

Announcements

★ Homework 1 posted on Compass

Due Monday, 11:59pm, Sept 9th.

Can submit answers (and see score) more than once: persistence pays off!

★ Register those iClickers! link on course site

★ Venus/Saturn viewing-- special dates

★ Last Time: Introduction

★ Today: The Night Sky

- ▶ Constellations
- ▶ Celestial Sphere
- ▶ Phases of the Moon

Millions of Miles from Home – Dune

Topics for Today

What are constellations?

How does the sky appear to move as the Earth rotates?

Why do the constellations we see depend on the time of year?

Why do we see phases of the Moon?

Next time: Meteors, Asteroids, & Comets!



The Night Sky

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This semester we are focussing on killer skies danger and violence in the cosmos

but also how much of the most dangerous aspects of the universe are also necessary for life.

but before we get to the killer and nurturing aspects of the sky, the extreme and unusual events -- that's the rest of the course, we need to have a basic understanding of the everyday and every night sky--that's today. If you already had Intro to Astronomy, sit back and review.

A Sky Full of Stars



On a clear night, and from site far from city lights, over thousands of stars are visible to the naked eye. How do we organize these stars? How do we remember where particular stars are in the sky.

A Sky Full of Stars

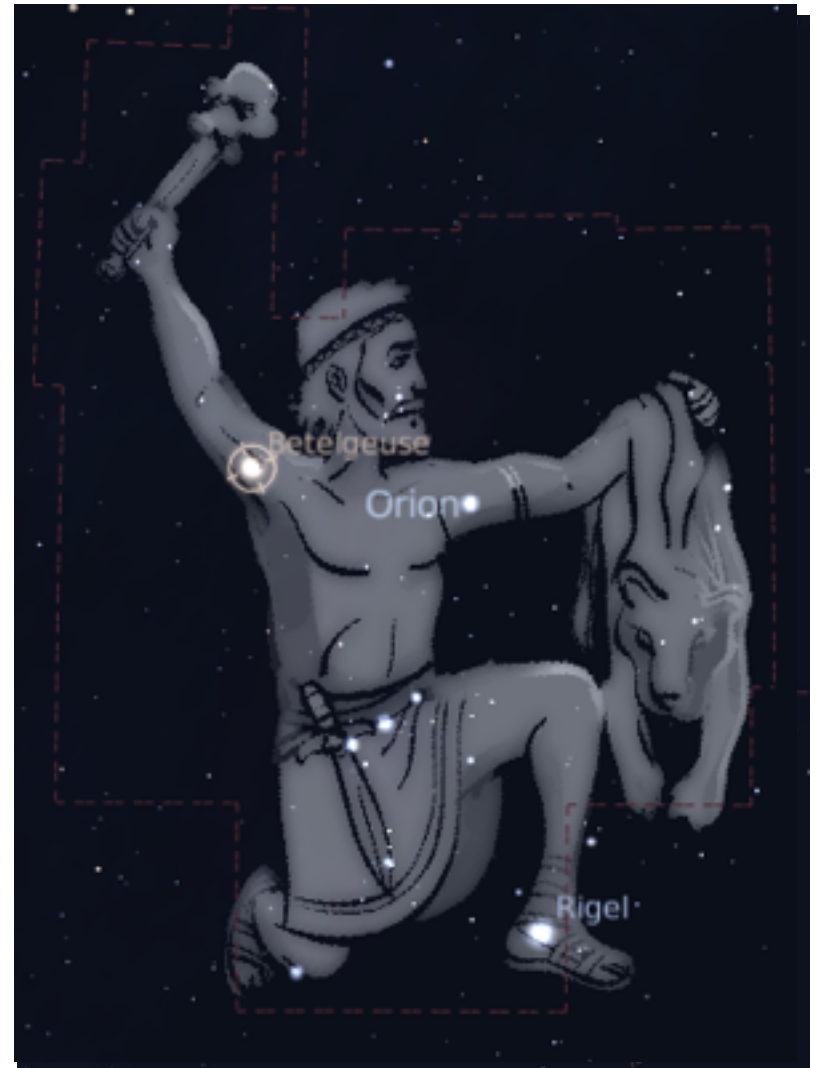


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Constellations

Since ancient times

- ▶ groups of stars that appear to form patterns in the sky
- ▶ Devised by ancient people to help recognize the stars



Orion, the Hunter

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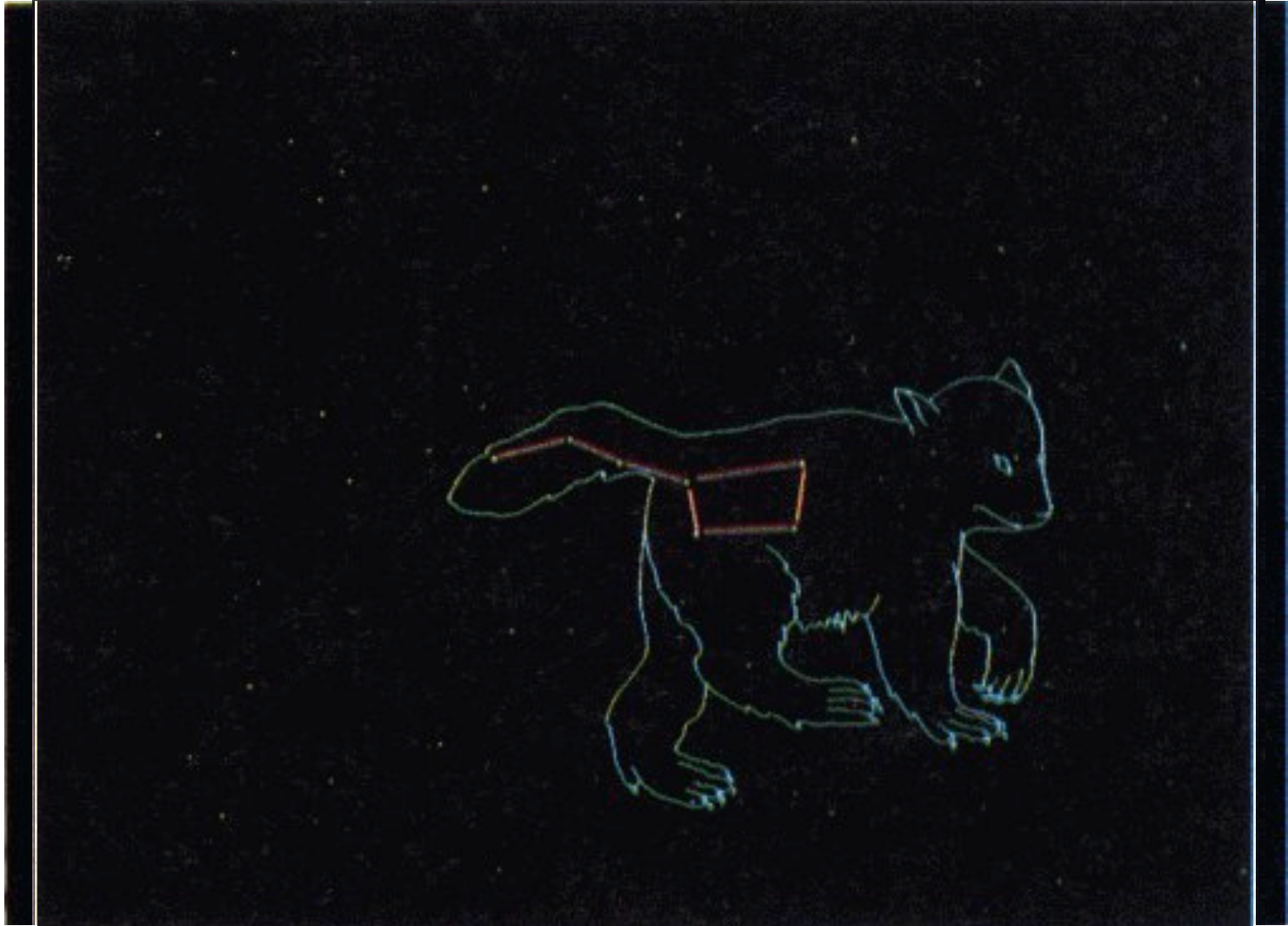
Constellations were originally a game of “connect the dots” of humans finding patterns in the sky

The constellations named within Western culture originated in Mesopotamia, Babylon, Egypt, and Greece beginning as much as 5,000 years ago.

Colloquially, groups of stars that appear to form patterns in the sky, devised by ancient people to help recognize the stars

Shapes of constellations resemble objects familiar to those people Example: Orion the Hunter. Some historians suspect that many of the myths associated with the constellations were invented to help the farmers remember them. For example, Scorpius is only visible in the northern hemisphere's evening sky in the summer.

Constellations can vary greatly between cultures



Tail of a bear (Ancient Greeks and Native Americans)

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There are thousands of dots up there
and not everybody connects the dots the same way!
...or even groups the same dots together

though some groupings are so striking that everybody sees them
although doesn't agree on what picture you get when connecting the dots

legend goes: song "Follow the Drinking Gourd"
coded instructions--use pointer stars to find North
Astronomy was on the side of the good guys!
song revived in civil rights movement

Orion the Quarterback?

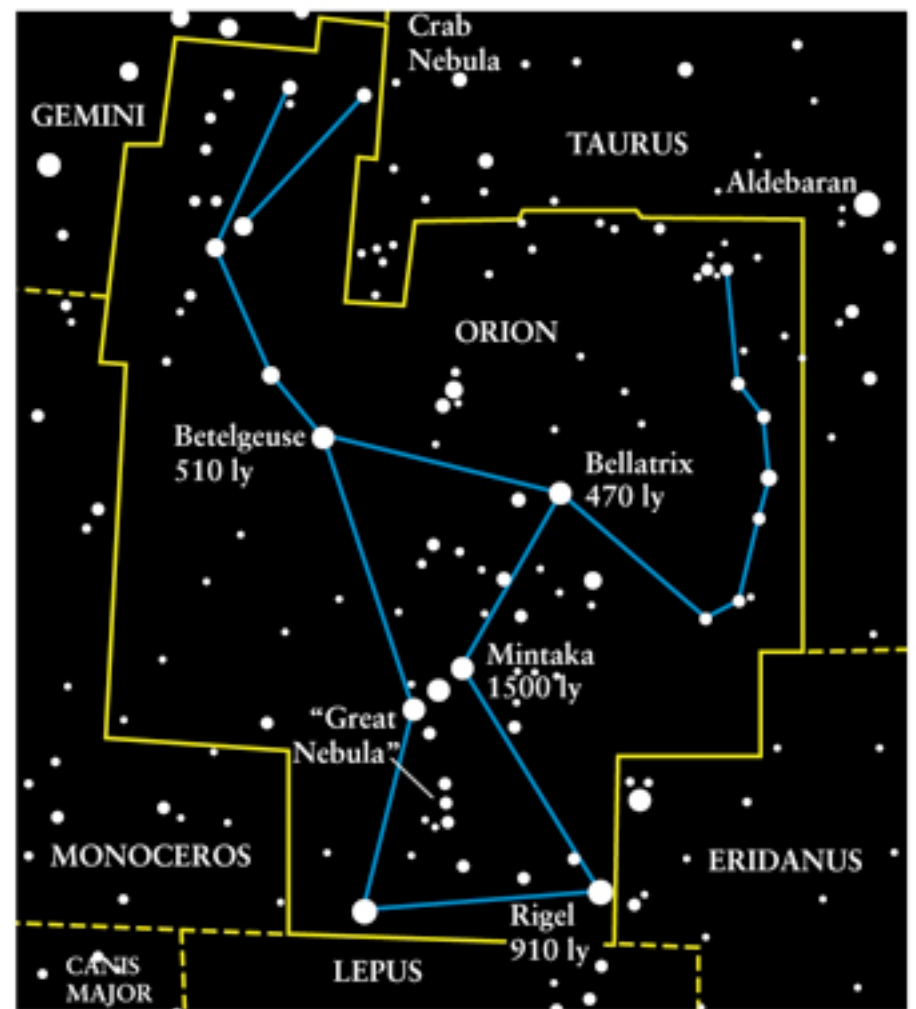


You are welcome to try to connect the dots your own way

Constellations Today

For modern astronomers:

- ▶ constellations are **regions** of the sky
- ▶ completely cover the sky like states on a US map
- ▶ not just stars in “connect the dots”
- ▶ every star lies in exactly one constellation



Questions so far?

analogy with States: any point in the US is always in one state and only one state

Point out: Orion region covering everything inside these boundaries

Cosmic Roadkill

Crucial fact of astronomical life:

- **distances** to stars (and Sun, Moon, planets) hard to measure
- distances not obvious to naked eye

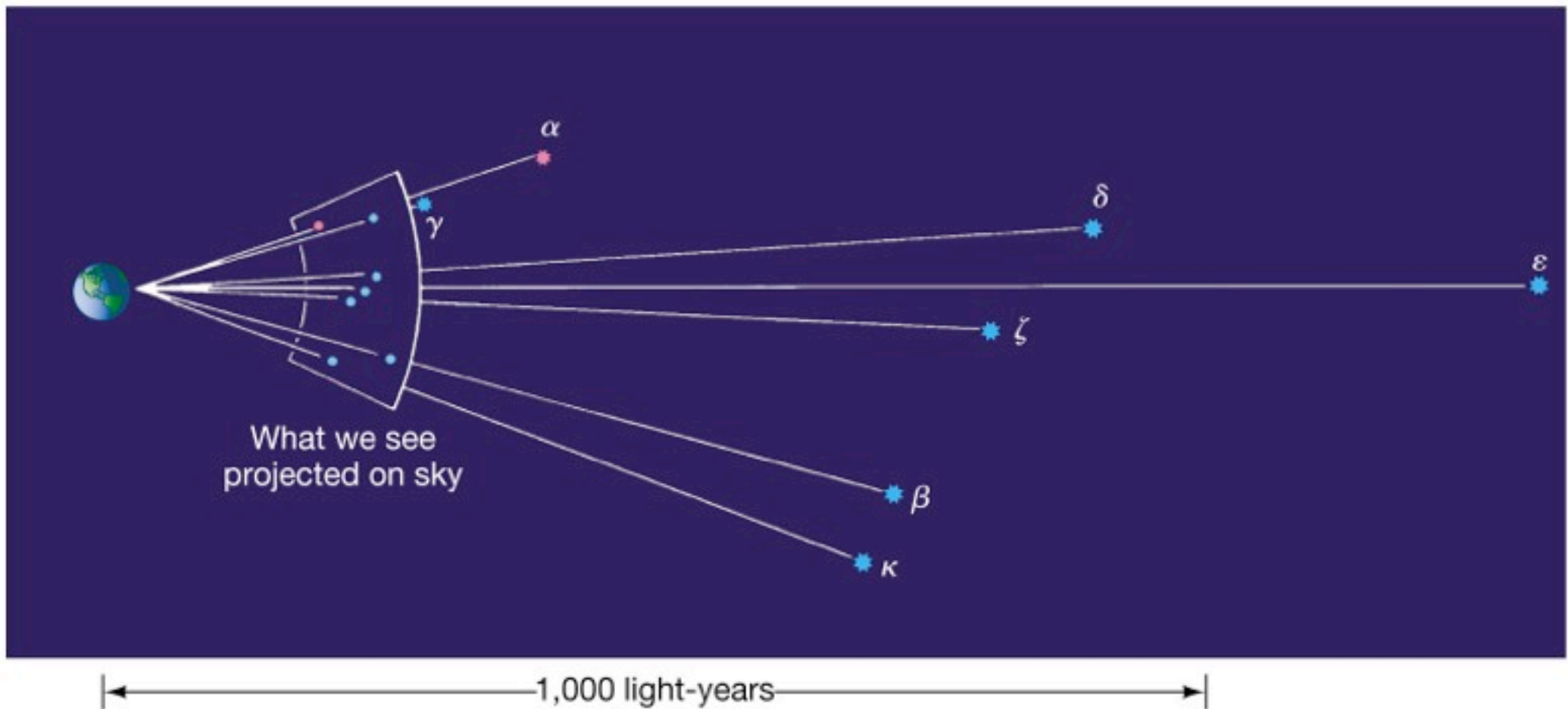
The sky shows **no “depth”**

- in reality, stars spread over a 3-dimensional volume in space
- but eye can't tell distance, so stars appear “flattened” onto 2-dimensional sky

Always must keep in mind difference:

- what you observe: 2D sky, versus
- what's really going on: 3D space

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



The only thing the stars in Orion have in common is that they lie in approximately the same direction from Earth.

Procyon (14 ly away), a star in the winter sky, is closer to Alpha Centauri (4 ly away), a star on the other side of the sky, in reality than Betelgeuse (430 ly away), a star it appears very close to in the sky.

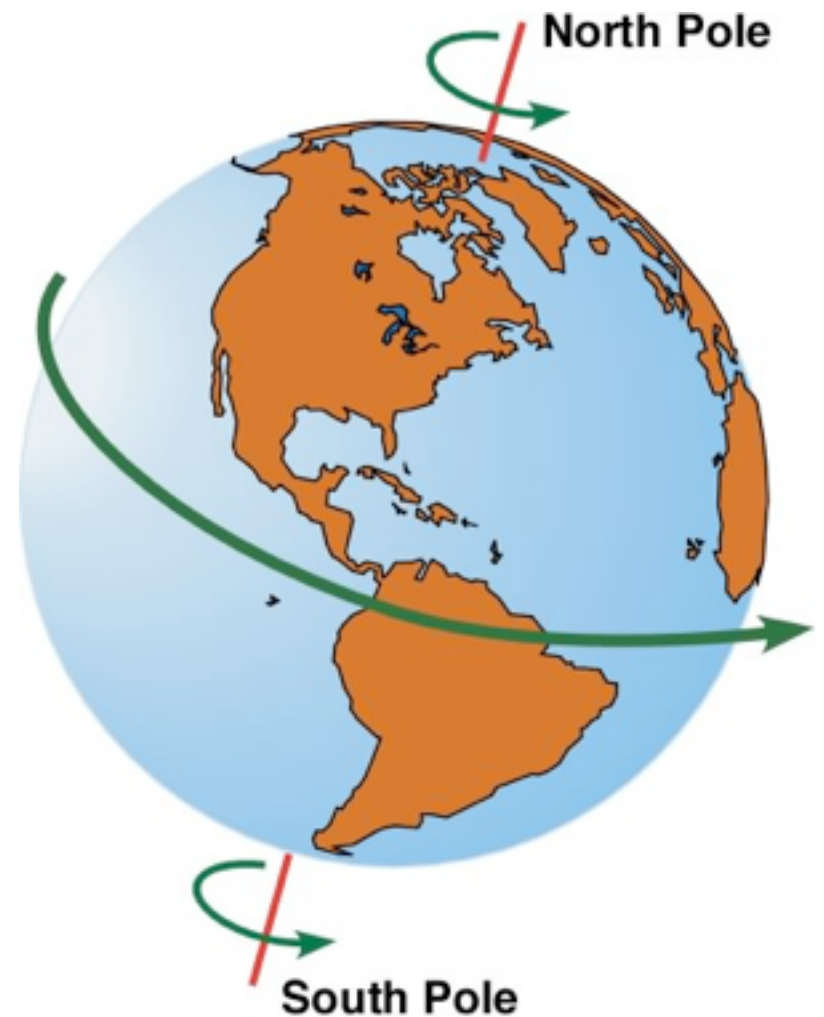
The View from the Merry-Go-Round

We observe stars while riding on a spinning planet

- Earth spin about axis once daily

So stars appear to move in the sky as do Sun, Moon, planets

- rise in the east
- set in the west
- period = time for one cycle in sky = 1 day



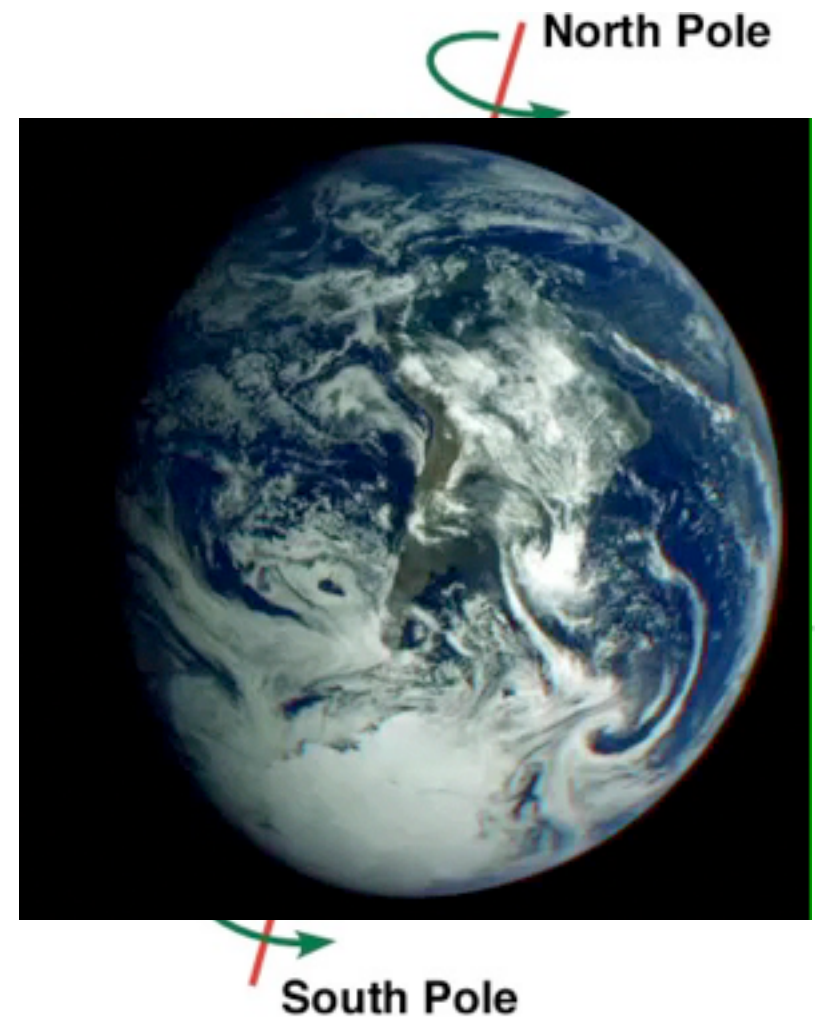
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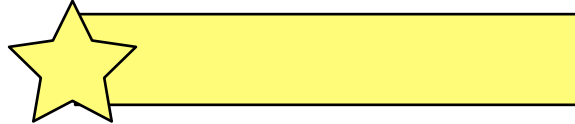
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iClicker Poll: Star Trails

Imagine you could see paths (“trails”) of all stars as each moves across the night sky



What pattern would you see?

- A. arcs of circles
- B. arcs of ovals
- C. parallel line segments
- D. none of the above

How could we do this experiment?

Star Trails



star trails as seen in
Southern Hemisphere (Australia)



Polaris = North Star
Are these apt names?

star trails as seen in
Northern Hemisphere

So why do we see this pattern?

So why is Polaris called polaris?
Why is it called the North Star?

Circumpolar Stars



Dr. Jean-Charles Cuillandre

**The stars appear to move in circles
around the North Celestial Pole**

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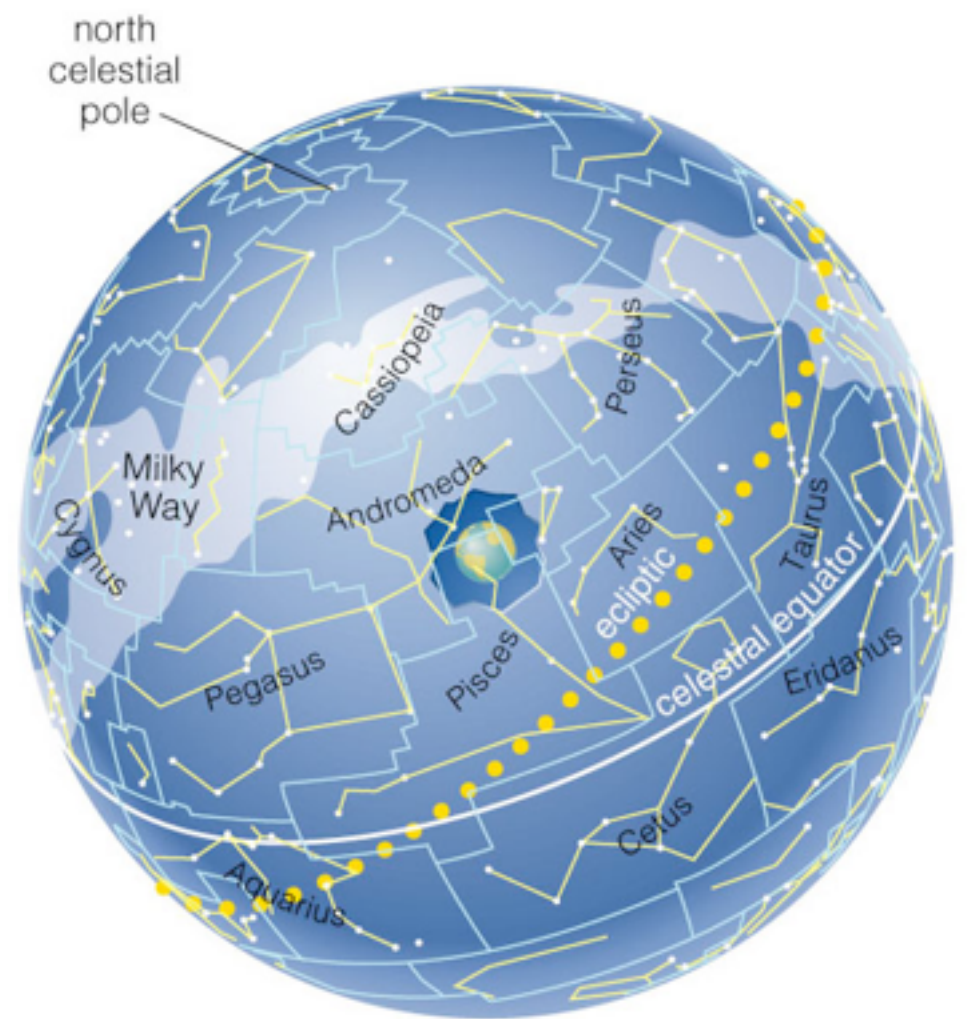
Watching a time-lapsed movie of the stars, we clearly how the stars all seem to rotate around the North Celestial Pole (but really the Earth is rotating).

The constellations appear to fill a great celestial sphere

Stars seem to be on the inside of a sphere around the Earth

A useful model for describing the sky

In reality, stars are scattered through space at different distances



Ancient astronomers believed the sky was a great sphere surrounding Earth, with the stars stuck on the inside—like thumbtacks in a ceiling.

The celestial sphere is an imaginary sphere of infinite radius surrounding the earth. Locations of objects in the sky are given by projecting their location onto this infinite sphere. While technically impossible to depict the perspective of looking down on the celestial sphere (being infinite in size), it is often convenient to depict a celestial sphere of finite radius – such as was done with the figure.

