NEWS IN FOCUS

ISRO

View of the Moon from one of Chandrayaan-2's cameras.

SPACE

India counts down to risky Moon landing at south pole

If the touchdown is successful, Chandrayaan-2 will be the first craft to visit this region.

BY T.V. PADMA

After countless setbacks and delays, India will attempt to set a lander down on the Moon in the early hours of 7 September Indian time. If the landing is successful, the nation will be only the fourth to achieve such a feat.

Chandrayaan-2 shot into space six weeks ago — more than a year behind schedule — comprising an orbiter and a lander, Vikram, loaded with a six-wheeled rover. The mission's main aims are to investigate the unexplored lunar south pole and provide the most detailed maps yet of sources of water on the Moon.

But before the exploration can begin, India's space agency (ISRO) will have to put its faith in Vikram's autonomous landing system, which will attempt to place the four-legged lander gently on the Moon's surface. Although ISRO crash-landed an impact probe, released by the Chandrayaan-1 lunar orbiter, on the surface in 2008, the Chandrayaan-2 mission is the agency's first attempt at a 'soft' landing.

When Vikram is 35 kilometres above the Moon's surface, its thrusters will fire to slow the craft's descent from a speed of 6 kilometres a second to almost zero. Although Vikram is designed to select a landing site free of large boulders, the team's engineers worry that if the site is slightly sloping, or pockmarked with small rocks, the craft could topple, ending its mission.

The agency's chief, Kailasavadivoo Sivan, said at a press conference last month that the automated landing will be the "most terrifying moments" for the organization.

If the touchdown is successful, however, Vikram will be the first craft to land near ▶

the lunar south pole, where it will release the rover Pragyan, which can travel for up to 500 metres. Previous US, Soviet and Chinese missions have landed nearer the equator.

"The Chandrayaan-2 landing site will be in completely new terrain," says Brett Denevi, a planetary scientist at Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland.

The most important reason for choosing the site is the high likelihood of finding water there, says Mylswamy Annadurai, who led the Chandrayaan-2 project before retiring last year.

Ever since Chandrayaan-1 detected signatures of frozen water on the Moon, scientists have been trying to identify deposits and calculate how much is there. This could help them to explain how water came to be on the Moon in the first place. Evidence gathered by Chandrayaan-1 and other spacecraft show there is water ice across the surface of the south pole[1,2], and possibly buried deposits, too[3].

The presence of water at the lunar south pole also makes it an attractive potential outpost for future astronaut missions, as does the fact the area is thought to be rich in minerals such as magnesium, iron, calcium and titanium. NASA is planning to send astronauts to the south pole by 2024. "There is a lot of international interest in the lunar south pole due to the resources it can provide," says Denevi.

Chandrayaan-2 carries 13 instruments from India and one from NASA, which is on the lander and will collect data to more precisely measure the distance from Earth to the Moon. Of the Indian instruments, eight are on the orbiter, which separated from the lander on 2 September and is currently circling the Moon.

Denevi says she's most excited about the orbiter's imaging infrared spectrometer, which will map light reflected off the lunar surface over a wide range of wavelengths. This information can be used to identify and quantify surface water, which absorbs light strongly at certain wavelengths. Although Chandrayaan-1 provided some of the first key evidence for water on the Moon, its wavelength range did not cover the full absorption band, making it difficult to calculate the abundance and distribution of water[4]. "As far as I know, this will be the first time this full wavelength region has been covered," Denevi says.

"The entire world is waiting for our data."

The orbiter is also carrying a radar operating at two frequencies to detect water ice inside permanently shadowed craters, and to map the thickness and electrical conductivity of lunar rocks, says Ryan Watkins, a lunar scientist at the Planetary Science Institute in Tucson, Arizona. This will be the first radar mapper of this type to orbit the Moon, she says.

A probe on Vikram will also measure a strange phenomenon known as 'Moonquakes'. The Moon has become some 50 metres 'skinnier' over the past several hundred million years, and, as it shrinks, its brittle crust breaks and generates quakes. Annadurai says there is much about the Moon's core that is unknown, such as its composition, and Vikram's data could help researchers to better understand it.

Although Vikram, which carries three instruments, and the Pragyan rover, which has two, are designed to last only one lunar day — about 14 Earth days — Sivan says they will be able to collect a wealth of information in that time. "The entire world is waiting for our data," he says. ■

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2. Fisher, E. A. *et al. Icarus* **292**, 74–85 (2017).
3. Rubanenko, L., Venkatraman, J. & Paige, D. A. *Nature Geosci.* **12**, 597–601 (2019).
4. Pieters, C. M. *et al. Science* **326**, 568–572 (2009).

HUMAN GENOME

No 'gay gene': study looks at genetic basis of sexuality

Five DNA markers are linked to sexual behaviour — but can't predict a person's preferences.

BY JONATHAN LAMBERT

The largest study yet on the genetic basis of sexuality has revealed five spots on the human genome that are linked to same-sex sexual behaviour — but none of the markers is reliable enough to predict someone's sexuality.

The findings, which were published on 29 August in *Science* and are based on the genomes of nearly 500,000 people, shore up the results of earlier, smaller studies and confirm the suspicions of many scientists: although sexual preferences have a genetic component, no single gene has a large effect on sexual behaviours (A. Ganna *et al. Science* **365**, eaat7693; 2019).

"There is no 'gay gene'," says lead study author Andrea Ganna, a geneticist at the Broad Institute of MIT and Harvard in Cambridge, Massachusetts.

Ganna and his colleagues also used the analysis to estimate that up to 25% of sexual behaviour can be explained by genetics, with the rest influenced by environmental and cultural factors — a figure similar to the findings of smaller studies.

"This is a solid study," says Melinda Mills, a sociologist at the University of Oxford, UK, who studies the genetic basis of reproductive behaviours.

But she cautions that the results might not be representative of the overall population — a limitation that the study authors acknowledge. Most of the genomes come from the UK Biobank research programme and the consumer-genetics company 23andMe, based in Mountain View, California. The people who share their genetic and health information with those databases are mostly of European ancestry and tend to be older. UK Biobank participants were between 40 and 70 years old when their data were collected, and the median age for people in 23andMe's database is 51.

The study authors also point out that they followed convention for genetic analyses by dropping from their study people whose biological sex and self-identified gender didn't match. As a result, the work doesn't include sexual and gender minorities (the LGBTQ community) such as transgender people and intersex people.

Scientists have long thought that a person's genes partly influence their sexual orientation. Research from the 1990s showed that identical twins are more likely to share a sexual orientation than are fraternal twins or adopted siblings (R. C. Pillard and J. M. Bailey *Hum. Biol.* **70**, 347–365; 1998).

But these studies all had very small sample sizes and most focused on men, says Mills. This hampered scientists' ability to detect many variants linked to sexual orientation.

In the latest study, Ganna and his colleagues used a method known as a genome-wide association study (GWAS) to look at the genomes of hundreds of thousands of people for single-letter DNA changes called SNPs. If lots