

Lesson 03

Earth's Moon

Part 1

Moon's orbit



The **Moon** is the only natural satellite of Earth.



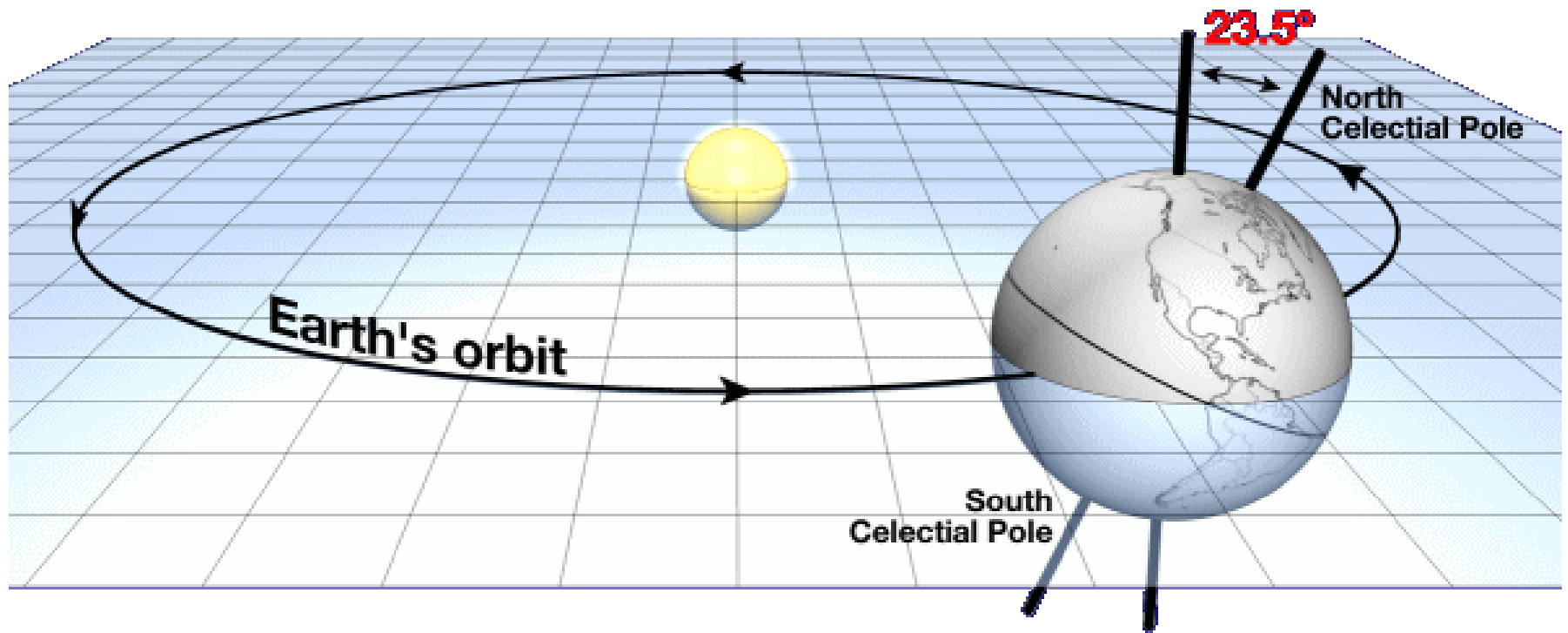
Satellite is any object (natural or manmade) that orbits a planet. Moons are **natural satellites** of planets. Spaceships and other craft are **artificial satellites**.



Facts about Earth's Moon

- Name: **Luna** (Roman goddess of night)
- Equatorial diameter: 3470 km
- Mass: 7.35×10^{22} kg
- Bulk density: 3.34 g/cm^3
- Atmosphere: none
- Surface gravity: 1.62 m/s^2





Remember: Earth's orbit is aligned with the **Plane of the Ecliptic**. However, the Earth is **tilted on its axis of rotation by 23.5°** from upright, so the Plane of the Ecliptic does not align with the Earth's equator.



