

The Solar System: Planets, Moons, and Orbits



- The Solar System: our Sun and everything bound to it by gravity



- Includes the Sun, eight planets, hundreds of moons, and countless asteroids



- The Sun holds 99.86% of the system's total mass



- Learn how planets, moons, and orbits form one connected system

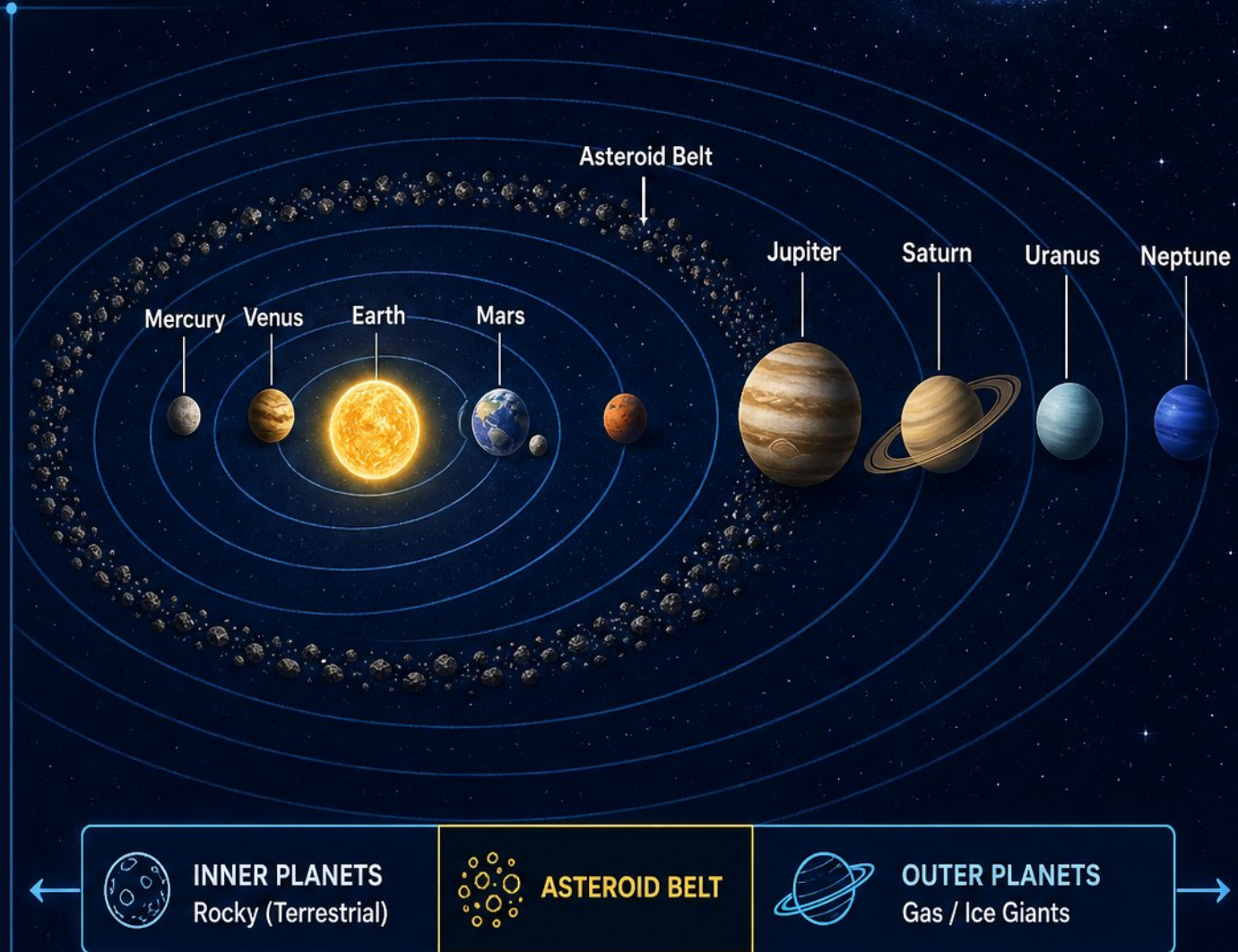


- Build a clear, foundational understanding of our cosmic neighborhood



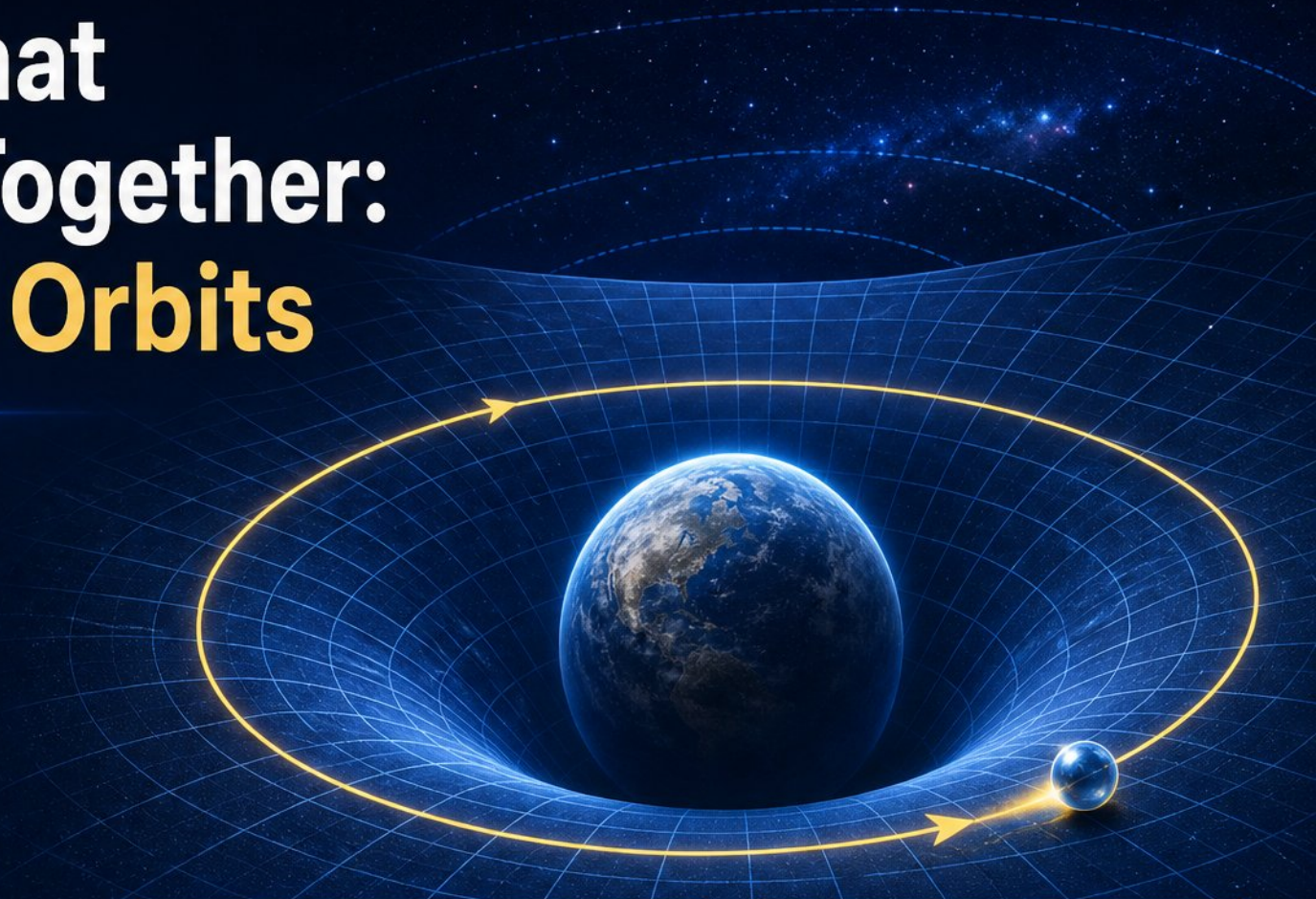
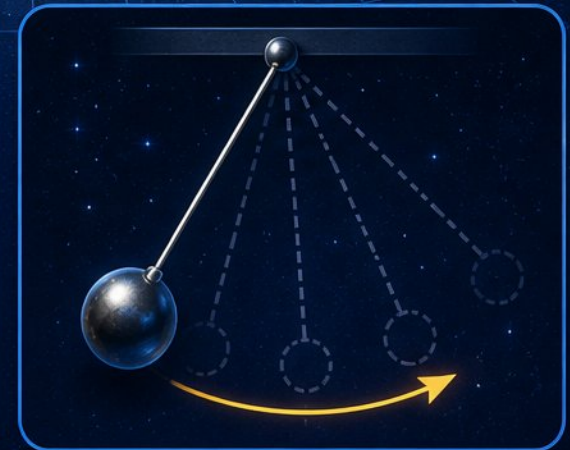
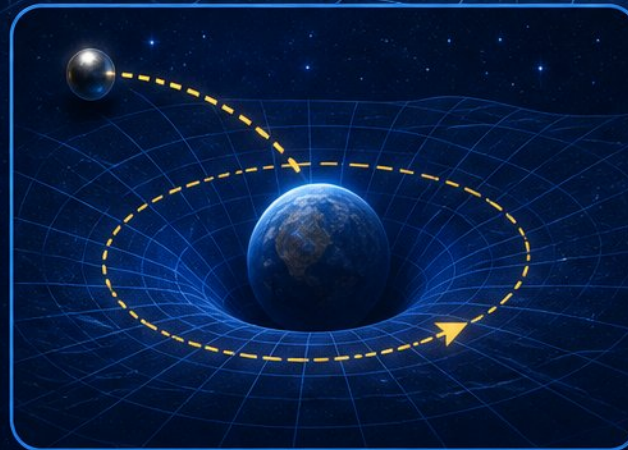
Our Cosmic Neighborhood: A Quick Tour

