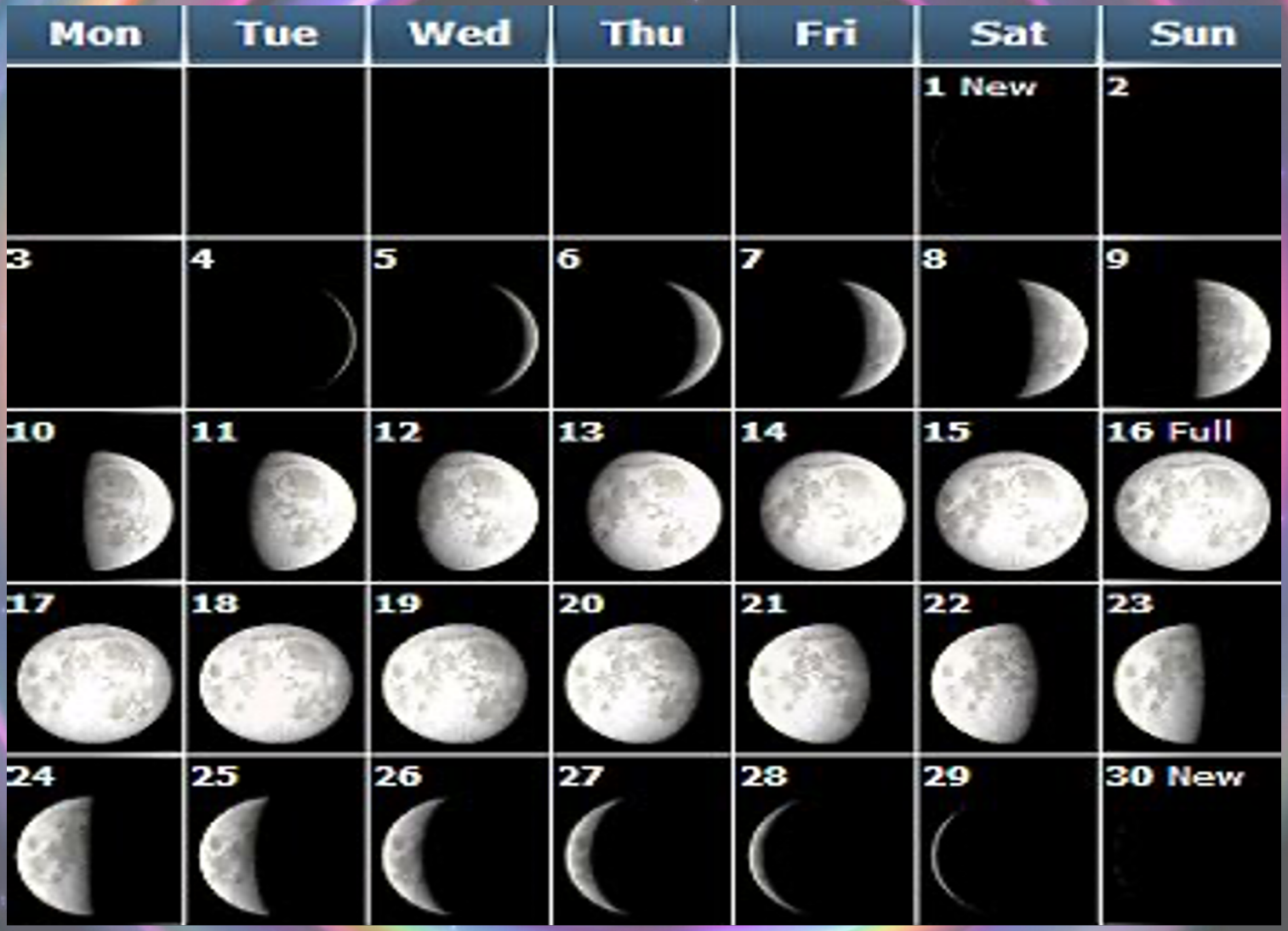
