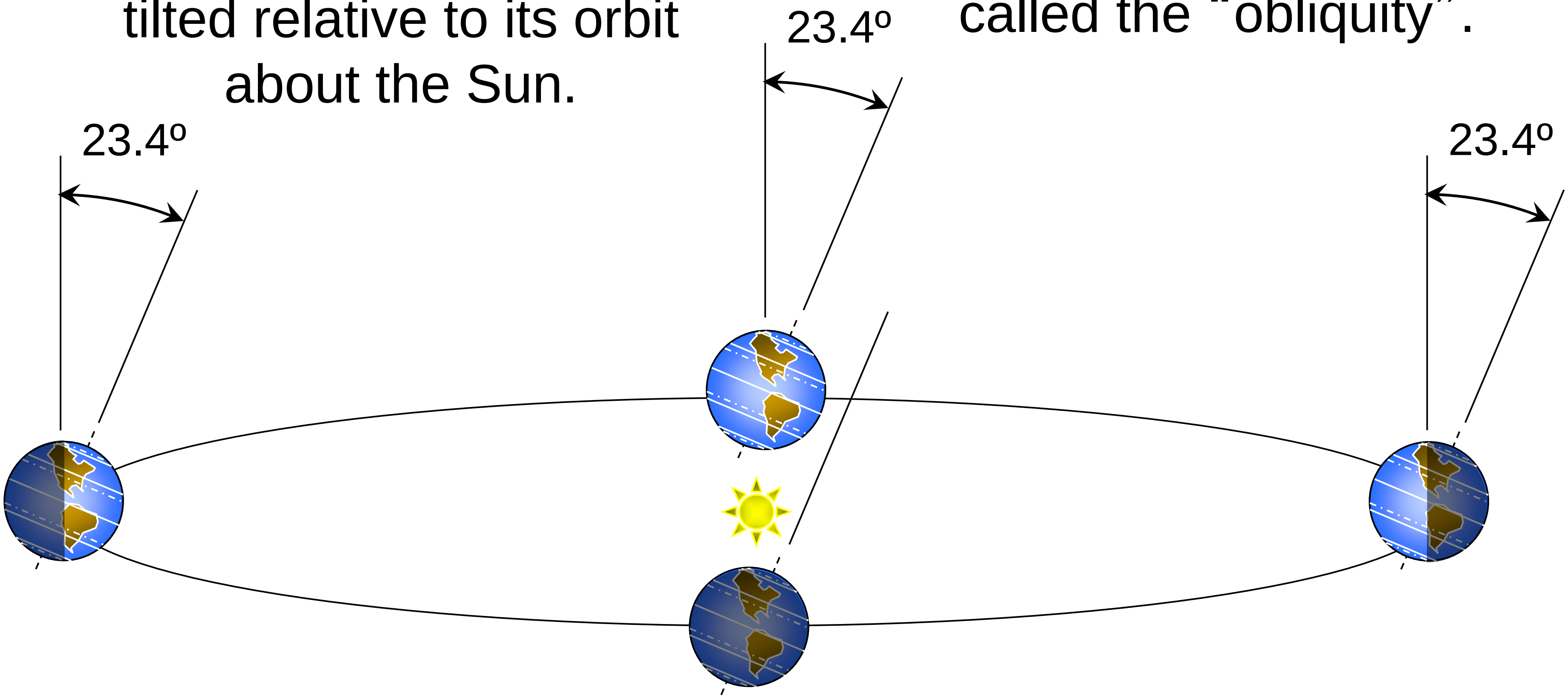
Seasons of the Sun

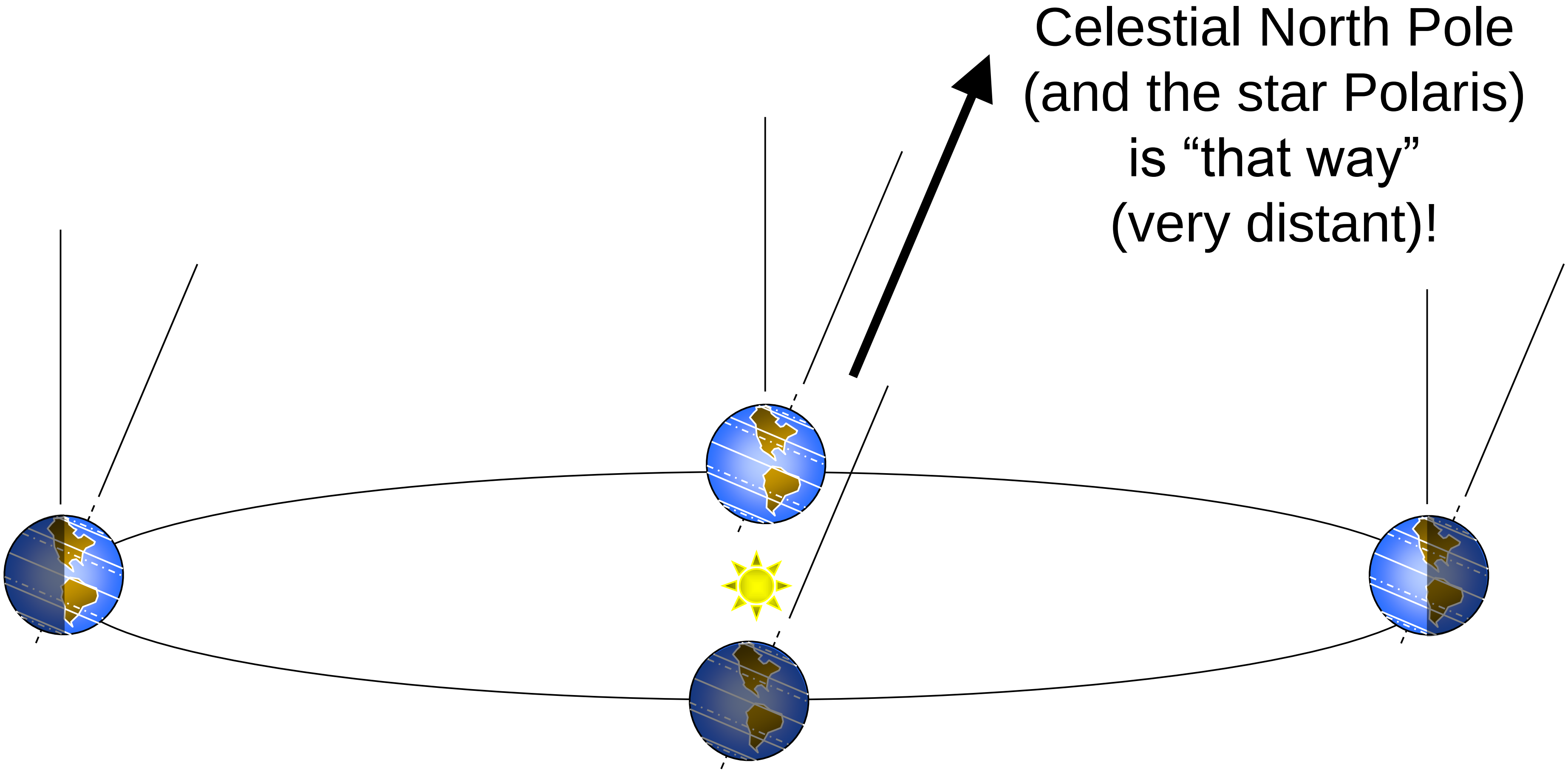
Understanding the Tropical Year

Earth’s axis of rotation is tilted relative to its orbit about the Sun.