- The Solar System is in the Milky Way galaxy and formed about 4.6 billion years ago
- One star (the Sun), eight planets, five dwarf planets, hundreds of moons, and countless asteroids and comets
- The Sun contains 99.86% of the total mass and dominates everything with its gravity
- Two main zones: inner rocky terrestrial planets and outer gas/ice giant planets, separated by the asteroid belt



The Force That Holds It All Together: Gravity and Orbits

- Gravity is an attractive force between all objects with mass; stronger with more mass.
- An orbit balances forward motion (inertia) with gravity's inward pull.
- Orbits are elliptical, not perfect circles; objects are in constant free fall.
- Think of a cannonball falling around Earth or a marble curving on stretched fabric.



Meet the Planets: The Eight Worlds in Order



- Eight planets from the Sun: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune.
- Four small, rocky terrestrial inner planets vs. four large gaseous/icy outer planets.
- Key differences: size, composition, distance, temperature, and moon counts.
- Mnemonic: My Very Educated Mother Just Served Us Noodles.

The Sun: Our Local Star and System Anchor



- A 4.6-billion-year-old yellow dwarf star made of hydrogen and helium



- Contains 99.86% of the Solar System's total mass



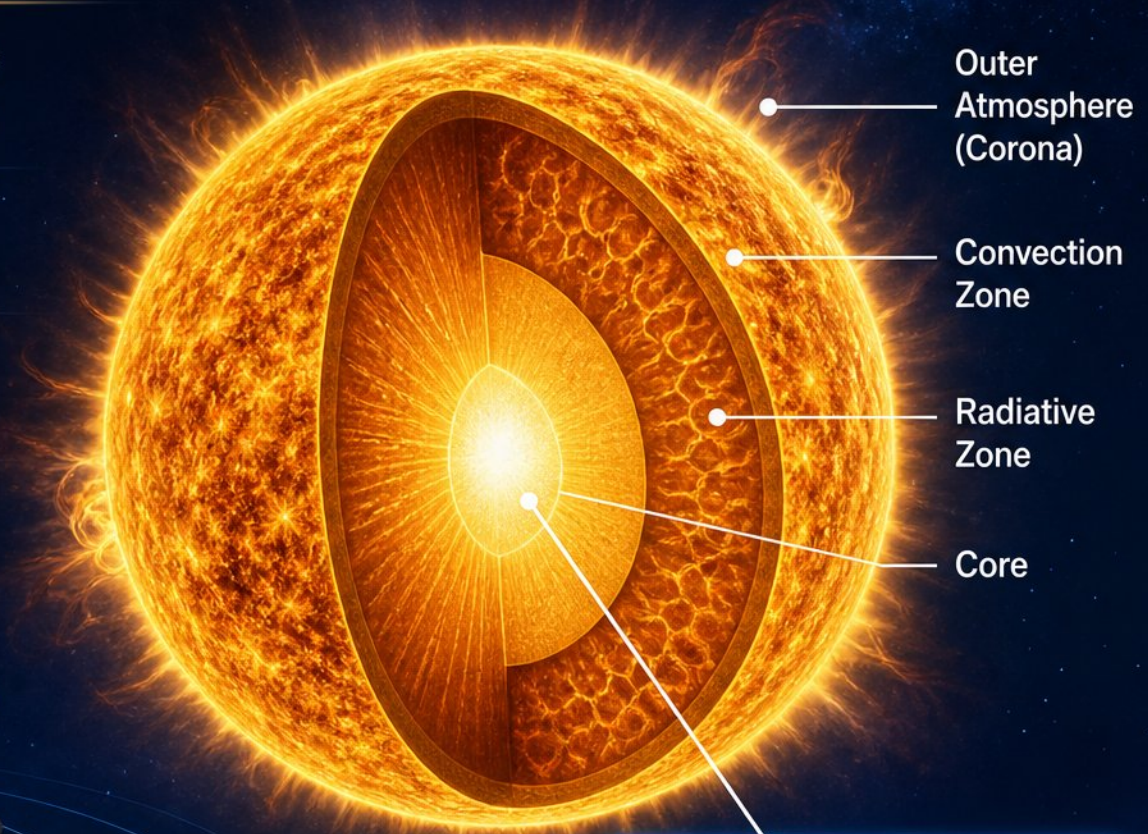
- Gravity keeps all planets, moons, and debris in orbit



- Energy from core nuclear fusion makes life on Earth possible



- Structure: core, radiative zone, convection zone, outer atmosphere



Sun: Central Anchor

CORE NUCLEAR FUSION



Hydrogen nuclei fuse into helium, releasing energy that powers the Sun.

