MARS FRONTIER

Vol. 4

The Commission

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The High Commissioner

Feb. 17, 2042

Douglas Morgan.

The news that the former astronaut turned Senator had been appointed the first High Commissioner of the Mars Commission—effective immediately—was encouraging. He was well known, experienced in politics—ever important for an international effort requiring diplomacy and lots of money—and knew the various space agencies well. He was also brilliant to the point of arrogance.

Commander William Elliott contemplated Morgan's power and personality as he walked across Aurorae Outpost to meet the chief of construction, who happened to be his wife. Greenhouse 9 gave him a good view of the site, so Will could stay inside and talk to Ethel by cellular communicator, seeing her expressions and the places toward which she was pointing through the thick but transparent Kevlar. It saved almost an hour, compared to donning and doffing a pressure suit.

Greenhouse 9's magnificent view momentarily pushed Morgan from his mind. He turned toward the rugged cliffs of Aurorae's northern escarpment twenty kilometers distant; they were one of the most spectacular aspects of placing the hub of Mars exploration in the eastern Mariner Valleys, and were a presence rather like the Front Range from downtown Denver. Then he turned south to catch a glimpse at Face Rock, a natural sandstone formation about thirty meters high that stood guard over the Outpost. From exactly the right angle, the silhouette of the rock against the pinkish sky looked like

the profile of a face. The escarpment and Face Rock: Will had looked on both almost every sol—Martian day—for the last six years.

He grabbed his attaché—a combination of personal computer and videophone, packed into an object the size of a clipboard—and pushed the telephone icon, then Ethel's number. "Hi, hon. I'm now in greenhouse 9."

"I'll be right there." A pressure suited figure that was welding together the metal skin of the basement level's ceiling turned off the flame, rose, and walked to the greenhouse. Will was pleased to see the basement walls had fill against their exteriors. It had taken them almost five months to get the lower level enclosed. Two other figures were welding together reinforcing metal bars for the future walls of the first floor. Eventually wire mesh would be woven among the bars, they would be encased in airtight metal forms, heating tubes would be installed, and duricrete—a mixture of windblown Martian dust, sand, ground up caliche, and water—would be poured in to make meter-thick airtight walls. All the work had to be done in pressure suits.

Ethel began talking when she was still fifty meters away. "There's not much to report. I talked to Pavel a little while ago—Columbus 3's now almost five light-minutes away, so it took a while—and he resolved a problem we had with the welding. We'll have the metal ceiling sheets installed by tomorrow."

"We'll be ready to pour the ceiling?"

"Yes. This morning Neal got the last load of sand, so we have everything. We can lay the wire mesh tomorrow. The problem we're having is with the welding around the vehicle airlock. Lal's doing his best, but he's no expert."

“I know. We should give him a different job. Have you trained him in running the plastics equipment?”

“Yes. He’d be better inside, but we need people able to work in both places, so he needs to do something outside. I’d rather train him to weld better.”

Will thought a moment, then nodded. “Let’s see whether we can get him up to speed. He’s a glaciologist, not an engineer. But he’s committed to this place, so let’s help him improve his skills.” Will pointed. “When will we pour the first floor walls?”

“Two months.”

“It’s going to be a race to get the building finished by mid June.”

“We’re going to be late. But we have plenty of room to house the new arrivals for a month or two while the building’s finished.”

“I’ll help with the welding after lunch, and we can do a walk-around then.”

“Okay, see you at lunch.”

He blew her a kiss—which she returned—then headed back to his office in Habitat 1. He strolled slowly through the greenhouse to enjoy the verdure; they could never get enough of the plant life. That was one thing about Mars that was difficult on him—the landscape, in spite of its often-varied colors and sometimes stunning vistas, was stark and barren. Verdure was one of three things he particularly missed, the other two being moonlight and swimming pools.

As he approached his office, he passed the nursery, and his son Marshall, now two years old, saw him. “Daddy!” he exclaimed and ran over. Madhu Gupta-Anderson, who was watching Marshall and her own son, one-year-old Sam—who was just beginning to walk—pursued the boy.

“Hi, Marshall.” Will stopped to give his son a hug. “Are you having fun?”

“Auntie Madhu read us a story about the bear twins!” It was a story he asked for often and really loved.

“I love that story, too. I’ve got to go back to work, but I’ll see you at lunch.”

“Okay, daddy.” Marshall was disappointed. Will hugged him again, added a kiss, and headed for his office. He closed the door so that his voice wouldn’t distract Marshall.

He removed his attaché from his belt, unfolded the thin keyboard, and set it on his desk. He had a videomail message, much to his surprise, from Douglas Morgan. The message began with a three second still image of Dr. Morgan: neatly dressed, every hair in place, looking very organized and professional, with up to date contact information displayed underneath. Will could see he was dealing with a detail-oriented and confident administrator, one hitting the ground running.

“Good sol, Dr. Elliott,” Morgan began, using the greeting common on Mars. “You are the first person I’ve sent a greeting to since my appointment as High Commissioner of the new Mars Commission. Our relationship, clearly, is one of the most important ones to develop in the organization. The communications delays, the long flights to Mars and the rarity of opportunities for transportation between the planets, give Mars surface operations an autonomy that one would not expect of the lunar operations. Hence we both need to know what the other is thinking about and wanting to get done.

“We met very briefly back in 2030. It was my last year in the Astronaut Corps just before I ran for the Senate. I had just returned from the moon and you were about to head up. Other than that brief encounter, I regret that we never have conversed. Perhaps over the next two months, when Earth and Mars are very close and the time delay is the

least, we can establish an open line and chat informally. I gather your management style is rather like mine, based on personal relationships whenever possible.

"Your approach to Mars has been a shock to many people, but it has been gradually carrying the day. I am skeptical but impressed. You seek to make Mars a place for successful science and exploration that captures the imagination and attention of the public, a comfortable place to settle and raise a family, a source of natural resources for export—gold, fossiliferous rock, argon, nitrogen, and methane from Phobos and Deimos—and an opportunity for the public to become stakeholders through purchase of land. These five prongs should produce a Mars project that has long-term financial viability if they are balanced right. The first guarantees the project's scientific relevance and support from the scientific community. The second captures the imagination of the public, which is the ultimate source of government funding. The third produces a stable long-term workforce on the planet, which otherwise would have frequent turnover and consequent low staffing levels. The fourth draws support from commercial interests and lays the foundation for an economic base for Mars settlement, which will not be financially self-sufficient for a century, if ever. It also bolsters support from the public by giving it something to purchase, as does the fifth prong, the sale of land. By providing the public with things it can actually do to contribute to the Mars project, we reinforce its interest and solidify its support.

"The trick is balancing these five. Too much commercialization can lead to the chimera of financial self-sufficiency and undercut the financial commitment of governments. Too much popularization can undercut the support of the scientific community. Too much of an effort to make Mars a comfortable place to raise a family

can undercut its image as a place of exploration and raise the issue of wasteful use of resources. Our task is to manage all five, which means the message that goes out through the media must be carefully balanced.

"Perhaps that's the main thing my office can do, because the Mars Commission doesn't do very much. It's really an international committee providing oversight to an ongoing operation. The ground support personnel remain under the employment of their various space agencies and contractors: life support and ecology for Mars, the moon, and other space facilities is located in Seville, space medicine is mostly in Moscow, the interplanetary transit vehicles are monitored and supported from Berlin, Mars shuttles in San Diego, lunar and Mars habitats in Milan, rangers and conestogas in Indiana, surface science in Houston, Moscow, Berlin and Tokyo, etc. The Mars Commission itself is on the grounds of the Johnson Spaceflight Center and like the Lunar Commission, with which we share a building, and our employees are NASA employees. We're not allowed to fly the United Nations flag outside; only the flags of the members, with the American flag in the center on the highest pole. I have permission to hire a multinational support staff and will implement it aggressively. The Mars effort remains very much an American project, and that is to be expected as long as we pay more than half the bill. I hope to increase the financial share of the other agencies, both to increase the budget and bring about more balance. Otherwise, we risk alienating international public support. The more nations sending couples to Mars to settle, explore, represent their cultures, and do science, the better.

"Those are a few thoughts for you. I look forward to hearing from you at your earliest convenience. Bye."

The picture of Morgan slowly faded. Will stared at the screen, impressed. Morgan not only grasped his own philosophy, but had summarized it more succinctly than he ever had. The idea of recruiting professional couples from as many nations as possible, sponsored by their governments—at a mere half billion dollars per couple—was intriguing and encouraging. Why send individuals to spend twenty-six months away from their spouses and children—risking collapse of their families—then replace them, when one can send couples to stay fifteen to twenty years, raising their children on Mars, becoming experienced experts in the skills needed on the Red Planet, and accumulating a much larger personnel base? It made eminent sense once one overcame the taboos against sex in space, children in space, and families in space; not to mention space as a place for pure science, space as a place for pure exploration, space as a place free from the grubby financial aspects of terrestrial capitalism, space as a place to build a utopian community, and various other notions.

Will vaguely remembered meeting the man at Kennedy Space Center. It was a brief encounter; they had exchanged a few sentences. He remembered a vague feeling of unease. It reminded him that, isolated and millions of kilometers from Earth, it was difficult to be frank and completely natural with a stranger. He had to start slow and seek outside opinions. He switched screens and typed a reply.

“Dr. Morgan, congratulations on your appointment to the position of High Commissioner of the Mars Commission. I am delighted. Thank you for calling me right away; I’m flattered that you thought of me so quickly after your appointment. I look forward to getting to know you better. I can clear some time morrowsol so that we can talk more spontaneously.

"I'm very impressed by how well you summarized the philosophy we have been developing. It is possible because Mars exploration was delayed so many decades and the technology became reasonably mature. We have been stockpiling fossiliferous rock, nitrogen, and argon for export. The propellant making facilities on Phobos and Deimos are back on line, thanks to a visit by the Columbus 3 crew, and are producing methane for export. What I would like to see us do, in the next few months, is lay the groundwork for the sale of Martian real estate to the public. Marketing research by the Mars Exploration Society proposes a sales price of $1,000 per square kilometer for 'range' land—that is, unimproved land—more than 150 kilometers from the outpost. That's $10 per hectare or $4 per acre. But as one approaches an outpost, the value goes up exponentially; at 75 kilometers of distance it quadruples, halve the distance and it quadruples again, etc., primarily because we can provide more services and are more likely to exploit resources on land close by. The study recommends sale to the general public in $2,000 units, with specials to sell it in ten square kilometer units to investors and thousand-square-kilometer blocks of range to larger corporations, at discount prices. The report estimates that the Commission could raise $50 million dollars this way; not huge, but useful.

"My other suggestion regards safety. We still have no idea why Paul Renfrew lost control of his ranger; a freak accident caused by a momentary lapse in attention is most likely, but is not a satisfactory explanation. There are questions about the airbags impeding his escape and delaying his rescue and why they didn't partially plug the air leaks. There are a dozen major vulnerabilities in our operation. The new buildings and greenhouses, made of local materials, are huge unknowns. I'd like to see us appoint an outside panel to review safety every two years. The Columbus 4 arrivals should serve as a

safety inspection team before they learn too much about our procedures; we need their unbiased input.

"Assuming you serve as High Commissioner for ten years, you will probably guide Mars's growth from fifteen adults and two children to about seventy-five adults and fifteen children. Think of the science we'll be able to do with that much resources! But getting there won't be easy and will be expensive. I pledge our effort up here to make that level of expansion practical and inevitable. Bye."

He reread his comments, edited them, then put on the jacket of his uniform so that he'd look the part. He displayed his script on the screen so that it would serve as a teleprompter and recited his written notes naturally. It guaranteed that he, too, would look organized and professional. He sent the result. Then he took off the jacket and recorded a quick video message to Heather Kimball, President of the Mars Exploration Society.

"Heather, good sol to you. I just received a very friendly and upbeat message from Dr. Douglas Morgan. I don't know how to ask this: can you call some friends and get a frank assessment of Morgan's personality and approach to people? I don't know whether to let down my hair with him or not. You know how it is; I've been away so long, I don't know half the people I have to deal with, so I can't determine whether being frank with them is productive and fosters a strong relationship, or whether it allows them to take advantage of me and undermine my positions. It's a very awkward situation to be in, not knowing whom one can trust. Let me know whether you can help. Bye."

2

Opposition

18 Feb. 2042

The next sol, Will spent four hours with Douglas Morgan. The round trip time for communications was an irritating11.3 minutes, but that was as short as it would get in twenty-six months; it was the day when Earth and Mars were at opposition. Just before starting his call with Morgan, Will received a reply from Heather Kimball. “Hi, Will. I’ve made a few inquiries. Everyone says Doug Morgan is smart and technically good at what he does, but he isn’t personally creative. That was true of his piloting, his engineering work on the moon, and his Senate career. He is a fair man, accessible, and a good listener, and those skills have made his success. He’s good at adopting ideas others have advocated and making them his own. He loves the limelight and is articulate.

“He is often sure he’s right, and that can happen a lot because he’s bright and he knows it. He doesn’t seem to hold grudges or write people off. Most people are very excited that he’s the first High Commissioner of the Mars Commission. He’ll probably be easier to work with than Harold Lassen, who was conservative and hard to change. Harold was a bureaucrat. You were never sure what deal he was making behind the scenes with someone to get their support for some idea of his.

“Here’s my suggestion. You need a full-time secretary in the Mars Commission building. Whatever duties you give him or her, the person has to serve as your confidential eyes and ears and tell you what’s going on. I’m sure the person can earn his or her salary; there’s plenty of official correspondence that needs to be done on behalf of the Outpost. Put simply, you need a lobbyist in the Commission whom you trust. I have a

few people in mind, too; I can send you the names. You have friends in Houston who can make sure you get the right person for the position. But you'll need to arrange for the salary. Let me know if I can be of further help. Bye."

He liked her advice, but he doubted he'd have time to respond; Morgan was scheduled to videomail him in a minute. So he thought about her advice, then ran to the Mars Exploration Society's website to see what the latest Mars headlines were. Their webmaster was skilled at linking to the latest news; he sent some links straight to Will. The Outpost's computers were programmed to scan the MES website every ten minutes, so it was always updated.

The lead headline was quite interesting: *New Commissioner Calls for Comprehensive Mars Safety Review.* The wording of the article echoed Will's videomail of yestersol. Morgan was indeed good at adopting the creativity of others.

But before Will could consider what to do about the use of his ideas, a video message arrived from Morgan. The discussion had begun.

"Good sol, Will. I'm glad we can spend this time together. By the way, today is my official first day at work; interesting that it's also opposition!

"I want to start by commenting on your suggestions yesterday. Regarding the sale of land, we can move it forward immediately. The new treaty sweeps away political, legal, and diplomatic obstacles. Ideally, we should launch the sales a few days after Columbus 4 arrives in order to capitalize on the publicity the landing gives. But it will be difficult to be ready for land sales in four months. Down here, we have to set up the software and hire the people, and the lawyers have to get the legal arrangements in place. Up there, you need to obtain the marketing information on the range to be sold. We have

excellent aerial surveillance of Aurorae Borough and of all land along the Circumnavigational and Polar Trails, but we need to redo some of the data for the purpose of marketing. That will take time at the Outpost. If we drove a ranger slowly along the road where land is to be sold—for example, through Little Colorado Canyon and the rim of the escarpment—or even flew a Sunwing low over the ground to capture a sideways view, we'd have better visuals for stimulating land sales. Can all that be ready in time? I don't know.

"Regarding the safety review: I agree another review is timely when the Columbus 4 crew arrives.

"I have a suggestion. We should initiate a brainstorming about the future shape of Mars exploration. I envision two panels, one on Earth, one on Mars, exchanging their views for about an hour each. The Earth panel needs to be pretty large; I'd like to involve representatives of several space agencies. We've got to get the money people involved as well. Everyone tells me that Columbus 5 will involve four interplanetary transit vehicles, just like Columbus 4. There are no plans to improve the ITVs or develop an expanded model. Consequently the number of people flying to Mars every two years will be constant for six or eight years. This must be viewed as an opportunity for the Mars facilities to mature because I will make a strenuous effort to maintain the total cargo mass shipped—75 tonnes—and that means we'll be able to improve and expand your infrastructure considerably. The mass shipped per resident must continue to decline or we will have no surplus for new equipment.

"What priorities do you see for the Mars mission? Let's exchange views about that matter. Bye."

Will had scribbled notes while Morgan spoke. He reviewed them quickly and added a few points he had to make, then recorded his reply.

“Good sol, Doug. If I may suggest this, let’s talk on a first name basis. I’d prefer the informality.

“Regarding land sales, we can rearrange our work schedule to run sunwings and rangers to gather the visuals that are needed. The sunwings have excellent hazard avoidance software; Houston can program them and all we’ll need to do is monitor them. The rangers require a bit more time, but a manageable amount.

“Regarding the safety review, I’m glad to see, based on the headlines I’ve read, that you’ve adopted the idea and we’ll move forward on it.

“Regarding a symposium about the future of Mars exploration, I’d favor a planning horizon of six or eight years. It needs to be convened right away while the planets are close. In the future we need to schedule a scientific symposium for every opposition. With the short transmission times we could even include geology field trips via video link.

“Regarding Mars exploration, we need to devote six of the next eighteen months cleaning up the Circumnavigational Trail and completing geological exploration of its environs. I’d send six vehicles that could split into two or three mini-expeditions that would range as much as a thousand kilometers off the trail to investigate sites of interest. The priority after that should be to complete the Polar Trail to the South Pole and clear a Tharsis Trail, which would connect the three big volcanoes, then run northward to Uranius Patera and maybe to Tempe Fossae.

"Two other trails have been proposed. The so-called 'Virgo Trail' is named for the Tropic of Virgo, Mars's equivalent of the Tropic of Cancer. It would not follow the 25th north parallel closely, though: it'd access the mouth of Kasei Vallis, Tharsis, Olympus Mons, Elysium Mons, and the highland-lowland dichotomy. The southern equivalent is the so-called Pisces Trail, which would access Nirgal Vallis, the Thaumasia Mountain range, Thaumasia, Daedalia, Cimmeria, Hesperia, Hellas, and Noachis. We can complete all four trails in five or six years, at which point we'd have about 75,000 kilometers of dirt tracks and almost all of Mars would be within a thousand kilometers of a trail. Exploration and scientific study could shift to greater use of aircraft, assuming we can get bigger ones, or to use of large 'Mobile Lab' or 'Mobile Hab' vehicles.

"So those are the exploration priorities. We also need more sophisticated equipment for drilling more deeply so that we can recover deposits from early Mars, more automated exploration equipment, and a new generation of satellites. There are a lot of plans for expanding the Outpost; I favor the use of large domes imported from Earth because we badly need open spaces up here, filled with greenery and possibly containing a swimming pool and a basketball court.

"I also want to raise a mundane matter with you: I need a secretary in Houston who can help me with correspondence. I'd oversee the hiring so I know what sort of secretary I'm getting. If the person is someone I can trust, I can even have him or her make calls on my behalf in circumstances when the time delay is a serious barrier to communication. As you can imagine, such an assistant could be immensely helpful to me.

"Those are a few comments for you to chew on. Bye."

Will had twelve minutes before Morgan could reply, so he read the articles about the Mars safety review. They never mentioned that he was the originator of the idea. He wondered whether to comment on that; he didn't want to be taken advantage of, but he also didn't want to sour their relationship from the start.

Morgan's responses, when they came, were mostly positive; he was in favor of clearing of the trails, the drilling, the mobile habs, and the increased supply of automated probes. He raised the additional matter of expanding the biological research facilities. But he did not like the secretary. "I wonder why you now need something you haven't had for several years," he explained. "The Commander of Mars Operations doesn't need a local lobbyist; he has the ear of the High Commissioner. If you need some secretarial help here and there, I can assign someone to make calls. My own secretary can help with more sensitive matters. The Outpost already has support staff for all sorts of technical matters, even a professional editor to help prepare manuscripts for publication. It seems to me that's sufficient."

Will thought about the response. He wasn't going to push the matter yet; he needed new arguments. He hit reply, agreed about the biological research facilities, and added that a low-pressure greenhouse was needed to study agriculture under conditions that would simplify the construction of domes. Morgan was positive about the idea and suggested that such a greenhouse be put on the Outpost's construction schedule, assuming the budget would accommodate it. He raised the question of whether the water supply reservoir should be seeded with microorganisms and fish; it was an eight thousand tonne block of ice. The top two meters of ice was sufficient to protect the rest from ultraviolet and cold, and the bottom could be thawed.

They continued exchanging ideas informally until lunchtime, when Will paused for lunch and Morgan for a meeting. Will was about to head for lunch in the Renfrew Building—so named for the late Paul Renfrew, their dear friend and colleague who had died in an accident while exploring Mars just six months earlier—when he got a call from Eve Gilmartin. “Will, can you come to the sick bay real quick?”

“Sure; a problem?”

“I’ll leave that to you to decide. Just stop by.”

“Okay, I’m on my way.” Puzzled, Will headed for habitat 2. When he arrived, he was surprised to see Ethel.

“Don’t worry, daddy,” replied Eve.

“Daddy?”

Ethel nodded and smiled. “That’s right. I’m pregnant again.”

“Really!” He kissed her. She kissed him back, pleased. “What good news.”

“Of course, it means I can’t work outside more than an hour every three sols because of the radiation exposure.”

“That’s true. We’ll have to rearrange the construction schedule, and it’ll slip more.”

“More than you think,” added Eve. “As the outpost’s physician for women and children, I can tell you something that is not publicly known: Ethel is not the only woman expecting a child.”

“Oh?”

“I’ll ask the affected party to let you know right away. Furthermore, I can add that those two women are not the only ones hoping to have children soon, so there may be another surprise in store for your work schedule. Just warning you.”

“Thank you. Could you suggest that the other party or parties also let me know?”

“I’ll mention it, but it’s hard to plan for a possibility.” Eve sighed. “Everyone is healthy, thank God. Let’s hope the Martian environment doesn’t have surprises in store.”

“I hope the baby hasn’t been harmed by all the radiation I’ve been exposed to lately,” worried Ethel. She turned to her husband. They strode out of the sickbay arm in arm.

“How did you know?” asked Will.

“I wasn’t sure, but my period was late and I was feeling a bit off, so I came in for lunch a half hour early and found Eve.”

“It didn’t take long; five months.”

“No. It’ll be interesting to see what Marshall’s reaction is.”

“How do you feel about this?”

She shrugged. “It’s the right thing to do. I want Marshall to have a brother or sister. It’ll be a lot of work, but we have a good support system here.”

“A very good support system.”

They walked the rest of the way to the cafeteria in silence. Their son was already there, eating with Sam Anderson and Érico Lopes, who had been watching both boys that morning. They brought Marshall to their table and lavished attention on him to distract themselves from the news they didn’t feel ready to share with everyone else yet.

“Will, how’s the discussion going with Morgan?” asked Roger, stopping by.

“Pretty well, I think. He seems to be on our side.”

“Does he favor science, family, commercialization, or what?” asked Neal.

“He favors a balance among five priorities: science, exploration, family, exports, and land sales. But of course no one knows what ‘balance’ means.”

“How much influence does he have?” asked Rosa Stroger. “NASA still calls the shots. They can veto almost anything on the grounds of safety.”

“All those details still have to be worked out,” replied Will. “The Mars Commission’s only weeks old. It has an international governing council that sets priorities, but NASA provides the staff and Congress authorizes almost half the funding.”

“This beastie may not be better than the old arrangement,” exclaimed Roger.

“Everyone should start working on a memo about the priorities they think we should set for the next columbiad and for the next four columbiads,” said Will, referring to the twenty-six month cycles between the arrival of the Columbus spacecraft from Earth. “We need a medium-term plan. We can’t create a long-term plan, which I’m defining as five columbiads or more. It’s just too uncertain.”

“Any changes to the work we have to do between now and Columbus 4’s arrival?” asked Érico.

“We have to call a town meeting and make some decisions about sale of land in Aurorae Borough, and we may have to reallocate some human resources for health reasons.”

“Health?” asked Shinji, surprised.

Will nodded and did not elaborate.

3

Landing

26 June 2042

A sleek teardrop-shaped space vehicle dropped out of Mars orbit. The shuttle *Olympus,* carrying six human beings and fifteen tonnes of cargo, hit the Martian atmosphere at some 19,000 kilometers per hour and bit deeply, plunging to within fifty kilometers of the surface before rising back out of the atmosphere. Some two hours later it swung back toward Mars in a much-truncated orbit, hitting the atmosphere at 14,000 kilometers per hour, and this time it rode through the atmosphere all the way to the surface. After a four-minute bumpy ride through hypersonic entry that briefly enveloped the shuttle in ionized plasma, the *Olympus's* speed dropped enough for drogue chutes to be deployed, followed by the main parachutes a few seconds later. The teardrop slowed further, to a mere thousand meters per second, and as it fell into thicker air below Martian "sea level" the drag slowed it further to five hundred meters per second. Doors in the metal heat shield covering the bottom of the teardrop opened, exposing rocket engines, and seconds later they flamed alive, burning off the *Olympus's* remaining speed. Landing legs extended. The *Olympus,* following the Outpost's radio beacons, modified its course ever so slightly, then settled on its tail of orange-tinged, bluish methane-oxygen fire, touching down gently exactly in the center of its landing bullseye.

The silver teardrop, sixteen meters long and six meters wide at its bottom, sat on its six landing legs. Inside, the six crew, relieved that everything had gone perfectly—everything happened very fast—said their silent prayers of thanks and unstrapped themselves. In the bridge and the great room of the Outpost there was applause.

Two conestogas—large, eight-wheeled surface vehicles—immediately headed for the landing site. They circled the shuttle to make sure it was safe. Once the landing systems were shut down, mission control—Will and Roger—gave the conestogas permission to move in. The six new residents of Mars suited up and exited, joyfully walked around their vehicle, marveling at the new world they had safely reached, then stepped inside the conestogas with as much cargo as they could load into them. The conestogas entered the basement of the new building, allowing everyone to step straight into regular air. Will and five others were there to greet them.

"Yevgeny! Alexandra!" Will called out. A Russian couple, the Lescovs, were the first to step out, laden with bulging suitcases. They saw Will and waved. He walked over and shook hands with both. "Welcome to Mars!"

"Thank you," replied Yevgeny. He smiled broadly; he and Will had known each other on the moon. "Long time no see, Will."

"A very long time, Yevgeny. I'm glad you're both here."

"We're delighted," replied Alexandra. "Where's Ethel?"

"At work; you'll see her later. Let me greet the others who are arriving, then I'll show you to your quarters." Will turned to greet Charles and Martha Vickers, two Americans who were just arriving; he was a geophysicist and expert on meteorites, she was a psychiatrist. Then Will shook hands with Dr. Tang Enlai, the first Chinese astronaut on Mars and an accomplished exobiologist. "Welcome, Dr. Tang. I'm thrilled to have representation from China here."

"And I am pleased to be here; thank you. I look forward to working with you."

“Thank you.” Will made an extra effort to be friendly; he wanted Dr. Tang to feel at home. The last man stepping off was Dr. Olaf Norlander, a Swede and an expert on driving Prospectors, telerobotically operated rovers. He greeted him as well, then turned back to the Lescovs.

“Follow me, and I’ll take you to your new quarters.”

“We can find them ourselves; we don’t want to inconvenience you!” exclaimed Alexandra.

“Oh, it isn’t an inconvenience at all.” Will pointed to a little metal wagon, looking like the sort a child would own. He helped them put their three pieces of luggage in it. Alexandra stopped to admire the workmanship, then nodded. At the airlock into the rest of the Outpost she stopped to look at the work again.

“Good quality welds, and the metal looks pretty good, too.”

“You really can’t tell very well by video.”

“No, you can’t! The quality of work here is excellent.”

“It has to be; our lives depend on it.”

They closed one airlock door, then walked five meters through a tunnel and opened another door. It led them into Renfrew.

“You’ve moved your family into here, right?” asked Yevgeny, looking at the duricrete walls.

“Yes. Renfrew has been airtight for over a year, now, and it has proved very reliable. With another baby on the way, we needed more space.” Will pointed to the stairway that went up to the top level. “The building has exits on both ends, and both

levels have airtight emergency shelters near the middle. The kids will never be alone until they know what to do."

"Still, I would worry if I had children here," said Alexandra. "I suppose you get used to it."

"I'm not sure you ever get used to the dangers, but what can we do?"

"It's difficult," agreed Yevgeny. "Alexandra and I decided not to have children at all for that reason, and now it's really too late. But I suppose we'll enjoy your kids."

They walked across the Great Room, waving to the two people in the kitchen preparing lunch. Then they passed through another airlock, then through a greenhouse. The wagon barely fit and brushed against tomatoes and corn constantly as they walked through. The Lescovs looked at the plants and marveled; after months in space, they craved greenery.

"How did the *Olympus* do?" asked Will. "It was on Columbus 1. It's nice to have it back."

"It's been pretty extensively refurbished," replied Yevgeny. "You might not recognize it. The new crew module in the cargo bay is more comfortable and reliable than the old one."

"Much better life support," added Alexandra. "Easier to maintain, too."

"And new pumps and engines," continued Yevgeny. "The guys at the International Space Station II worked on it for six months."

"I'm relieved. The 'Shuttle B' design is widely regarded as more safe. One thing we can't afford is an accident."

“They are much better,” agreed Alexandra. “And since these engines have been tested extensively with ethylene propellant, they are more flexible.”

“I’m very interested in the proposed Phobos-Deimos science mission,” said Yevgeny. “Six weeks on each moon would allow us to do quite a lot of research and lay the groundwork for future stations on each. We’d also be able to upgrade the fuel-making plants more extensively than a one week visit allows.”

Will nodded. “I’ve been fascinated by the proposals. We’ve got plenty of science equipment we can deploy there, and now we have maneuvering units that make movement easier.”

“And with two interplanetary habitats at Embarcadero, each with ion engines, we can move one to each moon to provide housing and redundancy for the mission,” added Yevgeny.