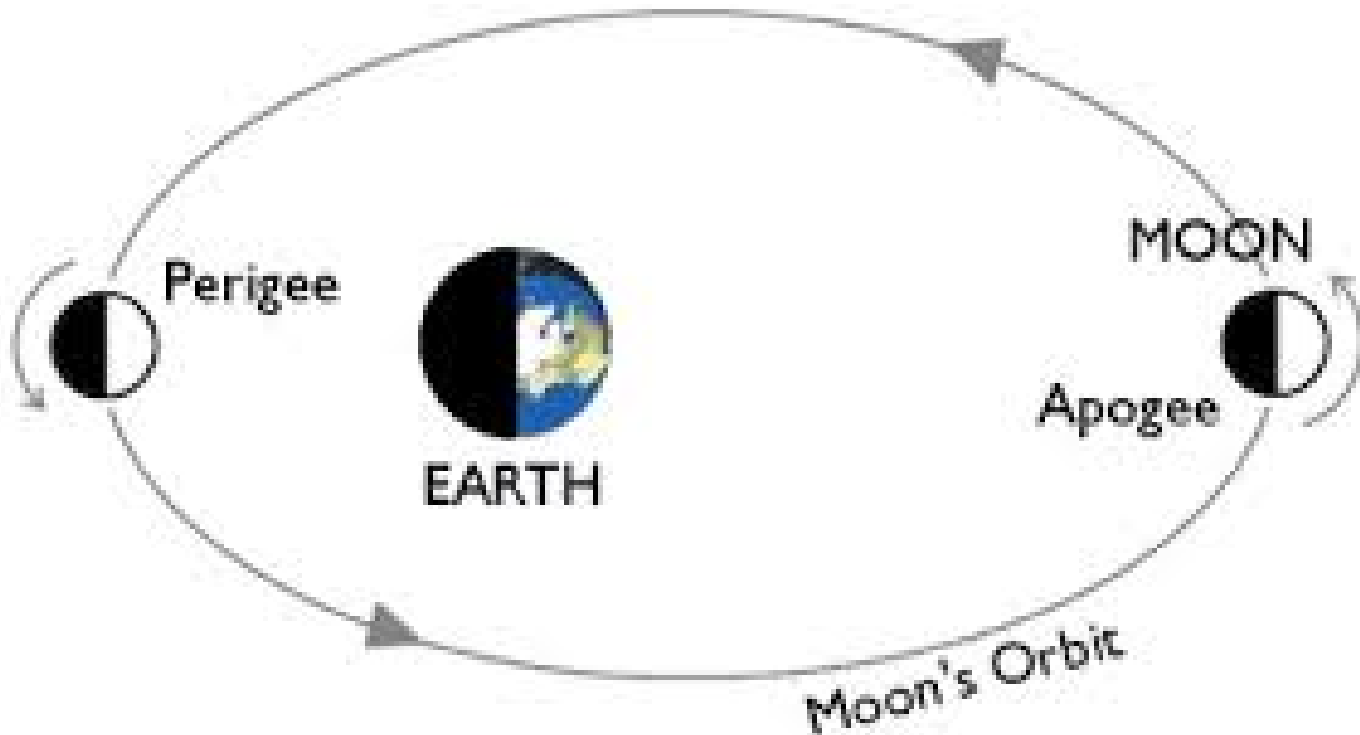
The moon's orbit has an **inclination** of (tilted by) **5°** relative to the **plane of the ecliptic**. The moon's orbit and Earth's equator do not exactly align. They are offset by **~19°**.



The moon's orbit is **very eccentric**.

Perigee = closest physical position to Earth in its orbit. 357,000 km away

Apogee = farthest physical position to Earth in its orbit. 405,000 km away



The size of the moon's visible disk in the sky changes as seen from Earth over the course of the month due to the changing distance.

Perigee

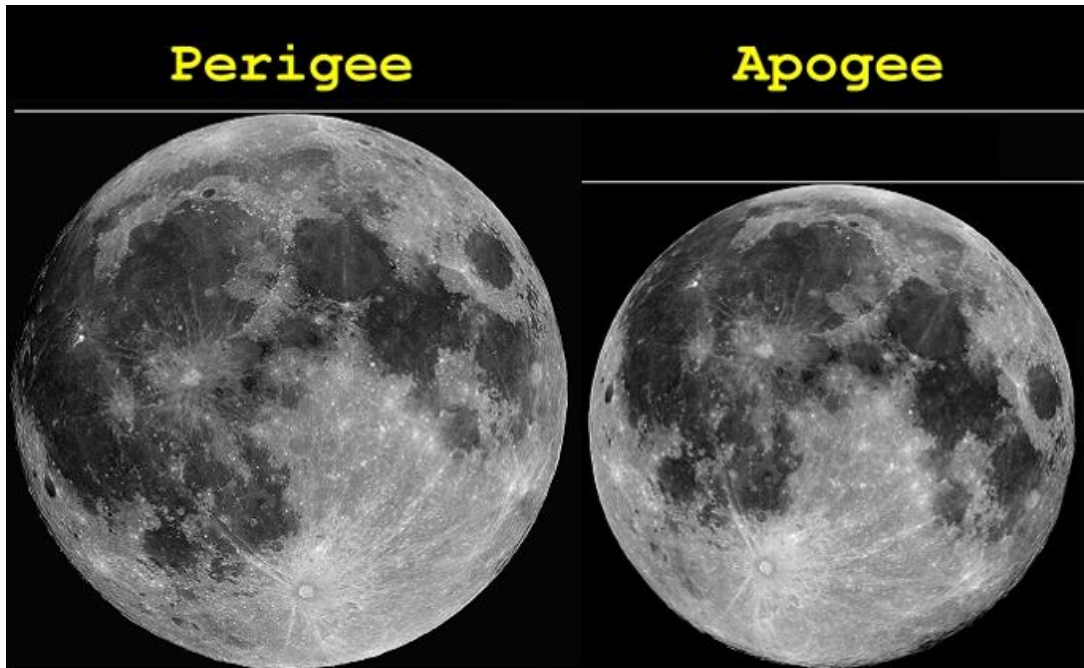


Apogee



A **full moon** when the moon is at **perigee** is called the **supermoon**. The moon will appear to be its largest size.

