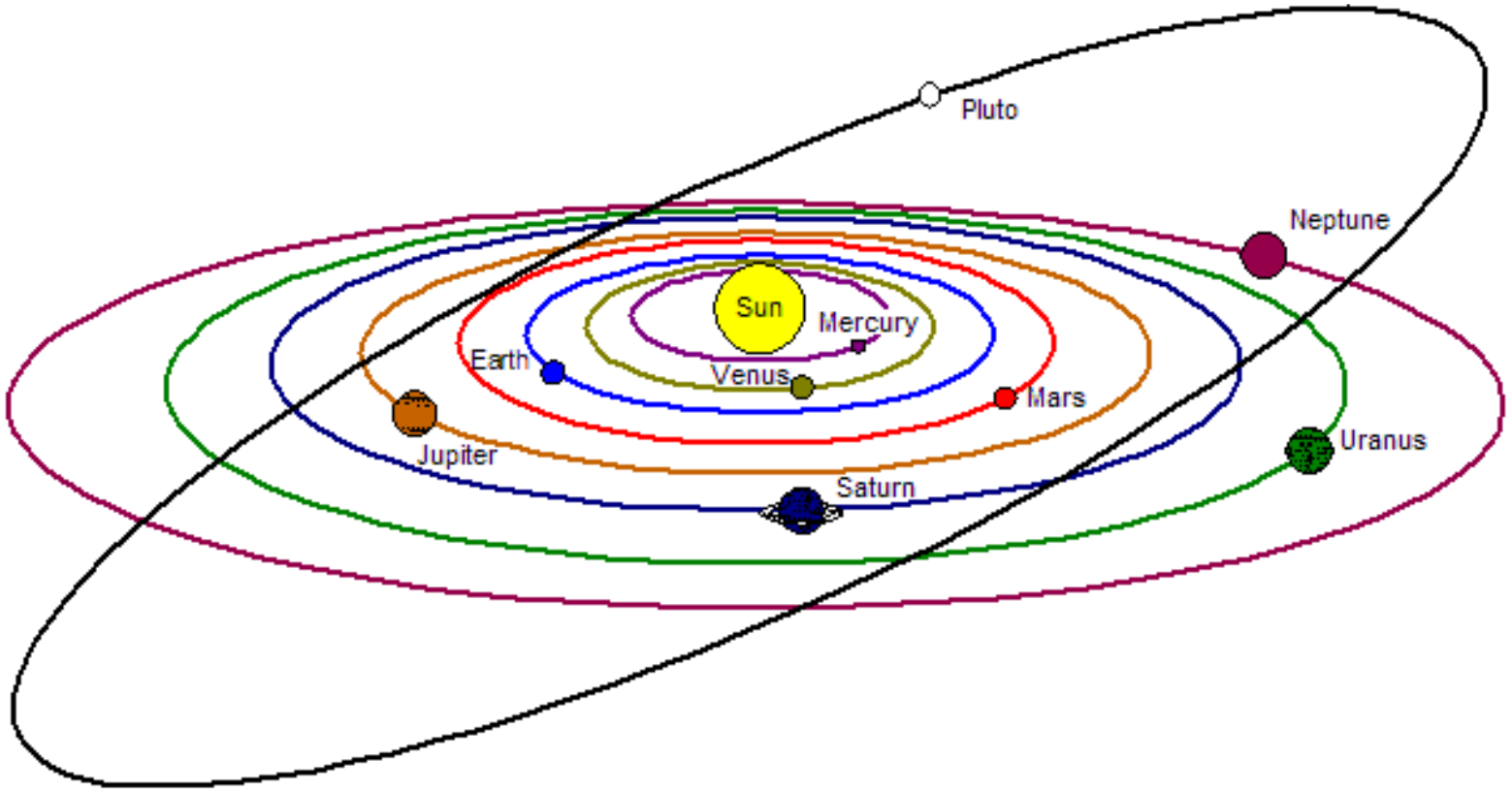
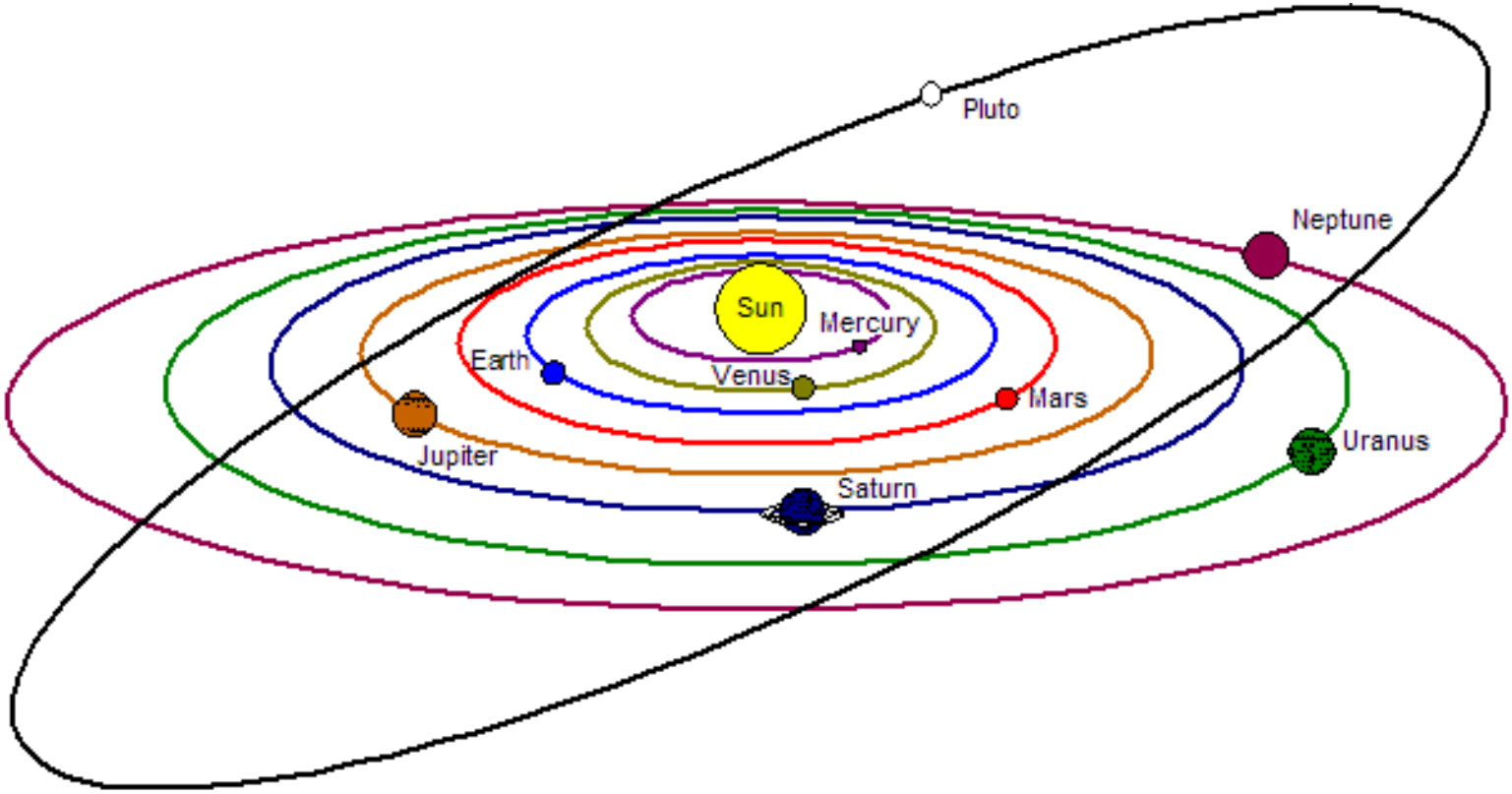
Lesson 02

