

ASTR/PHYS 1060: The Universe

Chapter 2: Celestial Sphere, Seasons, Moon Phases and Eclipses

Name for the Class Llama

(last year's options)



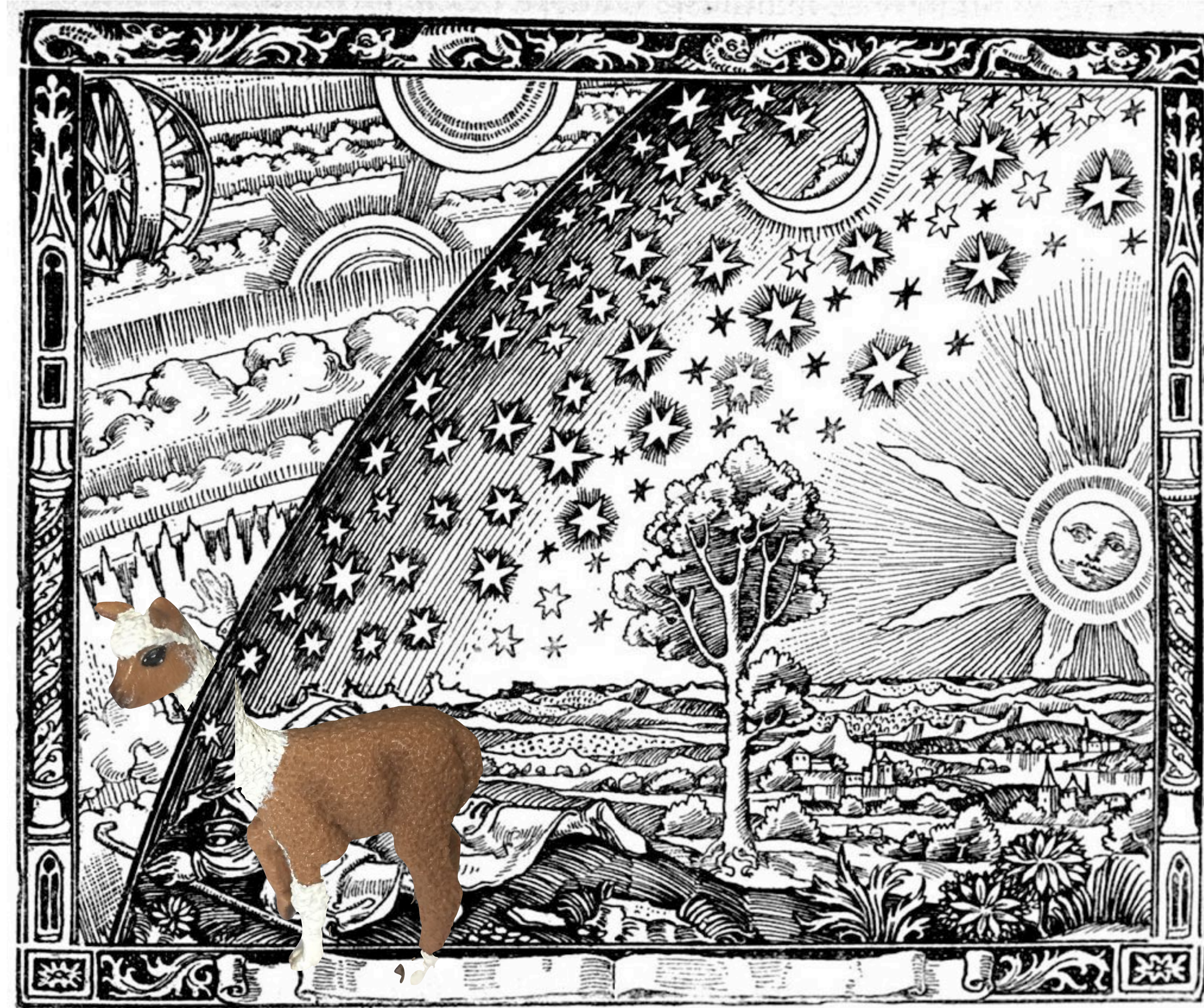
- A) Sir Jeffrey McGoat, Esq.
- B) Space Ranger Goat
- C) Gerald “The Space Odyssey” Goat Llama
- D) Goaterade / Goaty McGoatFace

Name for the Class Llama

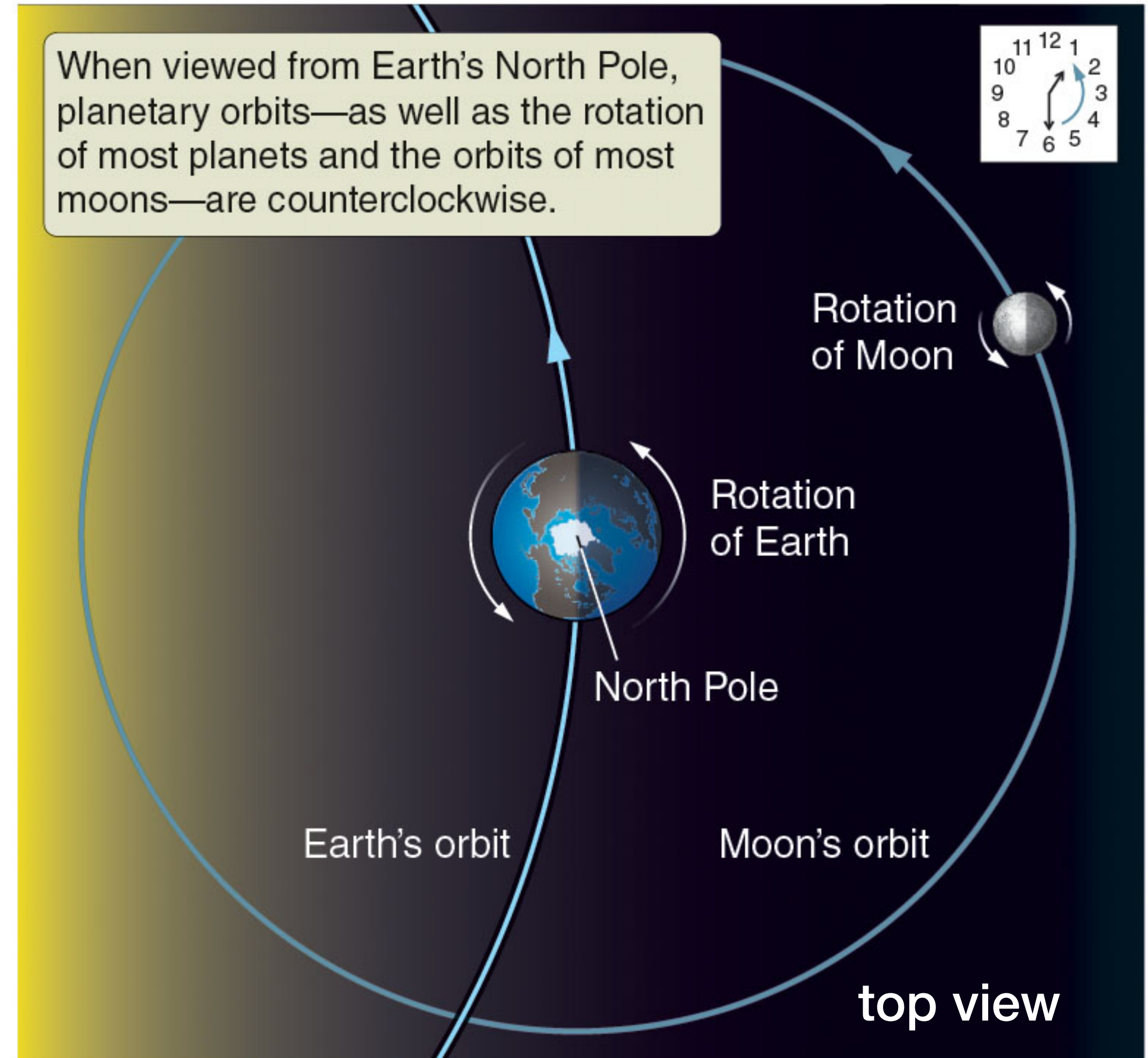
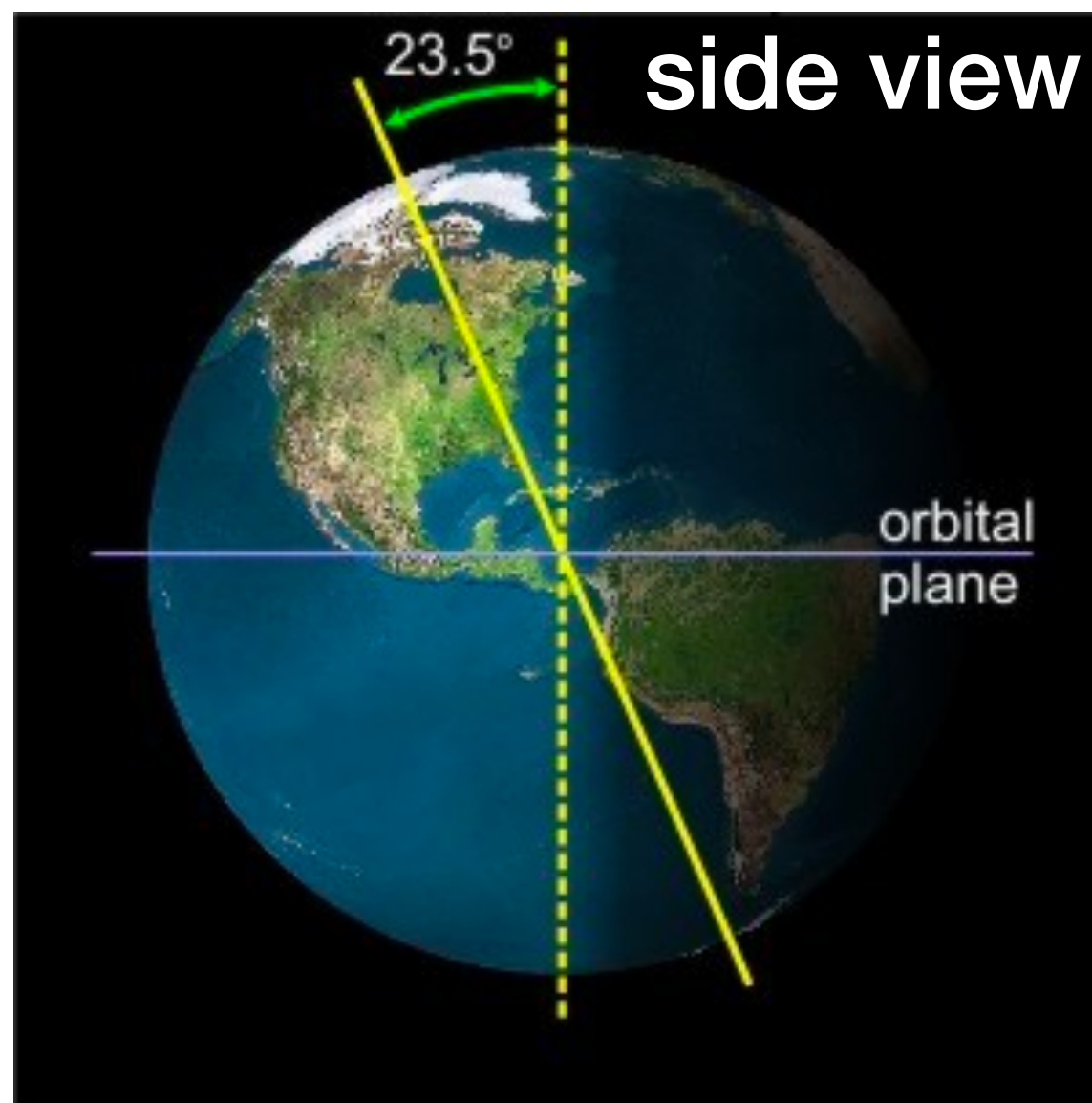
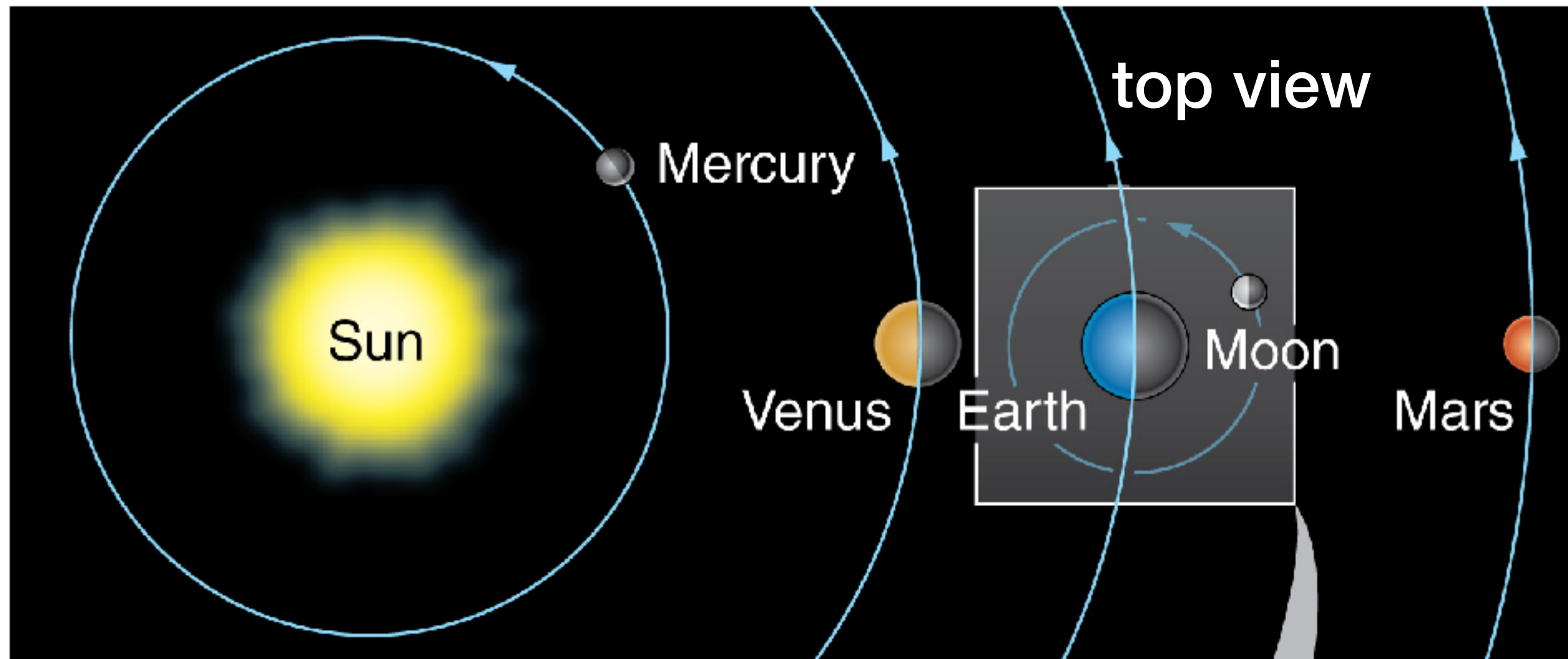
- A) Keanu Llama / John Wick
- B) Bob Lazar
- C) Cuzco Emperor of the Universe
- D) the G.O.A.T.



Orienting Ourselves on the Earth



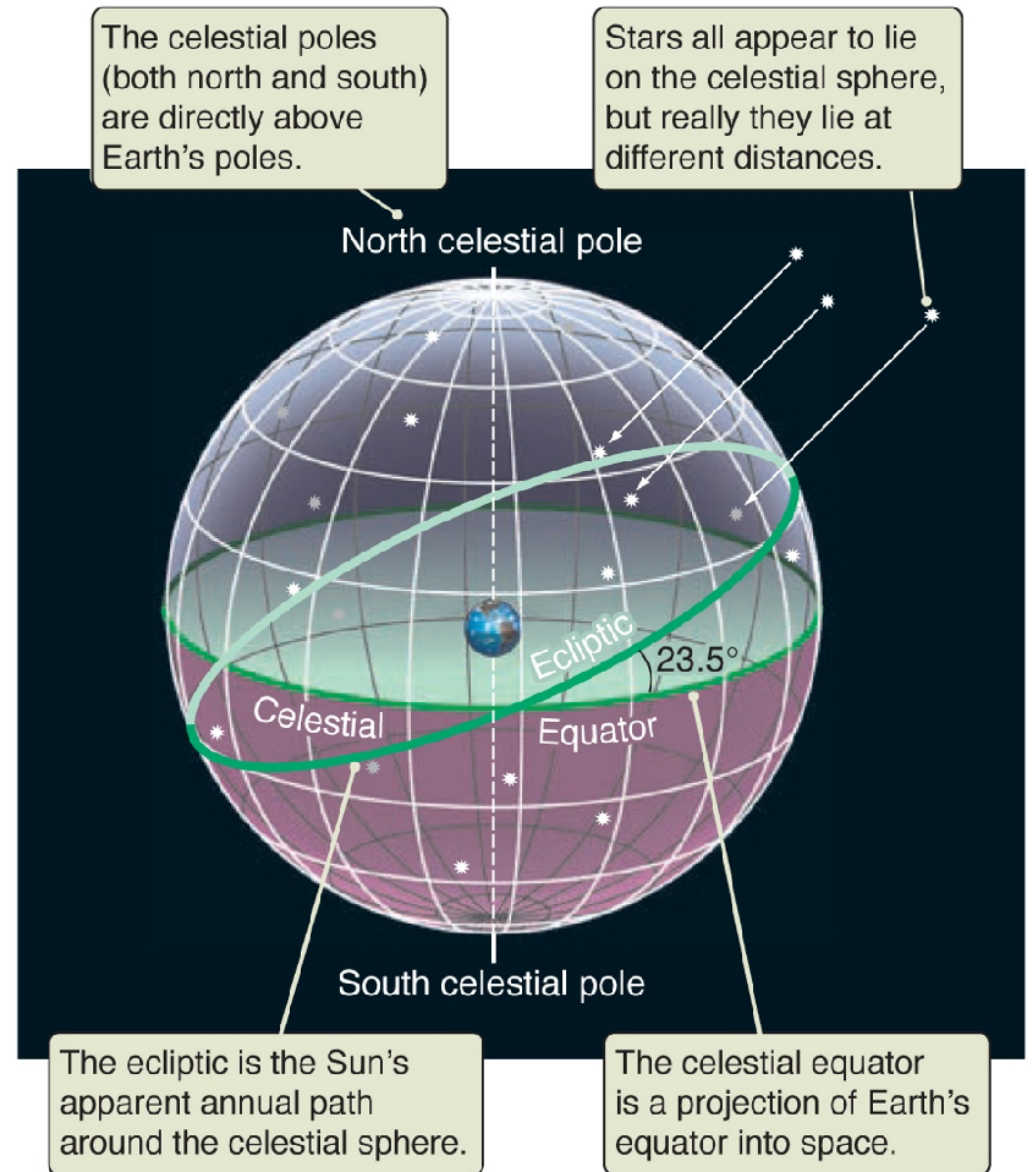
It's all just geometry and timing



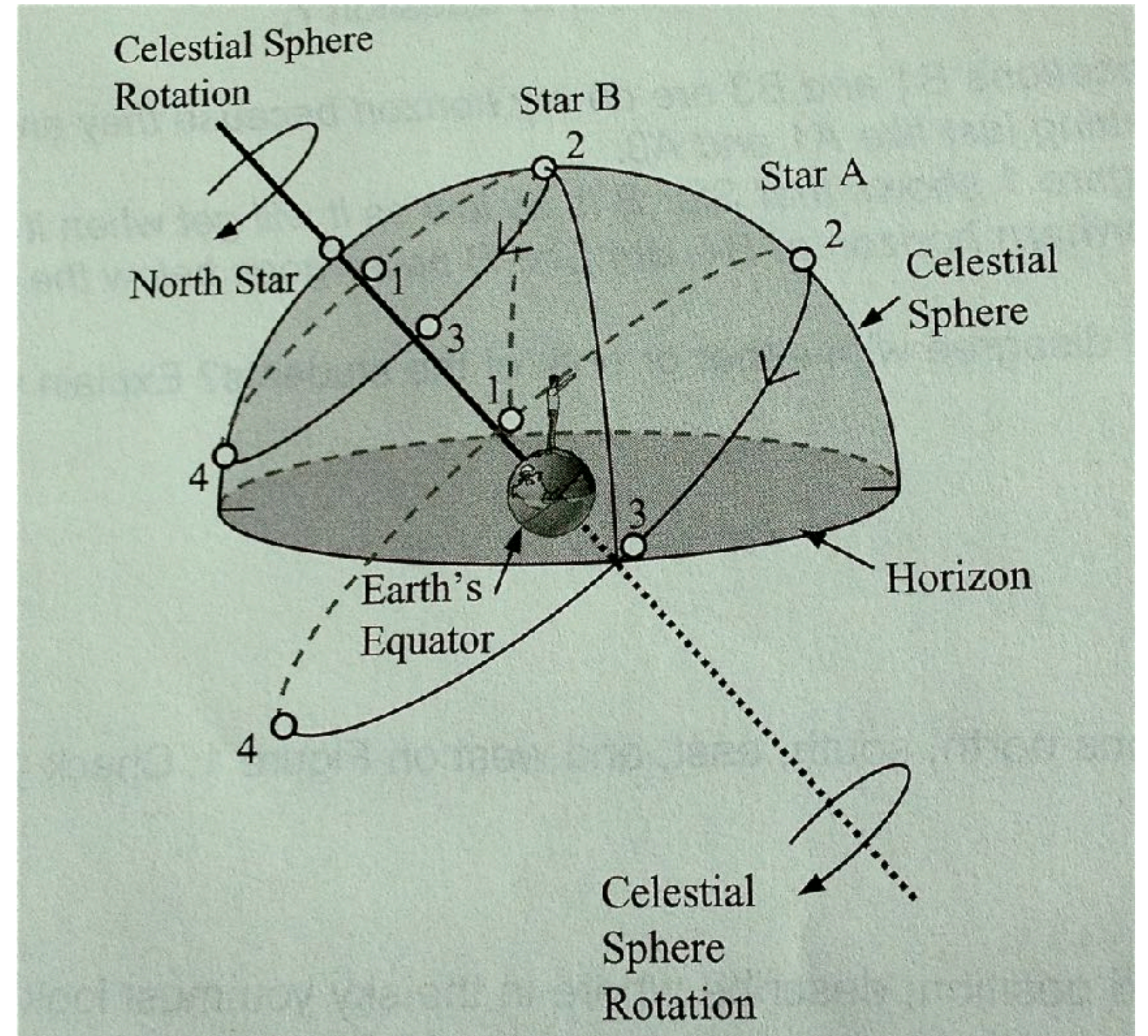
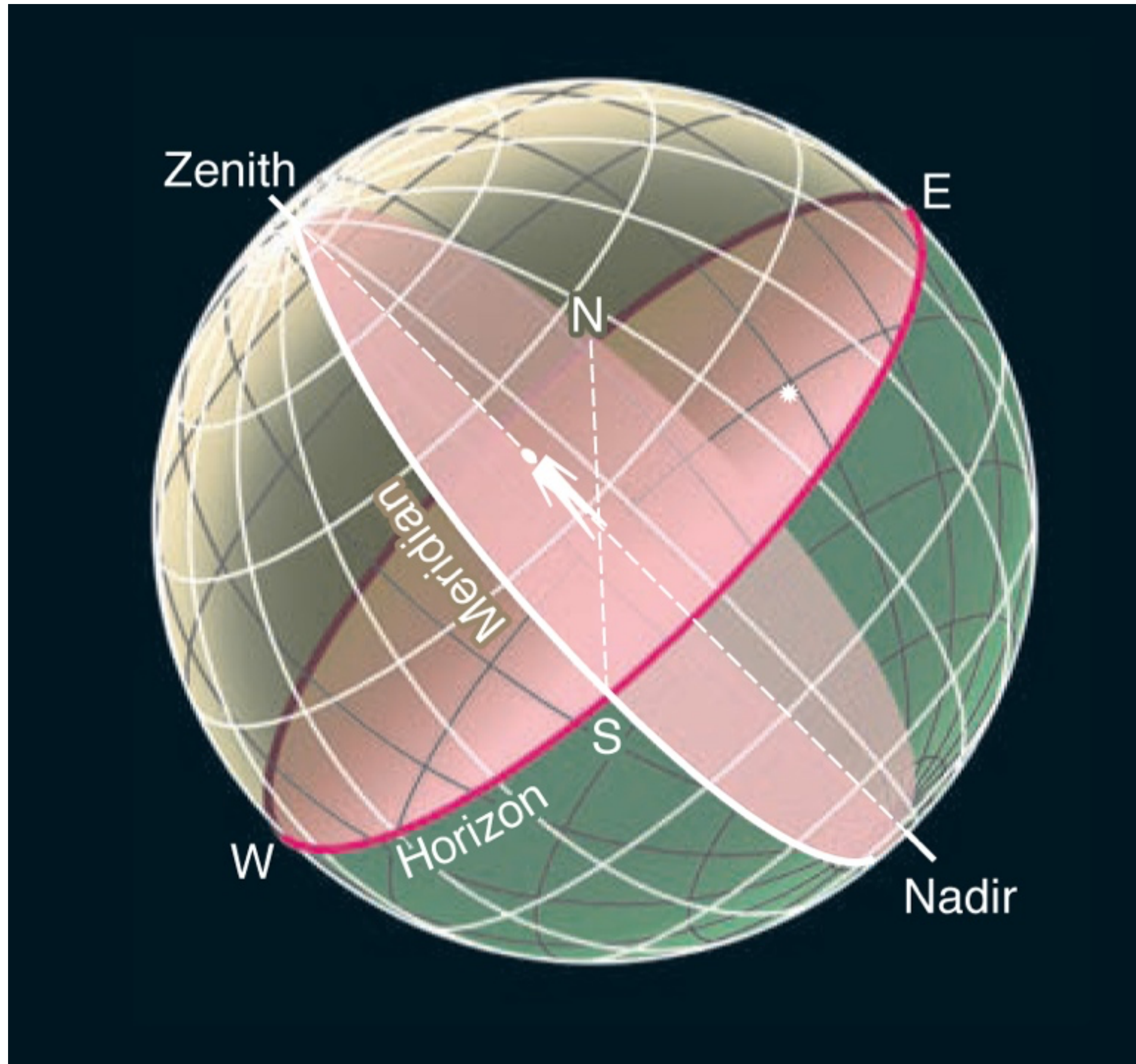
Important Points & Planes on the Celestial Sphere

Project stars and planets on a sphere surrounding the Earth

It is fictitious, but convenient for locating objects in the sky



Orienting Yourself relative to the Celestial Sphere





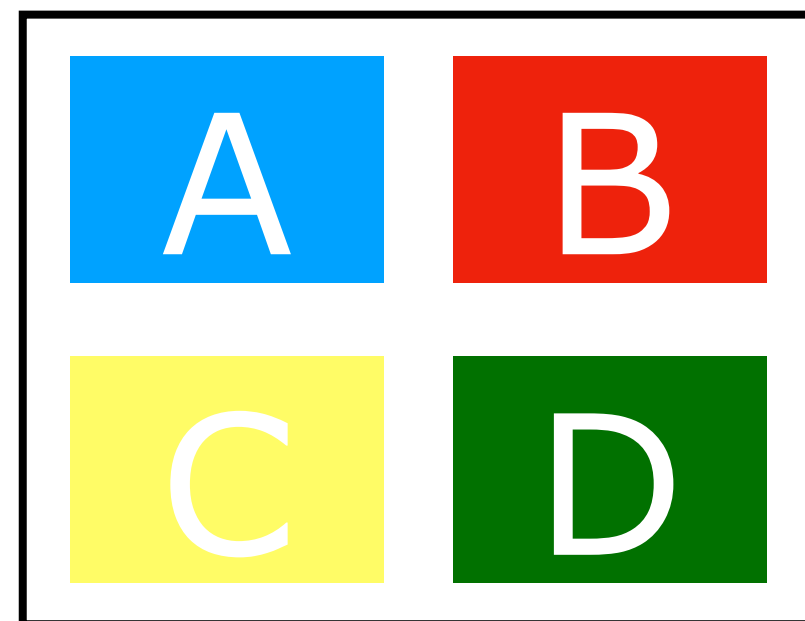
<https://www.youtube.com/watch?v=IJhgZBn-LHg>

(Vsauce)

ASTR/PHYS 1060: The Universe

Chapter 2: Celestial Sphere, Seasons, Moon Phases and Eclipses

Grab an ABCD page up front if
you don't have one



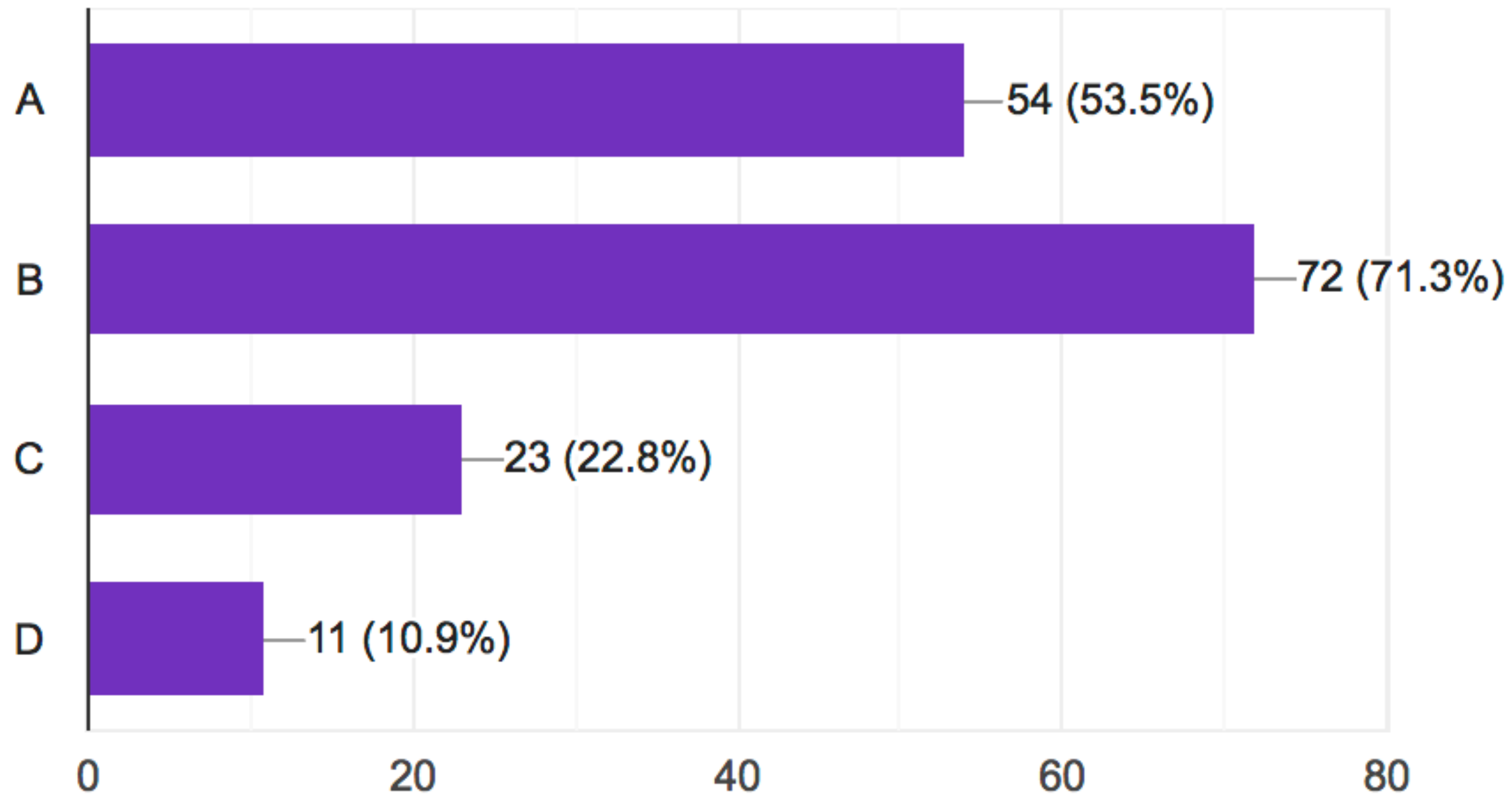
(Hint: it looks like this)

Ch. 3 Reading Quiz to be completed in Canvas
due by 9:10am on Thursday

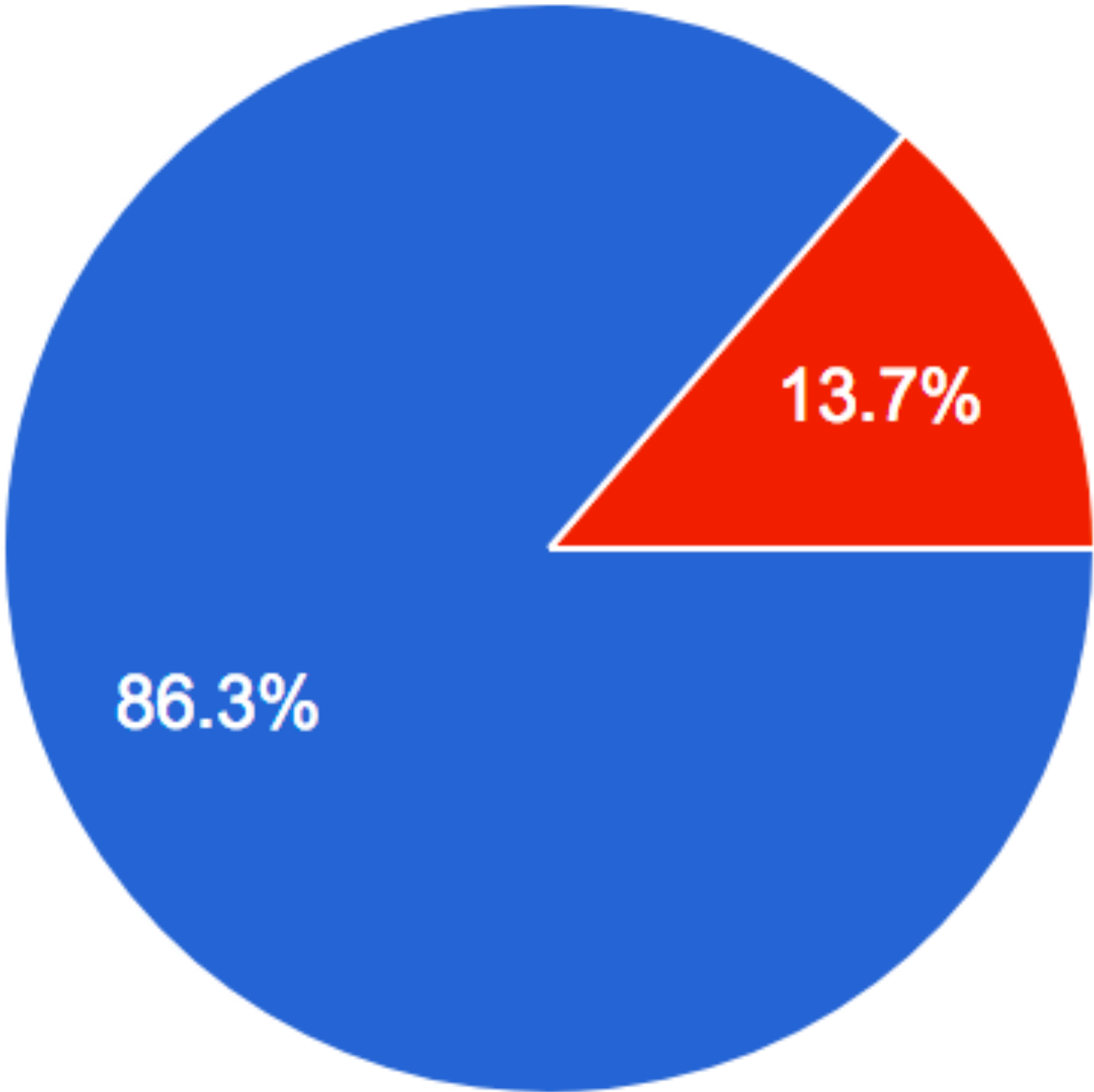
First HW posted on website under:
[http://www.astro.utah.edu/~wik/courses/astr1060fall2019/
homework.html](http://www.astro.utah.edu/~wik/courses/astr1060fall2019/homework.html)

My primary reason for taking this course is...

