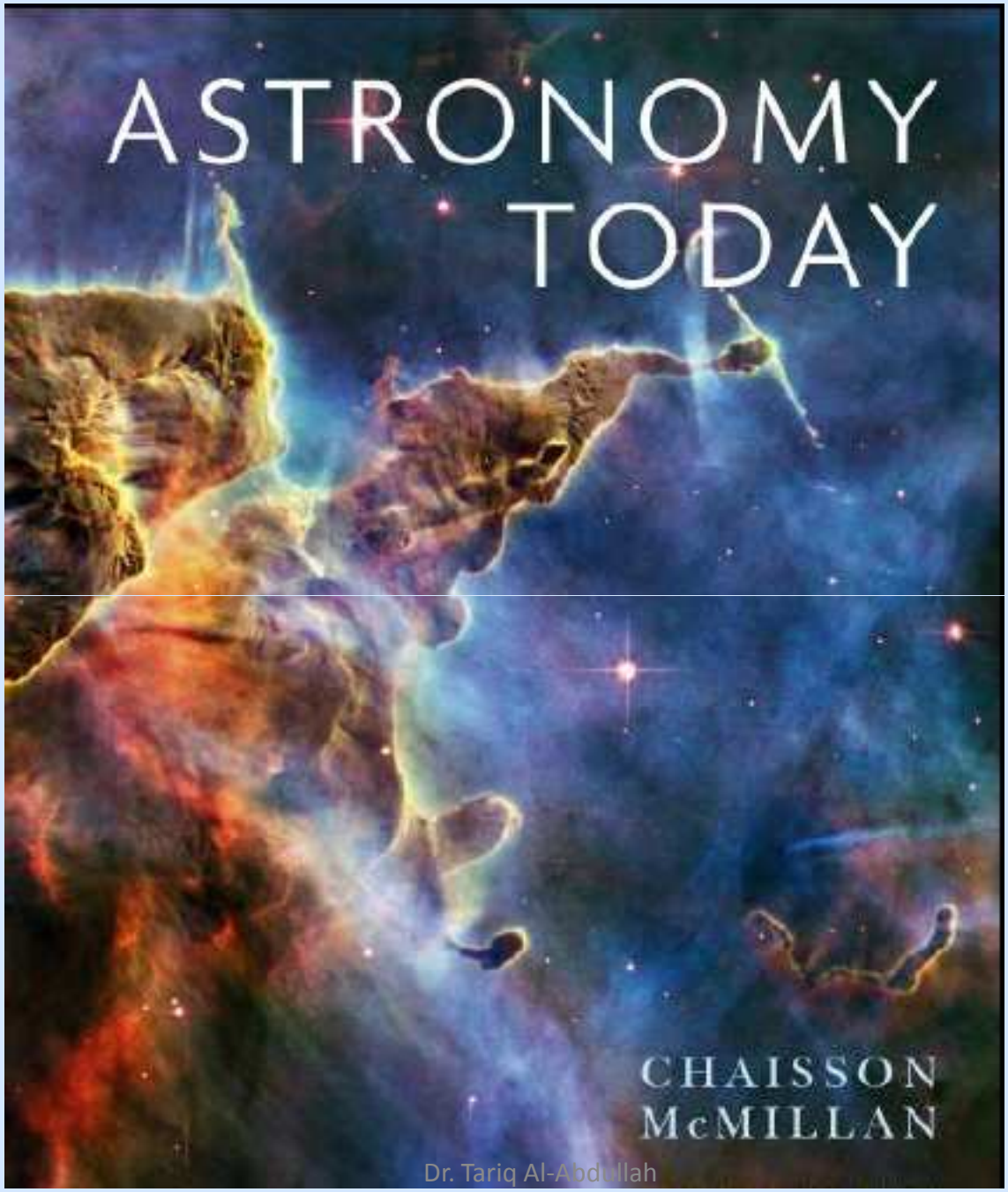
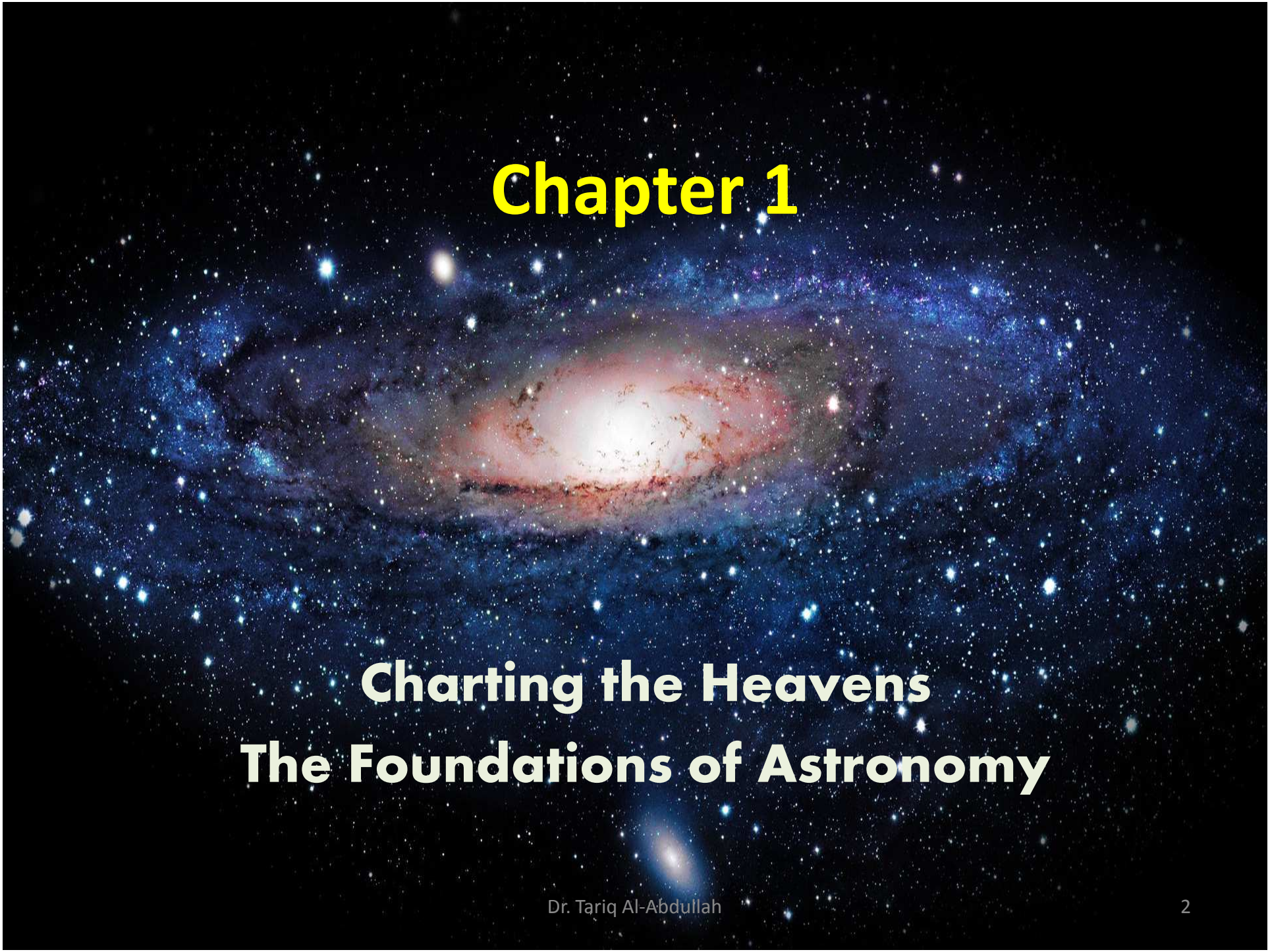

ASTRONOMY
TODAY
CHAISSON
McMILLAN



Chapter 1

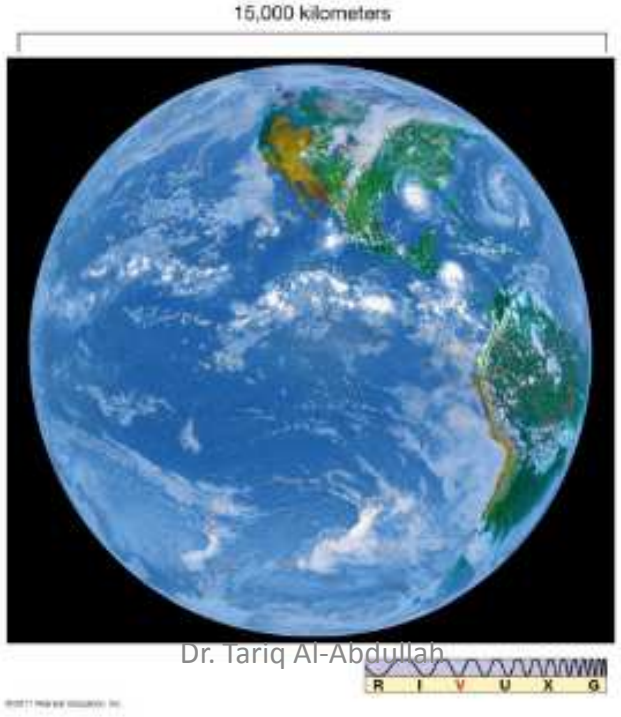
Charting the Heavens
The Foundations of Astronomy

Learning Goals:

1. Our Place in Space
2. The Obvious view
3. Earth's Orbital Motion
4. The Motion of the Moon
5. The Measurement of Distance