“It’s the only way to stay six weeks; the shuttles don’t have the consumables otherwise,” agreed Will. “I have to be satisfied the safety margin’s there. I’m in favor of flights to the moons, especially if they carry cargo to orbit for eventual transport to Earth. And NASA’s being much more conservative with us, since Paul’s accident.”

“What about the Mars Commission?” asked Alexandra.

“The Commission still doesn’t have much say. As you know, the United States has managed to retain most of its control because it provides the Commission most of its services. So right now the Commission is toothless. But that isn’t to say we don’t have to convince Morgan; we do.”

“The Commission has become an exercise in frustration,” said Yevgeny. “I wonder whether it was such a good idea, now.”

“Maybe all of us can help make it a good idea, then,” replied Will. “Over time, it can grow stronger.”

They passed through another airlock and entered Habitat 1. The sound of children greeted them. “Day care is still here, but it’s moving to Renfrew,” explained Will. As they walked across the habitat toward the stair at the other end, Ethel came out of the child care area.

“I thought it would be you,” she said to Alexandra and Yevgeny.

“How are you?” asked Yevgeny, smiling. He stopped to kiss Ethel on both cheeks; Alexandra did the same.

“It’s been a long time since that stay at ISS-2, Yevgeny,” replied Ethel. “And I haven’t seen you, Alexandra, since our time at Shackleton in ’33.”

“Nine years! Time flies,” she replied.

“Welcome to Aurorae,” said Ethel. “It’s nice to have old friends join us. You’ve signed up for three columbiads, right?”

Yevgeny nodded. “Three, and I doubt we’ll stay more. That’ll be plenty.”

“We’ll be in our fifties by then. Maybe we’ll retire early,” added Alexandra. “We’ll have plenty of money and a modicum of fame.”

“How long will you stay here?” asked Yevgeny. “If you wait for the new baby to grow up, it’ll be 2060!”

Will sighed. “We may be too old to fly back to Earth by then! Now they’re saying Columbus 5 will test the new nuclear thermal engines, and once the reliability is assured, in a few columbiads they may switch to three month flights each way. With proper

radiation shielding, kids probably could manage a three-month flight. So who knows? Maybe we'll go back in a decade."

"On the other hand, in 2060 this place will be getting big and interesting," said Ethel. "There could be several hundred people living in the Outpost by then. Maybe we'll be the first residents of the Aurorae retirement home, about 2075."

"It hinges on cheaper transportation," agreed Yevgeny. "I wouldn't count on the nuclear thermal engine. Environmental concerns have forced redesigns and the development cost has doubled. And a Swift Shuttle with a much larger cargo bay has to be built to transport hydrogen to orbit cheaply."

"The timing was bad," agreed Will. "NASA was foolish to pretend the Swift shuttle wouldn't work. Now no one wants to use the Areas and Ariane, which reduces demand for them and raises the cost to use them to launch hydrogen. The Swift can launch argon for the ion tugs seven times more cheaply! But if lunar water drops in cost a lot, we can throw away the oxygen and just use the hydrogen."

"Oxygen afterburners," replied Yevgeny, shaking his head. "The specific impulse is reduced, but it's still fifty percent higher than hydrogen-oxygen combustion and it uses all the water instead of eleven percent of it."

"Let's hope NASA can convince the current administration to develop them," agreed Will. "It's ridiculous to build solid-core nuclear engines and not use them, or force people to use them even though they're much more expensive. The oxygen afterburners are relatively cheap, I understand."

"But the current Democrat Congress is anti-nuclear." Yevgeny shrugged. "Maybe the Chinese will develop them instead."

Will laughed. “That might be the incentive the U.S. needs! Let me help you get your luggage up the stairs.”

Ethel went back into the day care area. Will and the Lescovs left the wagon at the bottom of the stairs and carried the luggage up the stairs to the two-room apartment that used to be Will and Ethel’s. Then Will said goodbye and headed back to the bridge.

The *Daedalia* landed four hours after the *Olympus.* Then in the late afternoon the *Alba* came down at pad 6 with the last six members of Columbus 3. All eighteen new people had arrived safely. It was a great relief for everyone. Furthermore, the three shuttles—two that had just arrived from Earth and one that had already been on Mars—brought down thirty-six tonnes of consumables and equipment. Unpacking everything and setting it up would take the next four weeks, in and around training sessions and safety drills. And when all of the work and training was over, three automated cargo vehicles would blaze into Mars orbit with forty-five more tonnes of equipment, requiring them to initiate another round of shuttle flights.

The rest of the sol was devoted not to unloading the shuttles, but to showing the new arrivals around and helping them unpack. Then at sunset—7:20 p.m. that night—everyone gathered in the Great Room in Renfrew Hall for a banquet. Will and Ethel had invited Dr. Tang to join them. Michiko Suzuki, a Japanese meteorologist, also sat with them.

Will was the last to sit because he helped serve the food. After filling his plate, he stopped to survey the happy, boisterous gathering. The new arrivals and the veterans were mixed together, as he had hoped they would be; all the old hands had been assigned a “buddy” to assist on arrival, and most had sat with them. The great room was filled;

indeed, the life support system would be strained by their carbon dioxide output. But there was enough room to evacuate everyone in case of a leak, and there were pressure suits in the building in case there was trouble requiring them.

The room had five tables, each with six or seven people around it. Will's table had, in addition to himself, Ethel, Marshall, Tang Enlai, Michiko Suzuki, and Shinji Nagatani, because he was Michiko's "buddy." The table next to them had Érico Lopes, their Brazilian geophysicist and repair man; Carmen Segovia-Lopes, a Spanish pilot and engineer, who was five months pregnant, just like Ethel; Lisa Kok, their Dutch horticulturalist; Karol Havlicek, their Czech mechanical engineer and repair guru; Andries Underwood, their newly-arrived South African sedimentologist; Francisco Almeida, Brazilian, a Prospector operator with horticultural and food preparation experience; and Enrique Delrio, Mexican, a welder and construction specialist.

Table three was occupied by Eve Gilmartin, physician; Gaston Gilmartin, horticulturalist and animal care specialist; Jacques Deschanel, an eobiologist and paleontologist; and Therese Deschanel, an ecological specialist; the four of them were French. Seated with them were Louise Tremblay, a French Canadian rocket engineer; Eammon O'Hare, a big, red-haired Irishman who was an electrical and software engineer; and Irina Lesz, Polish, a laboratory assistant. The entire table was speaking in French.

Table four had Neal Stroger, an American geologist, and Rosa Stroger, an American nuclear engineer; Rosa was three months pregnant. Seated and talking intensely with them were two other Americans: Kevin Dunbar, a nuclear engineer, and Jennie Dunbar, a child care specialist and jane-of-all-trades. Watching and participating as best they could were Roger Anderson, an American geologist; his wife Madhu Gupta-

Anderson, a dietician and horticulturalist who was also an accomplished Indian classical dancer and artist; and Sam, their seventeen-month old son.

Table five had Yevgeny Lescov, a pilot and geologist, and his wife Alexandra, a civil engineer, architect, mechanic. They were obviously close friends with an American couple, the Vickers: Martha, the psychiatrist, and Charles, a Prospector specialist and repair expert. Olaf Norlander, the Swedish Prospector specialist, joined them. Koyo Takenaka, their Japanese Prospector specialist, and computer repairman, was regaling everyone with stories of narrow scrapes some of the Prospectors had experienced on Mars. Lal Shankaraman, a glaciologist from India, was talking boisterously in Hindi with Sridhar Pradhan, a geochemist from the same country.

Looking over the crowd, Will was impressed by its remarkable diversity and its vast talent. Of the thirty-three adults present, twenty-nine had doctorates and the others had Masters Degrees, sometimes more than one. They represented sixteen nations. Three had been on Mars for six and a half years; four, four years; eight, two years; eighteen were newly arrived.

When he sat next to Dr. Tang, the exobiologist leaned close and said "Commander, I was surprised to see you hauling food from the kitchen and serving it!"

"Why? Service never diminishes anyone."

"You should see him washing the floors," quipped Shinji.

"Really?" Tang's eyebrows went up. "When I arrived, I was expecting that this place would be different from anything I had experienced before. And it has not disappointed me in that score. But it has been different in surprising ways. I see that you lead by example, and I am grateful for that."

"You are very kind, Dr. Tang," replied Will.

Call me Enlai; I suppose everyone uses first names, here."

"Yes, they usually do. Call me Will; people usually do."

"Thank you."

"Are you comfortable in your room?" Ethel asked.

Enlai nodded. "Yes, it is more spacious than the accommodations on the trip out, so it feels absolutely luxurious. I walked over to the biology facility, where Jacques and I familiarized ourselves with the equipment and confirmed our decisions who would have what space as their own. Now I can't wait to get outside and walk around. Perhaps tomorrow I'll hike to the top of Boat Rock."

"It's got a nice view, and we've built a little observation area on the eastern end," replied Ethel.

"Really? I'd like to see that," said Michiko.

"I'll be happy to show you tomorrow," volunteered Shinji quite quickly.

She smiled shyly. "Thank you, I'd love that."

"How was the flight out?" asked Ethel.

Enlai shrugged. "Alright. The ITVs are pretty crowded, as you know. At least we felt safe; with four ITVs and two shuttles, there was plenty of redundancy. As you know, our flight paralleled 2009ZA12 for about a month, and the rock was actually visible out the window for ten days. The Prospector we dropped onto it gathered quite a bit of data and returned samples to us. Charles Vickers was very pleased with the data we gathered."

"We watched the whole effort closely," agreed Will. "How did you happen to be chosen for this trip?"

Enlai chuckled. “It’s a strange story. China has nearly one hundred astronauts, and some fifty have worked on the moon at our station attached to the international Shackleton Station. All of them were anxious to be chosen to come to Mars. I’ve never been to the moon; it’s not exactly an important destination for an exobiologist! But I had an advantage over everyone else because the Chinese government was urged by NASA *not* to send a geologist or an engineer, since Mars already had plenty. There aren’t many Chinese exobiologists.”

“What’s your opinion of the new evidence for life on Venus during its first billion years?”

“I think it’s quite solid! So far, twenty fragments of Venus had been picked up on the lunar surface, the biggest weighing half a kilo. They’ve all been dated. Their geochemistry clearly reveals a steadily warming climate, an early ocean, carbonate deposits, and evidence for microorganisms.”

“But no microorganisms in the atmosphere today?” asked Ethel.

Tang shook his head. “The atmospheric samples so far indicate that the planet’s sterile. I suppose there’s too little water and too much sulfuric acid. It’s a shame; I was hoping we’d find something.”

“Well, we still can find life here,” replied Will.

“And when will Earth reach the runaway greenhouse condition? A billion years?” persisted Ethel.

Enlai nodded. “About that. Earth’s fate is to become another Venus, unless humans have the luck to last a billion years and the will to change the planet’s conditions.

Of course, perhaps it will then be Mars's fate to become another Earth, at least briefly before its atmosphere thins out."

"Who knows," replied Will. "We actually don't talk about terraforming much. Many people are surprised by that. But it's too far into the future and we know too little about this world."

"Of course. I will do my best to contribute to our deeper knowledge. I have committed to stay four years. You probably also know that my government has insisted that I not be diverted to tasks other than exobiology."

"Yes, so I was informed. I should have no difficulty honoring that commitment while you are at the outpost. But if you are on expedition you'll have to do the same tasks that everyone else on the expedition does. I suggest that you go out on an expedition at least once per year. It'll give you exposure to the actual outcrops, which is invaluable context for your work."

"Thank you, I'm anxious to take your advice."

"I'm looking forward to getting to know you, Enlai," said Ethel. "I hope China will increase its commitment to Mars and send more people."

"That will probably be possible. I know the government is considering the idea of purchasing one or two ITVs. Eventually we could send four astronauts every columbiad."

"And you would be welcome," added Will. "I hope we'll start to send six ITVs, then eight, then maybe even ten. As they're improved, they'll get more reliable and less expensive. In a century it could cost two years' salary for someone to buy a ticket to Mars and back. I think China will have a great role in Mars, by then."

“We will be the world power, with India close behind,” agreed Enlai. “America will be number three. The twenty-second century will be quite interesting. Too bad we won’t live to see it.”

“It would be interesting to see,” agreed Will. “Please excuse me for a moment.” He picked up his cup and walked to the food table to pour himself some coffee. Madhu was there getting herself a cup as well.

“Are you ready?” she asked him.

“Yes, pretty much. You?”

“The program’s set.”

“Excellent. You look tired.”

“It’s been a draining sol.”

“For everyone. I gather the chemotherapy drugs have been offloaded. Are you planning to start taking them?”

“I’m not sure yet. Shinji did another MRI yestersol and nothing showed up on the images. The spot is completely gone. Maybe all that prayer got rid of it.”

“I hope so. So, he doesn’t recommend the chemo?”

“No, he doesn’t.”

“I’m relieved, Madhu; I really am.”

“You can’t imagine my relief! We’ll see whether the situation changes.”

Will returned to his seat and resumed his conversation with Dr. Tang. They turned to exobiology. “We really need to check the snowdrifts in Arabia Terra,” Tang said at one point. “There’s been liquid water running underneath them for about twenty thousand years, if the calculations are correct. The Prospectors have been able to sample the

surfaces and the wet reg at the base of the ravines, but not the water running through the ravines. We need to send a crew down with shovels to dig into the snow and look. Of course, there's the issue of possible contam. . . .contam. . ." Tang stopped and started to hold his breath. Then, suddenly, he sneezed quite strongly. "I apologize, Commander. We will have to watch for biological contamination—"

"Dr. Tang, could you be allergic to something? Such as Martian dust?"

"I don't think it's the dust. I was tested before I left Earth and the reaction was negative. Ever since Laura Stillwell sneezed her way through the last few months here, there has been pretty good testing. No, Commander, this may be that strange virus we had on the flight out."

"You think so?" exclaimed Shinji, who had been listening. "That was a flu virus of some sort. But no one has had it for three or four months."

"I'm not so sure of that," replied Tang. "Several people have had minor symptoms since; runny noses, for example."

"No one told me," said Shinji, irritated. "This is rather serious. Marshall has never been exposed to cold or flu viruses before. Will, Ethel, and I haven't been exposed for seven years."

"I think you should talk to Martha," suggested Will, since she had been the physician on the flight out. He looked around at the crowd. "It's time to get started." He stood up and walked to the front of the room. He didn't say anything, but everyone saw him and in a few seconds they stopped talking.

"Thank you, everyone. I want to welcome Columbus 4 to Mars. I know most of you have enjoyed your first sol here because environmental control has informed me that

you all took long, hot showers. I guess sponge baths and navy showers got on your nerves."

Everyone laughed. The routine in space was to have a sponge bath every other day, a "navy shower"—where one showered to get wet, soaped up, then showered to wash off the soap—every fourth day, and a real shower every fourth day. "I don't know whether any of you noticed the flood in greenhouse 3 a few hours ago, caused by a faulty valve that failed to shut when bathwater filled habitat 2's holding tank. The eighteen of you consumed three tonnes of water! But don't worry, we've got plenty, and we've got the heat to heat it up. Still, you might want to cut back a bit!"

Will paused to let them laugh again. "Human beings have now been on Mars three columbiads; about three and a third annums; or, if you prefer, six and a third years. Our population has increased from six adults to thirty-three adults and two children, with three more babies on the way. Look around the room; this is it. We are humanity on Mars. We are the world's entire society. We are all the residents of the Red Planet. Over the next eighteen months, we have to—and we will—become a team together.

"We have a lot to do in that time. We have to expand this outpost to feed us and provide plenty of extra space for emergencies and some level of comfort. We will be offering services to new land owners in the area and will be obtaining gold and fossils for export. Our efforts at eobiology are slated to increase significantly with new personnel and equipment; it appears we are on the verge of a breakthrough in understanding the earliest few hundred million years of Martian history, an era that will also tell us about the rise of life on Earth. We will be making trips to several Noachian terrains to locate some particularly early crustal suites, which will necessitate the clearing of a major

section of the so-called Pisces Trail across the southern mid latitudes. We hope to get to the edge of the southern layered deposits to recover regolith frozen since the Noachian, in case it has frozen microorganisms or prebiotic compounds in it.

"Exploration has several other priorities. We'll have two teams out for much of the time. The entire Circumnavigational Trail will be revisited and the road will be widened and improved. The Polar Trail will be finished to the South Pole. We will clear the Tharsis Trail and visit all the big volcanoes; we might even get to the top of one. Finally, we will be proposing to Mission Control that the *Olympus* fly to Phobos, then Deimos for a total of about three months, enough time to do major exploration and some development of the fuel manufacturing facilities there.

"We've got historic tasks ahead of us. The result will be another crucial chapter in the exploration, development, and ultimately the settlement of Mars. I'm very excited to have all of you involved in this adventure.

"One aspect of our work here that is more important than is often assumed is the development of culture. Madhu Gupta-Anderson has devoted a lot of time to mosaics and wind sculptures at the base of Face Rock; a few months ago at a borough residents' meeting the hectare of land at the base of Face Rock was declared a public park. It was our first act of borough government regarding the disposal of 'range,' as we have started calling the land outside. When you're outside, go walk through the mosaics and admire the natural art objects that have been set up there. Tonight we will experience a different sort of cultural development: music, singing, and dance. So without further adieu, I turn the program over to Madhu."

4

Pandemic

early July, 2042

Yevgeny swished the water around in the black beaker. “It’s beginning to freeze, I think.”

Will looked at the beaker in Yevgeny’s gloved hand. “The air is thirty below zero out here. With the black color, the beaker will stay warmer than that, though. I’m glad you brought the beaker out. It’s amazing to see liquid water outside on Mars, isn’t it?”

“It sure is! When I did this on the moon it boiled away in an instant.”

“Ah, you guys are just playing,” replied Alexandra.

“Hey, play is an important vehicle for learning!” replied Yevgeny. “You might recall that when I took the beaker of water outside at Shackleton and exposed it to a vacuum, people laughed; but then Igor repeated the experiment in the center of a large temporary shadow and measured how much of the water vapor deposited on the regolith, published a paper about it, and the calculations have been crucial for understanding the formation of the volatile deposits!”

Alexandra nodded and pointed. “Can we take a look at the site of the dome?”

“I thought we’d start walking around the new building,” replied Will, pointing to the building that had been finished on the outside.

“Alright,” replied Alexandra, but she didn’t sound very enthusiastic. Will led the Lescovs to the new building. The windows in the top floor were still blocked by metal shutters. “I gather we’ll install the windows you brought in a matter of a week or so.”

“Yes, that’s about right,” agreed Alexandra. “You completed the frames already; the windows screw into place in about an hour and they can be sealed with sealant pretty

quickly as well. We'll have to lower the pressure of the lower floor, though, for safety purposes, so no one will be able to stay in their rooms during the work day. But they'll be safe to occupy at night."

"When do you think we'll be in the position to make windows ourselves?"

Alexandra considered the question a moment. "Possibly three years. As you know, I don't want to start another building for at least a year; I want to get this one finished and reconsider our entire approach. We need to come up with new ways to construct buildings. Part of that means developing a system to make large parts of buildings inside a pressurized environment, then transport the pieces outside and put them together. It also means manufacturing wall board, window frames, airlocks, and other basic items that we can't make now or we make too slowly. We've learned the basic techniques for making duricrete buildings and I doubt we'll improve on them, though I am wary about the safety of our construction techniques; construction may be less safe than a shuttle launch."

"You're right, and as you know, I want safety to take precedence."

"That's one reason I want us to consider importing more habitats. The new design, as exemplified in Habitat 4, is quite sophisticated; 339 square meters of space in a single eleven-tonne inflatable. That can accommodate eight to twelve people."

"But I want to cut our imports as much as possible," replied Will. "Right now each new personnel slot requires the import of 4.3 tonnes of equipment and life support systems, plus 0.7 tonnes of consumables per columbiad. Eliminate the habitat and we reduce the mass per person to 3.0 tonnes."

"I know, I understand that. But with the Swift Shuttle doing the lifting to low Earth orbit, cargo importation is now a sixth as much per tonne. It's not that expensive to import a habitat any more."

"But they really aren't as comfortable as the new buildings," replied Will. "We've lived in both. The habitats have much thinner walls, the fireproof wallpaper keeps peeling off, the floors sag a bit even when they're heavily reinforced, and they really aren't as soundproof as one would like."

"That's because the habitats have walls of plastic and the duricrete buildings have walls of rock! But once we make sheetrock—which will be one of my priorities—they'll change the character of the habitats drastically. They'll be much quieter and more solid. I'd like to redesign one of the habitats—1 or 2, probably—and you'll see what I mean."

"I look forward to it," said Will, though he sounded skeptical. They walked over to the bowl-shaped depression thirty-two meters across where the Mars Exploration Society's dome would be erected in the near future. Alexandra asked a few questions. Then she nodded. "Can we go down to the solar power units and the wells?"

"Sure," replied Will. He led them downhill—north—toward a ravine torn in the landscape by a flood several billion years earlier. *Billions.* Will contemplated the enormity of the ages of things on Mars while facing toward, and gazing at, the 1.5 kilometer escarpment that rent the northern horizon twenty kilometers away. The edge of Aurorae Chaos—though they usually called it the Aurorae Valley, it sounded better—was the most impressive sight around the Outpost, and was a constant fascination.

Soon they were approaching the ravine, which was about 150 meters from Face Rock. Draped over the water reservoir filling it was a plastic sheet thirty meters wide and

about fifty meters long. Metal or plastic supports supported it from underneath and made little pointed peaks in the plastic every five meters.

Beyond the ravine were three pads of white plastic thirty-five meters square. Each one was occupied by an inflated cylinder thirty meters in diameter, the axes aligned north-south. The half of the cylinder facing the sun was transparent, except for a strip of solar panels running along the part of the cylinder closest to the sun. The half of the cylinder opposite the sun was silvered and reflected light onto the panels, which generated 150 kilowatts of electricity and provided 150 kilowatts of heat to tubes circulating gas along the backs of the panels.

About one hundred meters to the north and east of the solar power units were the wells. Alexandra pointed to the eastern one. “So, which is which?”

“The eastern one is for oxygen and the northern one is for methane,” replied Will. “The oxygen well goes down four hundred meters and has seven thousand cubic meters of underground storage space; that’s how much water we’ve taken out so far. Right now we can store only three tonnes of oxygen, but with the new equipment on the way that allows higher pressures, we can raise that to twelve tonnes, more as the underground volume grows.”

“Seven thousand cubic meters, and what’s the porosity of the rock?” asked Yevgeny.

“About ten percent, so that’s sixty-three thousand cubic meters of rock—about one hundred eighty thousand tonnes—that we’ve heated to one hundred centigrade. Basically, it’s a sphere forty meters across, four hundred meters beneath the surface. It already has enough heat stored up in the rock to keep the Outpost warm for several

months. The methane well is identical, except it's only 1/3 as big. We hope, in about five years, to have high pressure storage for one hundred twenty tonnes of oxygen and thirty tonnes of methane, which would be enough for a fully fueled shuttle launch. We may complete a smaller well to store liquid ethylene as well."

"That's a long time from now, though," replied Alexandra. "We'd have to extract how much water from the ground? About one hundred thousand tonnes? Wouldn't it be easier to build storage tanks?"

"Storage tanks probably are better, but we don't have the ability to make them yet. Yes, we have to extract ninety thousand tonnes of water at current gas storage pressures; maybe only thirty thousand if we can safely store the gas at a high pressure. So far the pore-cavities are pretty gas-tight; we can extract 95% of the gas we put in. The hot gas constantly vaporizes the ice in the pore spaces, and the water vapor, which is under pressure, goes into cracks around the cavity and freezes them shut. The computer models suggest we can build up quite a gas-tight ice ball around the cavity."

"And the solar power units are supplying the heat directly?" asked Yevgeny.

"Yes, we're circulating either methane or oxygen through the heat exchangers, adding water to make steam, then pumping the mix down in the cavity. The steam helps conduct the heat to the remaining ice because the cold causes the steam to condense and creates a pressure gradient. When we let the pressure out of the well, the zone of liquid water partly flashes to steam and creates a pressure gradient to push the vapor back to the shaft. Two solar power units are hitched to the oxygen well. The heated oxygen also flows through buried pipe to the Outpost to provide it with heat."

“Poor man’s nukes,” said Alexandra, referring to the solar power units. “But we’re now replacing them with reactors.”

“I’d say ‘supplementing,’ not ‘replacing.’ This is a touchy political matter. The outpost will need over 600 kilowatts of power with thirty-five people living in it. These three SPUs make 450 kilowatts. We’ve got two nukes coming and they’ll make 150 kilowatts each, but they’ll be mobile and will power expeditions except during dust storms, when they’ll be needed here. I wanted more SPUs as well, but the White House vetoed it; they didn’t want to ‘dejustify’ the nuclear power program.”

Yevgeny snorted. “Politics. The SPUs mass half as much, and what are the prices? Ten million versus five hundred million for a reactor?”

“Exactly.” Will shrugged.

Yevgeny pointed at the ravine. “Can we take a look?”

“Sure, there’s a door.” Will pointed, then led them to the upper end of the ravine. He pulled aside a plastic flap, which was velcroed and tied in place. They stepped in. Immediately a patina of frost formed on the outside of their visors.

“It’ll clear in a minute,” advised Will. “The air under here is twenty centigrade warmer than outside, and it’s saturated with humidity.”

The visors began to clear immediately and they could see the ice: almost ten thousand tonnes of it, stretching as a great, flat sheet to the front of the storage area. “We store up the water and release it into here every two or three sols, making a temporary lake a few centimeters thick. It freezes in less than a sol. At the far end it’s eight meters thick.”

“Any thawing underneath?” asked Alexandra.

Will nodded. “Yes, we’ve pumped in heat. There’s about a meter of liquid water at the far end. The sunlight penetrates the ice and warms the ground, and the ice traps the heat. When this storage area has a hundred thousand tonnes of water in it—we can expand this storage enough to accommodate that much—the estimate is that two thirds of the water will be liquid and covered by at least five meters of ice. We can oxygenate the water and introduce bacteria and algae, then eventually fish.”

“Cool,” replied Yevgeny. “The bigger the lake, the more efficient it becomes at trapping solar heat.”

“Exactly.”

They stared at the expanse of ice for another minute, then turned and headed out. Will closed up the plastic door tightly. Yevgeny pointed to the cliff side of Boat Rock, which ran westward from Face Rock. “Say, Will, could we spray a couple tonnes of water on the side of Boat Rock some time? I’d like to simulate a snowfield. We could study the rate of evaporation into the air and the quantity of liquid water flowing underneath the snow pack.”

“There’s a proposal to do that on the website somewhere. We’re interested, but no one has had the time, and now we have plenty of water.”

“I’ll take a look.”

“It should be quite useful. It’s one of. . . of . . . of.. .” Will paused and tried to control an impending sneeze. He had never sneezed in a pressure suit before and he struggled to remember how he could stop it. “Ah—” And he did stop the sneeze, mostly; his lungs heaved, but nothing came out.

“What was that?” asked Alexandra, alarmed.

“A sneeze. I stopped it, though. As I was saying, the snowfield experiment is on the agenda. Now that we have thirty-three adults, we can do so much more.”

“But it means we have to spend a lot more human resources maintaining the Outpost,” noted Yevgeny.

“More people; but a smaller percentage of the total staff,” replied Alexandra.

“Not necessarily. In order to reduce imports, we’re doing more for ourselves, and that takes more people. Running the Outpost takes forty percent of our human resources.” Will paused, suddenly distracted by his nose. It was doing something he hadn’t experienced in years; seven years, to be exact. “Oh my God, my nose is running.”

“What?” replied Alexandra.

“I have a runny nose. And there’s nothing I can do about it, in a pressure suit.”

“Better head for the Outpost fast,” replied Yevgeny. “Alexandra and I will be fine out here. I want to get up to the top of Boat Rock.”

“Alright. Bye.” Will turned and began to walk back to the Outpost. Mucus began to drip out of his nose and run down his face; he could taste it in his mouth. He automatically raised his hand to wipe his nose, even though the helmet made that totally impossible. He began to run to the nearest airlock.

Once inside, he pulled off his helmet as fast as he could. His nose was not pouring, but the mucus was very liquid—like water—and flowed quickly. He looked around. The nearest box of facial tissue was one hundred fifty million kilometers away. But there was toilet paper. Still wearing his suit, he headed for the nearest bathroom and blew his nose.

It was still running; the sneeze had triggered it, but now it was continuing on its own. Come to think of it, he had had a very slight sore throat that morning, and had felt a bit tired. He reached up and felt the skin near his throat; he had slightly swollen glands. He headed straight to sickbay in Habitat 2.

Once he entered the sickbay he heard the crying of a baby. It was Sam; Eve was examining him and Madhu was watching. Will stuck his head in and looked.

"Can I help you?" asked Eve. "Well, no, I can't right now. Sam's got a fever."

"It's the virus or whatever that Columbus 4 brought. I have a runny nose."

"Will, come in here." It was Shinji's voice, coming from another room. Will walked to the next door; Shinji rose from the bed and sat up. "I've got it, too," said Shinji. "It's a strange infection. Three different patients and they all have slightly different symptoms."

"And some of us have had no exposure to germs for quite a while."

"No, not true. You have bacteria in your gut and on your teeth, and your immune system keeps them under control. Your immune system is not debilitated."

"But does that mean this won't be serious?"

"I wouldn't say that! It could be."

"How did the infection get here? How could it keep people sick on the flight for six months?"

"Some germs can lay dormant for months or years. Dr. Tang was suffering from a reinfection or a second outbreak. That can happen, also." Shinji waved at Will's pressure suit. "I can't examine you with that on. Go change, then come back. Here." He reached over and grabbed a sterilized piece of cloth. "Use this as a handkerchief. We won't be

making tissue for a while. Bring the cloth back when it's dirty; there's a hamper for the medical wash outside. We'll wash it thoroughly and sterilize it again."

