

An artist's conception of a newborn planet  
embedded in the dust around a young star  
(NASA/JPL-Caltech/R. Hurt).

# **THE SUN'S PLACE IN THE SOLAR SYSTEM**

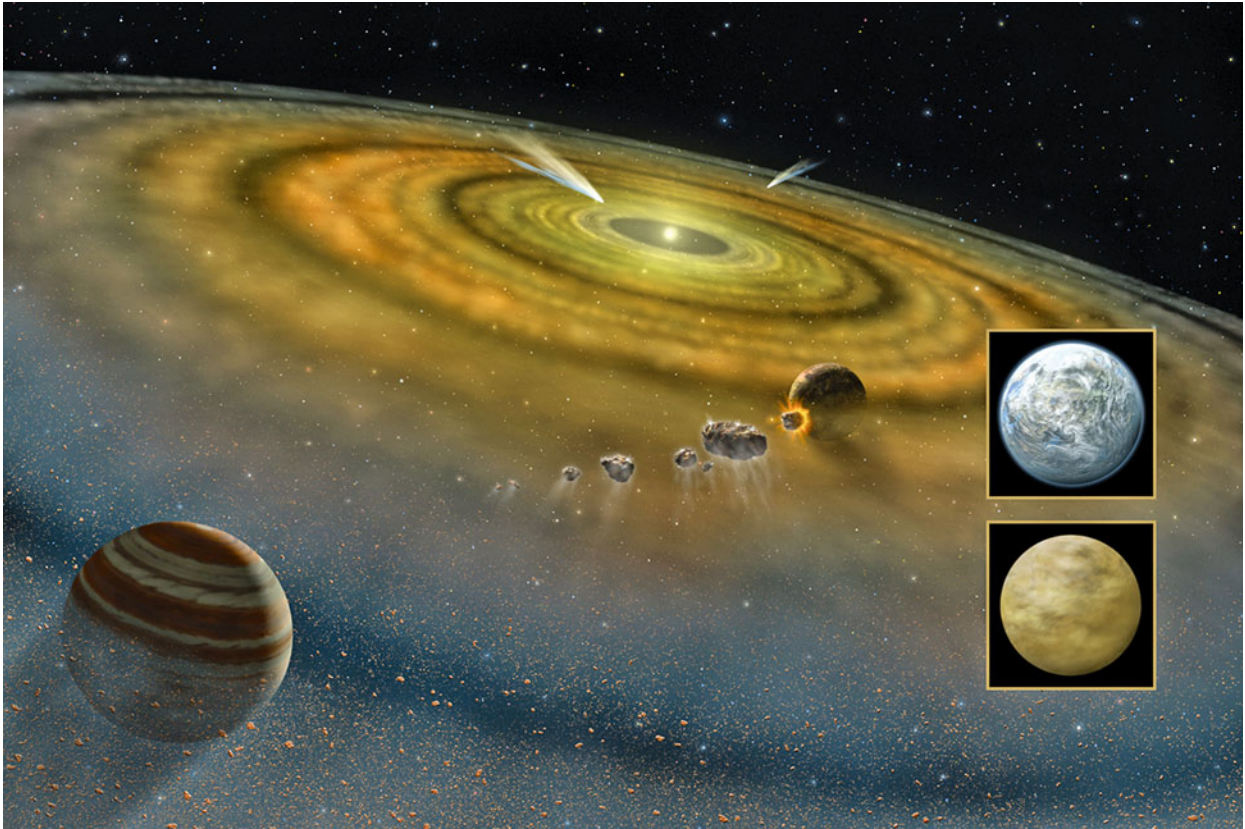


Illustration showing what our newborn Solar System might have looked like (NASA/FUSE/Lynette Cook).