Earth's Orbit and The Seasons

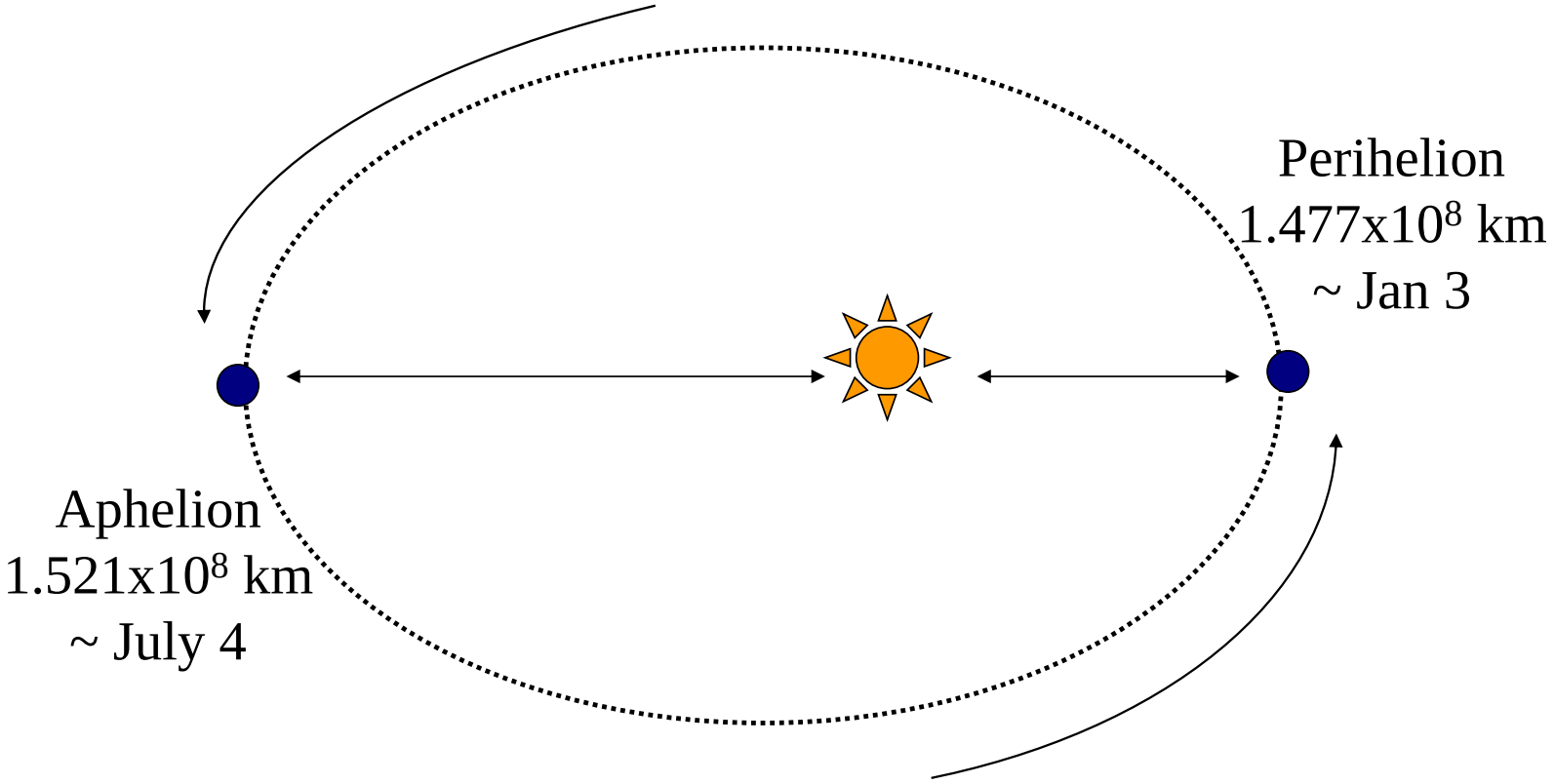
Earth's orbit lies 3rd away from the Sun. Earth's orbit lies in the **Plane of the Ecliptic**. All planets in our solar system also orbit the sun in the plane of the ecliptic, except Pluto whose orbit is offset.



The **plane of the ecliptic** is the imaginary plane in space that extends outward from the equator of the sun. The eight planets of the solar system lie in the plane of the ecliptic. The solar system (ideally) looks like a flat disk of orbiting objects around the sun.

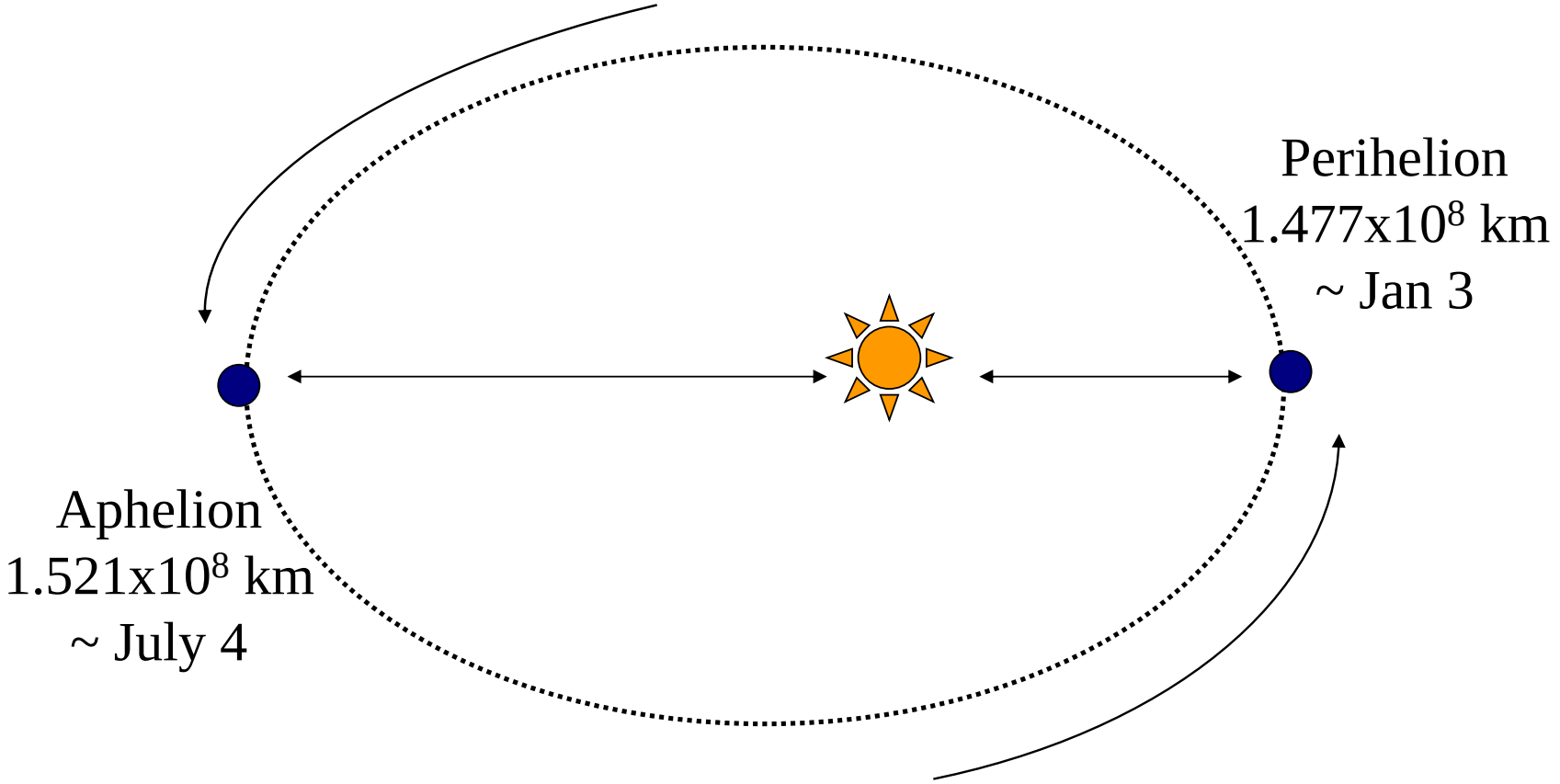


Earth's orbit around the Sun is *not a perfect circle*. Earth's orbit is an **ellipse** (oval shaped). Because Earth's orbit is elliptical, the Earth is sometimes closer to the sun and sometimes farther from the sun. The Earth's average orbit distance away from the sun is ~150,000,000 km.