"Thanks." Will took the cloth and wiped his nose. He walked back to the men's pressure suit donning area and changed into his clothes, then returned. On his way back he received an email on his attaché indicating that Mission Control was hard at work on the medical issue. No doubt someone had picked up the conversation on one of the Outpost's many microphones in public places. When Will returned to sick bay he noted that the microphone light in both of the examining rooms was red, indicating that Mission Control was listening. The video light was green; they weren't watching, though every room in the Outpost had microphones and cameras, and their output was being taped and stored on Embarcadero in case of an emergency.

Shinji examined Will quickly, then called in Eve, then Martha arrived. She had treated everyone on the flight out and confirmed the symptoms. Everything suggested a virus, which meant antibiotics were of no use. Instead, the symptoms had to be treated. Will got medication to reduce any fever he developed and dry up his runny nose. And of course they took blood.

"What will this do to Ethel and the other pregnant women?" he asked, toward the end of his visit.

"This is potentially very dangerous for pregnancy," replied Eve. "I've already sent all three of them voice messages to come in for examination immediately. It's potentially dangerous for Marshall as well; Ethel's bringing him in."

"I think he was sick this morning, come to think of it," noted Will. "The kids here get sick so rarely, we really haven't watched him closely. But this morning he seemed tired."

"I spoke to Ethel two sols ago about the danger," continued Eve. "After Martha and I conferred about the outbreak on Columbus 4. This is a variant of the flu virus, but it is not the standard Manila 3C virus that dominated the flu season on Earth last winter. And it seems to have mutated on the flight out, which is very unusual; it may be because of the close quarters, the low humidity in the ITVs, or the heavy medication the crew took to fight the first outbreak, a few weeks after leaving Earth. Only the toughest bugs survived."

"We should have used higher doses," said Martha, shaking her head.

"It's too late now," replied Shinji. "We have a potential epidemic on our hands and we have to get it under control right away."

Supper was a rather subdued affair. Four adults had runny noses and two stayed in their quarters because of mild fevers. The pregnant women all stayed away as well, either because they already were infected or because they wanted to avoid infection. Sam remained in sick bay with his mother at his side. Marshall was quite feverish as well by then, but was resting in his own bed. Will had time to come to supper, but only quickly.

"How's Marshall?" Lisa Kok asked him.

"So far, he's just got a typical childhood sickness and Ethel and I just have fairly typical colds. Sam's got a fever of 39.5, though; that's 103 Fahrenheit, which is pretty high. Fortunately the anti-fever medication has knocked it down."

“Do they have all the medications they need?” asked Alexandra.

“Yes, the sick bay is extremely well equipped. The doctors know what they’re doing and there are several specialists on Earth advising them. The worry is the immune systems; they may not be ready to deal with something like this.”

“It raises the issue of the inhabitability of this place again,” grumbled Yevgeny.

“And the wisdom of having children here,” added Michiko.

“I don’t agree,” replied Will. His voice rose; he no doubt sounded a bit defensive. “God forbid, that we feel we have to import all of the Earth’s illnesses to make this place habitable! But we do need to import more vaccines or mild forms of some of these illnesses. Life is never easy. We still don’t know what happened to Paul Renfrew and we probably will never know. We still don’t know what’s happening with Madhu’s lungs. We don’t know whether exposure to Martian dust or the radiation levels have anything to do with the lesions. The new MRI equipment and software on its way will make incredibly detailed images, but they still may not solve the mystery.”

“Life is still better here than it is in many places in rural India,” added Lal. “Our health challenges are different, that’s all.”

“If this were the eighteenth century instead of the twenty-first, half of us would be dead by now,” added Charles Vickers.

“That’s true,” replied Yevgeny. “But this isn’t the eighteenth century, and we’ve chosen to come here.”

“I’m very sorry I exposed everyone to the virus,” said Tang. “I feel great sadness. But there really were no noticeable symptoms until I sneezed. Looking back on the first sol here, I realize I felt a bit tired and had a sore throat. But I was also overwhelmed by

the excitement of arriving, and I experienced three different environmental control systems in twenty-four hours: the ITV, the shuttle, and the Outpost. I attributed the sore throat to the changes in temperature and humidity that resulted."

"Don't blame yourself, Enlai," replied Will. "You weren't the only person to arrive sick. At least one other person on Columbus 4 has stopped at sickbay for antihistamines."

"We need to pull together on this one," replied Yevgeny. "Commander, how many people are affected so far?"

"Seven adults," replied Will. "Five of whom can't use a pressure suit. By tomorrow it'll be all seven. We'll have to rearrange work schedules so that they can work inside and free up those who can go outside."

"You can count on me, Commander," exclaimed Tang. "If my government complains I'm doing anything other than biology, I'll email them personally and explain it. This is a potential emergency."

"It is an emergency," agreed Will. "Half this Outpost could be in bed in a few sols. Shinji Nagatani is sick, so we have one less physician to treat the ill. Eve could get sick from this as well. Martha got it on the flight out, so she should be alright."

"We'll pick up the slack," replied Yevgeny.

By noon the next sol, Will's words had a ring of prophecy to them. All fifteen of the adults who had been on Mars before Columbus 4 had arrived were feeling sick. Half were staying in their rooms. Ethel and Marshall both stayed in bed, which meant Will had little free time after taking care of them.

"You should see the headlines!" growled Roger. He stepped across the hall from his apartment to visit Will. He had left the doors open so he could hear Madhu and Sam if they called. "Everyone's referring to the 'Mars Plague.' The cheap tabloids are saying this is a mutated virus because of Martian or space conditions and that it'll wipe out humanity if it is every transmitted back to Earth. A few extremists are saying we have to be quarantined permanently or even killed!"

Will shrugged. "There will always be extremists. Remember the persistent group of kooks who insisted that Shinji, Ethel, and I had been killed to keep secret the fact that no one was really sent to Mars? That's why we never 'returned.' I guess my tv appearances have knocked the wind out of their arguments."

"Not all of them. There are still people who maintain no one has gone to the moon *yet*, even if five hundred people have visited there since, including a Saudi prince and a U.S. senator! There are kooks out there who maintain all your t.v. appearances are really by a look-a-like, and that the Mars Commission is a fancy cover for a bunch of guys with expensive villas in Tahiti. But this is different, Will. You need to pay attention to it. The 'Mars plague' is a mainstream rumor and a mainstream tendency."

"I'm sure it'll be nipped in the bud by the public information folks."

"I hope so. I think you need to go on television."

"Looking like this! How persuasive will I be?"

"Get your nose dried up and borrow some makeup. I sense a public relations mess. This could dampen enthusiasm and cost us a few hundred million."

Will looked at Roger. "This is unusual of you, Roger; you don't usually smell public relations problems."

“I hate public relations. It’s a giant con job on the public. But everyone does it and it has rules. And you’re good at it. If you weren’t so photogenic and articulate, Mars would have half as many people right now. The Mars Commission doesn’t know what it has with you in charge here. I wish I could do what you can, but I can’t.”

“Okay. Thank you for your compliment. I’ll look into the situation.”

“Good. I know I compliment you pretty rarely; I’m not that kind of guy. But you have to do something now.”

“Okay.”

Roger helped watch Ethel and Marshall as well as Sam and Madhu while Will got on the videophone, mostly from the easy chair in his small living room where he could rest. He called Morgan. The response of the High Commissioner of the Mars Commission was not encouraging. “Will, we’re on top of the matter. Don’t worry. I’ve made several statements to the media about the ‘Mars plague’ silliness and I’m ignoring the ‘eternal quarantine’ nonsense. It shouldn’t be dignified with a response. If you have ideas, email them to NASA’s staff in the Office of Public Information. I have barely a skeleton media staff, so I’m leaning heavily on them. Bye.”

So Will videomailed the NASA OPI people, copying Morgan, suggesting a video of the cafeteria at lunch so the public could see people weren’t dying and urging an international media strategy. Several hours later they replied that he should talk to Morgan, since they had jurisdiction over U.S. media only and could not plan an international media strategy. Morgan replied to both that he’d focus more on getting statements out to the European and Japanese space agencies. Then an hour later NASA’s Office of Public Information emailed Will—and did not copy Morgan—saying they’d

coordinate everything after all and he should not talk to anyone else, including Morgan. Clearly, they were frustrated by the Commission's lack of action, too, and he was caught in the middle. As he stared at his screen wondering what to do, copies of emails addressed to the French and Japanese crew members arrived from their respective countries, asking for interviews; apparently the NASA people had emailed them. Will checked the Mars Exploration Society's news website; statements by Morgan were drowned in a deluge of negative publicity. He emailed Morgan, summarized some of the messages, and suggested that NASA's OPI was taking control. Morgan didn't respond.

Disgusted and tired, Will called Heather Kimball, head of the Mars Exploration Society, for help to untangle the bureaucracy, then took a nap in the chair. At that point Érico, the least ill of the fifteen of them, went to the great room and brought back soup for everyone. "They just took Rosa to sick bay," he reported. "Her fever spiked up, so they're giving her an intravenous solution."

"How many months pregnant?" asked Roger.

"Three," replied Will, worried. "I'm surprised they didn't tell me."

"Have you checked your email?" asked Érico.

"No."

"It should be there; Eve told me she was sending you written reports."

"I'll check. She called Ethel when I was videomailing Earth and said she was coming over to check everyone here right after lunch. I'll ask her then."

"By the way, two more people report mild reinfections," added Érico. "This bug is coming back around to hit the Columbus 4 folks again. When I visited Shinji—he's now staying in bed, too—he said Charles and Alexandra have slight runny noses this sol.

Oh, that reminds me. At lunch, Louise said she planned to devote time to making facial tissue tomorrow. She doesn't know how to run the equipment, but will figure it out."

"I'll talk to her," said Ethel, who was listening from her bed in the next room. "I don't want her to break anything!"

They continued to chat quietly over lunch; no one had much energy. Then Eve showed up, making her daily rounds to visit the sick. She updated Will. In the last sol the situation had grown steadily worse, but not dangerously so. Will found himself encouraging her, rather than the other way around.

Will called Yevgeny and put him in charge of Mars surface operations temporarily, so he could focus on the publicity matters and get some sleep. Then he made another round of calls to find out whether anyone felt anything had to be done about the media. Some said, reluctantly, yes; others said, don't be ridiculous, this is not a problem, ignore it and it'll go away. Will was not able to serve as a bridge for people millions of kilometers from him, yet less than a kilometer from each other. He took another nap, then finally crawled into bed to get some serious sleep.

He was awakened at 3 a.m. by a phone call from Eve. "Will, I have bad news. Rosa just lost her baby."

"What!" Will sat up in bed. "How's this possible! The baby was healthy, right?"

"Yes, as far as we knew. But her fever shot up very fast and we were not able to pull it down fast enough. She just had a miscarriage. Of course, the miscarriage might have had nothing to do with the fever. We'll never be sure."

That reminded him of what he had said earlier in the sol. “I know. Life is still uncertain and can be harsh. Poor Rosa; she was so looking forward to the baby! I’ll try to get down after breakfast to express my deepest condolences.”

“She’s resting now; this was a terrible shock. Thank God she’s young. That’ll help. How are Ethel and Marshall?”

“They’re asleep right here in bed with me, and they seem to be doing fine. Thanks for asking.”

“You’re welcome. See you in the morning.” The line clicked shut. Will rolled over and tried to sleep, but he couldn’t; he was too sad. He finally got back to sleep, but when he awakened a few hours later he ached from exhaustion, had a fever, and felt lousy. But he had to get at least some of his duties done.

At least he didn’t have to go get breakfast for everyone. Dr. Tang appeared pushing a cart loaded with all sorts of goodies. He knocked on their door and when Will answered, he was surprised.

“Good morning! What’s this?”

“Breakfast. It occurred to me that when everyone is sick, food should go to them. And perhaps it is a bit of your personal example rubbing off on me.”

“You are very kind, Enlai. Very kind indeed. Bring it in.”

Enlai rolled the cart into the family’s small living room. Will and Ethel’s bedroom door was in the right-hand wall; Marshall’s bedroom door was to the left. Straight ahead, the room had one small window in the meter-thick duricrete walls. It faced east and offered a view of the Outpost; at the moment sunlight streamed in and landed on a red-flowered geranium in a pot that sat on a dining table. The living room also had a couch

that could seat three, three chairs that were pulled under the table, a high chair, and a large screen television hanging on one wall. A small table held an attaché.

Ethel came out of the bedroom in her nightgown and sat to eat. Marshall sat in his high chair. Enlai poured tea for Ethel and dished out plates of food. He had brought a plate of special food for Marshall.

“This makes me feel better already,” said Ethel.

“That makes my sol. Commander, I hope you are getting better?”

“Slowly. I didn’t sleep well last night, unfortunately.” He turned to Ethel. “How’s Marshall’s fever?”

“It’s half a degree Centigrade lower. I think the worst may have past.”

“I hope so.”

“So do I,” added Enlai. “I have to go across the hall to Roger and Madhu’s to serve them as well. Then I’ll stop back for seconds, then head for Érico and Carmen’s. I can stop back then, also.”

“You are immensely kind, Enlai. Immensely,” said Ethel.

“I am at your service, my friend.” Enlai smiled warmly; he was genuinely trying to be of assistance.

“Check back with us after you visit to Érico and Carmen; not before,” replied Will.

“That’s what I’ll do, then.” Enlai turned and pushed the cart out of the apartment.

“That’s really sweet of him,” said Ethel.

“Yes, it is,” agreed Will, still a bit surprised by the visit.

He drank coffee, ate a good breakfast, and took his medications. They made him feel better. The virus was hitting him like a very severe cold, but perhaps the worst was past for him as well. It was hard to tell. He washed, shaved, dressed, and headed for the sick bay to see Rosa Stroger. Neal was with her.

"I had to come down to say how immensely saddened I am," Will said, putting his hand on Rosa's shoulder. "After I got the call last night, I barely slept. I was in too much grief. I'm comforted only because I know you are young and strong and can try again."

"Thank you, Will," Rosa said, in a voice that was surprisingly weak. "Yes, I'll pull through this."

"Good; we're expecting it! Is there anything I can do?"

"Oh, no, nothing. And you're sick anyway."

"I have a slightly delicate suggestion. Would you like a memorial service of some sort for the baby? It might help bring closure for everyone."

Rosa smiled. "Yes, Will, that would be lovely! I think it'd help."

"Then get well, because we can't hold it until your health is recovering. I'll ask Madhu and Roger to help me in planning devotional services. It'll help."

"Oh, yes, it will," agreed Neal. "Thank you, Will."

They chatted several more minutes, then Will headed out. He felt well enough to make a quick tour of the Outpost, so he did. In the industrial area he encountered Irina Lesz busily making paper.

"What's this?" he asked.

"Facial tissue; you requested it."

He looked at the roll, then felt it. "It feels more like toilet paper."

“Well, that’s what it really is. We don’t have equipment or guidelines for making facial tissue, just toilet tissue. But I tried it out; its absorbency is pretty good.”

“Good. I guess it’s better than nothing.”

“I hope so. The big problem is a lack of plant matter to make tissue from. We might manage a hundred sheets per person.”

“That’ll supplement the cloth handkerchiefs. Thank you, Irina.”

“I’m glad I can do something to help! The bug had me wiped out for a week with a fever on the flight out. Of course, my nose never ran then.”

Will thanked her again and continued to walk slowly around the Outpost. About the time he returned to his apartment his attaché buzzed with a message from Earth. He walked to his office—he hadn’t been in it for two sols—to listen and watch in privacy.

It was Heather Kimball. “I got your message yesterday, Will, and I’ve been thinking about it. I’ve asked Louisa Turner to send you a videomessage about what she can do to help you, not only with publicity, but with office management on Earth. She’s worked for NASA’s Office of Public Information and for Hill and Knowlton, the big public relations firm, in their Washington operation. She published a book about her lobbying days in Washington. She made enough money at different times to retire early—she’s only 52—and she’s looking for a project that can also be a cause. She loves space exploration and is a fan of Mars. We talked the other day and when I mentioned the possibility of working for you, she was fascinated. You may have some trouble with her working a bit independently, but it probably will be worth it in the end. This is not some experienced secretary; this is an experienced leader. And Will, you can trust her. That’s something I’m sure of. She’s not going to work secretly for someone else and she’s not

going to leak stuff. She's discrete. If you don't hear from her in twenty-four hours, let me know. Bye."

Will immediately sent a videomail back, thanking her profusely for the contact. He didn't have long to wait. Two hours later, Louisa Turner sent him a message.

"Good sol, Dr. Elliott. I am a bit embarrassed to send you this videomessage, but Heather insisted. I understand you're looking for someone who can help run an office for you here on earth. The person has to be devoted to Mars, loyal to you, and very experienced, since communication has a large time delay built into it. You need someone who is well organized, too. I'm the sort of person you need. I'll attach my c.v. I know public relations and have a lot of contacts in Washington. My contacts in Paris are decent and I can work on developing them in other capitals. What you need is someone who can talk to people live, which you can't do, and who can make contacts or explore options, then refer the information back to you.

"If you're interested, I'd love to talk to you further. We'll have to discuss salary and benefits, of course, and I'll need at least one full-time assistant of my choosing. I don't know what the Mars Commission has agreed to give you. Let me know. Goodbye."

Will smiled. She was perfectly dressed, articulate, she knew how to state her qualifications without pushing them, and she anticipated his needs well. She seemed eminently suited for the job. But the Mars Commission would be a problem; Morgan still hadn't approved anything at all.

He hit reply. "Good morning, Ms. Turner; or can I call you Louisa? Feel free to call me Will, it's easier. Perhaps we could start with a small project to see how well we work together. I need advice with a public relations matter. As you know, we have a flu-

like virus raging up here. Last night Rosa Stroger had a miscarriage as a result. This virus is causing all sorts of uncertainty about human exploration of Mars. But no one will give me direction how to respond or permission to do so, and the matter has gotten caught in a turf battle between NASA and the Mars Commission. NASA has started to write the other space agencies and they're contacting their nationals up here for interviews, but we still don't have talking points or any strategy. The Mars Commission has not yet done anything. I think at this point I should set up a series of interviews; let them complain later. I hesitate to do it because I'm not experienced at drawing up the talking points and the other support advice I used to get from OPI. I suspect you can help. Are you interested? Let me know. Good bye."

Will sent the message from his living room, then crawled back into bed with Ethel and Marshall. The boy was definitely feeling better that sol and his fever was lower. Ethel, however, was very worried.

They watched some television and napped. Then Will's attaché beeped. Seventy minutes had passed. Still nothing from Morgan or NASA; it was Louisa Turner. He headed back to the living room to listen.

"Will, please do call me Louisa, or even Lulu. That's what my friends call me. I've attached talking points; *gratis* of course. They're the obvious ones that occur to me. Actually, I'm not sure you really need them, except maybe as a crutch. Will Elliott, you are a natural spokesman. You exude confidence. You have a relaxed, articulate presence. From what I've seen, you have very good instincts. But talking points do help.

"Now, who to talk to? I've seen you speak to reporters in the past if they call you, bypassing the public information people. OPI doesn't like the situation, but it does

happen. This is the time to do that, especially when no one is sure who is in charge. If you have a list of journalists who have your contact information, send it to me and I'll figure out how we can tell them to call you. I have two journalist friends who owe me favors; I can suggest they contact you. Of course, we'll have to leak your contact information. It would be best to leak it via Heather so no one can trace it back to me; that would kill any plan to hire me! Let me know what you think. Bye."

No direct answer whether she'd work on the project; she started to work on it instead! Will opened the talking points document attached. She had thought of some excellent questions and very powerful responses to them. He found himself editing them a bit, adding a few ideas of his own, changing some of the language to fit his speaking style—though she hadn't done bad at capturing his approach and words. In ten minutes it was obvious that Louisa was going to work. He attached a list of four journalists he had worked with and videomailed her back.

"Louisa, I made a few changes to the talking points. I needed the basic draft; it stimulated a lot of thinking. You did an excellent job. I am impressed. Yes, send these and the list of contacts to Heather. I'll take other questions as well, of course. I can talk to a dozen folks in the next few sols, and at least half should be outside the U.S.

Thank you very much for this favor. Let's explore this option further. Bye."

5

Dome

late July-lateAugust, 2042

Will recorded answers to the last two questions the BBC correspondent had sent him, then turned to the questions emailed by a reporter for a German daily newspaper. He dictated his answers and the text appeared on screen as he spoke. He reviewed the result, sent it, and turned to a very quick, simple question sent by a South African reporter. Andries Underwood, their South African geologist, had walked through the Outpost humorously interviewing people about their illness, and the video had proved very popular on many television networks, stimulating scores of requests for comments. Will answered the question and hit “send.”

For five sols, as he and everyone else had slowly healed, the media requests had poured in. Almost everyone had been interviewed at least once; most used the talking points to shape their response. Most crewmembers who kept blogs updated them. The volume of personal stories pouring out of Mars tipped the balance and came to dominate the Mars headlines. Most offices of public information cooperated; Louisa Turner’s talking points found their way to many of them via the interviewees. But NASA and the Mars Commission remained ominously silent.

Will turned to his videomail to view the next message and noted, with a sigh, that it was from Douglas Morgan. With trepidation, he hit “view.”

The man’s face was rent with lines of anger. “Will, what the hell’s going on up there? Five days and we still haven’t heard a word from you! Meanwhile, you seem to be coordinating a publicity campaign! How dare you undermine me in this fashion? I was

struggling to gain some control over the process and you *emasculated* me! If I could, I'd fire you for insubordination. Everyone's trying to hollow out the Mars Commission for their own benefit, and you've been doing the same! You owe me a big apology, Elliott, at the least! I'd seriously consider a resignation letter as well!" The screen went blank; the usual follow-up page with contact information was absent.

Will was stunned and furious. Morgan, trying to gain control? He had seen no evidence of that! He reached out to hit the reply icon, but paused to reconsider. Morgan was smart. It was likely he had tried to organize a response. He still had only skeleton staff. And the communications delay complicated everything.

He closed his eyes momentarily and said a Bahá'í prayer. It calmed him and helped detach him a little. He took a breath and hit reply.

"Doug, I apologize for the mess. On my part, I emailed you twice, first to stimulate action, second to warn you about NASA's actions. I had received copies of email requests from France and Japan for interviews. I never heard from you. Maybe my email to you got lost, or maybe your reply got lost; I don't know. All thirty-three adults up here started to get interview requests, thanks to NASA's actions. My staff was concerned about the bad publicity and they had creative responses, like Andries' video. No one offered to coordinate the responses, so it fell on the Commander of Mars Operations. I organized talking points, explained them to the staff, and often they asked my advice before they recorded responses. So I ended up coordinating matters.

"I apologize that I stopped communicating with you. I was waiting for a response to the second videomail. I should have pursued you more. The Mars Commission needs a media plan and I have not yet seen one. NASA appeared to be taking over and I did not

want to cooperate with what looked like a blatant effort to undermine the Commission. Under those circumstances I had to fill the vacuum.

"So, where do we go from here? I'm in my office for another hour before the memorial service and I hope to hear from you."

Will reviewed the message. It was calm and rational. It did not mention the source of the talking points or of many of his interviews, but he didn't feel bad about that; the interviews with his crew had started before any of Louisa's contacts had reached him, and some of the people who interviewed him were old contacts. He sent it.

He sat nervously, staring out the window and wondering whether he should have addressed the request for a resignation. It was twenty-five minutes before a reply arrived.

"Will, thanks for your response." Morgan looked and sounded much calmer. "I did receive your second email and didn't respond because by then I had authorized NASA OPI to coordinate the media response. They telephoned me and said they wanted to take over. They had, in fact, already started to do so, and I was furious when I forced them to admit it. But lacking sufficient staff, I had little choice, so I authorized their actions. They never emailed you about it? Maybe they figured the first email they sent you was enough and they were waiting for you to respond. Needless to say, they're furious you never coordinated with them and I was furious you never got back to me.

"Where do we go from here? NASA has a set of talking points. I'll attach it. What talking points have you been using? Where did you get them? I suppose we should continue with the interviews, but the illness and the bad publicity are pretty much over, so I think the campaign can wind down. What do you think about that? Bye."

The conciliatory tone was promising. Will opened the talking points and smiled; they were his! No doubt NASA had received them from the French, Japanese, Russians, South Africans, Mexicans, or someone else who had gotten them from one of their nationals on Mars. It was deliciously ironic. He re-read the document again. NASA had made some changes, but not many. So he replied and attached a copy of his version.

"Doug, I'm attaching a copy of our talking points, and you will see they are virtually the same as NASA's! They have evolved a bit over the last five sols up here as we've encountered new questions, but you can see the two documents start with the same questions and answers. A group of us drafted them, and I guess they got to NASA via another space agency.

"I agree that the crisis is over and the media campaign should wrap up. May I suggest a joint conference call involving you, me, and whoever will coordinate the media? I apologize again for the troubles; it is all our responsibilities to make the communication work, and I fell down on my obligation. Bye." He sent and wondered whether Morgan would reply before he had to go to the memorial service.

Morgan, aware that Will's time was short, replied as quickly as possible. "Thanks Will. Wow, they are the same talking points! I like your version better, actually. I appreciate the copy and your frankness. I, too, apologize for failing to communicate enough and then getting angry about the lack of communication. You are right: we have to make communication *work.* It's not like we can run into each other next to the water cooler. I'll talk to the NASA OPI folks about a time we can call you. Let's redouble our efforts. Bye."

Will breathed a sigh of relief. Morgan had apologized as well. Perhaps the crisis would prove to have a silver lining if it improved their communications.

There was no further time to contemplate the situation: the memorial service for Rosa and Neal Stroger's unborn child, whom they had named Joseph, was about to begin. Will hurried to the Great Room in Renfrew. Everyone was there except Ethel, who was watching Marshall and Sam. Sam was out of the sickbay and recovering; no one was left in the sickbay.

Rosa and Neal were Catholics and had been fairly active in their church at home. It was impossible for the memorial program to resemble a Catholic mass—Mars had no ordained priest—but Madhu and a small informal task force did their best to make the program as moving and meaningful as possible. The Great Room was decorated simply with potted geraniums and a simple arch of white plastic that Ethel had made for weddings, in this case symbolizing a portal to the next world. The program was begun by ringing the Outpost's bell three times. A recorded hymn was played, followed by readings from the Old and New Testaments. Roger, a devoted Protestant and the only person able to give anything resembling a sermon, spoke based on the texts. Two Christian hymns were sung by the audience as best they could. Then Madhu unveiled the text of a monument she had designed that she would build in the garden below Face Rock next to the monument memorializing Paul Renfrew.

It was Will's turn next. He walked to the front of the room. "Ever since the first creatures on Earth began to think, human beings have yearned for immortality. No one has found a fountain of youth yet; medical science has not banished death. But the next best thing is to be remembered, and humans have sought that honor for thousands of

years. We can give that gift to Joseph, even if we never met him. Last night I sent a message to the Commission asking that the new building we are finishing be named Joseph Hall. The request was approved earlier this sol."

Everyone applauded. Will returned to his seat and the music rose again. They stood and sang another song. Finally, everyone filed forward to give Neal and Rosa a hug in a moving display of solidarity.

The refreshments were brought out, but before anyone started eating them, Neal raised his hand. "Attention, everyone!" he said. "Rosa and I can't express how grateful we are for your love and support over the last few sols. We're really moved to tears." And he paused, because tears came to his eyes. His voice quavered. "This cloud in our lives has at least had a silver lining, and if the sacrifice of our little one has brought everyone together, the loss of his life was not completely in vain. Thank you."

No one was sure what to say after that. Several hugged Neal again. Will bowed his head and said a quick prayer. The illnesses of the last week had cemented the thirty-three adults together into a community more swiftly and deeply than he could have imagined. He turned to Madhu. "Thank you for the beautiful program. I think you've brought closure not only to the Strogers' loss, but to the sickness as well."

"I hope so. And naming the building for Joseph; that's a perfect solution."

Will nodded. "It felt right."

"Let's hope a better quarantine and better vaccines can prevent this from happening again. I shudder to think what disaster could result if a plant disease devastated our greenhouses."

"We thought six-month flights provided plenty of isolation. That has to be reconsidered."

"At least you've nipped in the bud the criticism of the Mars project as vulnerable to disaster and overly risky," exclaimed Yevgeny, who was standing nearby. "But I gather, Will, that the Commission's not very happy about your publicity blitz."

"No, they weren't, but Morgan and I have talked it through and we're planning a series of meetings to resolve media problems. Thank you for your interviews on Russian television. Everyone says you did a good job. It was 'on message,' as they say."

"Thanks. But who is 'everyone'?"

Will smiled. "The Mars Exploration Society mobilized its various chapters."

"The talking points you gave me were pretty sophisticated; more than anything I've seen the Mars Exploration Society produce."

"How many talking points have you seen from them?"

Yevgeny hesitated. "Well, none."

Will looked at him closely. He wondered whether Yevgeny was receiving secret messages from the Commission, inquiring what he knew of Will's efforts. "My hope is that the Mars Commission can get control over the entire public relations process. Otherwise we'll be subject to fourteen different national publicity agendas at once. That's no way to coordinate a project so as to maximize public support."

Yevgeny nodded. "I agree. NASA is being arrogant. I suspect everyone will be willing to let the Commission set the public relations agenda; except maybe the French."

"Well, I'm willing," exclaimed Will, with a smile. He turned and walked toward the refreshments, thinking about Louisa Turner and her very competent work.

