

Announcements

- Those who successfully registered their iClicker on Friday should have a grade of 100% for an item 01_23 in ICON.
- Astronomy tutorials have begun. For hours, see the link from the class web site.
- For those taking the lab: Remember to print out the lab write up before going to lab.

Today's lecture

- How to locate objects on the sky
- Celestial sphere, coordinates on the sky
- Motion of stars on the sky
- Motions of the sun and planets
- The seasons

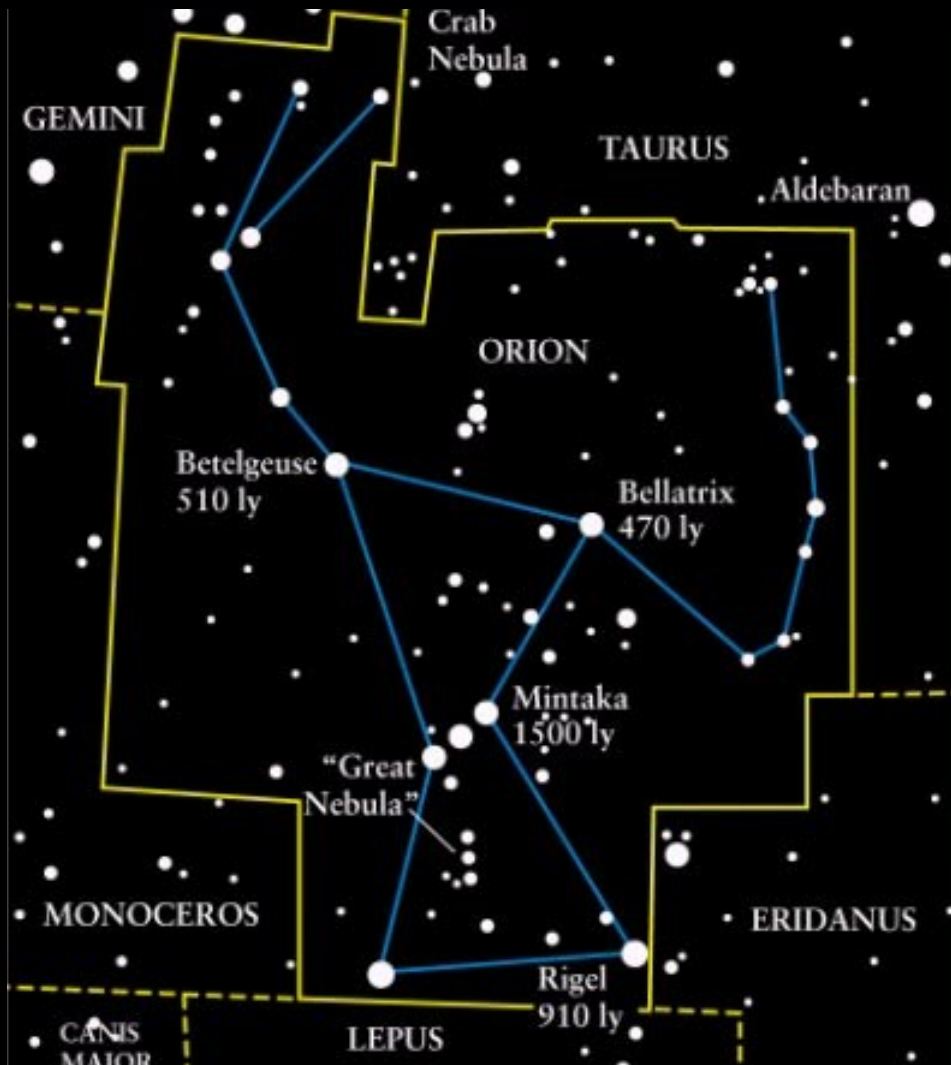
What causes the seasons?

- A) The orbit of the Earth is an ellipse, not a circle, and the Earth is closer to the Sun in summer than in winter.
- B) The rotation of the Earth is tilted relative to its orbit.

How does one locate an object on the sky?

1. By drawing imaginary patterns on the sky (the constellations) and then locating the object relative to the stars in the constellations.
2. By drawing an imaginary coordinate system on the sky, then specifying the objects coordinates.

Eighty-eight constellations cover the entire sky.

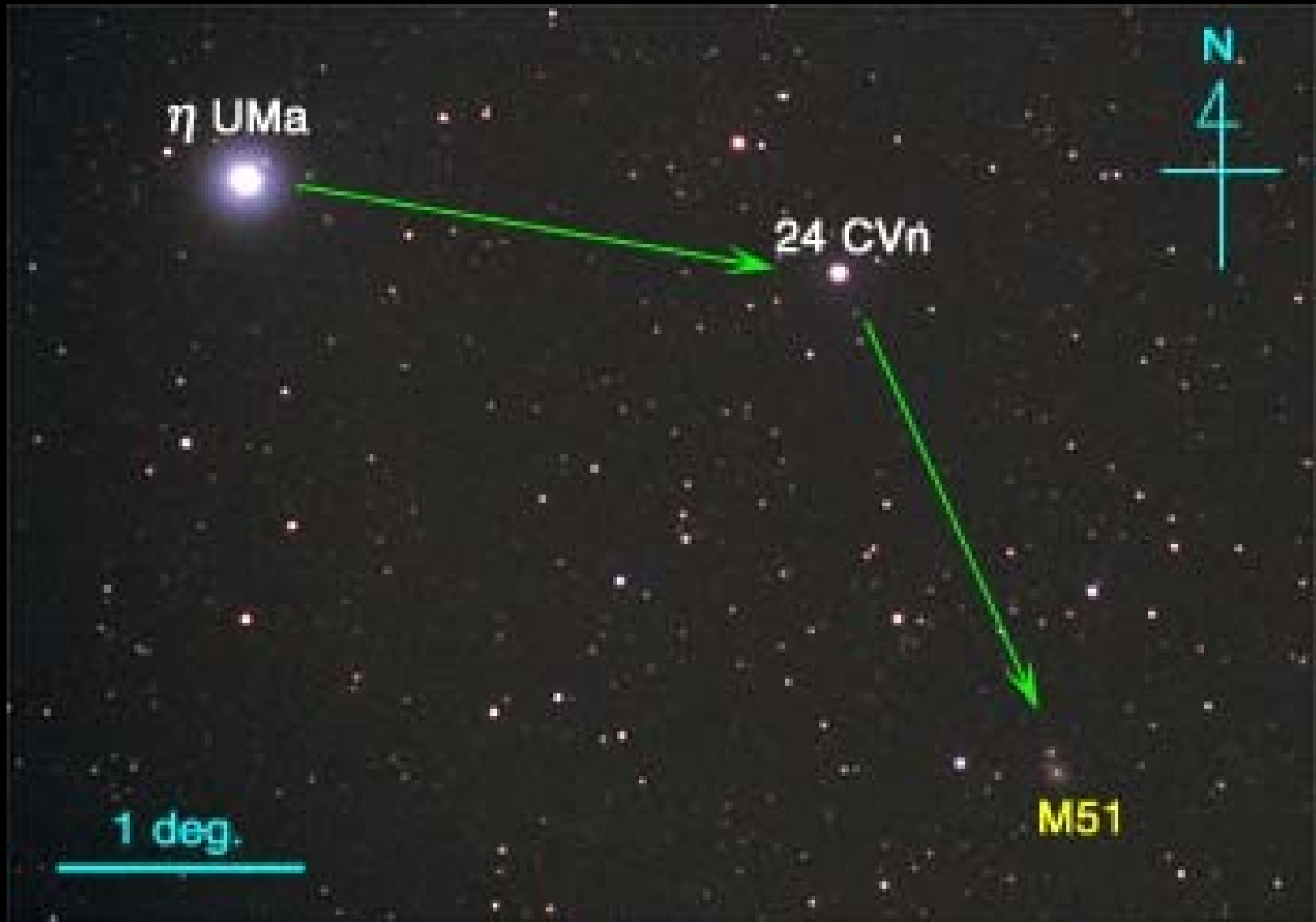


- 6000 stars visible to unaided eye (only half are above the horizon).
- 88 semi-rectangular groups of stars called constellations.
- Some stars in the constellations are quite close while others are very far away.

