AST210 First Class 8 Sep. 2014
"Great Moments in Astronomy"

Overview of the Course

This course is intended for students with SOME science background, not necessarily physical science. It is not suitable for students with no science background e.g. Arts and Humanities only (go to AST101, AST201 instead).

It requires only the simplest math.

The aim of this course is to study the development and application of the scientific method over many centuries and how it has allowed us to understand the functioning of the Universe, its origin and its future.

We shall learn the principles and laws of the Universe in the context of how they were worked out.

That often involves political, philosophical, religious, environmental and sociological issues.

Not always were scientists peacefully accepted and respected!

Thomas Kuhn's “Structure of Scientific Revolutions” (1962) describes these processes well.

Instructor

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(I am available immediately after lectures;
further office hours will be posted)

Web Site :

www.astro.uroronto.ca/~ast210

Link is on Blackboard.

Blackboard : Must have UTORid & "utoronto.ca" e-mail address! Go to:

portal.utoronto.ca

E-Mail : You will receive e-mail messages via Blackboard, and correspond with the Instructor and TAs via:

ast210@astro.utoronto.ca

[Look at website now...]

Text Book: T. Koupelis, "In Quest of the Universe", (7th Edition) [At Bookstore]

Note: 5th and 6th editions are OK, page numbers will be found in the notes and course description, but you need to make sure you cover any missing bits.

Lectures & Lecture Notes

- I will post my slides on Blackboard, usually before lectures. You may wish to annotate these (on paper or on screen).
- We will not be using clickers, but I strongly urge you to come to classes. You may miss stuff not in the notes!!
- Cellphones and recreational use of electronics during class will not be tolerated!

• Please make sure you are registered with UTORid, and THEN make sure your *.utoronto.ca e-mail address is your only e-mail address entered on ROSI !!!

• Try NOT to use forwarding from “utoronto.ca”. The free sevices (hotmail, yahoo, gmail etc.) often are slow, or refuse to accept forwarded e-mail from “utoronto” from time to time.

• If you do NOT have your “utoronto.ca” address on ROSI, Blackboard sees you as noemail@utoronto.ca and emails from the course to you go into a black hole instead!

• Please go to the Web page frequently. The lecture notes will be posted on Blackboard.

Planetarium Shows

Planetarium Shows will be scheduled in the next few weeks. They will make the material of the first few lectures more comprehensible.

We have a small planetarium in the Astronomy Building, NW corner of Russell & St. George.

Lecture 1
Earth-Centred Universe

What can we learn without modern instruments?

Chapter 1 of Text

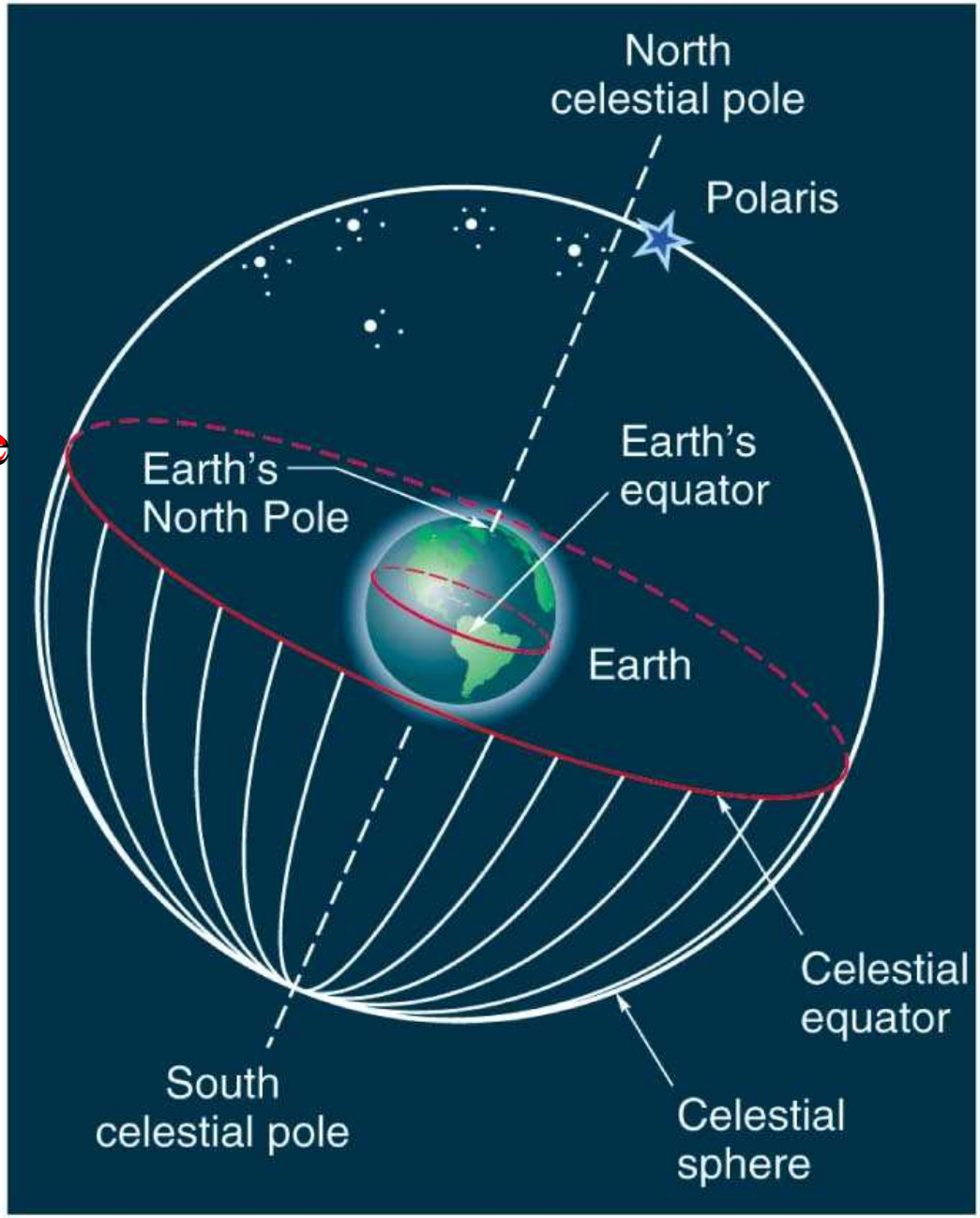
- **The celestial sphere**
- **Constellations**
- **Celestial Coordinates**
- **The Sun's Motion Across the Sky**
- **The Ecliptic**
- **The Sun and Seasons (next lecture)**

The Celestial Sphere

1. ***Celestial sphere*** **is the imaginary sphere of heavenly objects that seems to center on the observer.**

2. ***Celestial pole*** **is the point on the celestial sphere directly above a pole of the Earth.**

Because of their daily motion, objects in the sky appear to be on a sphere surrounding the Earth.

