Bringing it back

NASA's spacecraft OSIRIS-REx is planning to bring back a sample from a near-Earth asteroid in 2023, and it has just delivered its first scientific results. It is only one of the projects from various space agencies that will put small bodies and sample return into the spotlight in the upcoming decade.

Sample return of extraterrestrial materials from the Moon was quite common towards the end of space race. In total, the American Apollo programme brought a whopping 382 kg of lunar samples to Earth. The corresponding Soviet Luna programme acquired only ~300 g, but with fully robotic procedures. In contrast, the amount of extraterrestrial material brought back since the end of the Luna 24 mission in 1976 sums up to a handful of microparticles from the Stardust and Hayabusa missions. Now, after 45 years, sample return is coming back in force, with a wider scope and selection of target types.

Why is sample return so important? After all, sample-return missions are more technically challenging and risk-prone than standard spacecraft procedures. One reason is technological: we need to master sample return if we want to explore the Solar System with crewed expeditions. But there is also a purely scientific one. As Rosario Brunetto and Cateline Lantz describe in their [Comment](#), sample return is essential to close the virtuous cycle that links remote sensing, in situ exploration and laboratory analyses together in order to characterize a body from the global- to the micro-scale.

In this sample-return revival, the Moon is back in the spotlight as old and new space powers are pushing to visit our satellite again. NASA has big plans that involve the assembling of a base in lunar orbit, the Lunar Orbital Platform-Gateway, which would allow easier back-and-forth from the lunar surface. Also, on 26 March 2019 the White House directed NASA to move crewed Moon landing up to 2024. Russia has revived its Luna programme, which will include sample return in the second half of the 2020s. And China will build on its success streak after the recent landing of Chang'E 4 on the Moon's far side with a [sample return planned for next year with the Chang'E 5 spacecraft](#).

But the attention now seems focused on more ambitious targets, such as Mars. The recent US budget request for NASA in 2020 specifically includes an entry for a future Mars sample-return mission, with the first step of the programme happening with the [Mars 2020 rover](#). However, the area where sample return is really flourishing is the smaller bodies of the Solar System.

This *Nature Astronomy* issue features OSIRIS-REx, a NASA mission that aims to bring back a sample from near-Earth asteroid Bennu in 2023, after spending a couple of years orbiting the asteroid in order to characterize it. OSIRIS-REx arrived at Bennu at the end of last year, and the relevant papers of this issue cover the Approach and Preliminary Survey phases, between August and December 2018, which are crucial to get a first impression of the asteroid. The *Nature Astronomy* papers are part of a package of seven papers whose publication has been coordinated with *Nature*, *Nature Geoscience* and *Nature Communications*. This allocation allows each paper of a complex mission like OSIRIS-REx to be presented in the journal most-suited to maximize community relevance. At the same time, the unity of the package is preserved by gathering all of the papers in an [online collection](#) that also includes commissioned pieces to provide context and perspective.

And these first results already deliver a series of surprises, together with valuable confirmations of ground-based observations. Intriguingly, [the top-shape of the asteroid with indications of an internal collapse](#), as well as the [diversity of surficial albedos and textures despite the rather uniform composition](#), point at a [more complex history than expected for such bodies](#). The mission planners must have rejoiced at the fact that [hydrated minerals are widespread across Bennu's surface](#) rather than being localized, but the dominance of boulders instead of the expected fine regolith would not have pleased them, as it will complicate the sample acquisition.

Bennu is not the only near-Earth asteroid currently hosting a spacecraft: the JAXA mission Hayabusa2 is orbiting asteroid Ryugu with the plan of bringing back a sample to Earth by 2020 (Hayabusa2 will return a sample more quickly than OSIRIS-REx, but it won't reconnoitre its asteroid at the same level of detail). Hayabusa2 has already accomplished several impressive milestones, as described by Hikaru Yabuta's [Comment](#), including the first successful touchdown to acquire the sample. Having two spacecraft around two similar but distinct targets (both Ryugu and Bennu are carbonaceous asteroids and the former

is roughly double the size) will allow us to perform in-depth comparative planetology, which will only be strengthened when both samples hit the laboratory.

Small bodies have been enjoying some special attention in space exploration for quite some time, but the next decade will exhibit a string of missions from a variety of actors. JAXA has built a full vision behind its small-bodies programme, as described by Masaki Fujimoto and Elizabeth Tasker, which transfers the old 'follow the water' mantra to interplanetary scales. NASA will launch a series of spacecraft targeting some interesting main-belt asteroids, Jupiter Trojans, near-Earth objects and — if the CAESAR mission is selected this summer — an ambitious sample return from a comet. China is also planning a sample return from a comet or asteroid. In contrast, ESA does not seem to have capitalized on its success with the Rosetta mission in the near-term.

Such interest should actually not come as a surprise. As Richard Binzel writes in a [Comment](#), small-body missions can provide answers to important scientific questions with relatively limited budgets. The pristine surface and interior of small bodies without those processes that alter planet-sized bodies provide scientists with a window to the past through which they can reconstruct the history of the Solar System at different epochs (and distances, now that we have started to observe trans-Neptunian objects from close by, with the flyby of MU₆₉ by New Horizons). At the same time, in situ resource utilization of asteroids will surely play some role in the future exploration of the Solar System.

These lofty objectives cannot be achieved without international cooperation. The OSIRIS-REx and Hayabusa2 teams demonstrate it clearly: as similar missions, they could have tried to outpace each other, whereas instead they are in close contact and they will exchange part of the samples they will gather. We hope that this approach will extend to other initiatives, which will need to walk the thin line between global advancement of humanity and national — or even private — interest. □

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