Chapter 2. Cycles and Seasons: Motions in the Sky

Note. A *solar day* is the amount of time between successive solar noons (when the Sun is at its highest point in the sky). This is taken to be 24 hours.

Note. A *sidereal day* is the amount of time it takes a particular star to travel from its highest point in the sky, back to that point. This is 23 hours and 56 minutes.

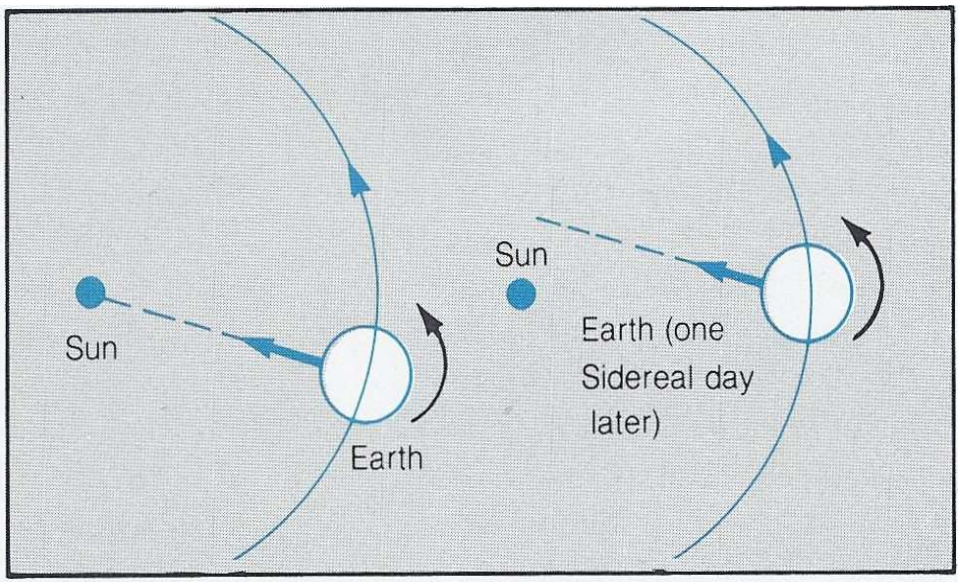

Figure 2.2, page 19.

The longer length of a solar day it due to the fact that the Earth moves (a small amount) in its orbit while it completes a rotation on its axis.

Note. Returning to the celestial sphere, the *meridian* is the imaginary line on the celestial sphere that passes from the north, overhead, to due south. We can now redefine solar day and sidereal in terms of transits of the sun or a start (respectively) across the meridian.

Note. We can project the Earth's north pole, south pole, and equator onto the celestial sphere producing:

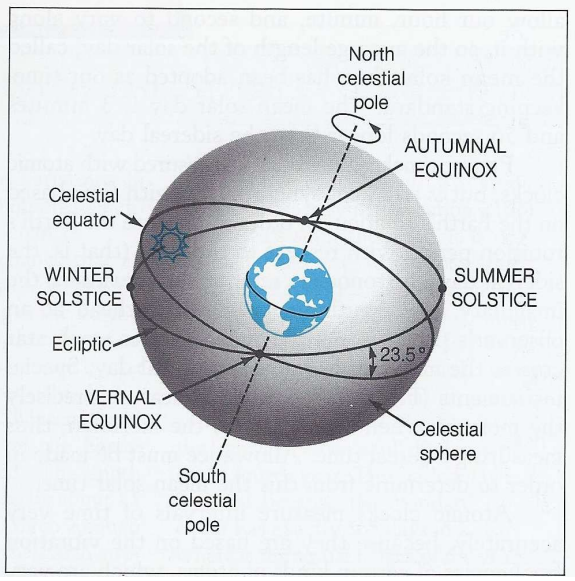

Figure 2.5, page 22.

