A PHYSICS LESSON

Our Solar System

The Sun, eight planets and many more

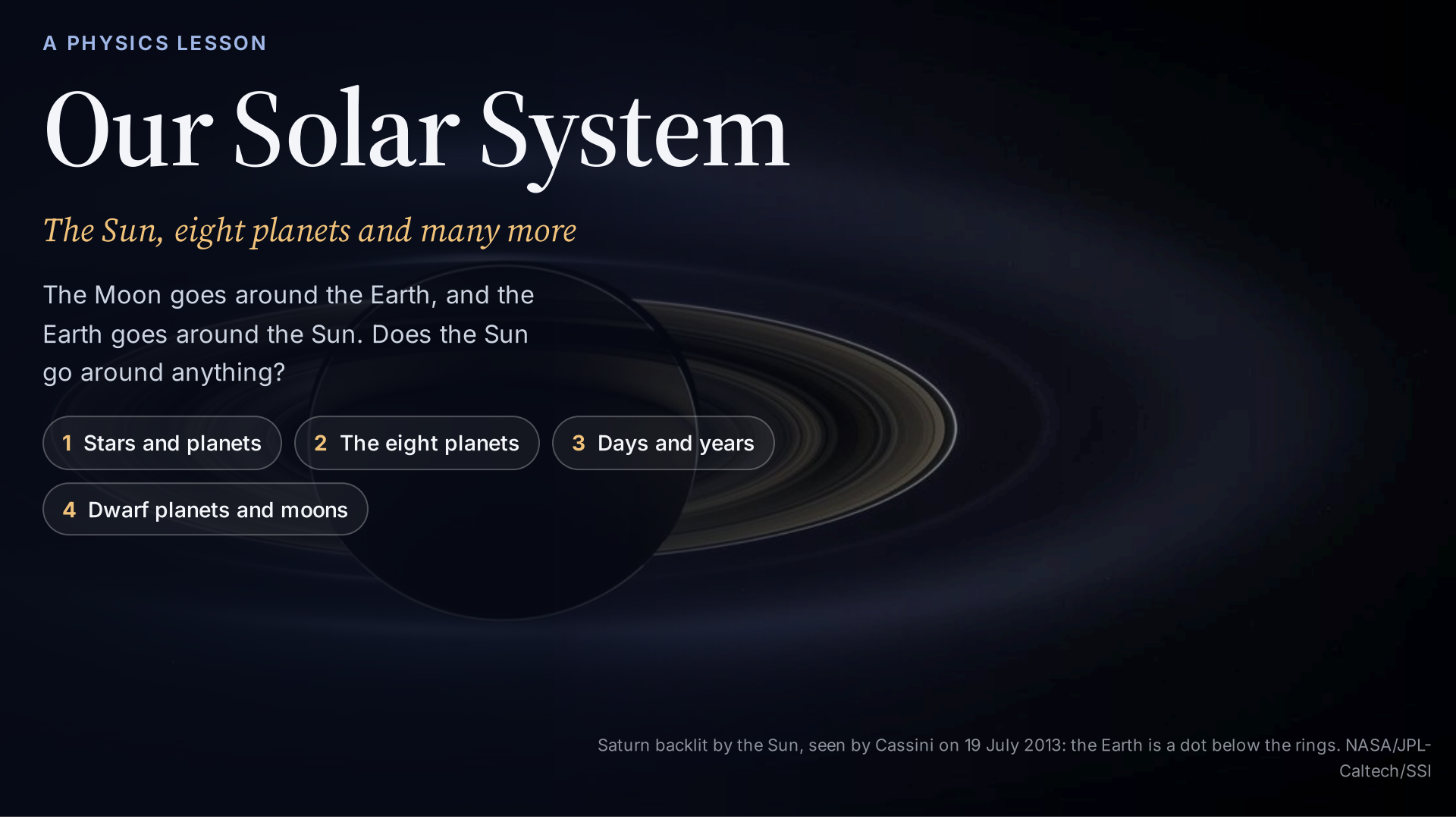
The Moon goes around the Earth, and the Earth goes around the Sun. Does the Sun go around anything?