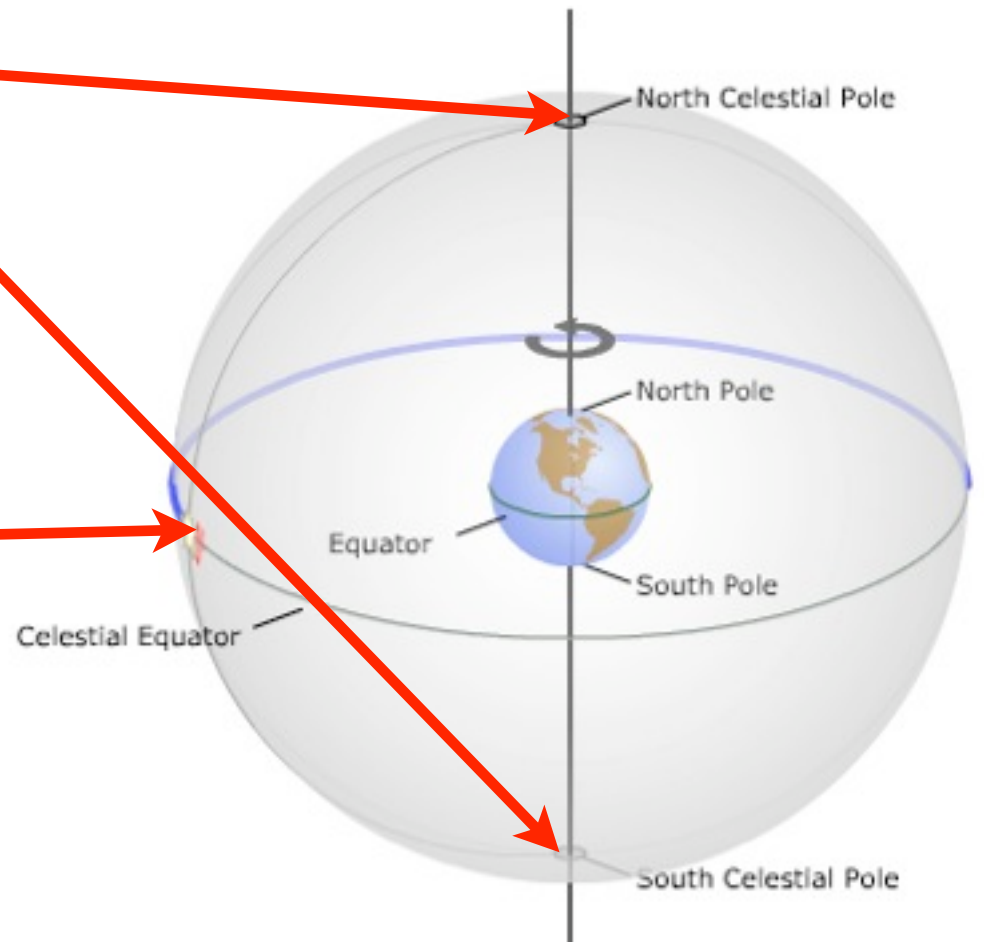
Celestial poles and equator

Celestial poles

- ▶ Projections of the Earth's north & south poles onto the celestial sphere

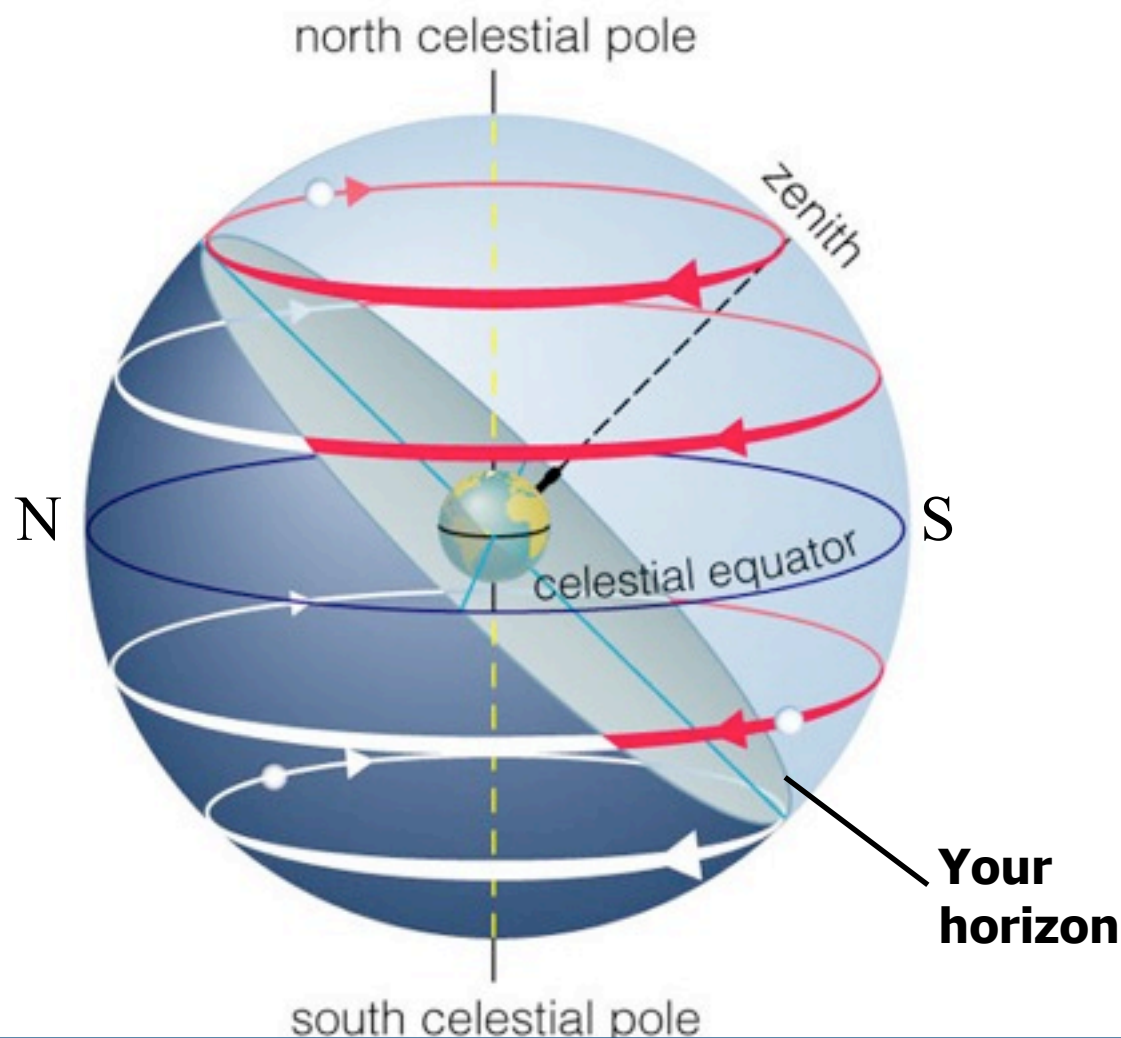
Celestial equator

- ▶ Projection of the Earth's equator onto the celestial sphere



The celestial sphere is fixed with respect to the universe. Its orientation does not change. However, because the earth rotates from west to east (counterclockwise from the perspective of looking down at the north pole), an observer standing on the earth will see the celestial sphere rotate from east to west (or clockwise when looking up at sky).

How does the sky appear to move as the Earth rotates?



Earth rotates west to east on its axis, so stars appear to circle from east to west about the celestial poles

Because the earth is rotating the sky appears to rotate. Viewed from above the north pole, the earth is rotating counter-clockwise. For an observer on the earth, objects move from east to west (this is true for both northern and southern hemispheres). More accurately put, when looking north, objects in the sky move counter-clockwise.

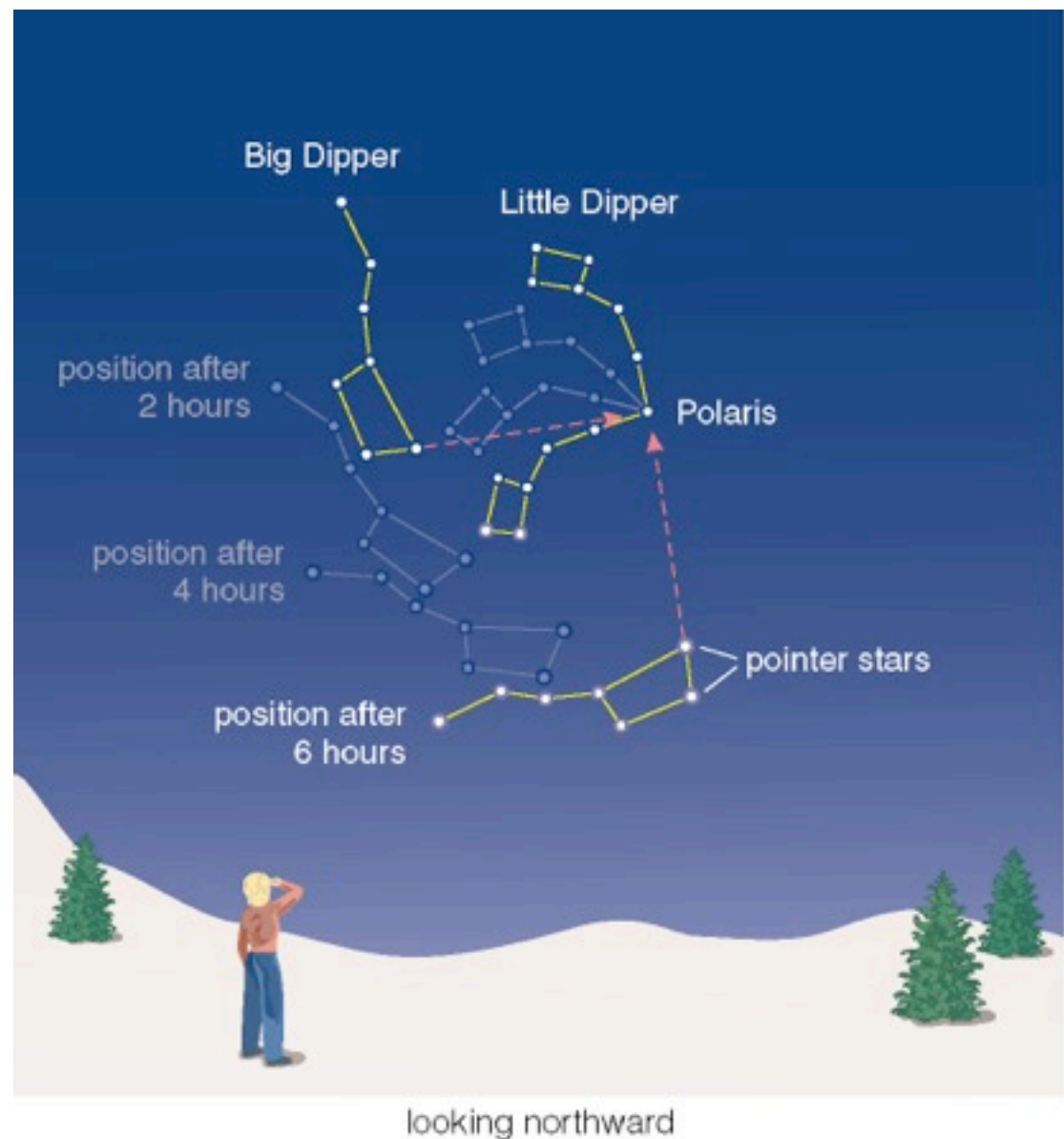
Polaris, the North Star

Follow the drinking gourd

Polaris is a star that appears very close to the North Celestial Pole

The whole sky appears to turn around it

If you find Polaris, you know where north is!



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Circumpolar stars have the same basic motion as the rest of the sky, but the circles they make are so small, they don't dip below the horizon

Big Dipper has traveled 1/4 of a circle in 6 hours, so how long to make a full circle?

If we take a long-exposure picture towards Polaris, we get star-trails!

If you find Polaris, you know which north is!

drinking gourd story:

in the bad old days, slavery in this country

but slaves would escape and seek freedom in north

and an Underground Railroad grew up to help them

but can't take highway, no maps, traveling in hostile territory,

--> makes sense to move at night

but how know where north is?

Types of star paths

Rise and set stars

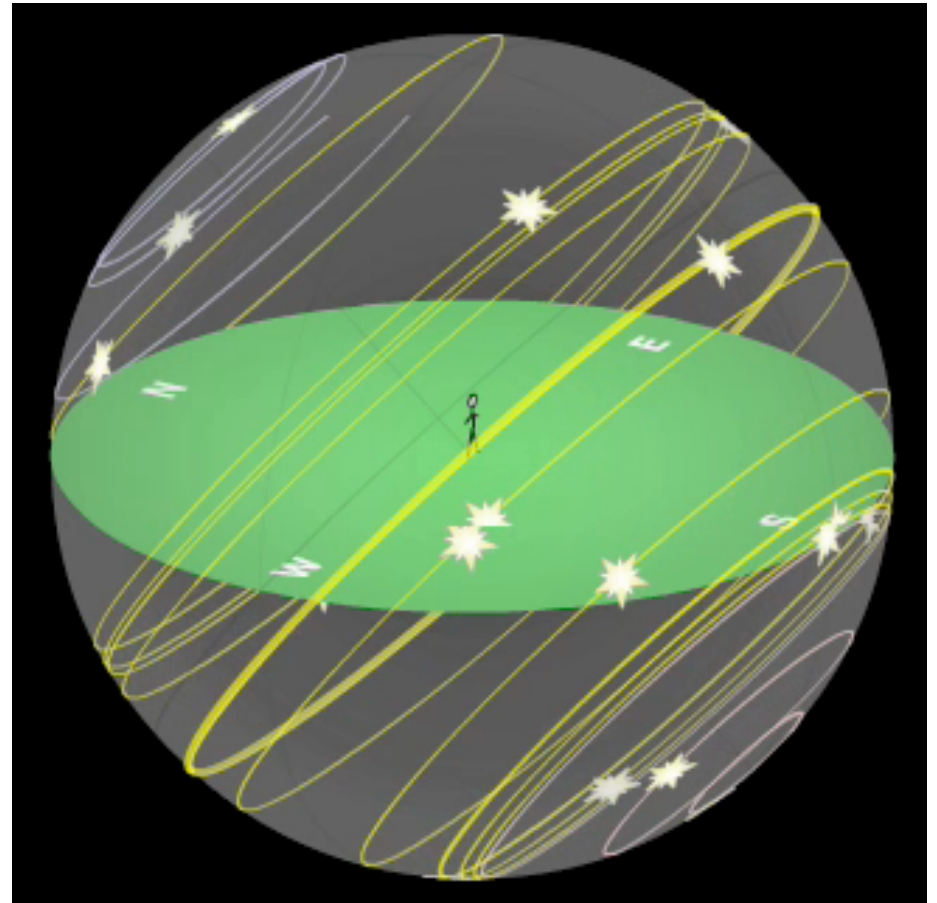
- ▶ Rise from below the eastern horizon and later set below the western horizon