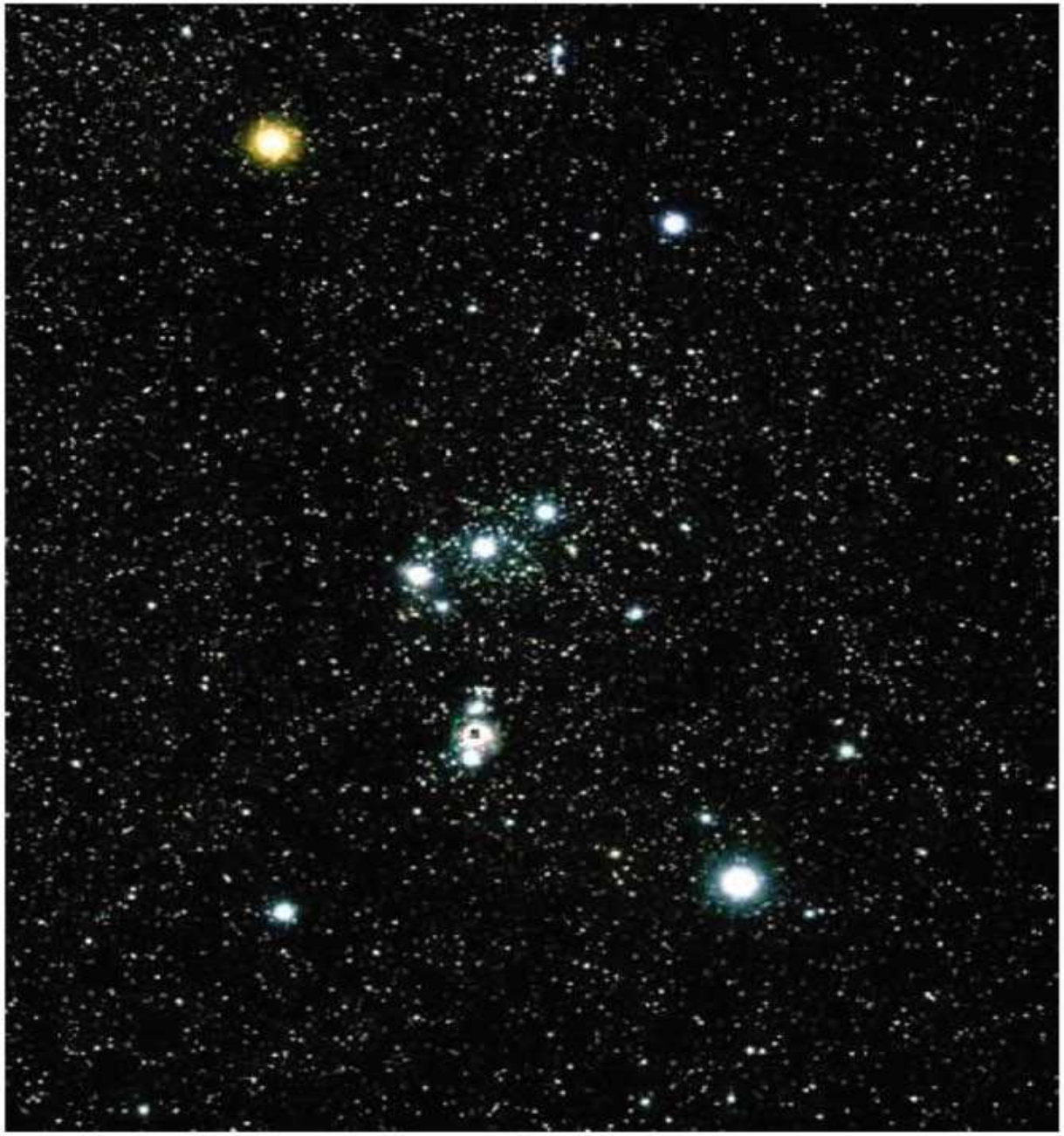


Constellations

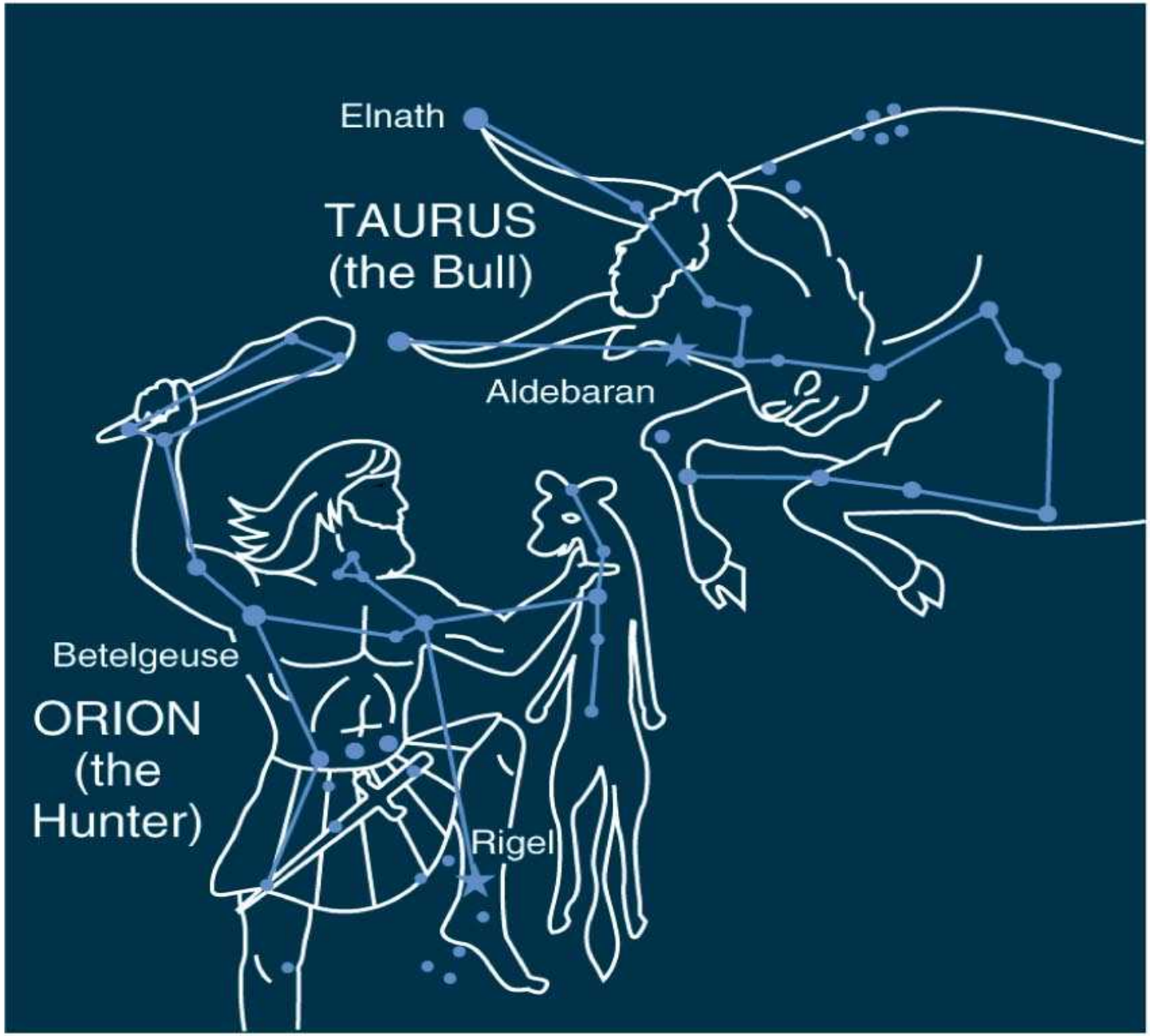
1. A *constellation* (from the Latin, meaning “stars together”) is an area of the sky containing a pattern of stars named for a particular object, animal or person.

2. The earliest constellations were defined by the Sumerians as early as 2000 B.C. Different civilzations saw different “patterns” in the sky. Our modern constellations draw from the Greeks and Romans.

3. The 88 constellations used today were established by international agreement. They cover the entire celestial sphere and have specific boundaries.



Orion


Elnath
TAURUS
(the Bull)
Aldebaran
Betelgeuse
ORION
(the
Hunter)
Rigel

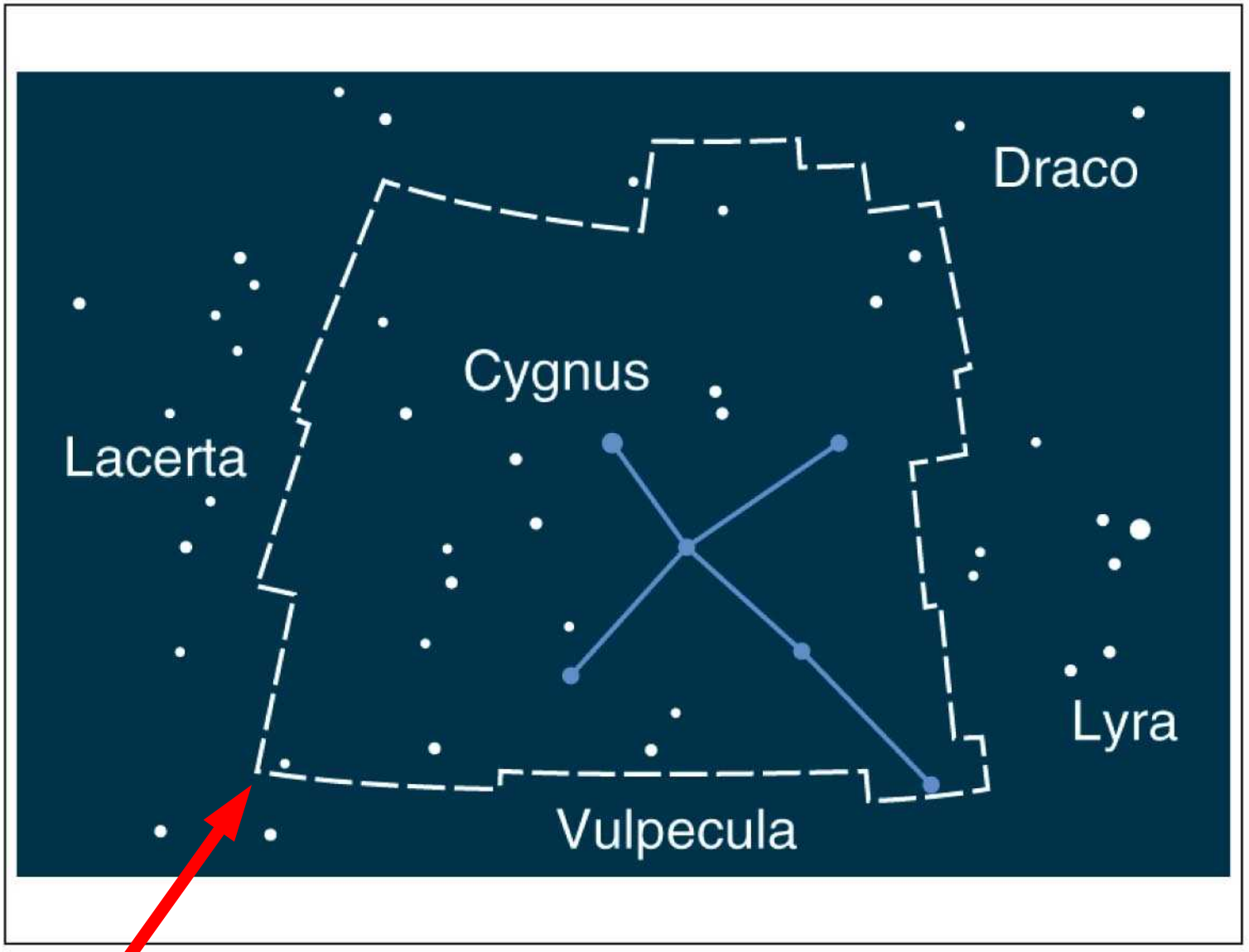
Constellations (cont.)

4. Constellations are simply accidental patterns of stars. The stars in a constellation are at different distances from us and move relative to each other in different directions and with different speeds.

5. Astronomers use constellations as a convenient way to identify parts of the sky.

The constellation Cygnus was seen as a swan, but we often call it the Northern Cross, as outlined here. The official boundaries of Cygnus are shown as white lines.

Figure 1.4



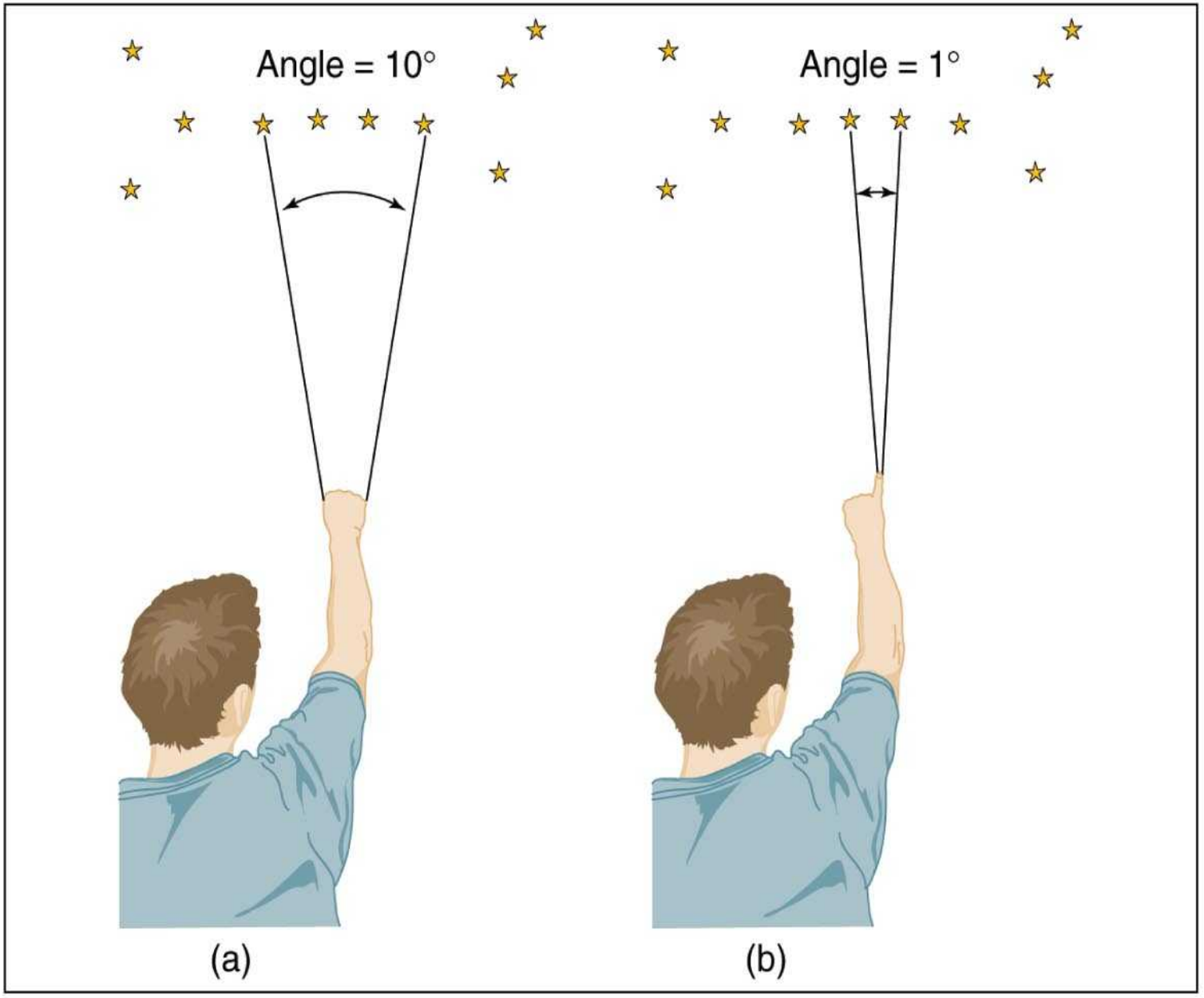
Agreed boundaries between constellations.

Measuring the Positions of Celestial Objects

1. The *angular separation* of two objects is the angle between two lines originating from the eye of the observer toward the two objects.

2. One degree is divided into 60 arcminutes. One arcminute is divided into 60 arcseconds.

3. A fist held at arm's length yields an angle of about 10°. A little finger held at arm's length yields an angle of about 1°.