The Inner Rocky Planets: Mercury and Venus

- Mercury: smallest planet, closest to Sun, 0 moons, extreme temperature swings
- Venus: Earth's 'twin' in size, thick toxic CO₂ atmosphere, runaway greenhouse effect
- Both have zero moons due to Sun's pull (Mercury) and slow retrograde rotation (Venus)
- Venus day (243 Earth days) > Venus year (225 days); Sun rises in the west



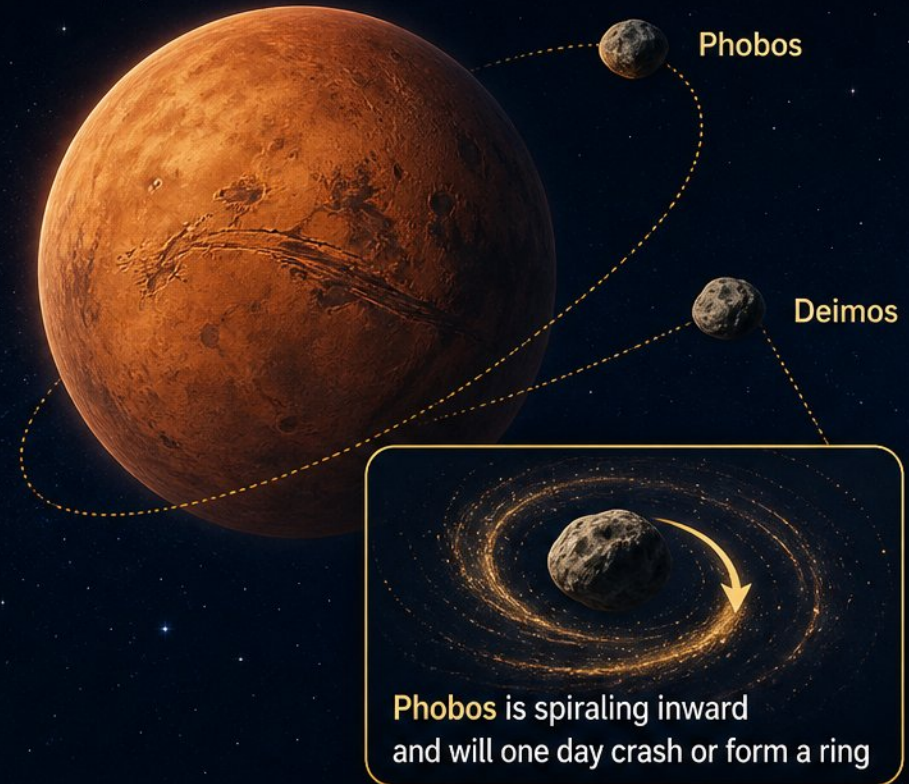
MERCURY



VENUS



The Inner Rocky Planets: **Earth** and **Mars**

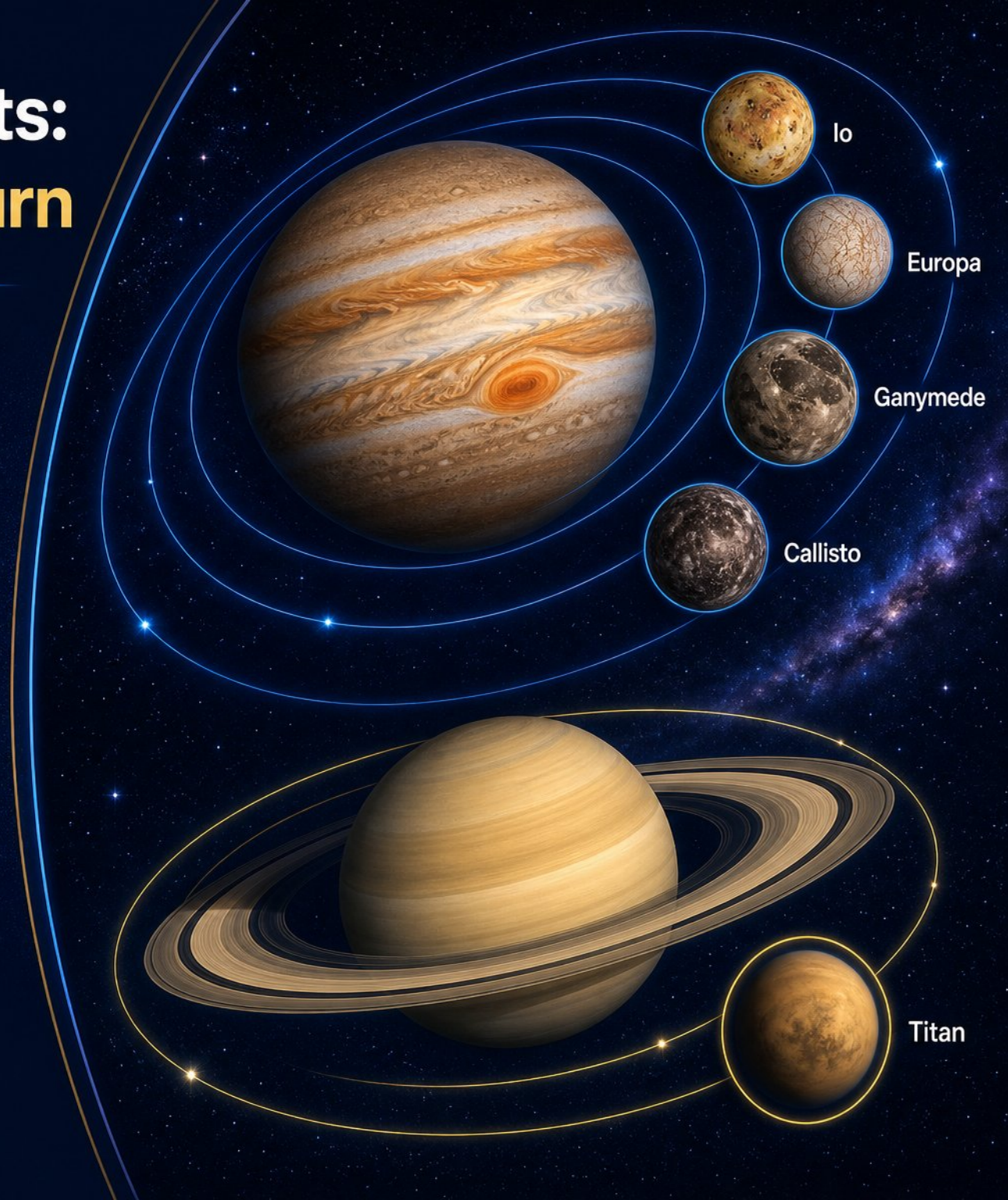


- Earth is the only known planet with liquid surface water and life
- Earth has one large moon formed from a giant impact

- Mars is half Earth's size, with the Solar System's largest volcano
- Mars has two tiny captured-asteroid moons: Phobos and Deimos
- Phobos is spiraling inward and will one day crash or form a ring

The Outer Giants: Jupiter and Saturn

