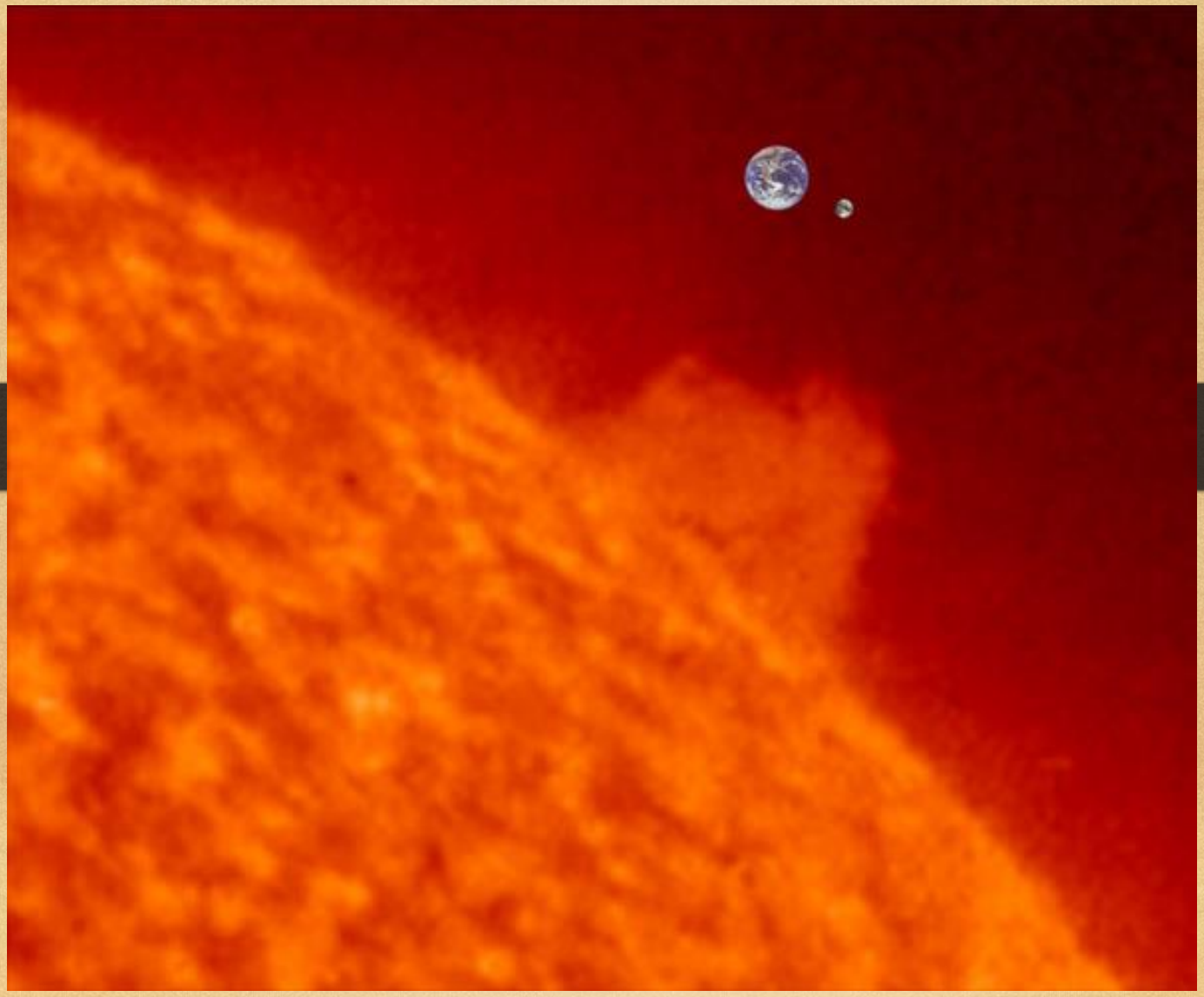
Ch 28: The Sun-Earth-Moon System



http://hyperphysics.phy-astr.gsu.edu/hbase/solar/picsol/sunmooear2.jpg

Objectives: Moon Formation, Moon Features

1. Explain the Impact Theory about the Moon's formation, including evidence supporting the theory.
2. Identify features on the Moon. This means I can:
   A. Define, draw and label the following surface features of the Moon on a diagram: albedo, highlands, maria, impact craters, regolith.
   B. Describe the history of the Moon's surface features; contrast the age, albedo and formation of maria vs. highlands.
   C. Determine the relative age of features on the moon using the principle of superposition.
   D. Explain the Moon's unique properties by comparing and contrasting the composition of the moon vs. the earth; layers and what they are made of.

Objectives –Solstices/Equinoxes, Eclipses, Tides

3. Identify the relative positions and motions of Earth, Sun & Moon. This means I can:
   - A. Explain what causes earth's day and night, seasons.
   - B. Compare and contrast summer solstice, winter solstice, autumnal and vernal equinoxes.
   - C. Describe the following motions and their effects: rotation, revolution, tilt of axis, synchronous rotation.
   - D. Compare and contrast solar vs. lunar eclipses including
     - I. Alignment of the sun, earth and moon.
     - II. The effect of perigee vs. apogee of the moon on solar eclipses
     - III. The amount of eclipse (total vs. partial) from the umbra vs. penumbra.
     - IV. Which type eclipse (lunar vs. solar) is more common and why.
   - E. Compare and contrast high & low tides as well as spring & neap tides according to sun and moon alignment, tidal range, frequency and location.

Objectives: Moon Phases

4. Describe the phases of the Moon. This means I can:
   - A. Match and label a diagram of moon phases with the appropriate phase title including the terms crescent, gibbous, quarter full, and new.
   - B. Explain why we view various phases of the Moon from Earth

Astronomy Basics

What is Astronomy?

1. The study of the universe beyond our atmosphere.

How can we study it? Here are things we'll be discussing

- This chapter on Sun-Earth-Moon and
- The next unit on the Solar System and Universe

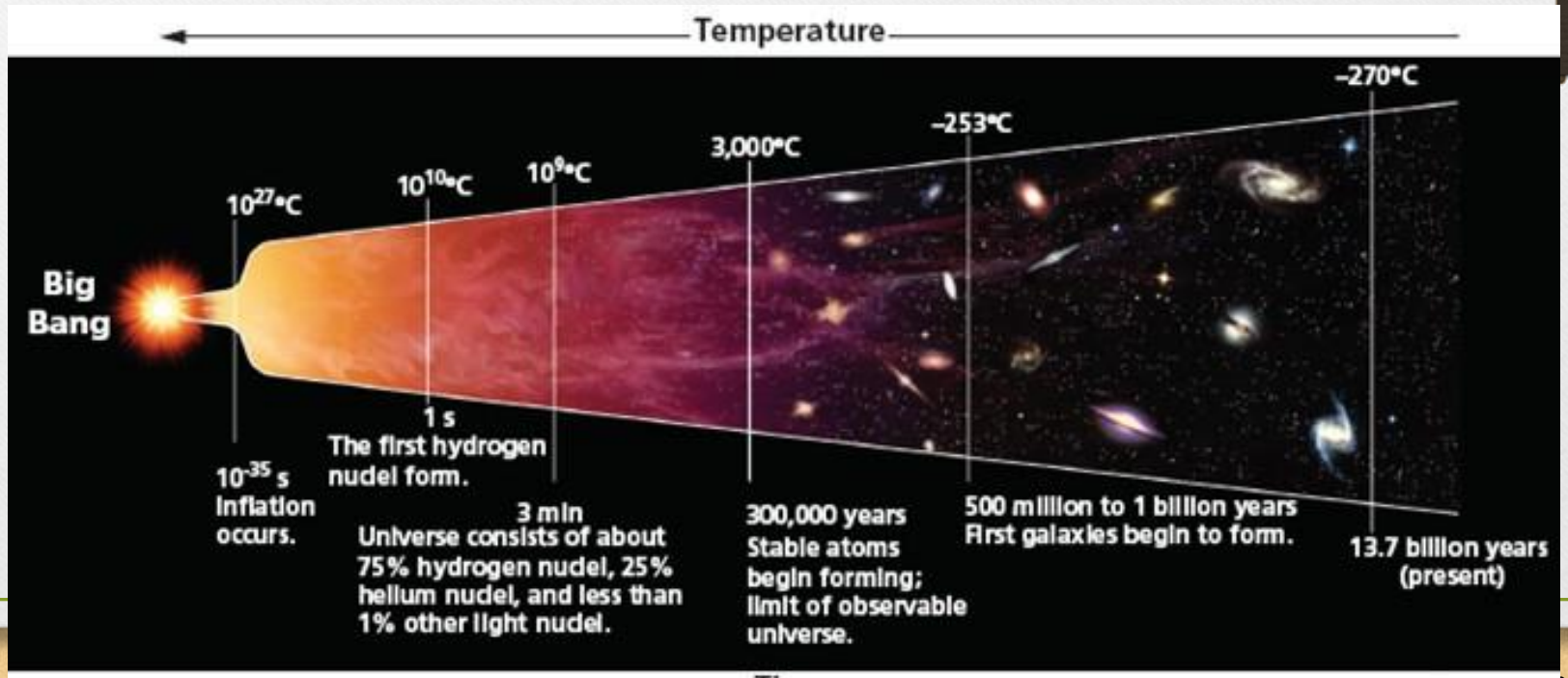
1. Study things that make it to Earth
   A. Meteorites
   B. Samples Collected
2. Study the light that makes it to Earth
3. Study light in space
   A. What is the light doing? / What's releasing light?

Universe Formation – Intro to Big Bang

In the next unit on the Universe, we will discuss theories on its formation. Here's a quick overview to help introduce where our Sun-Earth-Moon might have come from.

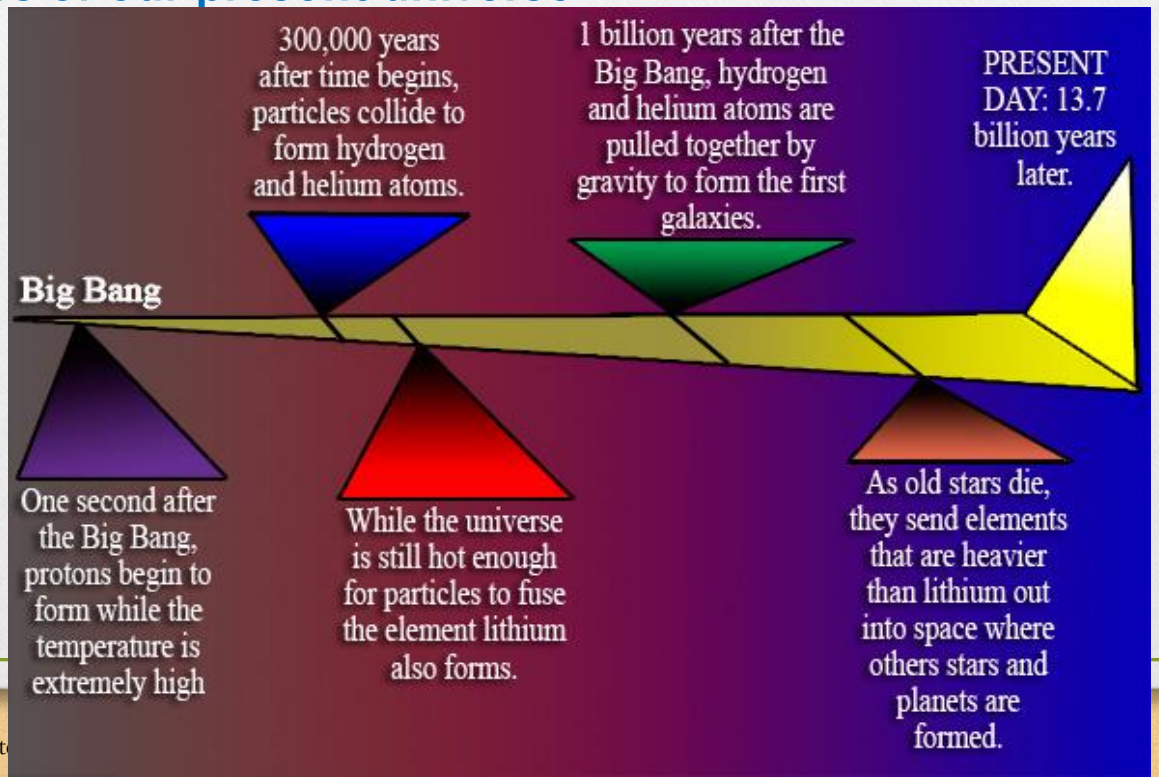
Big Bang Theory = Most popular theory

1. Based on the following observation: Galaxies are moving away from ours at great speed, in all directions, as if propelled by an explosive force – the "Big Bang".
2. Before the Big Bang? All universe compressed into hot, dense mass, just a few millimeters across, that existed for just a fraction of the first second of time.



Universe Formation – Big Bang Timeline

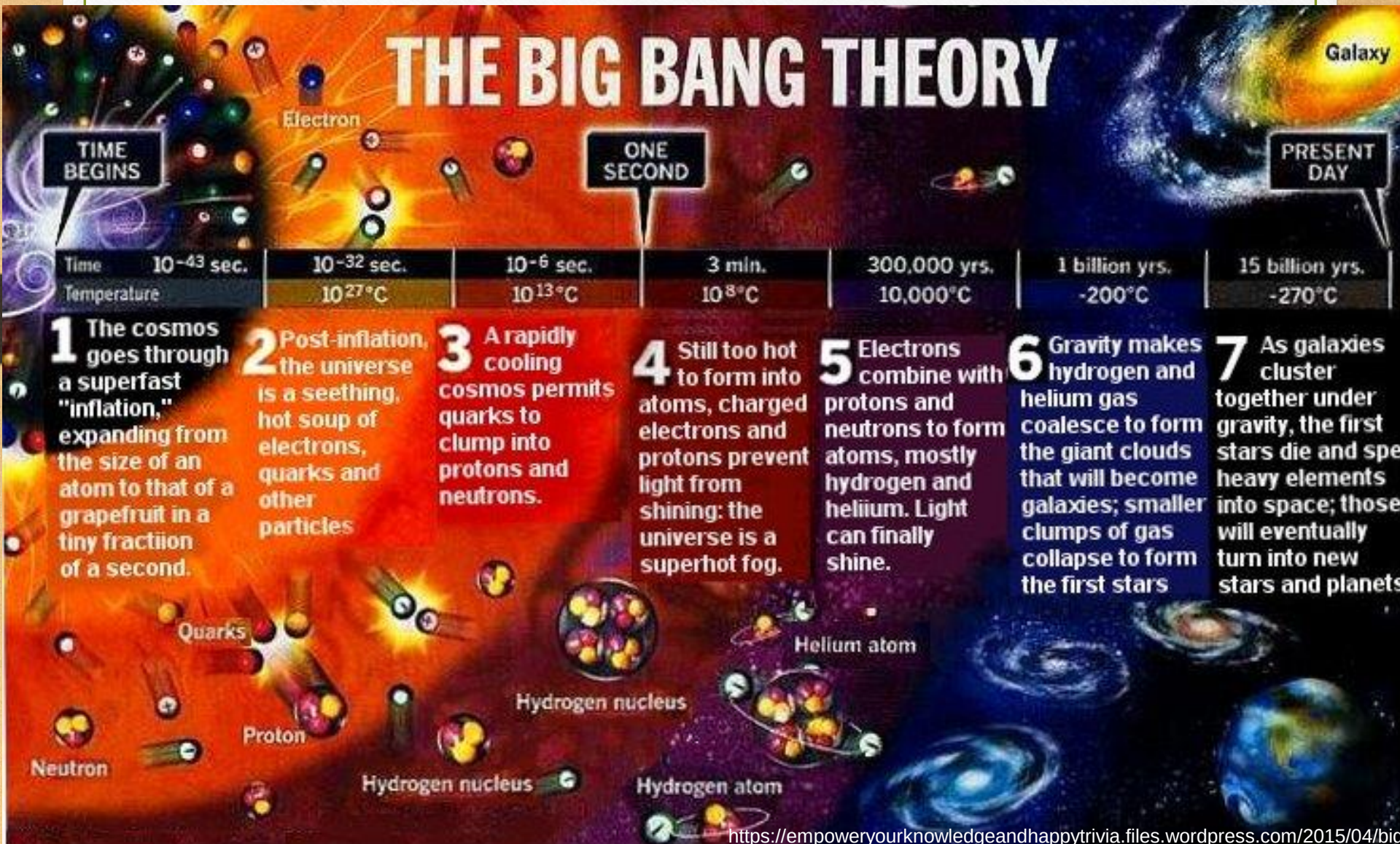
1. 10 – 20 billion years ago, an unknown type of energy causes a massive blast that cause the universe to expand from a pebble-size origin to astronomical size.
2. Expansion continues, but much more slowly now billions of years later.
3. As time passed and matter cooled, more diverse kinds of atoms began to form, and they eventually condensed into the stars and galaxies of our present universe.



http://utahscience.oremjr.alpine.k12.ut.us/sciber08/9th/stand_1/images/BigBang.jpg

Big Bang Theory Diagram & Questions

Several major questions still unanswered, including what is the original cause of the Big Bang itself. **Answers have been proposed, but none has been proven. ***Testing them is a challenge.



https://empoweryourknowledgeandhappytrivia.files.wordpress.com/2015/04/bic

After the Big Bang

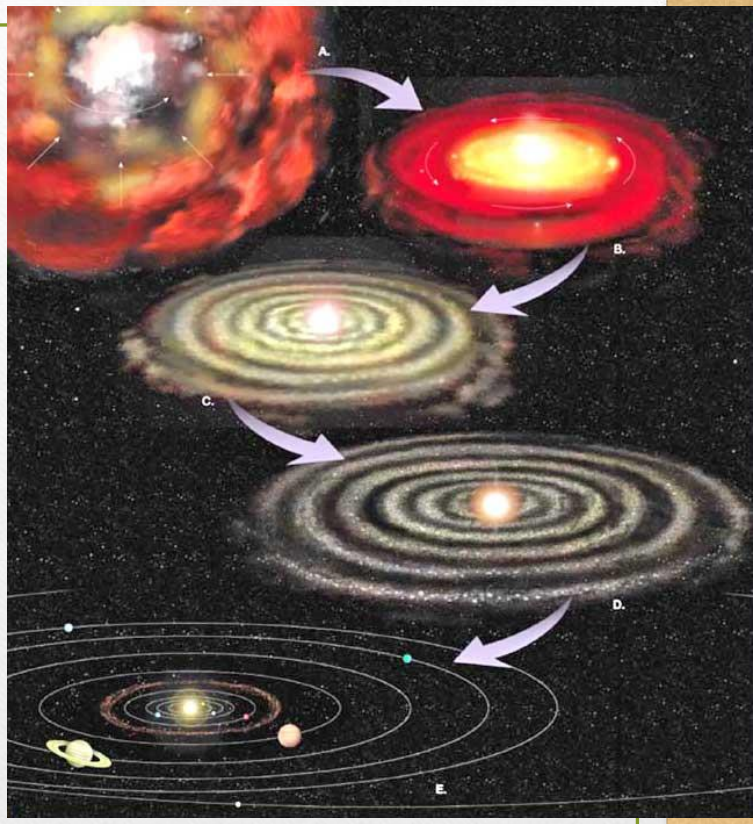
After the Big Bang

- Gravity pulls matter into small clusters
- Clusters of matter become huge clouds of dust and gas
- Clouds become solar systems and galaxies
- We will discuss how these form in more detail later in the course

Solar System Formation – Brief Overview

Collapsing Interstellar Cloud Theory

- Huge clouds of gas & dust
- Forms stars and planets when it condenses due to gravity
- The smaller it condenses/collapses, the faster it spins
- This spinning motion forms a flat rotating disk with a very dense center.
- Sun/star forms in the center, with planets forming as debris collides and is pulled by gravity.
- We will discuss in more detail in the next unit on the Universe



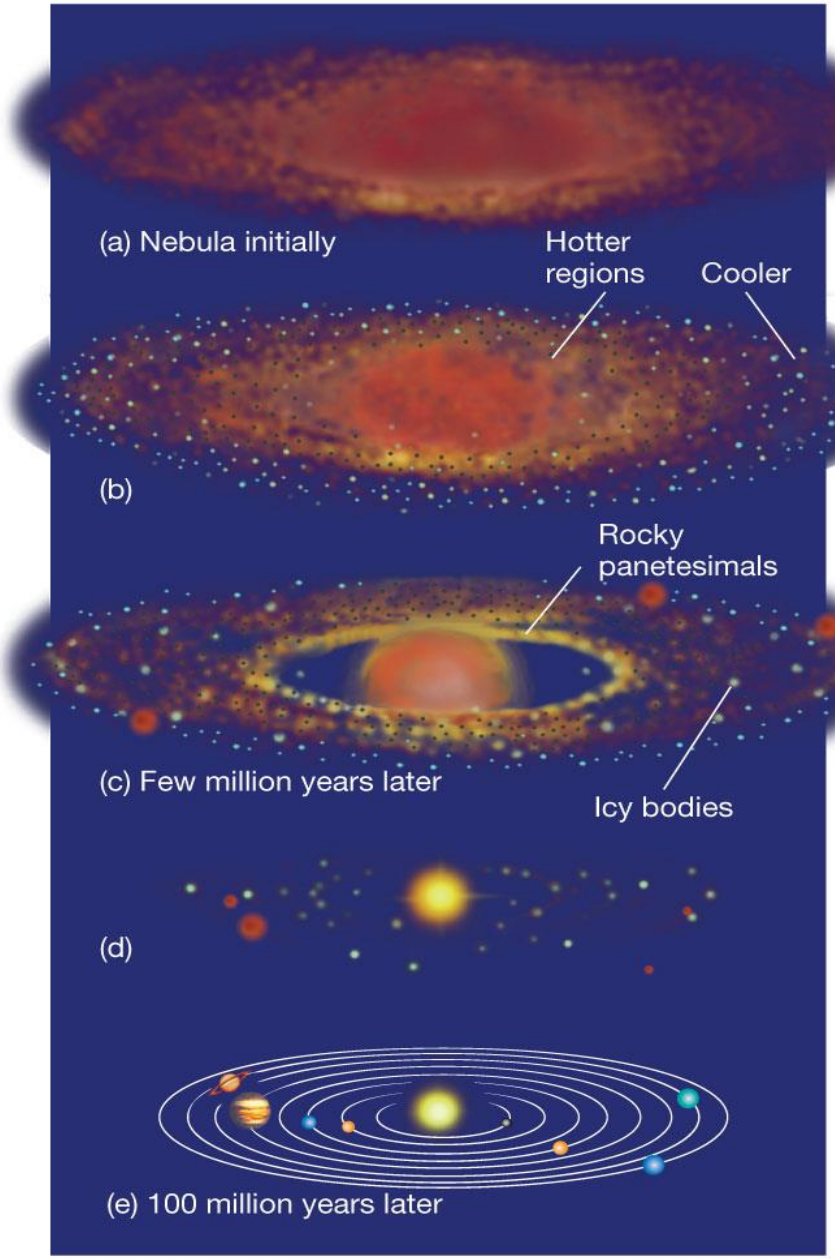
http://www.bibliotecapleyades.net/imagenes_ciencia/sol01_05.jpg

Moving from Solar System to Our Moon

One last diagram of solar system formation.

Now that we've seen that the theories of how the universe and solar system involve lots of matter and debris flying around and collapsing:

We'll move on to theories of how our moon was formed.

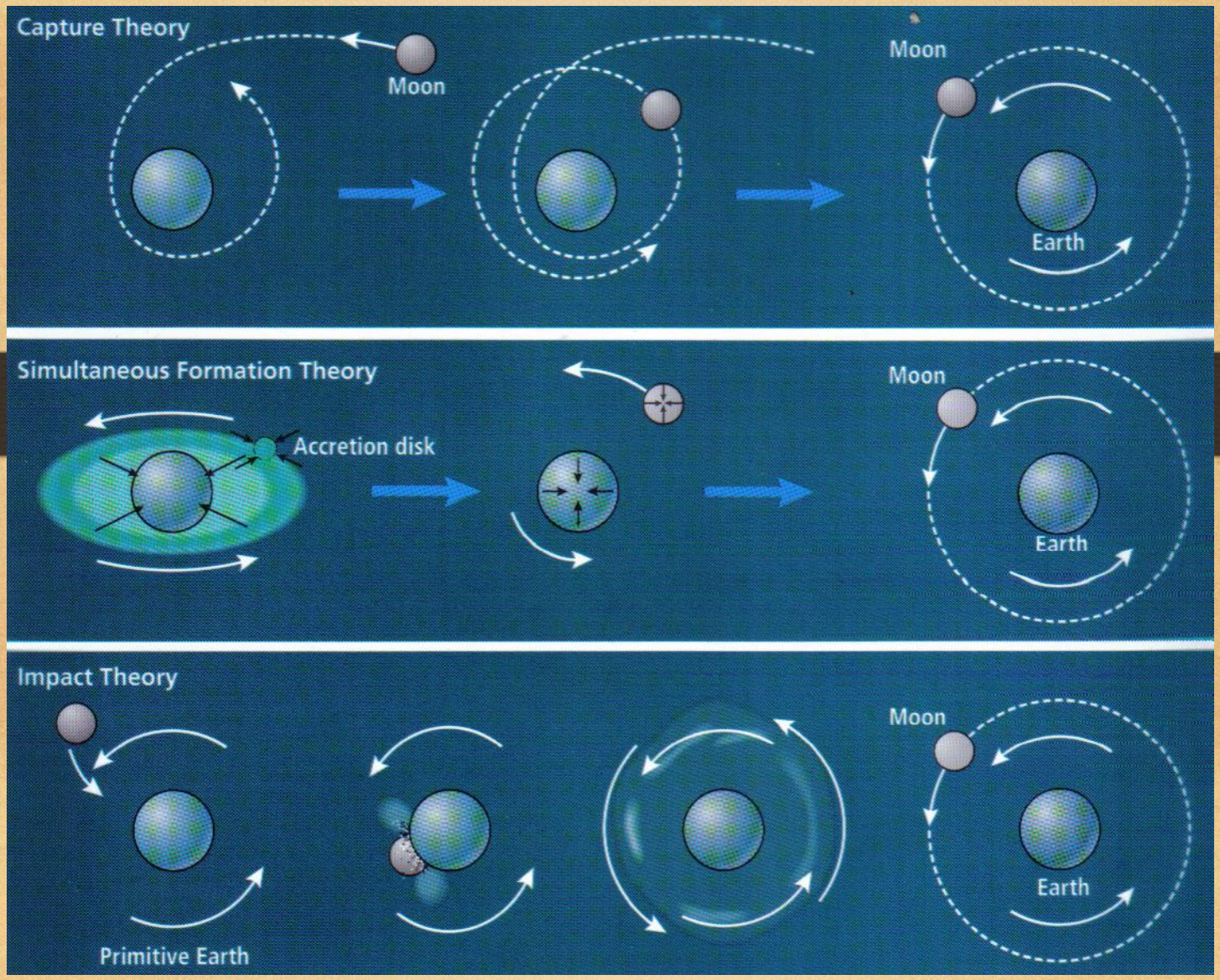


http://pages.uoregon.edu/jimbrau/BrauImNew/Chap06/7th/AT_7e_Figure_06_1

TT #87 How Did the Moon Form?

Formation Theories – 3 main ones What does this diagram tell about them?

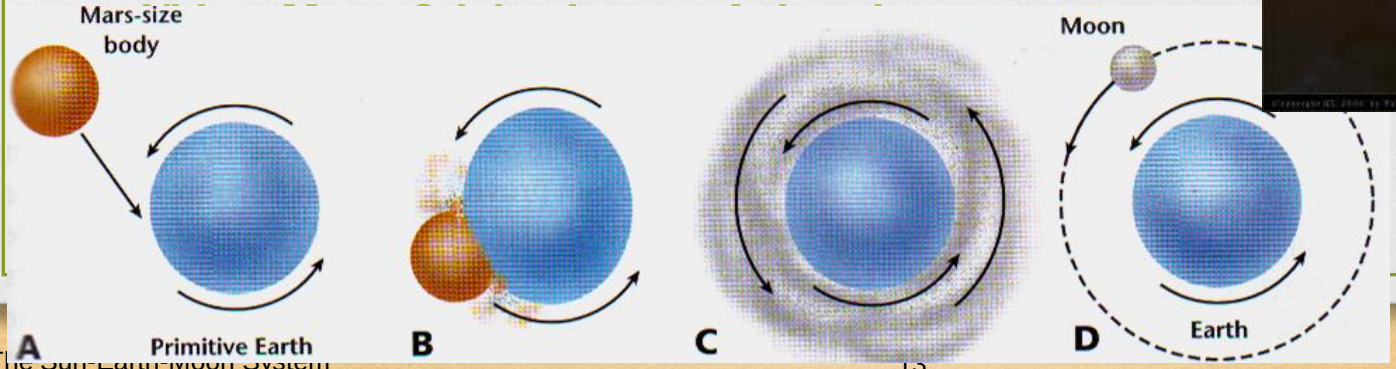
- Impact Theory is most widely accepted of the 3 Theories – the only 1 you need to explain



Impact Theory

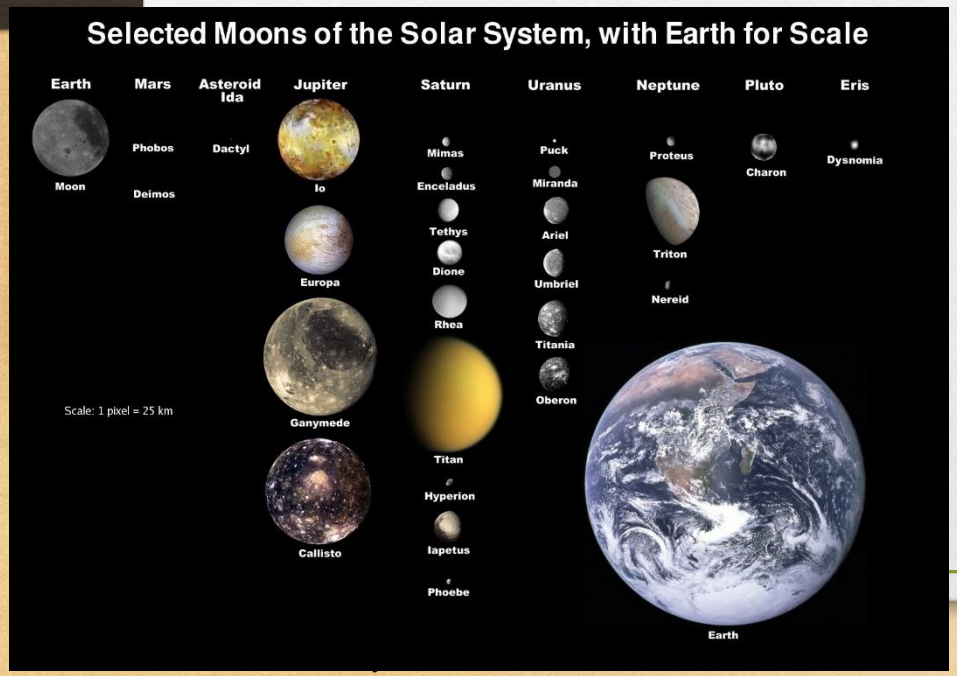
Impact Theory of Moon Formation

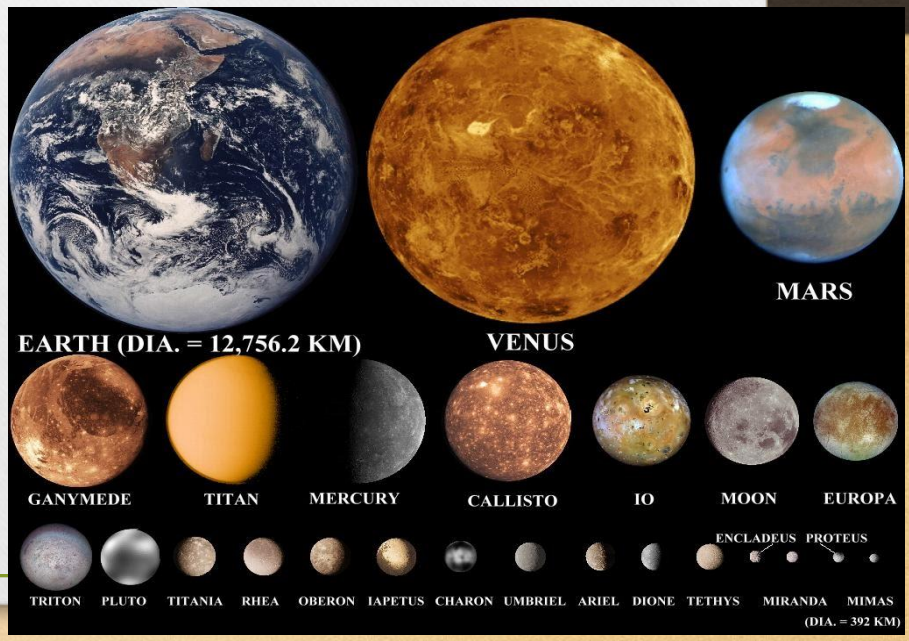
1. Theory states that the Moon formed because of a huge collision between the Earth & a Mars-sized object
2. Collision expelled material/debris from both the Earth & the space object
3. The flying debris combines to form the Moon
4. Positives:
   - A. Explains why there are both similarities & differences in composition between the Earth & the Moon
   - B. Explains why there is no water on the moon – heat from the impact would have evaporated any water
5. Most commonly accepted theory
6. Possible cause of crater that became Pacific Ocean?



Unique (Unusual) Lunar Properties - Size

1. Size:
   - A. One of largest moons in our solar system
   - B. Only large moon found in the inner planets
     - I. Mercury & Venus – Have no moon(s)
     - II. Mars – 2 tiny chunks of rock



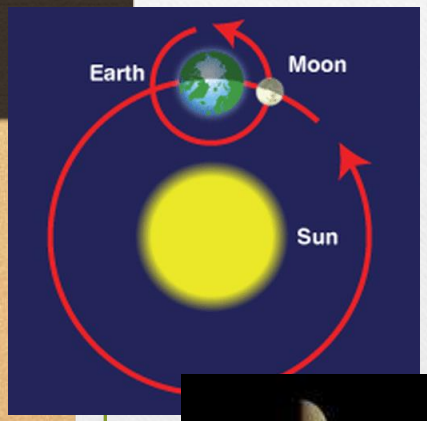


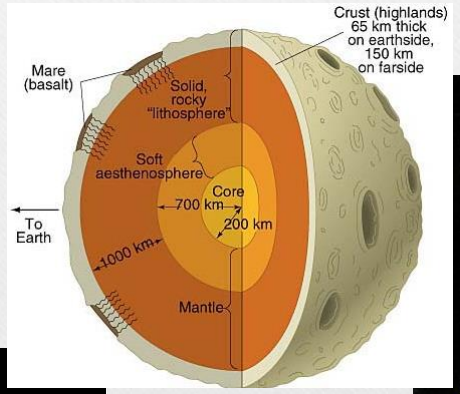
http://upload.wikimedia.org/wikipedia/commons/4/4f/Moons_of_solar_system_v7.jpg

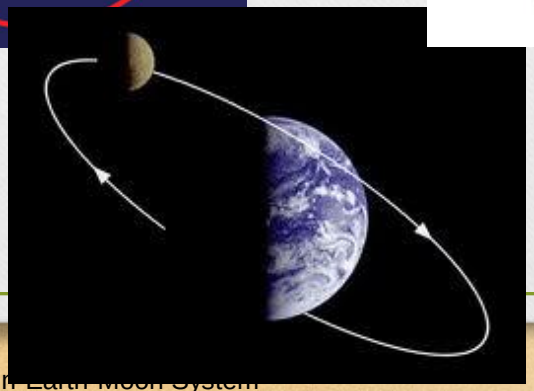
https://sites.google.com/site/junamir2/Terrestrial_Planets_and_Moons.jpg

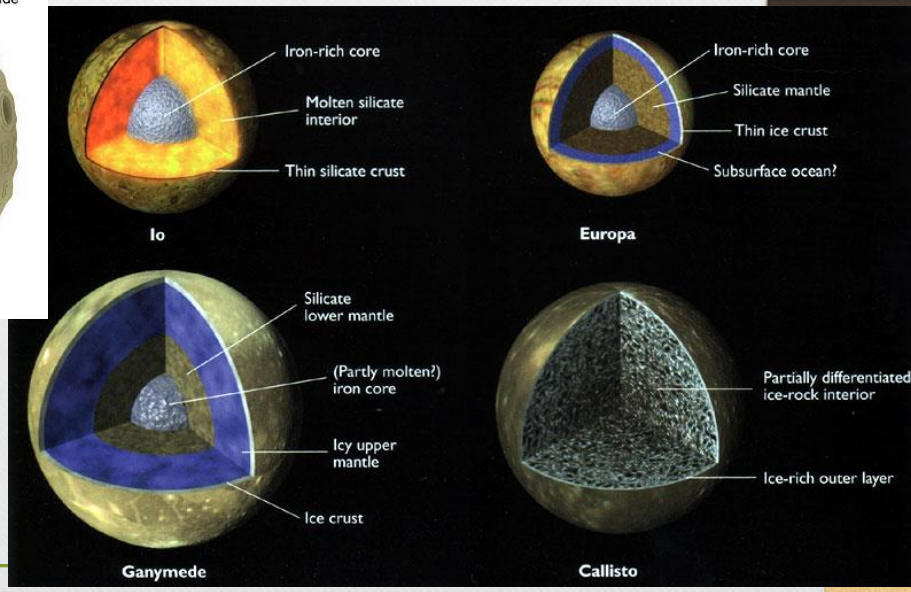
Unique (Unusual) Lunar Properties

2. Orbit:
   A. Orbits farther away from Earth than the moons around other planets
3. Composition:
   A. Solid and rocky
   B. Outer Planet moons in contrast are icy
      I. Moons of Jupiter, Saturn, Uranus, Neptune