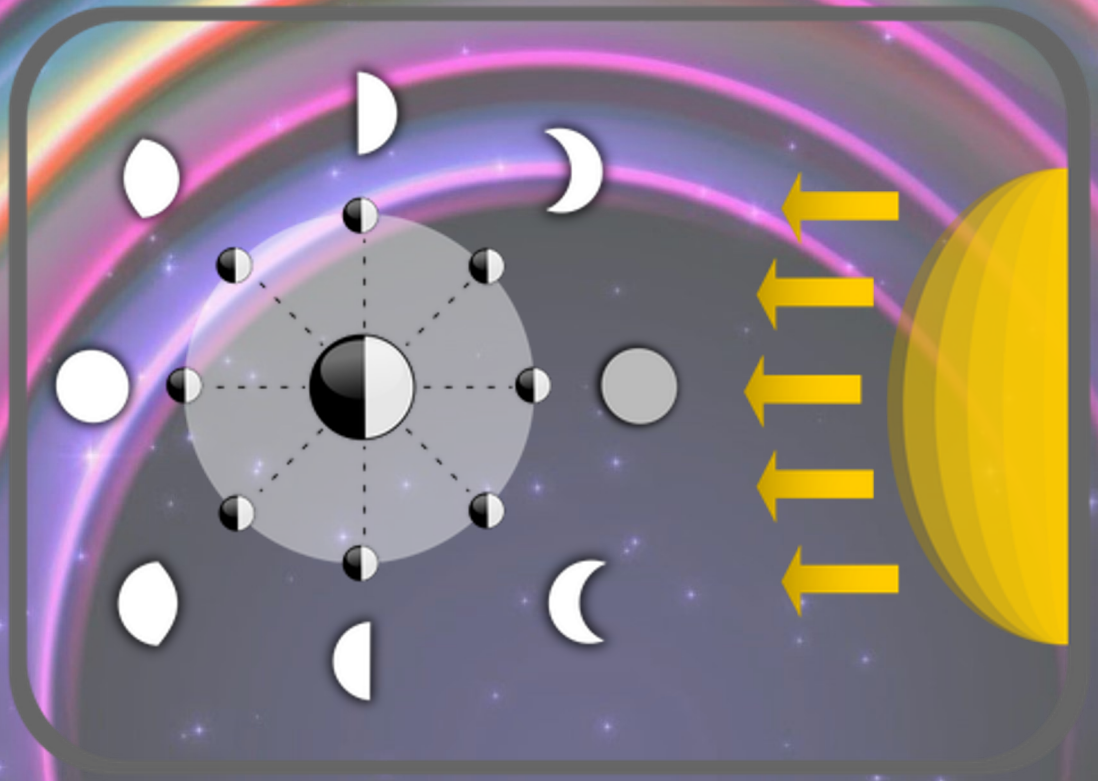
Where did the Moon come from?

