

Lecture 6: September 3, 2010

- What is the probability of being struck by lightning in your lifetime?
- What is the probability of winning a million dollars or more in the lottery?

Announcements:

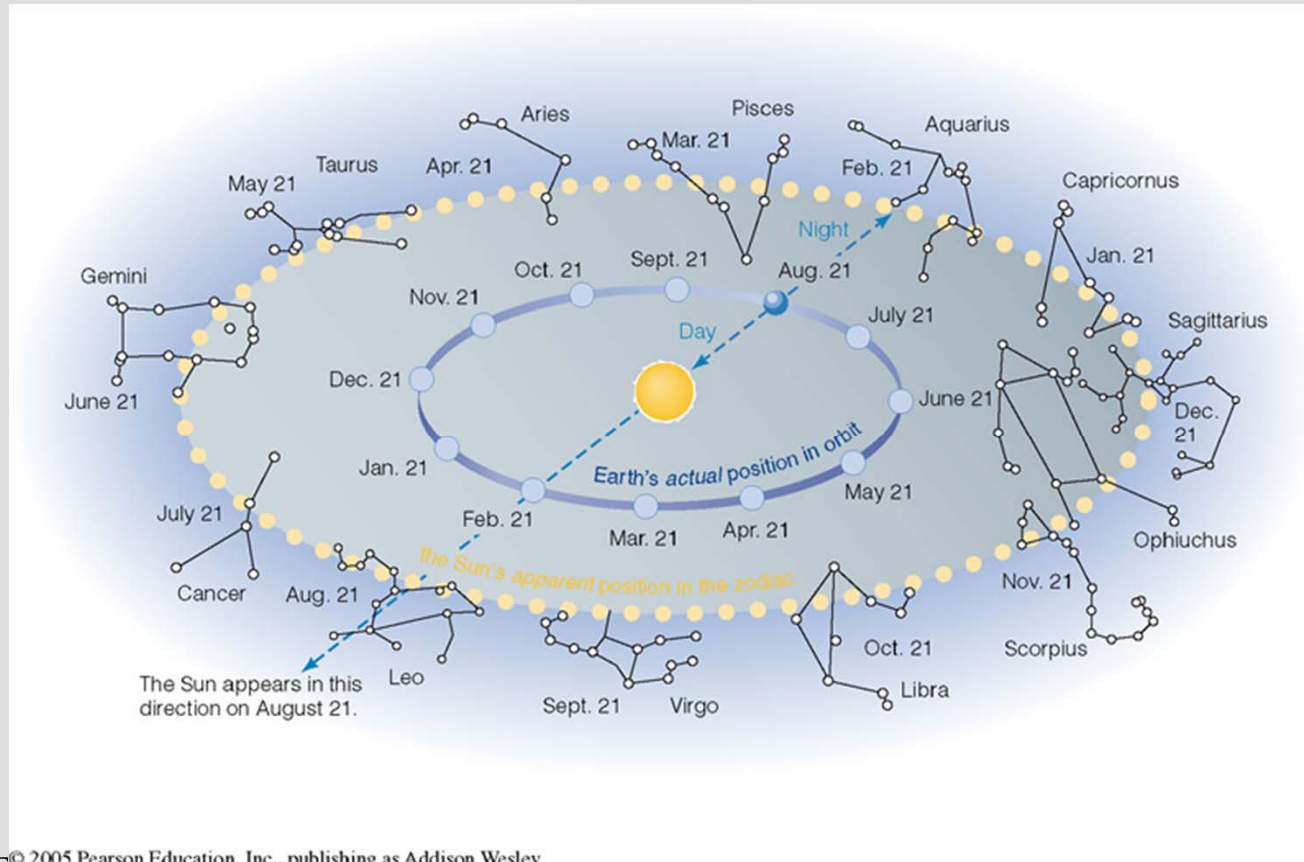
First homework has been posted

Due Next Friday(10th)

Will meet at Fiske Planetarium on Friday, 9/17

Annual Motion (IF 2.14)

- As the Earth orbits the Sun, the Sun appears to move eastward with respect to the stars.
- The Sun circles the celestial sphere once every year.