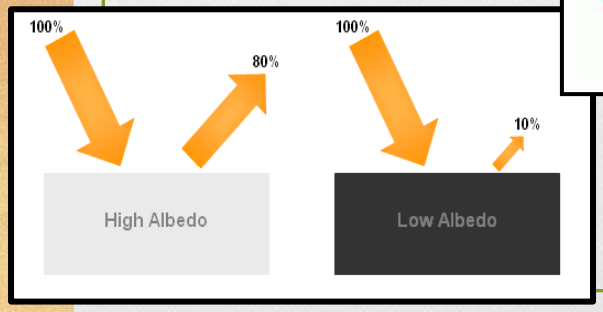


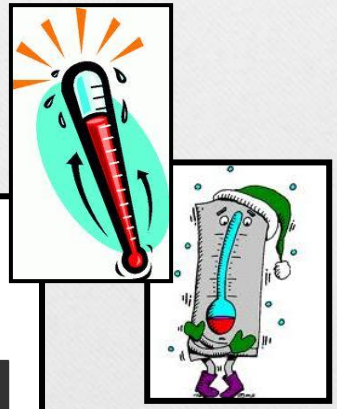


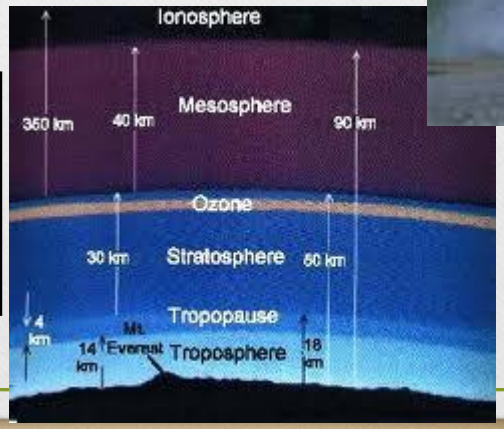
http://ircamera.as.arizona.edu/NatSci102/NatSci102/images/galmoonint.jpg

Lunar Surface Facts

1. Relatively dark surface
   - A. Only 7% albedo
   - B. **Albedo:** The amount of sunlight that a planet reflects
   - C. Most of the sunlight on the moon is absorbed instead
2. Extreme temperature differences between day and night of moon
3. No erosion
   - A. No atmosphere (no wind & no flowing water)
   - B. Impact craters remain unchanged

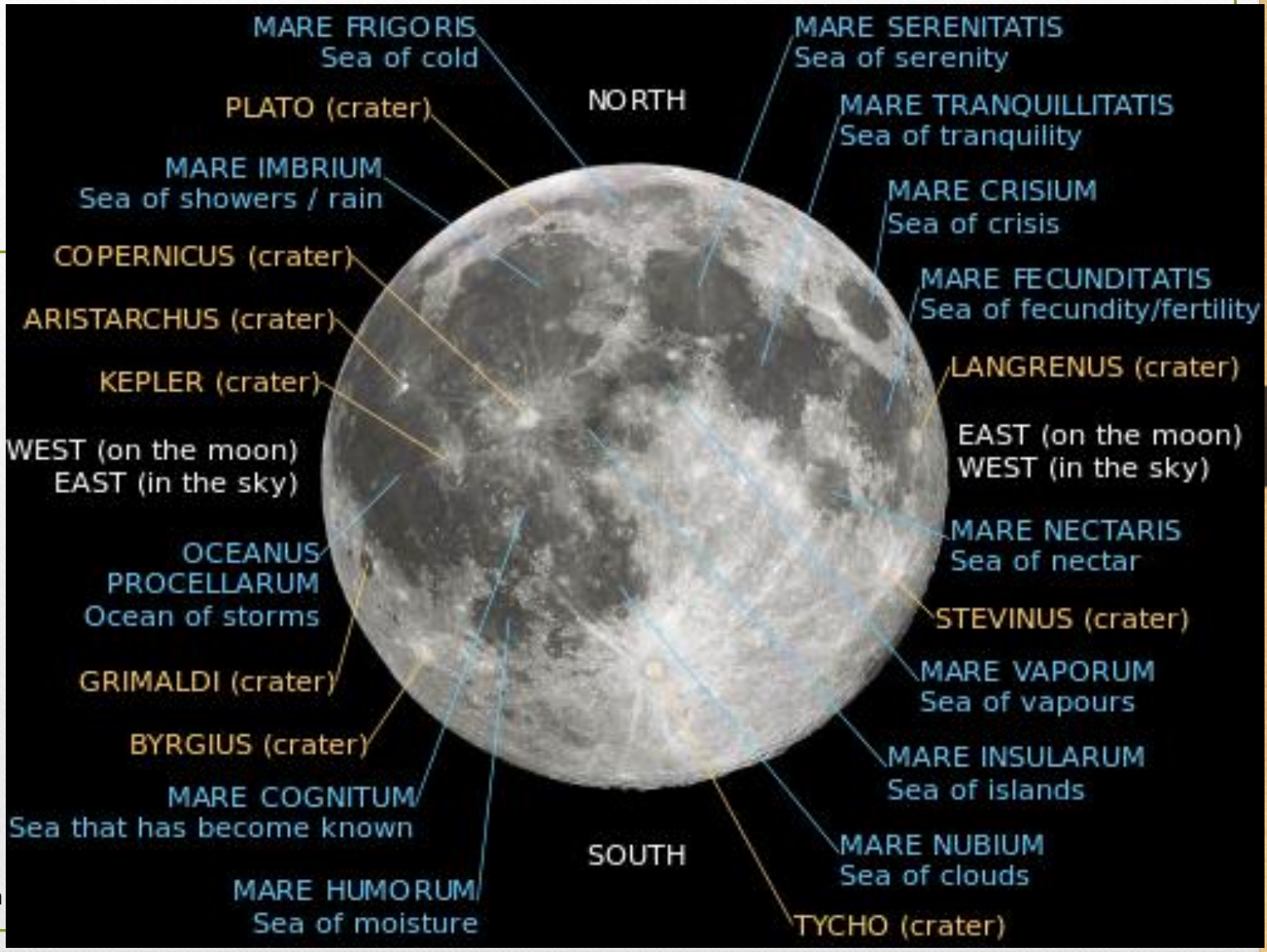






https://www.nc-climate.ncsu.edu/secc_edu/images/albedo.bmp

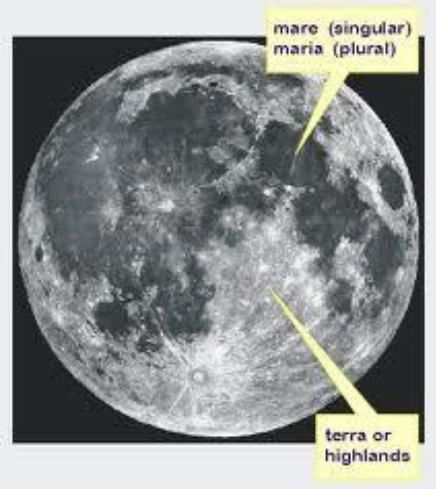
- How are craters named?
- Maria?

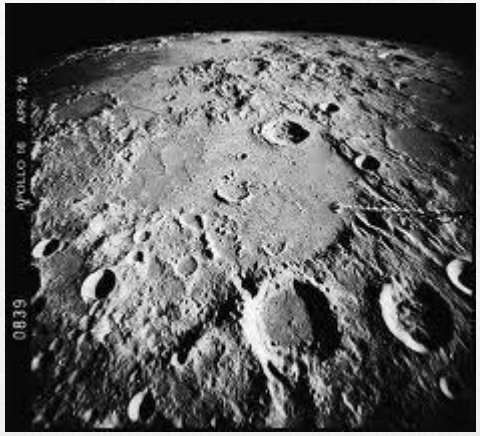


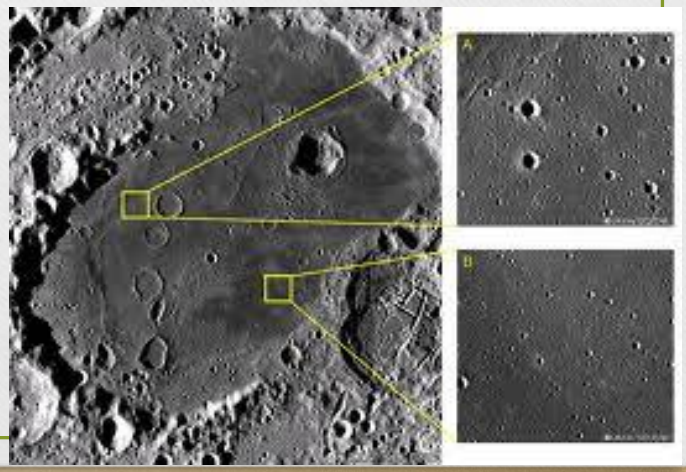
http://upload.wikimedia.org/wikipedia/commons/thumb/6/61/Moon_names.svg/500px-Moon_names.svg.png

Topography – Highlands, Maria

1. **Highlands:** Mountains, light in color, cratered (Light play-dough)
2. **Maria** ("seas"): Dark, smooth, low elevation, flat plains (Dark play-dough)

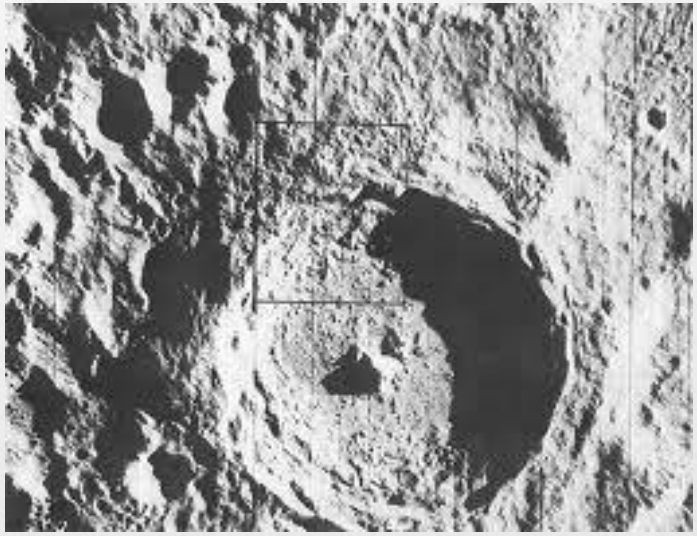






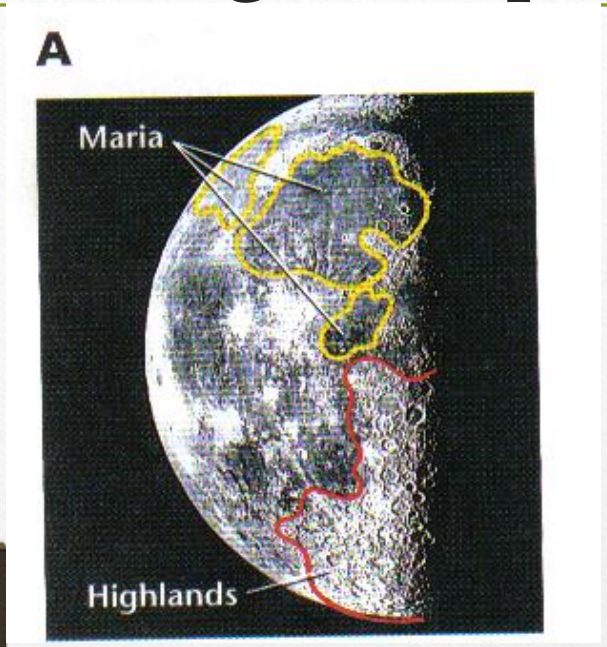
Topography Cont'd – Craters, Regolith

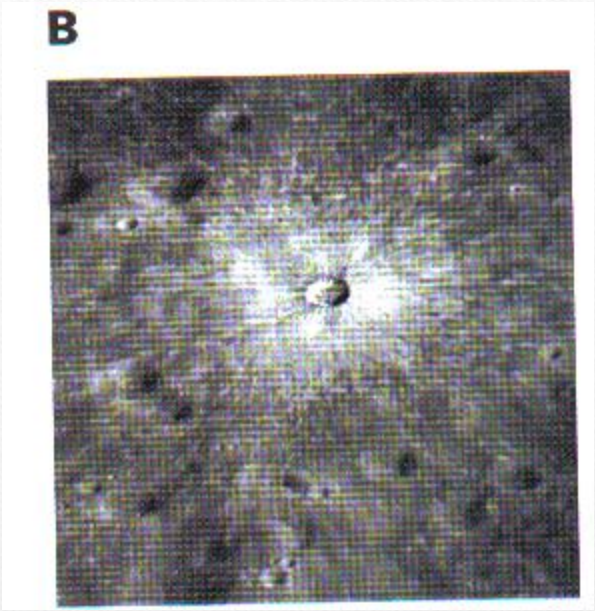
3. **Impact craters**: Depressions formed by space object crashing onto the Moon's surface (Use various objects to make craters in highlands)
4. **Regolith:** Layers of loose, rocky matter caused by the impacts
   - A. Very fine regolith has a texture like snow
   - B. Thicker in highlands than in maria

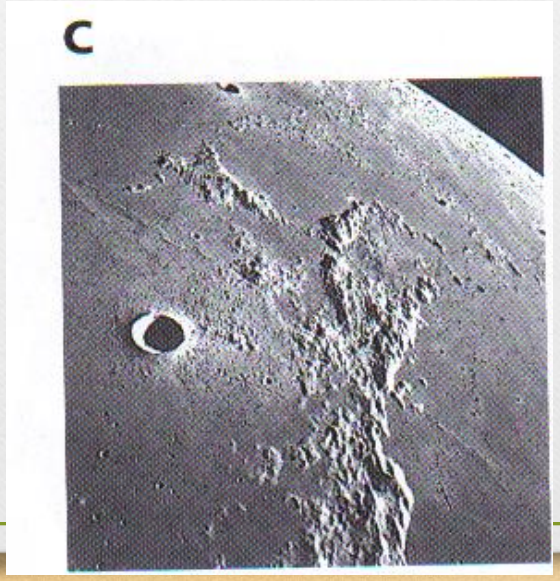


NASA-Apollo 16 photograph.

Fig 28-8 p. 754 Moon Topography

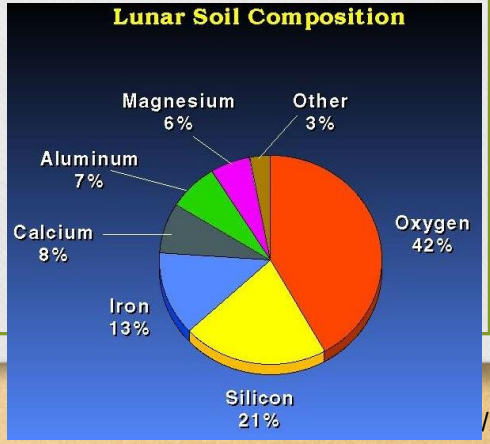






Composition of the Moon

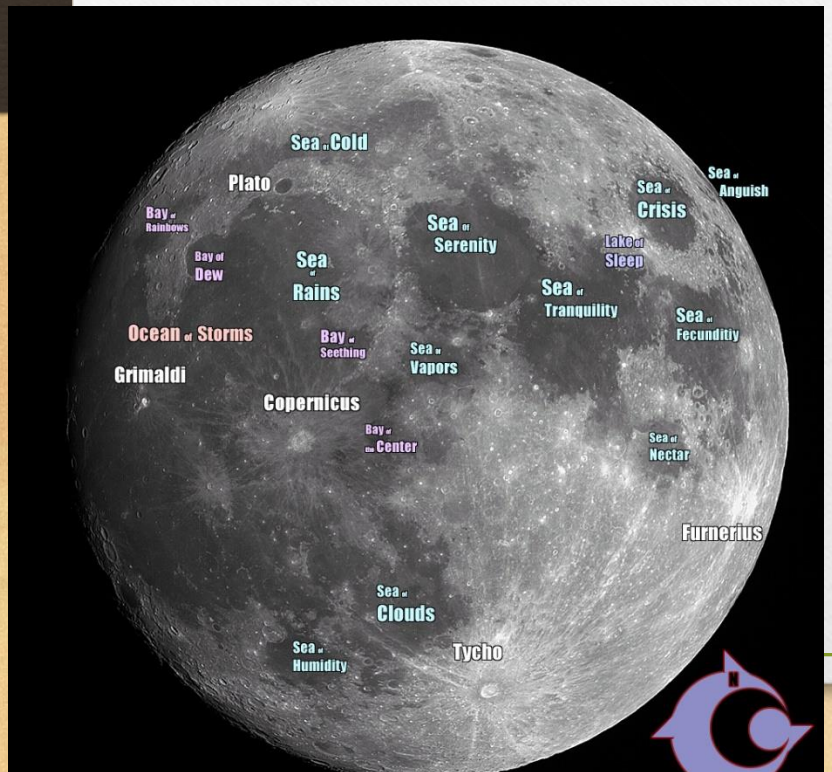
1. Made of minerals and rocks similar to those of Earth
2. Highlands
   - A. Made of Lunar Breccias (Breccia is similar to conglomerate but has jagged rather than rounded sediments)
     - I. Formed when small pieces of rock fuse together during impacts of space objects.
       (Impacts can fuse rock together into breccia OR break it into regolith)
     - II. Low in iron
3. Maria
   - A. Made of basalt.
     - I. (Dark-colored rock that contains iron-rich olivine & pyroxene.)
   - B. Similar to the ocean floor on Earth

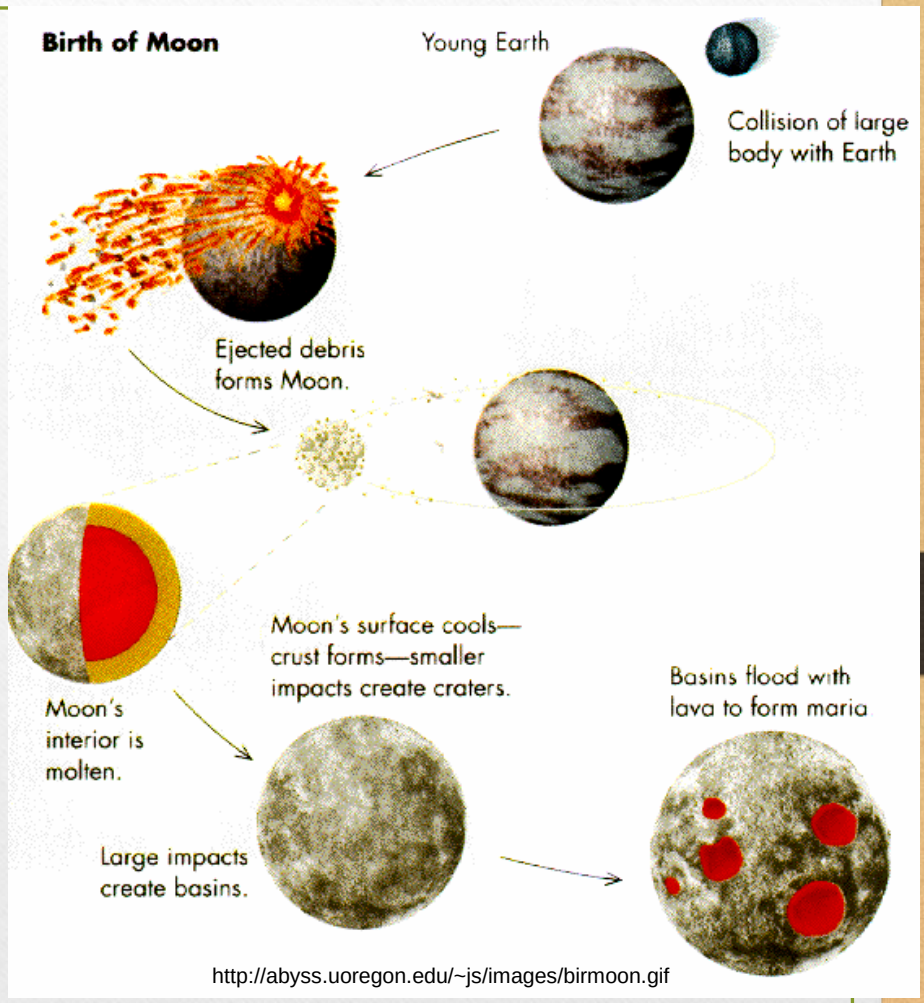


How old is the Moon?

