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With moons holding subsurface oceans, the outer planets are back in focus as the most promising places to find life beyond Earth. In addition to future missions, ongoing data analysis from past missions has an important role to play.

Last year, the discovery of the TRAPPIST-1 system of seven rocky planets made waves — literally — for three of them are in the zone for liquid water. Following many studies of their masses, composition and dynamics, it is too early to say whether there is surface water on any of the TRAPPIST-1 planets. And with more than three thousand other known exoplanets, and thousands more awaiting confirmation, the prospect of finding life beyond Earth has never been better.

But 'life' is a loaded term. Ask the public and they think 'aliens'. Scientists would be happy to detect microbial life. Our current technological capabilities only stretch as far as detecting certain gases in the atmospheres of some exoplanets. How exactly are we to find signs of biological activity? In their Comment in this issue of *Nature Astronomy*, Dirk Schulze-Makuch and William Bains suggest a middle way: look for complex life that is not necessarily technologically advanced. Take our own planet, for instance. The path to complex, multicellular life as we know it had several false starts, but technologically advanced life happened just the once. The next generation of telescopes — the extremely large ground-based telescopes as well as space telescopes — will be able to probe surface temperature, the presence of continents and biomarkers in the atmospheres of exoplanets.

Until then, it's worth focusing on our own Solar System. A recent conference, Environments of Terrestrial Planets Under the Young Sun: Seeds of Biomolecules, took place on 9–13 April at the NASA Goddard Space Flight Center. Vladimir Airapetian reports on the discussions of local and global-scale environments that fostered the conditions for prebiotic chemistry and later for biopolymers. Investigating the role of extreme weather in creating the wet–dry cycles that can drive the formation of biopolymers, for instance, requires observations, physico-chemical models as well as laboratory experiments. In another Meeting Report, John Forbes describes the gathering of astronomers, materials scientists, planetary scientists, astrobiologists, engineers and astronauts at this year's Breakthrough Discuss meeting, held on 12–13 April, at Stanford University. Most of the excitement centred on the possibility of life in "the subsurface oceans of Enceladus and Europa, surface lakes of liquid hydrocarbons on Titan, subsurface or past life on Mars, and even the clouds of Venus".

Much of the renewed attention on these distant bodies has been due to the astonishing images and discoveries of the Cassini–Huygens mission to Saturn and its moons. For instance, before Cassini snapped jets of water ice on Enceladus, nobody considered the icy satellite of Saturn to be of great interest. Now we know that the subsurface ocean contains not only water but carbon dioxide, carbon monoxide and organic materials at unexpectedly high densities. Thus, the ocean worlds ('worlds' is another loaded term) orbiting the outer planets are a key focus in the search for life.

Inspired by a talk by Melissa McGrath on radio signals from particles vented from Europa, Xianzhe Jia et al. put together old Galileo magnetometer and radio data from 16 December 1997 with fresh simulations and found that the space probe flew through a plume on Europa that day. The Hubble Space Telescope had previously imaged what looked like plumes from the solid surface, but the sightings were sporadic. This confirmation is being reported in the media as evidence for water, though we have no direct measurements of the composition of the plume. Rather, Jia et al. used water in their magnetohydrodynamic simulations, which fit the data. Nevertheless, this discovery has generated huge public interest in Europa, including that of a very keen supporter of space missions, Representative John Culberson, who is a political champion of the NASA Europa Clipper mission to orbit Europa. Moreover, on 17 May, NASA confirmed that it is soliciting proposals for Instrument Concepts for Europa Exploration 2 for a separate lander to explore the surface of Europa itself.

That Galileo is still delivering after 21 years shows the importance of continued funding long after a mission has ended. Take the Cassini mission as another example. Although the mission ended last year, its terabytes of data are still under scrutiny. Indeed, Robert West and co-workers use measurements of Titan's detached, upper layer of haze (above the main layer) to show that the gap between the two layers is seasonal, and the dynamics provide tight constraints on models for Titan's mesosphere. Besides its subsurface ocean, Titan is the only other Solar System body with a dense nitrogen-rich atmosphere. This haze is an important component of the methane cycle and a big producer of organics (including complex organics) that are deposited on the surface. But there are no concrete plans to send a probe to Titan before 2024. Fortunately, laboratory experiments can complement exploration. Nathalie Carrasco et al. have simulated the photochemical effects of ultraviolet radiation on the aerosols within the haze as they descend towards the surface.

Indeed, as covered in a previous Editorial, we are coming up to a gap in giant-planet exploration. Currently, there is only the Juno mission sampling the outer Solar System. It has returned stunning images of Jupiter's polar cyclones, and we anticipate more surprising discoveries. Future missions to Jupiter and environs include NASA's aforementioned Europa Clipper (2022–2025 launch); ESA's Jupiter Icy Moons Explorer (JUICE, 2022 launch for 2029 arrival) to Ganymede, Callisto and Europa; and NASA's Lucy mission to five of Jupiter's Trojans (2021 launch for 2027 arrival). Further ahead, NASA's proposed Ice Giants mission seeks to take advantage of the 2024–2037 planetary alignment — the same sort that allowed Voyager 2 to use a series of gravity-assist manoeuvres to reach Uranus and Saturn. Larger than Pluto, Neptune's moon Triton is another ocean world. ESA is exploring the possibility of joining Ice Giants, which would enable the agencies to do so much more. But even if all of these exciting missions are approved, unless Juno gets an extension beyond the end of its planned primary mission (16 July 2018), there will be a decade without any orbiters around the outer planets. Let's hope the unanalysed data held by mission scientists will continue to reveal their secrets. ❐

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