Astronomy

Fall 2026

Weeks 13 - 15

Thursday, November 5

- Project Day 3
- T: **Science concepts. The student uses models to explain the formation, development, organization, and significance of solar system bodies. The student is expected to:**

1D compare the factors essential to life on Earth such as temperature, water, gases, and gravitational and magnetic fields to conditions on other planets and their satellites.

(16) Science concepts. The student understands the benefits and challenges of expanding our knowledge of the universe. The student is expected to:

16C evaluate the evidence of the existence of habitable zones and potentially habitable planetary bodies in extrasolar planetary systems;

- O: I will expand my understand of Earth
- D: by finishing part C of the project and creating my own fictional planet (Part D)

Journal 3.1

- What is your favorite season and why?

Friday, November 6 (C-day)

- Project Day 4
- T: **Science concepts. The student uses models to explain the formation, development, organization, and significance of solar system bodies. The student is expected to:**

1D compare the factors essential to life on Earth such as temperature, water, gases, and gravitational and magnetic fields to conditions on other planets and their satellites.

(16) Science concepts. The student understands the benefits and challenges of expanding our knowledge of the universe. The student is expected to:

16C evaluate the evidence of the existence of habitable zones and potentially habitable planetary bodies in extrasolar planetary systems;

- O: I will confirm my understanding of Earth
- D: by finishing incorporating my planet (part D) in the presentation and prepare presentation notes (part E) and practicing my presentation.

Tuesday, November 10

- Project Day 5 – Presentations
- T: **Science concepts. The student uses models to explain the formation, development, organization, and significance of solar system bodies. The student is expected to:**

1D compare the factors essential to life on Earth such as temperature, water, gases, and gravitational and magnetic fields to conditions on other planets and their satellites.

(16) Science concepts. The student understands the benefits and challenges of expanding our knowledge of the universe. The student is expected to:

16C evaluate the evidence of the existence of habitable zones and potentially habitable planetary bodies in extrasolar planetary systems;

- O: I will demonstrate my understanding of Earth
- D: by my group presenting our project including my invented planet.

Thursday, November 12

- Substitute
- **How the Universe Works: Moons video with questions**

Tuesday, November 17

- **TEK — Astronomy 11(C):** Compare the planets in terms of orbit, size, composition, rotation, atmosphere, natural satellites, magnetic fields, and geological activity.
- **Objective:** Students will identify and explain major lunar surface features, including highlands, maria, craters, and rilles, and describe how impacts and volcanic activity shaped the Moon.
- **Demonstration of Learning:** Students will use NASA Moon Trek to investigate lunar surface features, compare highlands and maria, and explain geological processes using observations from lunar imagery.

Earth's Moon

- Earth's nearest neighbor in space.
- Once the frontier of direct human exploration.
- Born in a cataclysmic event into an original molten state, the Moon is now a dead world – no plate tectonic or volcanic activity and no air.
- Suffered early impact barrage.
- Plays major role in eclipses and tides.

The Moon

- Moon is ¼ Earth's diameter.
- Gravity is ⅙ as strong.
- A place of "magnificent desolation" – shapes of gray without color.

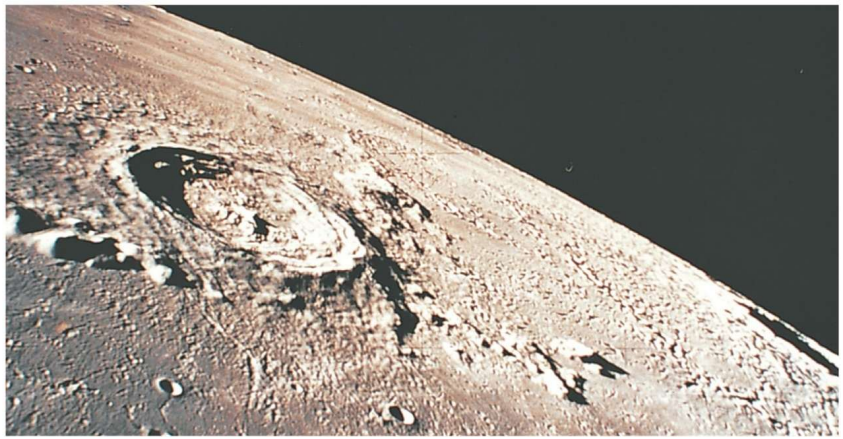
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- NASA

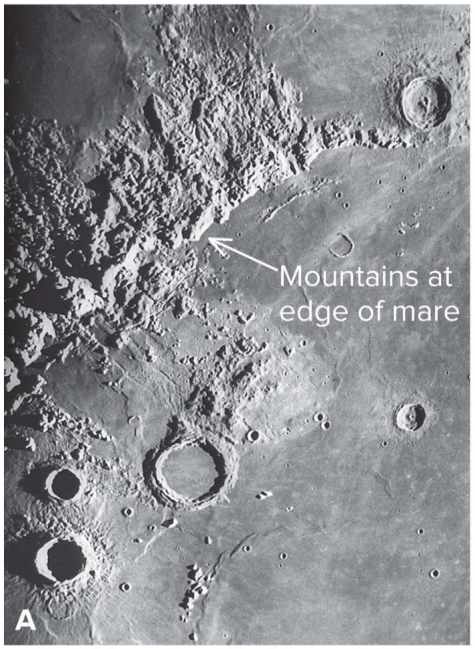
“Magnificent Desolation”