1. How do we know the age of various regions of the Moon?
   - ➢ Scientists dated rocks

2. Studies have shown that the Highlands formed before the Maria

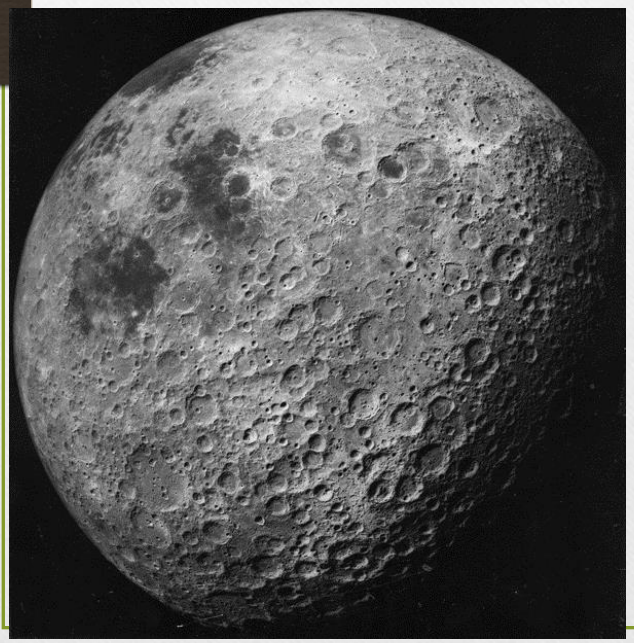


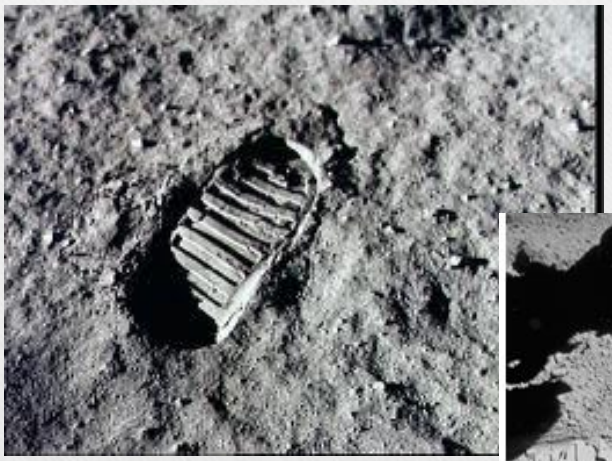


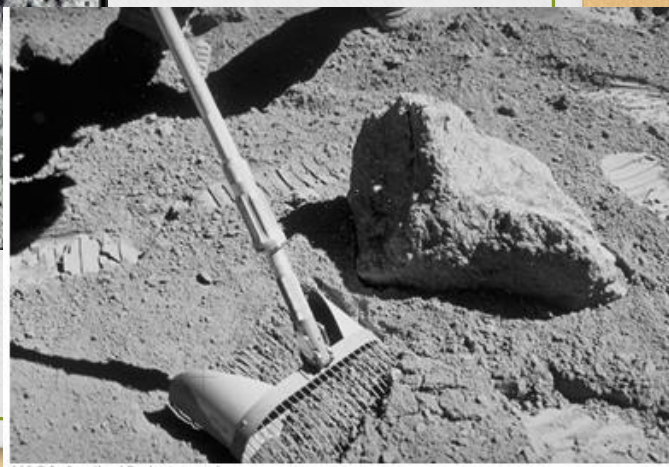
http://abyss.uoregon.edu/~js/images/birmoon.gif

Moon History – Highland Age

1. Highlands are 3.8 – 4.6 billion years old
   - A. Heavily bombarded during the first 800 million years by flying space objects
   - B. Caused surface to be covered with regolith,
     - I. Regolith = a layer of loose, ground-up rock caused by impacts
   - C. Regolith allows astronaut footprints to still be visible



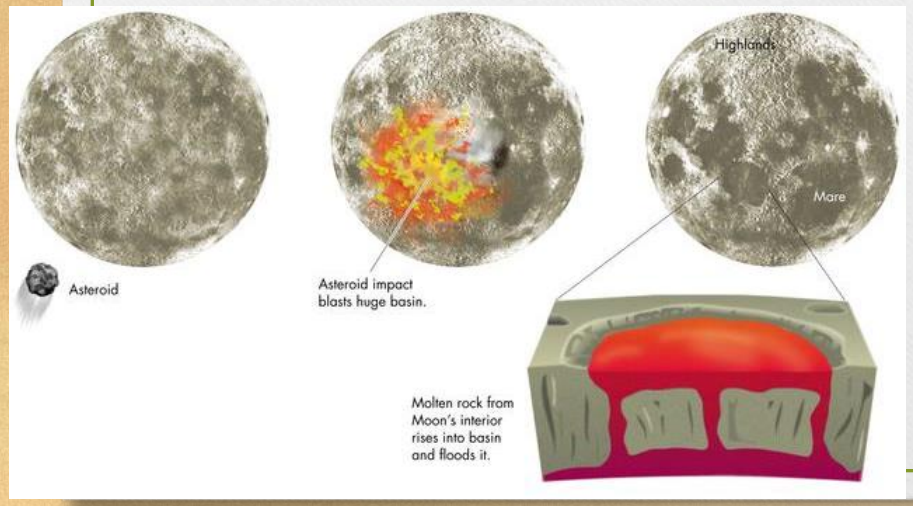




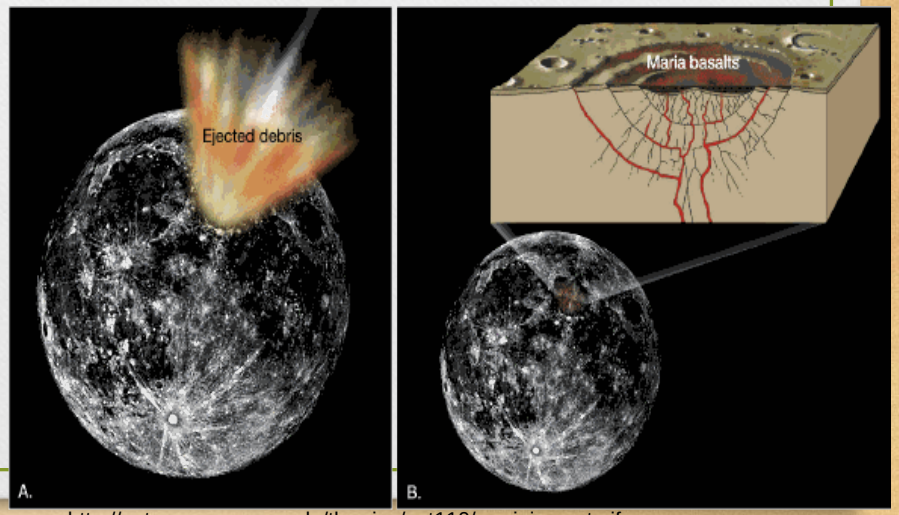
NASA-Apollo 16 photograph.

Moon History – Maria Age

2. Maria are slightly younger, 3.1 – 3.8 billion years old
   - A. Formed by lava filling up huge impact crater holes
     - I. Very intense impacts by space objects caused cracks in the larger craters
     - II. Lava flowed up through the cracks & filled the bottom of deep craters
     - III. As the liquid lava cooled it created smooth, flat maria
   - B. Not many space objects have hit since the maria formed, so maria are smooth with few craters



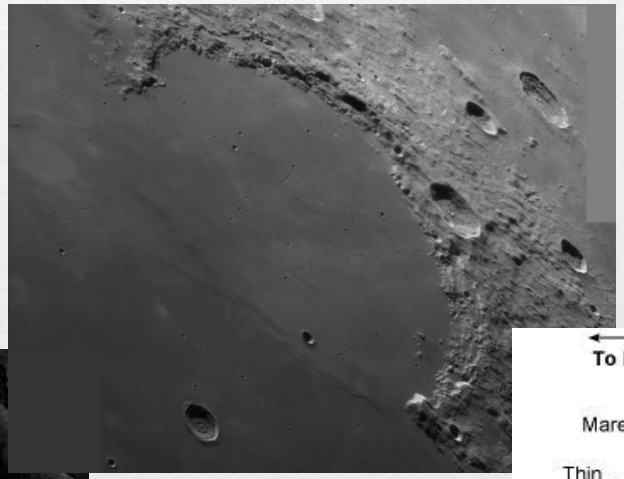
http://user.physics.unc.edu/~evans/pub/A31/Lecture10-Moon/maria-formation.jpg

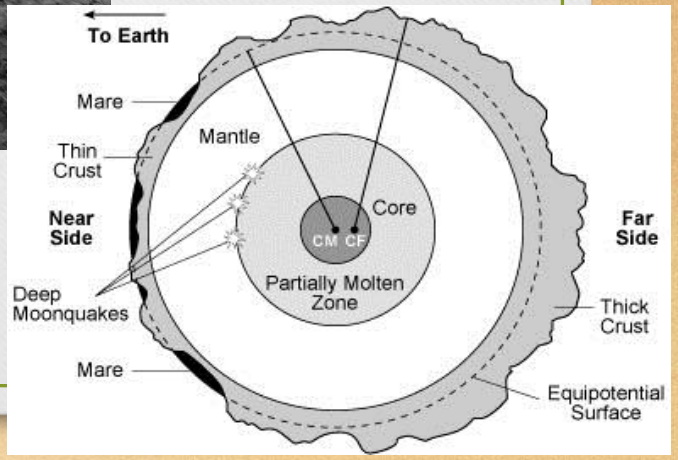


http://astronomy.nmsu.edu/tharriso/ast110/mariaimpact.gif

Moon History – Rilles, Far Side of Moon

3. Highlands remain high in elevation because lava did not completely fill the basins
4. Far Side of the Moon: NO Maria on the far side of the Moon
   A. The crust is thicker on the far side of the moon the impact cracks weren't deep enough to reach the lava

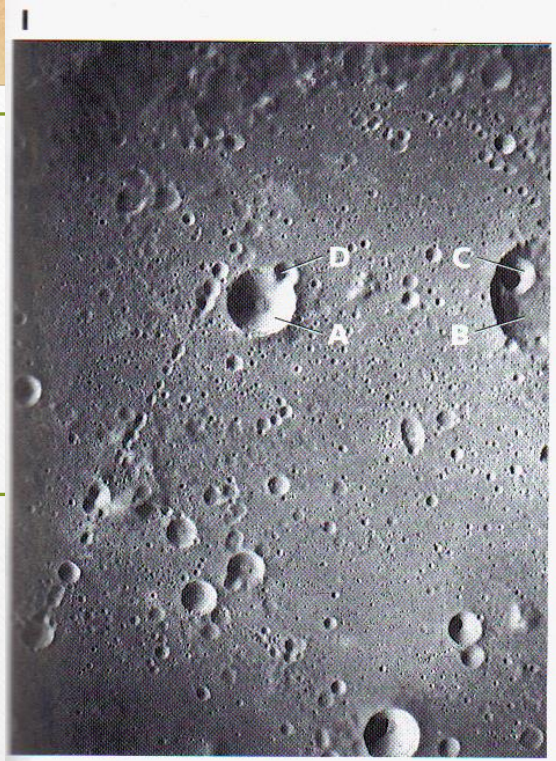


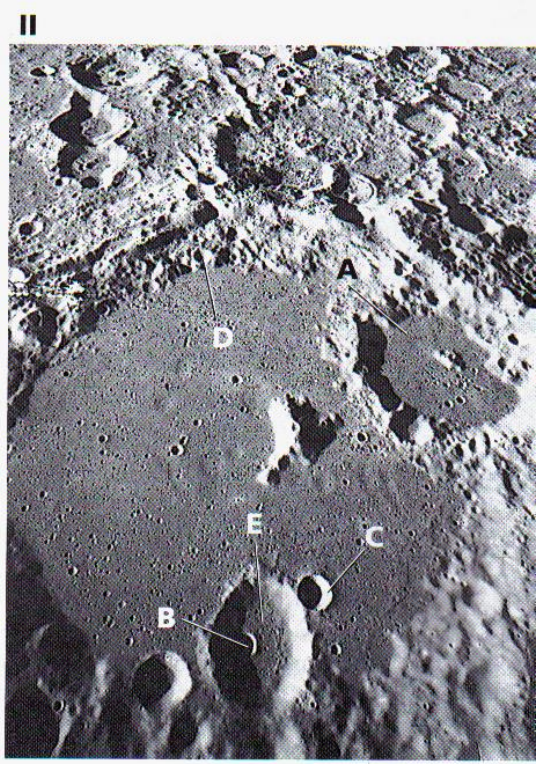


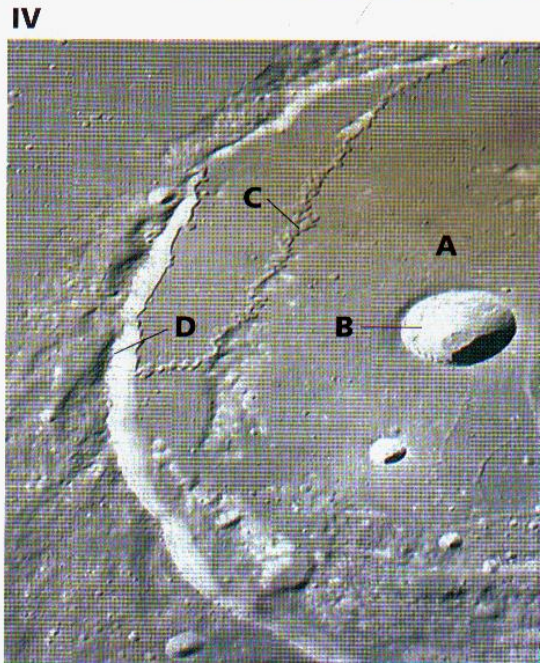
http://ase.tufts.edu/cosmos/pictures/Exp3/28/2016/Chapter5/Fig%205_22copy.jpg

Mapping Geolab p. 768

- Can you identify the labelled features?
- Can you determine their relative age? How?



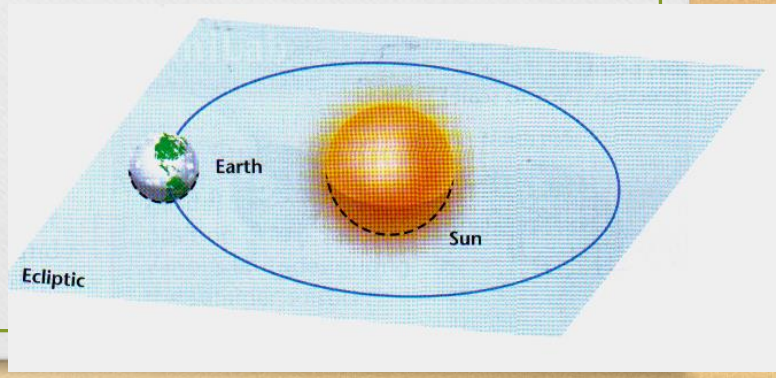




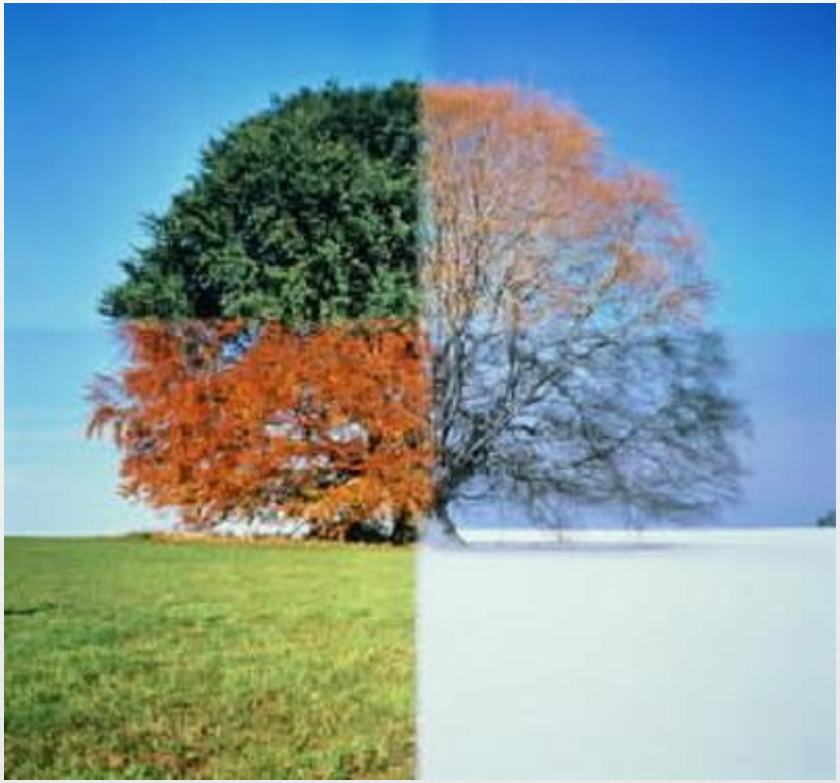
Sec 28.3 The Sun-Earth-Moon System

Motions of the Earth

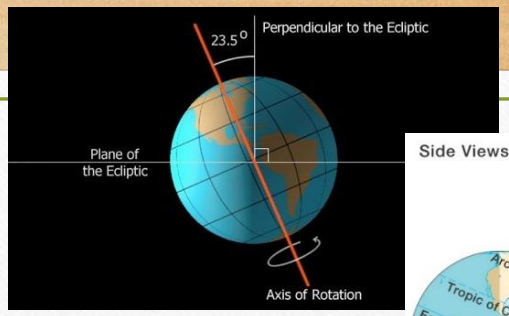
1. **Rotation**: Spinning of the earth around its axis
   - A. Daily motion
   - B. Causes day & night, and setting & rising of the sun
   - C. Causes the "appearance" of the sun rising in the east & setting in the west
2. **Revolution**: Orbital motion around the Sun
   - A. Annual Motion
   - B. Year = the time to complete 1 revolution
   - C. **Ecliptic**: Plane in which the Earth orbits the Sun

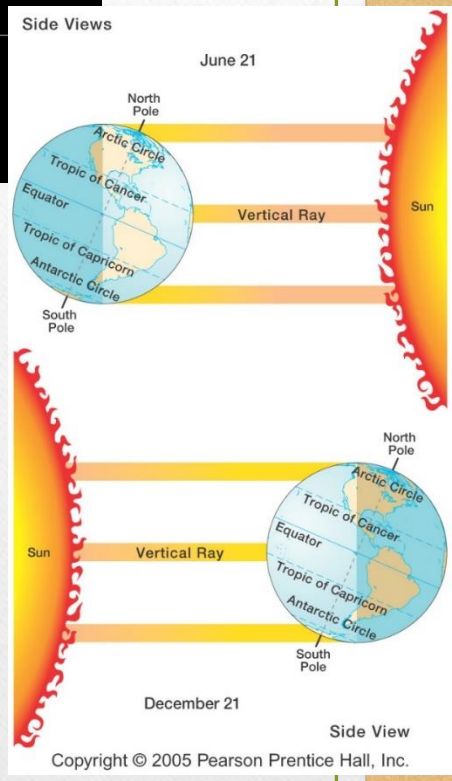


If the Earth's orbit around the Sun is the same, then how do we get seasons?



