

# The seasons

Astronomy 101  
Syracuse University, Fall 2020  
Walter Freeman

September 8, 2020

Winter is coming.

—Watchwords of House Stark  
(*A Song of Ice and Fire*, George R. R. Martin)

Winter is coming.

—Syracusians, as we buy snow tires and 50 pound bags of salt

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- If your group changed for whatever reason, you may do the project with your new group, or your old one
- Any astronomy questions about Project 1? (Anyone fishing for hints?)

# Announcements: Labs for Week 1

- Remember, you should install *Stellarium* before coming to lab
- See the intro videos for Stellarium (and Collaborate) sent out by email
- If you don't finish your lab during the lab time, work on it with your group and email it in within 48h of your lab
- Remember, email your labs to [suast101labs@gmail.com](mailto:suast101labs@gmail.com) – the instructions are on the lab document

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- Tell me in Zoom / Discord chat how **online** labs went Monday
- Students in China: were you able to access Blackboard Collaborate? (If you are watching this later, please email [suastronomy101@gmail.com](mailto:suastronomy101@gmail.com) and tell me – whether it worked well or not)

- The Earth moves around the Sun, so:
  - Some stars may be invisible during part of the year, since they are only above the horizon when the Sun also is
  - Those constellations that lie along the plane of Earth's orbit are called the *zodiac*
  - Astrology (claims to) care about which constellation is “behind” the Sun, even though we can't see it

# Let's look at this in animations

One way to define the seasons: which stars are “behind” the Sun!

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Type in chat!

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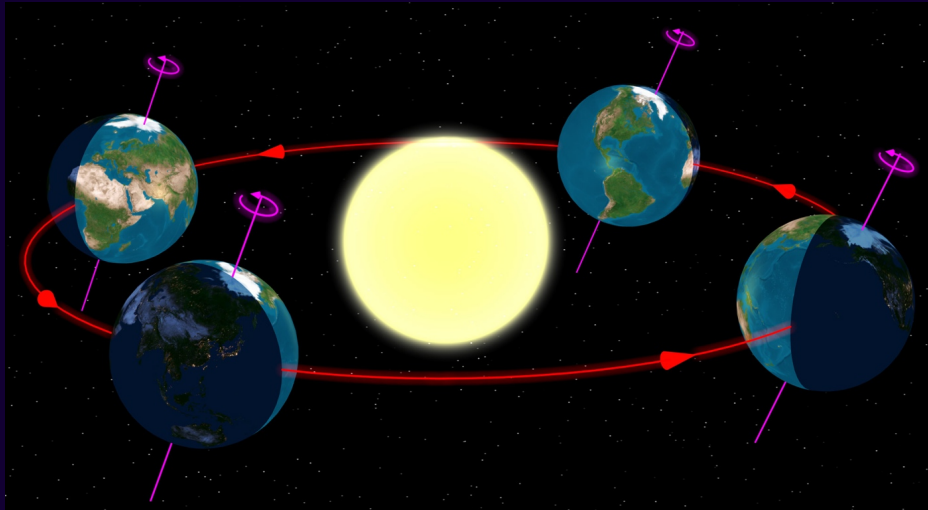
What can you observe in our world that shows that those explanations are wrong?

# 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 this in animations

# What consequences does this have for the sky?

How does the location of the Sun at noon depend on the time of year? Answer in Zoom / Twitch chat.



# A demonstration in Stellarium

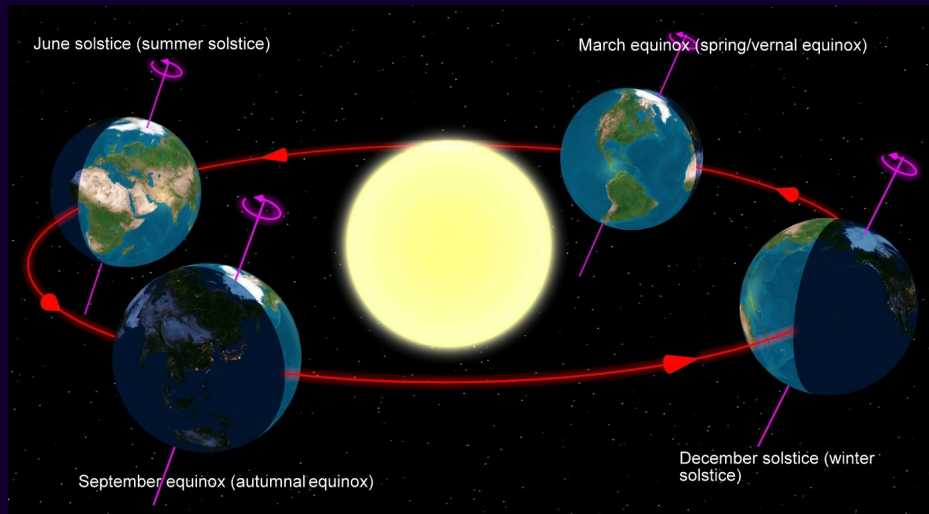
Let's use *Stellarium* to examine the Sun at different times of year.

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. You'll need to understand this for Project 2 coming up.

# 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:



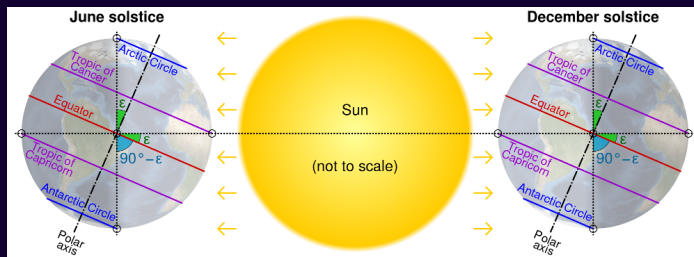
# The solstices and equinoxes

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

Perhaps the most famous artifact of this is Stonehenge:



# The tropics

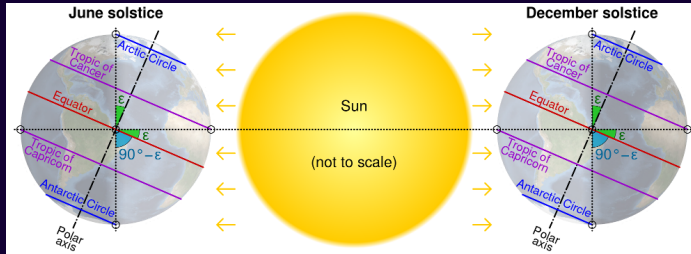


The region on Earth where the Sun alternates between the northern sky and the southern sky is called the **tropics**.

- The northern boundary is called the **Tropic of Cancer**
- The southern boundary is called the **Tropic of Capricorn**
- These occur at  $23.4^\circ$  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  $43^\circ$  N)?

# 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  $12^\circ$  S)?

What consequences does this have on Earth?

Which is true about the Sun on June 21 in Svalbard (latitude  $78^\circ$  N)?



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

# One last question

What if the Earth's axial tilt were increased to  $30^\circ$  from  $23^\circ$ ?

A: Syracuse would have hotter summers

B: Syracuse would have colder winters

C: More of Earth would be in the tropics

D: More of Earth would be in the arctic

E: Another Stark would meet a bad end