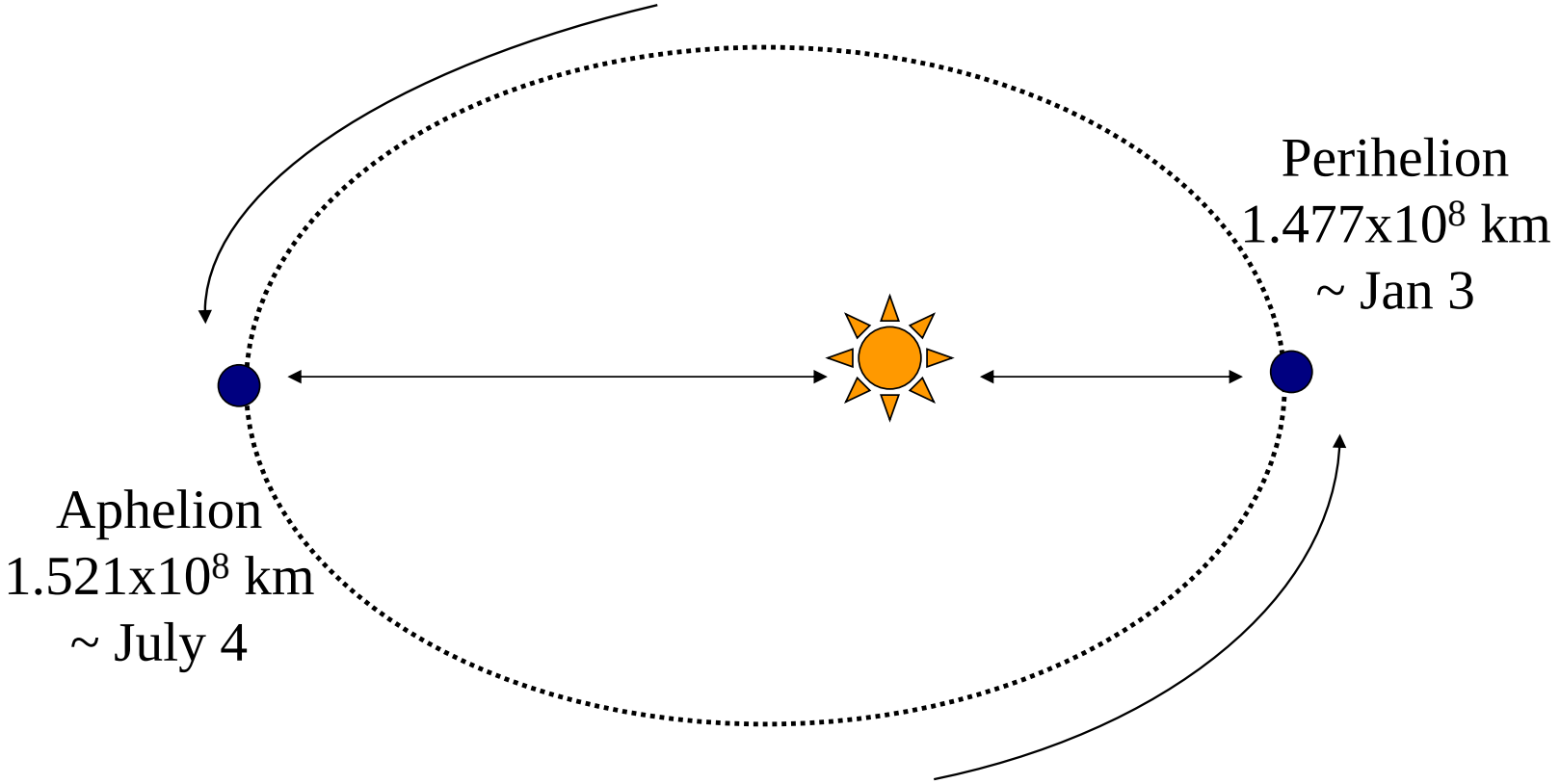


Perihelion (“around the sun”) is the position of Earth in its orbit where it is *closest to the Sun*. January 3

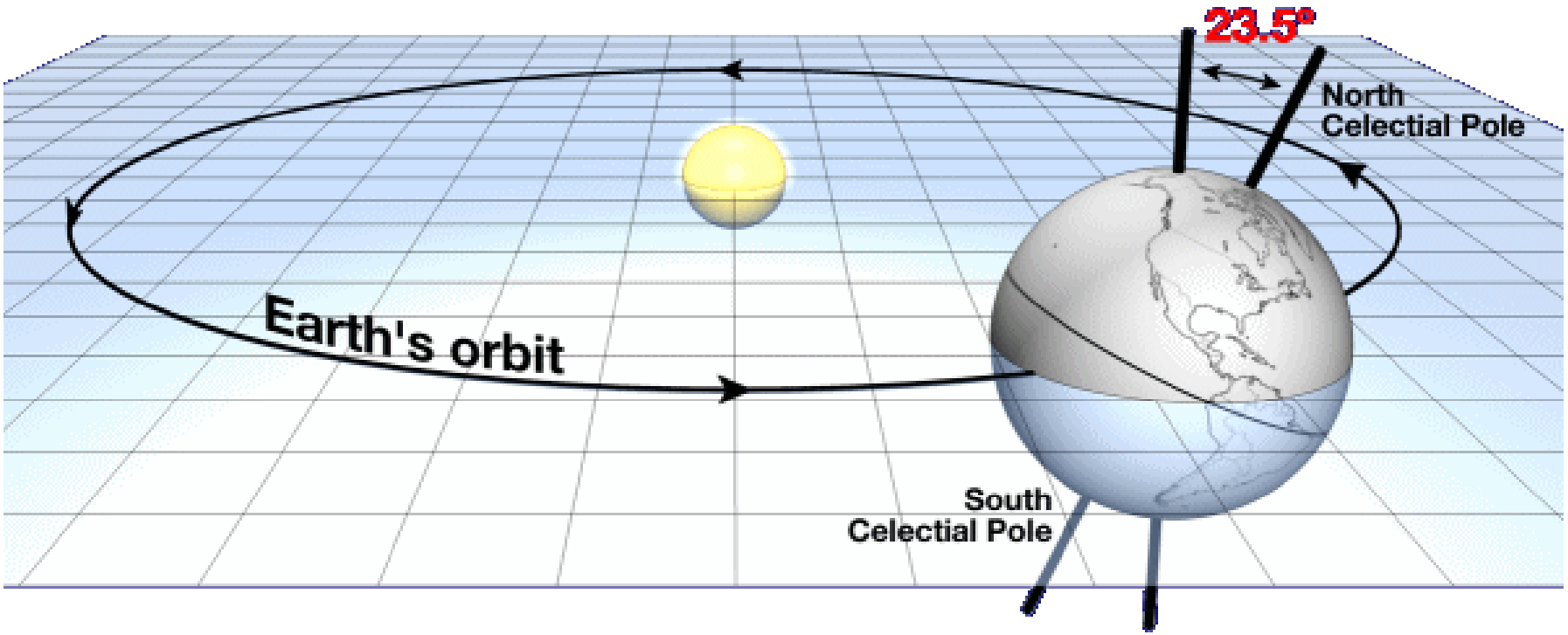
Aphelion (“not at sun”) is the position of Earth in its orbit where it is *farthest from the Sun*. July 4



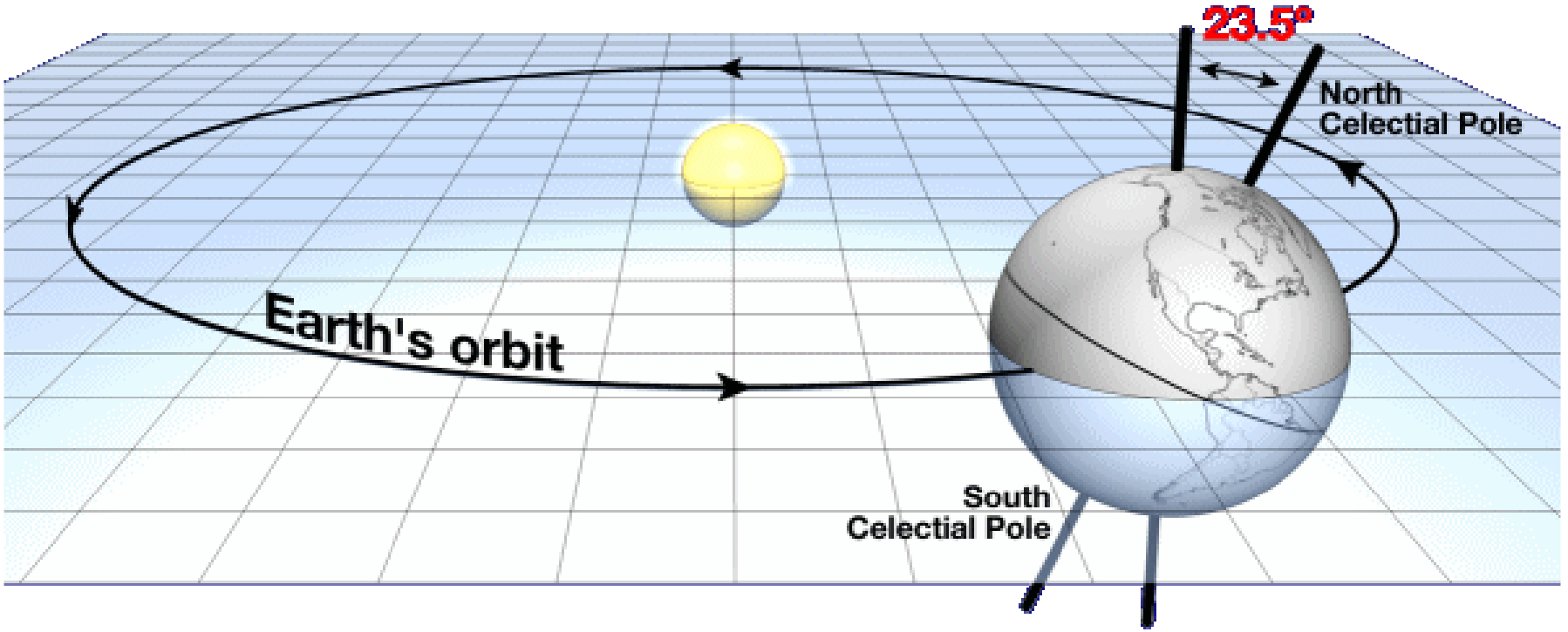
Earth's orbit (an ellipse shape) is almost a circle. The orbit shape deviates from a perfect circle by 3%. Notice that there is very little difference between the distance at perihelion and aphelion.



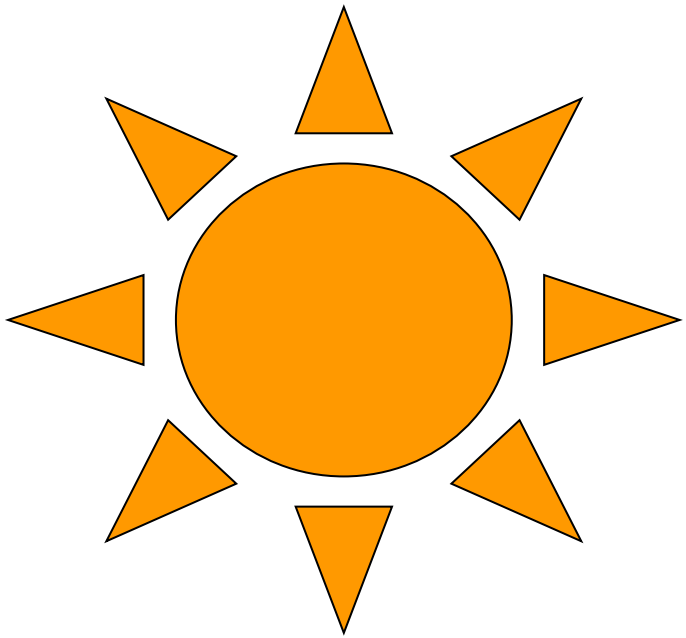
Currently, there is no measurable difference in Earth's surface temperature between perihelion and aphelion.