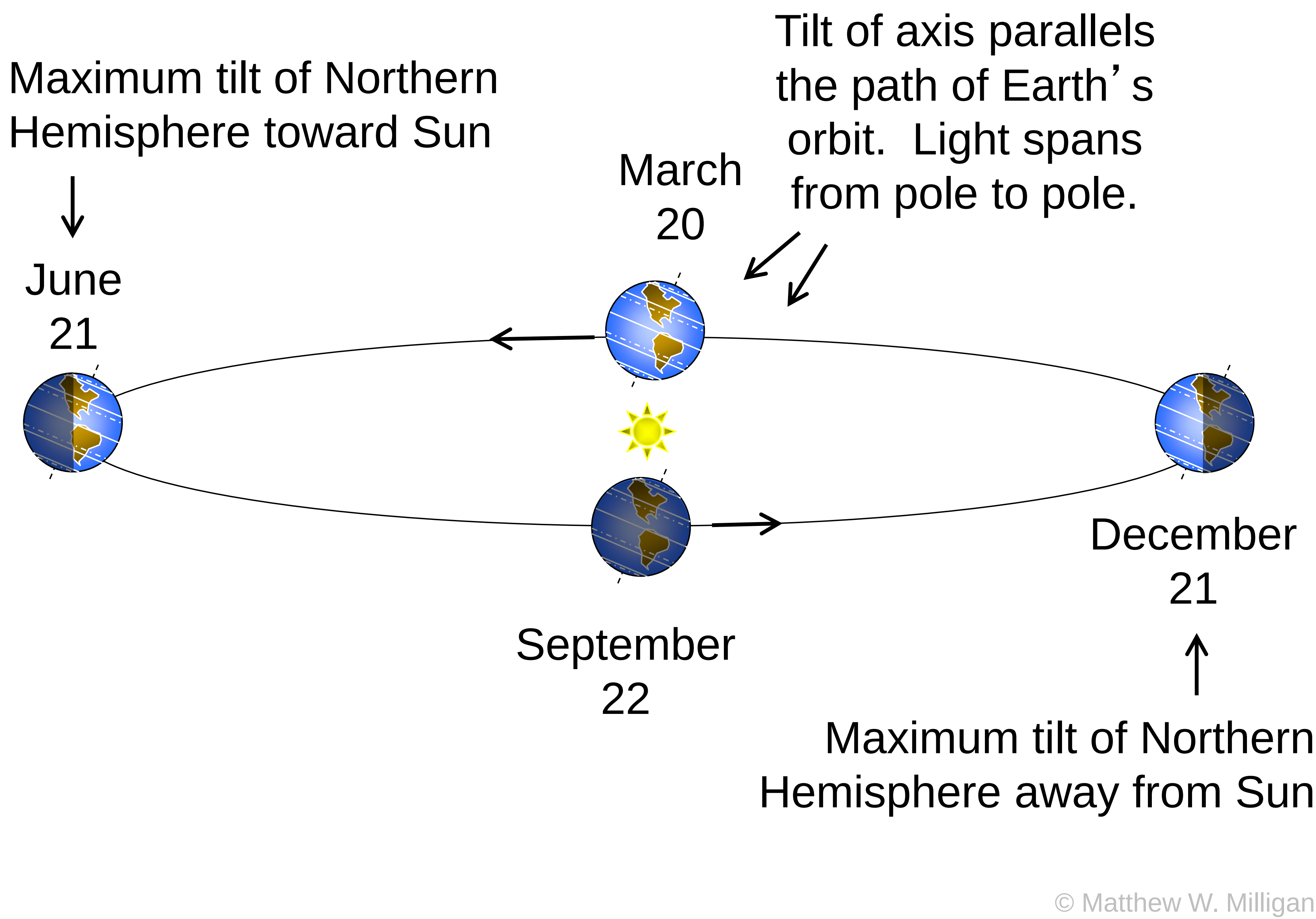
This angle of tilt is called the “obliquity”.