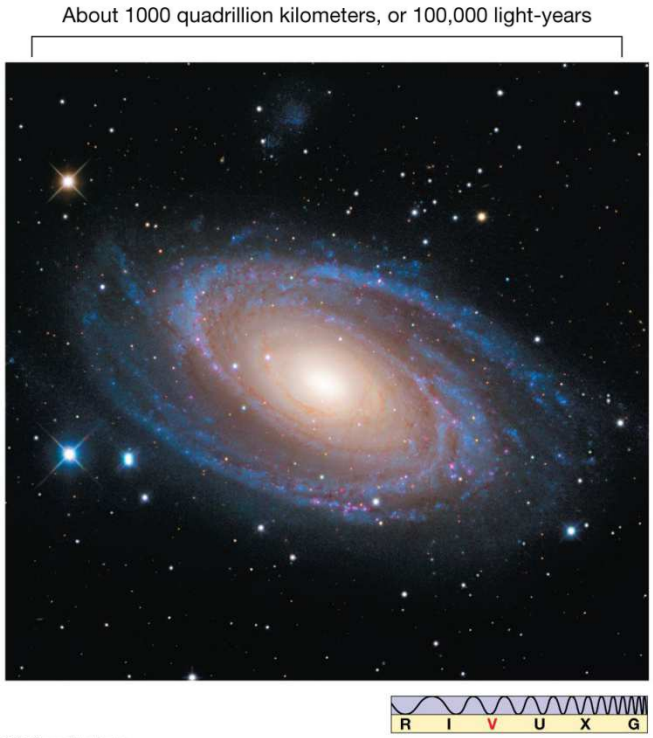
1. Our Place in Space

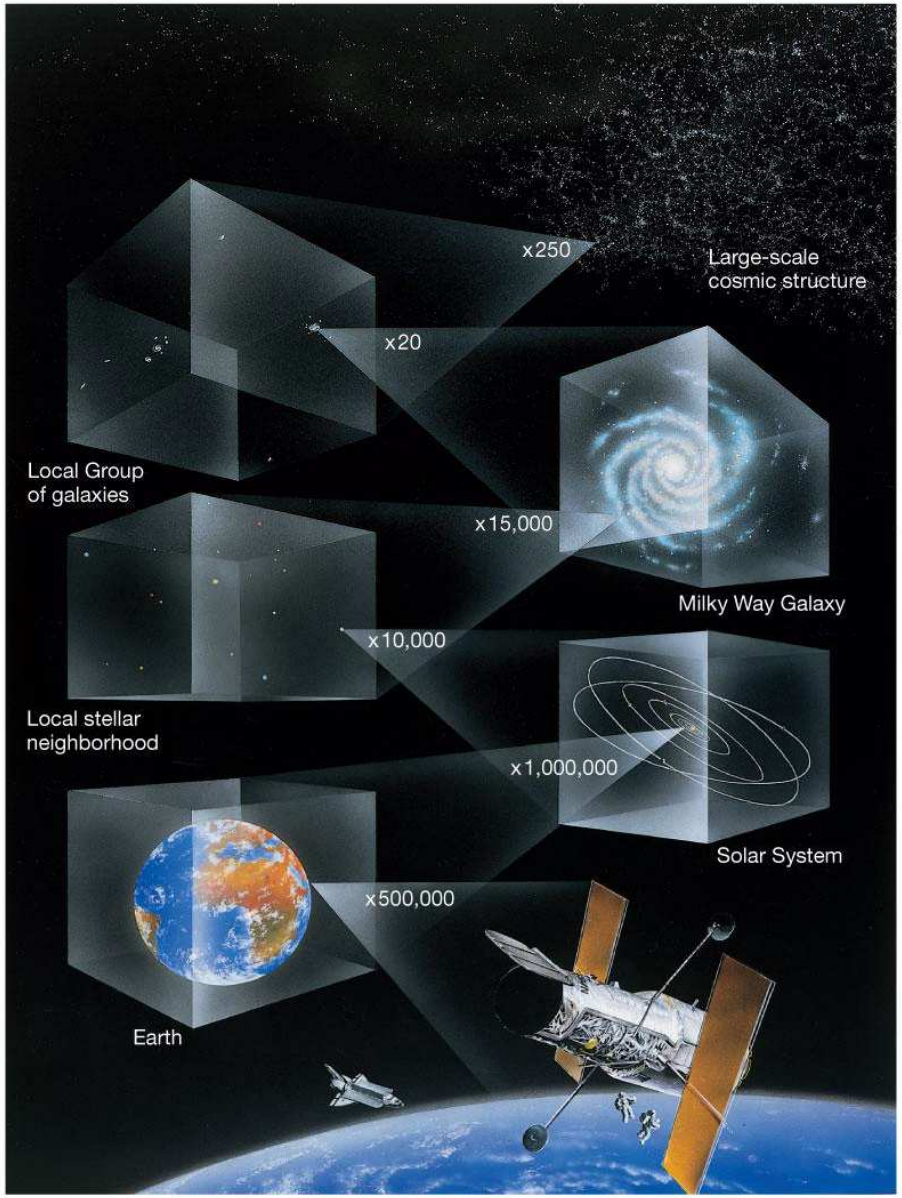
- Earth is neither central nor special.
- We live on a *rocky* planet called Earth.
- Earth → Sun → Milky Way Galaxy → Universe
- Universe: totality of the space, time, matter, energy.
- Astronomy: Study of the universe.



1. Our Place in Space

Scales are very large: measure in light-years, the distance light travels in a year—about 10 trillion km.

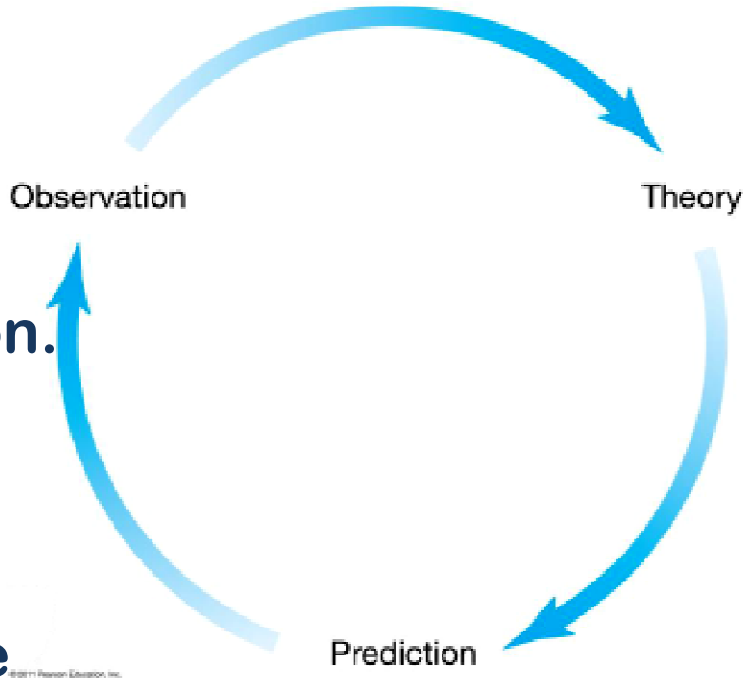




1. Our Place in Space

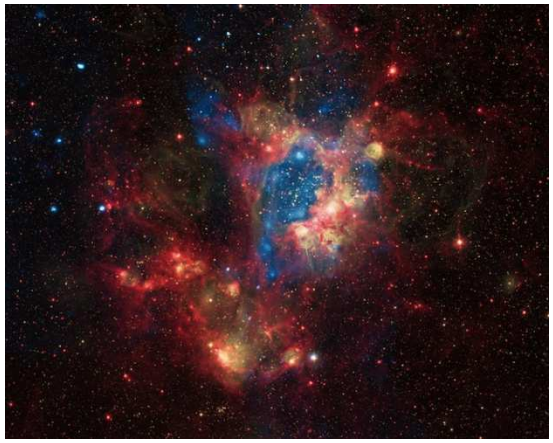
Scientific Theory & Scientific Method

- **Observations:** leads to theory explaining it.
- **Theory**: leads to prediction, consistent with previous observation.
- **Predictions:** new phenomena, If observations agree with the prediction, more predictions can be made. If not, a new theory should be made.



Scientific theories can be proven wrong, but they can never be proven right with 100 percent certainty.

2. The "Obvious" View

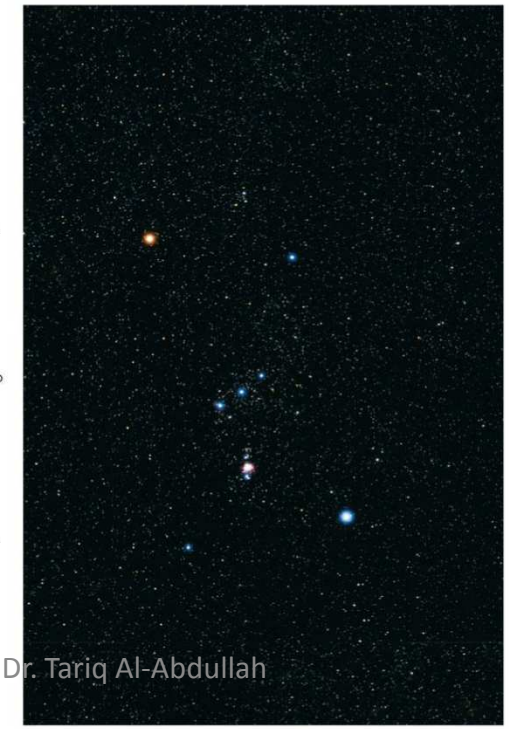


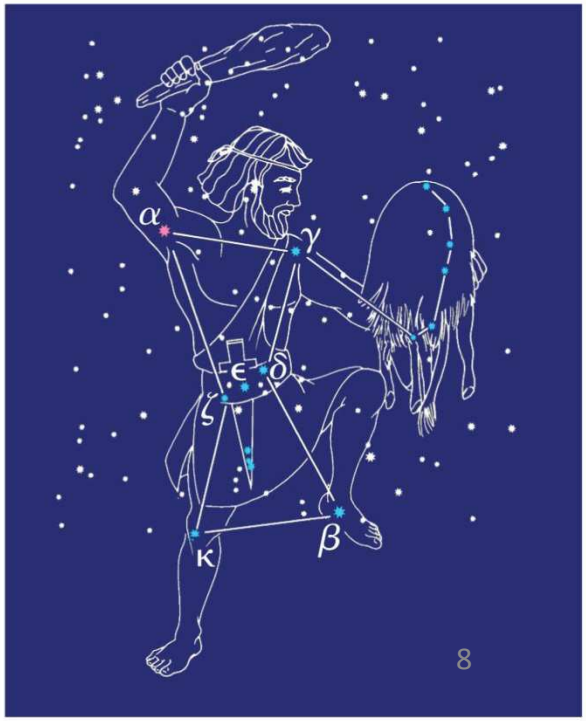
Cosmetics
vs
Cosmic

Astronomy
vs
Astrology

2. The “Obvious” View

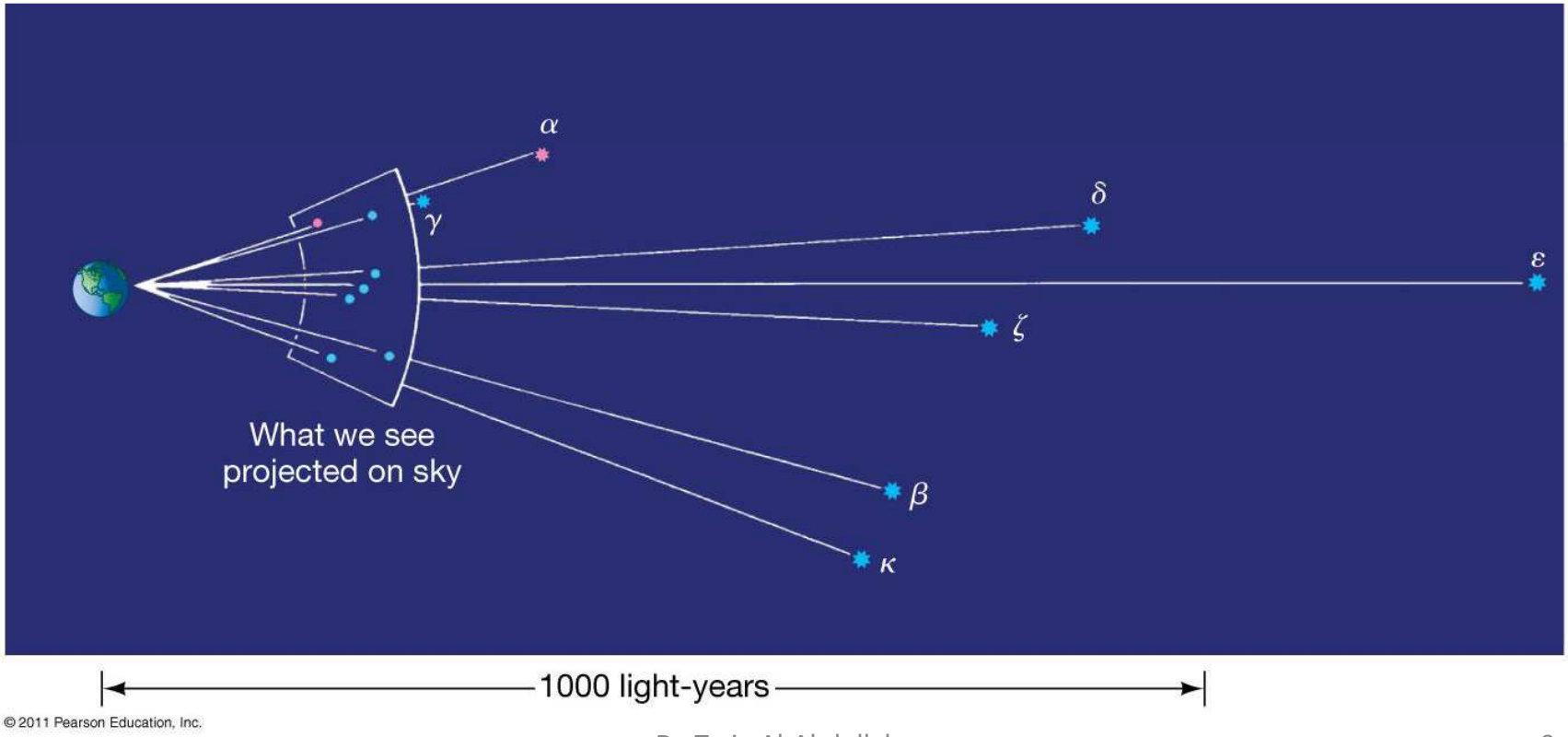
- Between sunset and sunrise 3000 stars are visible.
- Human eyes see patterns: Constellations.
- Polaris: which is almost due north, navigation.
- Orion as imagined by Greeks.
- Constellations served as a calendar, seasons, harvesting,





