Lecture Outlines

Chapter 1
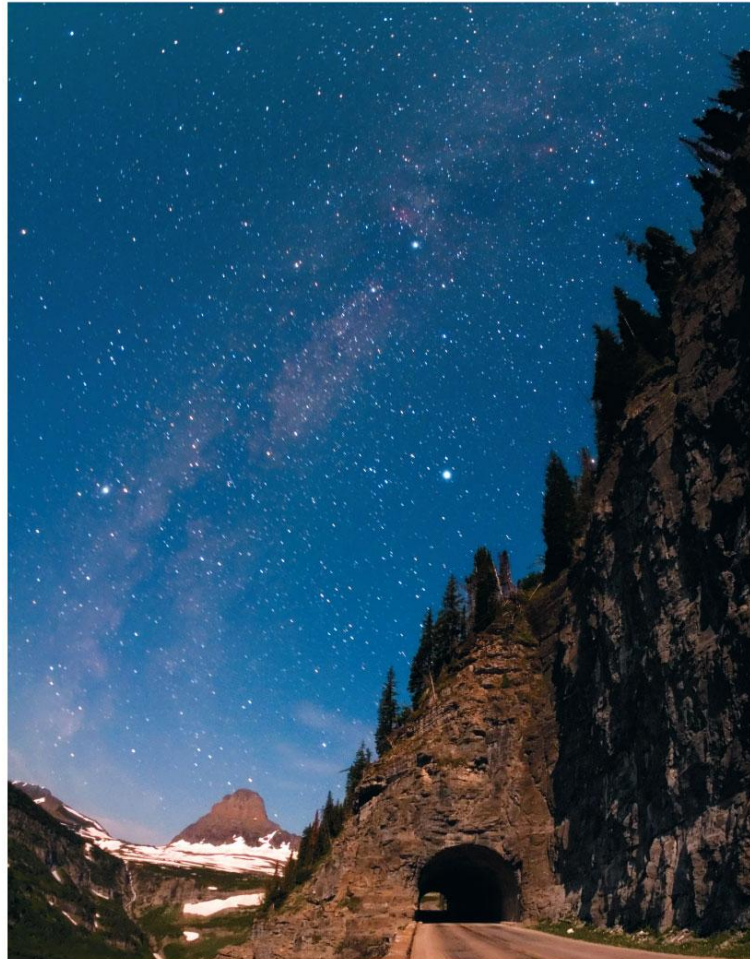
Astronomy Today

7th Edition

Chaisson/McMillan

Chapter 1

Charting the Heavens

Units of Chapter 1

1.1 Our Place in Space
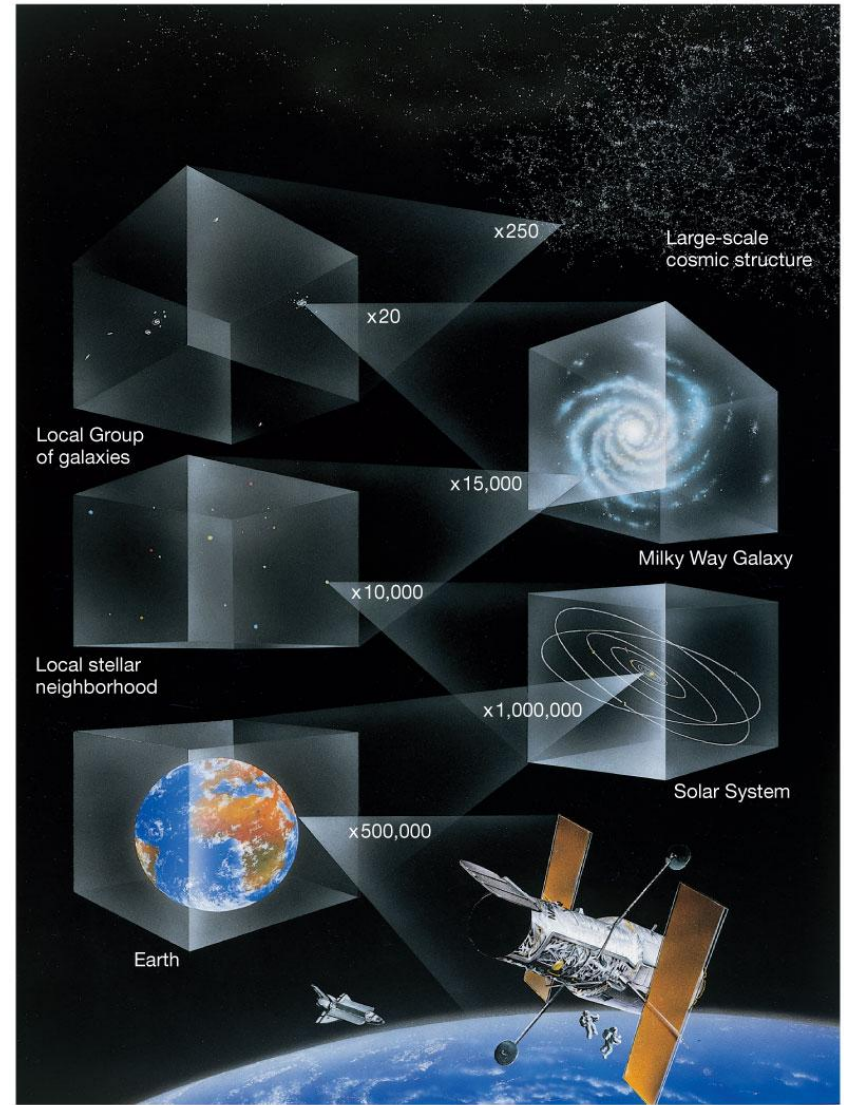
• **Earth** is average—we don't occupy any special place in the universe

• **Universe**: totality of all space, time, matter, and energy

15,000 kilometers

1.1 Our Place in Space

- **Astronomy**: study of the universe

- **Scales** are very large: measure in light-years, the distance light travels in a year—about 10 trillion miles
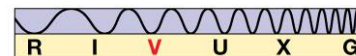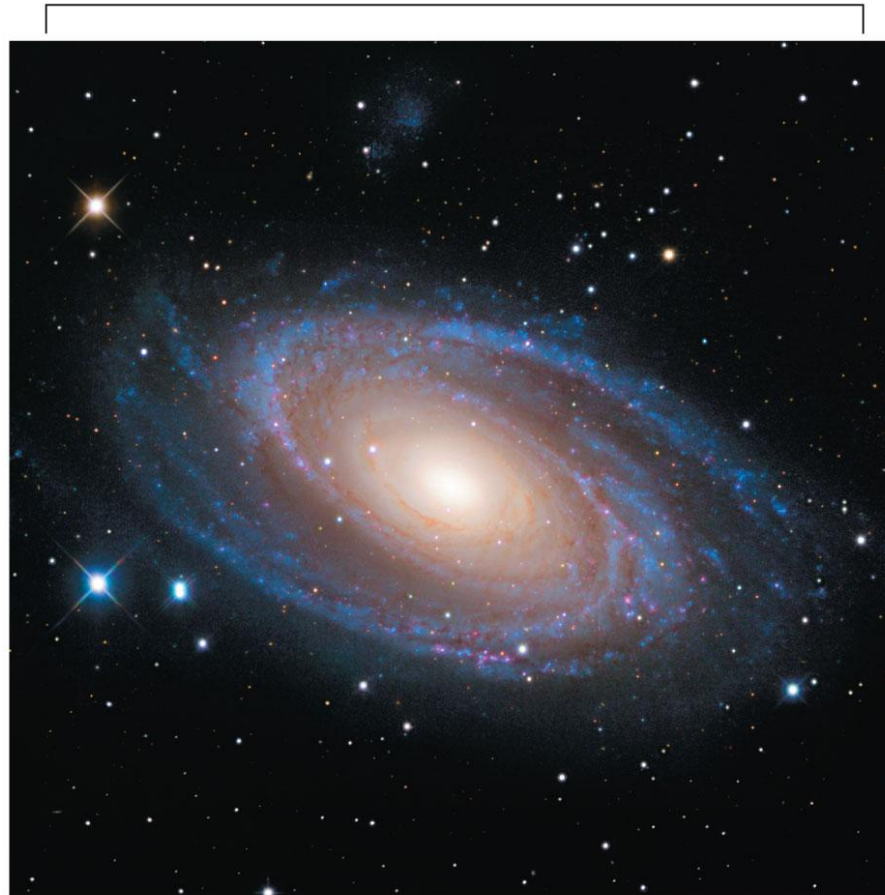
1.1 Our Place in Space

- **This galaxy is about 100,000 light-years across.**

About 1000 quadrillion kilometers, or 100,000 light-years

R I V U X G

© 2011 Pearson Education, Inc.

1.2 Scientific Theory and the Scientific Method

Scientific theories:

- **Must be testable**

- **Must be continually tested**

- **Should be simple**

- **Should be elegant**

Scientific theories can be proven wrong, but they can never be proven right with 100 percent certainty.

1.2 Scientific Theory and the Scientific Method

• **Observation** leads to theory explaining it.

• **Theory** leads to predictions consistent with previous observations.

Observation

Theory

Prediction

© 2011 Pearson Education, Inc.

