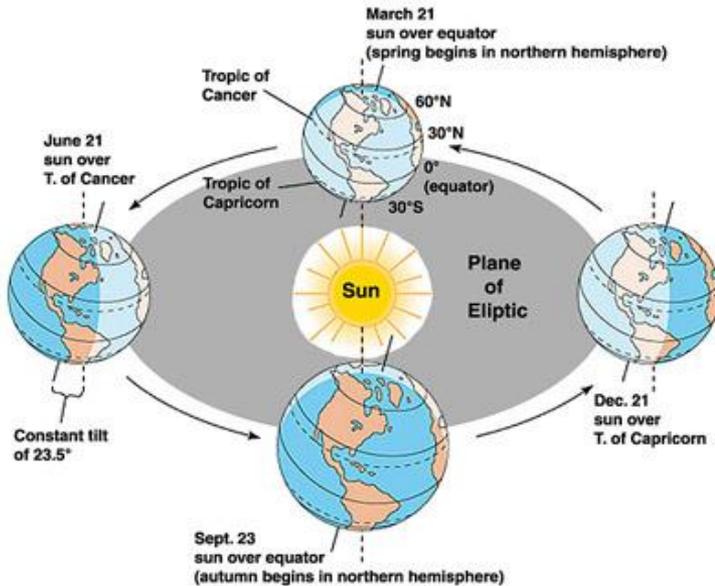
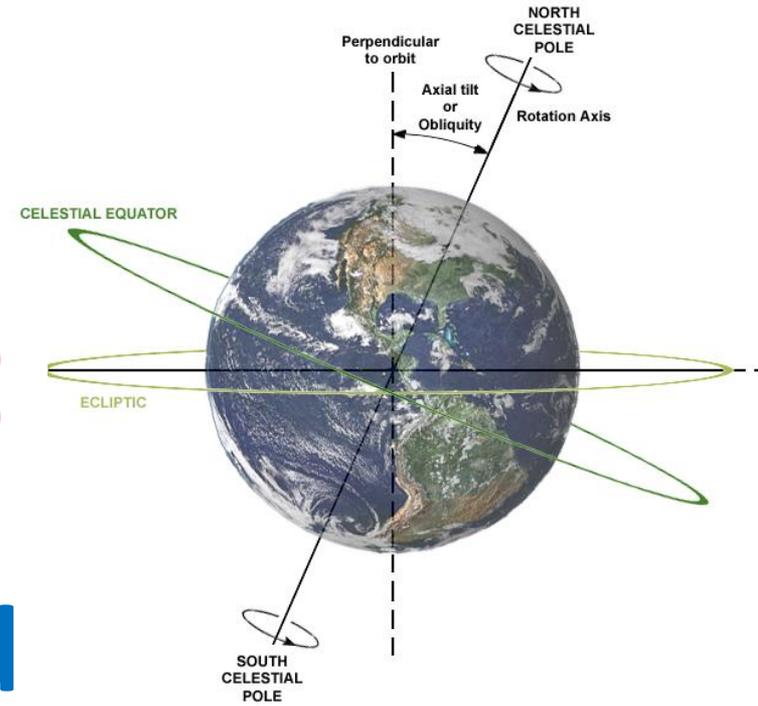


