Astronomy

Fall 2026

Weeks 5-6

Tuesday, September 8

- T: **8A** model how the orbit and relative position of the Moon cause lunar phases and predict the timing of moonrise and moonset during each phase;
- **8B** model how the orbit and relative position of the Moon cause lunar and solar eclipses; and
- O: Describe how and why the shape of the lit portion of the Moon seen from Earth changes during the month.
- D: Lunar Phases interactive, notes and class discussion

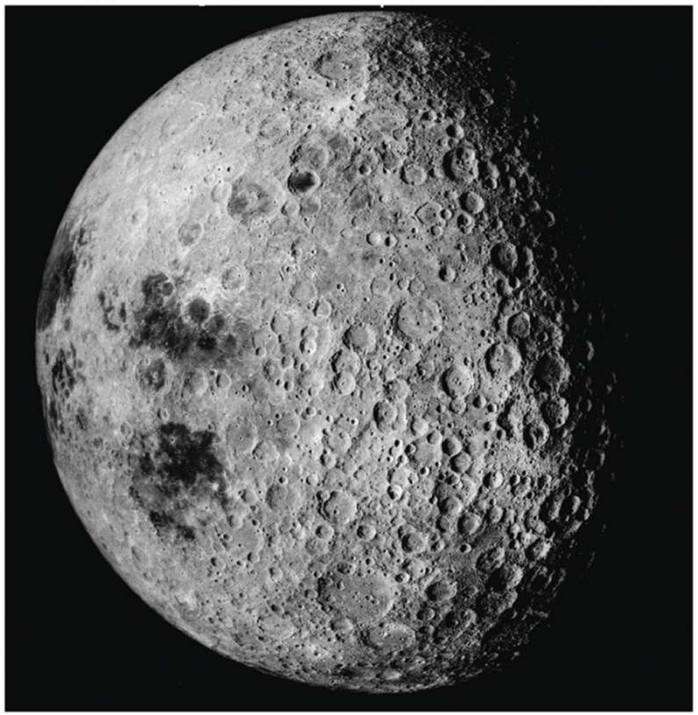
Journal 1.2

- What are some of your goals in the first 2 years after you graduate high school?

The Moon

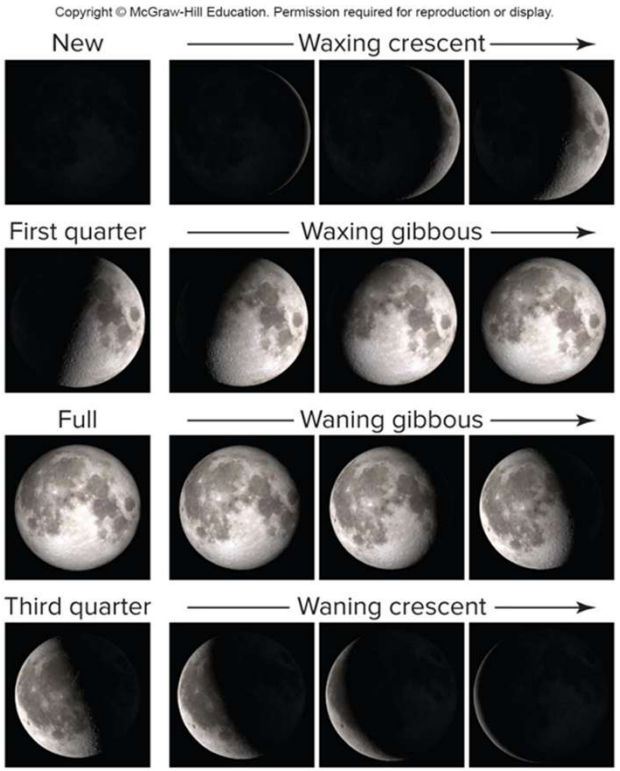
- Rises in the east and sets in the west.
- Moon move west to east relative to the stars

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- Apollo 16, NASA

The Phases of the Moon

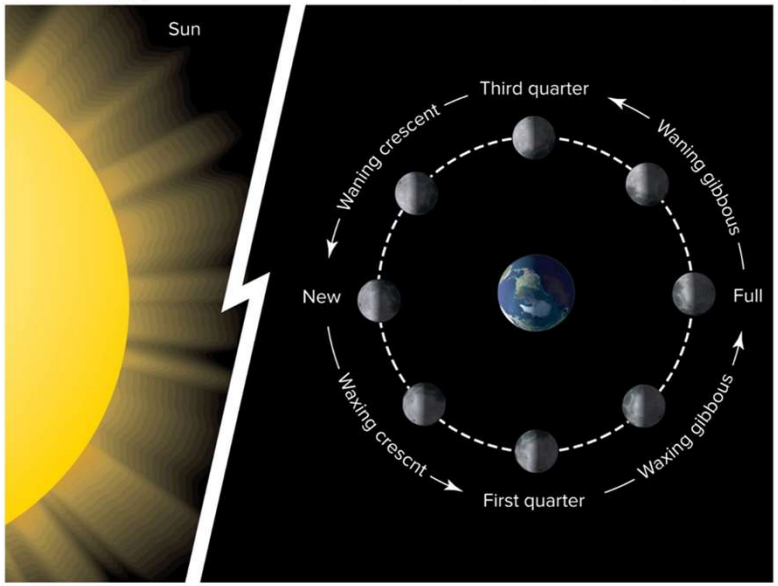


- Phases of the moon*:*
  - New
  - waxing crescent
  - first quarter
  - waxing gibbous
  - Full
  - waning gibbous
  - third quarter
  - waning crescent.

- Appearance of the Moon from Earth (moon images): NASA/Goddard Space Flight Centre Scientific Visualization Studio

The Phase Cycle

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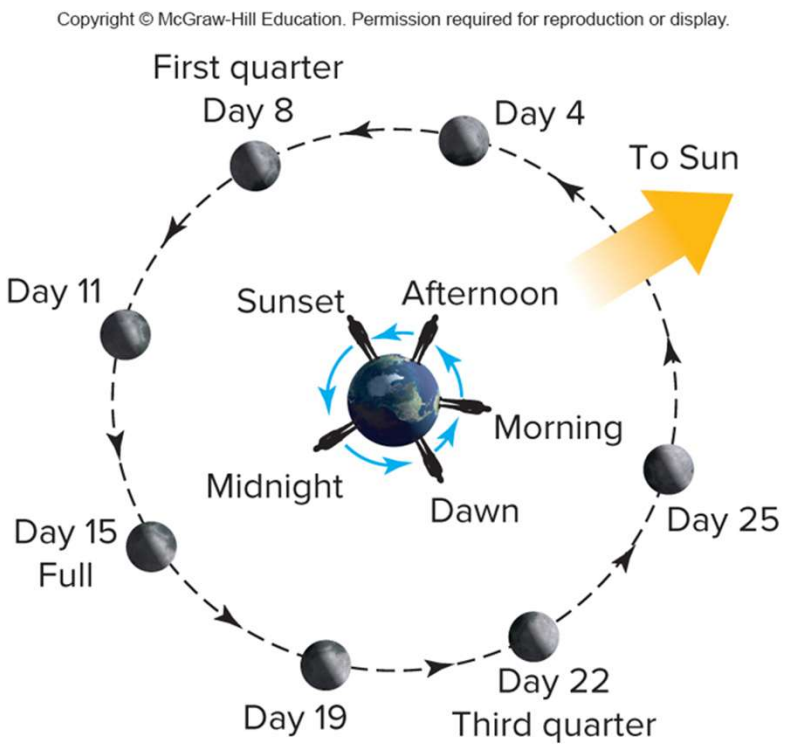


- The phases of the Moon are caused by the relative positions of the Sun, Earth, and Moon.

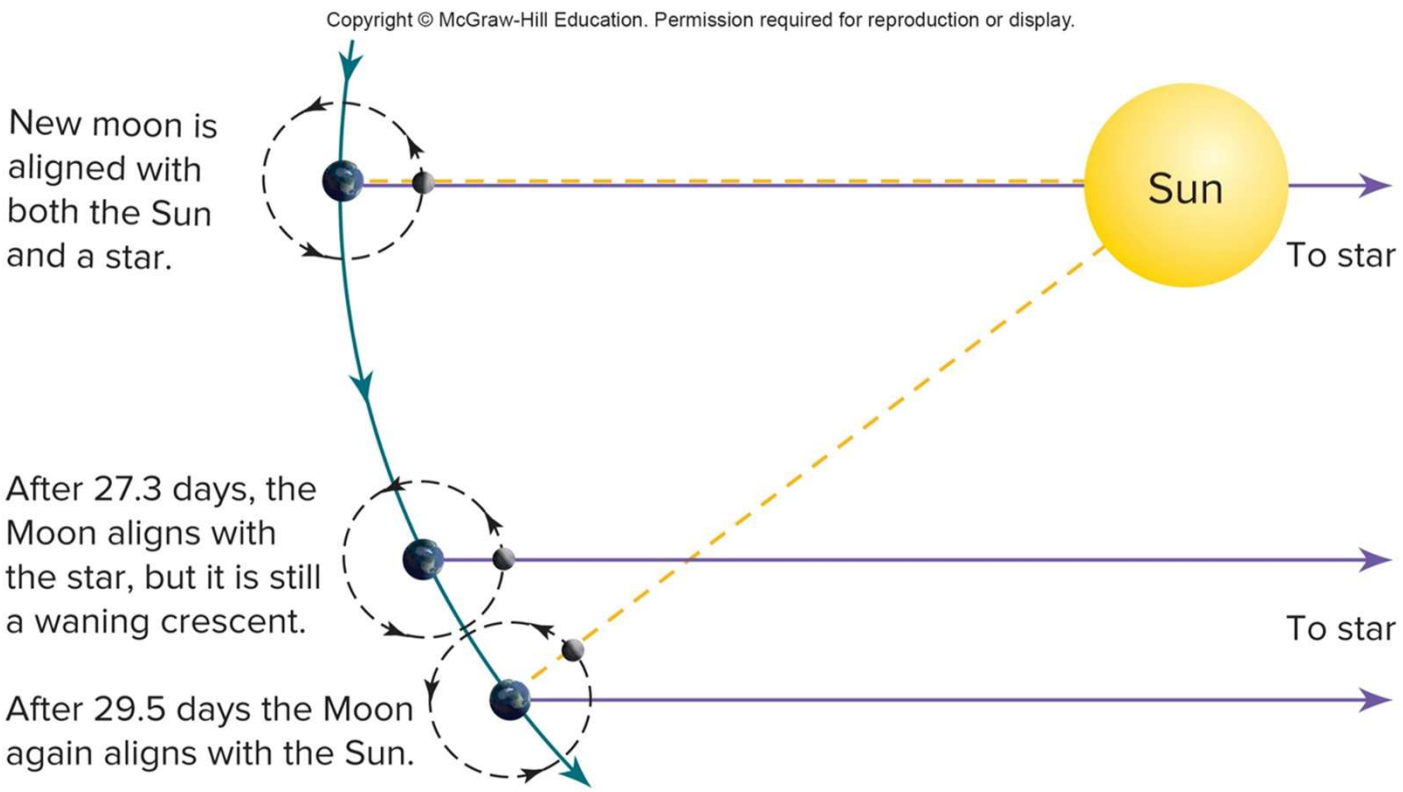
- (moon images): NASA/Goddard Space Flight Center Scientific Visualization Studio

Lunar Rise and Set Times

- Moon rises about 50 minutes later each day.
- Moon is visible at different times and places during the night or day depending on its phase.

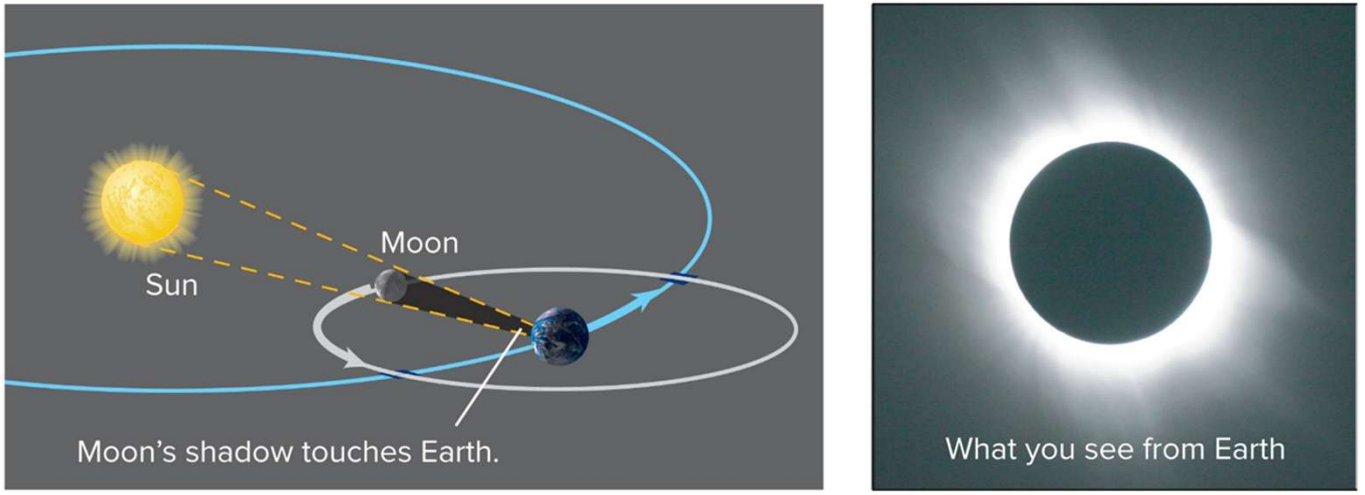


The Sidereal Month



Eclipses

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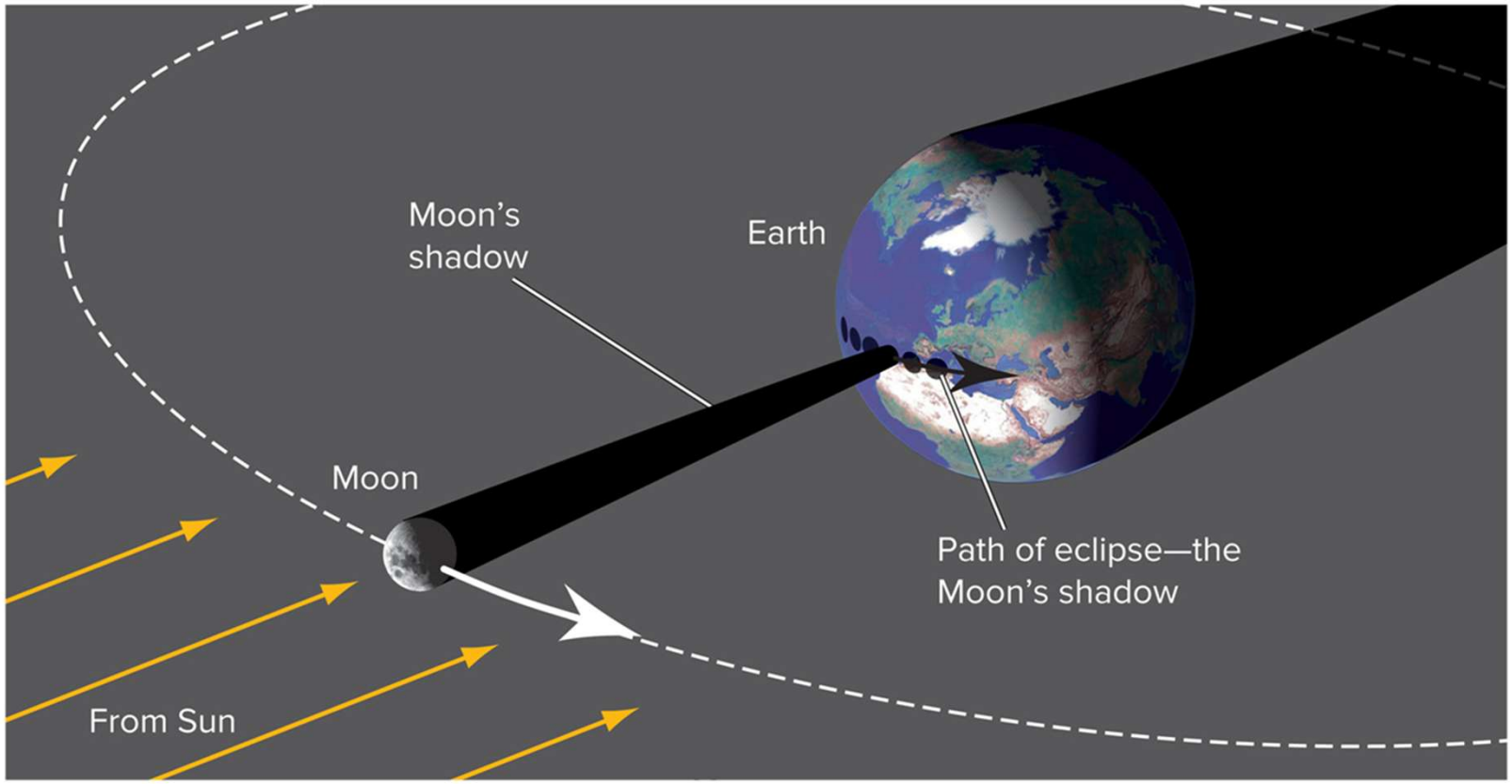


- An ***eclipse*** occurs when the Sun, Earth, and Moon align
- A ***solar eclipse*** is when the moon is directly between the Earth and Sun

- right: S.E. Schneider

Solar Eclipses

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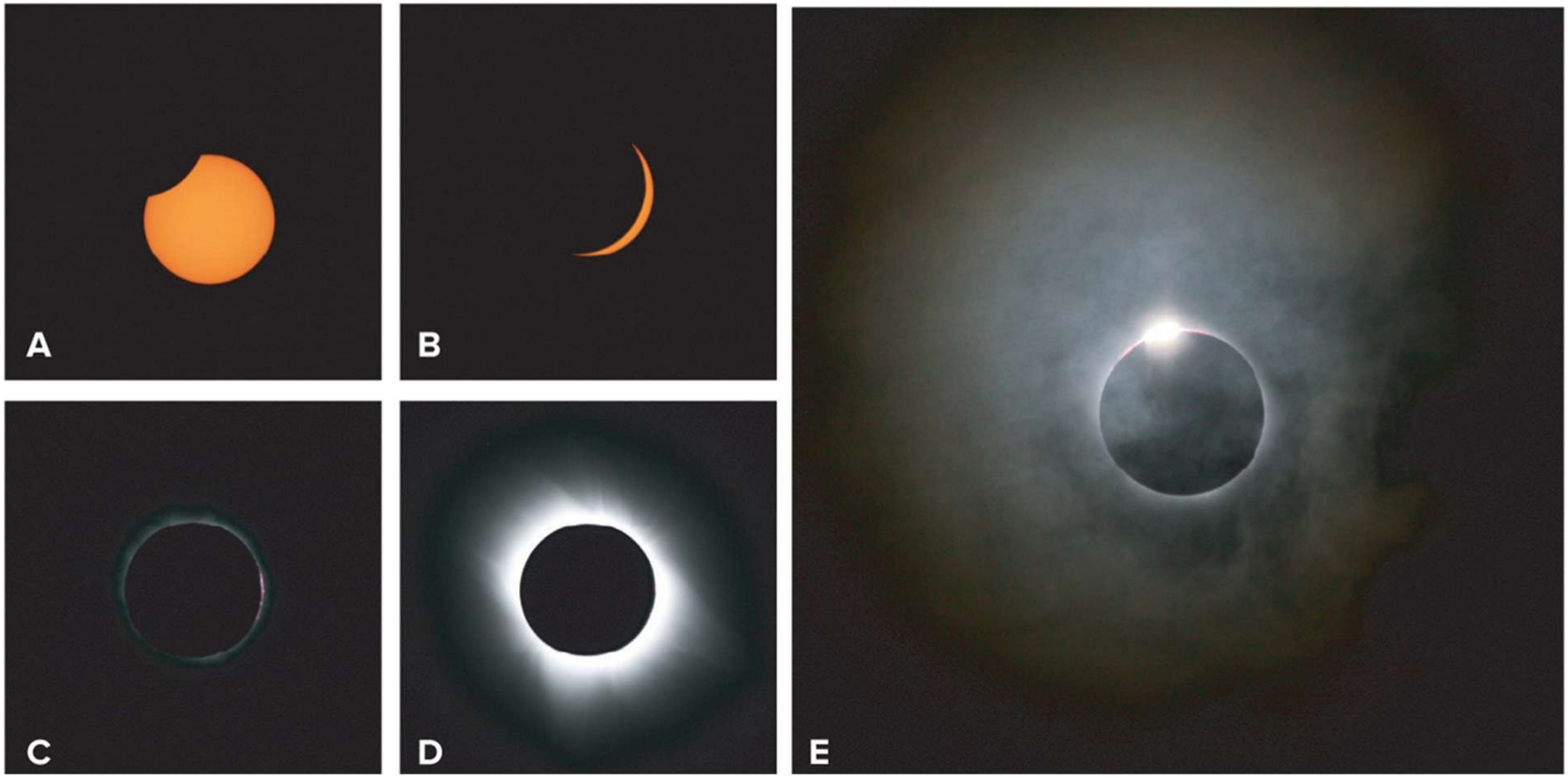


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Stages of a Solar Eclipse

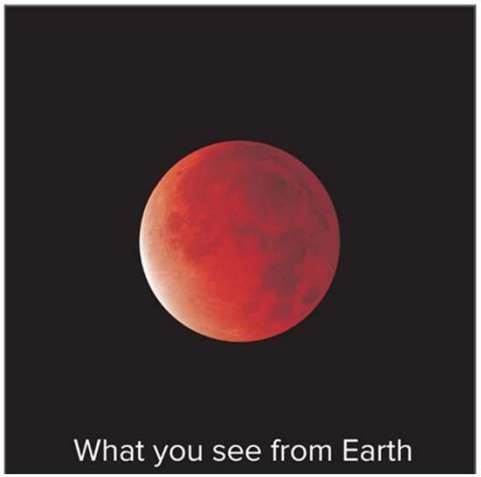
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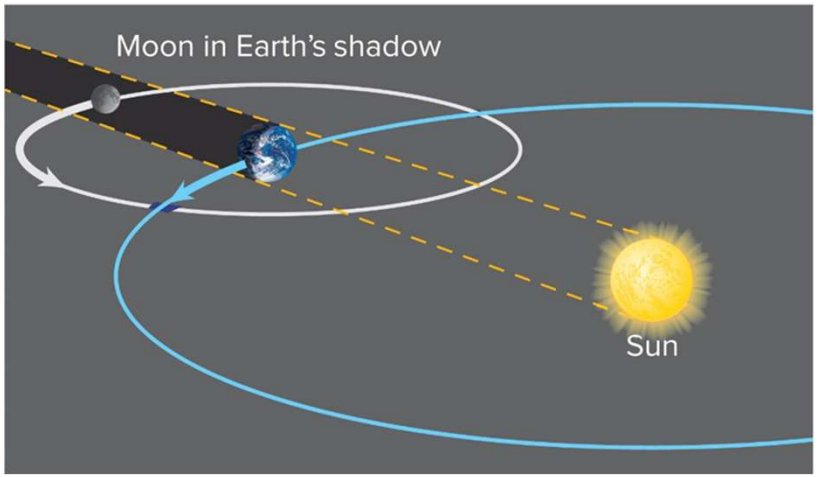


- (a-e): S.E. Schneider

Lunar Eclipses [1]

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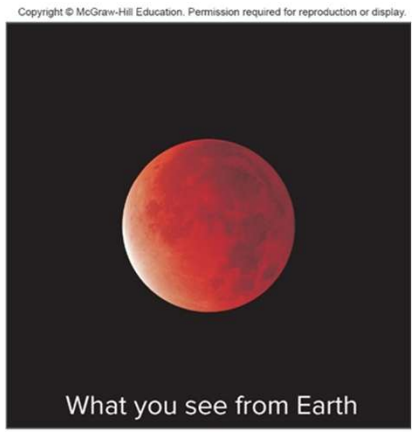


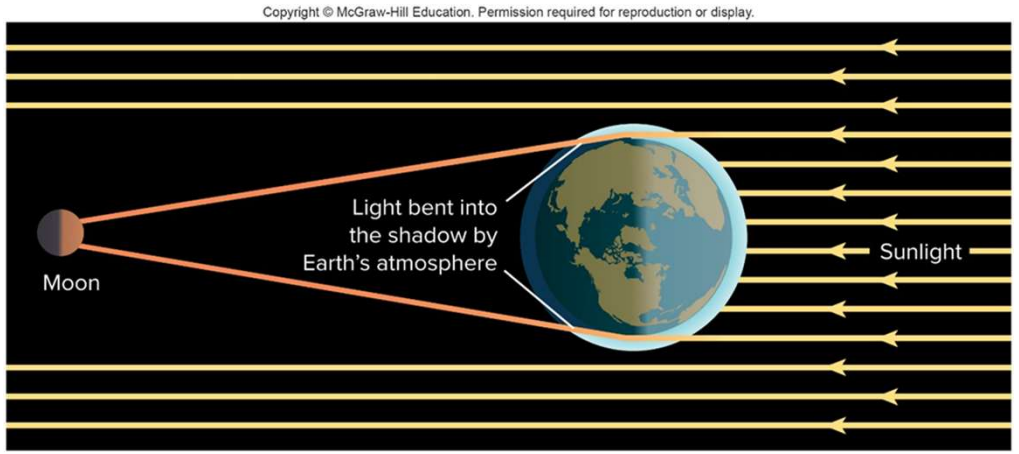


- A ***lunar eclipse*** when the Earth is between the moon and sun
- The moon appears red like a sunset

- Left: John Walker

Lunar Eclipses 2



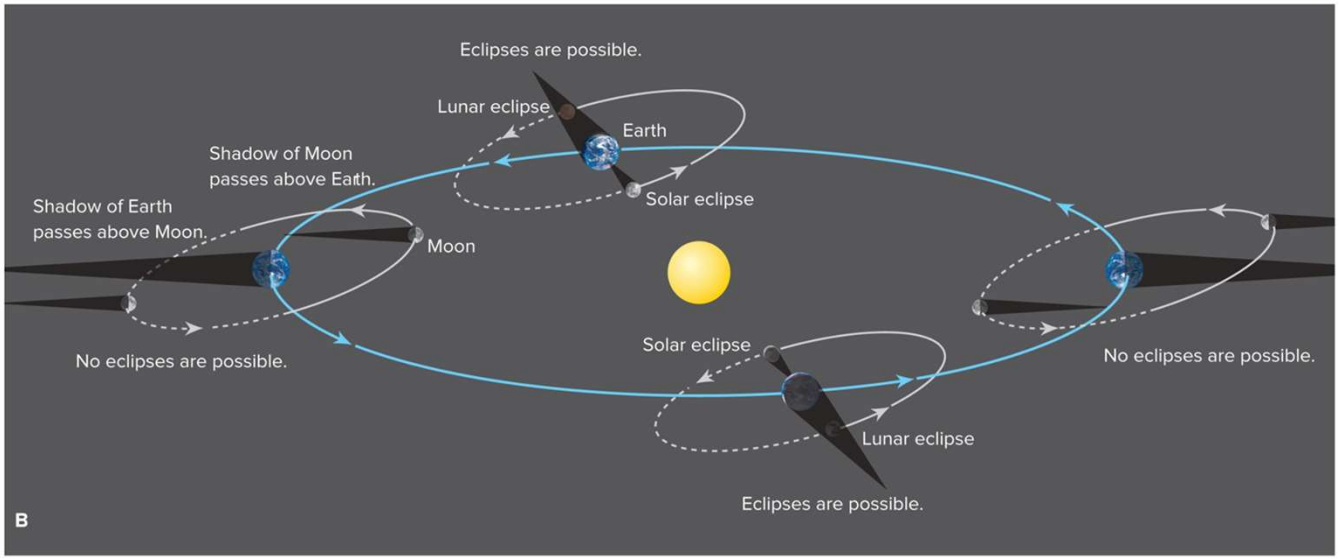


- Earth's atmosphere bends some sunlight into the shadow.
- The light reaching the Moon is red because interactions with Earth's atmosphere

- John Walker

Rarity of Eclipses

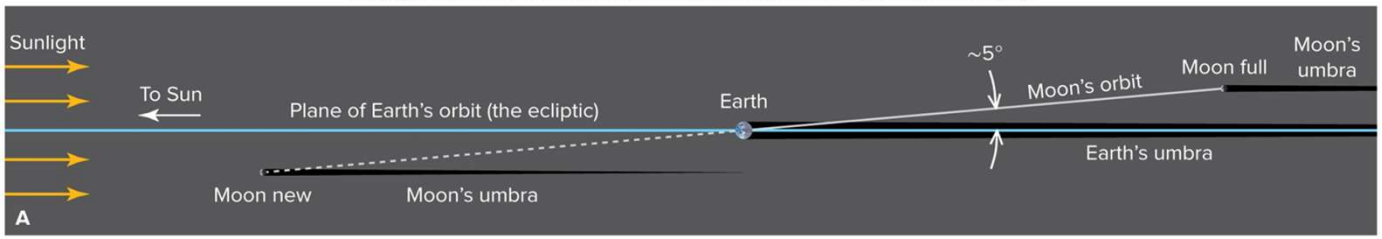
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- Because of the Moon's tilt relative to the ecliptic, eclipses will not occur at every new and full Moon.
- Twice a year the Moon's orbit gives the possibility of an eclipse – these times are called ***eclipse seasons.***

Eclipse Periods

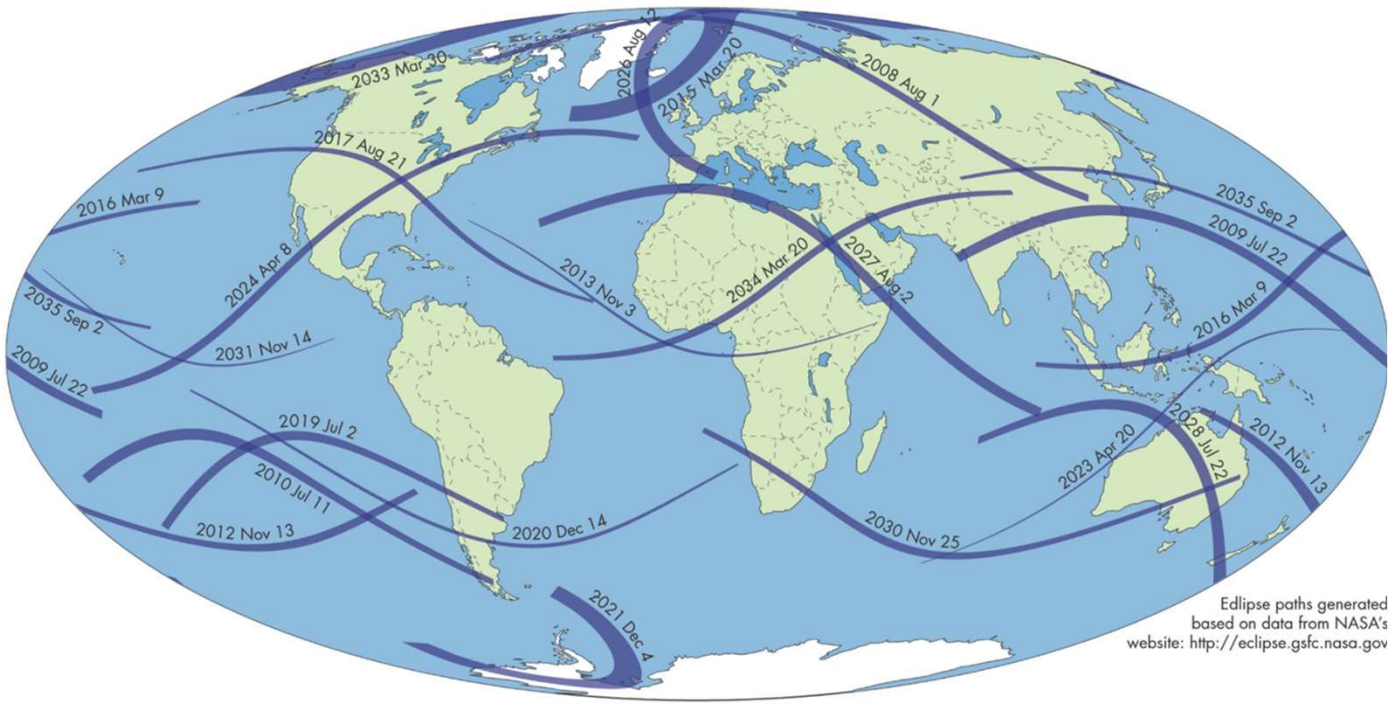
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- Eclipses do not occur every 30 days since the Moon's orbit is tipped relative to Earth's orbit.
- The tipped orbit allows the shadow of Earth (Moon) to miss the Moon (Earth).

Recent and Upcoming Solar Eclipses

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B

- b: Map by S.E Schneider based on data from NASA's website. http//eclipse.gsfc.nasa.gov

The Phase Cycle Appendix

- Looking down on Moon's orbit from above, moon travels counterclockwise. With sun to left: the left side of the moon is always bright, right side of moon always dark, at all positions as moon orbits around Earth.
- New phase: moon at 9 o'clock position. Moon in between Earth and sun, looks dark from Earth.
- Waxing crescent: moon moves from 9 o'clock down towards 6 o'clock, crescent seems to grow.
- First quarter: moon at 6 o'clock. From Earth, moon appears as right-half-lit sphere.
- Waxing gibbous: moon moves from 6 o'clock to 3 o'clock. Lit part becoming more circular.
- Full: moon at 3 o'clock, full circle visible.
- Waning gibbous: moon moves from 3 o'clock up towards 12 o'clock, circle shrinks towards half.
- Third quarter: moon at 12 o'clock position. From Earth, appears as left-half-lit sphere.
- Waning crescent: moon moves from 12 o'clock back to 9 o'clock. Half becomes ever-shrinking crescent back to new.

Thursday, September 10

- T: **9D** explain the significance of Earth's solstices and equinoxes.
- O: I will be able to **ensure my understanding of unit 1**
- D: by taking completing the Unit 1 SmartBook

Tuesday, September 15

- T:**(5) Science concepts. The student understands how astronomy influenced and advanced civilizations. The student is expected to:**
- **5A** evaluate and communicate how ancient civilizations developed models of the universe using astronomical structures, instruments, and tools such as the astrolabe, gnomons, and charts and how those models influenced society, time keeping, and navigation;
- **5C** describe and explain the historical origins of the perceived patterns of constellations and the role of constellations in ancient and modern navigation.
- O: I will be able to demonstrate my understanding of the first unit of astronomy
- D: by making a stellar grade on my test

Thursday, September 17

- T: **5B** research and evaluate the contributions of scientists, including Ptolemy, Copernicus, Tycho Brahe, Kepler, Galileo, and Newton, as astronomy progressed from a geocentric model to a heliocentric model; and
  6D understand the difference between astronomy and astrology, the reasons for their historical conflation, and their eventual separation.
- O: I will begin to understand ancient astronomers
- D: by taking notes, having a class discussion, and watching some informative videos.

Journal 1.3

- What movie or tv show would you recommend and why?

The Rise of Astronomy

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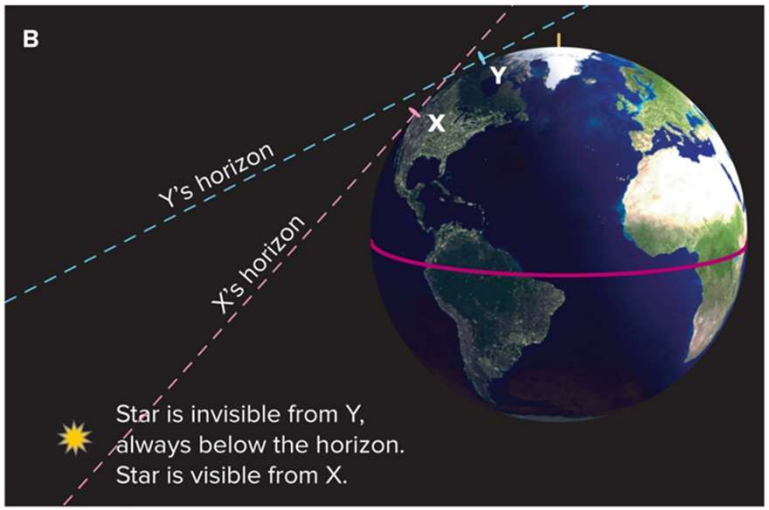
Ancient Greek Astronomers

- First to use a careful and systematic manner to explain the workings of the heavens.
- Limited to naked-eye observations and mathematics

Early Ideas: Pythagoras

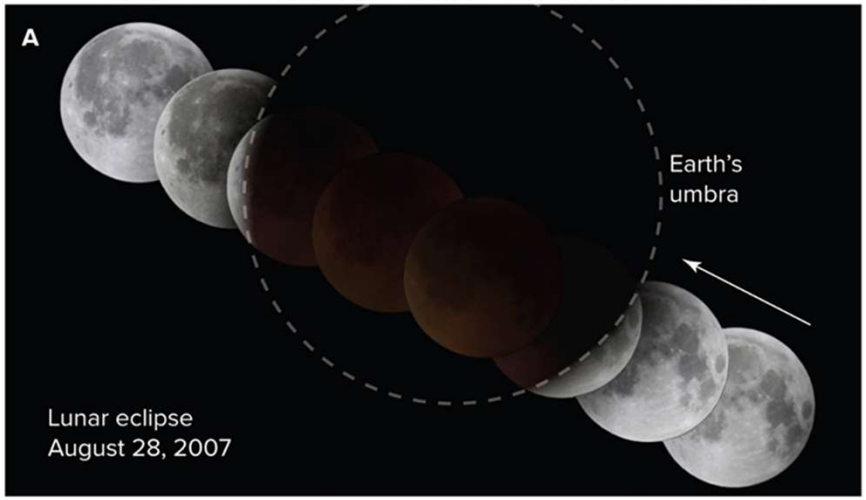
- Pythagoras (500 B.C)
  - Earth was round, based on the belief that the sphere is the perfect shape used by the gods.

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Early Ideas: Aristotle

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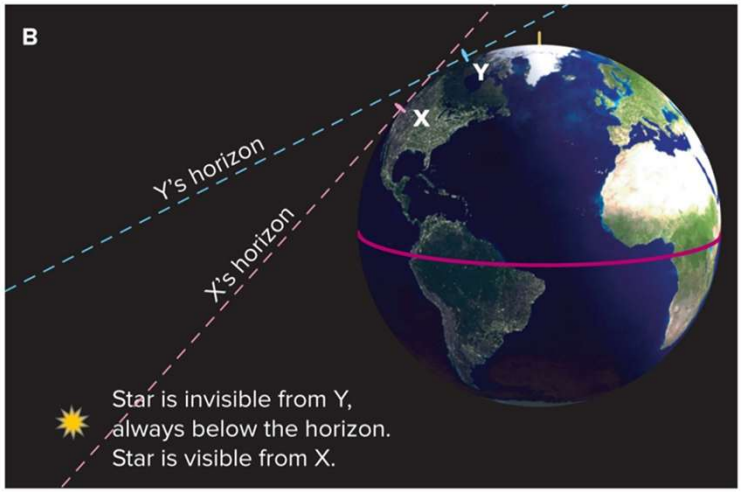


- By 300 B.C., Aristotle presented naked-eye observations for Earth's spherical shape:
- Shape of Earth's shadow on the Moon during an eclipse.

- a: © Stephan Hoerold/Getty Images; Arrangement by S.E Schneider

More Observations of a Spherical Earth from Aristotle

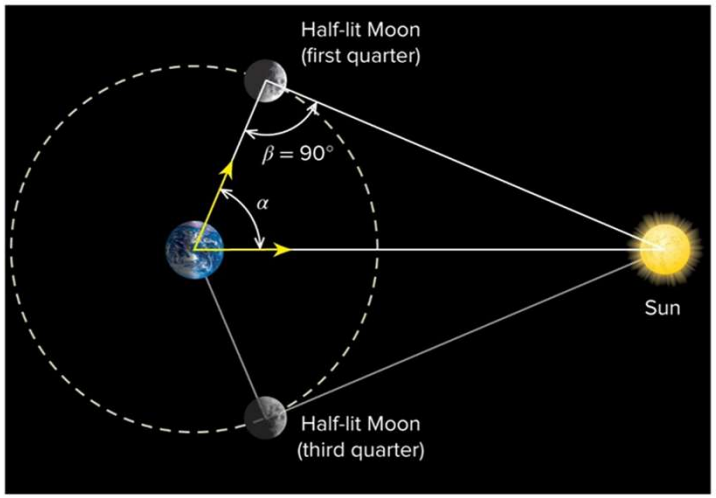
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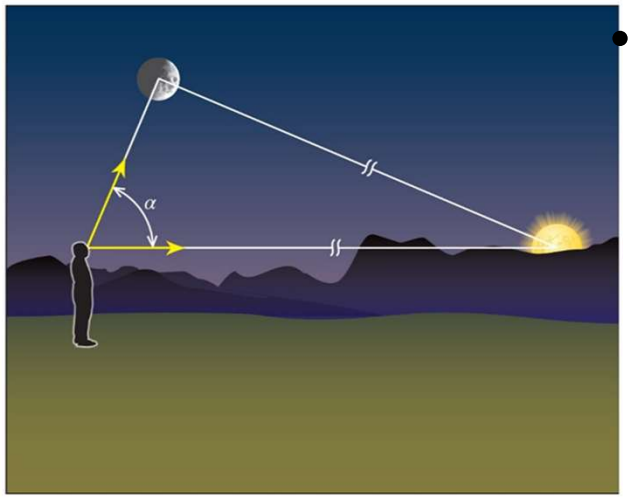


- He also moving south you see stars previously hidden by the horizon.
- Ships hulls disappeared first as they sailed away

Relative Distance and Size of the Sun and Moon

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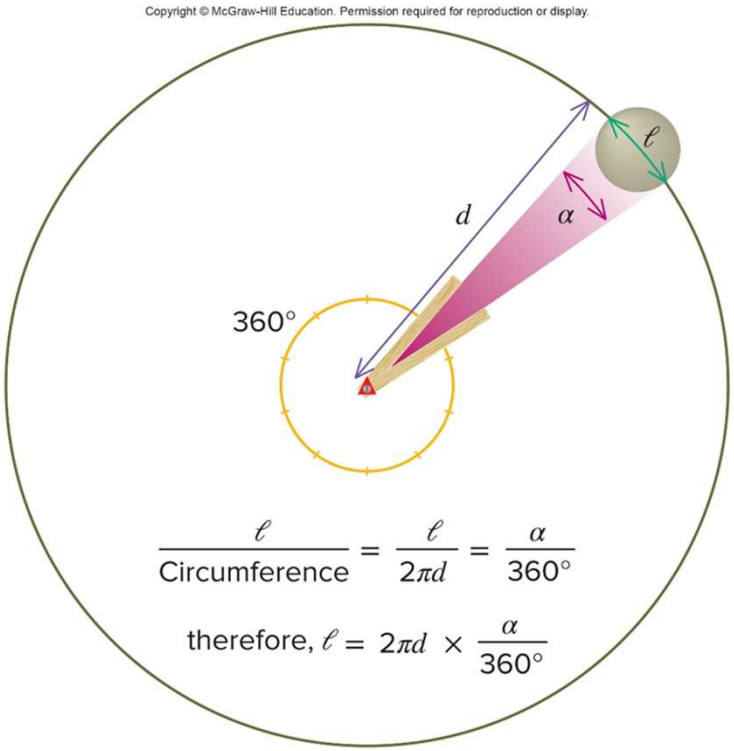


- These <u>relative</u> sizes were based on the ***angular size*** of objects

Measuring the Diameter of Astronomical Objects

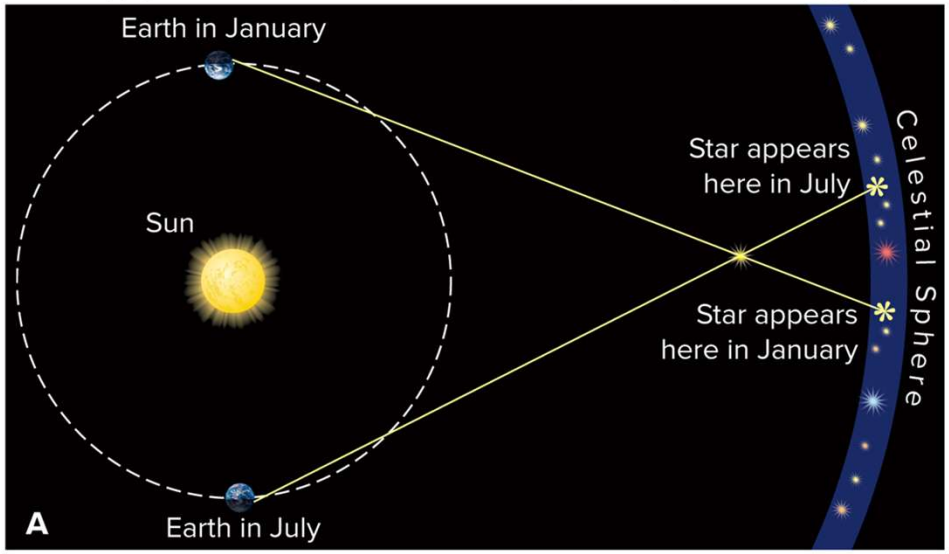
$$l = 2\pi d \times \frac{\alpha}{360°}$$

- l – linear size of object
- d – distance to object
- α – angular size of object

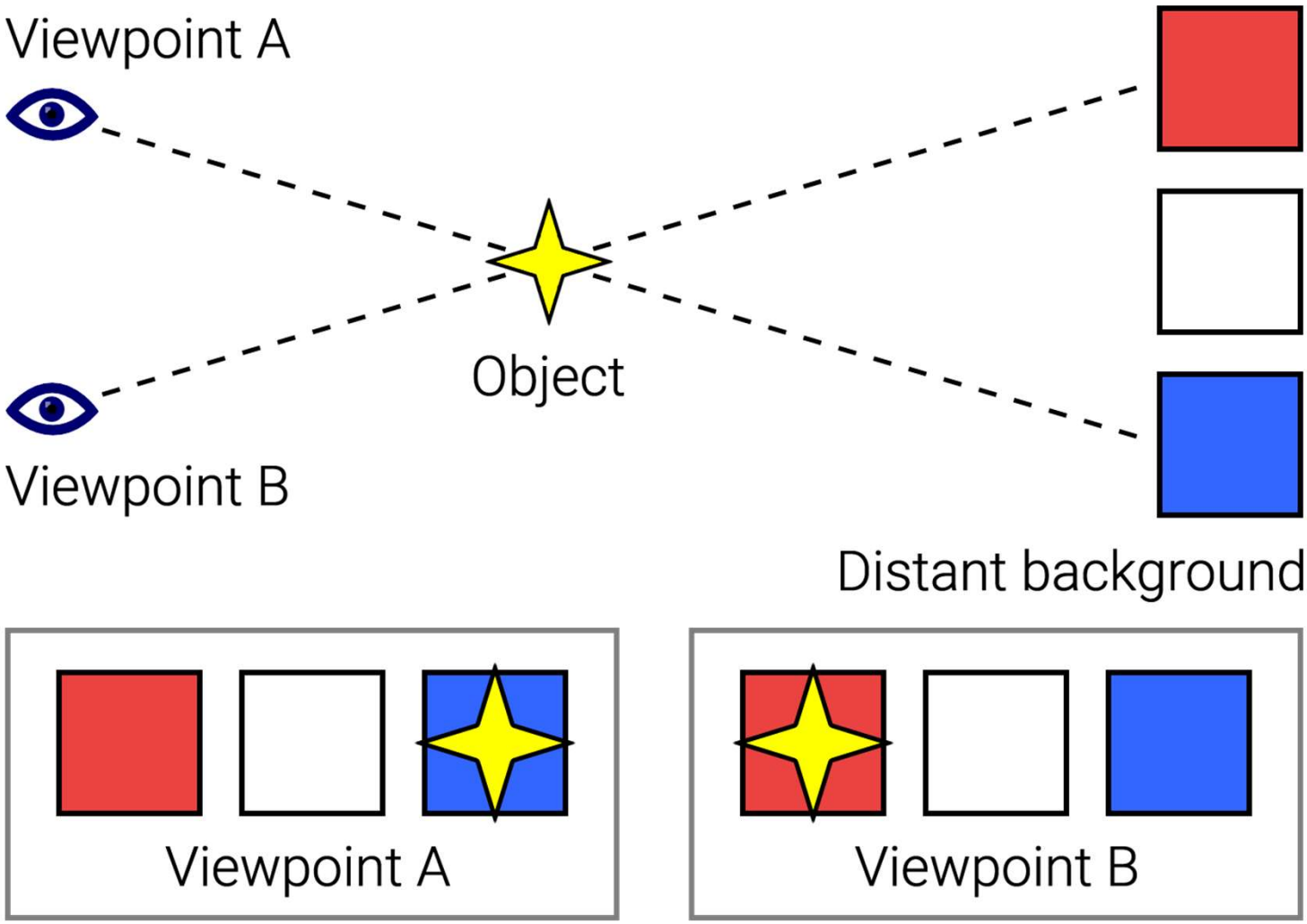


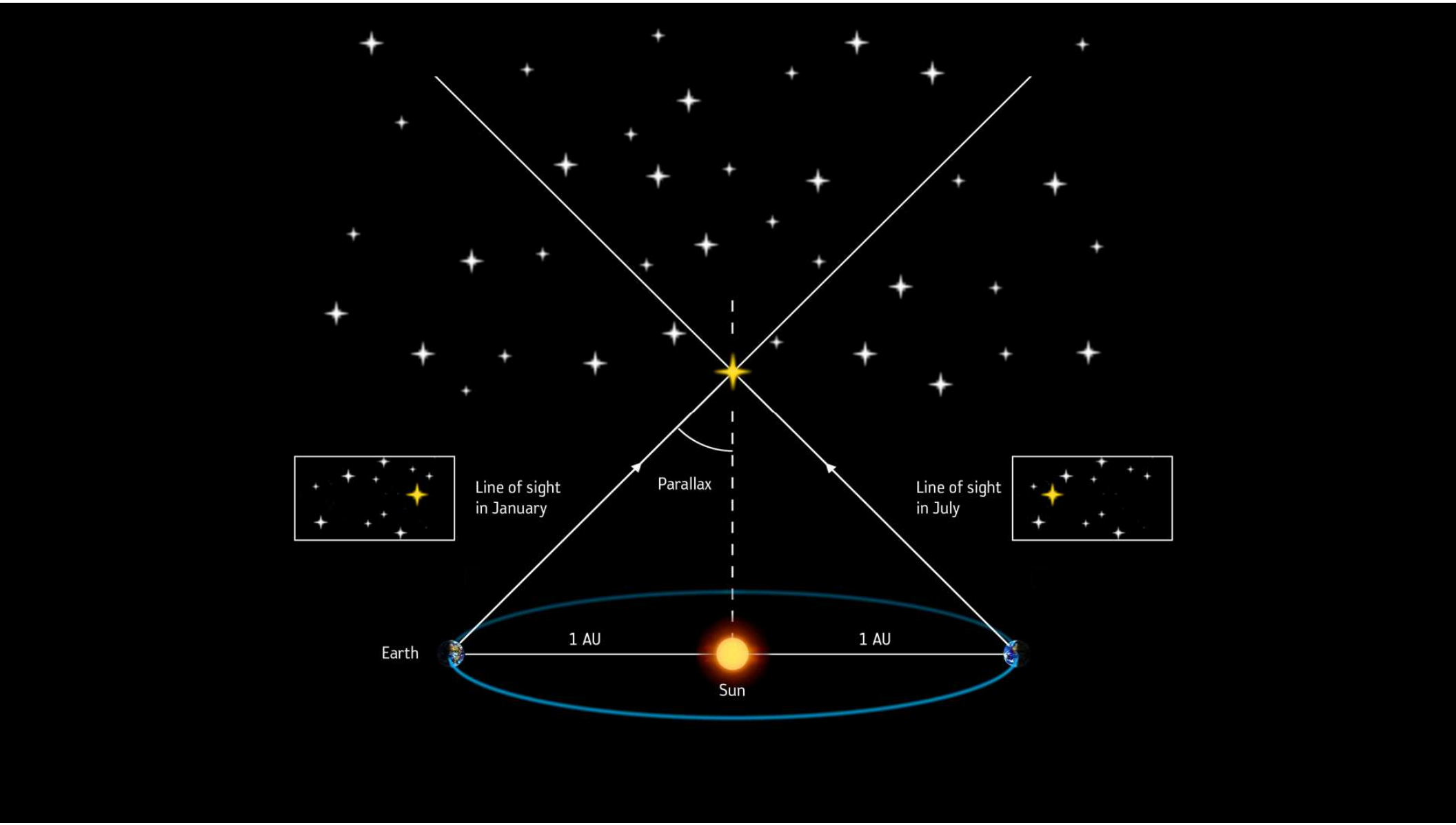
Early Ideas: Arguments for an Earth-centered Solar System

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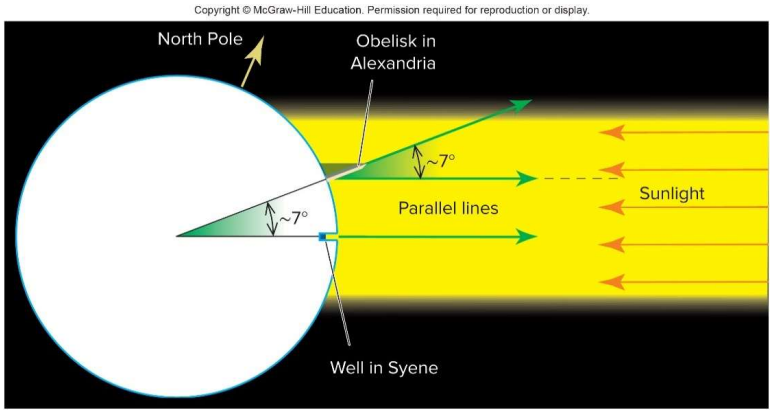
- Aristarchus, realizing the Sun was very large, proposed the Sun as center of the Solar System, but the lack of ***parallax*** argued against such a model.


Viewpoint A
Viewpoint B
Object
Distant background
Viewpoint A
Viewpoint B


Line of sight
in January
Parallax
Line of sight
in July
Earth
1 AU
1 AU
Sun

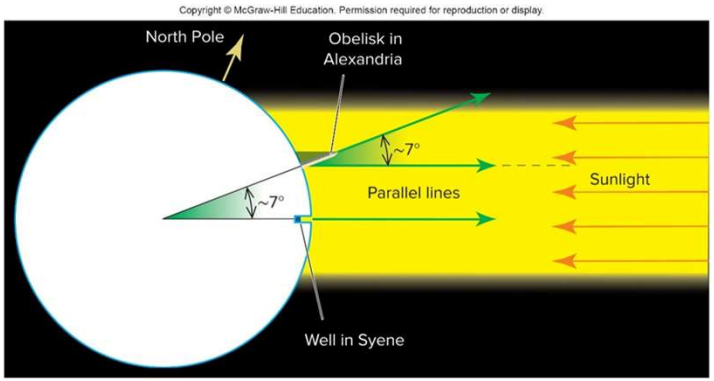
Early Ideas: Eratosthenes

- Eratosthenes (276 to 195 B.C.) made the first measurement of Earth's size.
- Circumference of 25,000 miles



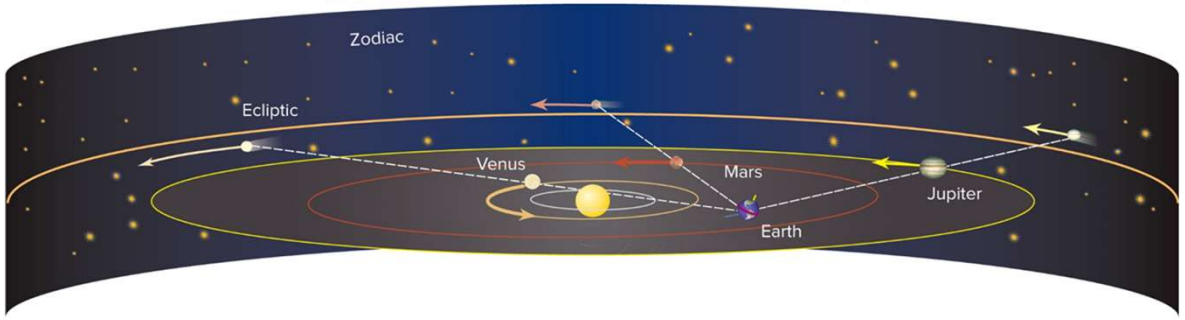
Early Ideas: The Size of Earth

- He compared the shadow of a stick at noon on the summer solstice in Alexandria to one in Syene to calculate the size of Earth



Planets and the Zodiac

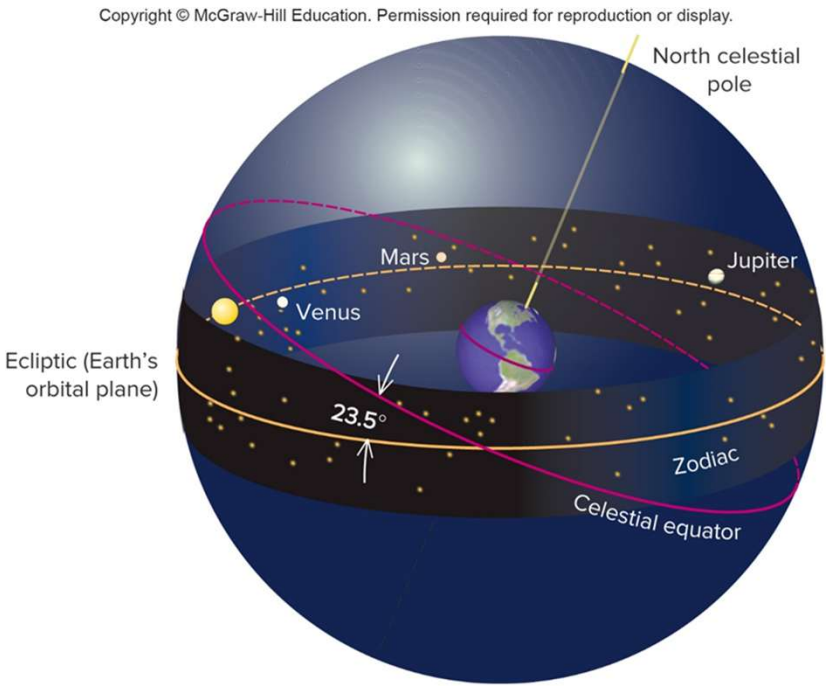
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- Planets (Greek for "wanderers") move relative to the stars in a very narrow band centered about the ecliptic and called the ***zodiac.***
- Planets are all essentially in the same plane

Motion of the Planets

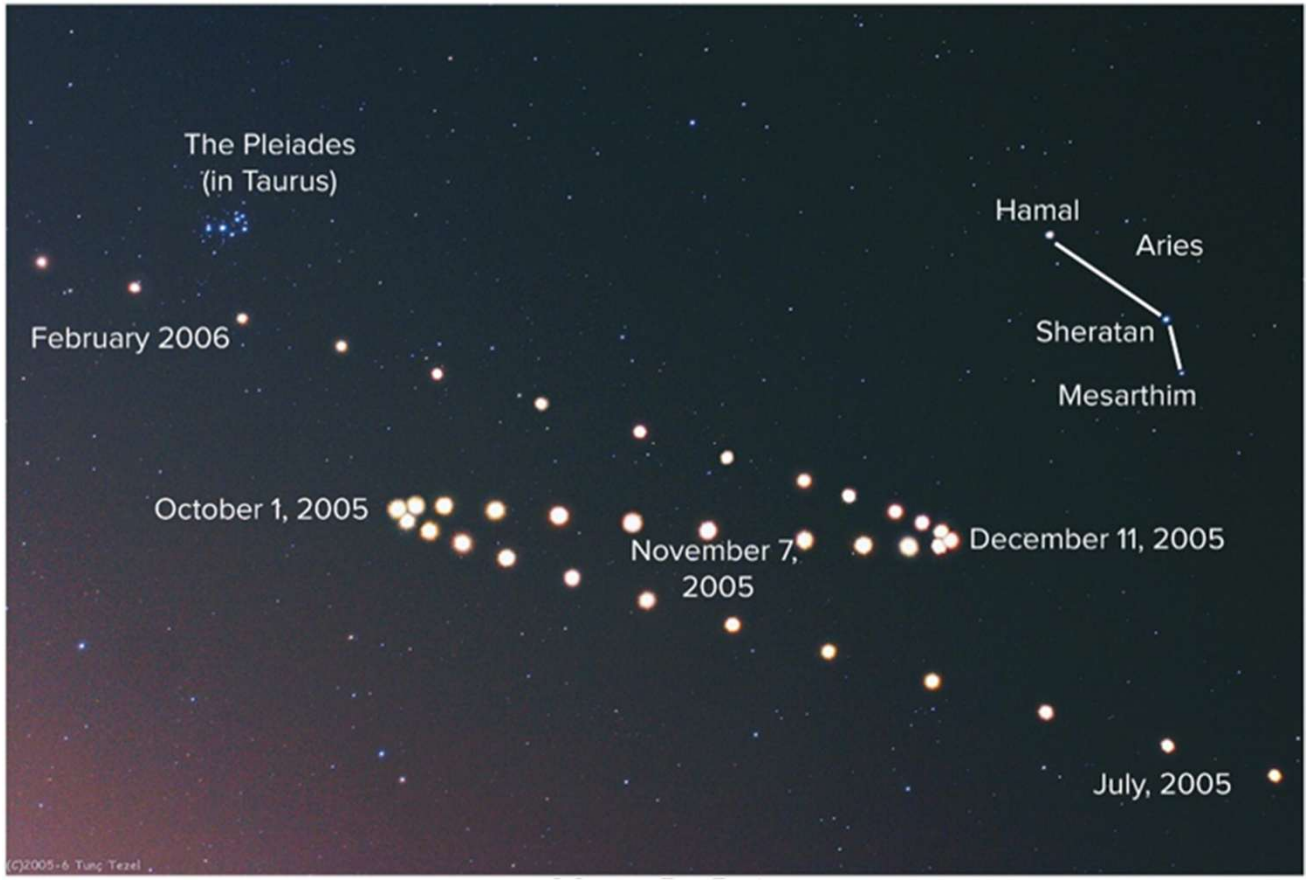
- Planets move West to East as compared to the stars
- Planets rise in the East and set in the West



Retrograde Motion

- Occasionally, a planet will move from east to west relative to the stars; this is called ***retrograde motion*.**
- Retrograde disproved that Earth was the center of the solar system.

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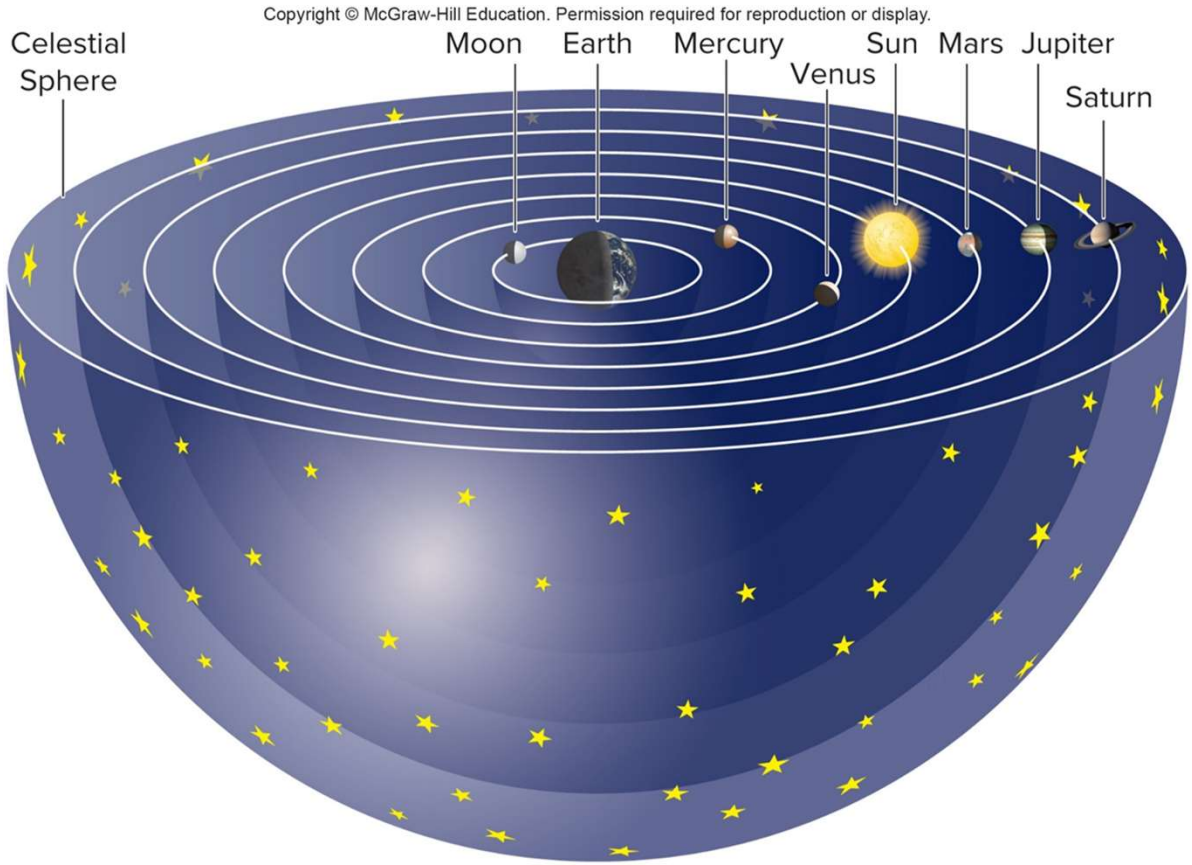


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Early Ideas: The Geocentric Model

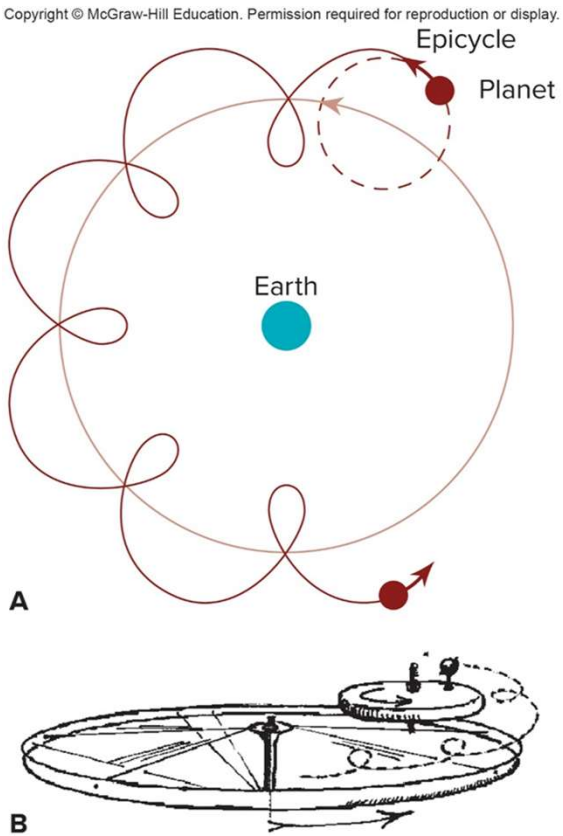
- ***Geocentric models*** explained why things always rose in the east and set in the west.
- Eudoxus (400 to 347 B.C.) proposed a geocentric model in which each celestial object on its own transparent sphere
- The faster an object moved in the sky, the smaller was its corresponding sphere.
- Failed to explain retrograde

Earth at the Center of the Universe!



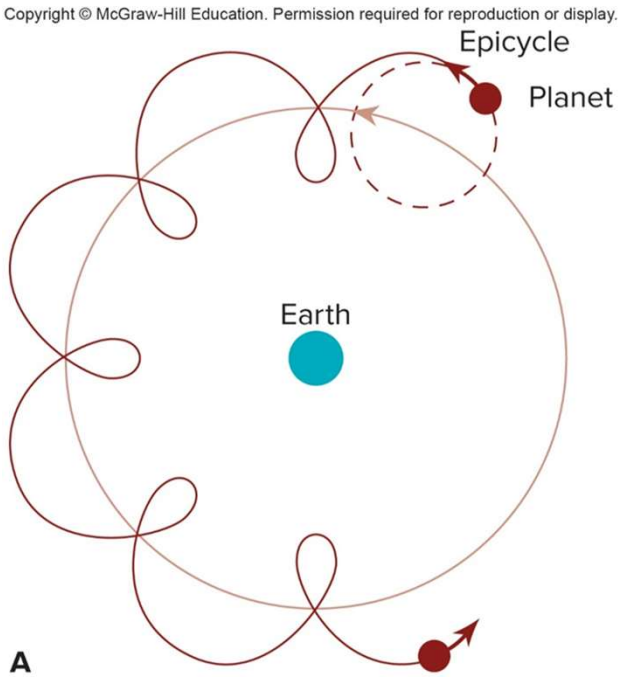
Ptolemy of Alexandria: Epicycles

- Ptolemy of Alexandria Geocentric with planets going in small circles (***epicycles)*** to explain retrograde



Ptolemy's Success

- Model kept being updated and becoming more complicated
- Eventually, geocentric models collapsed under the weight of "Occam's razor" and the ***heliocentric models*** prevailed.



Non-Western Contributions

- Islamic Contributions.
  - Studied and expanded upon ancient texts while the rest of Europe struggled though the Middle Ages.
  - Relied on celestial phenomena to set its religious calendar.
  - Created a large vocabulary still evident today (e.g., zenith, Betelgeuse).
  - Developed algebra and Arabic numerals.

Non-western continued:

Asian Contributions.

- Devised constellations based on Asian mythologies.
- Kept detailed records of unusual celestial events (e.g., eclipses, comets, supernova, and sunspots).
- Eclipse predictions.

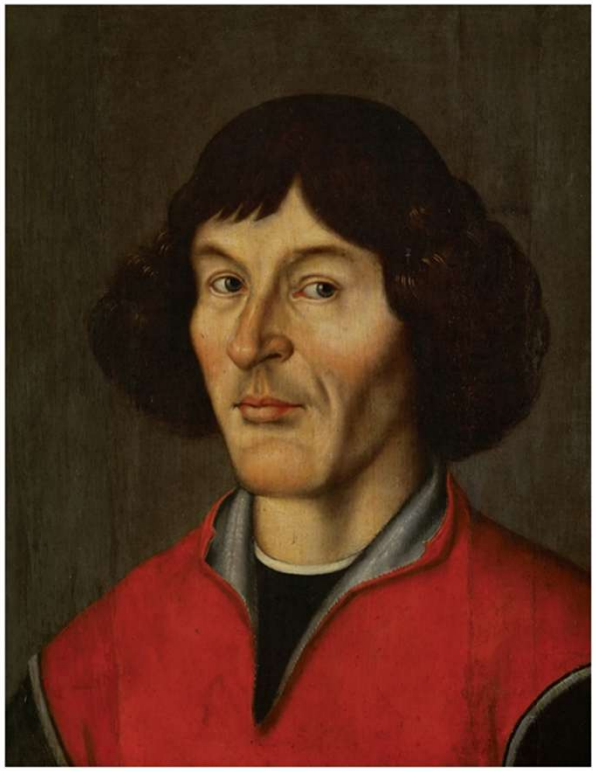
Friday, September 18

- T:**5B** research and evaluate the contributions of scientists, including Ptolemy, Copernicus, Tycho Brahe, Kepler, Galileo, and Newton, as astronomy progressed from a geocentric model to a heliocentric model; and
  6D understand the difference between astronomy and astrology, the reasons for their historical conflation, and their eventual separation.
- O: I will be able to compare and contrast the models created by ancient astronomers
- D: by discussing similarities in my groups, completing a Stellarium project, taking notes, and taking a quiz.

Astronomy in the Renaissance: Copernicus

- Nicolaus Copernicus (1473 to 1543)
- Could not reconcile centuries of data with Ptolemy's geocentric model.
- Consequently, Copernicus reconsidered Aristarchus's heliocentric model with the Sun at the center of the solar system.

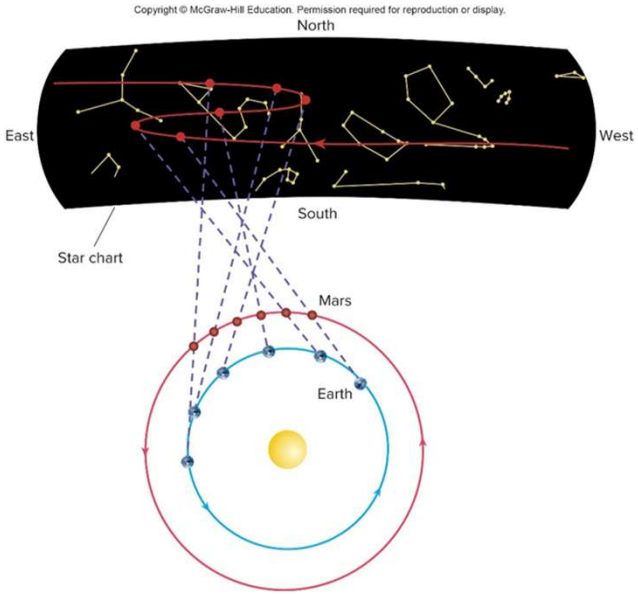
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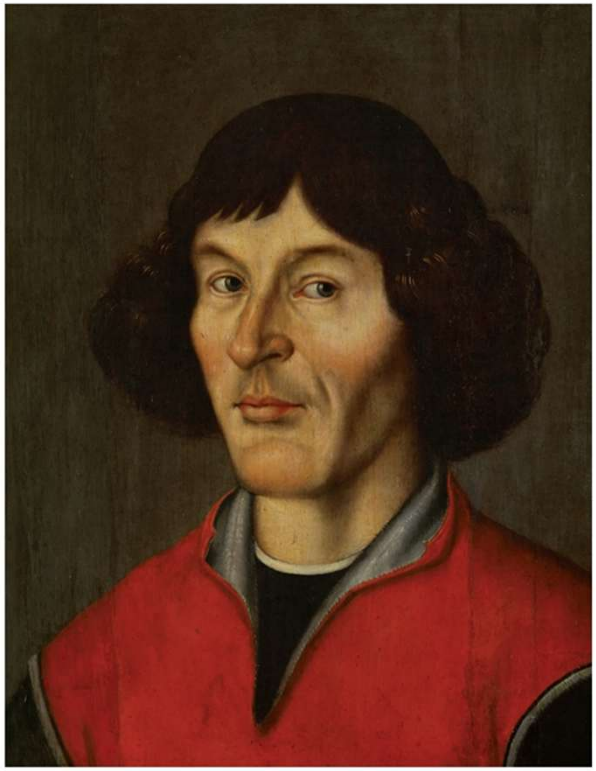
Copernicus's Success

- ***Heliocentric models*** explain retrograde motion as a natural consequence of two planets (one being Earth) passing each other.
- Copernicus could also derive the relative distances of the planets from the Sun, and explain why Venus and Mercury were always close to the Sun.



Copernicus's Failure

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- However, problems remained:
- Could not predict planet positions any more accurately than the model of Ptolemy.
- Could not explain lack of parallax motion of stars.
- Conflicted with Aristotelian "common sense".

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