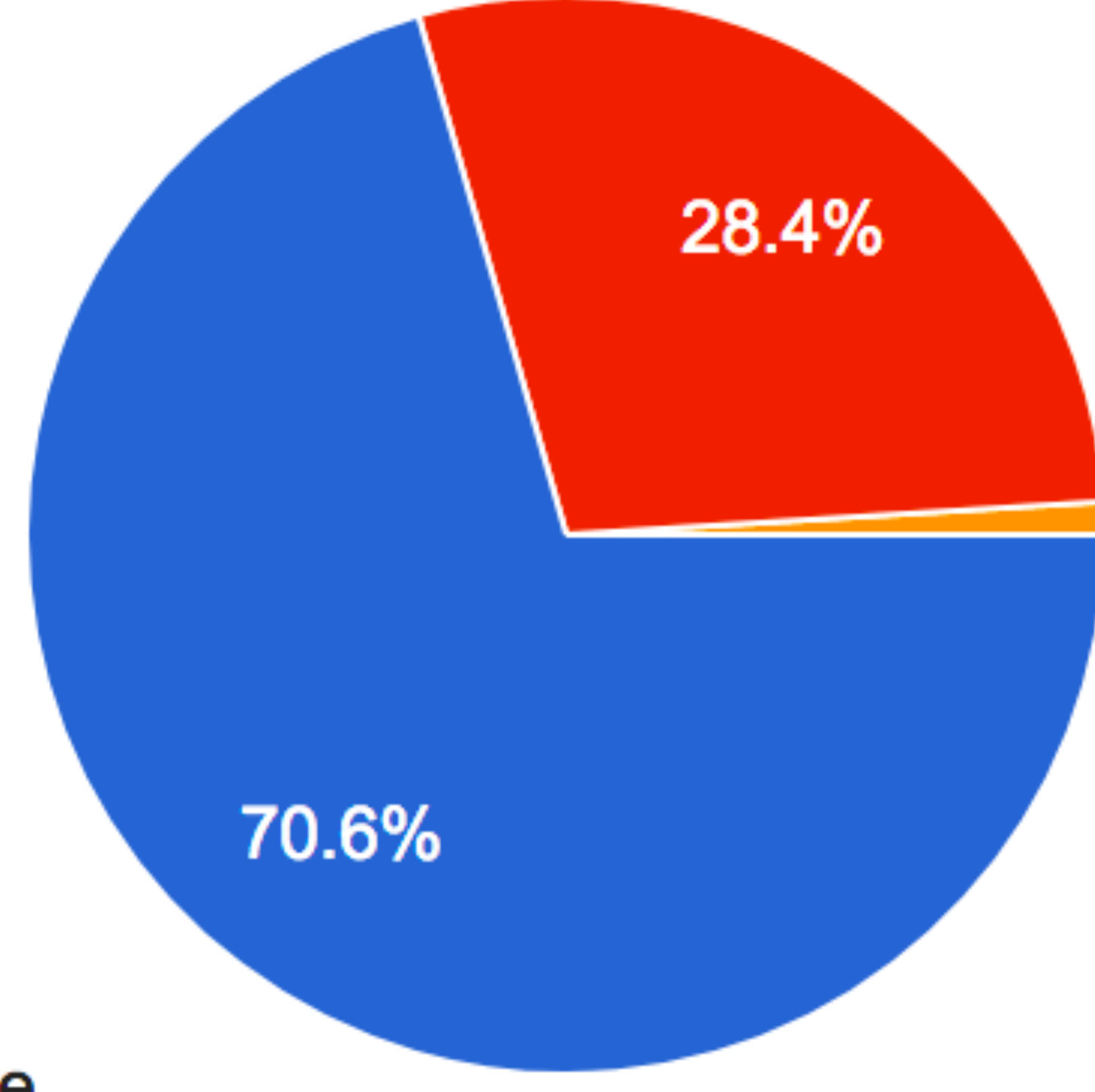
- A) I need to satisfy my Physical/Life Science Exploration requirement.
- B) I thought the topic looked interesting.
- C) The course fit into my schedule.
- D) Other: _____



I have looked through a telescope

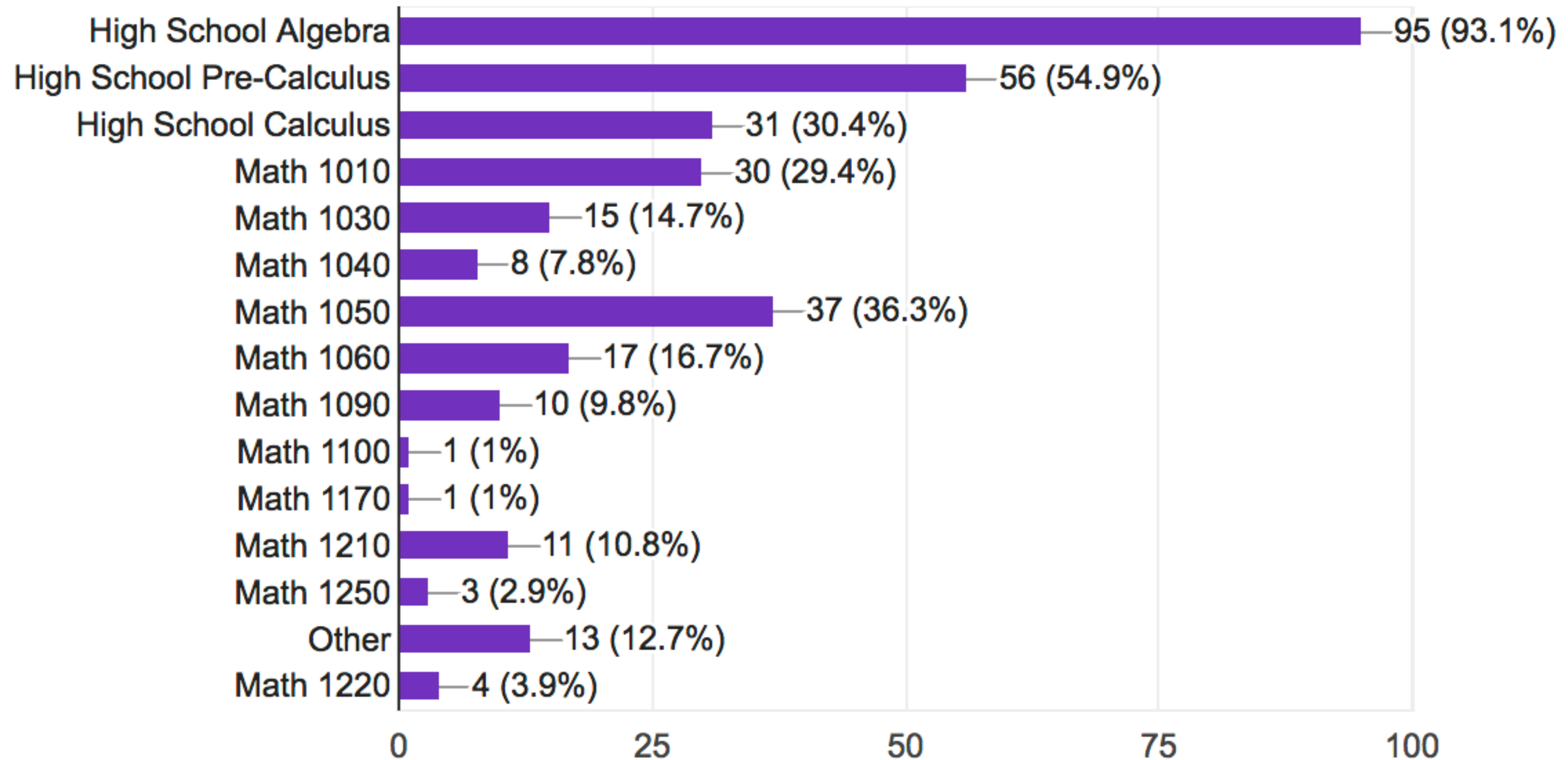


I have seen the Milky Way

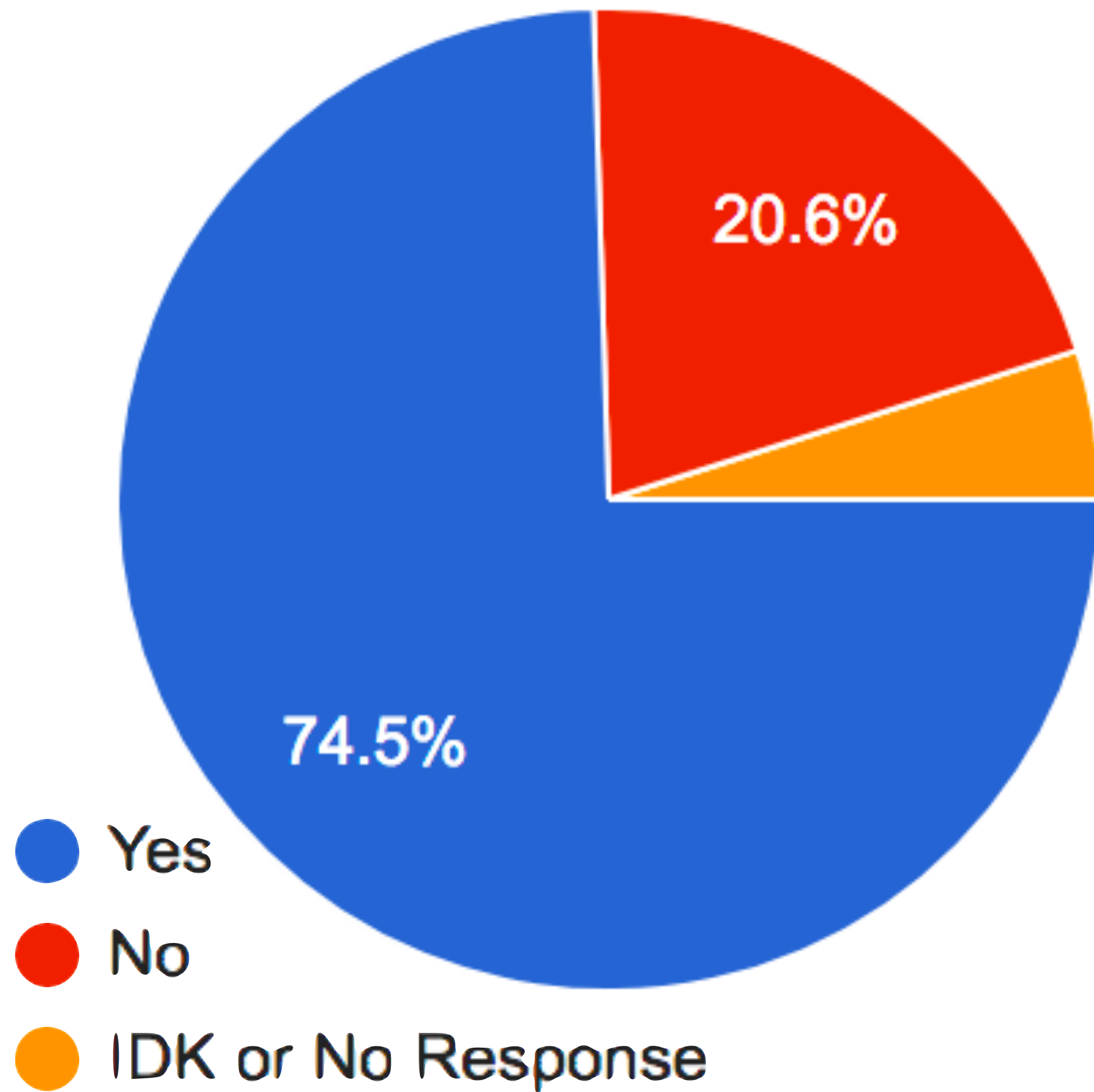


- Yes
- No
- IDK or No response

Math Courses Previously Taken

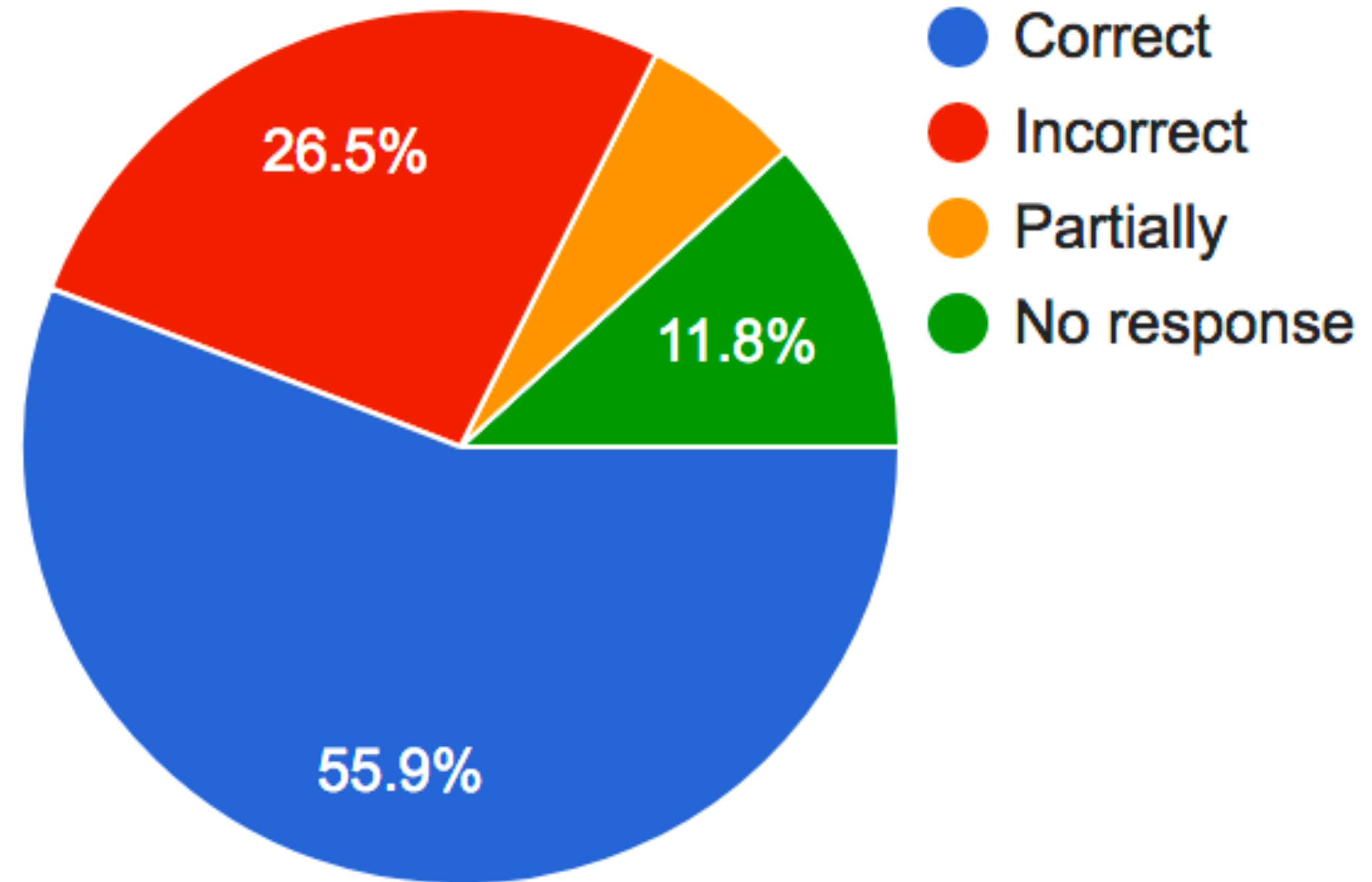


I am pretty good at algebra

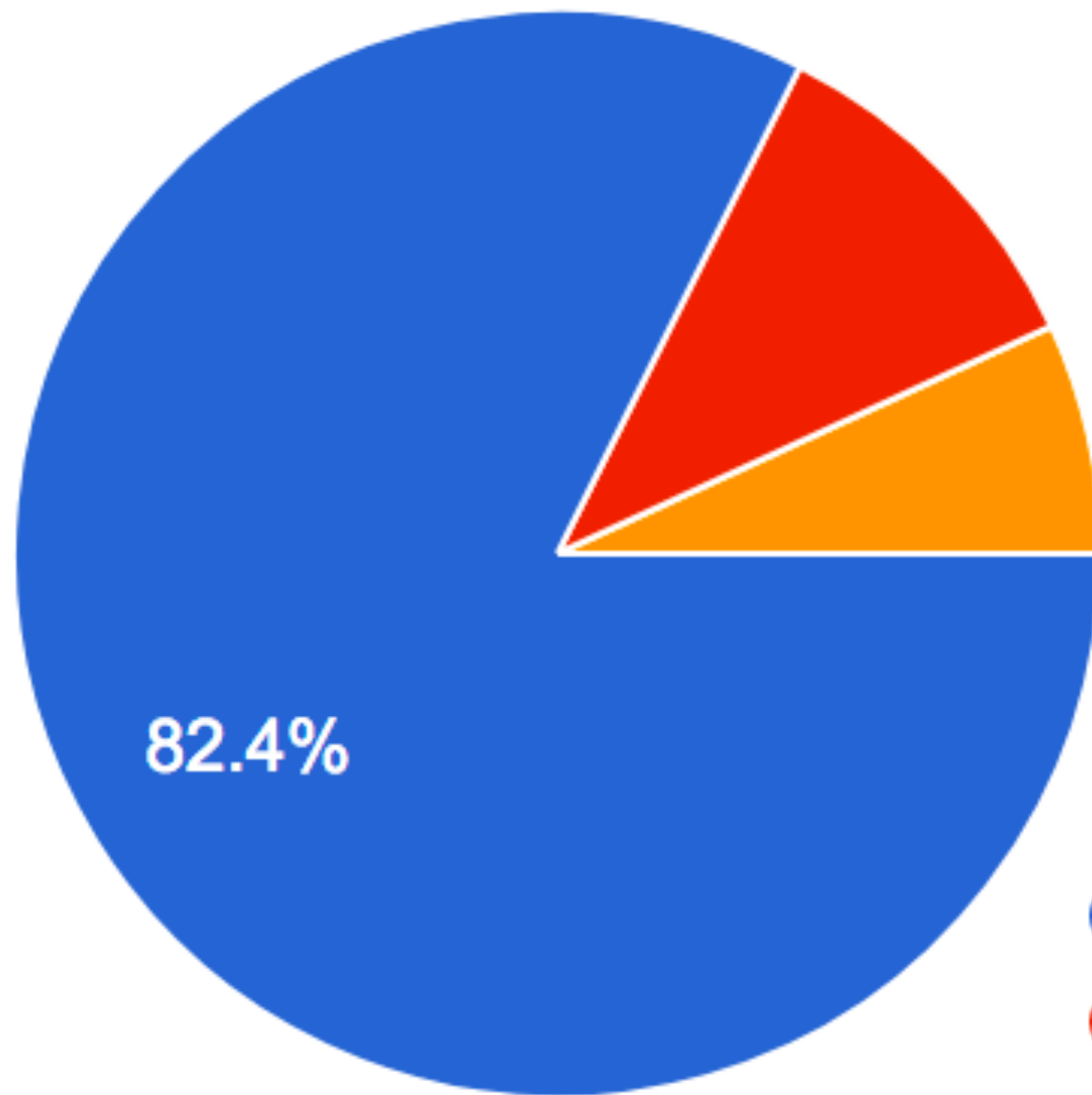


$$F = \frac{9}{5} \times C + 32, \text{ where } F = 50$$

The value of C is...