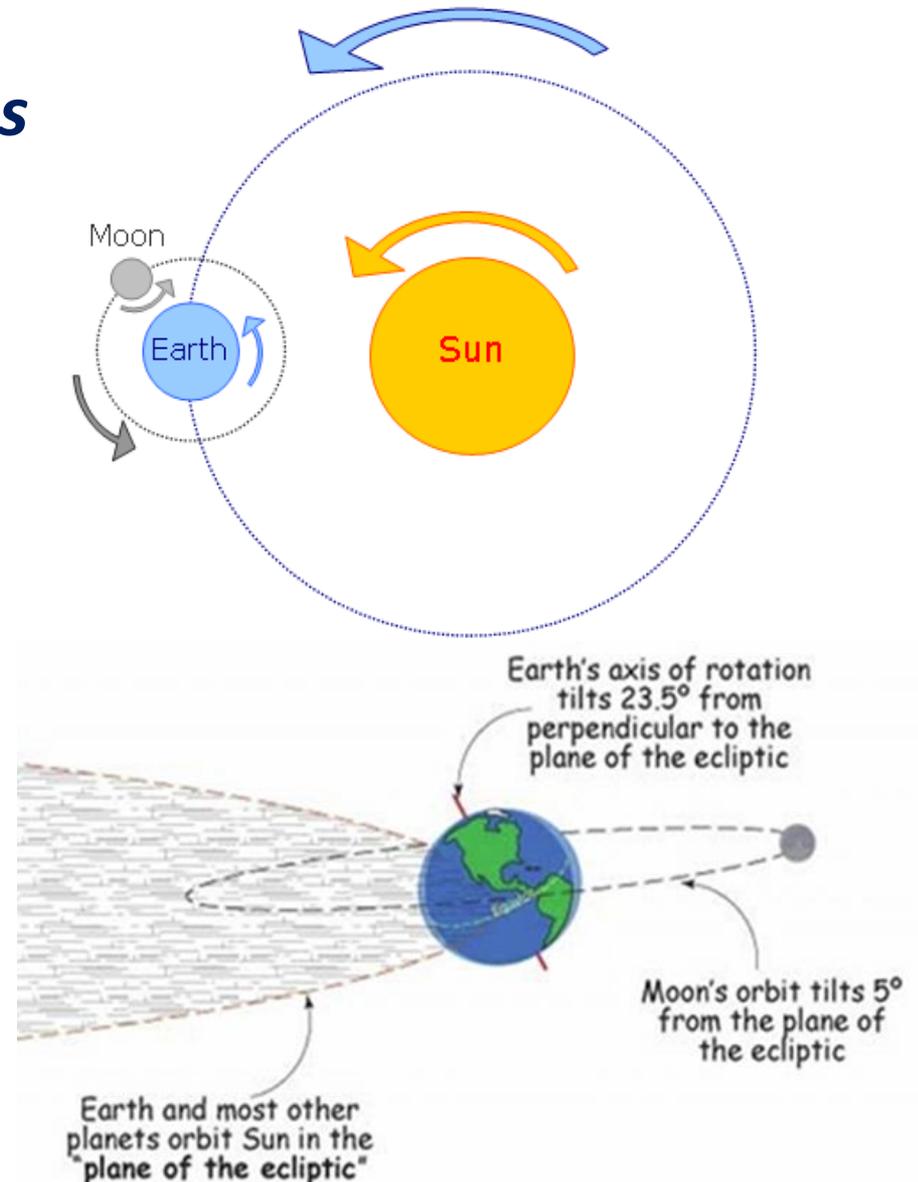


Planet Earth revisited

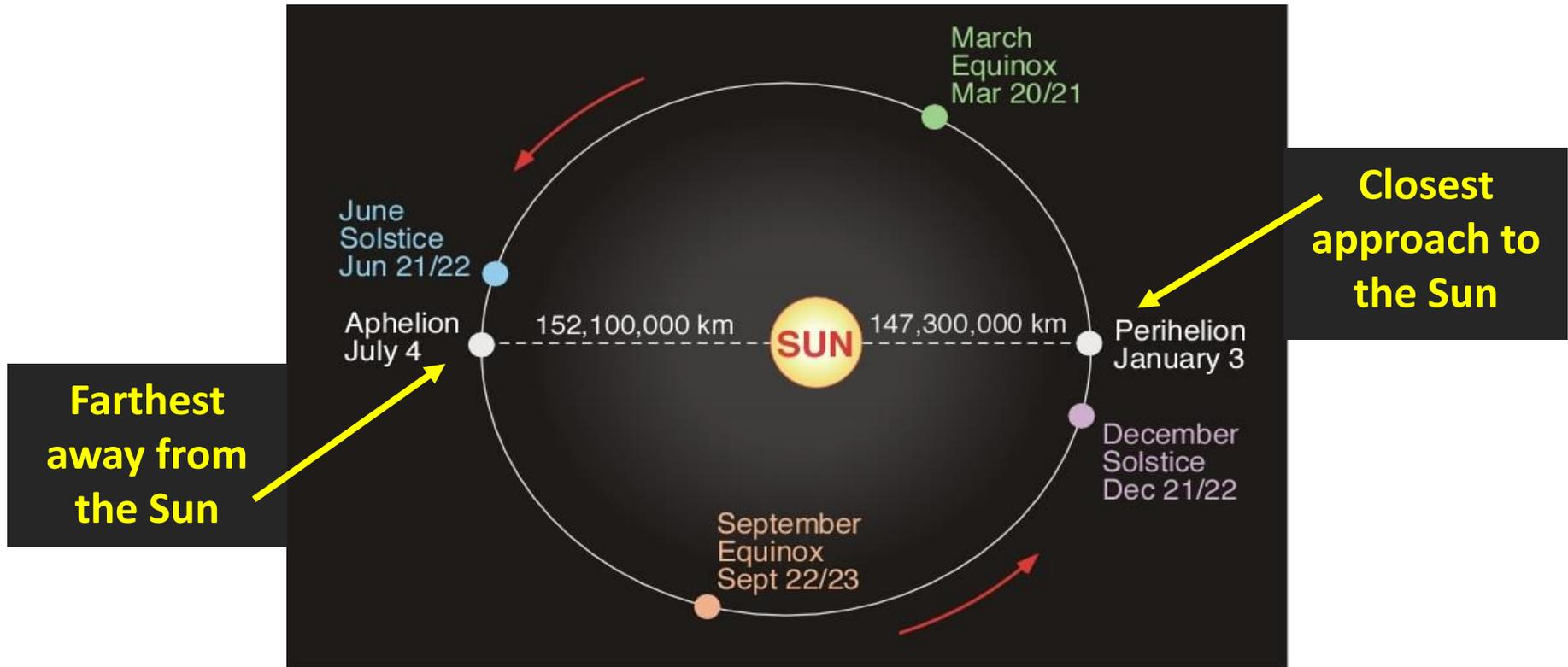


Sun, Earth and Moon Motions

- The Solar System *revolves* around the Milky Way galaxy center.
- The **Sun** *rotates* on its own axis.
- **Earth** *revolves* around the **Sun** (1 year) and *rotates* on its own axis (1 day).
- The **Moon** *revolves* around Earth and *rotates* on its own axis (*synchronous* with Earth).