Teaching Moon phases is fairly common (or should be) at various grade bands.

It fits nicely with the Patterns CCC.






Full Moon
Waxing Gibbous
1st Quarter
Waxing Crescent
New Moon
Waning Crescent
3rd Quarter
Waning Gibbous

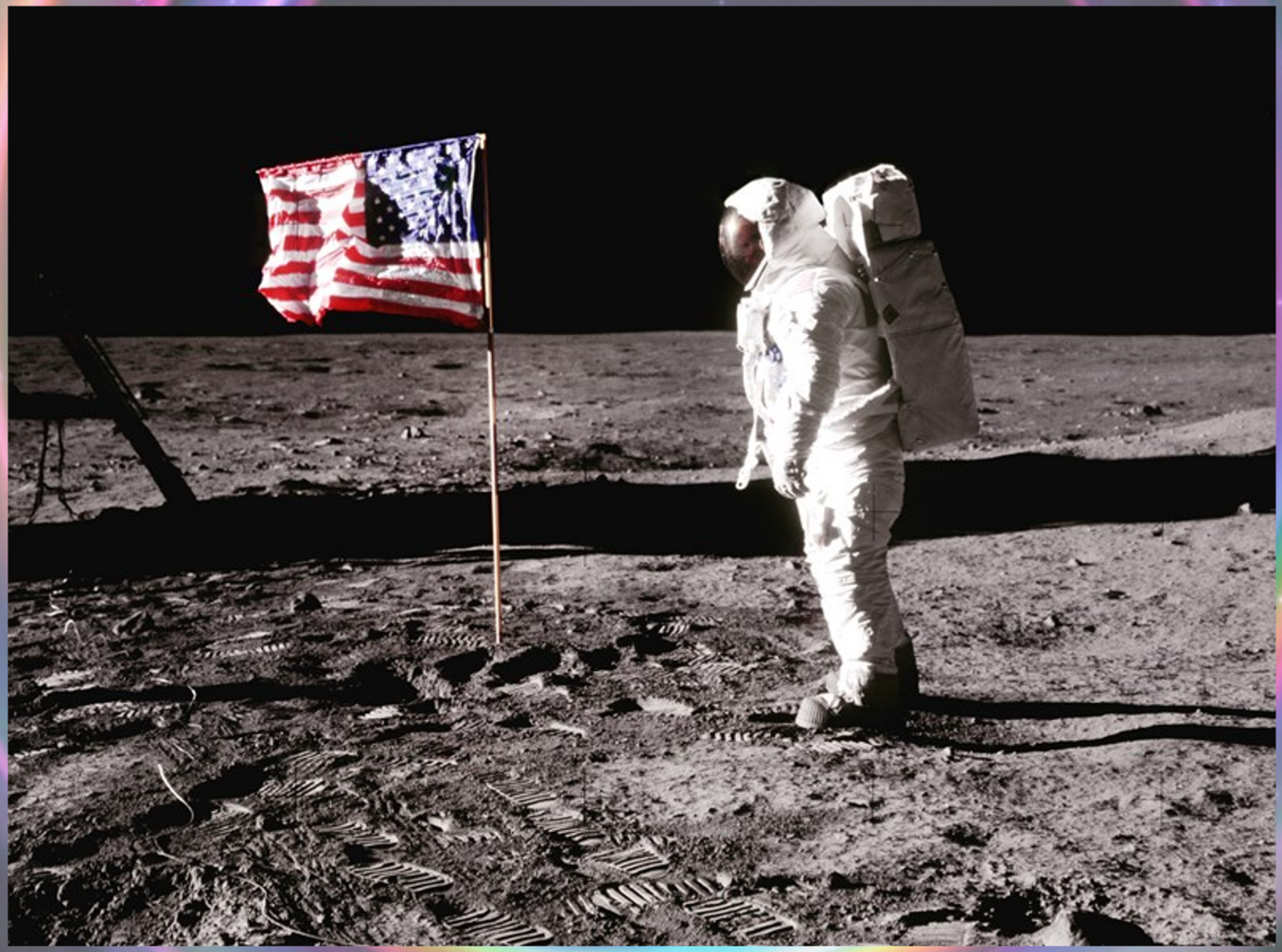
Step 1: New Moon

Step 4: Last Quarter

Step 2: First Quarter

Step 3: Full Moon

We can also teach about lunar exploration and the Space Race



How did we study the Moon?

For hundreds of years, the telescope…

But - The Luna series was a series of lunar probes sent out by the former Soviet Union.

- **Luna 1 had the first successful flyby before going into orbit around the Sun.**
- **Luna 2 crashed into the Moon.**
- **Luna 3 orbited the Moon and sent the first close up pictures of the Moon's surface and the first pictures of the far side of the Moon.**

How did we study the Moon?

Meanwhile, back in the USA -

- The Pioneer space probes were launched by the United States the same time the Luna space probes were in progress.
- All Pioneers 1,2, and 3 were successful in their mission.
- Pioneer 4 reached escape velocity from Earth and sent data back to Earth as it passed the Moon.

How was JFK involved?

- In 1961 President John F. Kennedy made it a national goal to land an astronaut on the Moon and return the astronaut safely to Earth.
- Lunar probes Ranger and Surveyor were sent to search for a safe landing site on the Moon. They were designed to send back pictures of the Moon's surface then crash into it.

Were the Russians ahead of us?