Finding M51



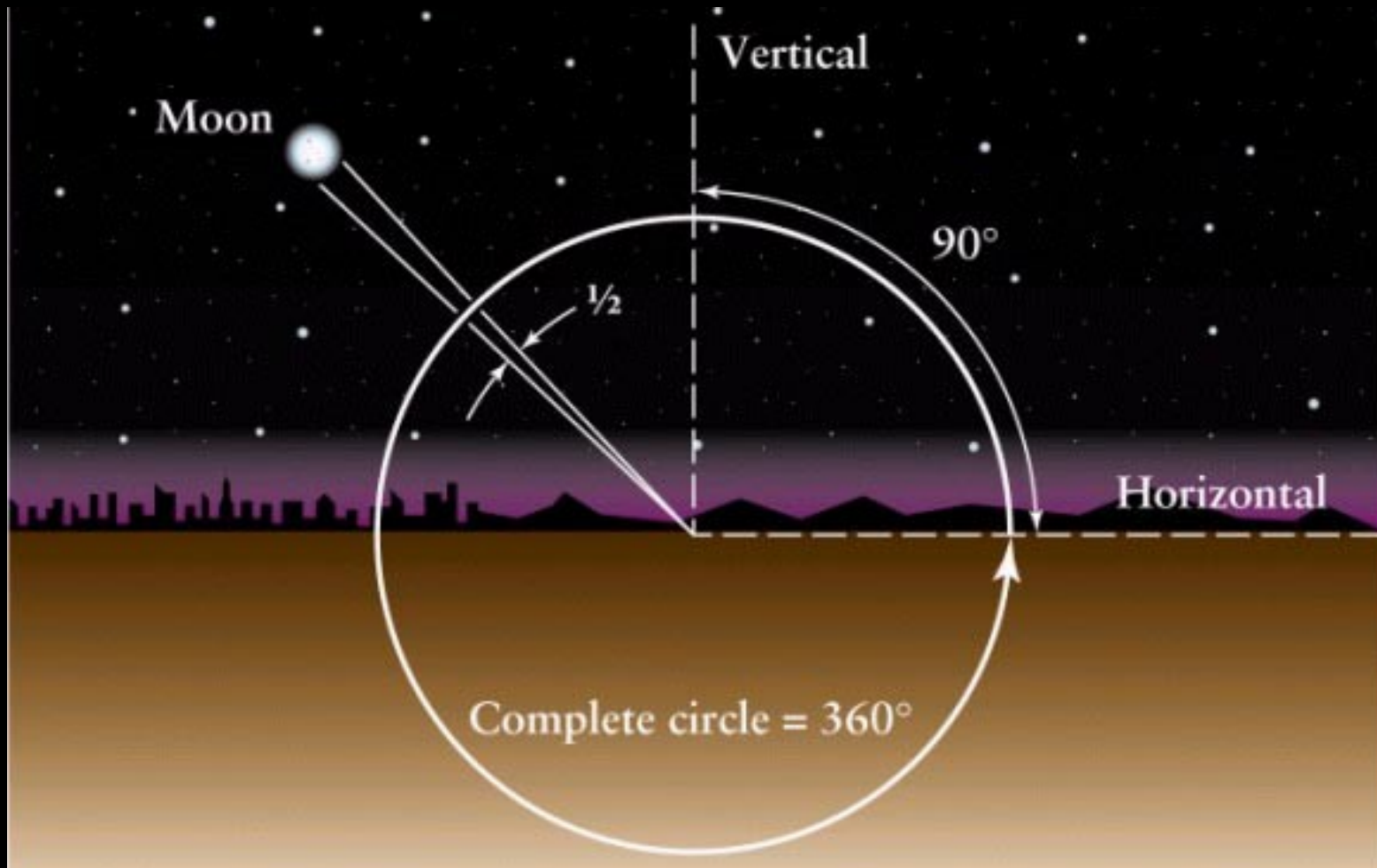
Finding M51

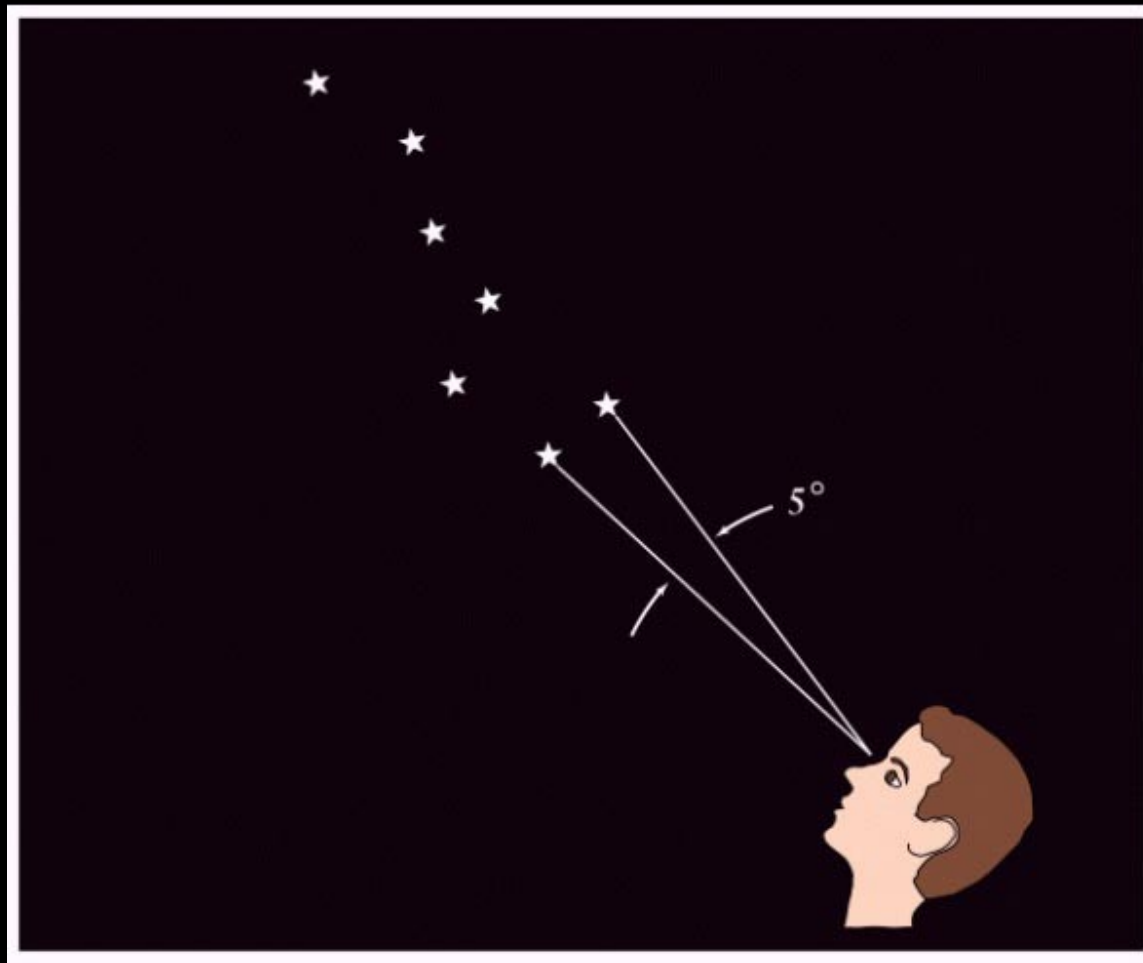


Finding M51



We use angles to denote the positions and apparent sizes of objects in the sky.





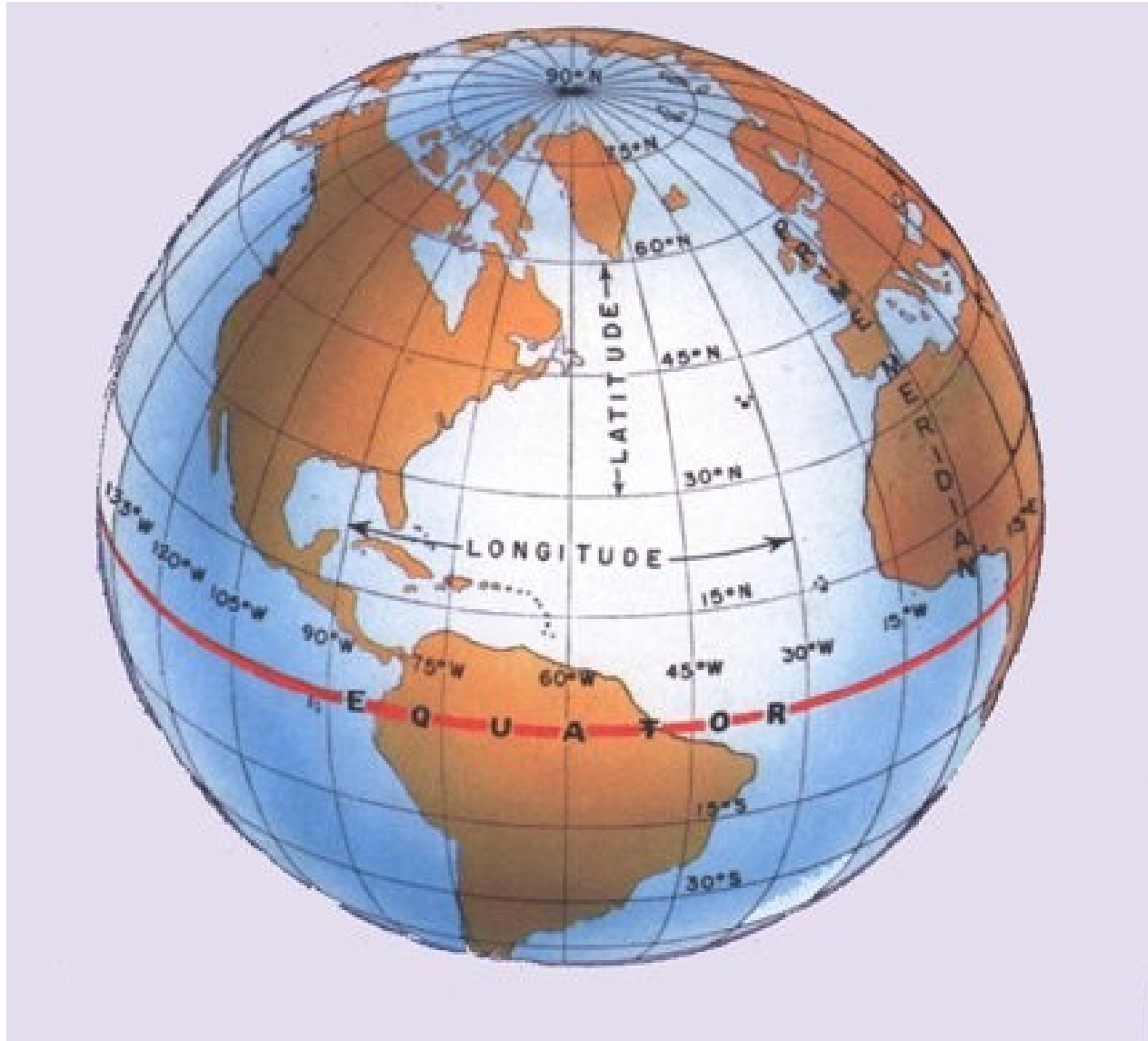
Your hand at arm's length is about 10 degrees wide