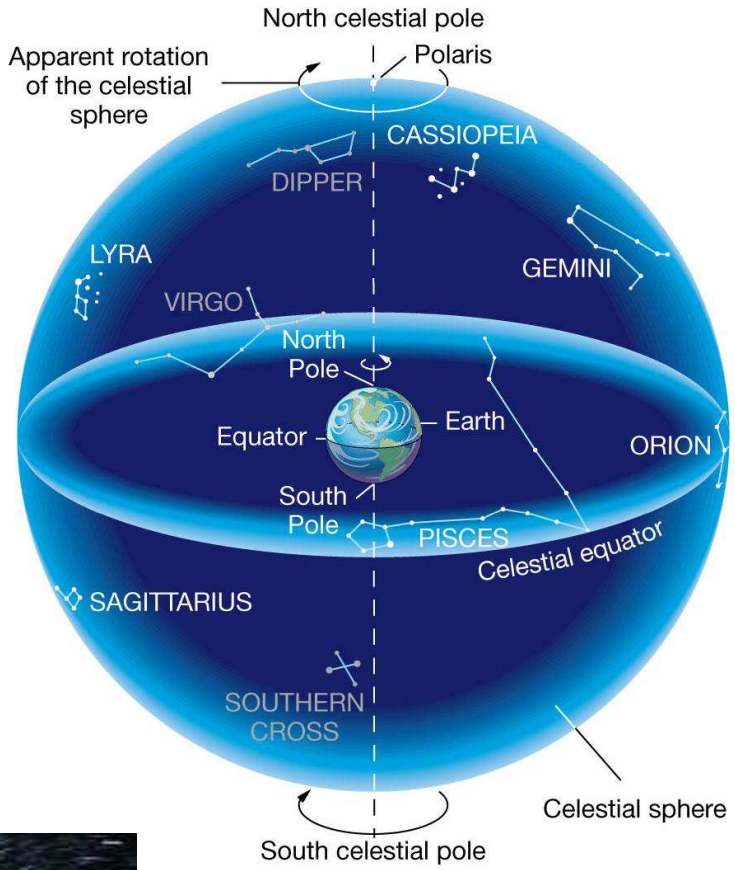
2. The "Obvious" View

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



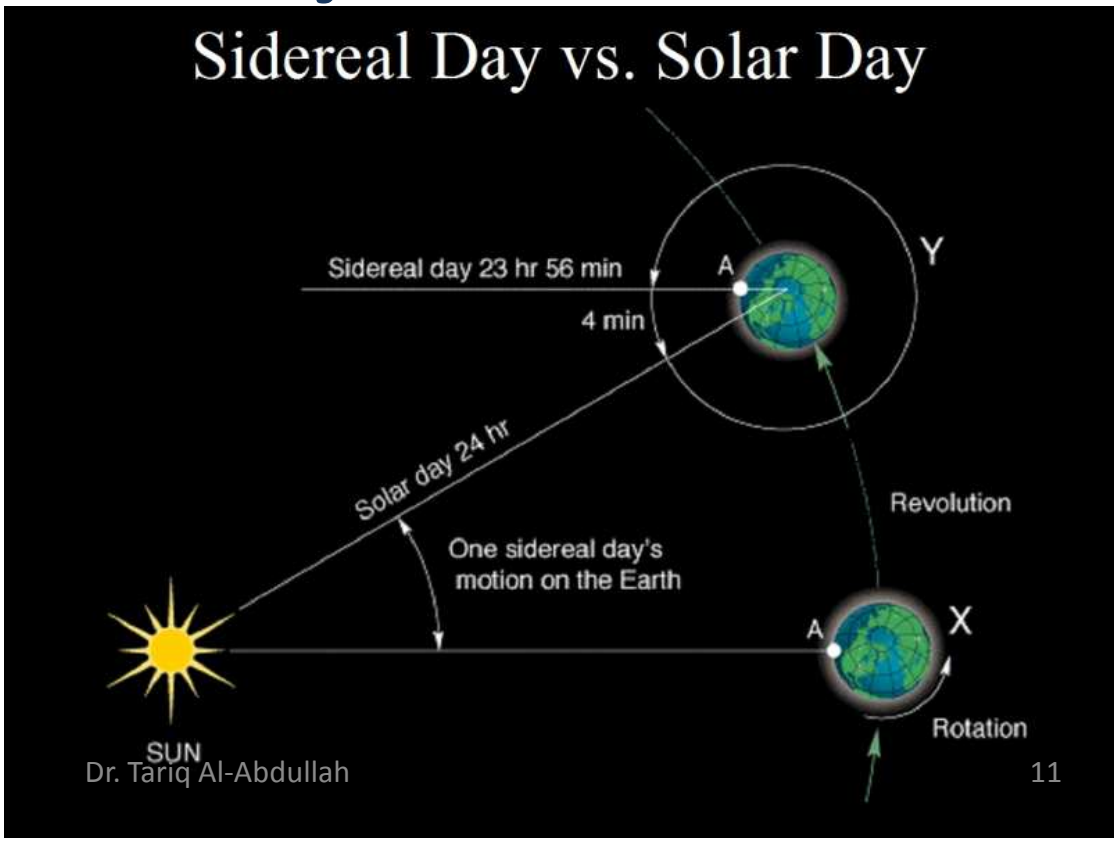
2. The "Obvious" View

- The celestial sphere.
- Constellations move smoothly across the sky.
- Ancient skywatchers were aware of this relative motion.
- ➔Stars attached to a celestial sphere
- Modern standpoints: Rotation of the Earth around itself and the sun.
- North and south celestial poles, and celestial equator.



3. Earth's Orbital Motion

- Day and night are central to our lives.
- ***Solar day*** : period of time from one noon to the next noon. (24hours)
- The daily progress of the sun and stars: *Diurnal motion.*
- ➔ w.r.t a star in the sky, locations shifted, a day changes.
- ***Sidereal Day*** : a day measured by a star.

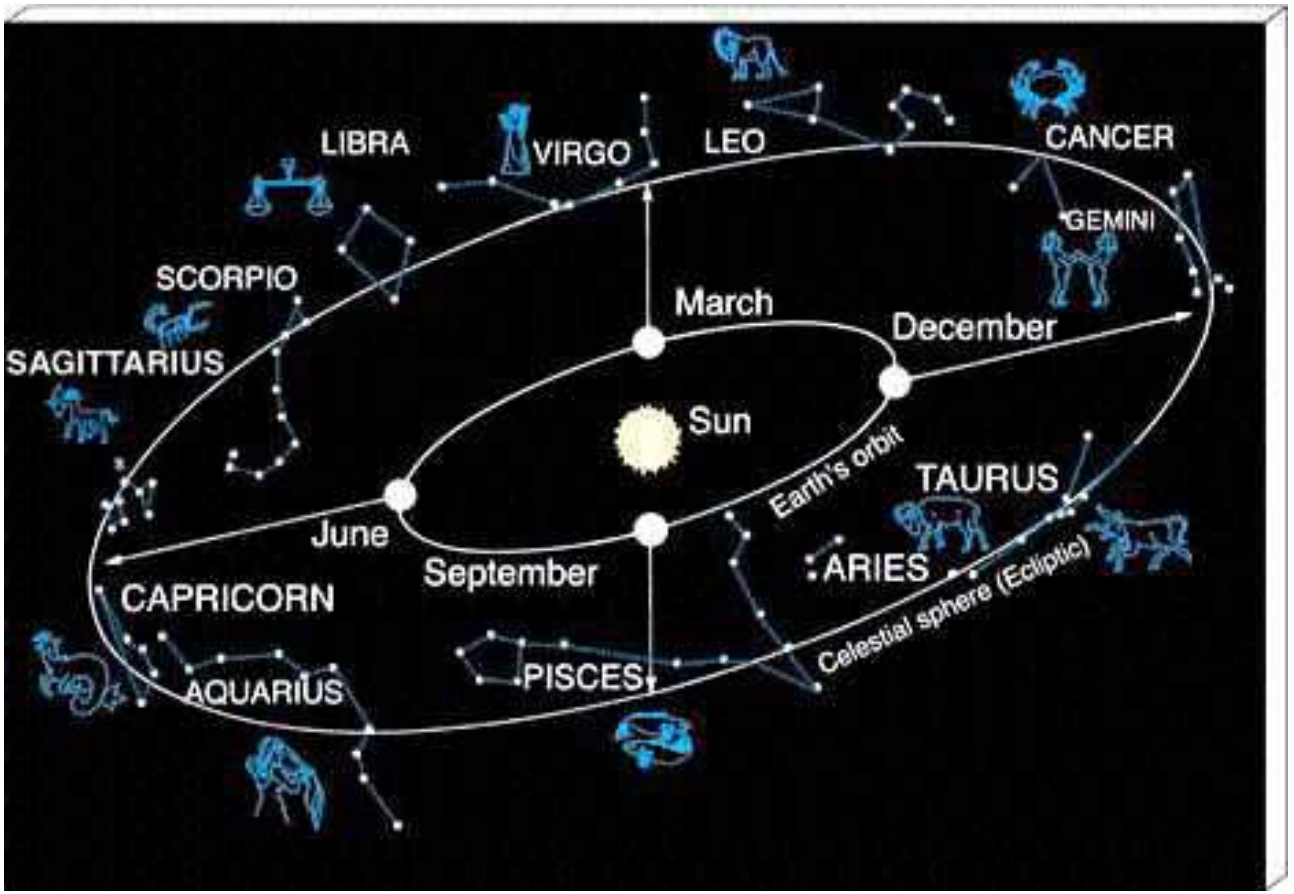


- Earth rotates at 15°/h
- 365 days to orbit the Sun.
- Additional angle:

$$\frac{360}{365} = 0.986^{o}$$

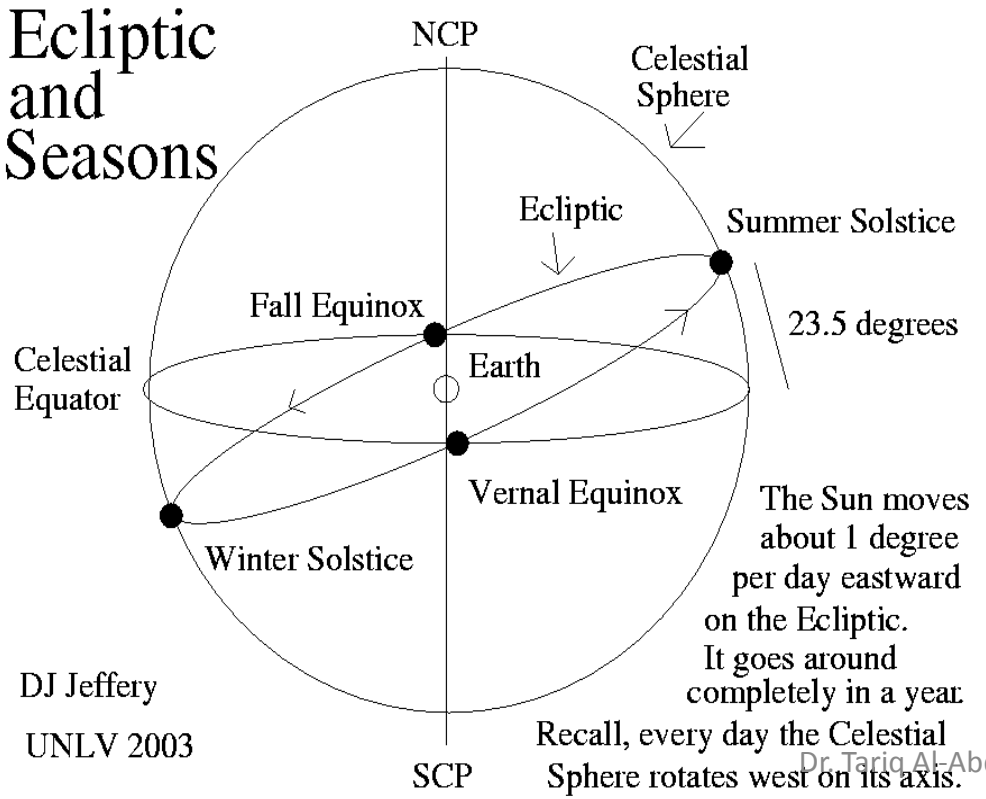
3. Earth's Orbital Motion

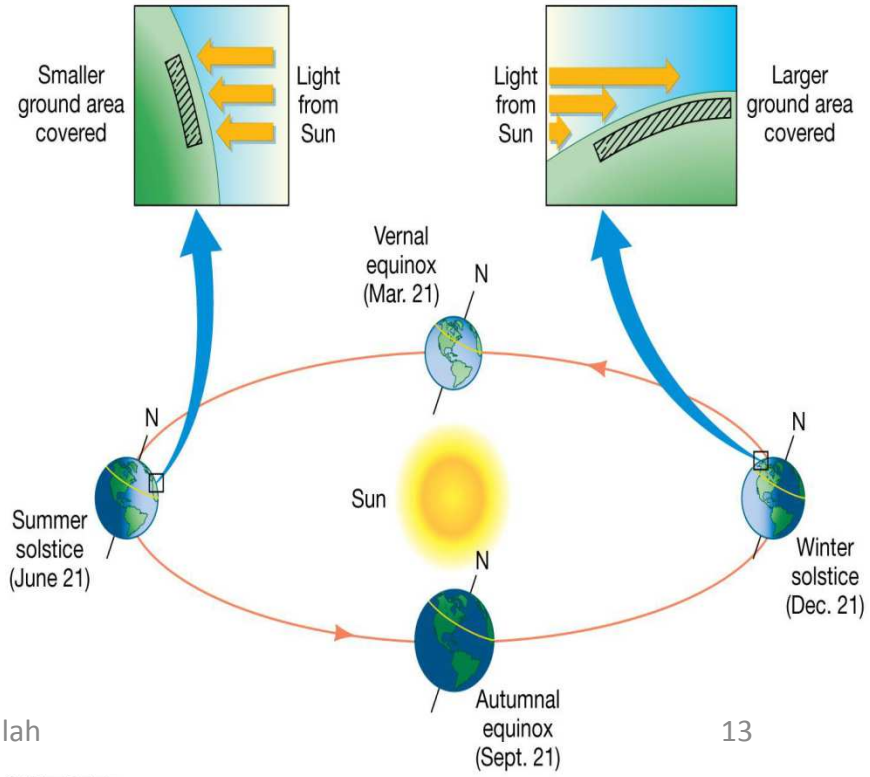
- Seasonal changes: constellations change with time.
- The apparent motion of the sun on the celestial sphere: *ecliptic*
- 12 constellation the sun passes as it moves along the ecliptic: *zodiac*



