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A LETTER FROM SPACE

In 1974 a new concept to improve the human prospect entered the arena of open discussion. Its thrust is to open for our use new sources of energy and materials while preserving our environment. First it was known as "space colonization," but now, as it is discussed with increasing seriousness in the circles of government, business, the universities, and

the press, we tend to use for it less dramatic names: "space manufacturing," or "high-orbital manufacturing."

The concept of human habitation in space is, of course, a very old one; in some form it can be traced back to the early days of science, and even earlier to mysticism. It has been a theme for fiction over several decades, and at least one fictional discussion of an inhabited artificial satellite, by Edward Everett Hale, was written during the latter half the nineteenth century. The Russian schoolmaster and physicist Konstantin Tsiolkowsky foresaw certain elements of the space community concept with remarkable clarity. In a novel, *Beyond the Planet Earth*, written about 1900 and published some twenty years later, Tsiolkowsky set his space travelers to work, on their very first voyage, constructing greenhouses in space beyond the Earth's shadow, and there raising crops to support a population of emigres from the Earth. His astronauts visited the Moon, but only as an excursion in passing; their most important destination was the asteroids, a vast resource of materials.[1-6]

Still other authors, most of them writing later in the twentieth century, played with the idea of habitats in space. Lasswitz in 1897, Bernal, Oberth, Von Pirquet, and Noordung in the 1920's, continued the theme,[7-14] as did Wernher von Braun, Dandridge Cole, and Krafft Ehricke in the 1950's and 1960's.[15-26] Although many of these ideas are echoed in this book, it would have been difficult, before the year 1969, to make of them a coherent picture without serious technical gaps.

Our goal is to find ways in which all of humanity can share in the benefits that have come from the rapid expansion of human knowledge, and yet prevent the material aspects of that expansion from fouling the worldwide nest in which we live. Necessarily, many of the concerns of this book are materialistic, but more than material survival is at stake. The most soaring achievements of mankind in the arts, music and literature could never have occurred without a certain amount of leisure and wealth; we should not be ashamed to search for ways in which all of humankind can enjoy that wealth.

A firm schedule for the development of resources in space would depend on decisions not yet made, but it appears that construction of a high-orbital facility could begin within

seven to ten years using launch vehicles no more advanced than those of today, and that it could be completed within fifteen to twenty-five years.

Governmental interest in high-orbital manufacturing stems in part from calculations on its economics. These suggest that a community in space could supply large amounts of energy to the Earth, and that a private, perhaps multinational investment in a first space habitat could be returned several times over in profits.

Much of the public interest relates to the human prospect that thousands of people now alive may choose within the next decades to live and work on a new frontier in space. If the concept is realized as soon as is technically possible, something like the following "letter from space" might be written within the next twenty years.