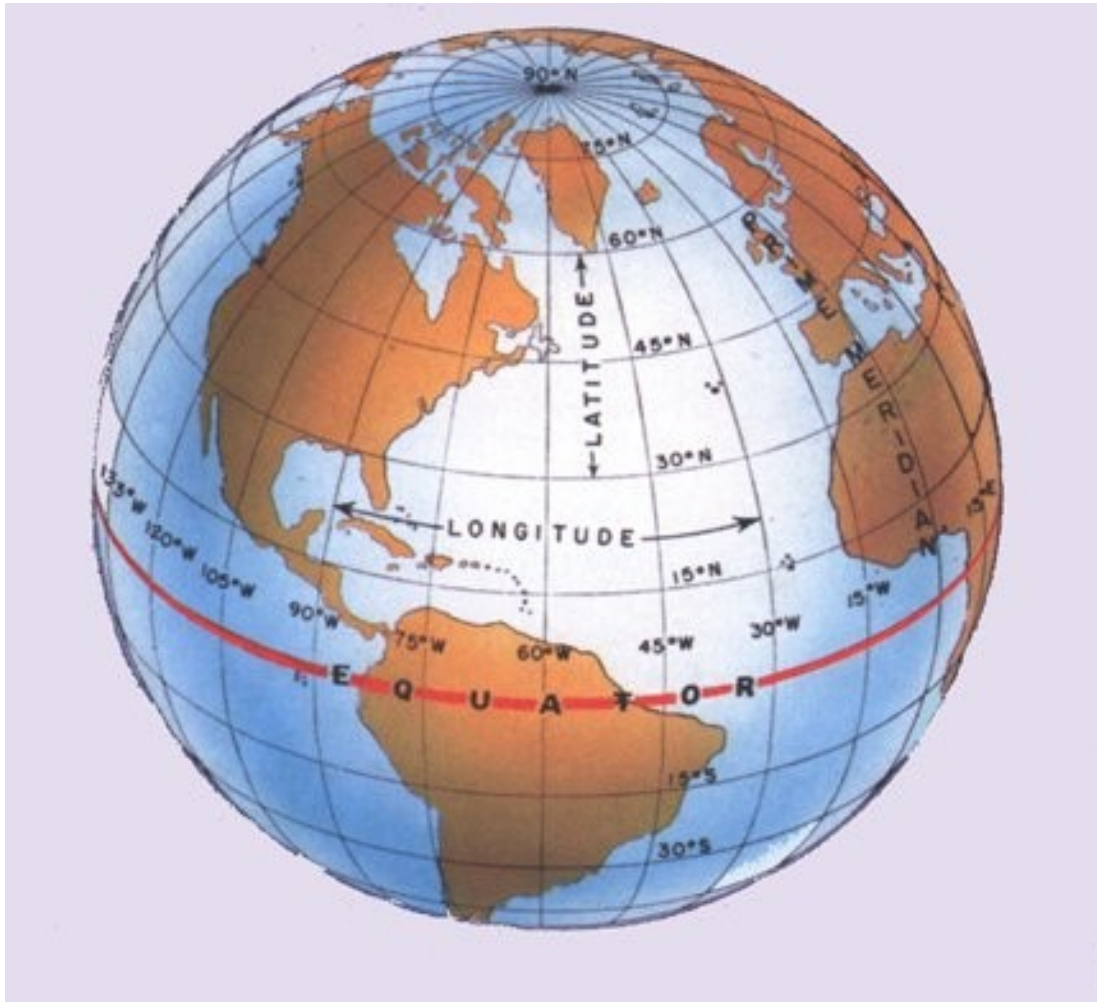
Your thumb at arm's length is about 2 degrees wide

Constellations are NOT:

- A) Groupings of stars on the sky as seen from Earth
- B) Useful in finding objects on the sky
- C) Groups of stars all created in one star formation event
- D) Different sizes

Coordinate system



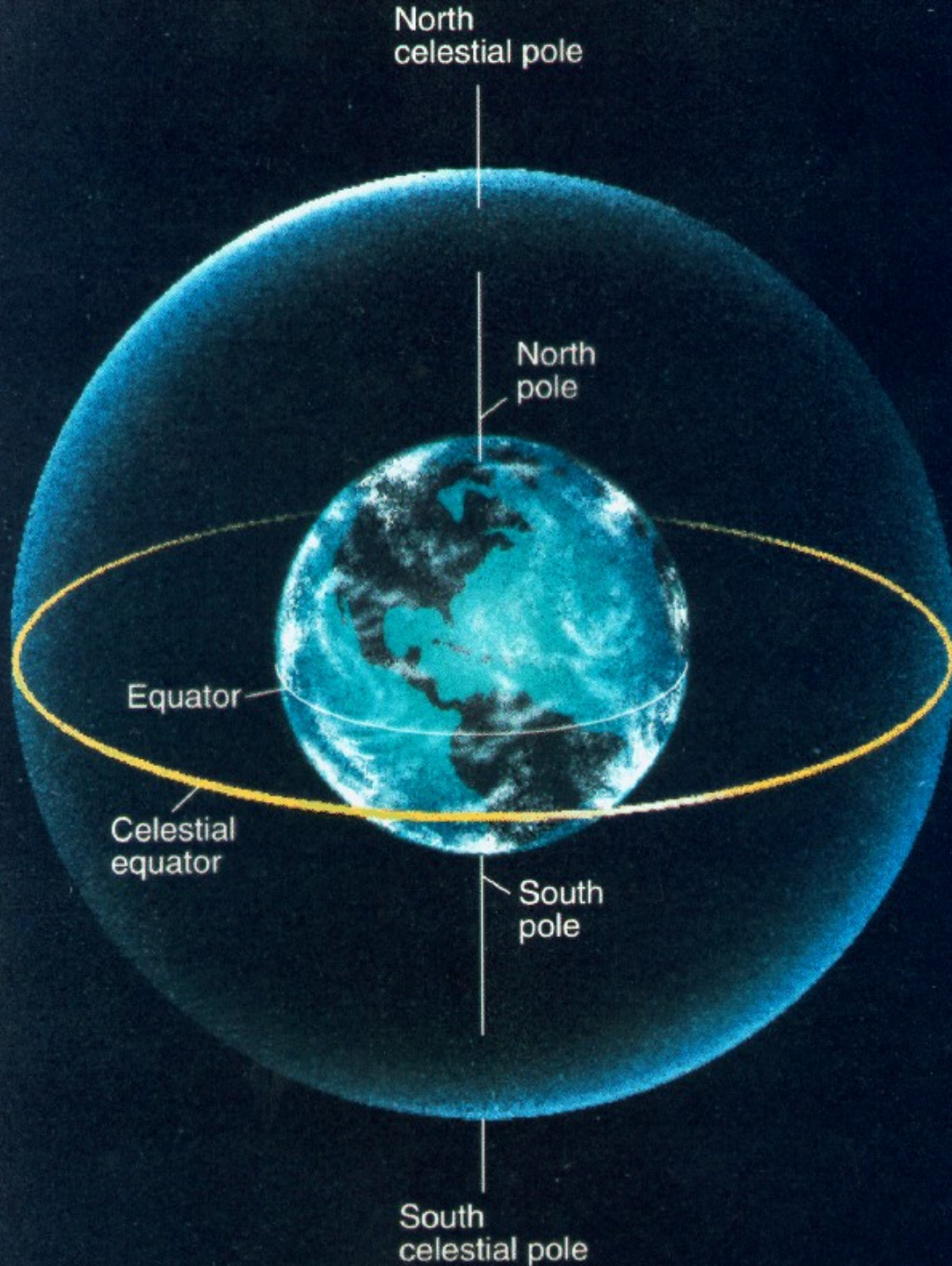


Coordinates are

Latitude = degrees North or South of the equator

Longitude = degrees East or West of the “Prime meridian”

Prime meridian is historically defined as longitude of the Royal Observatory in Greenwich, England



Sky coordinate system

Introduce the
'celestial sphere'

This is an imaginary
sphere drawn in space
with the earth at its
center.

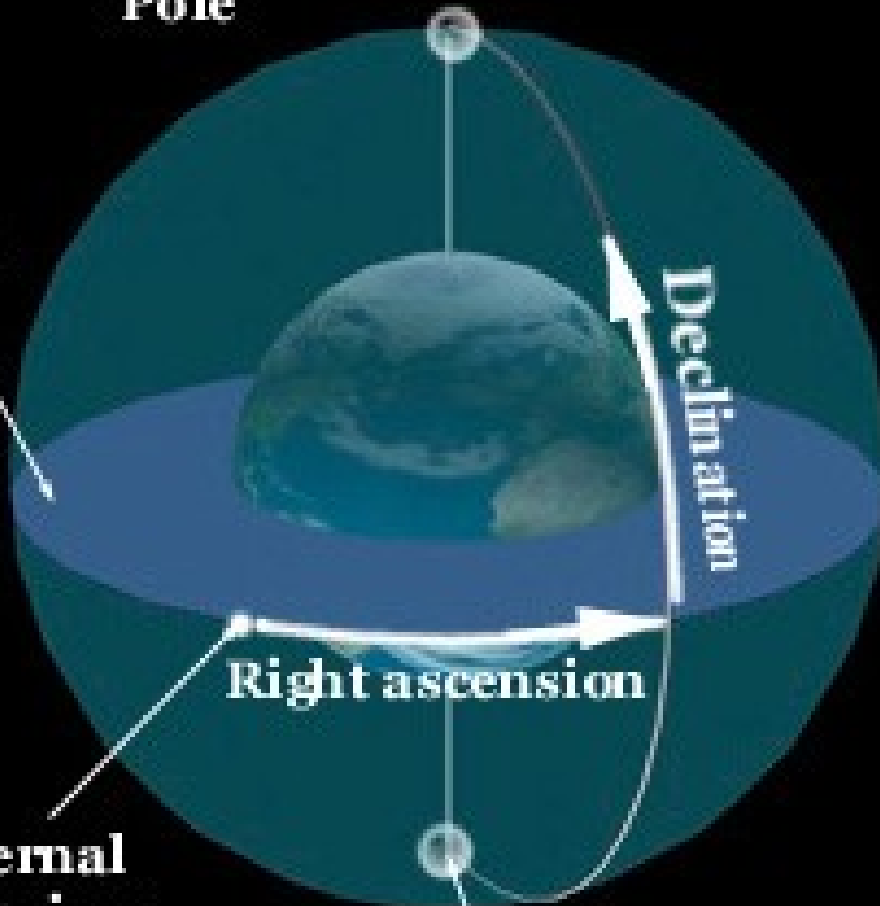
We align the sphere
with the Earth.