3. Earth's Orbital Motion

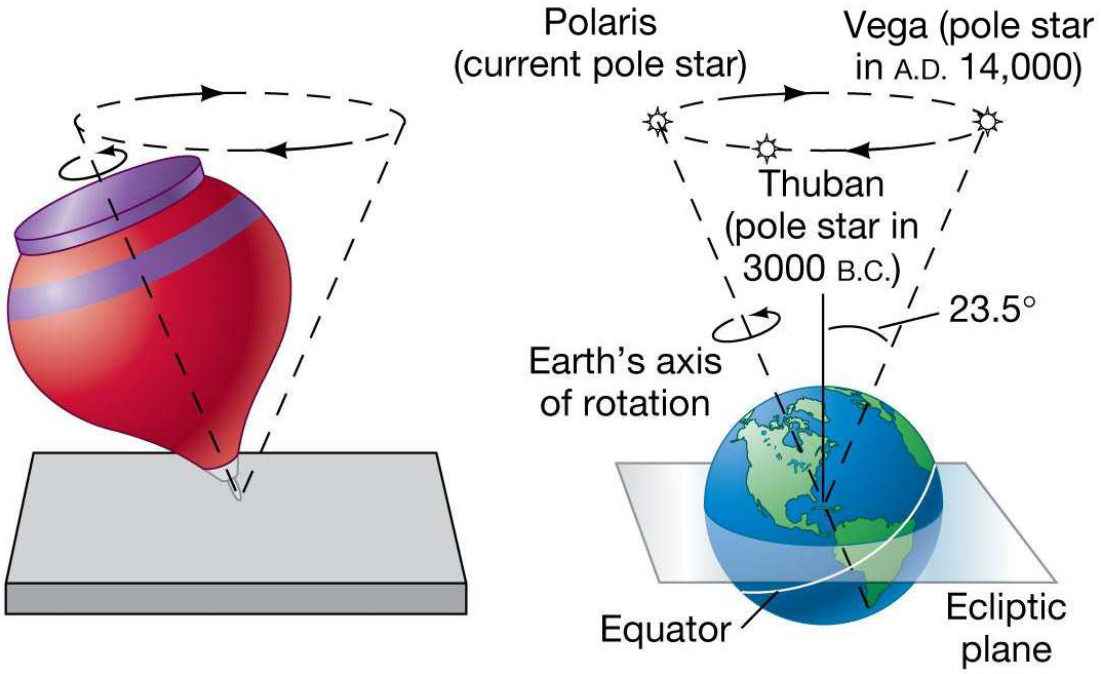
- The ecliptic of the sun inclined by a 23.5^{o} to the celestial sphere.
- Sun is at its northernmost point: *summer solstice* **[sun stand]**
- Sun is at its southernmost point: *winter solstice* **[6months later]**
- Two points: ecliptic intersects equator: *equinoxes.* **[Autumnal, vernal]**
- *Tropical year*: Interval time from one vernal equinox to the next.





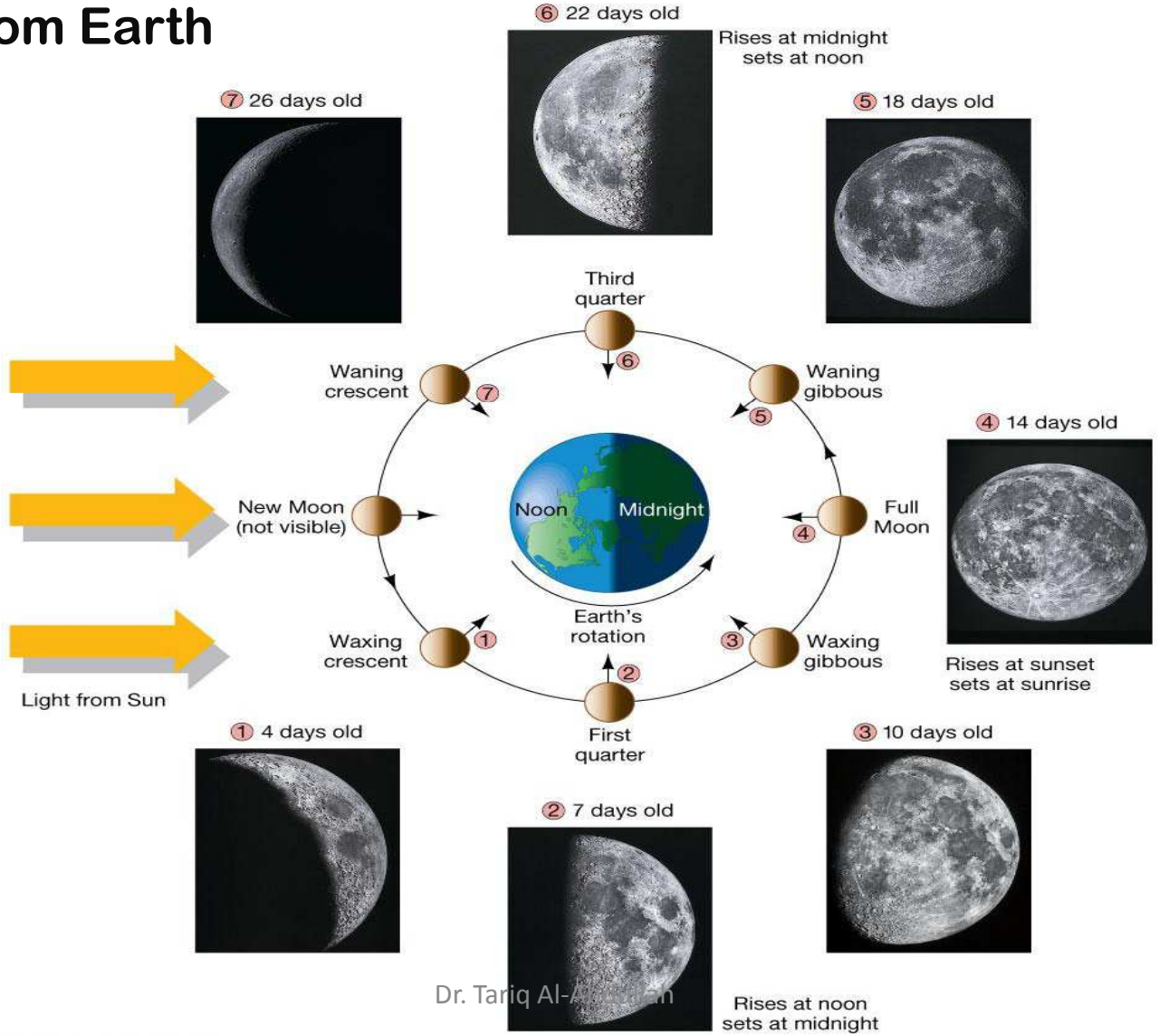
3. Earth's Orbital Motion

- Earth has many motions.
- Its axis changes its direction over almost 26,000 years
- This is called **precession**,
- Torques on Earth from gravitational pulls of the moon & sun.
- *Sidereal year*: complete orbit around the sun w.r.t a star = 365.256 days, 20 min longer than the tropical year (calendar).



4. The Motion of the Moon

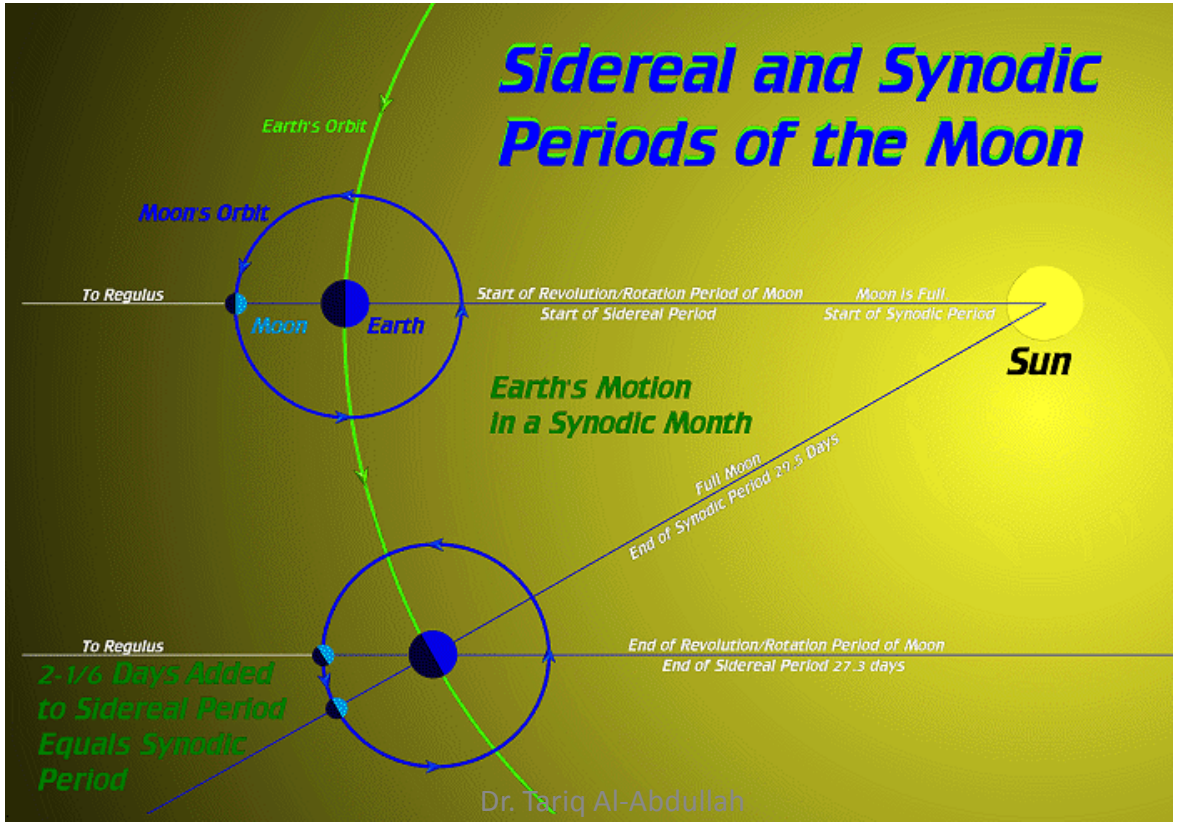
- **Revolves at 12º/day.**
- **Phases are due to different amounts of sunlit portion being visible from Earth**