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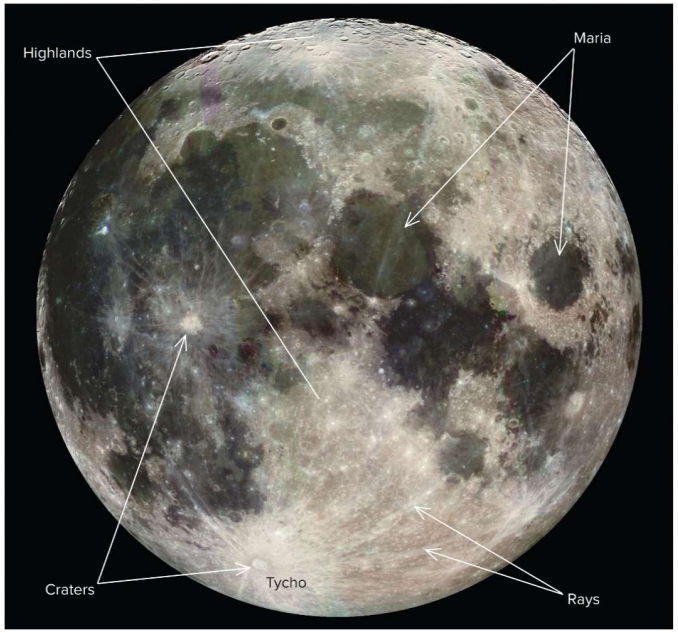


- a: NASA; a: © UC Regents; UCO/Lick Observatory

Surface Features

- Surface divided into two major regions.
- ***Highlands*** – Bright rugged areas composed mainly of anorthosite (a rock rich in calcium and aluminum silicates) and pitted with craters.
- ***Maria*** – Large, smooth, dark areas surrounded by highlands and composed primarily of basalt (a congealed lava rich in iron, magnesium, and titanium), which is more dense than anorthosite.

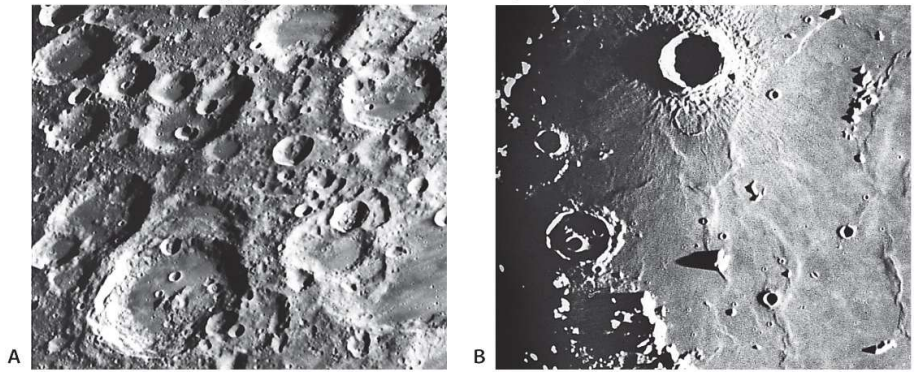
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- NASA/JPL/USGS

Craters

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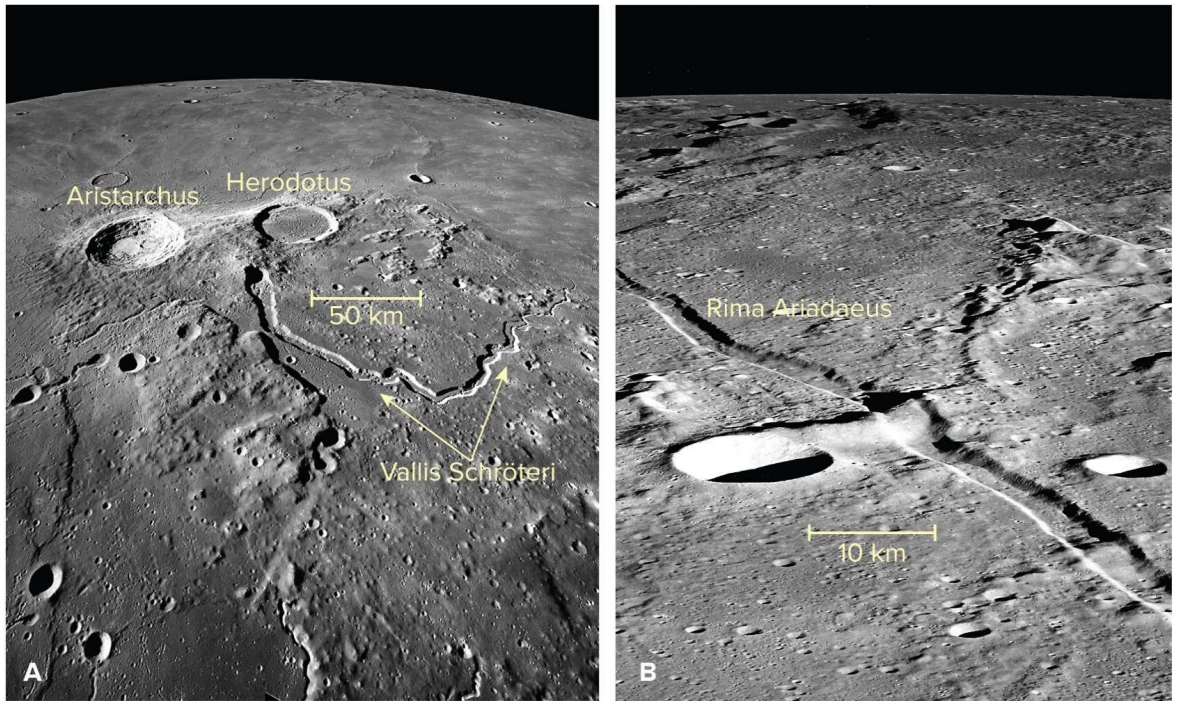


- Very few appear to be volcanic.
- Raised rim, sometimes with a rebound peak in the center.
- Range in size from centimeters to more than 200 km.
- Some appear “fresh, while other, “softer” ones are much older.

- (a, b): © UC Regents; UCO/Lick Observatory

Rilles

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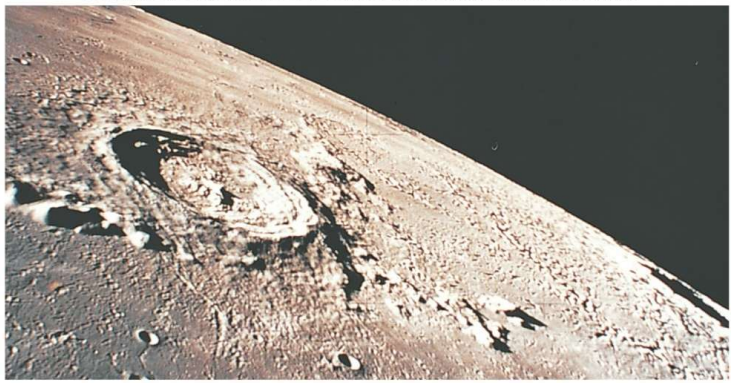
- Lunar canyons carved either by ancient lava flows or crustal cracking.

- (a, b): Lunar and Planetary Institute/NASA

Origin of Lunar Surface Features

- Nearly all lunar features (craters, maria, rays) are the result of impacts by solid bodies early in the Moon's history.
- A circular crater forms when a high-velocity projectile disintegrates upon impact in a cloud of vaporized rock and fragments that blast a hole in the surface.

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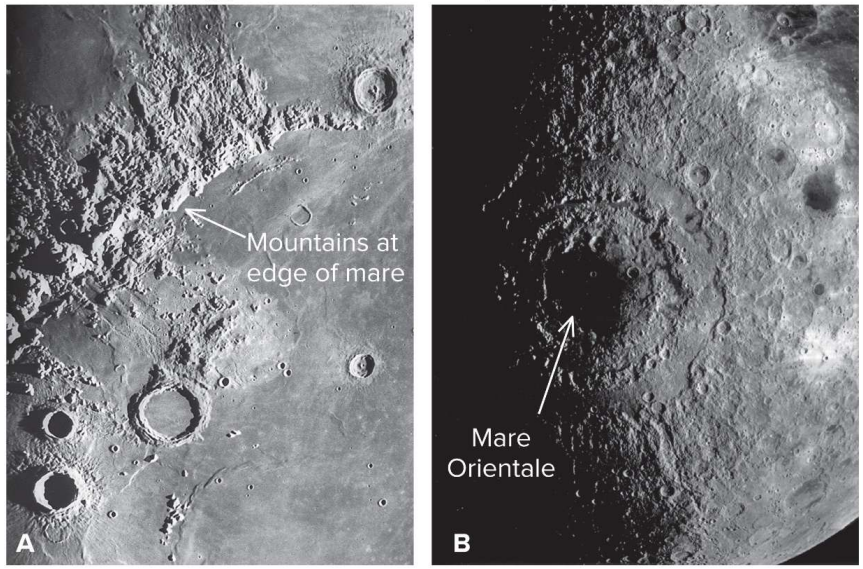
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- a: NASA

Mare Orientale

- In the Mare Orientale region, it appears that multiple very large bodies struck the surface.
- This impact threw up huge craters and associated mountain chains, as well as produced multiple crater rings around the mare.

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- Radiometric dating places the resulting lava 1.2 billion years after the Moon's formation.

- a: © UC Regents; UCO/Lick Observatory; b: NASA, Lunar Orbiter 4

Formation of Maria

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- The maria formed when early in the Moon's history, a few large bodies (over 100 km) struck the Moon. The Lunar Prospector spacecraft found evidence that impacts allowed lava to reach the surface at later times.

