The International Space Station will be the centre of attention for human spaceflight for the next 20 years. **But what comes next?** There's a whole universe waiting out there to be discovered: the astronauts who fly on board the Space Station's 400-km high orbit are really just dipping their toes into the limitless of ocean of space. Already, ESA and other space agencies are involved in careful long-term planning that might see humans travelling further out into our Solar System.

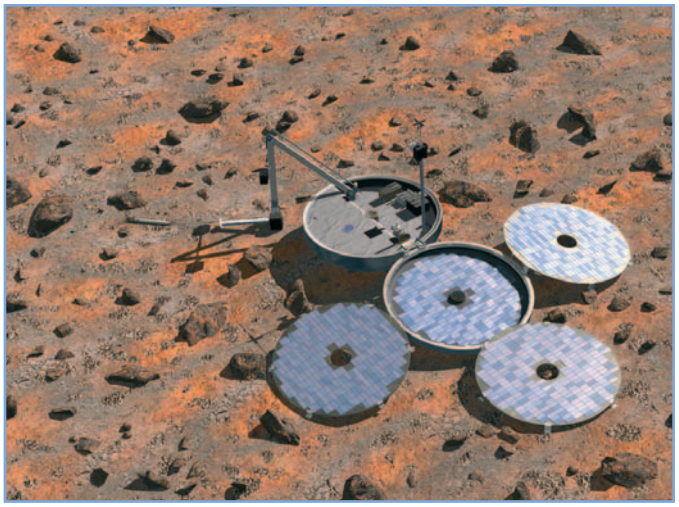
Where to begin? If space is an ocean, then the Moon is our nearest island. The last time it saw human visitors was in December 1972, when the final American Apollo astronauts returned from a mission to the lunar highlands. But space scientists have not been ignoring the Moon for the last thirty years. Instead, a series of space probes in the 1990s have sent back information that could make future human missions both easier and more useful.

The most exciting possibility is that water may exist on the Moon's airless and apparently bone-dry surface, frozen in the permanent shadows of deep craters near the Moon's poles. The water is probably left over from comet impacts millions of years ago – which makes it scientifically very interesting. Comets are made from the original material that formed the Solar System almost five billion years ago. It would be nice to find a sample of the stuff almost in our own backyard.

That water could also make a **lunar base** possible. Astronauts could use solar power to convert it into oxygen and even rocket fuel. At the very least, lunar water would greatly reduce the need to ferry water supplies from Earth.

For a real, working Moonbase, we will have to develop new rockets and landing craft. That technology will be very useful for the next

outward step: all the way to the planet **Mars**. Right from the beginning of the space age, Mars has fascinated scientists and engineers. The early Mars probes, launched back in the 1960s and 1970s, were great achievements, but they brought back disappointing news for all those who hoped that Earth's neighbour planet might support life. The place is very cold – never warmer than 15 degrees, even at its midsummer equator, and in the winter night temperatures fall to around -130°. Its atmosphere is almost 95% carbon dioxide, and far too thin even to protect the surface from ultra-violet radiation from the Sun.



But later probes have brought back better news. Spacecraft photographs – the entire planet has been mapped from orbit – show that water once flowed on the arid Martian surface. Clearly, Mars was once much warmer. Even if the planet bears no life today, it may have done so in its youth. Possible fossil bacteria have already been found in a meteorite of Martian origin: there may be plenty more waiting for us on Mars itself. And not just fossils: some at least of the planet's lost water may still be there, lying beneath the Martian surface. If so, there is a good chance that Martian life may have gone underground with it: there are certainly bacteria on Earth that could live happily under such conditions.

In fact, the search for **extraterrestrial life** is a major reason for further exploration. Life beyond the Earth could well be the most exciting scientific discovery of all time. It is probably out there somewhere: after all, the Universe is a big place. There are at least 100 billion stars in our own **galaxy**, and perhaps as many galaxies scattered throughout deep space. Until quite recently, though, **astrobiologists** (scientists studying extraterrestrial life) were not optimistic about life in our own Solar System – beyond the Earth, that is. But in the last few years, new discoveries both on Earth and in space have changed things dramatically.

On Earth, biologists have found that life-forms are much tougher than most scientists once imagined. Earth micro-organisms have been found thriving in astonishingly hostile environments. Deep beneath the oceans, for example, near the volcanic vents known as black smokers, some microbes grow and multiply at temperatures above 110 degrees – according to some scientists, perhaps as high as 170 degrees. Others thrive in acid conditions that would strip the skin from a human, while others still make a comfortable living in hot rocks kilometres below the ground. Some even prefer cold to heat: Antarctic life-forms can manage very well in what amounts to a permanent deep-freeze.

In the meantime, space probes have discovered many more places in our Solar System where these extremophile – "extreme-loving" – organisms might comfortably live and multiply. The "underground rivers" of Mars, if they exist, are one of the best possibilities. But there are plenty of other places, too. Almost five times as distant from the Sun as our Earth, in orbit around the giant planet Jupiter, the moon Europa seems to conceal a liquid, salty ocean beneath its surface – more than enough to support life. Indeed, given what we now know about the Earth's toughest life-forms, there is at least a chance that microbes could thrive even inside some comets.

We will never know for sure until we go there and **find out**. It will take time to create the advanced technologies needed for long-range human spaceflight. These will obviously include more powerful and more efficient rockets, as well as life-support systems capable of keeping people alive and reasonably comfortable for long periods away from Earth. Long before humans set foot on planets or asteroids, though, we will need to know much more about what they are likely to find there. What are the radiation hazards, for example? What are the dangers – and the opportunities – of strange environments far out in the Solar System?

So the first steps in the exploration of deep space will certainly involve sophisticated robot craft with highly advanced sensors and excellent long-range communications systems. Still, humans are better at exploring than any robot, and we are learning more all the time about long-term spaceflight – from work on board the ISS. That new knowledge will be essential when the time comes, perhaps twenty or thirty years from now, to send men and women on the next outward steps.