A **full moon** when the moon is at apogee is called the **micromoon**. The moon will appear to be its smallest size.



The size we perceive from Earth's surface is a function of distance. The supermoon full moon is ~12% greater in area than the micromoon full moon.



The Moon's Motions

- Rotation period: ~ 27.3 days. The moon rotates or spins one time in 27.3 days.
- Sideral month: 27.3 days. One full orbit with based on the fixed positions of the background stars.
- Synodic month: 29.5 days. One full revolution with a complete lunar cycle based on the position of the Sun.*

The moon revolves around (orbits) the Earth while the Earth revolves around (orbits) the Sun. Both the Earth and the moon are rotating but at different rates.



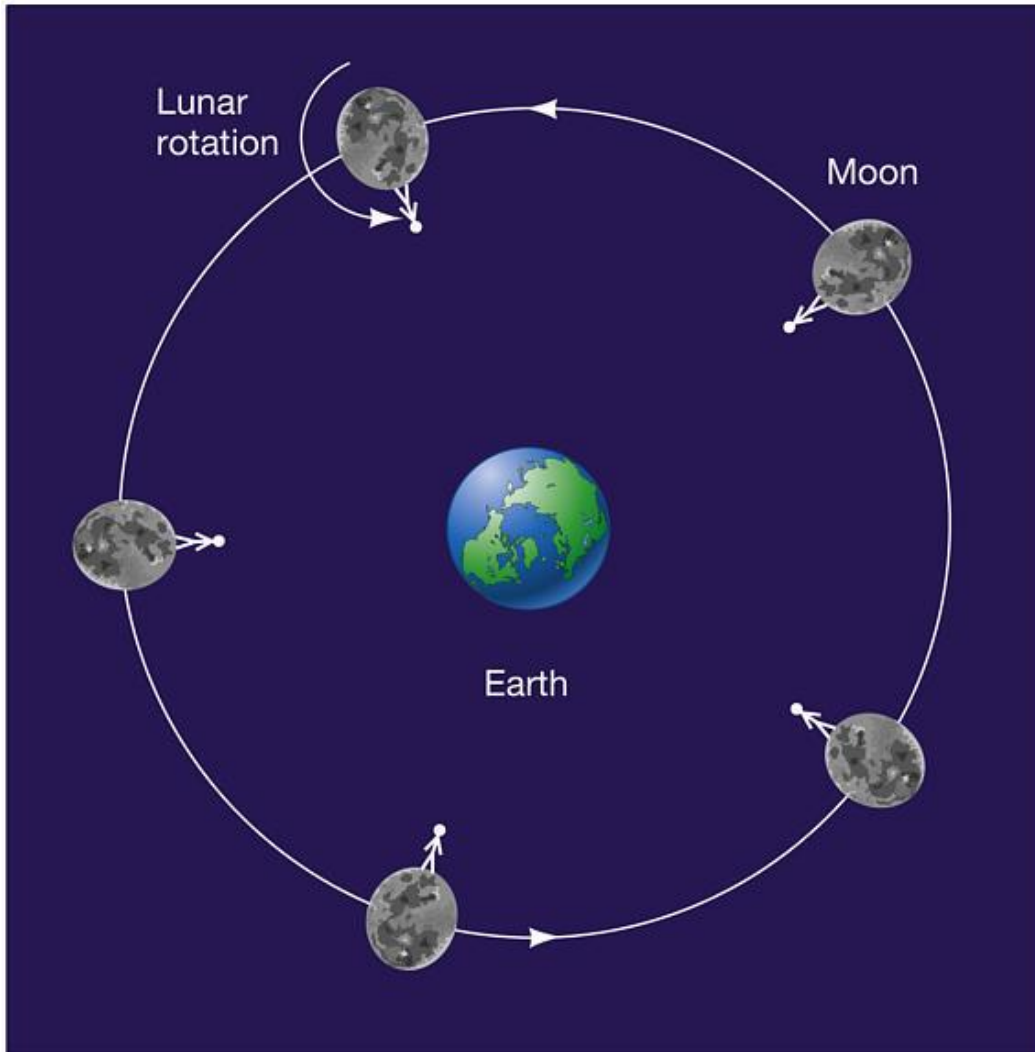
The moon's shape is not a perfect sphere. The moon has a slight bulge that faces the Earth at all times as it orbits the Earth. This is called the **nearside of the moon**.



Only the **near side of the moon** faces the Earth. The **dark side of the moon** (far side) always faces away from the Earth.



The moon's rotation period (27.3 days) exactly matches the moon's sidereal month (27.3 days).

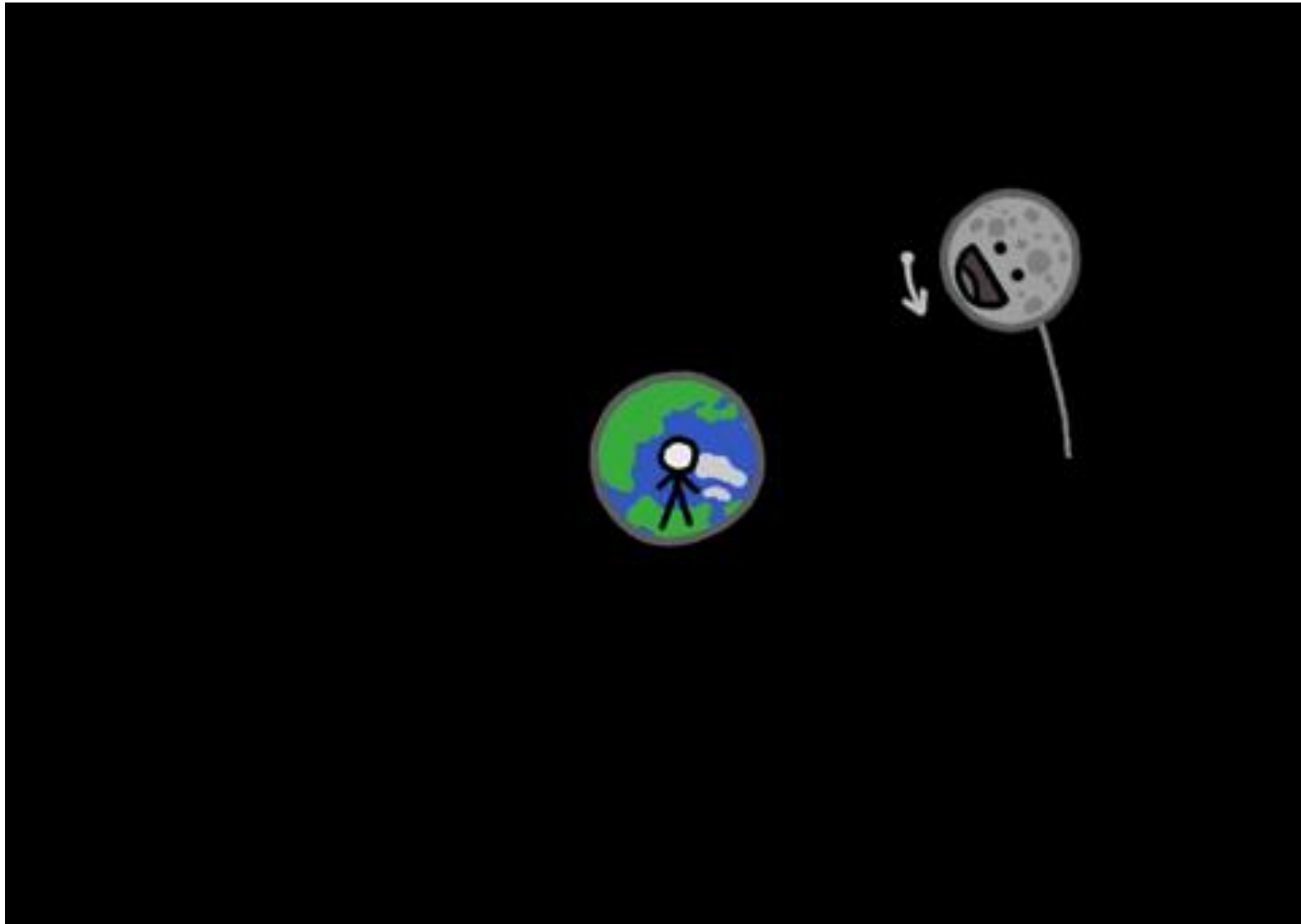


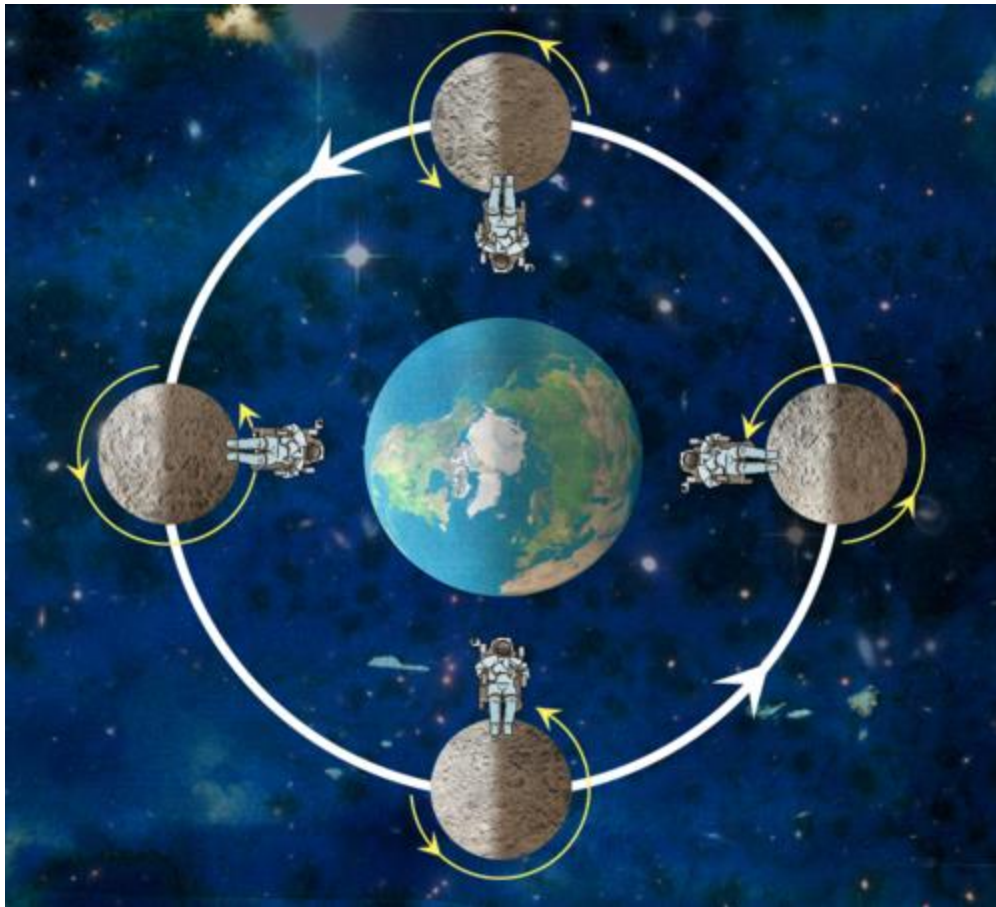
This is called a **synchronous orbit**. The moon rotates on its axis with exactly the same period that it revolves around the Earth.

Synchronous means at the same time.



Animation showing the synchronous orbit. The moon is tidal locked to the Earth by gravity.



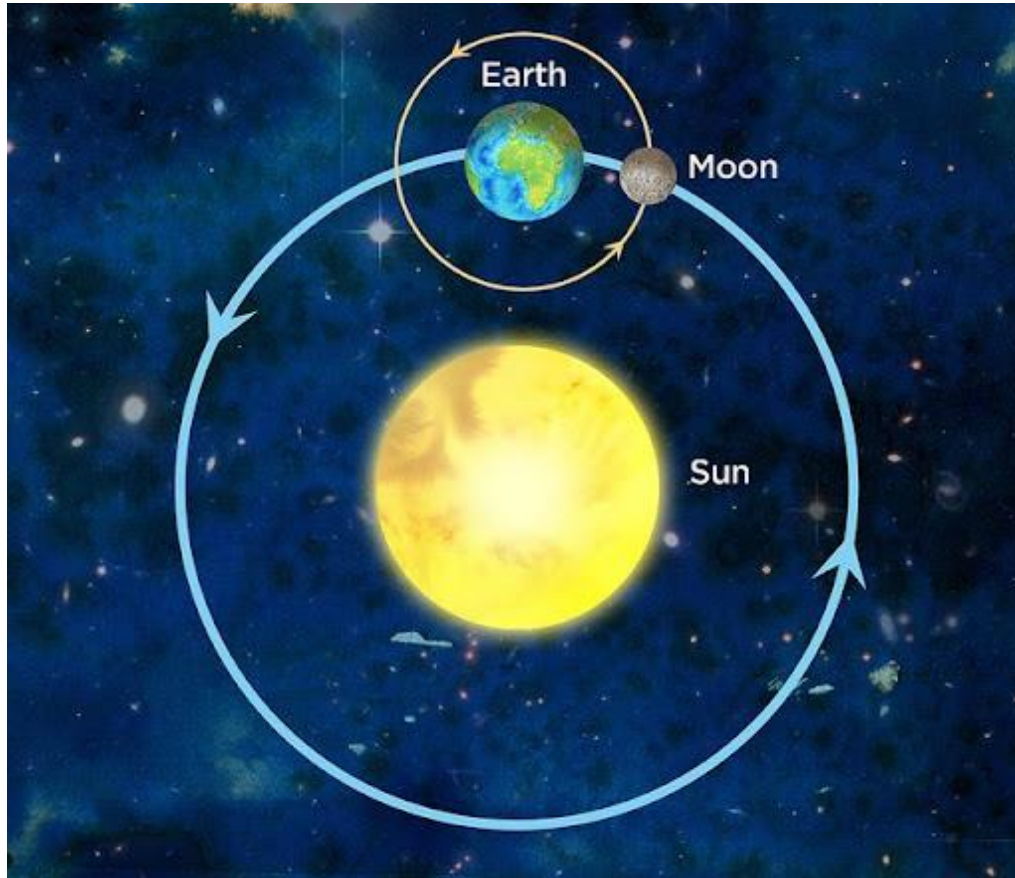


The reason that one side of the moon (the bulged side) faces the Earth at all times due to the synchronous orbit is because of a process called **tidal locking**.

The gravitational attraction between the moon and the Earth (pull force) **has locked** on the bulge of the moon. As the moon spins, that face is continuously pulled towards the Earth making it face the Earth at all points in moon's orbit.



The moon revolves around the Earth. The Earth revolves around the Sun.