We can also project the lines of latitude onto the celestial sphere producing *declination* lines (ranging from $-90°$ to $90°$). If we project lines of longitude we will generate *right ascension* lines. These are measured in hours, minutes, and seconds and declination and right ascension are called the *equatorial coordinate system.* Since the axis of the Earth is tilted (with respect to its plane of orbit about the Sun), over a year the Sun traces out a circle on the celestial sphere that intersects the celestial equator in two points. This circle (on which the planets travel) is called the *ecliptic first point of Aries* (although the point presently lies in Pisces). The Earth's axis "wobbles" however and the first point of Aries slowly moves. When the point enters Aquarius, this will make the "Age of Aquarius."

Note. The constellations through which the ecliptic passes are called the *zodiac*. The position of the Sun determines "your sign" See Figure 2.7 on page 24.

Note. The Earth's axis is tilted $23\frac{1}{2}^\circ$ with respect to its orbit. This gives the seasons:

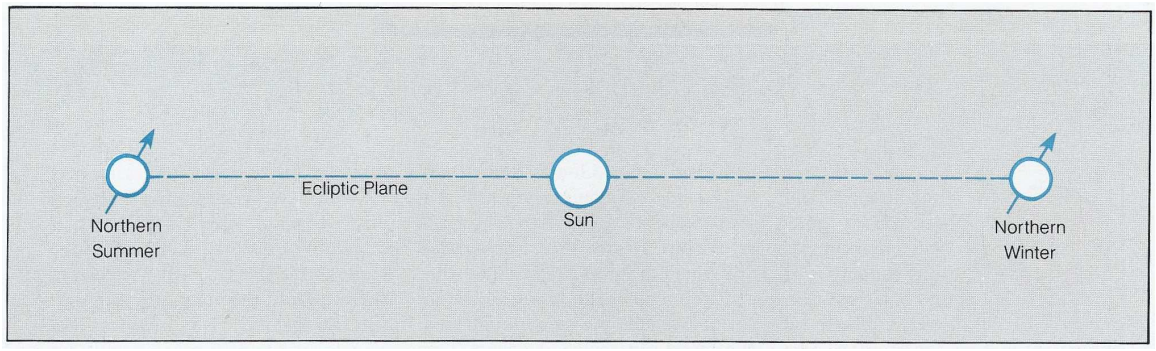

Figure 2.8, page 26.

Due to the tilt, there are places on the Earth where the Sun will be overhead at some time during the year. These are the *tropics*. There are also places where there is a day when the Sun never rises. These are the *arctic* and *antarctic*.

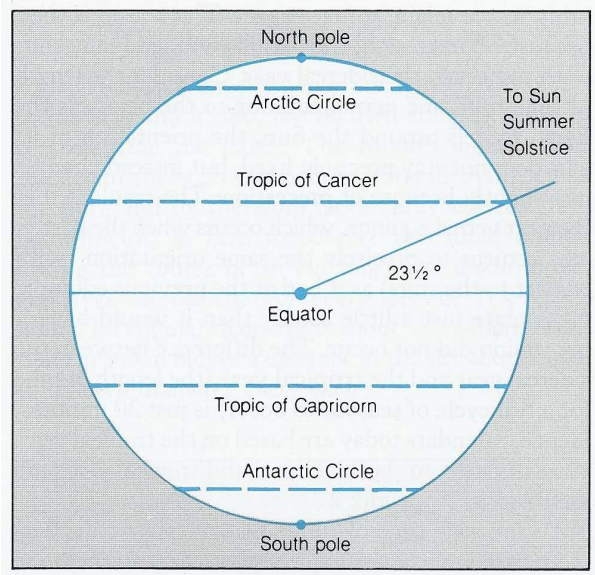

Figure 2.10, page 27.

Note. The configurations of the Moon (or phases of the Moon) are due to its relative position with respect to the Sun as follows:

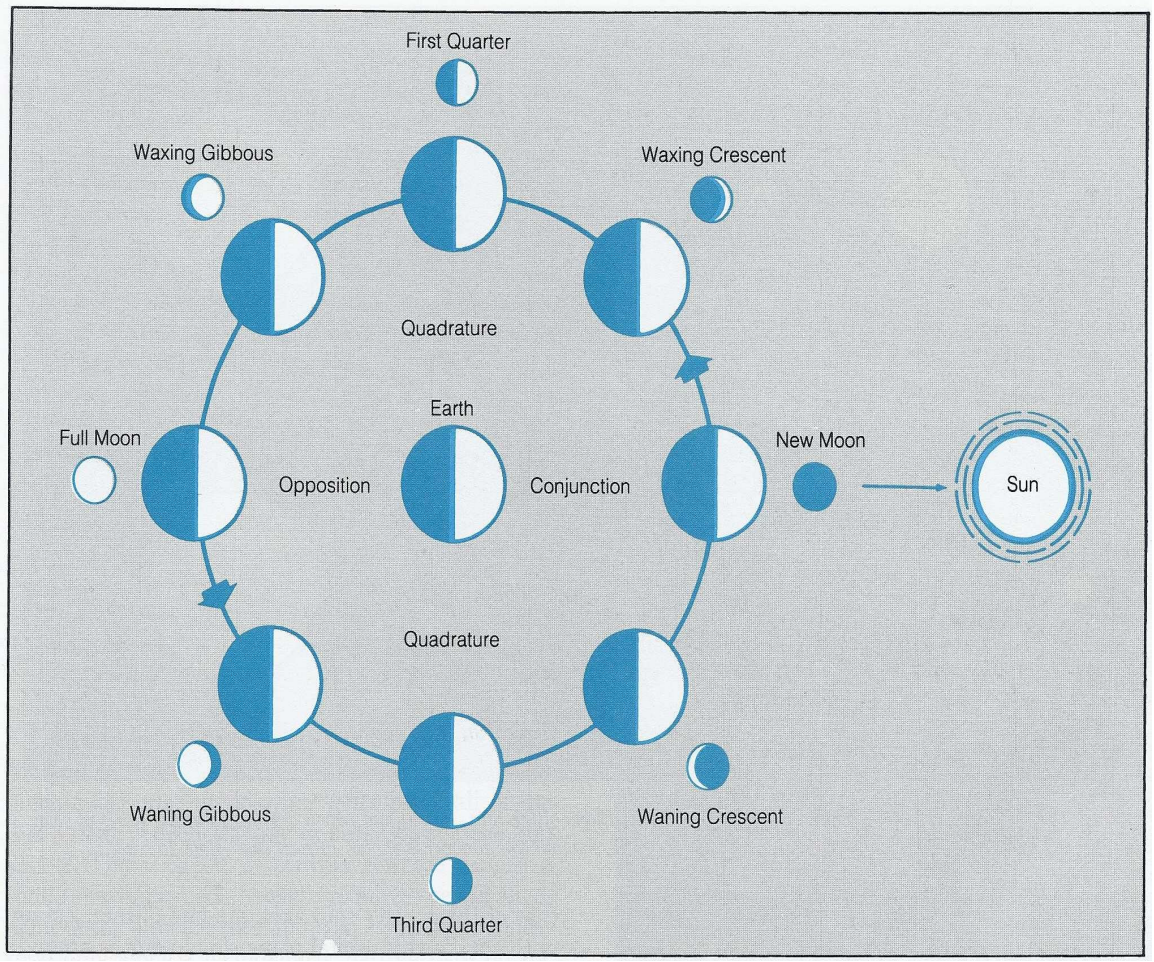

Figure 2.16, page 31.

Notice that "waxing" is a phase when the lighted part of the Moon is growing, "waning" is a phase when the lighted part of the Moon is shrinking, and "quadrature" is when the Sun-Earth-Moon angle is 90°. Also, the same side of the Moon always faces the Earth. it is said to be in *synchronous rotation*.

Note. A *solar eclipse* occurs when the Moon passes between the Sun and the Earth. This is an eclipse of the Sun. An *annular eclipse* of the Sun occurs when the Moon is at a point for from Earth in its orbit and it does not completely cover the Sun's image. Since the Sun is not a point source, the Earth's shadow consists of a dark inner part (*umbra*) and a lighter outer part (*penumbra*):