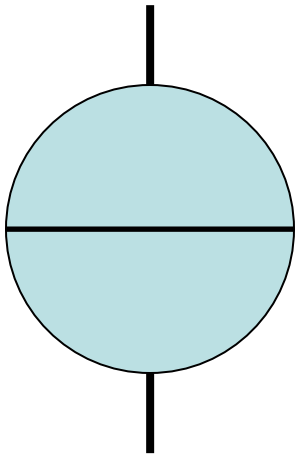
Earth's orbit is aligned with the **Plane of the Ecliptic**. Earth is **tilted on its axis of rotation by 23.5º** from upright, so the Plane of the Ecliptic does not align with the Earth's equator.

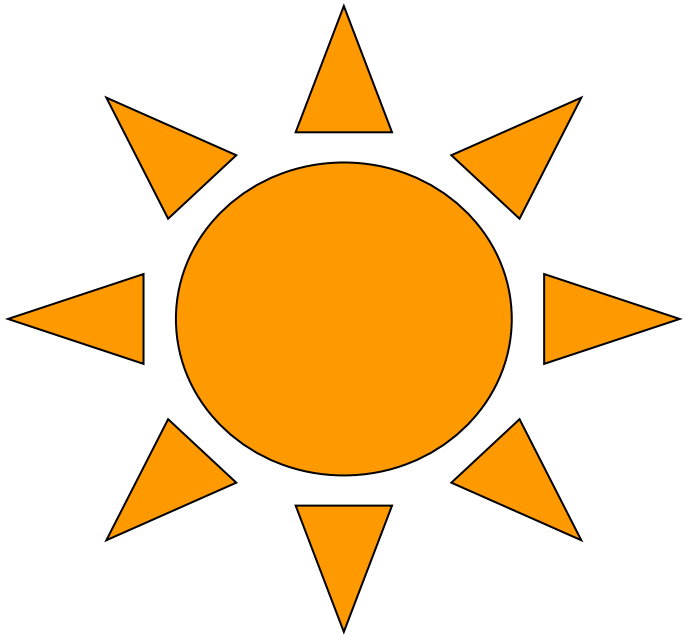


The tilt on the axis of rotation is also called **obliquity**. The tilt remains constant as the Earth orbits the Sun. The tilt of the Earth causes the different hemispheres of the Earth to be either facing the Sun or facing away from the Sun.