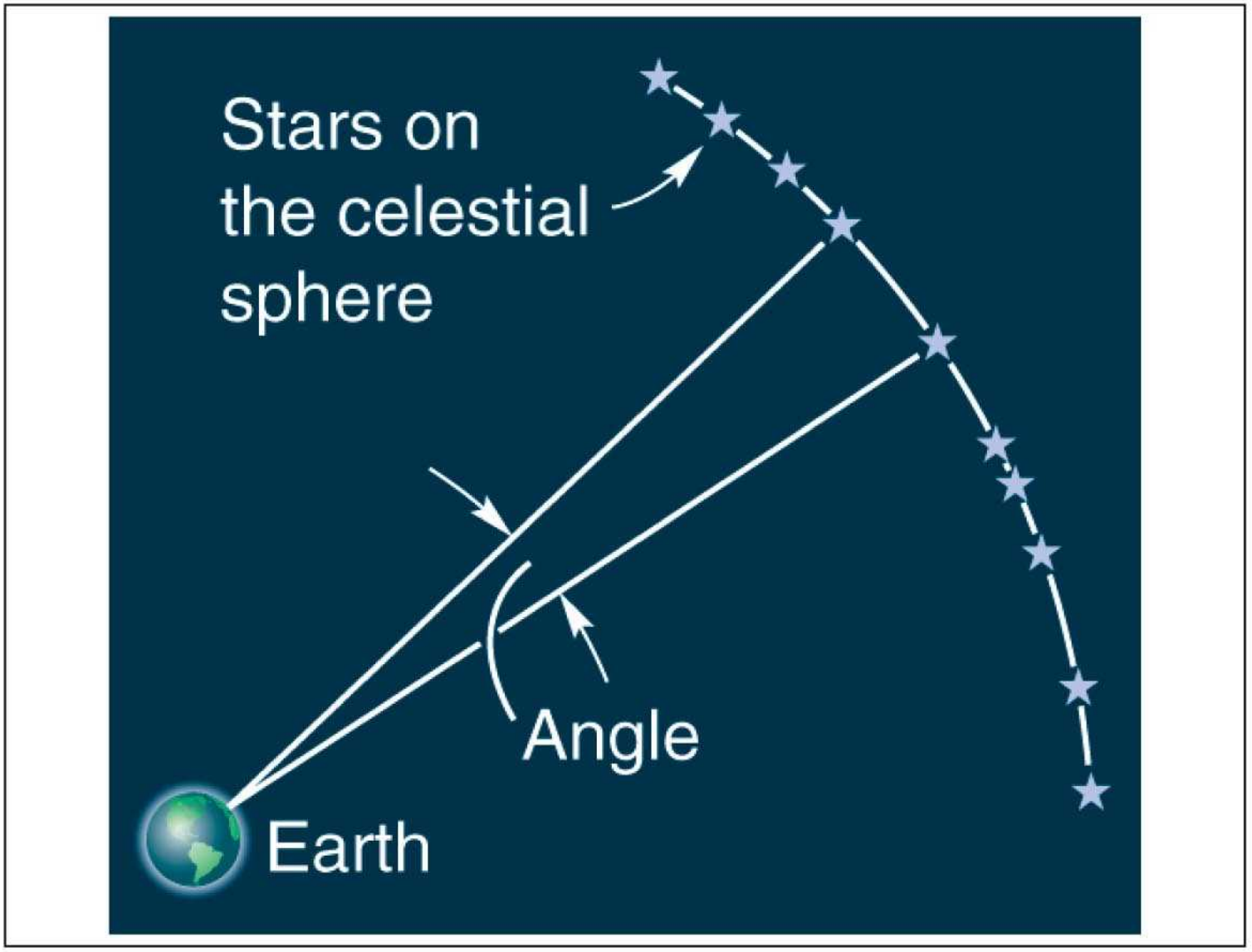


(a) Your fist held at arm's length yields an angle of about 10 degrees. (b) Your little finger held at arm's length cuts off an angle of about one degree.

Figure 1.8

The two stars, when viewed from Earth, have an angular separation as shown.

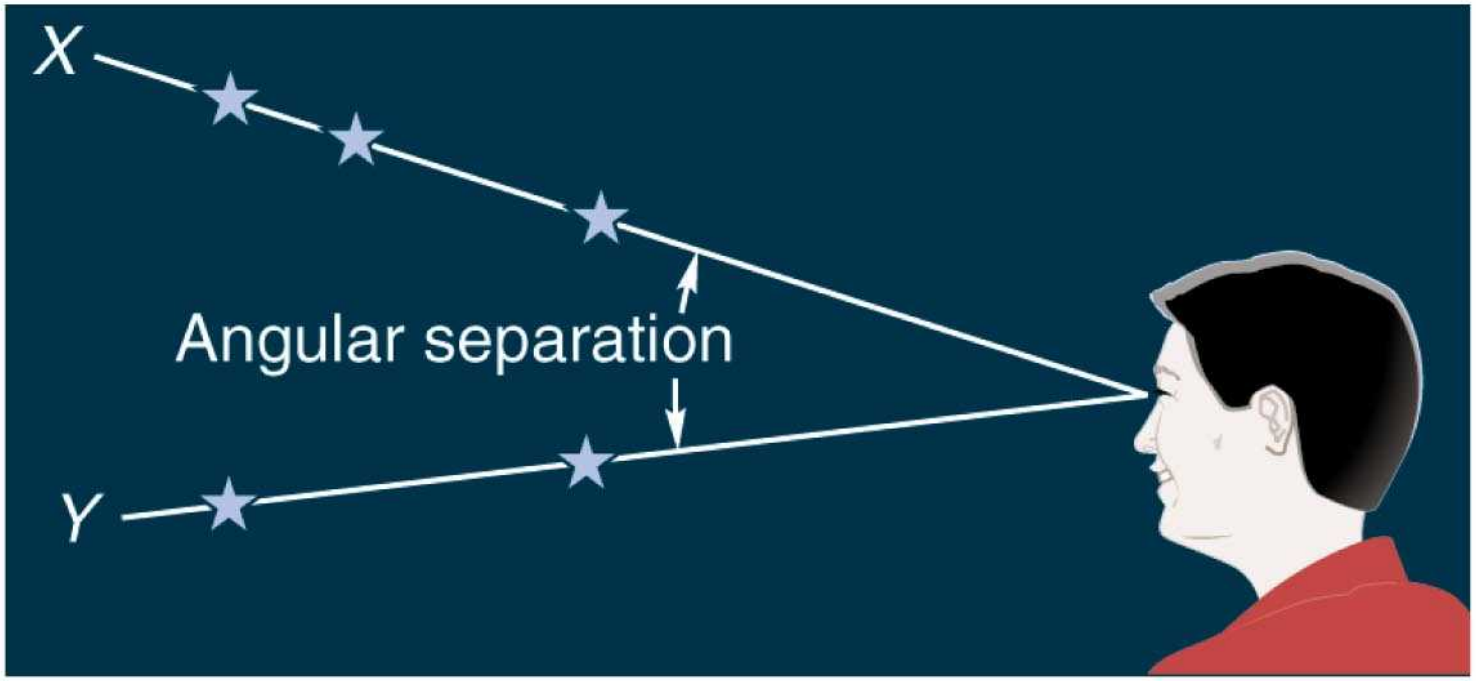
Figure 1.5



Angular separation of two stars as seen from Earth.

The angular separation of stars says nothing about their distances apart.

Figure 1.6



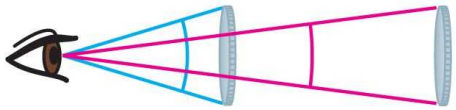
The angular separation of stars on the sky says nothing about their spatial distances apart.

Angular Size

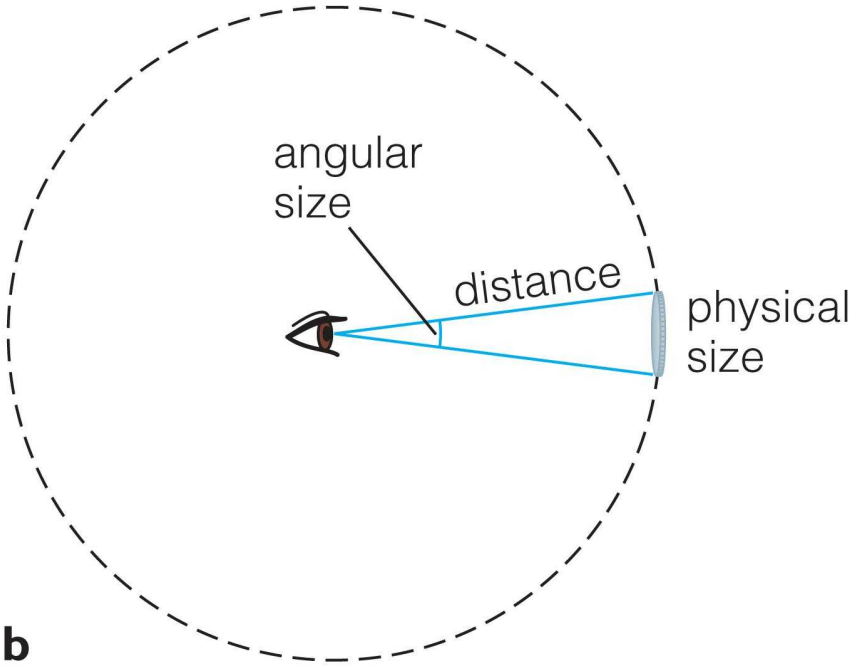
Physical Size = Angular Size X (2 X π X Distance / 360°)

(Degrees for angular size; $\pi = 3.1416$)

a



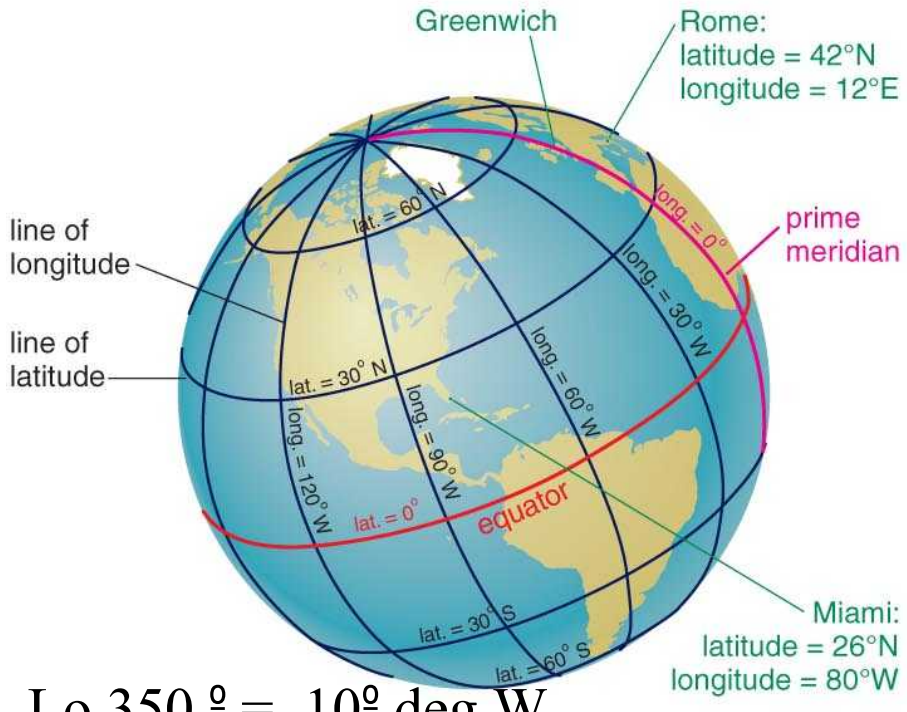
An object's angular size appears smaller if it is farther away.