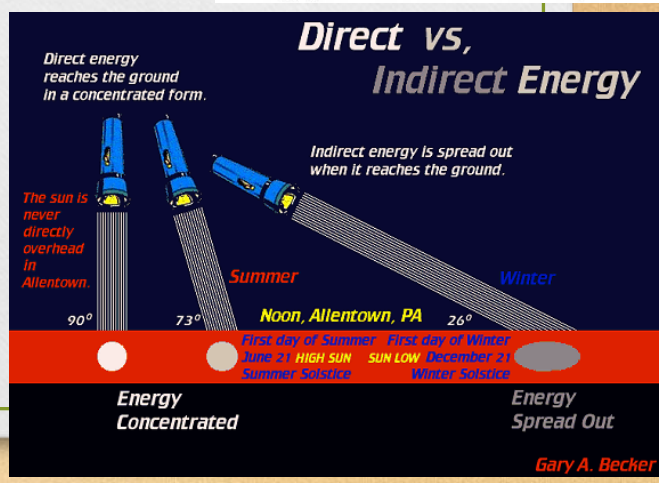
Effects of Earth's tilt



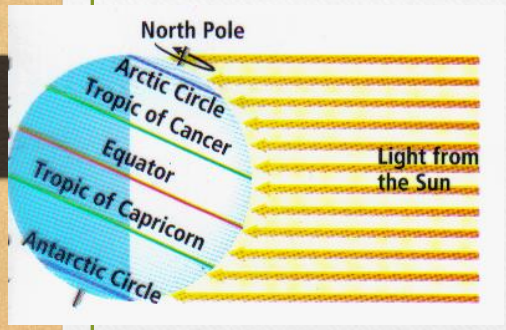


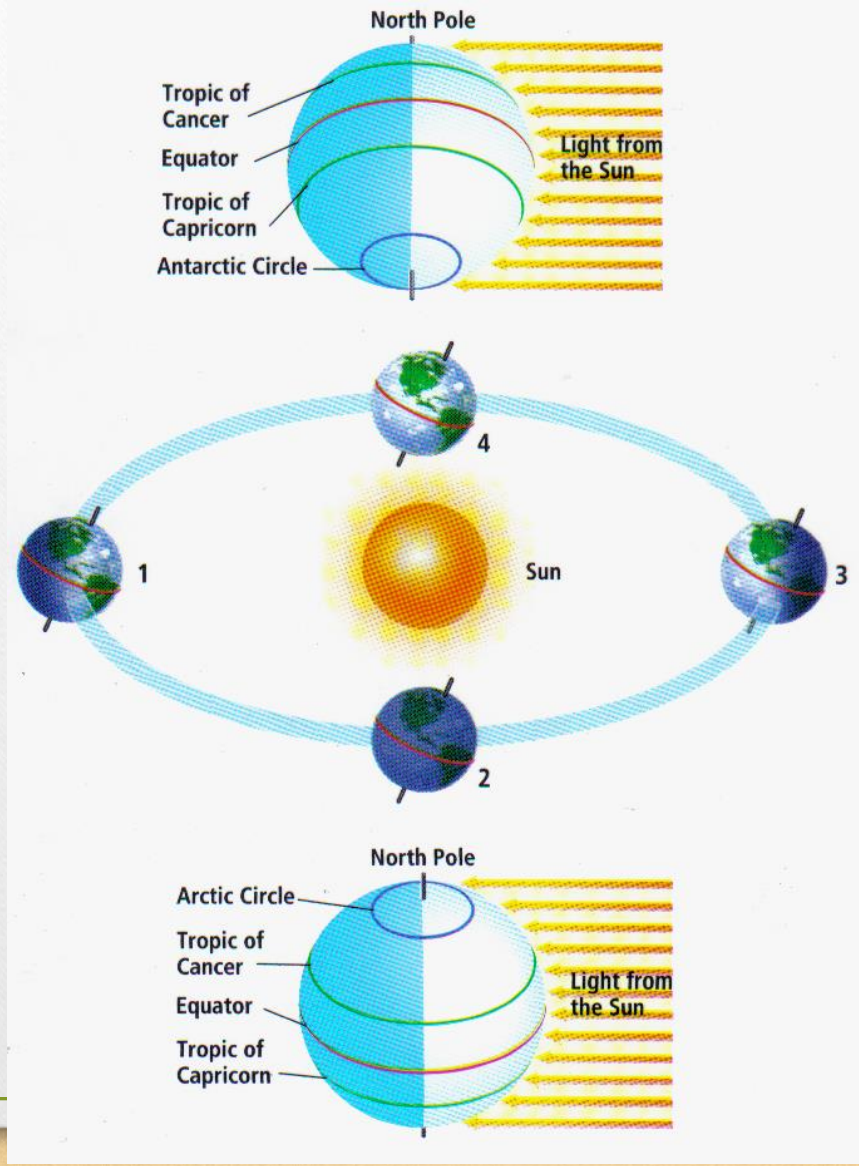
Effects of Earth's tilt; Seasons

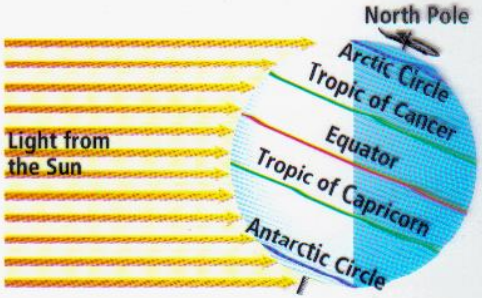
1. Tilted at 23.5° compared to the ecliptic
2. Tilt AND revolution are both needed to cause seasons
3. Tilt causes the intensity of the Sun to vary with location
   - A. Direct Light = Warmer (more intense)
   - B. Indirect Light = Cooler
4. Hemisphere tilted TOWARDS the sun;
   - A. Has longer daylight
   - B. Is in the summer season
   - C. The sun appears higher in the sky
5. NOTE: Seasons due to TILT (**Not** distance)



TT #88 Solstices & Equinoxes



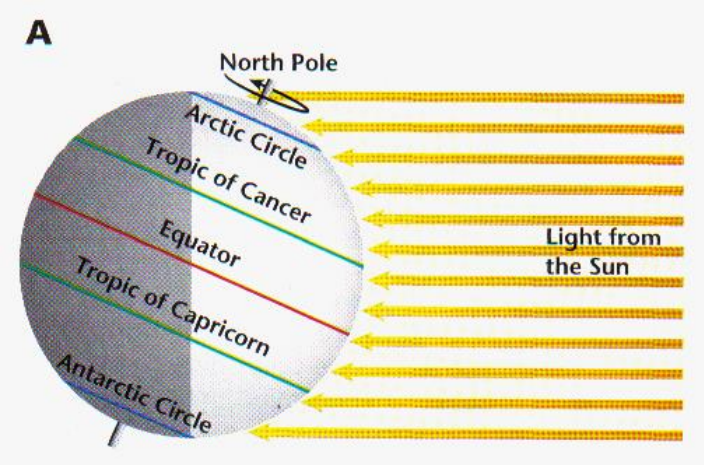


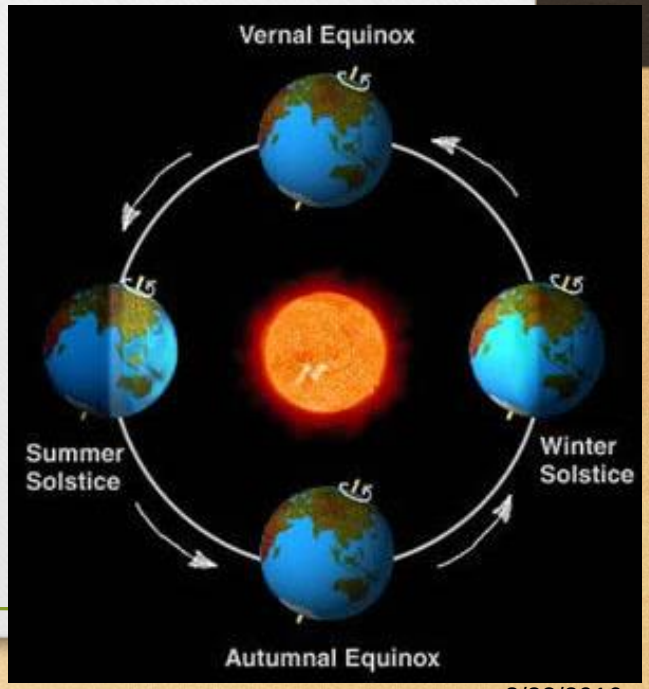


Solstices

Solstice: Is the day when the sun reaches its greatest distance N or S of the equator

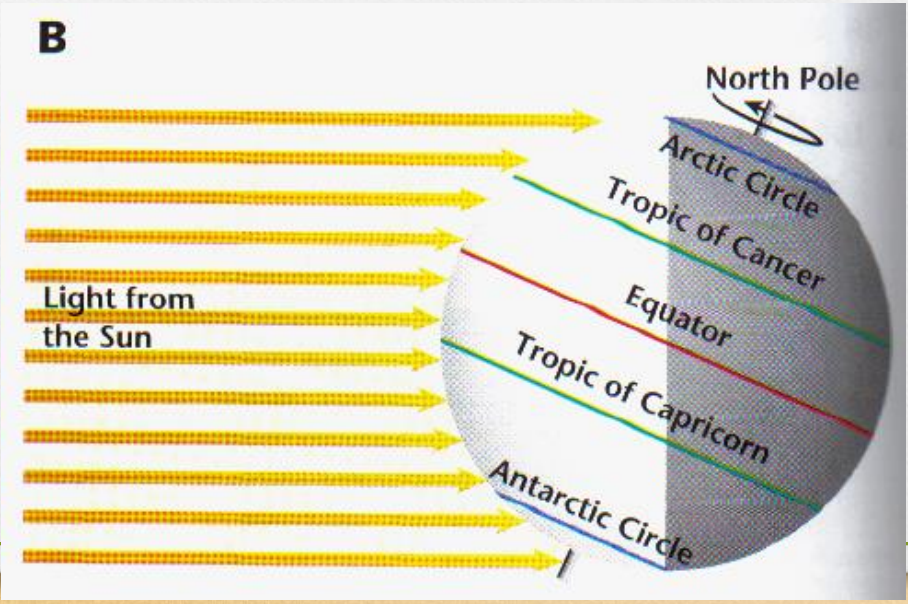
1. **Summer solstice** (for N. Hemisphere) is when the sun is the furthest north
   - A. Longest amount of daylight, shortest night
   - B. Most direct light is at 23.5°N – Tropic of Cancer
   - C. June 21
   - D. Arctic circle has constant daylight
   - E. Antarctic has constant darkness

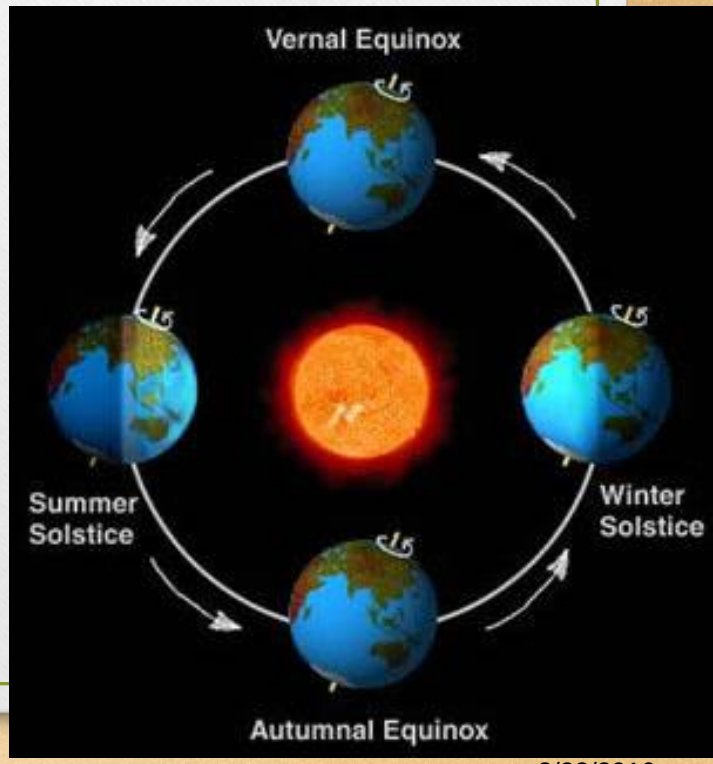




Winter Solstice

2. **Winter solstice** (for N. Hemisphere) is when the sun is the furthest south
   - A. Shortest amount of daylight, longest night
   - B. Most direct light is at 23.5°S – Tropic of Capricorn
   - C. December 21
   - D. Arctic circle has constant darkness
   - E. Antarctic has constant daylight

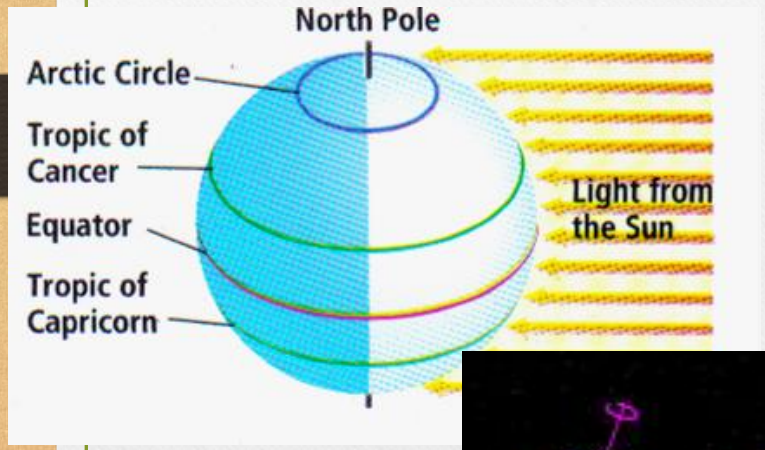


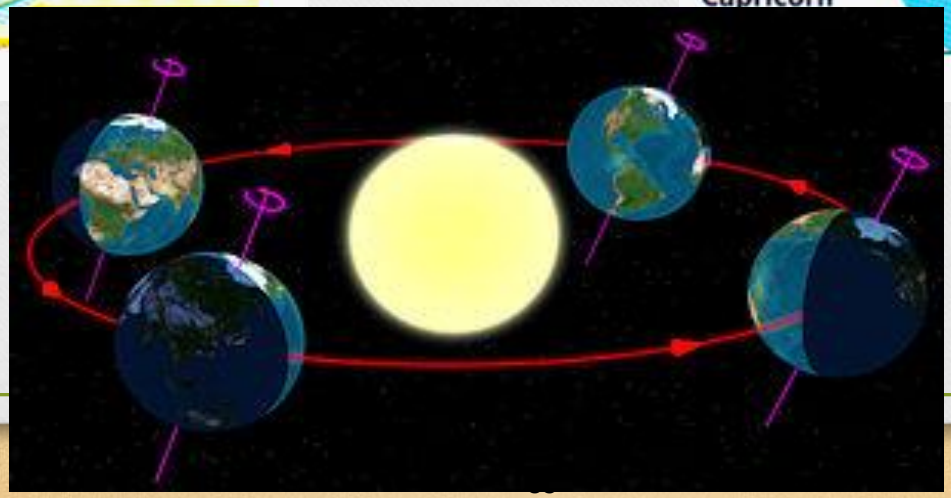


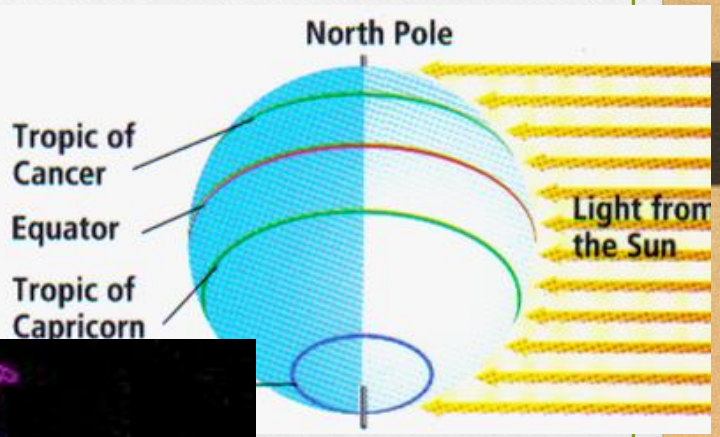
Equinox

Equinox: Sun is directly over the equator

1. Equal amount of daylight and night
2. Neither hemisphere is tilted towards the Sun
3. Autumnal equinox: Sept 21
4. Vernal (spring) equinox







Chichen itza equinox

http://commons.wikimedia.org/wiki/File:ChichenItzaEquinox.jpg

Fig 28-18 p. 762 Moon Phases

WHAT DO YOU THINK CAUSES MOON PHASES?

On a piece of paper draw and describe a diagram of lunar phases and what causes them:

1. Show the phase and describe how much of the entire moon is lit.
2. Include where the earth is and where the sun is for each phase.

Webcam – Which do you think are possibilities?

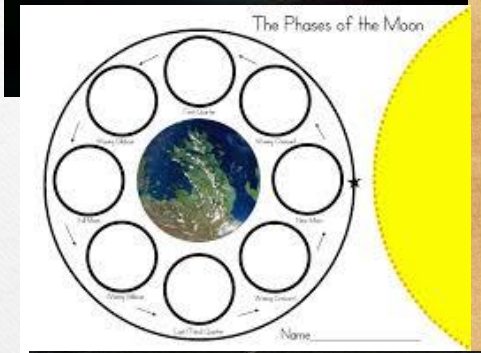
NOW – get ready for an OREO Moon Phase Lab and discover how the phases really happen!!

Lab: OREO Moon Phases – YUMMM!!

Need: 6 Oreo cookies, Paper towel, Plastic knife,1 Group Phase Sheet, Individual Phase Sheets

**BE CAREFUL – no replacement cookies!!

1. Carefully twist 4 of the cookies apart.
2. Cut the frosting in half, so that each piece is ½ covered with frosting.
3. Place all 8 pieces on a circle on the group sheet, ensuring that the white (sunlit) side is in the correct rotation, showing which side is sunlit.
4. DOUBLECHECK! Is the proper side of each cookie half "lit" by the sun?



Lab: OREO Moon Phases – YUMMM!!

5. NOW, twist and separate your last 2 cookies, and remove the frosting totally from all.

6. "Score" and break each side into 2, so that you have 8 "half pieces".