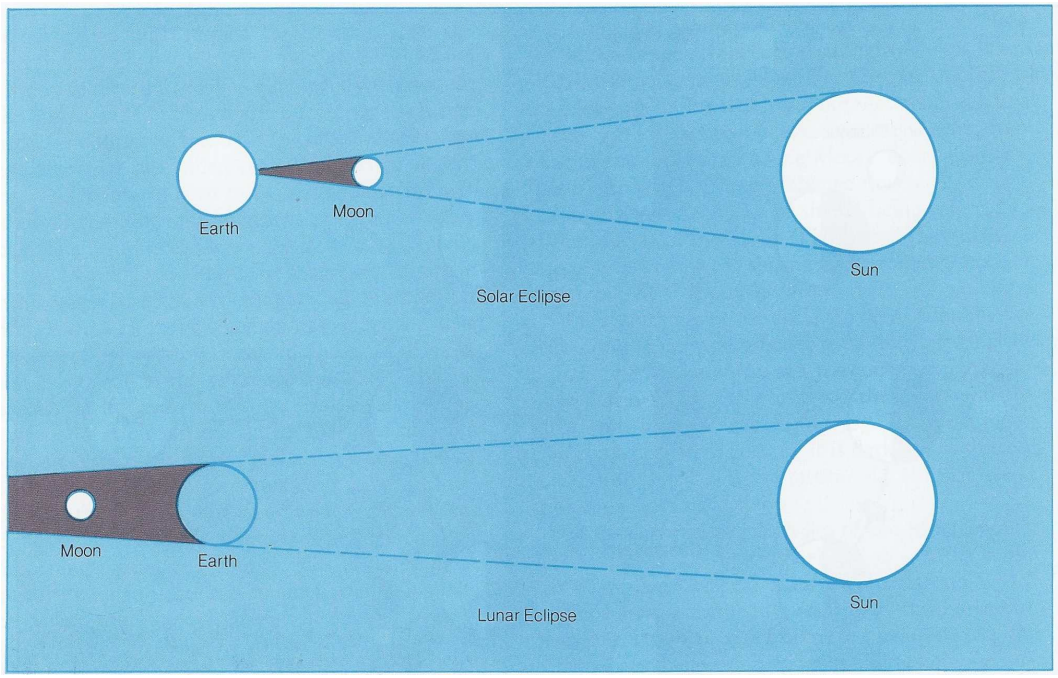

Figure 2.17, page 32.

Note. The *inferior planets* are those closer to the Sun that the Earth. These are Mercury and Venus. The *superior planets* are those outside the Earth's orbit (which are, in order, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto). For an inferior planet, we can define the following 3 configurations:

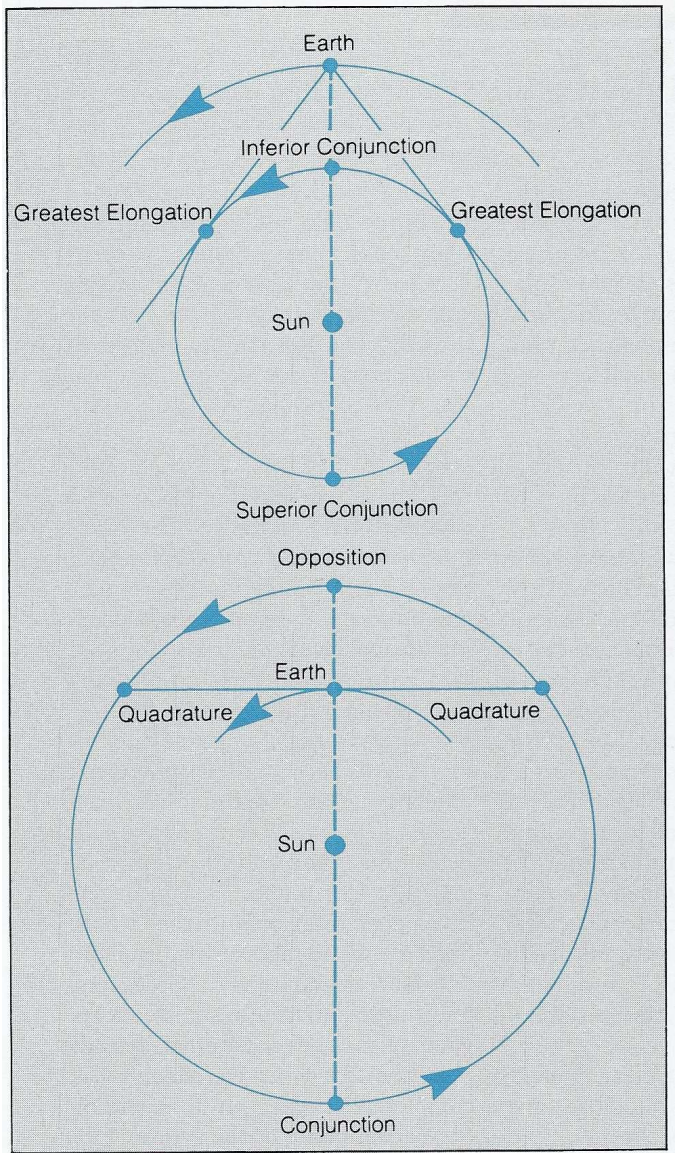

Figure 2.22, page 35.

Note. Finally, we can explain the backward movements (*retrograde motion*) of a superior planet by the differential rates of revolution about the Sun of the Earth and each these planets:

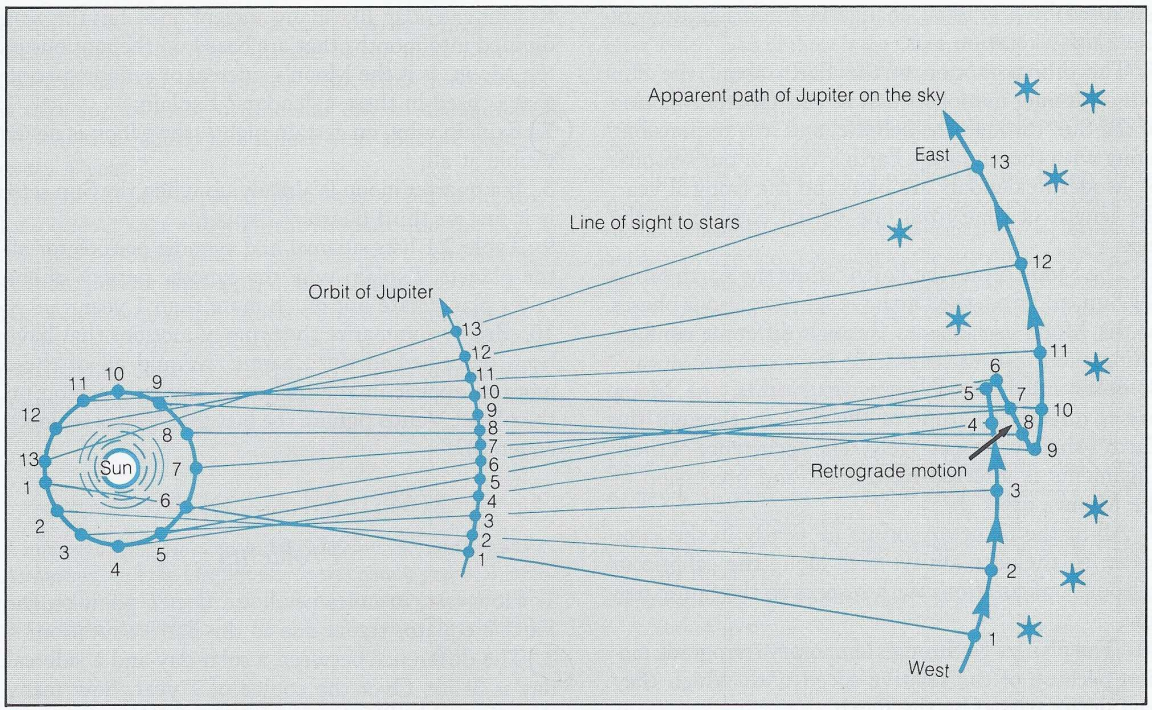

Figure 2.24, page 37.

Note. We can project these lines onto the celestial sphere and use them to determine the seasons:

1. summer solstice (around June 21),

2. winter solstice (around December 21),

3. vernal (spring) equinox (around March 21),

4. autumnal equinox (around September 21).

Revised: 3/30/2019