North Celestial Pole

Celestial Equator

Vernal equinox

South Celestial Pole



Coordinates are:

Declination = degrees North or South of the equator.

Right ascension = degrees East of the “Vernal equinox”.

Vernal equinox is defined as the position of the Sun on the first day of spring. Note it is a point on the sky, not the earth.

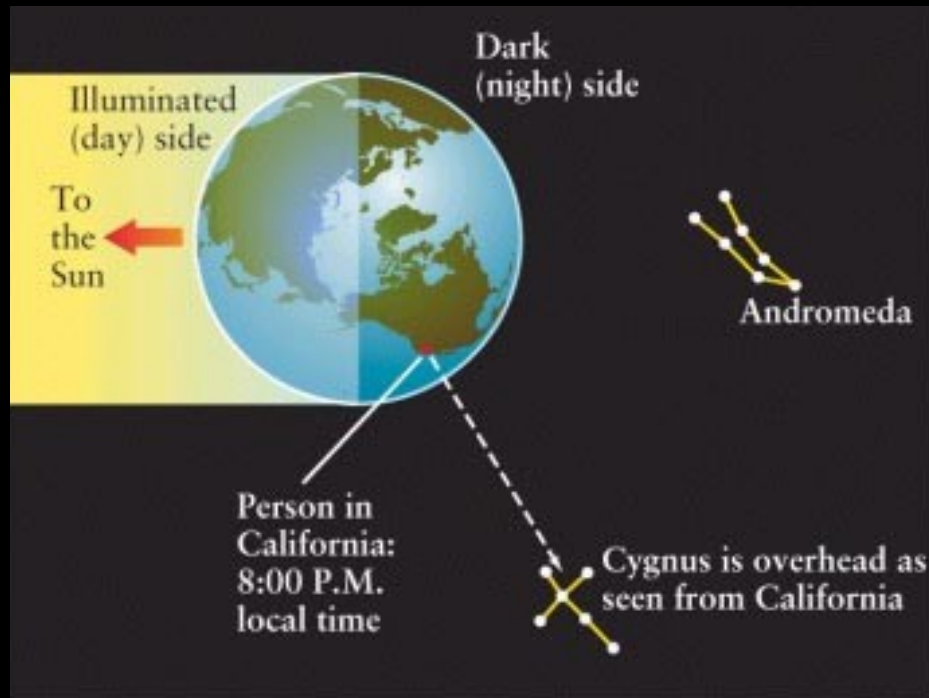
Which of the following is true?

- A) longitude is to declination as latitude is to right ascension
- B) longitude is to right ascension as latitude is to declination
- C) longitude is to elevation as latitude is to declination
- D) longitude is to elevation as latitude is to right ascension

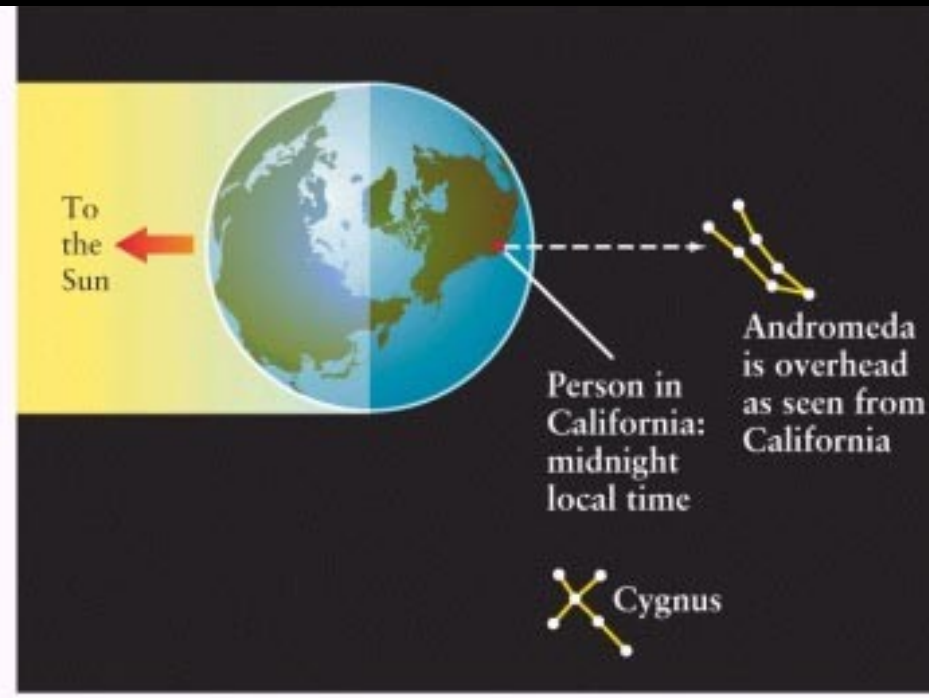
Motion
of
stars
on the
sky



The rotation of the Earth causes the stars to appear to move on the sky.



a Earth as seen from above the North Pole



b 4 hours later

Angular Measure for Small Angles

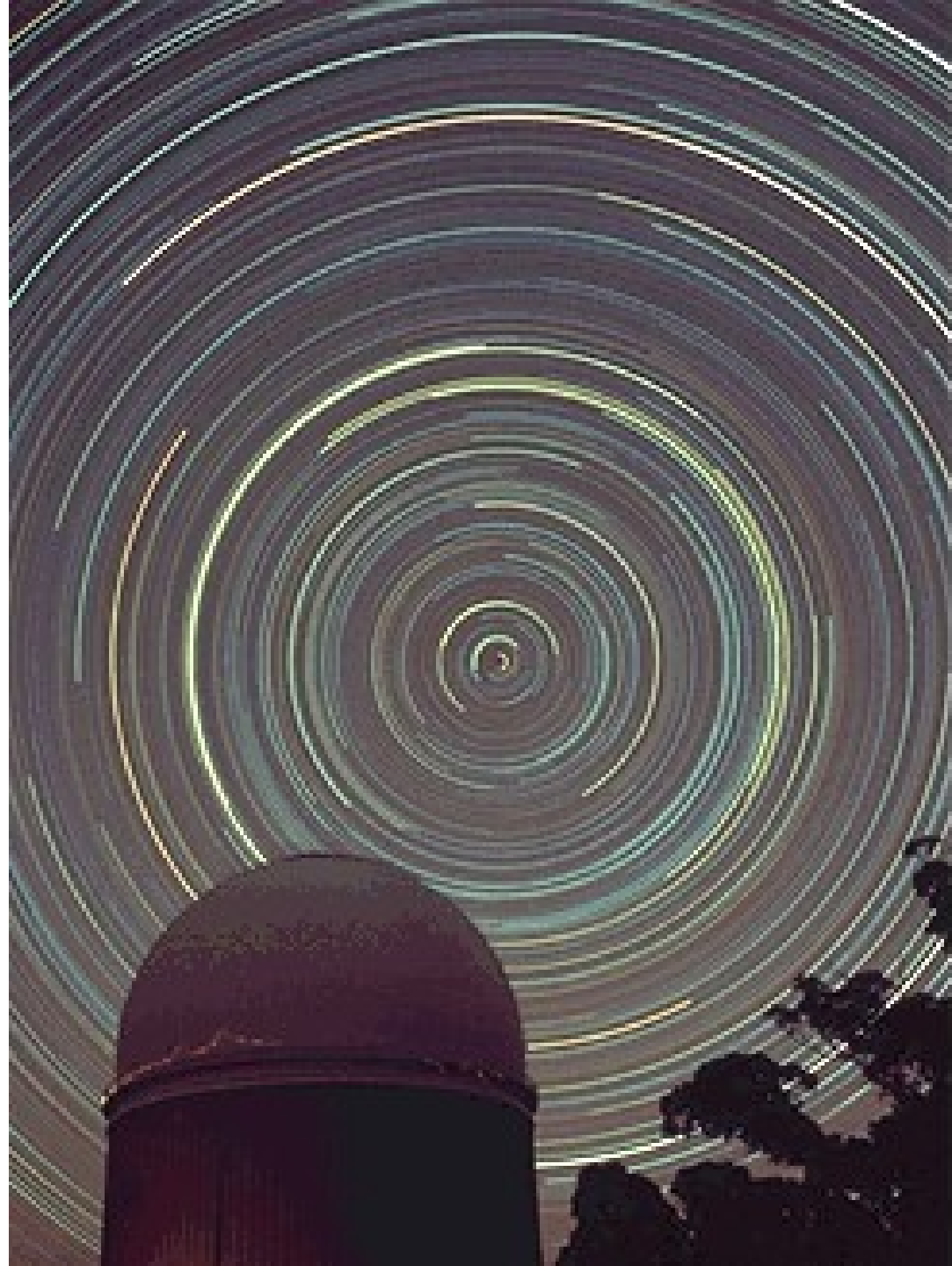
$$1^\circ = 60 \text{ arcminutes} = 60'$$

$$1' = 60 \text{ arcseconds} = 60''$$

e.g., On January 1, 2004, the planet Saturn had an angular diameter of 19.7" as viewed from Earth.

How long was the exposure for this photograph?

- A) 4 hours
- B) 6 hours
- C) 10 hours
- D) 12 hours
- E) 20 hours



Motion of the sun and planets on the sky

The Earth and other planets orbit around the Sun.