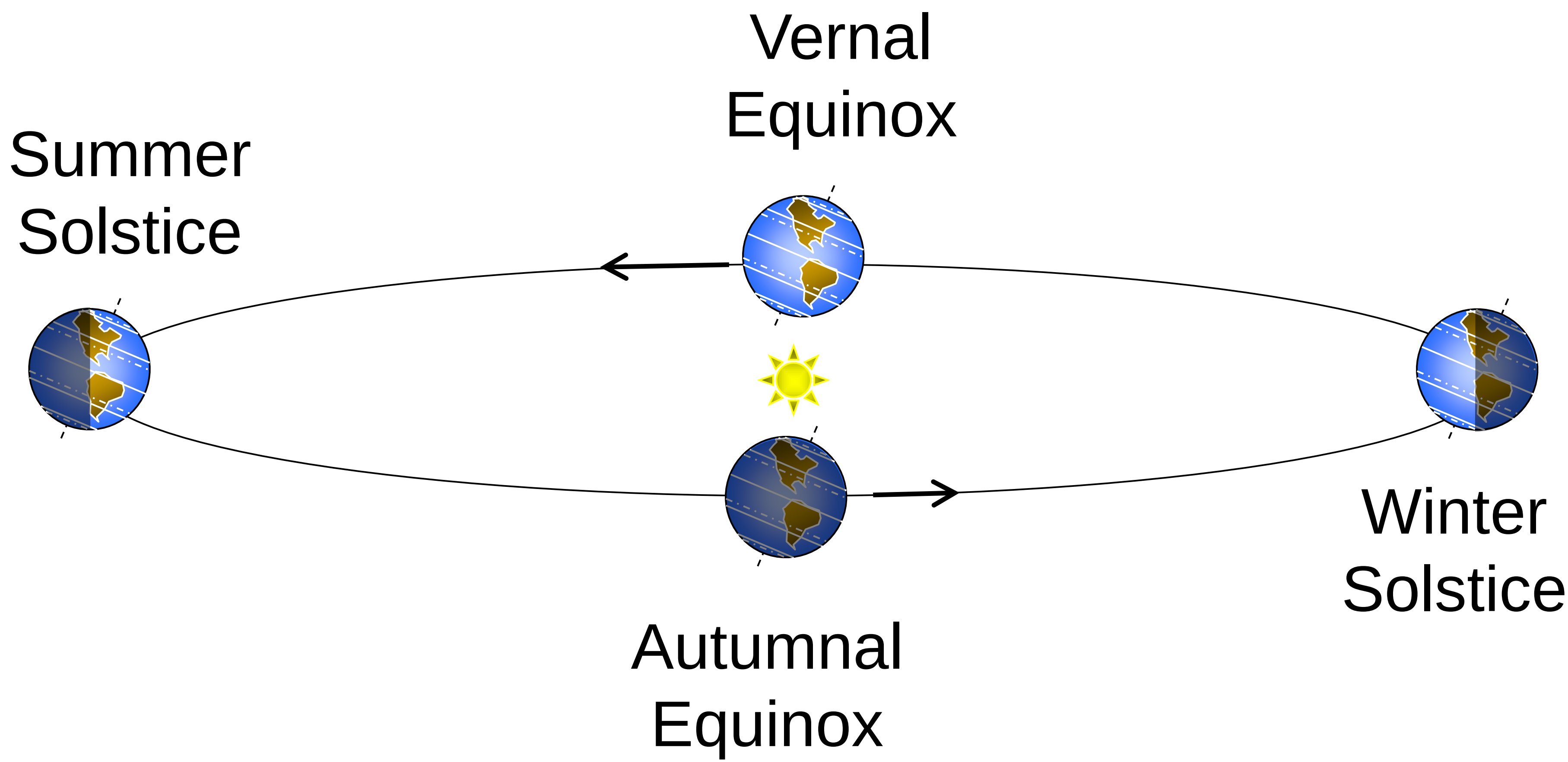


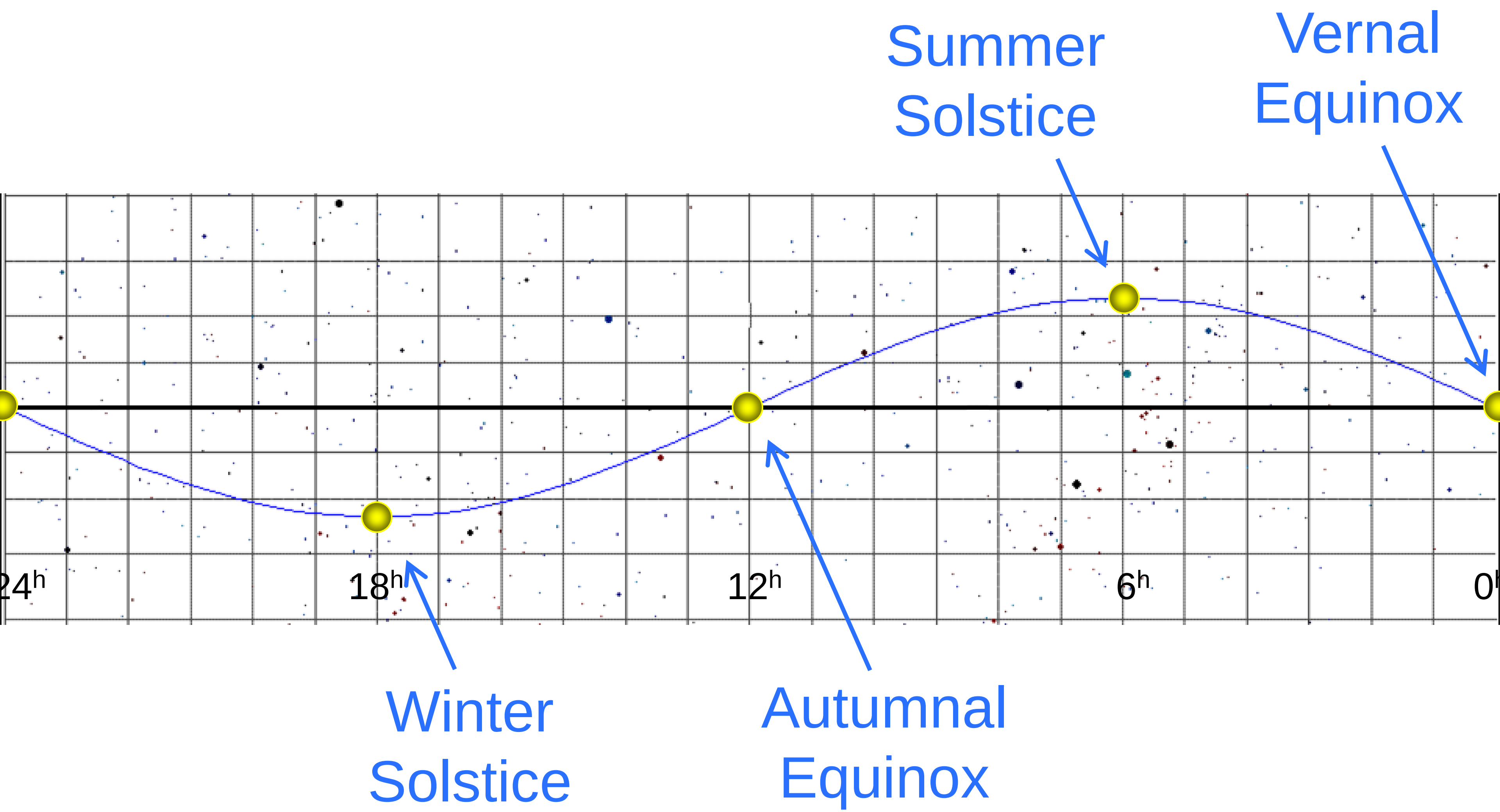
The axis remains tilted by the same amount and “leans” in the same direction of space as Earth orbits the Sun.