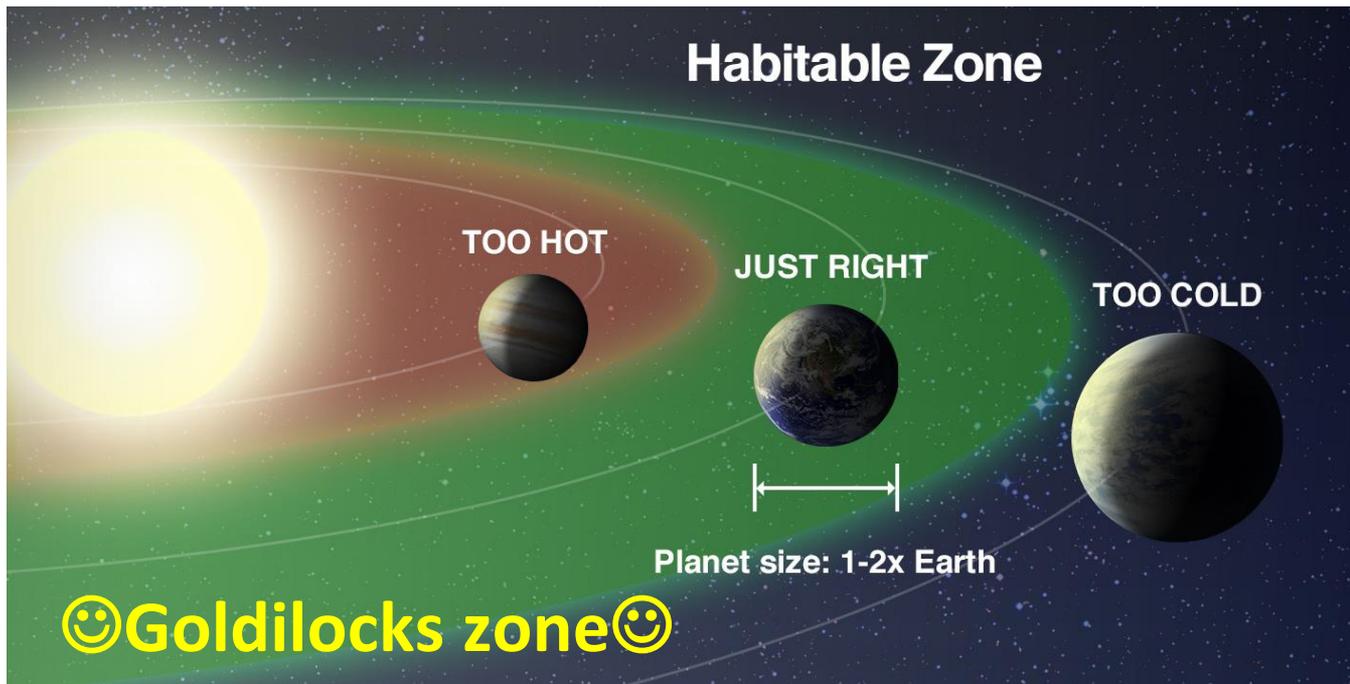
Earth Orbit



- The **orbit** of the Earth is *almost a perfect circle*: our mean distance to the Sun is about **150 million km** (~93 million mi) or about 25,000 times bigger than the radius of the planet itself.
- The **orbital speed** of the Earth (how fast it travels along its orbit around the Sun) is about **30 km/s** (~67,000 mph).

Circumstellar Habitable Zone

- In astronomy and astrobiology, the **range of orbits around a star** within which a planetary surface **can support liquid water** (*however concept is still evolving*).
- CHZ depends on the **size and energy of a star** and **planet type**.

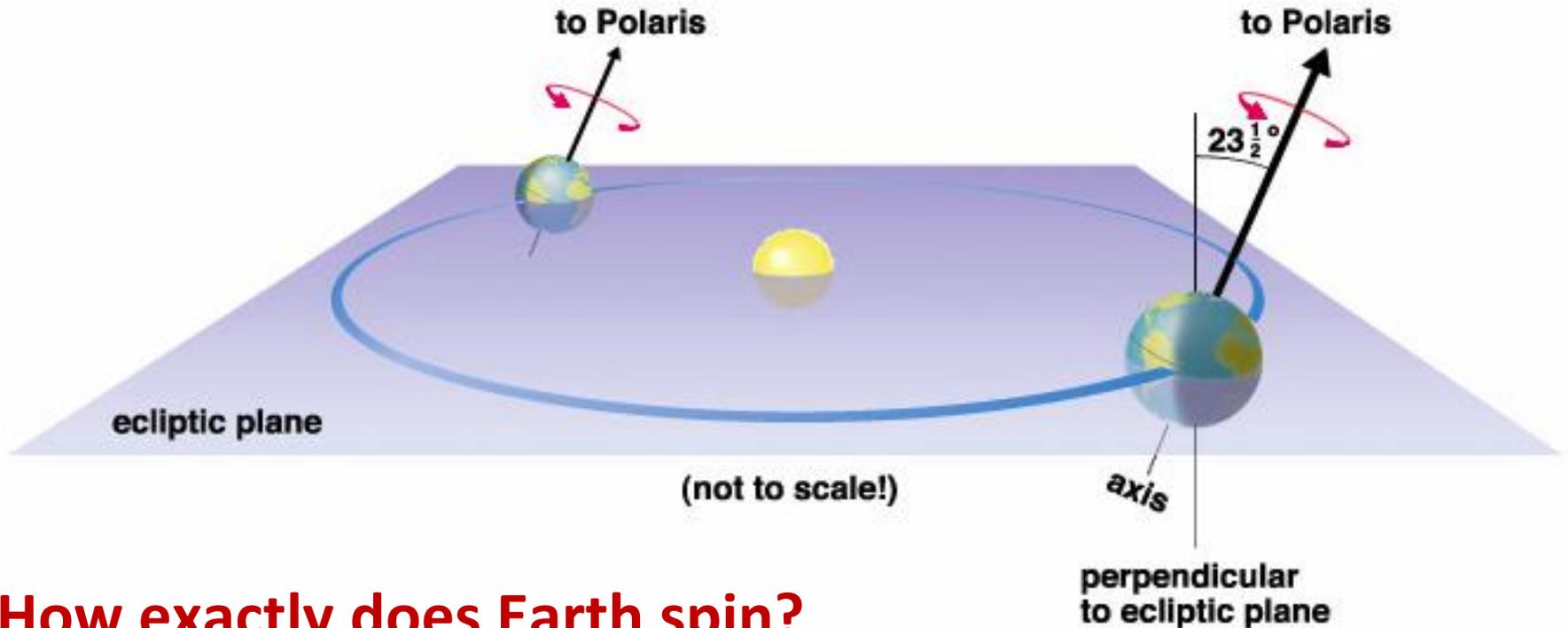
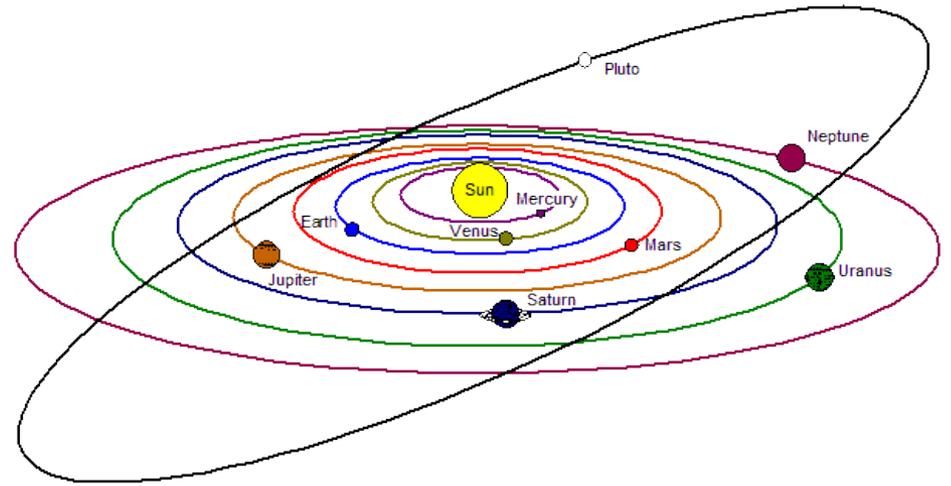