Circumpolar stars

- ▶ Stars always above the horizon

Never-rise stars

- ▶ Stars always below the horizon



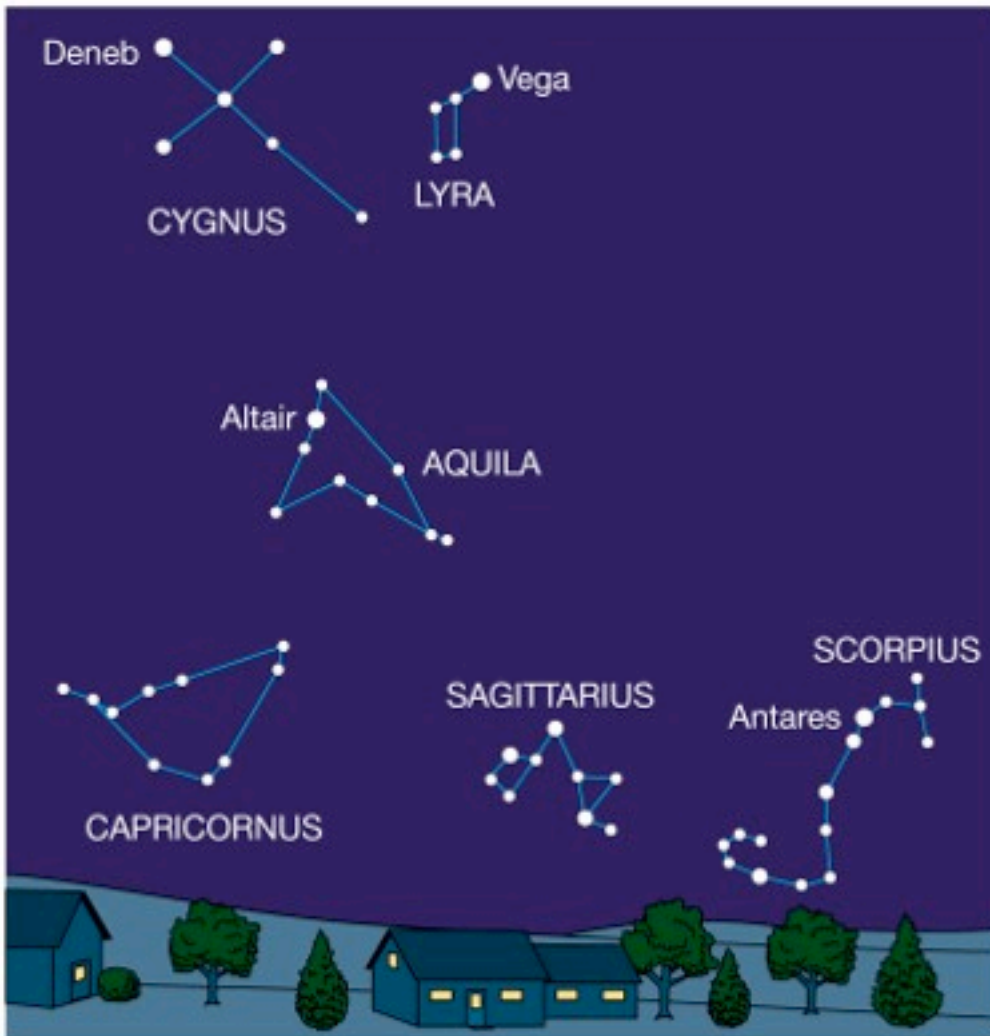
Rise-set star paths in yellow
Circumstellar in blue
Never-rise in red

Animation is for an observer in Champaign IL (40N). Note that the stars rise at an angle to the horizon (not straight up). The angle rise and set stars (including the sun) make with the horizon as they rise is the same for all rise and set stars for that observer.

Stars near the celestial poles make small circles and may not pass the horizon plane. These stars are indicated by blue (northern hemisphere stars) and red (southern hemisphere stars) in the figure to the left.

Why don't we see the same constellations throughout the year?

Summer



(a) Southern horizon, Summer

Winter



(b) Southern horizon, Winter

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What's going on? Stars are always out there, not moving so why don't we see the same ones every night?

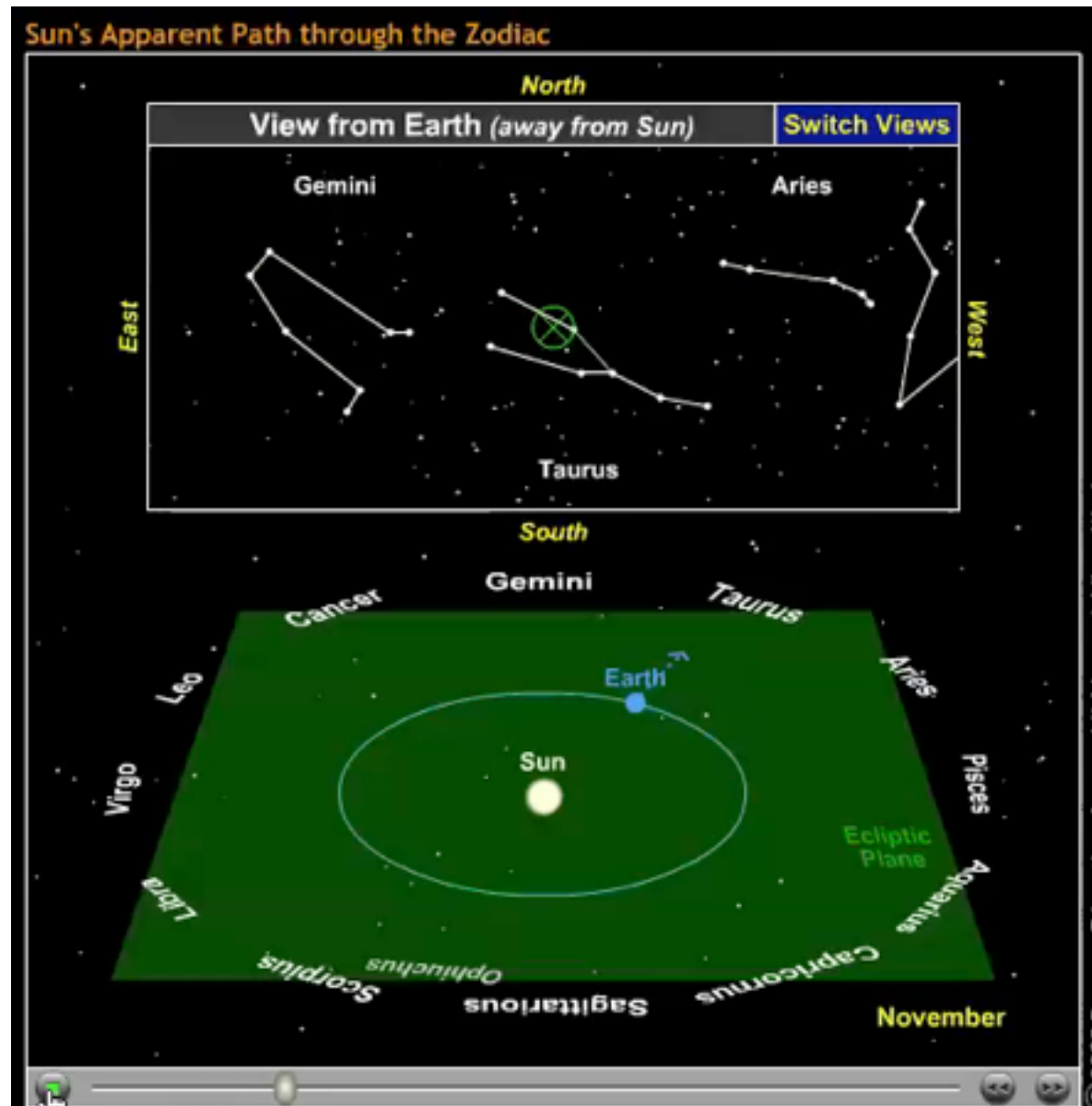
Ideas?

The Earth also revolves around the Sun, which changes our view of the stars.

Earth's orbit around the Sun causes a “seasonal migration” of stars

Stars in the direction away from the Sun are visible at night

In May,
Scorpius is visible at night
In November,
Taurus is visible at night



We can see how different stars appear at different times of year by looking at the position of the Sun against the backdrop of stars

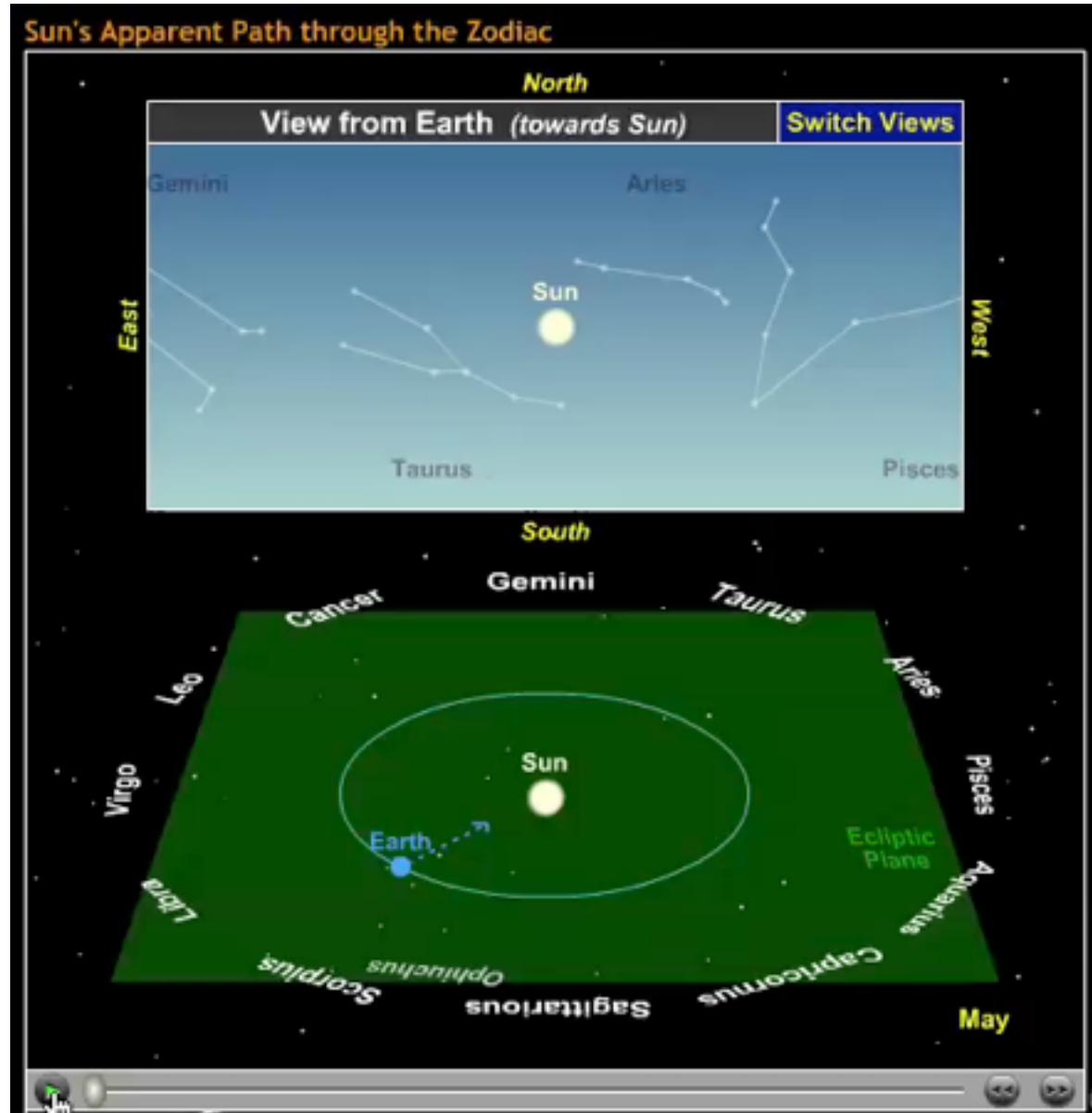
The side of the Earth facing the Sun is experiencing “day,” while the side of the Earth turned away from the Sun is experiencing “night.”