1 Stars and planets

2 The eight planets

3 Days and years

4 Dwarf planets and moons



Saturn backlit by the Sun, seen by Cassini on 19 July 2013: the Earth is a dot below the rings. NASA/JPL-Caltech/SSI

Heavenly bodies

Everything natural out in space is a **heavenly body**: the Sun, the planets, the Moon, comets, rocks drifting between the planets. Some shine by themselves, others only reflect light.



The Sun

Yes. It is a **star**: a ball of very hot gas that makes its own light and heat.



The Moon

No. It reflects the light of the Sun, like a mirror. Without the Sun, it would be dark.



Venus, very bright at dusk

No. It is a planet: its thick white clouds reflect a lot of sunlight. After the Sun and the Moon, it is the brightest body in our sky.



A star in the night sky

Yes. Every star is a sun, much farther away than ours. That is why it looks like a tiny dot.

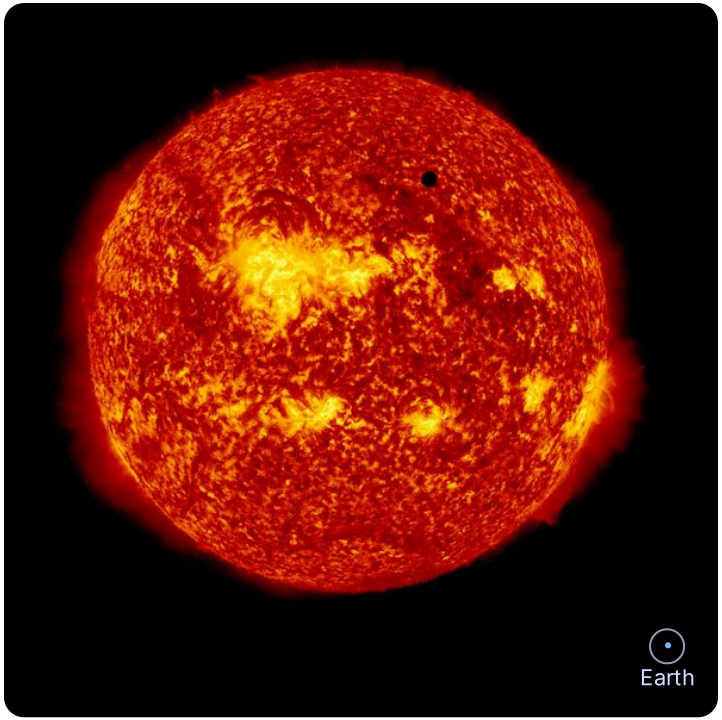
REMEMBER

A **star** shines by itself, thanks to the energy it makes. A **planet** or a **moon** does not: it only reflects the light of a star.

The Sun, our star

The Sun sits at the centre of our system. The **Solar System** is the Sun and everything that travels around it.

- **Made of** very hot gas: out of 100 atoms, 91 are hydrogen and 9 are helium.
- **Size:** 1,390,000 km across, as wide as 109 Earths side by side.
- **Temperature:** about 5,500 °C at the surface and 15 million °C at the centre.
- **It spins** on itself in about 25 days.
- **It travels too.** With all its planets, it goes around the centre of our galaxy, the Milky Way, once every 230 million years.



The Sun in ultraviolet light, seen by NASA's SDO on 5 June 2012: the small black disc is Venus passing in front of it. Bottom right, circled: the Earth, at the same scale as the Sun. NASA/SDO

What makes a planet?