2.3 Seasons

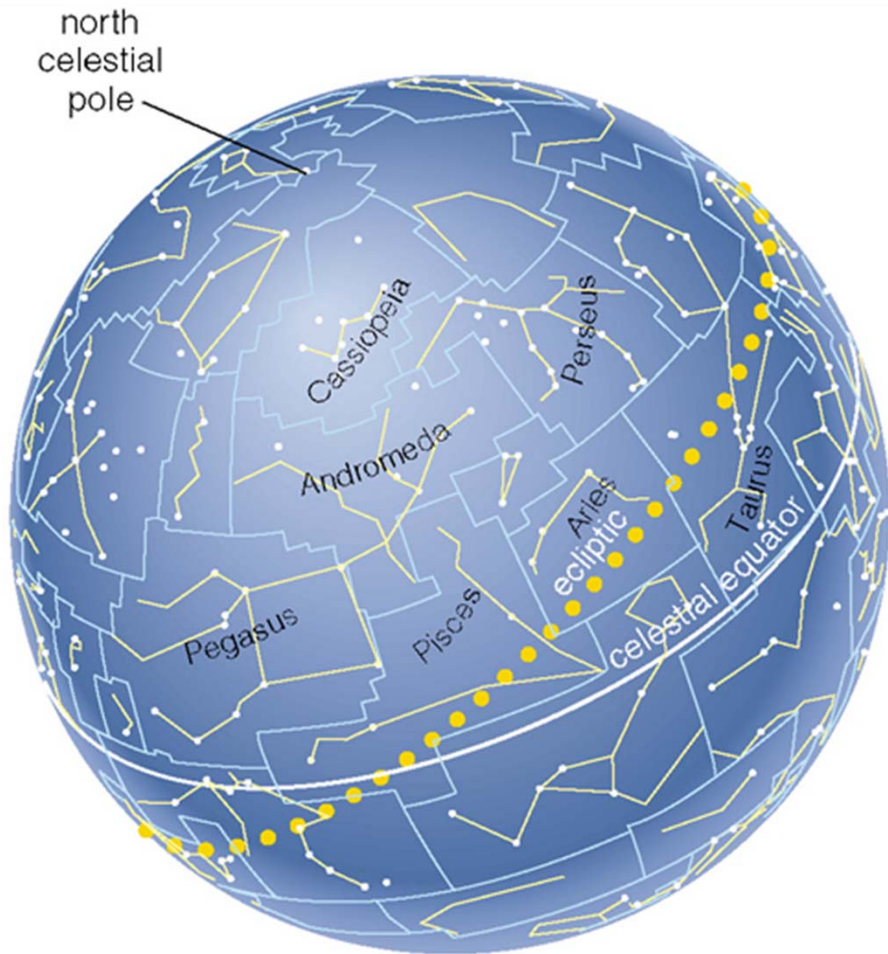
Our goals for learning:

- What is the cause of the seasons on Earth?
- Why are the warmest days typically a month after the beginning of summer?

Annual Motion

- The Earth's axis is tilted 23.5° from being perpendicular to the ecliptic plane.
- Therefore, the celestial equator is tilted 23.5° to the ecliptic.
- As seen from Earth, the Sun spends 6 months north of the celestial equator and 6 months south of the celestial equator.
- **Seasons** are caused by the Earth's axis tilt, *not* the distance from the Earth to the Sun!