b

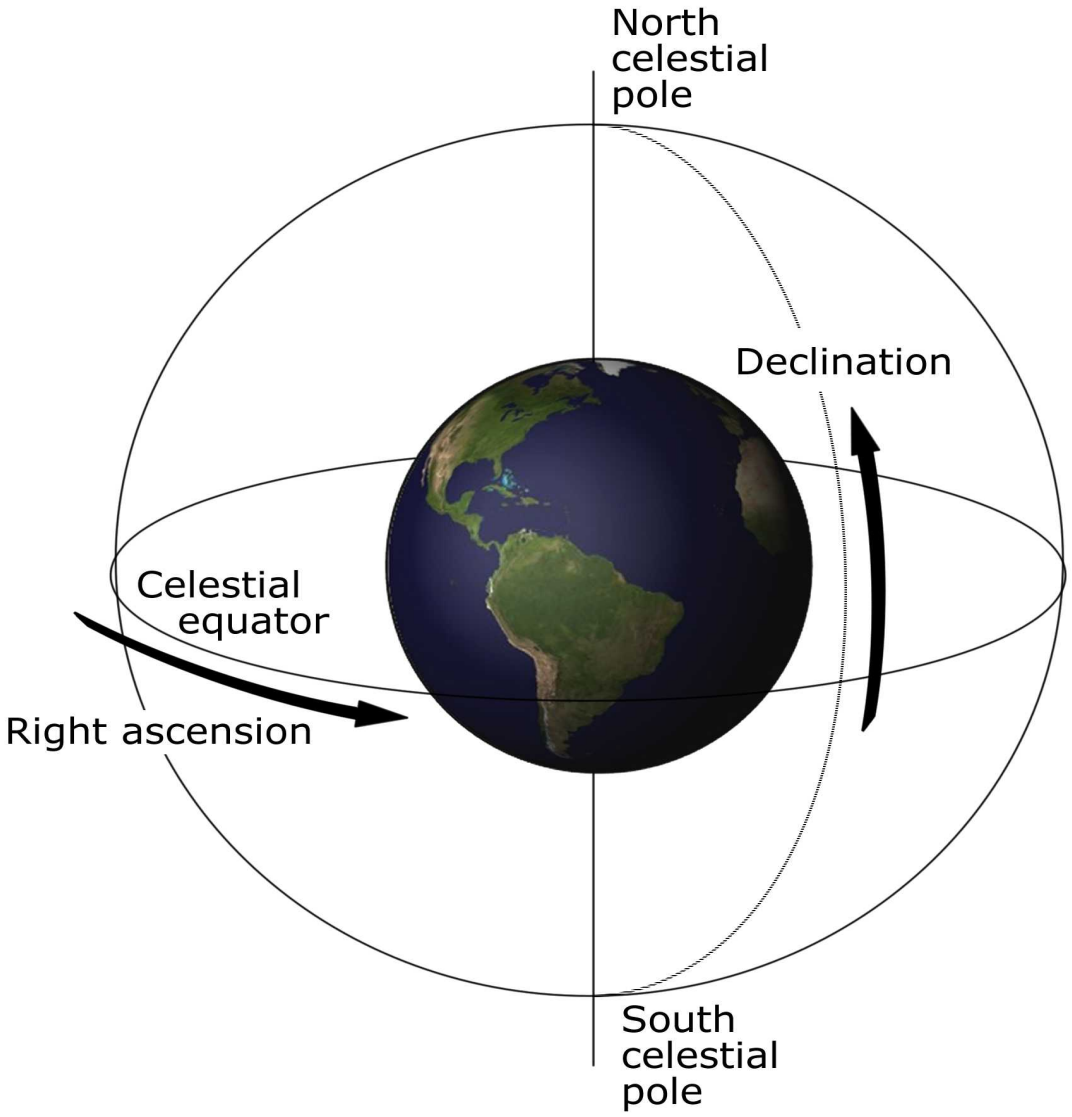
Review: Coordinates on the Earth

- **Latitude:** position north or south of equator
- **Longitude:** position east or west of prime meridian (runs through Greenwich, England)



Note: Lo 350 º = 10º deg W

Celestial coordinates



Celestial Coordinates

1. **Longitude and latitude uniquely define the position of an object on Earth. Similarly, right ascension and declination define the position of an object on the celestial sphere.**

2. **The *declination* of an object on the celestial sphere is its angle north or south of the *celestial equator* (a line on the celestial sphere directly above the Earth's equator); the scale ranges from –90° to +90°.**

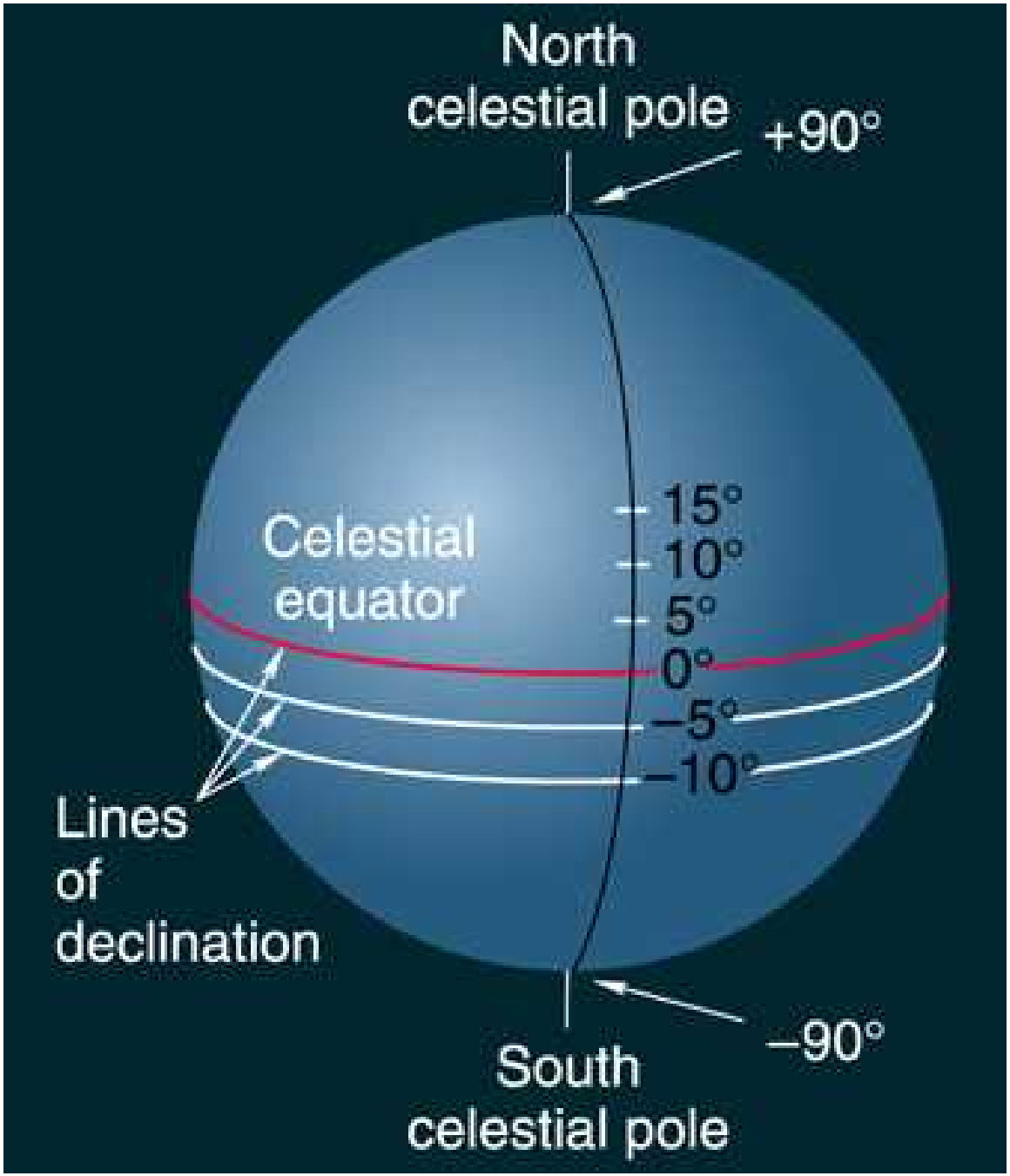
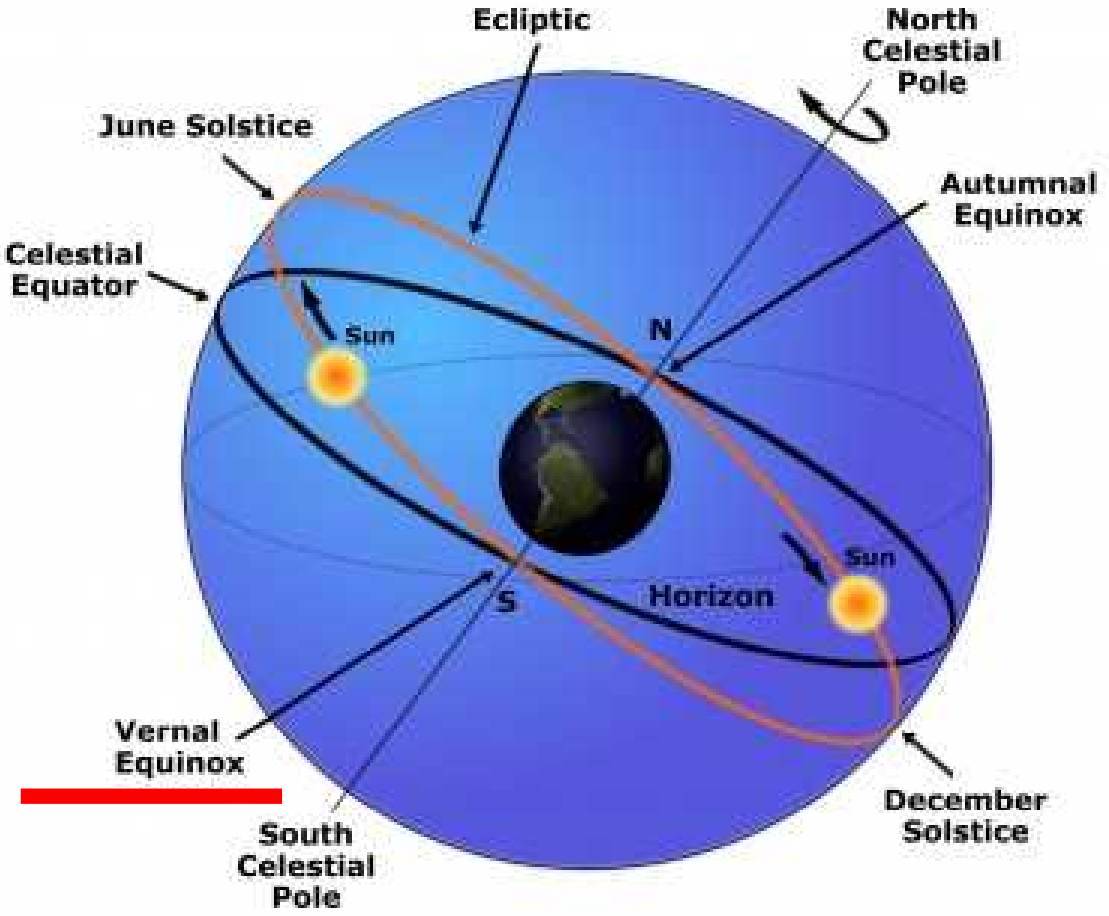

North
celestial pole
+90°
Celestial
equator
15°
10°
5°
0°
−5°
−10°
Lines
of
declination
−90°
South
celestial pole

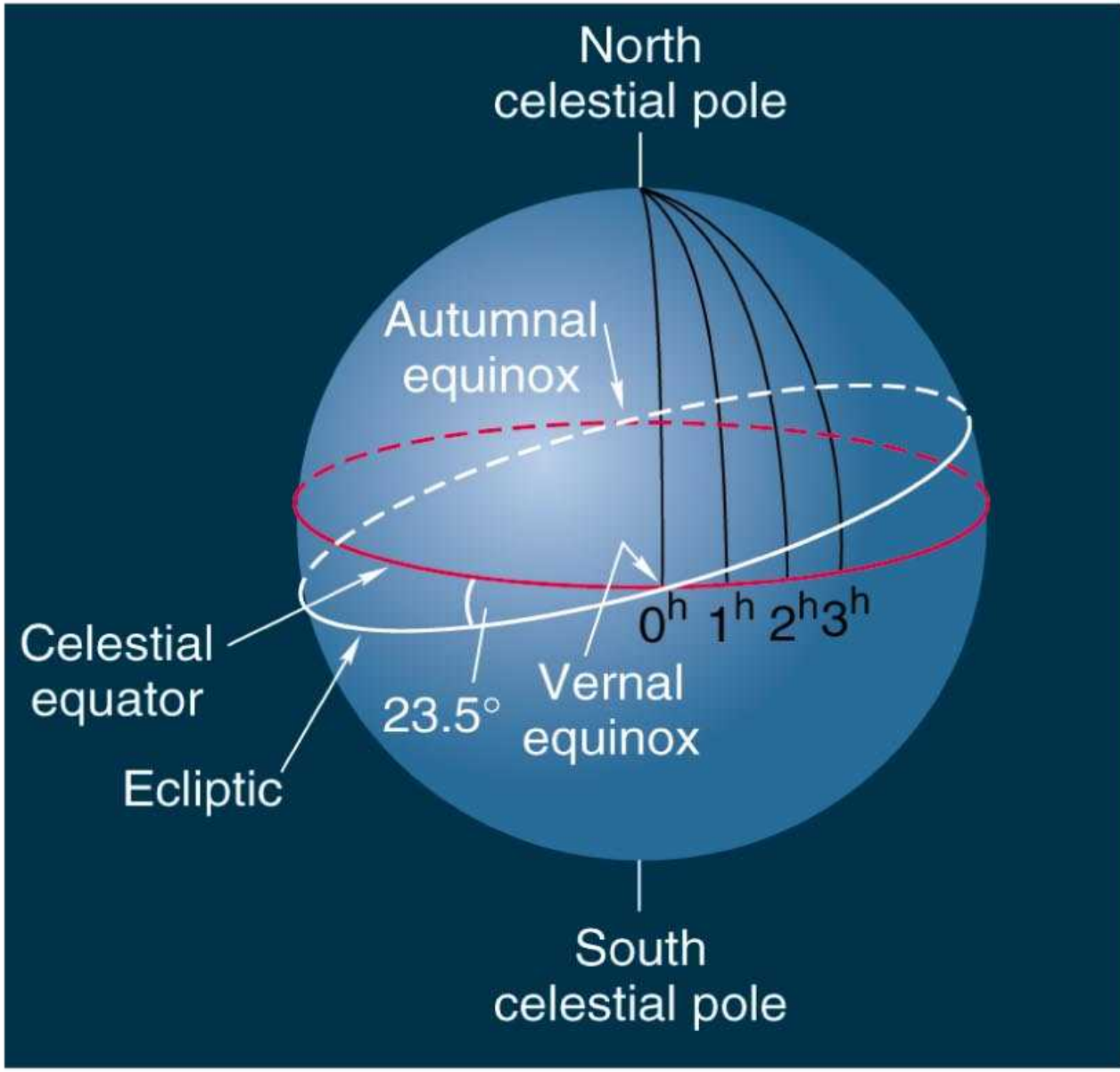
Fig. 1-9a

Just as Greenwich serves to define the Prime Meridian on the Earth's surface, so the Vernal Equinox serves to define the zero right ascension line.

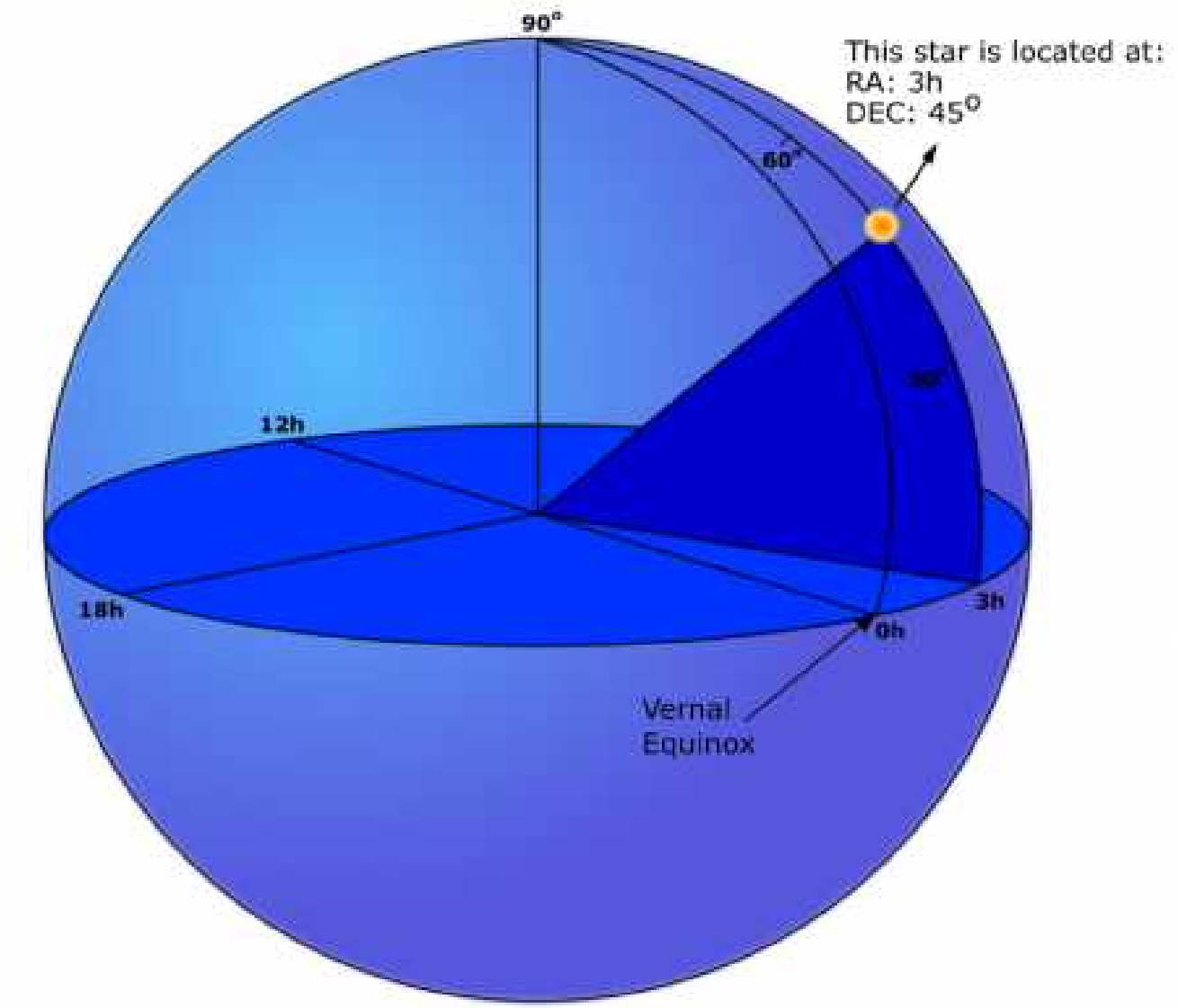


(b) Right ascension measures the angle around the celestial equator eastward from the vernal equinox, where the Sun crosses the equator moving northward.

Figure 1.9b



Right Ascension and Declination: Celestial Coordinates



Celestial Coordinates (cont.)

3. The ***right ascension*** of an object states its angle around the celestial sphere, measuring eastward from the vernal equinox (the location on the celestial equator where the Sun crosses it moving north). It is stated in hours, minutes, and seconds (with 24 hours encompassing the entire celestial equator).

The Sun's Motion Across the Sky

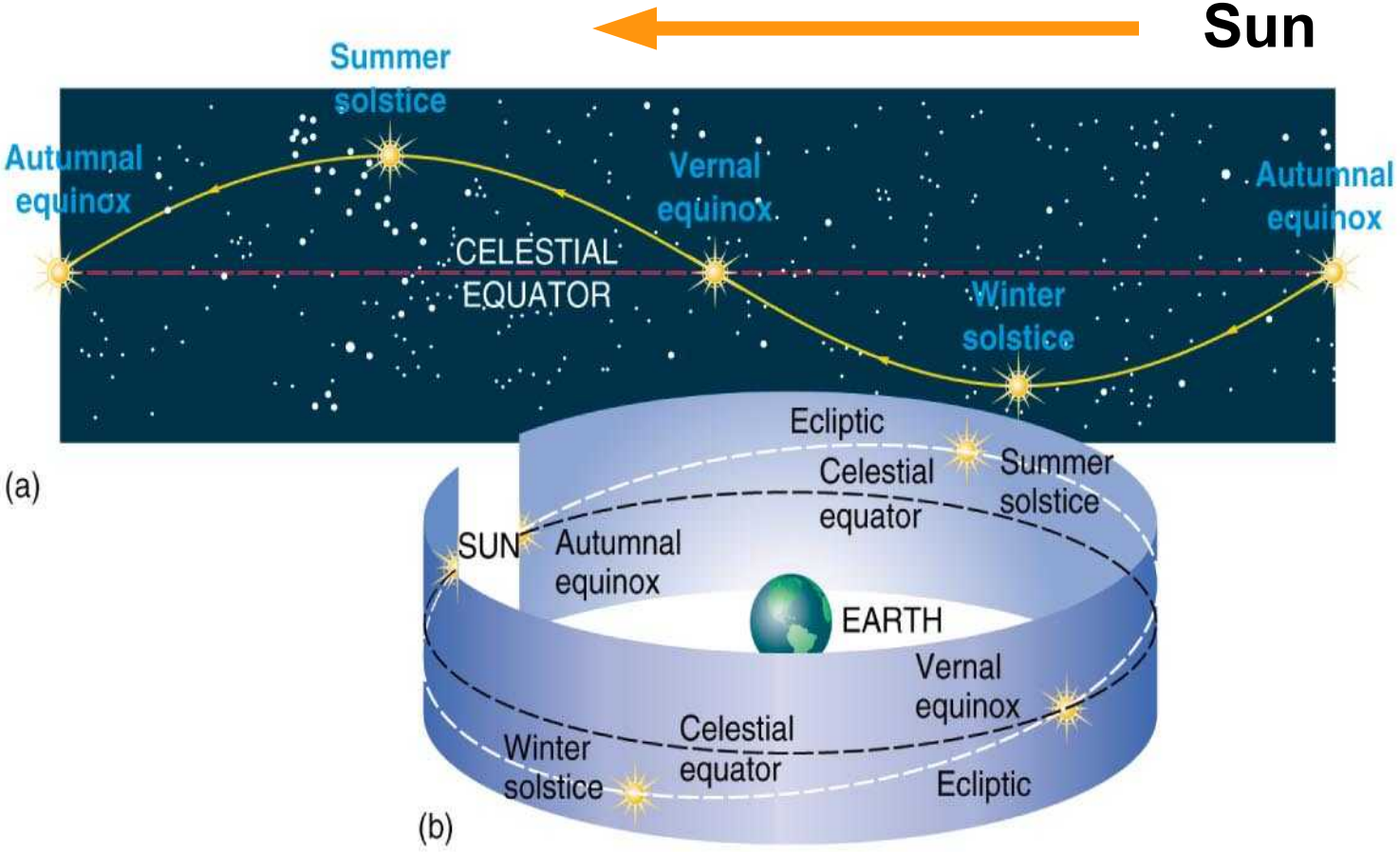
1. **The Sun seems to rise in the east and set in the west just like the rest of the stars. However, as time goes on, the Sun appears to move constantly eastward among the stars.**

2. **The time the Sun takes to return to the same place among the stars is about 365.25 days.**

The Ecliptic

Part (a) is a map of the stars within 30 degrees of the equator. Picture this map wrapped around the Earth as shown in part (b).