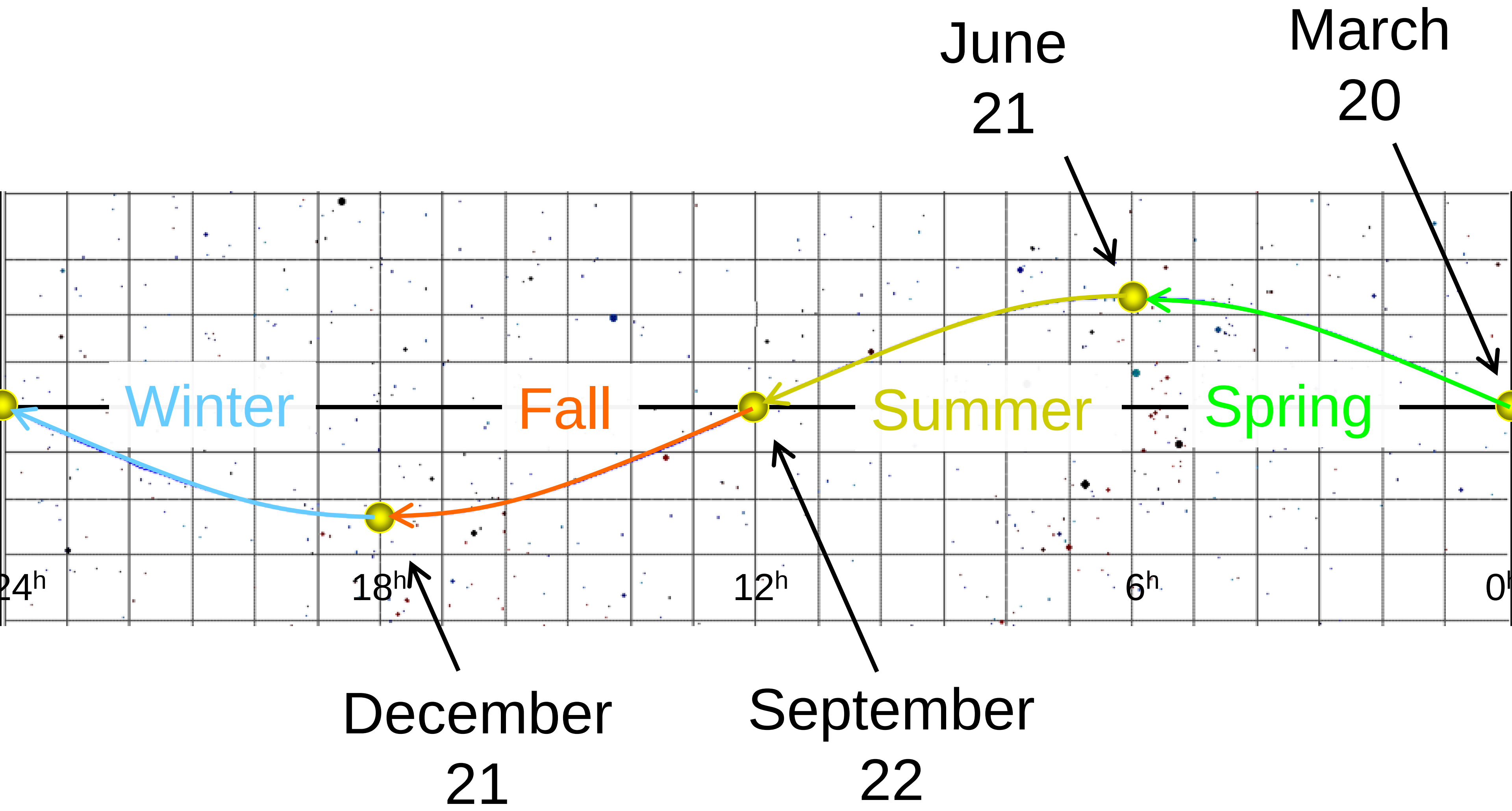


Because the stars are so far away, it appears like the axis of the Earth is always pointing at the same point on the celestial sphere – the Celestial North Pole.


Maximum tilt of Northern Hemisphere toward Sun
Tilt of axis parallels the path of Earth's orbit. Light spans from pole to pole.
March 20
June 21
December 21
September 22
Maximum tilt of Northern Hemisphere away from Sun
© Matthew W. Milligan


Vernal
Equinox
Summer
Solstice
Winter
Solstice
Autumnal
Equinox


Summer
Solstice
Vernal
Equinox
24h
18h
12h
6h
0h
Winter
Solstice
Autumnal
Equinox



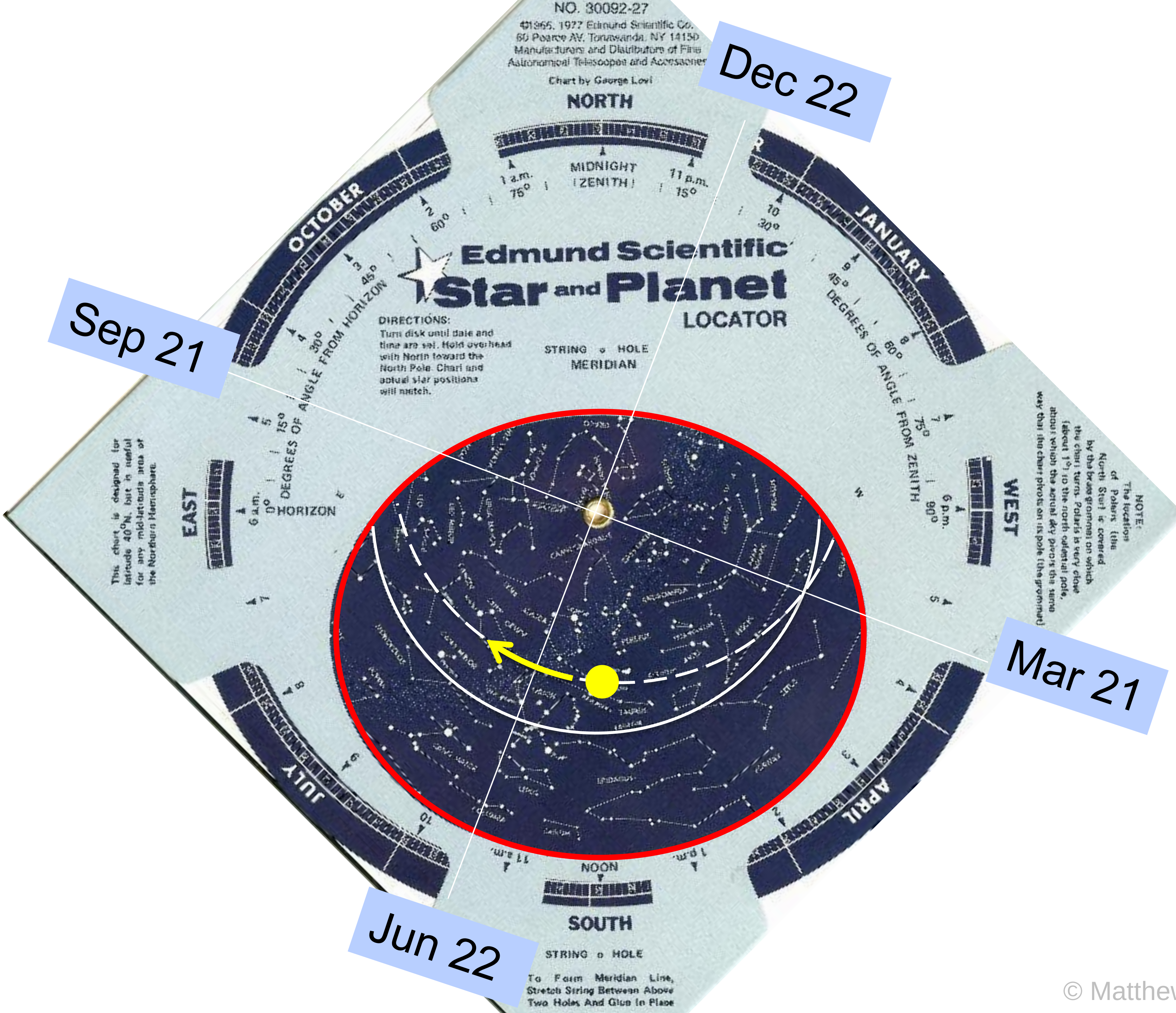
Note: the dates can vary by a day or two year to year.