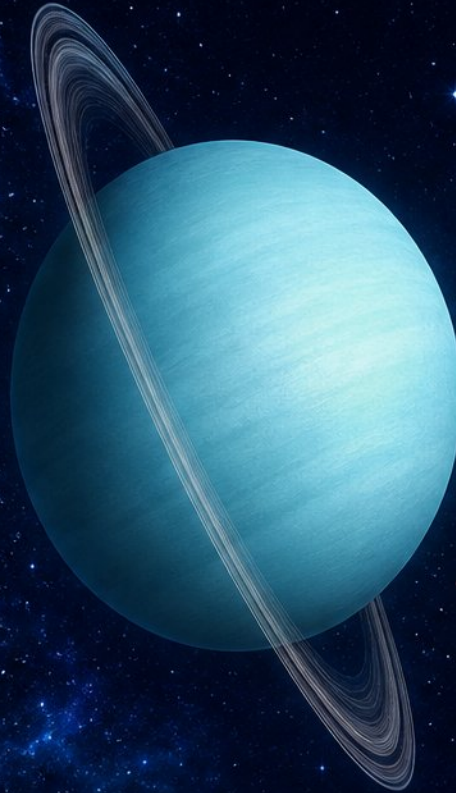
- Jupiter: largest planet, over 300 Earth masses, with Great Red Spot
- Saturn: spectacular ring system, least dense—could float in water
- Jupiter's 101 moons: volcanic Io, ocean-world Europa, giant Ganymede, ancient Callisto
- Saturn leads with 292 moons: Titan has methane lakes and a thick atmosphere



The Outer Giants: Uranus and Neptune

- Uranus and Neptune are ice giants, smaller and denser than Jupiter and Saturn
- Uranus tilts nearly on its side from an ancient collision, with 29 known moons
- Neptune is the windiest planet; its largest moon Triton orbits backward, captured from the Kuiper Belt
- Their blue-green color comes from methane absorbing red light in the atmosphere

URANUS



Uranus tilts nearly on its side, likely caused by an ancient collision.

NEPTUNE



Triton orbits backward, captured from the Kuiper Belt.