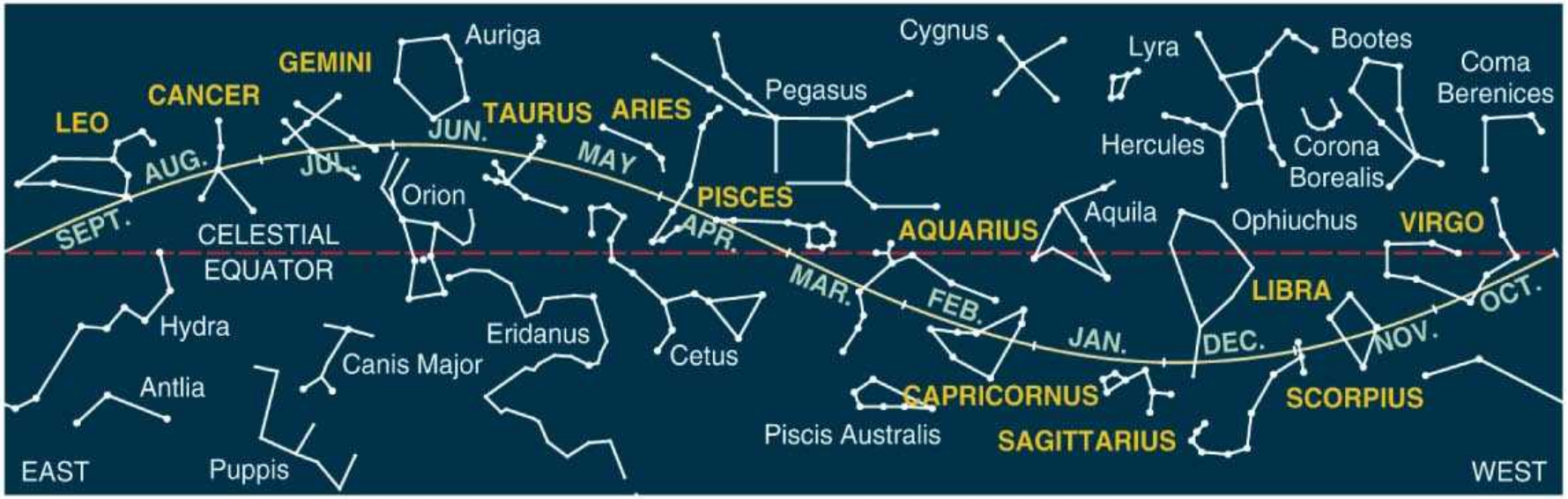
Figure 1.10



Sun's path across the sky over the year

Constellations of the Zodiac

The ecliptic is the apparent path of the Sun on the celestial sphere.



The zodiac is the band that lies 9° on either side of the ecliptic on the celestial sphere and contains the constellations through which the Sun passes.

The Sun and the Seasons

1. For an observer in the Northern Hemisphere, the Sun rises and sets farther north in the summer than in the winter.

2. The Sun is in the sky longer each day in summer than in winter. This is one of the reasons for seasonal differences.

3. In summer, the Sun reaches a point higher in the sky, than in winter. Each portion of the Earth's surface receiving more energy in a given amount of time in the summer than in winter. Sunlight passes through more atmosphere in winter than in summer, resulting in more scattering and absorption in the atmosphere.

Apparent path of Sun across sky of Northern Hemisphere in winter, spring/autumn & summer.

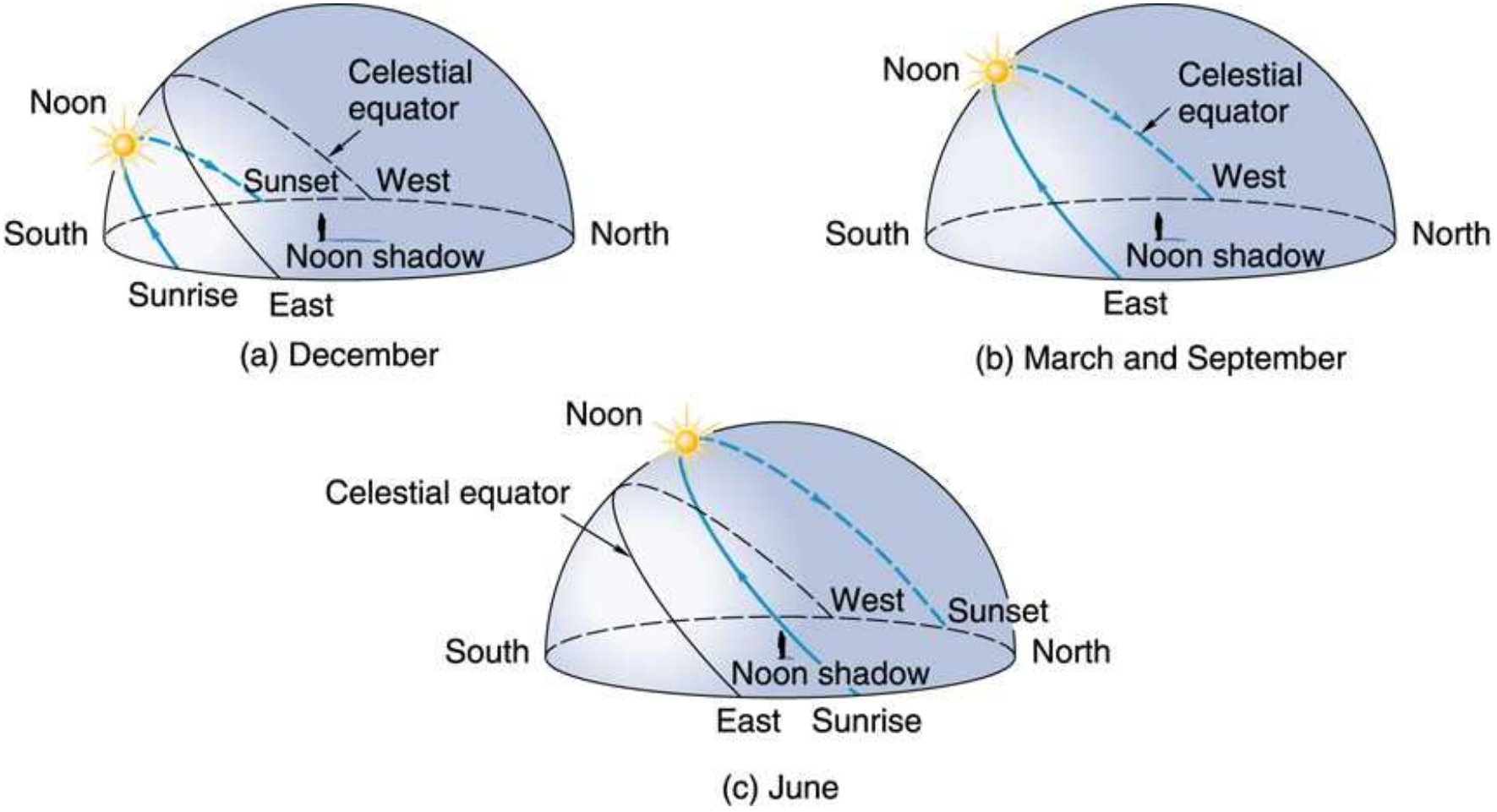
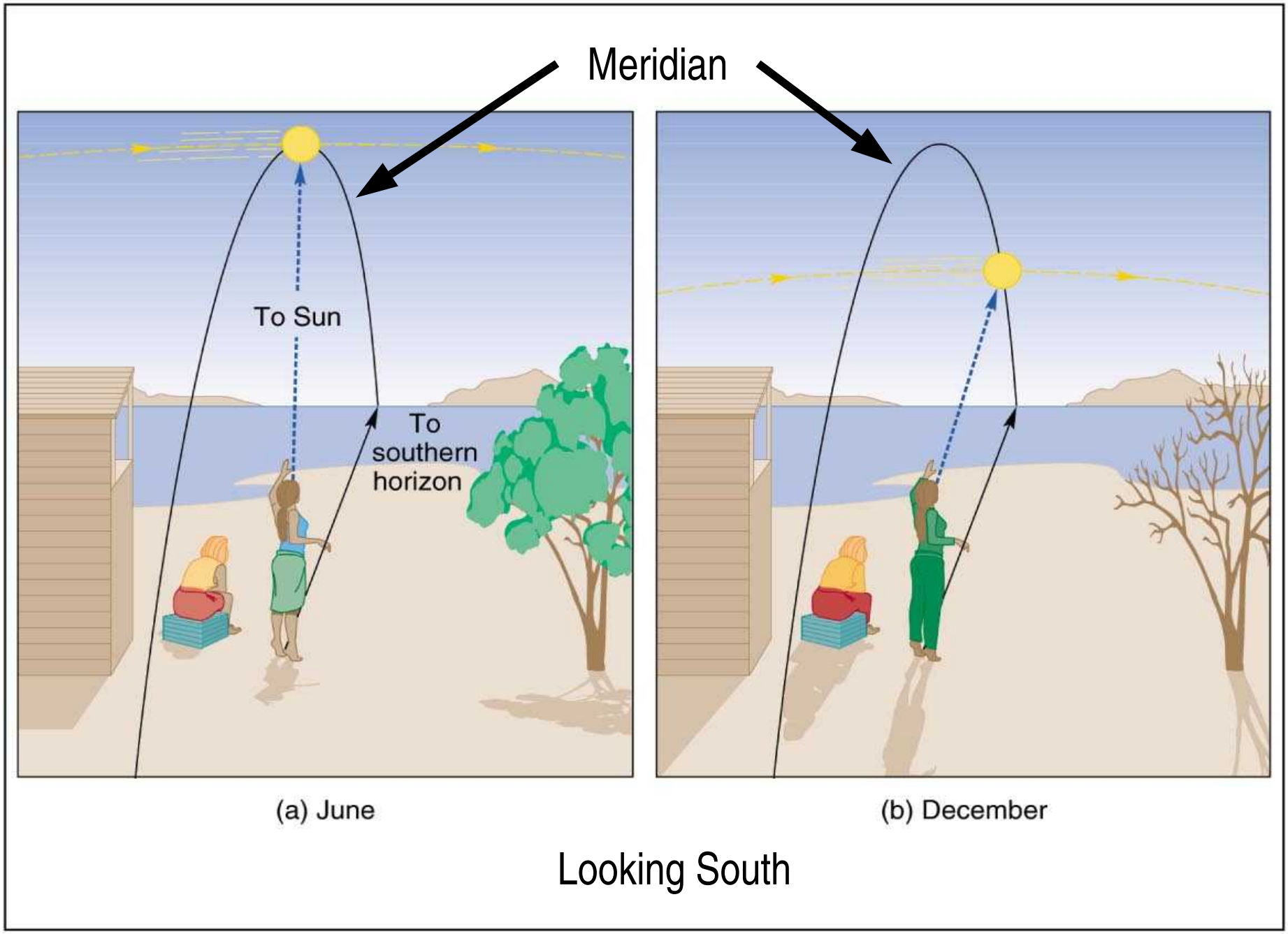
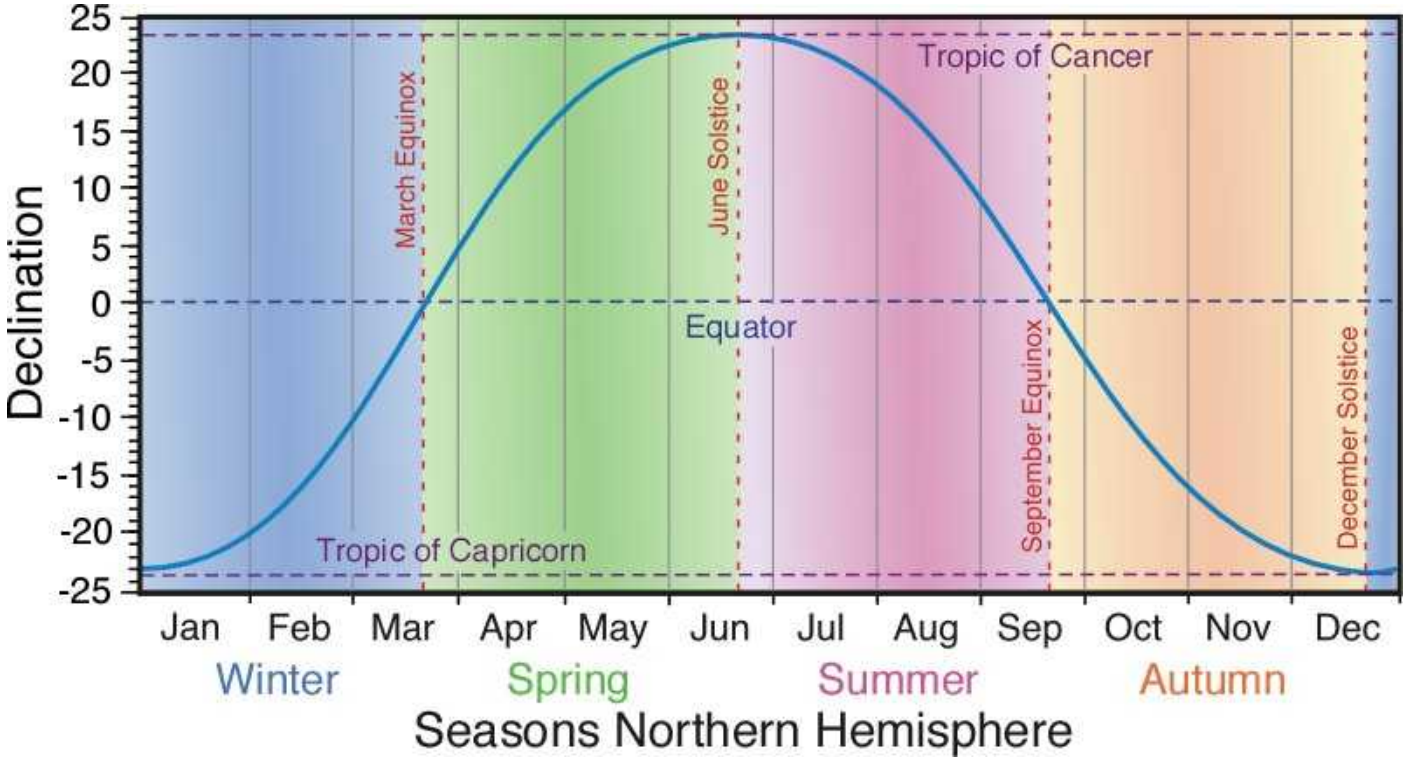