Over the next week, the virus disappeared almost as fast as it had appeared. Half of the Outpost had been on sick leave; now everyone was back to work full time except Rosa, who was still recovering from the miscarriage, and Ethel and Carmen, who were taking it easy because of their pregnancies. The three shuttles had brought thirty-six tonnes of consumables, machinery, and equipment from orbit. The consumables had to be stowed and old inventory destroyed or moved to other locations to serve as backup. Several people on Earth updated the inventory databases; based on high-resolution video and computerized reading of bar codes, most of the inventory work could be done remotely, freeing the Outpost personnel to do other tasks. The new equipment and machinery included an expansion of the machine shop, with lathes and sophisticated metal cutting tools capable of making a wide variety of objects from weldalite, copper, and nickel-iron alloys. A new chemical synthesis unit and an expansion of the plastic extrusion unit had to be installed. A large regolith sifter and a plaster-making kiln were assembled from imported and locally manufactured parts. Finally, high-quality pressure windows made on Earth were installed in Joseph Hall, allowing the top floor and the half of the bottom floor other than the garage to be pressurized properly and permanently, which meant the spaces could be finished and occupied.

Time was also taken for safety classes, classes about use of Mars pressure suits—which were much easier to learn on Mars than elsewhere—and several short field trips to brief the new arrivals about safety when outside and the procedures they followed when exploring. Most people were already familiar with the procedures, either from their experience on the moon or their work in mission control. Extensive training had occurred

on Earth before departure, but experience had shown that training and certification on Mars was more effective.

Two weeks after the funeral they decided to shift media attention to the sale of Martian land, with NASA's public information people coordinating the effort. The first blocks released for sale were all located in the borough and Aurorae's inhabitants were given two sols to make their purchases before the public. At breakfast several people were consulting the choices on their attachés.

"I can't decide whether to go for proximity or beauty," said Martha Vickers. "There are some great parcels in Little Colorado Canyon, but they're remote."

"I suppose we had better go for beauty," Alexandra said to Yevgeny. "Because we could be accused of conflict of interest if we bought land close to the outpost."

"How?" replied Yevgeny. "The nearest two one-kilometer squares are not for sale, and it'll be a century before the outpost outgrows them!"

"There are resources of gravel, sand, and dust we might exploit for construction purposes."

"Outside the two square kilometers reserved for the outpost? Not for a long time."

"I rather like the low ridge north of here, half way to the escarpment," commented Kevin Dunbar. "It has nice views in both directions and isn't far away."

"But we aren't buying anything," replied Jennie to him, causing Kevin to scowl.

"I'm buying parcels all around the two kilometer square," replied Will. "We'll have to expand in one direction or another, so if you buy parcels all along the perimeter no one can accuse you of steering the development."

“You’re buying close in?” asked Roger, started. “Will, the land along the perimeter is for sale at thousand times base value; that’s a million dollars per square kilometer, $10,000 per hectare! That’s an absolutely crazy amount.”

“Look, Roger, this place probably has a glorious future, and we’re dedicated to creating that future, so we know the land’s value will go up eventually. Let’s say it triples in value in thirty years; that’s a good investment, isn’t it?”

“Hum. . . no, not really. I’m making seven percent on my investments, which is a doubling in value every decade, so in thirty years the investments will increase eight fold. And there’s no guarantee you’ll get three times as much, either. I’m pretty sure of my seven percent.”

Will wasn’t sure what to say in reply. “I like your approach, Will,” said Yevgeny a moment later. “If any land will have value, it’s close in. I wonder whether the escarpment edge is worth a hundred times base value.”

“I’m banking on it,” replied Érico.

“Like I said, we’ll outgrow our two square kilometers eventually,” said Will.

“How much are you investing?” Alexandra asked Will.

He hesitated. “A couple million.”

“A couple million!” exclaimed Roger. “Are you crazy!”

“Hey, we’ve been here a long time and have accumulated far more than we need for our retirement. Why shouldn’t we invest in this world’s future?”

Roger shrugged as if to say “Suit yourself.” That ended the discussion.

Almost six weeks after Columbus 4 arrived, the unpacking and setting up was finished and the training had been completed. On August 1, three automated cargo vehicles or ACVs, each with fifteen tonnes of cargo, aerobraked into a “one-sol elliptical orbit” around the Red Planet and rendezvoused with Embarcadero Station. Embarcadero had two remote-controlled manipulator arms able to transfer cargo modules between vehicles. Four Lifters—automated vehicles based on Phobos and Deimos, each with fifty tonnes of oxygen and methane—had flown to Embarcadero as well, where they were parked a few kilometers away.

The Outpost had prepared for the arrival of the ACVs for months. The *Pavonis,* which had been on Mars for several years, had full methane and oxygen tanks—155 tonnes altogether—and 155 tonnes more was stored in metal tanks to refuel the *Olympus* after it arrived. Refueling the *Hadriaca* required every spare kilowatt to make new methane and oxygen, which took forty sols. The three shuttles were loaded with Earth-bound cargo: liquid argon bound for ion engines in Earth orbit, liquid nitrogen for Earth orbit and the moon, Martian rocks for consumers on Earth, four tonnes of gold, and rock samples for scientific analysis.

The *Pavonis* blasted off first, uncrewed, followed by the *Olympus* a sol later. The *Pavonis* opened its cargo bay doors and approached Embarcadero’s remote controlled arms; the first arm pulled out the earth-bound cargo pallet and the second arm, already holding ACV1’s Mars-bound cargo pallet, put it in shuttle’s cargo hold. ACV1 then flew to remote-controlled arm one and received its Earth-bound cargo. The procedure was repeated for the *Olympus* and ACV2. Lifter 1 docked to the shuttles and refueled them so they could return to the Outpost. Lifters 2 and 3 docked to the two ACVs, fired their

engines, and pushed them on a seventeen-month trajectory to the inner edges of the asteroid belt, then back to the Earth, where the ACVs and Lifters would aerobrake into Earth orbit, the ACVs with thirty tonnes of spare methane.

Seven tense sols of precise, slow, patient maneuvers were necessary to complete the procedures. Only when they were finished was the *Hadriaca* launched, for if it had been necessary it would have carried a crew to repair equipment or force balky docking apparatuses to function correctly. Using Embarcadero's arms, it exchanged cargo with ACV3 and refueled from Lifter 1. Then Lifter 4 pushed ACV3 back to Earth, Lifter 1 returned to Phobos to refuel, and the *Hadriaca* landed at the Outpost.

There was celebration on Mars when the *Hadriaca* landed safely. The shuttles brought items of immense importance: two more rangers, another conestoga, three more greenhouses on top of the four brought by the crew, a new and larger sunwing model-B, two more nuclear reactors, scientific and medical equipment, spare consumables, medicines, and other essentials.

But most important, at least to Will and the other veteran residents, was the 'Mars Dome,' privately funded and launched by the Mars Exploration Society. The private non-profit organization had spent one hundred fifty million dollars to get it from a design idea to a finished product in Mars orbit. It planned to recoup most of the expense through the sale of twenty-five tonnes of Mars rocks that were on their way to Earth on the ACVs. The dome, thirty-two meters in diameter and twenty high, transparent to ninety percent of the visible sunlight that fell on it, could be safely pressurized to as much as an Earth atmosphere of pressure. It had four airlock openings built into it, two of which were wide

and high enough to accommodate rangers. Over the previous nine months Ethel and others had made the parts for one big airlock and the two smaller airlocks for pedestrians.

The very sol the *Pavonis* landed with the Mars dome, a team of workers hauled it to the shallow excavation they had already prepared for it and began the long, slow process of inflating it with 1.5 tonnes of oxygen and 300 kilograms each of nitrogen and argon. When the inflation was finished the dome's Kevlar sides rested against the airlock shells that had already been welded together. In two sols the dome was glued, clamped and bolted in place against the airlocks, allowing them to be used.

Will was walking to the dome to be part of the party entering it for the first time when his attaché beeped with a message from Douglas Morgan. He headed back to his apartment and activated the message. Morgan looked very serious.

"Good sol, Will. Congratulations about the dome. I can't wait to see the video. Be sure to get someone to do a walk-through every day, so we can load the imagery into the virtual reality. There are twenty thousand Mars Exploration Society members who can't wait to take a look.

"Now, personnel matters. I've decided that, for now, we'll continue to use NASA's OPI, with my office overseeing coordination with other agencies. NASA OPI did a good job with the land sales; five million dollars has been sold to the public so far. The companies are the big investors and OPI can't bring them in, so I'm reinforcing the land sales division. Heather Kimball has been pushing that I hire someone named Louisa Turner for media relations. Please tell Heather, who I know is your friend, to back off a bit. I respect her highly, but she can overdo it. I suspect Turner helped you with the media campaign; my friends in NASA OPI say the campaign had her name written all over it.

She and Heather are close. I'm not asking for a confession, Will, just a warning: these things have to be coordinated by me.

"Last week you again raised the issue of acquiring 'smart help' on Earth. That wasn't the way you explained the position, but you did use that phrase. Needless to say, that's one thing I don't want you to have right now. Earn my trust first, Will. If you prove loyal I may make you a partner in this enterprise, because our strengths complement each other. Or some do; we're both good with the media. So there's your loyalty test. Bye."

The screen went blank. Was he being frank, or was it a ploy? Will stared at it for fully a minute, reviewing Morgan's words. They offered a carrot and a stick: if he toed the line, his autonomy and responsibility would increase. Morgan even left open the possibility of hiring Turner by ignoring the likelihood she had helped with the media campaign.

He wondered whether plan B was wise: to employ Turner through the Mars Exploration Society. Will and Ethel could give the MES a gift to cover the salaries and benefits of Turner and her assistant. After six and a half years on Mars, the two of them were worth twelve million dollars, and they had very little to spend it on. If they pursued that path, it might alienate Morgan.

Will taped a quick, warm acknowledgment and headed for their new, very special, dome. Roger, Alexandra, Yevgeny, and Madhu were waiting impatiently when he arrived. He apologized for the delay and they entered the airlock. When they opened the inner door of the airlock they were hit in the face by a wall of hot, dry air. But they ignored that and entered the space slowly, marveling at its seemingly enormous size.

"My God, this place is huge!" exclaimed Will.

“I wouldn’t call it huge,” replied Alexandra. “But then, you’ve been stuck in habitats or greenhouses for over six years.”

“You can say that again!” exclaimed Will. He walked across the bowl-shaped floor of thick, black plastic. His footsteps made rustling noises on the plastic that echoed in the cavernous space. He reached down to feel the floor; it was icy cold to his touch, since it was in contact with subfreezing ground.

“One hundred feet across,” added Roger, as he walked across. “That’s a measurement from my childhood; it carries emotional weight that thirty-three meters doesn’t. My childhood house had a back yard about this big.”

“It’s bigger than our back yard was,” replied Will. He looked up and shouted “Hello!” and a look of delight crossed his face when the echo immediately came back to him.

“Imagine what this place will be like with plants,” added Alexandra, a bit embarrassed by her boss’s exuberance.

“We have quite a few fruit trees that are getting too big for the greenhouses,” added Madhu. “If this thing hadn’t arrived, we would have had to prune them back. It’ll be tricky to get them through the buildings and airlocks, but once they’re here they’ll be able to grow very nicely.”

“A place where the kids can climb trees,” added Will. “We’ll have to build a swing set, too.”

“I hope we don’t fill the space completely,” observed Yevgeny. “We need a place to gather in the open air.”

“Don’t worry,” replied Madhu. “The trees will be in very large pots on wheels. We’ll normally leave them spaced out to maximize their exposure to sunlight, but if we need open space, we can roll them together. The thick forest will be fun as well.”

“Can we hold a picnic in here?” asked Yevgeny.

‘We can have a barbeque!” replied Will. Yevgeny laughed, but Will was serious. “Check out the stats for this place. The quantity of air in here is so large, we can burn three or four kilograms of wood quite safely. The smoke will be noticeable, but it’ll clear up in a few sols by natural means.”

“That’s one advantage of large spaces like this,” agreed Madhu. “If the species are carefully balanced and maintained, big spaces require a tenth as much environmental maintenance equipment per cubic meter of air as the greenhouses. This thing will be a boon to our environmental control equipment because it doubles our volume of interior air, and thus gives us a much bigger reservoir to dilute waste gasses in.”

“Are we going to grow food in here?” asked Alexandra.

“Some,” replied Madhu. “We now have sixteen greenhouses, which is enough to feed thirty-two people under emergency circumstances and twenty-four in normal configuration. This dome has enough space to feed up to seven. We have thirty-five residents and two on the way, and enough food from Earth to cover half our needs. So we don’t need the dome for agriculture. But if we use some of this space for agriculture—especially orchard—we can improve the range and quality of our food and we can build up our surplus. Either way, we reduce our dependency on imported consumables.”

“As long as we keep as much of this space for recreation as possible,” commented Yevgeny.

“Look at the website. We’ve been making big plastic growing trays that can be lifted, moved, and stacked by two people. We’ll be able to cover this floor almost completely during the day with vegetables and fruit trees, then clear sections for recreational use on nights and weekends. It’s a pretty good plan.”

“Clever,” he replied.

“I suppose my concern is the heat,” said Will. “We should remove the infrared screens and let as much heat out as we can.”

“They’re already removed,” replied Madhu, pointing to two lines of small boxes that ran vertically from floor to apex. Inside the boxes were several different “blankets” that could be pulled up along horizontal tracks around the dome. “Right now the sun is providing three hundred fifty kilowatts of light and the black floor is converting most of it to heat. But there isn’t much in here to heat up; just air and a thin dome. So it rises to a pretty high temperature. By late afternoon it’ll be sixty Centigrade in here, then it could fall below freezing at night. If we add several tonnes of plants, dirt, and water in containers, the temperature swing will be buffered.”

“At least that’s what we hope,” added Alexandra. “This dome couldn’t be completely tested on Earth. The computer modeling is approximate, even incorporating our experience with the greenhouses. We may have to add a water tank or cover the floor with a layer of rocks a half meter high with a plastic sheet over them, in order to add a few tens of tonnes of heat reservoir.”

“We need to store the heat for nighttime,” said Will.

“No, dust storms are the problem,” replied Madhu. “If we have six to nine months when the insolation is reduced to as little as one tenth of normal, we’ll need a big source of heat to prevent everything in here from freezing.”

Will’s attaché beeped. He looked; it was a call from Ethel. “Hi,” he said.

“Say, can Marshall and I come in? We’re walking around.”

“Sure, why not? It’s hot in here; maybe 40 Centigrade. But the air is breathable and there’s no humidity, so it’s tolerable.”

“We won’t stay long. Bye.”

Will put his attaché back at his side. They all walked around the open space. The dome had a pretty good view; the protective berm of reg and ice outside the plastic was waist high. A minute later there was a sound at the airlock. It opened; Ethel and Marshall looked in. The little boy stared wide-eyed at the big open space and the bright sunlight. Then he shouted with glee.

“Marshall!” exclaimed Will.

“Daddy!” he replied, and with a laugh Marshall ran across the space to him. Will watched him coming, then dodged to the side and began to run in a big circle. Marshall laughed and chased Will, who was careful not to outrun his son too much. Finally Marshall caught him, at which point Will turned and began chasing the two and a half year old.

Everyone laughed to watch the antics. Roger got on his attaché and called Érico. He soon arrived with Carmen and four others he had intercepted on the way. Érico brought a baseball with him.

“Where did you get that?” asked Roger.

“I had it all along. Here, catch!” Érico tossed it to Roger, and a four way game of catch quickly developed in the dome.

Ethel looked at Will, who was now sweating as he ran around with his son. She picked up his attaché, which he had put down on the floor. “I’m calling Francisco; he’s in charge of lunch this sol. Shall we make it a picnic in here?”

Will nodded. “Yes, that’s a great idea. The life support equipment isn’t installed yet, but this place is so big, we can all be in here for an hour and not affect air quality noticeably.”

6

Flight

mid October 2043

Will kicked the hardened clay of the runway under his foot. It yielded very little; "scratched" would be a better description of what his boot had done. Several years earlier they had spread an eight-centimeter thick layer of mud and roasted caliche on the kilometer-long runway, section by section, and covered it with a black plastic sheet to heat it and hold in the water. The chemical reaction had used up the water and made it hard. The result was an excellent surface for airplane takeoffs and landings. That was important because their solar powered "sunwing" aircraft, while capable of vertical takeoffs and landings, saved a lot of energy and mass using a runway.

He looked at the solar biplane in front of him. The propellers were spinning; it was almost ready to take off. It was their new "supersize" model able to transport half a tonne of cargo or three persons from runway to runway, or two thirds of that with vertical takeoff and landing capability. A big, ungaintly looking thing, it had two sets of wings. The lower wings attached to the bottom of the central pod were 3.8 meters wide and extended 48 meters to either side. The upper wings were attached to the top of the central pod and staggered two meters behind the lower, with numerous crisscross wires holding the biwings together. The upper wings were divided into six sections, each with a propeller. An equipment pod twelve meters from the central pod held fuel cells, fuel tanks, electrical transformers, and landing gear. The central pod was a pressurized plastic cocoon 7 meters long, 2.5 high, and 1.5 meters wide.

"We never had anything like this on the moon," said Yevgeny to Will.

“The wings are so big, you’d think there’s no air here, either!”

“It’s amazing we can build something so large, yet it has so little mass. I’m not sure I’d want to fly in it; it looks too flimsy!”

“It’s a novel experience, believe me. But our sunwings have proved to be excellent aircraft. On two occasions we’ve had close calls, but in each case it was pilot error, and both times the pilot wasn’t on board. The new software should help. They’ve stayed up for some pretty long periods, too; during the last duststorm season we kept Sunwing 3 up for five months.”

“That doesn’t strike me as that unusual; is it? A sunwing model has been flying in the atmosphere of Venus for almost three years and there are other models on Earth serving as aerial communications towers at 30,000 meters that regularly stay up a year.”

“Theoretically, our sunwings can stay up several years if they had to; the solar panels don’t degrade and the thing can fly on six of its fourteen motors. But there’s never been a need for them to stay up that long because they’re constantly hauling supplies. We’ve dropped emergency ice blocks and rations at twenty locations along the Circumnavigational and Polar Trails and another dozen along the future routes of the Pisces and Tharsus Trails, and we visit Prospectors every few months to move them to another location or pick up samples. They’ve also photographed about five percent of the surface at ten centimeters resolution, and most of that is with the sensor package that tells us just about everything we could ever need to know about the geology, short of visiting. Their work deploying weather and seismology stations, picking them up for repair, and serving as mobile weather stations has been invaluable.”

“I’m just not so sure I’d ever want to ride in one!”

“We’re ready for takeoff,” exclaimed Érico over the radio. He was inside the Outpost controlling everything remotely.

“Acknowledged,” replied Will. He looked at the others; everyone began to back away from the aircraft. A moment later the propellers revved up to a higher speed, kicking up dust around the vehicle. It began to roll down the runway.

They watched as it picked up speed. Will glanced at a display on his pressure suit’s exterior computer screen. While to his eye it seemed to be taking off pretty quickly, the computer summary showed it performing less than expected.

It rose into the air about six hundred meters down the runway and continued to climb. Érico banked it to the north and it flew toward the escarpment, reaching the wall of rock in about four minutes. They could see distinctly that it had climbed higher than the cliff top, 1,500 meters above the floor of the valley. The sunwing then banked and flew back to the Outpost, swung around to the east, and headed toward the runway. Some fifteen minutes after takeoff, dust rose from its wheels as it touched back down. It taxied toward them, then stopped thirty meters away.

They all applauded. “Érico, how did the takeoff go?” asked Will.

“That’s the part that worries me. If the aircraft had been loaded with its half tonne of cargo, it might not have been airborne by the time it reached the end of the runway. We’ve got excess drag somewhere, or less power than expected. Motor 7 was overheating, too; if it had stayed up much longer we probably would have had to turn it off.”

“Let’s figure out the problem, then,” replied Will.

“This thing is scheduled to resupply and rotate personnel for the Pisces Trail expedition,” said Yevgeny. He was scheduled to lead the mission part of the time.

“We have enough capacity without it, but it’ll be a strain,” agreed Will, worried. “The two expeditions on the Circumnavigational are already keeping our Sunwing-As busy, and when work starts on the Tharsis Trail we definitely need this baby; the older sunwings can’t fly that high with any amount of cargo.”

“We’ll have the problems resolved by then,” replied Érico. “I think,” he added.

Will glanced back at the computer screen. He had videomails from Earth waiting and wanted to go inside the outpost, or at least get away from everyone else so that he could concentrate on them.

“The data is on its way to Honolulu,” said Érico. “I have some ideas, but they can analyze the data better than we can.” Érico paused to read a message. “Oh, sorry Will, I’ve got to go! I’m getting a call from sick bay. Carmen’s on her way there now.”

“Really? This is it?”

“It seems to be.”

“I’ll be on my way. Ethel really shouldn’t be far behind. She’s overdue.”

“Looks like we beat you. Bye.”

“Bye.” Will switched to a general frequency. “I’m heading inside. Bye.”

Various people who were outside responded, then Will headed for a buggy, a small, four-wheeled, one-person all-terrain vehicle nearby. He drove to the Outpost, about a kilometer to the north, sent the buggy back to the runway slowly on computer autopilot, and entered Habitat 1 through the east airlock. Alexandra and Enrique had been

putting together a new wall across the old Great Room. She walked into the docking unit to keep an eye out for him.

"Come look at the wall," she said. Will nodded. He walked into Habitat 1 to look at the metal frames they had assembled that defined a series of private rooms along the outer wall, each with its own porthole. The Great Room, kitchen area, bridge, and repair area had been emptied of their contents and plastic divider walls removed. The new walls were sheetrock. Will tapped a panel. "This is good, hard stuff. What's on the outside; paper?"

"Plastic. The panel is a mix of hydrated sulfates—like gypsum, which is used on Earth—clay, and nylon fibers. The sulfates are from Monmouth Crater and are reasonably good quality, so we don't have to do much to it. Strong and pretty light in Martian gravity."

"It is; and sound-absorbent. And you've reinforced the floor; I can tell."

"We're putting a tonne of sheetrock on it. The support comes from the metal frame of the walls below. You should see the work down below; the rooms are finished and the new life support equipment's installed."

"I'll look some other time. When will you have the first floor finished?"

"Give us ten sols for this side. Then the three occupants on the other side will move over here; I think they'll be much more comfortable. Then we'll remove all the walls in the other half of the Habitat; the divider between the old Great Room and the Geo-Bio Lab, the walls dividing the bedrooms from each other and the sick bay, etc. Then we'll put in the new rooms. I'm leaving room for four toilets, four shower stalls, and four water closets with sinks. When we're finished we'll have an oval lounge in the

middle of the Habitat. Then Yevgeny and I will move out of the apartment upstairs and I'll remodel it as well."

Will pointed to the Great Room's high ceiling. "What are you doing with the space up there?"

"We'll leave it open over the lounge. Over the bedrooms I'll add a balcony with railing and three storage rooms."

Will looked up, then looked at the metal frames more closely. He frowned. "I thought there were going to be three bedrooms on this side instead of four."

"I know you wanted three, Commander, but four is the recommended number."

"Yes, but if you put four here, you have to put four on the other side as well, not to mention the basement and balcony levels. How many rooms will this habitat have?"

"Four below, four on each side, and three above; fifteen total. This habitat was originally designed to provide housing and work space for six. With this design we have a smaller lounge in the middle, but it's plenty; and we can accommodate eight."

"Alexandra, I don't want this habitat to accommodate eight. First, we need more quality space, and that means slightly larger bedrooms, offices, and labs. Second, we can now build plenty of space. We don't need to cramp ourselves."

"Will, I understand. But Habitats 1, 2, and 3 can provide quite comfortable housing and work space for eight. Habitat 4 can handle twelve. It's a question of efficiency, and I love efficiency. When Columbus 5 arrives we may not need more space if we reuse what we already have."

"Alexandra, I *want* another building for Columbus 5. I want this place to grow."

"Will, we don't need another building. Maybe another habitat—"

“I don’t want another habitat either! That’s eleven tonnes we don’t need to import.”

“Another building will take three or four person-years of work, and we’ll still have to import three or four tonnes of building materials, especially windows. The difference is only six or seven tonnes. Spend twenty million more, and you have three or four person-years more work for exploration.”

“But that’s my decision, Alexandra, not yours.”

“I’m sorry; I thought innovation and creativity is what makes this place advance and get better.” Alexandra’s voice quavered a bit; she was getting upset.

“Okay; let’s talk more later. I appreciate your concern for efficiency, and you’re right, we can use our human resources better. I wish we had communicated better about this design. But I can’t talk more right now. Érico just got a call; Carmen’s gone to the sick bay to have her baby.”

“Oh, really! That’s big news!”

“And I need to get Ethel. So with your permission, I’ve got to run. Bye.” Will waved and hurried back into the docking unit, which would take him to the geology building and thence to Renfrew. He was upset with Alexandra. They’d have to talk about the design for Habitat 1 when both had calmed down, and he’d have to decide whether to ask her to start over.

Will hurried back out of the Habitat and headed for their apartment. Ethel was lying in bed, where she had been for much of the last month. “Carmen’s going into labor,” he said.

“Oh? She beat me.” Ethel patted her stomach. “I can’t wait to get her out of the oven. This one’s been really hard. This is our last child, dear.”

“As you’ve told me almost every sol for the last nine months. I think most people here find two children excessive.”

“There are some women here who regard one child as excessive. But my standards are different. My Scots Presbyterian grandmother had seven.” Ethel lifted her hand and Will helped her up. “Let’s go down and wait.” She picked up her overnight bag just in case and they started walking.

“Where’s Marshall?”

“With Lisa. She’s been doing a lot of child care. I think she’s coming around.”

“Good. I hope she and Karol decide to get married first.”

“No guarantee of that. How was the sunwing flight?”

“Reasonably good. Take off took an extra hundred or so meters.”

Ethel shook her head. “I’m concerned about the aerodynamics.”

“The wind tunnel tests and the atmospheric tests on Earth all worked fine.”

“I suppose I’m old fashioned, then. It looks funny, one wing above and staggered behind the other.”

“If one were directly above the other, only one would get sunlight. That wouldn’t be enough to keep the plane in the air twenty-four point six hours a sol with a half tonne of cargo.”

“That kind of capacity will really help a lot. And I know, sunwings like this have flown on Earth before, and staggerwings were proven technology a century ago.”

They crossed greenhouses 8 and 1 and entered Habitat 2. The great room had a small crowd already. There was no news, so they all sat, drank tea and coffee, and chatted. Érico came out periodically to visit and give the news. After a half hour Will got away briefly to listen to the now three video messages.

"Will, the new timetable for the Phobos-Deimos Mission in March is on the website," exclaimed Morgan. "Have everyone take a look. I think this addresses some of the concerns about excessive time devoted to maintenance and expansion of facilities, but I wouldn't minimize their importance. The experimental 'landing' of the *Cimmerium* on Deimos is important; minimizing radiation exposure is definitely more important than maintaining a gravitied environment. Hence the importance of devoting a week setting up the landing facility and moving the *Cimmerium's* solar panels.

"Now, regarding the proposed interview involving you and Liz Gordon on top of the escarpment: our people think it's a good idea and should boost land sales. They've modified a few of the talking points; I've attached the result to this videomail. Please don't follow the old version. Bye."

Will wondered what they had changed. It had been Louisa's idea, but it officially came from her as the Mars Exploration Society's new media head. He opened the email and glanced at it. Then he listened to Louisa Turner's first videomessage. "Will, regarding the talking points, the Commission's people are crazy. Sometimes they think you're a used car salesman and should hock your wares shamelessly. Other times they think you should be diffident and say nothing about land sales at all. The talking points and sound bites had a good balance. You are Commander of Mars Operations and must preserve your dignity, yes, but people know you believe in Mars and that's one reason

you are a celebrity, so they expect you to make mild sales pitches. Ignore their modifications, please. The Commission people can be idiots, frankly. Working with them is not working out well, from my point of view. Thank God I'm in Denver instead of Houston; I think I'd walk down the hall and kill them. Besides, I hate flat places. The MES people here are sympathetic even if they have no idea what I'm talking about half the time. At least they listen to me. Bye."

Will had to smile; Louisa knew she was right, which was one reason NASA OPI disliked her so much. At least Morgan had met with her once face to face, and Heather Kimball even managed to set up a meeting between her and the Chief Administrator of NASA. But before replying, he had to hear Turner's other message.

"Hi, Will. We've got to postpone the interview with Gordon. Carmen's baby will steal all the headlines. I'll email NASA OPI with the recommendation. Bye."

That simplified things. He sent her back a quick message agreeing, then sent a similar message to Morgan about the need to wait. That gave him time to prepare a response about the talking points. Then he went back to habitat 2's great room. He was surprised by the commotion he saw.

Kevin Dunbar had just arrived from his work outside, setting up two new one-tonne nuclear reactors. "Look, don't bother me about my clothes," he was saying to his wife, Jennie. "There's no way there's any radioactivity on them. I don't climb all over the nukes, remember; we've been working on them robotically. Besides, the clothes stay inside the outpost."

"And your hands touch the pressure suit, then touch your clothes."

“Jesus Christ, Jennie, I know procedures! I’m telling you I would not have transferred radioactive dust to my clothes, and besides, there isn’t any radioactive dust outside anyway!” He rolled his eyes and looked away from her.

“Let’s both calm down, please,” said Ethel, who was seated near the Dunbars.

“Well, she’s always nagging me about one thing or another!”

“Nagging! If you had any common sense, I wouldn’t be reminding you of duties and responsibilities!” she replied, and tears swelled in her eyes. Will looked around. Martha Vickers, their psychiatrist, had arrived a few minutes earlier. He looked at her and she looked back at him; they communicated with their eyes without saying anything. Martha rose. “Come on, you two, let’s go for a walk and cool off. Right now we’re all rather tense because of the situation.” She beckoned them and, after a moment of hesitation, they followed her out of the Great Room. It wasn’t the first time she had taken them out of a socially awkward situation.

Ethel looked at Will, then stood up. “I need to stretch my legs, too.”

“Okay.” Will walked to her side and took her by the arm. They headed in the opposite direction of the Dunbars.

“I can’t stand shouting. I think it’s the pregnancy,” Ethel said once they were out of earshot.