The Sun's Apparent Path through the Zodiac

If we could see the stars during the day, the Sun would appear to move relative to the stars

One full circuit in one year

Traces out a path through the Zodiac

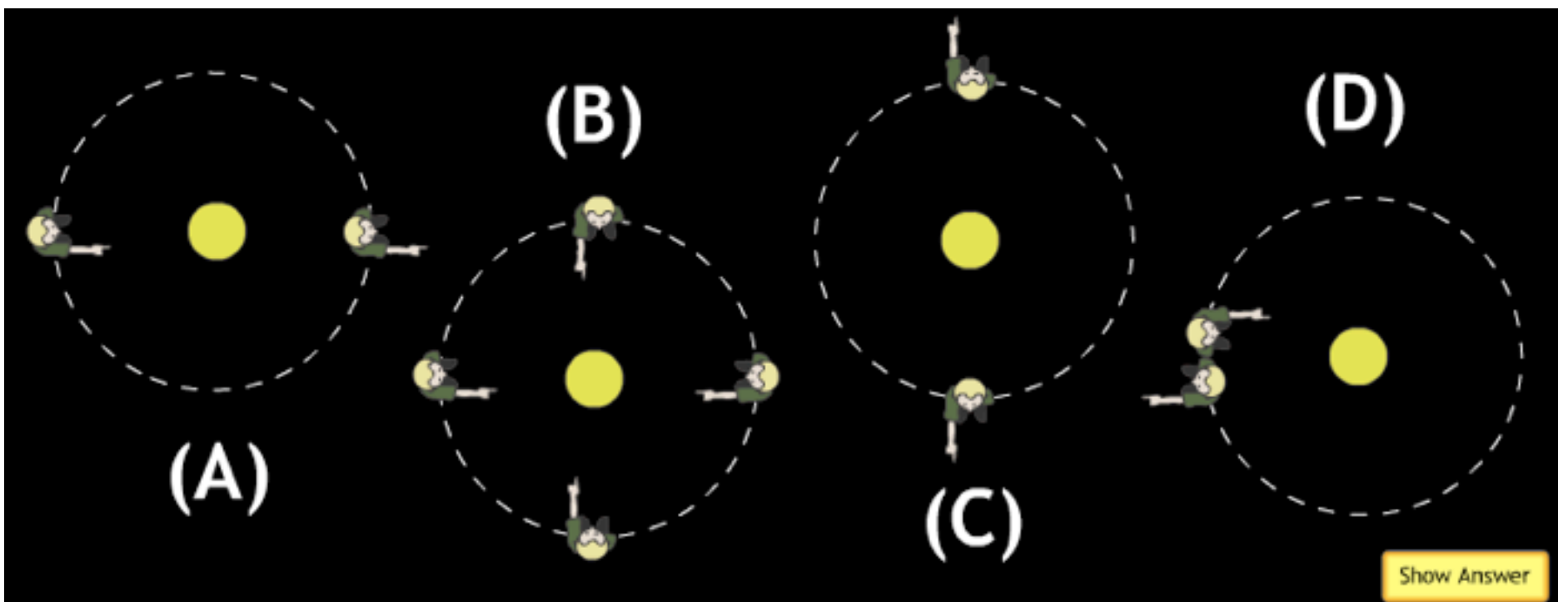


Questions?

The Sun appears to pass through a ring of constellations called the Zodiac. In January, you would see the sun in front of the constellation Sagittarius. By March, it is in front of Aquarius.

iClicker question

Which group of students is correctly illustrating why we see different constellations in the night sky in the summer than in the winter?



Answer C

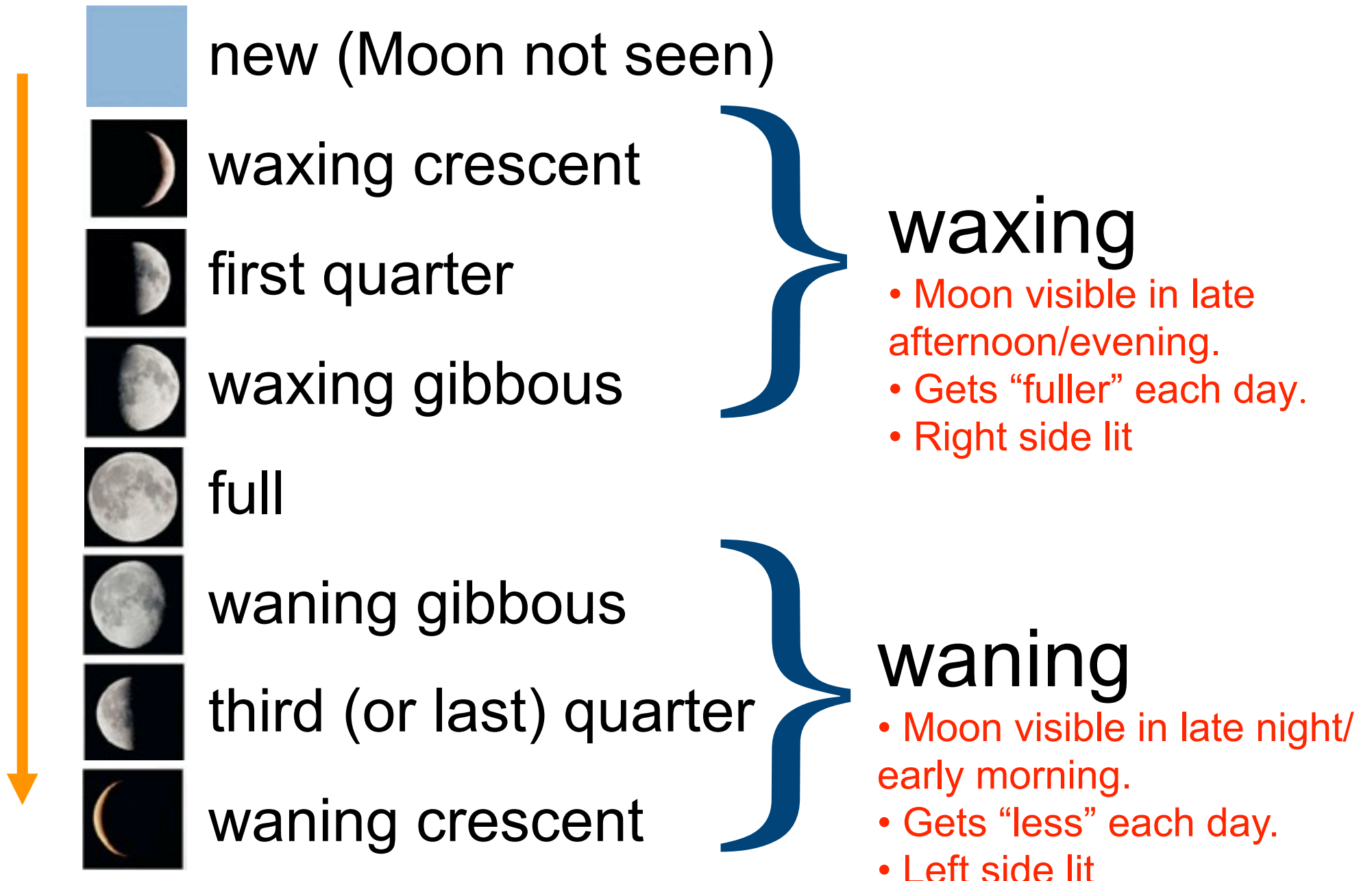
Constantly Changing Moon



Over the course of about a month, we see the moon go through a series of *phases*

Cycle takes 29.5 days from start to finish
Month = "Moon"th!

Names of the Phases



About 1 week from new–1st q, 1 week from 1st q–full, etc..
Let's explore why we see lunar phases

Are the Moon's phases caused by Earth's shadow?