Fig. 1-12


Meridian
To Sun
To
southern
horizon
(a) June
(b) December
Looking South



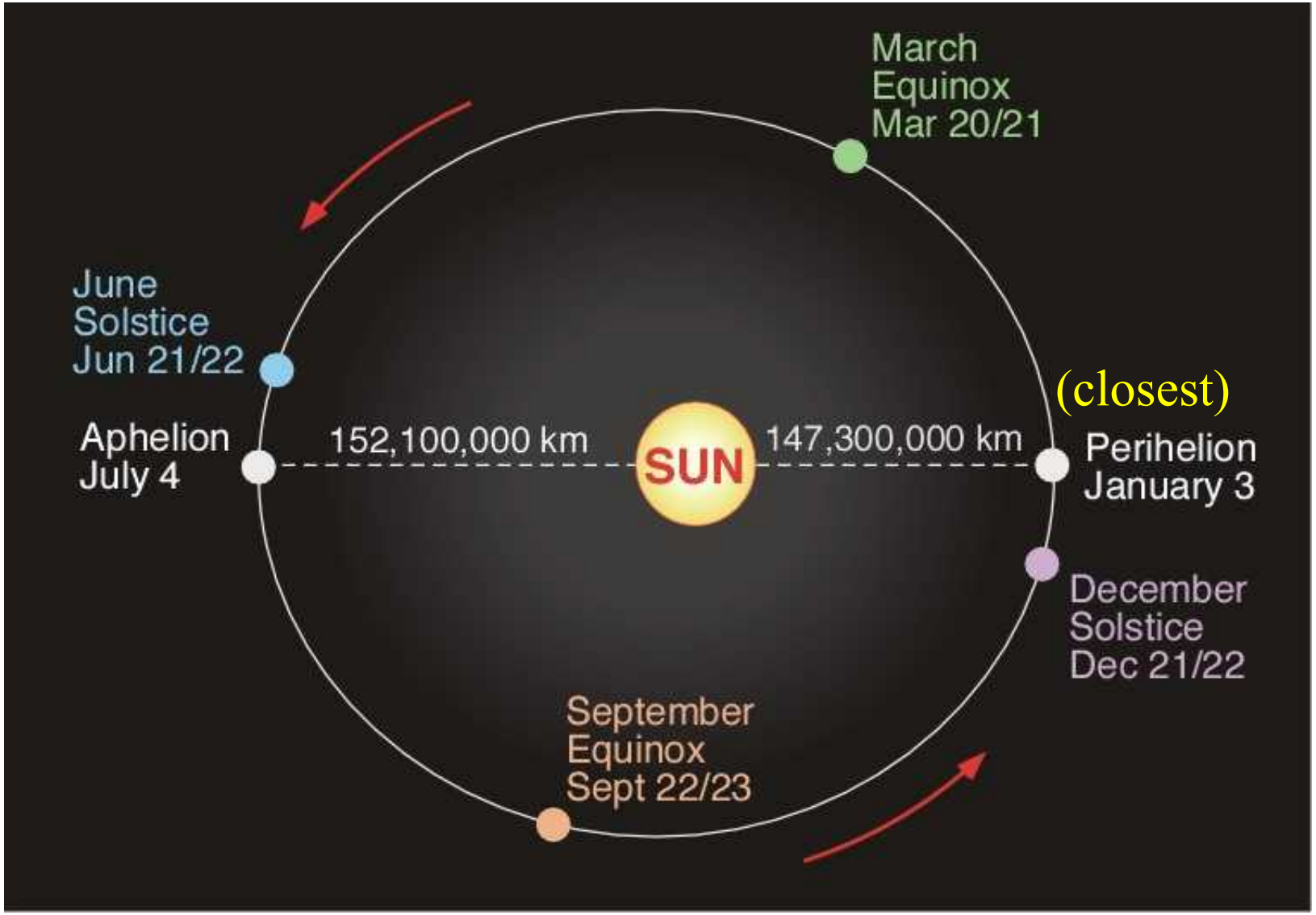
Angle of the Sun's declination and latitude of the subsolar point throughout the year. Seasons are for the *Northern* Hemisphere.

The Sun and the Seasons (cont.)

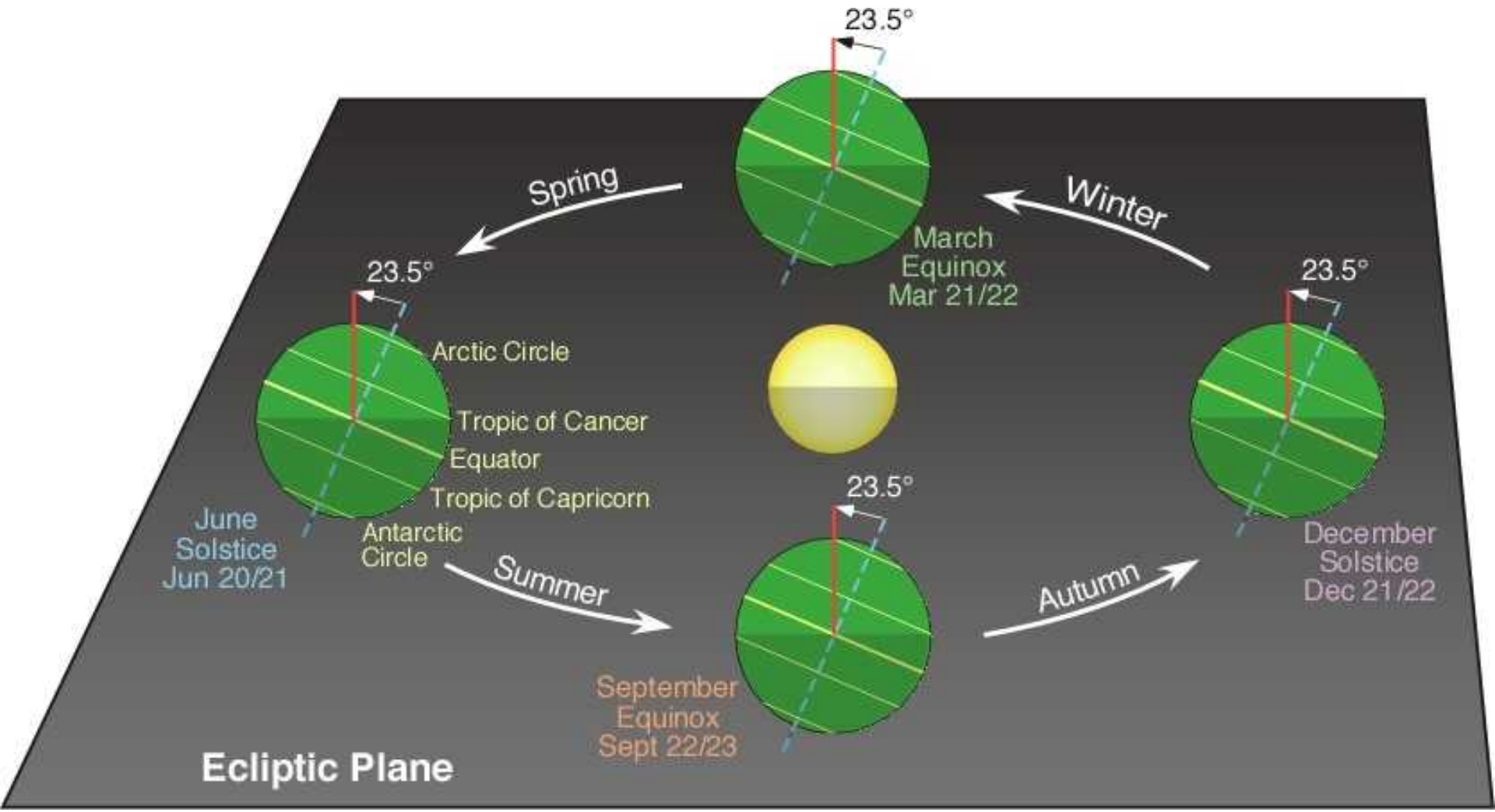
4. For an observer in the Southern Hemisphere the above explanation is backward: the Sun is lower when it's further North (Southern winter).

5. The distance of the Earth from the Sun does not vary much during the year and thus is not a determining factor for the seasons.

6. The orientation of the Earth with respect to the Sun is the main reason for the seasons.

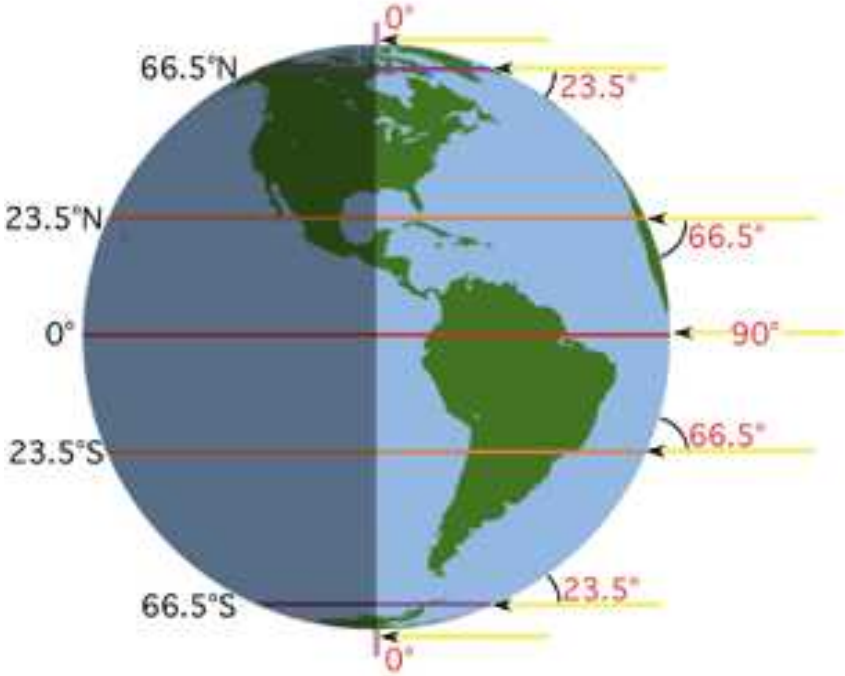


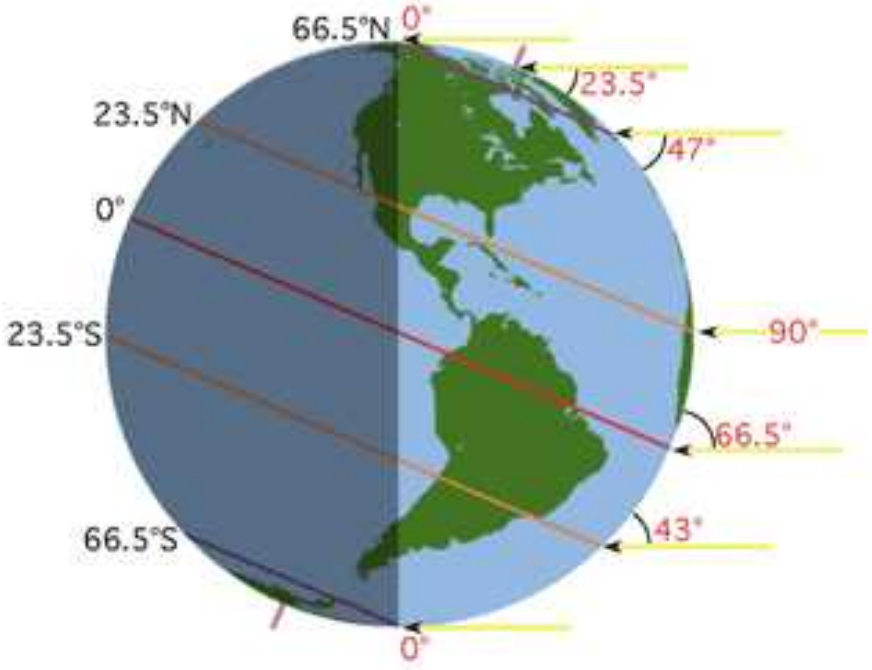
Position of the equinoxes, solstices, aphelion, and perihelion relative to the Earth's orbit around the Sun.



The Earth's rotational axis is tilted 23.5° from the red line drawn perpendicular to the ecliptic plane. This tilt remains the same anywhere along the Earth's orbit around the Sun. Seasons indicated are appropriate only for the Northern Hemisphere.

Why it's colder in winter.





At Equinox

At June Solstice

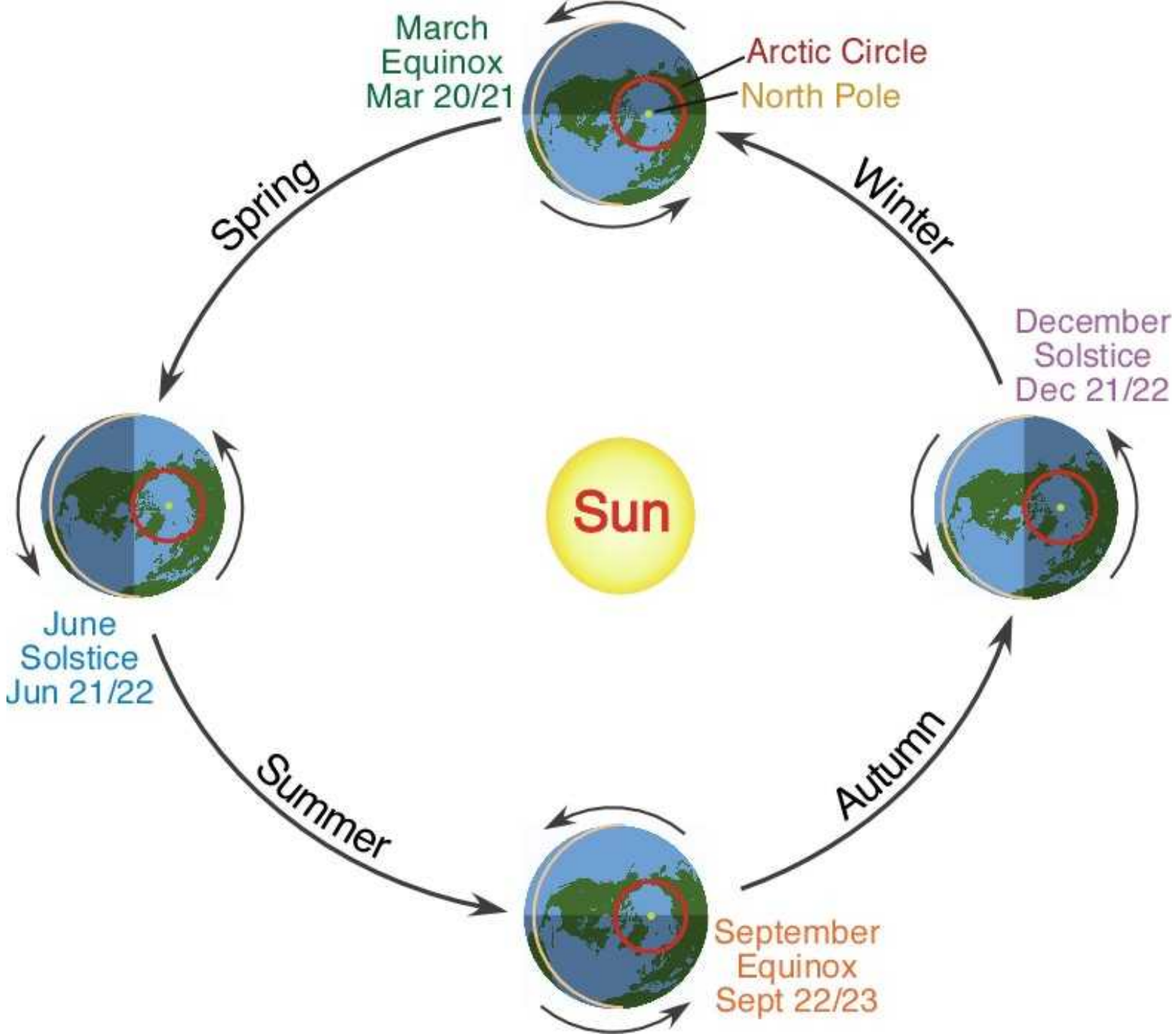
Angles of incidence of sunlight over the Earth

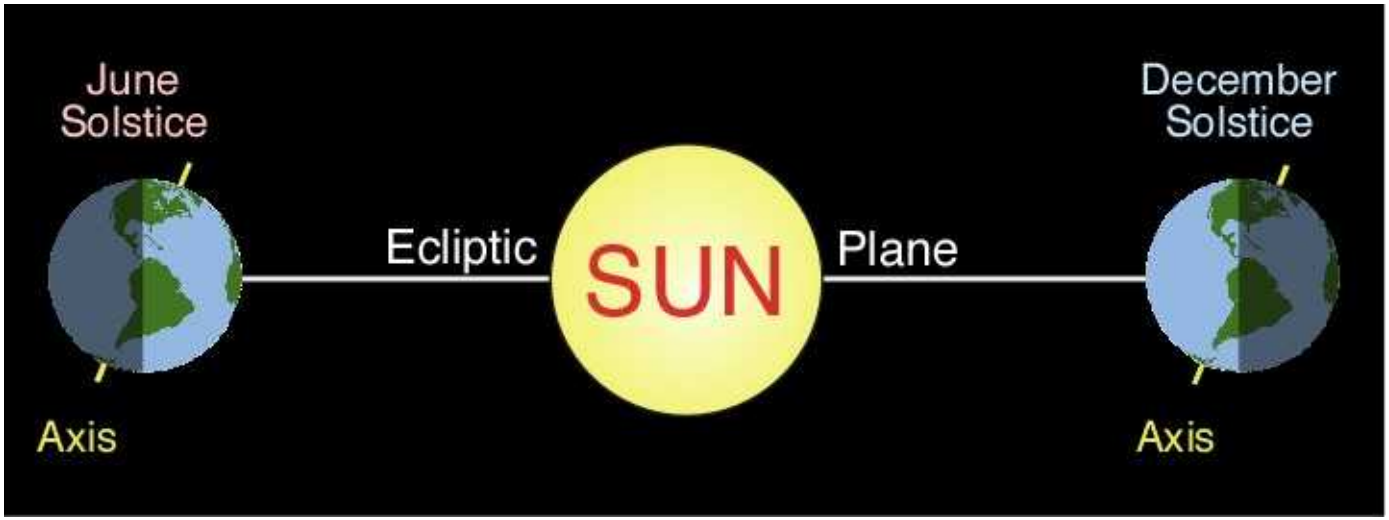
The Sun and the Seasons (cont.)

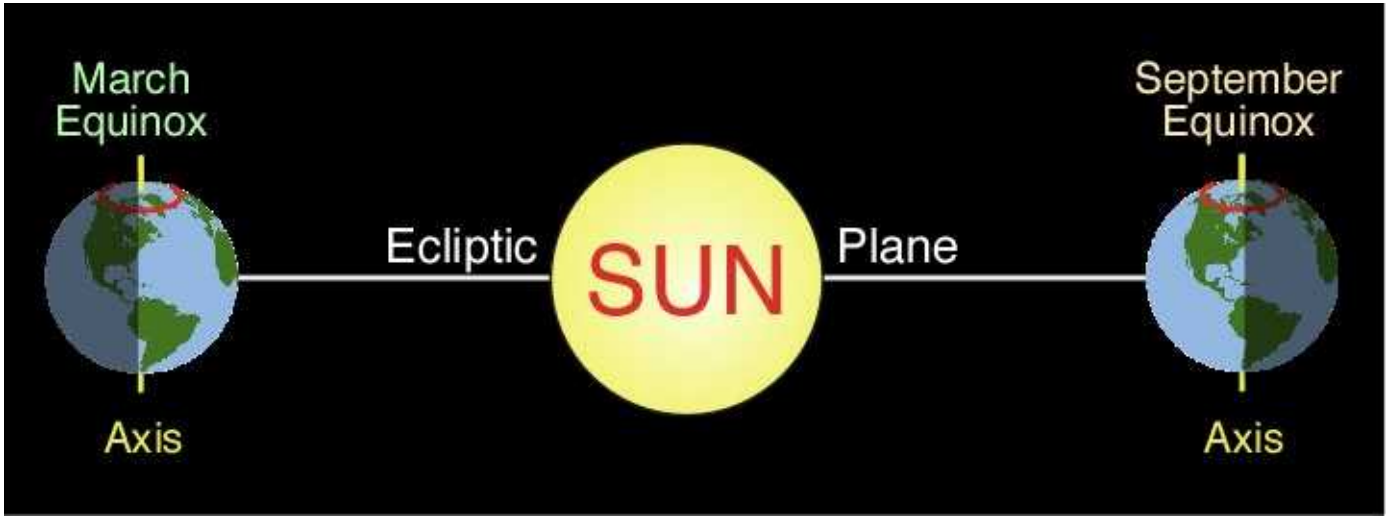
7. ***Altitude*** **is the height of a celestial object (such as the Sun) measured as an angle above the horizon.**

8. **The *summer* and *winter* solstices are points on the celestial sphere where the Sun reaches its northernmost and southernmost positions, respectively.**

9. **The *vernal* and *autumnal equinoxes* are the points on the celestial sphere where the Sun crosses the celestial equator while moving north and south, respectively.**


March
Equinox
Mar 20/21
Arctic Circle
North Pole
Spring
Winter
December
Solstice
Dec 21/22
Sun
June
Solstice
Jun 21/22
Summer
Autumn
September
Equinox
Sept 22/23


June
Solstice
December
Solstice
Ecliptic
SUN
Plane
Axis
Axis


March
Equinox
September
Equinox
Ecliptic
SUN
Plane
Axis
Axis

Readings for next Lecture

- The Calendar.
- The Moon's Motions and Eclipses
- Motions of Planets Across the Sky
- Ch. 1, sec. 4 The Moon's Phases
- Ch. 1, secs. 5 & 6: Eclipses
- Ch. 1, sec. 7 Planetary Motion
- Ch. 1, sec. 8 Rotations
- Ch. 1, secs. 9-10 distances, Scales

(These are all as in the 6th Edition of Text)