• **Predictions** of new phenomena are observed. If the observations agree with the prediction, more predictions can be made. If not, a new theory should be made.
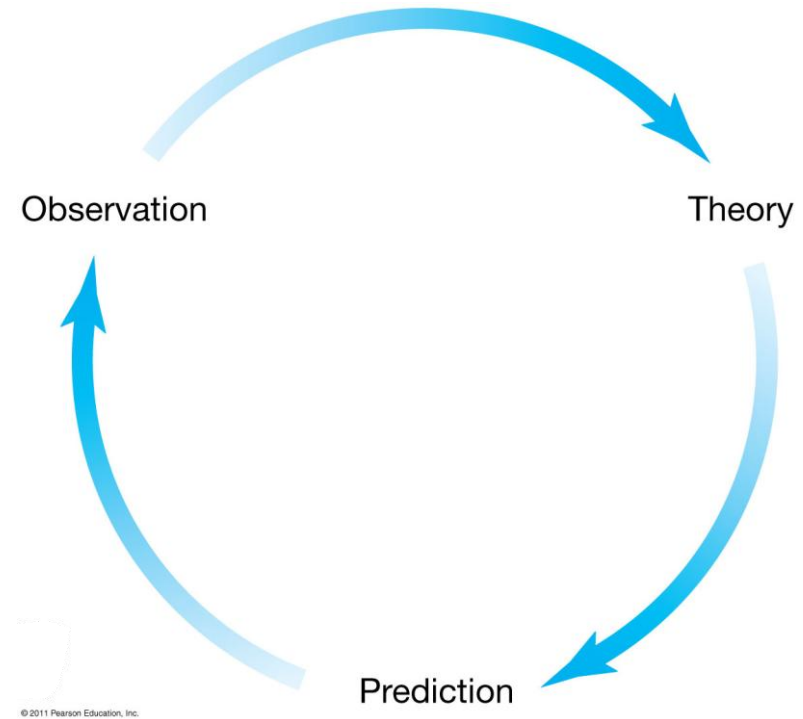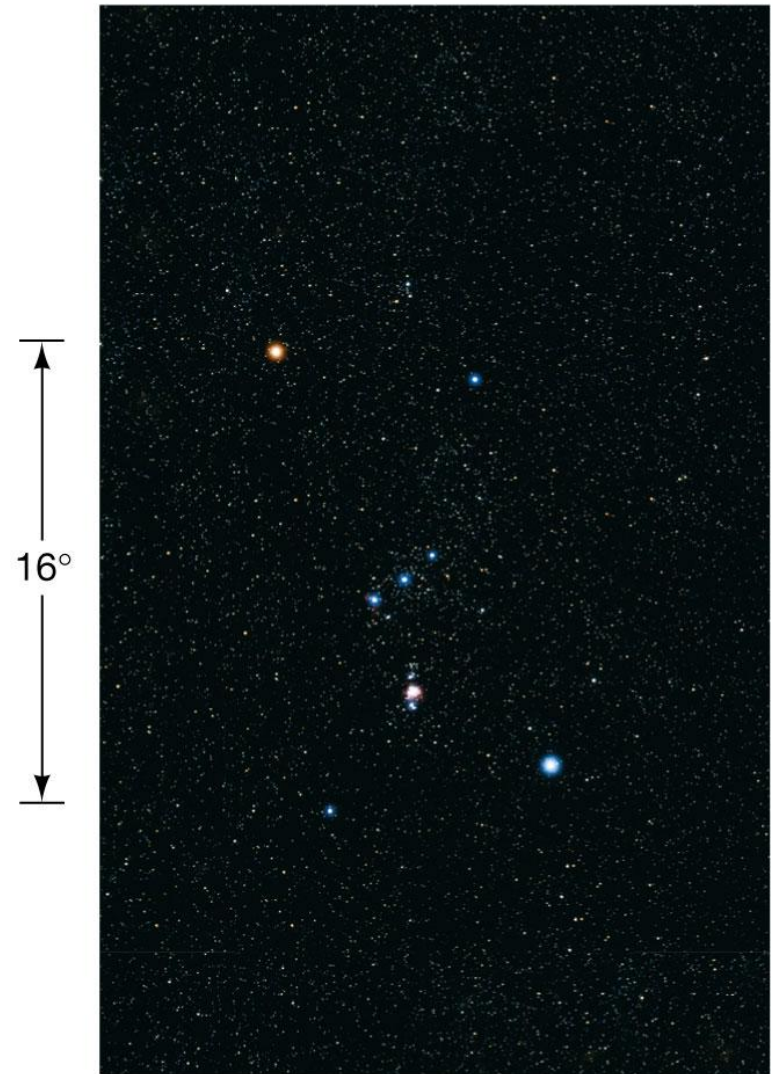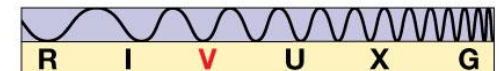
1.3 The "Obvious" View

**Simplest observation:
Look at the night sky**

**About 3000 stars visible
at any one time;
distributed randomly
but human brain tends
to find patterns**

16°

(a)

R   I   V   U   X   G

© 2011 Pearson Education, Inc.

1.3 The "Obvious" View

Group stars into constellations: Figures having meaning to those doing the grouping

Useful: Polaris, which is almost due north

Useless: Astrology, which makes predictions about individuals based on the star patterns at their birth
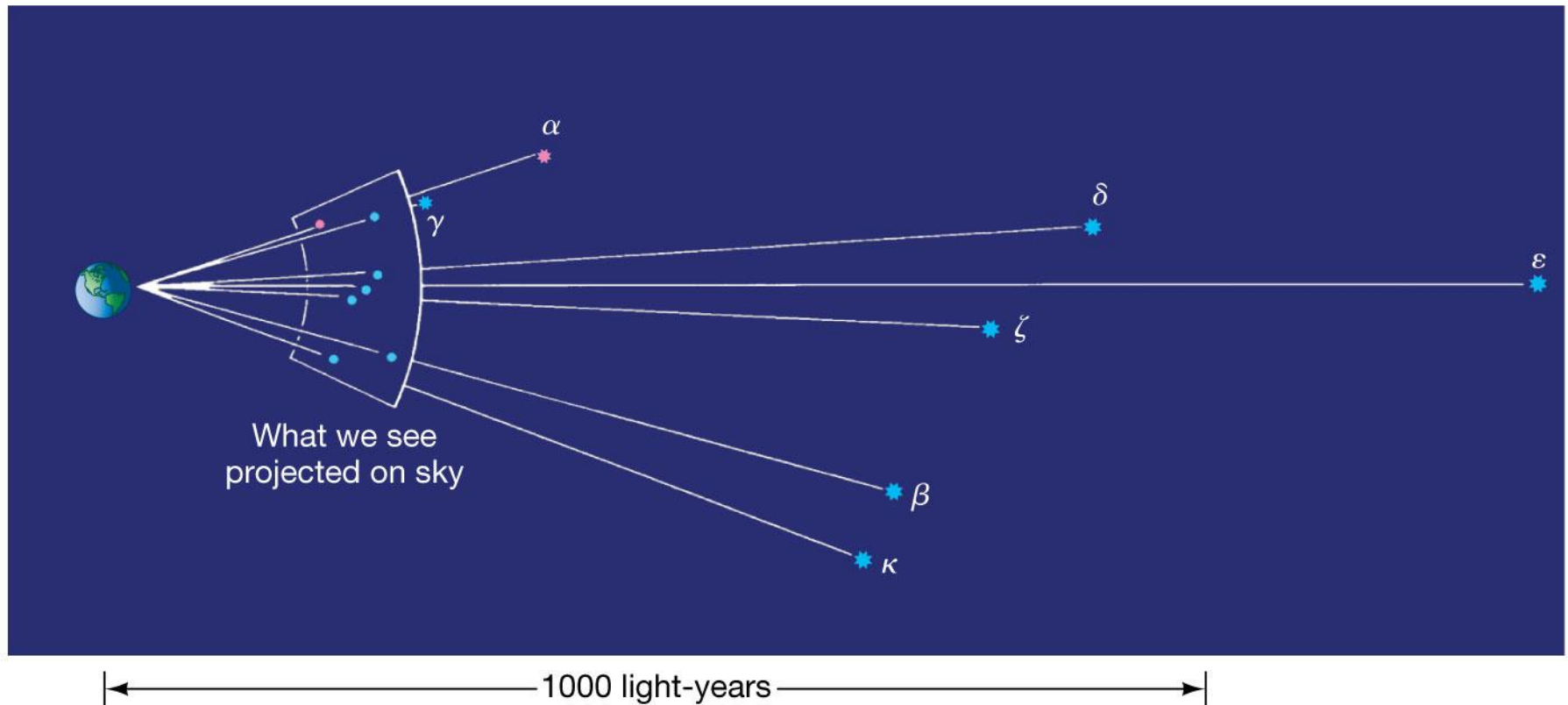

(b)

1.3 The "Obvious" View

Stars that appear close in the sky may not actually be close in space

1.3 The "Obvious" View
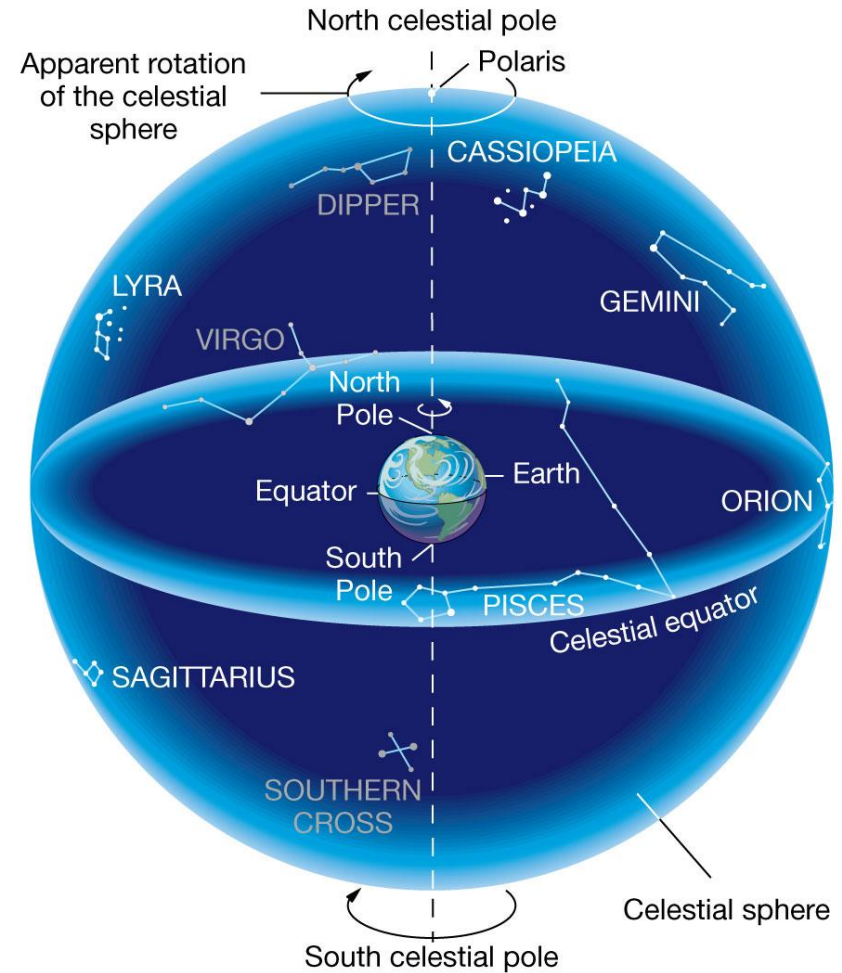
The celestial sphere:

Stars *seem* to be on the inner surface of a sphere surrounding the Earth

They aren't, but can use two-dimensional spherical coordinates (similar to latitude and longitude) to locate sky objects