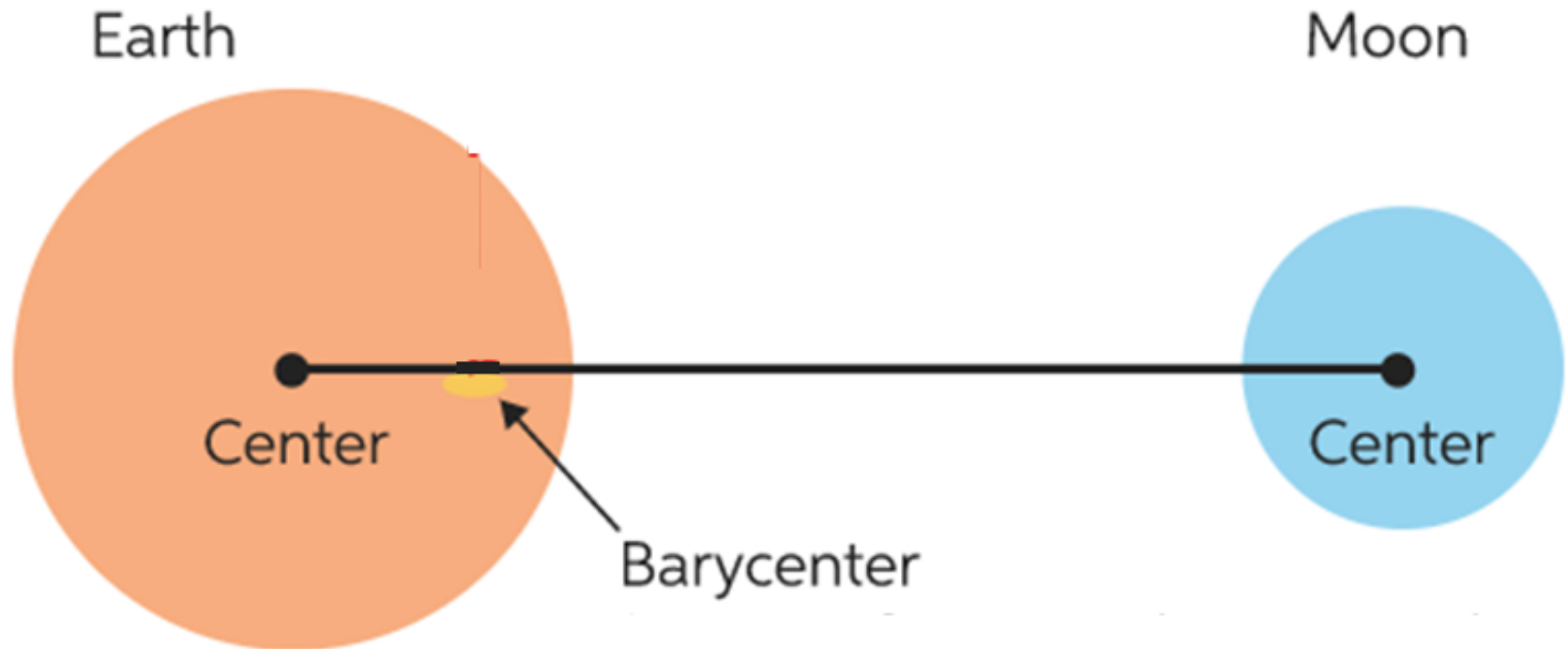


The Earth-moon gravitational attraction causes the **Earth to wobble slightly in its orbit** around the Sun.

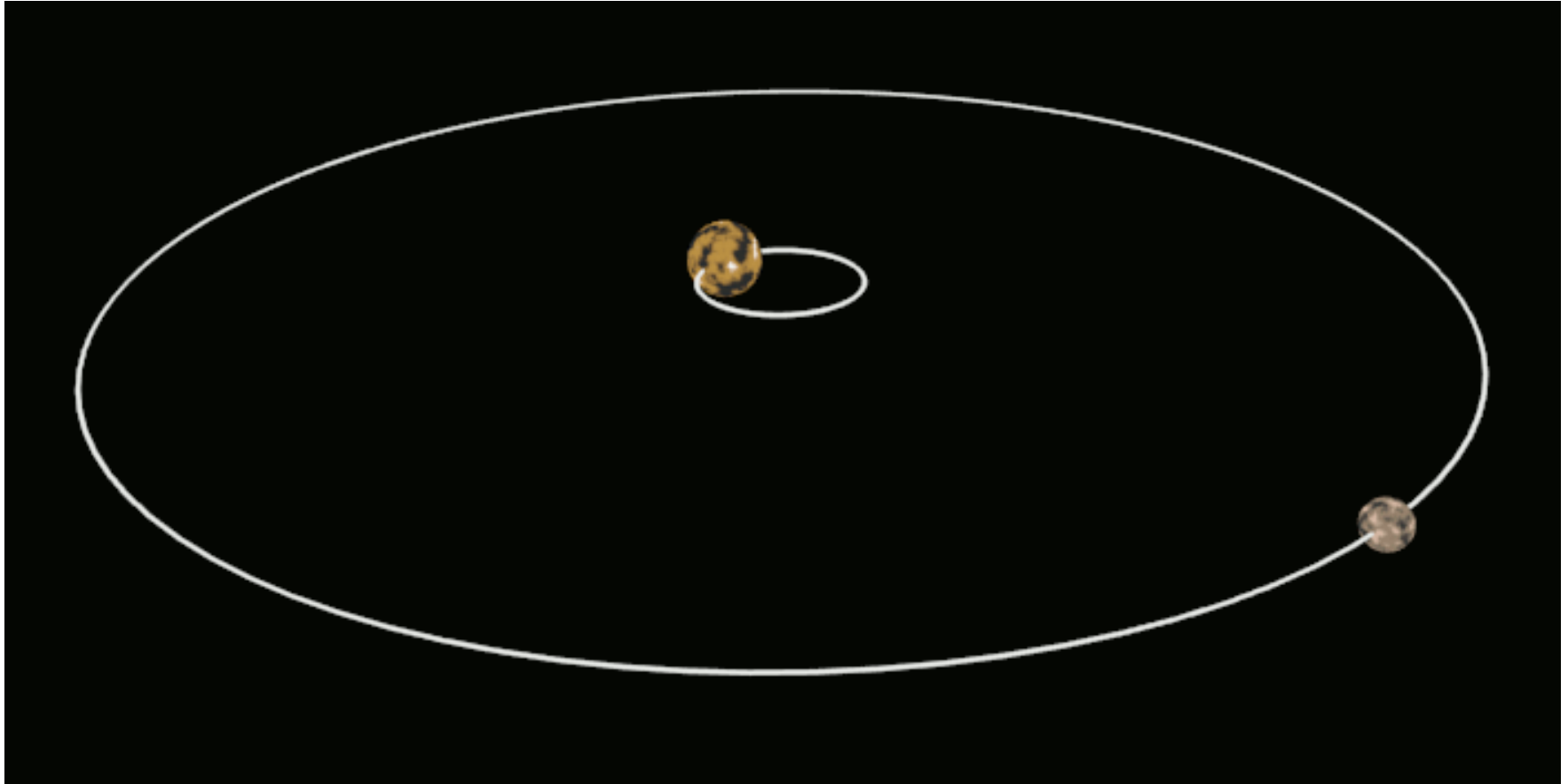
The center of mass between the Earth and the moon is called the **barycenter** (which means center of weight).



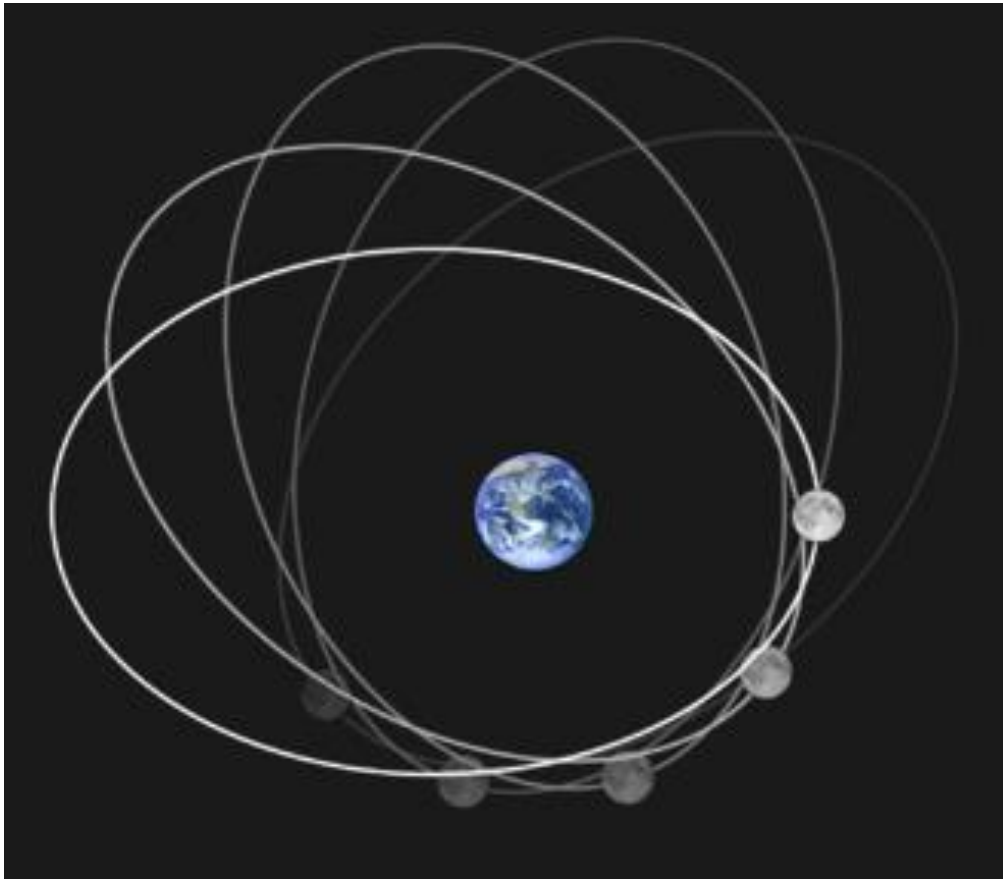
The **barycenter** lies offset from the Earth's geometric center. The Earth wobbles around the barycenter in a smaller circular motion. The moon's center of its orbit lies at the barycenter.



Animation showing the slight circular wobble of a planet as its moon orbits.



The moon's orbit orientation around the Earth slowly processes (migrates in slightly different direction) from year to year. This is called **apsidal procession**.



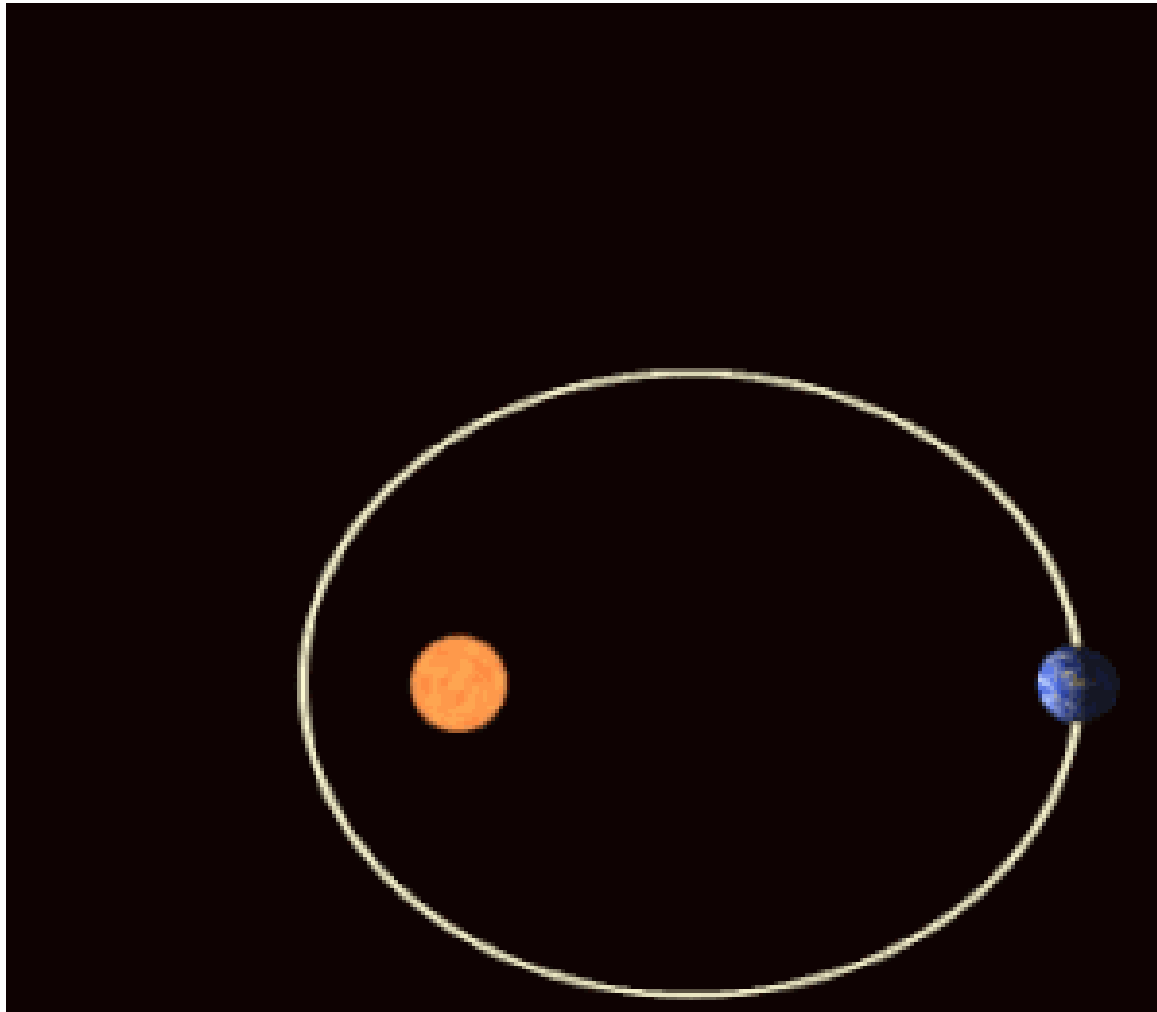
The Earth's tilted on its axis of rotation.

The moon's orbit is not aligned with the Earth's equator.

The moon's orbit is elliptical and the distance between the moon and Earth is constantly changing.



Apsidal procession results when the orbital orientation slightly migrates with time. Notice that the orbit's elliptical shape is constant, but the orientation changes.



Follow up questions.

What is the shape of the moon's orbit?

What happens to the moon because of the shape of its orbit?

What is unique about the shape of the moon?

What does the term synchronous orbit mean?

What does the term tidal lock mean?

What does the term barycenter mean?

What happens to the Earth in its orbit around the sun because of the moon's gravitational attraction?

