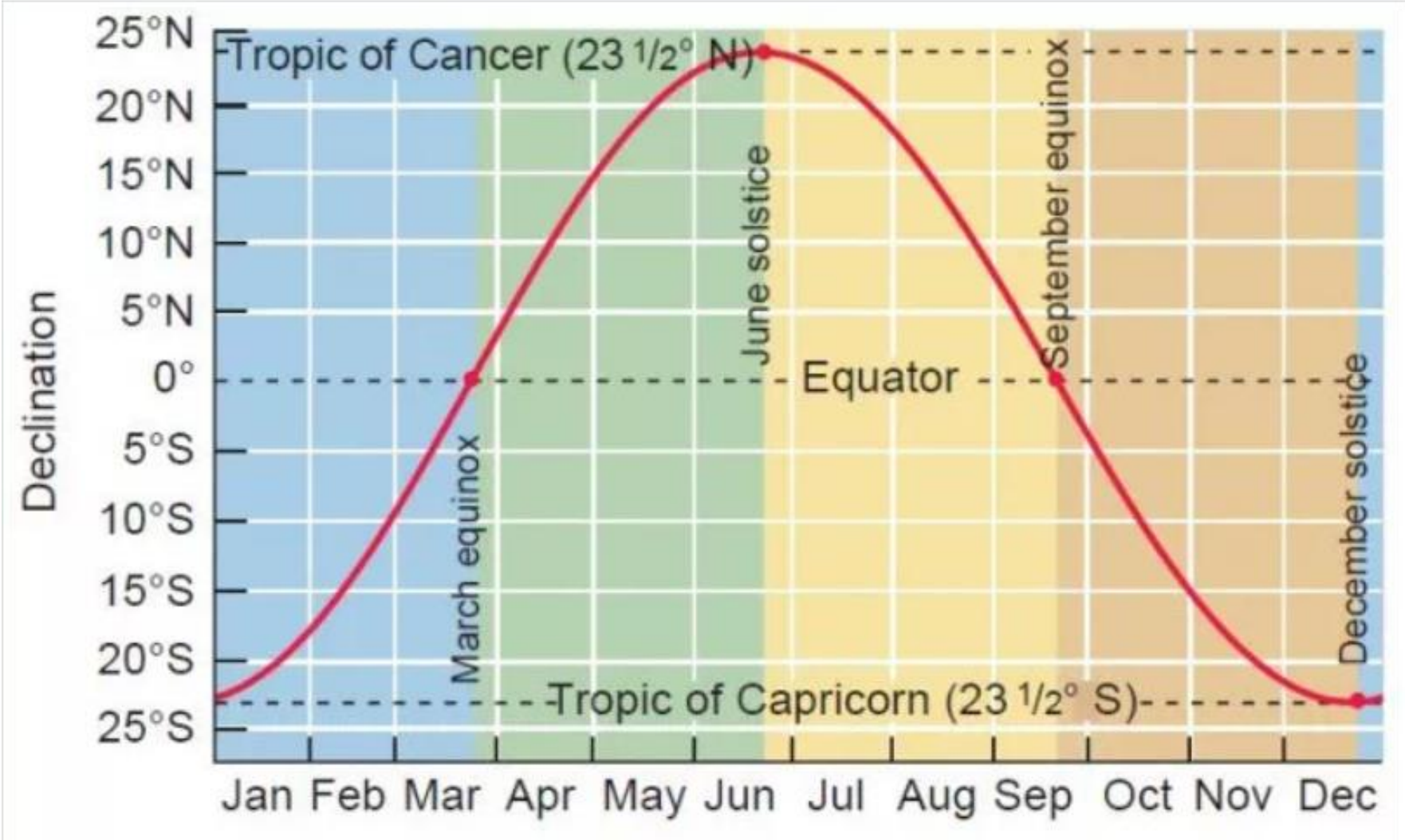
•Occurs on or about March 20 and all latitudes experience 12 hours of day and 12 hours of night.

- This is because all latitudes are bisected evenly by the circle of illumination.

The Annual March of the Seasons

During the year the changing relationship of Earth to the Sun results in variations in day length and in the angle at which the Sun's rays strike the surface of Earth. As a result of this, three conditions are noted:

- The latitude (or *subsolar point or the declination of the Sun) receiving the vertical* rays of the Sun varies
- The solar altitude at different latitudes changes
- The length of day at different latitudes also changes


25°N
20°N
15°N
10°N
5°N
0°
5°S
10°S
15°S
20°S
25°S
Declination
Tropic of Cancer (23 1/2° N)
Equator
Tropic of Capricorn (23 1/2° S)
March equinox
June solstice
September equinox
December solstice
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Seasons

Summer

High sun and long days = More and better light

Seasonal differences matter more with increasing latitude (see Earth-Sun relations exercise)

Winter

Low sun and short days = less quality and quantity of light

Reasons for Seasons

Table 2.1 Five Reasons for Seasons

Factor	Description
Revolution	Orbit around the Sun; requires 365.24 days to complete at 107,280 kmph (66,660 mph)
Rotation	Earth turning on its axis; takes approximately 24 hours to complete at 1675 kmph (1041 mph) at the equator
Tilt	Axis is aligned at a 23.5° angle from a perpendicular to the plane of the ecliptic (the plane of Earth's orbit)
Axial parallelism	Remains in a fixed alignment, with Polaris directly overhead at the North Pole throughout the year
Sphericity	Appears as an oblate spheroid to the Sun's parallel rays; the geoid