Thursday, November 19

- **TEK — Astronomy 11(D):** Compare the factors essential to life on Earth such as temperature, water, gases, and gravitational and magnetic fields to conditions on other planets and their satellites.
- **Objective:** Students will explain how the Moon's gravity, internal structure, atmosphere, and surface conditions affect its environment and the ability of humans to survive there.
- **Demonstration of Learning:** Students will complete a lunar survival challenge by selecting essential equipment, developing a survival plan, and justifying their decisions using scientific knowledge of lunar conditions.

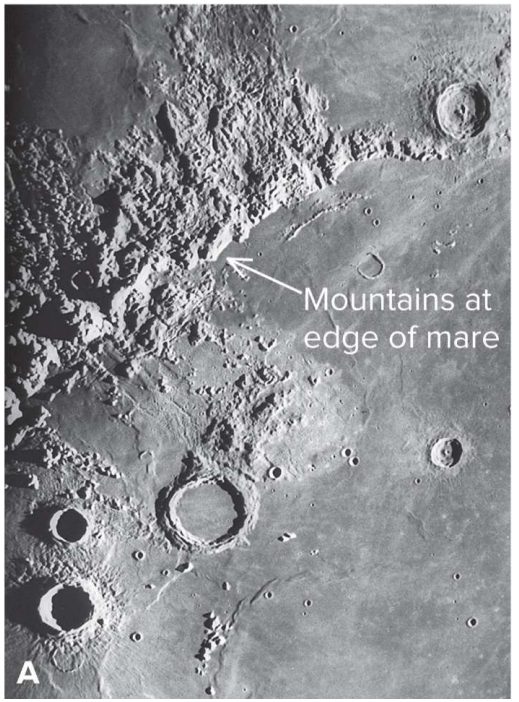
Journal 3.2

- What is one family tradition I look forward to each year around the holidays?

Structure of the Moon

- The Moon lacks the folded mountain ranges and variety of volcanic peaks seen on Earth.
- Lack of activity due to Moon cooling off much faster than Earth.
- Moon's higher surface-to-volume ratio (relative to Earth) allows heat to escape from it faster.
- Being much less massive than Earth, the Moon also has a smaller source of radioactive material to supply heat.

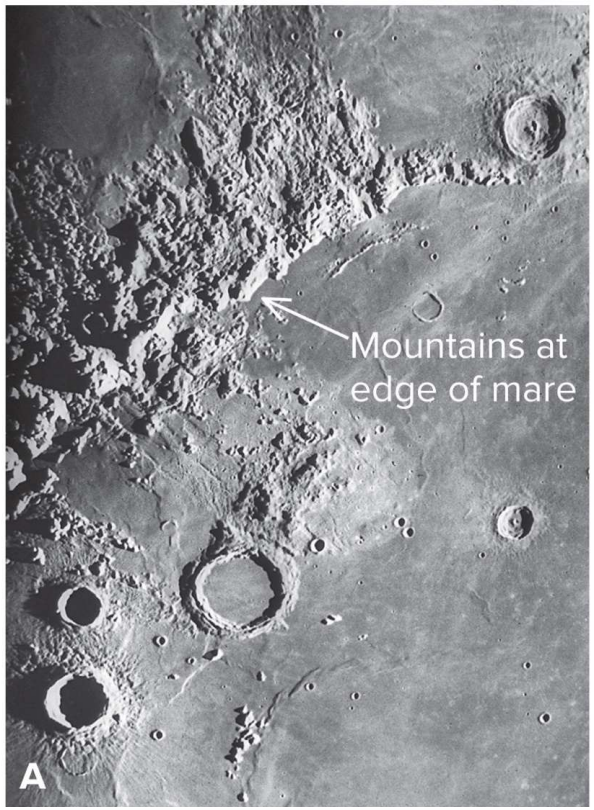
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The Interior of the Moon

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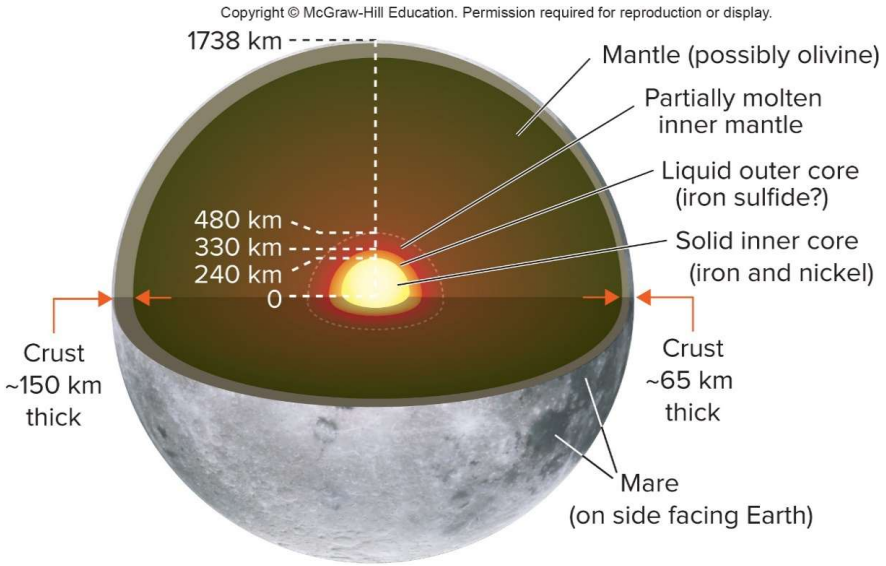


- Interior (including crust) studied by seismic detectors set up on Moon by astronauts – essentially found to be inactive and has simpler structure than Earth's.

- a: © UC Regents; UCO/Lick Observatory

The Surface of the Moon - Regolith

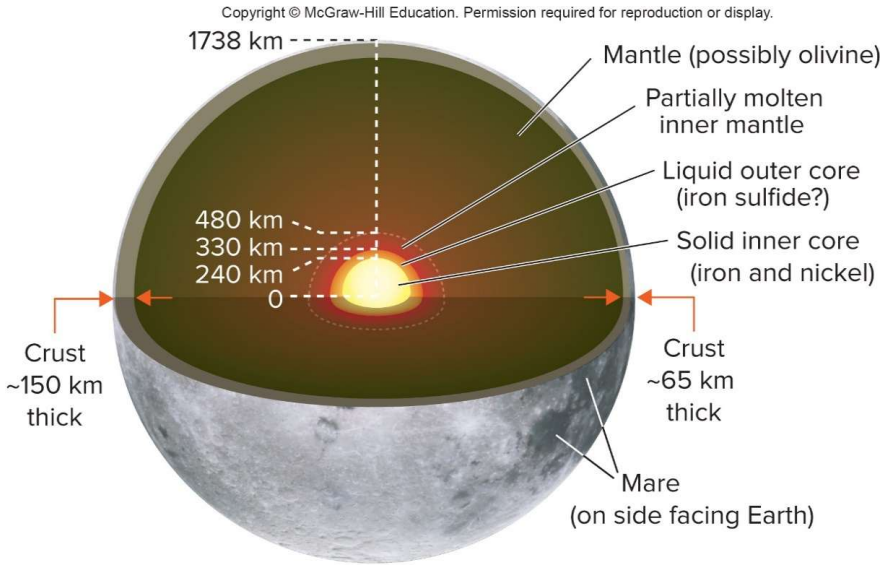
- Surface layer is shattered rock chunks and powder (from repeated impacts) forming a ***regolith*** tens of meters thick.



- Regolith is basaltic in maria and anorthostic in highlands.
- Regolith may extend to several hundred meters in some places.

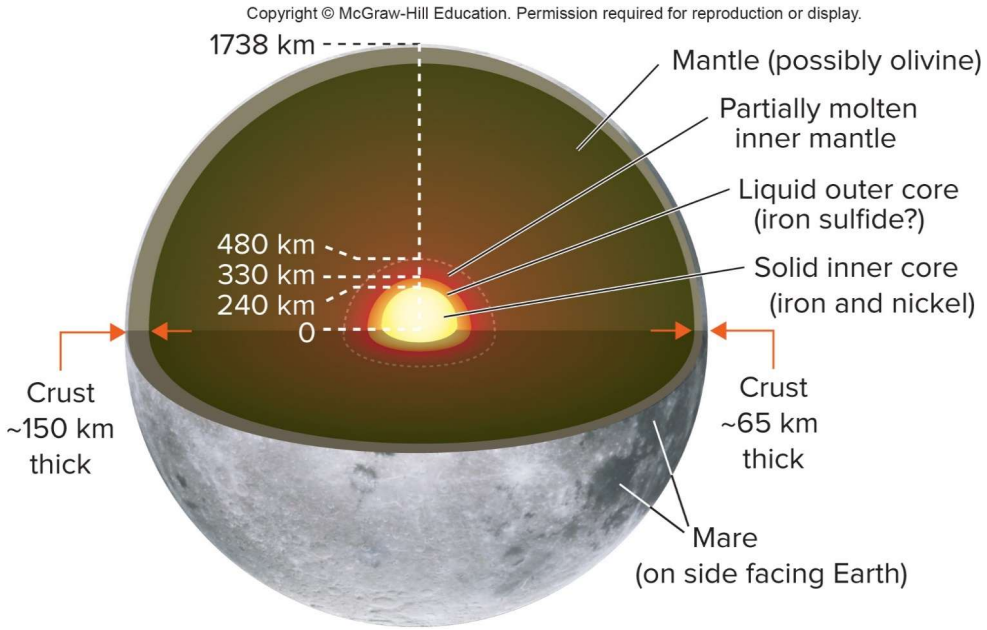
The Interior of the Moon - Crust

- Average thickness of 100 km, although crust is thinner on side that faces Earth.
- Reason for asymmetry is not clear, but may be related to the difference in Earth's gravitational force across the Moon.



- Very few maria exist on side of Moon away from Earth.
- Crust is composed of silicate rocks rich in aluminum and poor in iron.

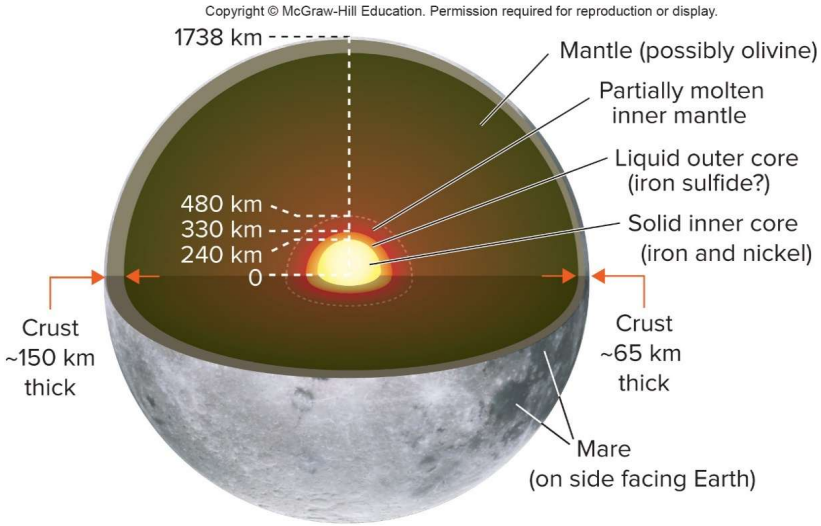
The Interior of the Moon - Mantle



- Relatively thick, extending 1000 km down.
- Probably rich in olivine.
- Appears too cold and rigid to be stirred by the Moon's feeble heat.

The Interior of the Moon - Core

- The Moon's low average density ($3.3\ g/cm^3$) • tells us
- interior contains little iron.
- Some molten material may be below mantle, but core is smaller and contains less iron and nickel than Earth's.



- The relatively cold Moon interior, low iron/nickel content, and slow rotation imply no lunar magnetic field – found to be the case by the Apollo astronauts.

Lunar Atmosphere

- Moon's surface is never hidden by lunar clouds or haze, nor does reflected spectrum show any signs of gas and hence no winds.
- Lack of an atmosphere means extreme changes in lunar surface temperature from night to day.

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Why Does the Moon Lack an Atmosphere?

1. Lack of volcanic activity to supply source of gas.
2. Moon's gravitational force not strong enough to retain gases even if there was a source.

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- Lack of atmosphere and plate tectonics implies that the Moon has been relatively unchanged for billions of years and will continue to be so into the foreseeable future.

- a: NASA

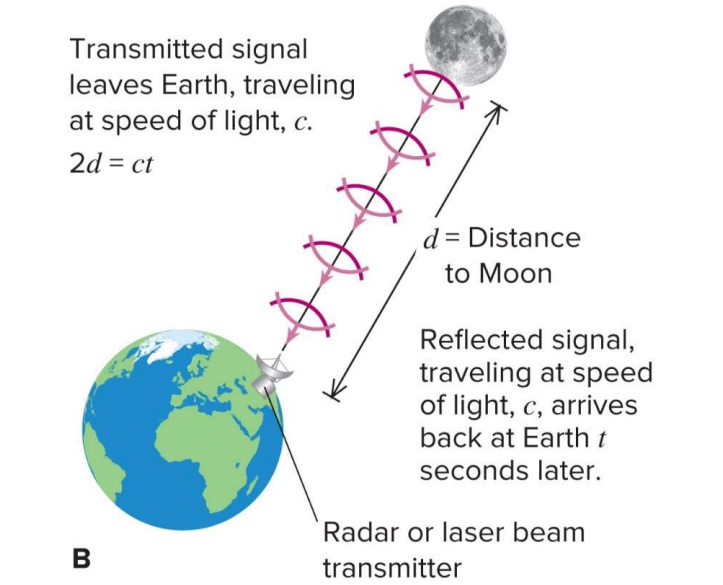
Friday, November 20

- **TEK — Astronomy 11(B):** Describe the characteristics of the Sun and its position in the solar system.
- **Objective:** Students will explain the Moon's orbital motion, synchronous rotation, and orbital inclination and compare scientific hypotheses about the Moon's formation.
- **Demonstration of Learning:** Students will use Stellarium Web to investigate the Moon's motion and phases, explain the relationship between orbital inclination and eclipses, and evaluate evidence supporting the giant-impact hypothesis through a 24-question investigation.

Orbit and Motion of the Moon

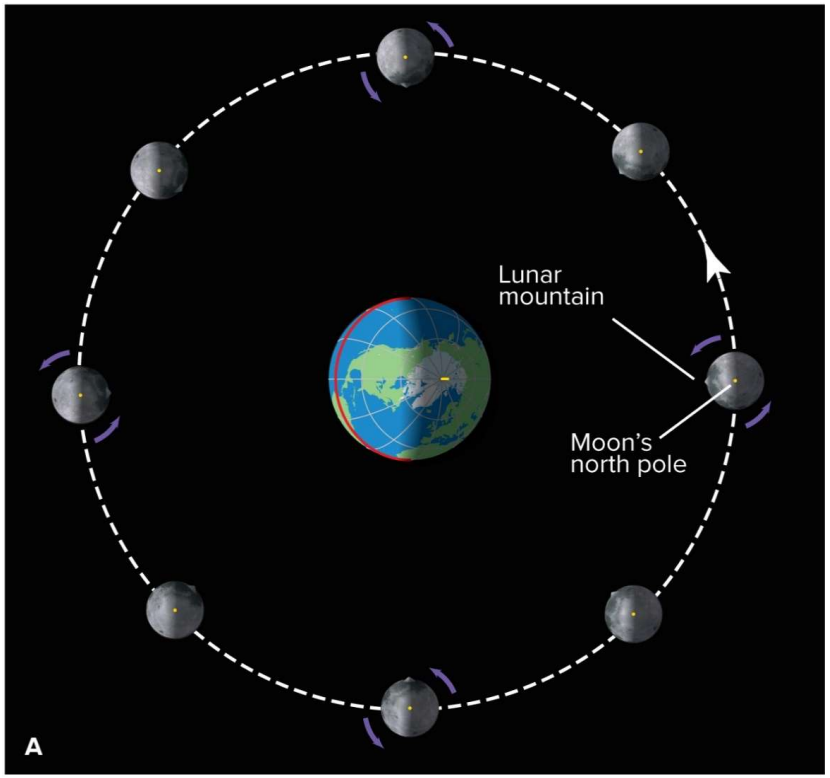
- The Moon's orbit around Earth is elliptical with an average distance of 380,000 km and a period of 27.3 days relative to the stars.
- Determining the Moon's distance can be done with high precision by bouncing a radar pulse or laser beam off the Moon.

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Synchronous Rotation

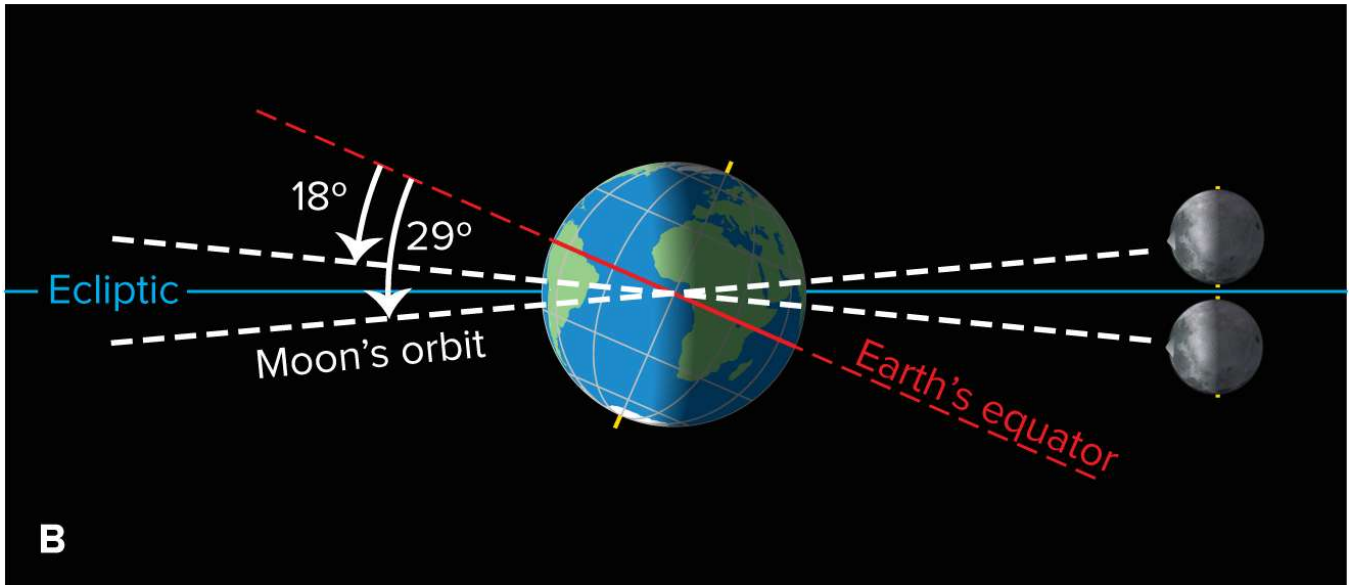
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- The Moon keeps the same face toward Earth as it orbits.
- The fact that the Moon rotates at the same rate as it orbits Earth is called s***ynchronous rotation.***