Annual Motion



ecliptic

the apparent path of the Sun through the sky

equinox

where the ecliptic intersects the celestial equator

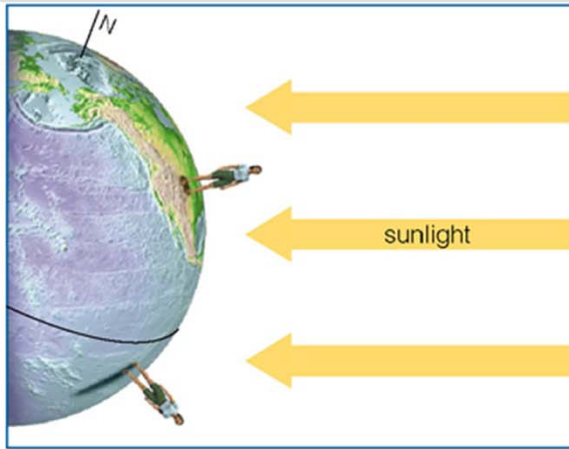
solstice

the ecliptic is farthest from the celestial equator

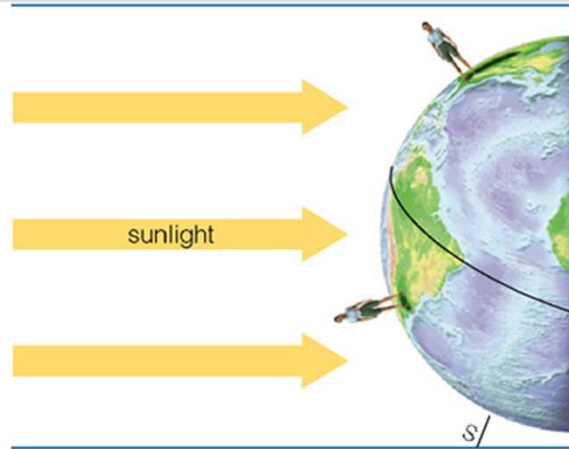
zodiac

the constellations which lie along the ecliptic

The Cause of the Seasons



Summer Solstice: Midday sunlight strikes Earth more directly in the Northern Hemisphere—meaning the Sun is higher in the sky and casts smaller shadows—than in the Southern Hemisphere.



Winter Solstice: The situation is reversed from the summer solstice, with midday sunlight striking the Southern Hemisphere more directly and the Northern Hemisphere less directly.

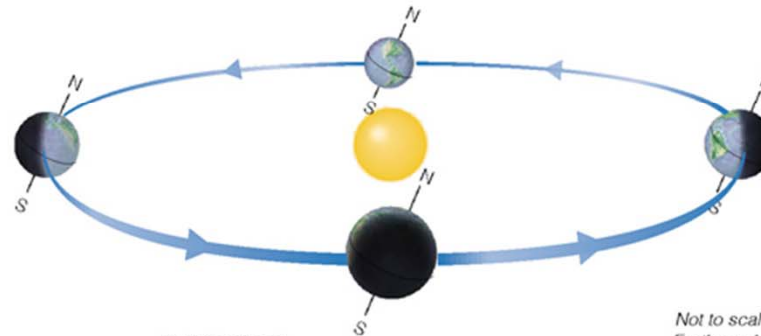
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Spring Equinox

The Sun shines equally on both hemispheres. Northern Hemisphere is entering spring; Southern Hemisphere is entering fall.

Summer Solstice

Northern Hemisphere receives its most direct sunlight of the year (beginning of summer); Southern Hemisphere receives its least direct sunlight (beginning of winter).



Winter Solstice

Northern Hemisphere receives its least direct sunlight of the year (beginning of winter); Southern Hemisphere receives its most direct sunlight (beginning of summer).

Fall Equinox

The Sun shines equally on both hemispheres. Northern Hemisphere is entering fall; Southern Hemisphere is entering spring.