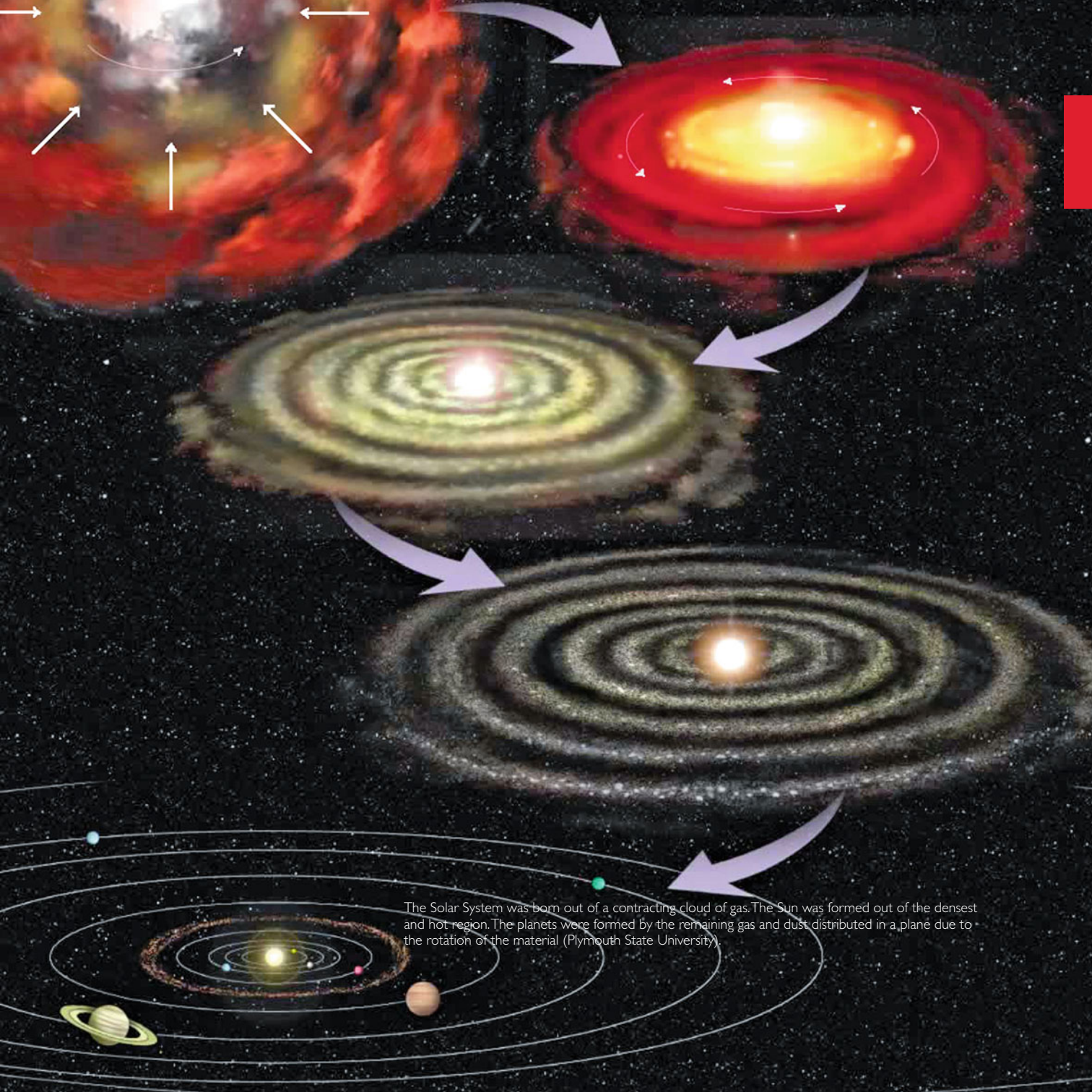
## OUR SOLAR SYSTEM IS BORN

**T**HE SOLAR SYSTEM was born about 4.5 billion years ago. Astronomers believe the Sun and the planets were created from a collapsing cloud of dust and gas.

An exploding star, likely a nearby supernova, made the cloud of gas contract. As the gas contracted more and more due to increased gravitational forces, it got warmer. At some point, nuclear reactions

ignited in the central part and a new star was born. Further away from the star, gas and dust were also collapsing, and these smaller clumps later became the planets, moons, comets, and asteroids.



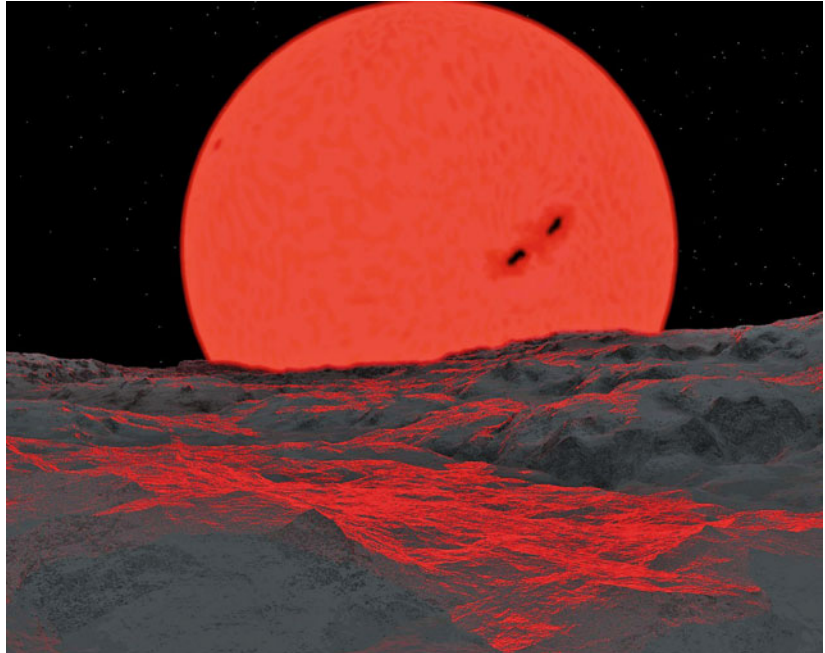


The Solar System was born out of a contracting cloud of gas. The Sun was formed out of the densest and hot region. The planets were formed by the remaining gas and dust distributed in a plane due to the rotation of the material (Plymouth State University).

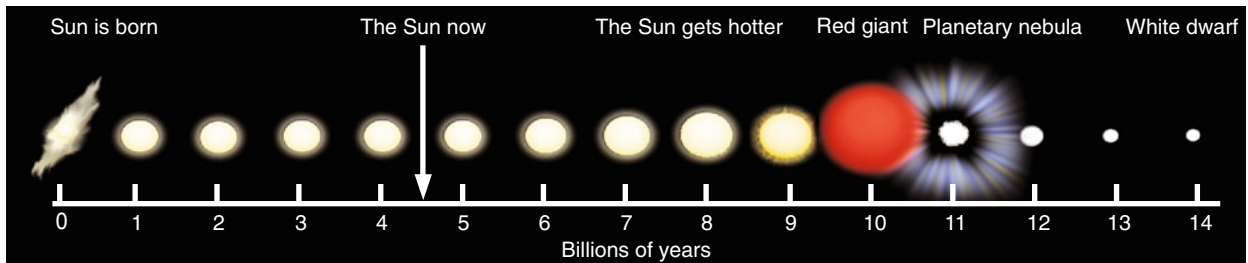
# THE LIFE SPAN OF THE SUN

**T**HE SUN IS 4.5 BILLION YEARS old and born out of a cloud of gas. The cloud contracted, and when the pressure and temperature in the central part got high enough, the nuclear reactions started and the Sun was born.

In the next 5 billion years, more and more of the “fuel” hydrogen will be converted to helium, and the temperature of the Sun will increase. When all the hydrogen is spent, the Sun will expand to a red giant and swallow Mercury, Venus, and maybe also Earth. It will be 250 times bigger than today. Then the Sun will eject its outer layers and lose mass. The ejected gas will form a planetary nebula around the remaining hot core, which will then be called a white dwarf. It will be just the size of Earth and will slowly cool down and eventually fade out over the following billion years. This is a typical lifespan for relatively small stars such as the Sun.