There **may be** at least **500 million** habitable worlds in the Milky Way!

- **NASA Kepler Mission**: a space observatory (telescope) performing search for Earth-size **exoplanets** orbiting other stars.

Ecliptic Plane

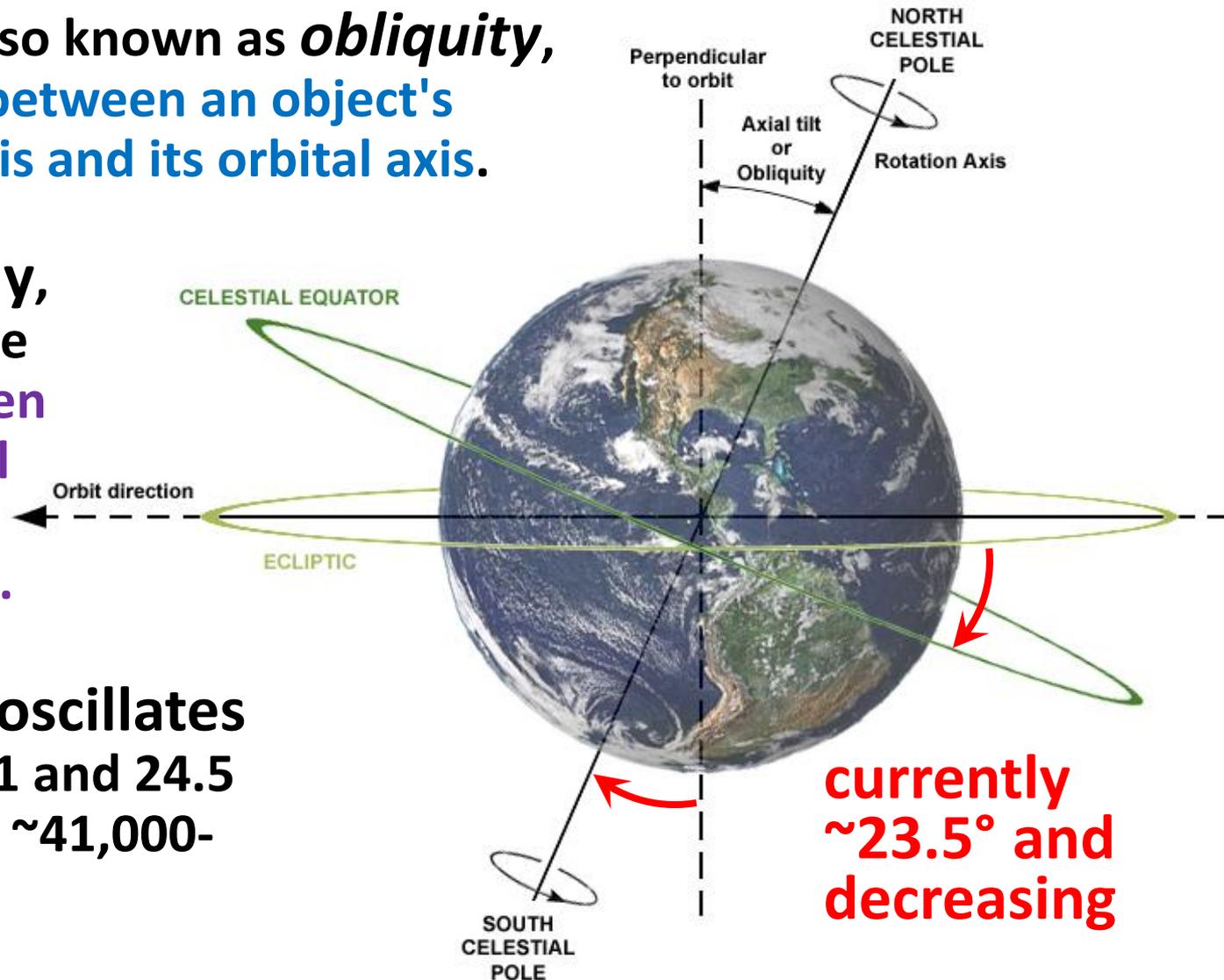
Imaginary plane containing the Earth's orbit around the Sun.



How exactly does Earth spin?