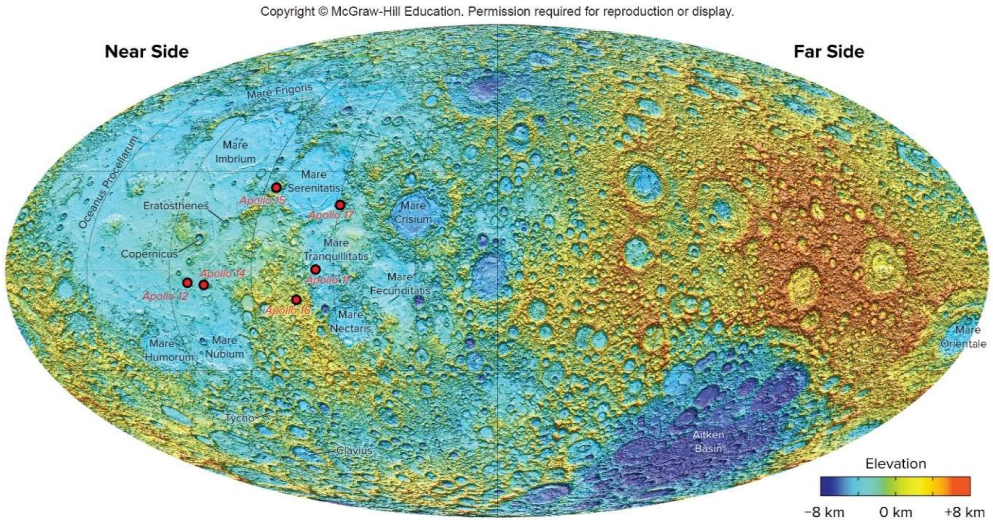
The Moon's Orbit

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- The Moon's orbit is tilted about 5° with respect to the ecliptic plane.
- It is also tilted with respect to Earth's equator – very unlike most of the moons in the solar system.

Origin and History of the Moon



- The Moon is also very large relative to its central planet – again unlike most of the other moons in the solar system.
- These oddities indicate that the Moon formed differently from the other solar system moons!

- Map produced by S. E. Schneider using data from the Lunar Orbiter Laser Altimeter provided by the NASA Planetary Data System

Lunar Formation Hypotheses

- Before Apollo missions, three hypotheses of the Moon's origin:
  - Moon originally a small planet orbiting the Sun and was subsequently captured by Earth's gravity during a close approach (***capture theory***).
  - Earth and Moon were twins, forming side by side from a common cloud of gas and dust (***twin formation theory***).
  - The Moon spun out of a very fast rotating Earth in the early day of the Solar System (***fission theory***).

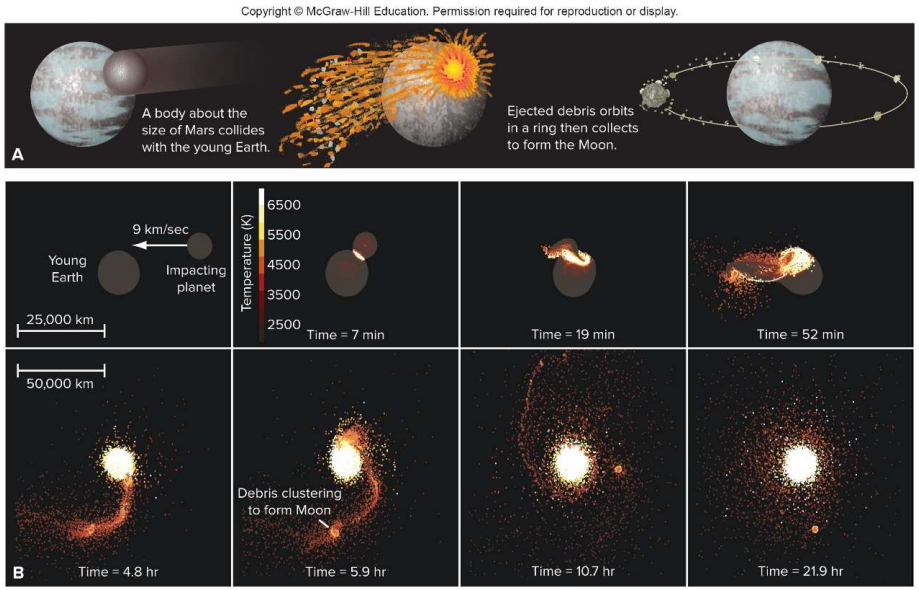
Lunar Formation Predictions

- Each of these hypotheses gave different predictions about Moon's composition:
  - In capture theory, the Moon and Earth would be very different in composition, while twin theory would require they have the same composition.
  - In fission theory, the Moon's composition should be close to Earth's crust.
- Moon rock samples proved surprising:
  - For some elements, the composition was the same, but for others, it was very different.
  - None of the three hypotheses could explain these observations.

The Large Impact Hypothesis

- The new Moon formation hypothesis:
  - Moon formed from debris blasted out of Earth by the impact of a Mars-sized body.
  - Age of lunar rocks and lack of impact site on Earth suggests collision occurred at least 4.5 billion years ago.

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The Large Impact Solution

- This “large impact” idea explains:
  - The impact would vaporize low-melting-point materials (e.g., water) and disperse them explaining their lack in the Moon.
- Only surface rock blasted out of Earth leaving Earth’s core intact and little iron in the Moon.
- Easily explains composition difference with Earth.
- The splashed-out rocks that would make the Moon would more naturally lie near the ecliptic than Earth’s equatorial plane.
- Earth’s tilted rotation axis is explained.