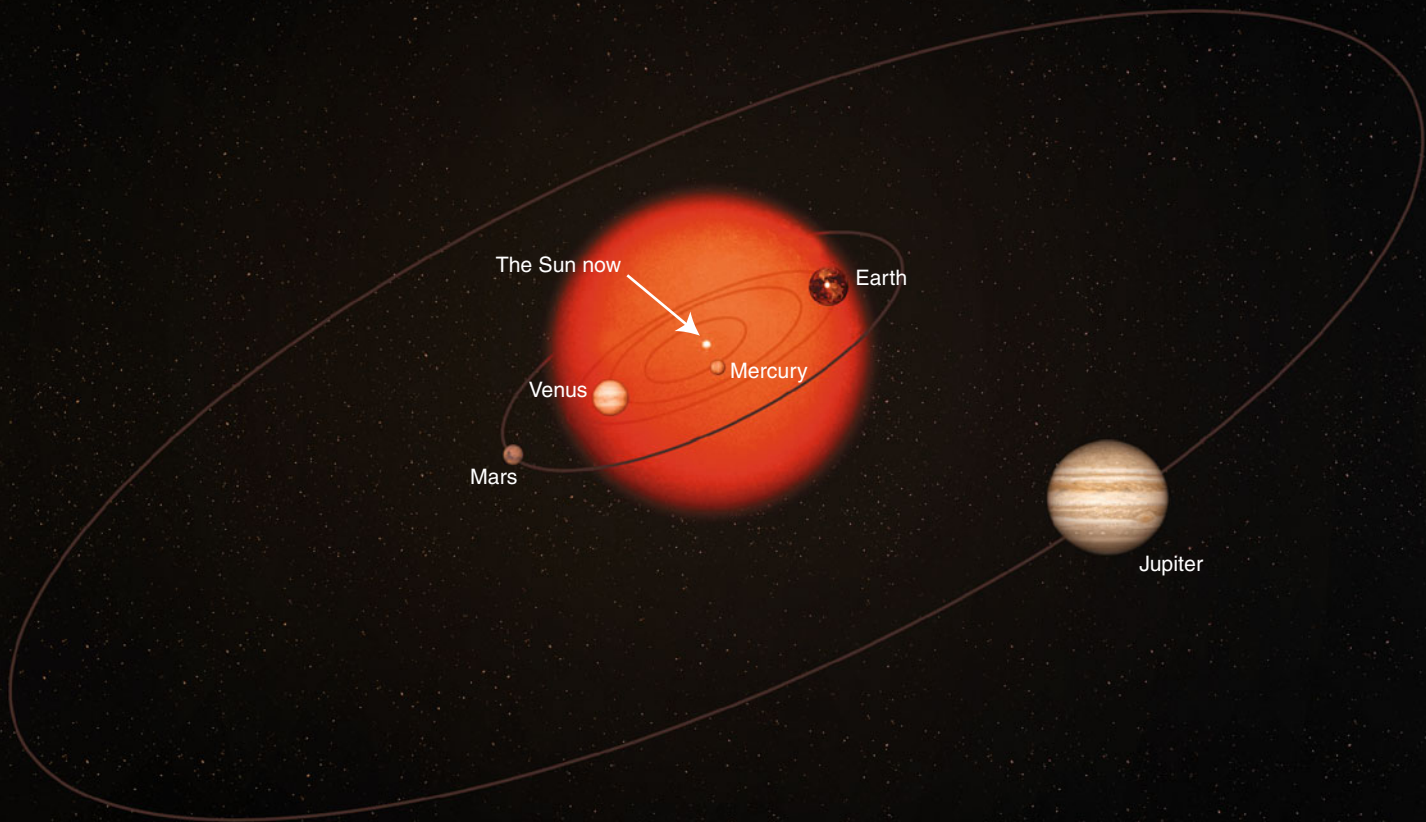


Artist's concept of what we think a rapidly growing Sun would look like from an already extinct Earth (J. Bryant).



The life cycle of the Sun through 14 billion years (T. Abrahamsen/ARS).





The Sun will expand and swallow Mercury, Venus, and maybe also Earth in about 5 billion years (T. Abrahamsen/ARS).

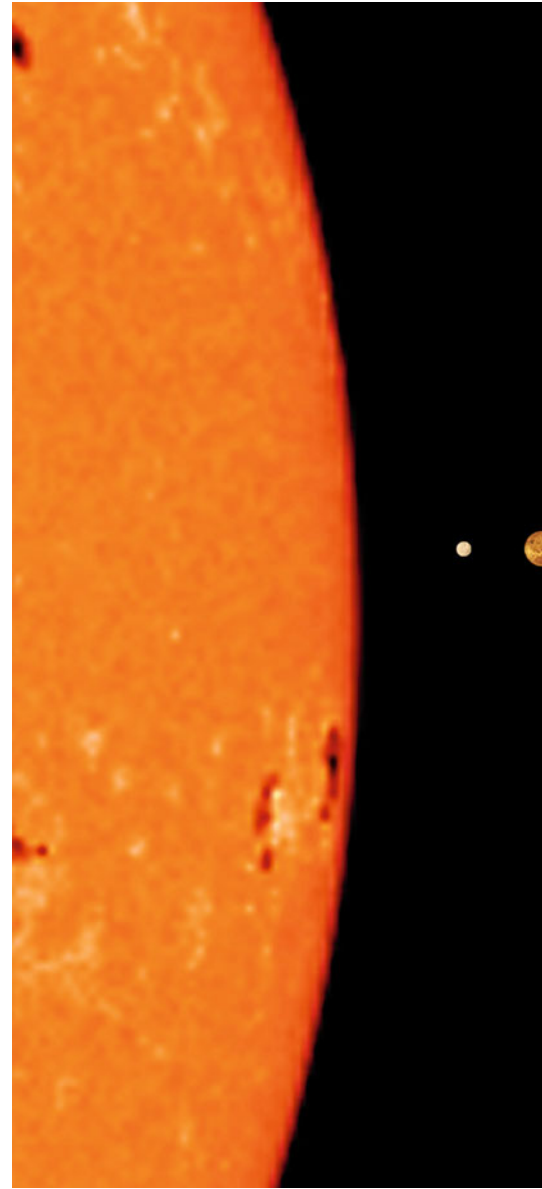
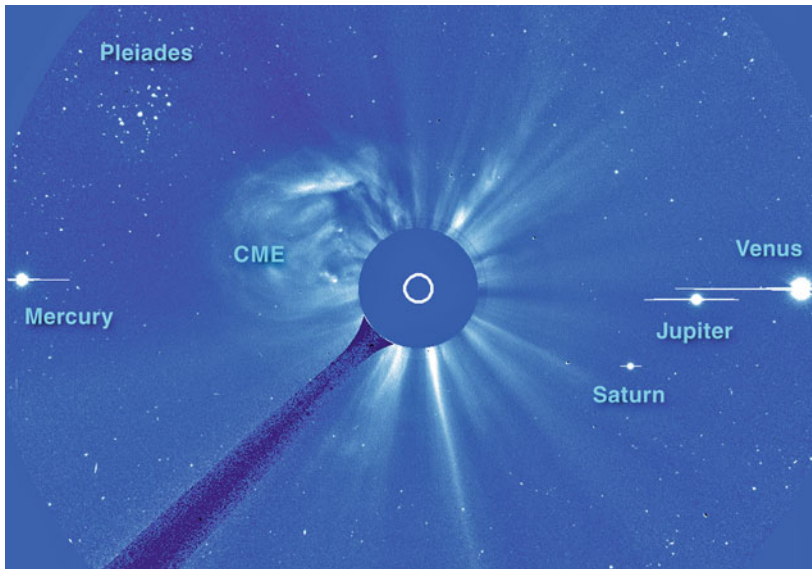