- **1957: The Soviet Union launched the first artificial satellite (*Sputnik I*)**
- **April 12th, 1961: Yuri Gagarin, Russian cosmonaut, was the first human in space.**
- **The former Soviet Union had orbited a cosmonaut and also had a cosmonaut, Gherman Titov, complete a 17 orbit flight that lasted over 25 hours.**
- **Voshkod II – March 18, 1965 – Alexei Leonov conducts first space walk (EVA).**

How was the US progressing?

The Mercury missions (1959-1963):

The "Right Stuff"

-Alan Shepard – 1st American in space

-John Glenn – 1st to orbit Earth

The Gemini missions (1963-1966):

- Two astronauts

- Extended time, EVA, rendezvous, etc.

Apollo stage (1967-1972)

- Get to the Moon, land on it, come back

Are there any similarities?

Earth

7930 miles diameter

23 degree axis tilt (seasons!)

Surface temps -120 to 120°F

Thick atmosphere of nitrogen and oxygen, mild greenhouse effect

Lots of liquid water on surface

Moon

2160 miles diameter

7 degree tilt (~no seasons)

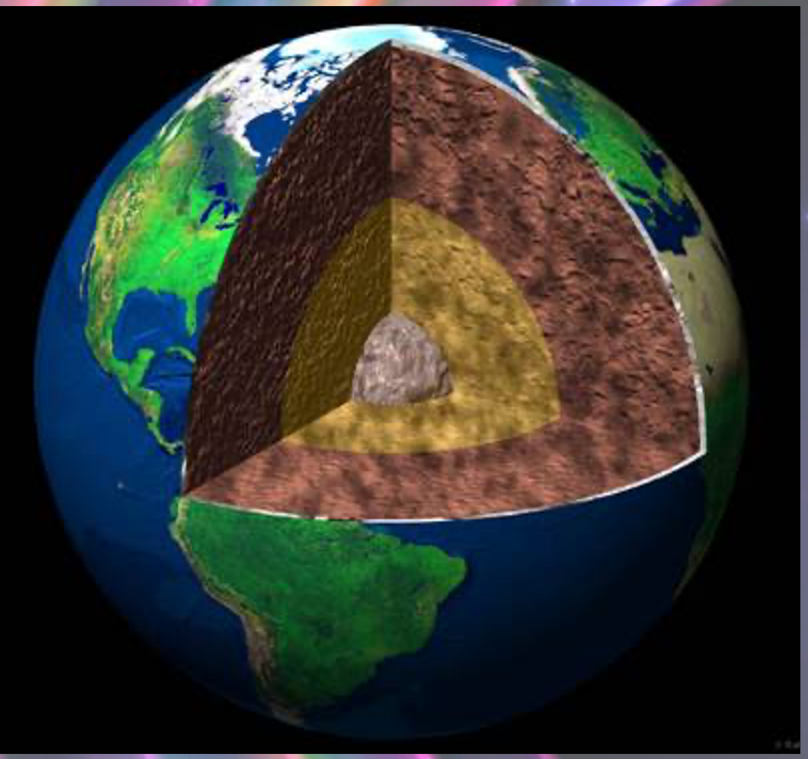
Surface temps -224 to –243°F)

No atmosphere

No liquid water, ice at poles in shadows?