4. The Motion of the Moon

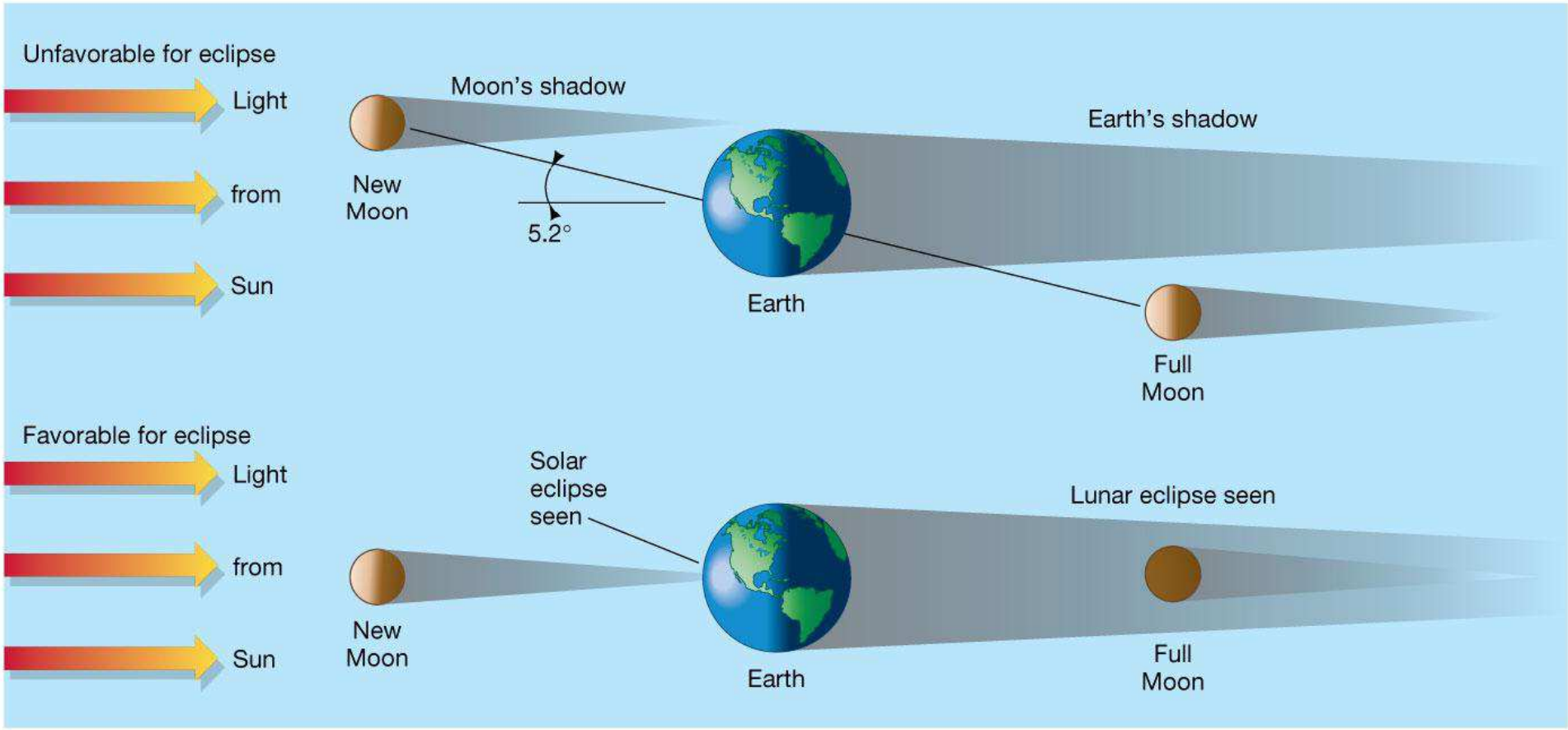
- Moon takes about 29.5 days to go through whole cycle of phases—*synodic month*

- Time to make full 360° rotation around Earth, *sidereal month*, is 27.3 days



4. The Motion of the Moon

Eclipses occur Earth, Moon, and Sun form a straight line

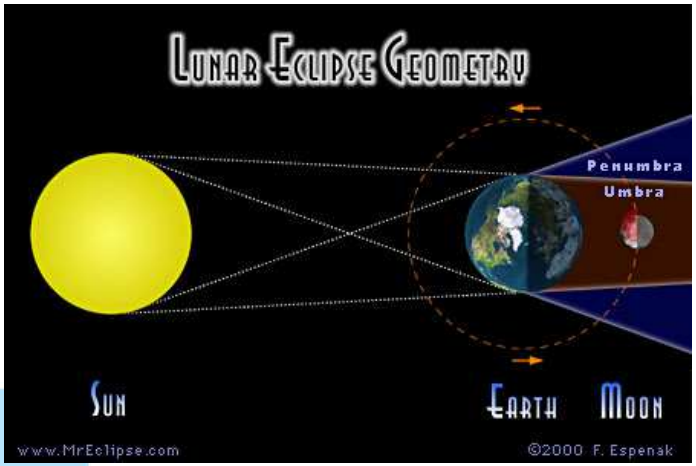


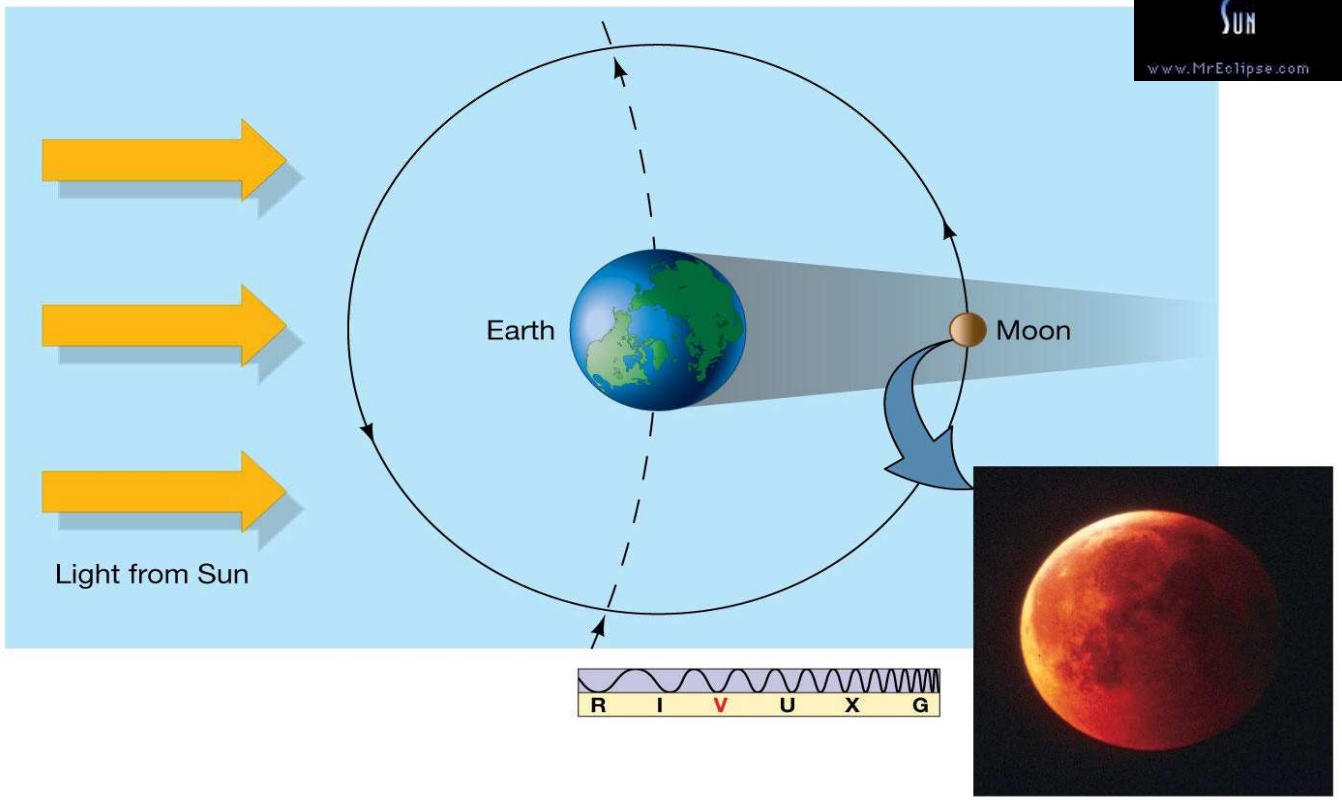
(a)

4. The Motion of the Moon

Lunar eclipse:

- Earth is between Moon and Sun
- Partial: part of Moon is in shadow
- Total when it all is in shadow

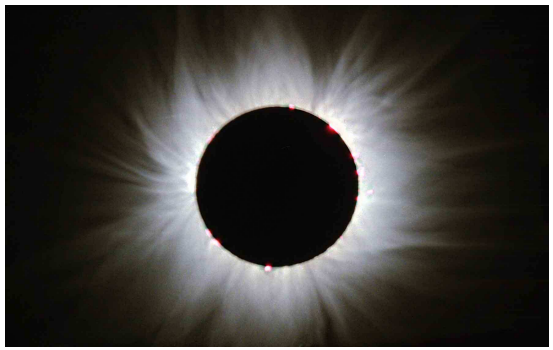


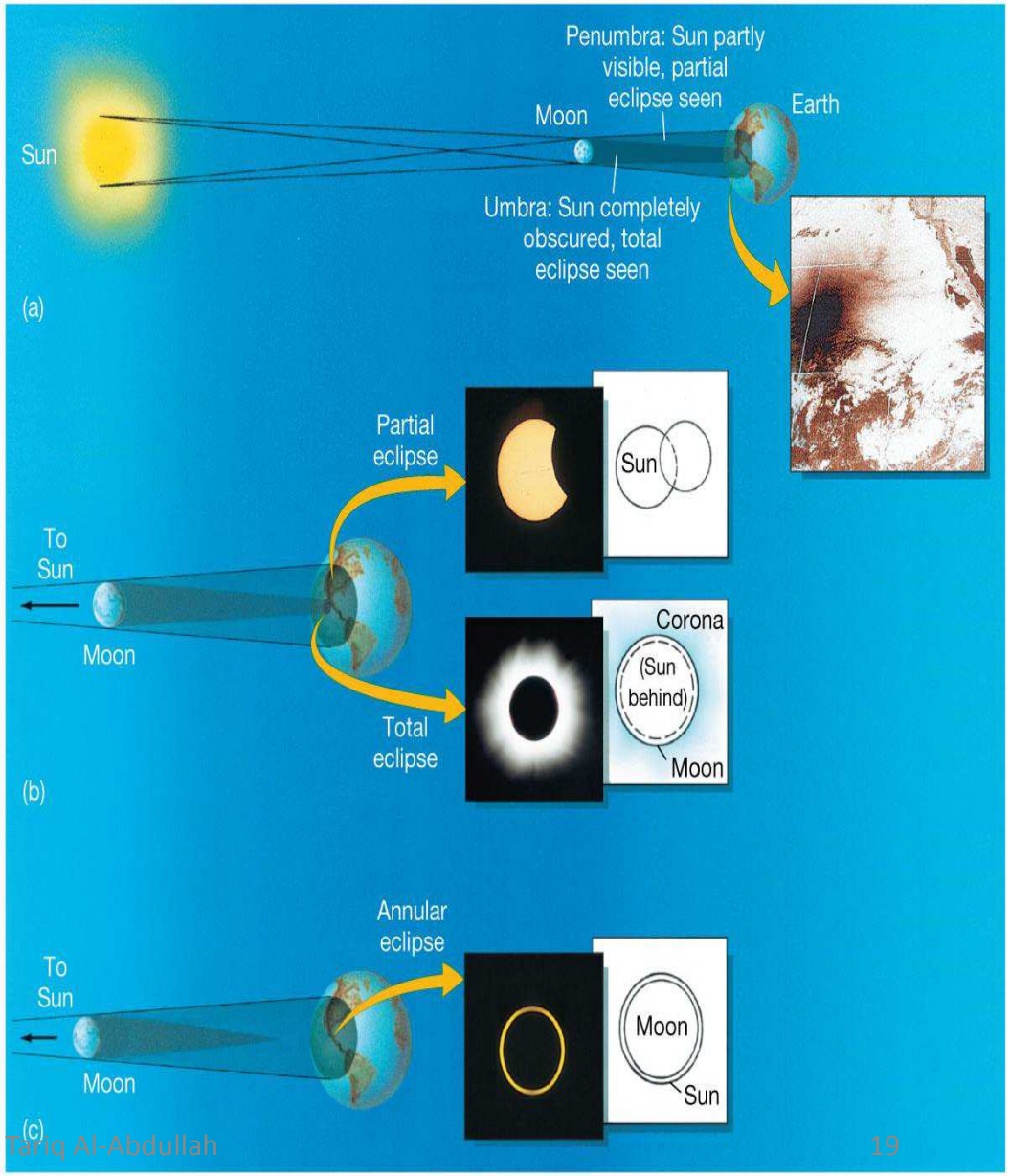


4. The Motion of the Moon

Solar eclipse: Moon is between Earth and Sun

- **Partial when only part of Sun is blocked**
- **Total when it all is blocked**
- **Annular when Moon is too far from Earth for total**