More Precisely 1-1: Angular Measure

- **Full circle contains 360° (degrees)**

- **Each degree contains 60′ (arc-minutes)**

- **Each arc-minute contains 60″ (arc-seconds)**

- **Angular size of an object depends on its actual size and distance from viewer**

1° = 60'

1 arc minute

1 arc degree

360 arc degrees in a full circle
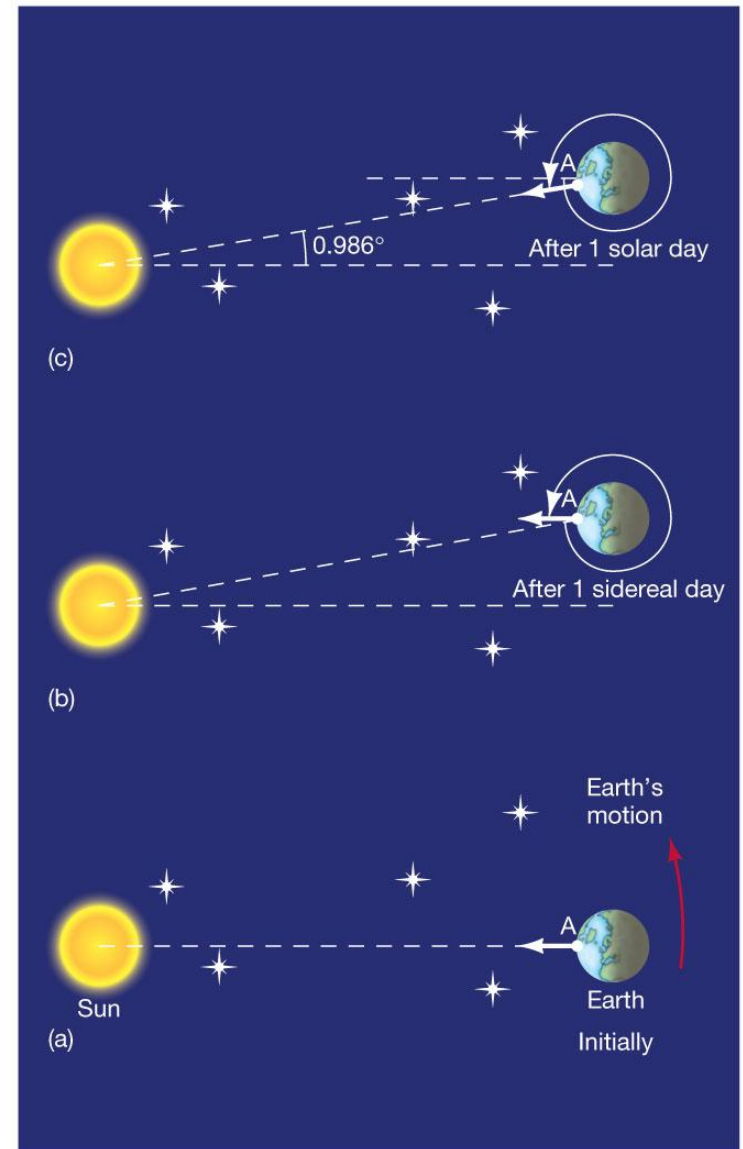
1 arc second

1' = 60"
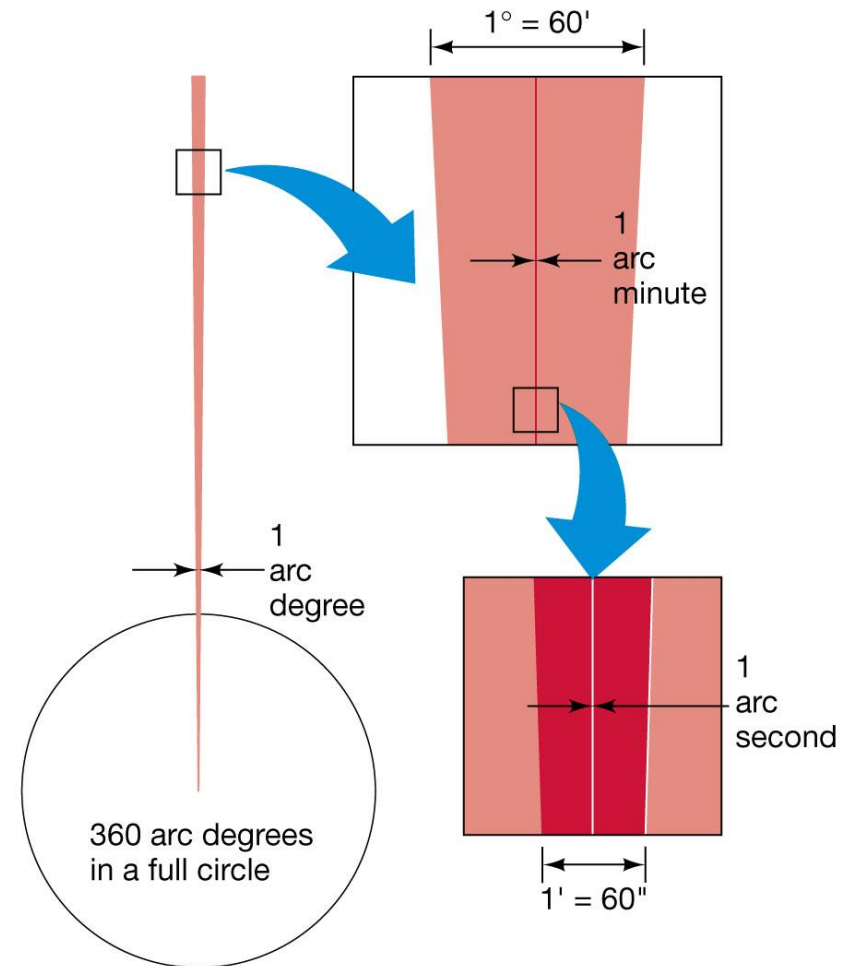
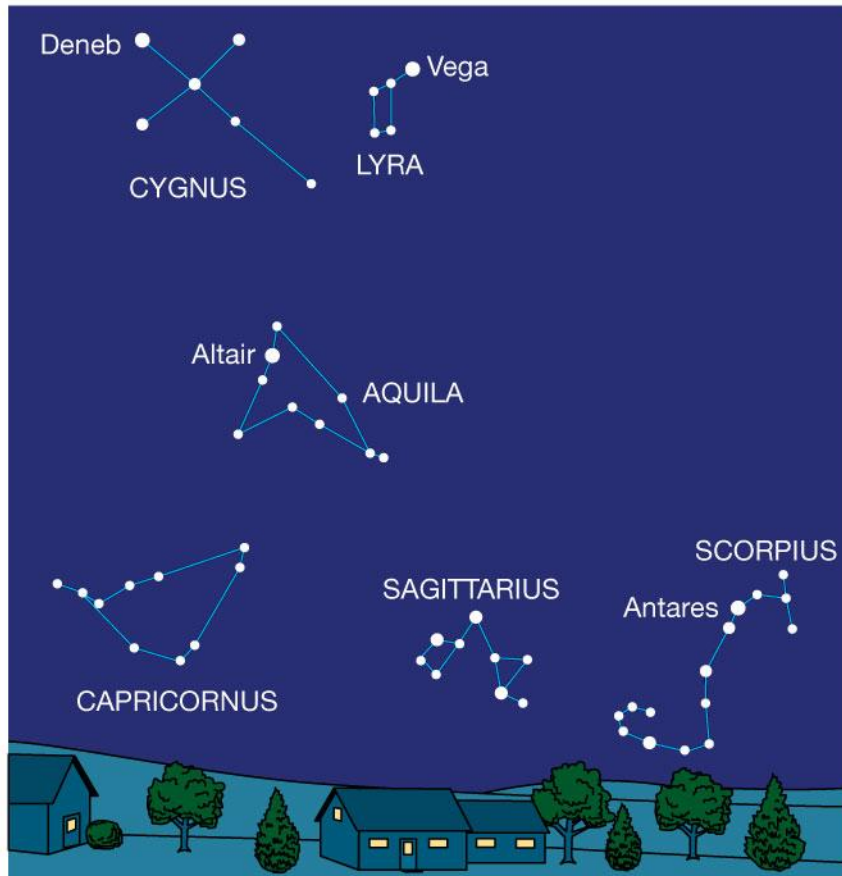© 2011 Pearson Education, Inc.