“Everything echoes in the habitats anyway.”

“I wish they could get along. It seems to me when I knew them seven or eight years ago, they were fine together.”

“Well, now they’re on Mars together and see each other constantly. Jennie was never an astronaut either; she’s here to do child care, cooking, and cleaning.”

“And I wish she was doing more of those things!”

“I know. She’s in some sort of crisis. I gather Martha’s seeing her almost every sol and may prescribe some medication.”

“Good!” They walked in silence for a while. They reached the Mars Dome and lingered briefly; in the last two months it had been filled with plants and was now quite attractive. It also had the smells of greenery, something they craved. They paused around the little fishpond that had been built on one side of the dome. “So far, the thirty-three of us are doing pretty well,” commented Ethel. “The outpost has a critical mass for a lot of activities.”

“Like weekend theatre, and tv nights, and a monthly flea market,” agreed Will. “Not to mention birthdays to celebrate almost every week, and plenty of people to rotate child care among.”

“It’ll be interesting to see how that changes when there are four children to raise.” Ethel turned and headed for the airlock. Will followed. They passed through and entered Joseph Hall. Ethel paused just inside the building. “Oooh.”

“What is it?”

“A contraction.”

“You’ve been having them on and off for a few sols.”

“Yes, but this was bigger. It hasn’t really gone away yet.”

“This is not a good time to have a baby, my dear; someone else is already in labor!”

“I know, but since when can we control when we have a baby?”

“Do you think this is it?”

"Ah. . . . yes, I think so."

"Then let's stop at the Great Room to get your bag, then head back to sick bay."

It was a long afternoon, followed by a long night. Ethel had another long contraction half an hour later, followed by a sharper one twenty minutes later. It was indeed the beginning of labor. Shinji and Eve moved another bed into the same room and the two women and their husbands shared the same small space. The rest of the outpost sat in the Great Room; they walked to the cafeteria to get meals, but brought them back to habitat 2 to sit on the floor together and wait. The Mars Commission got permission to broadcast the image from the Great Room on cable television and millions tuned in to see the latest.

It was a strange sort of race. Carmen was two weeks overdue; Ethel was right on time. Carmen had gone into labor three hours before Ethel, but it was Ethel's second child and labor went faster. As a result, Ethel and Will's daughter, Elizabeth, was born at 5:36 a.m. on Tuesol, October 12, 2042. Érico and Carmen's daughter, Corazón, was born at 7:03 a.m., an hour and a half later.

It wasn't until several hours passed before the new mothers were ready for the video arrival of their families on Earth. The round trip communications delay was about a half hour, but the joy of a new baby partially overcame the inconvenience of live, asynchronous conversation. Families essentially lived around each other for a few hours, watching and commenting. When it was over, mothers and babies took a long nap.

It was the next morning when Ethel and Carmen were ready to present their children to the Outpost. Will and Érico were there—all four had slept in the sickbay that

night—and the two couples, their two babies, and Marshall all conferred briefly before walking over to Renfrew Cafeteria.

"Are you sure we have to do a live video feed as well?" asked Érico. "It seems exploitive."

"It's up to you," replied Will. "We are celebrities and there are millions of people who want to see the babies."

"It's off message, isn't it?" asked Carmen. "Weren't you planning to go up to the top of the escarpment and be interviewed about land sales?"

"I was, but that can be done next week or the week after. Families on Mars are exactly the message we want to convey. We want to show the majority of the middle class people on Earth—the people paying taxes to keep us here—that this place is worth the money and represents an important element in humanity's future. Settlement, families, and ordinary life are keys to doing that. They encourage people to commit decide to this place in any way they can; and the principal way they can commit is to buy range land. It's an investment, after all."

"Until the real estate bubble bursts," quipped Érico.

"We're working to keep that from happening."

"Another reason to show the baby on television is to minimize the number of articles in cheap tabloids claiming that your baby had an alien for a parent or has two heads," added Ethel. "The things printed about Marshall were really disgusting. If we are careful to make this whole process seem normal, we'll minimize the silliness."

“That’s a good point,” said Érico. He looked at Elizabeth, who was in Will’s arms. “First two boys were born on Mars, then two girls. And I gather Rosa’s pregnant again, and they think it’s a girl as well.”

“Maybe it’ll help balance out the gender ratio here!” said Carmen, looking at Ethel, and they both laughed.

“The more we have, the better,” replied Will.

Ethel hit him. “You’ll have to take a second wife, first, buster.”

“I’ll remember that,” replied Will, teasing her. He cuddled Elizabeth closer to him. “Let’s go meet the crowd.”

7

Plastic Bag

early April, 2043

"Are you ready to catch?" Will asked Marshall.

"Ah-huh," replied the boy, waving his hands. Will carefully threw the ball underhand to his son, who was standing about two meters away. Marshall reached out and managed to catch the big, soft ball in his hands momentarily before it bounced out. But he didn't mind; he chased it under an orange tree, grabbed it, and ran back to his place. He threw the ball with fairly good accuracy back to his father, who caught it easily.

"Very good," Will said. Marshall, now three, had developed quite a bit of coordination over the last few months.

"Oh, the fish are nibbling my toes!" exclaimed Ethel, delighted. She was sitting on the stone edge of the pool and had her feet dangling in the cool water. She held Liz as she leaned over. The baby continued to nurse at her breast, ignoring the strange angle.

Sam ran over. He was in the dome also with his parents. Madhu was sitting under a tree reading a book; Roger had been reading a story to his son.

"Be careful!" said Ethel as the two year old leaned over the edge of the pool. He saw the tilapia surrounding Ethel's feet and a worried look spread over his face.

"Do they hurt?"

"No, they tickle."

"Tickle?"

Ethel nodded. Sam laughed, not sure what to make of that, then ran back to his father.

Several other people sat in the dome, relaxing, reading, sipping a drink, or eating. It was Satursol afternoon; a lazy time. The dome had proved immensely popular as a recreational area. People craved the greenery, the water, the sound of the water trickling, the aromas of flowers; and the immense transparent surfaces of the dome made them feel like they were outside. The high ceiling was itself liberating. The problem was radiation; the dome was much safer than interplanetary space, but still exposed people to about ten times as much radiation as one would get high in the Rocky Mountains.

Dr. Tang came in, his attaché dangling from his waist. He looked up at the sky. "Darn; still gray and overcast."

"It's dust storm season," replied Roger. "It's a lot better than a few weeks ago."

"True, but I miss the sun!" replied Tang. "I guess I can be thankful it's such a light storm season." He watched Will throwing the ball back and forth with Marshall. "By the way, we just identified two new species this morning."

"Really? Congratulations! That raises the number to what; forty-seven?"

"Forty-eight, in four subphyla and two phyla. The latest chemical analysis again supports the common origin hypothesis."

"Hum." Will contemplated the eternal question the hypothesis raised: did Earth get its life from Mars, or Mars from Earth? The former was more likely, since the Mars achieved some level of environmental stability a few million years earlier.

Tang watched the ball go back and forth, smiling every time Marshall tried to catch it. Will tossed the ball to him. "Enlai, you need a little exercise. Would you like to throw the ball to Marshall?"

"Yes, I would!"

"Good. That'll give me a chance to catch up on messages."

Marshall did not look pleased, but it was momentary; Tang threw the ball very slowly and precisely to him, and Marshall caught it easily. Will watched, then retreated under a tree laden with ripe lemons, sat cross-legged on the grass—the dome had real grass!—and grabbed his attaché. He had a brief email from Louisa Turner: *Your talk to the Brown University Alumni Association on Tuesol should be titled "Living Well on Mars." We've reviewed the draft. We think the theme of family life on Mars is excellent but that you should emphasize more the importance of creating a reasonably high quality of life based on social ties and mutual support, as that makes up for the lack of material advantages. We've got a psychologist reviewing the points you listed and giving you some facts to use. This is a talk that will be immensely popular with Mars fans. We'll have the details to you in a few hours.*

Will had to smile; he and Louisa were learning how to collaborate quite well. He had started a blog, partially ghost written by Turner. Mars exploration was growing in popularity. He was pleased that his ideas were working out so well, but he had to admit the professional staff's polishing and their recommendations about pacing and repetition of ideas was what made them effective.

His second message was from Sebastian Langlais, the former Commander of Columbus 2. He opened it and read.

Dear Will: As you probably have heard, I'm now Long-term Commander of Shackleton Station. Unlike previous commanders, I'll be here six months with an assistant commander to run the support efforts on Earth, then I'll rotate back to Earth for six months where I'll supervise the support operations while the assistant commander

will run Shackleton. The constant change of commanders has made continuity much more difficult than on Mars. I hope as Long-term Commander I'll be able to bring more unity and consistency to the activities. Mars is our model! The Lunar Commission should consider a long-term commander for all lunar operations, but I don't see the national efforts accepting that arrangement any time soon. It's quite a breakthrough that NASA has decided to allow a German to take this job!

The exciting development here is that tourism is about to expand. Launch costs have dropped and demand grown enough to fill six two-week flights per year. We're grouping them in summer and winter clusters so someone can stay two, four, or six weeks. The rest of the year there will be six cargo and passenger flights. The new radio telescope initiative, about fifty kilometers backside of here, uses our spaceport and needs several hundred tonnes of cargo and lots of construction personnel, who will stay in the hotel when the tourists are absent.

LeMonnier Station is becoming an interesting challenge. The French are pushing the Europeans to expand it because it's not Shackleton. They have proposed some excellent projects, like the Imbrium Deep Drilling project, which should penetrate the Imbrian magmas and get to the mantle. But they're also spending a couple billion on a Helium 3 extraction project. The He3 concentration in the regolith is lower there, but never mind, the plant has to be at LeMonnier! And it's just about proved that He-3 fusion is not the breakthrough everyone craves, but don't tell the French. So LeMonnier grows because of a boondoggle and we gain experience that may help with the extraction of platinum-group metals from nickel-iron. We know that can make money.. But here's the kick: the supply of hydrated minerals there is not large enough, so we'll have to ship

them water. We're already running an automated water truck there once a month and soon it'll be two.

"I'd better run. Say hello to Ethel for me. I was looking at pictures of your kids on your website the other day. The little one is so cute, and I can't believe how big Marshall's getting! My son Helmut has decided to apply for the ESA Astronaut Corps when he completes graduate school. He's a junior at Université de Strasbourg studying geology, meteorology, physics, and engineering. He wants to emigrate to Mars. The Commission's informal quota—half the arrivals will be persons planning to stay at least three columbiads—is beginning to get the attention of a lot of young, idealistic students. Of course, I tell Helmut that idealism really isn't an adequate reason to go to Mars; life there is still hard and options are limited. But he's enthusiastic anyway! You may be his commander in six or eight years.

I hope to hear from you some time. Let's keep in touch. Bye.

Will re-read the message. He had tried to maintain contact with the various commanders at Shackleton, but it had been frustrating because the person at the other end was there only six months. Because of the fast communication with Earth, mission control had a much larger role in the day to day operations and the commander was correspondingly less important. In actual fact, the real commander was essentially in Houston, not at Shackleton. With Langlais in charge of both the Shackleton and Houston operations and going back and forth, the effort would have much better continuity.

"Ethel, listen to this," he said, and he read the message aloud. The others in the dome listened as well.

"Fascinating," she said when he finished. "It's good to know that the moon is run by a friend."

"It may make collaboration easier," added Madhu.

"Well, right now they're in competition," replied Roger. "And they're getting about twice as much funding, right?"

Will nodded. "That's about right. They're closer and can get tourists."

"How big are the lunar facilities now?" asked Érico.

"Shackleton International Station can accommodate forty, including tourists," replied Will. "The Chinese station there can accommodate twelve. LeMonnier can accommodate eight, but the plan is to expand it to sixteen. The Japanese station at Grimaldi can accommodate four, but it's staffed only half the year."

"Shackleton's actually not much bigger than Aurorae, then," noted Tang. "Though all the lunar facilities together accommodate about fifty percent more people than us."

"And they're much more tied to Earth," added Will. "They can't have a dome like this because of micrometeoroids and the two-week nightspan, except at the poles where the low sun is hard to use for agriculture. They're still importing a fair amount of food. And they're more dependent on Earth because they *can* be." Will glanced at Marshall, who was now chasing Sam among the trees. "I'd better write him back." Will turned back to his attaché.

Dear Sebastian: It's great to hear from you! Congratulations on your appointment to the position of Long-term Commander of Shackleton. I'm glad you'll be in charge even when you're on Earth; that's an excellent arrangement that should

greatly improve the efficiency of the operation. I'm so envious! I remember how much you complained about the long time delays, especially during meetings. Well, Morgan and I are conducting two meetings a week, on average, involving heads of staff here and on Earth, to get everyone on the same page about current and future priorities. It's been long, slow, and frustrating, but we're making progress. My efforts to get a reliable assistant in Houston who can serve as my ears in the hallway have been thwarted, which means I'm often working in a vacuum and my ideas drop into an alien administrative context. That has been frustrating.

But in spite of that, things are going very well. The Pisces Trail is cleared about half way around the southern hemisphere and has gone through some very significant terrain. Our study of the Noachian period has advanced and it's telling us a lot about the origin of Mars and therefore of the Earth as well. The Tharsis Trail has been cleared from Pisces northward to Olympus Mons and our people will reach the top in a few weeks. Our new Sunwing-B is finally functioning well. Our 'PhD' mission has finished its six weeks on Phobos and is approaching Deimos. And while we don't have helium 3 to make money for us—assuming you ever make any from it!—both fossil and land sales are promising.

I'm writing you from inside our recreational dome. It's Satursol and a group of us are relaxing and watching the kids run around. The dome has fruit trees and two hundred square meters of vegetables and berries that can be stacked when we want to relax here. Now that we have fourteen greenhouses and this dome, theoretically we can raise one hundred percent of our food. It's the first time agricultural self-sufficiency has been

possible. Right now the dust storm has cut agricultural output in half, though, so we're using every kilowatt the nukes can make to compensate for the weakened sunlight.

Ethel says hello. The kids are growing very fast. Marshall's now over three years old and the other sol he said 'hey dad, Marshall has the word Mars in it!' Maybe he was just lucky to recognize the words. But his reading skills are coming along, and physically he's fine. He still hates wearing the weights and sometimes takes them out of their pockets when he wants to run around and jump a lot, but he wears them most of the time and they clearly have helped his bones to develop normally. Lizzie is now six months old and is smiling a lot, making sounds, rolling over, and doing the other things six month olds do. She seems to have a lot of allergies, which is worrisome. The next flight will bring allergy tests and medications. We have one adult here who is having severe reactions to Martian dust. I remember the runny nose I got on the moon from moon dust. It went away in three days. But this person has had a runny nose for eight months!

Got to run. Let's keep in touch. Maybe we can collaborate. Bye.

Will re-read the message, sent it, then got up to play with Marshall. He threw the ball back and forth and lamented that the Mars Commission couldn't trust someone on Mars to make all the decisions, including how to allocate terrestrial resources to provide support. It seemed unlikely that interplanetary flights would get short enough, safe enough, and frequent enough for a commander to go back and forth. Still, his prestige, seniority, and fame among the public gave him considerable clout, and his patience for tediously long and slow meetings had allowed him to arrange for most of the projects the Mars residents requested. He had managed reasonably well.

His thoughts were interrupted by an urgent string of beeps emanating from his attaché. He hurried over and opened the channel. Rosa Stroger, who was the day officer, suddenly appeared on the screen. “Will, can you come to the bridge immediately?”

“Sure; what’s wrong?”

“We’ve got an incident in orbit.”

His heart sank and he could feel adrenaline surge into his bloodstream. “How serious?”

“It isn’t serious now, but come anyway.”

“Okay. Érico’s here as well. I’ll bring him.”

“Acknowledged. Out.” Will turned to Érico, who had been listening to the conversation, like everyone else in the dome. “Let’s go.”

“What is it?” asked Ethel.

“I don’t know.”

Will and Érico jogged to the airlock and hurried through into Renfrew Hall. They ran the length of it, then turned and went through a greenhouse to the Geology Building, and from it into a tunnel leading to Habitat 1. One of the new rooms—equal to two old bedrooms in size—was a new and expanded bridge. Five large screens hung from the wall. One held the basic environmental data of the four habitats and the life science module; air pressure, composition, temperature, and humidity, giving average data and data from at least two sensor arrays in the structure that were either unusually high or unusually low. General data for the structure, such as electrical demand, was also displayed. The second screen held similar data for the two new buildings—Renfrew and Joseph—and simpler data from six greenhouses. A third screen gave the data for the

other greenhouses, the dome, and conestogas 1 and 2. The fourth screen had data for the other rangers and conestogas and reactors 1 through 4; if any of the vehicles were turned off, their sections of the screen were dimmed. Screen five carried the data on the *Olympus*, which was approaching Deimos. Screen six had the data for the *Solis*, the interplanetary transit vehicle temporarily in orbit around Deimos. Data from the other shuttles and ITVs was not displayed, but could be instantly if necessary.

Will immediately saw that screen three wasn't showing data from the greenhouses; instead there was a picture of the bottom of the *Olympus*, showing one open engine port. Extra data from the *Olympus* had been projected onto screen 4, displacing the ranger section normally found there. The engine bay port status was being broadcast, and engine 3's data was red; **bay door open** it said.

"What's wrong with the engine 3 bay door?" he asked.

"Good question," replied Rosa Stroger, calmly. She pointed at the image. "That's from the *Solis*. We can see that the sensors are correct; the door isn't closed."

Will contemplated the image. The Mars shuttles were giant capsule-shaped vehicles; the bottoms not only had the engines, but the heat shields as well. Any opening in the bottom had to close for atmospheric entry.

"At least we have the *Solis* to provide a view," said Érico. "How many times have you tried to close it?"

"Six. We've sent the commands from here and Yevgeny has been sending the command from the cockpit."

"Spacewalk?" asked Will.

“Maybe. We’re concerned about landing on the moon with an open bay door; Deimos has a lot of dust.”

“The metal landing pad is a pretty clean surface, though,” replied Will. “They could perform a spacewalk in Deimos orbit and close it.”

“Let’s not get ahead of ourselves,” said Érico, who was their expert on orbital flight. “Houston will analyze the data also. Any indication what the problem is?”

“The motors have been working real hard; they’re using a lot of power. Something is blocking the door,” replied Rosa. “We may have to perform a walk because we may need to clean the door and verify that it’s shut.”

“Phobos dust,” said Will. It had long been a concern that dust kicked up on landing would get into the mechanisms and make the bay doors hard to close. They had never had a problem before, however.

“Maybe,” said Érico. “The chance of dust doing this is regarded as fairly remote.”

“What are our options?” asked Will.

“First a spacewalk. That should work, but if it doesn’t we’d send up another shuttle to bring the crew down and land the *Olympus* on autopilot.”

“No one has ever tried landing via engines alone before,” said Érico. “The *Olympus* could refuel on Deimos, use very gentle aerobraking to bring it into a circular low Mars orbit, then fire its engines and burn off about 8,000 kilometers per hour. At that point, it would enter the atmosphere fast, but not fast enough to generate significant heating.”

“And we’d need a delta vee of 4,000 kilometers per hour to land,” added Will.

“Yes; aerobraking would be minimized.”

"I'm glad that's possible; it would get the equipment back here, at least."

"Probably. Since it hasn't been tried, there are a lot of unknowns."

Will nodded, contemplating the situation. He approached the main console and the open microphone. "Hello *Olympus*, this is Commander Elliott; do you acknowledge?"

"Roger, we acknowledge," replied Yevgeny. "We heard some of your conversation. It confirmed the scenarios already rolling around in our heads."

"We've got plenty of options," confirmed Will. "We have four shuttles and a much more forgiving environment than low earth orbit. What do you guys think? It'll be a few hours before we get analysis from Houston."

"We'd like to dock to the *Solis* and get the complex spun up so we have some gravity. Alternately, we'd like to land on Deimos and get started with the primary mission. But both options can wait."

"Good. Sit tight. We're doing our analysis down here, and we know Houston will devote a big, high-powered team to this problem. Let's wait and see what appears to be the best course of action. We want to get you guys home safely, and hopefully the *Olympus* as well."

"We'll get her home too," promised Yevgeny.

It was a long wait. NASA—who was in charge during emergencies of this sort—assigned a team to study the problem, and they analyzed the data meticulously. Almost twenty-four hours passed before they made a recommendation. Meanwhile, the *Olympus*, tired of waiting, docked to the *Solis* and a slow rotation was set up to create a tenth of a gee, enough to use toilets, sinks, and showers conveniently, and possibly enough to

dislodge the obstacle (though it did not). The docking to the ITV also gave the crew an emergency evacuation route, though none was thought to be needed.

While everyone waited, Will continued with his usual work. At one point Martha Vickers showed up with Jennie and Kevin Dunbar. They came into Will's office and closed the door. The Dunbars looked very uncomfortable.

"I need a new accommodation," Kevin said. "Jennie and I are separating."

"Oh," replied Will, surprised, but not wanting to look judgmental. "Alright. Let me think about what we have available."

"There's a good room on the top level of Habitat 4," Kevin continued. "I've thought about the various possibilities, and I think I prefer a room with a window. It's empty right now."

"Top level of Habitat 4; there's a lot of space there," agreed Will. He pulled up the space inventory for the habitat on his attaché, then zeroed in on the top floor. "Here; room 4?"

"Okay." Kevin sounded resigned to it.

Will looked at Martha. "Is there anything else I need to know?"

"They are trying to resolve their differences," she replied. "I'm impressed by the efforts both Kevin and Jennie are making. The change of environment, the closeness of the quarters here, the different social situation, and the loss of family supports together have destabilized their relationship. They're hoping that a trial separation will help."

"So do I. I've been divorced and I know how difficult it can be. If I can be of any help or support, please let me know."

“Thank you Commander,” replied Jennie, with a forced smile. Kevin nodded as well.

They headed for the door; there was nothing else to say. Will turned to his attaché and assigned the room to Kevin. A few minutes later Alexandra came by his office adjoining the bridge to confer with him about construction. “Hasn’t this new space worked out well?” she asked, looking around the Habitat.

“Yes, it has,” Will agreed. “The enlarged bridge is just the right size for the additional screens and people we occasionally have to squeeze in, and my new office is perfect. I like the door giving me direct access to the bridge.”

“That’s what you need. We’ve finished testing the new metal production and fabrication unit. It’s remarkably flexible: the unit can mix metal carbonyl liquids in whatever proportions requested, reduces the mix to a solid metal alloy—usually as a sheet, but we can produce beams and a dozen other basic shapes—then the unit hot- or cold-rolls the product to give it greater strength and cuts it into any shape you want up to 2.5 meters by 4.5 meters. The software allows it to work all night untended, except for some monitoring from the bridge.”

“I’ve heard that it’s a real breakthrough,” agreed Will. “The robotic welders are working well, too, I understand.”

“Yes. We now need something new to do with the equipment, though, Will. I’d like to remodel Habitat 2 or 3. As you may have heard, everyone living here is pleased with the new design.”

“I have heard that; I’ve even talked to them myself. You’ve convinced me that it works and I congratulate you. But I’d like to see a design for a brand new building at some point, even if we don’t have to build it in the next year.”

“It’s premature. We’ve still got machinery to test, and to do that I need to use the products to remodel some spaces.”

“But surely there is *some* planning that’s necessary? There have been constant complaints over the last six years that the construction department needed a larger workspace. A new building could have a large basement area for construction.”

“But we have access to the garage and that works well. The vehicles don’t take more than a sol or two per week for maintenance. We should be able to expand our rolling equipment, using products made by it, until we can make pieces up to five meters by ten; that’s the maximum dimension the airlock will let us take out of the space.”

“Okay, work on that. Are you sure we won’t need housing for Columbus 5?”

“Not if we remodel our existing space.”

“Alright. Make plans to remodel Habitat 3, then 2. Talk to the physicians; they need more space for the sick bay.”

“I already have, and I’m planning on it.”

“Good.”

“Will, we’ve got the recommendation from mission control!” exclaimed Érico from the bridge next door.

“Oh, thanks.” Will turned back to Alexandra. “I’d better go. We need to talk more about this, though.”

“I agree! You and I have different approaches. Let’s talk them through.”

“Definitely. After this crisis is over, though. Bye.” Will showed Alexandra out, then walked into the bridge.

Érico was not impressed by NASA’s plan. “A landing on Deimos and a spacewalk to inspect and repair the problem. That’s what all of us would have recommended an hour after the problem developed!”

“Now we have the satisfaction of knowing we would have been right,” replied Will. He turned to the videoscreen where Yevgeny and his two companions could be seen. “You guys ready?”

“Sure,” replied Yevgeny. “We’ll despin and undock in half an hour and land an hour later. We’ll have the problem fixed two hours after that.”

His prediction proved fairly accurate. It took about half an hour to close up the hatches, stop the rotation of the *Olympus* and the *Solis*, and separate the vehicles. Landing took ninety minutes—they used very gentle bursts from the shuttle’s verniers to avoid stirring up dust—but the crew used the time to suit up for the extravehicular activity. An earlier crew had spread a sheet of aluminized mylar over the surface of Deimos and anchored it with several dozen stakes pushed into the moon’s fluffy regolith, providing shuttles with a landing pad that was easy to see, smooth, and dust-free. They landed on it without incident.

Yevgeny and the others put on special backpacks equipped with maneuvering jets to move them above the surface easily and headed out. It would be much easier to inspect the vehicles when there was a surface underneath them against which they could push. Even a tiny bit of gravity guaranteed that nothing could drift away. In fifteen minutes they approached the stuck engine bay door underneath the *Olympus.*

“My God!” exclaimed Yevgeny immediately, as he inspected the partially open door. “I can see a small piece of plastic stuck in the motor! That’s the culprit!”

“Plastic?” asked Will, surprised, from the Outpost.

“Yes; plastic! Like a cellophane wrapper or a plastic bag.”

“It’s a plastic bag for storing sandwiches!” exclaimed Andries Underwood a minute later. “You know, the ‘resealable’ kind!”

“You’re kidding!” replied Rosa.

“No; that’s what it is,” confirmed Jacques Deschanel. He was carrying the camera and maneuvered in close so they could watch Yevgeny’s effort to extricate it from the motor. It took time, but finally the plastic came free. They applauded.

“Someone’s head will roll on Earth,” said Érico. “Maybe there are crumbs inside with a bit of DNA on them!”

“There are crumbs, and maybe a bit of ham,” said Yevgeny.

“Ham?” exclaimed Rosa.

“I’m kidding about that part,” replied Érico.

“Bring it inside so it can be analyzed,” advise Will. “Does the door close now?”

“We’ll try; stand back,” replied Rosa. The astronauts backed away from the door and she pushed a button. They watched the door slowly slide into place, leaving only a faint circular crack to reveal its location.

“The door has locked tight,” reported Rosa.

“Fantastic!” exclaimed Yevgeny. “Because we have some exploring of Deimos to do. I don’t want to be stopped by a sandwich bag!”

8

Flag Raising

late April, 2043

Will poured over the email from Ginger Petropoulos, the Mars Commission's director of land sales, with great care and interest. In the last week he had emailed all the directors of various departments of the Commission, asking friendly but specific questions about their operations, and all had replied. Because Morgan and he met with all of them monthly, they all knew him, and he had managed to befriend them almost all of them in spite of the frustrating time delay. Furthermore, Morgan had cultivated a culture of openness.

As was his custom, Will scribbled notes on his attaché as he read, then quickly numbered the points he wanted to cover, which caused them spontaneously to reorder themselves on the screen. Ready, he activated a videomail and dictated a reply, which was faster and more efficient than a written message.

"Thanks, Ginger, for the report. By the way, even if it is 2 a.m. here, I'll be up at least another hour, so feel free to call back if you want to add any comments. I know this is a good time to call Houston, so I'm up for that reason.

"I'm encouraged by the land sales. Imagine, 25,000 people were willing to shell out an average of a thousand bucks each to buy a chunk of Mars! We've sold an area the size of Connecticut, including fifty kilometers of Aurorae's escarpment edge! Roger Anderson thinks we can get better quality video of the escarpment lots, so I suggest you submit a request that we re-shoot it. We can run the sunwing right along the rim and only fifty meters above the surface, so the edge appears in the picture.

"As for corporate sales, I talked to Andries Underwood yestersol, who is our remote sensing expert here. He will propose several sunwing flights over Tithonium Vallis to verify the exact dimensions of several igneous layered complexes. One of them has chromium ores, which is essential for making some kinds of stainless steel. There's also a second area with probable gold deposits. Next month I'll be heading up the canyon with two rangers to check out three mineralized zones, and we'll schedule some photo opportunities so that your people can make sales videos. I'm thrilled to hear that Muller Mining AG is interested in investing here. A one hundred million dollar sale of mineral rights would be good for us and eventually the company would recoup its investment, though I suppose it'll take at least twenty years! It sound like Muller is more concerned with supporting the exploration of Mars anyway. Give me his contact information if you want, and I'll send him a message of appreciation.

"So it sounds like we can raise $125 million in land sales! I can't believe it. That'll almost support a full-time position for mineral extraction and export, which means the position can pay for itself and justify the investments. Let me know what else I can do to help. Bye."

Will sent the message, copied Morgan, and turned to the next issue: recruiting nations to send people to Mars. Morgan himself handled that matter but copied Will on everything. He read the latest report about recruitment efforts, organized a quick outline, and sent a videomail to the boss. "Doug, I'm very excited about the response your team has received for Columbus 6. Thank God the Swift Shuttle and tourism to low earth orbit has lowered launch costs so much, though it also lowers our revenue from selling argon and Phobosian methane. At two hundred fifty million bucks per passenger, there are a lot

of countries that can afford to send one astronaut, and a fair number who should be cajoled into sending two! We might have trouble figuring out how to use them all here! If you need any of the Spanish-speaking astronauts up here to talk to Argentina, you can be sure it'll be done in twenty-four hours. Érico has asked whether he can contact some friends in Portugal and you can count on his help.