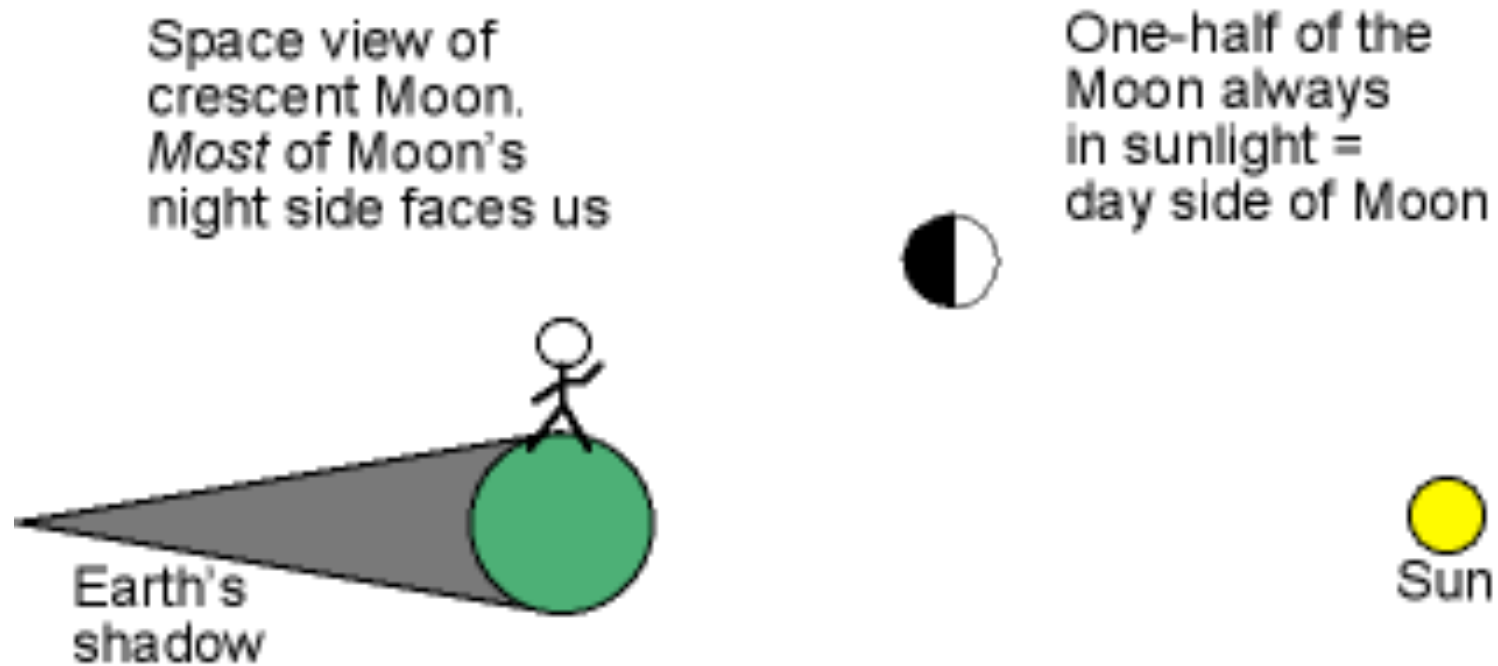
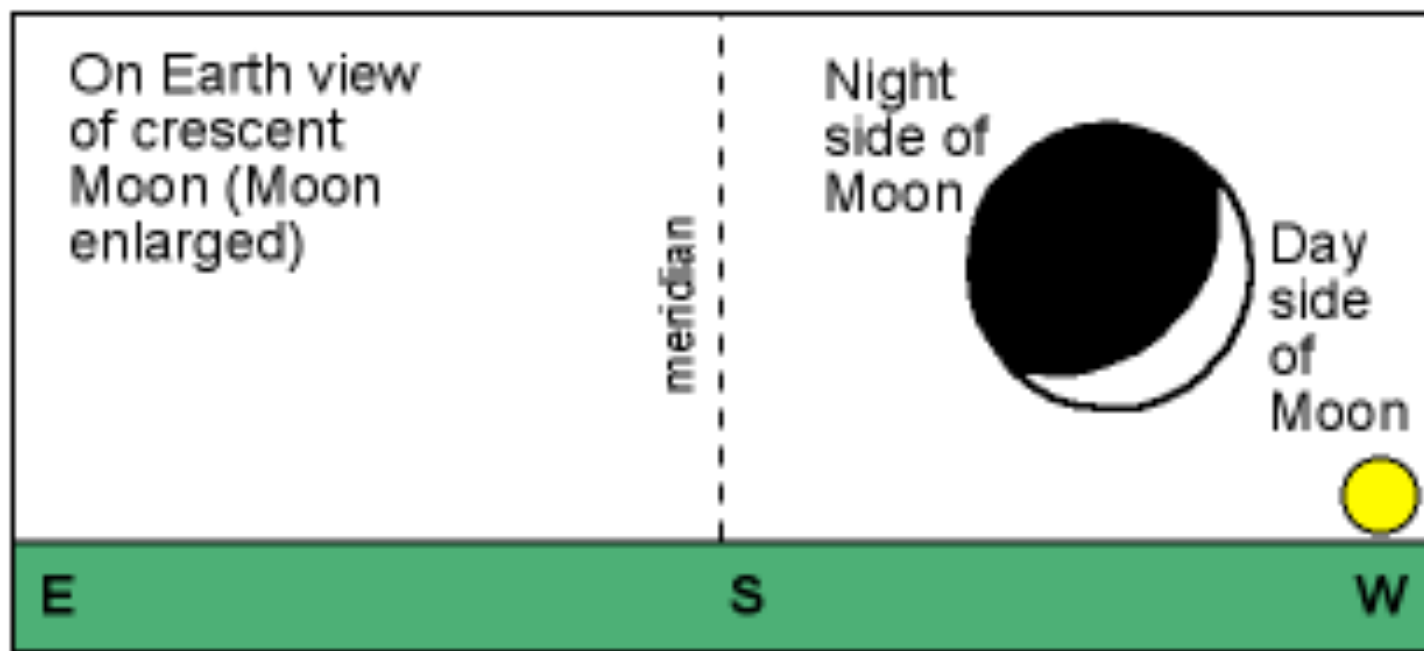
If so, then a crescent moon (as at left) would occur when the Moon was *opposite* the Sun in the sky

Many people think that lunar phases are caused by Earth's shadow on the Moon. They think that the Moon is a thin crescent in the sky rather than a full circle because Earth's shadow is falling on the Moon making most of the circle dark. If Earth's shadow falling on the Moon caused lunar phases, then the crescent or new Moon phases would be opposite the Sun in the sky.

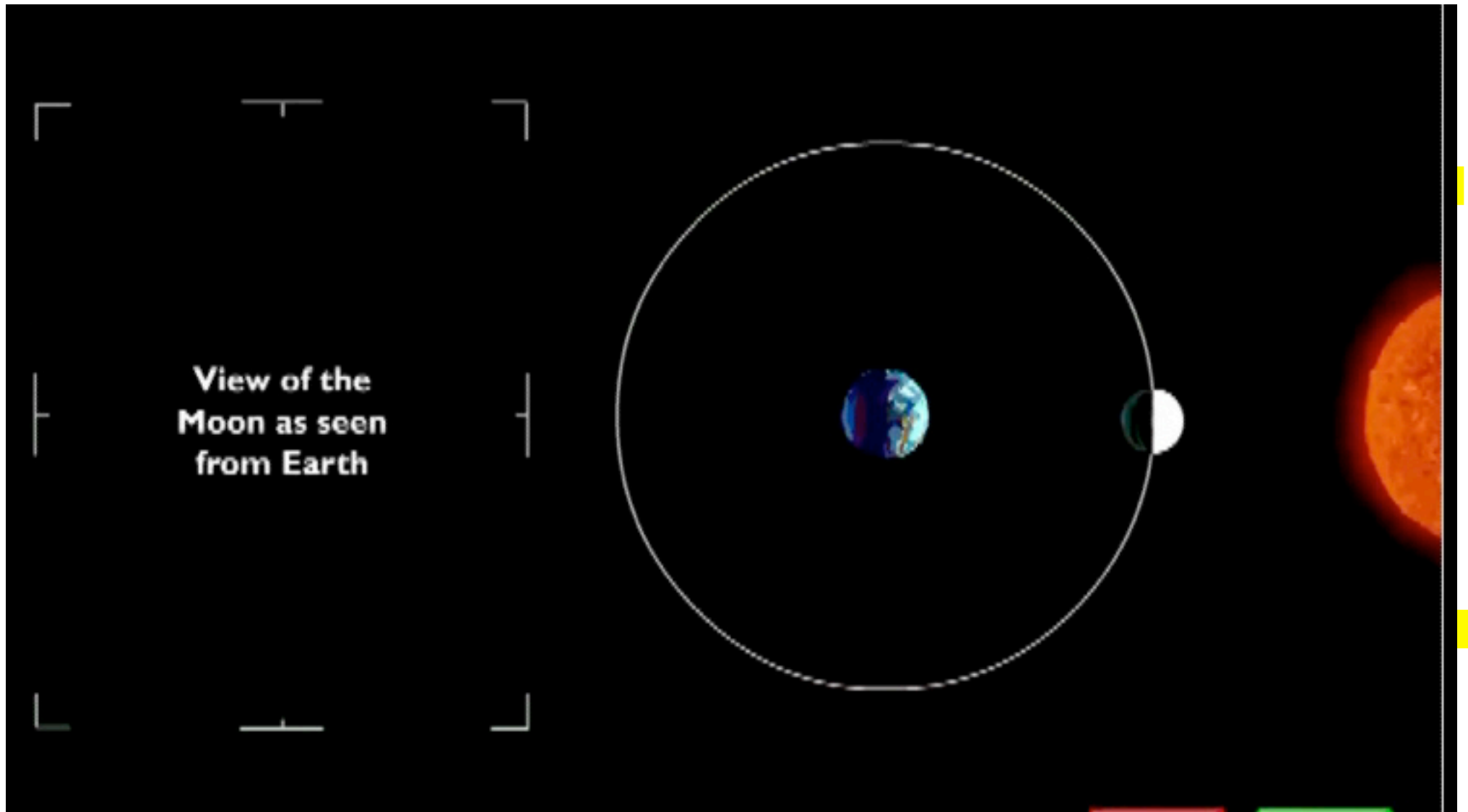
A crescent moon is in the WEST at sunset



A crescent moon is in the same direction as the setting Sun!



You will observe only a small fraction of the Moon's illuminated side when it is close to the Sun. In fact, the smaller the angular distance between the Moon and the Sun, the less of its illuminated side you see. When the angular distance is less than 90° separation, you on the Earth will see less than half of the Moon's illuminated (day) side and it will look like a a curved sliver of light---the crescent phase. You will see mostly the night side of the Moon. Because the Moon is spherical, the boundary between light and shadow (night) is curved.