Equinoxes

- On the day of an **equinox** the number of daylight hours equals the number of nighttime hours. This is true everywhere on Earth.
- An **equinox** is also defined as the point where the Sun crosses the celestial equator (*i.e.* ecliptic intersects equator).
- An equinox is a point in time and a point on the celestial sphere (*i.e.* a direction in space).

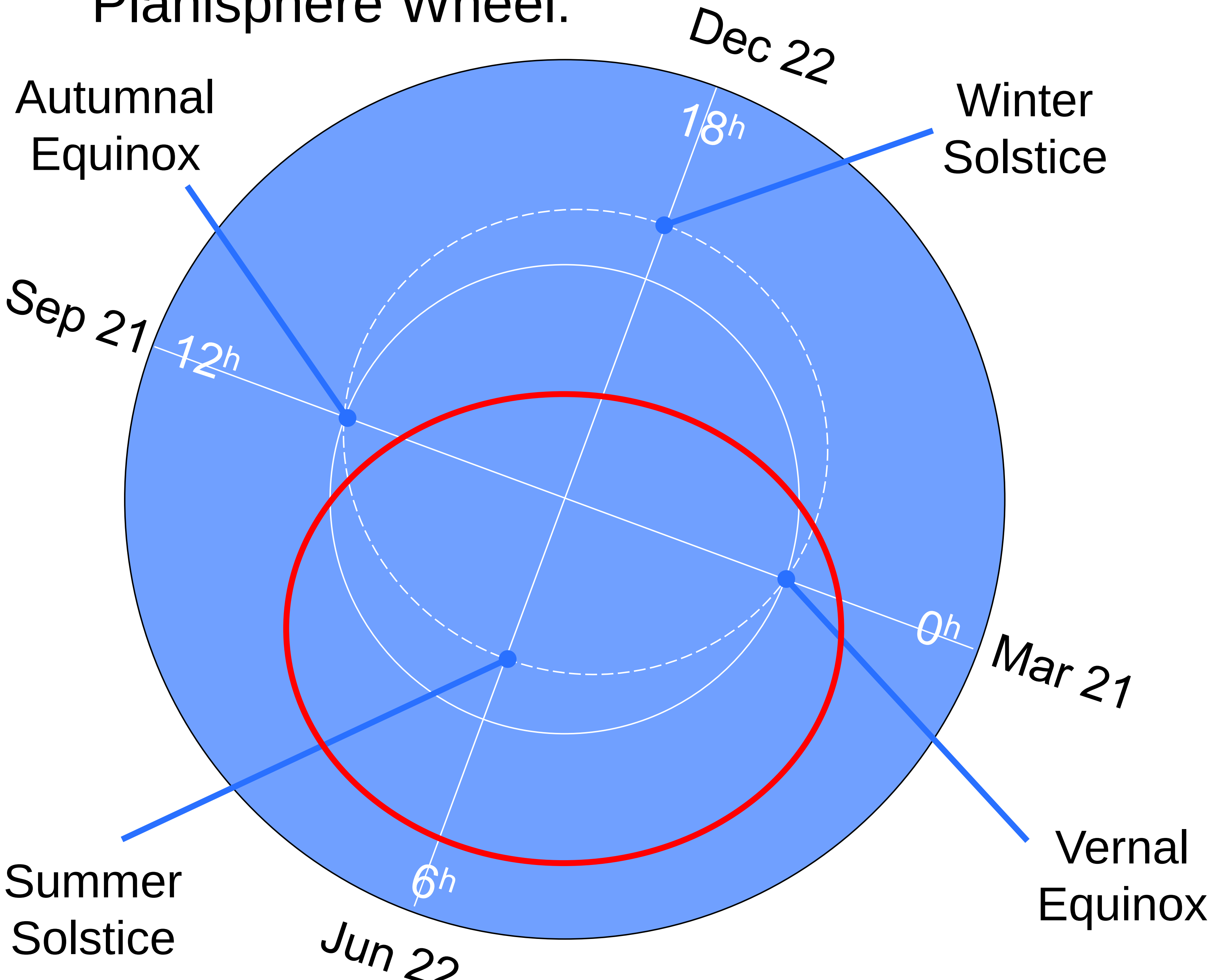
Solstices

- On the day of a **solstice** the number of daylight hours is maximized or minimized.
- A **solstice** is also defined as a point where the Sun's declination is maximized or minimized ($\delta = \pm\ 23.4^{\circ}$).
- A solstice is a point in time and a point on the celestial sphere (*i.e.* a direction in space).



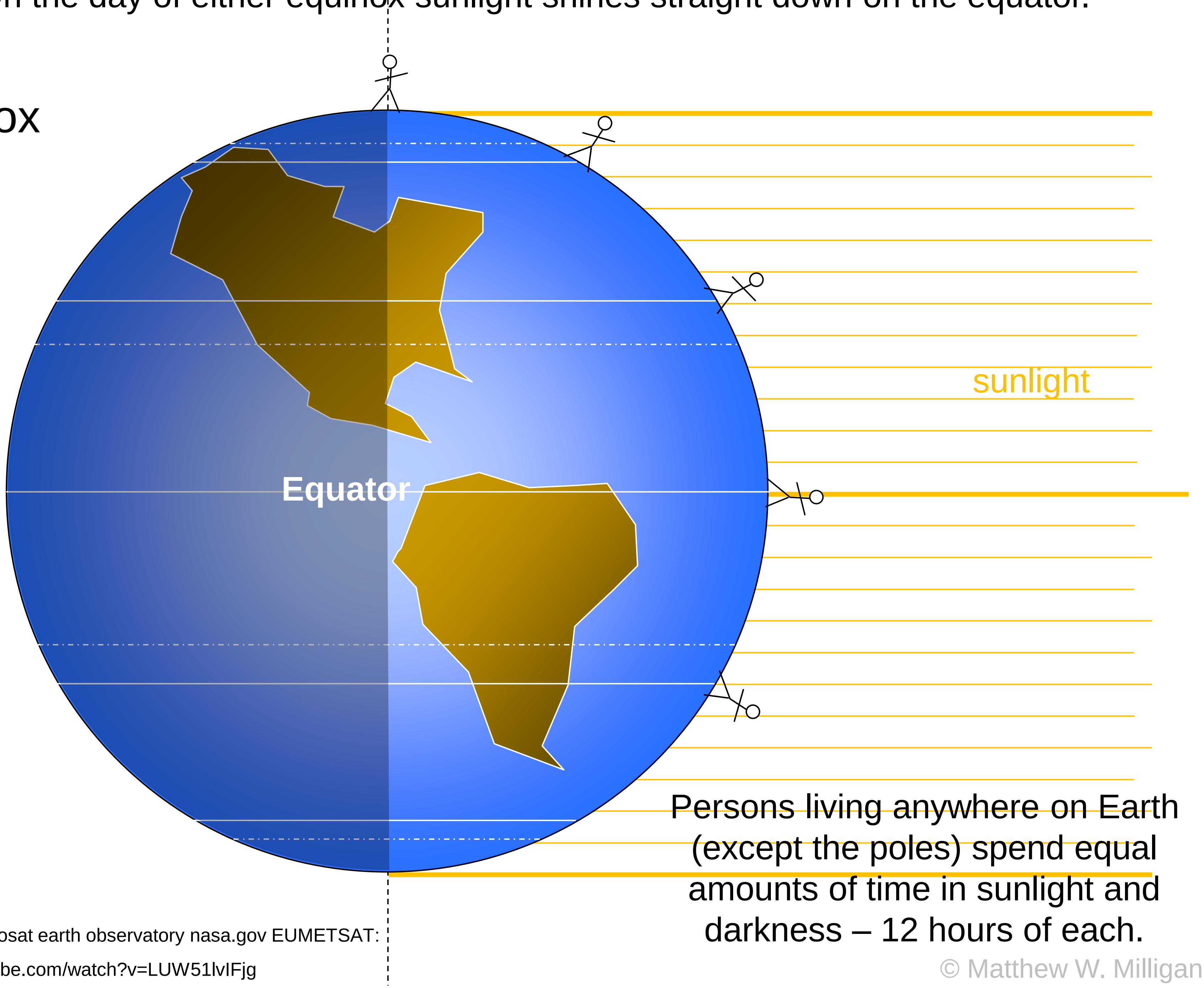
NO. 30092-27
©1966, 1977 Edmund Scientific Co.
60 Pearce AV. Tonawanda, NY 14150
Manufacturers and Distributors of Fine
Astronomical Telescopes and Accessories
Chart by George Lovi
NORTH
MIDNIGHT (ZENITH)
1 a.m. 75°
11 p.m. 15°
Edmund Scientific
Star and Planet
LOCATOR
DIRECTIONS:
Turn disk until date and time are set. Hold overhead with North toward the North Pole. Chart and actual star positions will match.
STRING o HOLE
MERIDIAN
OCTOBER
JANUARY
APRIL
JULY
EAST
WEST
SOUTH
NOON
HORIZON
DEGREES OF ANGLE FROM HORIZON
DEGREES OF ANGLE FROM ZENITH
6 a.m. 0°
6 p.m. 90°
11 a.m.
1 p.m.
This chart is designed for latitude 40°N, but is useful for any mid-latitude area of the Northern Hemisphere.
STRING o HOLE
To Form Meridian Line, Stretch String Between Above Two Holes And Glue In Place
Dec 22
Sep 21
Mar 21
Jun 22

Planisphere Wheel:



On the day of either equinox sunlight shines straight down on the equator.

Equinox



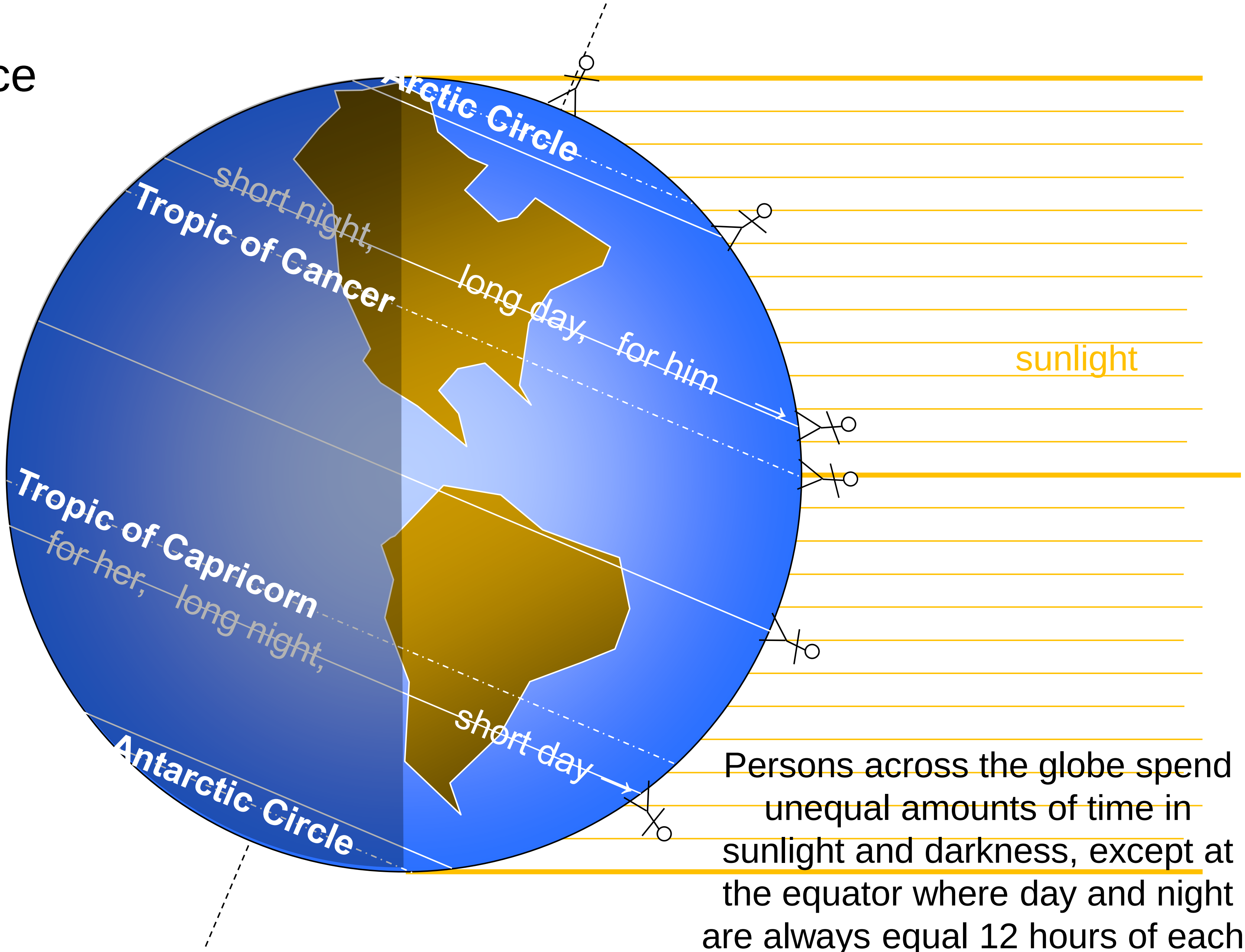
Persons living anywhere on Earth (except the poles) spend equal amounts of time in sunlight and darkness – 12 hours of each.