Moons: Worlds of Their Own



- A natural satellite that orbits a planet, ranging from tiny captured asteroids to objects larger than Mercury



- Earth's Moon stabilizes our tilt & causes tides; Europa likely has a subsurface ocean



- Titan has methane lakes; Enceladus jets water into space



- Moon counts are dynamic—new telescopes keep discovering small, faint moons



- Outer planets capture many moons with their immense gravity, plus collision debris



EARTH'S MOON



Stabilizes our tilt and causes tides.



EUROPA



Likely has a subsurface ocean.



ENCELADUS



Jets water into space.



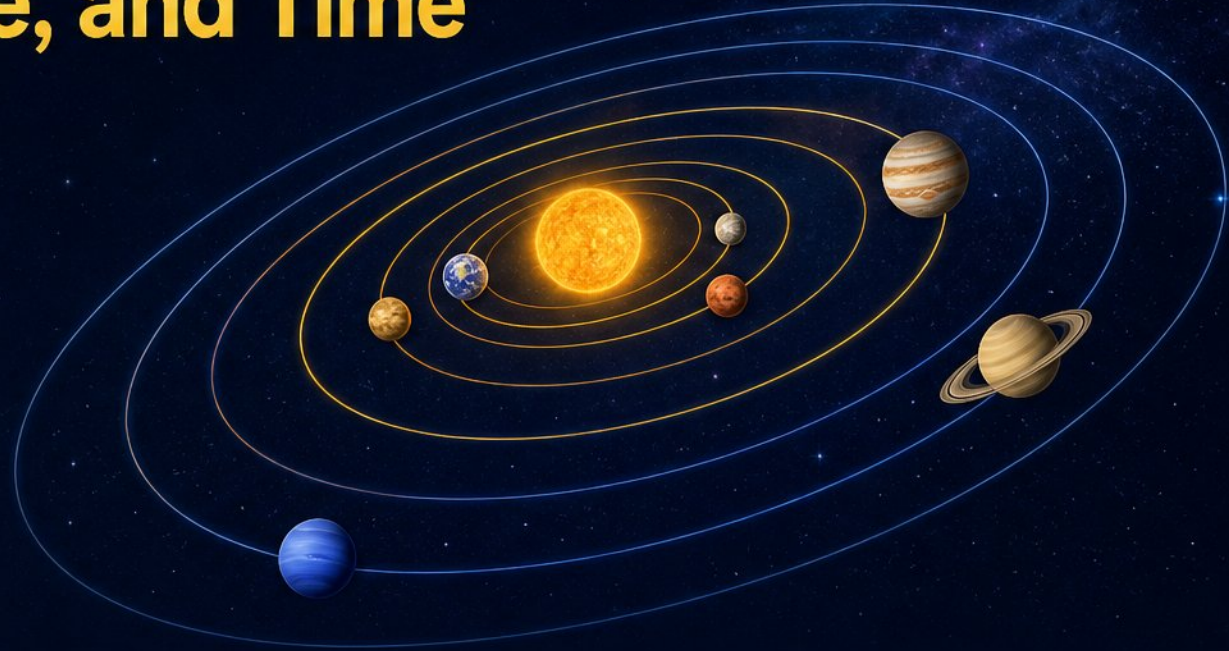
TITAN



Has methane lakes.

How Orbits Work: Speed, Distance, and Time

- **Mercury's year:** 88 Earth days;
Neptune's: 165 Earth years
- **Kepler's laws:** planets speed up
near the Sun; slow down farther out
- **Orbital speed:** Mercury ~48 km/s,
Neptune just ~5.4 km/s
- **Rule:** closer to Sun = faster orbit
needed to balance gravity



Mercury



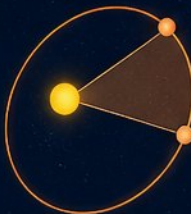
Venus



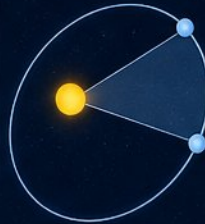
Earth



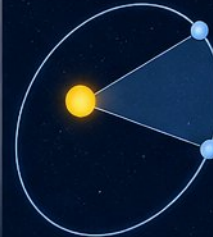
Mars



Jupiter



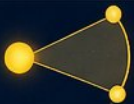
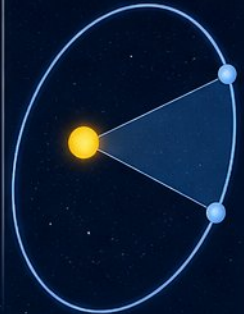
Saturn