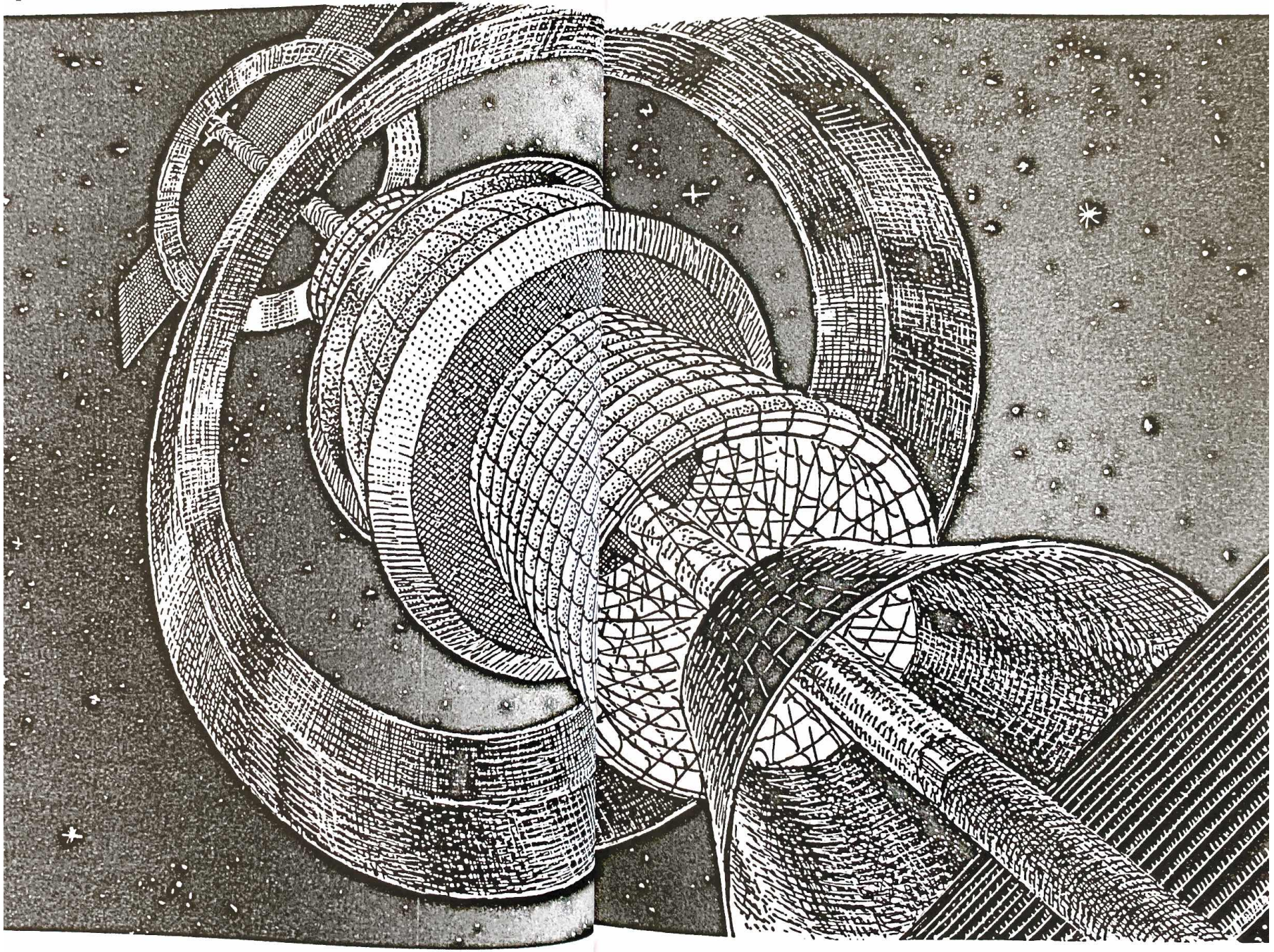
Dear Brian and Nancy:

I can understand that you want to hear from someone who's working and living in space before deciding whether to make the commitment yourselves.

According to your letter you've reached the "finals" in the selection process now. The next step will be the admission interview. After that, if you get an offer, you'll have to decide whether to go for the six-months' training. Though I never was in the Peace Corps, I understand that the selection methods are similar to theirs. Most people in your training group will pass the tests.

Then there's the big step of the first spaceflight, the three-week stay in orbit. By now the flight itself is quite routine; you'll find that the single-stage shuttle interior is much like that of one of the smaller commercial jets; there'll be one hundred and fifty of you traveling together. The g-forces will be higher than in commercial aviation, but still nothing to worry you. The trip into orbit will only take about twenty minutes, and then you'll experience something really new: zero-gravity. You may feel queasy at first—as if you were on a ship at sea. The three-week trial period is to sort out cases of severe space sickness, and to find out whether you are among those who can adapt to commuting each day between normal gravity and zero. That's important because our homes are in gravity obtained by rotation, and many of us work in the con-

Approaching Island One. Mirrors collect sunlight for farms and shielded living areas. Foreground panels radiate waste heat.



struction industry, with no gravity at all. Those who can adapt to rapid change qualify for higher paying jobs. The trial period also gives people the chance to decide that "this is not for me."

After three weeks you'll be ready to transfer to one of the "liners" on its next trip in. Jenny and I enjoyed that voyage. You'll be on the Goddard or the Tsiolkowsky and each takes a week for the outbound passage. About half of the passengers will be newcomers like yourself, and half will be returnees coming back from vacations on Earth. The ship rotates, so there will be gravity, normal in the public rooms and less than that in the sleeping cabins. In the six-months' training period you'll have had cram courses in foreign languages, so try talking with some of your fellow passengers from other countries. We like visiting nearby communities for dinners out fairly often, and enjoy talking with people we meet there even though our foreign-language ability is mainly the "restaurant" variety.