1.4 Earth's Orbital Motion

• **Daily cycle, noon to noon, is diurnal motion — solar day**

• **Stars aren't in quite the same place 24 hours later, though, due to Earth's rotation around Sun; when they are once again in the same place, one sidereal day has passed**

(c) After 1 solar day — 0.986°

(b) After 1 sidereal day

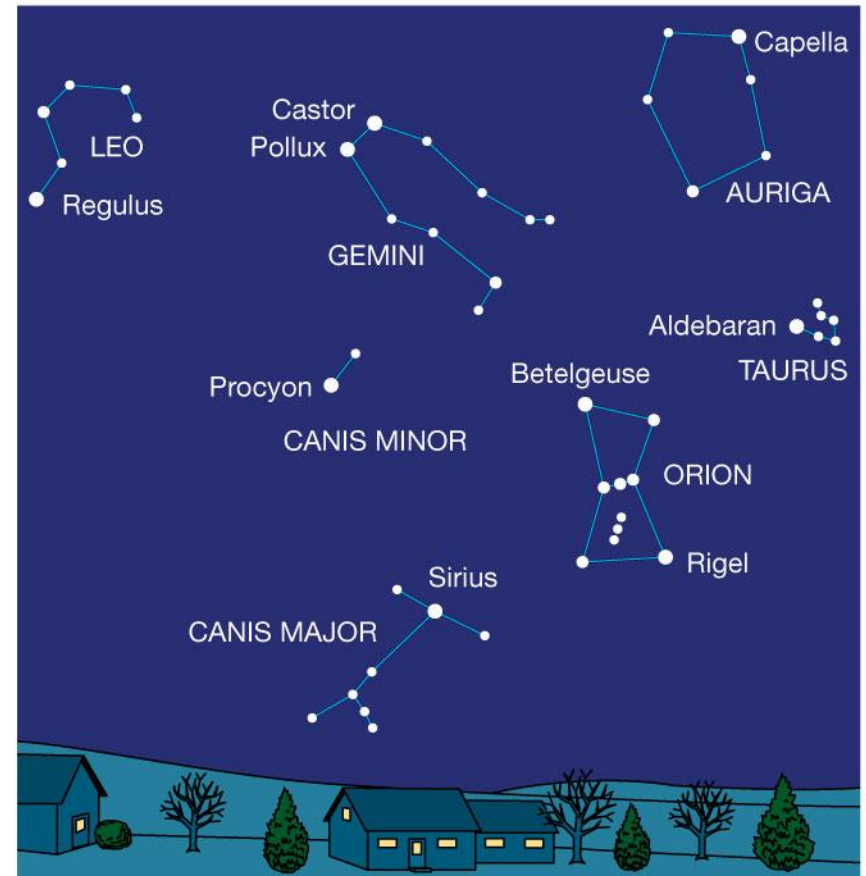(a) Sun — Earth Initially — Earth's motion

© 2011 Pearson Education, Inc.

1.4 Earth's Orbital Motion

Seasonal changes to night sky are due to Earth's motion around Sun

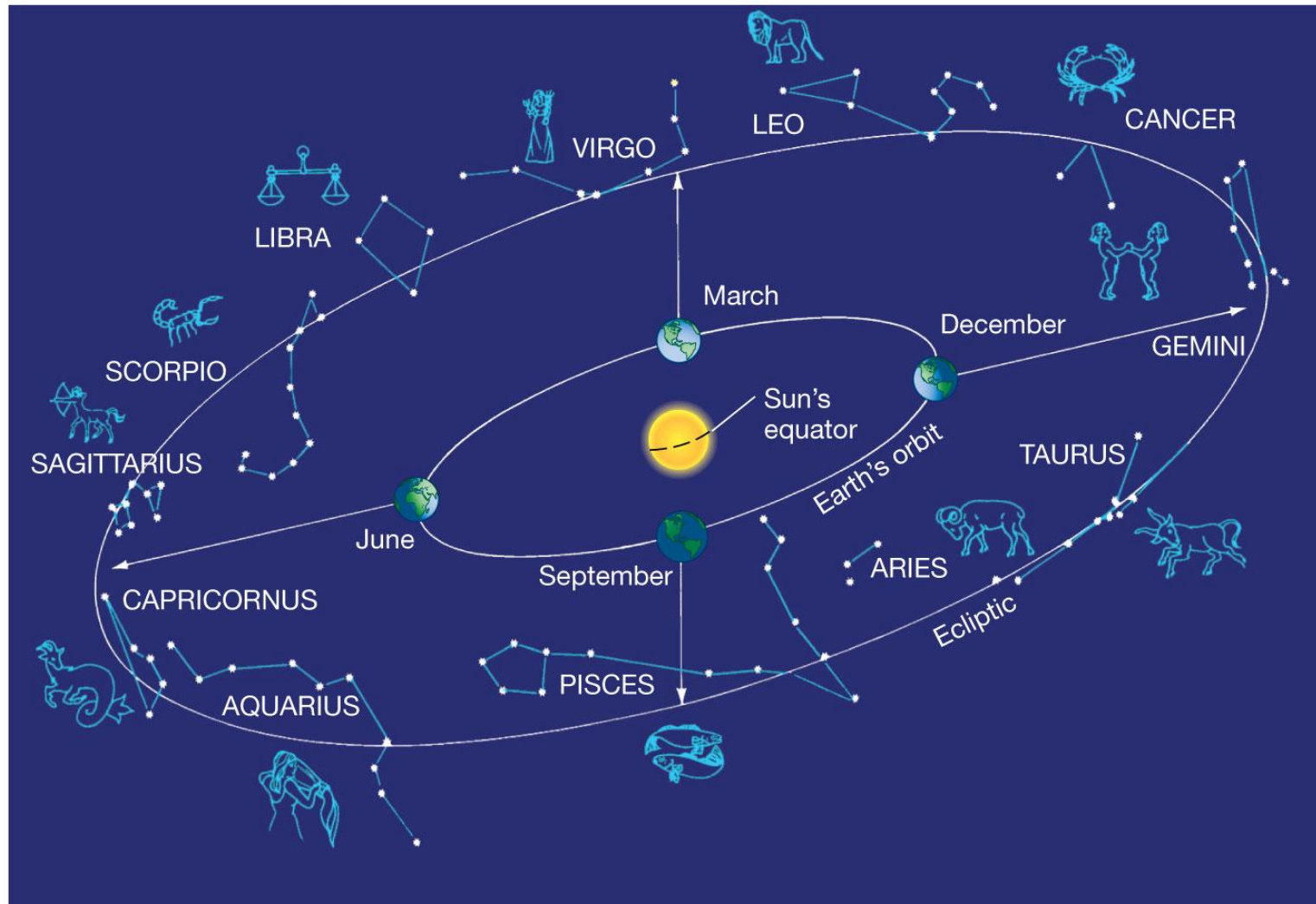(a) Southern horizon, summer

(b) Southern horizon, winter

© 2011 Pearson Education, Inc.

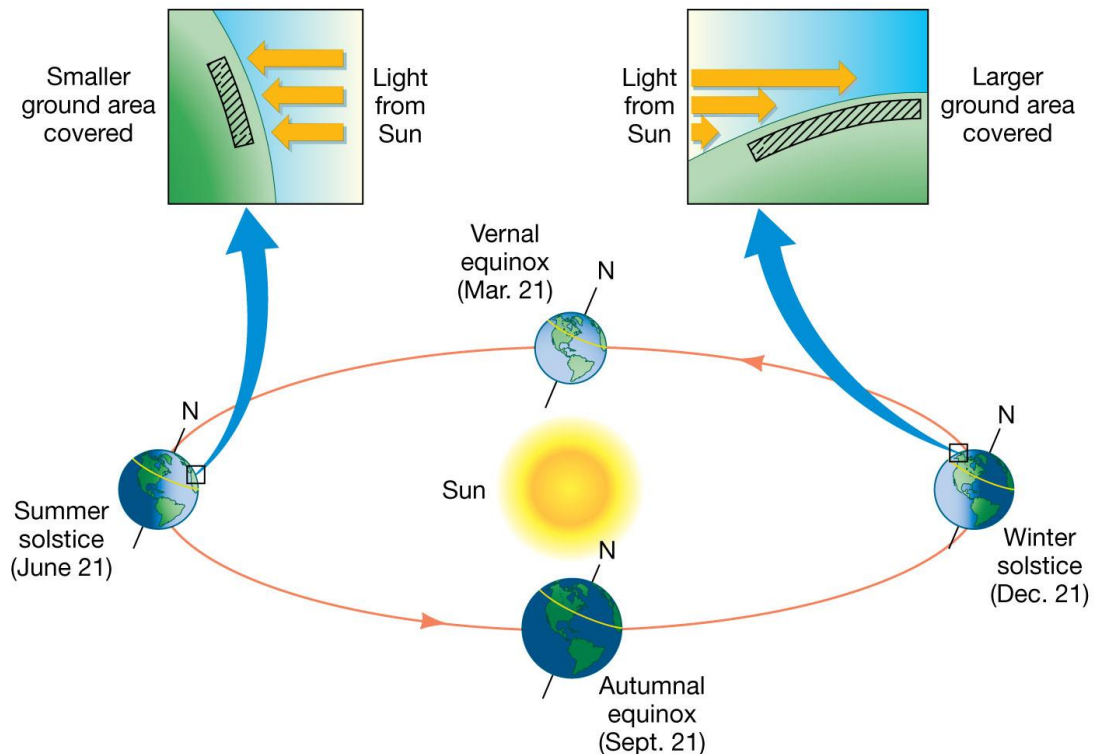© 2011 Pearson Education, Inc.