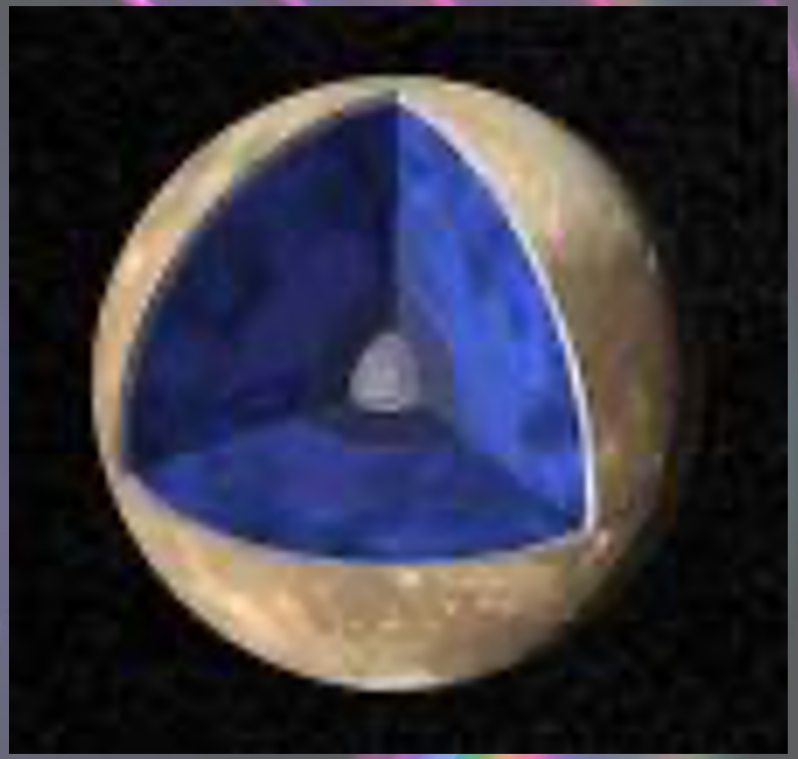
Are there any similarities?

Earth



Magnetic Field – from (liquid Fe/Ni core)
Hot, dense core
Plate tectonics, thin crust

Moon



No Magnetic Field
Small Moon Quakes
Small, Offset Core

What's the lunar surface like?

Low Albedo (7%)