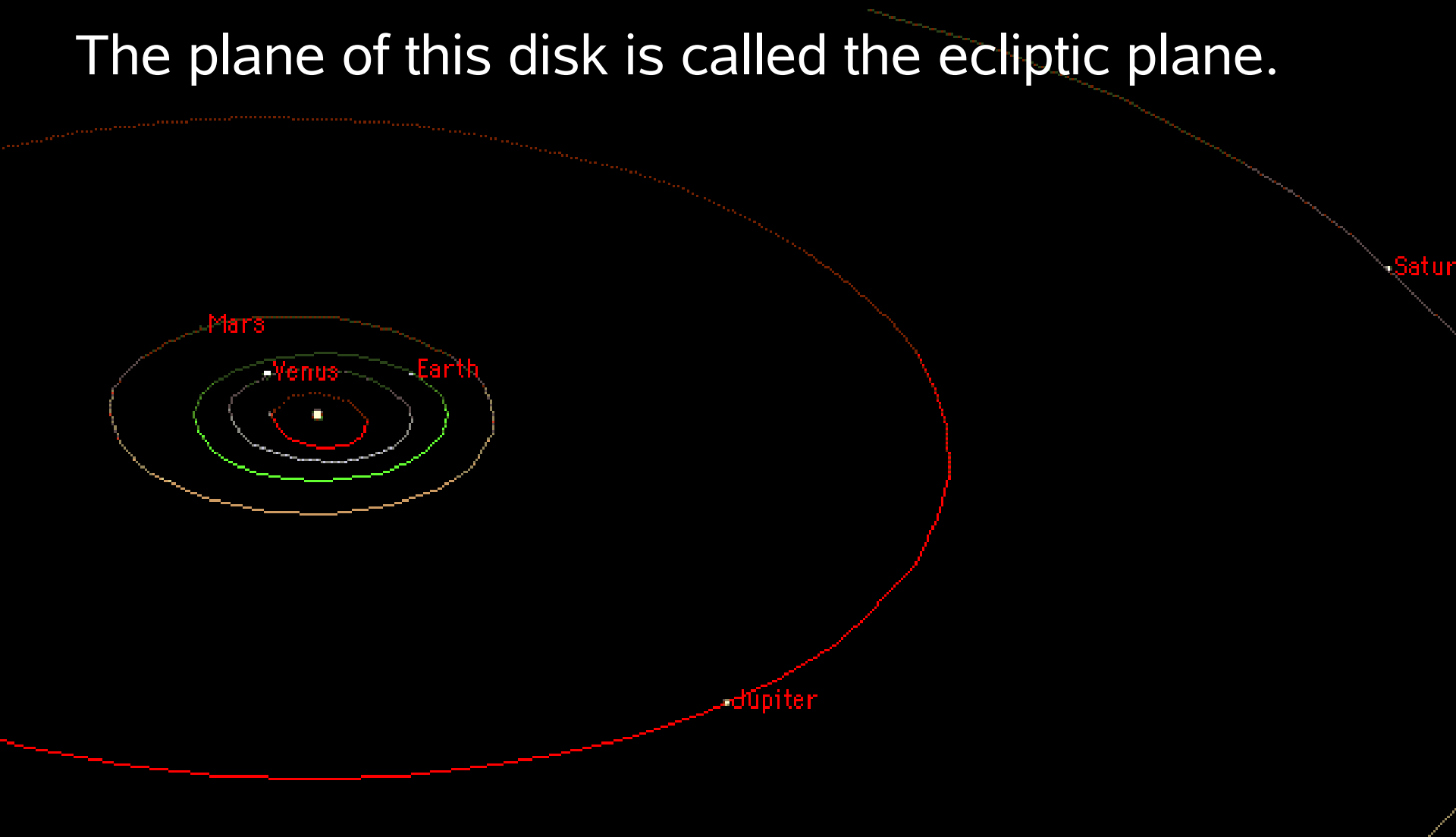
This causes the Sun and the planets to appear to move in the sky when viewed from Earth.

How does this work?

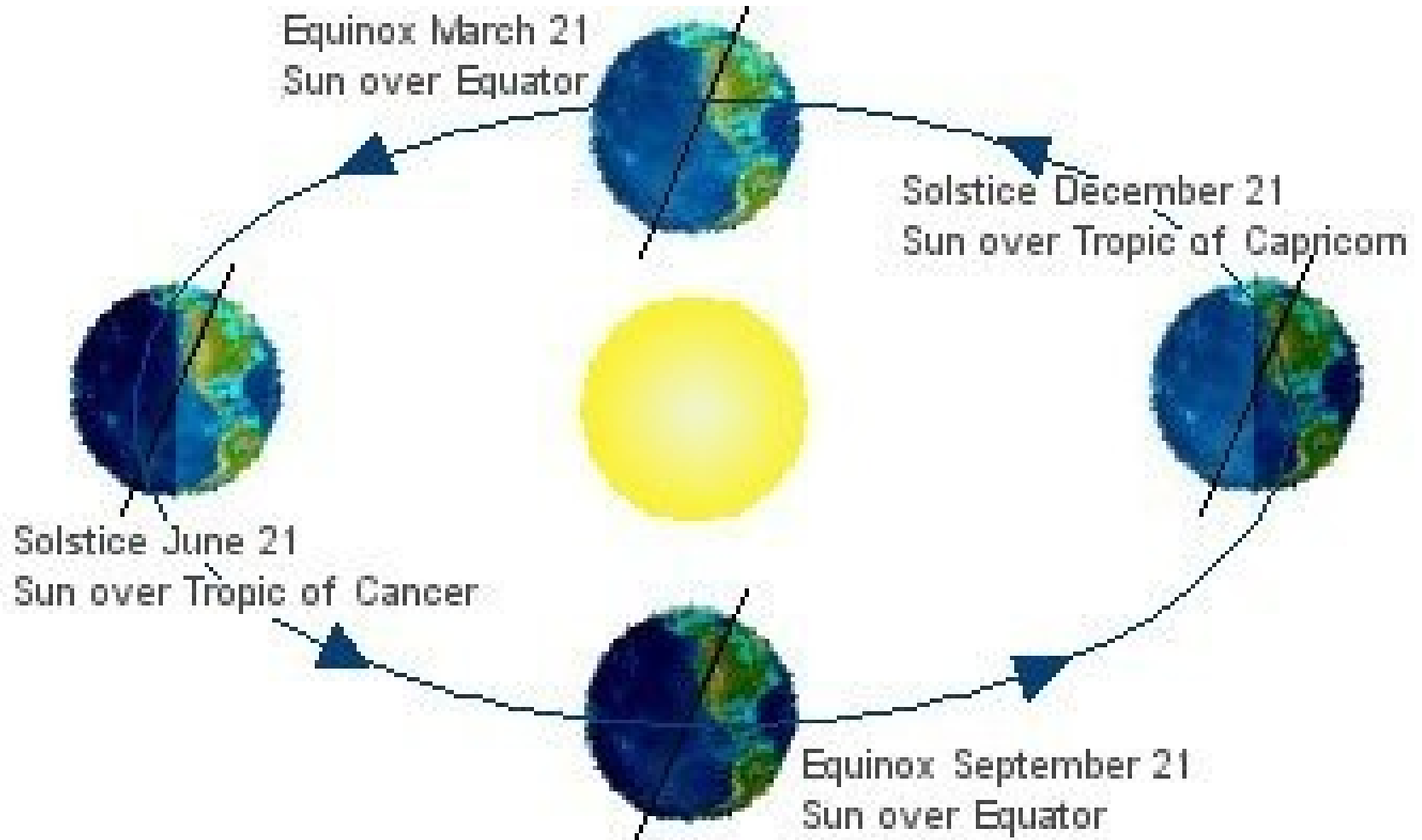
Crucial facts are that:

1) All of the planets lie in one disk around the sun.

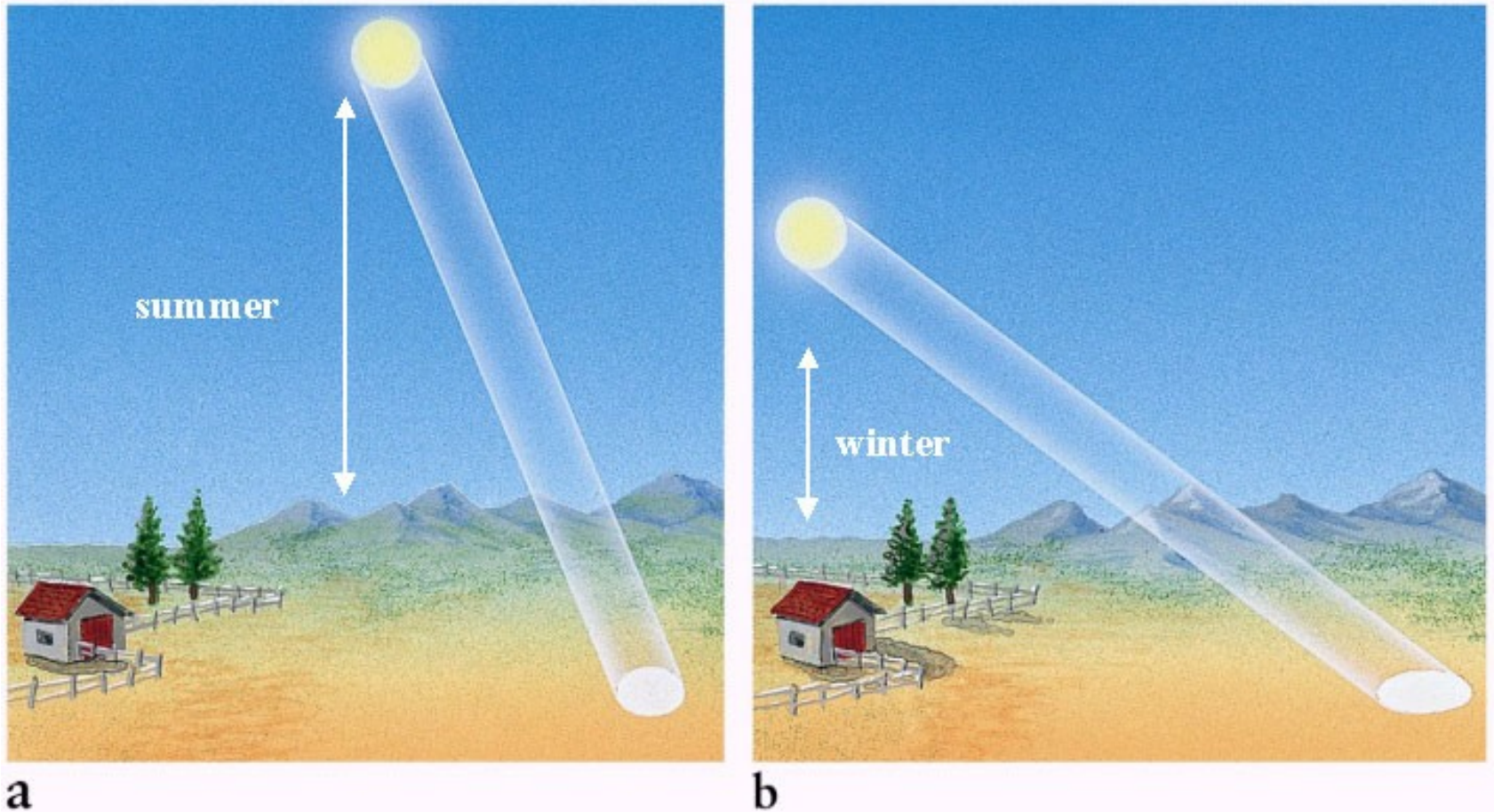
The plane of this disk is called the ecliptic plane.