1.4 Earth's Orbital Motion

Twelve constellations Sun moves through during the year are called the zodiac; path is ecliptic
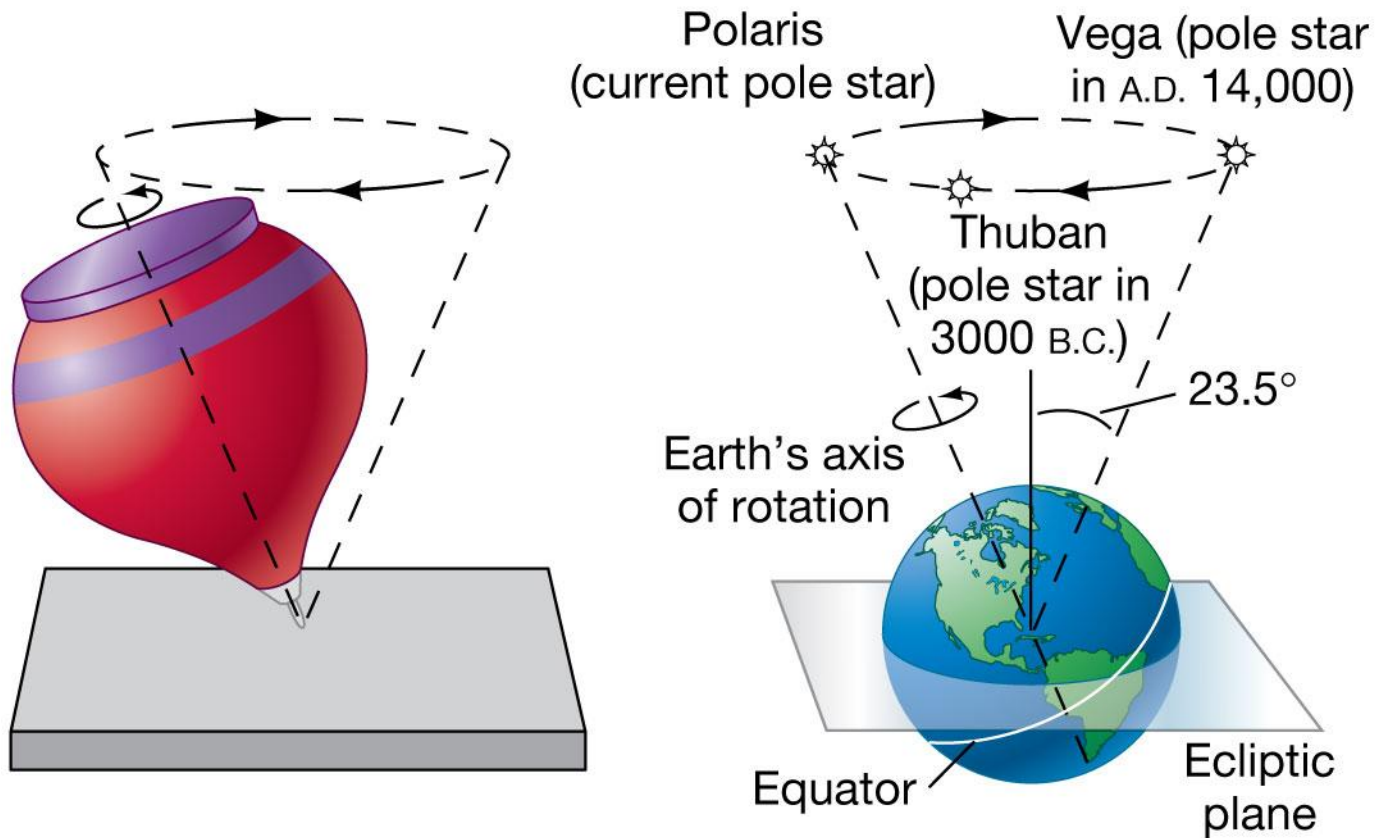
1.4 Earth's Orbital Motion

• **Ecliptic** is plane of Earth's path around Sun; at 23.5° to celestial equator

• Northernmost point of path (above celestial equator) is **summer solstice**; southernmost is **winter solstice**; points where path crosses celestial equator are **vernal** and **autumnal equinoxes**

• Combination of day length and sunlight angle gives seasons

• Time from one vernal equinox to next is **tropical year**

Smaller ground area covered — Light from Sun

Light from Sun — Larger ground area covered

Vernal equinox (Mar. 21)

Summer solstice (June 21)

Sun

Winter solstice (Dec. 21)

Autumnal equinox (Sept. 21)

© 2011 Pearson Education, Inc.

1.4 Earth's Orbital Motion

Precession: rotation of Earth's axis itself; makes one complete circle in about 26,000 years

© 2011 Pearson Education, Inc.

1.4 Earth's Orbital Motion

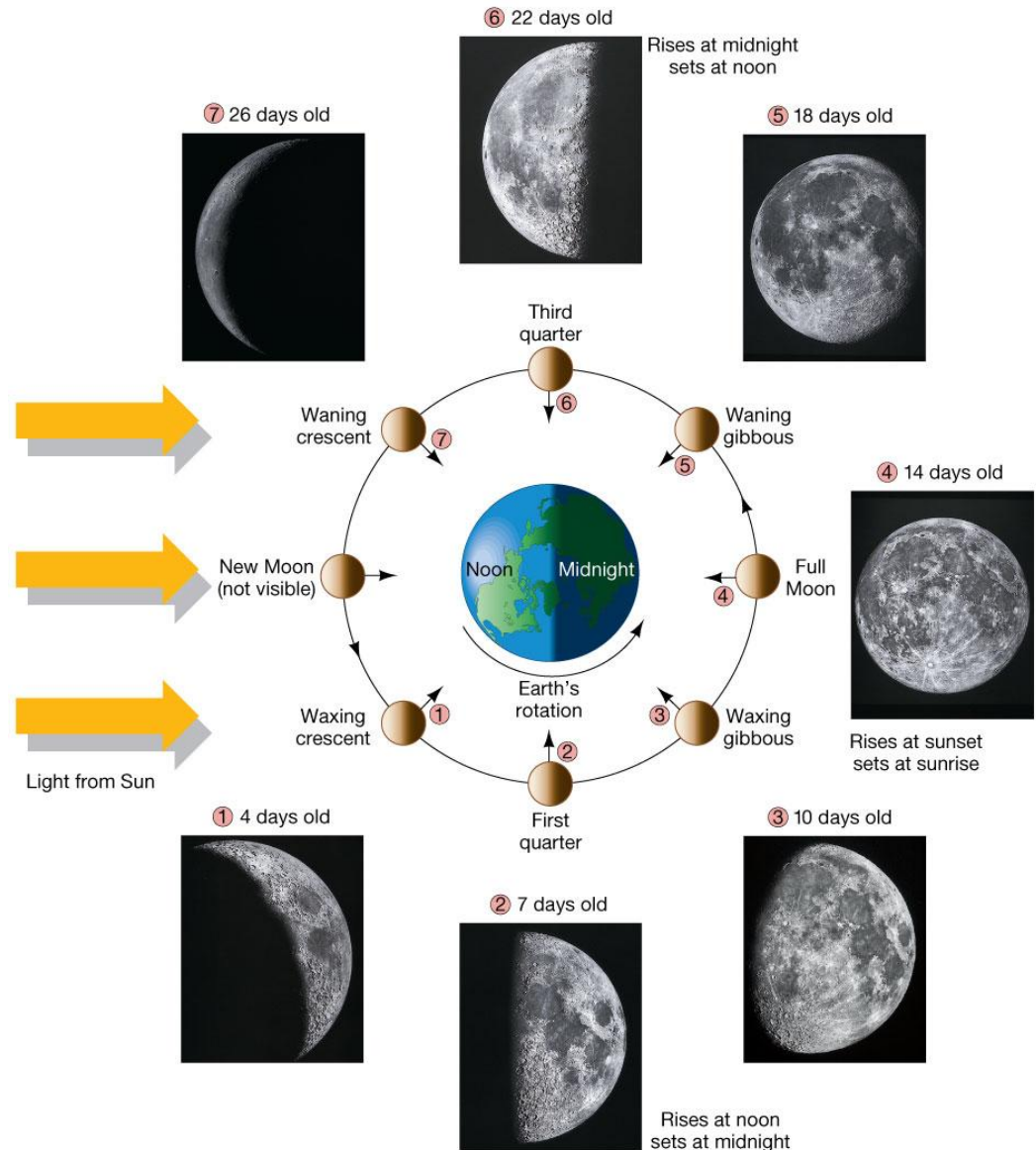Time for Earth to orbit once around Sun, relative to fixed stars, is **sidereal year**

Tropical year follows seasons; sidereal year follows constellations—in 13,000 years July and August will still be summer, but Orion will be a summer constellation

1.5 Motion of the Moon

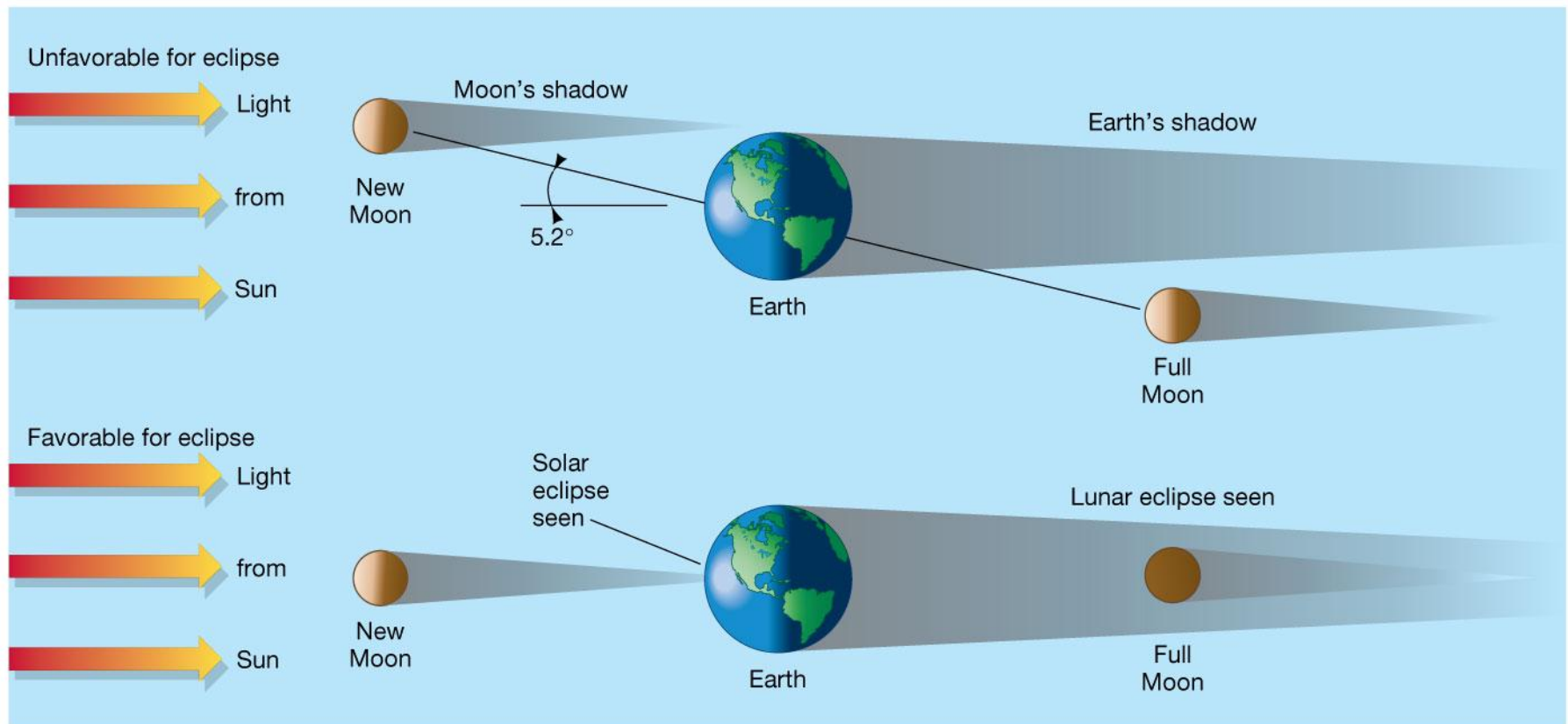**Moon takes about 29.5 days to go through whole cycle of phases—synodic month**