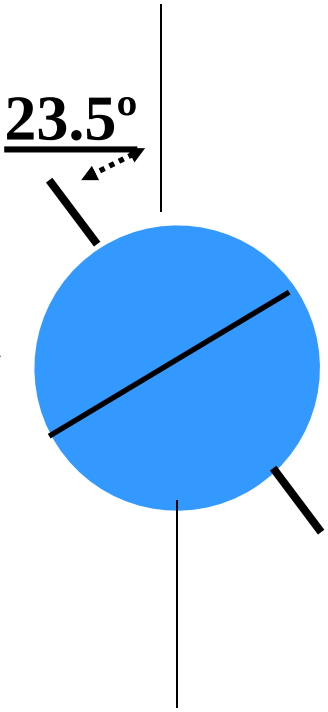


Zero axial tilt
No obliquity



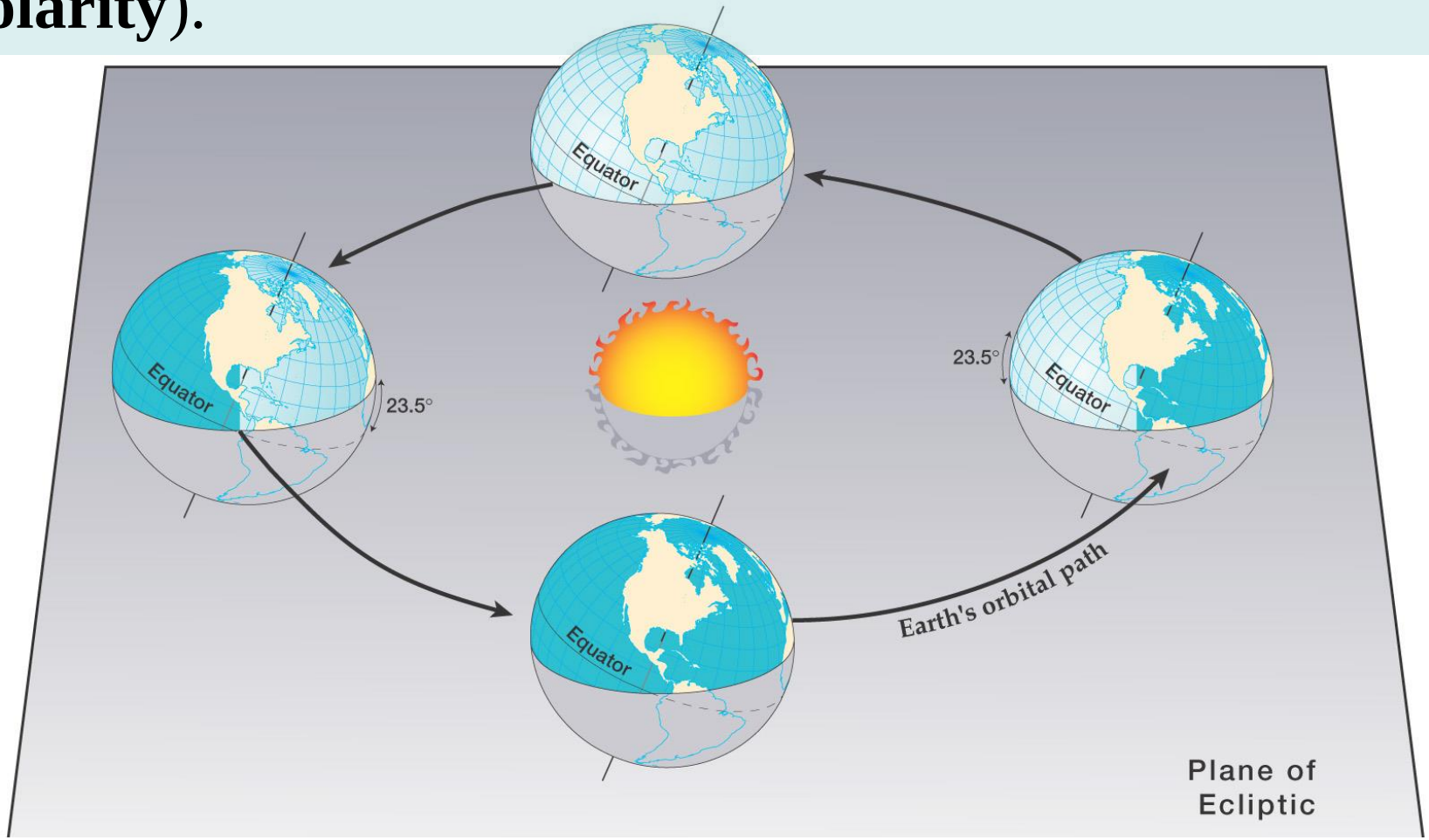


Earth's tilt on its axis = 23.5º

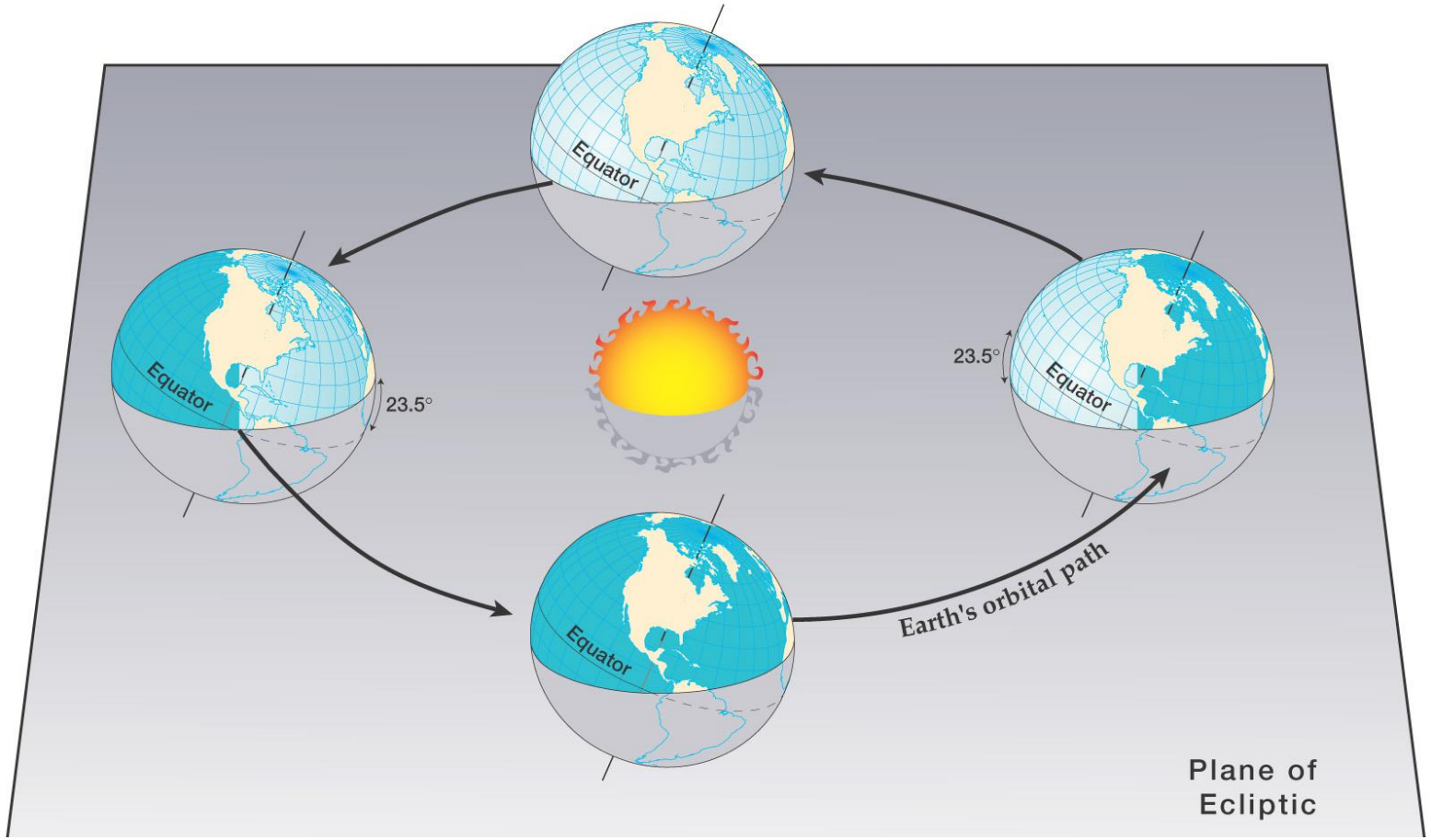


The line through the Earth is the Equator

The Earth's orientation in its orbit remains constant. The direction in space that the north and south geographic poles point remains the same regardless of the Earth's position in its orbit. This is called **axial parallelism** (sometimes called **polarity**).



The combination of Earth's tilt (obliquity) and axial parallelism, as the Earth moves around the Sun, will cause the northern hemisphere and southern hemisphere *to receive different amounts of sunlight over the year*. This is called **seasonality**.



Northern hemisphere tilted *toward the sun* (summer).
Southern hemisphere tilted *away from the sun* (winter).

Northern hemisphere tilted *away from the sun* (winter).
Southern hemisphere tilted *toward the sun* (summer).

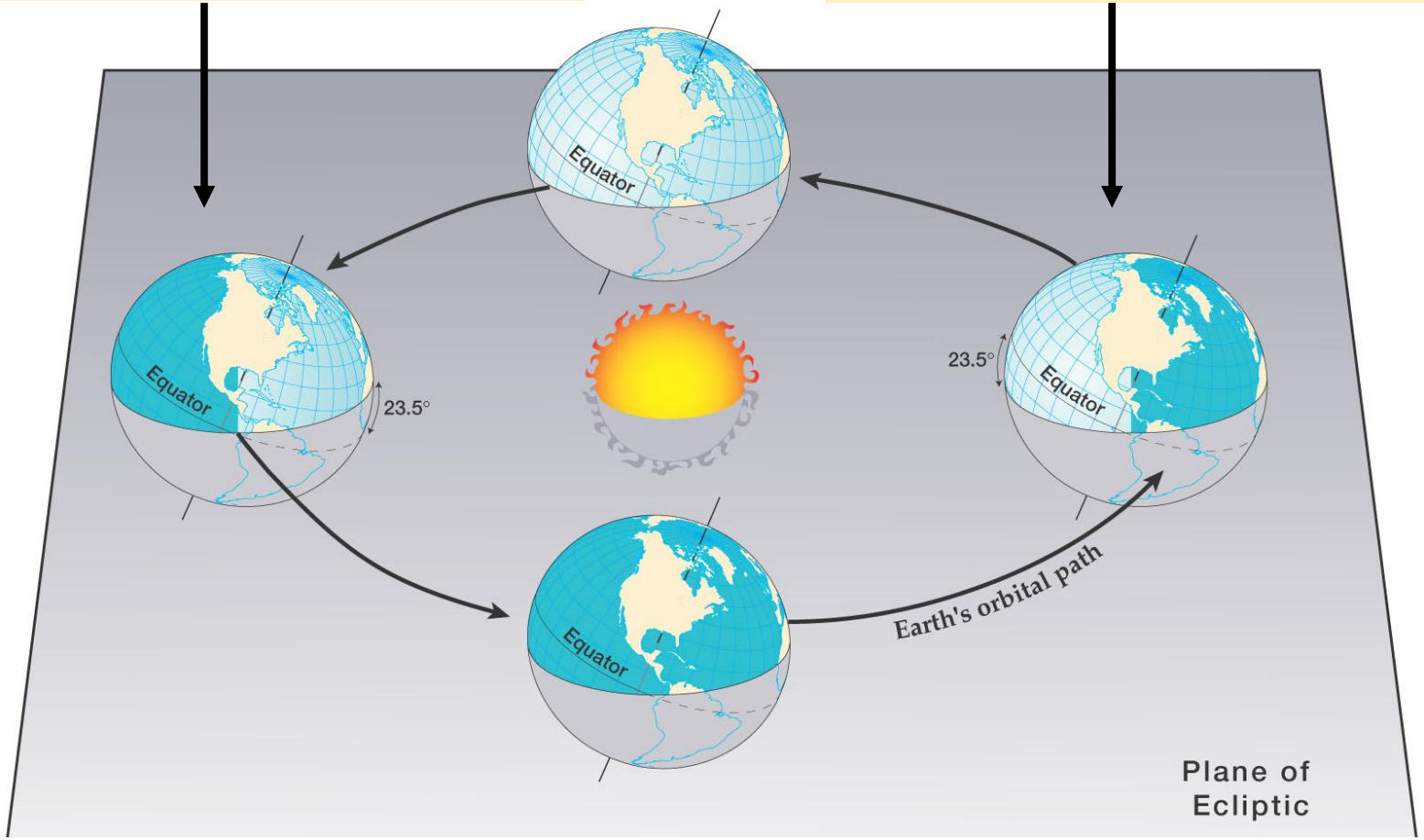
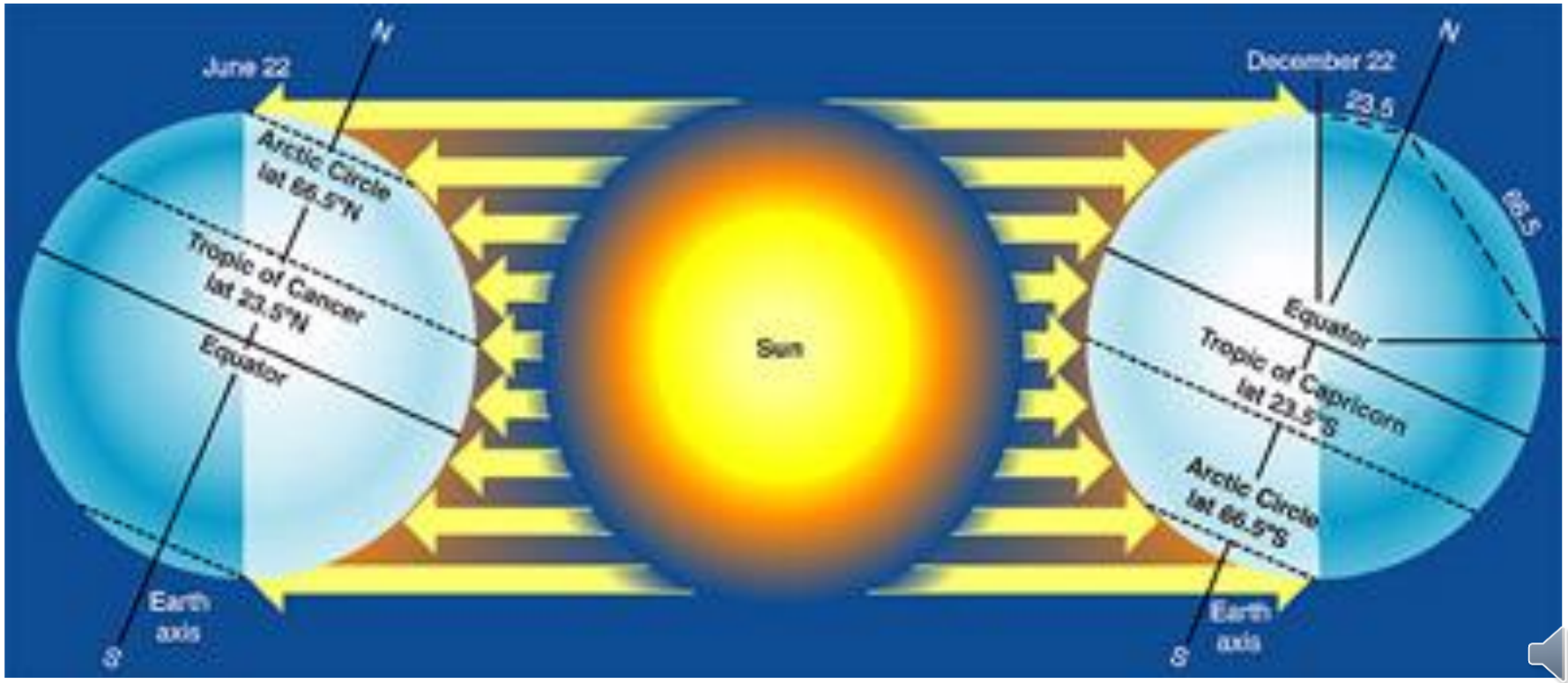


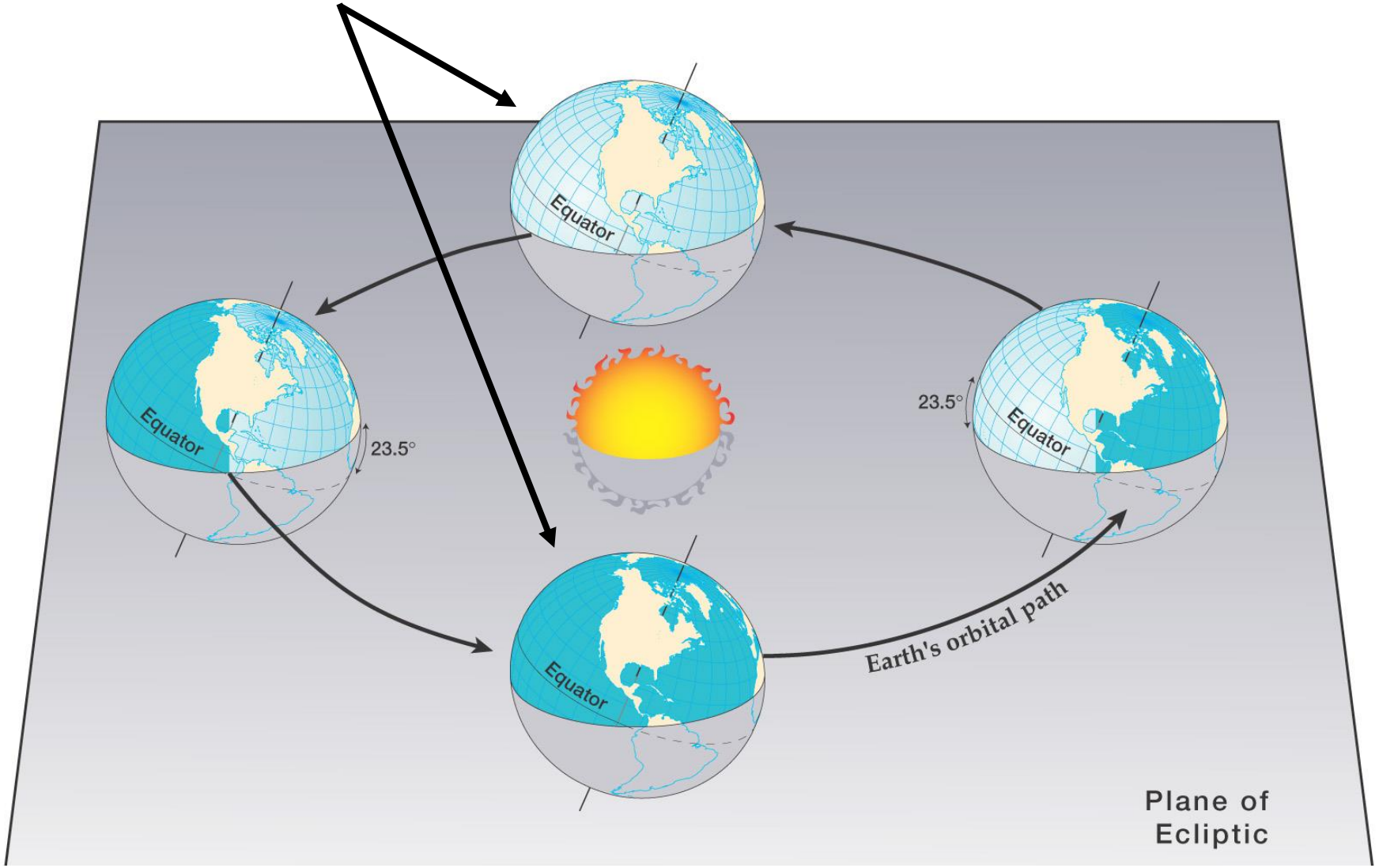
Diagram showing the distribution of incoming solar radiation during the summer solstice and the winter solstice.

Northern hemisphere tilted *toward the sun* (summer).
Southern hemisphere tilted *away from the sun* (winter).

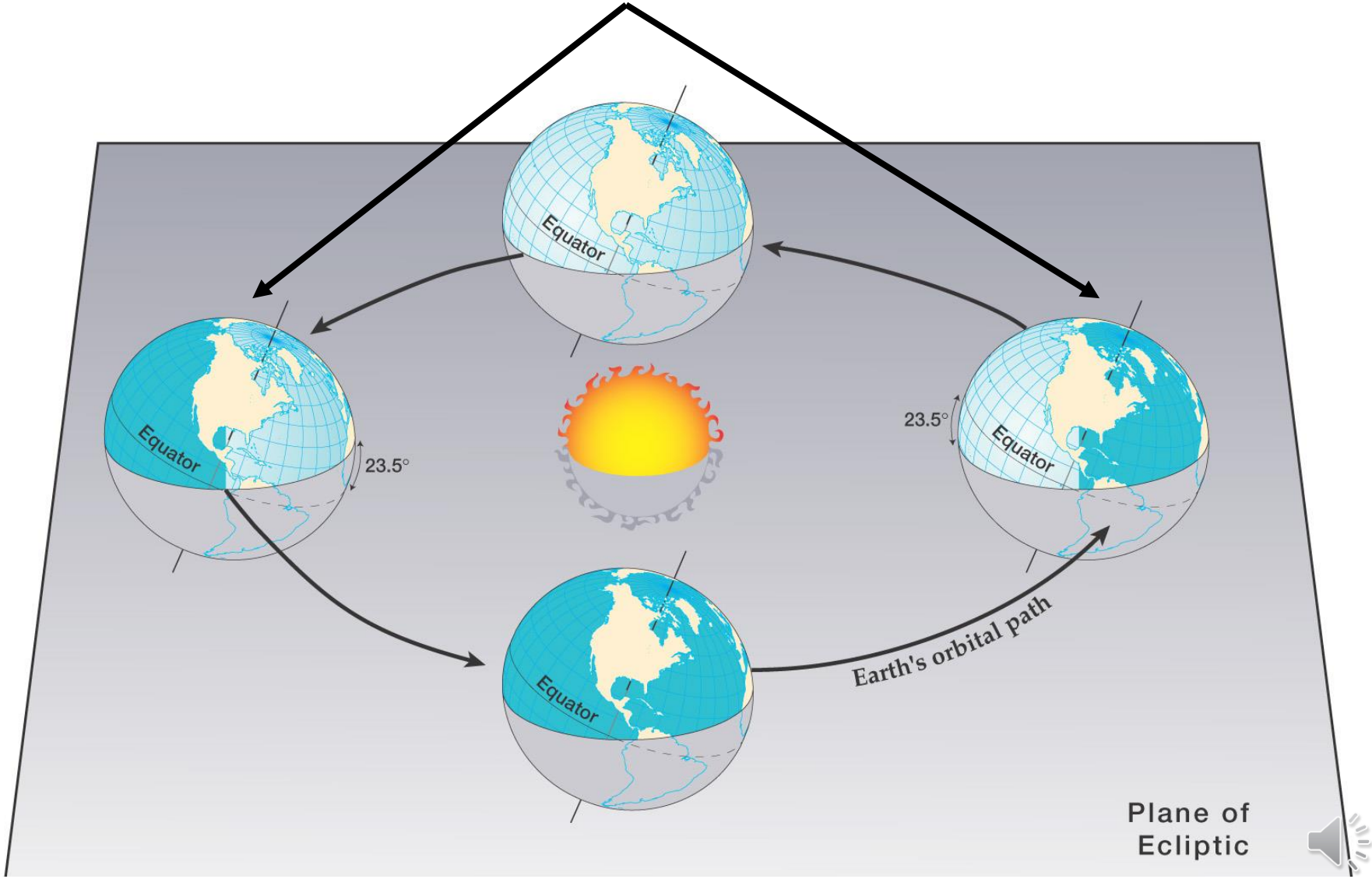
Northern hemisphere tilted *away from the sun* (winter).
Southern hemisphere tilted *toward the sun* (summer).



Sun is directly over the **equator** twice per year on the **equinoxes**. Northern and southern hemispheres get equal amounts of sunlight.