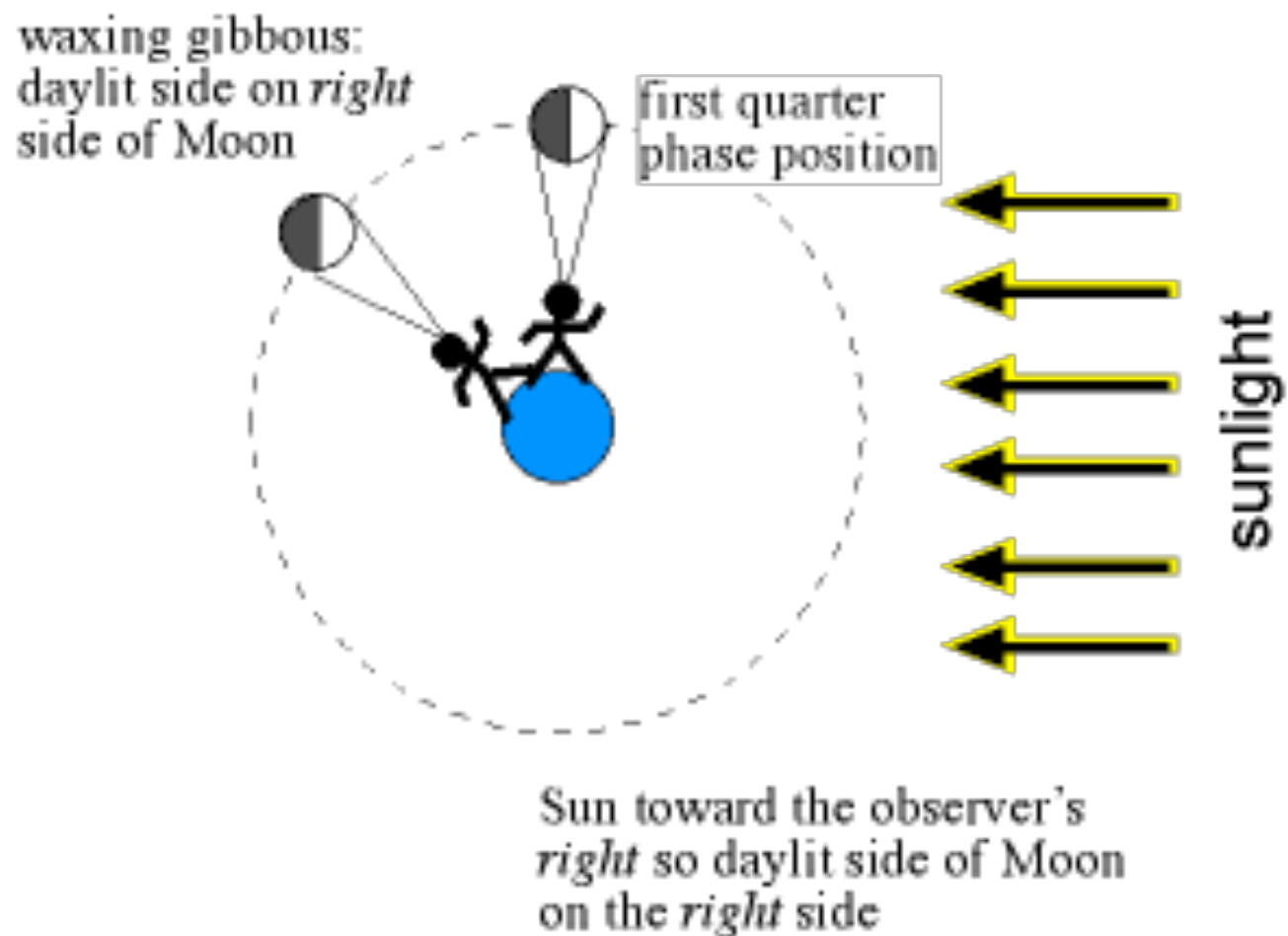


Lunar phases are caused by the relative positioning of the Earth, Moon, and Sun

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The figure shows that as the Moon orbits the Earth, the fraction of its illuminated side that you can see from the Earth changes. From high above the Earth and Moon orbit, you can see that the Moon is always half lit by the Sun and the lit half (the illuminated side, or day side) always faces the light source---the Sun. The other half (night side) faces away from the Sun. The outer ring of Moon pictures in various phases is the view of the Moon as we would see it from the Earth. Of course, this drawing is not to scale.

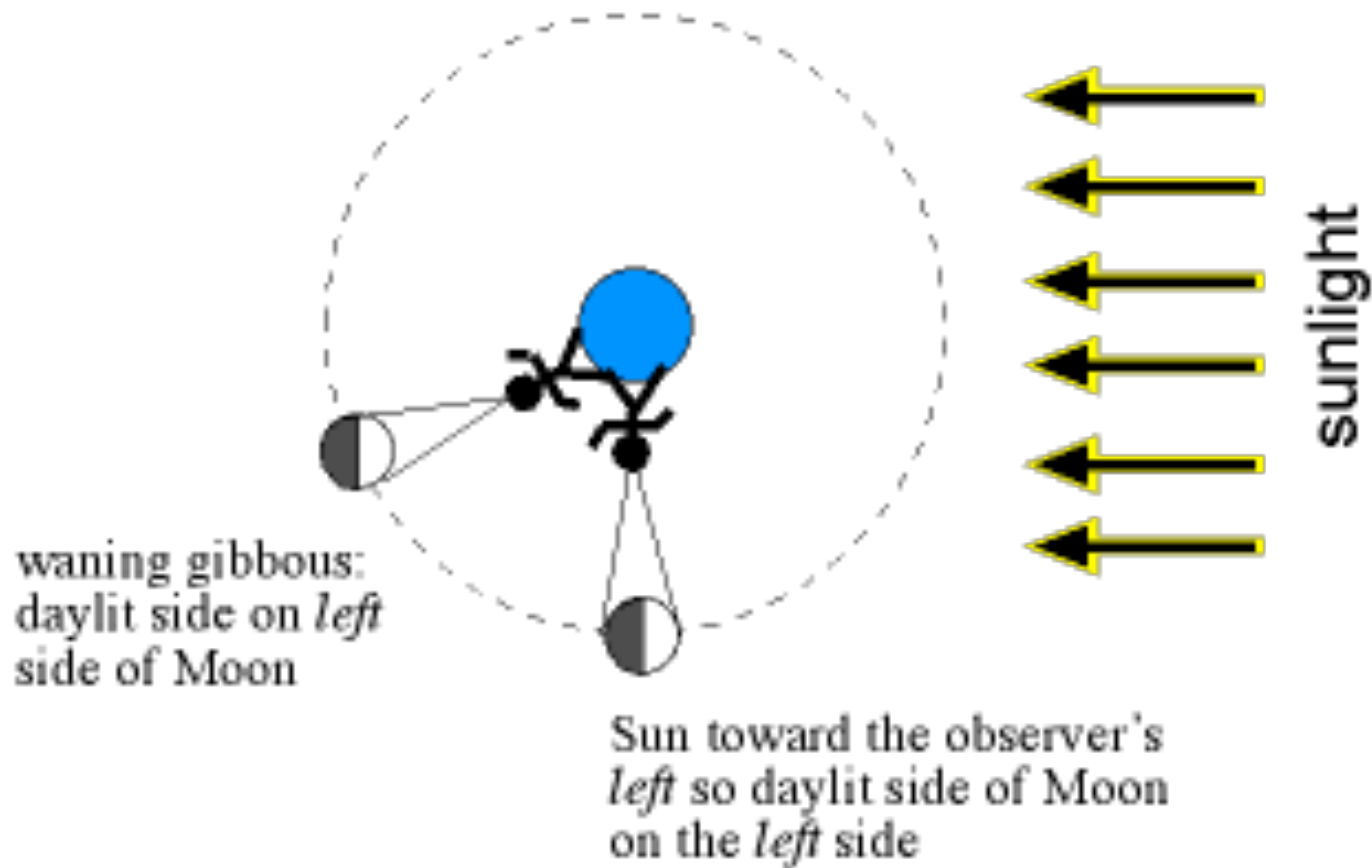
Waxing Phases



Waxing phases have the daylit side on the *right*

If the amount of illuminated side you can see increases with time, it is waxing as in waxing crescent or waxing gibbous. The daylit side of the Moon will be facing the right.

Waning Phases



Waning phases have the daylit side on the *left*

If the illuminated fraction decreases with time, it is waning as in waning crescent or waning gibbous. The daylit side of the Moon will be facing the left.

i>clicker question

In the picture below, the phase of the Moon is...

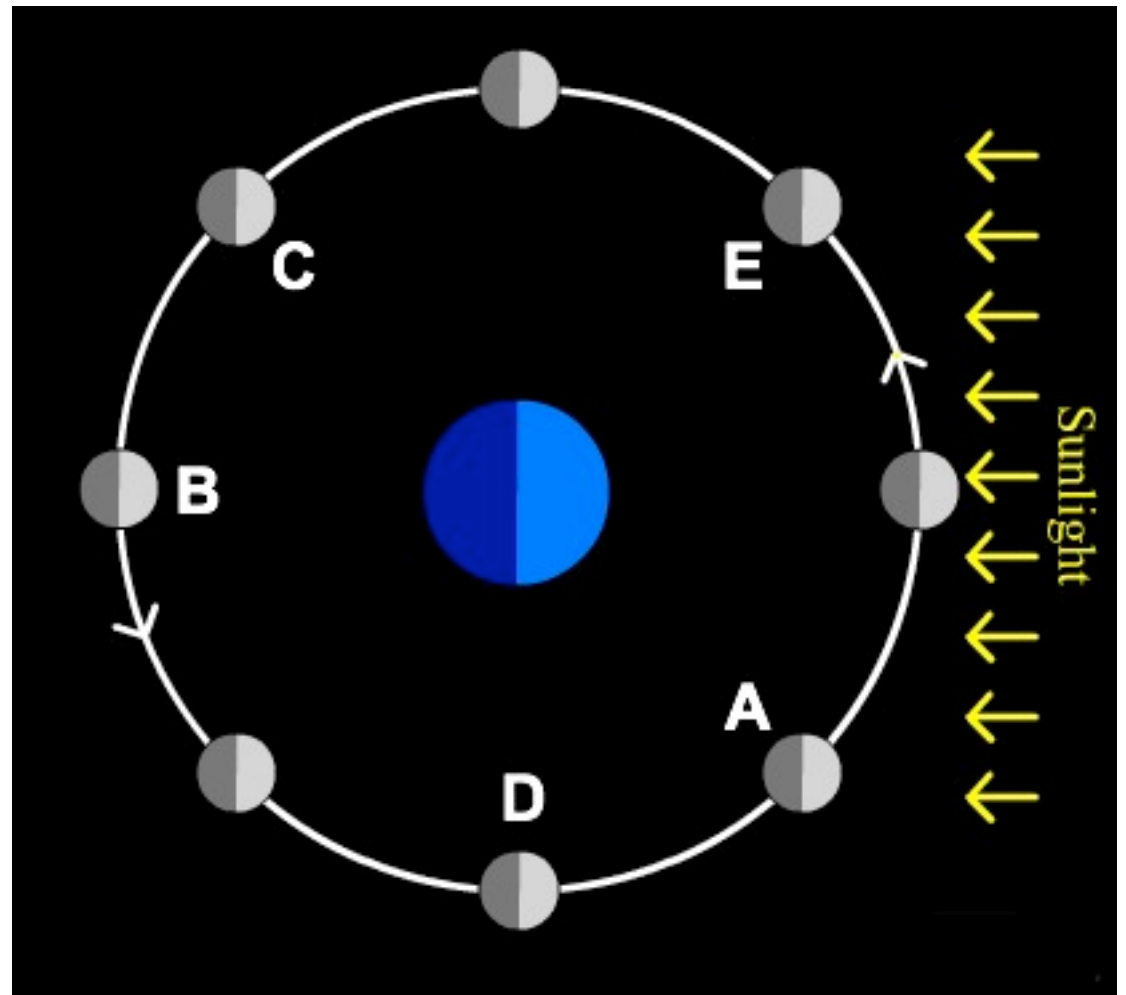
- A. third quarter
- B. full
- C. waning gibbous
- D. waning crescent
- E. first quarter



iClicker question

Moon shown in eight positions in its orbit.

Which letter position corresponds to a waxing crescent moon?



Answer E



Questions?