"I'll be happy to call the Turkish, Moroccan, and Pakistani Ministers for Space Exploration. I'm surprised Pakistan hasn't been clamoring to send someone, since the Indians are well represented on Mars. I'm even willing to call Iran; they have some pretty capable scientists. They may still be anathema to NASA, but it seems to me they can't be to the Mars Commission. If you want me to call someone, send the talking points, I'll flesh them out and send them back, you can look them over and comment, then I'll make the call.

"With the increased Russian commitment and the steady American and European commitments, we'll have more than eighteen for Columbus 6. Doug, can we increase the mission to thirty? The Commission could fly six ITVs with five on board each, plus two shuttles. They can fly as two complexes and dock together periodically. We're talking about a billion and a half for the additional equipment and transport costs, but twelve more people. Ground support costs will increase only modestly. The shuttles can handle the additional flights. So the expansion can pay for itself at $250 million per berth. We may find ourselves at a point pretty soon when countries will rush to send someone because it's cheaper, and the rush will make it even cheaper and make the rush bigger.

"Anyway, let me know if you want me to make any calls. Bye."

He sent the message and paused to wonder whether Morgan would listen to either the plea for expansion or the offer to assist. Then he turned to message number three: Pavel Rudenkov's final plans for their next building. The construction coordinator for Columbus 3 had spent six months on the moon overseeing construction of its first building made largely of local materials, then had returned to Moscow to become the terrestrial coordinator of construction on both Mars and the moon. His experience on both worlds made him extremely effective. Will reviewed the sophisticated new design: a three-story building to enclose a courtyard already partially surrounded by the Renfrew and Joseph buildings, which were at right angles to each other, twenty and thirty meters long each. The new building—tentatively named Lassen after the NASA director of the Columbus Program, recently retired—would be semicircular, allowing a dome to be erected over the courtyard. Renfrew and Joseph would have to undergo minor modifications to support the circular edge of the dome.

Alexandra Lescov, however, had been actively resisting the design, much to Will's chagrin. He wondered whether Rudenkov could help. "Pavel, I'm pleased with the design," he began. "It's a pretty big building; I'm concerned that we won't know what to do with 3,000 square meters of pressurized floor space. At our current habitation levels it would accommodate sixty or seventy people. On the other hand, if we can pull this off, we'll have the ability to enclose just about all the space we'll ever need, and we won't have to import housing from Earth ever again. So I'm in favor. But I'm sure Alexandra is opposed; she favors remodeling our existing space to accommodate Columbus 5, then slowly and systematically reviewing our plans in order to improve them. I admit, her remodeling of the habitats has been successful, and her mechanization of the manufacture

of housing materials has been remarkable. I just wish she'd make up her mind about the next phase. Can you talk to her? I'd like to get the Lassen Building moving. Time's passing; Columbus 5 arrives in fifteen months. Let me know the result. Bye."

Will sent the message and turned to a videomail from Louisa Turner. But as he was about to read it, he heard footsteps. Martha Vickers was walking by the bridge. "Why are you up?" she asked.

"Someone has to be in the bridge at all times, and late at night is the best time for me to get my videomails done when our clocks are out of synch with Houston."

"But you don't make up for the lost sleep, Will. You work too many hours."

Will shrugged. "We all work a lot of hours."

"And some work more than others. You just gave a very popular speech a few weeks ago called 'Living Well on Mars'; remember it? Hours like this are not 'living well.'"

"Then what are you doing up?"

"I just had to meet with someone who has insomnia. It's a persistent problem; I think it relates to the longer day-night cycle."

Will suspected he knew who Martha was referring to, but he did not want to violate the psychiatrist-patient privilege. "Several people on Columbus 3 had a difficult adjustment. I think I had trouble; I didn't sleep really well until almost a year after leaving Earth."

"That's possible." Martha sighed. "We've got several problems of this sort right now. I'm counseling one couple about pregnancy—one spouse in favor and one

against—and trying to hold together the marriage in another case. Several other people are homesick or just want to have a companion."

"Have you tried matchmaking?"

Martha hesitated. "I've considered it, but it's questionable professionally. On the other hand, this is a small place."

"We need to learn how to be each other's keepers when we're the only humans in tens of millions of kilometers."

"Back to 'living well on Mars.' Was the phrase your idea, Turner's, or someone else's?"

"Frankly, I'm not sure any more. I think the phrasing was mine, but the idea was Turner's."

"If you think that, you've obviously forgotten that 'living well on Mars' has been a theme of yours for the last four years." Vickers looked at him. "I think we need to take the concept more seriously in very practical ways. Why not get the entire crew together for a sol, or half a sol, and talk about the quality of life here, with the goal of improving it? We're in good enough shape that the meeting won't degenerate into a gripe session."

"Hum. . . " Will thought about it. "You know, that would be a good idea. We still have time to make changes in both the cargo and passenger manifests, so the meeting could have an impact in about a year."

"I could call a few psychology friends and ask them to give us some canned video talks—maybe ten or fifteen minutes in length—about living well. We could ask questions of them, then have a discussion about life here and how to improve it. We might be happier as a result, and it would reinforce the theme of your public relations campaign."

Will nodded. “It’s a win-win idea. Can you summarize it in an email? I’ll route it to Morgan. I keep him in the loop on everything.”

“Okay, I’ll take care of it first thing in the morning. Good night.”

“Good night.”

Martha started to go, but then stepped back. “And Will; get a good night’s sleep.”

He smiled. “Okay. Érico will be here at 3 a.m. to relieve me. After the kids go to daycare, I’ll take a nap.”

“Good!”

Will barely heeded Martha’s advice; messages and responsibilities allowed only an extra hour of rest. Lisa Kok needed his advice about the microflora in the soil of Greenhouses 6 and 8; some microorganisms were out of balance and their population explosion was leaking excessive quantities of nitrogen oxides into the air. Will recommended a few approaches, which satisfied Lisa. The outpost’s sixteen ecologies and six buildings required the full-time attention of four people.

Will spent the first two hours of the afternoon washing the floors in habitats 2 and 3 because no one else had done so. He had just finished and returned to his office when Alexandra Lescov stopped by.

“Will, I really don’t appreciate it when you ask Pavel Rudenkov to speak to me about something you want to talk to me about,” she said, anger rising in her voice.

“Alexandra, we need to talk about construction. I’m trying to talk Morgan into planning a larger Columbus 6; one with six ITVs and thirty people on board.

Construction here is essential for that to work. Otherwise we have to import 150 tonnes of stuff for those new arrivals, and that's too much."

"So is the plan to build the Lassen Building. It'll take ten persons over a year to build half the building and ten more another year to build the other half. That's an incredible commitment of time. Basically, the time the new arrivals would give us for a year will be completely consumed. You're talking about moving twenty thousand tonnes of reg with our existing construction equipment, which could exhaust their design lifetimes. You're talking about importing ten tonnes of building materials."

Will shrugged. "You haven't offered a better plan. We're growing by ten to fifteen persons in fifteen months, and maybe by thirty more two years after that. This place may have to more than double in size in three years."

"Will, I do have a plan; almost. My team has been talking to various companies on Earth, exploring options. I need a bit more time."

"A bit more is all you can have; celestial mechanics cannot be delayed. We have to finalize the cargo manifest in a month, maybe six weeks at most."

"Okay, give me three weeks I'll have a plan you'll be fascinated by. I promise."

"Fine; three weeks it is," agreed Will.

"Thanks." Alexandra turned and headed back to work.

Will turned back to his work as well, but not for long; he had to get to the great room in Renfrew early that evening. Everyone else had done the same. The crowd ate quickly because, a quarter of the planet to the west, Roger Anderson was leading an expedition of two rangers and a conestoga to the top of Olympus Mons. It had been a long, tough voyage over thousands of kilometers of rough lava flows, steering around

great fissures in the ground, surmounting Olympus's outer escarpments, and making dozens of field trips to impact craters, cinder cones, and flank eruption sites, all the time watching the atmosphere thin around them. The Martian volcanoes stuck up above nine tenths of Mars's blanket of air; they practically poked up into space.

The scene from the cameras mounted on the front of the leading ranger, and later from the helmets of the geologists, was spectacular. "My goodness, it looks like the moon!" exclaimed Jennie Dunbar when the broadcast was projected onto the great room's main screen.

"How would you know?" asked Kevin.

She scowled at his criticism; she had not visited the moon. "And you're a moon expert, nuke man?" she replied.

"You're right, that stretch in particular did look lunar," Will replied. "I think it was a cinder deposit, which can look like lunar regolith. It even had a lot of little craters."

"Though they may be phreatic," said Érico. "Phreatic means the lava erupted up through a wet layer and carried a lot of steam with it, making lots of explosions and craters. In this case, the lava probably erupted through a glacier."

"There's a glacier underneath?" asked Jennie.

Érico nodded. "There may be. Olympus Mons has often been covered by an ice cap in the past. It also gets blasted by meteoroids down to the size of large sand grains because the air's too thin to burn them up."

"The other thing that's lunar-like is the grayness," added Will. "There's a thin skim of very fine dust particles, but the rock is mostly unweathered and gray, like the moon."

Érico pointed to data at the bottom of the screen. “Right now they’re walking in a 110-kilometer per hour wind, and I bet they can’t feel it at all! The air’s too thin.”

The last kilometer—to the top of a peak along the edge of the central caldera—had to be reached on foot. The six astronauts struggled up the slope in their pressure suits, carrying the equipment they needed, chatting and joking in spite of their rapid breathing. The great room was silent and even the small children sensed the importance of what was happening.

“Come on, Lal,” Roger urged, as he approached the summit. He paused to let Lal Shankaraman catch up to him, and the two of them waited for the other four. Then the six of them stepped up the last few meters where the cinder cone flattened out on top.

“We made it!” exclaimed Jacques.

“We did,” agreed Roger. “Lal, the flag.”

“Just a sec.” Lal pulled the pieces of flagpole from his backpack and assembled them together, then mounted a United Nations flag on top. Will was startled to see which flag was going up on the top of the mountain. The American flag had been the one erected when they first landed on Mars. The other flags followed.

“Roger’s going to let him set up that flag?” asked Érico. “He’s gone soft!” He was even more surprised when he saw Roger take the U.N. flag without any comment or hesitation.

Roger wiggled the bottom of the flagpole into the cinders. Slowly and deliberately he raised the pole. “The six of us have come to the top of the solar system’s highest mountain as representatives of all of humanity,” he said. “We come here in peace and in

collaboration as brothers and sisters. Our expedition is devoted to show the way to human unity and solidarity all across Earth, and we dedicate this trip to it."

"Did Roger tell you he was setting up the U.N. flag?" asked Martha.

Will shook his head. "This will cause a stir in Houston."

The six astronauts move into a line facing the flag and they saluted it together. Then Lal started singing.

This land is your land, this land is my land,

From the Hellas Basin, to the cratered highland,

From Tharsis Montes to the Mariner valleys,

This land was made for you and me.

And then Lal added a second stanza:

As we were ranging across his deserts

Along his channels, o'er gleaming ice caps,

We fell in love with his ruddy vistas

This land was made for you and me

He had gotten only part way through the first verse when the other five astronauts joined in. Will felt a swell of pride as he watched. Then Érico began to sing the song as well, and everyone in the Great Room joined in. The astronauts on Olympus Mons heard them singing in the background and hesitated a moment, but then sang the song again. The entire Great Room joined them.

When they finished, everyone looked at each other, smiling, almost embarrassed. "I didn't realize we felt this way," Will said. He leaned close to the microphone near him.

“Greetings, Olympus Mons expedition from Aurorae Outpost. Congratulations, folks, you’ve accomplished quite a milestone.”

“Thank you,” replied Roger. “You should see the view! Here!” He walked toward the edge of the cinder cone and turned his helmet camera. Suddenly an immeasurable immensity opened up before their eyes. The mountain’s crater-pocked central caldera was over a hundred kilometers in diameter; the planet’s curvature could be clearly seen on the far side. The floor, six kilometers below them, had wispy streaks of dust crossing crevices, huge lava flows, and impact craters.

“Amazing,” exclaimed Ethel.

The expedition spent the rest of the sol on the edge of the caldera, the beginning of a four-sol exploration around the rim. The next morning another Olympus, the shuttle *Olympus,* having completed three weeks at Deimos, prepared to return to the Outpost. The door of engine bay number three had been closed tight and tested several different ways, including manually. Nevertheless, everyone worried about it. The *Olympus* fired engines one and two in order to head down; it left engine three closed up and silent. Tensions mounted as the shuttle approached the atmosphere. But engine 3’s bay door remained closed tightly through entry and opened on queue when the shuttle’s engines had to fire during the last minute of the flight. Shuttles can land on two of their three engines, so there was no danger. The *Olympus* made a perfect landing on pad 7. An hour later the crew of four entered the Outpost to the applause of everyone present.

“We’re all proud of you,” Will said a few minutes later to the crowd gathered in the great room. “This is the first time a space flight has taken off from a place other than

Earth, gone to another world, and returned to its departure point. And you went not to one other world, but two! In spite of complications, the mission was a great success. The amount of time humans have been on Phobos was almost doubled; the amount of time on Deimos was more than doubled. The water and fuel production capacities of both moons have been boosted and made more efficient. Both moons have now been thoroughly explored and several mysteries have been at least partially explained. The ground is prepared for erecting temporary shelters on both. Finally, fifteen tonnes of fossiliferous rock and gold are on board the *Ausonia* and are on their way to Embarcadero. We owe Yevgeny and his team a debt of gratitude." Will raised his hands and began to applaud. The others followed his lead.

Yevgeny stepped forward. "Thank you. All I can say is that we hope to go again. The Mars shuttles have gradually proved their capabilities; we know they can go to the moons and return safely. I hope the moons will now be visited three times per columbiad; once when a mission arrives from Earth, once when a mission returns to Earth, and at least once in between. If we raised the number of trips from three to five, there would be a flight every five months and we could permanently staff the moons. Maybe as the Mars facility continues to expand, that will be possible. As an interim step, let's at least extend the length of the next visit to four or five weeks per moon. If we can stop at an ITV to have access to gravity for a week or two in between, we should be fine." He turned to Elliott. "Thank you, Commander, for arguing successfully for this mission. I know you had to back down when it was planned for Columbus 3."

Will nodded. "That's true, but we now have more reliable shuttles and better support and rescue capacity. One issue we will have to resolve is whether a crew is

needed full time on the moons. Right now such a crew would have little to do. Perhaps four month-long visits could be justified. And there's a quality of life issue; even if Columbus 5 delivers crew modules to each moon, they won't be pleasant places to stay.

"And that brings me to an announcement. Martha Vickers and I have been talking to several experts in the Commission about quality of life issues here. In the last few months, as you all know, we have been selling Mars as a place with a high quality of life, at least from a social point of view. It occurs to us that if we plan to take the quality of life here seriously, we need to talk about it systematically. So I'm calling a one-sol conference for mid May, when all of us can get together. The Tharsis Trail crew is scheduled to be back here by then. The Pisces Trail crew will attend by video. We'll hear from some experts, then we'll brainstorm about ways life can be improved here. We have to ensure that life on Mars is reasonably comfortable and successful for those who stay long term. Furthermore, we are a large, growing, international team. With all the unrest and instability on Earth recently, we owe it to our nations to serve as a role model for peaceful, multicultural collaboration."

Will's announcement was greeted with some surprise but no comments. He was surprised no one asked a question, but since no one spoke, Will pointed to the buffet table and stepped down. Everyone headed for the food.

"Quality of life, huh?" Andries asked him over dinner. "Do we know what that means?"

"I'm not sure," replied Will. "The experts can advise us. The exact theme will probably be 'living well.'"

“Living well?” asked Roger. “I’d define that rather religiously. To live well is to accept Jesus Christ as one’s savior and live to serve Him. That can be done here on Mars as much as on Earth.”

“If nothing else, we can exchange our visions of living well,” replied Will. “It will be hard to promulgate a definition of the good life that everyone will accept.”

“Impossible,” exclaimed Roger.

“I have a simple and practical concern,” added Enrique Delrio. “Here at the Outpost, the good life is defined as getting married and starting a family. I’ll probably stay, but I have no plans to get married.”

“That’s very true,” agreed Kevin Dunbar, who was still separated from Jennie.

“That’s another topic to talk about,” agreed Will. “And it isn’t clear to me that a simple resolution is possible.” He glanced at his watch. “You must excuse me; I have an urgent matter to deal with.” Will pushed back his chair, glanced at his watch, and looked at Ethel. She nodded; she knew he had to go. The reactions against the raising of the U.N. flag had been growing and he was scheduled to discuss them with Morgan.

Will listened to his attaché reading emails to him via his earpiece while walking to his office. Douglas Morgan’s first message asked for ideas and cautioned him not to act without discussing things with him first. Louisa Turner’s promised dozens of ideas for him based on brainstorming in her office. “These criticisms are an opportunity,” she said in summary. “We need to stress the international nature of Mars exploration, that Mars is a laboratory for international cooperation and living, and a place to create an international culture that can help everyone on Earth to live together peacefully. The articles and

interviews I've proposed in the attachment will do that. The talking points follow from the main points; take a look."

Will wondered about that. He sat at his desk and watched Morgan's latest videomail. "Increasingly, this looks like a tempest in a teapot," he said. "I've called some friends in Washington. The flag raising has been a lightning rod for a small group of ultra-conservatives. The only Senator who has complained is Longstreet; I think you know his politics. The websites and magazines with negative editorials have been the very conservative ones as well. I'll attach examples. It's an effort to grab attention. If we react, the controversy will grow, not shrink. I know your crew on Mars feels insulted by the arrogance of the American nationalism and patriotism that has been expressed. The U.S. is paying for half of the Mars project and only gets about a third of the slots. But a response that emphasizes the international character of Mars will jeopardize U.S. funding. Our advice is bite your tongue. And definitely don't raise the U.N. flag over the Outpost. I gather someone suggested it. That could cause a very serious problem."

Will hadn't heard that idea, though it had occurred to him. He thought about Morgan's position, which was based on Washington inside talk, and Turner's approach, which was inevitably tinged by the utopianism of the Mars Exploration Society. He looked at the articles Morgan had sent. They were fairly conservative and all were American. Louisa's approach was the opposite.

He began to scribble points, arranging them, ordering them, clarifying them as he went. The time delay provided a real advantage. The video message he recorded was for Morgan, but he blind copied Turner.

“Doug, thanks for the information from your Washington insiders. I just skimmed the articles you sent me, and earlier I looked at video clips various persons sent me. I agree, the reaction against the flag raising has all been from right-wing America-first groups. The mainstream media has not picked up on it much. If we react, we may make the issue much more significant. Right now, news is quiet on Earth, so there will be even more attention if we say anything.

“So I agree with you; this is not the time for us to react to the criticism. Instead, I propose that we changed the subject. The time has come to plan the ‘Living Well’ conference. That conference will concretely assist all of us on Mars to live better and will help us relate to the majority of people on Earth. And inevitably, the international character of the place will be an undercurrent.

“If a need to respond develops—and it might if this controversy expands—I suggest we ask Roger Anderson to handle it. He raised the U.N. flag on Olympus Mons, he’s a Republican, and a political conservative. He has a lot of friends in Washington. And I can talk to him about what he might say.

“Inevitably people will ask me about the matter, but I can change the subject and talk about the conference instead. The conference has the ability to energize our supporters, too, because of its utopian nature. What do you think? Bye.”

Will sent the video message, satisfied that he had possibly cut a Gordian knot. Will turned to his other messages while he awaited responses. David Alaoui wrote him from Paris with the latest news about the Venus Orbital Station, which the French had scheduled for launch next year. Sebastian Langlais had updated him about the Helium 3 extraction project; it was working surprisingly well. He received a series of questions

from his fan mail response center to answer; he tackled a few. Then responses arrived from Earth.

"I'm surprised, Will, but I see the wisdom," said Turner. "I know a lot of people here want to confront the excessive nationalism the controversy represents, and I suspect there are quite a few people up there who feel the same. But your instinct is right: we need to focus on a positive message that keeps our priorities on top. The conference is the way to do that. I'm surprised I didn't think of that. I'll draft some transitions that will take attention from the flag to the conference. Bye."

He immediately hit reply. "Thanks for your help, Louisa. If I have any p.r. instincts at all, it's because of your advice for the last six months! This incident makes me wonder whether we might be able to develop a series of themes and try to stay on-message all the time. Maybe Mars is important enough to keep itself in the limelight without accidents or incidents. We may want to move the conference up a bit so as to keep up the momentum. If we did that, could you design a plan we could use over four to six weeks, with follow-up afterward? Bye."

Morgan had responded as well. "Will, I am delighted. Yes, the conference is the way to go; it'll focus the media on something positive and take the wind out of the sails of our critics in Washington. I really appreciate your thinking on this issue. I agree that Roger should comment briefly if the controversy continues, but I don't think it will. This may work out quite well for us. Bye."

9

Living Well

early June 2043

It took six weeks for the Tharsis expedition to return to the Outpost. The three vehicles drove off Olympus Mons, then traveled three hundred kilometers eastward on a section of the Virgo Trail to the Tharsis Trail, which they extended two thousand kilometers to Ceraunius Tholus and Uranius Patera. In the future the trail would be extended to Alba Patera, then the northern polar terrains.

The expedition returned to the Outpost three sols before the Living Well Conference. It convened in Renfrew's Great Room and even the children were included; they played in the back. The Pisces expedition, which had traveled three quarters of the way around Mars's southern hemisphere, rose at 3 a.m. local time and gathered in their conestoga to participate.

Once the Pisces crew was projected onto one screen in the front of the hall, Will rose. "We've got ten minutes before our first speaker, so let me review. Ground support folks are joining us in Houston, Seville, and Moscow; the right screen will carry an image from Houston unless there's a question from one of the other places. Our panel of speakers, who are also in Houston, will be projected onto the middle screen. Ask questions by email any time; the panel will answer them after they speak.

"The panel and questions will last three hours. After lunch here—breakfast for the Pisces crew—we'll brainstorm about the implications; as will the three groups on Earth. Then we'll exchange reports and I'll provide a wrap up."

"Will any of this conference will be released to the press?" asked Érico.

"There will be six press reps in Houston. Anything they hear they can use as background or quote anonymously, but don't worry; they're experienced and fair. The presentations by the panelists will be carried live on the Commission's website, as will my comments at the end; I'm the one who has to produce the right sound bites. Our ninety minutes of brainstorming this afternoon will be strictly confidential; nothing will leave Mars, except in the form of the report Érico will make."

"What about background?" asked Roger. "My team and I have been out of touch for four months, and I assume that's true of the Pisces expedition as well."

Will frowned. "What sort of background?"

"How many are leaving in October, is the Columbus 5 team unchangeable, is Columbus 5's cargo changeable. . . I have no idea whether it makes sense to ask for, for example, a hair dresser, or for them to import a bunch of golf clubs. Both could be quality of life issues. They aren't my issues, but they might be someone's."

Will nodded. "I understand. We've got thirty-three adults and four children here right now, with two more children on the way; the Strogers and Lisa Kok and Karol Havlicek are expecting—"

"Really? I didn't know about Lisa and Karol. Congratulations," said Roger.

"I was tempted to say Madhu was expecting, but I knew you wouldn't believe me," added Will, and everyone laughed. "Four are leaving on Columbus 4: Olaf Norlander, Francisco Almeida, Koyo Takenaka, Sridhar Pradhan."

"That's all?" exclaimed Roger. "I thought Seiji, Eammon, and Irina were leaving."

"You *are* out of date," replied Seiji. "Michiko and I are getting married."

"So are Eammon and I," added Irina.

Everyone laughed and Roger shrugged. "Congratulations to you all, and welcome to the marriage club."

Several laughed at that comment. Will glanced at the Dunbars; it was the sort of comment that could make them feel uncomfortable. "We'll have twenty-nine adults between missions," Will continued. "Columbus 5 is bringing eighteen, but only sixteen are signed up, so there is still some wiggle room if we want someone to do our hair and nails." People chuckled. "So Mars will have forty-seven adults about a year from now. As for cargo, Columbus 5's four ITVs and two shuttles will be able to aerobrake forty-five tonnes. Its two automated cargo vehicles will arrive later with twenty-four tonnes each. So we will receive ninety-three tonnes of supplies. There's still about ten tonnes of wiggle room in the cargo manifests."

"So much more," commented Roger.

"The transportation system has matured and costs have dropped to a tenth, thanks to the Swift shuttles, Martian argon for the ion tugs, and Martian methane for trans-Mars injection. The Mars shuttles will have to make two trips each to bring everything down. We won't devote six to eight weeks to bringing down the cargo and setting everything up; instead, we'll bring it down gradually, make more science trips to the moons, and haul more cargo up."

"Will Columbus 5 fly here using nuclear engines?" asked Lal.

Will glanced at the video controls; there was a light indicating the transmission from Earth was arriving and was being recorded. "This background session is getting longer than planned and our program is now arriving from Houston. Some of the methane

we flew to Earth will be traded for hydrogen to fuel the solid core nuclear engines that Columbus 5 will use. The two nukes will return to Earth orbit immediately after trans-Mars injection. Now let's turn to our panel discussion." Will turned and nodded to Enrique, who was running the show.

Will was nervous about how Louisa Turner would do. It had been difficult to persuade Morgan to permit her to be the mistress of ceremonies. He was also nervous about what the panelists would say. But both fears quickly dissipated. The Mars audience watched with deep interest. The first speaker, a psychiatrist named Mel Feinstein, spoke about the deep psychic needs of human beings, especially in the adult stage of life; he quoted Freud's *lieben und arbeiten,* "to love and to work," several times as epitomizing adult expression. He was followed by Father John Perry, a Catholic theologian, who talked about love, compassion, sharing, serving others, tenderness, and justice as powerful spiritual needs and gifts of human beings. Finally, Dr. Laurel Stanwood, a Yale anthropologist and historian, spoke about the quest for justice in societies, the need for common values to build a common society and culture, and the social dimension of human experience.

Throughout the presentations, the Mars audience emailed questions or walked to a video camera in the corner to send a video question. When Turner began the question and answer session, it seemed that she favored questions from Mars; or perhaps the thirty-three of them asked more questions than the others. For almost an hour the discussion continued before Turner provided a gracious wrap-up.

The kitchen crew pulled out sandwiches and salad, which had been prepared that morning, and everyone got their food. “So, Will, we’re not supposed to talk about this program for an hour?” asked Roger. “I say, brainstorm while we eat.”

“You don’t want a chance to digest the presentations?”

“No,” replied Roger, and many people nodded. The room fell silent, except for the sound of chewing.

“Okay,” said Will. “Let’s at least not hit Érico with things to write down yet. What did everything think of the presentations?”

“Superb,” replied Madhu.

“Fascinating; very insightful,” added Rosa.

“I suggest we do seminars like this more often,” added Gaston. “If you want to improve our quality of life, miniconferences like this really help. They give us something to think about together and apply to our common situation. They form common culture.”

“So much for a break,” replied Érico. He rose, sandwich in his left hand, and walked to the electronic board on the wall, where he began to jot down summary points.

“It gives us a new angle on our colleagues on earth, too,” added Lal. “We get to see them in a different setting, interacting with each other spontaneously. We get to build a common culture with them as well.”

“We need more cultural events here,” said Louise Tremblay, continuing the thread. “The concerts and skits Madhu have organized are really great. I wish they were a regular thing.”

“They take a lot of time,” replied Madhu. “Not only my time, but the time of the performers. Once we settled into our work schedules, they became hard to include. I have always felt that more art is essential for this place.”

“I love the Mars garden you laid out below Face Rock, Madhu,” exclaimed Charles. “Whenever I’m outside I try to walk through it. It’s amazing what beauty can be found in, and assembled from, natural Martian materials.”

“Thank you to everyone who brought back unusual wind-sculpted objects or unusually colored minerals,” she replied. “I’d like to extend the garden and do more of them, but child care takes a lot of time, and of course I have my duties.”

“But every time the Outpost gets bigger, we can rearrange duties,” noted Will. “The aesthetic dimension of this place can grow. It should grow.”

“That reminds me,” exclaimed Seiji. “Stanwood’s comments about history made me think that we really need an historian up here, and maybe a poet. All of us are very good with the technical and scientific sides of this world, but we’re lacking in the aesthetic and human sides. Maybe some of us majored in history and we need to cultivate those talents more.”

“The perspective actually can contribute to our survival here,” added Ethel. “Because we need all mindsets, all approaches to reality.”

“Of course, the irony is that as the Outpost gets larger, the amount of exploration per person actually may decrease,” replied Roger. “It raises the issue of why we’re here.”

“There are various counter arguments, though,” exclaimed Érico, who lowered his pen for a moment. “One is that Martian society has to mature gradually and that means providing more services to its residents. Another is that a larger pool of people is more

efficient and therefore has greater surplus labor to devote to additional priorities. A third is that as it gets cheaper to fly people here, the cost of exploration will continue to drop even if more people are engaged in it."

"And all of those are true," added Will. "Columbus 5 will fly eighteen people here for half the cost of flying the first six here. The first six could only devote three staff positions to exploration and science most of the time; we can field twelve out of thirty-three, and twelve more are occupied with science."

"Speaking of greater services," said Irina Lesz. "If we want to live well, we should discuss additional services us. I'd like a greater range of options for preparing hair, for example. Madhu does a good job of cutting hair, but she can't do everyone's hair forever; it's already taking her an entire Satursol morning every week. If we had someone with professional experience it could be part of that person's official duties. We might even want to let the person charge for services beyond the basic haircut."

"We'll have almost fifty people here," added Andries. "It seems to me that must be a critical mass for some services."

"But pay?" asked Érico, lowering his pen. "One of the characteristics of this place is the lack of capitalism."

"But how long can that last?" replied Roger. "Some day when we have thousands of people here, we'll have stores, all sorts of businesses, some essential work will be contracted out—like food raising—and families will eat at home instead of in the common cafeteria."