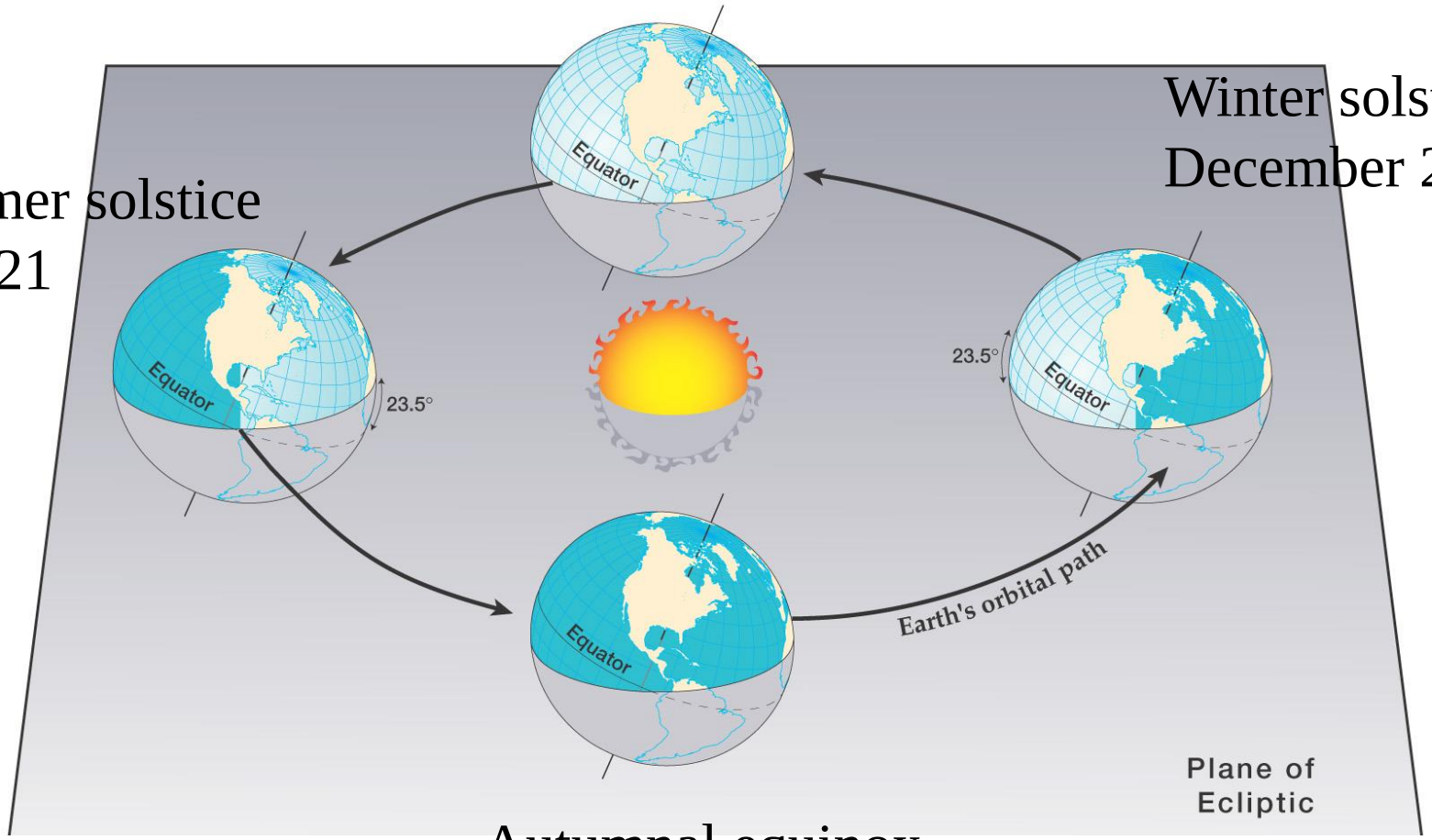
Sun is directly over the **Tropic of Cancer** and the **Tropic of Capricorn** on the **solstices**. The solstices are the days of the year that mark the longest time of daylight in each hemisphere.



Vernal equinox
March 21

Winter solstice
December 21

Summer solstice
June 21



Autumnal equinox
September 22

Where is the Overhead Sun?

~Mar 21 Vernal equinox over the Equator 0º

March 22 through June 20, Sun moves northward over latitudes between 0º → 23.5 Nº.

~June 21 Summer solstice over the Tropic of Cancer 23.5º N

June 22 through Sept 21, Sun moves southward over latitudes between 23.5º N -0º.

~Sept 22 Autumnal equinox over the Equator 0º

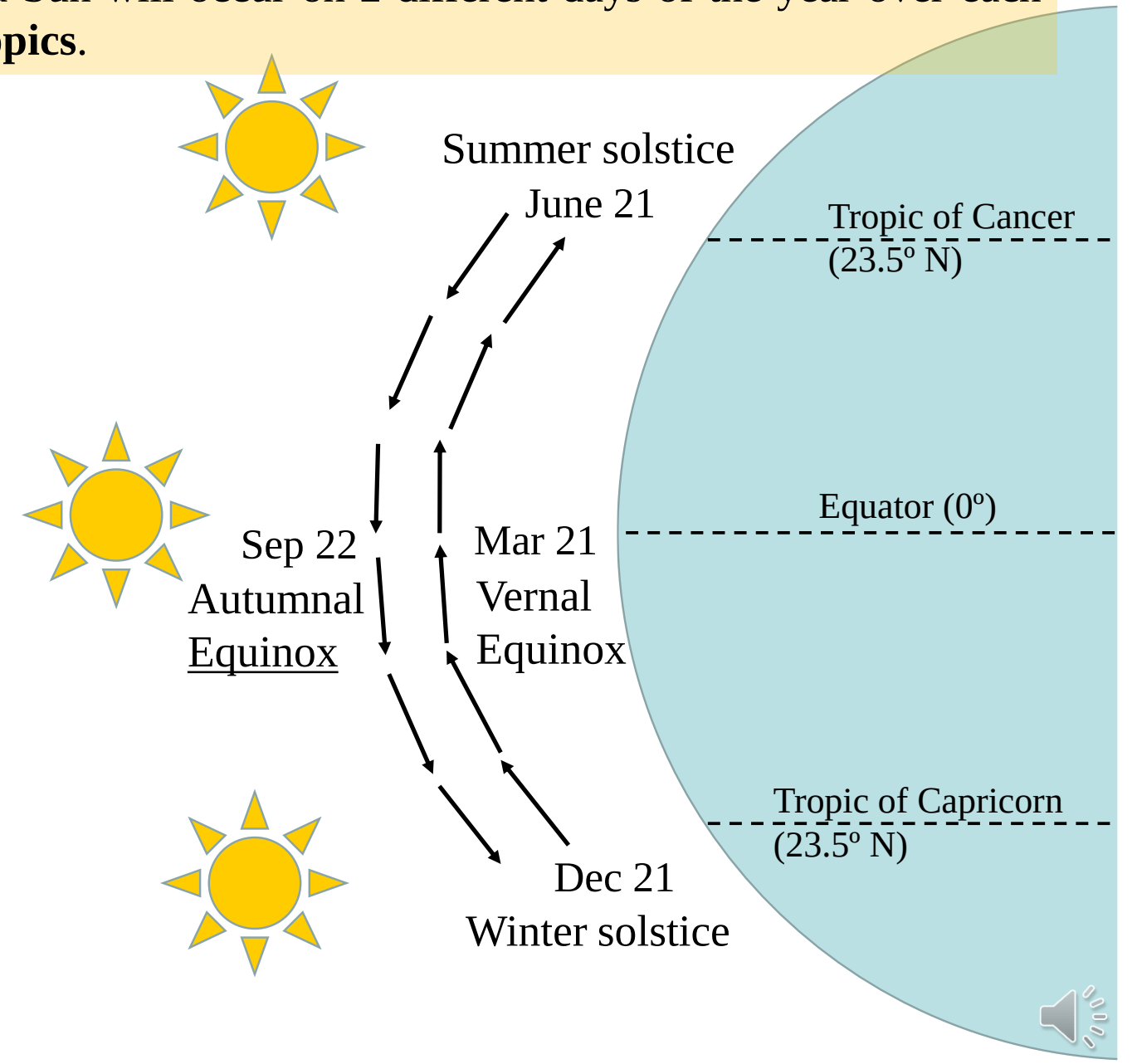
Sept 23 through Dec 21, Sun moves southward over latitudes between 0º → 23.5 Sº.

~Dec 21 Winter solsticeover the Tropic of Capricorn 23.5º S

Dec 21 through March 21, Sun moves northward over latitudes between 23.5º S -0º.

As the Earth orbits the Sun, the Sun's overhead position over the Earth's surface changes. The overhead Sun will occur on 2 different days of the year over each latitude between the **tropics**.