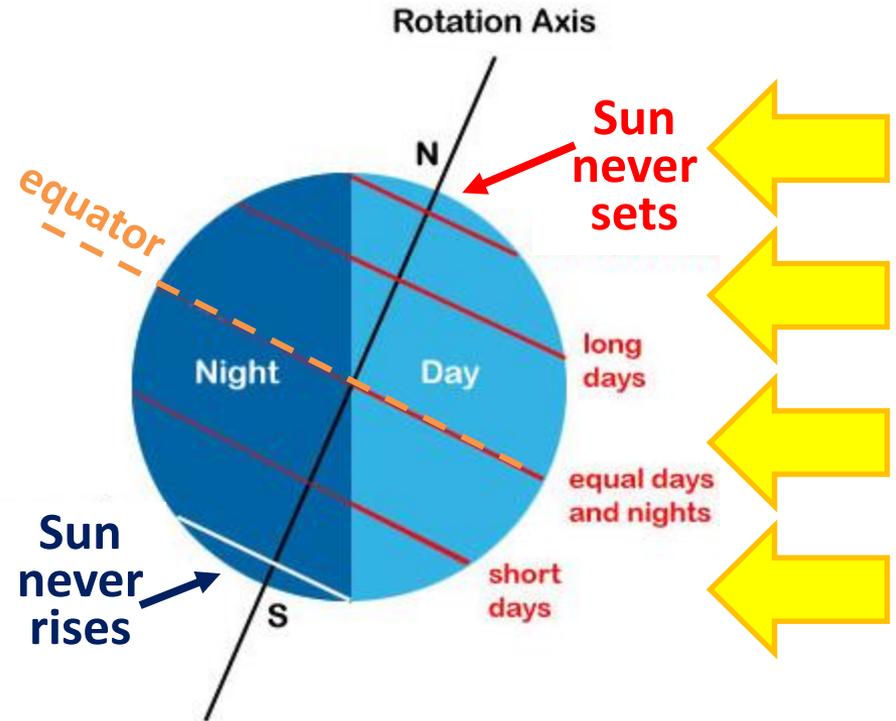
Earth Axis Tilt

- Axial tilt, also known as *obliquity*, is the angle between an object's rotational axis and its orbital axis.
- Equivalently, axial tilt is the angle between its equatorial plane and orbital plane.
- Earth's tilt oscillates between 22.1 and 24.5 degrees on a ~41,000-year cycle.



Day and Night

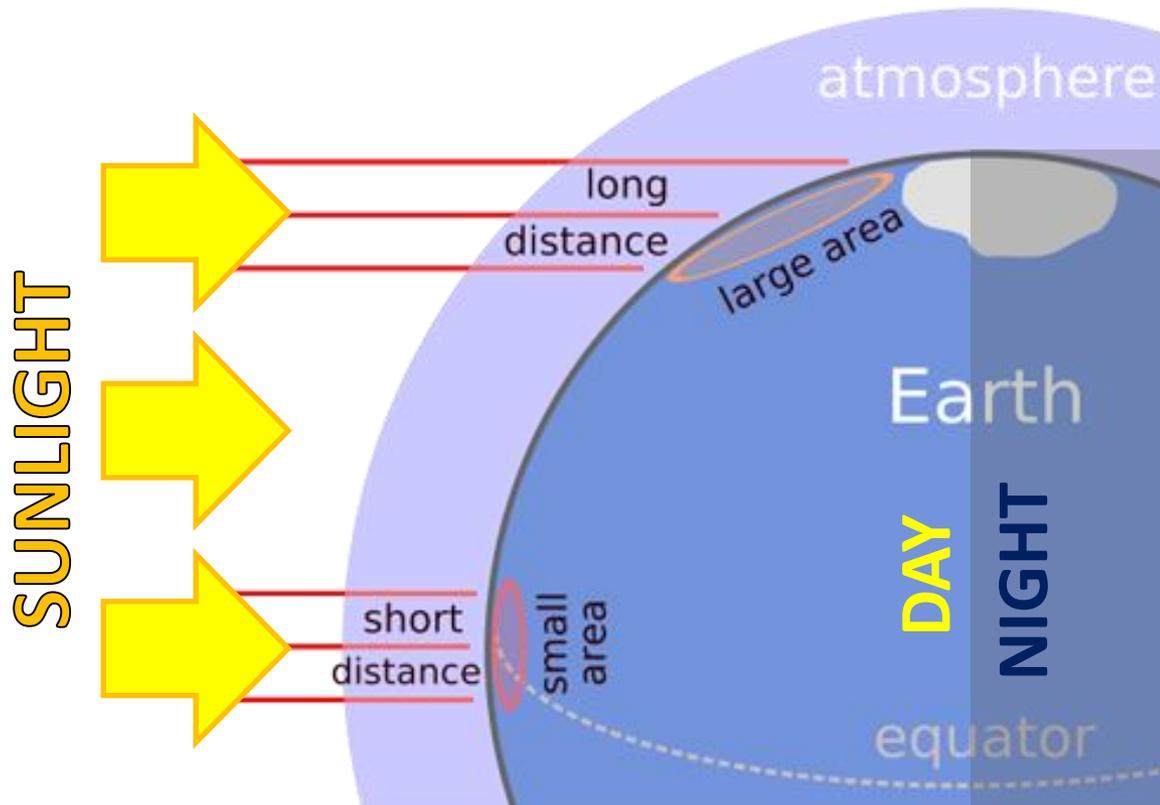
- Earth rotates on its axis, making **one full rotation every 24 hours** (86,400 seconds).
- Every moment of time half of the planet is exposed to sunlight (day) while the other half is turned away from the Sun (night).
- Different parts of the globe receive different illumination:



- due to the **Earth's tilt** - day-to-night ratio varies over **latitude**,
- depending on the position of Earth along its **orbit** - day-to-night ratio varies over the **course of the year**.
- Special **days** of the year: solstices and equinoxes.
- Special **lines** on the surface: tropics and polar circles.

Angle of Sunlight

Due to the Earth's curvature, the **amount of sunlight (energy)** reaching any given point on the surface **varies greatly with latitude**.

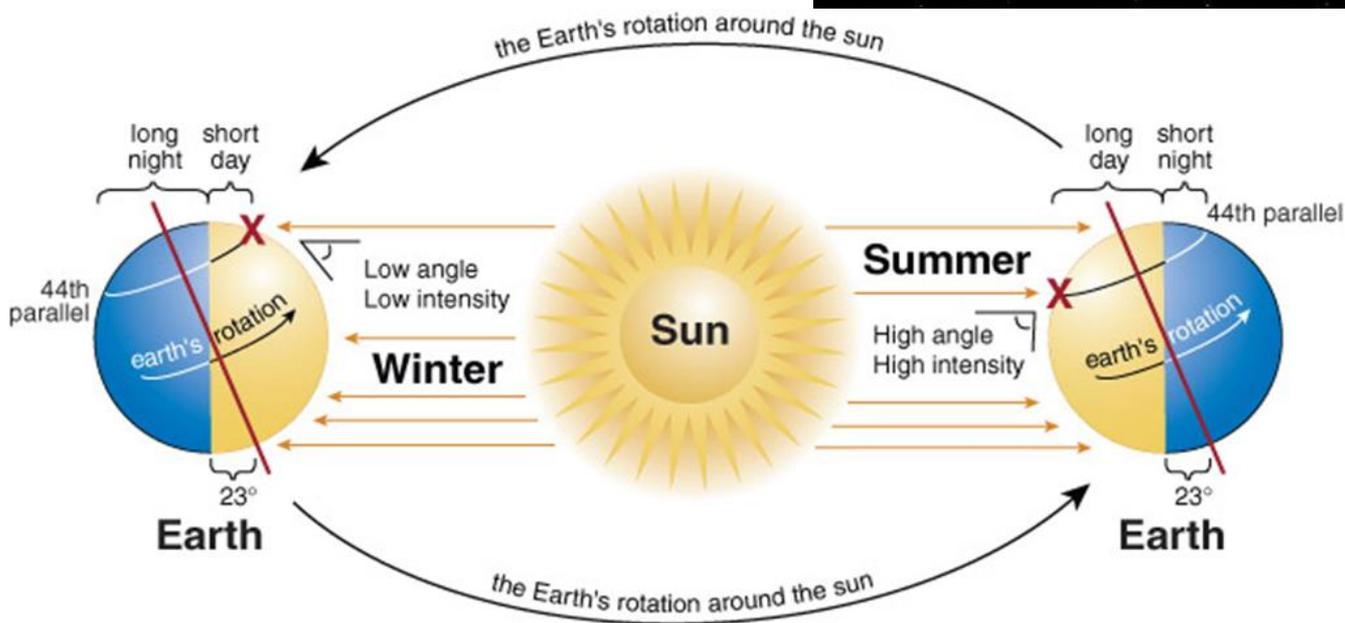
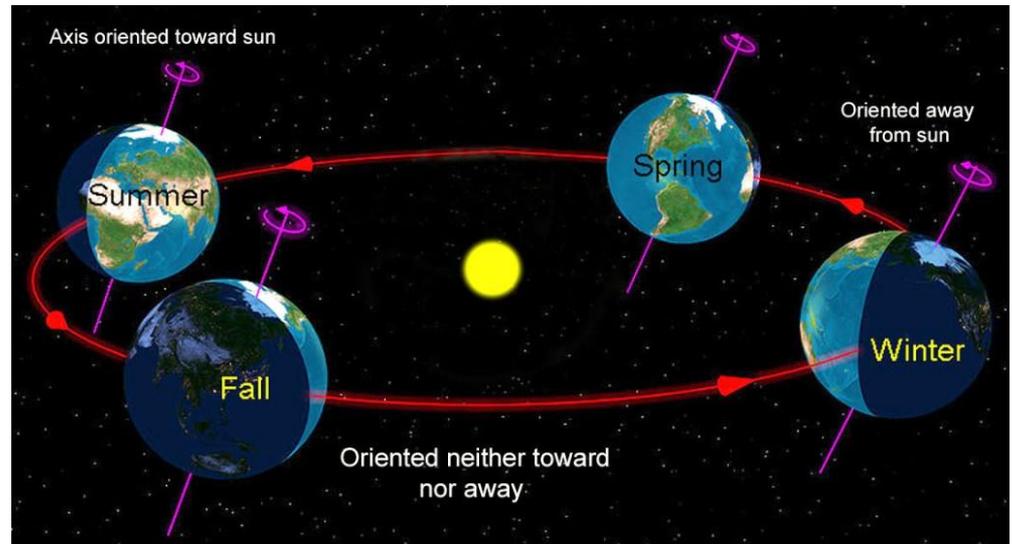


- Regions near the **Equator** receive most direct, that is concentrated Sun rays.
- At **high latitudes**, the same amount of the incoming Sun energy is spread over much greater area of surface.

The available amount of energy defines how much warmed up a certain area can get during the day time... **does it change?**

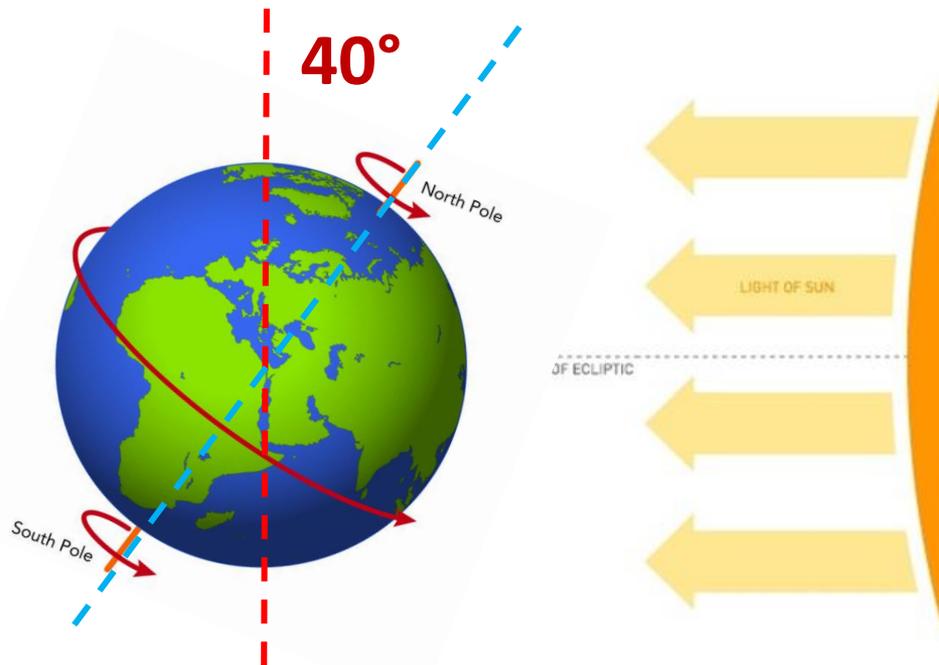
Change of Seasons

Due to the Earth's tilt with respect to its orbital plane, the **amount of sunlight (energy)** reaching any given point on the surface **varies over the course of the year.**



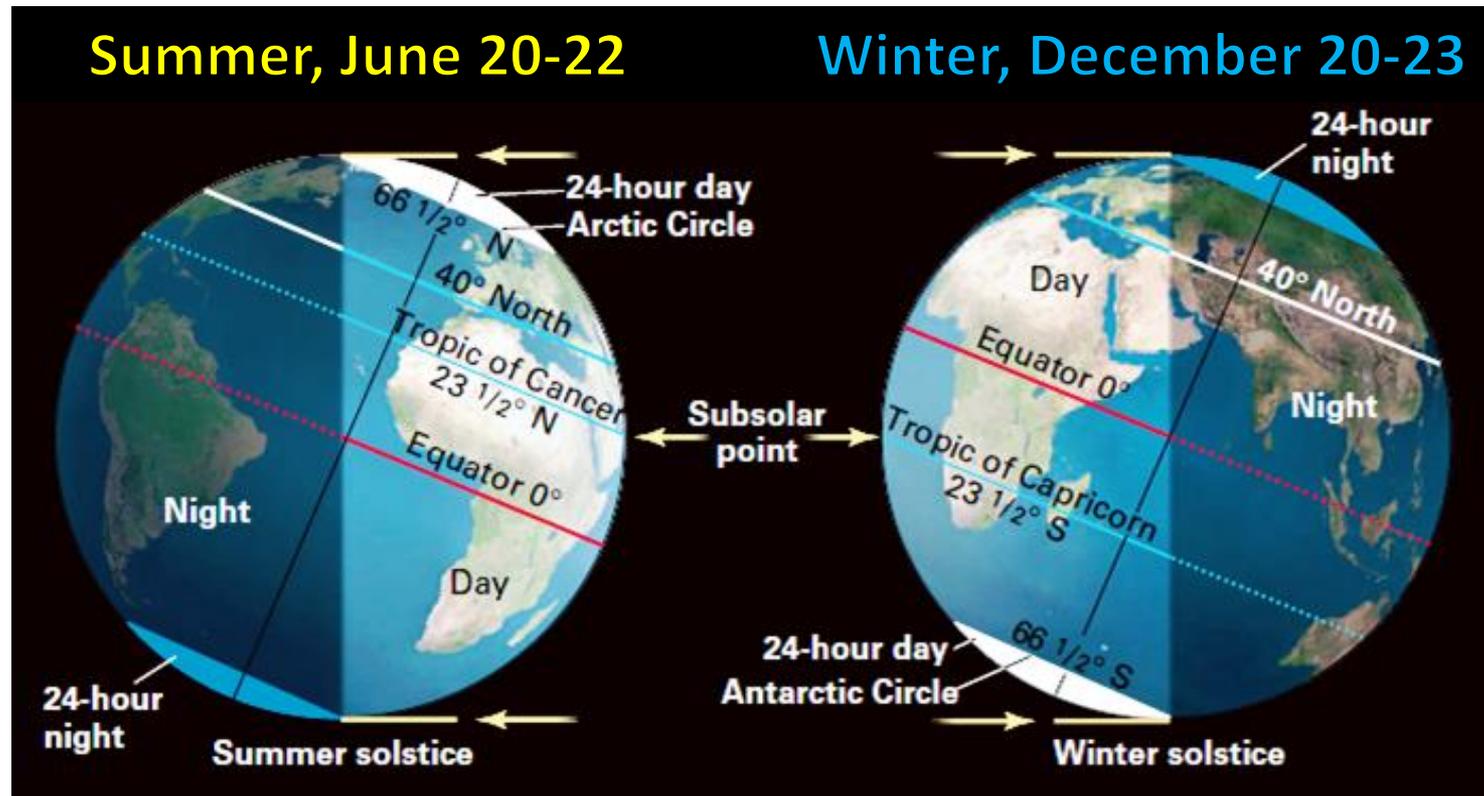
Astronomers and scientists use the dates of **equinoxes** and **solstices** to mark the change of seasons.

Exercise: if Earth was tilted at 40 degrees instead of 23.5 degrees, would winters in New York be **warmer** or **colder**?



Colder! And summers would be hotter since the **larger tilt** would mean that the hemispheres would be tilted **more away** or **more towards** the Sun. However, the equator would still be the same average temperature!

Solstice conditions (Northern Hemisphere)



- At **solstice** (Latin: “sun”+”stand still”), the Earth’s **axis of rotation is fully tilted either toward or away** from the Sun.
- Polar regions experience either 24-hour day or 24-hour night.
- The Sun is directly overhead at noon on one of the tropics.

December Solstice

Seasons in the Southern Hemisphere are opposite to those in the Northern Hemisphere.

Fairbanks, Alaska



← On December solstice, **1st day of Winter**, daylight length in Fairbanks, Alaska is just **3 hr 41 min 48 sec!**

At the same time, on the **1st day of Summer**, the Sun in Antarctica dips to the horizon but doesn't set! →

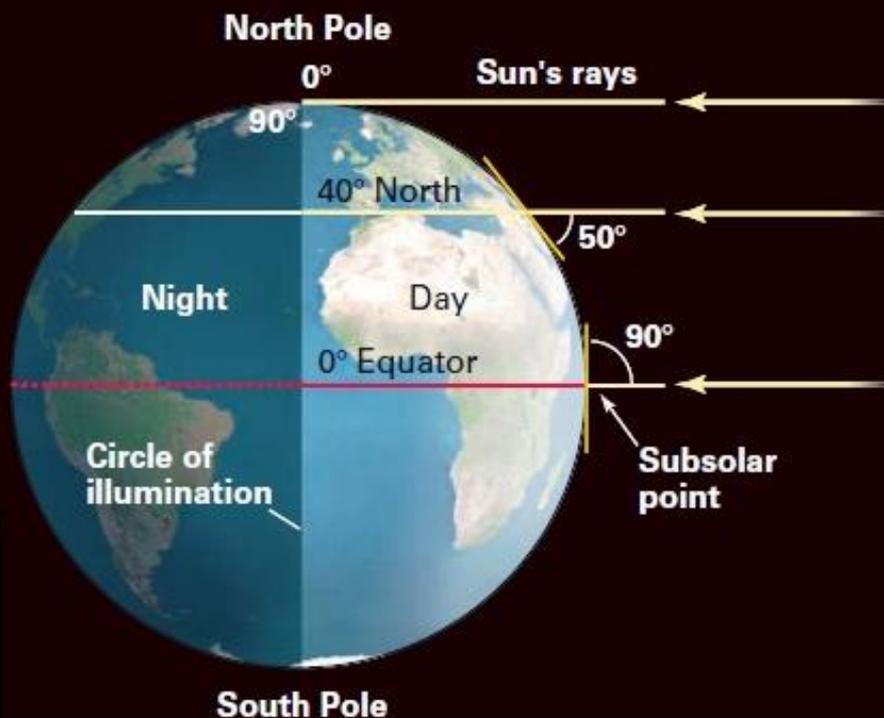


Midnight Sun in Antarctica

Equinox conditions

Autumnal (Fall), September 21-24

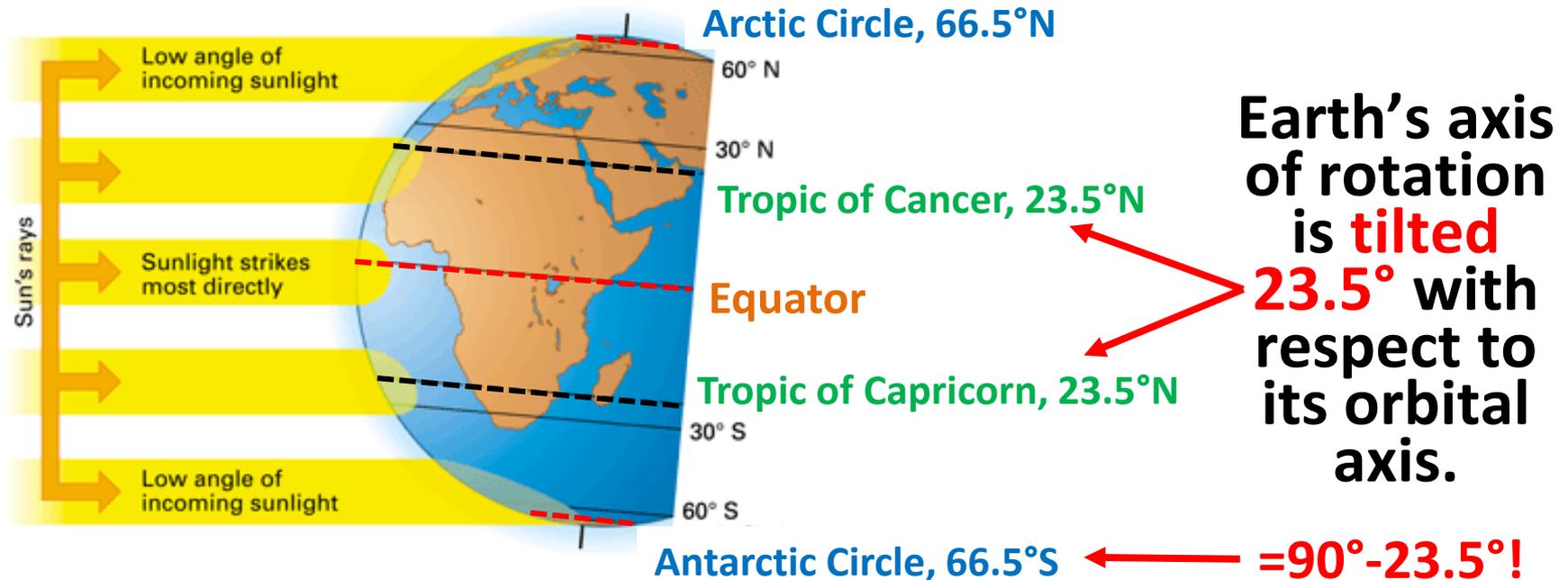
Vernal (Spring), March 20-23



- Both hemispheres are equally illuminated.

- At **equinox** (*Latin: "equal" + "night"*), the Earth's **axis of rotation is exactly at right angle** to the direction of solar illumination.
- The circle of illumination passes through the North and South Poles.
- At noon, the Sun is directly overhead on the Equator.
- At both poles the Sun is seen at the horizon.

Special lines on the Earth's surface



- **Equator**: day=night always!
- **Northern Tropic (Tropic of Cancer)** and **Southern Tropic (Tropic of Capricorn)**: most northerly/southerly circle of latitude at which the Sun may appear directly overhead.
- **Arctic Circle** and **Antarctic Circle**: northernmost/southernmost latitude at which the Sun can remain continuously above or below the horizon for 24 hours (polar circles get one 24-hour day and one 24-hour night a year.)