"Why should we do all of that?" replied Érico. "One of the things that makes Martian society special is its collectivist character. We eat together, draw our supplies

from a common inventory, and services are provided to all equally for free. We've achieved the pure socialism that Earth has only been able to yearn for."

"Because we're small," responded Roger. "It can't continue."

"Having everyone eat together, even the families, is special," agreed Enlai. "One gets to see family life as it occurs."

"But it has disadvantages; the kids want to eat with their friends instead of their parents," replied Ethel. "That's why we now take our food home two nights a week."

"Look, the principal factor driving our current practices is efficiency," exclaimed Will, intervening before the issue got hot. "And that will be the case in the future. When we have several hundred people here we may have to have several cafeterias, and they'll have to prepare frozen food and prepared meals for home use. Columbus 5 is bringing a robotic delivery cart able to maneuver itself through airlocks, so we'll have delivery capability in a year or so. Right now it's inefficient providing home food services because of the scale of our operation. When we have several hundred people we'll need a store, a full-time hair dresser, a lawyer, a financial advisor—it's hard getting those services from Earth—a chaplain, etc."

"I think we could use some of those services now," Lisa. "With fifty people, why shouldn't we establish a store? Right now if someone wants to have a chocolate bar every week, they have to plan it as part of their personal mass allocation. Let them buy it instead, and set the price to cover the cost of importing it. The store could also sell used items people don't want any more. It could sell items made here. too; we have several people with real talent for making furniture, objets d'art, clothing, pottery, woven things,

carved wooden objects, etc. Everyone could earn a bit of extra money making things for sale, and all of us would have a wider range of things to buy."

"I sort of agree," said Lal. "We could use a market place. It's one of the most ancient of human practices." He saw Érico hesitating. "Go on, Érico, write 'store/market place.'"

Everyone laughed, including Érico, who wrote as Lal suggested. Will started thinking about that idea. "That's doable for Columbus 5," he agreed.

"If we're going to buy and sell things, why not housing?" added Roger. "Most of us are planning to stay and raise families here. If we could buy our living spaces we'd invest money into improving them, and part of our salaries would be brought back to Mars."

Quite a few people nodded at that idea. "How many would consider buying their living quarters if we set up a system of issuing deeds and providing for resale?" asked Will. He was surprised by the number of hands that went up. "More than half of us."

"Everyone except Érico," quipped Roger. People laughed.

"That's achievable," said Will. "The thirty-three of us together are paid fifteen million dollars per year. Most of us are putting it in investments on Earth. If a third of it came back here temporarily in terms of real estate investments, it'd fund the importation of two tonnes of equipment, which could help cover the cost of improving our housing. Interesting idea."

"But could we liquidate the investment later?" asked Andries.

"I'm assuming we could sell anything we buy," replied Will.

“If we’re going to talk about improving housing, I have ideas,” said Érico. “We need more space per person. The Outpost has fifteen hundred square meters of pressurized housing and work space, other than the dome or the greenhouses, almost fifty square meters per person. That’s a lot better than the fifteen square meters per person we had when Columbus 2 arrived, but it’s still very cramped, especially when one remembers the needs of small children.”

“We’re considering our options,” replied Will, glancing at Alexandra. The two of them had still not talked about their differing approaches to construction.

“We need a lot more pressurized outdoor space,” added Ethel. “We’ll need a real playground with swings pretty soon and room for the adults to exercise and play games.”

“Thank God for the dome, though,” exclaimed Martha. “I don’t know how all of you managed without it for six years. Open space is very important to mental health.”

“I have a delicate matter to raise,” said Yevgeny. “Maybe fifty people represent the critical threshold for it, or maybe we need more like one hundred, but it sounds like we’ll have one hundred people in five years anyway. At some point we need more elements of democratic governance. I am not complaining about Will and his many leadership skills and organizing talents, just noting that every society that has ever prospered has had deliberative mechanisms.”

“Here, here,” said Roger.

“Our town meetings have largely ceased,” agreed Will. “We should hold them regularly. But maybe fifty is a threshold and we should think about electing an advisory council of some sort.”

“I’d favor that,” said Yevgeny. “The town meetings would be more effective if there were a council to develop recommendations for it to consider. As our child population expands, we’ll need to discuss education more, and we’ll have to assume some of the burden of paying for it. We might even have to tax the residents.”

“Taxes and politics; just what we need,” complained Neal. He shrugged as if to say he understood they were inevitable, however.

There was a lull in the conversation for a moment. “If there’s one change I’d recommend, it’s less work over all,” exclaimed Madhu, changing the subject. “We’re working fifty-five hours a week. It makes family life difficult.”

“On the other hand, we don’t have cooking, cleaning, and other house work,” pointed out Carmen. “We may gain back as much as we lose. I prefer this arrangement; it liberates women more effectively. Otherwise we work full time and have to assume more than half of the domestic responsibilities.”

“Perhaps I should rephrase my suggestion, then,” replied Madhu. “You’re right, fifty-five hours isn’t too bad when one considers the lack of housework. But the fifty-five hours a week would be more manageable if it were eleven hours a sol, five sols a week, rather than ten hours a sol, five sols a week, and half of Satursol. Furthermore, I’ve been here six years and would like to transition to other tasks, like the arts. I think we need the arts and are large enough to encourage them more.”

“I think both are possible,” replied Will. “People who want to get their work done in five sols should see whether their schedule can be changed to allow that. And Madhu, let’s talk privately about ways the arts can be fostered more.”

“Okay,” she replied. “Something else I wanted to mention: family life needs encouragement. It does not revolve around house work, cooking, and cleaning; sometimes it doesn’t even revolve around the family television. Roger and I have discovered that we need to plan time when we won’t go to the Great Room and socialize with everyone else. We have to schedule family time. I think all of us could use help figuring out the new pattern.”

“Good point,” said Érico, scribbling a phrase on the board.

“But I’m a bit concerned about switching too much time to ‘luxuries’ like art,” exclaimed Yevgeny. “If we worked less, we’d end up with less housing and less green space, because it takes time to create and maintain them.”

“I wouldn’t call art a luxury,” objected Madhu. “I wouldn’t call for all of us to become artists, either.”

“Back to the question of work versus family and socializing,” said Rosa. “We may work more hours, but we don’t have a commute every sol.”

“Speak for yourself!” replied Jacques Deschanel from Conestoga 1, located somewhere on the Pisces Trail. Everyone laughed.

“It’s true, though, that between commuting and domestic chores, we gain back as many hours as we would lose on Earth,” replied Will. “The people on expeditions work seventy hours a week, but they get extra vacation time later.”

“It’s a shame we don’t have any place to go on vacation, though,” replied Jacques. “I’d like a habitat up on the top of the escarpment, with good television access and a Jacuzzi. We need a place where we can get away from it all and relax.”

“That’s a great idea!” seconded Seiji. “It’d be good for honeymoons, too.”

“I’d prefer that we put any extra human resources we have into preparing for a larger population,” exclaimed Martha. “There are only thirty-seven human beings on this world. If we want to improve the quality of life, we need more colleagues, more friends, more potential mates, more services. We have to *grow* this place.”

“And that means working more hours, not less,” agreed Roger. “Our priorities for improving the quality of life work against each other.”

‘That’s life,” added Karol. “If living well means working *and* loving, it means we have to balance the two.”

“I’d make growing this place our top priority, otherwise,” exclaimed Érico, writing a big number “1” in front of the phrase. “Growing this place means more living space, more green space, better social evenings, more people watching your children. But obviously it can’t mean no time for socializing, raising children, or loving.”

“There are little things we can do to improve life that won’t take time from work, though,” said Roger, a twinkle in his eye. “If I had my choice, I’d like to have a dog.”

“A dog?” said Will. Then he laughed and everyone joined in, Roger included.

“No, seriously,” continued Roger. “We should import pets. They would improve the quality of life.”

“You can always have a rabbit,” offered Gaston, smiling.

“I have another matter to raise,” said Enrique. “I’ve said this before, too. I sometimes think the Outpost has become *too* couple friendly. Those of us who aren’t married, or at least don’t have a steady relationship, feel a bit isolated sometimes.”

“And sometimes those of us who are in a relationship but aren’t married feel pressure,” added Karol, looking at Lisa, who was pregnant with his child.

“I apologize that those things have happened,” replied Will. “I agree, sometimes we are so focused on building marriages and families here that others may feel pressure to conform. We have to be very careful about imposing values. But we all share some things in common. Among them are sexuality, the possibility of reproduction, and death. These things are complementary; you have to have a new generation because the old generation dies out. And as we just heard from the panel, human beings are designed psychically, socially, and dare I say spiritually, around these facts. Perhaps we are overreacting or overcompensating, because as we know, space exploration has offered the possibility of death all too often, but until now it has not offered the possibility of sexuality, of marriage, or of family. If we want people to stay on Mars, acquire a feel for this place, and become highly experienced in living and working here, they have to have the possibility of those things.”

“And it has been a battle, as you all know,” added Ethel, while Liz suckled at her right breast.

“As this place becomes bigger, I’m sure there will be more diversity of expression of these matters,” added Carmen. “Of course, this place will not be like the science fiction novels that postulated group marriage and all sorts of novel marital arrangements!”

“Some of the folks in the Mars Exploration Society still want to see such things,” added Yevgeny. Several chuckled; they knew about some of the stranger ideas for settling Mars in circulation.

“Are we running out of ideas?” asked Will. “I see Érico is prioritizing the points.”

“I am; we have a story to tell.”

Roger looked at his watch. “Lunchtime is over, we’re supposed to be starting our brainstorming, and I think we’re just about finished!”

“I think so,” agreed Will. “But I do want to offer one more thought. There’s one thing we all can do that will help grow this place and will not consume a lot of our time.” He paused and everyone turned to him, curious and interested. “We’ve been hesitant to coordinate our media appearances too much because the thirty-three of us are pretty independent folks, and we’re hard to discipline. Coordinating our public relations is a bit like herding cats. But folks, if you want to make a concrete and important contribution to growing this place, the best way to do it, slowly and over time, is to coordinate our message better. As you may know, in the last ten or eleven months I’ve been interviewed by the media three or four times as much as in earlier years. Some people have said this is because I’m ambitious. Some have said it’s because I saw an opportunity when the Mars Commission took over and was initially confused about public relations. The latter explanation has some merit; I was upset about the confusion and did act on my own on some occasions. But we now have a supportive policy of the Mars Commission and NASA OPI and excellent advice from private groups on Earth. We have a series of successive monthly media themes that reinforce each other very deliberately. If you’ve followed the public opinion surveys, after ten months the strategy is beginning to bear fruit. The international public’s support for Mars exploration is on the rise. Morgan says it’s getting easier to raise money for this place.

“If you are willing to coordinate your interviews with the message of the month, we’ll figure out how you can do it; we can offer talking points that tie your expertise to

the theme of the month. If we can coordinate what we're saying about this place better, we will educate humanity about it quicker."

Everyone was listening to Will intensely. He paused to look at them. Most nodded. "Good idea," said Madhu.

"There's more," said Will. "One way to make Mars attractive to the rank and file of humanity is to stress our peaceful, cooperative life. Whenever Earth has a crisis of some sort, Mars becomes a lower in priority. But under those circumstances we should talk about how our multicultural, pluralistic society is relevant to Earth's future. Over time, all of us here have become internationalists. That's a message that can help our people—our species—on the mother world."

"That's exciting," said Lal.

"I'll be glad to cooperate," exclaimed Seiji.

"Hey, so will I," added Roger. "I never thought I'd be an internationalist, but I guess after six years I've become one."

"A Republican internationalist; is that possible?" said Érico, smiling. "Will, should I put this on the list?"

"Sure. Write 'better coordination of our media presence'; that's neutral enough."

Érico scribbled on the board. "Okay; anything else?"

"Let's make a report to earth," replied Will. "We'll be first instead of last, and reserve our right to make another report afterward."

Érico began to organize notes, conferring with Will while the others ate or drank a bit more. Then he taped a fifteen minute report and sent it. Meanwhile, Will stepped out to view messages from Earth. Morgan had sent a videomail. "Will, I just had a very

pleasant talk with Louisa Turner over lunch. You were right; she has done an excellent job with this conference. I think we can hire her to develop our own Office of Public Information. I've suspected for months that she was collaborating with you behind the scenes, but ever since the flu pandemic ended you've been very careful to run everything past me, so I haven't minded. I'm in favor of the Commission pulling in talent, and she has a lot. Bye."

Will beamed with pleasure over the message. He replied immediately. "Doug, this has indeed been a good conference. My people have really enjoyed it and have a lot of ideas. And I have great respect for Louisa Turner; Heather Kimball was right about her immense talents and sound judgment. I'd be in favor of including her in the Commission in any way possible."

10

Step by Step

early June, 2043

The conference ended at 3:30 p.m. The rest of the afternoon, Will was busy with media interviews, stressing the theme of living well. Turner had drafted talking points and Will had run them past Morgan the day before; but after supper Morgan and Turner called Will from Morgan's office for a three-way discussion of media strategy.

It wasn't until the next morning that Will and Morgan spoke about the gathering. "Thank you for hosting this conference," Will said, in response to a brief message asking for a discussion. "I've never seen the folks here in the Outpost so uplifted by a single event. The panel discussion fascinated everyone and proved to be a catalyst for a very frank and detailed discussion about our future. There were a lot of good suggestions; we've already started implementing some of them. I'll send a memo to you later this sol about the implications I see. We should reexamine the crew roster and see whether we can fill the few remaining positions with people able to provide some key services here; specifically I'd like to get someone here with a master of business administration, a law degree, and/or an accounting degree. The person could run a store, provide financial advice, and offer legal advice. I have less confidence we can import a hair dresser, and even less that we can fly up a pet dog!

"One very significant development is that almost everyone wants to use their media contacts to coordinate the public relations message better. Of course, most people also want a say in how we choose our themes, but that's okay; we can consider their ideas. The conference bodes well for our future here.

"Anyway, let me know what you thought about the conference. Bye."

Will turned to other tasks. He sent a voicemail to Alexandra, proposing that they meet at 11 for their long-delayed discussion of a construction plan. He sent another to Madhu suggesting they discuss art and entertainment further. He emailed Lisa Kok and asked her about what she would do if she had more time to make consumer goods. Then he looked at the biographies of a dozen candidates for the remaining two slots on Columbus 5 and was delighted to see that one candidate with strong credentials in robotics had a husband who was a lawyer and accountant (though he had not applied for the mission). He immediately emailed Morgan about the man.

By then, a half hour had passed and Morgan's reply had arrived. "Good sol, Will. I look forward to your memo, which I am sure will be specific and detailed. I was very impressed by the conference. The speakers were perfect; everyone here in Houston went home thinking a lot about their own lives, and we had an excellent brainstorming about Mars. Our ideas resonated well with the report Érico sent.

"I've also been rethinking some aspects of the Commission. You and I have worked together for about fifteen months, and I think our relationship has strengthened and deepened. I've come to appreciate your honesty, fairness, and the clarity of your thought. It's very difficult to communicate clearly across the gulf of interplanetary space, but you have a remarkable talent for doing it. We've never really met, yet I feel I know you, and you probably feel that you know me as well. Without such a feeling of familiarity, coordination of human resources on two worlds would be much more complicated and fraught with mistrust, even suspicion. Columbus 1 and 2 both had difficult relationships with ground control, but we have resolved them.

"I think the time has come to strengthen our relationship by giving you the position of Assistant Commissioner for Mars Operations. You are already in charge of Mars operations as commander, but by making you Assistant Commissioner I am raising you to the number two position in the Commission's organizational structure. This makes our structure more like the Lunar Commission's, where Sebastian Langlais is Commander of Shackleton and de facto the Commission's number two. As our number two, you will have greater authority to ask questions and offer suggestions.

"If it weren't for the fact that you can communicate so clearly across the gulf, this promotion wouldn't work. With the promotion, I hope we will coordinate our operations on the two planets even better.

"So, Mr. Assistant Commissioner, what are your thoughts? Let me know. Bye."

Will stared at the screen in shock, amazed that his relationship with Morgan had strengthened so much. He was silent a long time. Finally he hit the reply icon on his attaché. "Doug, thank you for your reply. You have rendered me speechless. I'm not sure what to say. I'm very flattered that you have so much confidence in me. You can be sure that my personal priorities are devoted entirely to making the Mars operation grow. I'll be honored to serve the Mars Commission in any capacity you see fit to give me. Bye."

He sent the message and stared out the window, wondering about the future. The promotion had implications for what he could accomplish for Mars. Finally, he stood up and walked around the outpost, watching staff doing their jobs and asking trivial questions. He walked past the day care room in Renfrew, where Jennie Dunbar was watching all five children. He headed to the basement of Joseph, where Ethel was hard at

work on a metal docking unit. She was inspecting the work of their two robot welders when he arrived.

"What's going on?" she said, looking at Will's face, on which the emotions of delight and seriousness played simultaneously.

"Morgan just sent me a videomail appointing me Assistant Commissioner. That makes me number two in the Mars Commission structure."

"Really?" Ethel looked at him, surprised and delighted. Then she emitted a squeal of delight and grabbed him, kissing him.

"Wow!" he said. "I guess you approve."

"Approve! It's about time someone realized what my husband can do! This is great news."

"Better not tell anyone yet. I'm sure there will be a news release, and when I get it I'll circulate it to everyone."

"Good. How do you feel?"

"I don't know. I'm in shock. It makes me wonder what else I can do; how much more I can get done, how many new ideas I can come up with. . .it's a challenge to me."

"I'm glad you see it that way. Some would feel pride in themselves and lose their humility, or would sit back and get lazy."

"No, I won't do that. I guess I had better mop more floors."

"No, you should mop fewer floors, so you have more time for your new responsibilities! I can't tell you how happy I am, Will." She kissed him again. "I love you."

“And I love you too, honey.” He kissed her as well. “I guess I’d better get back to work.”

She nodded. He headed back to his office in Habitat 1. He began to repeat a Bahá'í prayer he had memorized decades ago, as a child, that was particularly soothing.

Back at his desk, he found a videomail from Louise Turner congratulating him. She added, “After talking to Morgan yesterday, I found that I could work with him; I even liked him. He wants me to work for the Mars Commission, so I guess I’ll have to part with the beautiful Rocky Mountains and resign myself to coastal flatlands, heat, humidity, and occasional hurricanes. We should do a three-way negotiation about my duties. The three of us will make a pretty good team: Doug’s good at negotiating, hiring, managing, and watching the money; you’re good with the vision thing, which is not his strength, plus you’re a good manager of the Mars side; and both of you are good on camera talking about the things you’re good at. But you need professional media relations help, which I can provide. So I look forward to it. Bye.”

He thanked her and looked at his other messages. As he scanned everything, Morgan’s public announcement of his appointment arrived. He sent it to the personnel just as someone knocked on his door.

“Come in. Oh, Alexandra. What can I do for you.”

“You asked me to come at 11, remember!”

“Oh, that’s right. Sorry; I’m still in shock. About an hour ago Douglas Morgan sent me a videomail offering me the position of Assistant Commissioner.”

“You mean you’re going back to Earth?”

"No, I'll remain Commander of Mars Operations. It means as commander, I am also the number two person in the Commission. It greatly strengthens the Outpost's position in the command structure and should make it easier for us to get what we need."

"Oh; excellent! Congratulations!" Alexandra offered her hand.

Will smiled and shook. "Thank you. It means I haven't had a chance to pull together my thoughts for our meeting, however. I apologize that we've been thinking for a long time—many months—about meeting and resolving our differing philosophies about construction here on Mars. Maybe we can reach some sort of reasonable compromise; I don't know. We can't afford to wait any longer, I hope you agree. We have to get started on housing for Columbus 5 and we have to plan the housing for Columbus 6."

"Oh, I do agree, Will. But maybe compromise is the wrong word. My team and I have been hard at work, thinking about the direction we should take. We've changed our ideas radically in the last six months and you don't know even what they are. So let's sit down and I'll tell you what our philosophy is, in the Construction Department."

Will nodded. "Fair enough." He moved his chair to a little meeting table, and Alexandra sat in the chair that was already there.

"Rather than starting with a philosophy, let me start with an idea; an image," said Alexandra. "I'll get to the philosophy later." She put her attaché in a stand on Will's table so that the screen was vertical and easy for both of them to see. "Display Integrated Design 1, please," she commanded. Her attaché had no keyboard; Alexandra preferred to do her inputs by voice.

An image appeared on the screen of a circular depression in the ground with a transparent dome over it. A crescent-shaped building hugged the north side and was matched by a similar building on the south side, leaving an oval-shaped area between them. The buildings had no details visible on them; no doors and windows; they were transparent shapes.

"Add some trees for scale," commanded Alexandra, and two rows of six trees each appeared along the north and south sides of the oval-shaped middle. "Now add the swimming pool." A blue pool appeared at the west end in the narrow space between the buildings.

"This is about the size of the dome we have?" asked Will.

"No; bigger. The swimming pool is twelve meters long and three wide. I had to throw one of them in; I know how much you want to go swimming again. The dome is forty meters in diameter and would be manufactured by Adastra Ltd. of Saskatoon, just like our current dome. We've worked closely with them over the last six months to design this one. Even though it's larger, it'll have a mass of only four tonnes, which means it can be launched into low earth orbit by a Swift Shuttle. The life support and environmental equipment will be built into the two buildings, four tonnes per building."

"How many people are we talking about?"

"This dome will have 1,200 square meters of agricultural space and 1,200 meters of housing and work space, so it can feed twelve and accommodate up to twenty-four."

"How can you provide for that many people with such a small life support mass?" said Will skeptically.

“Because this is an integrated system. Right now our habitats are designed to be self-sufficient; they filter all air and purify all water, then recycle them or release them into the greenhouses or into the Martian environment. In the integrated system, the plants do much of the work to purify the air and a combination of microbes in the soil and sunlight do much of the work to purify the water. The rest is done by equipment we can make here, with some imported filters and equipment for the final purification step.”

“Ah-hah.” Will nodded, absorbing the idea. “And the buildings? They look rather small to me.”

“If they were duricrete, they would be. Each crescent building varies from six to ten meters wide, and if they were of duricrete like Renfrew and Joseph, two meters would be taken up by the thickness of the walls. These buildings have walls just ten centimeters thick. Radiation shielding is provided by the high outer wall of the enclosure, by their crescent shape, by the presence of the other building not too far away, and by a roof—including a two-meter overhang—covered by two meters of regolith. The roofs will be agricultural areas, so the buildings won’t diminish the area for farming. Computer, add agricultural areas, please.” A moment later the screen changed; both roofs were covered by squares of grains and vegetables, including a rice paddy, while the central area surrounded by trees was covered by other vegetables. “The area under the overhang will be low-radiation public space,” added Alexandra.

“How are you going to build buildings with walls just ten centimeters thick? You’ll have to make them out of metal to make them airtight. That’s a huge amount of welding and a lot of refining of meteoritic nickel-iron.”

Alexandra shook her head. “The buildings, like the dome, are bags of kevlar, nomex, and other plastics manufactured by Adastra. Each building starts its life as a carefully designed bag of exactly the dimensions we want, capable of holding in as much as entire terrestrial atmosphere of pressure. Each bag has a mass of only one tonne; they’re remarkably light when they have no machinery in them, no floors, and no interior walls. The plastic is only one millimeter thick. And they’re transparent, which means we can put windows anywhere we want, and we can move the windows later. We have no pressure-tight windows to worry about. We inflate the bag, haul in our steel struts and sheetrock through an airlock, and build the entire building inside the bag. Its walls will be almost flush against the bag’s walls. And we do the same outside, erecting supports for the extremely heavy roof—that’s one reason to make the building narrow—and adding vinyl siding outside the bag to protect it from damage. And since all the construction is done inside another bag—the dome—pressure suits are never necessary.”

Will smiled, excited by the proposal. “And what do you call the philosophy?”

“Integrated design. The habitats are integrated into the dome; the large volume of air in the latter dilutes smells and gives the odors space to break down naturally. The agriculture is integrated into the life support system, removing carbon dioxide from the dome’s air. The radiation protection system—two meters of wet regolith above the building—is integrated into the life support system as soil for the plants and as water filtration. The trees are integral, as a source of fruits and nuts, a privacy screen in front of the housing, and an aesthetic element. The swimming pool can be the fish farm, and it can be covered by plexiglass to become a miniature basketball court.”

“And according to your calculations, this requires how much mass imported from Earth?”

“Fourteen tonnes. That cuts our imports per new arrival. Furthermore, each building will require about a quarter as much work to build as the duricrete structures we’ve relied on so far. The most important construction materials, nickel-steel and sheet rock, can be manufactured in Joseph Hall.” Alexandra turned to the computer. “Project the final image, please.” The bags were instantly replaced by three-story apartment buildings, with children running around on a patio next to the swimming pool. Adults sat at tables relaxing and eating at another patio.

Will smiled when he saw the last touch. “Very nice. If this works, you deserve a Nobel Prize! No one will want to live in the current housing; they’ll want to move here!”

“That’s the idea. It’s all a part of ‘living well,’ remember! We can convert the existing space into work areas and storage; there will always be a use for it.”

“One problem I see is the scale. Accommodation for twenty-four is a good size when our flights involve eighteen or nineteen people; it leaves room for future population growth. But Columbus 6 may bring thirty people.”

Alexandra shrugged. “A fifty-meter dome would have 1960 square meters and could accommodate forty people.”

“Have you run this plan past Rudenkov and the other construction people?”

Alexandra hesitated. “No, I haven’t. They know something about our research. But Pavel has a strong commitment to duricrete construction. He developed it here and Joseph Hall is a monument to its success. I am not opposed duricrete buildings, but I have always felt that they were too squat, too thick to be attractive, and too labor intensive to

be practical. With plastic bubbles, we don't have to build with a meter of steel-reinforced duricrete any more."

"I hear you. You've 'dejustified' the technique." Will paused. "I hate the term 'dejustify.' It's a fancy word that means we can't change because we've already done something one way and spent money on that way. Well, too bad. If another way is better, we should switch. We'll have to talk to Pavel and the other construction folks. We have to get a green light from them, not just because I want them on board, but because I want an independent assessment."

"That's fine; it'll stand the scrutiny."

"We have some time to conduct a thorough review. We can't get this ready for Columbus 5."

Alexandra frowned. "Why can't we? Adastra can make the bubbles in three months for about fifty million bucks. The technique is the same one used to make the Mars dome; the dimensions are changed, that's all. Columbus 5 leaves Gateway in seven months. There's a nuclear rocket launch to Gateway in six months, and the bubbles could be part of that shipment."

"That's just about impossible, though, because the politics will take seven months. Or even seven years. That's what I'm afraid of. We have to convince the construction people, the Commission, we'll probably have to convince either NASA or ESA as well, and then we have to find the money."

"It's a good thing you're Assistant Commissioner, then!" exclaimed Alexandra.

"I never thought of it that way."

“What about the Mars Exploration Society? This is actually easier than the Mars Dome they sent. Its mass is two thirds as much and it can be launched using the Swift, which is much cheaper. Adastra will charge less as well because they already bought and paid for the manufacturing equipment with the Mars Dome contract.”

“MES might be easier and more practical. But it would also be politically controversial.”

“Maybe if MES proposes it, the Commission will feel compelled to act instead.”

“Perhaps, but I don’t play games like that.”

“Okay,” said Alexandra, considering. “I can prepare a detailed proposal. Do you think we could put it on the Outpost’s website? That way we could seek input from the construction people, the Commission, space agencies, and the public at once.”

Will considered the request for a moment. “Yes, we could justify publishing the plan on the grounds that time is short. But I want to read the report very carefully before it goes up. This idea will be controversial; I want to be sure it’s right.”

“Okay.” Alexandra smiled. “So, for once, we’re both in agreement about construction priorities?”

Will nodded. “Yes. I’m sorry it was so difficult; but it was worth the wait!”

That evening, Will was surprised by a big strawberry chocolate cake at supper to congratulate him for his promotion. Almost everyone at the outpost was thrilled; it strengthened their collective voice in the processes that shaped Martian settlement and exploration.

Two sols later, Alexandra had the Integrated Design proposal finished. The section about the life support equipment ran fifty pages since it involved rethinking and minimizing the work the equipment had to do; appended to the proposal were three reports previously completed, totaling one hundred pages, that specified what a combination of habitat and greenhouse could accomplish. The Mars Dome provided most of the data, since it had two thirds of the area of the dome being proposed. The main difference was the lack of wastewater treatment in the Mars Dome, but several greenhouses provided that data. The paper was a massive technical *tour de force* justifying the new approach.

But it was also immediately controversial. A day-long panel discussion about it the next week involving Alexandra and her staff, Pavel Rudenkov and his staff, Will Elliot, and Doug Morgan, only partially resolved the concerns, but it was sufficient for Morgan to act. “I’ll tell you what I took away from the discussion, Will,” said Morgan the next sol. “There are an awful lot of technical matters to be resolved. But everyone agrees—or concedes—that it’s a good idea to build buildings inside their own customized bubbles; it’s simple and safe, though no one is yet sure exactly what procedures are necessary to do it. And everyone agrees or concedes it’s a good idea to build buildings inside domes; not only does it protect the buildings from the Martian environment, but potentially integrates the life support systems better.

“But now to the technical matters. No one is sure exactly what combination of life support equipment is needed, though the guesses seem to be pretty good. The construction folks in Moscow are upset because all their approaches and experience have been rendered partially ineffective. I think they made an excellent point: Alexandra’s

construction schedule is too optimistic. The construction support crew in Moscow isn't doing the actual construction work; that has to fall on the people at the Outpost. From what I see, the construction team up there is unanimous and enthusiastic in their support. So the Moscow people will have to come around.