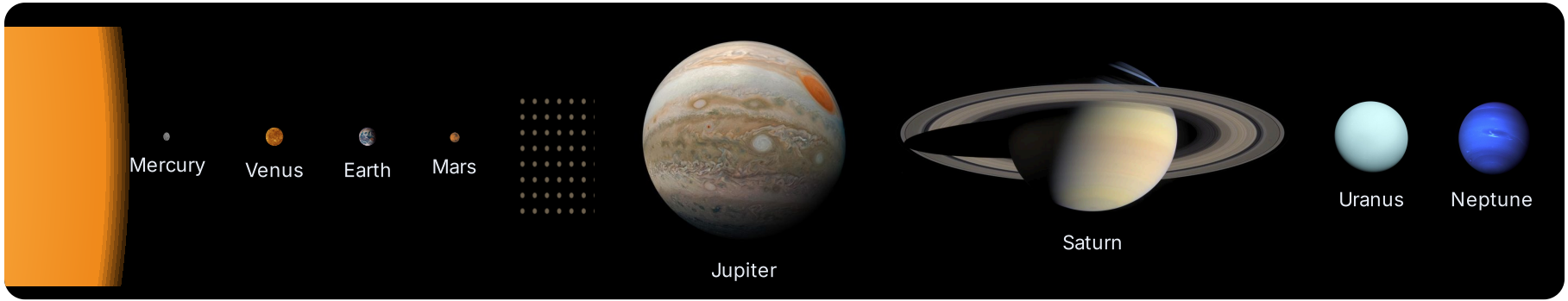
Since 2006, astronomers agree that a **planet** is a body that ticks all four boxes:

1. It travels around a **star**.
2. It is round like a **ball**: it is heavy enough for its own gravity to make it round.
3. It does **not shine** by itself.
4. It is **alone** on its orbit: no other planet shares its path.

> A planet can have **moons** going around it. They do not count as planets, since they travel around a planet rather than around a star.

The order of the planets

Going out from the Sun: Mercury, Venus, Earth, Mars, then the asteroid belt, then Jupiter, Saturn, Uranus and Neptune.



The planets and, on the left, the edge of the Sun, all at the same scale. NASA photos; Jupiter: Kevin M. Gill (CC BY), from NASA/JPL-Caltech/SwRI/MSSS.

TO REMEMBER THE ORDER

Four small rocky planets, then the **asteroid belt**, then **four giants**. The Earth is the third planet from the Sun, Jupiter the fifth and the biggest, Neptune the eighth and the last.

The sizes are to scale with each other, but not the distances: the real gaps are far too big for the page. The next slides show them.

Two families of planets

The rocky planets

Mercury, Venus, Earth, Mars



- Made of rock and metal.
- A **solid surface** you could stand on.
- Small, and close to the Sun.
- Few moons, or none.

The giant planets

Jupiter, Saturn, Uranus, Neptune



- Made mostly of **gas**: no solid surface.
- Huge: together they hold more than 99 % of the mass that goes around the Sun.
- Far from the Sun, and cold.
- Rings, and many moons.

The **asteroid belt**, between Mars and Jupiter, separates the two families. An asteroid is a small rocky body, often shaped like a potato, that goes around the Sun.

The astronomical unit

Distances in space are so big that kilometres get clumsy. Astronomers use the **astronomical unit** (AU): the distance from the Earth to the Sun.

1 AU ≈ 150 million km (exactly 149,597,870,700 m)



Mercury is at 0.4 AU, Venus at 0.7 AU, the Earth at 1 AU and Mars at 1.5 AU: the four rocky planets are crowded close to the Sun. Neptune is 30 times farther than the Earth.

> Light, the fastest thing there is, takes about 8 minutes to travel 1 AU, and 4 hours to reach Neptune.

The rocky planets, one by one

	 Mercury	 Venus	 Earth	 Mars
Diameter	4 879 km	12 104 km	12 756 km	6 792 km
Day (spin)	58.6 days	243 days	23 h 56 min	24 h 37 min
Year (around the Sun)	88 days	225 days	365.26 days	1.88 years
Temperature	430 °C by day, −180 °C at night	464 °C	15 °C	−65 °C
From the Sun	0.4 AU	0.7 AU	1 AU	1.5 AU
Moons	0	0	1 (the Moon)	2 (Phobos, Deimos)

- **Mercury** has almost no air to hold the heat: scorching by day, freezing at night.
- **Venus**, Earth's "sister", is about the same size, but hidden under thick clouds of carbon dioxide.
- **Earth**, the "blue planet", is the only one with liquid water at its surface.
- **Mars**, the "red planet", owes its colour to iron oxide, that is, rust, in its soil.

Photos: NASA/JHUAPL (Mercury), NASA/JPL (Venus: a radar image from Magellan, the clouds hide the ground), NASA/GSFC (Earth), NASA/JPL/USGS (Mars).