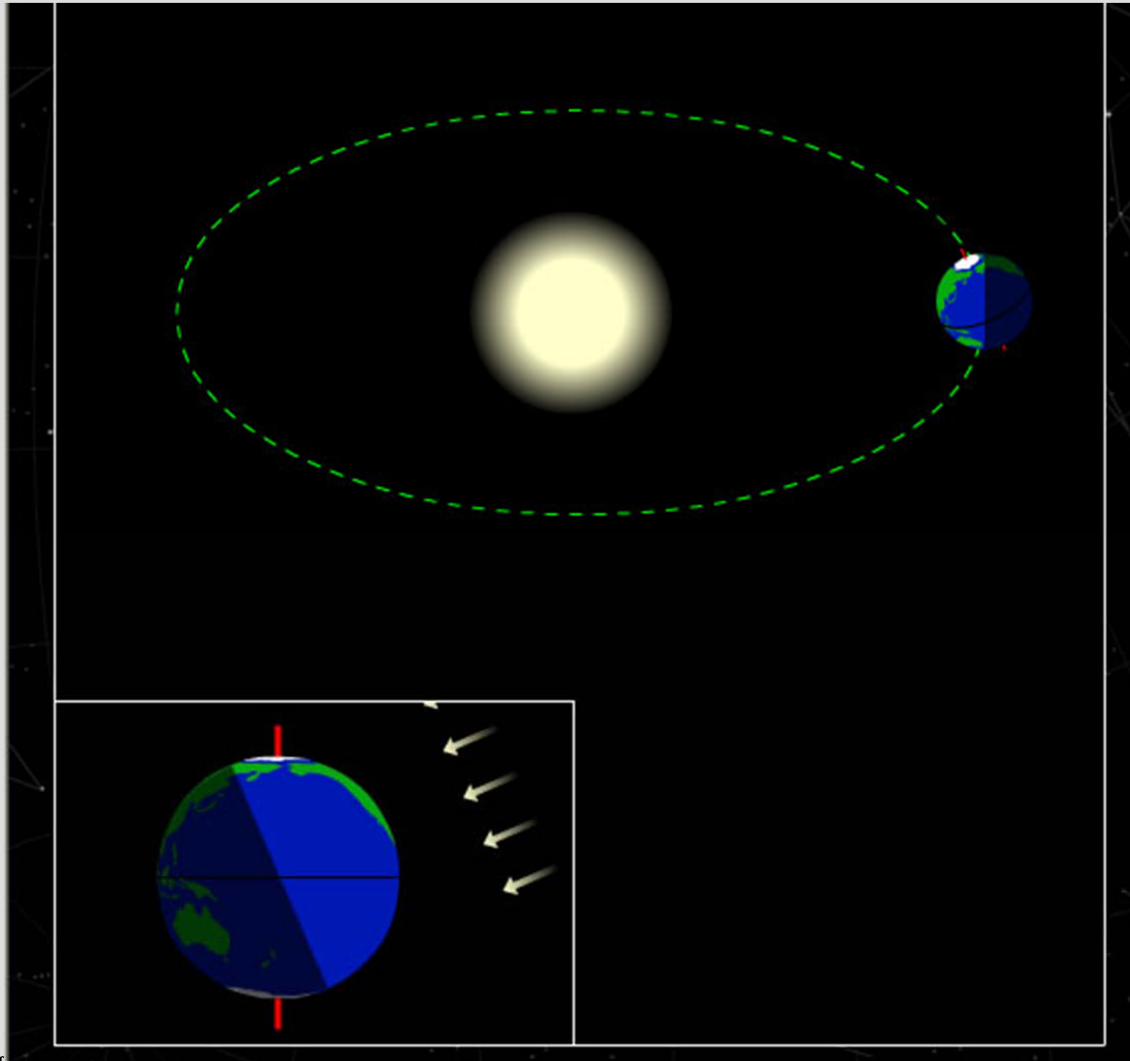
Not to scale! On the scale the orbit is drawn, Earth would be too small to see (and the Sun would be a tiny dot).

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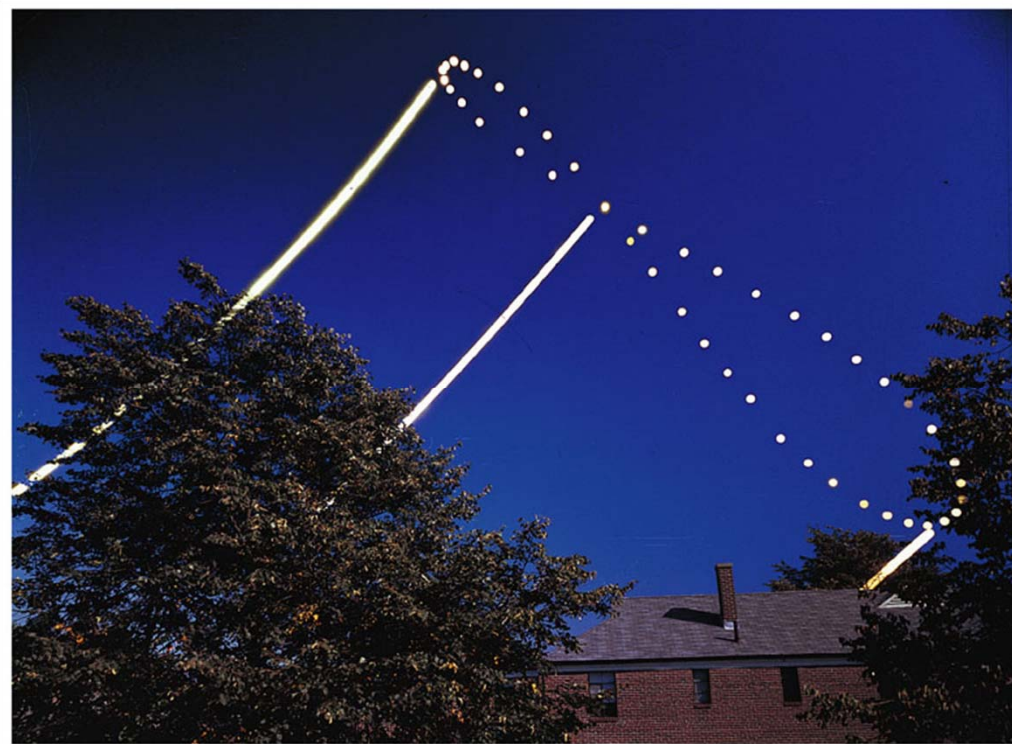
Axis tilt causes uneven heating by sunlight throughout the year.