"In sum, I'm on board. I think this is an exciting new development. Our problems are two-fold. First, we have to assure ourselves that redundancy will be sufficient if the cargo were lost en route to Mars or if the dome-habitat combination fails. With the reconstruction plan Lescov has been pursuing, the existing Outpost can accommodate forty-six; Columbus 5 raises your population to forty-seven, too high for ordinary situations and impossible in an emergency. Clearly, we need a backup plan. Maybe a Habitat 5 and another Mars dome will do that, but together their mass is twenty-two tonnes; a lot to haul to Mars. Possibly we can reduce that somewhat.

"If the proposed dome-habitat combination is successful, you'll have a capacity to accommodate about seventy people. If Columbus 6 flies thirty and everyone were to stay you'd have seventy-seven—not counting additional children!—so we have the redundancy problem again. Maybe the problem can be solved if we fly out fifteen tonnes of extra food, since you have plenty of water and plenty of electricity to make oxygen. There are other solutions we could investigate also, such as a habitat 5, some greenhouses, and maybe another Mars dome. I want you and Alexandra to work on that problem in close collaboration with the key folks down here.

"Our second problem is identifying a source of money to pay for this. The Canadians are an obvious place to start, since Adastra's in Saskatoon. I'll work on that.

"We can anticipate the Russian Space Agency will lobby against the proposal. Maybe Turner can help me deal with that. Bye."

Will had to smile as the screen went black. Morgan was more convinced than he. He hit reply. "Good sol, Doug. I think I'm more concerned about some aspects of the plan that you are. I'm particularly concerned by Pavel's calculation that the construction will take at least as long and maybe longer than the duricrete technique, which we know works, and which the crew here has experience with.

"But my crew has experience with the sheetrock and metal beam construction technique as well, and we have experience with the Mars dome. I'll indeed work with Alexandra to resolve the cargo mass issues and the redundancy issue. It may be easiest to fly an additional automated cargo vehicle.

"I'm very excited to work with you on this project. Communication has been a real struggle; the speed of light is just too slow. But we're creating a culture of communication that can overcome the barriers.

"On another matter, yestersol I emailed you about Silvio Diponte, husband of Julia Diponte, the robotics expert. Have you contacted him to see whether he might be interested in coming to Mars? He's a lawyer, an accountant, and a businessman; exactly the skills we need up here. He was top of his class, too; he's smart. And they're both in their early thirties and childless; a perfect combination for Mars. I'd like to see him considered for Columbus 5.

"We'll talk more later. Bye."

Will sent the message and videomailed Alexandra to ask her to come by at 3 p.m. to begin the work Morgan had assigned to them. Then he began to review the cargo

manifest; a deceptively simple list of items that fit together with each other, and with everything already on Mars, like a giant jigsaw puzzle. An hour later he got a call from Louisa Turner.

"Good sol, Will. Thought I'd let you know that Morgan has just asked me to spend next week in Europe, mostly Paris, to work on the Europeans about the new integrated design plan. It would seem there's no one in the Mars Commission headquarters who can speak half decent French. What's the world coming to; or at least, what's *le monde anglais* coming to? I'm sure the French feel barbarians are sweeping across the world and closing in on the true center of civilization. I'll do my best. I wish you all had invited me to sit in on the panel discussion yesterday; now I have to watch six hours of videotapes and get two hours of briefings. When I get back I'll go to Houston to find an apartment. I plan to keep my house in Boulder, the mountains are just too beautiful. I'll split my time between the two places.

"One thing I told Morgan that I am sure he is ignoring; maybe you'll pay attention. 'Integrated design' is a nice phrase for the philosophy, but it has to be accompanied by a name for the thing being built. 'Dome' and 'habitat' are taken. Even 'hab' is used. You need something that conveys the sense of 'house' and the sense of 'ecology' or 'space.' Otherwise, the media can't talk about our plan easily, and that's a problem. There was coverage about it today on one web page I check and it was titled 'A House in a Bottle.' The image they ran was of one of those old sailing ships in a bottle! It was clever, it was funny, and the article was favorable, but the impression was wrong. We need a name. Think about it. Bye."

Will and Alexandra reviewed the cargo manifest closely and came up with a few ideas, but none that would save enough mass. Lisa arrived and reviewed the consumables manifest; they could save mass, but at the expense of quality of life, because many of the imports were items they could not make or raise on Mars, like steak and toothpaste. Roger and Ethel came in and reviewed the scientific and manufacturing components, respectively. They had a few ideas that helped save about a tonne of imports, but at the expense of weeks of additional manufacturing work on Mars.

"This is not working," said Roger. "I think we'll have to fly another ACV. Is that possible?"

Will shrugged. "Theoretically. There's a backup unit available that could be used. But we're talking about the cost of manufacturing the extra fifteen tonnes of stuff, launching it into orbit, mating it with the ion tug, operating the ion tug, maintenance and refurbishing of another ACV, and lunar propellant to push it to Mars; altogether that's 80 million bucks. If we can avoid that expense, and if the moon can use the cargo that's already been manufactured, it's a big savings."

"It seems to me there's one solution to the problem," said Ethel. "And that's to be consistent. Are we confident in this new system or not? It's based on the Mars Dome that we've been enjoying for over a year now and on the life support and agricultural systems we've been operating here for seven years. It isn't a radical new technology. We can make the new system work. If unexpected things happen, we patch the dome, we jury-rig the life support, or whatever. We're not dealing with rocket engines that can explode and strand us.

"So, my suggestion is very simple. Cut out the second Mars dome that's already scheduled. Why would we need a second one if this new integrated system is better? That saves fifteen tonnes and allows us to import one of the new eleven-tonne systems, with four tonnes to spare. If we eliminate the three tonnes of building parts we had planned to import for the new duricrete building, that's seven tonnes. Finally, we have two six-tonne habitats scheduled for Phobos and Deimos, respectively. They come with micrometeoroid armor and that makes them very heavy. But we plan to bury the habitats anyway, and the chance of them being punctured before burial is very small; furthermore, we can supply armoring here, and can patch small micrometeoroid holes. So I'd replace those two habs with reinforced plastic bubbles lacking the micrometeoroid protection. That would reduce each to four tonnes, free up four tonnes, and raise our surplus to eleven tonnes. That allows us to import *two* of these new systems, which gives us plenty of redundancy."

"That's brilliant!" exclaimed Alexandra. "I would have never dared suggest it!"

"We dejustify the Mars Exploration Society's contribution," said Will. "That's a problem. But we need to sell this not as a rejection of their system, but as a child of it."

"Of course," agreed Alexandra. "This new system would have been impossible without their dome."

"You haven't completely balanced the manifest, though," pointed out Roger. "Because there's still six to ten tonnes of cargo on the 'priority 2' list. If you eliminate some of the items on the 'priority 1' list, people will want their stuff on the 'priority 2' list to be flown instead."

"That's true; we make enemies by bumping some priority 1 cargo and we make other enemies by blocking their 'priority 2' cargo." Will pondered the problem.

There was a long, discouraged silence. “I have always wondered why we didn’t fly more on the ITVs,” said Lisa. “They can safely aerobrake sixteen tonnes into orbit. That’s supposed to include up to four tonnes of consumables, but the consumables are scheduled for consumption on the flight out. It does give the ITVs spare aerobraking capacity to go into orbit. But why not fly out more consumables on the ITVs? If the mass is too much for aerobraking, jettison some of it.”

“That would increase our total transportation capacity sufficiently,” agreed Roger. “No one would have ever agreed to that suggestion in the past, but these ITVs have been flown several times. They’re known to be reliable.”

“They could always spray an extra half tonne of ablatant onto the aeroshield,” added Ethel. “No one would have dared do something like that on Columbus 1 or even Columbus 2. But this is Columbus 5.”

“The technology is better,” agreed Will. “Of course, each tonne of cargo needs about two cubic meters of volume, so you’re decreasing the housing space on what will be a crowded flight. But that’s easier to fix. There’s usually extra cargo volume on the shuttles. Either it could be used for housing, or it could store cargo until a week before the aerobraking maneuvers.” Will nodded. “Yes, that might work. I’ll propose it.”

“And the deliberation will go on for two or three months,” growled Roger.

The entire outpost was abuzz at supper that evening about how to resolve the cargo problem. Will also told everyone about the problem of a name for the integrated system, but the various suggestions, like “habidome” did not seem right.

As supper wound down, Rosa and Neal Stroger rose and started to walk around the Outpost. Rosa was overdue by a week and she wanted the baby—a boy—out. The walking helped start some contractions. Soon everyone heard that she had headed for sick bay. Once again, the Great Room in Habitat 2 became a large waiting room. All night people drifted in, drank a cup of mint tea, heard the latest, then went home.

The next morning, the baby was still not born. People brought their breakfasts to sit and wait a while, then went to work. The same happened at lunch and supper; it was a long labor.

"Poor dear," said Ethel, shaking her head. She looked at her watch. "It's now twenty-four hours."

"I'm glad I'm never going to have a child," said Alexandra.

"I hadn't planned on it," replied Madhu. "And look at me!"

"Well, I'm now 42 and being careful," replied Alexandra. "And neither of us wants a baby. I *love* my work."

"'Lieben und arbeiten,'" said Ethel, repeating Freud's famous "love and work" adage that had been quoted at the "Living Well" conference. "Say, Alexandra, speaking of work: how do you like the term 'oasis' to describe the dome-habitat combination?"

"'Oasis.'" Alexandra pondered. "A possibility, I suppose."

"Except we've been using 'oasis' to refer to places where we may establish temporary bases," noted Madhu. "The term's already used."

"I personally wish we could call them 'mirs,'" exclaimed Alexandra. "A 'mir' is a marvelous Russian term; it means peace, but it also means a peaceful place, a peaceful community. It has utopian connotations."

“But it’s language specific,” noted Madhu.

“And the term will remind everyone of the old Mir space station,” added Ethel.

“I rather like ‘dome,’” noted Madhu. “It’s too bad we’ve already used the term. It means ‘house’ in Russian, so it has connotations of space in English and home in Russian. The word’s widely used in French and other romance languages as well.”

“The term ‘Mars Dome’ has killed it,” said Ethel, shrugging. “Which is too bad. I never liked ‘Mars dome’ anyway. It worked well for the Earth media, but sounds strange when we use it here!”

“There’s always ‘habidome,’” said Alexandra. “But it’s long, it starts with a sound that many languages—including Russian—lack, and it feels clumsy.”

“How about ‘biodome’ then?” suggested Madhu. “It eliminates the ‘h’ and captures the life aspect of the structure.”

“Still rather long,” replied Ethel. “And it stresses the agricultural side at the expense of the life side. ‘Biohome’ would capture both, I suppose.”

“But it has an ‘h’ and a word from one language,” noted Alexandra.

“Yes. Hum.” Madhu thought. “Then what about ‘biome’? It’s a system integrating life together; plant life, animal life, human life. And it has a certain climate; each one of our domes will have a climate and appropriate vegetation for that climate. And it’s a scientific word widely used in most languages, or readily translatable. Doesn’t that capture what we’re talking about?”

Alexandra smiled. “Biome! I like it! Short, and it works in a vast number of languages!”

Ethel nodded. “I agree. It’s something we might be able to use.”

“Thank you, Madhu!” exclaimed Alexandra. She stood up. “I think I’ll go tell Will. Where is he?”

“Putting the kids to bed; you’ll have to wait. Marshall will want him to read at least four stories and won’t want to say his prayers without mama.”

“Okay.” Alexandra sat, disappointed.

There was the sound of a baby crying. All three of them leaned forward at once. “That’s coming from the sick bay,” said Madhu.

“I think so,” agreed Ethel. “There’s an announcement to make!”

“Richard Allen Stroger has greeted the world,” agreed Alexandra.

11

Weddings

Oct. 5, 11, 22, 2043

The Mars dome was filled with sunlight and greenery and beautifully decorated for the weddings of Shinji and Michiko and Eammon and Irina. The two brides were both wearing wedding gowns, thanks to reuse of the original gown made for Ethel—which had been considerably improved over the years—and use of the new gown that Ethel and Madhu had insisted be part of Columbus 4's cargo manifest. The grooms wore their finest suits; Shinji's looked pretty tired, since he had been on Mars for almost eight years.

The Japanese wedding was held at 9 a.m. in order to accommodate the television guests in Tokyo. The Catholic wedding followed at 11 a.m., a reasonable, though early, hour in Europe. Will presided over both. An Irish priest provided a full wedding mass in Ireland for Eammon's parents, in which Irina's family and the wedding party participated fully via television. Eammon, as a Catholic deacon, had been empowered to distribute the eucharist to those who wished to partake; a small amount of consecrated bread and wine had been imported eighteen months ago. It was the first Catholic mass held on Mars. When it ended everyone headed for the great room in Renfrew for a reception line with both pairs of newlyweds, the banquet, and entertainment.

"This is working better than I thought," said Will. "I was afraid we wouldn't be able to balance the needs of two couples."

"The reception may be the tricky part, though," replied Ethel.

The couples sat together at the head table, then led everyone through the buffet line. While Ethel went through the line with the kids, Will stopped to embrace Shinji. “My friend, I am so happy for you, I could burst!”

“Thank you, Will. I never could have imagined, when I was suddenly picked to fly on Columbus 1, that I’d be staying here and settling down!”

“You’ve been trying to leave this planet for years!”

“I know; it’s quite strange.” Shinji looked at Michiko. “I think we will be very happy together.”

Michiko smiled and squeezed his arm. Will smiled as well. There was a fifteen-year age difference between them—he was forty-eight and she was thirty-three—but that didn’t seem to matter.

Eammon and Irina had already sat at the head table with their food. Eammon leaned over to speak to Will. “Thanks for your words at the mass.”

“Yes; they were beautiful. I had no idea you were a philosopher as well as a geologist!” added Irina.

“I’m not; I was drawing on scripture. That’s always safest,” replied Will. He didn’t say he had been paraphrasing Bahá'í scripture; he knew from experience that Eammon, as a conservative Catholic, was not very comfortable with references to the Bahá'í Faith.

“Your words about the magnetic power of love were very moving,” Irina said.

“I hope the two of you experience the great power of love throughout your lives, and I hope you share that power with others,” Will replied.

“And with our children,” added Eammon.

Will got in the buffet line to fill a plate with food. Marshall had barged ahead and filled a plate for himself; everyone spoiled him. So Will took his time and listened to the argument developing between Érico and Roger, which others listened to as well. “I’m so glad the Republicans are going to lose this one,” the Brazilian said, knowing it was the sort of comment that would raise Roger’s hackles. “Eight years in the White House are about seven years too many—”

“As a democracy, we don’t elect Presidents for a year, and you’re prediction is a year early!”

Érico was not to be fazed. “Brazilians don’t elect Presidents for a year either! We aren’t a little, unsophisticated country. But conservative Americans won’t stomach the thought of an openly gay Vice President, even if he is a Born-again Baptist!”

“Let’s just say his gay credentials are stronger than his evangelical credentials. I don’t know why our Presidential candidate announced his VP pick a year early.”

“Because the guy’s incredibly popular with demographics the Repubs usually can’t reach!”

“Well, laugh if you want, but if the Democrats get in the White House, I wouldn’t expect Mars to receive any more nuclear reactors! And I can guarantee there won’t be any solid-core nuclear engines to fly people here.”

Érico shrugged. “I didn’t want the nukes in the first place, but we now have four of them, and they should last ten to fifteen years. Who knows, by then we might be exporting uranium to low Earth orbit; we’ll have nuclear power in space *and* we’ll be able to protect the Earth’s environment from radioactivity. No Swift Shuttles have

crashed yet, but it's a matter of time. Mars has the uranium; all we need is an isotope enrichment plant."

"I'm not sure I want nuclear engines, either," added Kevin Dunbar, who worked with Rosa Stroger on their reactors. "We know a six-month flight to Mars is safe. A three-month flight may cut the radiation exposure in half, but it doesn't save propellant mass because the vehicles are moving too fast to aerobrake. And then to send the vehicles back to Earth, we have to extract nine times as much water from the moons, break it all into hydrogen and oxygen, and throw away the 8/9 of the mass that's oxygen. We can't haul the oxygen down here because we have no need for it. So the cost to fly here ends up being more, and the return flight is much more expensive. And for what? The privilege of hosting a dozen tourists every columbiad?"

"The engine will be useful for manned flights to Mercury," commented Louise Tremblay.

"And you think the Americans are going to lease these engines to the French?" asked Érico. "I don't see the U.S. proposing a Mercury flight for some time. Besides, solar-electric propulsion is getting more powerful and effective all the time, and it works real well at Mercury."

"Don't sell the U.S. short," replied Roger. "We're on Mars now because the U.S. was willing to put in the lion's share of the technological investment to develop the hardware. And the U.S. was willing and able to do that because it remains the world's largest economy. It's still almost three times the real size of the Chinese economy and it remains ahead of the European Union because the Europeans don't want to reproduce

and don't want to let immigrants in, so every year they have fewer and fewer people able to work and pay taxes."

"And the U.S. is the richest society in the world to have lots of poor people!" added Louise. "It's a scandal."

"Well, we can be thankful we have no poor people on Mars," said Will, intervening when the emotions were rising. "And this sol, with two marvelous weddings, we have no unhappy people, either."

There was a long pause in the line. "It was a beautiful pair of weddings," agreed Louise. "And they were so different!"

"Oh, I thought behind the differences there were profound, human similarities," replied Kevin. "They may get married in different ways, but they are all happy this sol." And Kevin sounded happy as well, so much so that Will looked at him, wondering why. He and Jennie had been separated for six months, and after a week or two of awkwardness, everyone had adjusted to the new social situation.

"Our humanity unites us, in spite of everything else," commented Roger. It had become almost a cliché on the Outpost, especially since the "Living Well" conference four months earlier.

Érico had reached the food, so he focused on filling his plate and the friendly argument ended. Roger followed, then Louise, then Kevin. Will was behind them all. As he finished filling his plate, he saw Kevin lingering to speak to him. "By the way, Jennie and I have decided to try living together again," he said. "We decided yestersol. I'm moving back in tonight."

“Oh, good. I’m glad for both of you and hope it works out. The last few months have been rough, I think.”

“Yes and no. We both have had to look inside ourselves, and while that’s been painful at times, it has also been a real growing experience. I hope it works this time.”

“You’ll be in my prayers.”

Kevin smiled. “Thanks, Will. I’m sure that’ll help.”

Will nodded and headed for his table. Ethel had her hands full feeding Elizabeth, who, at eleven and half months, had a lot more enthusiasm for eating on her own than the skills to accomplish it. The high chair was covered with mashed peas, splashes of milk, and soy yogurt. Ethel stared at Will angrily, so he put down his plate and took over with Lizzie, allowing Ethel to get her food before something ran out. Meanwhile, Enlai was talking to Marshall and occasionally helping him as well.

“This big boy doesn’t need much help,” he said to Will.

“Yes, he’s really coming along.” Marshall was now three and a half. “Lizzie isn’t doing badly, either.” He helped the little girl with another spoonful. “I’m so glad, Enlai, that you can stay another columbiad.”

“I’m happy as well. It would be a shame for the Chinese language not to be uttered here for a time. My parents aren’t happy; they want me to come home and get married.”

“Hey, if you get married here, you can have two children, and no one will complain.”

“Or six; Eammon told me that’s how many he wants to have. I think Irina has a lower number in mind.”

“Yes.” Will rearranged his place setting so that he could sit and eat while helping his daughter. “It’s sad to see Columbus 4 leaving next week.”

“We’ll miss them, but at least most people are staying. They’ve got science to do at Phobos, and they have to grab equipment to land on 2018XB.”

“A month on an asteroid and the first drilling done on one. They accomplish yet another first.”

‘There aren’t many left,” agreed Enlai. “Last month we raised a flag at the South Pole. Earlier this year we scaled the solar system’s highest mountain. We cleared the Tharsis and Pisces Trails, completed the Polar Trail, cleared a quarter of the Virgo Trail. . . really something. I suppose we’ll finish the Virgo Trail before Columbus 5 arrives?”

Will shook his head. “No, I think we should keep most people here at the Outpost and do a few short expeditions. Most of our surface exploration crew has hit their two-year radiation limit and they have to reduce their exposure for six months to a year and be watched for cancer before they resume their efforts. The new folks will be anxious to go out and we need to leave them something to do. The Virgo Trail’s really important, too; it’ll cross Elysium and some of Mars’s youngest volcanic surfaces, then follow the highland-lowland boundary in an area where the highlands have suffered severe erosion. There are a lot of important scientific goals.”

“I gather you plan to write a textbook?”

“The plans have gone beyond that. I want all of us to write a textbook/website together summarizing what we know about Mars. This is a good time. Opposition’s in six months, and as you know there’s a massive Mars Sciences Conference being planned for Aurorae and Houston, involving two weeks of scientific expeditions when the time delay

is at minimum and almost continuous papers and panel discussions. If we sit back and write for much of the next half year, we'll make that conference the most exciting scientific gathering in human history."

"Unless a future conference includes discovery of viable life here," replied Enlai. "But that's looking less and less likely all the time."

"Unfortunately." Will turned to feed Lizzie again. "What are the odds of finding life here, do you think?"

"Who knows." Enlai considered. "Less than ten percent, now. The mid latitude snow packs are sterile. Pretty soon, I'll be in favor of seeding this planet with terrestrial life!"

"It's a shame the entire biosphere here died. I suppose there's a lesson for us, though."

"Yes. Mars and Venus teach the same lesson. At least the next few years will see the human presence expand to Venus," said Enlai.

"Yes, and my friend David's the commander! I congratulated him the other sol."

"I emailed him as well. I know David very slightly. Very generous of the French, to include an American and a German. I just wish they'd drop their opposition to the biomes."

Will smiled. "I think we'll see that change in the next sol or so. Louisa is talking to them right now. The publicity campaign she waged really complicated things; it made the Russians feel pressured. But everyone's coming around now, at the eleventh hour."

"Media campaigns cannot substitute for diplomacy. I'm glad to hear it. The Chinese and Japanese are now in favor of the biome integrated system. I can't wait to see one, too."

"Me, too," agreed Will.

The two weddings were a brief pause in the very hard work to prepare for Columbus 4's departure. On the morning of October 11, 2043, the *Pavonis* blasted off with Koyo Takenaka and Sridhar Pradhan on board, bound for Phobos. Four hours later the *Alba* followed with Olaf Norlander and Francisco Almeida. Each shuttle was loaded with nine tonnes of fossiliferous Mars rocks and a few hundred kilograms of gold and platinum. They explored a few areas of the moon not previously reached, then removed two of its four drills—the newer ones—and packed up a tonne of old scientific instruments, which were now destined for the asteroid 2018XB. They refueled and took off for Deimos, where they made another four-sol visit for exploration and maintenance. Then they docked to Embarcadero, where the interplanetary transit vehicles *Ausonia, Solis,* and *Daedalia* waited.

Columbus 4 had to be prepared for trans-Earth injection. The *Daedalia* was staying in Mars orbit, but the other two ITVs were heading back to Earth, attached to the two shuttles. Three Lifters were there to provide the shuttles with the methane and oxygen they needed for trans-Earth injection, for rendezvous with 2018XB, and for a post-rendezvous orbital correction to head for Earth. Thirty tonnes of extra methane would be hauled back in the shuttles' fuel tanks for sale. The Mars rocks and precious metals had to be transferred to storage in the ITVs. The crew module of the shuttle *Alba*

was removed from the cargo hold and docked to Embarcadero; it would provide emergency accommodation for Columbus 5 and might eventually be placed on one of the moons.

Six hours before trans-Earth injection, Will received marvelous news and immediately called Commander Prathan to let him know.

"Sridhar, we have final clearance for the two biomes," he announced. "The announcement will be made to the media in about an hour. I wanted you all to know, since you've made quite a sacrifice for this world."

"Thanks, Will. We hate to leave!"

"Not everyone can stay here. Some people come to make a two-year contribution; some four or six; some, a more or less permanent contribution. It's all welcome. And you guys have just added to our knowledge of both moons, you're hauling back to Earth about a hundred million bucks in cargo, and you're spending a month at a new worldlet on the way back to Earth. Those are important contributions."

"How will the two biomes be ready in time? Columbus 5's cargo departs in six weeks! The ITVs and crew depart in twelve!"

"Not any more," replied Will. "The political process took too long. Columbus 5 will depart two weeks later and will use a nuclear engine and two Mars shuttles. Biome 1 will be in the cargo bay of the Mars shuttles. ACV-2 will leave Gateway even later—late February—instead of mid December and will be pushed to a higher velocity than anything ever sent to Mars. It'll use a ballute to aerobrake into orbit safely. It'll have Biome 2 on board."

“That sounds risky. I wish I were here to help set them up. But maybe I’ll be back!”

“I hope so, Sridhar. Once you get to Earth, you’ll be able to help us anyway; you’ve got good contacts in India. So have a great trip back to Earth, a fascinating and fruitful adventure on 2018XB, and stay safe.”

“Thanks, Will. You all stay safe, too.”

Finished 12:17 p.m. April 6, 2003; rewritten Sept. 30-Oct. 8, 2008

Will goes outside to see the new construction site and surveys the entire Outpost and its natural setting. He returns inside and exchanges videomails with Douglas Morgan, the new High Commissioner of the Mars Commission.
Date: Feb. 18, 2042

Morgan calls for a conference to consider development of Mars over the next six to eight years. He favors land sales. Will proposes the Tharsis, Polar, Cancer, and Pisces Trails to Morgan. Morgan is interested in expansion of the biological and agricultural facilities. Over lunch, Will goes to the sickbay and finds that Ethel is pregnant with their second child. They also learn there is another pregnancy [Carmen] and another couple trying [the Strogers].
Date: 19 Feb. 2042

The *Olympus* arrives first with Alexandra and Yevgeny Lescov, Charles and Martha Vickers, Tang Enlai, and Olaf Norlander. The *Daedalia* and the *Alba* follow in four-hour intervals; 18 arrive safely. That evening was the welcoming banquet. Will discusses evidence for life on early Venus with Enlai. He gives a welcoming speech.
Date: 26 June 2042 (landing sol)

Will takes the Lescovs on a tour outside and they discuss construction, the solar power units, and the growing water reservoir. He sneezes and has to hurry inside; his nose has started suddenly to run. Within a sol everyone from before Columbus 4 is sick. NASA and the Mars Commission feud over what to do and who will coordinate it. Roger expresses worry about the seriousness of the criticism in the media. Rosa loses her baby at 3 a.m. Will offers her a devotional service; she is grateful. Heather Kimball recommends Will ask Louisa Turner for public relations help. She immediately gives him good advice and very clever talking points.
Date: early July, 2042

As the pandemic waned, a funeral was held for Joseph Stroger, for whom the new building was named. A few weeks later the automated cargo vehicles arrived and the shuttles, unmanned, were launched with cargo for Earth. Three Lifters arrived from Phobos and Deimos to provide fuel for the ACVs and shuttles as well. The ACVs head home; fifteen tonnes of cargo belongs to the MES (fossiliferous rocks). The 45 tonnes of cargo are unloaded. The dome is inflated and people go inside to explore it. Morgan calls Will and says that Louisa Turner can’t be hired; she was the author of the secret media

blitz and he knows it. Then a group walks through the new dome. They invite others in, including Marshall, who chases his father. Érico brings a baseball for them to throw around. They convert lunch into a picnic for everyone in the dome.
Date: late August, 2042

6. Flight 82

The new Sunwing B (biwing) makes its maiden flight. Will goes inside and sees the remodeling in Habitat 1 and is surprised by it. He argues with Alexandra about the design. Morgan approves the PhD mission. Carmen's and Ethel's babies are born on Oct. 12, 2027. Rosa's pregnant again as well.
Date: mid October 2042

7. Heat Shield 97

It is Satursol and the dome is filled with relaxing people. Will exchanges emails with Sebastian, who is now permanently in charge of Shackleton. Turner is advising Will about talking points and staying on message. Yevgeny pilots a "PhD" mission, but after arrival at Deimos an engine bay door refuses to close, and they have to EVA to fix it. Once NASA approves, the shuttle lands on Deimos and an EVA is sent out to close the engine bay door. They found a zip-lock bag stuck in the electric motor that opened and closed the door.
Date: early April, 2043

8. Flag Raising 114

Will becomes far more active in the day to day management of the Mars Commission as he and Morgan began to work more closely together. He talks to the land sales person, urges Rudenkov to get Alexandra to endorse the new Lassen Building, and talks to Louisa Turner about message. Martha Vickers tells him about her work. The next sol Alexandra gets mad at Will for using Rudenkov, and promises a plan within a month. Roger Anderson leads an expedition to the summit of Olympus Mons, where they raise the U.N. flag, prompting fury from American nationalists on Earth. Morgan counsels silence; Will decides they must focus on the living well conference instead.
Date: late April, 2043

9. Living Well 132

The Outpost hosts a conference to discuss quality of life issues. Will summarizes the status; four are flying home; 29 are staying; eighteen are coming on Columbus 5; thirty may come on Columbus 6; nuclear engines will power both. Three outstanding speakers talk and many suggestions are made.
Date: early June 2043

10. Step by Step 149

Morgan is so pleased with Will's leadership that he promotes Will to Assistant Commissioner of the Commission. Alexandra comes to Will with her plan for construction on Mars, a radical new approach involving buildings inside their own Kevlar liners, in turn built inside domes, with the agricultural soil on the roof serving as radiation protection. Will starts to sell the plan. A group of senior staff meet and map out a plan to fly two systems to Mars. The next sol while waiting for Richard Allen Stroger to be born, Madhu coins the term 'biome' to represent the system.
Date: early June, 2043

11. Weddings 171-81

Shinji and Michiko get married in early morning, then Eammon and Irina in the late morning. At the reception, Roger and Érico debate politics and nuclear power, including its value in flights to Mars. Kevin tells Will that he and Jennie are getting back together. Will and Tang discuss the next nine months. As Columbus 4 prepares for TEI, the biomes are approved. But Columbus 5's departure is delayed two weeks and ACV2's departure is delayed 2.5 months, to March 1. Nuclear engines make the flights possible.
Date: Oct. 5, 11, 22, 2043