Phases are due to different amounts of sunlit portion being visible from Earth

Time to make full 360° rotation around Earth, sidereal month, is about 2 days shorter

1.5 Motion of the Moon

**Eclipses** occur when Earth, Moon, and Sun form a straight line

Unfavorable for eclipse
Light
from
Sun

Moon's shadow
New Moon
5.2°
Earth
Earth's shadow
Full Moon

Favorable for eclipse
Light
from
Sun

Solar eclipse seen
New Moon
Earth
Lunar eclipse seen
Full Moon

(a)

© 2011 Pearson Education, Inc.

1.5 Motion of the Moon
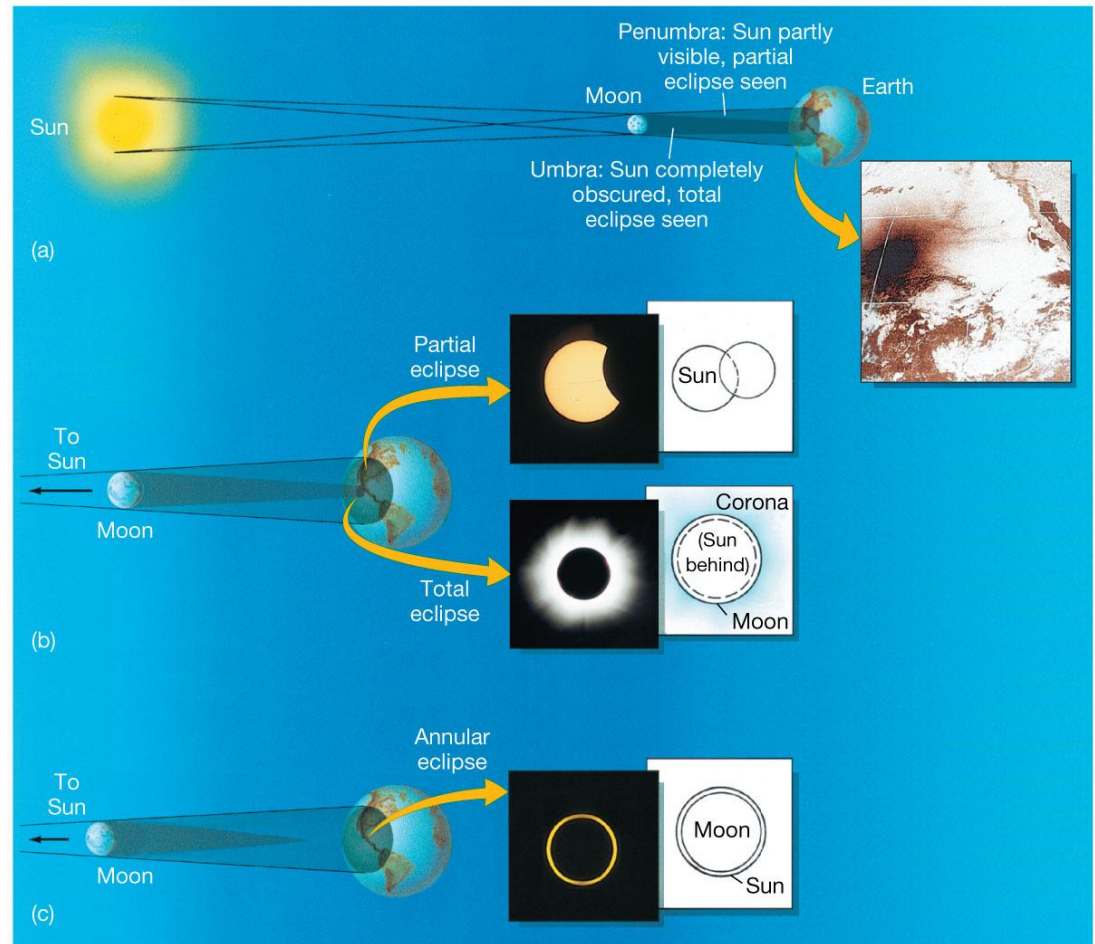
Lunar eclipse:

• **Earth is between Moon and Sun**

• **Partial when only part of Moon is in shadow**

• **Total when it all is in shadow**
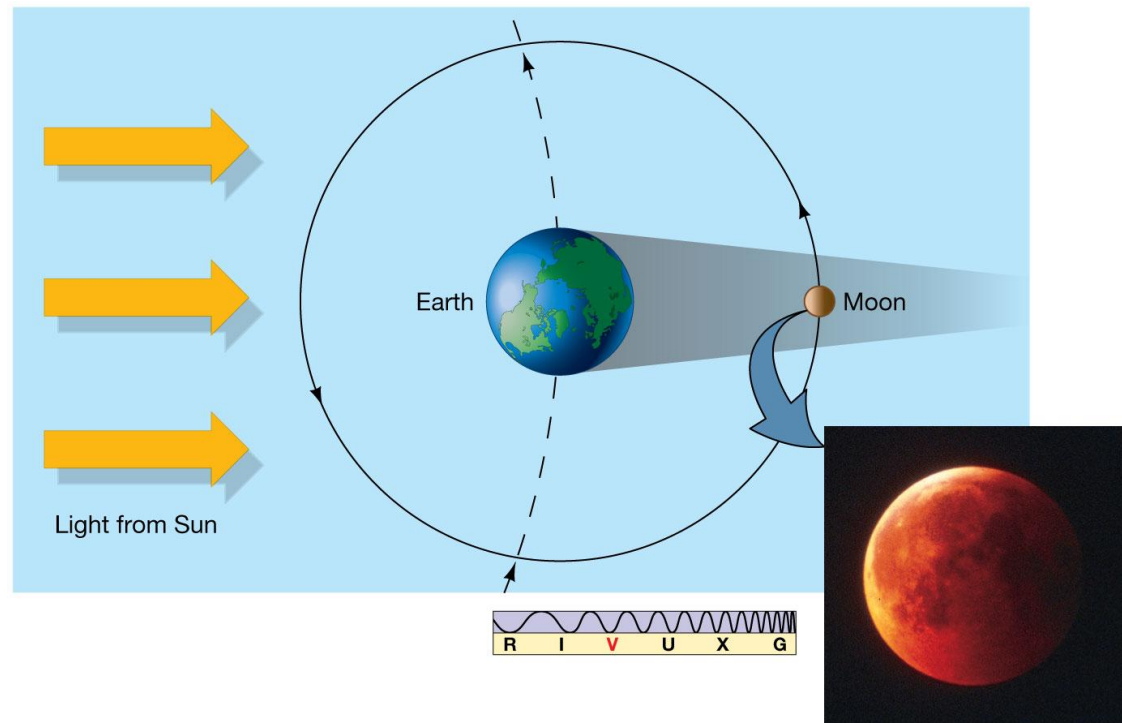
1.5 Motion of the Moon
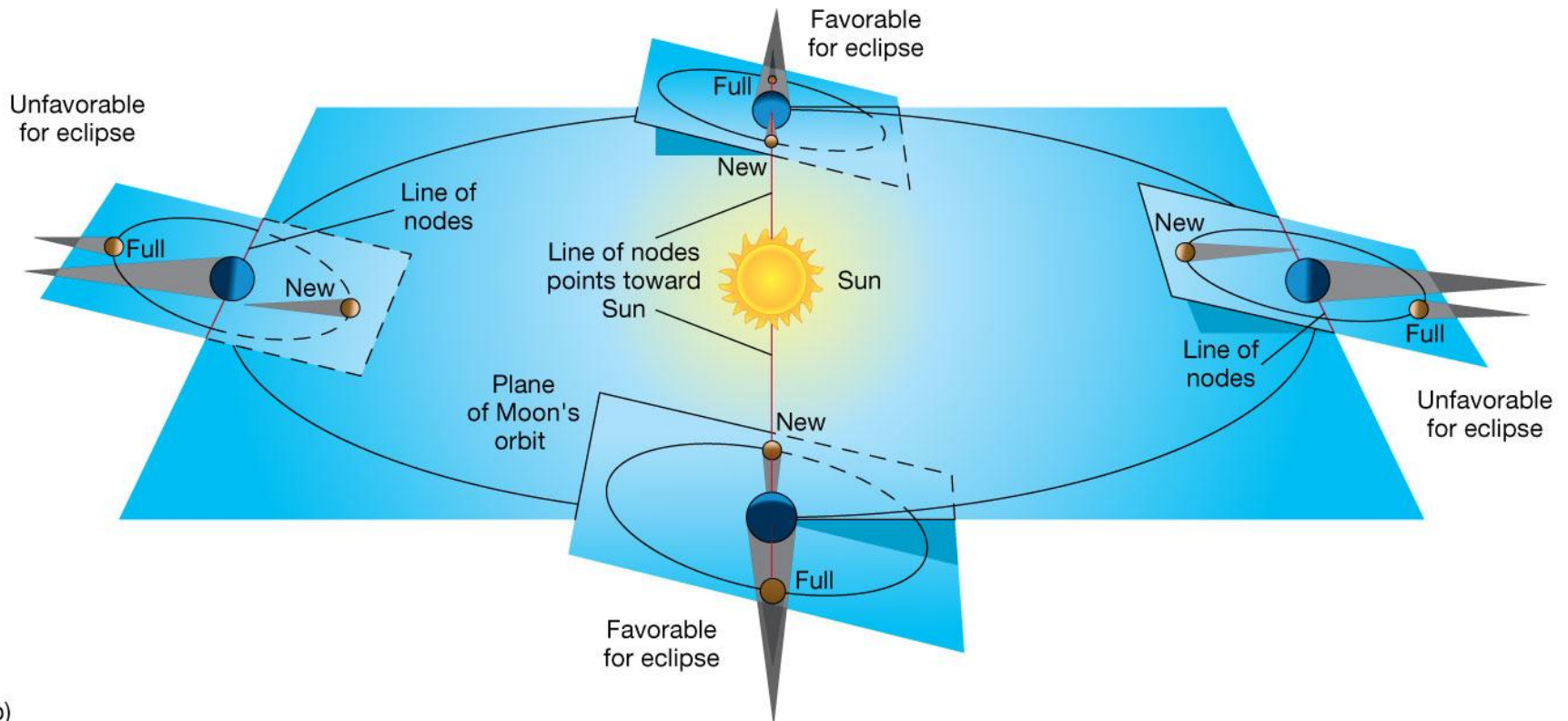
Solar eclipse:
Moon is between Earth and Sun