In space near the communities, the biggest things you'll see will be solar satellite power stations being assembled to supply energy for Earth. Those power stations are about ten times as big as the habitats themselves. You won't see much detail from the outside of the habitats because they're shielded against cosmic rays, solar flares, and meteoroids by a thick layer of material, mainly slag from the processing industries.

All the habitats are variations of basic sphere, cylinder or ring shapes. We live in Bernal Alpha, a sphere about five hundred meters in diameter, with a circumference inside, at its "equator" of nearly a mile. We have track races and bicycle races that use the ring pathway. That path wanders all the way round, generally following the equator, and near it is our little river. Bernal Alpha rotates once every thirty-two seconds, so there is Earth gravity at the equator. The land forms a big curving valley, rising from the equator to 45 degree "lines of latitude" on each side. The land area is mainly in the form of low-rise, terraced apartments, shopping walkways, and small parks. Many services, light industries, and shops are located underground or in a central low-gravity sphere, or are steeply terraced, because we like to preserve most of our land area for grass and parks. Our sunshine comes in at an angle

near 45 degrees, rather like mid-morning or mid-afternoon on Earth; the day-length and therefore the climate are set by our choice of when to admit sunlight. We keep Canaveral time, but two other communities near us are on different time zones. All the communities serve the same industries, so the production operations run twenty-four hours a day, three shifts, but with no one having to work the night shift.

Alpha has a Hawaiian climate, so we lead an indoor-outdoor life all year. Our apartment is about the same size as our old house on Earth, and it has a garden. Alpha was one of the first habitats to be built, so our trees have had time to grow to a good size.

You'll notice immediately the small scale of things, but for a town of 10,000 people we're in rather good shape for entertainment: four small cinemas, quite a few good small restaurants, and many amateur theatrical and musical groups. It takes only a few minutes to travel over to the neighboring communities, so we visit them often for movies, concerts, or just a change in climate. There are ballet productions on the big stage out in the low-gravity recreational complex that serves all the residents of our region of space. Ballet in ⅒ gravity is beautiful to watch: dreamlike, and very graceful. You've seen it on TV, but the reality is even better. Of course, right here in Alpha we have our own low-gravity swimming pools, and our club rooms for human-powered flight. Quite often Jenny and I climb the path to the "North Pole" and pedal out along the zero-gravity axis of the sphere for half an hour or so, especially after sunset, when we can see the soft lights from the pathways below.

You asked about our government, and that varies a great deal from one community to another. Legally, all communities are under the jurisdiction of the Energy Satellites Corporation (ENSAT) which was set up as a multinational profit-making consortium under U.N. treaties. ENSAT keeps us on a fairly loose rein as long as productivity and profits remain high—I don't think they want another Boston Tea Party. There are almost as many different kinds of local government as there are national groups within the colonies; ours happens to be a town meeting style. That wouldn't work in a town of as many as 10,000 people, except for the fact that all of us are much too busy to make a hobby of electioneering,

and that the basics of habitat survival require a high level of competence on the part of the maintenance people. Our teenagers have to work a year in one of the life-support maintenance crews—it's a little like military service on Earth—and if the regular government or maintenance people were to get balky, they'd be replaced by volunteers awfully fast.

Jenny and I laughed a bit about your comment on having to give talks to civic groups—I remember we went through the same things ourselves.

For information to use in your lectures, I'll mention a few basics. The initial stock of water for each habitat is obtained by combining hydrogen brought from Earth with eight times its weight in lunar oxygen. Here at L5, oxygen is a waste product from the industrial processes that turn out metals and glass. Our soil, of course, comes from the Moon and is fertile once we add water and nitrates. Because of our unlimited cheap energy, we don't have pollution here. Where energy costs almost nothing, and raw materials are relatively expensive, it pays to break down every waste product into its constituent elements.

So far there aren't enough communities to make long-distance travel a problem, but when there are many of them, spaced over thousands of miles, we already know how the transport system will work. We can just accelerate an engineless vehicle to a high cruising speed by an electric motor at one community, and then after a trip of several thousand miles, we can slow it to a halt by an arresting cable at another community.

A long time ago someone calculated the maximum size for space habitats. They could be made in sizes at least as large as twelve miles in diameter, with a land area of several hundred square miles in each one. We're already talking about shifting the mining base from the Moon to the asteroids, where we'll have a complete range of elements including carbon, nitrogen, and hydrogen. In energy, it won't be any harder for us to get materials from the asteroids than from Earth, and it should be a lot cheaper because the transport system can take its time and won't ever need high thrust. Someone calculated how much "room for growth" there will be once we start to use the asteroidal material. The answer came out absurdly high: with the known unused materials

out there, we could build space communities with a total land area 3,000 times that of Earth.

To go on with our situation, it's a comfortable life here. Fresh vegetables and fruit are in season all the time, because there are agricultural cylinders for each month of the year, each with its own day-length. We grow avocados and papayas in our own garden and never need to use insecticide sprays. Of course we like being able to get a suntan without ever being bitten by a mosquito. To be free of those pests, it's worth it to go through the inspections before getting aboard the shuttle from Earth.

You asked whether we feel isolated. Some of us do get "island fever" to some degree, probably because we're really first-generation immigrants; it never seems to bother the kids who were born here. When you sign your contract there are clauses that help quite a bit though. One is the provision for free telephone and videophone time to Earth. Another sets up free transportation to Earth and return on a space-available basis. Jenny and I took six-months' leave after our first three years here. Our visit was luxurious, because our salaries are paid in part in Earth currency; we're both employed, Jenny as a turbine-blade inspector and I in precision assembly. Our housing, food, clothing, and the rest are purchased in SHARES (Standard High-orbital Acquisition-units Recorded Electronically) so our Earth salaries just accumulate in the bank. When we went back we had a lot of money to spend, and even on a luxury basis we couldn't go through it in six months.

We found something though, that may help to answer your basic question: by the time the vacation was nearly over, we were very ready to come back here. We missed our own place. Jenny is an enthusiastic gardener, and though other people were living in our apartment here and taking care of the greenery, she wanted to be at home to enjoy it herself. And I missed the friends I'd been working with. I can best describe the other thing that drew us back by saying that the space habitats are exciting places to be. They're growing and changing so fast that if you're away for six months you've missed a lot.

As to whether you'll really like it, of the people who came with us, more than half intend to stay after their five-year

contract is up. I understand that the settlement of Alaska has had about the same kind of "stay-ratio."

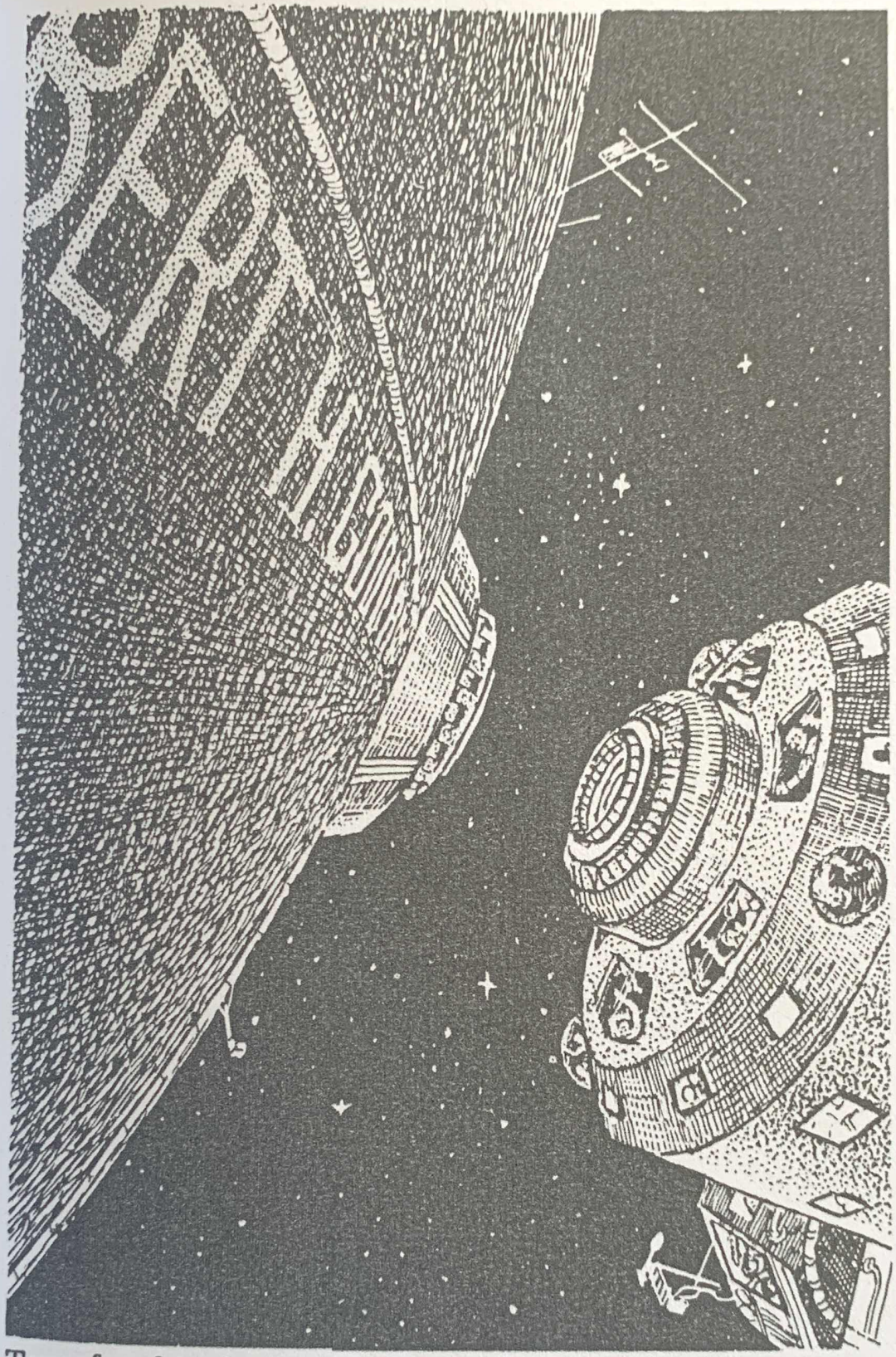
Now we're beginning to ask ourselves: will we want to retire to Earth or not? We don't have to face that for another twenty years, but we can see already that it won't be an easy decision. Some of us who are handy with tools have formed a club to design spacecraft for our own construction—rather like the homebuilt-aircraft clubs on Earth. We're thinking of homesteading one of the smaller asteroids, and the numbers look reasonable. Especially if our daughter and son-in-law decide to come along, with the grandchildren, I think we're more likely to move further out than go back.

If you decide to come out, let us know what flight you'll be on and we'll meet you at the docks. We'd like you to come over to our place for supper, and we'd be glad to help you to get settled.

With our best wishes for good luck on the tests,
Cordially,
Edward and Jenny

As we explore these possibilities we must remember that they are just that—not predictions or prophecies. The time scale may be longer than the fifteen to twenty-five years I estimate to be an achievable minimum; or I may be too cautious, and events may dictate a still faster scale. The "when" is not science but a complicated, unpredictable interplay of current events, politics, individual personalities, technology and chance. As a guess, though, I consider it unlikely that the first community in space will be established in less than fifteen years, and also unlikely that it will be delayed for another fifteen years beyond that. Neither of these dates is very far off; both are within the life-span of most people now alive. In the matter of dates, it is to me rather thought-provoking that Konstantin Tsiolkowsky, the great visionary space pioneer of nineteenth-century Russia, was himself too conservative on the date of the first Earth-orbital flight: he guessed the year 2017.

Robert Goddard (1882-1945), much of whose life was spent in the more practical and therefore much more difficult task of reducing the theory of rocketry to working hardware, left



Transfer ship docks at Island One. Arriving passengers will float through transfer corridor, then walk down to normal gravity.

us with a caution lest our vision be too narrow:

"It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow."