The seasons

Astronomy 101
Syracuse University, Fall 2022
Walter Freeman

September 13, 2022

Winter is coming.

–Watchwords of House Stark,
from *A Song of Ice and Fire*

Winter is coming.

–Syracusians, as we buy snowshovels
and 50-pound bags of salt

Announcements

- Homework 2 is due Thursday; we will discuss it then.
- The quiz for Homework 2 will be either at the end of class Thursday or in class Tuesday, depending on how far we get today
- Homework 3 is part of today's exercise; it will be due in a week (as usual) and the quiz will be next Thursday.

- Weekly survey/check-ins – update (they'll go out on Wednesdays, not Fridays, starting tomorrow)

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How do you know when a new year starts?

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How do you know when a new year starts?

You know that you have to plant your crops in mid-April. How do you know when that is?

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How do you know when a new year starts?

You know that you have to plant your crops in mid-April. How do you know when that is?

Your gods want you to celebrate them on the same day every year. (The gods will be very angry if you don’t get this right!) How do you make sure you keep your gods happy?

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The Zodiac lets us divide the year into twelve equal parts – better than our months!

What is a day?

How should we define a *day*?

- A: 1/365 of a year
- B: The amount of time from midnight to midnight, or noon to noon
- C: The amount of time it takes for the celestial sphere to rotate once
- D: The amount of time it takes for Earth to rotate once

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- E: Aren't these all the same?

There are *two kinds* of day!

- Solar day: judged by the position of the Sun (noon to noon)
- Sidereal day (sih-dee-ree-al): judged only by the rotation of the Earth with respect to the stars

- A solar day is four minutes longer than a sidereal day

Two kinds of day!

Demo in *Stellarium:*

	Day by the stars	Day by the Sun
Earth	Rotates 360 degrees	Rotates 361 degrees
Stars	Return to same places	Slightly more than once around
Sun	Slightly less than once around	Returns to (almost) same place
Hours	23 hours 56 minutes	24 hours

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What else changes as the year progresses?

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The seasons:

- Summer has more hours of daylight than winter
- Summer has higher temperatures than winter

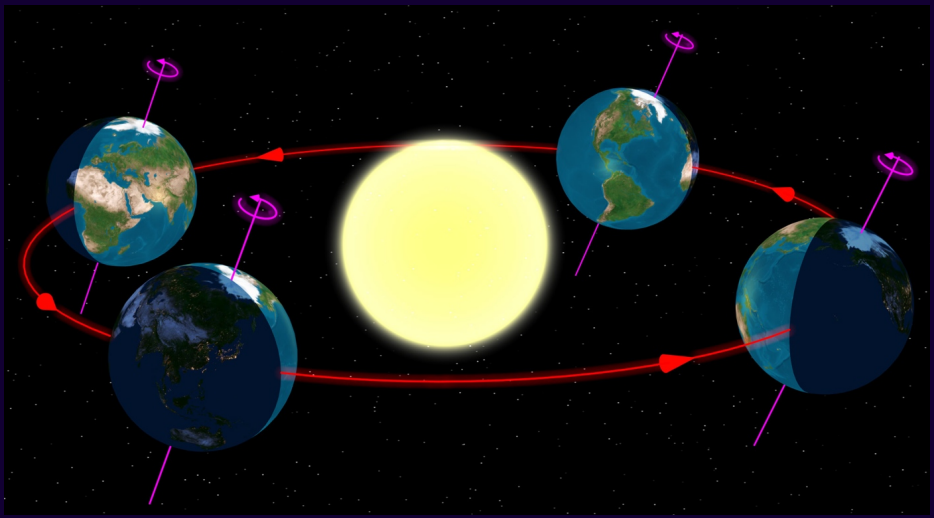
Why is this?

The tilt of the Earth's axis

The Earth's axis of rotation is not lined up with its orbital axis.

It's tilted by 23.4 degrees.

The axis of rotation changes only very slowly (over millennia).



Let's look at the consequences of this

What consequences does this have for the sky?

As the year progresses, thinking only about noon, will the Sun:

I. Move higher and lower in the sky
II. Move east/west relative to the stars

A: I only
B: II only
C: I and II
D: None of the above

A demonstration in Stellarium

Let's use *Stellarium* to examine the Sun at different times of year.

Notice:

- The Sun is higher or lower in the sky depending on the time of year
- The Sun moves westward with respect to the stars:
  - Every *solar day*, the Sun's east/west position (azimuth) stays fixed, but the stars move East
  - Every *sidereal day*, the stars' position stays fixed, but the Sun moves West

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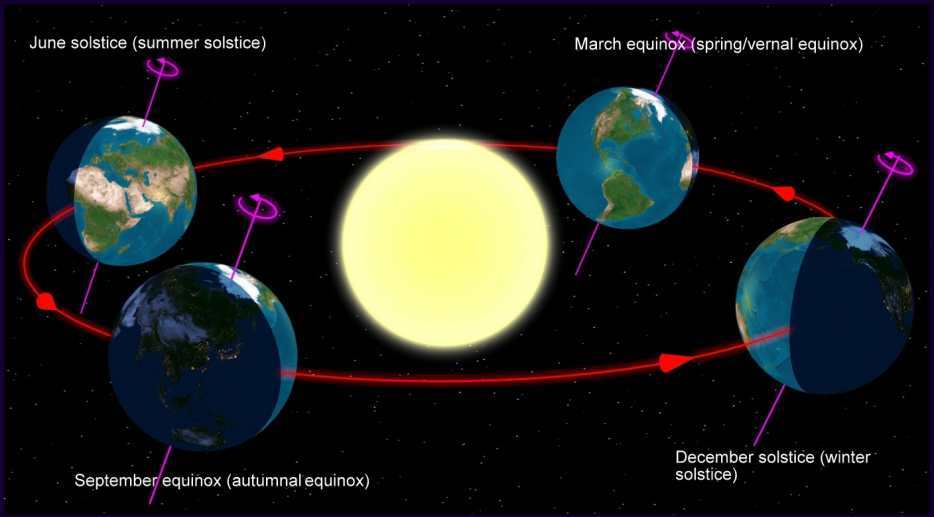
  - Every *sidereal day*, the stars' position stays fixed, but the Sun moves West
  - "One solar day is a bit more than one sidereal day"
  - "One sidereal day is a bit less than one solar day"

The solstices and equinoxes

We give special names to the points in Earth's orbit where the Earth's axis is tilted directly toward/away from the Sun:

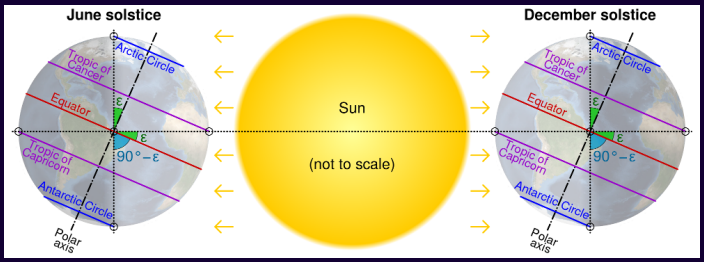


The solstices and equinoxes

Many cultures have ascribed significance to the annual movement of the Sun.

Perhaps the most famous artifact of this is Stonehenge:

The tropics

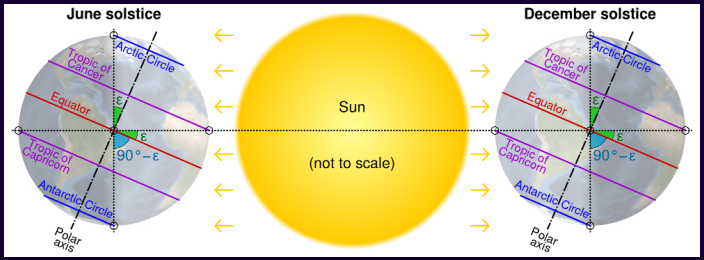


The region on Earth where the Sun alternates between the northern sky and the southern sky is called the tropics.

- The northern boundary is called the Tropic of Cancer
- The southern boundary is called the Tropic of Capricorn
- These occur at 23.4° N/S latitude

On the June solstice, the sun reaches the zenith along the Tropic of Cancer.
On the December solstice, the sun reaches the zenith along the Tropic of Capricorn.

The Arctic and Antarctic



The region where the sun either never rises or never sets during part of the year is called the Arctic (north) or Antarctic (south).

- North of the Arctic Circle, the sun never rises on the December solstice, and never sets on the June solstice.
- South of the Antarctic Circle, the sun never sets on the December solstice, and never rises on the June solstice.
- These occur at $90 - 23.4^\circ = 66.6$ N/S latitude

What consequences does this have on Earth?

Thinking only about noontime (when the sun is highest in the sky), will the sun ever reach the zenith in Syracuse (latitude 43° N)?

A: Yes
B: No

What consequences does this have on Earth?

Thinking only about noontime (when the sun is highest in the sky), will the sun ever reach the zenith in Lima, Peru (latitude 12° S)?

A: Yes
B: No

What consequences does this have on Earth?

Which is true about the Sun on June 21 in Svalbard (latitude 78° N)?

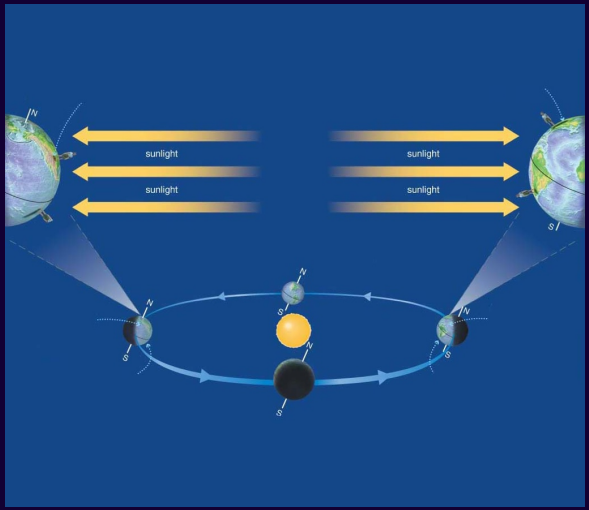
A: It will never rise
B: It will never set
C: It will reach the zenith of the sky
D: It will travel from east to west in the northern sky
E: It will travel from east to west in the southern sky

The seasons

The tilt of the Earth toward/away from the Sun controls the amount of sunlight we get at different times of year!

This happens for two important reasons. Thinking about the Northern hemisphere...

- The Sun is visible in the sky for longer in June than in December
- Sunlight strikes the Earth more directly in June than in December



Complete the handout, and start on your homework if you want.

After this, we will review the quiz.

This is why the Earth is hotter in summer.
It has nothing to do with the distance from the Sun!

Let's look at some questions from the quiz...