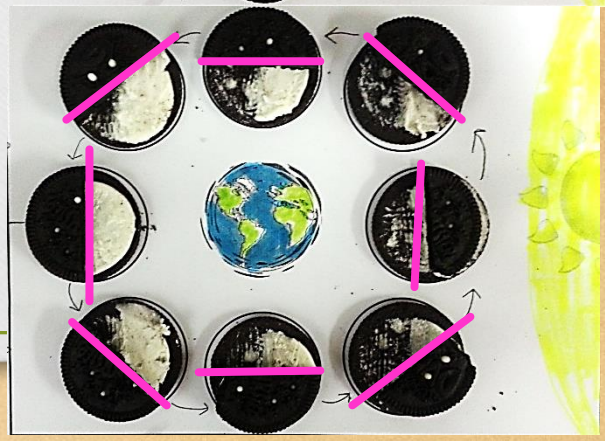
7. We can only see the side of the moon that faces the earth.

   - Take one of the dark pieces and cover up the side of the moon that is away from the earth.

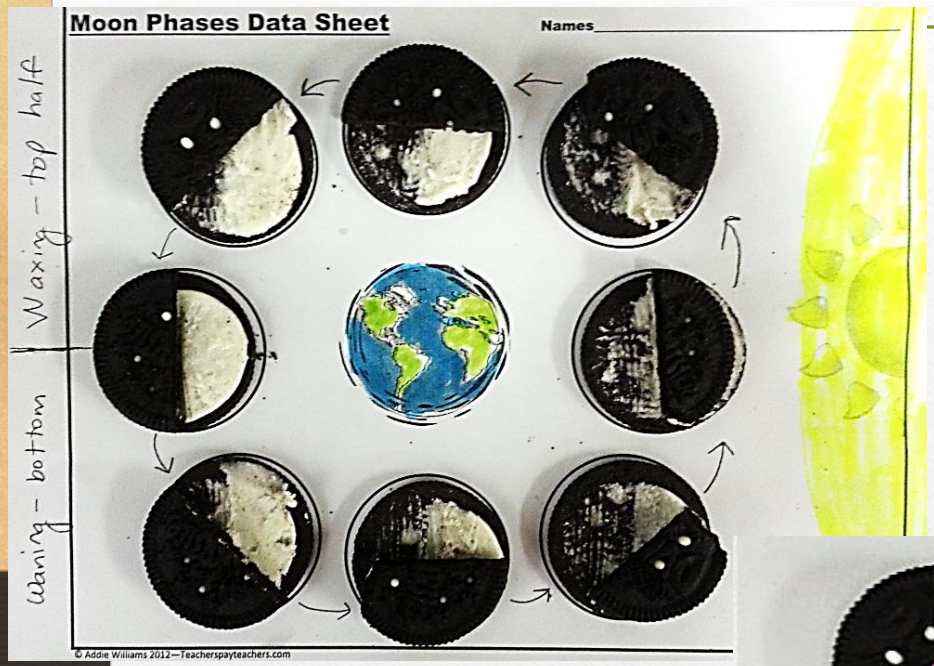
8. NOW, how much of the lit side do you see? On the GROUP sheet, draw a picture outside each "moon" in the ring, showing what it would look like from the earth – full, crescent, etc

9. Have teacher approve the drawings on the group sheet.

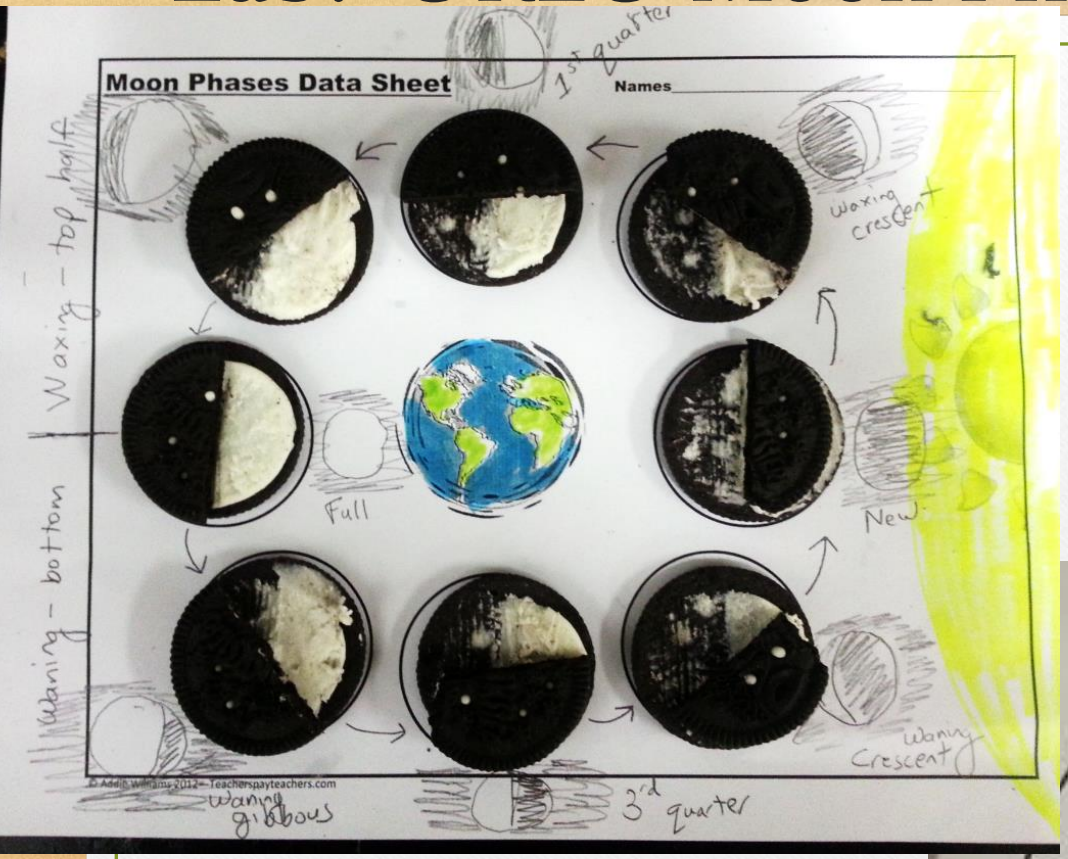
10. Once approved, draw the phases on your individual sheets. AFTER DRAWINGS – eat & answer questions!!

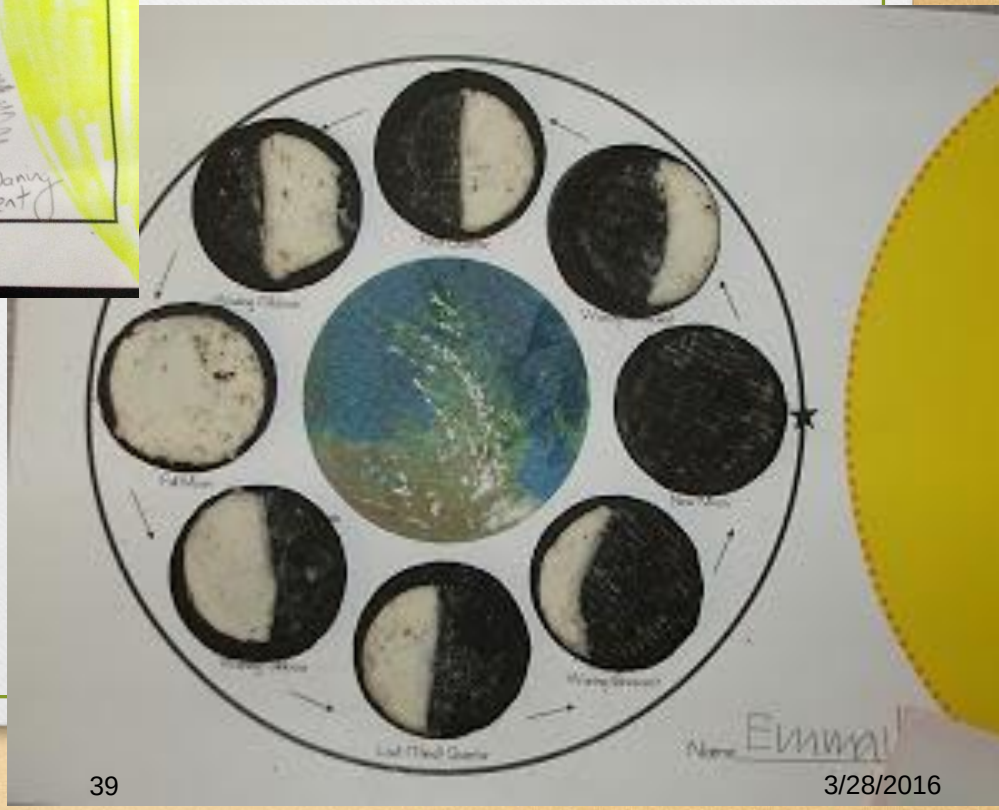


Lab: OREO Moon Phases – YUMMM!!



Lab: OREO Moon Phases – YUMMM!!

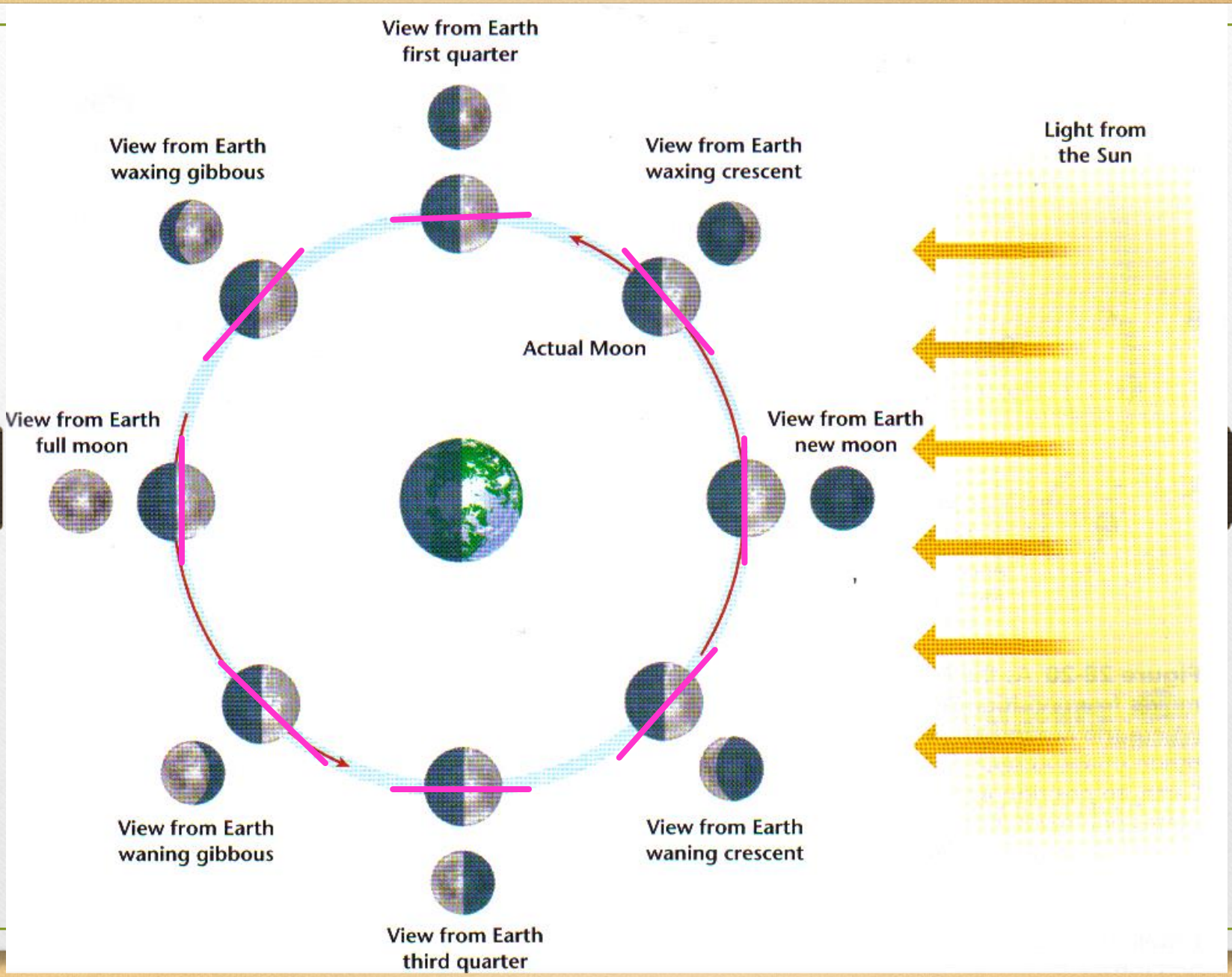




Lab: OREO Moon Phases – YUMMM!!

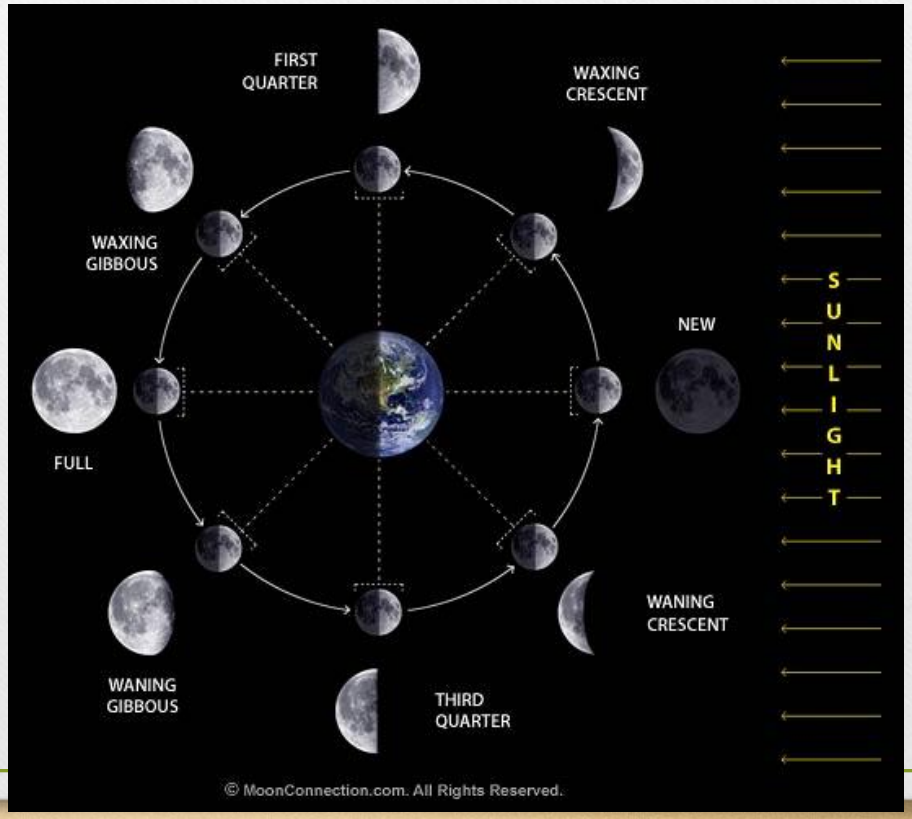
PLAY VIDEO – Moon Phases!!

Fig 28-19 p.763 Moon phases as viewed from Earth



Summary of Oreo Moons

- ½ of the Moon is illuminated at all times.
- Why don't we always see a half moon?
  1. We do not always see the illuminated half
  2. Depends on where the Moon is <u>in its orbit</u> around the Earth

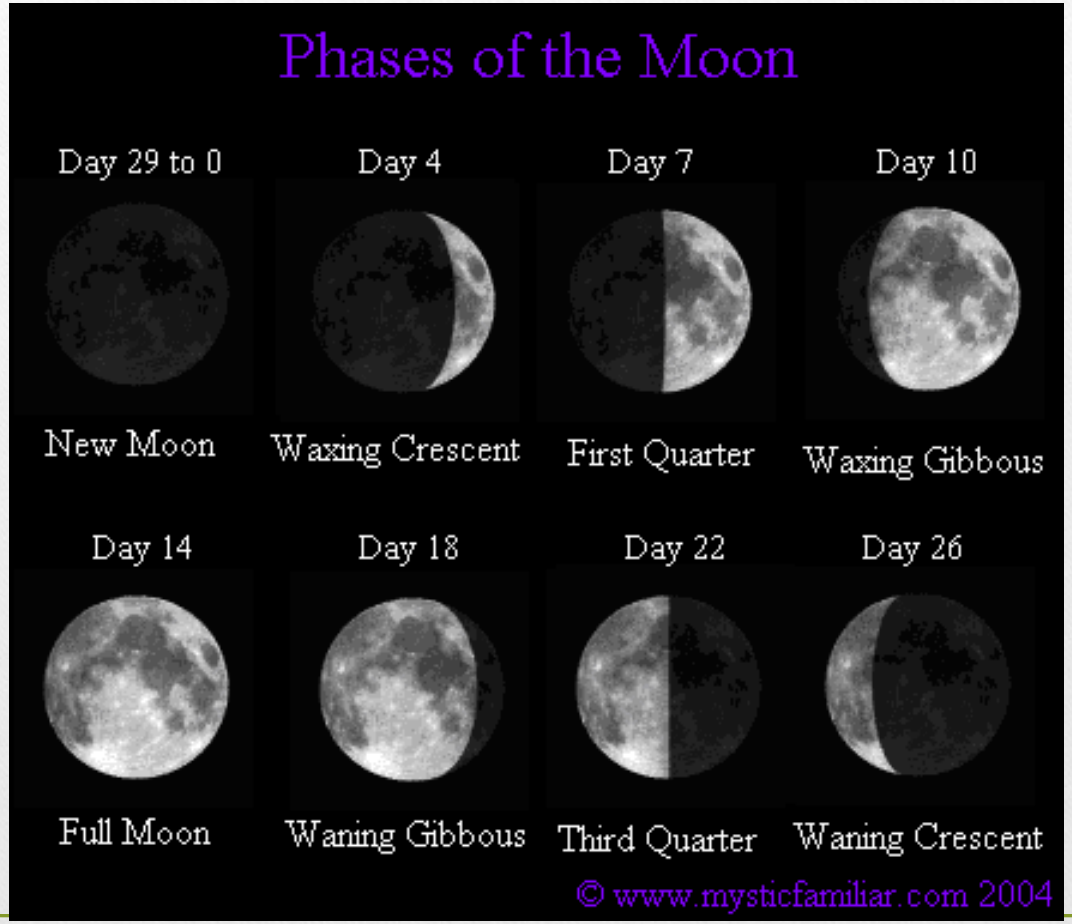


Moon Phases Definition

Moon Phases Definition =

Sequential changes in the appearance of the moon (as seen from earth)

1. **Note**: ½ of the moon is always lit by the Sun, but we may not see the lit side