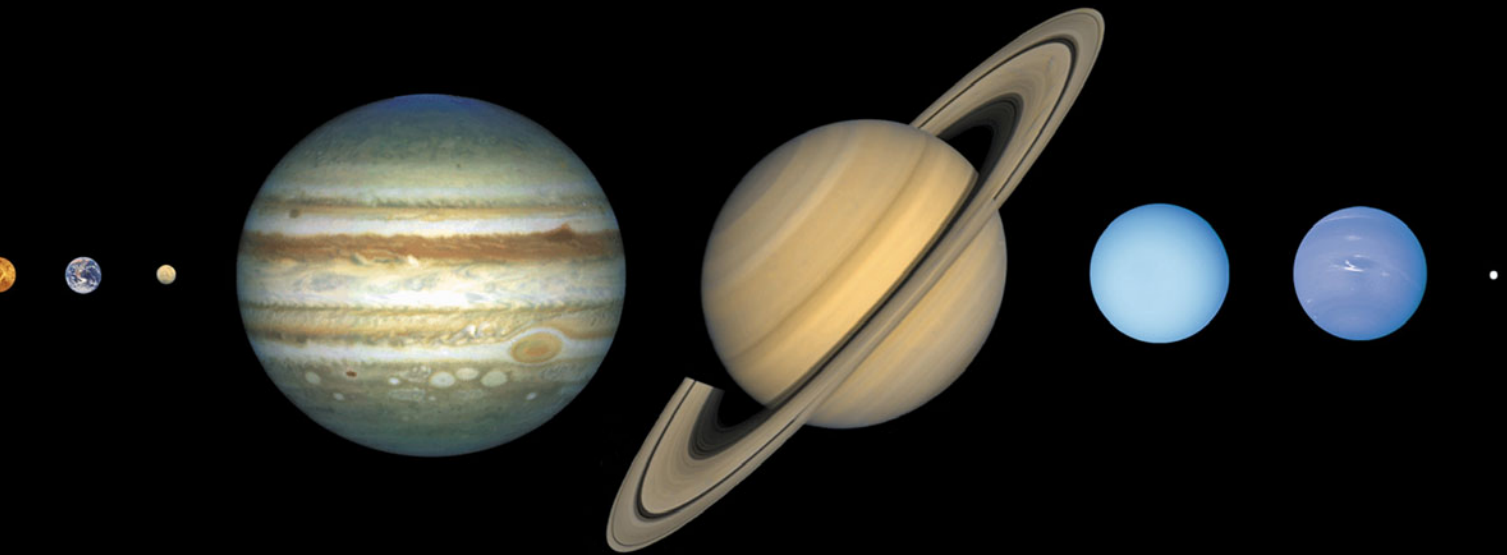
# THE SOLAR SYSTEM

**T**HE SUN IS THE CENTER of the Solar System and also the largest object, containing more than 99.8% of the total mass of the Solar System. The eight planets rotate around the Sun in separate orbits, kept in place by gravitational forces from the Sun. In addition, there are billions of other objects orbiting such as asteroids, comets, moons, and dwarf planets.

The four inner planets – Mercury, Venus, Earth, and Mars – are called the rocky planets and are all relatively small. Further out are the big gaseous planets – Jupiter, Saturn, Uranus, and Neptune. Outside Neptune is the small and strange dwarf planet Pluto. Pluto was earlier regarded as a planet but was reclassified as a dwarf planet.

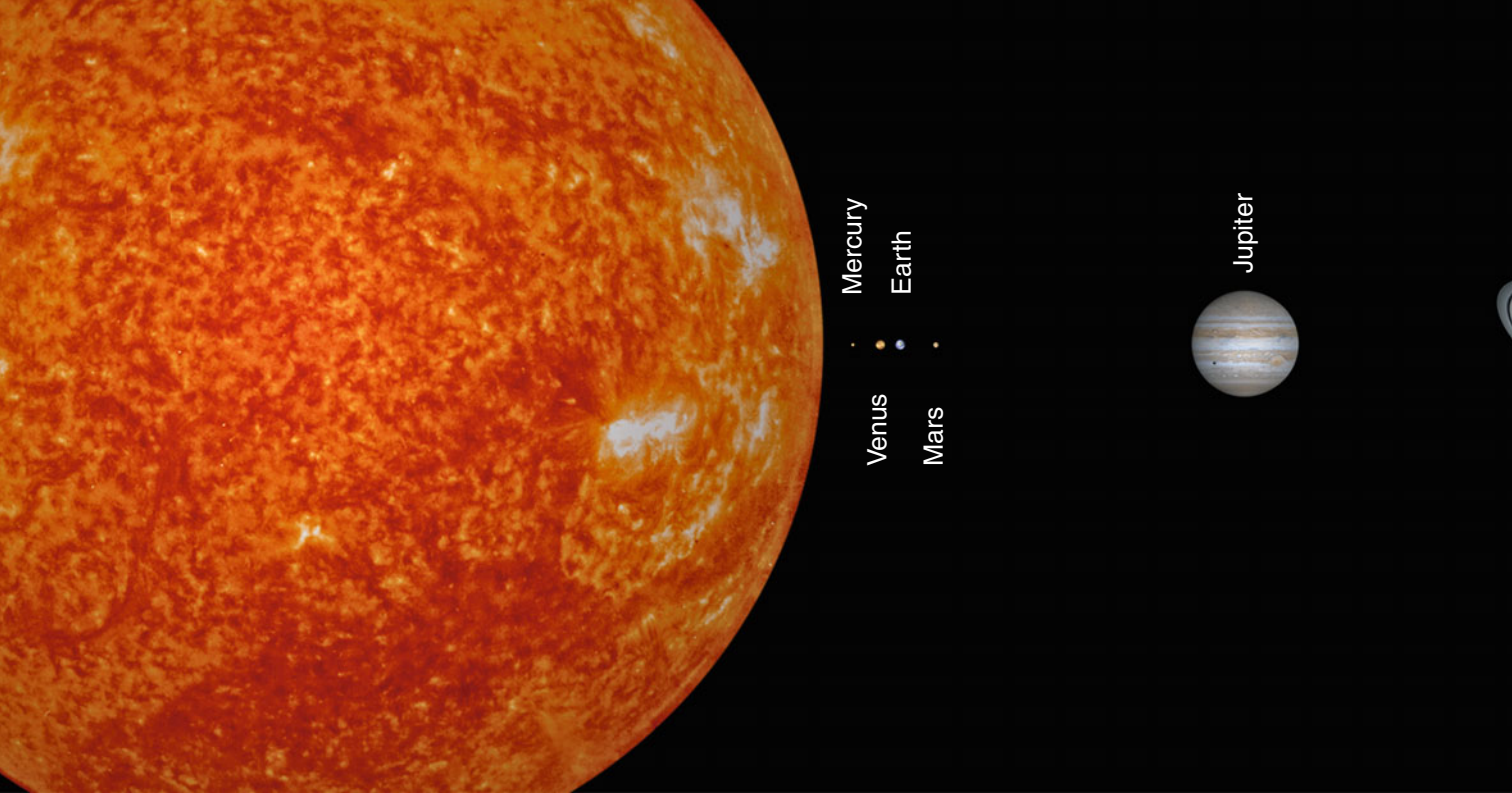
A unique image of the planets close to the Sun observed with the LASCO-telescope on SOHO. An occulting disk inside the telescope blocks the bright light from the solar disk creating an artificial solar eclipse. Mercury, Venus, Jupiter, Saturn, and the Pleiades are visible. Just outside the occulting disk one can see enormous ejections of gas from the hidden Sun. The horizontal strikes from the planets are artifacts from the digital camera (ESA/NASA).





The Sun and the planets, size to scale. The distance between them is not to scale (NASA).





The Sun and the eight planets (D. Jarvis).

## THE SIZE OF THE SOLAR SYSTEM

**T**O BETTER UNDERSTAND the enormous sizes in the Solar System, one can construct a model reduced by a factor of 1:10,000,000,000 (10 billion times smaller). In this scale, Earth would be 1.3 mm in diameter, the size of a needle head. The Moon would orbit 4 cm from Earth. The Sun would be the size of a

grapefruit. If you hold up “Earth” and a friend holds up the “Sun,” he or she has to stand 15 m away from you to get the scale right.

In such a model, Jupiter would be 1.5 cm in diameter and about 75 m from the “Sun.” Saturn would be 150 m away and Uranus and Neptune 300 and

450 m, respectively. The closest star would still be 4,400 km from your Sun, about the distance between New York City and Los Angeles.

Saturn



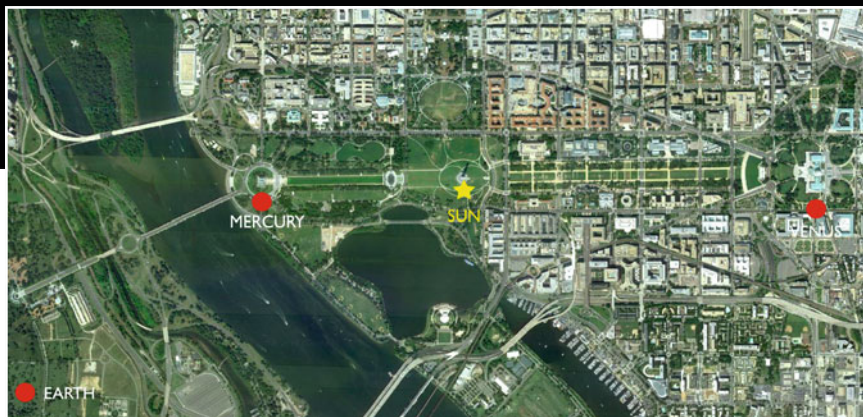
Uranus



Neptune



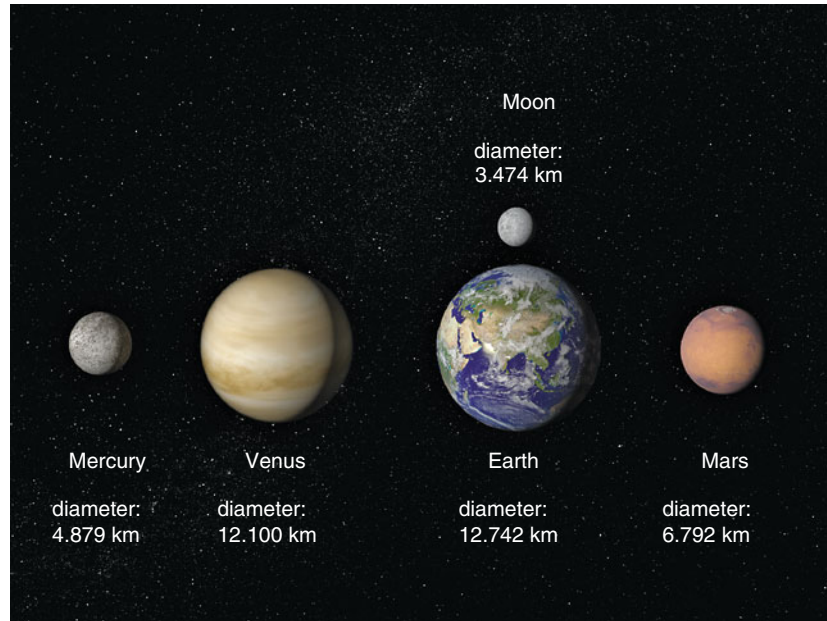
If Earth was the size of a basketball and the Sun was located near the Washington Monument in Washington, D. C., Earth would be near Arlington National Cemetery. Mercury would be almost by the Lincoln Memorial, Venus by the US Capitol, while Mars would be located by the National Arboretum. Uranus would be at Dulles International Airport and Neptune at Gettysburg (Google map).



## THE ROCKY PLANETS

**T**HE INNERMOST PLANETS are all quite similar to Earth, consisting mainly of rock and metals and with a hard crust. They have a relatively high density, rotate very slowly, and have no rings and few moons orbiting them.

Earth is the largest and the only one with liquid water. Mars is the one most similar to Earth. Here we find old canyons where water may have flowed. Its polar caps are covered with ice. Several orbiters, landers, and robotic rovers have explored the Martian surface in great detail. The ultimate question is whether some sort of life has existed on Mars.

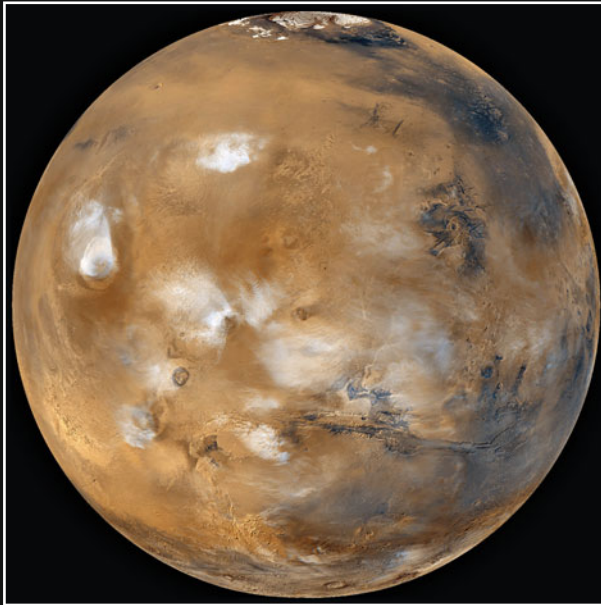


The four innermost planets to scale (T.Abrahamson/ARS/NASA).



Panorama view from the Mars rover Spirit (NASA).



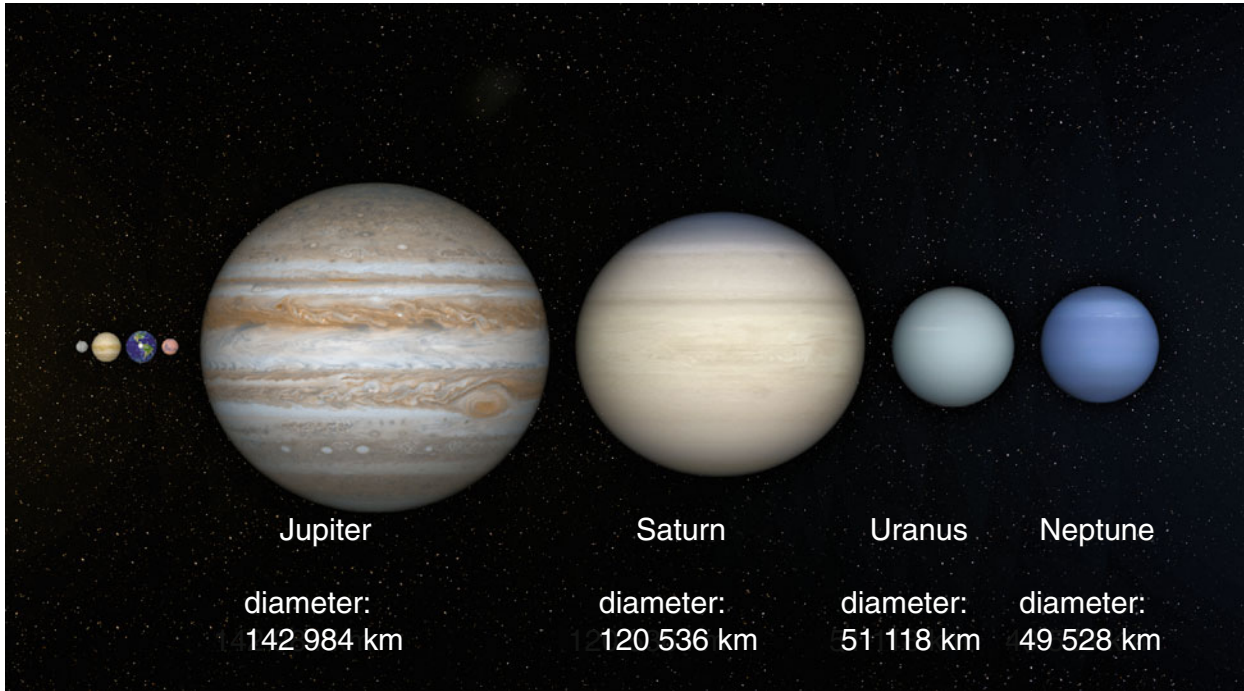


Mars with the reddish color and the ice-covered polar caps (NASA).



Venus is covered with thick clouds. With special instruments one can still take pictures through the clouds and see the surface (NASA).

Mercury with its numerous craters (NASA).



The large gaseous planets shown to scale. They are all much bigger than the inner rocky planets (T. Abrahamsen/ARS/NASA).

## THE GASEOUS PLANETS

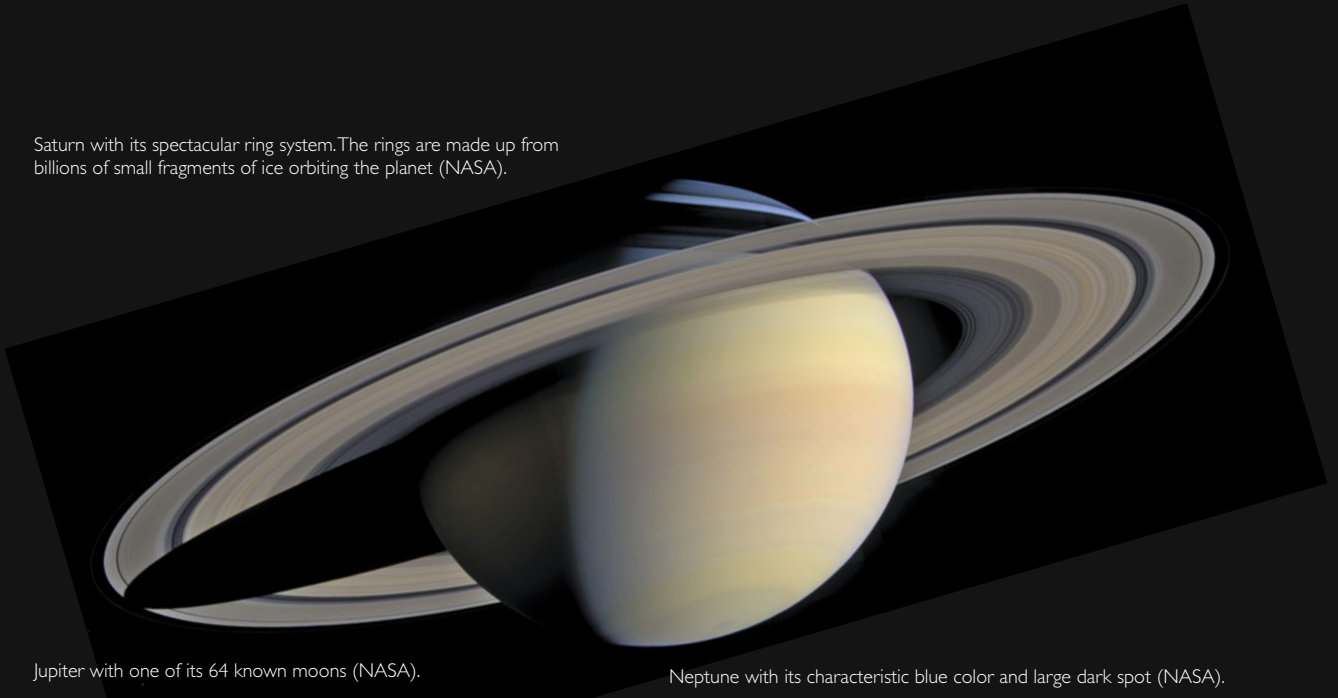
**T**HE OUTER PLANETS are often called the gas giants (Jupiter, Saturn, Uranus, and Neptune), even though they both consist of gas, liquid, and ice. They mainly consist of hydrogen and helium, and their density is fairly low. Uranus and Neptune also contain large amounts of compressed water deep

inside. They rotate much faster than the inner planets and have extensive atmospheres. Saturn is known for its amazing ring systems, but the other gas planets also have rings.

These giant planets all have a large number of moons. Jupiter has 64 known moons, while Saturn has 34

moons. One of Saturn's big moons, Titan, is quite mysterious, covered by a thick layer of clouds. In January 2005, the *Huygens* probe landed on Titan and sent back the first pictures to show us what it looks like on the surface.

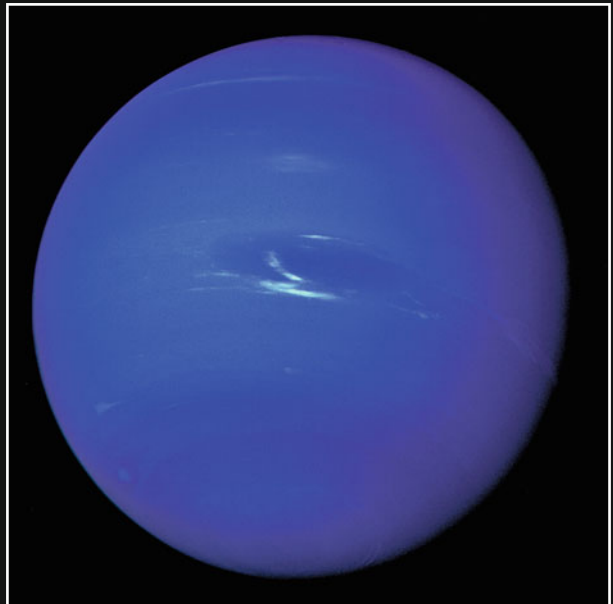
Saturn with its spectacular ring system. The rings are made up from billions of small fragments of ice orbiting the planet (NASA).



Jupiter with one of its 64 known moons (NASA).



Neptune with its characteristic blue color and large dark spot (NASA).







A spectacular sunset seen from the space shuttle. In the upper part, one can see a section of the robotic arm on the space shuttle (NASA).

## THE SUN AND EARTH

**W**E OFTEN SAY THAT THE SUN “rises” and the Sun “sets.” However, we know that the Sun is not moving in that way, but rather it is the Earth rotating around itself. It takes Earth 24 h to rotate once. That is why we have day and night. Earth’s rotation is also the reason for the apparent movement of the stars and planets over the night sky.

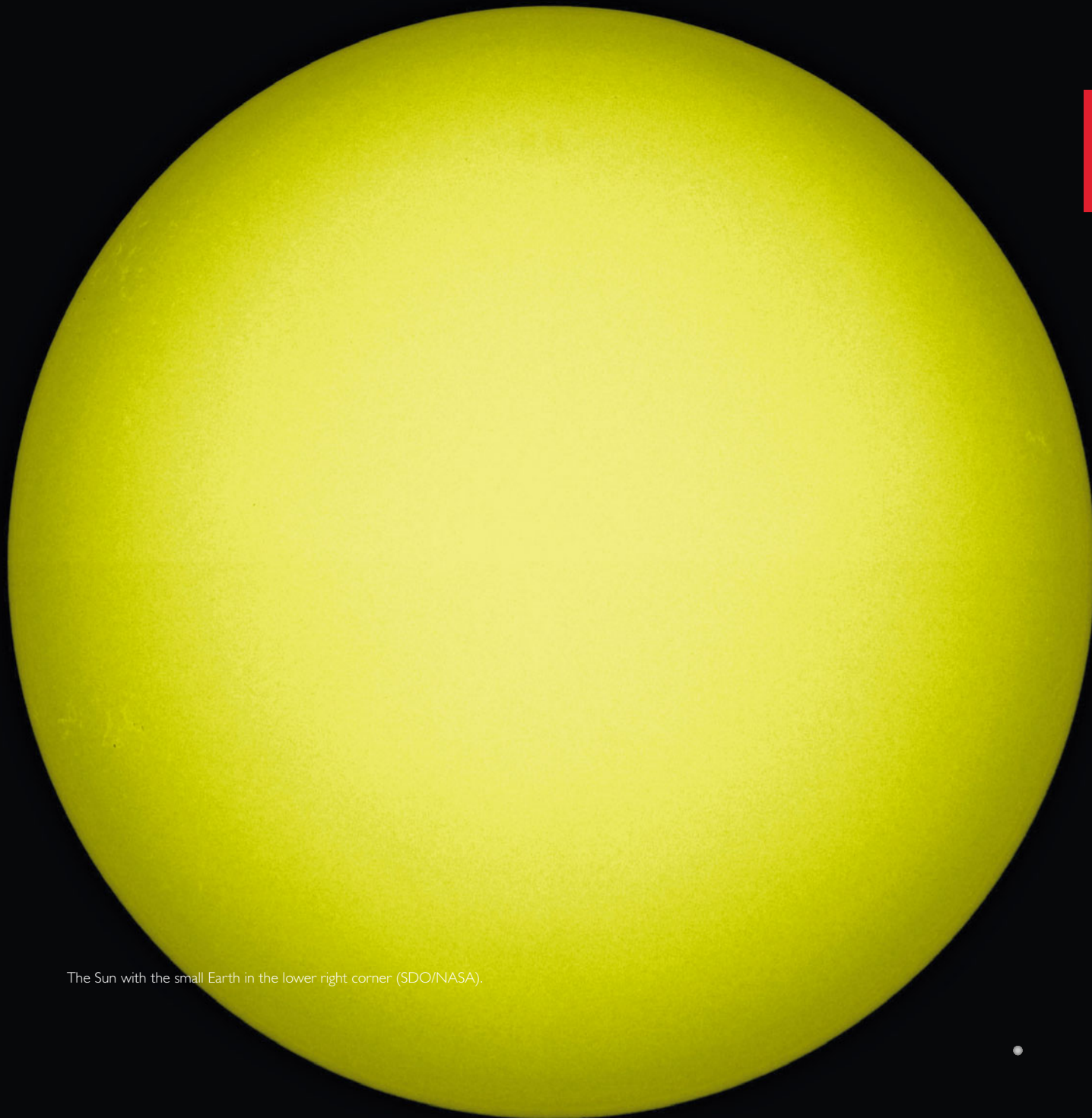
To the right is a picture of the Sun with Earth beside it. Are you having trouble seeing it? The reason is that the Sun is

sooooooooooooo much bigger! You can find Earth as a small blue dot in the lower right corner.

Earth is about 13,000 km in diameter, while the Sun’s diameter is about 1.4 million km. One can put 109 Earths side by side across the Sun. If one could fill the Sun with planets the size of Earth, it would fit 1.3 million planets.

**Fascinating Facts:** Since the Sun is over 300,000 times “heavier” than Earth, the gravity on the Sun will be much greater than here on Earth. If you weigh 35 kg on Earth you would weigh over 1,000 kg if you could stand on the Sun.

**Fascinating Facts:** Earth is “speeding” around the Sun at a velocity of 108,000 km/h without us being “blown” off its surface.



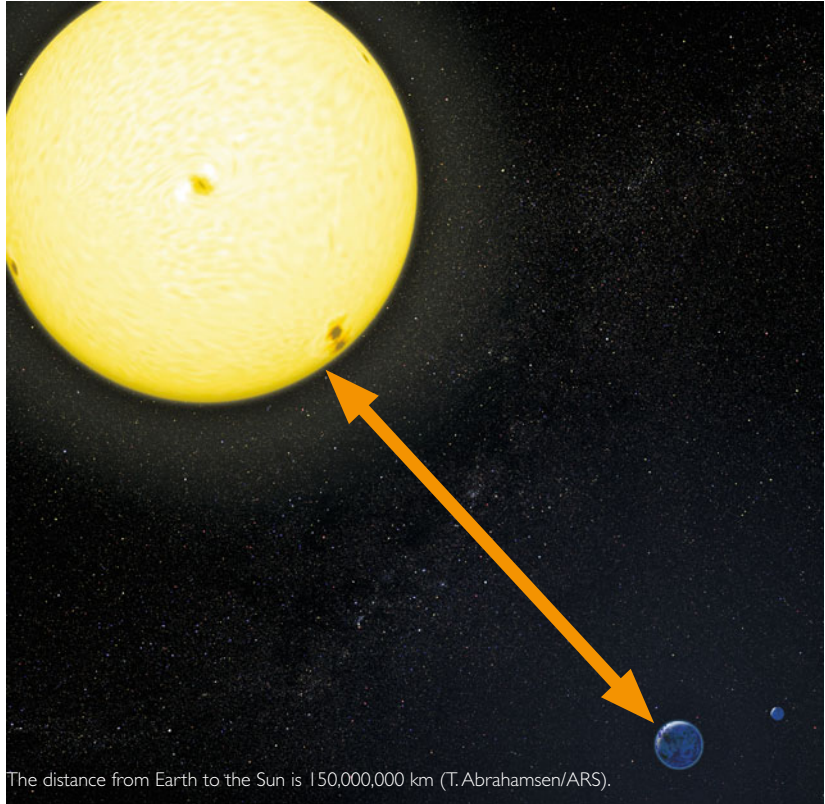
The Sun with the small Earth in the lower right corner (SDO/NASA).

## THE DISTANCE TO THE SUN

**T**HE SUN LOOKS RELATIVELY small in the sky because it is so far away. The distance to the Sun is 150 million km, and the light spends 8 min and 20 s to reach Earth. If you could travel to the Sun with an aircraft, it would take you about 17 years to get there. How old would you be when you arrive? And how old would you be when you return to Earth?

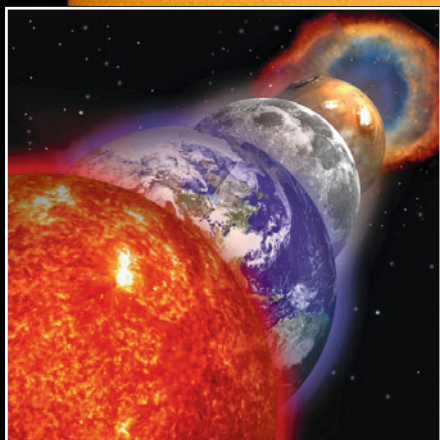
**Fascinating Facts:** A distance of 150 million km is hard to grasp. If you had a piece of yarn that long and rolled it up, it would be a ball 75-m tall, weighing 60 million kg (or 60,000 m. t.). That is approximately 30 space shuttles. It would be enough yarn to knit sweaters for 200 million people.

Driving a car at 100 km/ph it would take you 170 years. A horse running 13 km/h would spend 1,317 years. If you walked (5 km/h) it would take you 3,424 years.



The distance from Earth to the Sun is 150,000,000 km (T.Abrahamson/ARS).





The distance between the Sun and the planets is tiny compared to the distances between objects out in the universe (NASA).



An airplane with its vapor trail is passing in front of the Sun, and a few dark spots called sunspots are visible (J. Koeman).



There are more than a million asteroids orbiting the Sun, and together with comets, they are an important part of our Solar System (NASA/JPL-Caltech).

## ASTEROIDS AND COMETS

**B**ETWEEN MARS and Jupiter we find the Asteroid Belt, where a large number of asteroids orbit the Sun. Asteroids are irregular rocks, the largest a few hundred kilometers in diameter. On rare occasions, asteroids can stray off course and can hit Earth. Such a collision would be catastrophic for our society,

and a surveillance system to detect Earth-directed asteroids has been put in place.

Comets consist of ice, rocks, dust, and frozen gas and orbit the Sun in very elliptical orbits. Some of them orbit the Sun in a few years, while others spend a million years traveling this distance.

When comets get closer to the Sun, they heat up and ice and frozen gas evaporates. Together with the dust they form a gigantic halo around the comet nucleus. The radiation from the Sun will “blow” gas and dust particles away from the nucleus and form the characteristic comet tail.

Comets leave behind a stream of dust and particles. When Earth is passing through the debris from a comet, we experience a large number of meteors – what we call a meteor shower (NASA/JPL-Caltech/P. Pyle).



Comet Hale Bopp on April 8, 1997. The comet displays both a broad dust and gas tail and has an orbital period of about 2,400 years (M. Druckmüller).



The asteroid Ida with its small moon Dactyl photographed by the Galileo spacecraft. Dactyl is the first asteroid moon to be discovered (NASA).



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Our Explosive Sun

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