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EXPLORATION

The worlds beyond

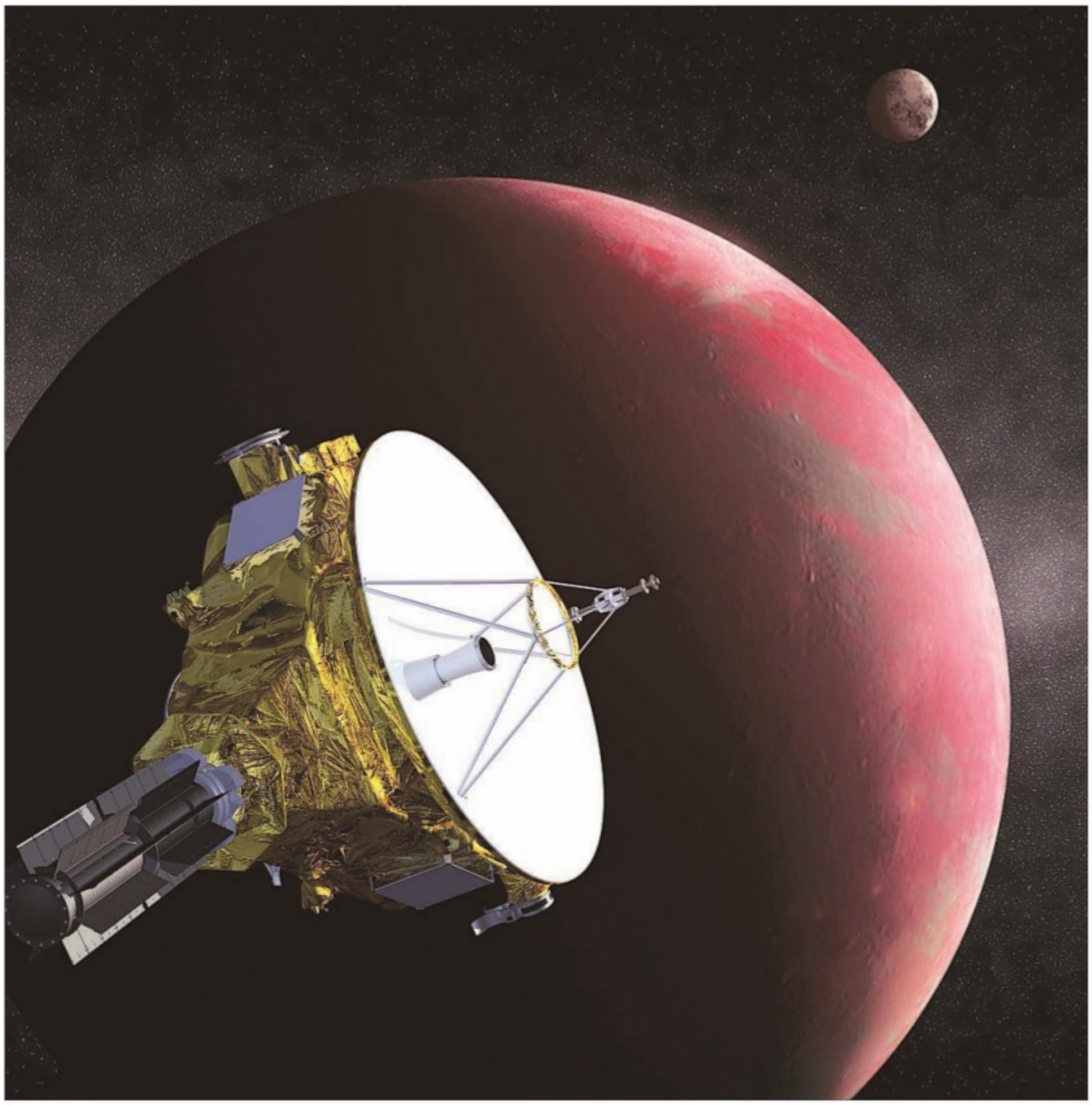
The number of missions to the outer planets is about to dwindle

ON JULY 14 a NASA space probe called *New Horizons* will reach Pluto. Its nine-year journey to the distant reaches of the solar system should be worth waiting for. Even though Pluto was reclassified as a dwarf planet in 2006, with the discovery of other similarly sized bodies nearby, the mission is expected to produce plenty of data for planetary scientists to pore over, before zooming off into the Kuiper Belt, a region of icy hunks of space rock even farther out than Pluto. It is due to arrive there in 2019. Other space rendezvous are in the works, including NASA's *Juno*, which is due to arrive at Jupiter in October next year. But then the stream of missions to the outer planets — namely Jupiter, Saturn, Uranus and Neptune — turns into a trickle.

At the same time, existing probes will reach the end of their lives. *Cassini* was launched in 1997 to explore Saturn and its moons. By 2017 its propellent will be depleted and — provided it survives a series of fly-bys through Saturn's rings — it will burn up as it plunges through the planet's thick atmosphere. Sometime before 2025 even the stalwart Voyager probes, both launched in 1977, will lack the power to continue sending back data.

Voyager 1, now in interstellar space, is the most distant man-made object in the universe, and *Voyager 2* is not far behind.

The upshot is that, for a decade or so, discoveries will come mostly from objects closer to Earth: regular excursions to Mars are planned, as are a probe to Mercury, and missions to comets and asteroids, such as the European Space Agency's (ESA) *Rosetta*, which placed a lander on comet 67P/Churyumov-Gerasimenko in November last year. There will also be plenty of instruments launched to look at Earth itself. The hiatus might not end until two proposed space missions are launched in the early 2020s to explore Jupiter and its icy moons, particularly Europa. But neither NASA's *Europa Clipper* nor ESA's *JUICE* (for Jupiter Icy moons Explorer) is likely to arrive to begin work until 2030 at the earliest.



An artist's impression of NASA's *New Horizons* spacecraft, which is expected to reach Pluto on July 14 after completing a nine-year journey of 3 billion miles. REUTERS

THE BRAKES GO ON

IT SEEMS an abrupt slowdown after a golden age of missions by NASA and ESA. But building a space probe is both complicated and expensive. It takes years of planning and jostling for funds — as well as a hefty dose of luck to ensure that complex equipment works well. "We are benefiting today from some good science and good funding in the 1990s," says Leigh Fletcher, a scientist at Oxford University who specialises in the outer planets. And money became much scarcer in recent years.

In 1991, the recent high-water mark for NASA, the agency received $13.9 billion (worth today some $25 billion). Its budget fell to a low of $16.9 billion in 2013. (It has edged up again lately, to $18 billion this year). The cash allocated to planetary science specifically has remained at about $1.3 billion since it was slashed in 2012.

Some of NASA's cash has been shifted to other projects, especially the *Space Launch System*, a big new rocket, and the Orion spacecraft that will sit atop it. As the intention is that this will carry people to the Moon and, in theory at least, beyond, both are part of America's planned return to the kind of crewed space exploration last undertaken in the 1960s (though considerable doubts remain about whether those plans will, in fact, come to pass). Some of NASA's co-operation with ESA on future missions has been scaled back as a result of budget cuts. At least some work on powering future long-range missions is continuing.

NASA's planetary science division agreed in 2013 to pay $50m a year to the Department of Energy to resume production of plutonium-238, which is used as a power source in probes to distant objects and to places where solar power is less reliable.

The Europeans, by contrast, have kept their funding fairly steady. But ESA's budget of just €4.4 billion ($4.8 billion) is small compared with NASA's. Other countries are interested in space and have missions under way or in the making, including China, Japan and India. But so far they have no ambitions to venture beyond Mars.

THE SO-WHAT TEST

DOES the coming gap in planetary exploration matter? Supporters argue that studying the geology, atmospheres and evolution of planets, moons and comets provides valuable science. Others have loftier ambitions: "Keeping planetary science going, I believe firmly, is critical to the long-term survival of the species on this planet," says Jim Green, director of NASA's planetary-science division.

Because space missions have such long lead times, some worry that the looming run of lean years will have deleterious effects even if budgets start to rise again. Their concern is that valuable knowledge will be lost in the interim. "When we do get back [to previous funding levels], there will be a missing generation, almost," says Candace Hansen, the head of NASA's Outer Planets Assessment Group. "It's really difficult to go through boom-and-bust cycles," Oxford University's Dr Fletcher adds. "You've got to keep the scientific community and the engineers ticking over to maintain the expertise we have in outer solar-system exploration."

Fabio Favata, the head of ESA's science planning and community co-ordination office, points out, by way of example, that scientists can prepare for an upcoming mission by offering post-doctorate research posts in the sorts of subjects the probe is designed to explore, building up specific areas of expertise in anticipation of its arrival. But if no probes are on the way, there are no such posts to offer.

There are two oases in the coming exploration desert. One is Mars. Two rovers — *Curiosity* and *Opportunity* — are both still trundling across its surface. Two orbiters, *Odyssey* and the *Mars Reconnaissance Orbiter* (MRO), are well past their expected lifetimes but still performing. The MRO also provides highly detailed pictures of the Martian surface, which is useful for planning rover trips and for scouting future landing sites. Both craft can serve as radio relays for the rovers on the ground; in 2013 NASA sent another probe called *MAVEN* to Mars, but it has only a limited relay ability. Another backup will arrive in 2016, when the ESA's *ExoMars* craft enters orbit in October. NASA's Dr Greene says plans have not yet been finalised for an additional Mars orbiter to go up in 2022 or later, which may include a camera similar to the one on the MRO.

The other bright spot is Earth. NASA has five Earth-observing missions being launched to January 2015. The agency has also kept funding on track for the $8 billion *James Webb* space telescope, despite the project's budget ballooning from an original estimate of $2 billion. The *Webb* will be a successor of sorts to the 25-year-old *Hubble* space telescope, which floats above Earth, and which has been one of the most successful space missions of the past quarter century. Among other things, the *Webb* will help to find dwarf planets, comets and Kuiper-belt objects. But observing from a distance is ultimately no substitute for getting up close.