Phases of the Moon

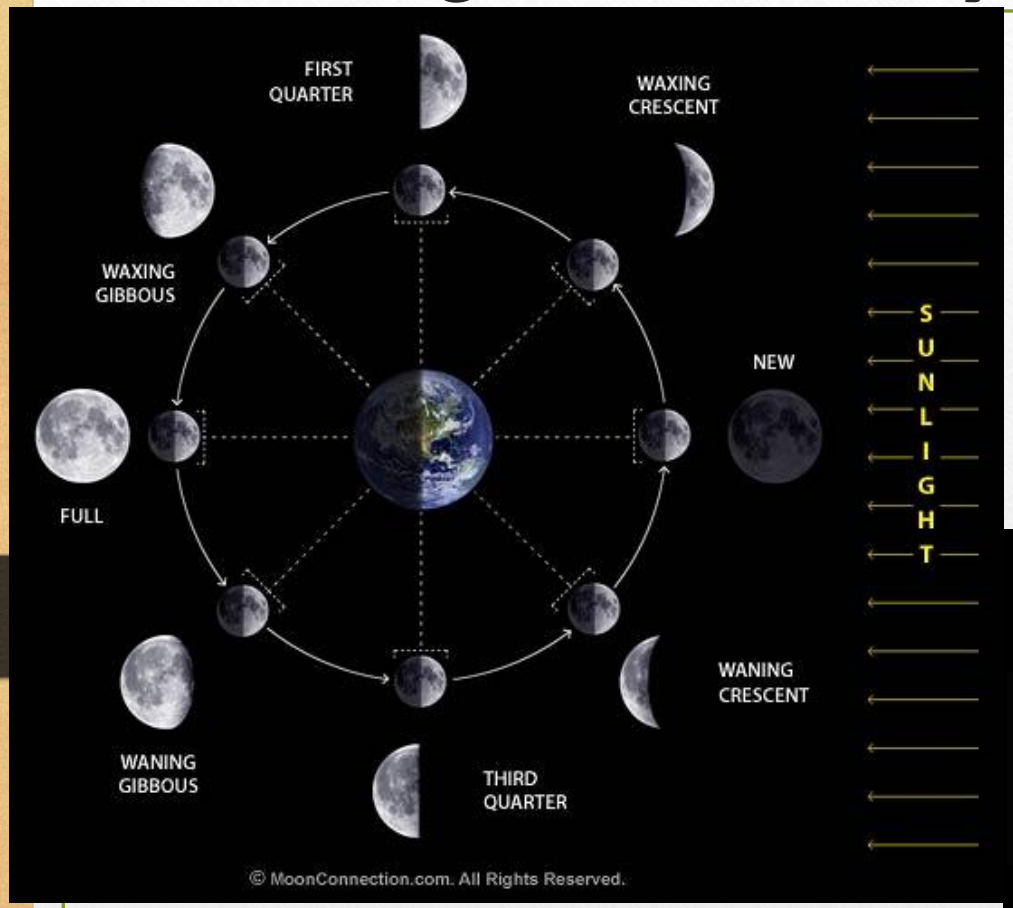
1. **New Moon**: Moon is positioned in a straight line between the earth & the sun
   A. Can't see the moon as the lit side is away from the earth
   B. Instead, we see the dark, shadowed side
   C. Occurs every 4 weeks
2. **Crescent:** Less than ½ of the lit side is visible
3. **Quarter:** ½ of the lit side is visible
   A. Occurs 1 week after the new moon
4. **Gibbous**: More than ½ of the lit side is visible

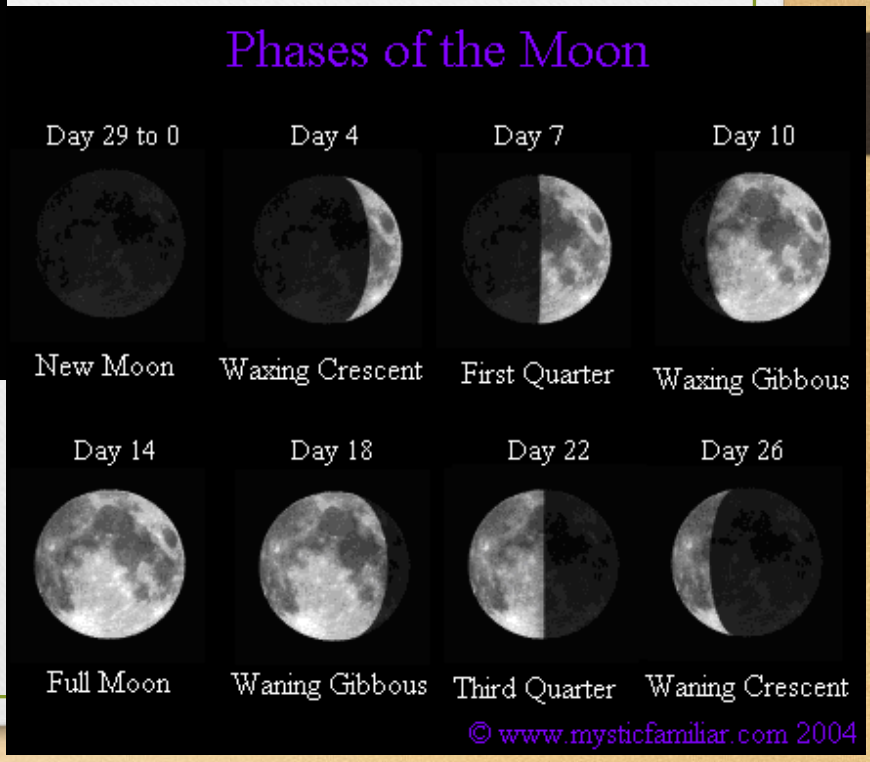



Phases of the Moon cont'd

5. **Full moon:** Sun, Earth and Moon are again positioned in a straight line, BUT this time the Earth is between the sun & moon
   A. Entire lit side is visible
   B. Occurs 2 weeks after the new moon
6. Now the moon begins its journey back to a New Moon, again going through the Gibbous, Quarter & Crescent phases.

Diagram Summary of the Phases

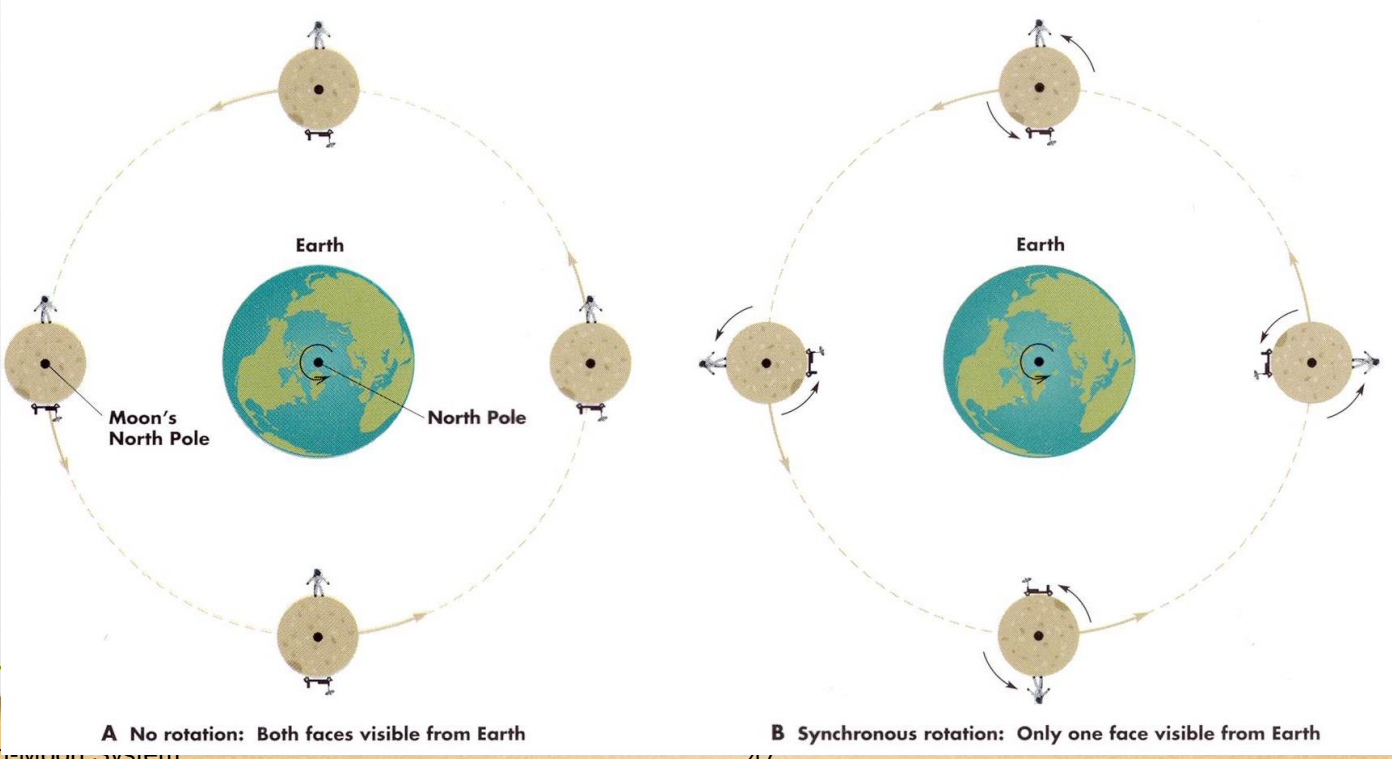




Motions of the Moon – Synchronous Rotation

Do this slide IF TIME: Synchronous Rotation:

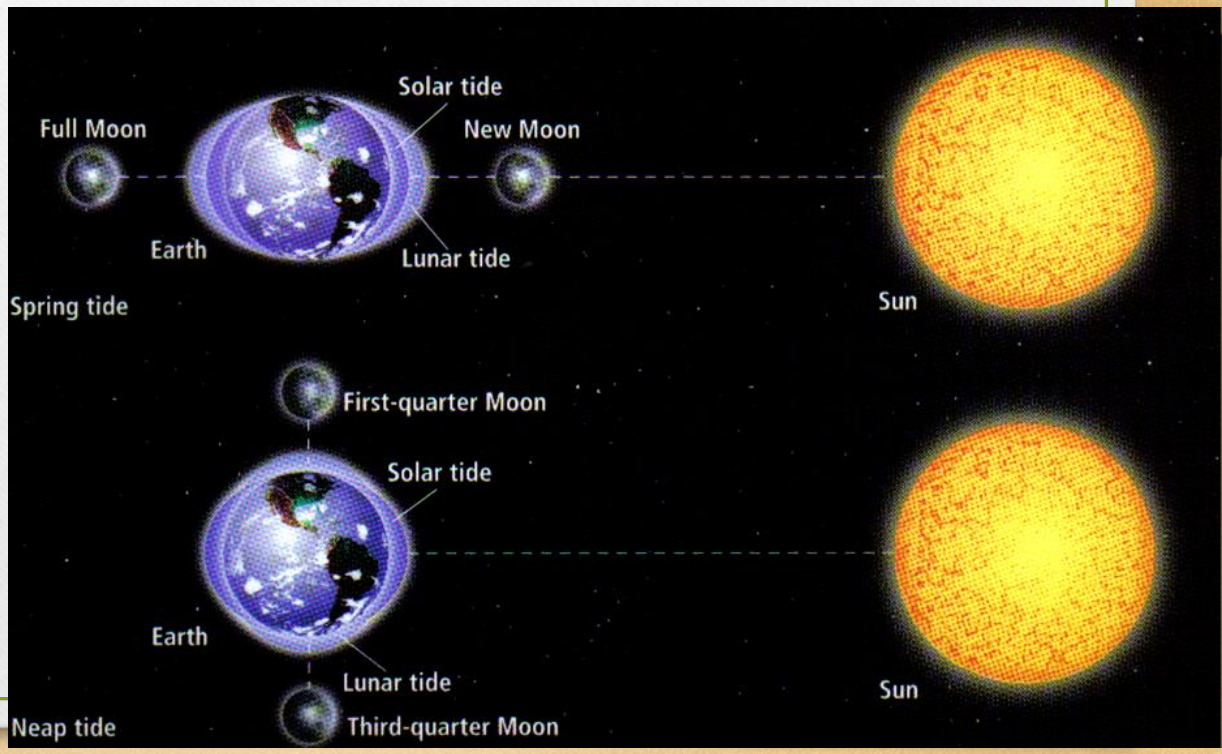
1. The Moon makes 1 revolution (orbit around earth) and 1 rotation (on axis) in the same amount of time
2. So the same side of the Moon always faces the Earth
3. We never saw the far side of the moon until space program
4. Video: Synchronous Rotation



Tides

Tides

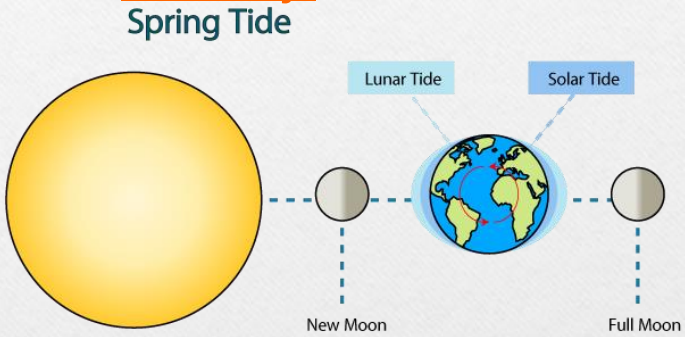
1. Moon's gravity has a bigger effect on the Earth's tides than the Sun's due to the moon's nearness
2. High tides occur on the sides of Earth towards & opposite of the moon
3. High tides occur every 12 hours. Low tides also occur every 12 hours

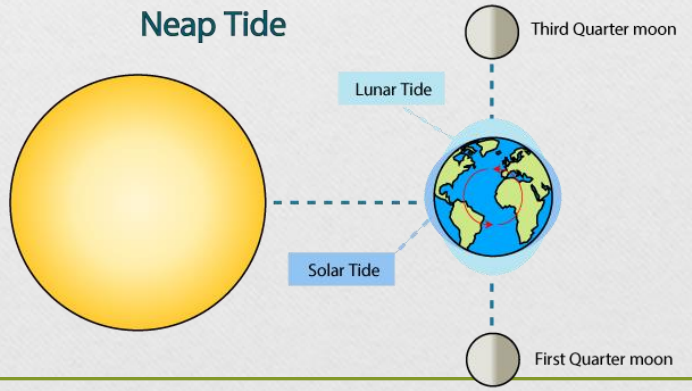


Tides

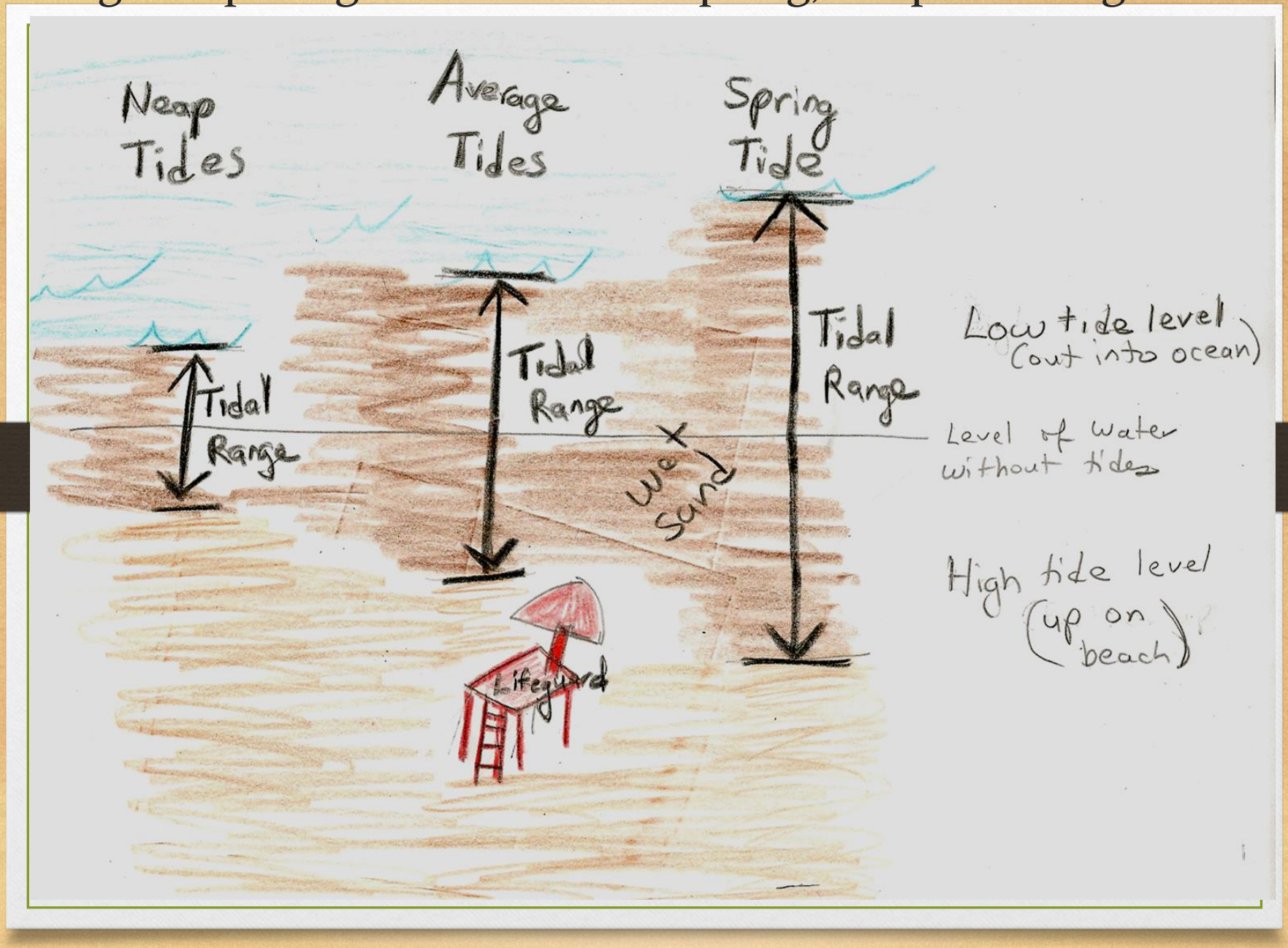
1. Spring tides occur when the earth, sun & moon are aligned
   A. Large tidal range: Very high tides & Very low tides
2. Neap tides occur when the moon is at right angles to the earth & sun line
   A. Small tidal range: not very high tides & not very low tides

- Video: Cause of Tides, 2 minutes
- Video: Time Lapse of High/Low Tides at Bay of Fundy Dock, 1 minute
- Animation: Spring & Neap Tides, 1 minutes
- Do you need to draw a diagram to remember?