Uranus



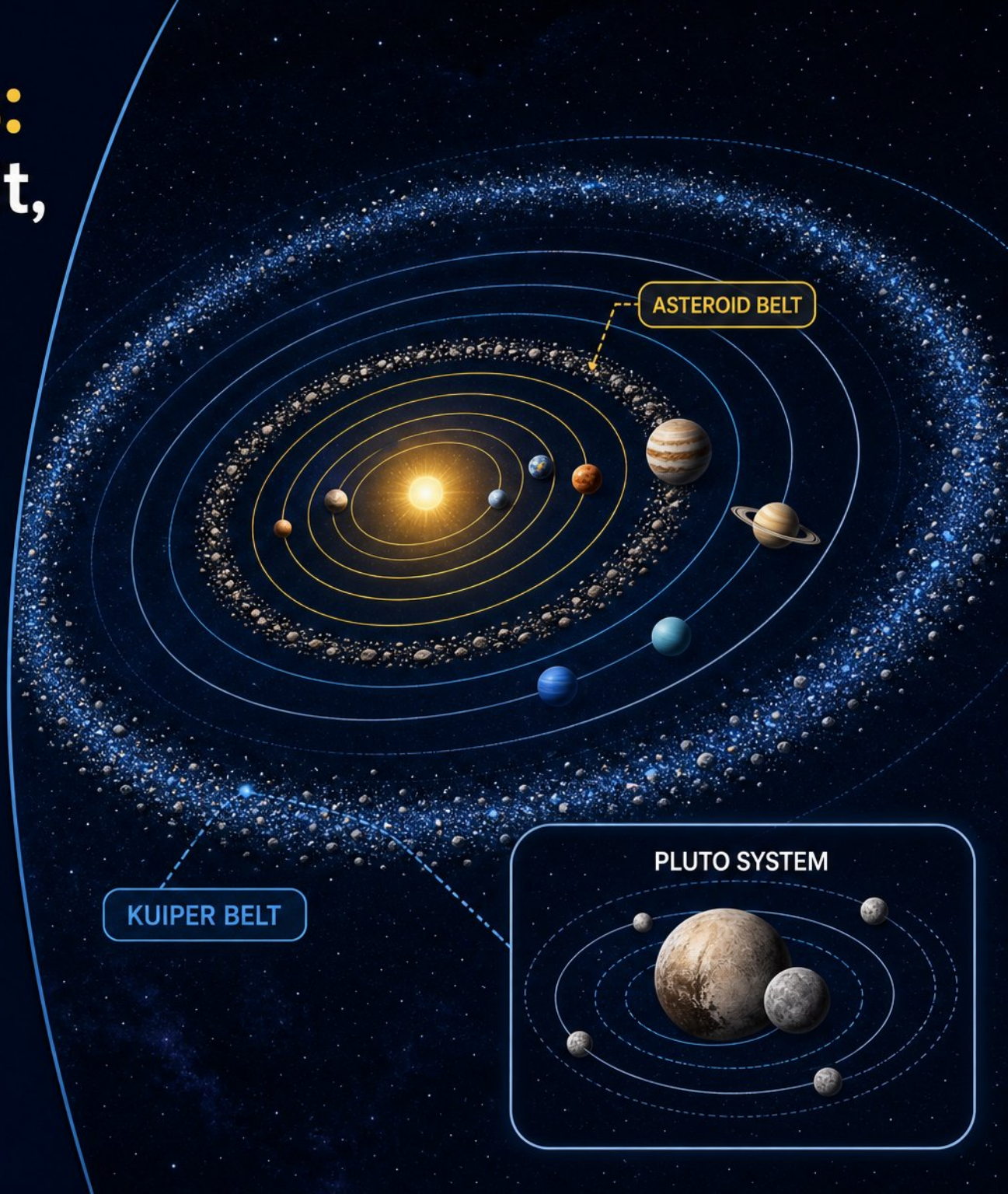
Neptune



Shaded area = equal area
swept in equal time

Nested Orbits: The Asteroid Belt, Kuiper Belt, and Beyond

- Planets orbit the Sun; moons orbit planets: a nested, gravitational hierarchy
- Asteroid Belt between Mars and Jupiter: rocky debris that never formed a planet
- Kuiper Belt beyond Neptune: a distant ring of icy bodies, including Pluto
- Pluto has five moons, proving orbital systems can be multi-layered



Seasons, Tides, and Eclipses: **Orbits in Everyday Life**

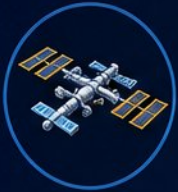
- Axial tilt (23.5°) creates seasons, not distance from Sun
- Moon and Sun gravity pull Earth's oceans, causing tides
- Perfect Sun-Moon-Earth alignment causes solar or lunar eclipses
- Orbital changes over thousands of years influence long-term climate
- Northern summer occurs when North Pole tilts toward the Sun