• Partial when only part of Sun is blocked

• Total when it all is blocked

• Annular when Moon is too far from Earth for total

1.5 Motion of the Moon

Eclipses don't occur every month because Earth's and Moon's orbits are not in the same plane
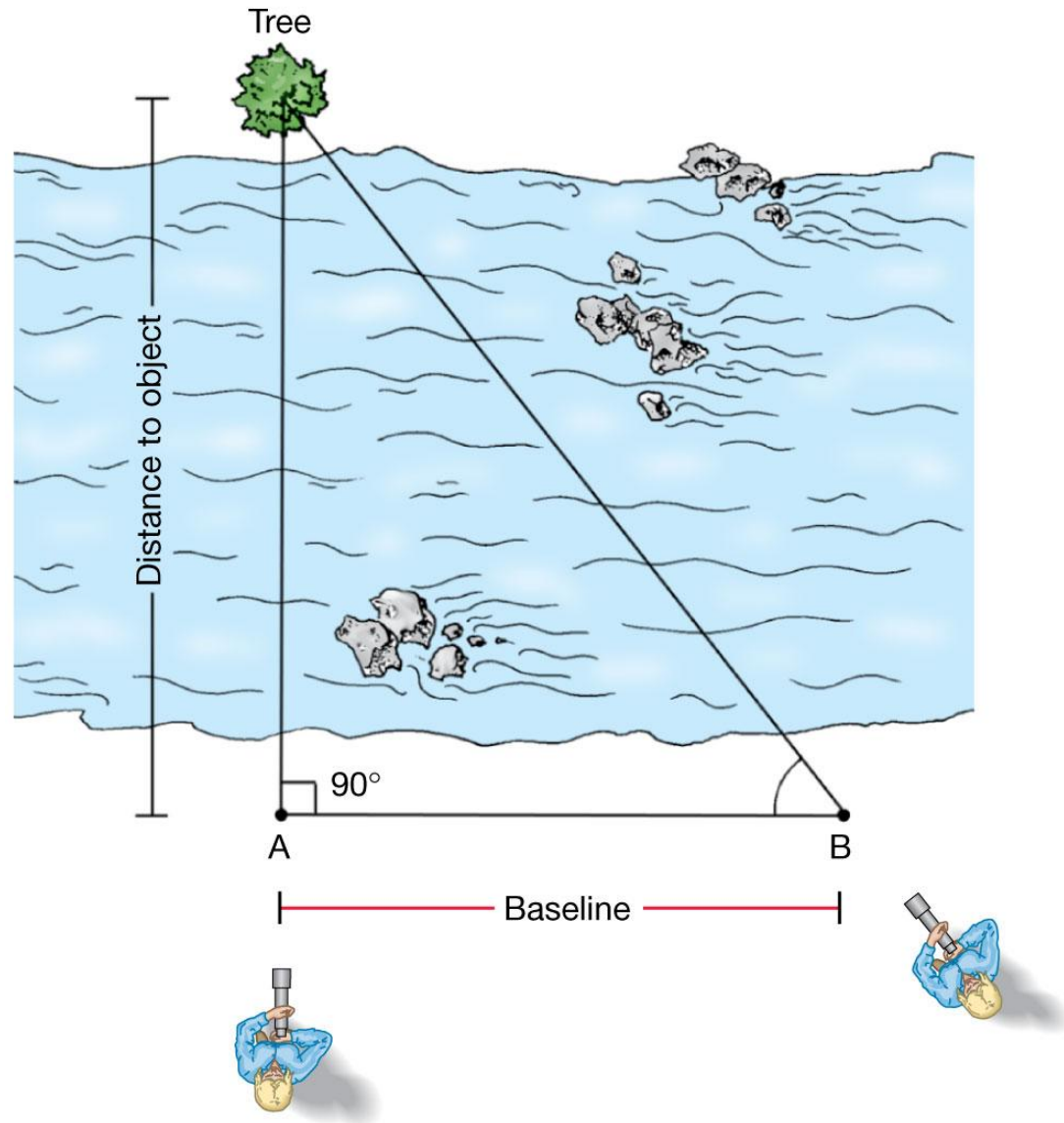
1.6 The Measurement of Distance

Triangulation:
Measure baseline and angles, can calculate distance

Tree

Distance to object

90°

A

B

Baseline

1.6 The Measurement of Distance

Parallax: **Similar to triangulation, but look at apparent motion of object against distant background from two vantage points**
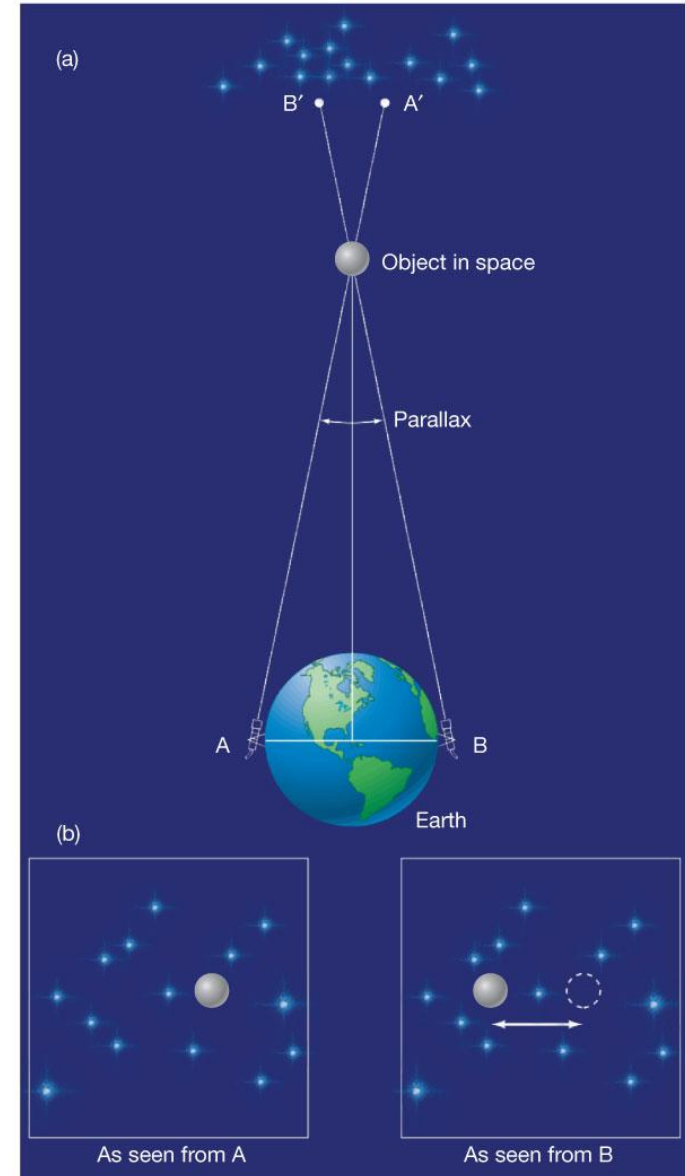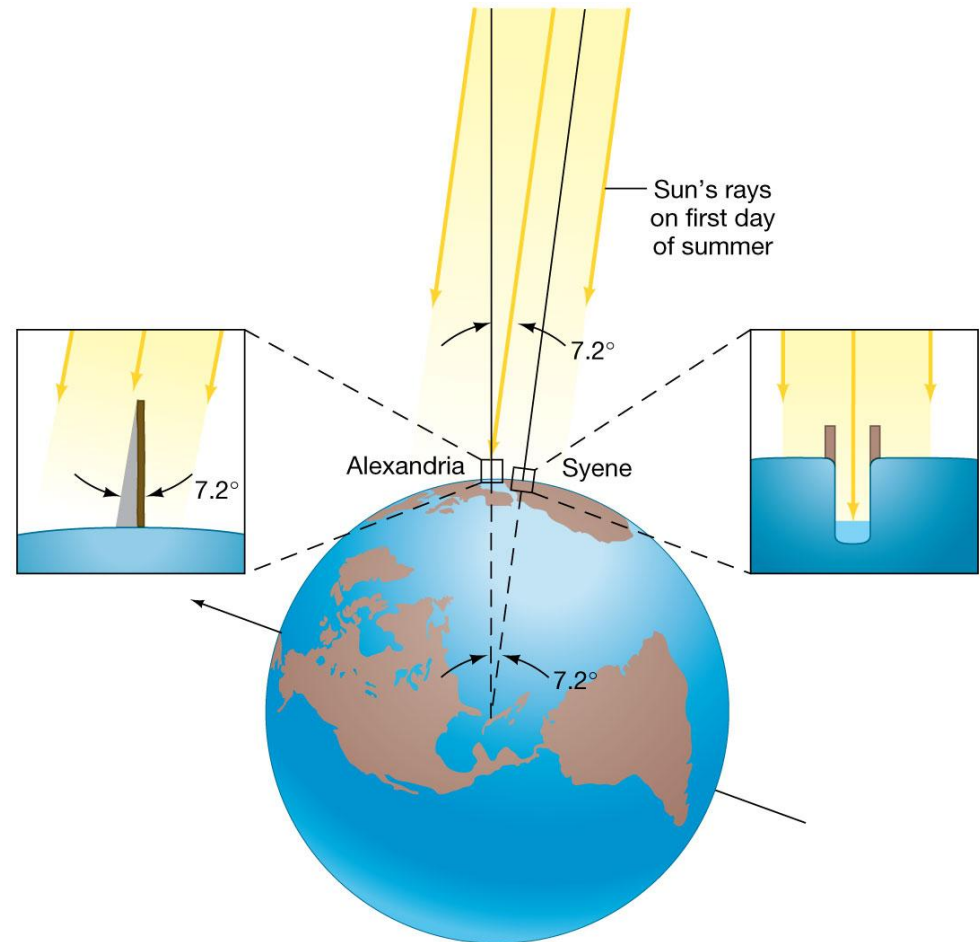
1.6 The Measurement of Distance

Measuring Earth's radius:
Done by Eratosthenes about 2300 years ago; noticed that when Sun was directly overhead in one city, it was at an angle in another.
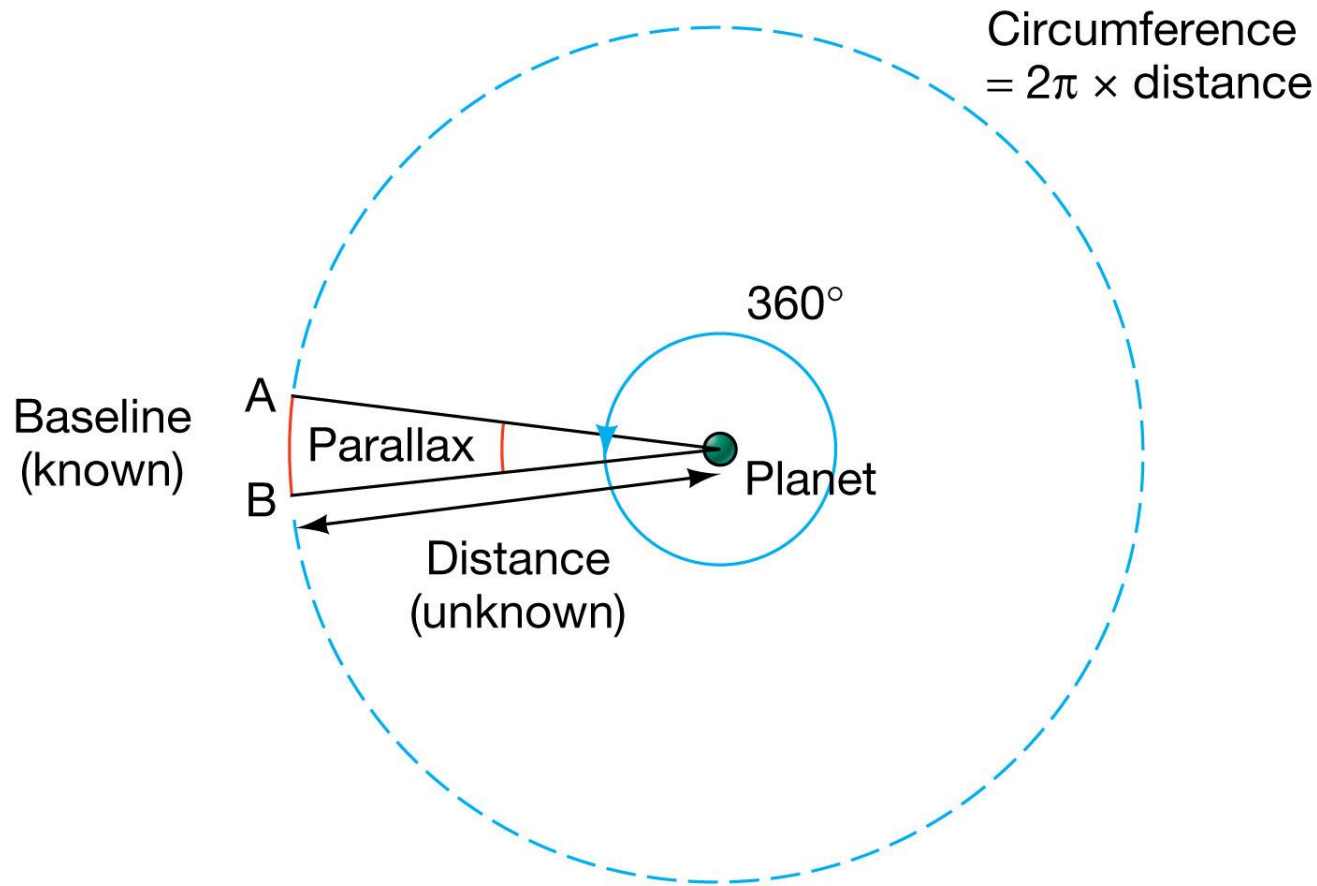
Measuring that angle and the distance between the cities gives the radius.

More Precisely 1-2:

Measuring Distances with Geometry

Converting baselines and parallaxes into distances
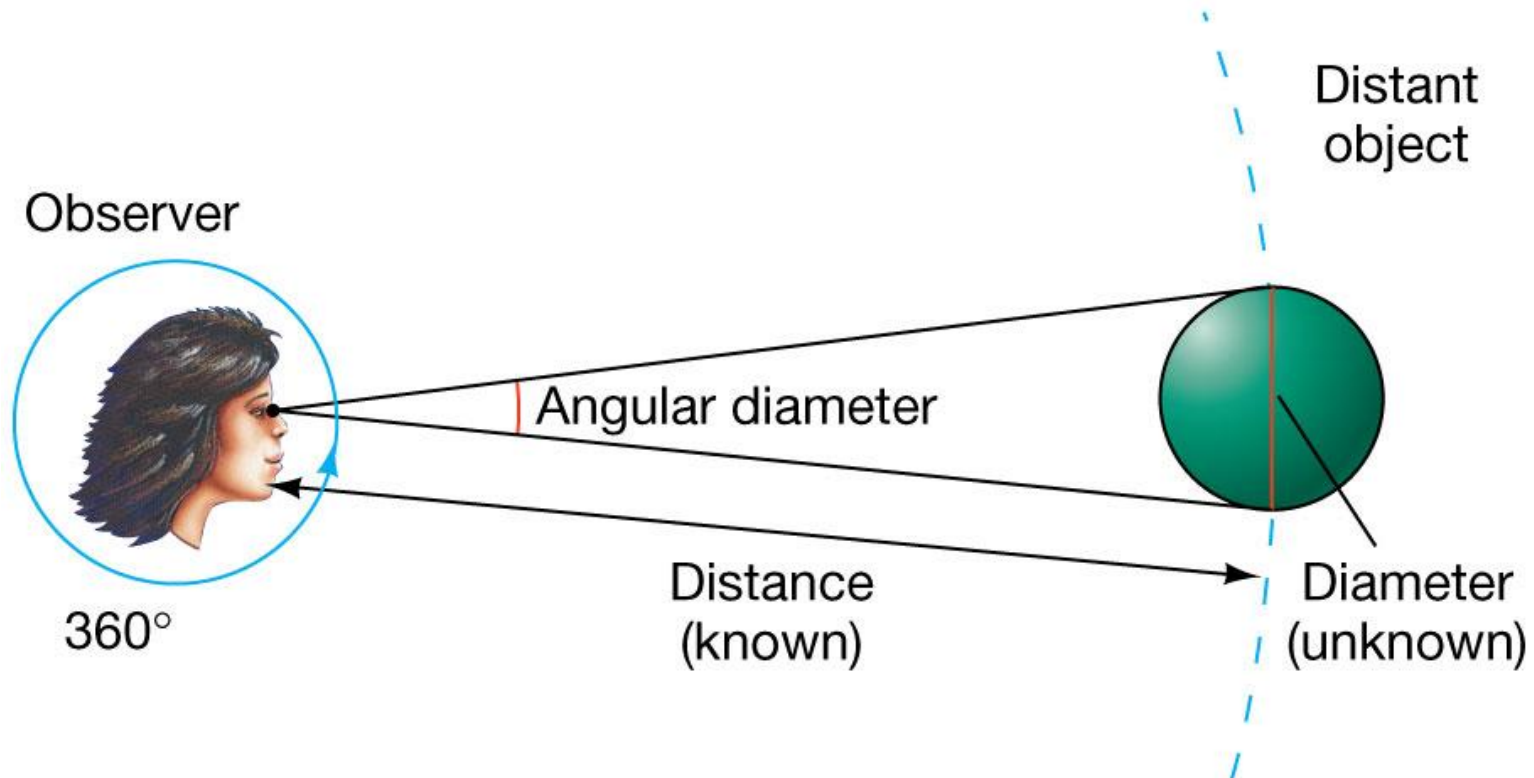

Circumference
= 2π × distance

360°

A

Baseline (known)

Parallax

B

Planet

Distance (unknown)

More Precisely 1-2:

Measuring Distances with Geometry

Converting angular diameter and distance into size

Summary of Chapter 1

- **Astronomy**: Study of the universe

- **Scientific method**: Observation, theory, prediction, observation, …

- Stars can be imagined to be on inside of **celestial sphere**; useful for describing location

- Plane of Earth's orbit around Sun is **ecliptic**; at 23.5° to celestial equator

- Angle of Earth's axis causes **seasons**

- Moon shines by reflected light, has **phases**

Summary of Chapter 1 (cont.)

- **Solar day ≠ sidereal day**, due to Earth's rotation around Sun

- **Synodic month ≠ sidereal month**, also due to Earth's rotation around Sun

- **Tropical year ≠ sidereal year**, due to precession of Earth's axis

- **Eclipses of Sun and Moon** occur due to alignment; only occur occasionally as orbits are not in same plane

- Distances can be measured through **triangulation** and **parallax**