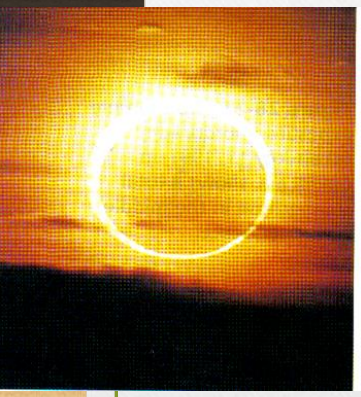
Drawing comparing water levels of spring, neap & average tide level



Solar Eclipses

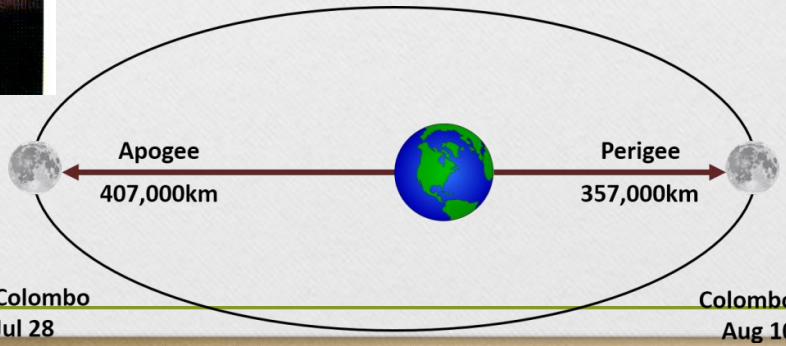
Solar eclipses: An area of the earth cannot see all OR part of the Sun

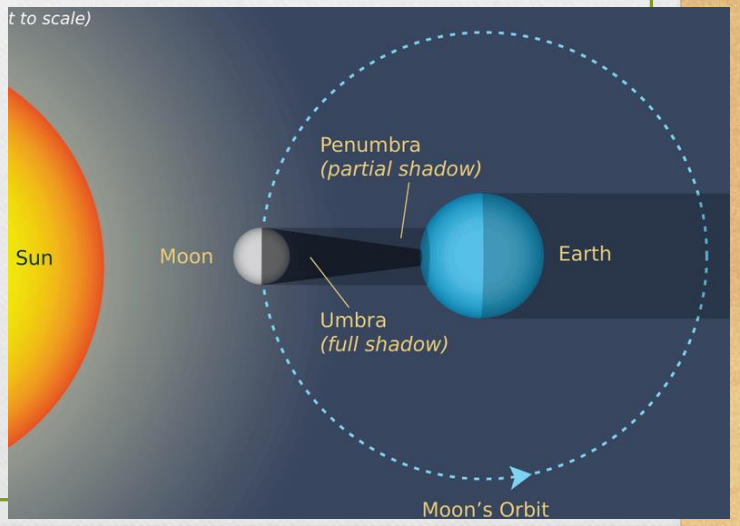
1. Occurs during new moon phase, as moon passes between the earth and the sun
2. Only occurs if all 3 are in same plane (Earth's ecliptic)
3. NOT monthly because moon is higher or lower than the ecliptic due to its tilted orbit
4. Moon's distance varies, sometimes its shadow doesn't reach Earth



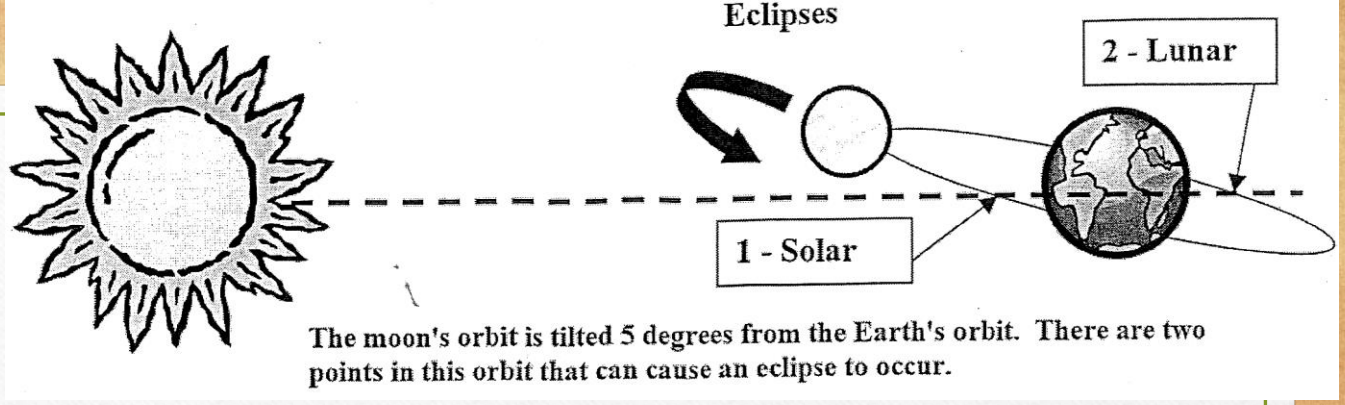
A. **Perigee** – Closest point to Earth in moon's orbit

B. **Apogee** – Farthest point

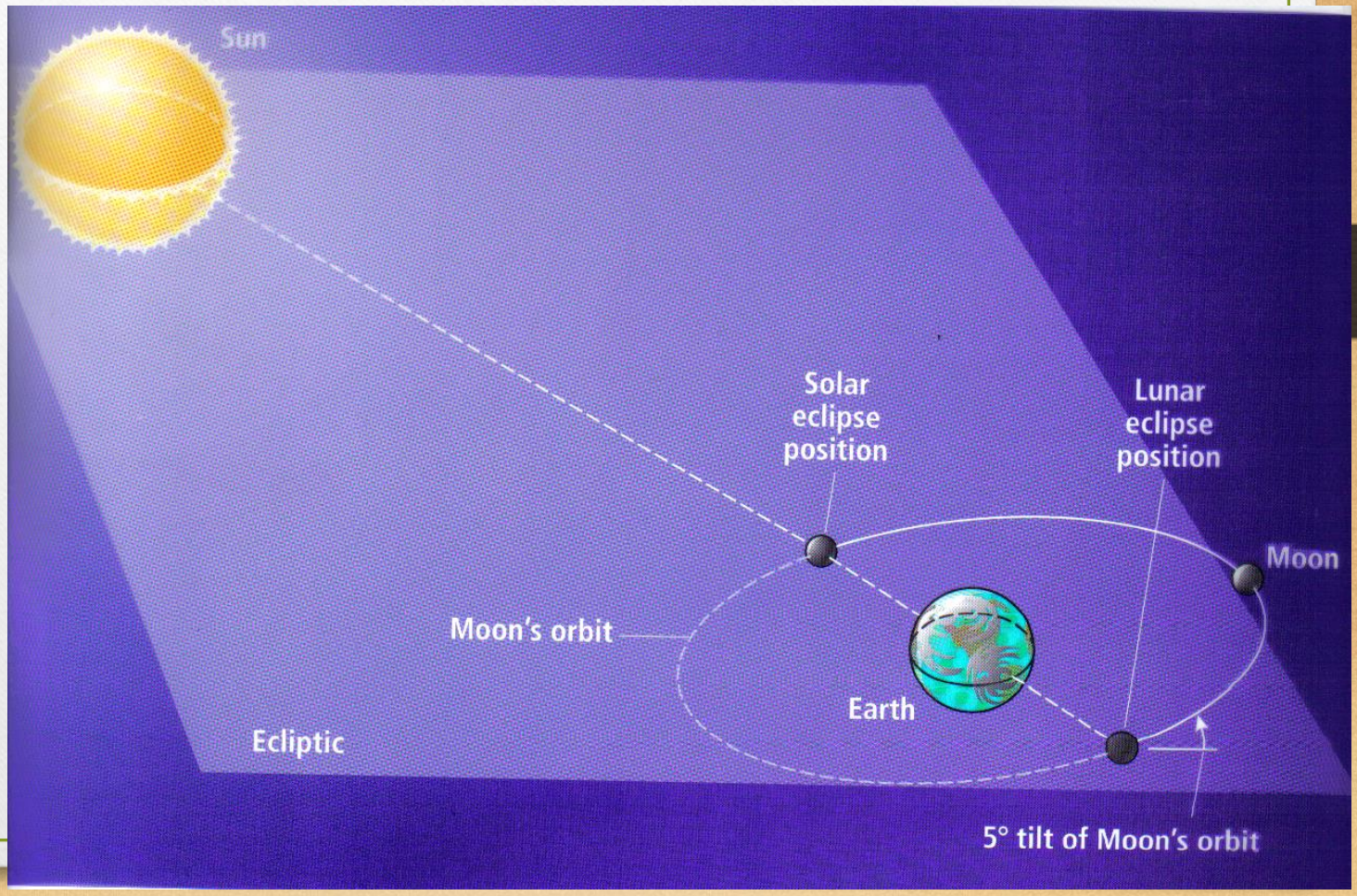




TT #89 The Ecliptic & the Moon's Orbit

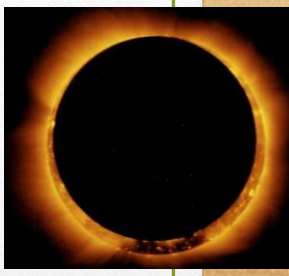


The moon's orbit is tilted 5 degrees from the Earth's orbit. There are two points in this orbit that can cause an eclipse to occur.

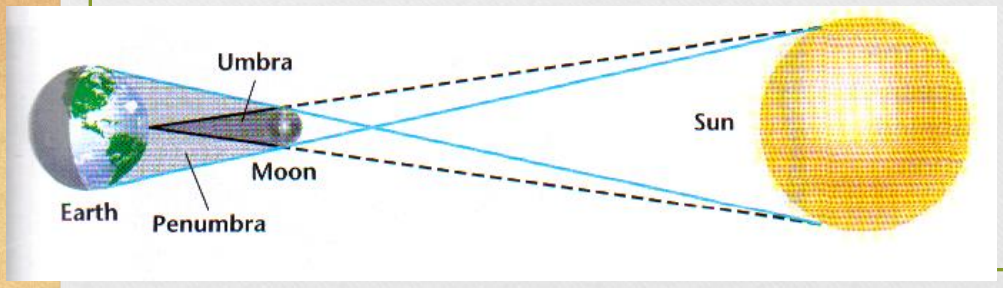


Solar Eclipse cont'd

5. Moon creates a SMALL shadow on Earth, blocking all or part of our view of the Sun



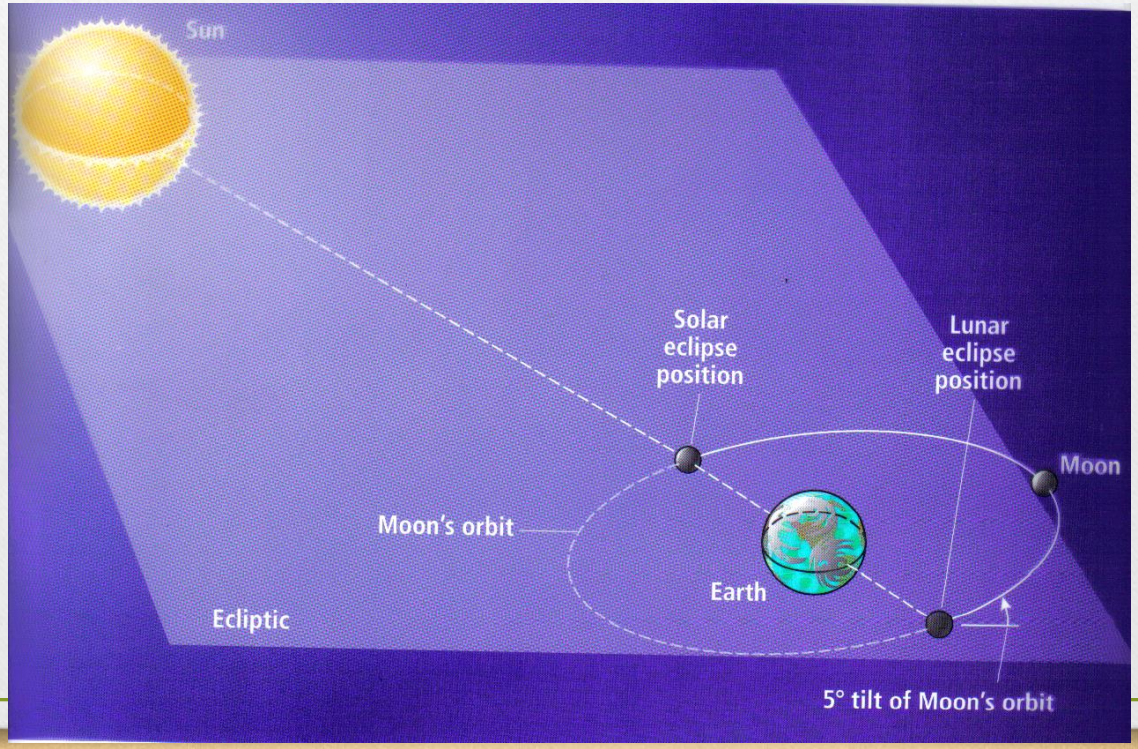
6. Total eclipse = ALL of the Sun is blocked
   A. NOTE: will still see corona, flares, etc. from Sun's surface
   B. Total eclipse is only seen from the **umbra**, which is the inner, dark, complete shadow
   C. Very few persons on earth will be in the umbra, because the moon's shadow is small
7. Partial eclipse = Only part of the sun is blocked
   A. Partial eclipse is seen by persons in the **penumbra** which is the outer, lighter, partial shadow
   B. More persons will be in the penumbra



Lunar Eclipse & Ecliptic

Lunar Eclipse: Earth's shadow covers part or all of the moon, & the moon can't be seen

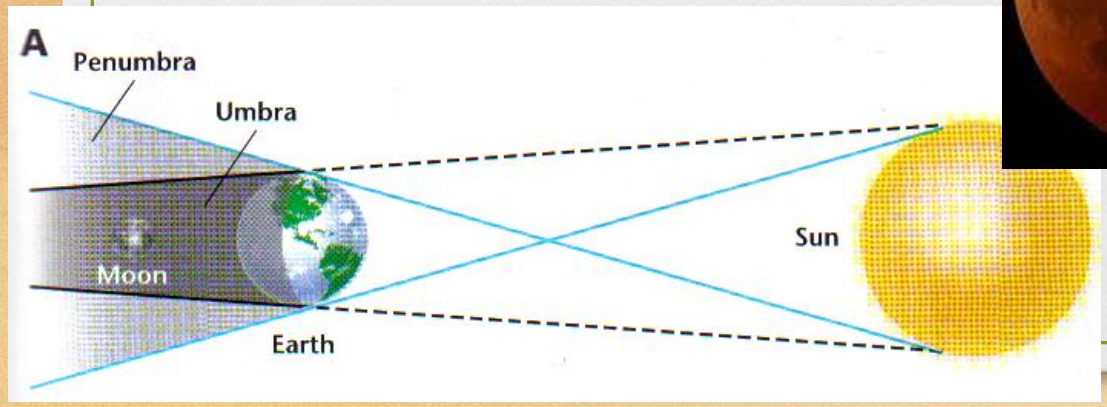
1. Occurs during the full moon, when the lit side SHOULD normally be seen
2. Earth is between the sun & the moon
3. Doesn't occur every month, because moon not on Earth's ecliptic (moon is higher or lower)



Lunar Eclipse – Umbra & Penumbra

4. Total lunar eclipse is seen if moon is completely in the Earth's umbra
5. Partial eclipse is seen if part or all of the moon is in the penumbra
6. Can be seen by the entire nighttime side of the Earth if the sky is clear
7. Lasts longer than a solar eclipse because Earth's shadow is larger
8. Occurs more often than a solar eclipse, because the alignment doesn't have to be as precise

Video: Lunar Eclipse



Problem-Solving Lab

Interpreting Scientific Illustrations

Predict how a solar eclipse will look

Depending on an observer's location, a solar eclipse can look different.

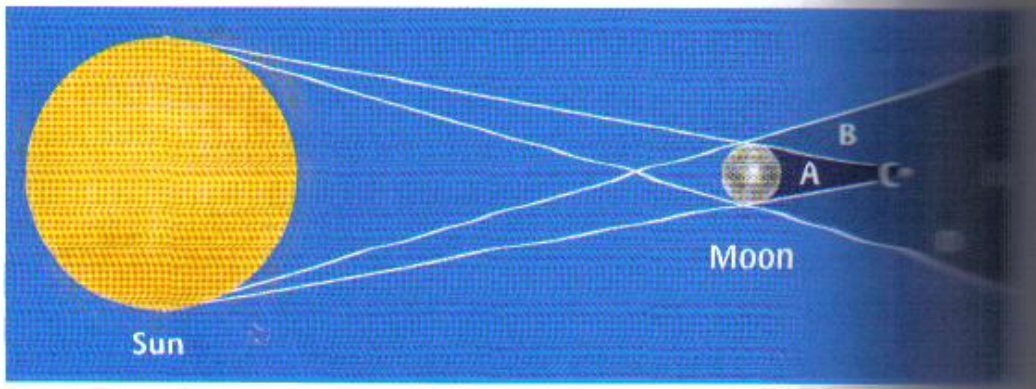
Analysis

1. Make a drawing of how the solar eclipse would appear to an observer at each labeled location in the illustration.

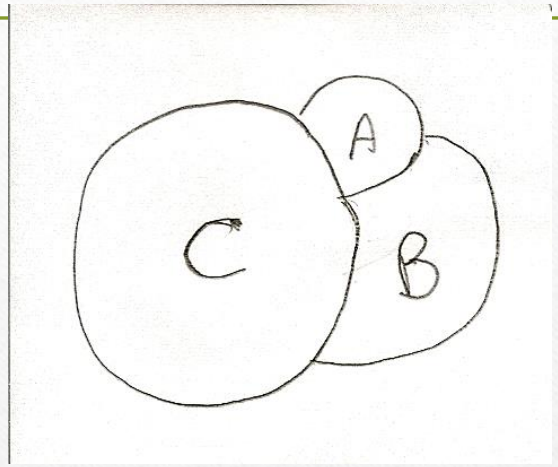
Thinking Critically

2. Design a data table showing your drawings of how the eclipse would appear at each location.

3. What type of eclipse does each of your drawings represent? Include this information in your data table.



Review #1: 28.2



1. In the diagram above, which crater is
   - A. Oldest? How do you know?
   - B. Youngest? How do you know?

2. Albedo 45% vs. 26%. Which is brightest? Why?

Review #2 – Solstices & Equinoxes

1. Describe an equinox
2. Describe the two solstices
3. Does the distance from the Sun cause the Earth's seasons? Why or why not?
4. How are the seasons in the northern & southern hemisphere related?
5. Why is the tilt of Earth on its axis important?
6. When the North Pole experiences 24 hours of daylight, what is happening at the South Pole?

Review #3 – Seasons & Phases

1. What are the causes of the seasons on Earth?
2. What would our seasons be like if Earth's axis were not tilted?
3. If Earth's axis were tilted 45 degrees, at what latitudes would the sun be directly overhead on the
   A. summer and winter solstices
   B. Vernal & autumnal equinoxes?
   C. How would our seasons be different?
4. Explain why the Moon goes through phases as seen from Earth.

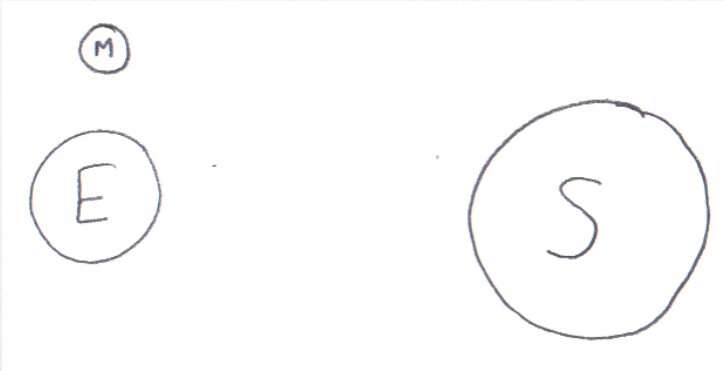
5. In the diagram above: Name the phases shown

Review #4 - Eclipses

1. Explain what causes a lunar eclipse by describing the following:
   A. Positions of earth, sun & moon?
   B. Which moon phase?
2. Explain what causes a solar eclipse by describing the following:
   A. Positions of earth, sun & moon?
   B. Which moon phase?
3. Does a lunar or solar eclipse occur more often? Why?
4. Why do eclipses not occur each month during the appropriate moon phase?

Review #5 - Miscellaneous

1. What is apogee? Perigee?
2. What causes day & night?
3. How long does earth's rotation take?
4. What type of tide is shown in the diagram below? What moon phase is occurring?



5. How often does low tide occur?