video from meteosat earth observatory nasa.gov EUMETSAT:

http://www.youtube.com/watch?v=LUW51lvIFjg

On the day of either solstice sunlight shines straight down on one of the tropics.

Solstice

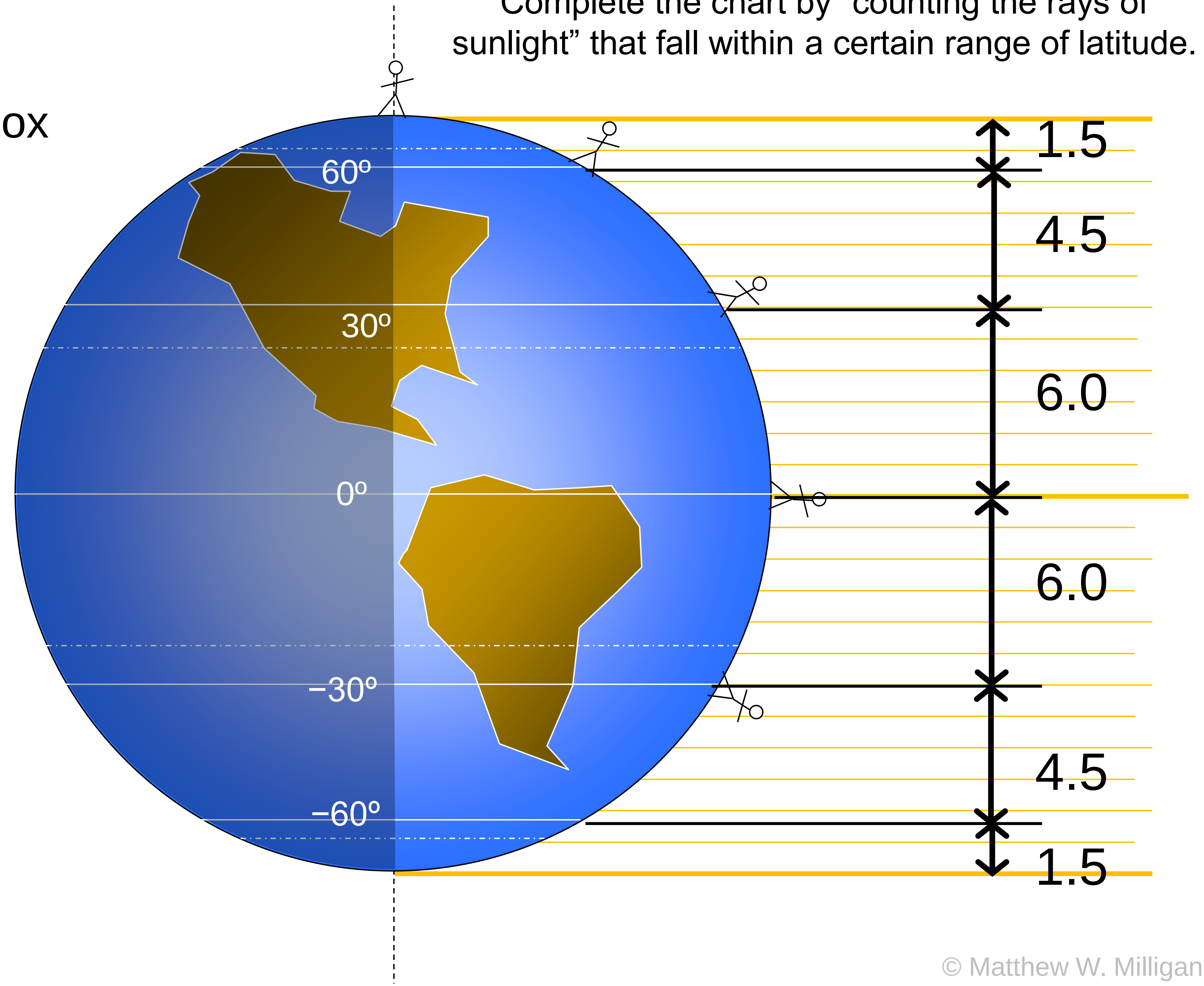


Persons across the globe spend unequal amounts of time in sunlight and darkness, except at the equator where day and night are always equal 12 hours of each.

Latitude	Amount of Light	Length of Day	Total Energy
60º – 90º			
30º – 60º			
0º – 30º			

Complete the chart by “counting the rays of sunlight” that fall within a certain range of latitude.