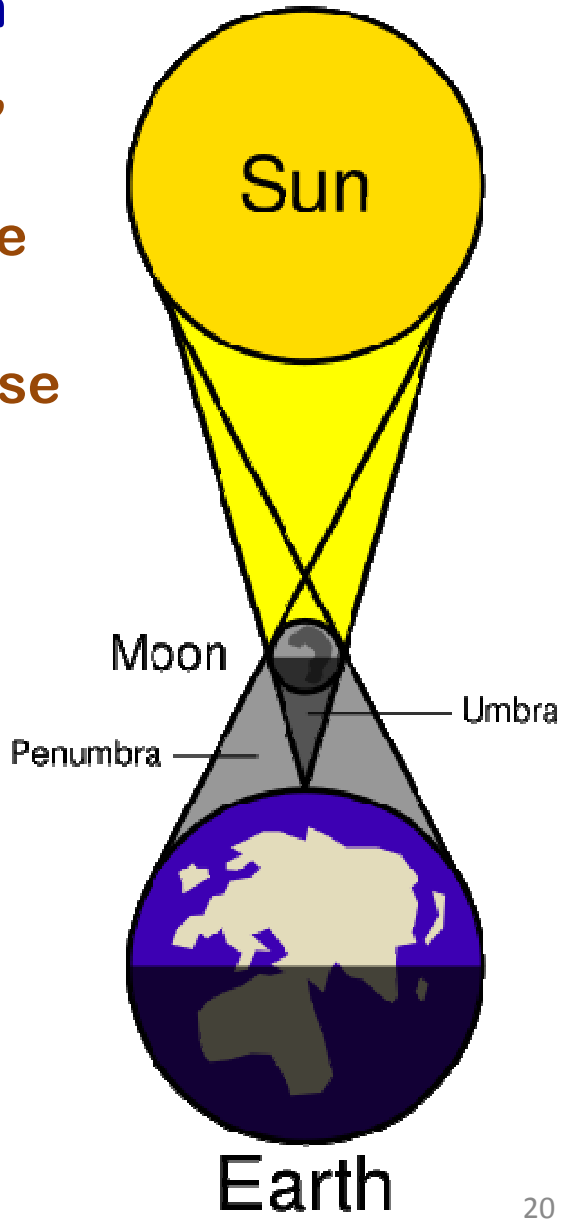




4. The Motion of the Moon

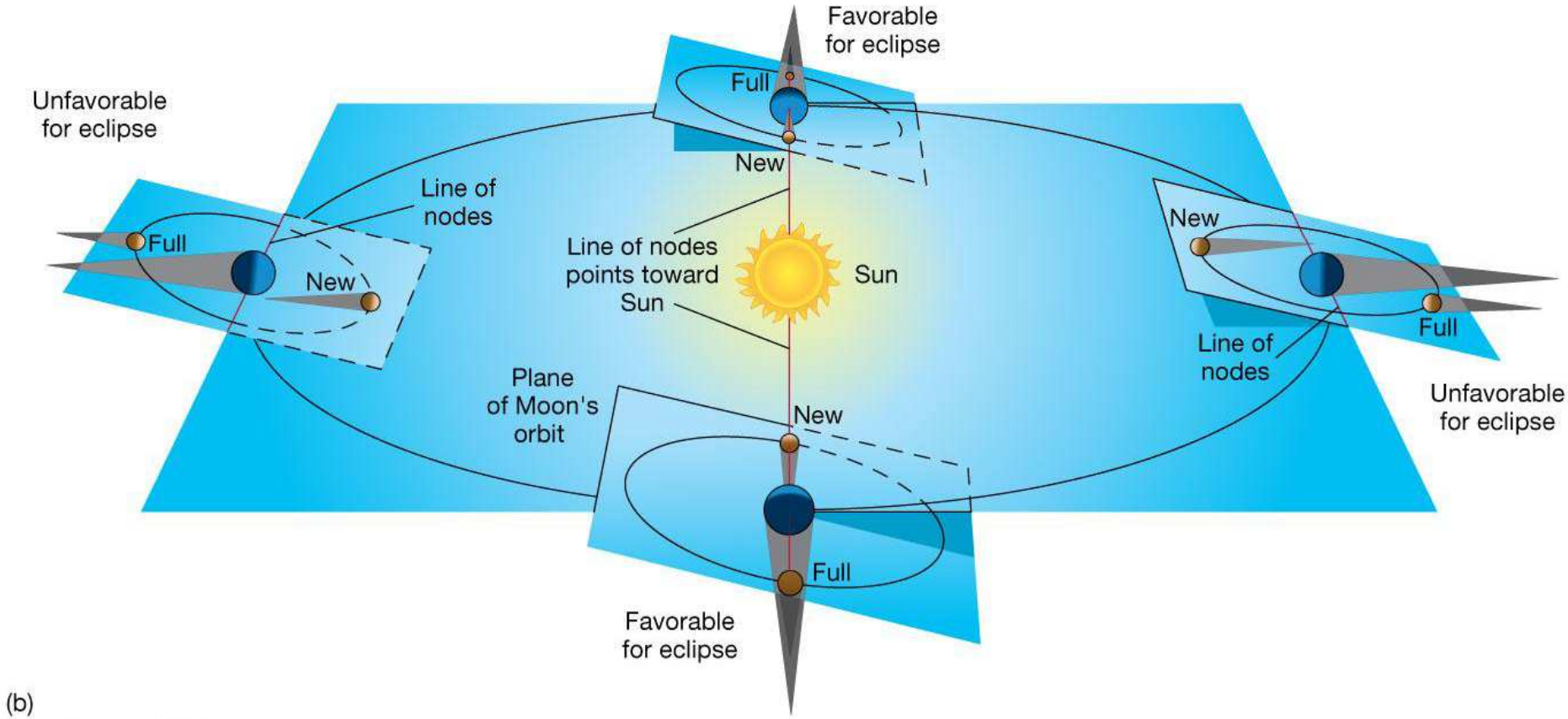
Solar eclipse: Moon is between Earth and Sun

- *Umbra*: the central region of the shadow, where the eclipse is total.
- *Penumbra*: within the shadow, but outside the umbra, where the eclipse is partial.
- Umbra is small (270km width), total eclipse stays only for few minutes. (7.5 min)



4. The Motion of the Moon

Eclipses don't occur every month because Earth's and Moon's orbits are not in the same plane

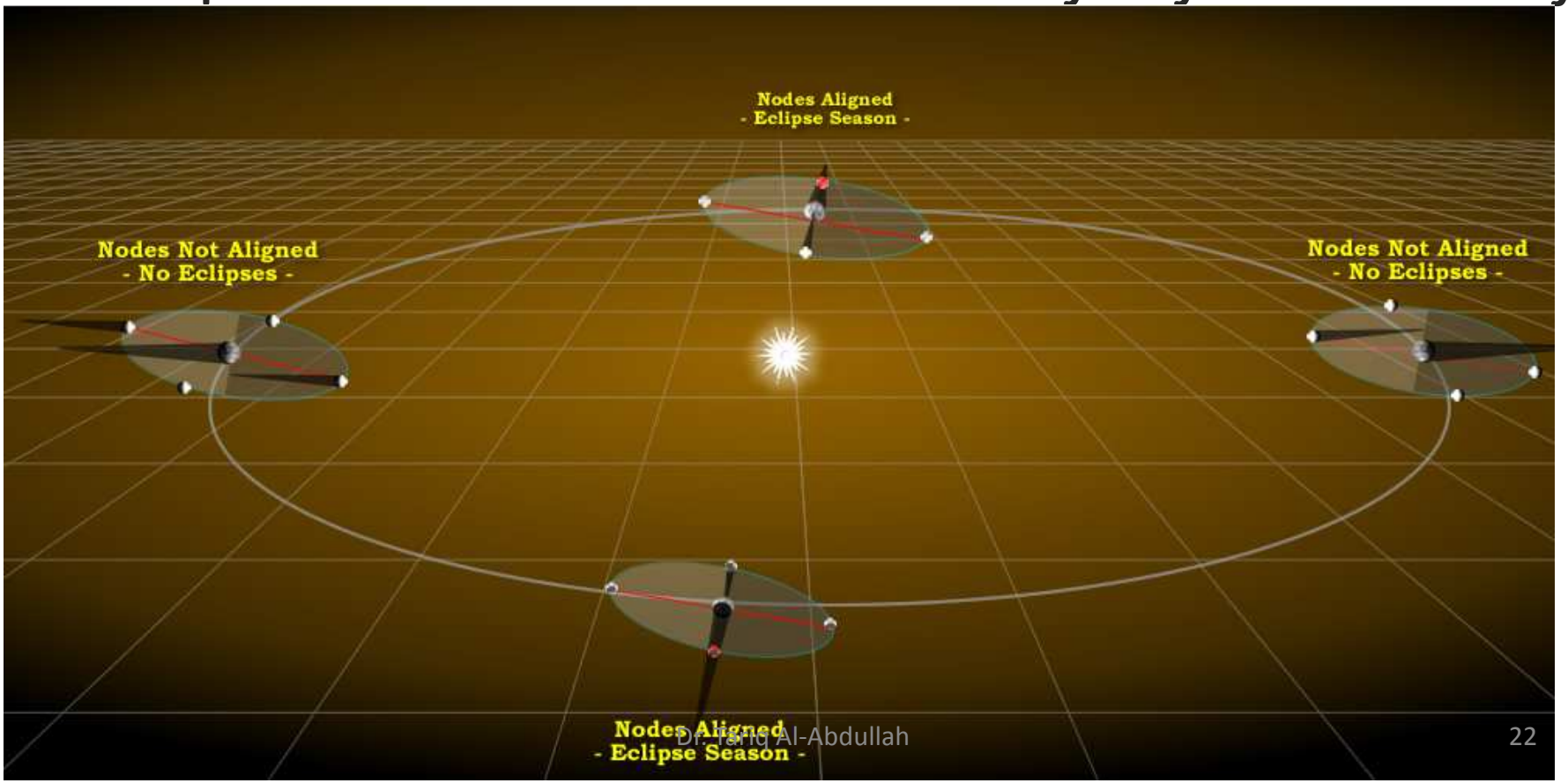


(b)

4. The Motion of the Moon

Eclipse Seasons

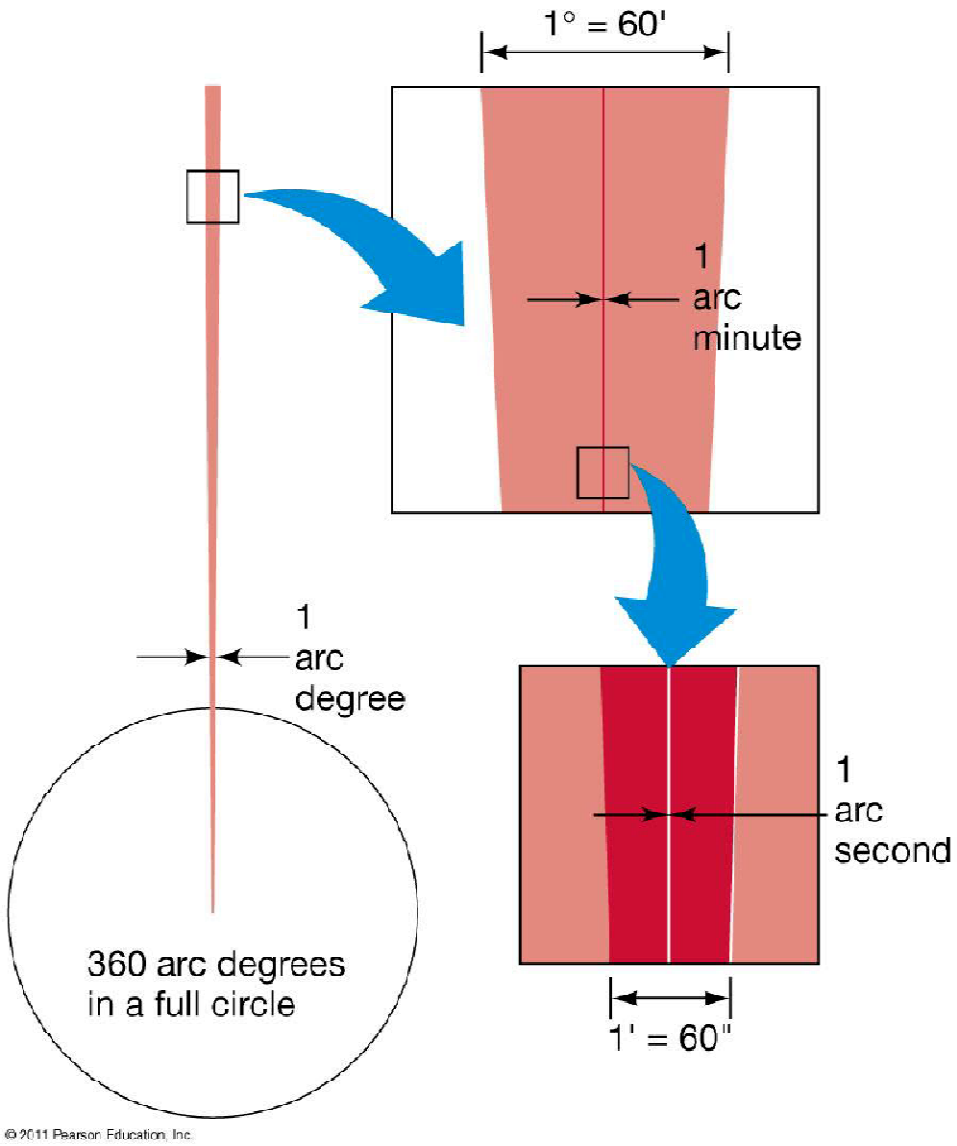
- Moon's orbit is slightly inclined to the ecliptic (5.2°).
- Line of the nodes is directed toward the sun, favorable configuration for eclipses, otherwise, unfavorable.
- Eclipse seasons, when eclipses occur.
- Eclipses recur in the same location every 18 years and 11 days)