Highlands

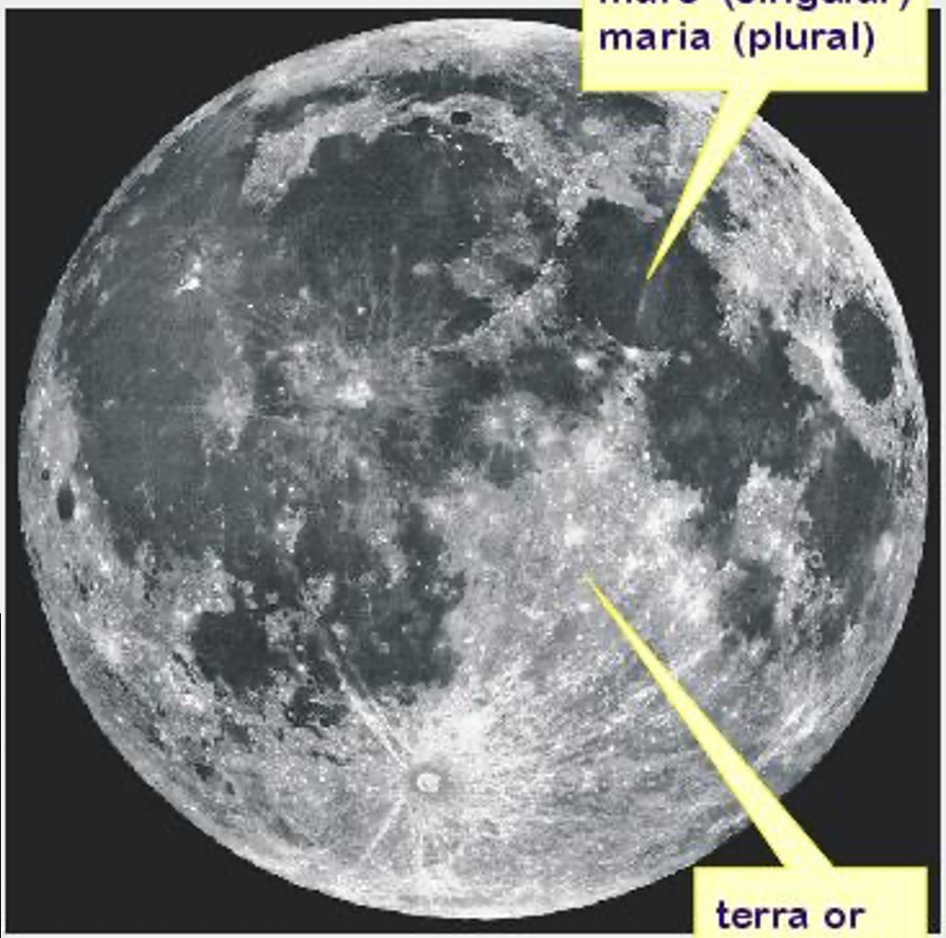
Maria

Rilles

Impact craters

Ejecta

Rays



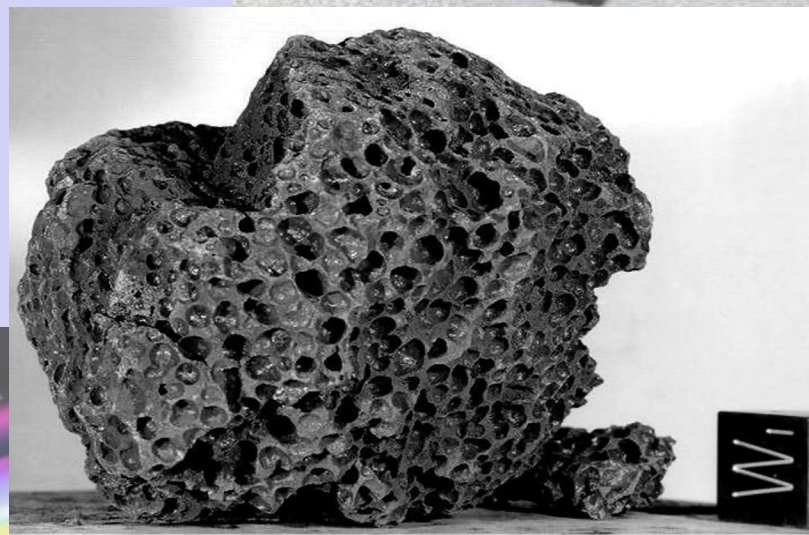
What makes the Moon unique amongst other moons in our solar system?

- It's the largest moon compared to the radius and mass of the planet it orbits (used to be Pluto-Charon).
- It is a solid, rocky body, in contrast with the icy composition of many moons of the 4 gas giants.
- Its orbit is farther from Earth relative to the distance of many moons from their host planet.