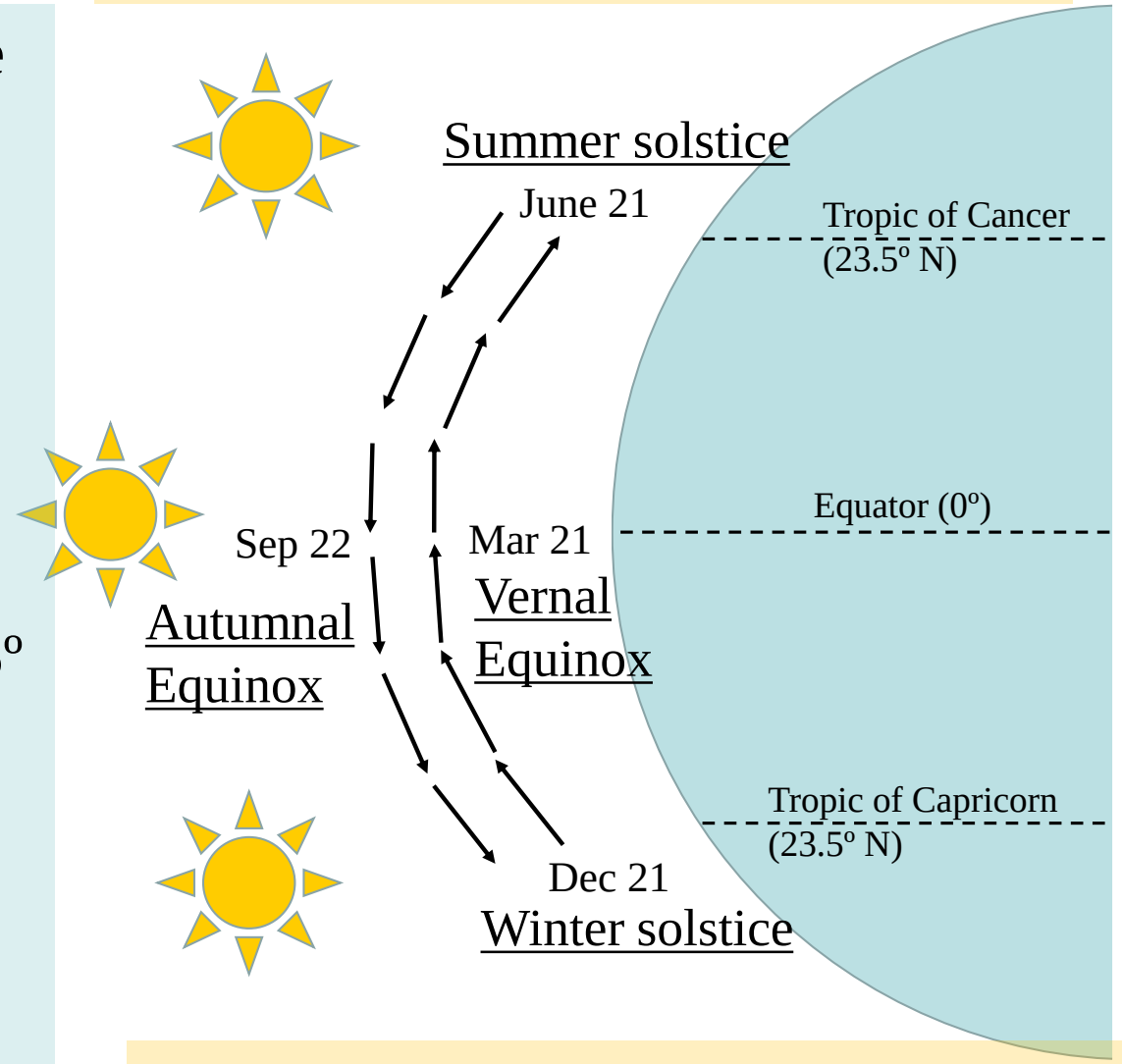
Where is the overhead Sun?



The Sun will **never** be directly overhead at latitudes north of the Tropic of Cancer.

The **tropical latitudes** are the latitudes on Earth between the Tropic of Cancer and the Tropic of Capricorn.

The tropics (23.5º N -23.5º S) have very warm to hot temperatures all year because the Sun is always high in the sky and they receive direct sunlight most months of the year.



The Sun will **never** be directly overhead at latitudes south of the Tropic of Capricorn.

During an **equinox** (equal day)

- The sun is directly over the **equator.**
- Vernal equinox (March 21)
- Autumnal equinox (Sept 22)
- Solar radiation from the Sun is evenly divided between the northern and southern hemisphere.
- All places on Earth have 12 hours of light (day) and 12 hours of dark (night).

During the summer solstice: June 21

- The sun is directly over the **Tropic of Cancer** (23.5º N)
- It is midsummer in the northern hemisphere, the northern hemisphere has its greatest tilt toward the sun.
- All latitudes north of the equator have longer daylight and shorter night time.
- All latitudes between the **Arctic circle** (66.5º N) and the **north geographic pole** (90º N) have 24 consecutive hours of daylight.

During the summer solstice: June 21

- It is midwinter in the southern hemisphere, the southern hemisphere has its greatest tilt away from the sun.
- All latitudes south of the equator have shorter daylight and longer nighttime.
- All latitudes between the **Antarctic circle** (66.5º S) and the **south geographic pole** (90º S) have 24 consecutive hours of darkness.

During the winter solstice: December 21

- The sun is directly over the **Tropic of Capricorn** (23.5º S)
- It is midsummer in the southern hemisphere, the southern hemisphere has its greatest tilt toward the sun.
- All latitudes south of the equator have longer daylight and shorter nighttime.
- All latitudes between the **Antarctic circle** (66.5º S) and the **south geographic pole** (90º N) have 24 consecutive hours of daylight.

During the winter solstice: December 21

- It is midwinter in the northern hemisphere, the northern hemisphere has its greatest tilt away from the sun.
- All latitudes north of the equator have shorter daylight and longer nighttime.
- All latitudes between the **Arctic circle** (66.5º N) and the **north geographic pole** (90º N) have 24 consecutive hours of darkness.

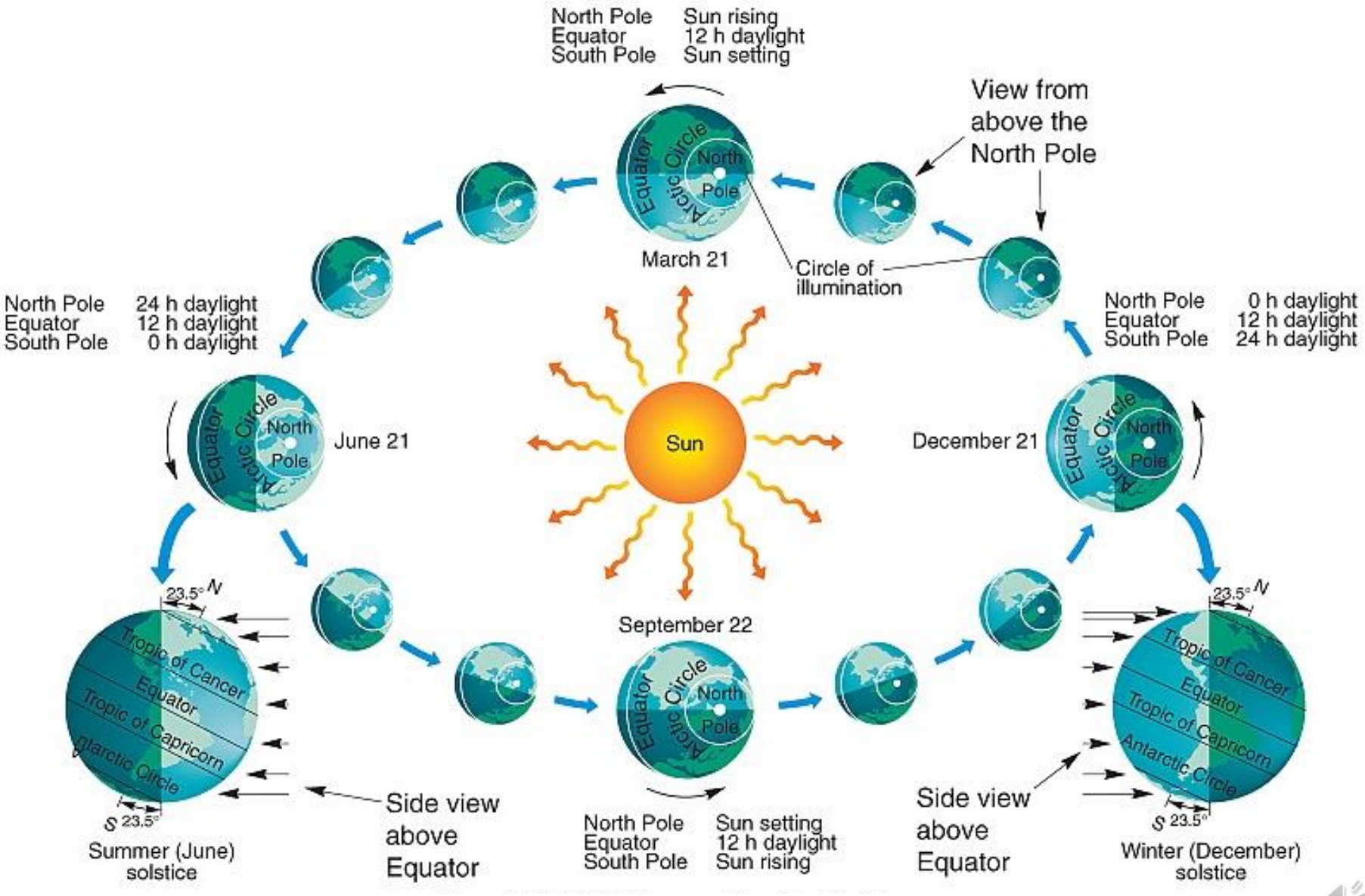

North Pole Sun rising
Equator 12 h daylight
South Pole Sun setting
View from above the North Pole
Equator
Arctic Circle
North Pole
March 21
Circle of illumination
North Pole 24 h daylight
Equator 12 h daylight
South Pole 0 h daylight
North Pole 0 h daylight
Equator 12 h daylight
South Pole 24 h daylight
June 21
Sun
December 21
September 22
23.5° N
Tropic of Cancer
Equator
Tropic of Capricorn
Antarctic Circle
23.5° S
Summer (June) solstice
Side view above Equator
North Pole Sun setting
Equator 12 h daylight
South Pole Sun rising
Side view above Equator
Winter (December) solstice

Image of the 24 hour Sun in the Arctic Circle during the peak NH summer.

Note that the Sun's position in the sky for all 24 hours is near the horizon—the Sun does not rise high into the sky.