5. The Measurement of Distance

Definitions:

- **Full circle: 360°**
- **Each 1° : 60′ (arc-minutes)**
- **Each 1′ : 60″ (arc-seconds)**
- **Angular size of an object depends on its actual size and distance from viewer**



5. The Measurement of Distance

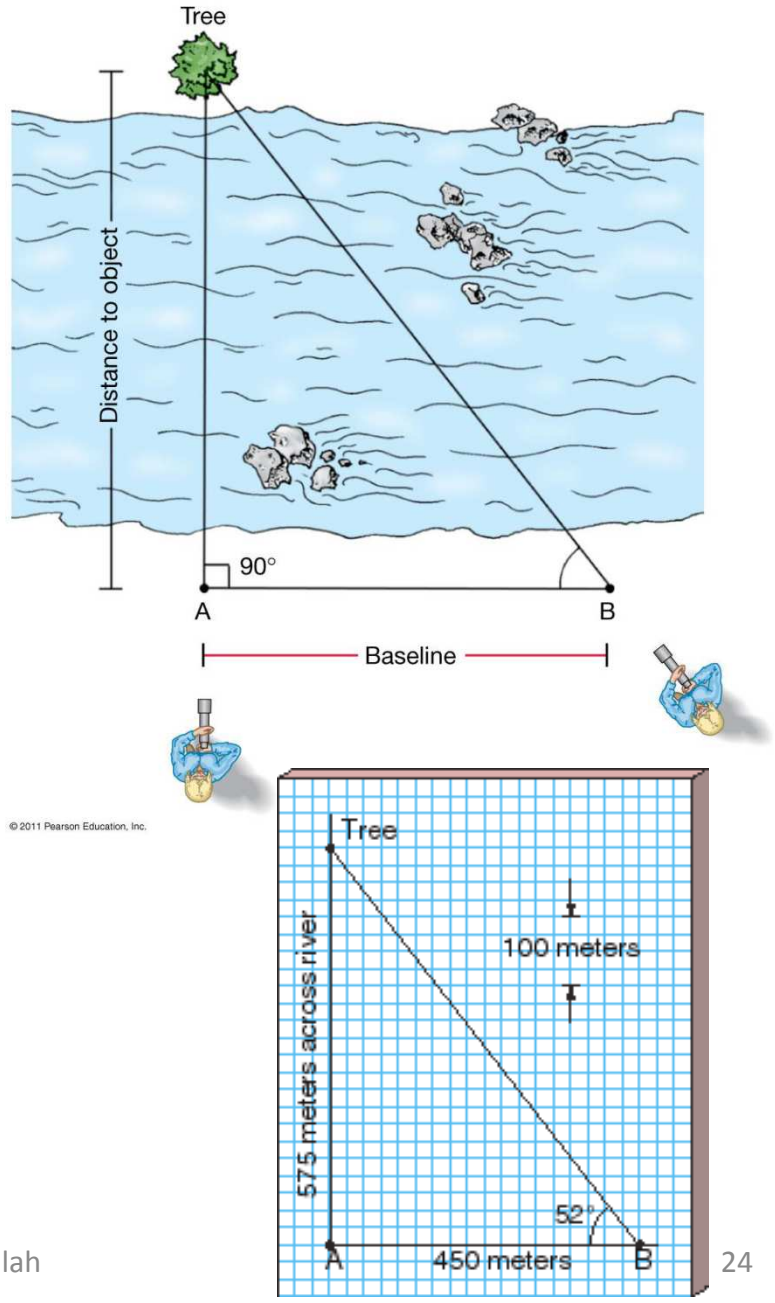
* *How astronomers track and record the positions of the stars.*

* **Triangulation method:**
  Measuring baseline and angles can calculate distance.

* **Experience with geometric scaling.**

* **For astronomy, triangles become longer and narrower.**

* **No sufficient accuracy.**

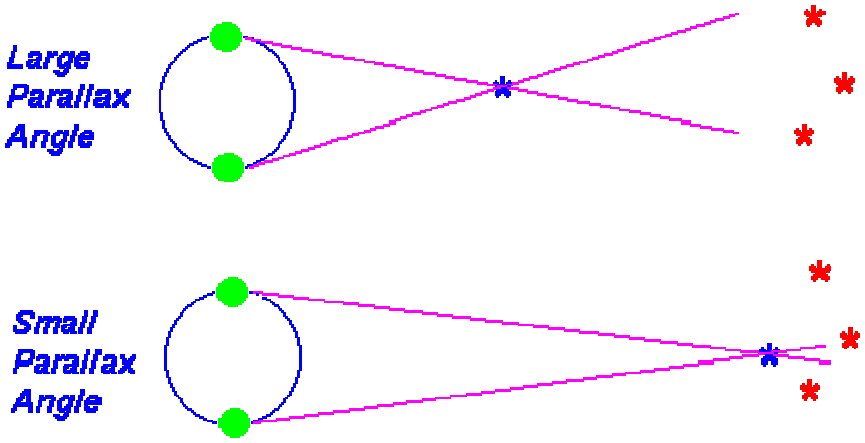


5. The Measurement of Distance

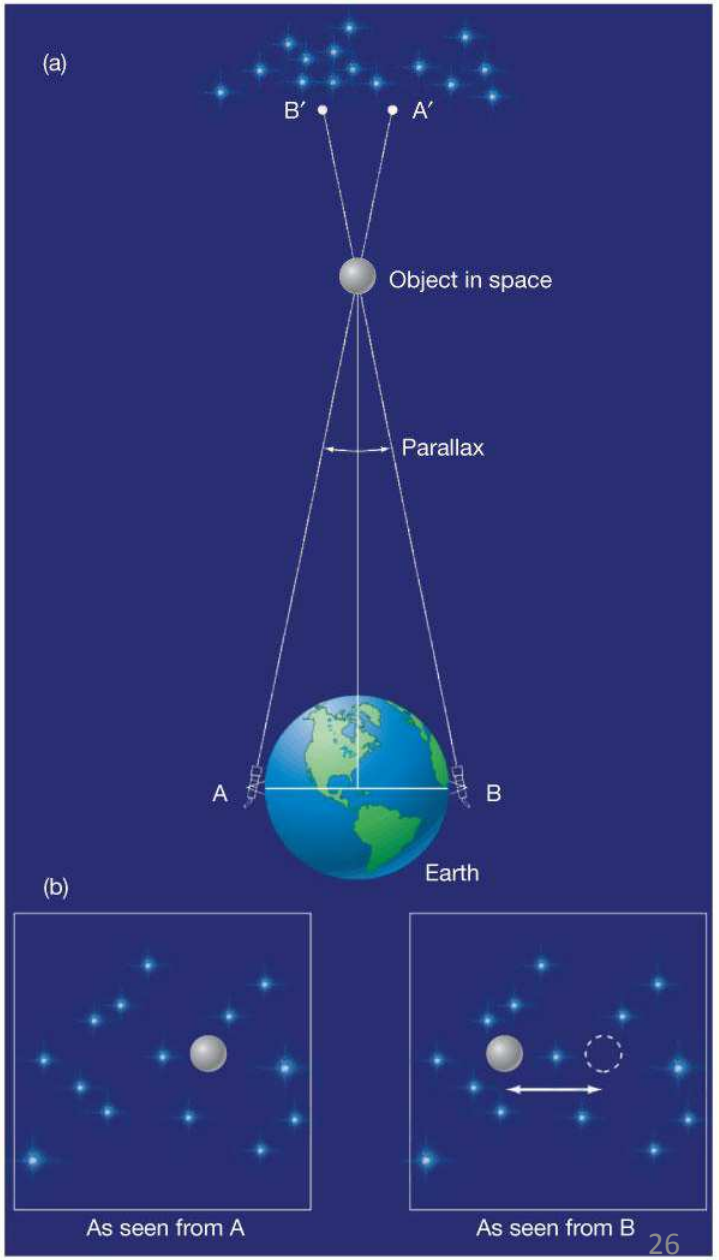
5. The Measurement of Distance

* Parallax: The apparent displacement of an object relative to a far background when the observer's location changes.

- Parallax is inversely proportional to an object's distance.



- **Parallax is very small;**
- **Venus: 1´ ==> 45 million km**



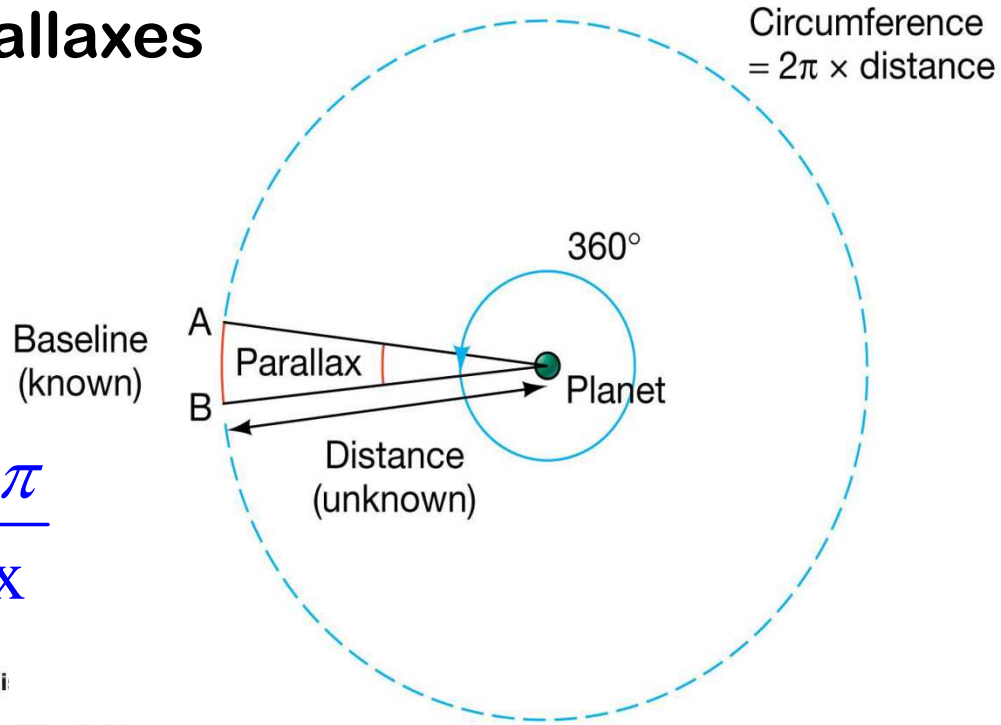
© 2011 Pearson Education, Inc.

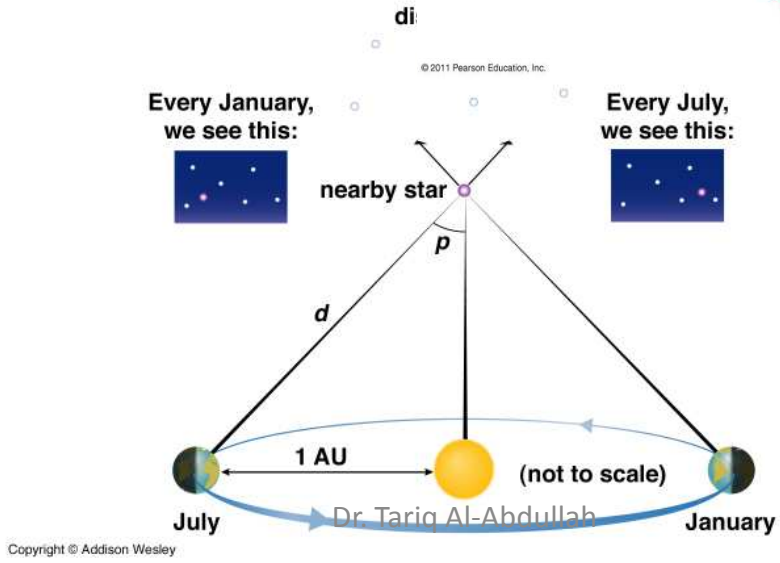
5. The Measurement of Distance

Converting baselines & parallaxes into distances

$$\frac{\text{baseline}}{2\pi \times \text{distance}} = \frac{\text{parallax}}{360^\circ}$$

$$\text{distance} = \text{baseline} \times \frac{360^\circ / 2\pi}{\text{parallax}}$$

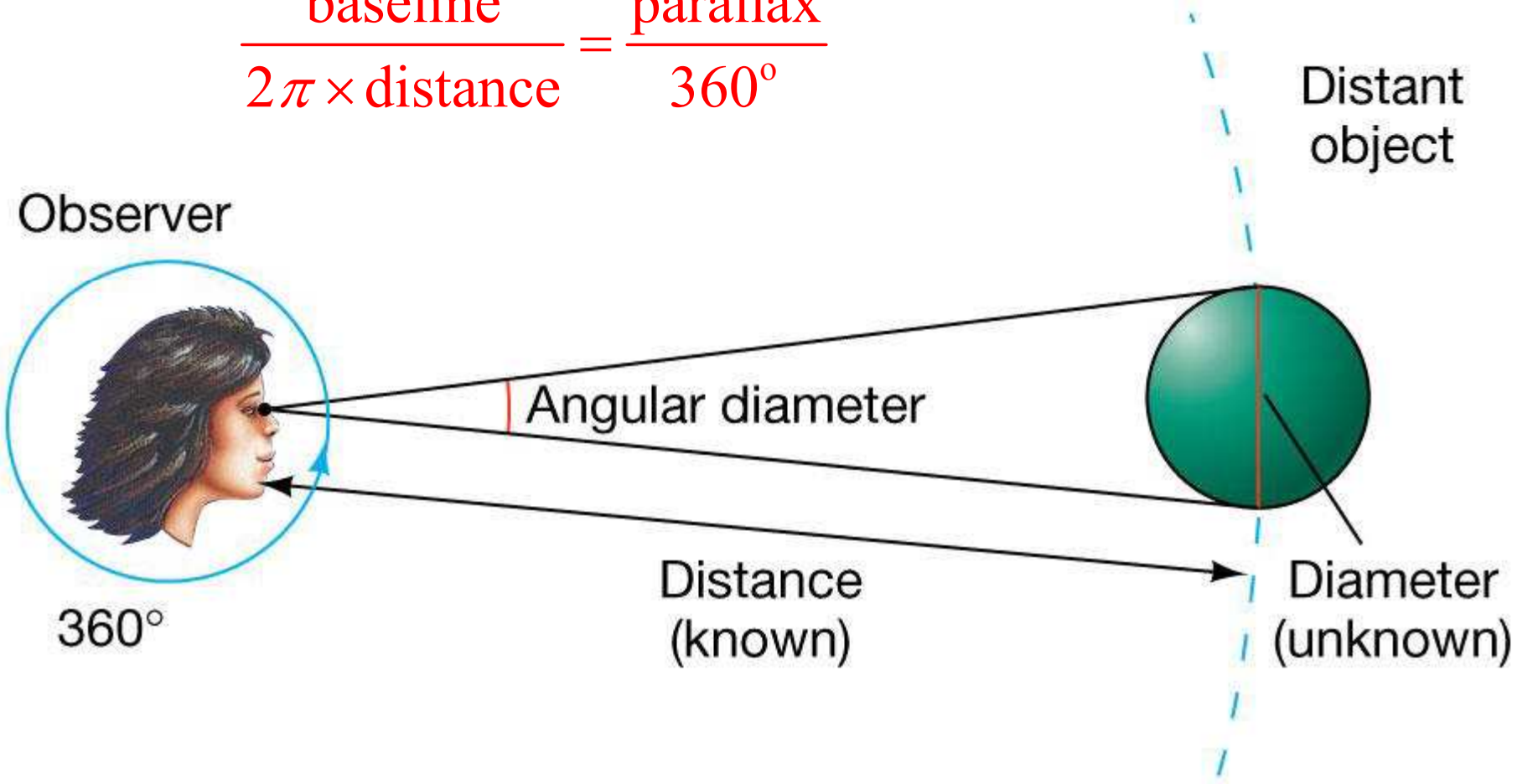




5. The Measurement of Distance

Converting angular diameter & distance into size

$$\frac{\text{baseline}}{2\pi \times \text{distance}} = \frac{\text{parallax}}{360^{\circ}}$$



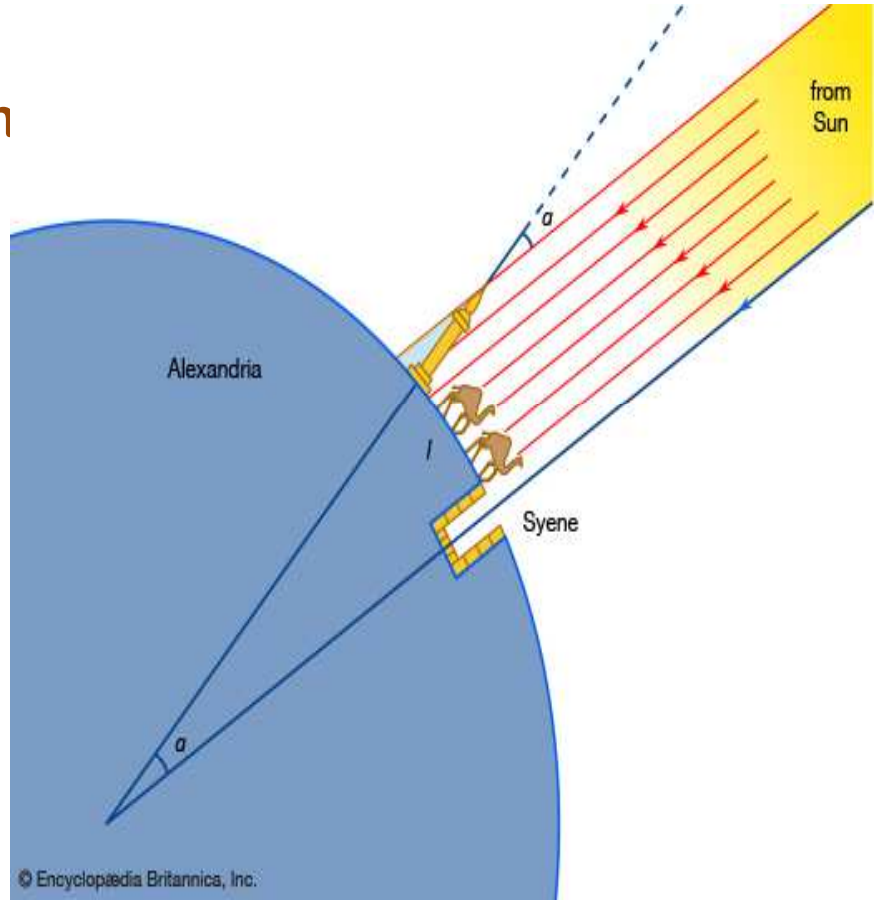
5. The Measurement of Distance

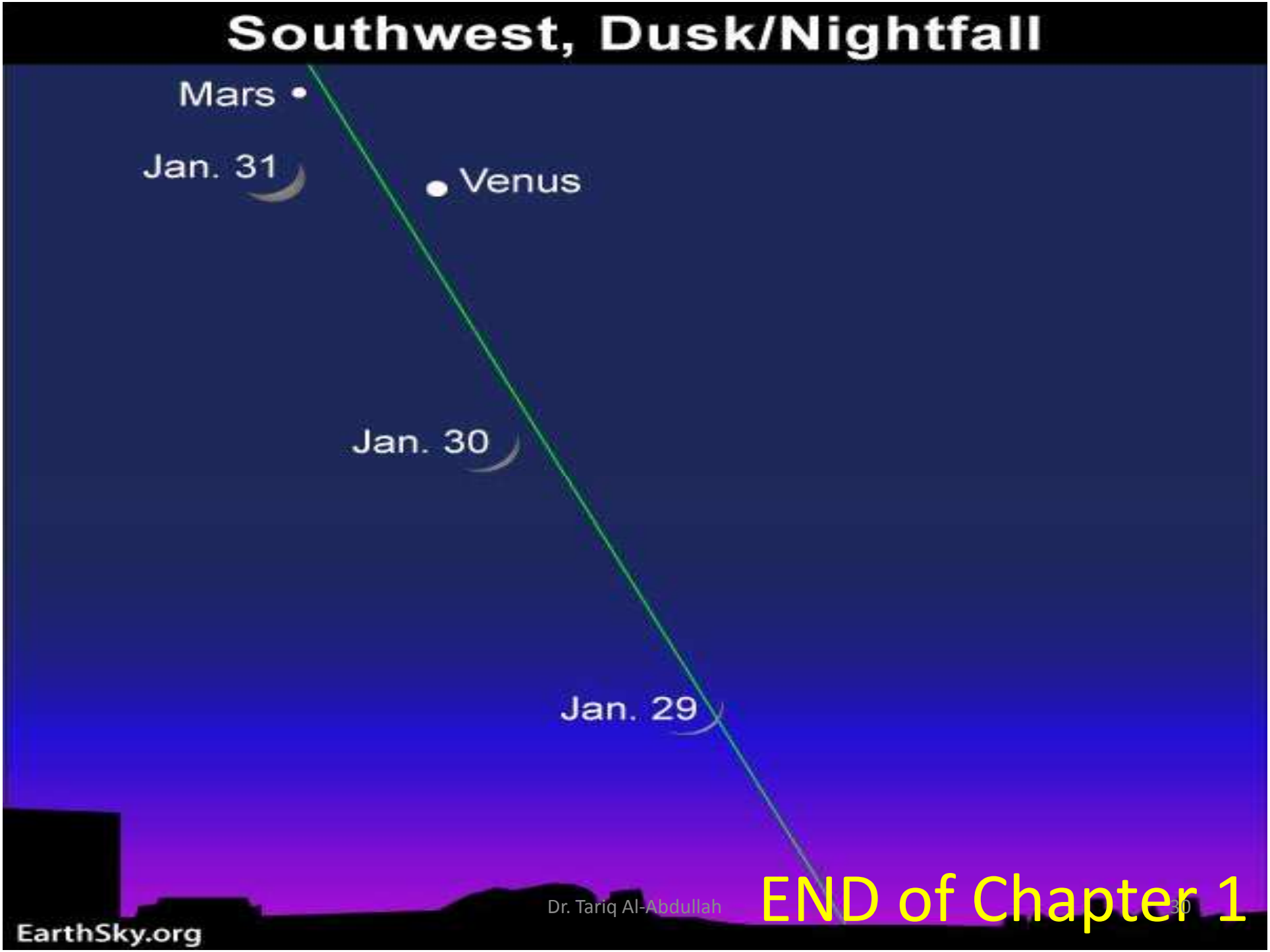
Sizing up the planet

- Greek Philosopher Eratosthenes (200 B.C.)
- On noon, first day of summer, the sun passes directly overhead in Syene.
- Alexandria is 5000 stadia to the north (each stadium is 0.16 km)
- On noon, the angular displacement of the sun is 7.2º.

$$\frac{7.2^\circ}{360^\circ} = \frac{5000 \text{ stadia}}{Earth's\ Circumference}$$

- Earth's radius is 6366 km.
- Using orbiting spacecraft, Earth's radius is 6378 km.





END of Chapter 1