Human Applications: Satellites and Space Exploration



- Orbits let us place satellites for communication, GPS, and weather monitoring



- Low Earth Orbit suits space stations; geostationary suits TV and weather



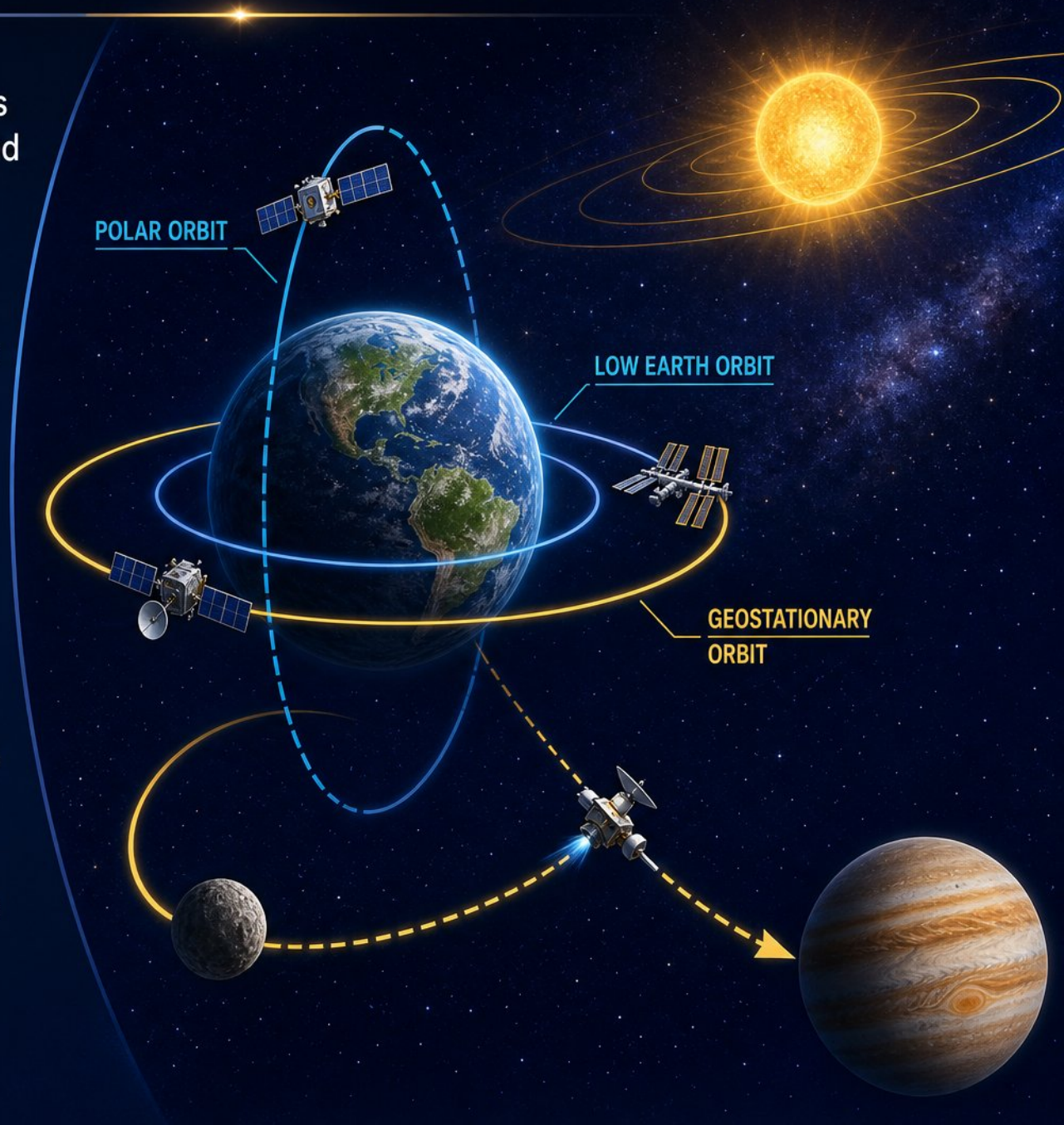
- Polar orbits enable global mapping as Earth rotates beneath



- Gravity assists slingshot spacecraft to distant planets, saving fuel



- Tracking near-Earth objects applies orbital knowledge for planetary defense



Putting It All Together: One Connected System



- Sun's gravity anchors 8 planets, 443+ moons, and billions of asteroids in nested orbits



- Orbital motion explains seasons, tides, and everyday celestial changes



- GPS, satellite communications, and weather forecasts all depend on orbital mechanics



- Moon counts continue to rise; orbits evolve over millions of years



- The night sky is a living laboratory—start by observing the Moon and bright planets



Keep Exploring: Resources and Next Steps



- **Free apps:** Stellarium, Sky Tonight, and Starly for interactive sky maps



- **Top websites:** NASA Solar System Exploration, Space.com, BBC Bitesize



- **Try binoculars:** spot Jupiter's moons, track lunar phases, watch meteor showers



- **No telescope needed**—just curiosity and a dark sky



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