Equinox

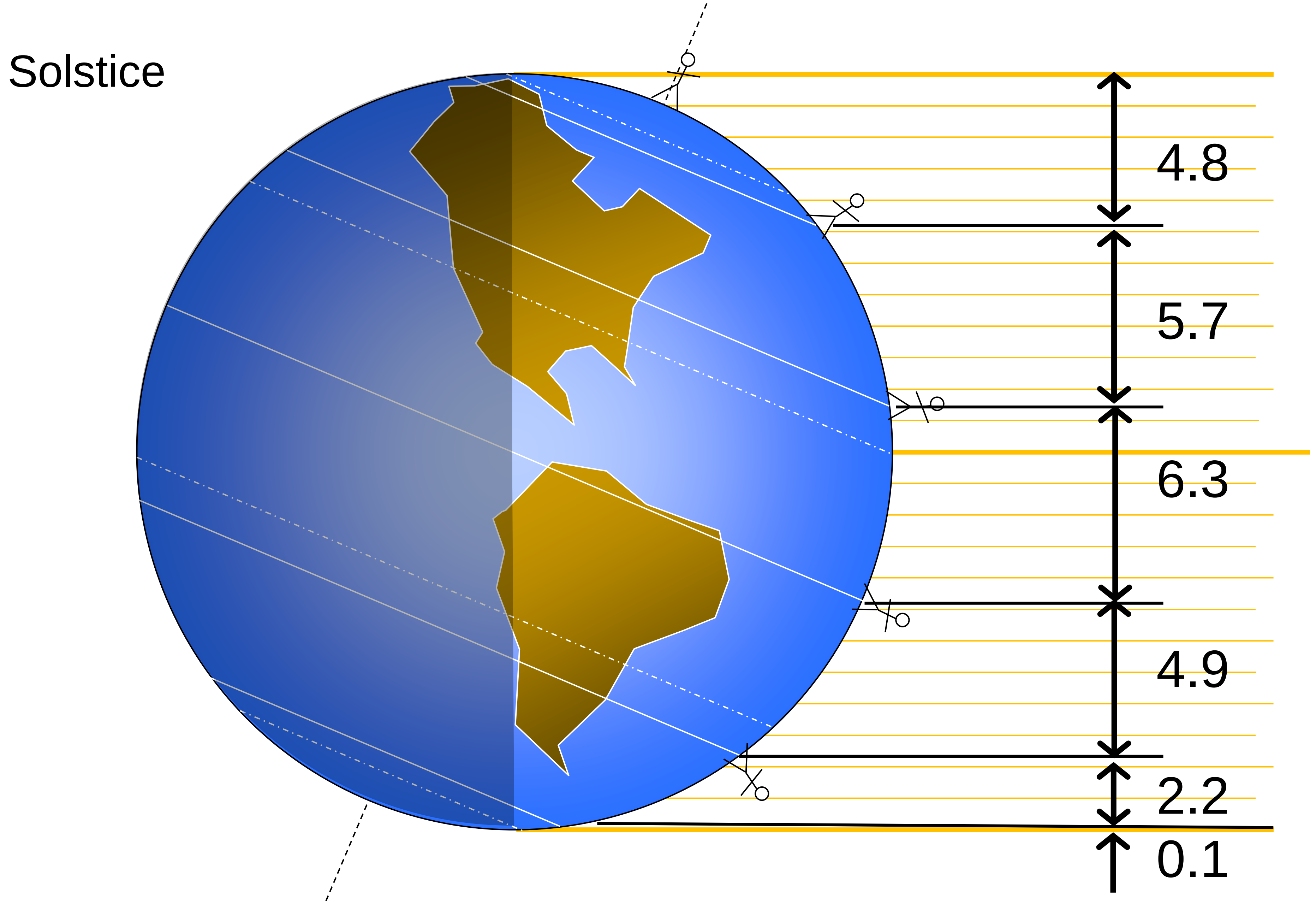


Latitude	Amount of Light	Length of Day	Total Energy
60º – 90º	1.5	12	18
30º – 60º	4.5	12	54
0º – 30º	6.0	12	72

Note: the values shown here are *relative* numbers without specific units and provide a rough way to *approximate* the amount of sunlight hitting the Earth. To do these calculations more correctly is a very complex problem…

Latitude	Amount of Light	Length of Day	Total Energy
60º – 90º		24	
30º – 60º		16	
0º – 30º		12	
-30º – 0º		8	
-60º – -30º		4	
-90º – -60º		1	

On the day of either solstice sunlight shines straight down on one of the tropics.



Latitude	Amount of Light	Length of Day	Total Energy
60º – 90º N	4.8	24	115
30º – 60º N	5.7	16	91.2
0º – 30º N	6.3	12	75.6
0º – 30º S	4.9	8	39.2
30º – 60º S	2.2	4	8.8
60º – 90º S	0.1	1	0.1

	total energy			
Latitude	Vernal Equinox	Summer Solstice	Autumnal Equinox	Winter Solstice
60º – 90º N	18	115	18	0.1
30º – 60º N	54	91.2	54	8.8
0º – 30º N	72	75.6	72	39.2
0º – 30º S	72	39.2	72	75.6
30º – 60º S	54	8.8	54	91.2
60º – 90º S	18	0.1	18	115

	total energy			
Latitude	Vernal Equinox	Summer Solstice	Autumnal Equinox	Winter Solstice
60º – 90º N	18	115	18	0.1
30º – 60º N				
0º – 30º N	72	75.6	72	39.2
0º – 30º S	72	39.2	72	75.6
30º – 60º S	54	8.8	54	91.2
60º – 90º S	18	0.1	18	115

Notice that energy received in the Earth's tropics is fairly steady throughout the year – not much variation through the seasons.

	total energy			
Latitude	Vernal Equinox	Summer Solstice	Autumnal Equinox	Winter Solstice
60º – 90º N	In a temperate zone the energy received varies significantly causing the seasonal changes we are used to in the United States.			
30º – 60º N	54	91.2	54	8.8
0º – 30º N	72	75.6	72	39.2
0º – 30º S	72	39.2	72	75.6
30º – 60º S	54	8.8	54	91.2
60º – 90º S	18	0.1	18	115

	total energy			
Latitude	Vernal Equinox	Summer Solstice	Autumnal Equinox	Winter Solstice
60° – 90° N	18	115	18	0.1
30° – 60° N				
0° – 30° N	72	75.6	72	39.2
0° – 30° S	72	39.2	72	75.6
30° – 60° S	54	8.8	54	91.2
60° – 90° S	18	0.1	18	115

In the polar regions there is a great swing in the values. Also the total energy received over the course of a year is significantly less than temperate or equatorial regions:

72 + 39.2 + 72 + 75.6 = 258.8 total

54 + 8.8 + 54 + 91.2 = 208 total

18 + 0.1 + 18 + 115 = 151.1 total

The Tropical Year

- **Tropical Year** = 365.2422 days, which is the time for the Sun to complete one trip "through the tropics", *i.e.* the time to go from one vernal equinox to the next.
- This is a complete <u>cycle of seasons</u> during which Sun appears higher and lower in our sky.
- Length of day and angle of sunlight relative to Earth's surface control the seasons.

Distance Variation

- As Earth orbits the Sun, the distance varies by about ± 1.7%.
- Average Distance: 149.6 Gm
  Minimum Distance: 147.1 Gm
  Maximum Distance: 152.1 Gm
- Dates of the year (approximate):
  Minimum: January 3; Maximum: July 4
- This has very little effect on the Earth's temperature and the seasons! The change in distance causes only ± 3% change in energy received from the Sun.