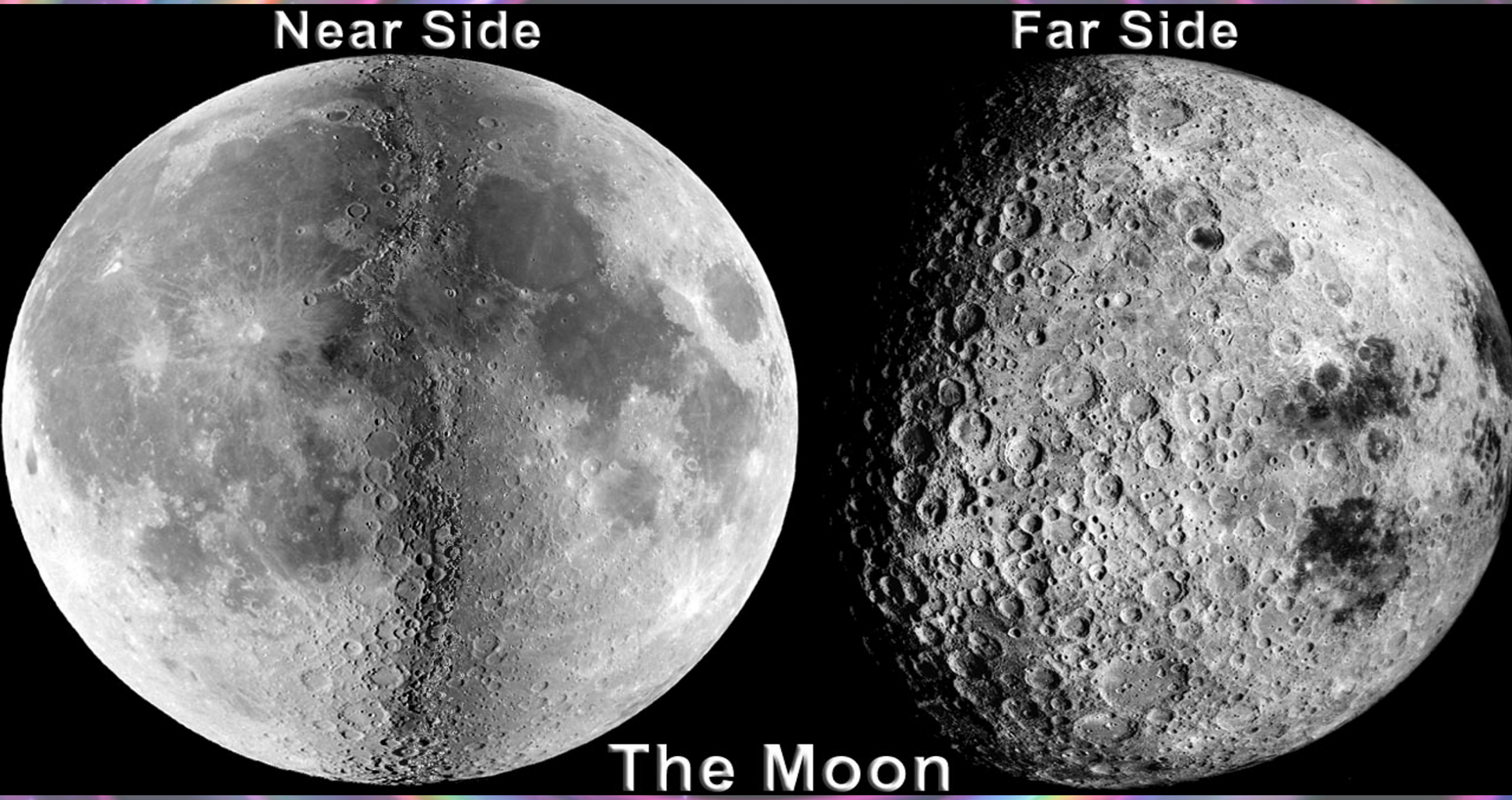
What did we learn about the Moon's composition from lunar rock samples?

- Made up of minerals similar to Earth's: **Silicates**
- Highlands: Predominantly **BRECCIAS**
  - Rocks consisting of angular fragments that are cemented together.
  - Composed of plagioclase feldspar (Ca, Al rich)

- Maria: Predominantly BASALT (no water)



How different do the two sides of the Moon look?



What is that "one small step" preserved in?

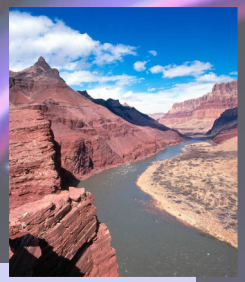
Because the Moon was heavily bombarded during its its' early life – the impacts caused breaking and heating of surface rocks and resulted in **REGOLITH** on the surface:

REGOLITH is a layer of loose, ground-up rock on the surface – includes dust, soil, broken rock, and other materials, averages several meters in thickness.

A few points to ponder while you do this next MEL

- The Moon's lower density – "lighter" - relative to terrestrial planets
- Less iron than whole Earth, more aluminum and titanium
- Moon's chemical signature ~ Earth's mantle
- Doesn't orbit in equatorial plane of Earth (ecliptic)
- Earth/Moon - high angular momentum – gets farther from Earth each year (Earth's rotation slows as a result).

Earth



Active wind/water erosion

Impacts

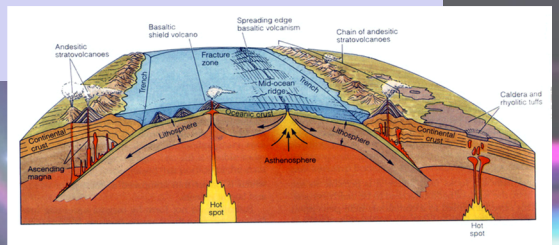
Active volcanoes

Earthquakes

Active magnetic field

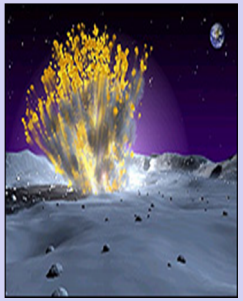
Few craters

<u>Geologically Active! – plate tectonics</u>



Moon

NO Active wind/water erosion



Impacts

NO active volcanoes

Small moonquakes

NO active magnetic field

Loads of craters

<u>Geologically Inactive! – no tectonics</u>

How did the Moon form? Where did it come from? Let's do the MEL…

Plausibility of Models Explaining How Our Moon Formed

Name: _____ Date: _____Teacher: _____ Period: ____

Please work on this individually.