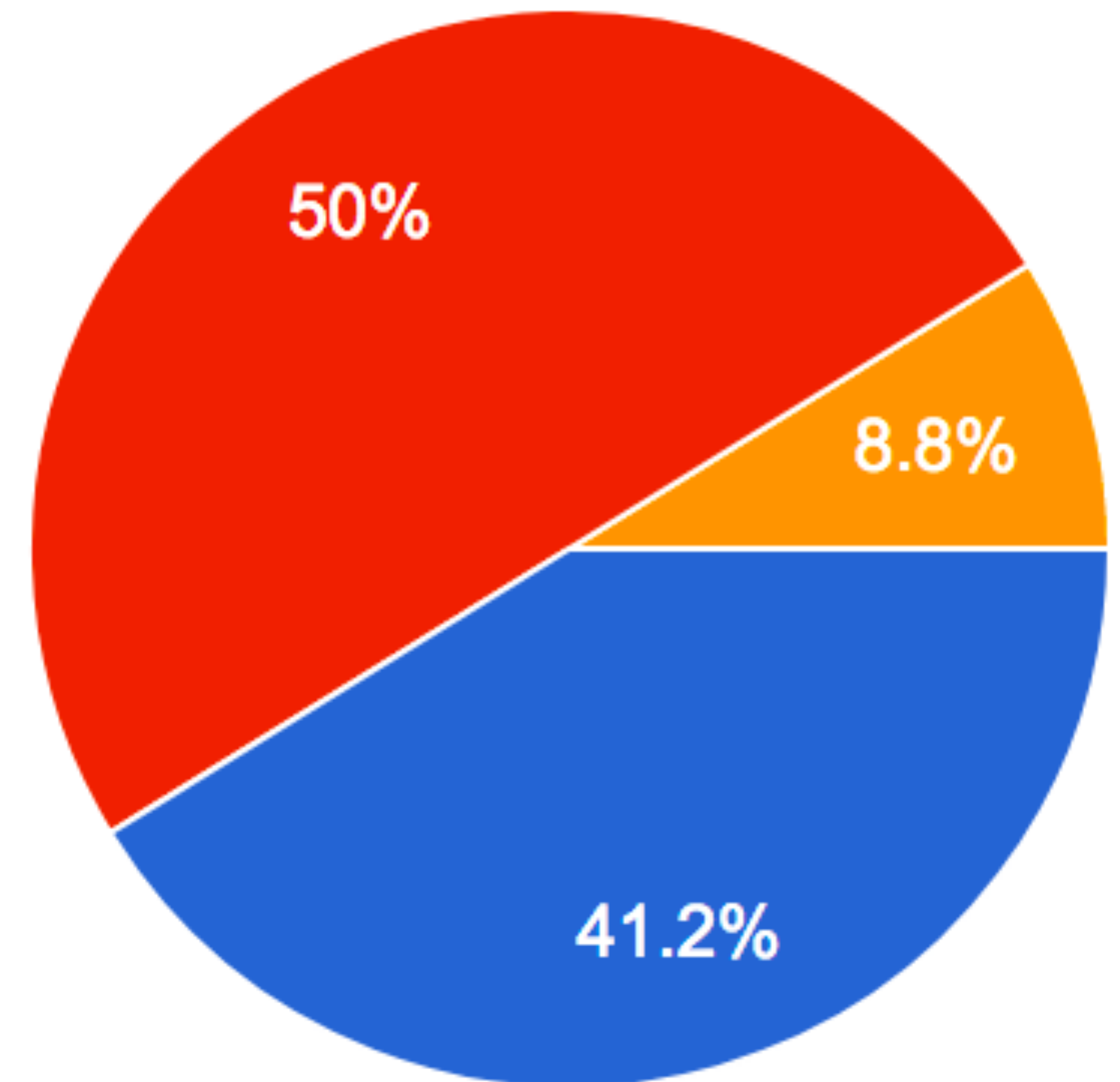


I believe that intelligent extraterrestrials exist



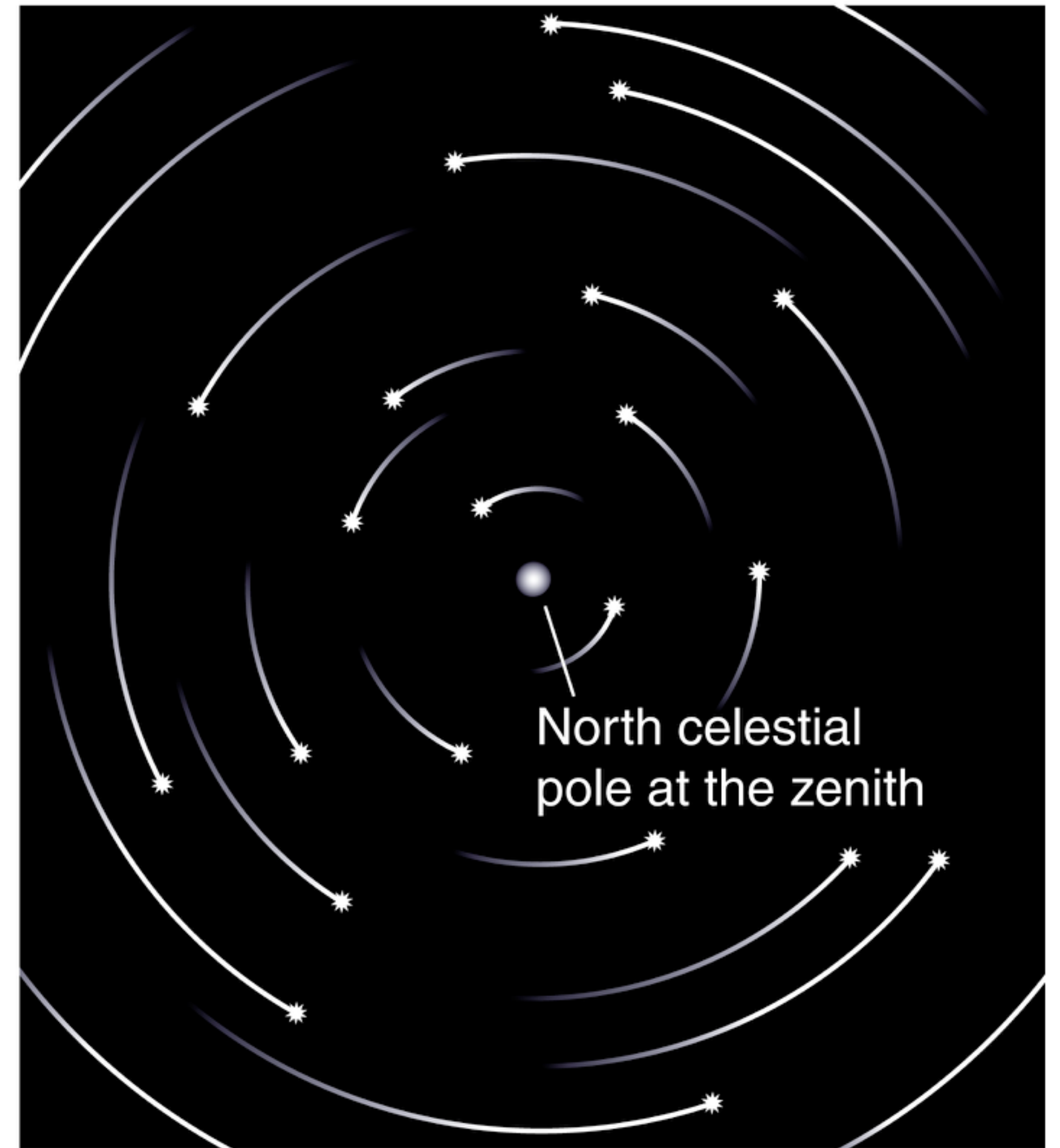
- Yes
- No
- IDK or No response

I believe Earth has been visited by aliens



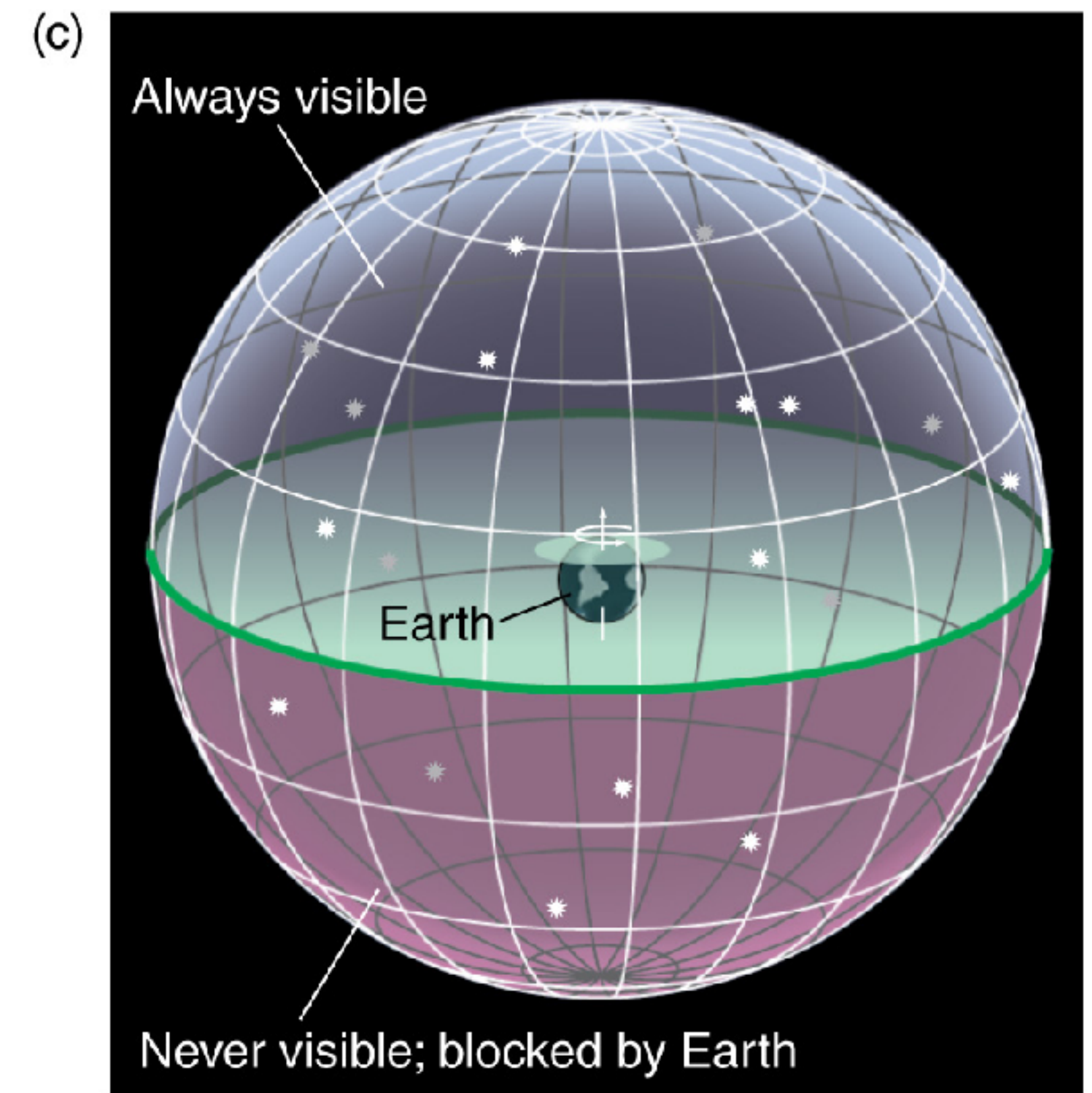
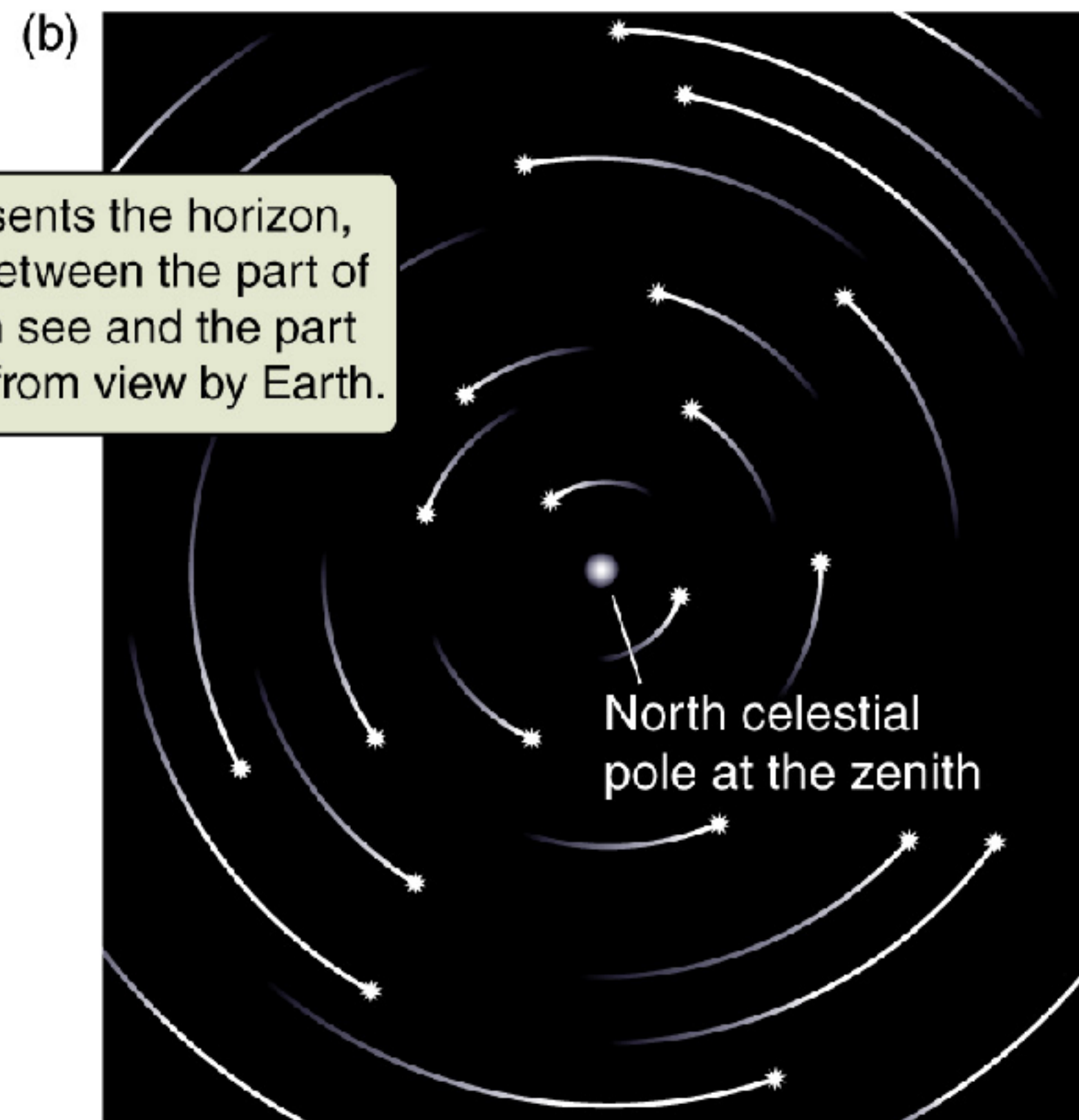
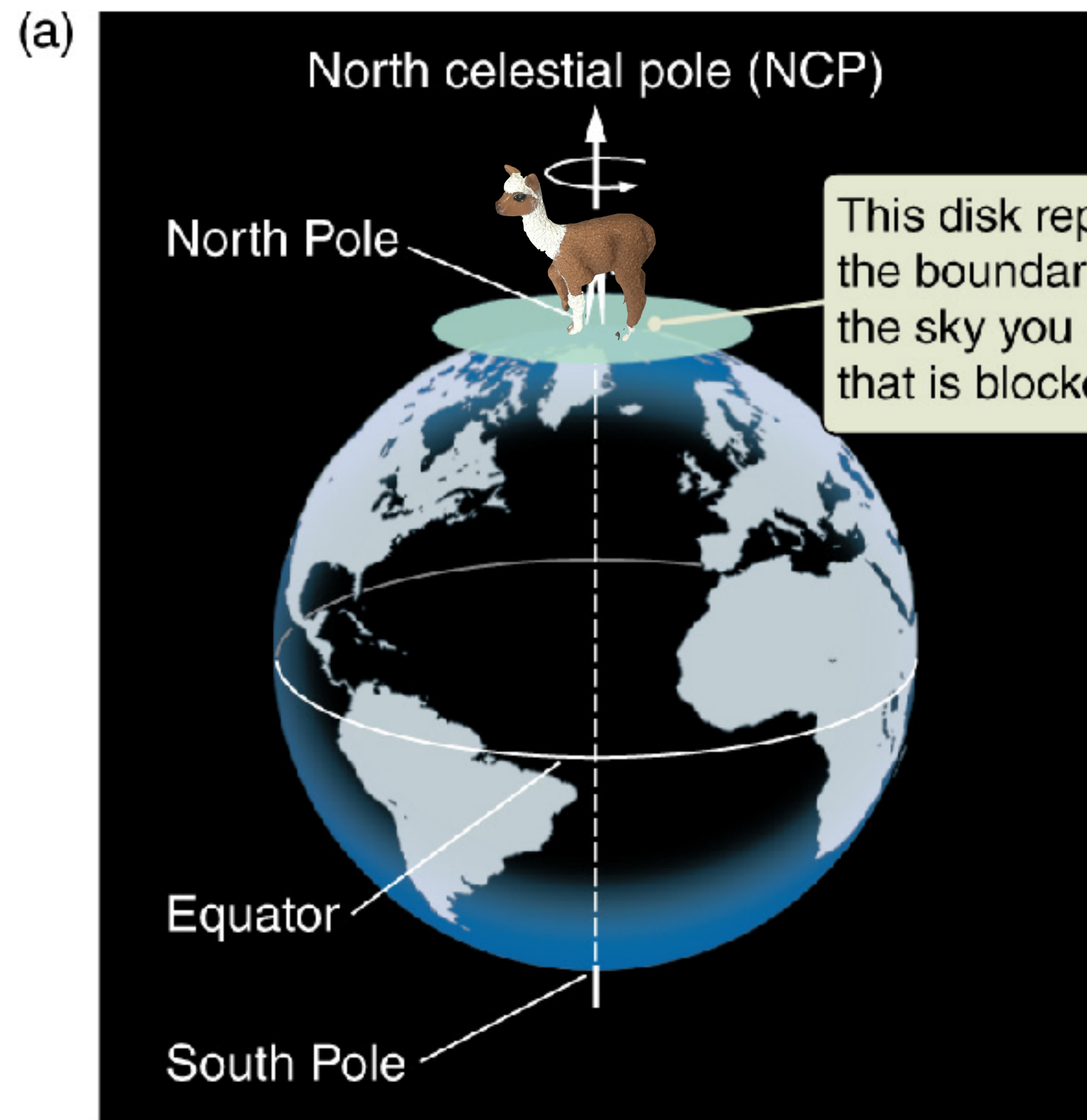
If the north star is directly above Cuzco, Emperor of the Universe, (at their zenith), where are you on the Earth?

- A) North Pole
- B) Anywhere on the Equator
- C) Exactly at 0 degrees longitude on the Equator
- D) South Pole



As Earth rotates, the stars appear to move in a counterclockwise direction around the **NCP**.

North Pole!

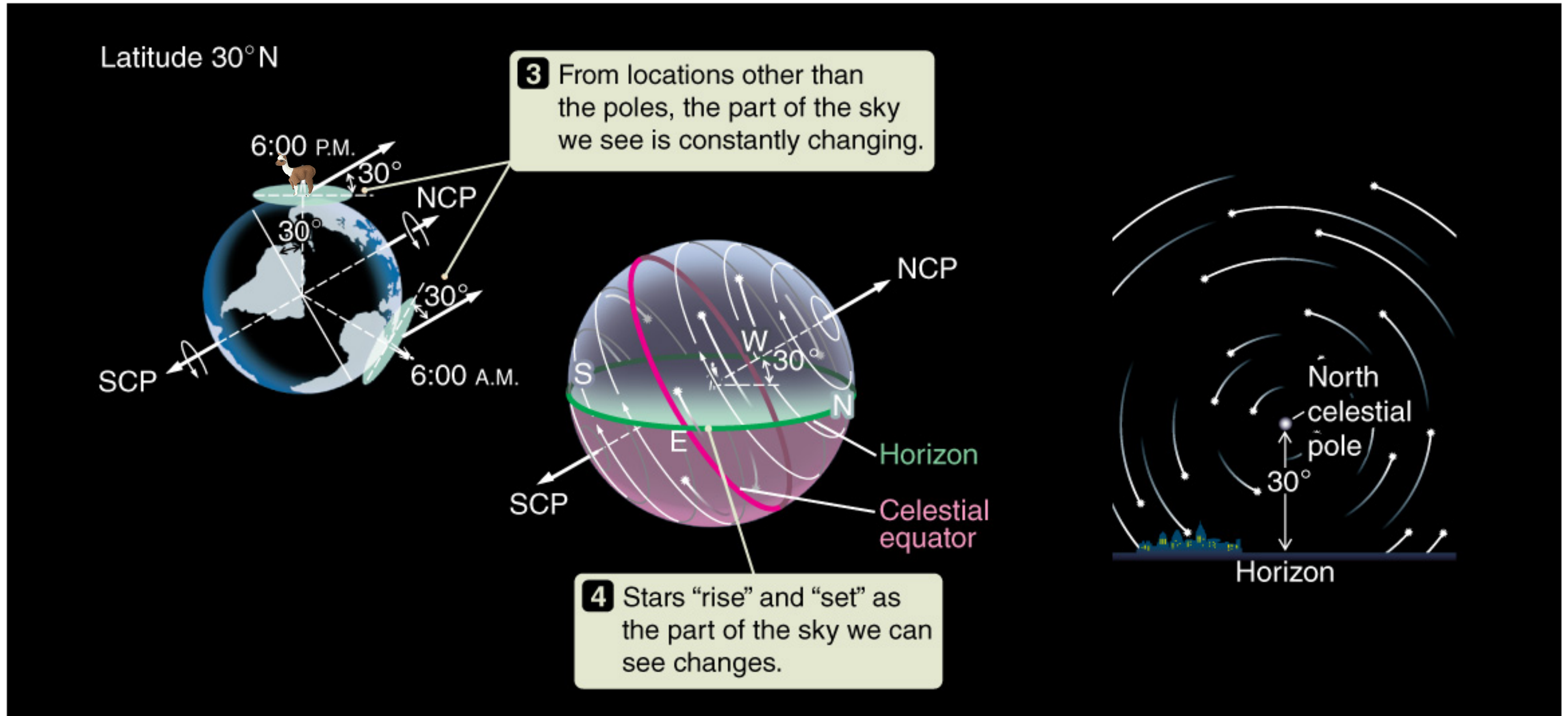


From the North Pole looking directly overhead, the **north celestial pole (NCP)** is at the zenith.

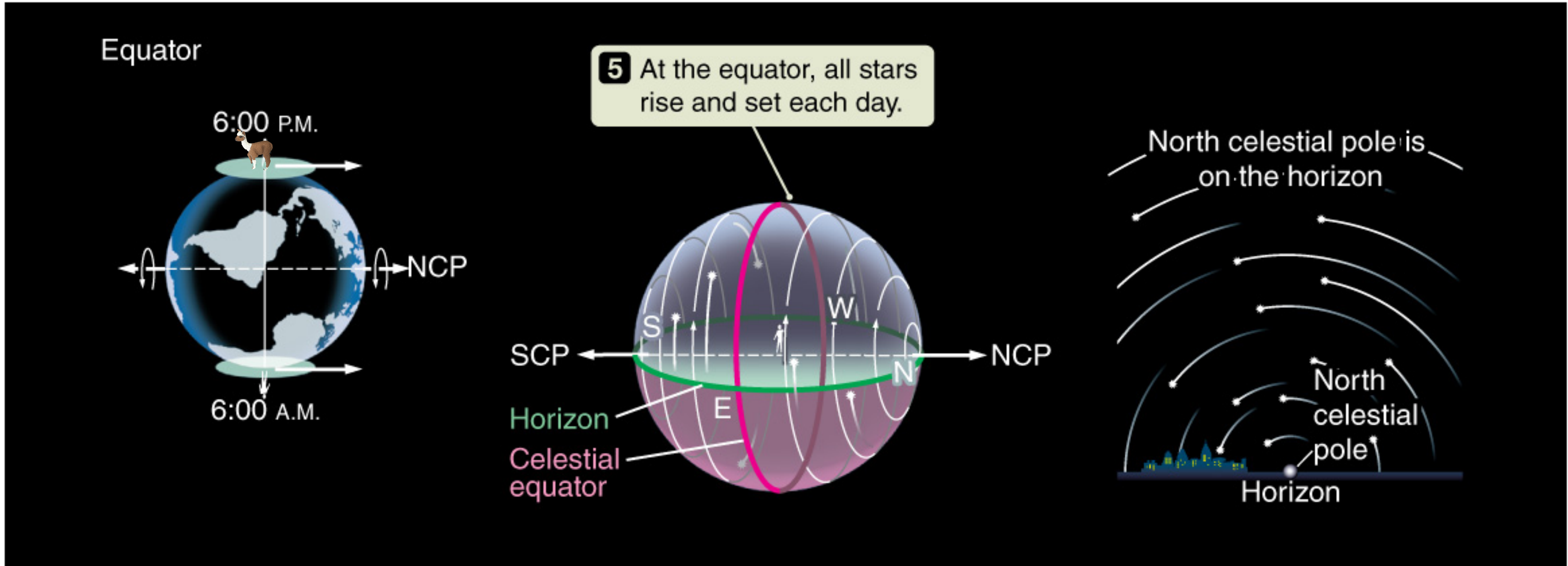
As Earth rotates, the stars appear to move in a counterclockwise direction around the **NCP**.

From the North Pole, you always see the same half of the sky.

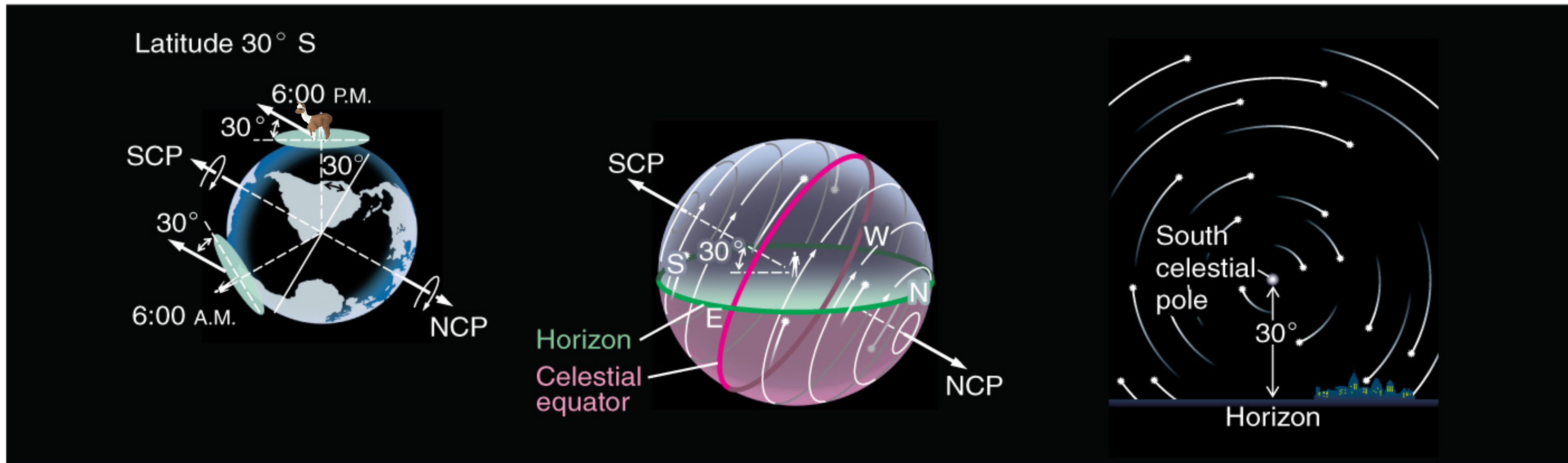
If you're 30 degrees north of the equator:



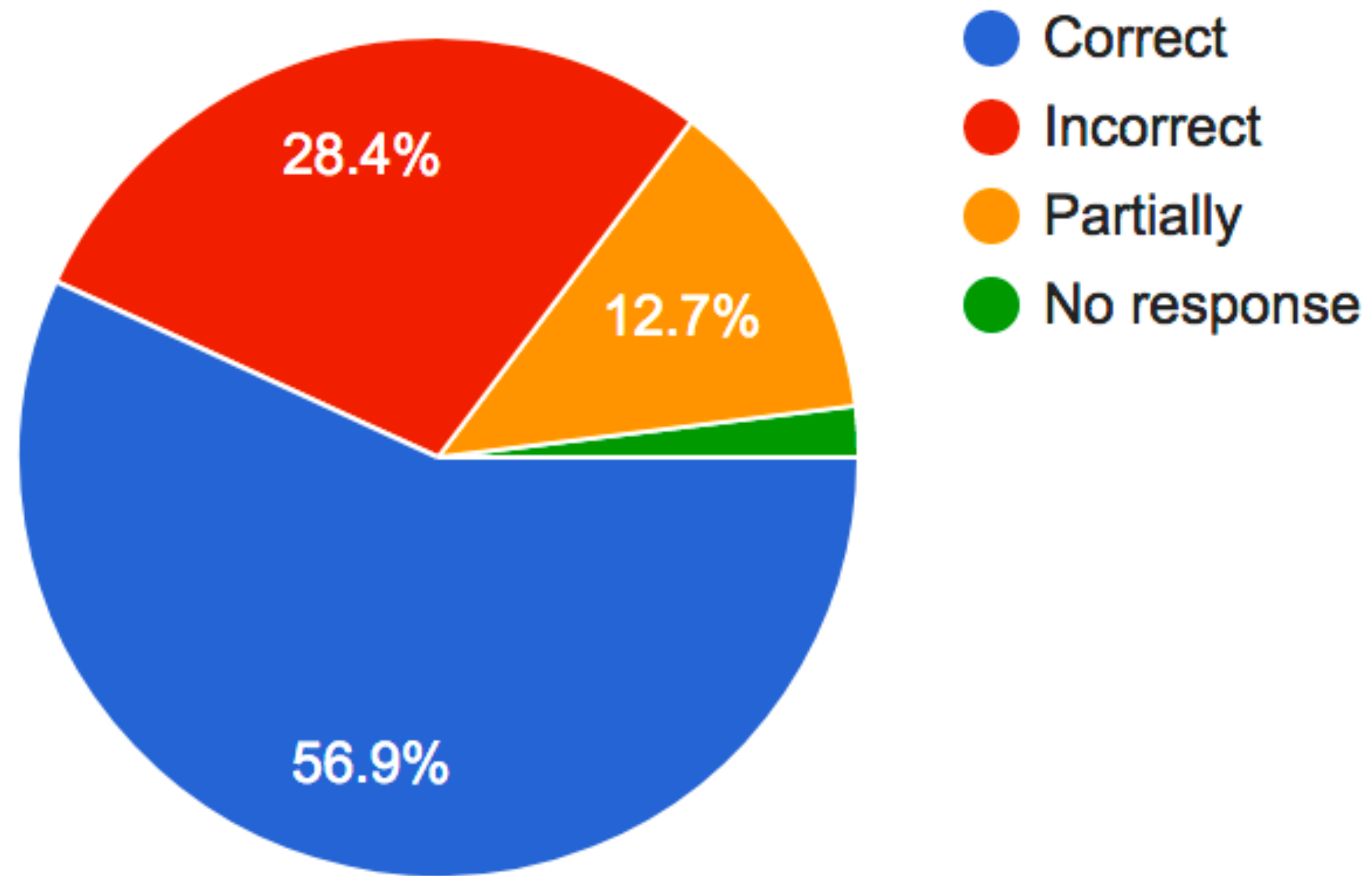
At the Equator, where you can see the entire sky:



Southern Hemisphere, same as in the north but relative to the South Celestial Pole



What causes the seasons?



A) Distance from the Sun

B) Tilt of the Earth

C) Distance from the Sun AND tilt of the Earth

In SLC, where does the Sun set on the horizon?

- A) Same place every day
- B) A random (but predictable) place each day
- C) A different place each day of the year
- D) A different place each day for half the year, then repeating that pattern in reverse the second half of the year

In a group, try to answer: On what days does the Sun set in these locations?

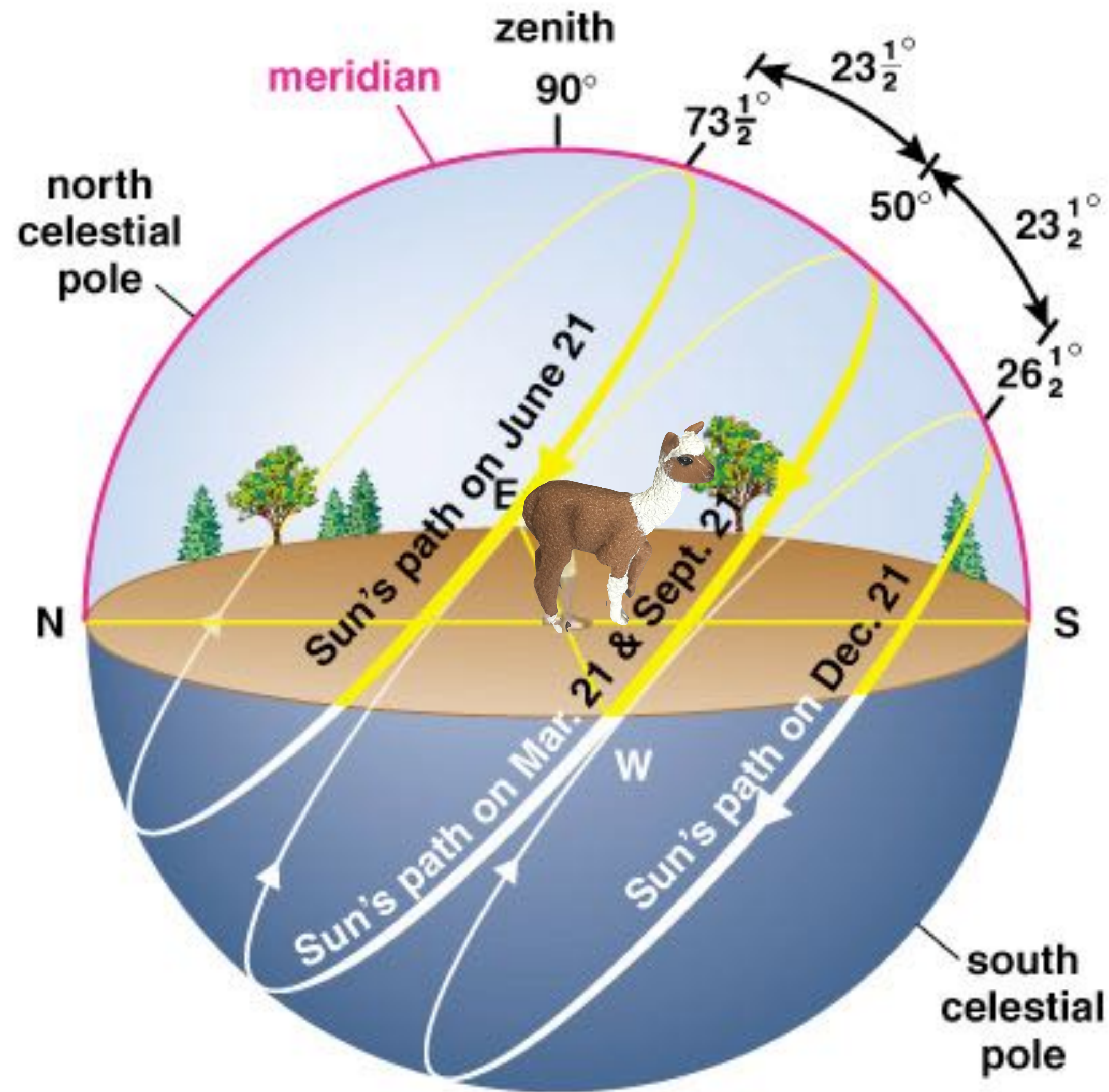


Winter Solstice
December 21st

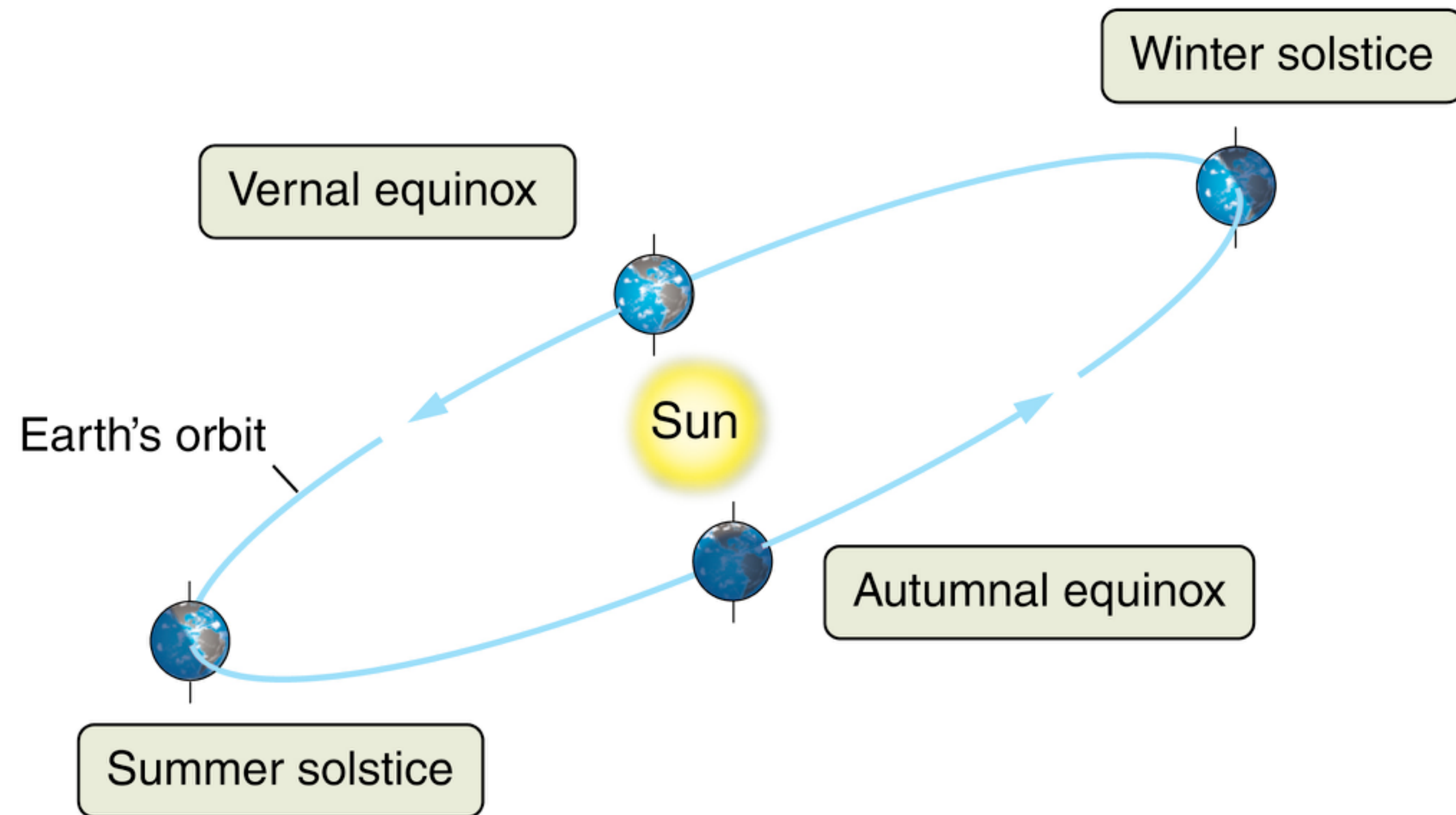
Fall/Spring Equinoxes
September 21st
March 20th

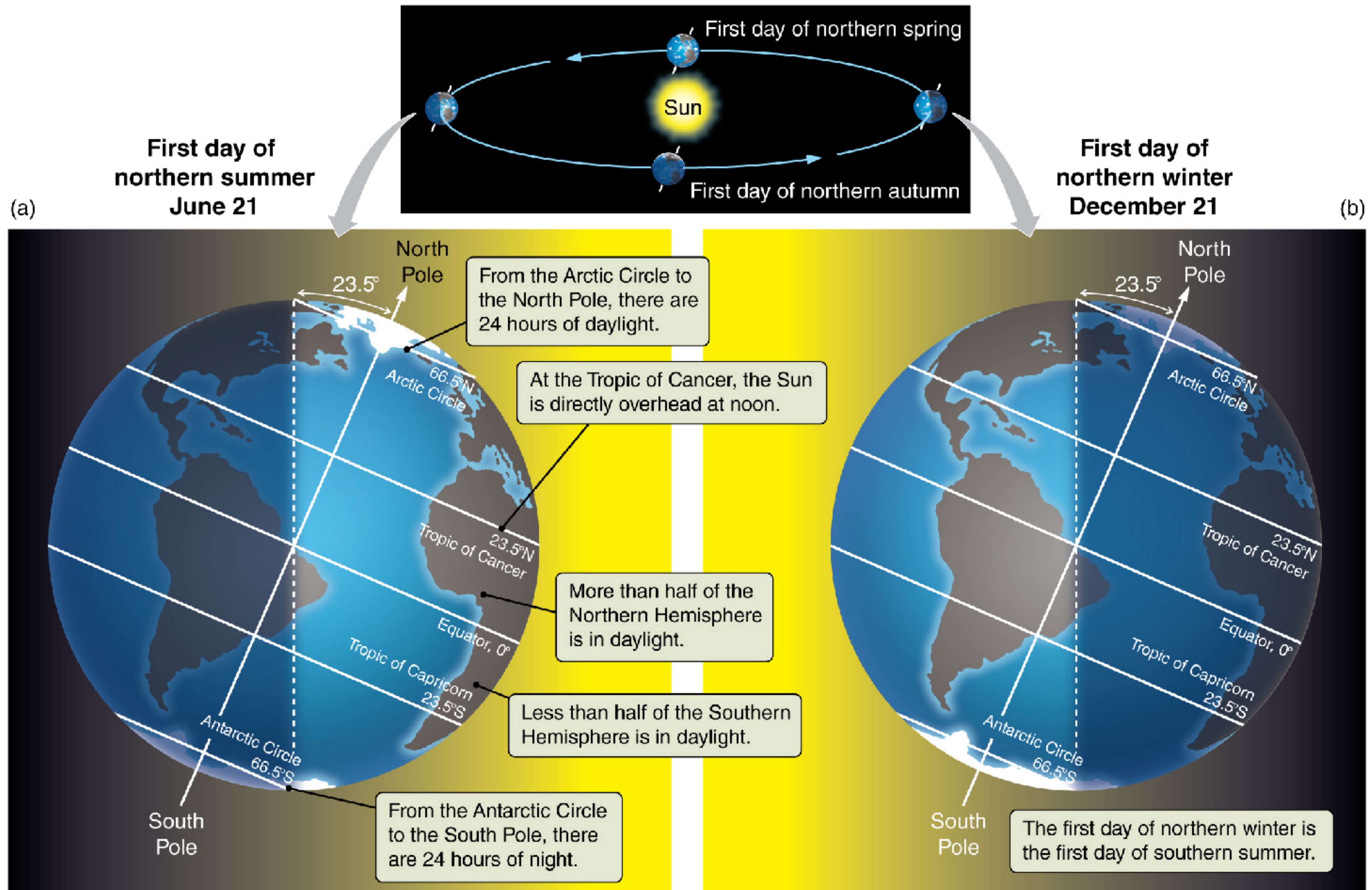
Summer Solstice
June 21st

Max altitude of the Sun determined by where we are on Earth and where the Earth is in its orbit