2) The rotation of the Earth is tilted relative to its orbit by 23.5°



Over the course of a year, the Sun's position in the sky changes.



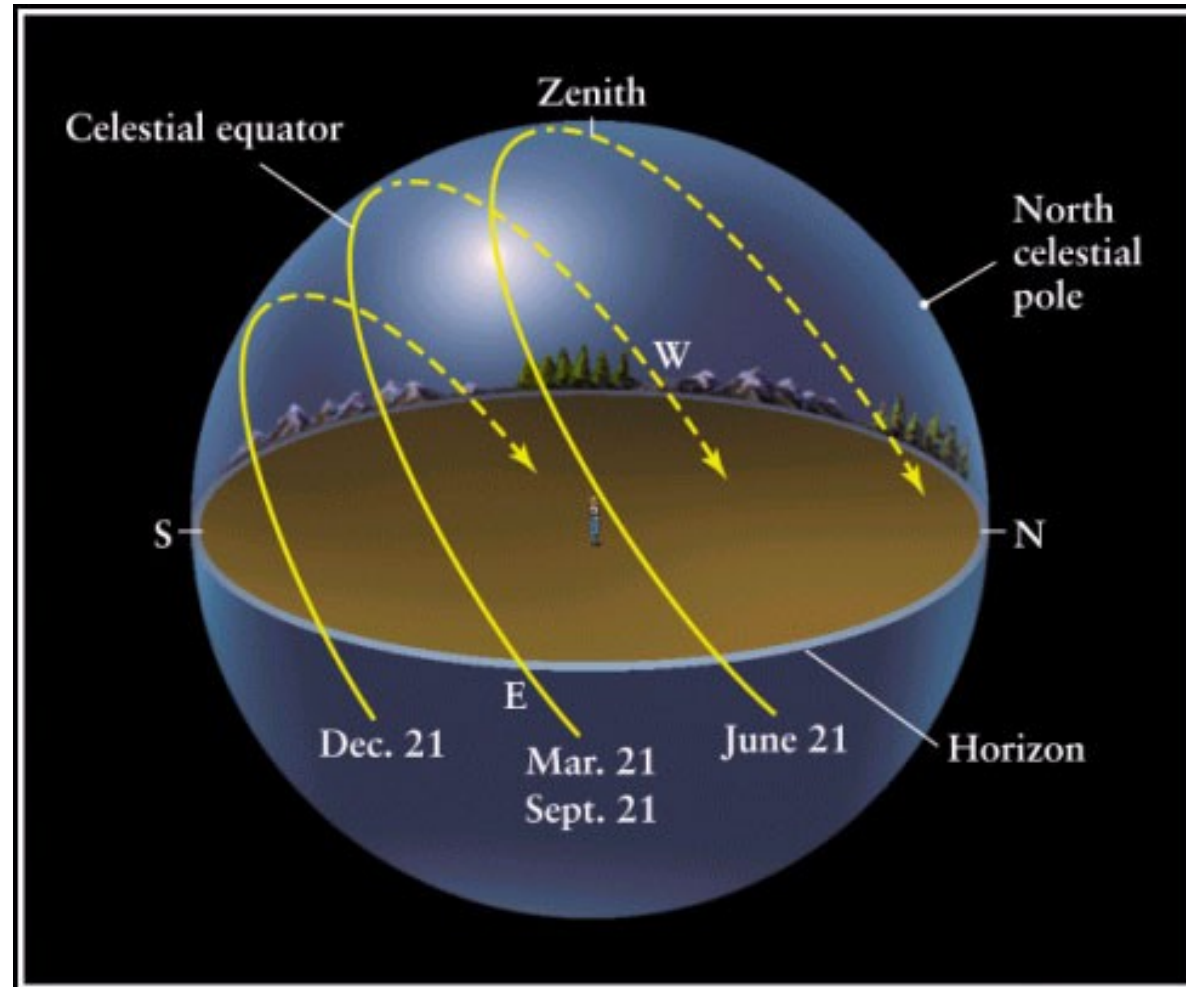
The ground receives more light, thus more heat, per square meter in the summer than in the winter.