The giant planets, one by one

	 Jupiter	 Saturn	 Uranus	 Neptune
Diameter	142 984 km	120 536 km	51 118 km	49 528 km
Day (spin)	9 h 55 min	10 h 39 min	17 h 14 min	16 h 07 min
Year (around the Sun)	11.9 years	29.4 years	84 years	165 years
Temperature	−110 °C	−140 °C	−195 °C	−200 °C
From the Sun	5 AU	10 AU	19 AU	30 AU
Moons	95	274, the record	28	16

- **Jupiter** is the biggest planet. Its Great Red Spot is a storm wider than the Earth.
- **Saturn** has the most beautiful rings, made of ice and rock: a small telescope shows them.
- **Uranus** lies on its side: its axis is tilted by 98°, so it rolls around the Sun.
- **Neptune**, blue because of the methane in its air, was found in 1846 by calculation before anyone saw it.

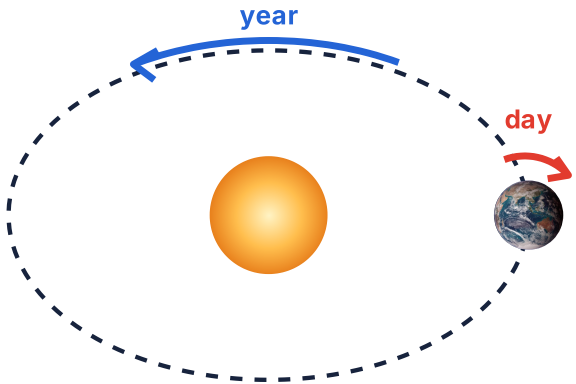
Numbers from NASA's planetary fact sheets. New small moons of the giant planets are found every year, so the counts keep growing: older books give smaller numbers. Photos: Kevin M. Gill (CC BY), from NASA/JPL-Caltech/SwRI/MSSS (Jupiter); NASA/JPL/Space Science Institute (Saturn); NASA/JPL-Caltech (Uranus, Neptune).

Spinning and going around

A planet does two things at once:

- **Rotation:** it spins on itself. One turn is a **day**.
- **Revolution:** it travels around the Sun. One trip is a **year**.

> **? Which planet has a day longer than its year?**
>
> **Venus.** It spins very slowly: one turn takes 243 Earth days, but it goes around the Sun in only 225.

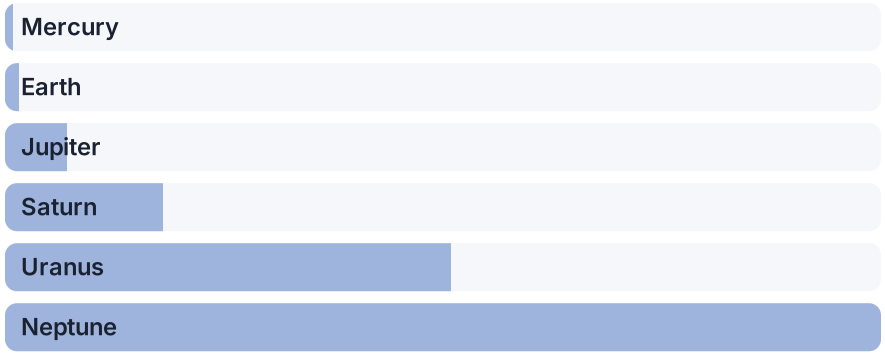


What the tables show

Read the tables from the closest planet to the farthest. Two patterns appear.

1. The farther, the longer the year

Mercury goes around in 88 days, Neptune in 165 years. A far planet has a much longer path, and it also moves more slowly, since the Sun pulls it less.



2. The farther, the colder… except Venus

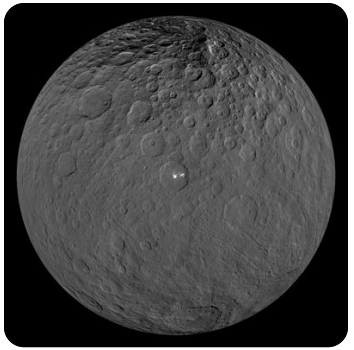
Far from the Sun, a planet gets less heat: Neptune is at −200 °C. But Venus, farther than Mercury, is the hottest planet: 464 °C. Its thick air of carbon dioxide traps the heat like a blanket. This is the **greenhouse effect**.