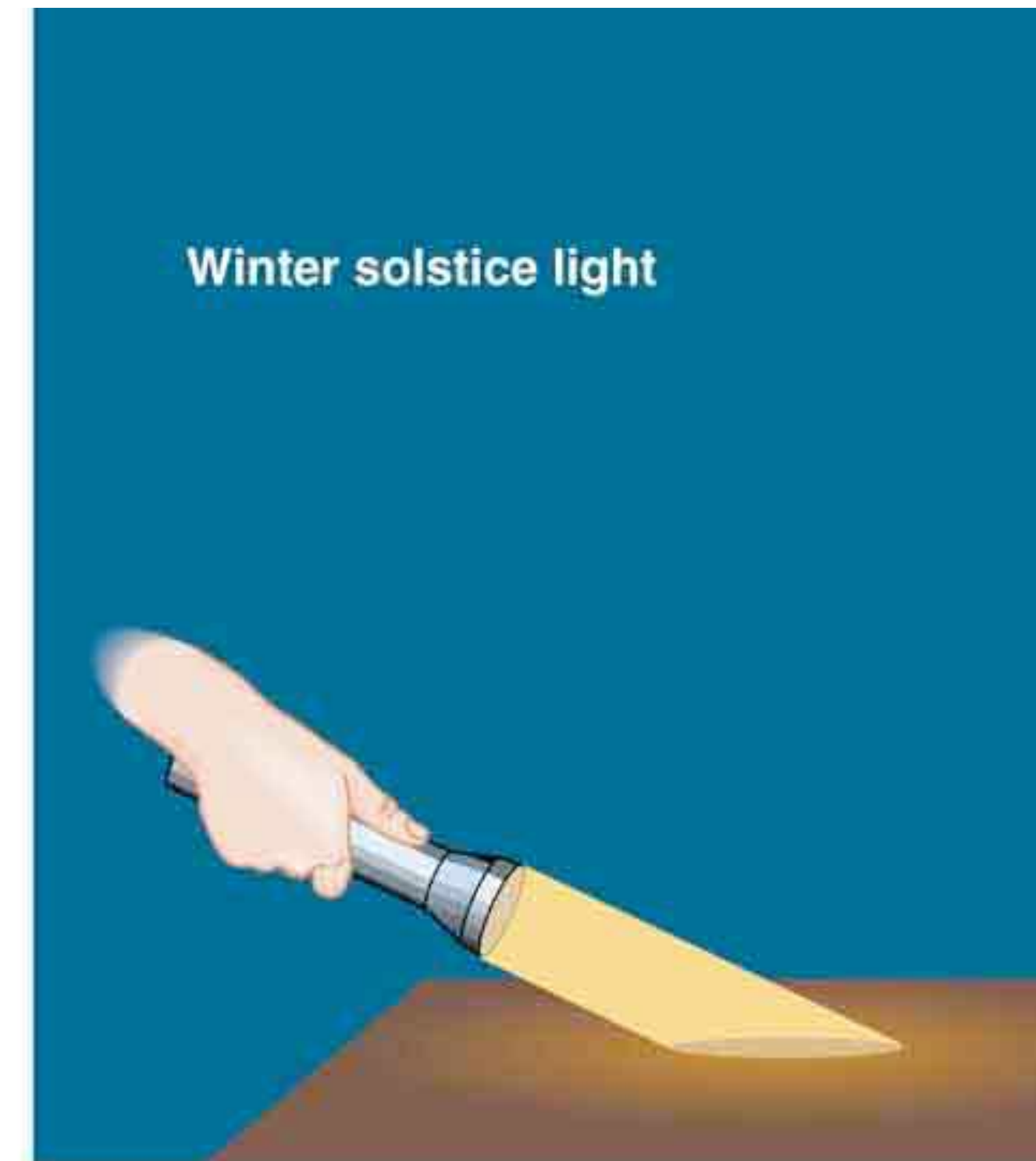
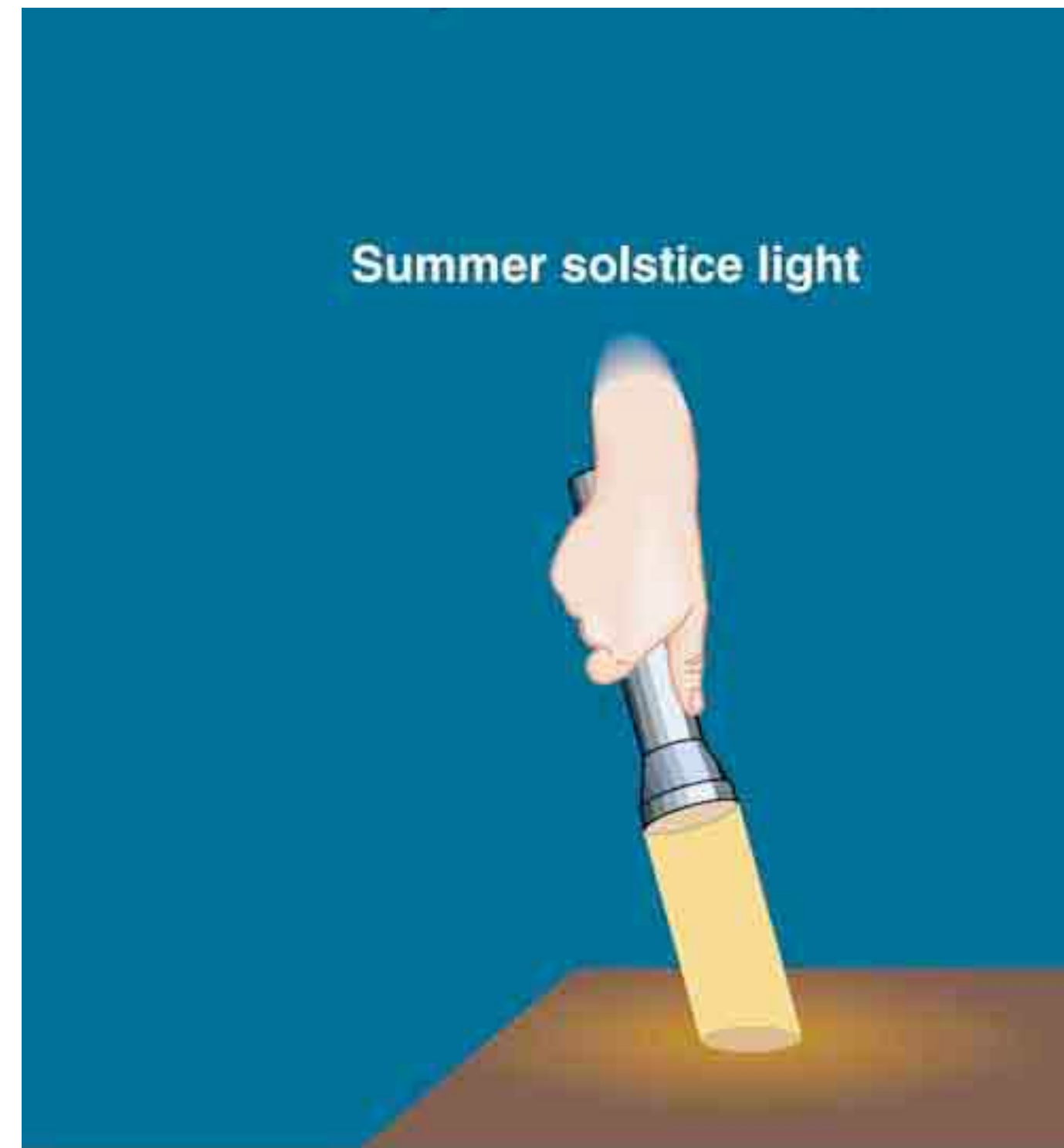
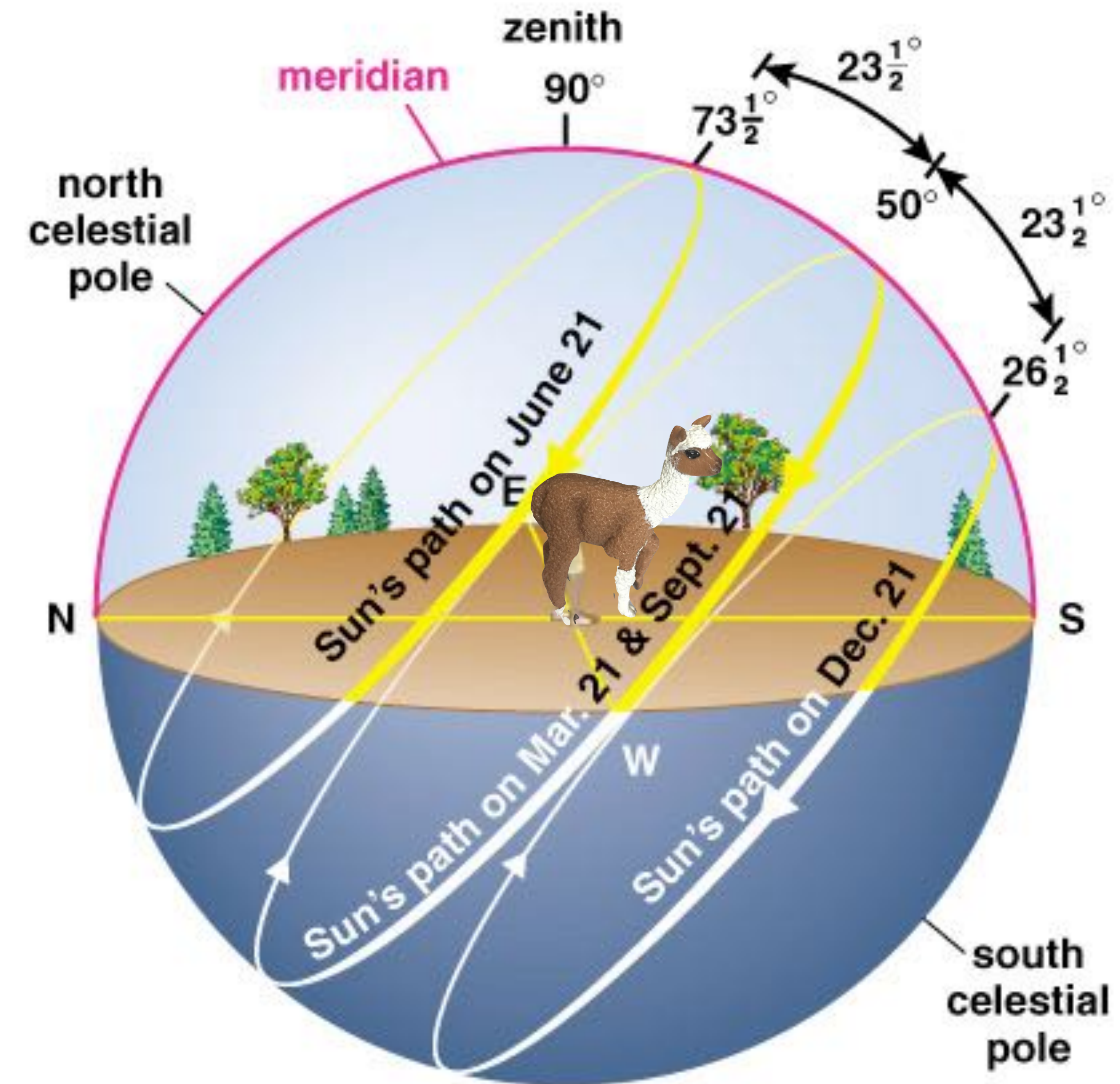


Motion of Earth around the Sun





The 2 reasons we have seasons



Seasonal Poetry



The two reasons we have seasons
Are both due to the Earth's tilt,
When our nearest pole
Points toward Sol
Its light shines to the hilt
And stays in the sky
Like a too-long deployed spy
At risk of committing treason!

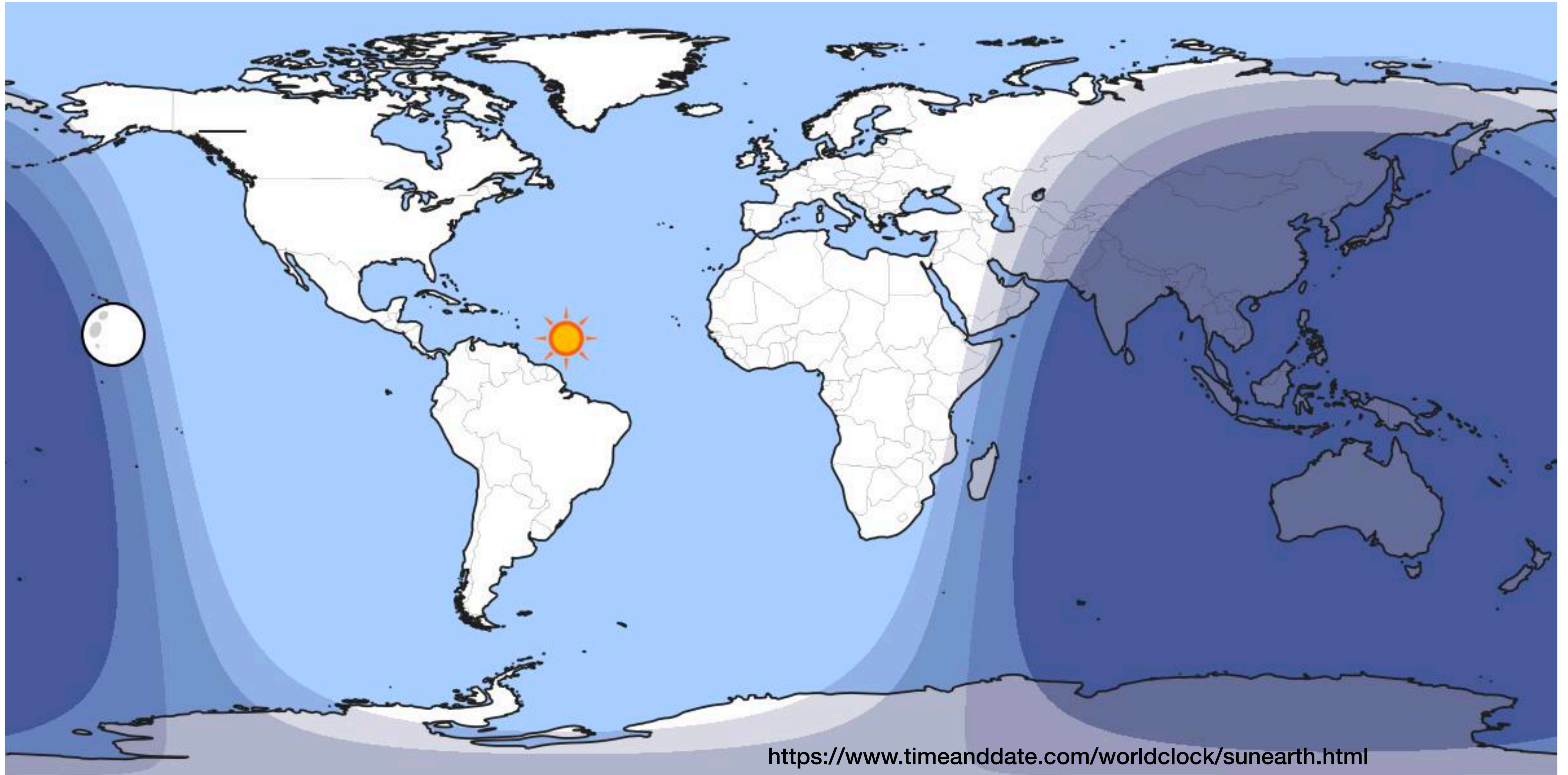


Where and when are we?

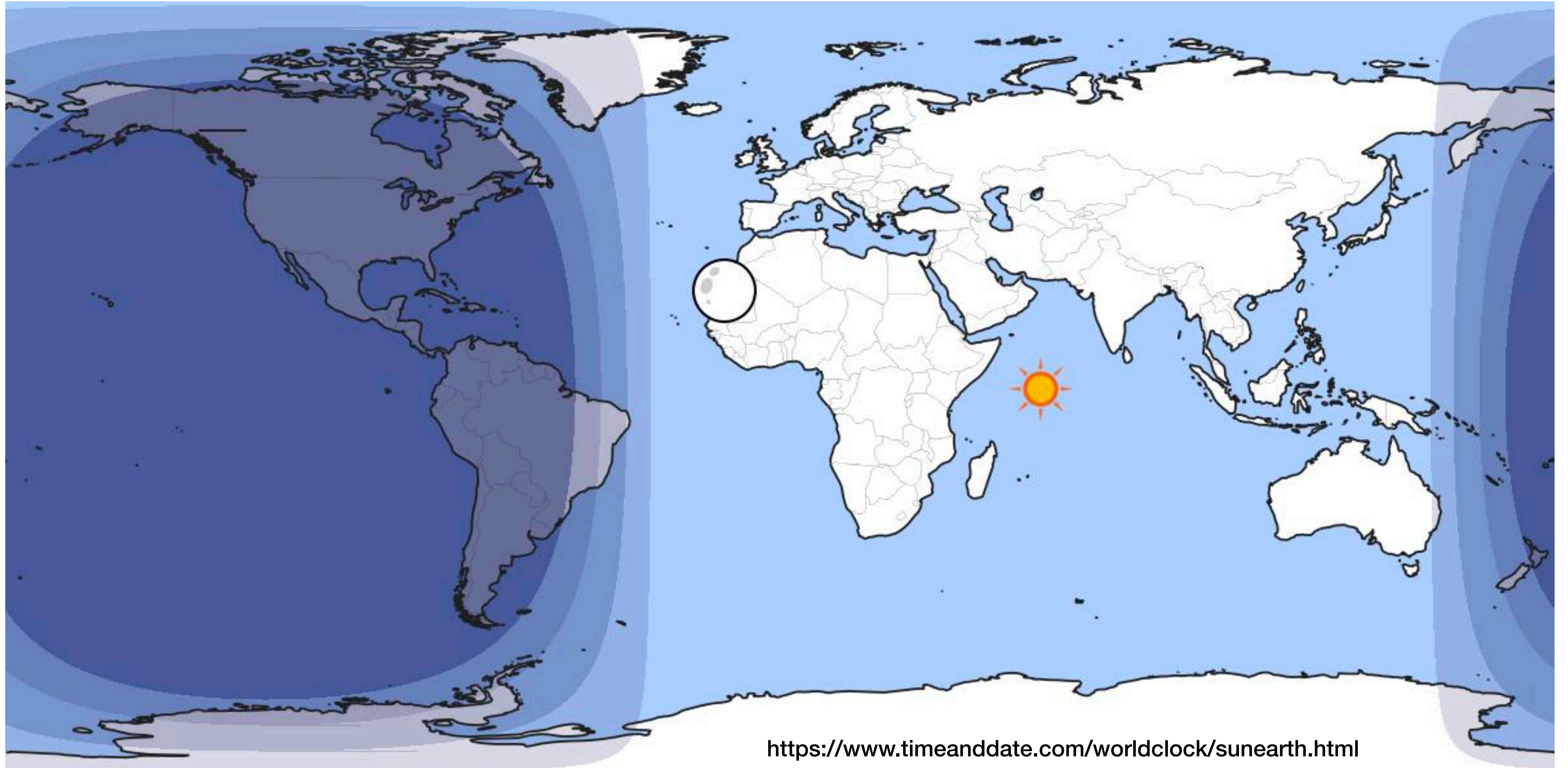


http://www.youtube.com/watch?v=Xm_Cn8-DCNc

Right now!

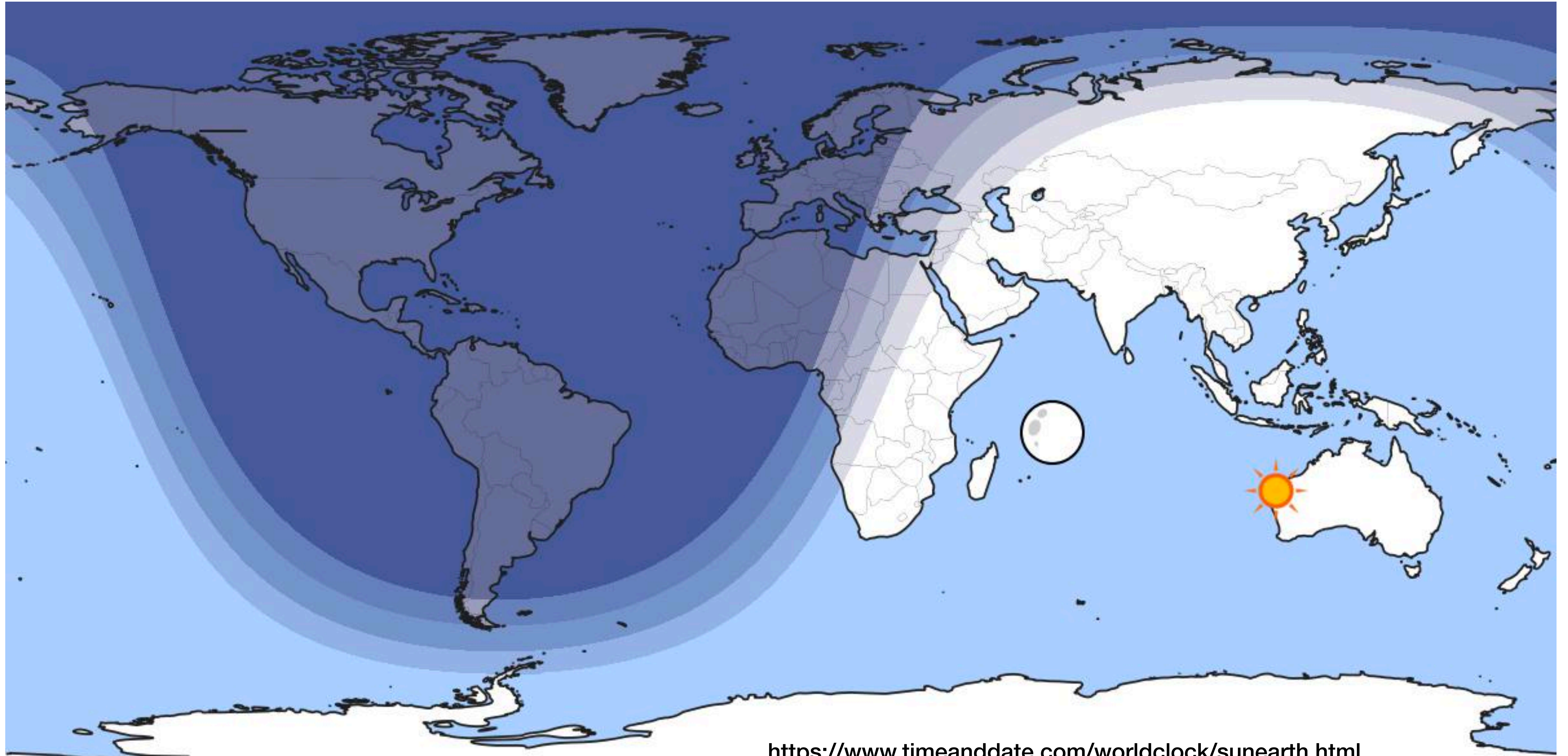


Fall Equinox



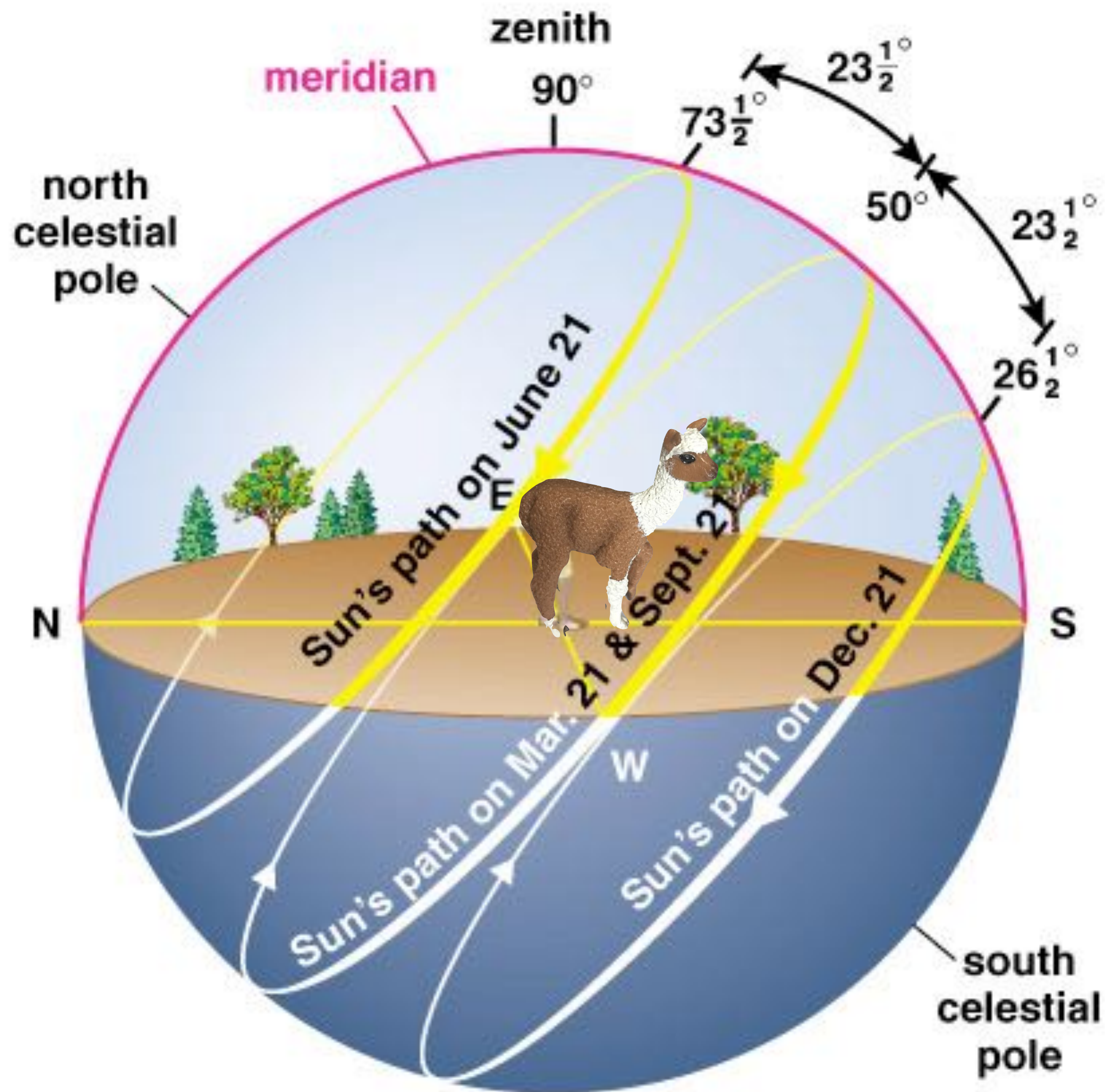
<https://www.timeanddate.com/worldclock/sunearth.html>

December Solstice



<https://www.timeanddate.com/worldclock/sunearth.html>

Location: 40 deg N (same as SLC)

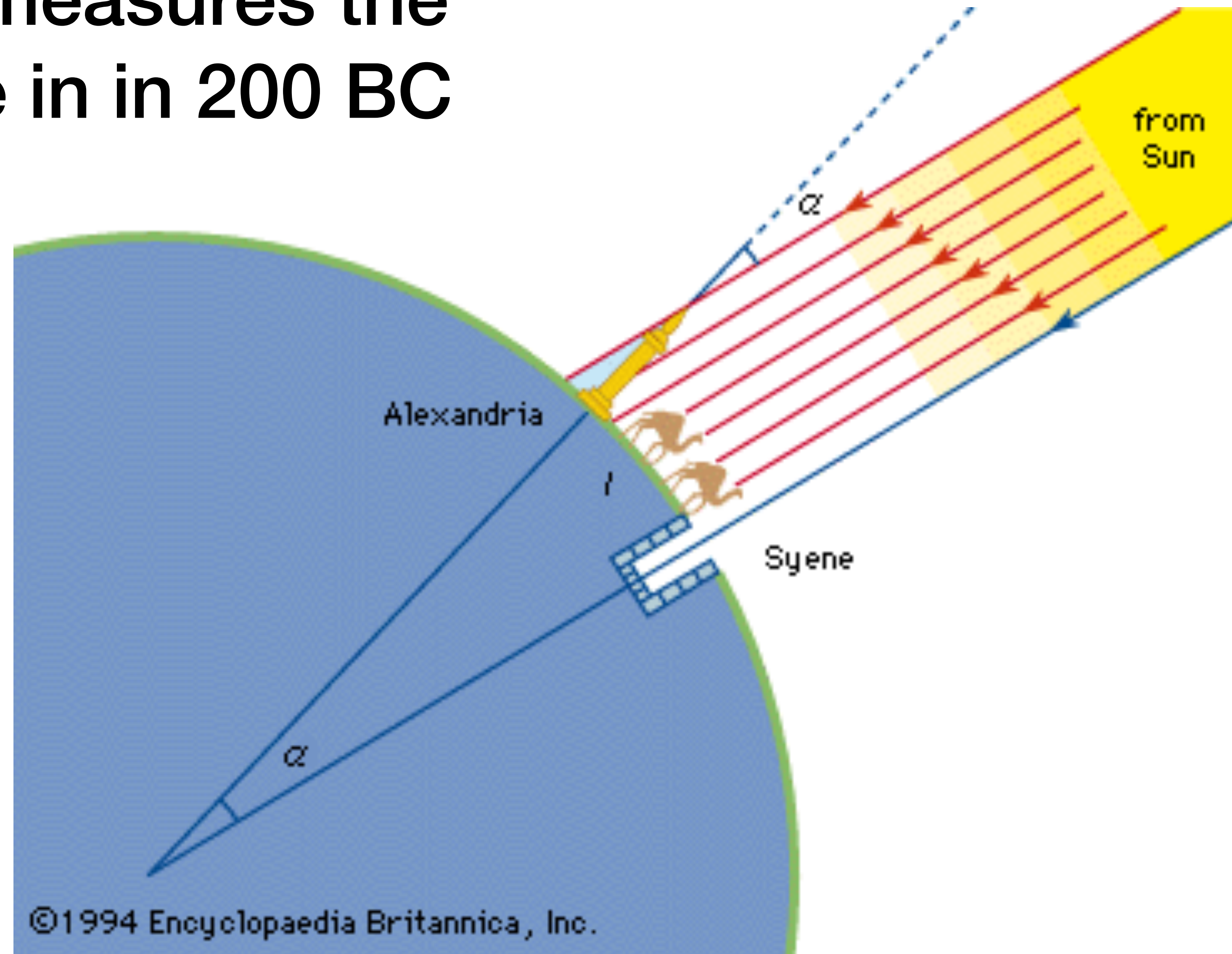


Copyright © Addison Wesley

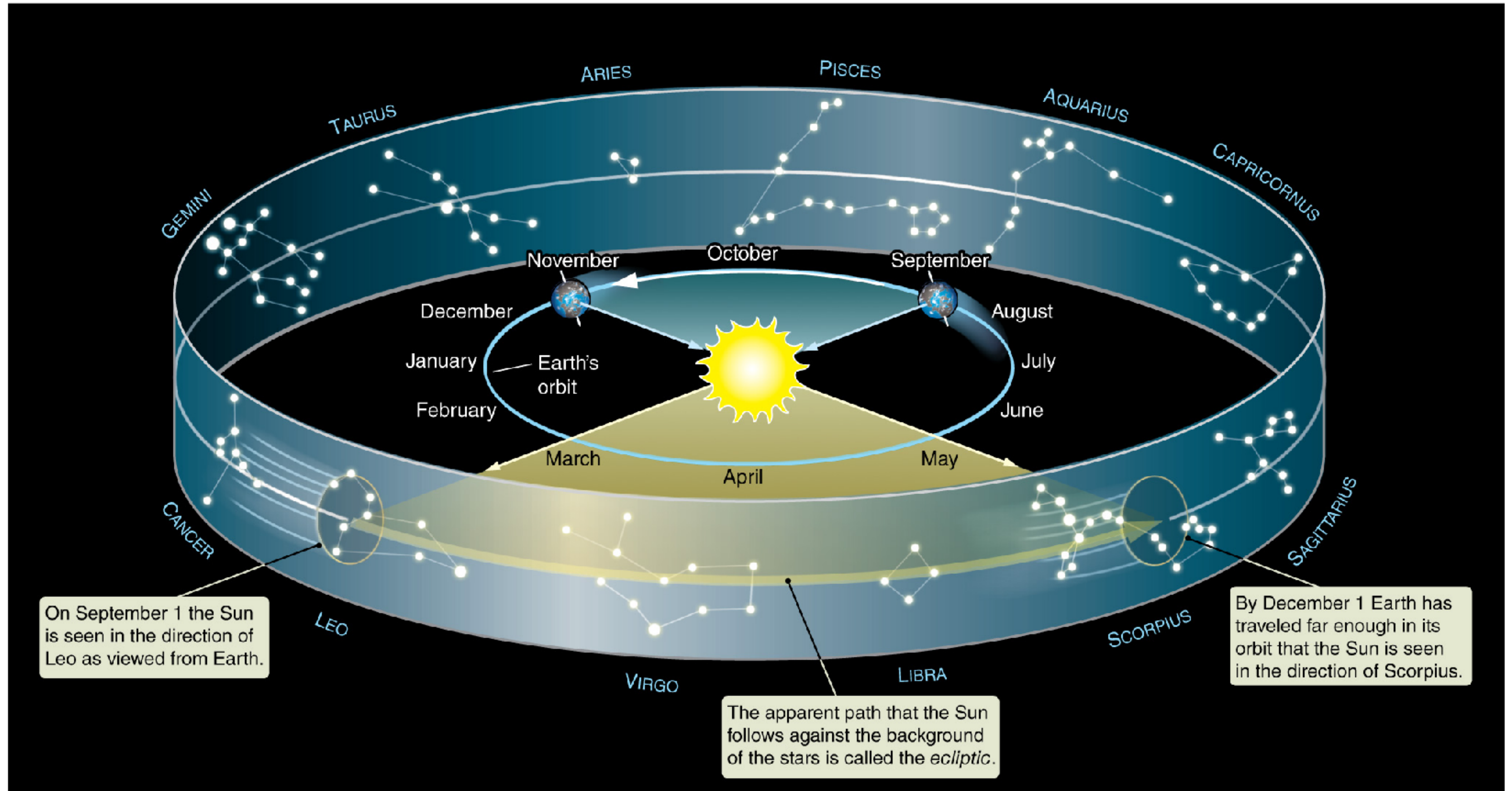
Where would you have to be for the sun to pass directly overhead on June 21st?