Read the following information carefully.

Humans create *models* to help explain things.

Below are two models. These provide different explanations for how the Moon formed.

Model A: The Moon was an object that came from elsewhere in the solar system and was captured by Earth's gravity.

A person who supports this model makes the following argument:

The early solar system contained a lot of material that was moving around the Sun. Gravity from a nearby planet could pull a large chunk into orbit around it instead. The Moon was caught by Earth's gravity. Now the Moon orbits Earth.

Model B: The Moon formed after a large object collided with Earth and material from both combined to create the Moon.

A person who supports this model makes the following argument:

The early solar system contained a lot of material orbiting the Sun. Rocks would run into each other. These stuck together to make bigger chunks. When a big object crashed into Earth, some material was ejected and formed the Moon.

Plausibility is a judgment we make about the potential truthfulness of models. The judgment may be tentative (not certain). You do not have to be committed to that decision.

Circle the plausibility of each model. [Make two circles, one for each model.]

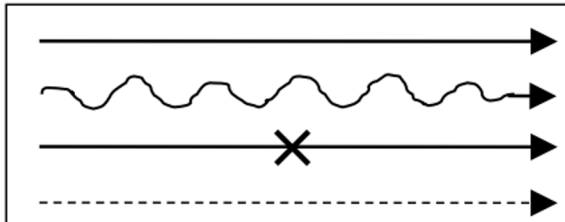
	Greatly implausible (or even impossible)									Highly plausible
Model A	1	2	3	4	5	6	7	8	9	10
Model B	1	2	3	4	5	6	7	8	9	10

Name_____ **Date**_____ **Teacher**_____ **Period**_____

If you worked with other students, their name(s):_____

Directions: Draw 2 arrows from each evidence box, one to each model. You will draw a total of 8 arrows.

Key:



- The evidence **supports** the model
- The evidence **STRONGLY supports** the model
- The evidence **contradicts** the model (shows its wrong)
- The evidence has **nothing to do with** the model

Evidence #1
Earth's average density is higher than the Moon's.

Evidence #2
Simulations of other star systems show that planets form when smaller objects collide.

Model A
The Moon was an object that came from elsewhere in the solar system and was captured by Earth's gravity.

Model B
The Moon formed after a large object collided with Earth and material from both combined to create the Moon.

Evidence #3
The Moon's orbit around Earth is tilted compared to Earth's orbit around the Sun.

Evidence #4
The composition of Earth and the Moon is similar near their surfaces. Their cores are different.

Please work on this part individually after you complete your diagram.

1. Now that you have completed the diagram, reconsider the plausibility of Models A and B (and C, if there is one). Circle the plausibility of each model. [Make one circle for each model.]

	Greatly implausible (or even impossible)									Highly plausible
Model A	1	2	3	4	5	6	7	8	9	10
Model B	1	2	3	4	5	6	7	8	9	10
Model C (if there is one)	1	2	3	4	5	6	7	8	9	10

2. For the model you selected as most plausible, explain why you think so.

3. Which arrows changed your plausibility judgments about the models? If your plausibility judgment did not change, which arrows supported your original plausibility judgments? Consider 2 lines of evidence. For each line, does it support, strongly support, or contradict one of the models? Why? When writing your explanation, consider the following:

- Use the specific information from the evidence text and figures to support your response. Ex: when looking at graphs or figures, be sure to describe the patterns in the data.
- Describe any cause and effect relationships found in the text.

Evidence #_____strongly supports | supports | contradicts | has nothing to do with Model_____*because*:

Evidence #_____strongly supports | supports | contradicts | has nothing to do with Model_____*because*: