

Preface

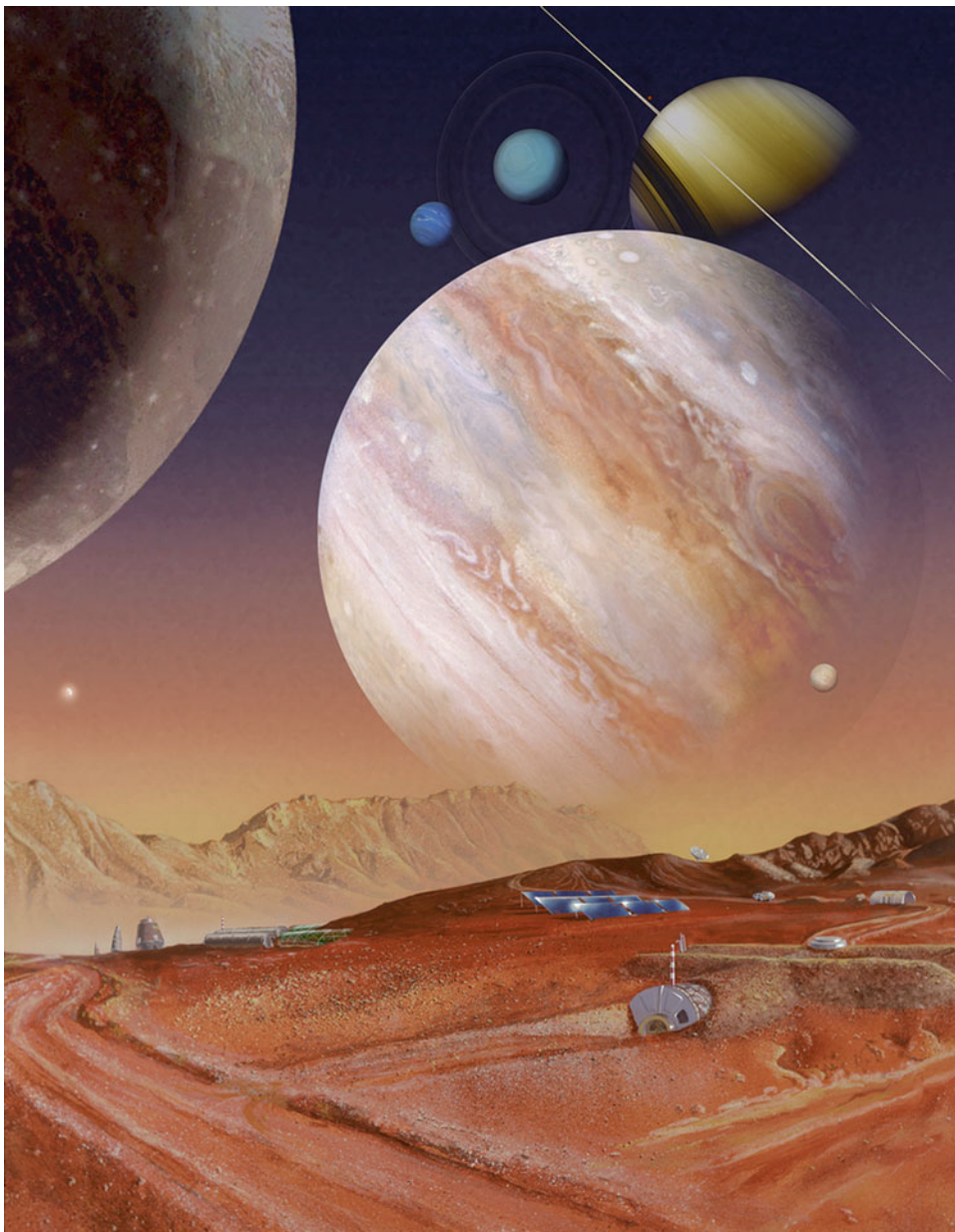


Fig.P.1 Mars is the next logical site for human habitation. But what other sites offer promise? (Paintings ©Michael Carroll)

The outer Solar System may seem an unlikely destination for future human travels, let alone settlements. The cold and distant worlds of gas, rock, and ice seem to repel rather than to beckon. Humans have been to the Moon, and we have our sights firmly upon Mars and the asteroids, but could there be a role to play by the outer Solar System in the drama of humanity's future?

If humankind is to explore and eventually settle the outermost reaches of our Solar System, we cannot do it by bringing everything with us. The distances are far too great. We must, in a sense, live off the land. There is another destination, much closer, that offers us resources to do just that – the Red Planet, Mars.

A lot has been made of Mars. Although the Red Planet is not as close to Earth as Venus is, its atmosphere is clear enough to view the surface through telescopes. Mars intrigued at the outset, with its Earthlike seasonal tilt and day, its polar caps, and its mysterious, undulating dark regions. Flagstaff astronomer Percival Lowell brought the popularity of Martian canals to a frenzy, crafting detailed maps of Martian “canal” networks and “oases” and writing popular speculative books about life on Mars. Writers such as Wells, Burroughs, and Bradbury took their cue from the work of early astronomers such as Lowell,¹ continuing the nineteenth- and twentieth-century culture's love affair with the Red Planet.

We are left with the legacy of these writers and scientists. Most of the Mars they described has crumbled before the scrutiny of space probes, but our desire to find Martian life – even in microbial form – continues to inform, some would say contaminate, our priorities for space exploration. During a recent meeting of the American Astronomical Society's Division for Planetary Sciences, one researcher quipped, “If you compare what we know about Mars to what we know about Ganymede, it's shameful.”

Still, if humans are to venture beyond the Moon for any length of time, the best place to go is one where we can live off the land. Mars has the resources to do so. It possesses large amounts of water, and its rarified atmosphere is 95 % carbon dioxide (CO₂), a molecular combination of carbon and oxygen. Water can be electrolyzed to produce hydrogen and oxygen. The hydrogen can be reacted with carbon dioxide from Martian air, to make methane, an efficient rocket fuel, and more water, which can be electrolyzed again. So the final products are methane and oxygen. Oxygen is something that most explorers prefer to breathe and is a major part of rocket propellant. Martian water is also useful for drinking and for tending plants, which themselves manufacture oxygen using the Martian CO₂.

Groups ranging from major aerospace corporations to private industry have carried out engineering studies in many forms, fleshing out scenarios for human Mars missions and settlements. They foresee the manufacture of Martian concrete and bricks to construct everything from rover garages to underground housing. Their crystal balls glimmer with visions of greenhouses full of bamboo, which grows fast and makes strong

1. Lowell also helped to discover the dwarf planet Pluto. Using observations of Uranus and Neptune, he predicted where a new planet should be and searched in vain for it. However, it was later discovered that Lowell Observatory captured the planet in photos in 1915, a year before Lowell's death. Pluto was discovered by Clyde Tombaugh in 1930. In recognition of Lowell's contributions to its search, the planet's symbol incorporates the initials of Percival Lowell, PL.

building material. Some even envisage genetically engineered goats, tilapia, strawberries, and poi to feed the masses of incoming Earth settlers.

Mars seems the next logical step. But Mars is taking the lion's share of planetary probe pie, and many believe it is time to shift a few more of our resources farther out. "What about Venus?" some ask. After all, the hellish world is Earth's twin in size, closest to us in distance, and complex both geologically and atmospherically. But Venus will be no home for humans in the foreseeable future using reasonable technology. All of our landers have succumbed to its 900 °F surface temperatures in just over an hour, and even the most current advances in engineering could not extend that stay much beyond a day or two. Brutal pressures claw at electronics, and acids eat away at insulation, while the heat demands cooling energy that might be used otherwise. It is not a nice place to visit.

However, if we look the other direction, beyond Mars, we find surprisingly rich resources and promise. True, the outer Solar System is dark and bitterly cold. Distances make communication and travel difficult. But the outer worlds, giants of gas and ice, possess entourages of icy and rocky moons replete with water, minerals, and hydrocarbons, and it is there where we may find a new future.

Arthur C. Clarke believed that the realm of the outer planets was a natural destination for humankind. He said, "We are exiles here on dry land, in transit between the ocean of water in which we were born and the ocean of space where most of history will run its course."

Mars settlement advocate Robert Zubrin takes it a step further, asserting that we *must* go. "The Hawaiian islands popped out of the ocean. The birds flew overhead and dropped seeds, and brought life to those places. There is oxygen in the air because life put it there. There is soil on the ground because life put it there. This is what we do. It would be unnatural if humans, being the kind of bird that the biosphere has developed to spread life across space, didn't drop the seeds of life on the desert islands out there in the cosmos."

If people like Clarke and Zubrin are right, Mars will be a stepping-stone along the way to farther shores. The worlds awaiting us beyond, in the frigid darkness, harbor abundant natural resources and deep mysteries that will likely lead to our foundational understanding of our planetary system. Carolyn Porco, Principal Investigator for the Cassini Saturn Orbiter imaging team, puts it this way: "No matter how you measure it, whether you count the number of bodies, whether you add up the amount of mass, or whether you calculate the volume taken up by the orbits of those bodies, the vast majority of our Solar System lies out beyond the orbit of the asteroids. Inside are just a bit of flotsam. It's all in the outer Solar System."

Moreover, future travelers to the realm of the gas and ice giants will be confronted by glorious, spectacular views beyond anything experienced thus far. Aside from practical scientific and technological gain, travel to the icy cliffs, thundering geysers, incandescent volcanoes, and swirling storms will bring inspiration. As artist/explorer Frederick Church once said,

“Exploration is good for the soul.” Henry David Thoreau advised that: “We need the tonic of wildness ... At the same time that we are earnest to explore and learn all things, we require that all things be mysterious and unexplorable, that land and sea be indefinitely wild, unsurveyed and unfathomed by us....” Although we’ve plastered our Earth maps to their corners with information from satellite and ground surveys, our maps of the worlds beyond still have vast territories labeled *Thar be dragons*. The cosmos compels us to fill them in. We have gone there with our robots, but the history of space exploration shows us that where our robots go, the footprints of humans will follow.

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Living Among Giants

Exploring and Settling the Outer Solar System

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2015, XIX, 225 p. 151 illus., 109 illus. in color.,

Hardcover

ISBN: 978-3-319-10673-1