Dec. 21
Winter Solstice

March 21
Vernal Equinox

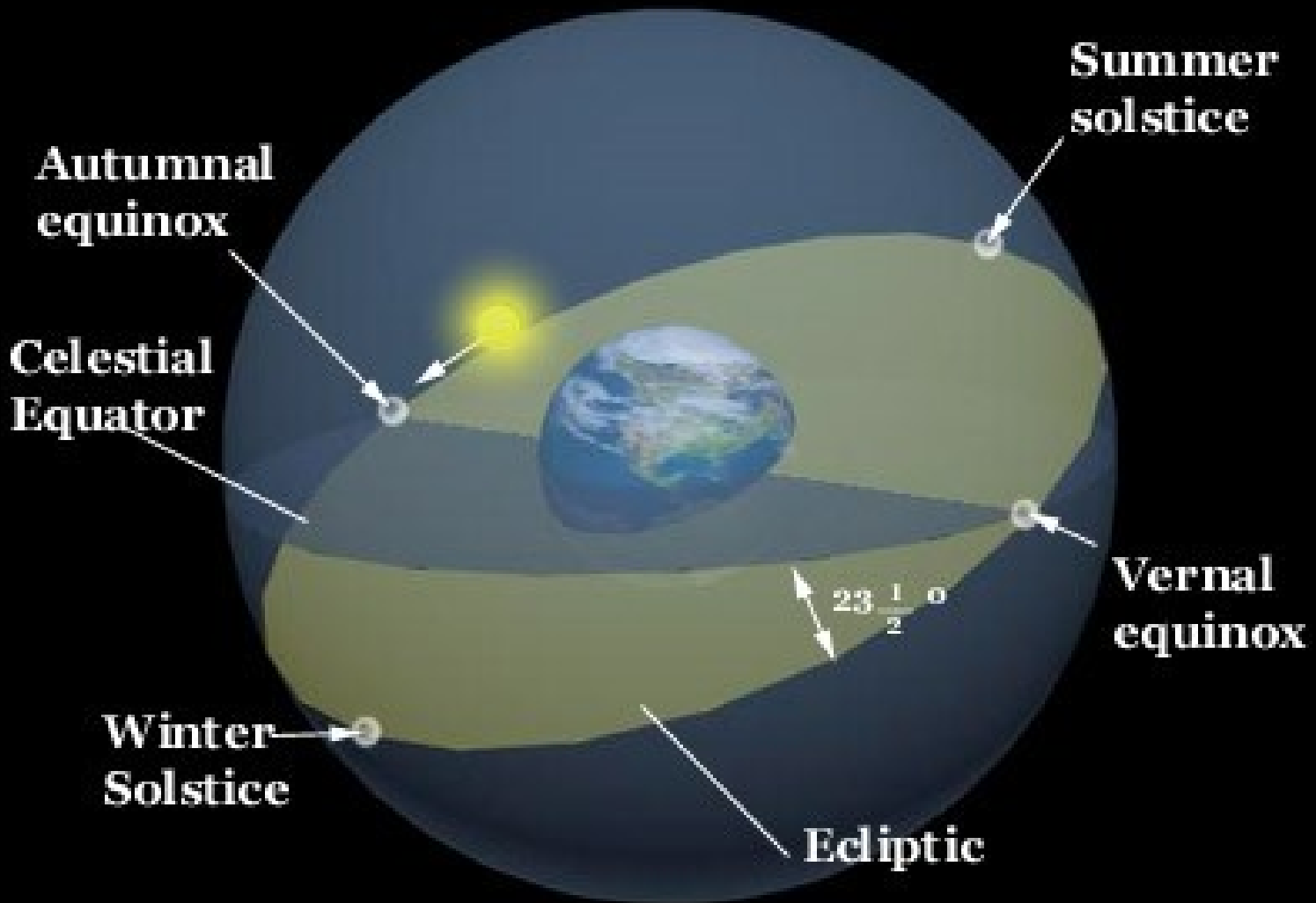
June 21
Summer Solstice

Sept. 21
Autumnal
equinox

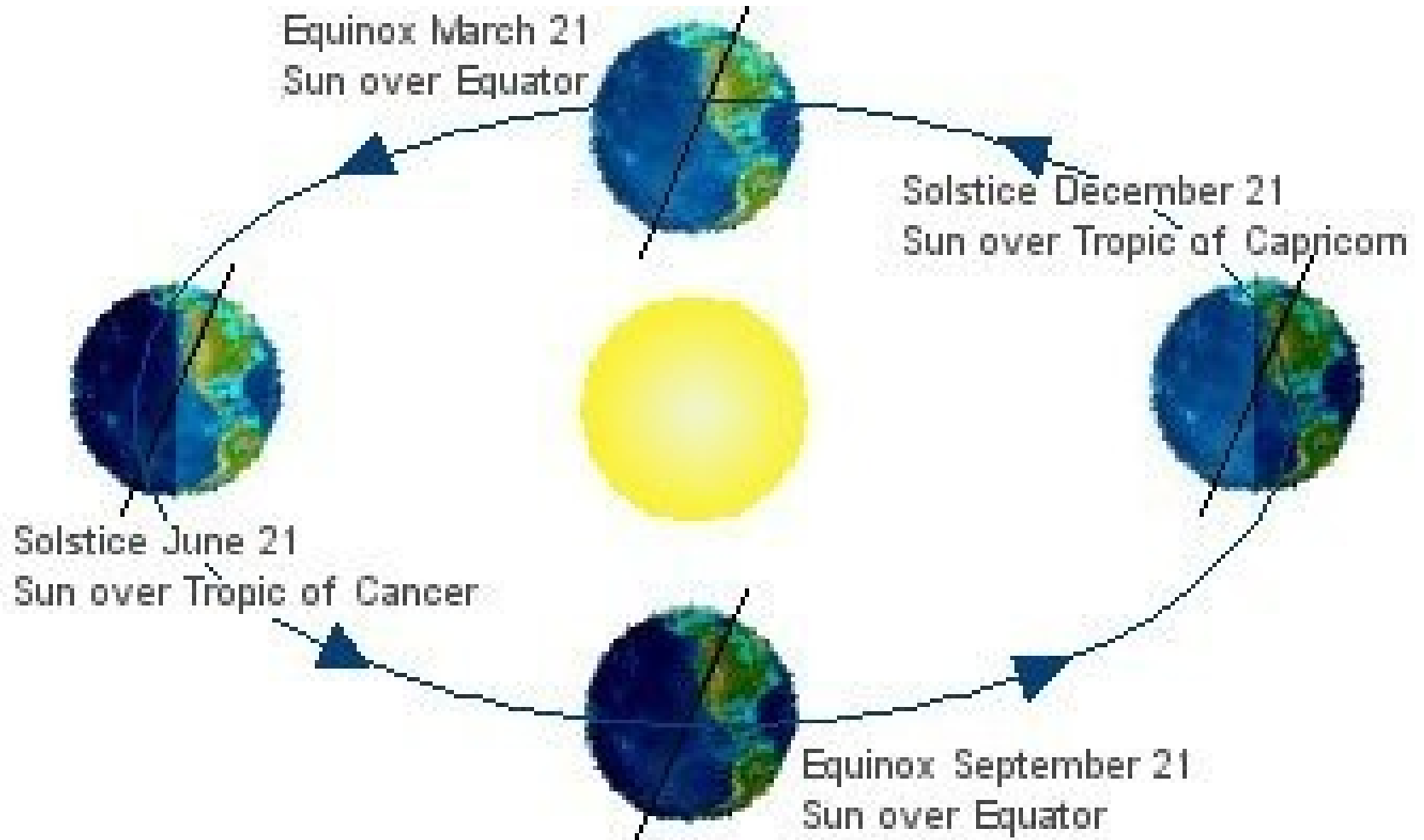


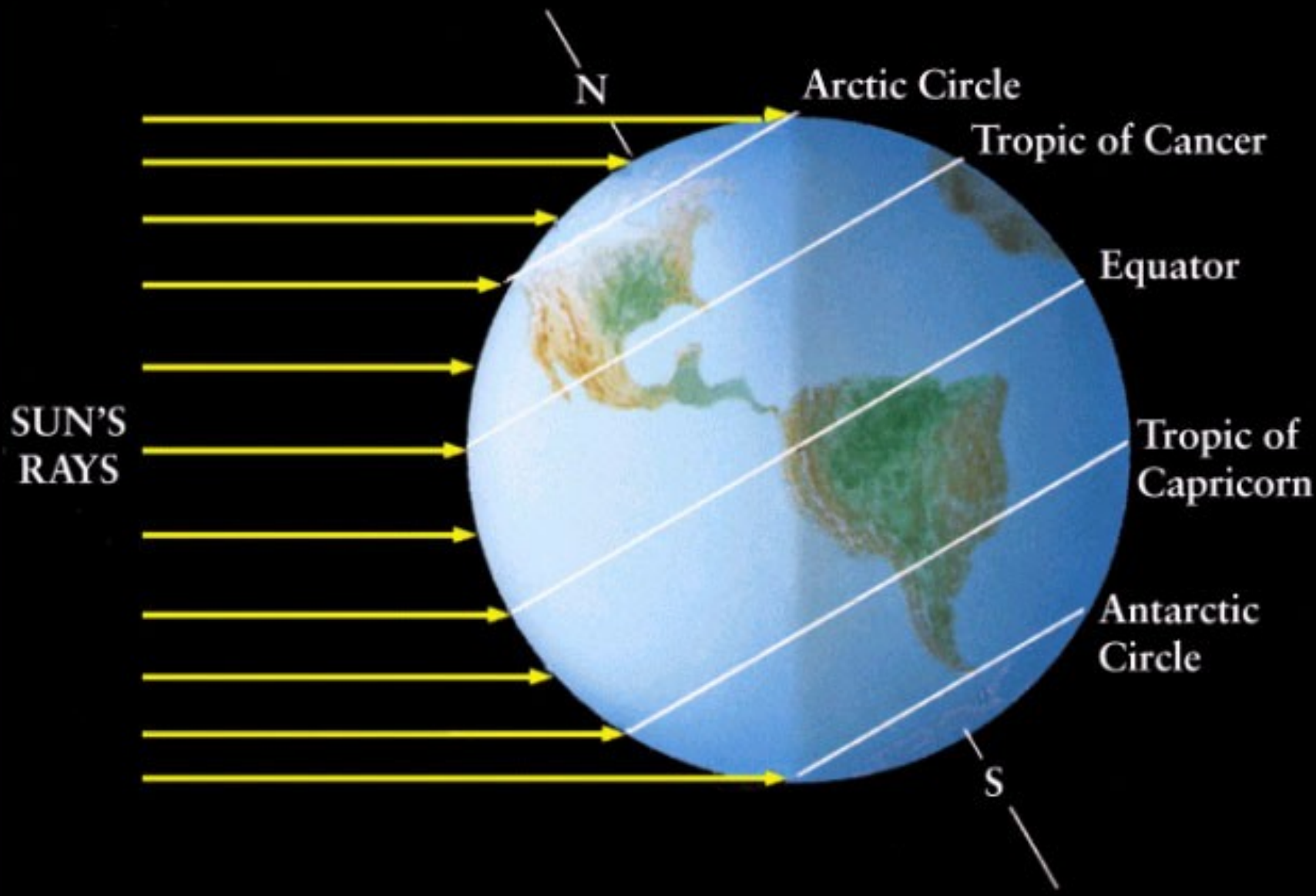
The sun is up longer in the summer than in the winter.
Again, the ground receives more sunlight in the summer.

Therefore, the sun and planets move around a circle (the ecliptic) on the celestial sphere which is tilted relative to the celestial equator

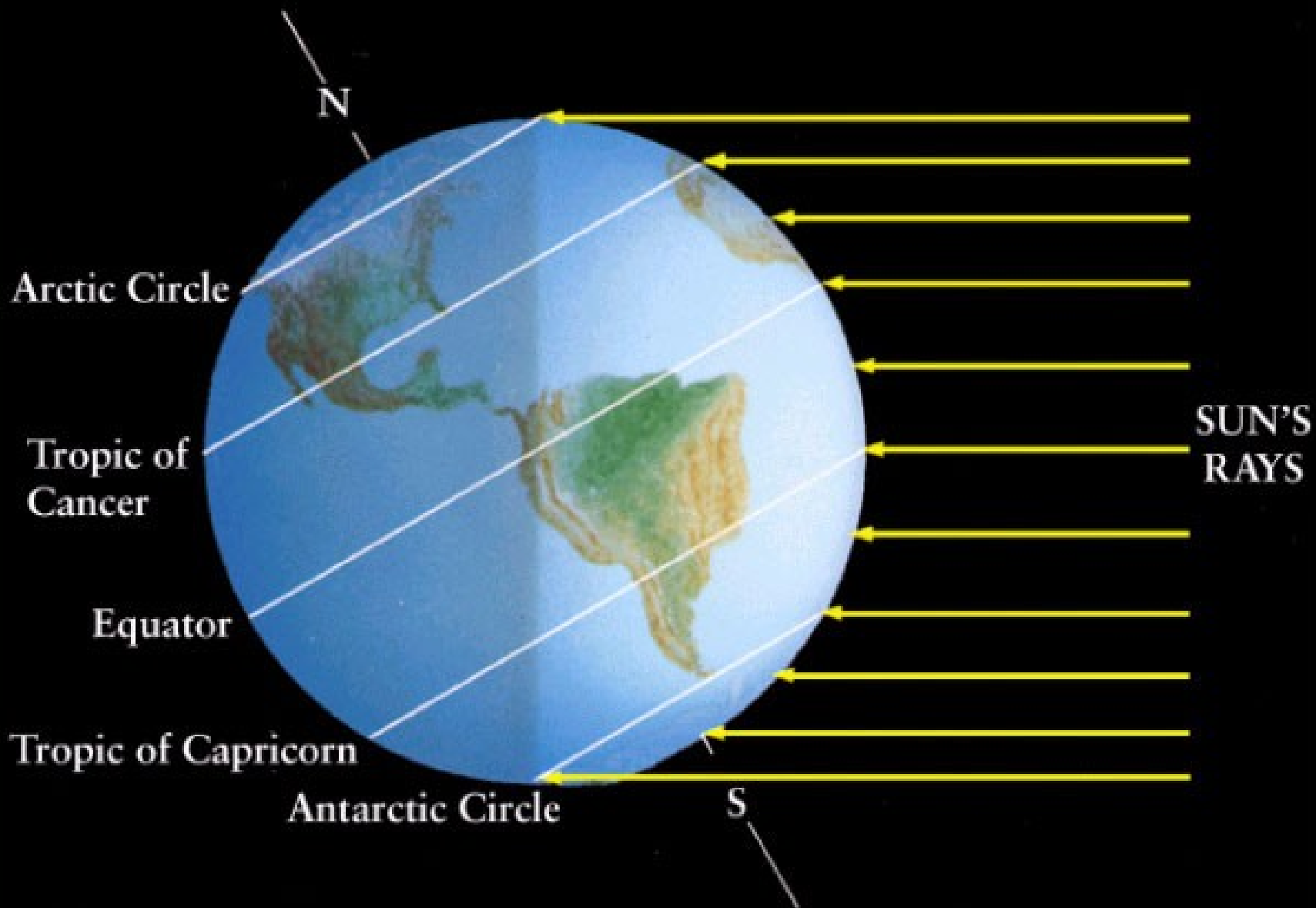


Earth's tilt causes the seasons





b Earth at summer solstice



a Earth at winter solstice

What causes the seasons?

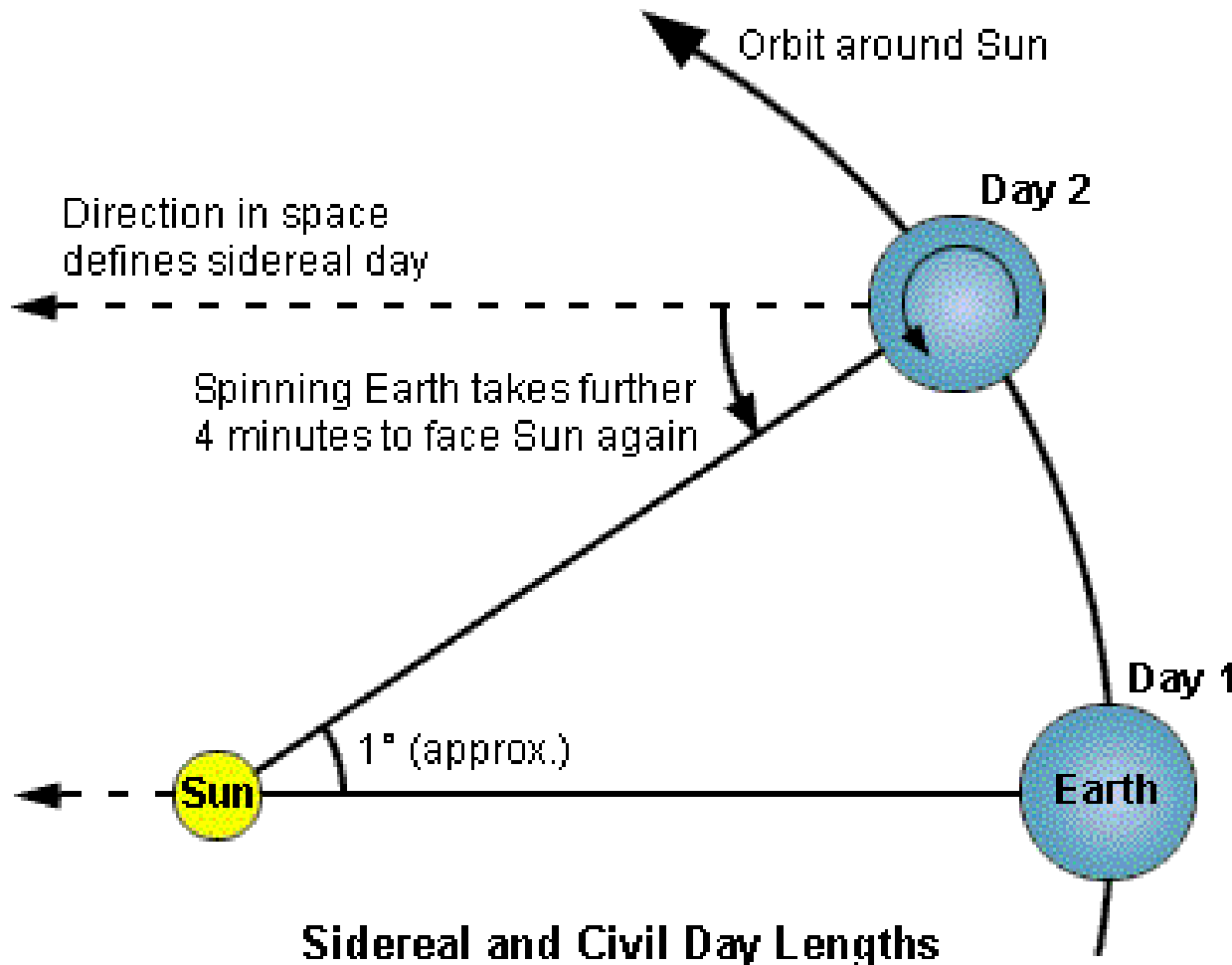
- A) The orbit of the Earth is an ellipse, not a circle, and the Earth is closer to the Sun in summer than in winter.
- B) The rotation of the Earth is tilted relative to its orbit.

How long does it take the Earth to make one full rotation?

- A) 24 hours
- B) 23 hours 56 minutes 4 seconds
- C) 365.242199 days

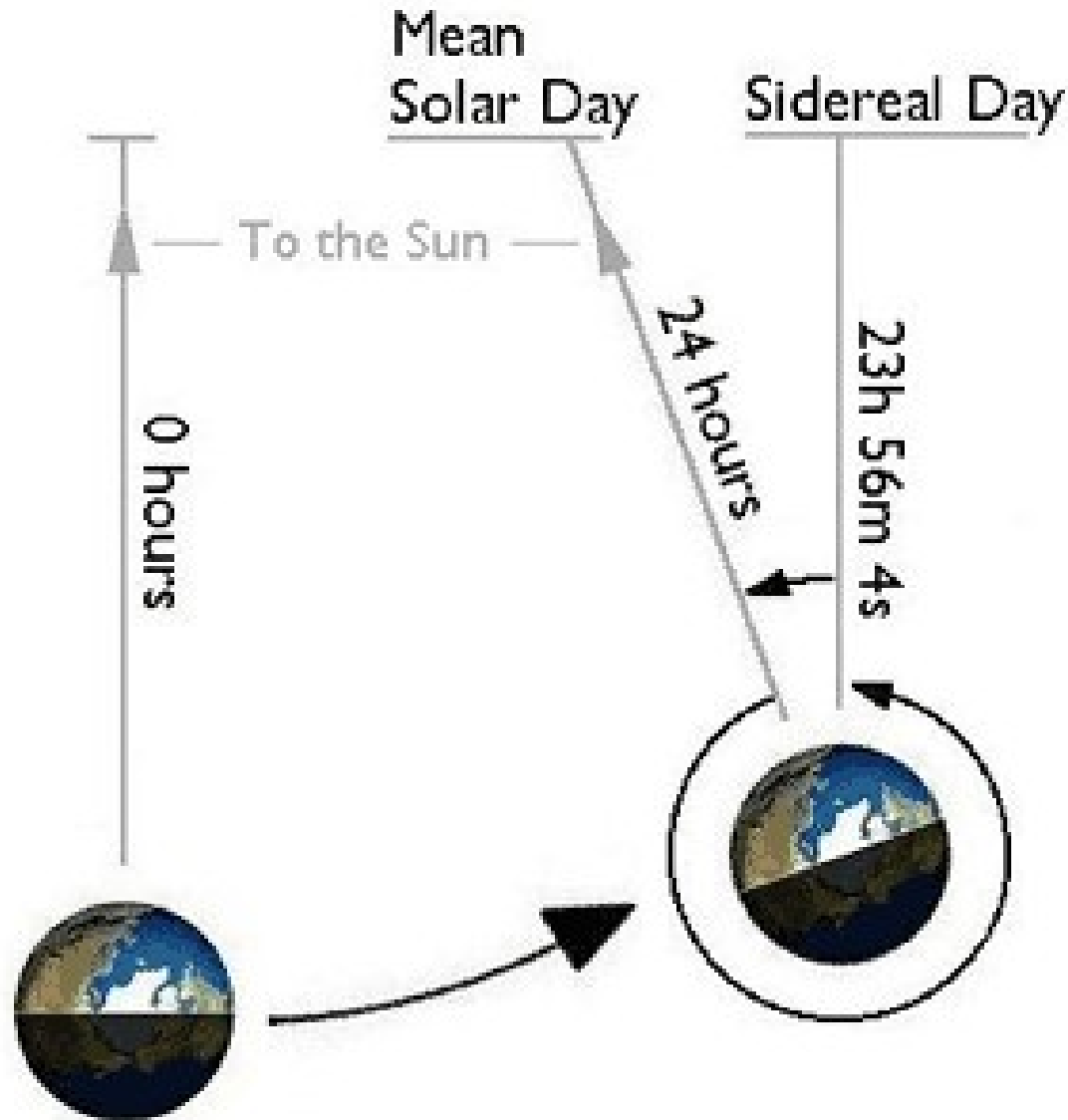
Sidereal vs. Solar Day

- The Earth's TRUE rotation period is 23h 56m 3s, not 24hrs! This is called the sidereal period or the rotation period relative to the stars.



It takes about 4 minutes more rotation for the Sun to be in the same place as yesterday. Hence a solar day, or time from noon to noon, is 23h 56m + 4m = 24 hours

Sidereal vs. Solar Day



Review questions

- How many coordinates are needed to locate a star on the sky?
- What are the names of the coordinates on the celestial sphere?
- What causes the seasons?
- Does the sun rise higher in the summer or winter?
- How long does it take the Earth to make one full rotation?