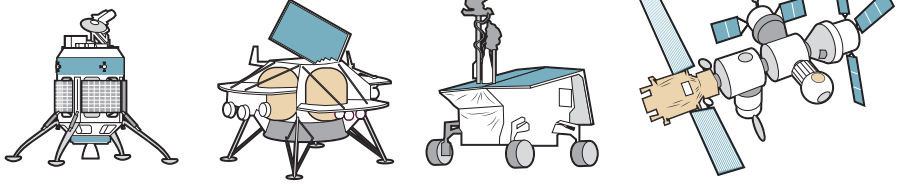
BACK TO THE MOON

NASA may send landers to the lunar surface for the first time since the 1970s, as part of a renewed exploration programme. Possible spacecraft include:



MX-1 LANDER

Builder: Moon Express of Cape Canaveral, Florida

Destination: Anywhere on the lunar surface

Capabilities: Carry small payloads selected through a NASA competition

Time frame: As early as 2019

PEREGRINE LANDER

Builder: Astrobotic of Pittsburgh, Pennsylvania

Destination: Anywhere on the lunar surface

Capabilities: Carry small payloads selected through a NASA competition

Time frame: As early as 2019

LUNAR ROVER

Builder: NASA

Destination: Anywhere on the lunar surface

Capabilities: Study or collect rock samples from different geological formations

Time frame: Early 2020s

LUNAR ORBITAL PLATFORM-GATEWAY

Builder: International space agencies

Destination: Lunar orbit

Capabilities: Provide laboratory and storage space for samples, a refuelling point for surface operations and a communications relay

Time frame: Mid-2020s

SOURCE: NASA

with the lunar push (see 'Back to the Moon').

Over the past decade, NASA has sent the Lunar Reconnaissance Orbiter to map the Moon; the Lunar Crater Observation and Sensing Satellite to crash land near the south pole in search of water; the Gravity Recovery and Interior Laboratory to plumb the Moon's gravity field; and the Lunar Atmosphere and Dust Environment Explorer (LADEE) to study its tenuous outer atmosphere.

These and other missions have opened new areas of research, says Dana Hurley, a planetary scientist at the Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland. "Our understanding has evolved so much in the last decade," she says.

Take LADEE, which detected traces of water in the Moon's atmosphere that were probably carried there by meteorites. Researchers need more detailed data to better understand how water moves around on the lunar surface and into the atmosphere. "We didn't even know to ask those questions before," Hurley says.

She and other US scientists, in a collaboration known as the Lunar Exploration Analysis Group, have been studying how future missions might answer key science questions. Getting better dates for impact craters on the Moon, for instance, could help establish whether the Solar System experienced a cataclysmic meteorite bombardment 4 billion years ago.

"To take the next really big leaps in lunar science is going to take landing on the ground and getting at it with instruments in a way very similar to what we've done for Mars," says Barbara Cohen, a planetary scientist at NASA's Goddard Space Flight Center in Greenbelt, Maryland, who has developed methods for dating planetary samples on the surface of other worlds (B. A. Cohen *et al. Geostand. Geoanal. Res.* **38,** 421–439; 2014). "We have a lot of pent-up demand."

For the first time, NASA might use commercial landers to reach the lunar surface. Companies such as Moon Express of Cape Canaveral, Florida, and Astrobotic of Pittsburgh, Pennsylvania, have been developing small landers. Neither they nor their competitors were able to claim the $30-million Google Lunar XPRIZE, a private effort to put landers and rovers on the Moon by the end of this month. Still, many expect NASA to call in the coming months for proposals that rely on small commercial landers.

"This is the right place. This is the right time," NASA's Sarah Noble told a planetary-science advisory committee on 21 February. "We are really poised to take advantage of this next era of lunar exploration and the opportunities these commercial companies are going to open up"

The first lander missions would probably be short-lived trips to sites on the Moon's near side. But scientists could piggyback on those trips to study topics such as the plasma environment around the lunar poles, or to begin establishing a network of geophysical landers that would listen for moonquakes. By the mid- to late 2020s, NASA might be able to bring samples back to Earth via the space station orbiting the Moon.

Other nations will grab the lunar limelight much sooner. India is slated to launch its Chandrayaan-2 rover later this year to explore near the Moon's south pole. And China is planning to send its Chang'e-4 rover to the lunar far side — a first for any space agency — by the end of 2018.

NASA's challenge will be to keep its latest initiative from falling by the wayside, as did its last big lunar programme — which ran from 2004 to 2010. "I'm excited about the lunar exploration campaign, but concerned we're not making enough investments to get to the surface," says David Kring, a planetary scientist at the Lunar and Planetary Institute in Houston, Texas. He notes that Trump directed astronauts to the Moon; robotic landers do not achieve that goal, no matter how much data they collect. ■

POLICY

EU pesticide review could lead to ban

Major assessment concludes that neonicotinoids harm bees.

BY DECLAN BUTLER

In a long-awaited assessment, the European Union's food-safety agency has concluded that three controversial neonicotinoid insecticides pose a high risk to wild bees and honeybees. The findings by the European Food Safety Authority (EFSA) in Parma, Italy, increase the chances that the EU will soon move to ban all uses of the insecticides on outdoor crops.

In 2013, the EU prohibited use of the three chemicals on crops attractive to bees — such as sunflowers, oilseed rape and maize (corn) — after an EFSA assessment raised concern about the insecticides' effects. Since then, researchers have amassed more evidence of harm to bees, and the European Commission last year proposed banning all outdoor uses, while still allowing the pesticides in greenhouses. The latest EFSA assessment strengthens the scientific basis for the proposal, says Anca Păduraru, a European Commission spokesperson for public health and food safety. EU member states could vote on the issue as soon as 22 March.

Neonicotinoids (often abbreviated to neonics) are highly toxic to insects, causing paralysis and death by interfering with the central nervous system. Unlike pesticides that remain on plant surfaces, neonicotinoids are taken up throughout the plant — in the roots, stems, leaves, flowers, pollen and nectar.

SOLVIN ZANKL/NPL

The EFSA assessment covered the three neonicotinoids of greatest concern to bee health — clothianidin, imidacloprid and thiamethoxam. The agency considered more than 1,500 studies, including all the relevant published scientific literature, together with data from academia, chemical companies, national authorities, non-governmental organizations (NGOs) and beekeepers' and farmers' associations. The assessment found that each of the three chemicals posed at least one type of high risk to bees in all outdoor uses.

The agency found that foraging bees are exposed to harmful levels of pesticide residues in pollen and nectar in treated fields and nearby contaminated areas, as well as in dust created when treated seeds are planted. It also concluded, on the basis of more limited evidence, that neonicotinoids can sometimes persist and accumulate in the soil, and so can affect generations of planted crops and the bees that forage on them.

"EFSA's advice is often criticized by interested parties such as NGOs and companies, but this is a good demonstration of how EFSA gives scientifically sound and impartial advice," says José Tarazona, head of the agency's pesticides unit.

A spokesperson for the global biotechnology firm Syngenta, which produces neonicotinoids, says that EFSA's conclusions are overly conservative. "When regulators make decisions about crop-protection products, what should matter is science, data and that the processes in place are respected and that the public interest is served," the spokesperson says. "Any further restrictions based on this report would be ill-conceived."

Honeybees can be exposed to harmful levels of neonicotinoids in pollen, according to an EU review.

EU member states were scheduled to vote on the proposal to outlaw outdoor uses on 13 December, but postponed the vote partly because many wanted to wait until EFSA completed its evaluation.

Member states plan to discuss the EFSA assessment at a meeting of the commission's Standing Committee on Plants, Animals, Food and Feed sometime in March, says Păduraru. "The protection of bees is an important issue for the commission since it concerns biodiversity, food production and the environment." ■

MATERIALS SCIENCE

Graphene is a surprise superconductor

Misaligned sheets of the carbon material can conduct electricity without resistance.

BY ELIZABETH GIBNEY

A sandwich of two graphene layers can conduct electrons without resistance if they are twisted at a 'magic angle', physicists have discovered. The finding could prove to be a significant step in the decades-long search for room-temperature superconductors.

Most superconductors work only at temperatures close to absolute zero. Even 'high-temperature' superconductors conduct electricity without resistance only at temperatures of up to around −140 °C. A material that displayed the property at room temperature — eliminating the need for expensive cooling — could revolutionize energy transmission, medical scanners and transport.

Physicists now report that arranging two layers of atom-thick graphene so that the pattern of their carbon atoms is offset by an angle of 1.1° makes the material a superconductor. And although the system still needs to be cooled to 1.7 degrees above absolute zero, the results suggest that it might conduct electricity much like known high-temperature superconductors — and that is exciting physicists. The findings were published in two *Nature* papers[1,2] on 5 March.

If confirmed, this discovery would be "very important" to the understanding of high-temperature superconductivity, says Elena Bascones, a physicist at the Institute of Materials Science of Madrid.

Superconductors come broadly in two types: conventional, in which the activity can be explained by the mainstream theory of superconductivity, and unconventional, where it can't. The latest studies suggest that graphene's superconducting behaviour is unconventional — and has parallels with that of other unconventional superconductors, called cuprates. These complex copper oxides have been known to conduct electricity at up to 133 degrees above absolute zero. And although physicists have focused on cuprates for three decades in their search for room-temperature superconductors, the underlying mechanism has baffled them.

In contrast to cuprates, the stacked graphene system is relatively simple and the material is well-understood. "The stunning implication is that cuprate superconductivity was something simple all along," says Robert Laughlin, a physicist at Stanford University in California.

Graphene already has impressive ▶