(IF Why does the flux of sunlight vary?)



Seasonal Change in Sun's Altitude

- The “Figure 8” (analemma) shows Sun at same time each day over a year.



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Seasonal changes are more extreme at high latitudes

Path of the Sun on the summer solstice at the Arctic Circle

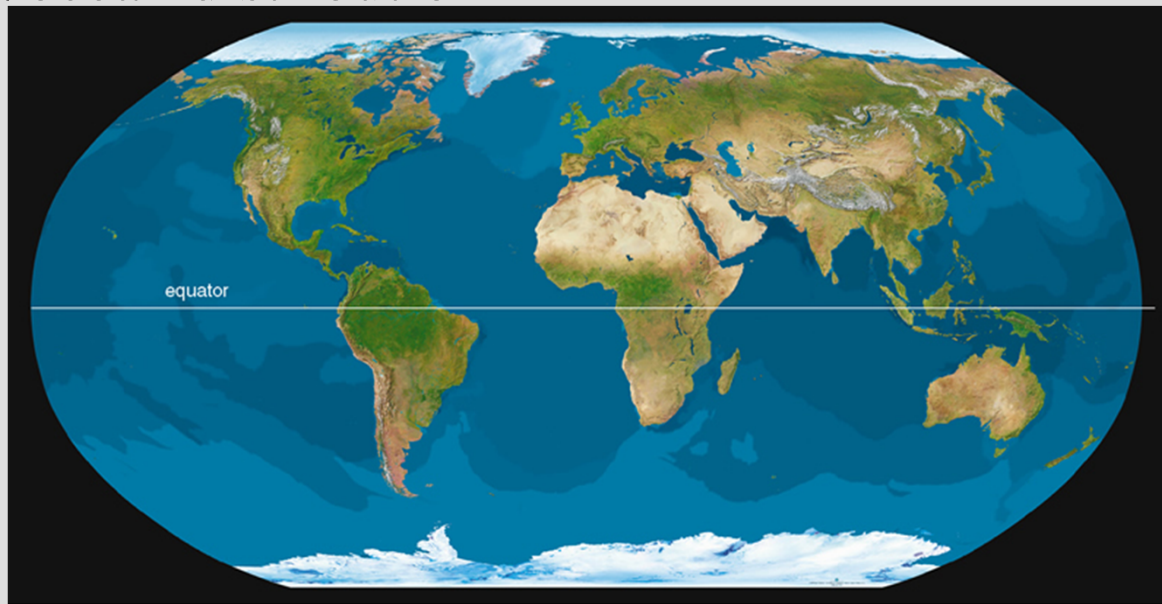


When is summer?

- The solstice, which occurs around June 21, is considered the first day of summer.
- It takes time for the more direct sunlight to heat up the land and water.
- Therefore, July & August are typically hotter than June.

Why doesn't distance matter?

- Small variation for Earth — about 3% (but distance *does* matter for some other planets, notably Mars and Pluto).
- Surprisingly, seasons are more extreme in N. hemisphere, even though Earth is closer to Sun in S. hemisphere summer (and farther in S. hemisphere winter) — because of land/ocean distribution



Let's Do That Quantitatively

- 3% farther implies 6% lower flux
- 6% lower flux means 1.5%
- $T=300\text{K} \rightarrow T \text{ drop is } 4.5\text{K} = 8\text{F}$
- But Temperature Drop in Winter is more like 40F

2.4 Precession

Our goals for learning:

- What is the Earth's cycle of precession?

Precession of the Equinoxes (IF 2.19)

- The Earth's axis precesses (wobbles) like a top, once about every 26,000 years.
 - Precession changes the positions in the sky of the celestial poles and the equinoxes.
- ⇒ *Polaris* won't always be the north star.

⇒ The spring equinox, seen by ancient Greeks in *Aries*, moves westward and is now in *Pisces*!