- A) At 23.5 degrees S latitude
- ★ B) At 23.5 degrees N latitude
- C) At the north pole
- D) On the equator

Aside: Eratosthenes measures the Earth's circumference in 200 BC



The Ecliptic



The Ecliptic

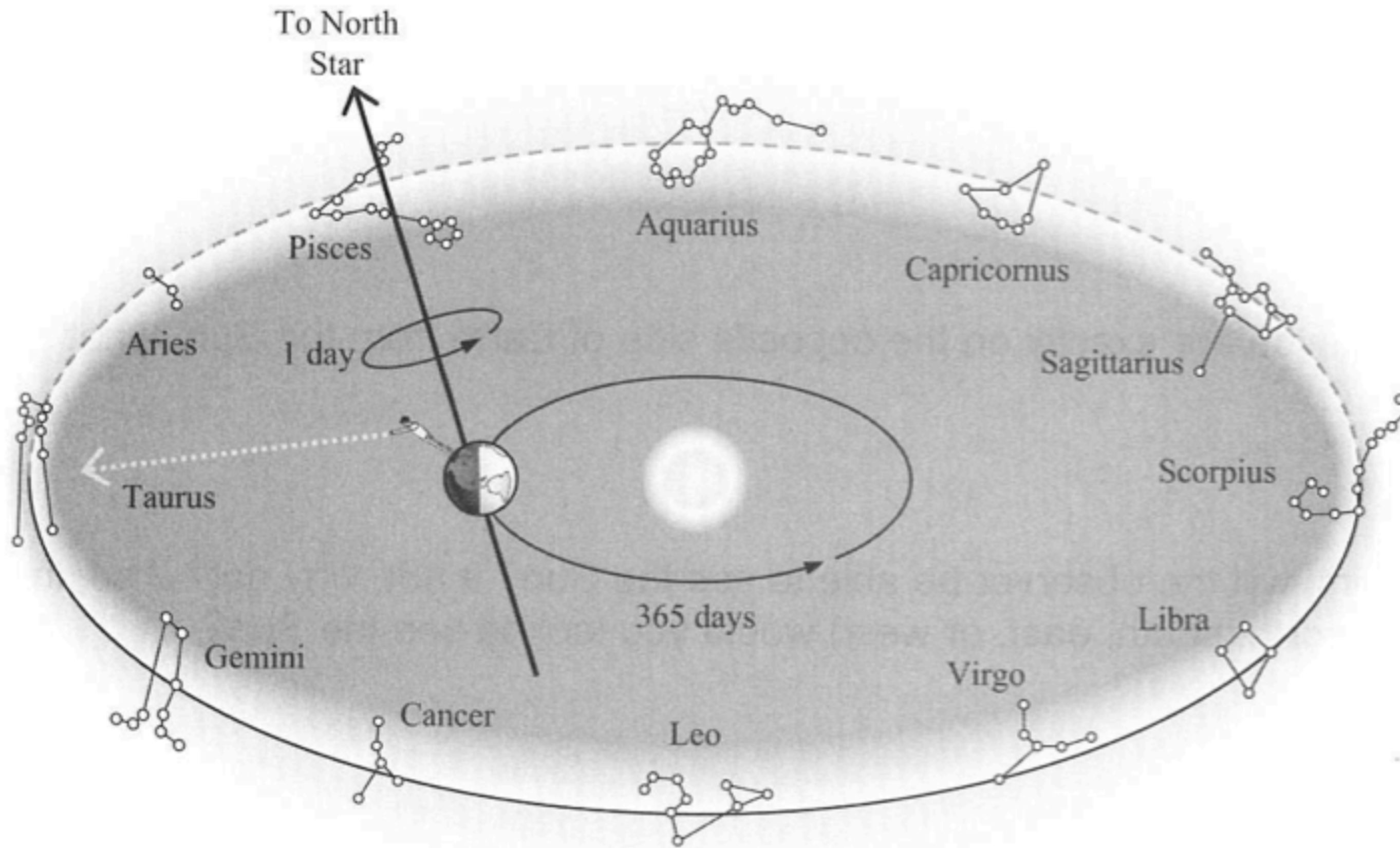


Figure 1

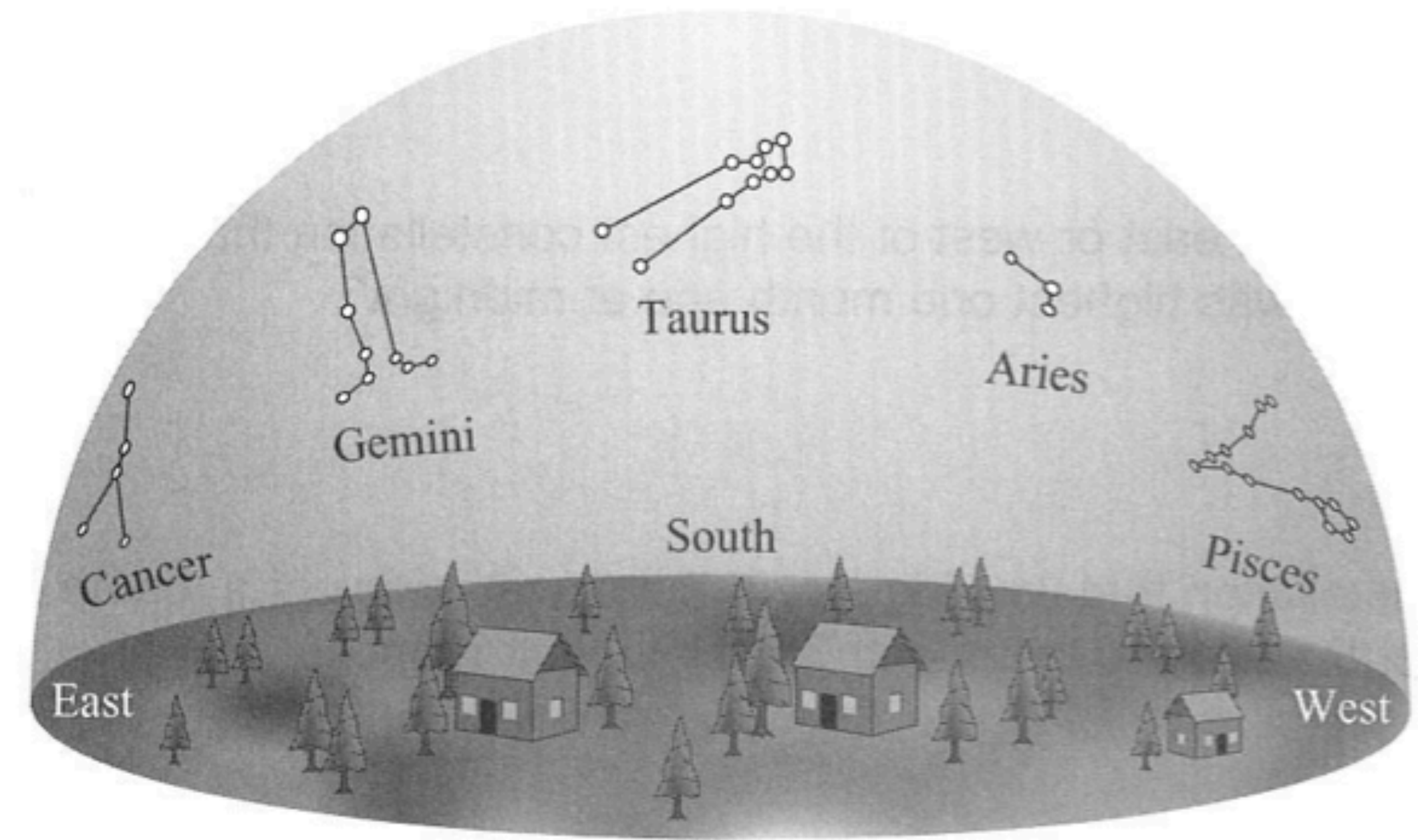
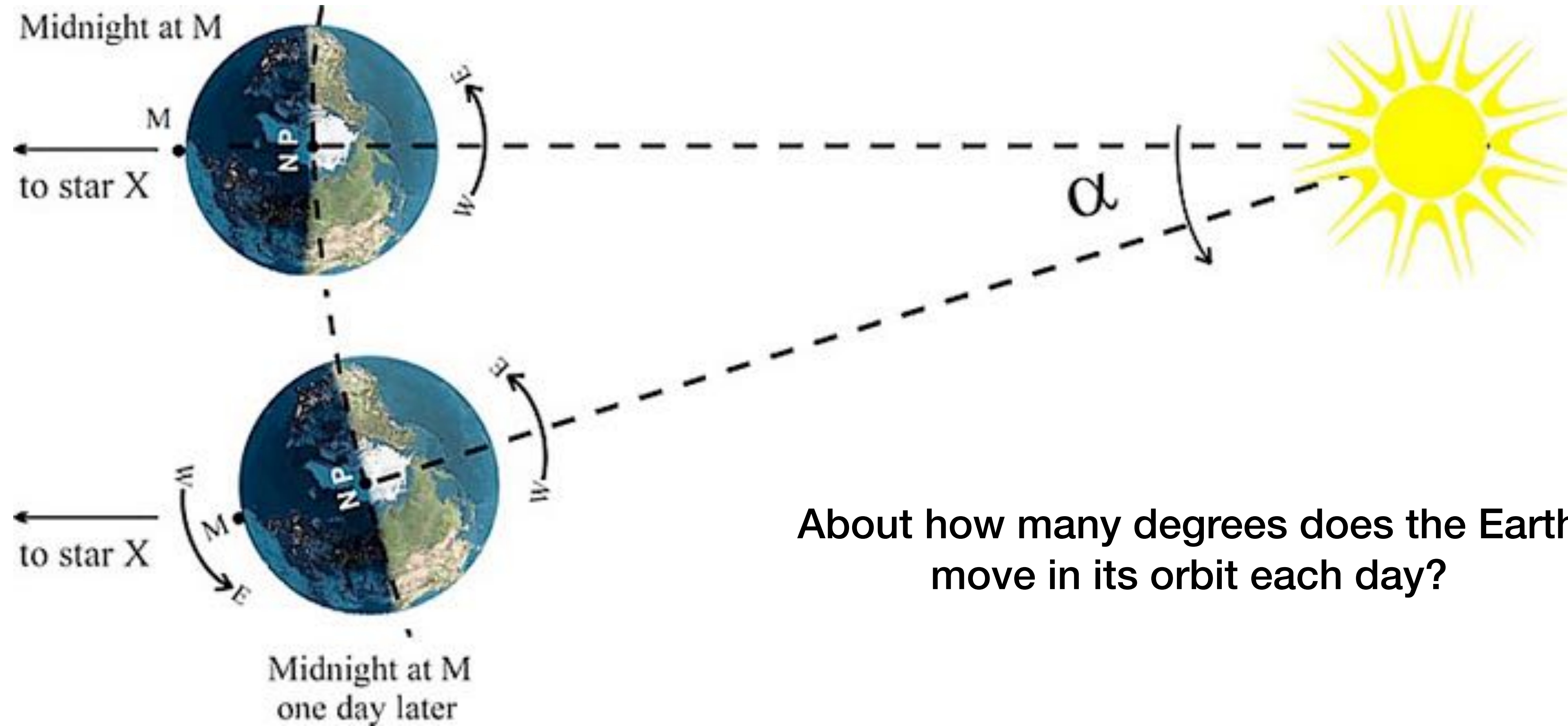


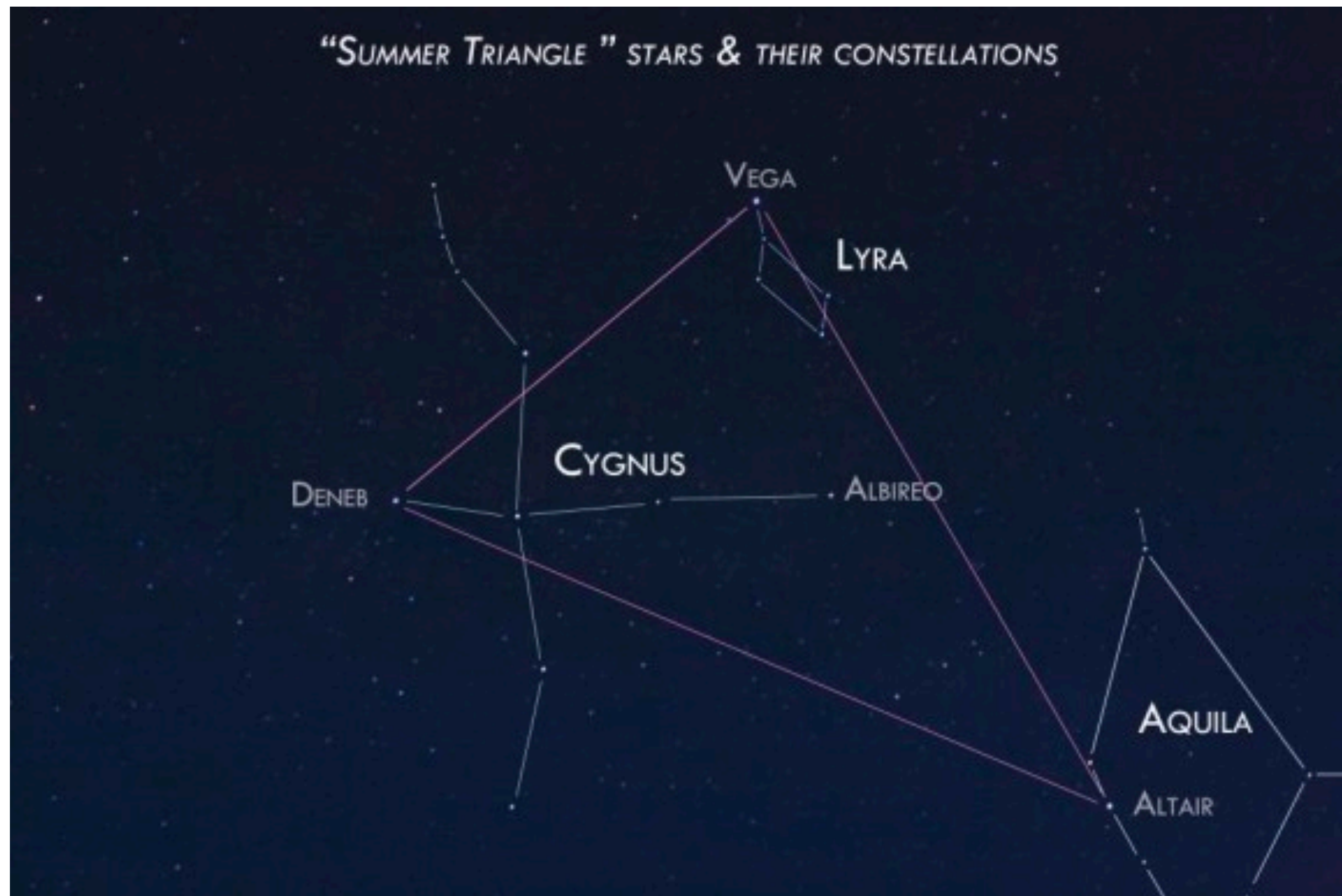
Figure 2

Why star rise/set times change



About how many degrees does the Earth move in its orbit each day?

Tonight, Vega (the brightest star in the constellation Lyra, part of the summer triangle), will set at 6:55am. What time will it set tomorrow night?



- A) 6:51am**
- B) 6:55am**
- C) 6:59am**

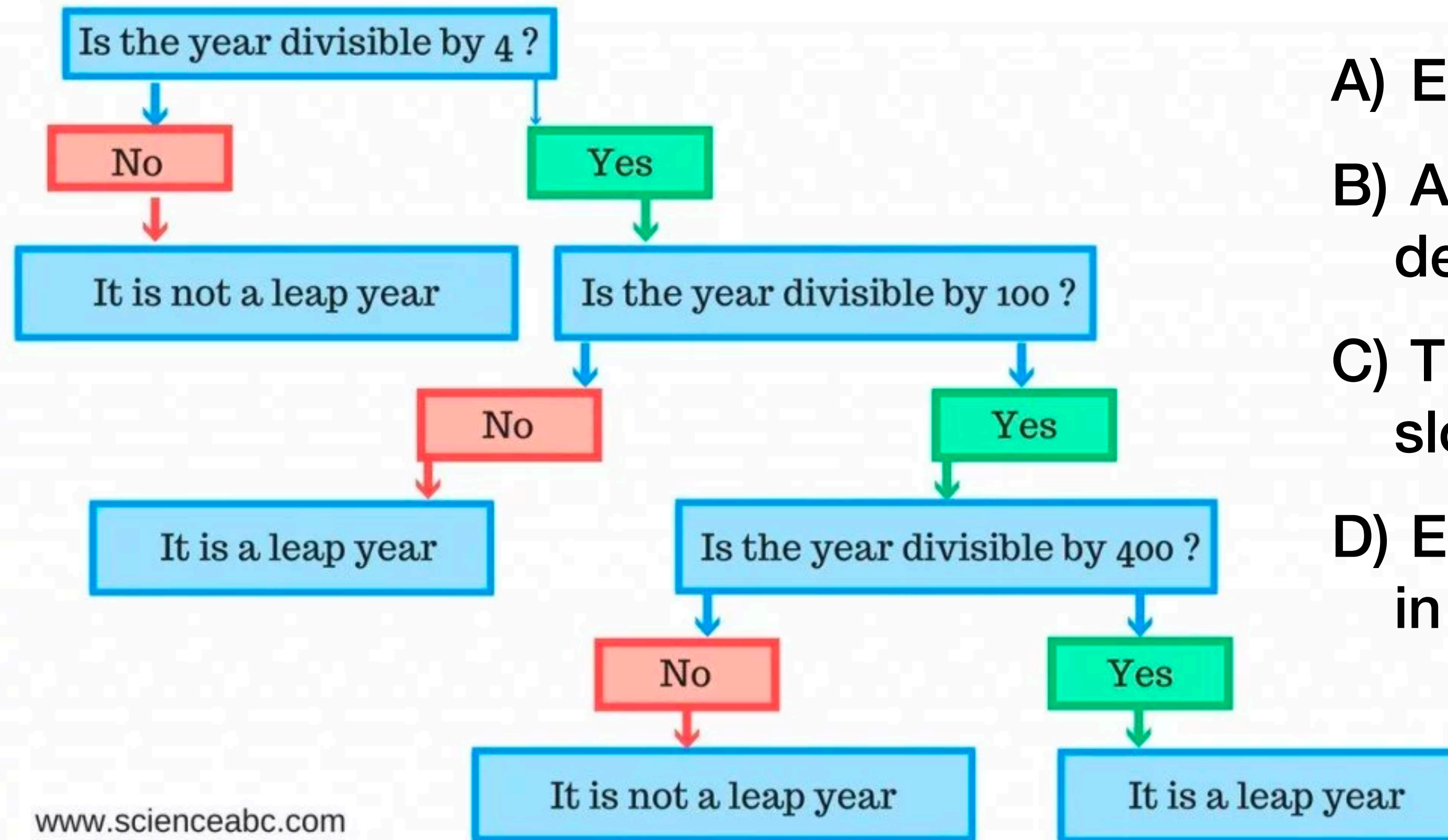
We need leap years because...



- A) Earth's Axis is tilted
- B) Amy Adams and Matthew "Emperor of the Universe" Goode are delightfully funny together!
- C) The direction the Earth's axis points slowly changes with time
- D) Earth does not go once around the sun in exactly 365 days

We need leap years because...

How to identify a leap year



Gregorian Calendar (what we use today)

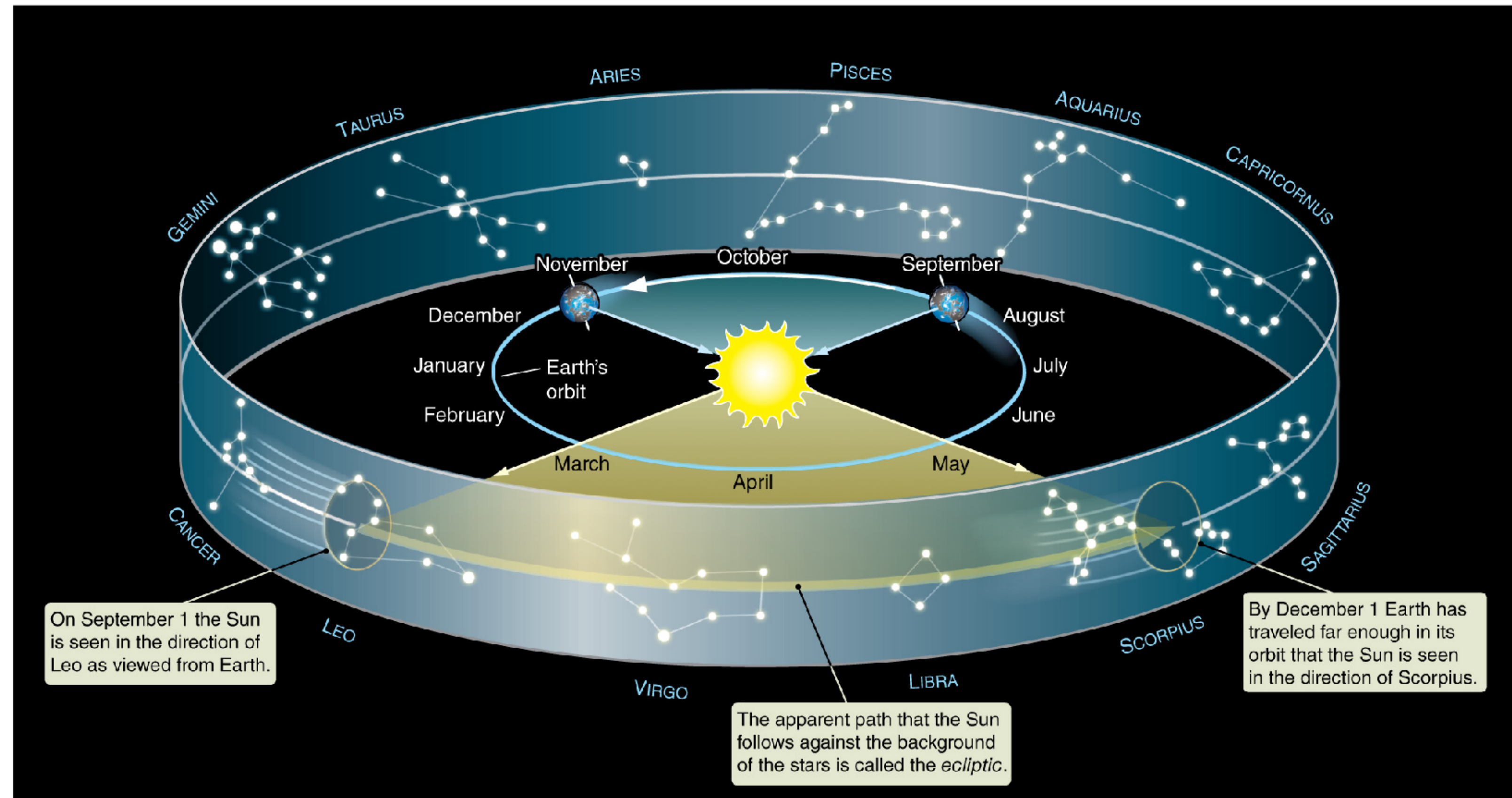
- A) Earth's Axis is tilted
- B) Amy Adams and Matthew Goode are delightfully funny together!
- C) The direction the Earth's axis points slowly changes with time
- D) Earth does not go once around the sun in exactly 365 days → 365.2422 days

Julian calendar was used for over 1000 years (leap day every 4 years). Every 400 years, the calendar is offset from the seasons by 3 more days.

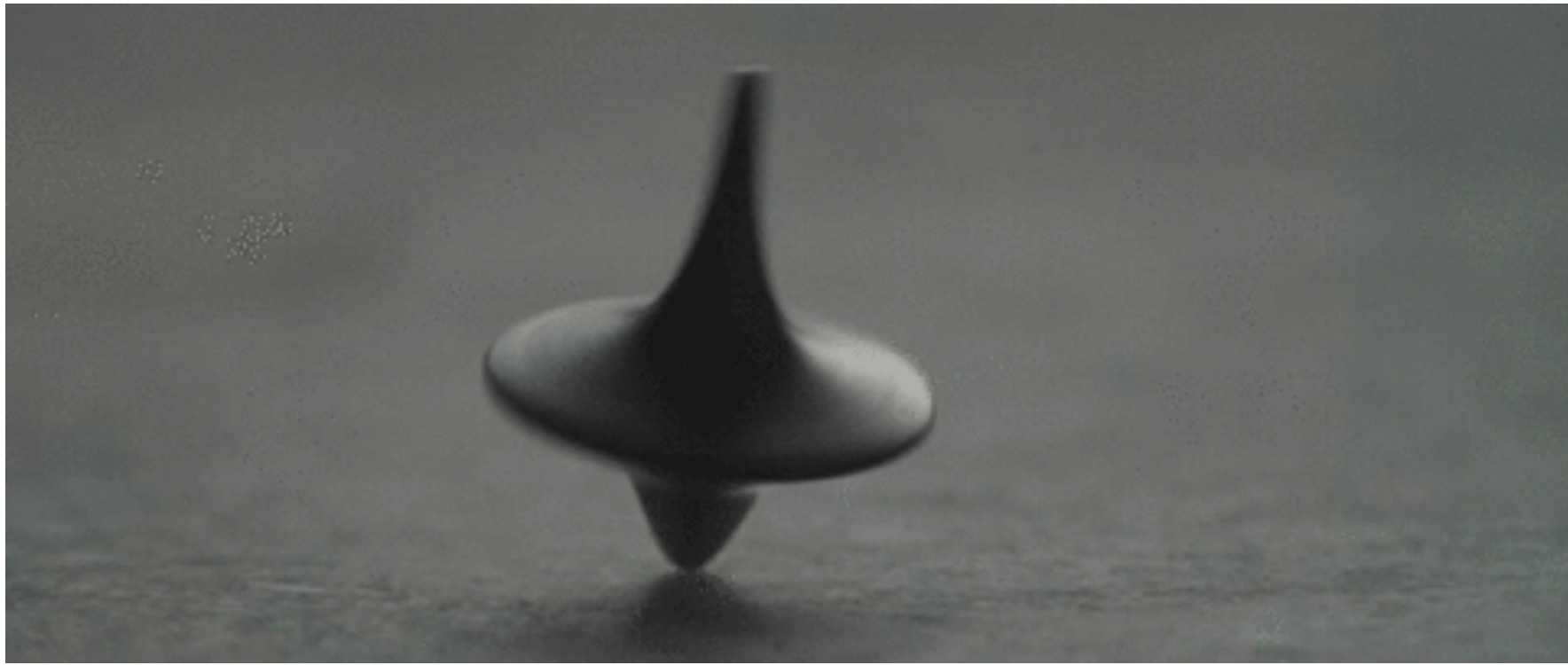
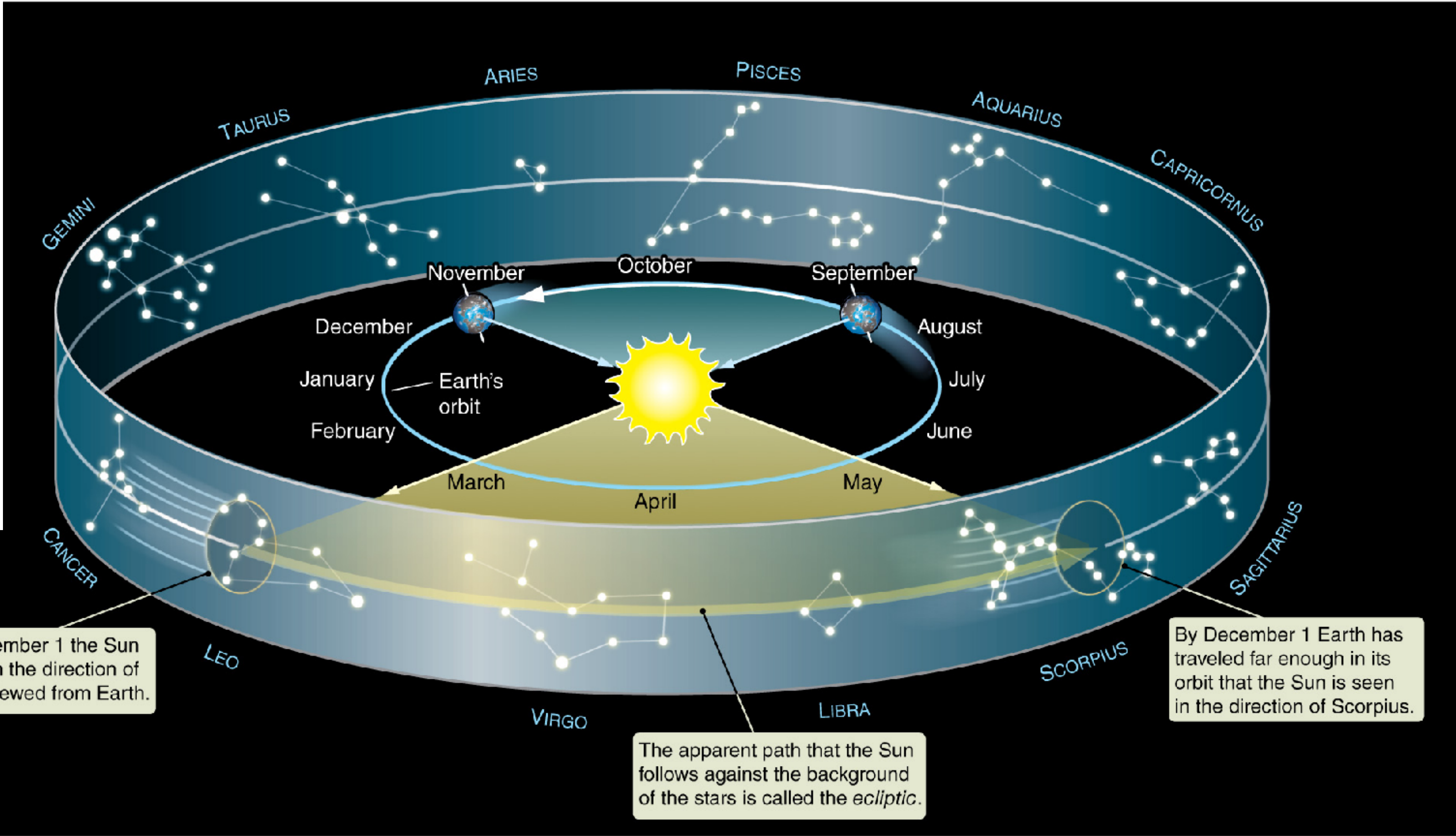
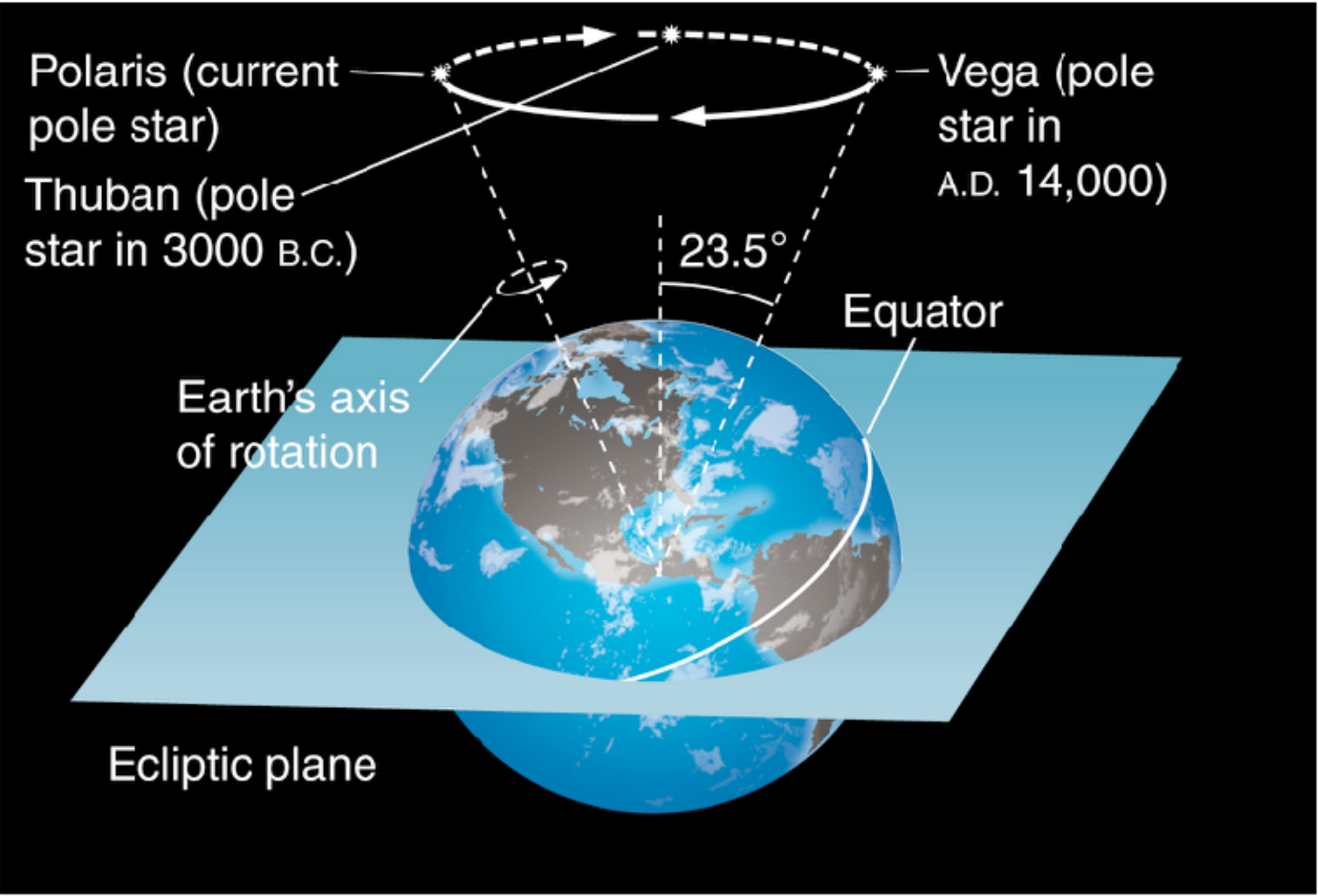
Hey you, what's your sign?

**Astrology
is
bunk!**

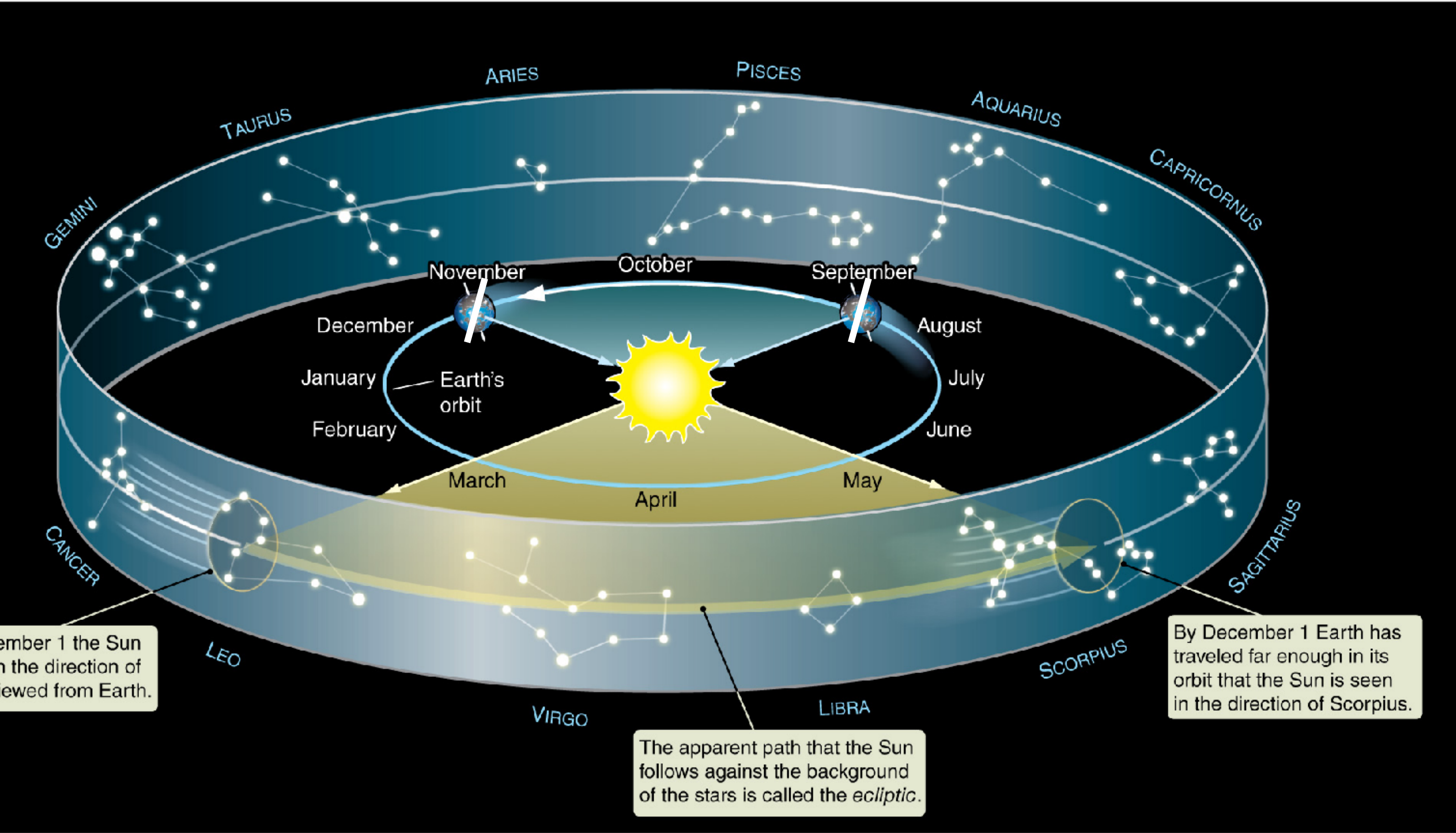
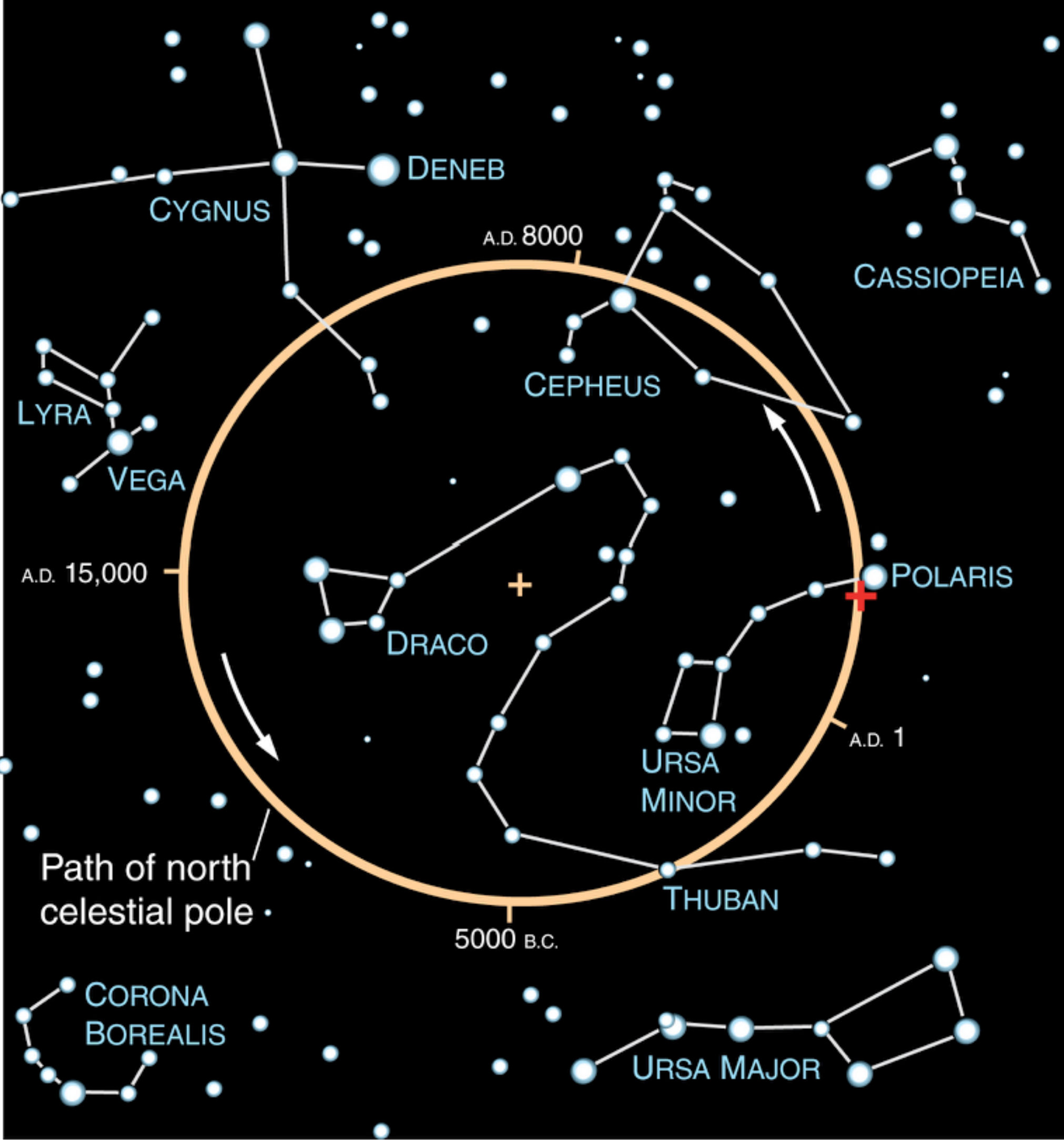
(HINT: This will be an exam question.)



Earth's axis wobbles like a top: called Precession



Earth's axis wobbles like a top: called Precession





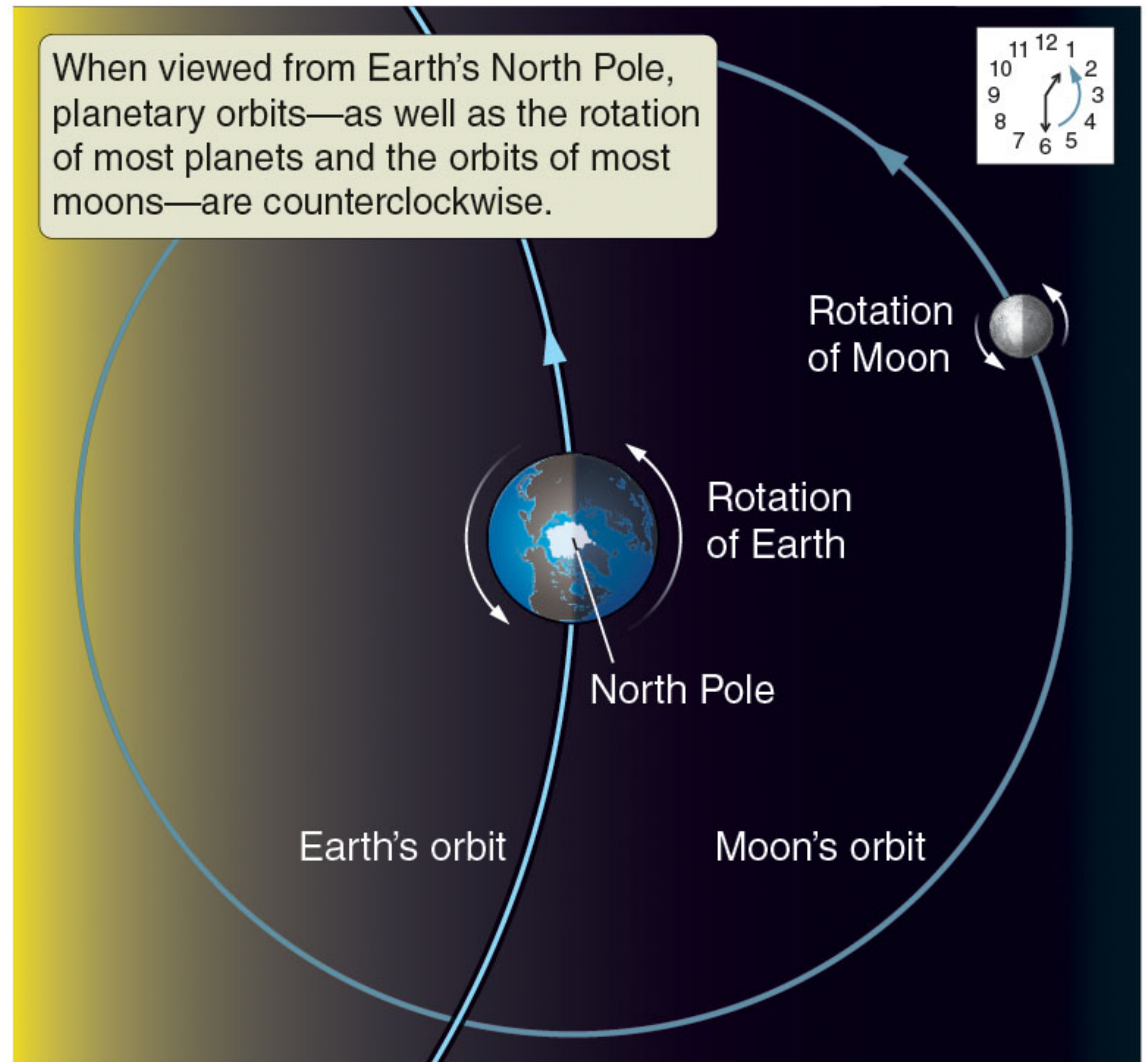
Group Activity Time!

When does the full moon rise?



- A) At Noon
- ★ B) At Sunset
- C) At Midnight
- D) At Sunrise

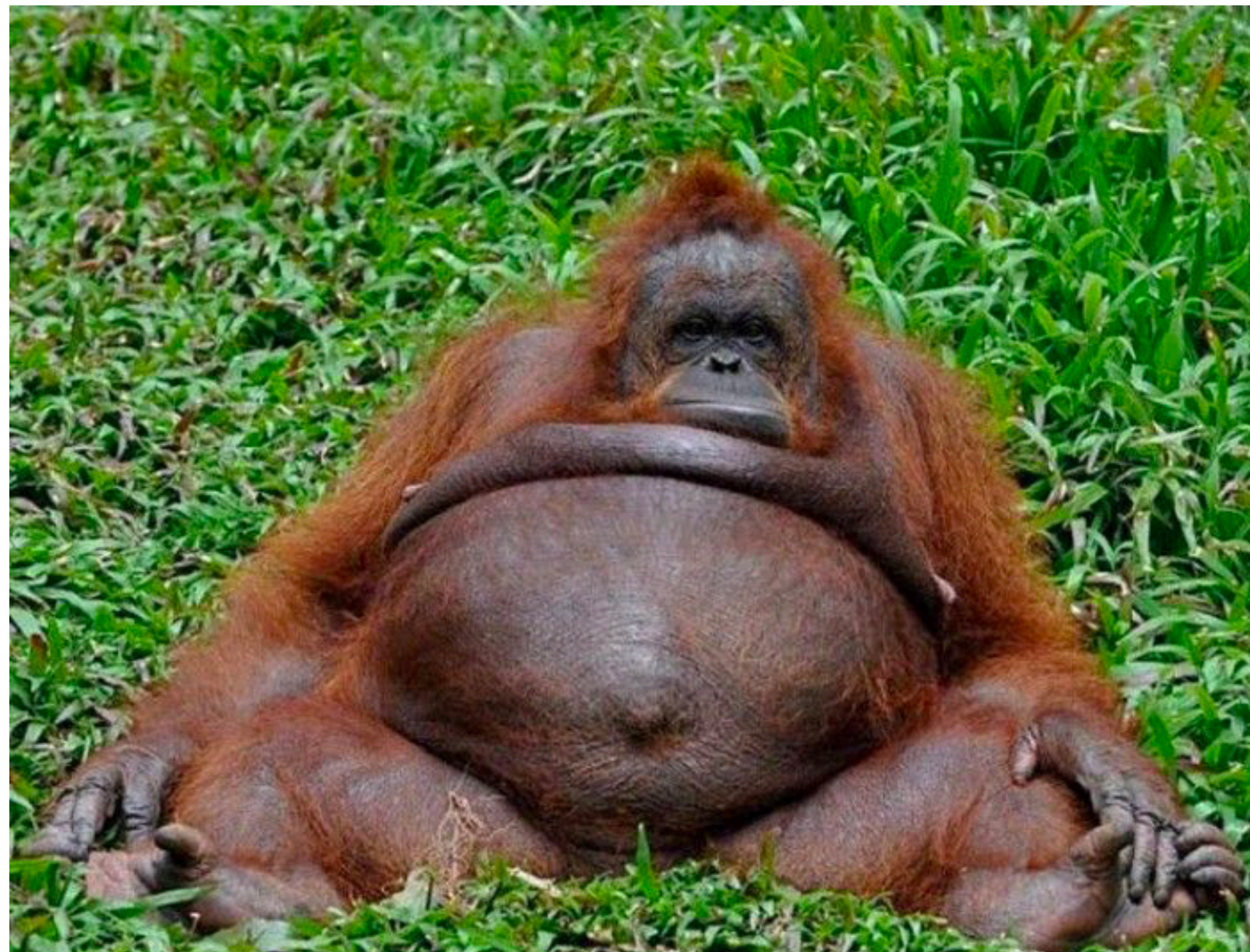
**Can figure out roughly
when the Moon will
rise, given its phase,
from this diagram
alone**



Phases of the Moon



Phases of the Moon



gibbous

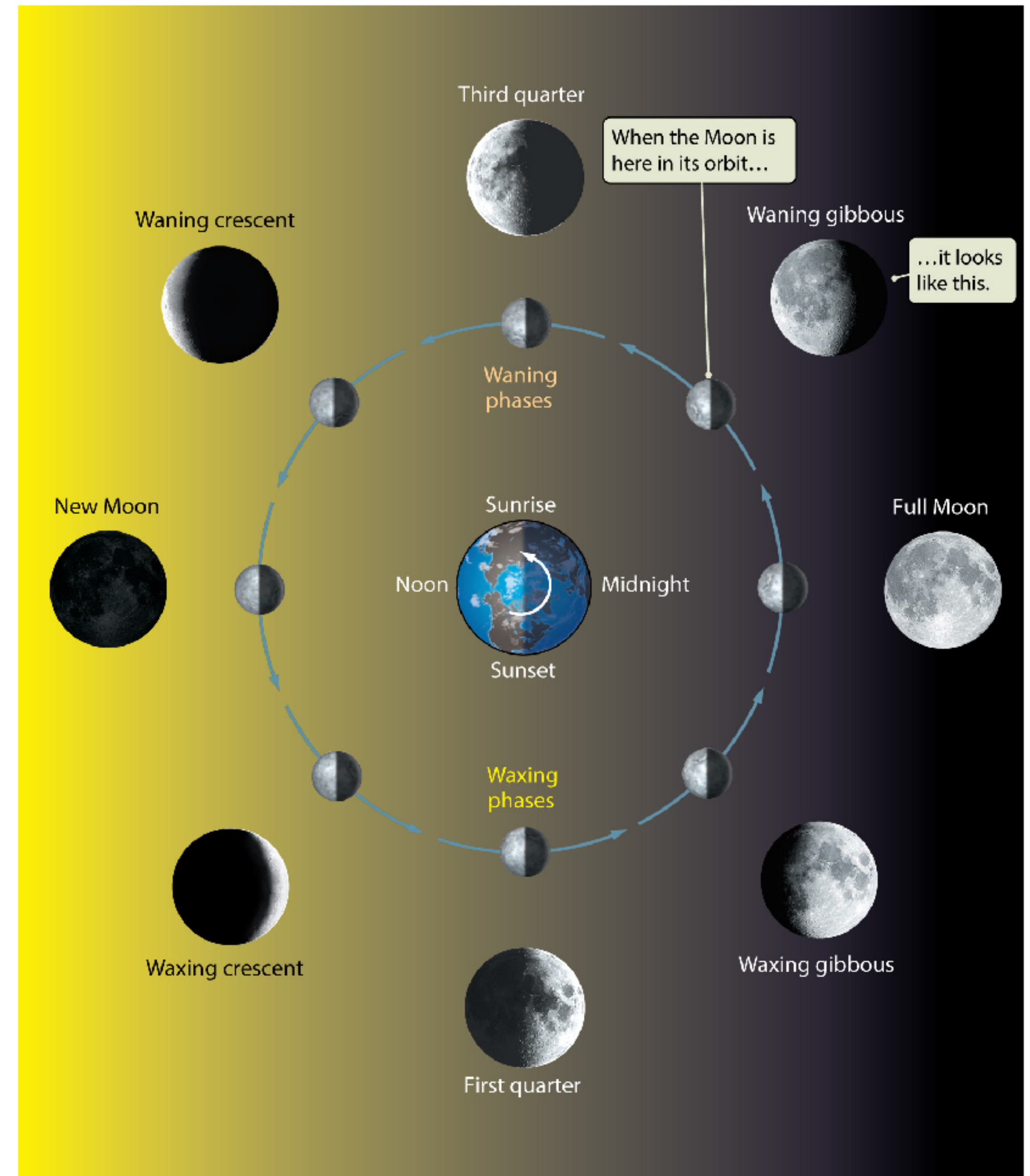
Waxing
←

Waning
→

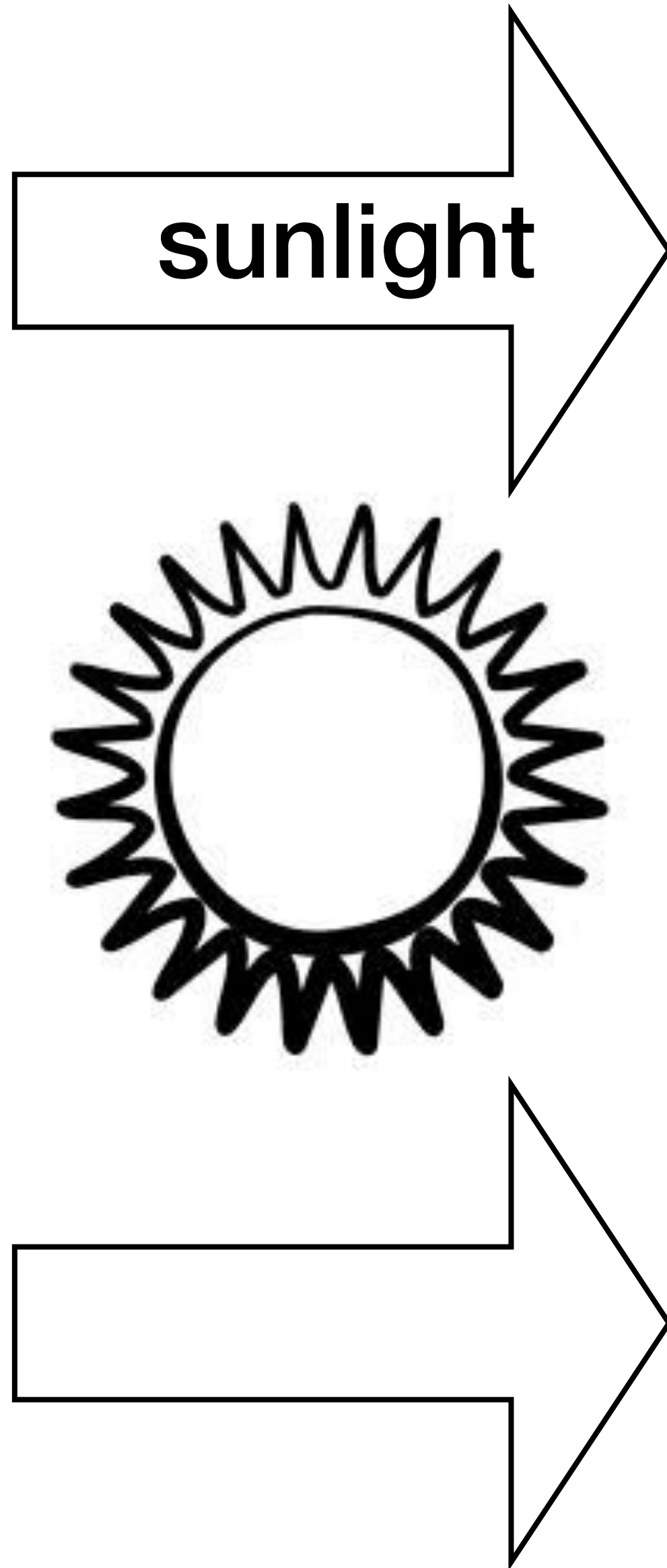


crescent

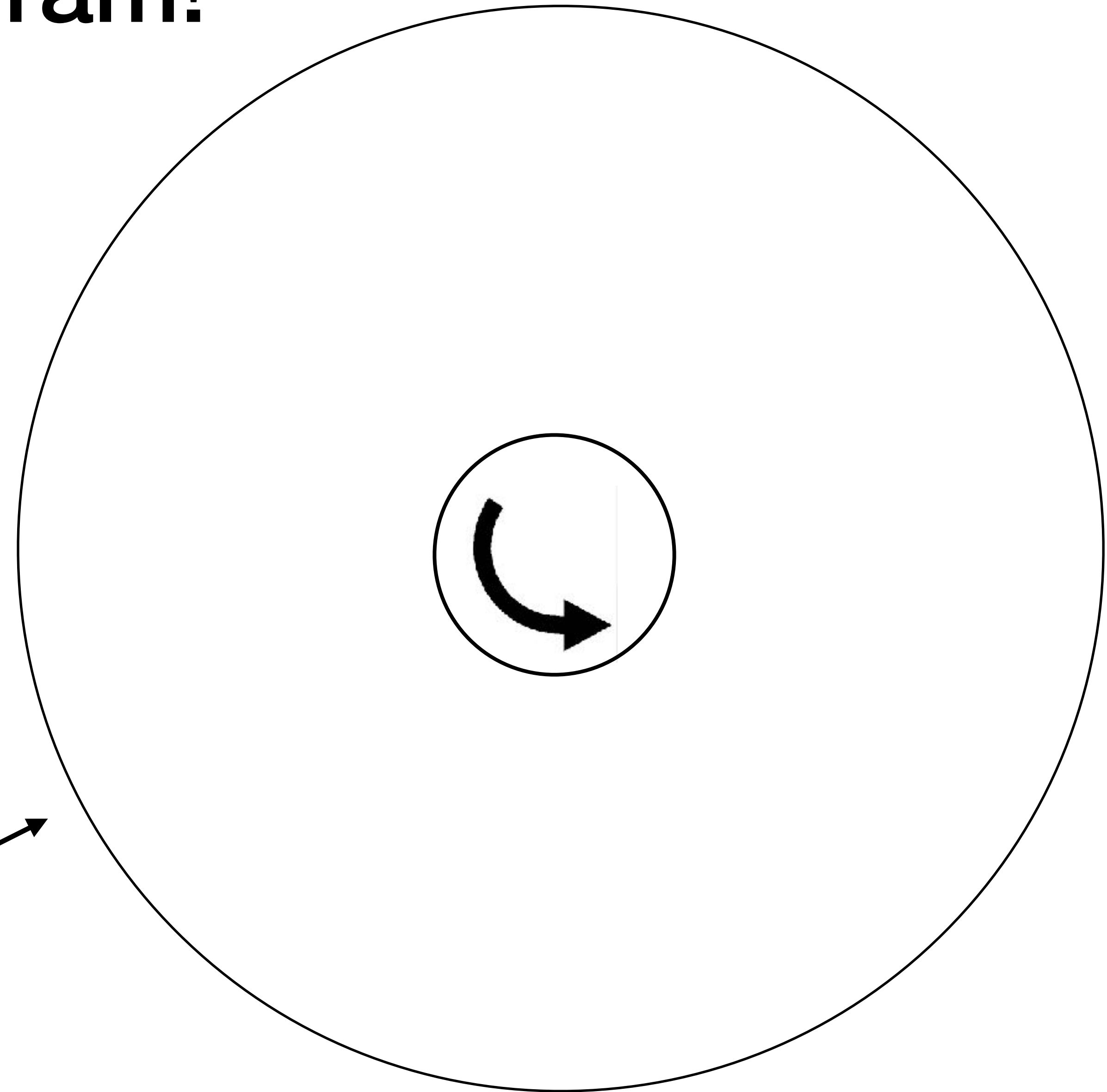
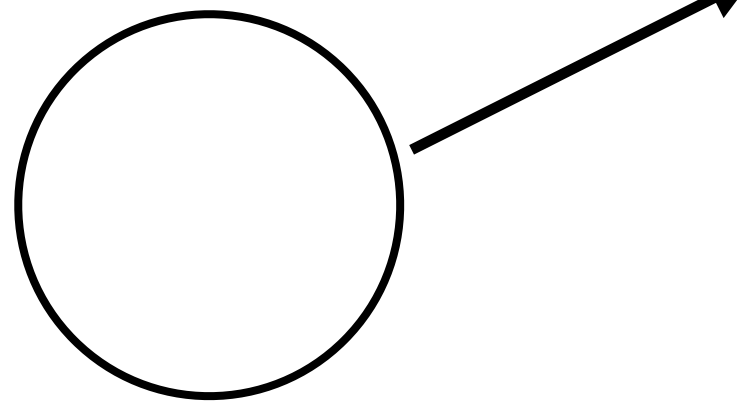
Moon phases are easy to figure out once you have the right mental picture



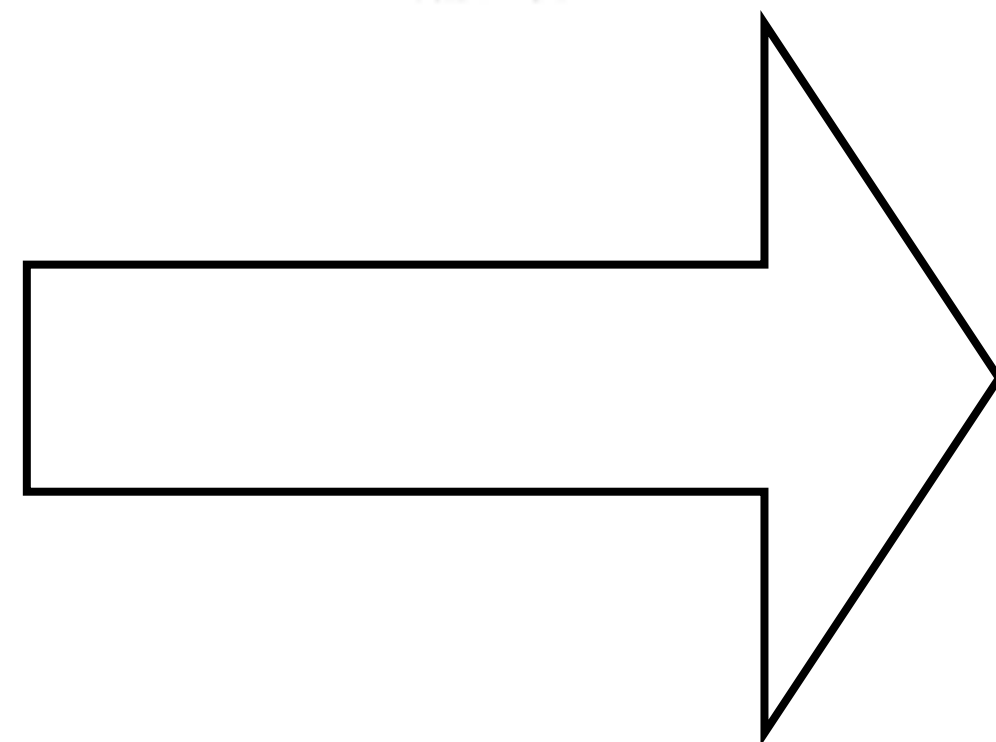
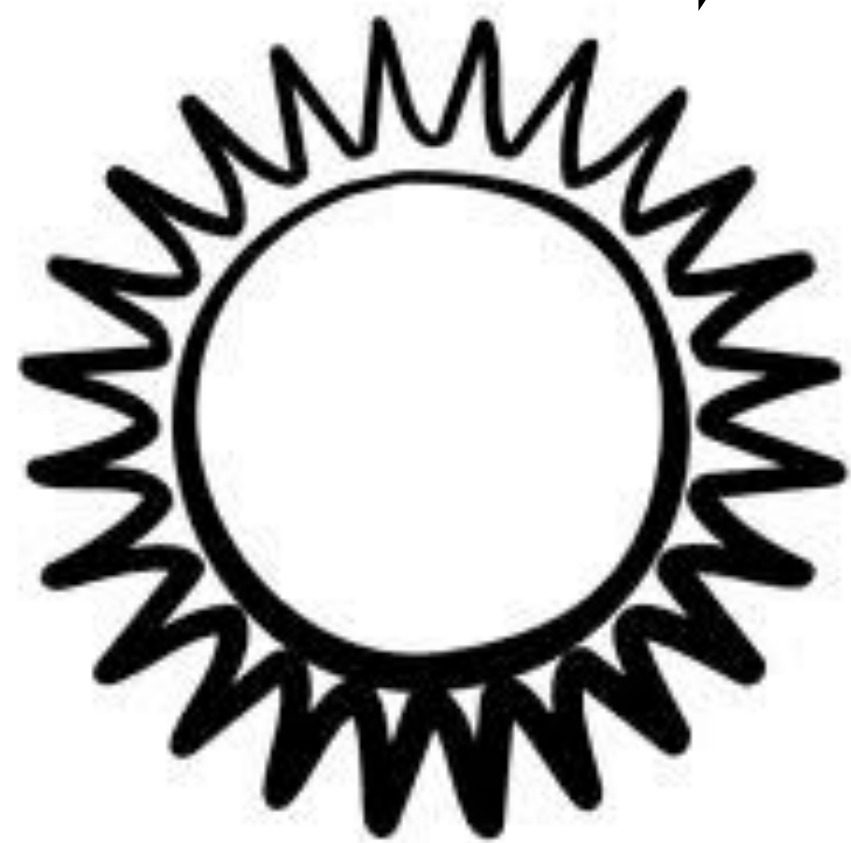
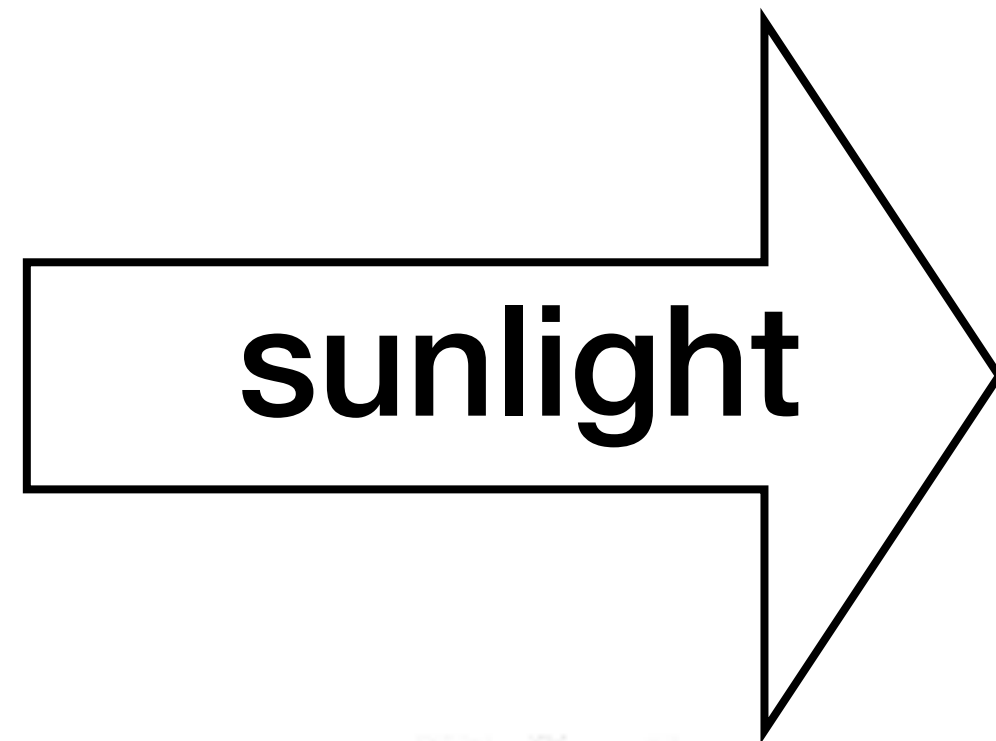
Draw the diagram!



Waning
Gibbous



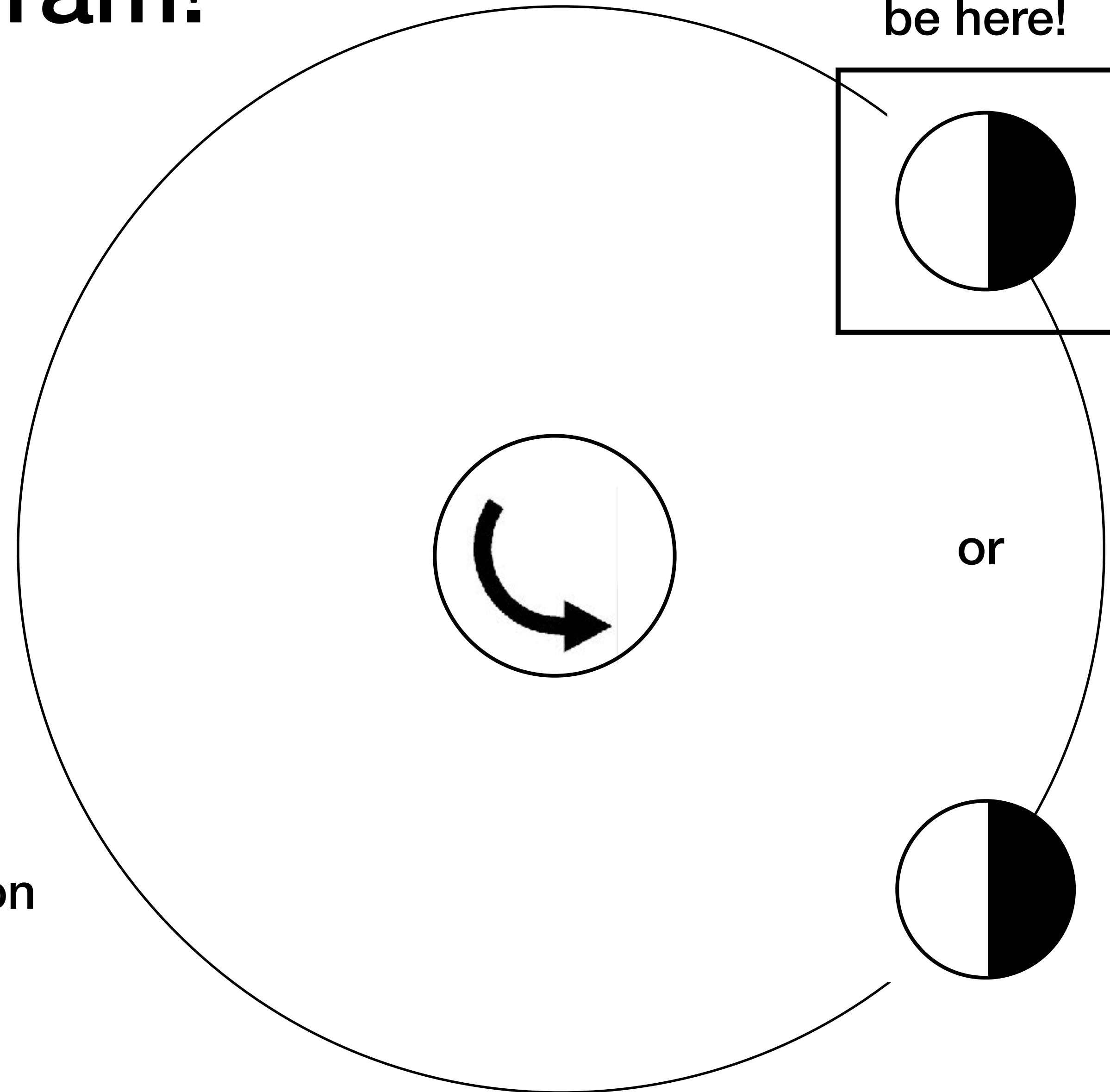
Draw the diagram!



Gibbous \neq Crescent,
so either

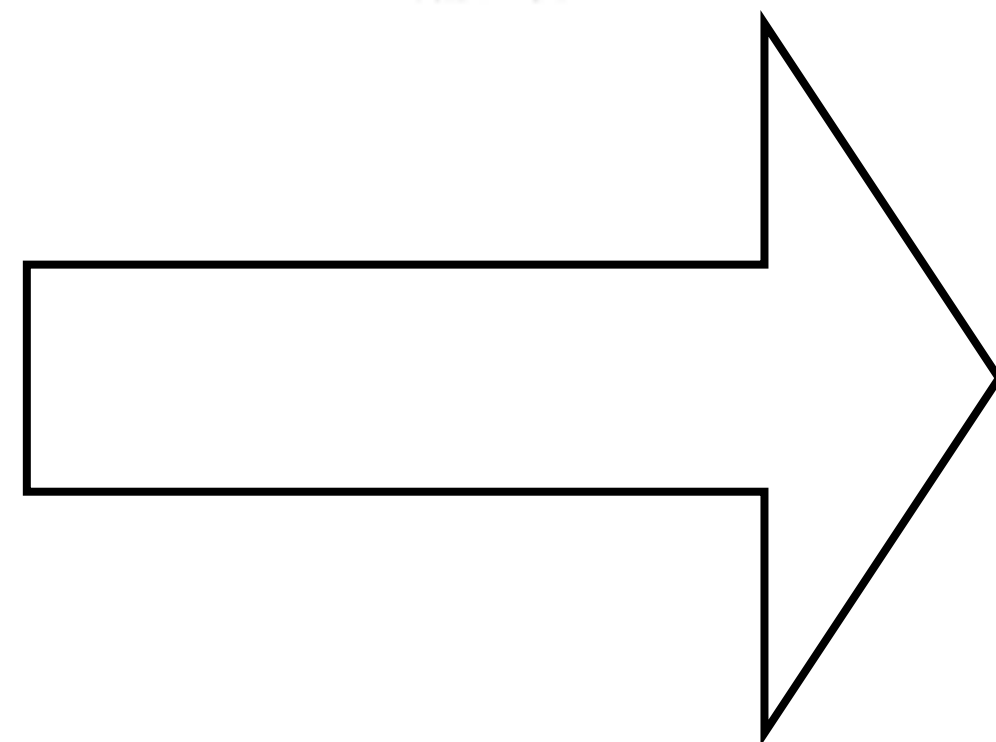
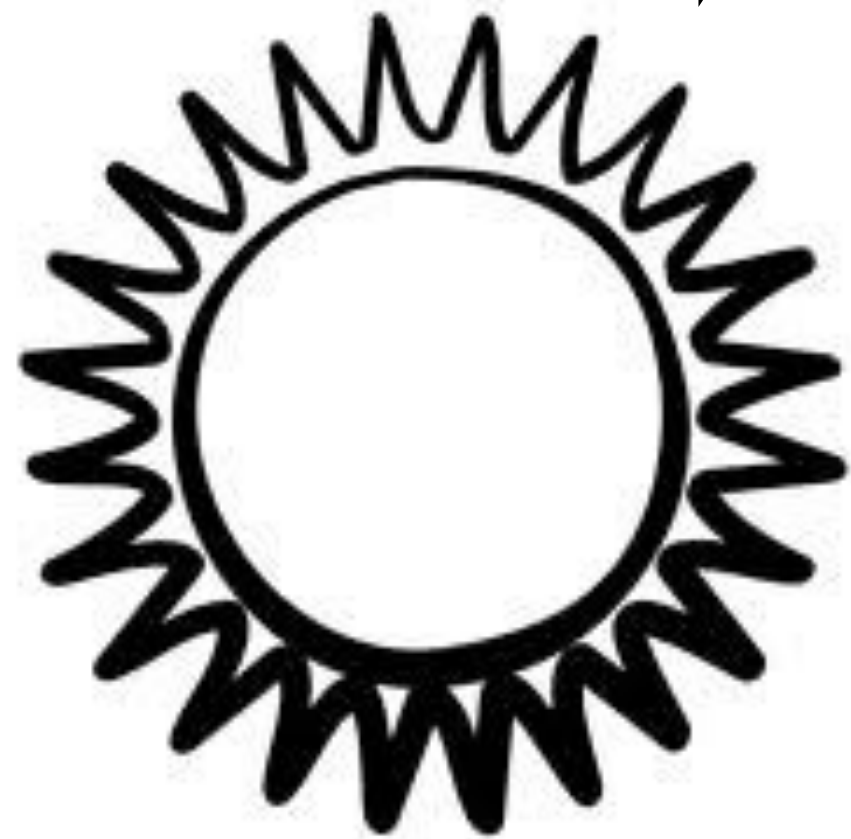
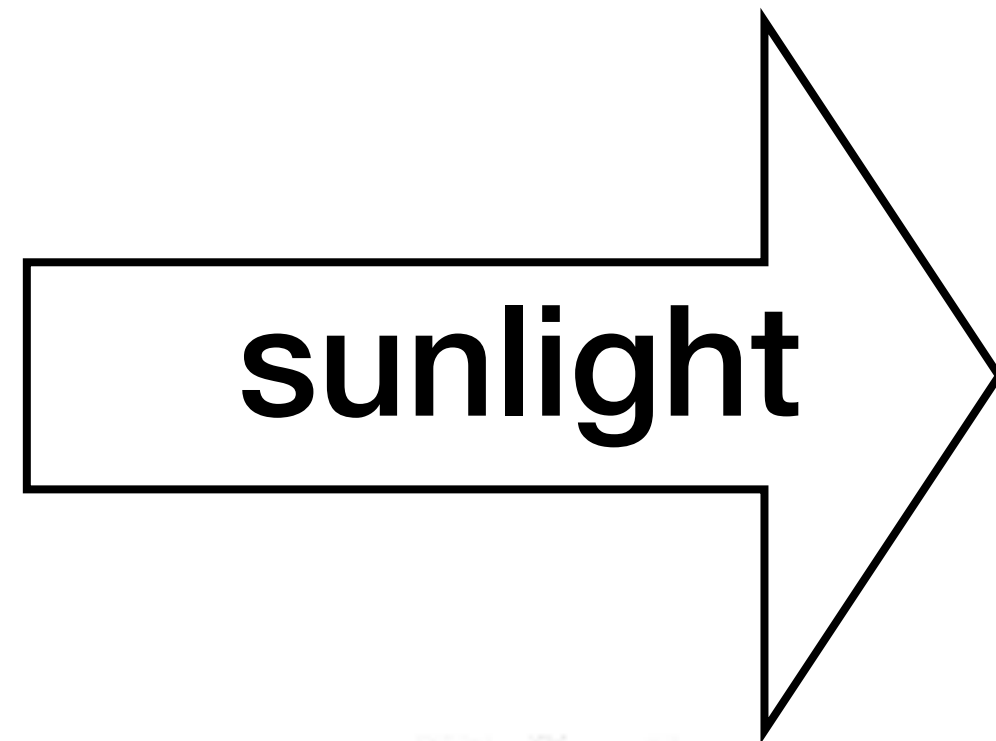


Waning = going away,
Moon orbits same direction
we rotate, so...



or

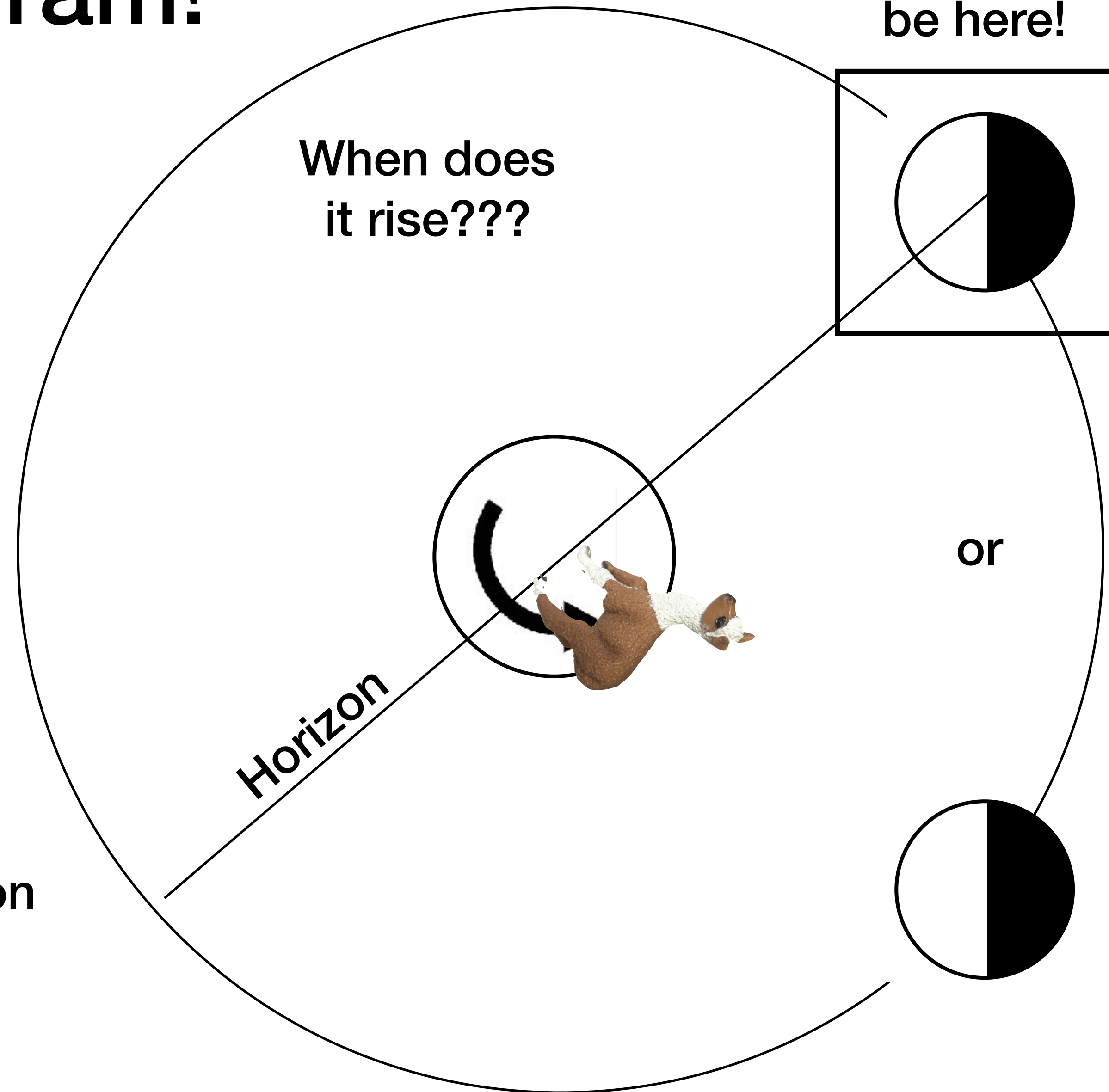
Draw the diagram!



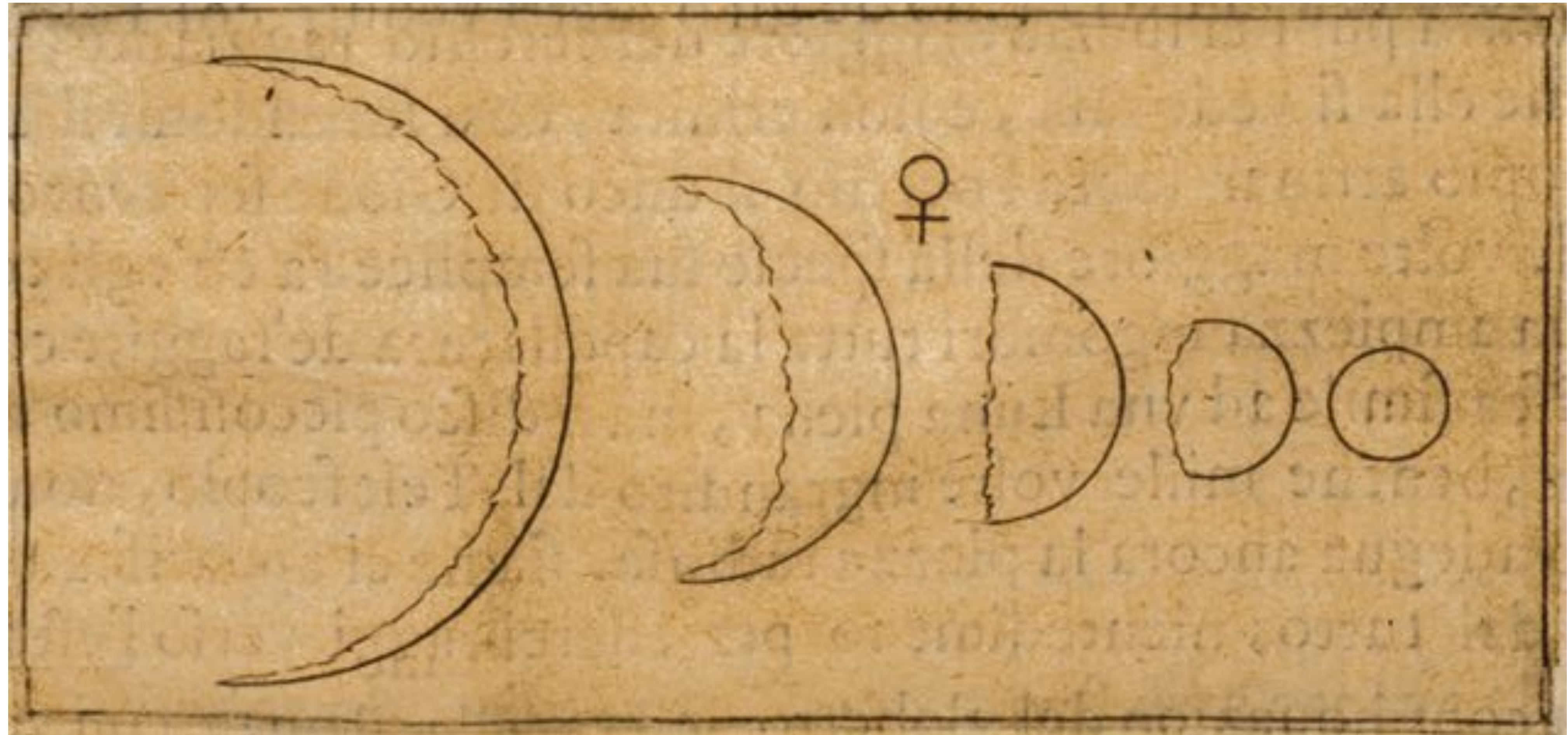
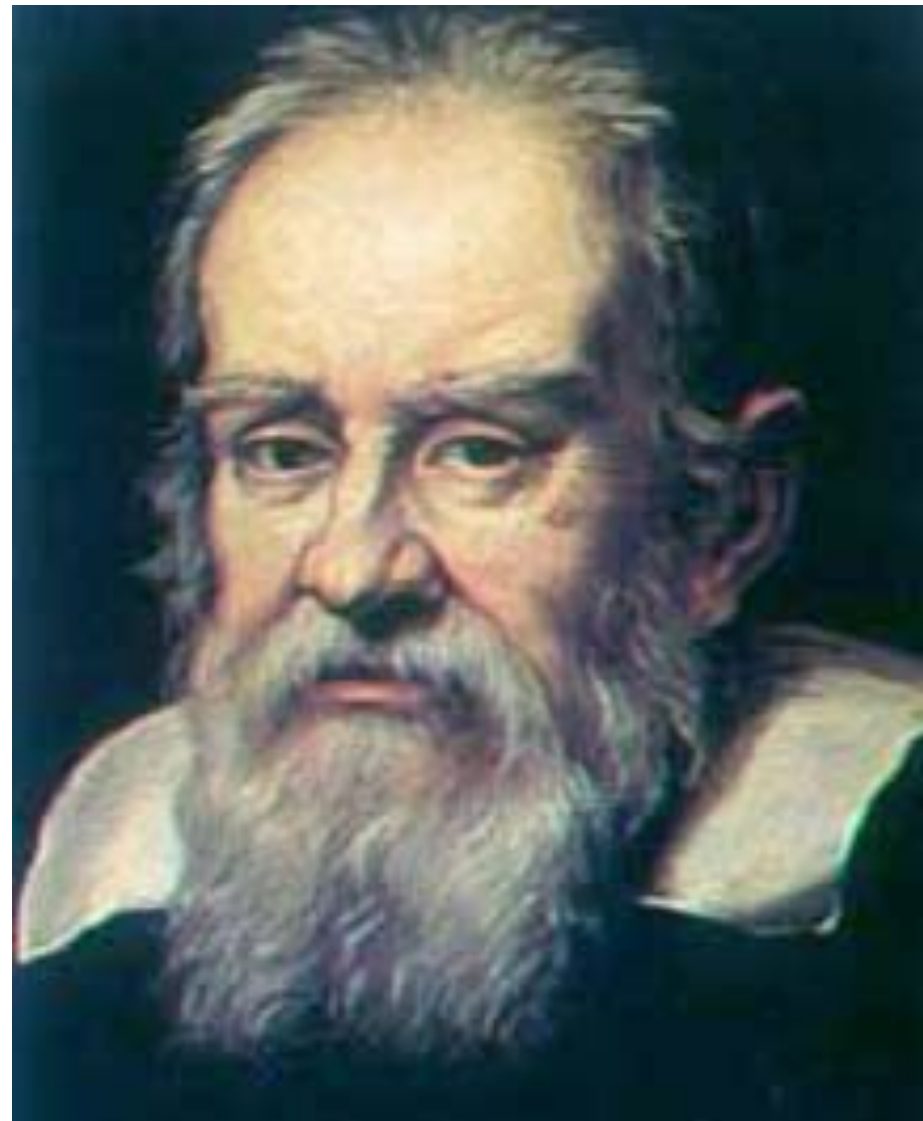
Gibbous \neq Crescent,
so either



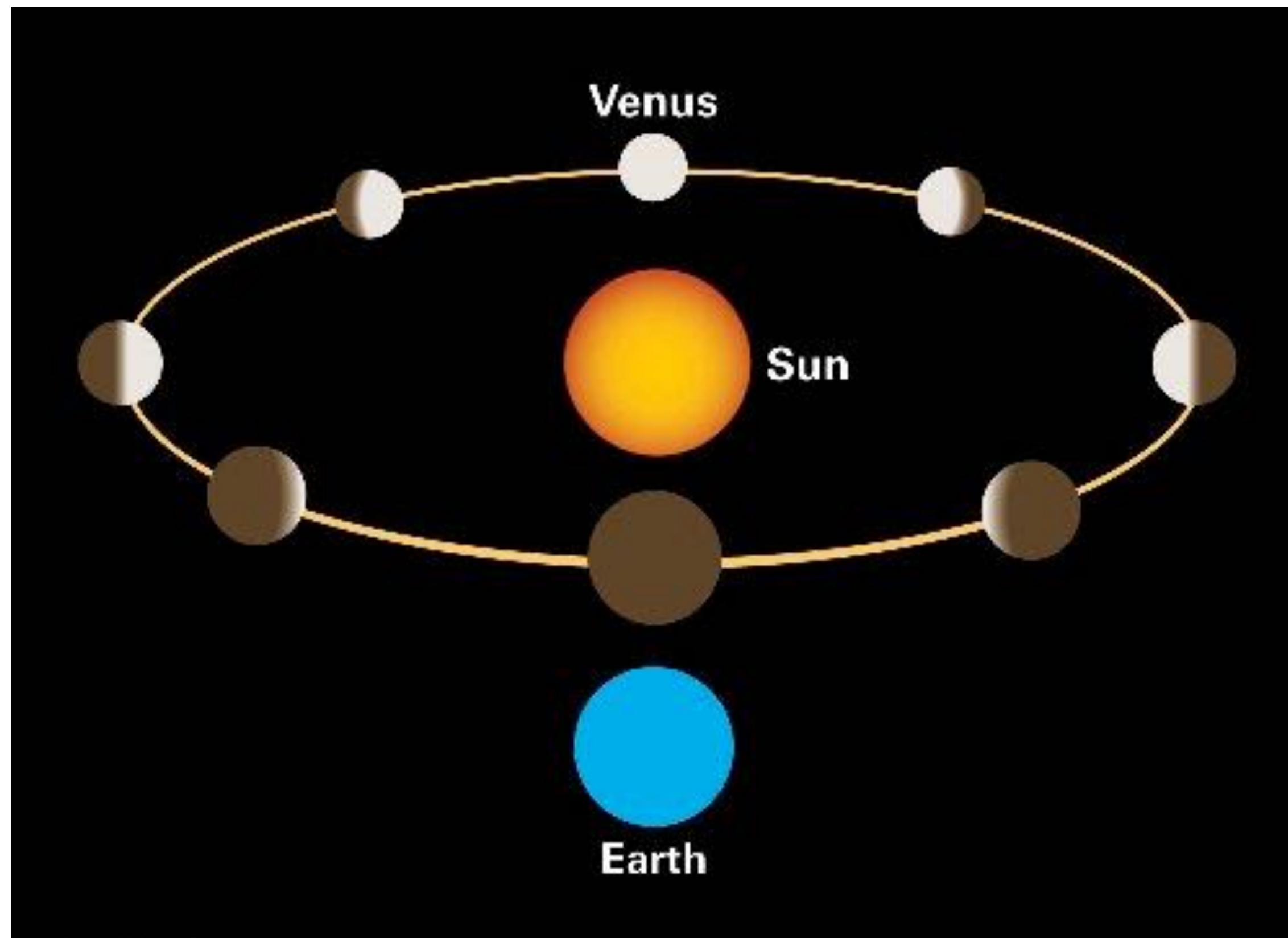
Waning = going away,
Moon orbits same direction
we rotate, so...



Galileo's observations of the phases of Venus in 1610



The apparent size of Venus correlates with its phase



© 2007 Thomson Higher Education

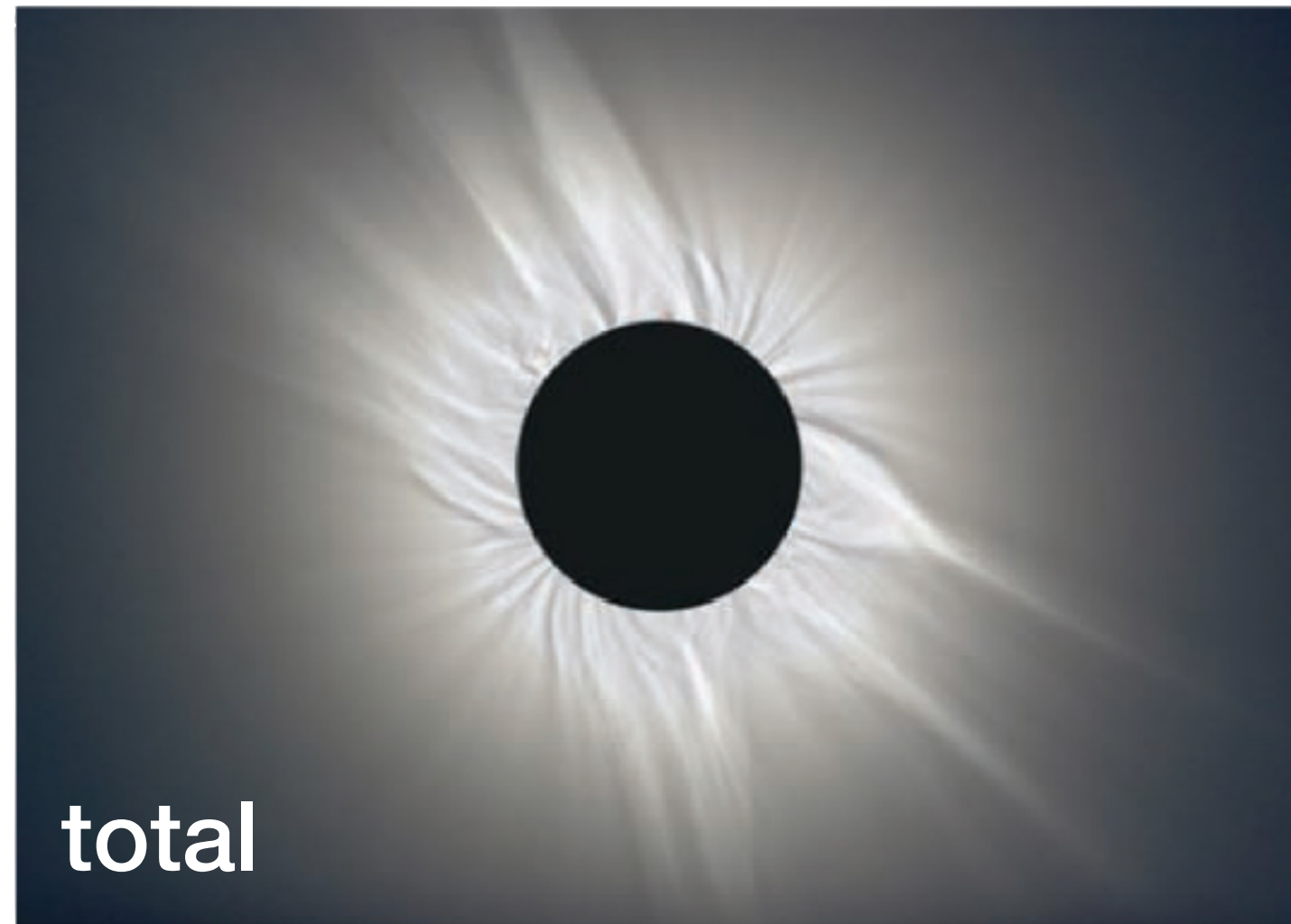


During what phase of the moon would you see a solar eclipse (the moon eclipses the sun)?

How about a lunar eclipse (the earth eclipses the moon)?

Why isn't there an eclipse at every full and new moon?

Solar Eclipses



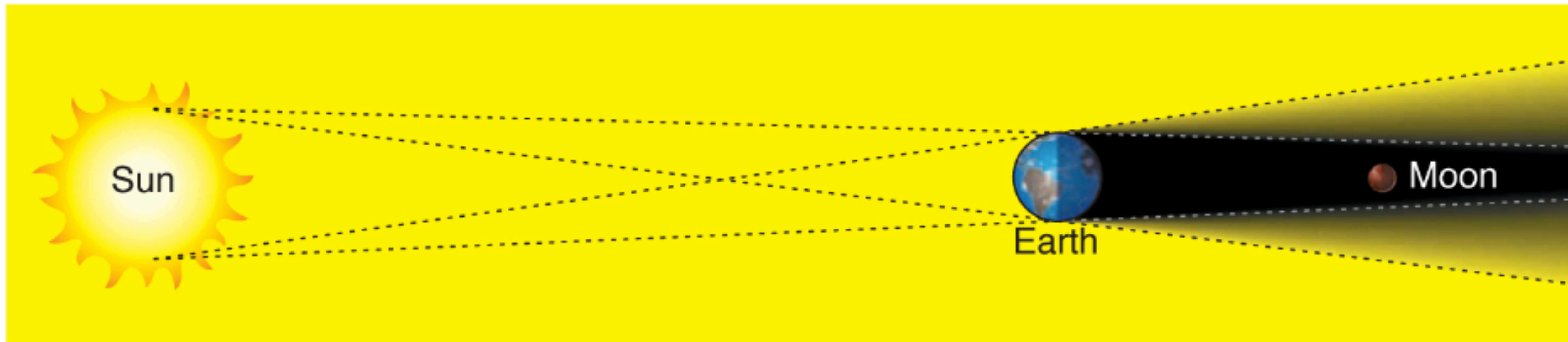
(a) Solar eclipse geometry (not to scale)



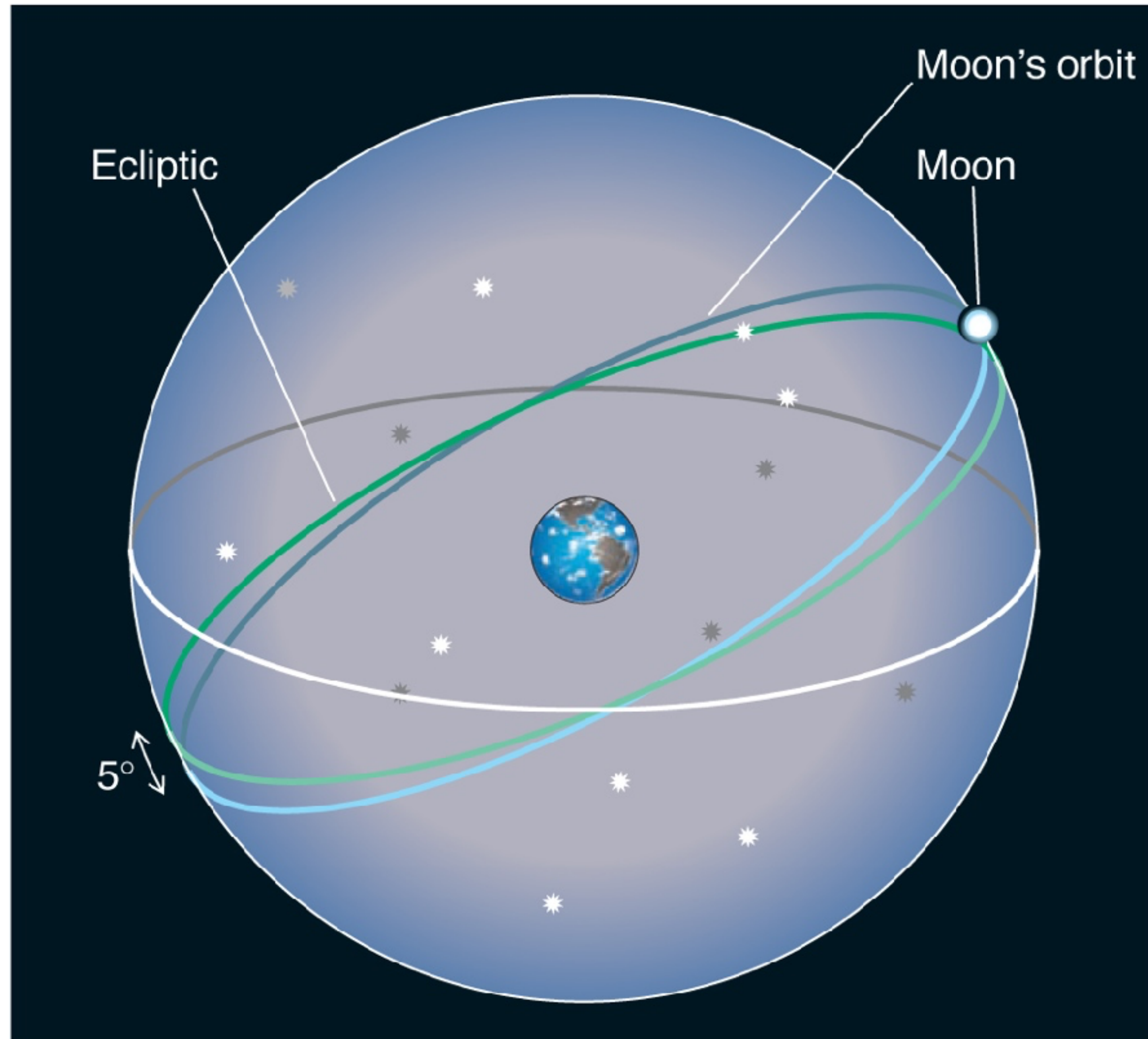
Lunar Eclipse



(c) Lunar eclipse geometry (not to scale)

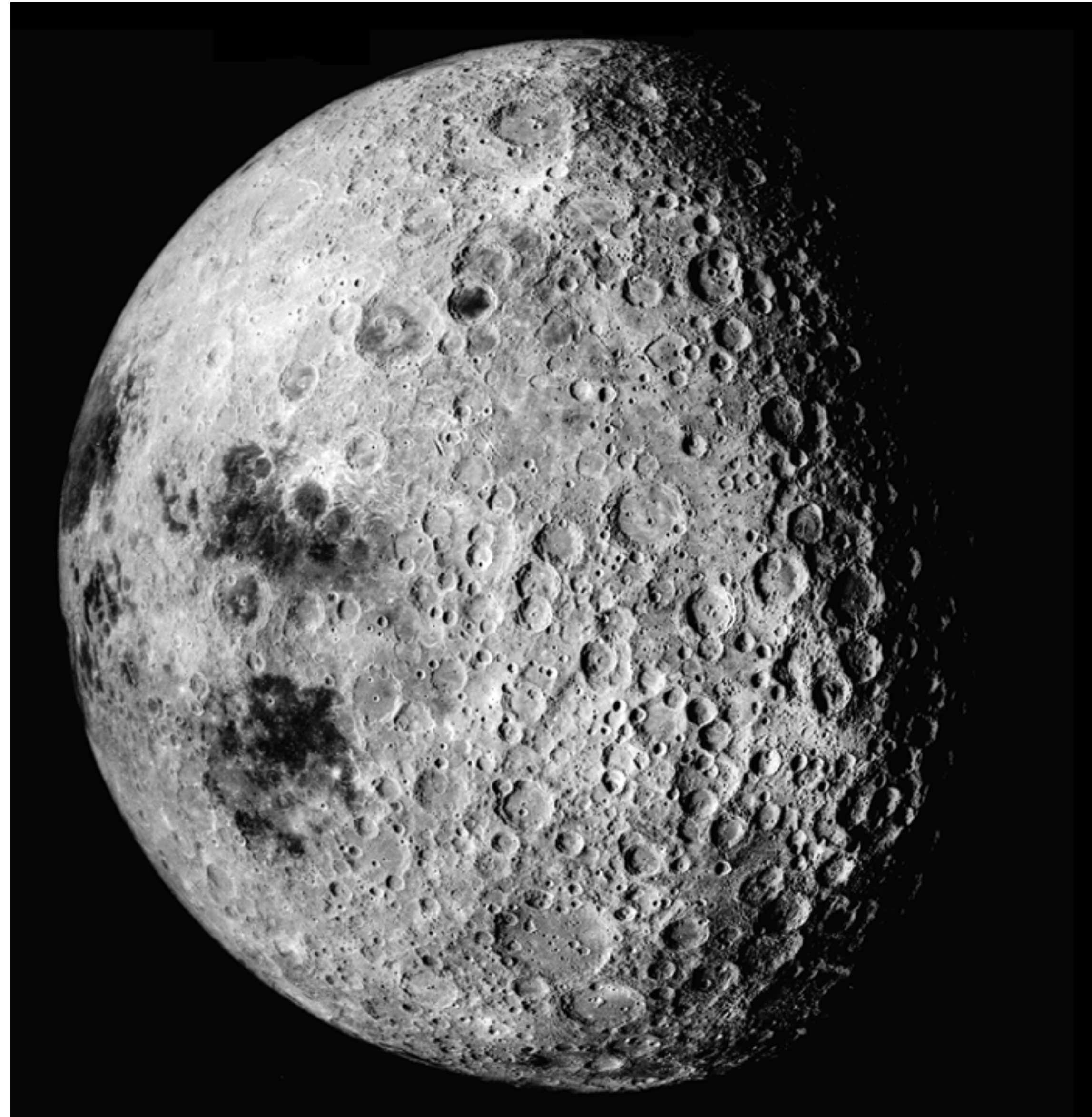


Eclipses are rare because the moon doesn't orbit in the ecliptic



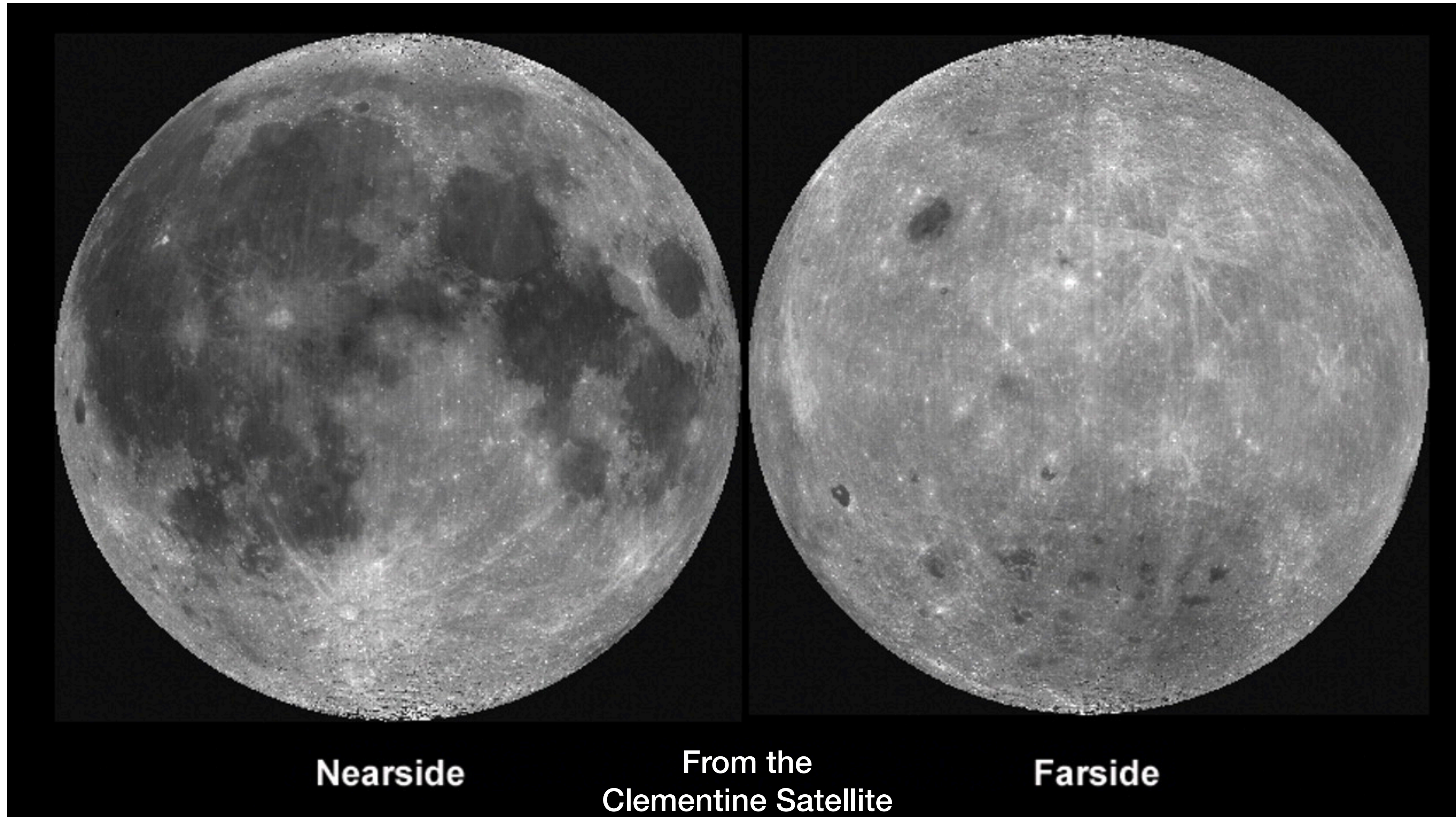
The Moon's orbit only crosses the ecliptic twice, so how many chances are there per year for a solar or lunar eclipse to occur?

Is there a “dark side” of the Moon?



Picture
Credit:
Apollo 16

Nope - but there is a “far side”

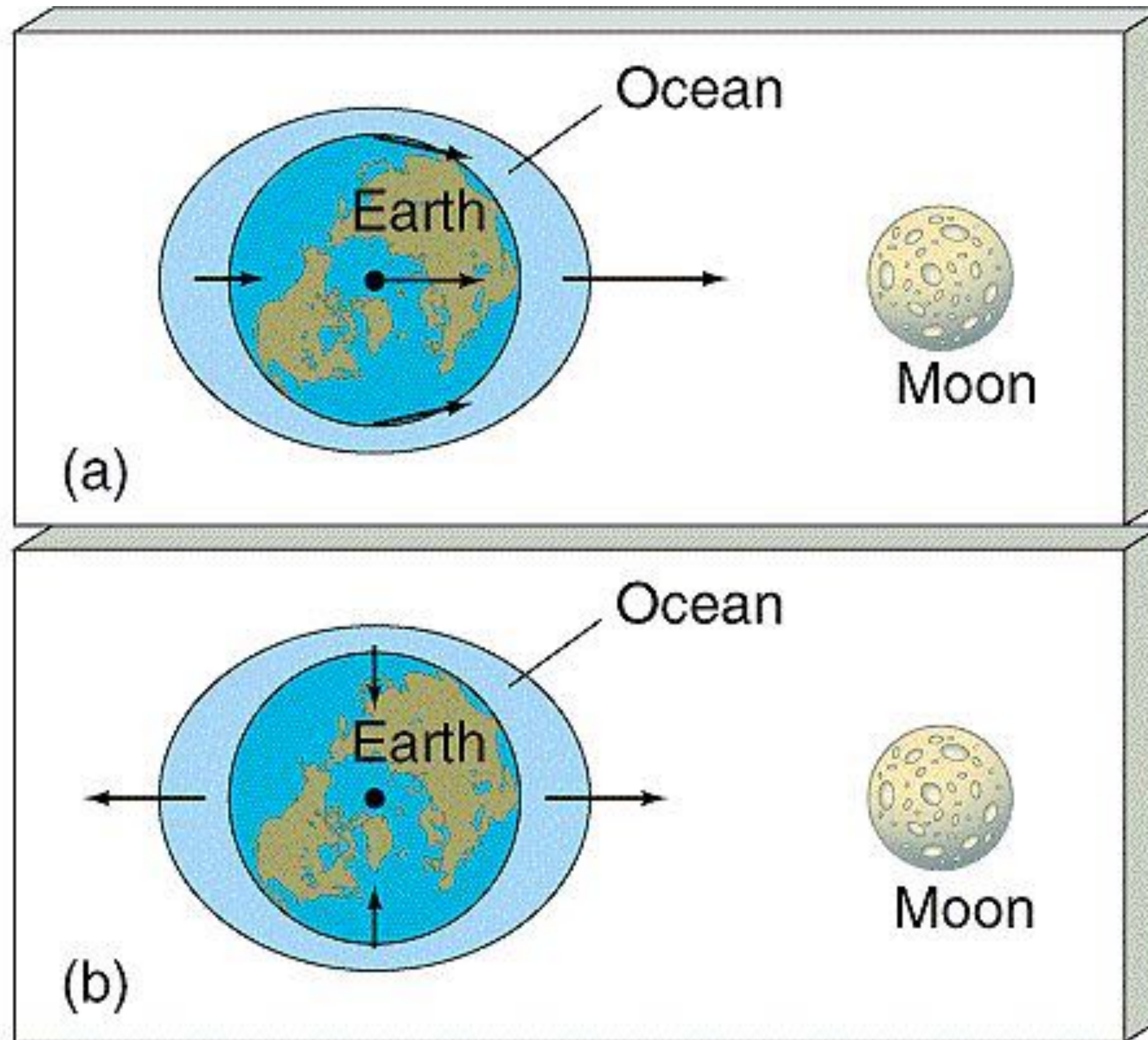


Nearside

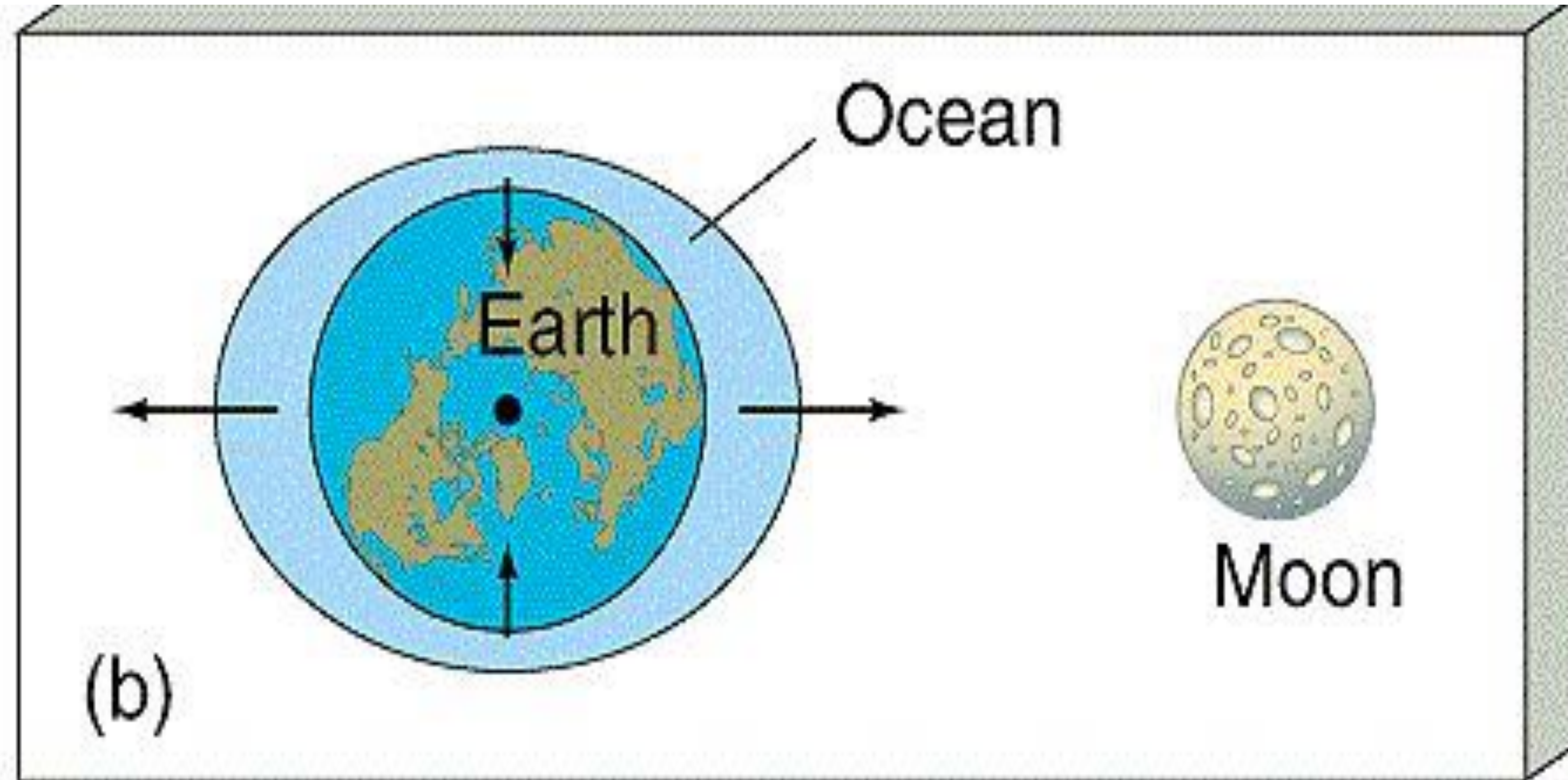
**From the
Clementine Satellite**

Farside

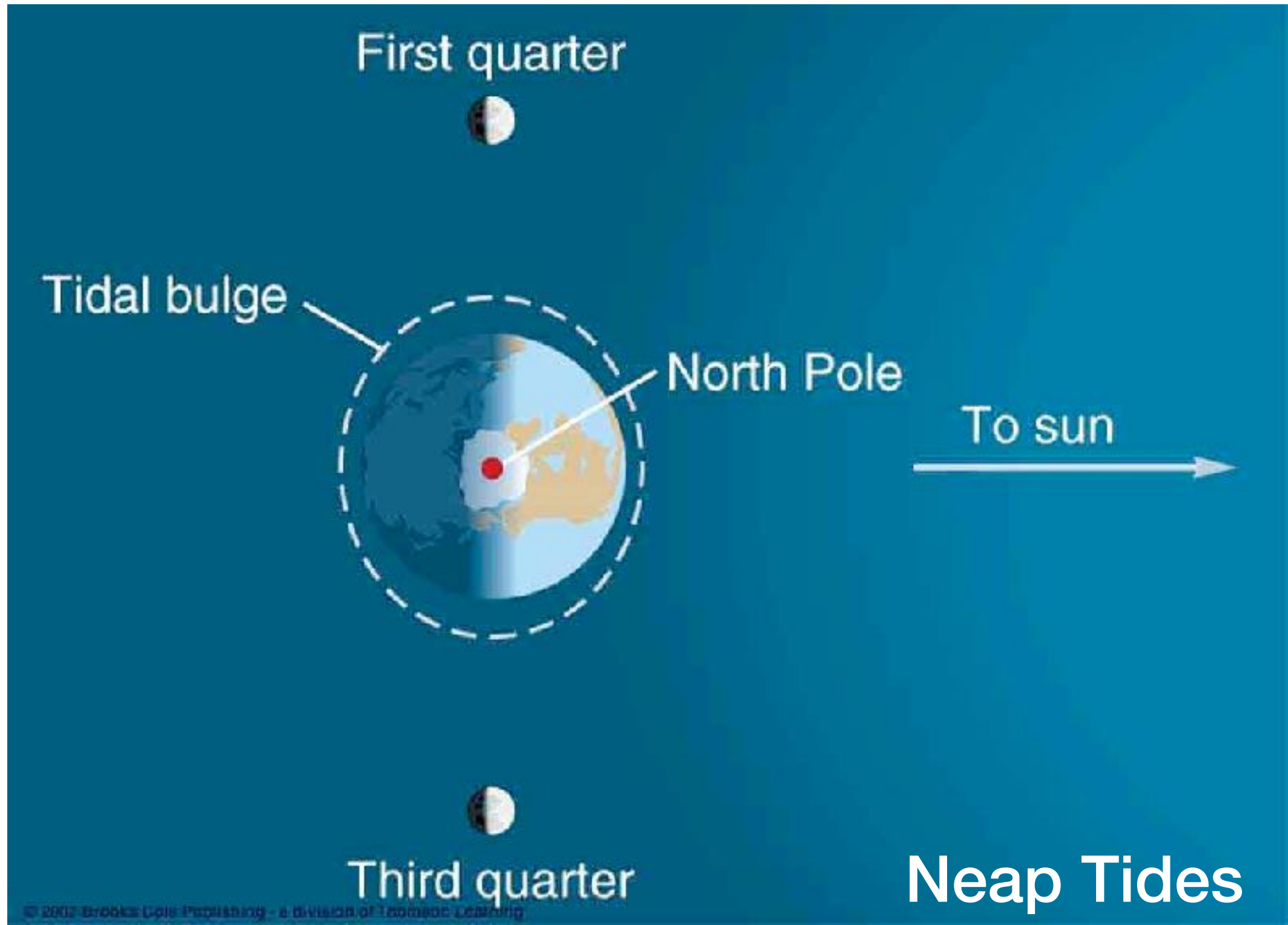
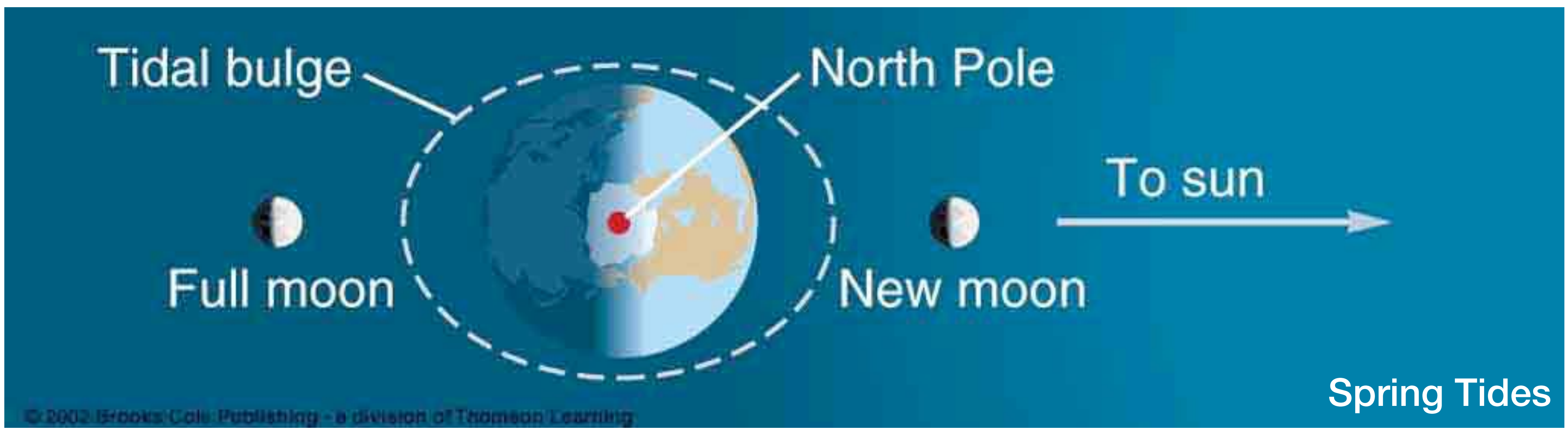
Tides



How many high tides do we have per day?

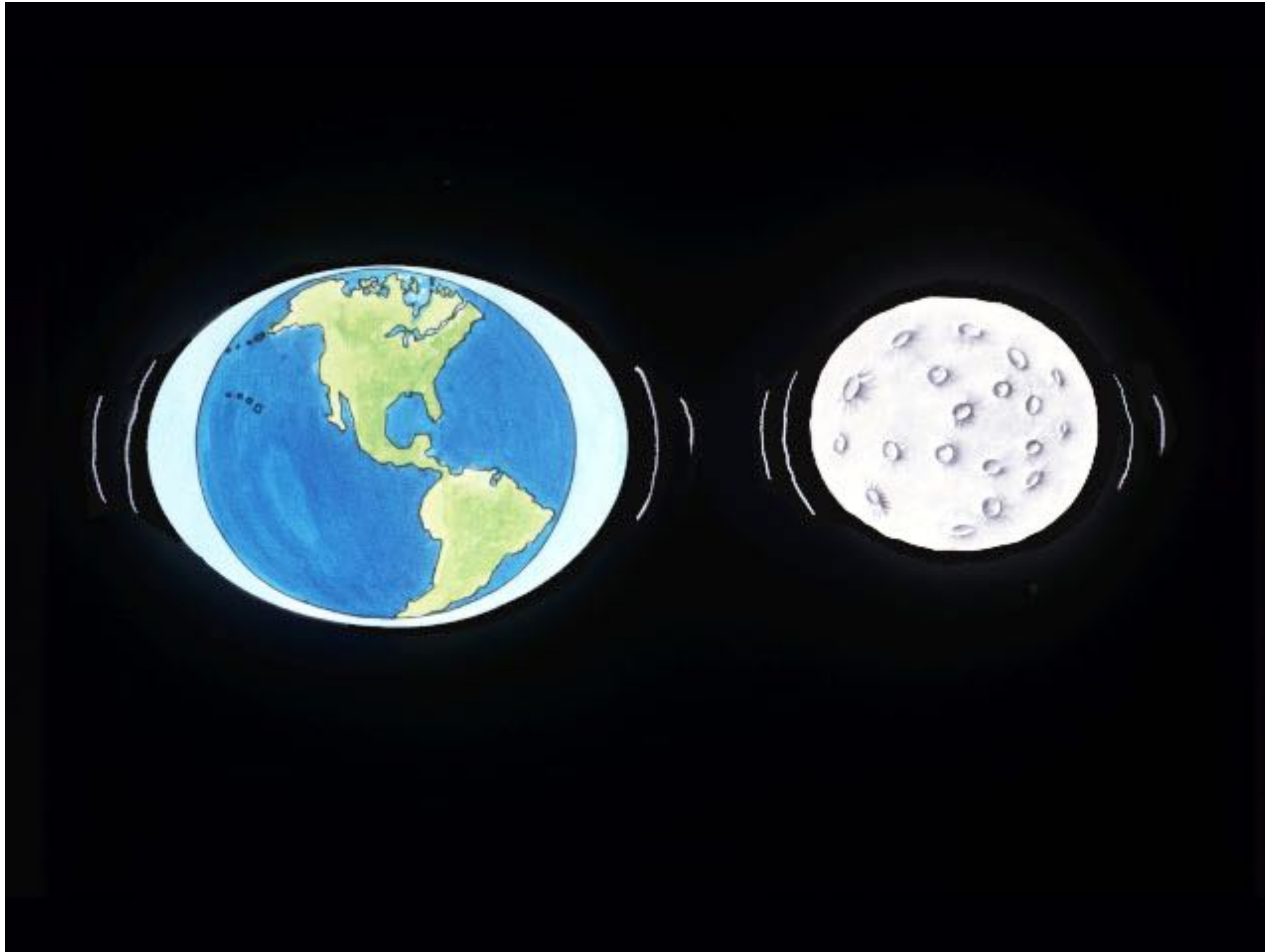


- A) One
- ★ B) Two
- C) Three
- D) Four



strength of the tides depends on Moon phase

Tidal Locking



Tides on the Moon, caused by Earth, are stronger and have “locked” one side of the Moon toward the Earth

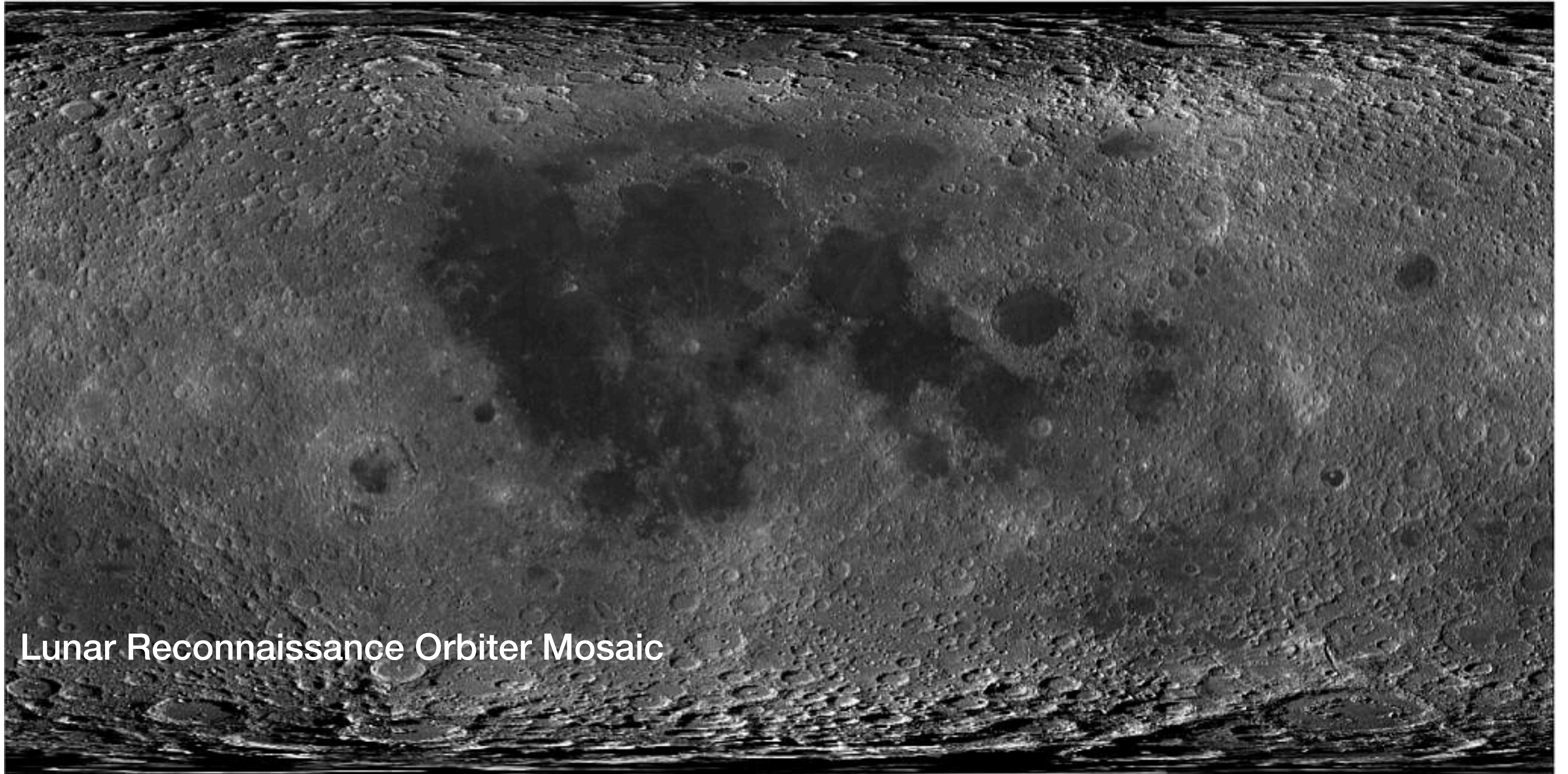
How long does it take the Moon to rotate?

These tidal forces are slowing down the rotation of the Earth, which means (to conserve angular momentum) that the Moon is moving away from us!

200 million years from now:
a day will be 25 hours long

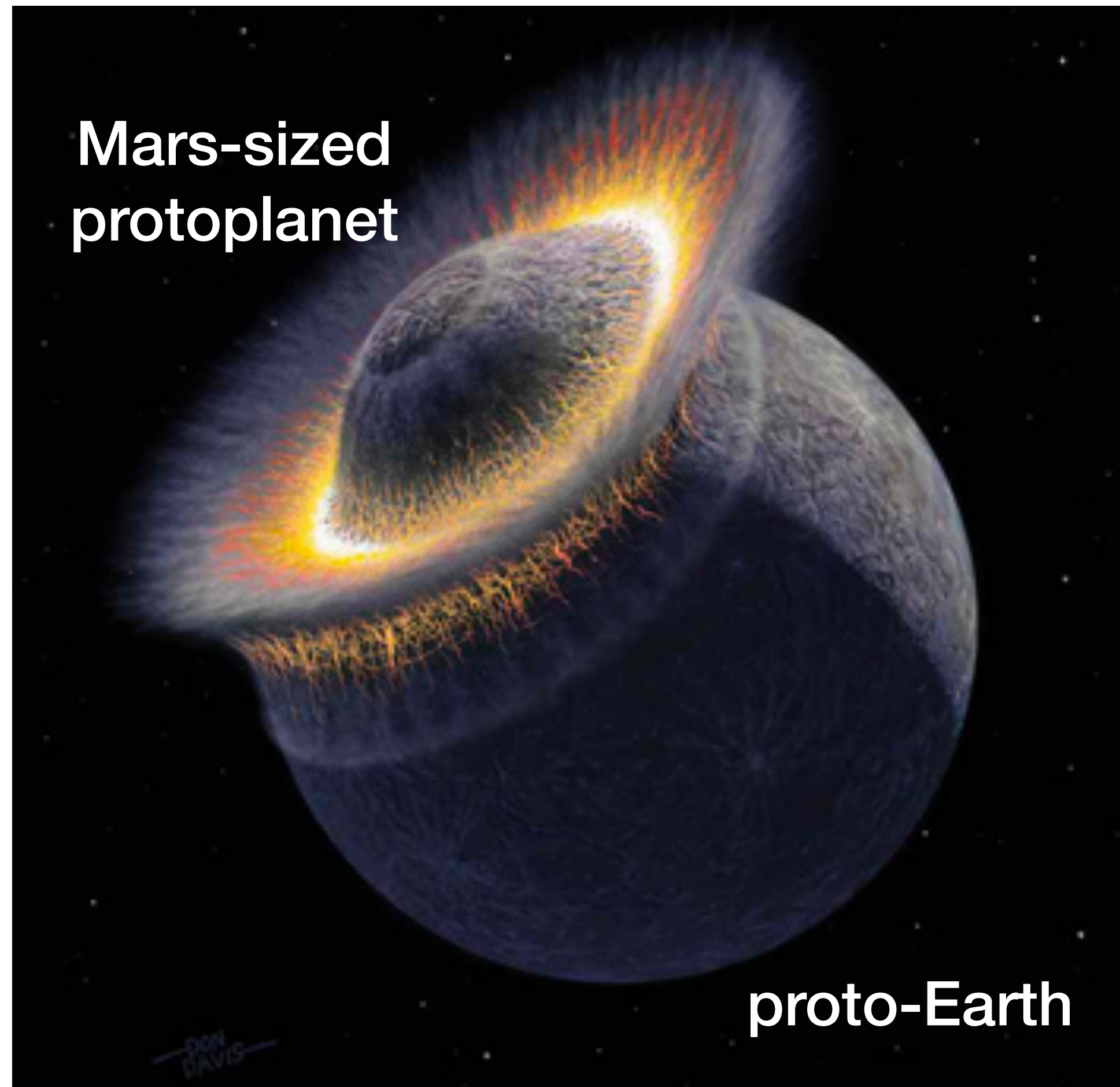
600 million years from now:
no more total solar eclipses

The two-faced Moon, in lame Mercator projection



Lunar Reconnaissance Orbiter Mosaic

The reason it's two-faced is known, but how that happened is not!



The Moon's crust is thicker on the far side than the near side!

Theory 1) two proto-Moons formed from collision, which later “gently” coalesced

Theory 2) the Moon formed very close to the Earth, became tidally locked soon thereafter, and the heat from the Earth “evaporated” crust on the near side, which preferentially condensed on the cooler far side

http://www.slate.com/blogs/bad_astronomy/2014/07/01/the_moon_s_two_faces_why_are_they_so_different.html