Dwarf planets and small bodies

A **dwarf planet** goes around the Sun and is round, but it is not alone on its orbit: it shares its path with many other small bodies.

Five are officially recognised: **Ceres**, in the asteroid belt, then **Pluto**, **Eris**, **Makemake** and **Haumea**, beyond Neptune.

Everything else that goes around the Sun, neither a planet nor a dwarf planet, is a **small body**: asteroids, comets…



Ceres, seen by NASA's Dawn probe NASA/JPL-Caltech/UCLA/MPS/DLR/IDA



Pluto, seen by New Horizons in 2015 NASA/JHUAPL/SwRI

PLUTO, DEMOTED

Until 2006, Pluto was the ninth planet. That August, in Prague, the International Astronomical Union wrote the definition of a planet, and Pluto, which shares its orbit, became a dwarf planet.

Natural moons

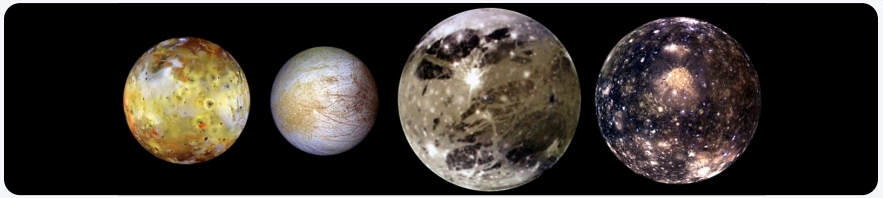
A **moon** (a natural satellite) is a body that goes around another body that is not a star: a planet or a dwarf planet.



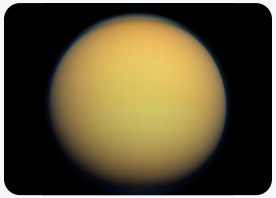
The Moon
Earth NASA/GSFC



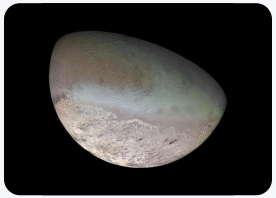
Phobos (and Deimos)
Mars
NASA/JPL-Caltech/UA



Io, Europa, Ganymede, Callisto
Jupiter, at one scale NASA/JPL/DLR



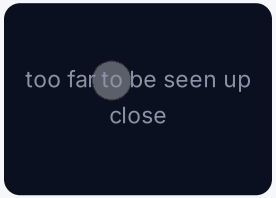
Titan
Saturn, the biggest of its moons
NASA/JPL-Caltech/SSI



Triton
Neptune NASA/JPL/USGS



Charon
Pluto NASA/JHUAPL/SwRI



Dysnomia
Eris

> Jupiter's four big moons were found by Galileo in 1610: with a small telescope, you can see them too, lined up next to the planet.

REVIEW

Test yourself

1 **Name the four giant planets.**

Jupiter, Saturn, Uranus and Neptune.

2 **The planets from smallest to biggest?**

Mercury, Mars, Venus, Earth, Neptune, Uranus, Saturn, Jupiter.

3 **Which planet has the shortest year? The longest?**

Mercury (88 days), the closest; Neptune (165 years), the farthest.

4 **Which is the hottest planet, and why?**

Venus: its thick carbon dioxide air traps the heat (greenhouse effect).

5 **Titan, Ceres, Ida, the Sun: what kind of body is each one?**

Titan: a moon of Saturn. Ceres: a dwarf planet. Ida: an asteroid. The Sun: a star.

6 **How far is 1 astronomical unit?**

The distance from the Earth to the Sun: about 150 million km.

TO SUM UP

The big ideas

1. The Sun is a **star**; the planets and the moons only reflect its light.
2. Eight planets in two families: four **rocky**, four **giants**, with the asteroid belt between them.
3. A **day** is one spin, a **year** one trip around the Sun; the farther the planet, the longer its year.

Go further

▶ The Solar System in Motion | What Is an Orbit? | Practise in the Practice Room

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