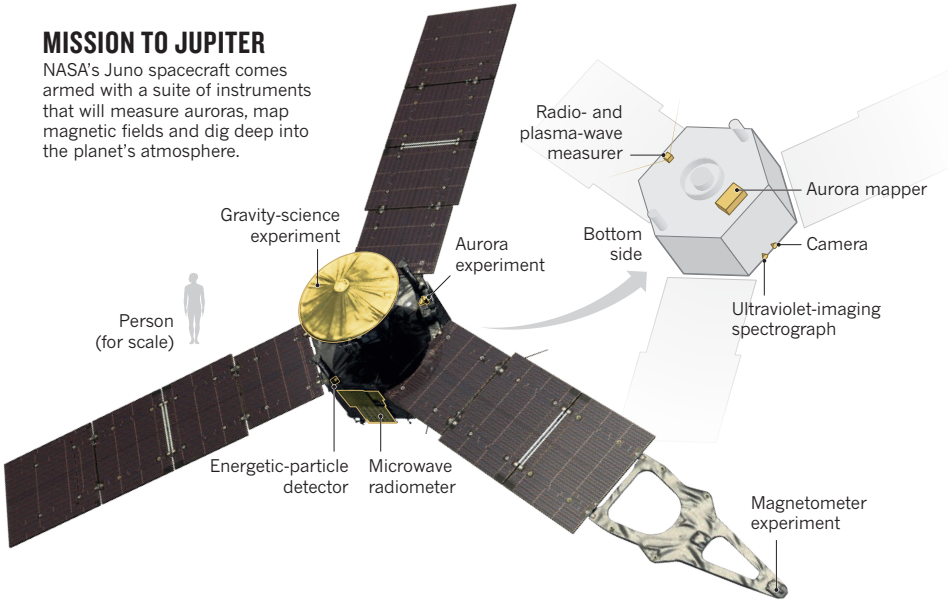


MISSION TO JUPITER
NASA's Juno spacecraft comes armed with a suite of instruments that will measure auroras, map magnetic fields and dig deep into the planet's atmosphere.

SOURCE: NASA

PLANETARY SCIENCE

NASA spacecraft nears Jupiter

Juno will explore the gas giant's composition and mysteries.

BY ALEXANDRA WITZE

On 4 July, NASA intends to finish a job that started with the agency's Galileo mission 21 years ago. At 8:18 p.m. Pacific time, the Juno spacecraft will ignite its main engine for 35 minutes and nudge itself into orbit around Jupiter. If all goes well, it will eventually slip into an even tighter path that whizzes as close as 4,200 kilometres above the planet's roiling cloud-tops — while dodging as much of the lethal radiation in the planet's belts as possible.

The US$1.1-billion mission, which launched in 2011, will be the first to visit the Solar System's biggest planet since NASA's Galileo spacecraft in 1995. Picking up where Galileo left off, Juno is designed to answer basic questions about Jupiter, including what its water content is, whether it has a core and what is happening at its rarely seen poles (see 'Mission to Jupiter').

Scientists think that Jupiter was the first planet to condense out of the gases that swirled around the newborn Sun 4.6 billion years ago. As such, it is made up of some of the most primordial material in the Solar System. Scientists know that it consists mostly of hydrogen and helium, but they are eager to pin down the exact amounts of other elements found on the planet.

"What we really want is the recipe," says Scott Bolton, the mission's principal investigator and a planetary scientist at the Southwest Research Institute in San Antonio, Texas.

A MURKY DISPOSITION

Jupiter's familiar visage, with its broad brown belts and striking Great Red Spot, represents only the tops of its churning clouds of ammonia and hydrogen sulfide. Juno — named after the Roman goddess who could see through clouds — will peer hundreds of kilometres into the planet's atmosphere using microwave wavelengths.

Exploration of Jupiter's interior should reveal more about the formidable atmospheric convection that powers the planet, says Paul Steffes, an electrical engineer at the Georgia Institute of Technology in Atlanta.

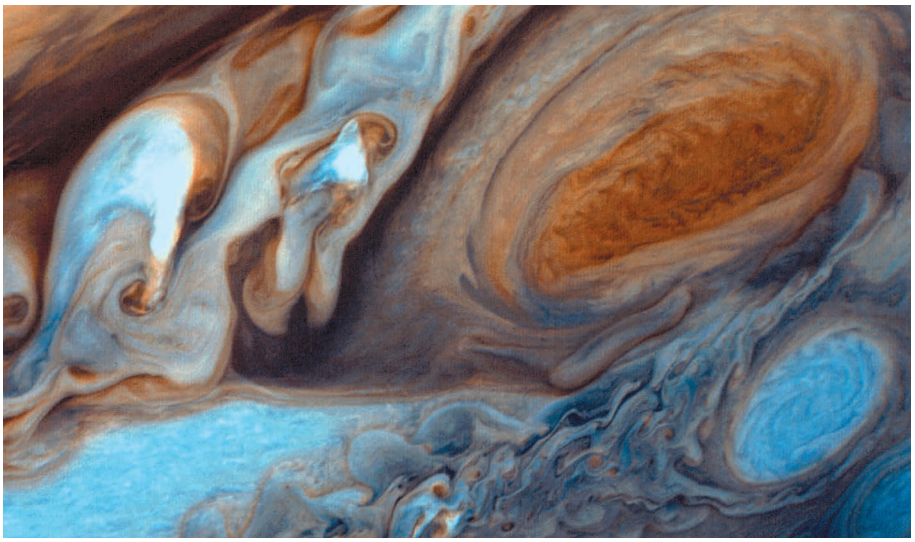
Steffes and his colleagues have run a series of laboratory experiments to simulate what different layers of Jupiter's atmosphere might look like: from near the cloud-tops, where experimental temperatures are –100 °C to deeper in the planet, where they rise to more than 300 °C.

By comparing Juno's observations to their simulations, the scientists hope to determine how much ammonia, water vapour and other materials swirl at different atmospheric depths. "Once we understand the recipe for Jupiter's atmosphere, we'll get a clearer insight into how it evolved," says Steffes. Different theories predict varying amounts of water in Jupiter's atmosphere, depending on whether the planet coalesced at its current distance from the Sun or somewhere else. Actual measurements of atmospheric water content could help to clarify this debate.

NORMAL IS GOOD

In anticipation of Juno's arrival, professional and amateur astronomers have been observing Jupiter with ground-based and space-based telescopes. For now, the planet is not experiencing any unusual atmospheric changes. "It's kind of in its normal state, which is good," says Amy Simon, a planetary scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland. This 'normal' behaviour gives researchers confidence that they will be able to understand Juno's findings.

The Great Red Spot continues to shrink, as it has done in recent years, and to interact less and less with the jet streams on either of its edges. The broad belt just north of the planet's equator has been expanding since late 2015 ▶



NASA/JPL

Jupiter's Great Red Spot also reveals a mosaic of currents that swirl through the planet's atmosphere.

— a change that might be connected to processes deep in the atmosphere.

"Trying to connect events that are happening at one level to events happening in another tells you how well coupled the whole atmosphere is," says Leigh Fletcher, a planetary astronomer at the University of Leicester, UK.

As Juno probes deeper and deeper into the planet's atmosphere, researchers hope to get information on a layer of hydrogen compressed into a liquid by increasing pressures. That liquid conducts electricity, which powers Jupiter's enormous magnetic field. Deeper still, the spacecraft will look for evidence of a core — a dense nugget of heavier elements that most scientists think exists, but has never been observed. Juno will make precise measurements of how Jupiter's gravity tugs on the spacecraft, which should reveal whether a core is present.

POLE POSITION

Juno will also get an unprecedented glimpse of Jupiter's poles. To avoid the most dangerous radiation belts that surround the gas giant — which over the lifetime of the mission could fry the spacecraft with the equivalent of more than 100 million dental X-rays — Juno will take a long elliptical dive around the planet on every orbit. The spacecraft will fly directly over Jupiter's magnetically intense auroras, and could spot unusual circulation patterns that resemble a hexagon-shaped feature parked on Saturn's north pole.

The lessons that scientists learn from Jupiter will apply to other gas giants, including those outside the Solar System. "If we understand how it formed, we'll have a much better handle on giant-planet influences in planetary systems around other stars," Fletcher says.

Juno will provide scientists' last chance to look at Jupiter for a long time. It is scheduled to make 37 total orbits before performing a kamikaze run in early 2018, burning up inside the planet's clouds to keep it from contaminating the moon Europa. The only other mission planned to the gas giant is the European Space Agency's Jupiter Icy Moons Explorer (JUICE) spacecraft, which could launch as early as 2022 and will focus mainly on the moon Ganymede. ■

Population growth and agriculture have stressed the Indus, which flows the length of Pakistan.

CLIMATE CHANGE

Indus River waters shrinking

Cooler, cloudier summers slow snowmelt in Himalayas.

BY JANE QIU

The Indus River, which supports the lives of 300 million people, is supplying Pakistan with less water than it did 50 years ago, particularly in the spring and summer, researchers have found. The news comes as demand for water is projected to rise sharply.

The findings contradict previous predictions that the river's volume would stay the same, or even grow, as climate change kicks in, although that increase is likely to occur in the next several decades, another team has found.

Danial Hashmi, a hydrologist at the Pakistan Water and Power Development Authority in Lahore, reported the river's shrinkage for the first time in February at a conference in Kathmandu. Further data from India have also shown seasonal shifts. "The Indus is certainly changing, and local communities are feeling the pinch," Shresth Tayal, a glaciologist at the Energy and Resources Institute in New Delhi, told a meeting in Columbus, Ohio, last month.

The Indus flows through India, Afghanistan and China before reaching Pakistan, which it crosses from north to south. For decades, population growth and agriculture have stressed the river, which, for 10 months of the year, dries up before it reaches the sea. Because demand is set to rise by 30% by 2025, "water shortage will be the single most destabilizing factor, not only for Pakistan but the entire region", says Arif Anwar, principal researcher at the International Water Management Institute in Lahore.

But since the 2009 'glaciergate' scandal — in which it emerged that the Intergovernmental Panel on Climate Change had mistakenly included in its fourth assessment report

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