THE MARS FRONTIER

Vol. 11

Self-Subsistence

Contents

1.

Fire in the Sky

Mar. 1, 2057

Commissioner Will Elliott rose an hour before dawn to watch the arrival from Earth. He pulled on his clothes quickly, grabbed his binoculars, and headed out the door of his apartment, leaving his wife Ethel asleep in their bed. But he did not head up one flight of stairs to Mars Control, as he had done many times before. Instead he headed for a dark spot to watch the arrival of the caravel *Courageous.*

Finding a dark spot on Mars would seem easy, but in fact it was not. Will did not don a pressure suit and go outside; it would take a long time and violate safety procedures, which required someone else to be outside and nearby. All the domes were illuminated at a low level and had insulating blankets pulled tightly over them to keep in the life-preserving heat against Mars's hostile nocturnal cold. But the construction area was pressurized, poorly lit at night, and uninsulated; he'd be chilly, but the view would be worth it. So Will headed west, across a series of bubble domes and their connecting tunnels, to Cathay, the dome where construction had just begun. He faced west and searched the heavens.

The thick plastic, frosted by the enclosure's humidity, distorted the heavens, but he soon spotted two faint, moving stars. The slower, brighter object was Embarcadero Station, their interplanetary transit facility; it was the destination of the *Courageous* and had emergency equipment ready in case of trouble. The fainter, faster object was the *Courageous,* racing toward Mars at 11 kilometers per second. In his mind's eye Will

could see the caravel-class vehicle: a plate thickened in the middle, thirty-two meters in diameter, nine meters thick at the rim and thirteen meters at the center, its bottom covered with a heat shield. Inside were 150 human beings, including his nephew, Paul Nuri, and his friend Sebastian Langlais's son, Kristoff. The interior normally rotated four times per minute to generate Mars-level centrifugal gravity, but as the vehicle approached Mars its rotation was stopped.

As he contemplated the caravel's design, the ship began to develop a western-pointing tail of incandescent gas. The dot became a small, glowing disc streaking quickly across the sky, blazing through the atmosphere of Mars. The aerobraking was relatively brief: three minutes. The caravel dipped to within fifteen kilometers of the surface and became, along with its flames, larger than either Deimos or Phobos. It moved faster and faster to Will's eye as it reached its closest approach. Inside, the inhabitants were experiencing three gees of deceleration. Then the tail faded as the ship rose back into space.

The sun popped above the eastern horizon. Will hadn't noticed the brief dawn spreading above the dusty eastern horizon, but it little affected the view of the spectacle. However, a half minute later the flame abruptly shrank, then ended. The arrival was over.

He reached down to his belt, where his tablet dangled. "Anisa, please connect me to Rostam in Mars Control."

The screen flashed alive with the image of an efficient, organized, middle-aged, red-haired woman. He changed the image of "Anisa," his electronic secretary, randomly every month or two, so as not to upset Ethel. "Acknowledged," "she" replied. A moment

later Rostam's face appeared. The Pakistani head of Mars Control was balding and in his late forties.

"Hey Will. How'd it look out there?"

"Beautiful; spectacular. Some sol you should come out and watch. Was everything nominal?"

"Yes, everything was nominal. The *Courageous* will dock with Embarcadero in 24 hours. I'd like to be outside sometime to watch; the screen doesn't do it justice."

"No, it doesn't. Give me a holler if there's anything new. I'm going for a quick walk around the outpost. Ciao."

"Ciao." Rostam closed the circuit and Will dropped the tablet back to his belt. He walked around every few sols or Martian days to see anything new; this time he'd be walking backward through the history of Aurorae Outpost, from the newest enclosure to some of the oldest. Cathay was the latest example of enclosure technology, seventy meters wide, thirty-five meters high, and two hundred meters long north-south. Except for the concrete foundations of a line of buildings near him on the west side, the ground was still bare. The dome had been pressurized just two months earlier and was still leaking a little air downward into the Martian subsurface in spite of sheets of shallow water still covering some areas and plastic subsurface dams in others. Most of Cathay would remain agricultural for the next four years, as would a future northward extension, "Cathay North 1." Because it was a large area recovered from desolate Martian "range" and was open to the ground, enclosures like Cathay were sometimes called "polders."

He passed through the pair of airlocks and the tunnel that took him to Andalus, their new "downtown." Andalus dome was 160 meters—525 feet—in diameter and

soared 80 meters into the sky. Its insulating blanket had been withdrawn from the eastern side to let in the morning sun, but the silvered western side was still in place and reflected dawn sunlight downward, brightly illuminating the scene. He followed a street, six meters wide, with five story buildings on both sides, to the central square. It was eighty meters long and sixty meters wide, including the four-meter deep columned portico along the southern edge. Most of its surface had been cobblestoned, with potted palms and oranges along several sides. The entire eighty-meter northern side of the square was formed by a single structure, "the Gallerie," a shopping and restaurant complex forty meters wide and five stories high, with a park and tennis courts on the roof. Workers were flowing in and out of the main entrance, which had a bulbous Moorish arch; the night shift had just ended and the day shift was beginning. They had a crash effort to get the space set up before the arrivals needed it. Many workers waved and he waved back.

Opposite the Gallerie was a long five-story building with an impressive Renaissance façade. It was not stone, but vinyl siding bolted to a metal frame, "painted" with a sand appliqué that made it look like Martian yellow dunestone, with brownstone highlights around windows and doors. The façade was only partially installed; where it was missing the transparent, airtight bubble underneath was exposed, showing the building's interior walls, wiring, and pipes like a human body missing its skin. The building was divided into apartments, with ground-level space designed for eventual conversion to commercial use.

The eastern end of the square had a Town Hall for the Borough of Aurorae with a large daycare facility in the basement. The western end was still open and would accommodate a substantial "seat" for the Mars Commonwealth. Attached to it would

eventually be a forty-meter observation tower called the “campanile.” There had been quite a controversy raging over the west end because many had wanted a place of worship built there. But the various religious communities couldn’t agree on the design and use of a common space, no one wanted a particular religion to receive the privilege of being the only one on the square, and the secular among Mars’s inhabitants—about half the total—didn’t want any religious presence at all.

The spaces behind the square of buildings and off the main streets were still unbuilt. Most would be filled with four to seven-story condominiums, though various religious communities competed for the land as well, in spite of the sales price of 1,000 redbacks per square meter. The foundation of the “temple” of the Universal Church of Jesus and the Creator, a Nigerian denomination with sixteen local members, had already been laid; most of its members were construction specialists who worked on the building on their spare time. It occupied a twenty-five by forty meter triangle on the northeastern approach street and was partially visible from the square itself.

He crossed the square and followed a street southeasterly to the dome edge, where he entered another tunnel. In fifty meters it took him to Bangalore Dome, 75 meters across, filled with forty identical cylinders four stories high and ten meters in diameter, typically housing six to sixteen people. The monotony of the design and the packed nature of the space had made it their least attractive dome; a European architectural critic had called it “the worst of California suburban development on Mars.” Because few had wanted to move in, it was filled mostly with the arrivals from the tenth columbiad—two years earlier, 2055—and thus was also dubbed the “C-10 Ghetto.”

After weaving in and around the cylinders, greeting early risers, Will crossed through a tunnel to Columbia, a 60-meter mixed residential and agricultural dome. The name reflected its climate, that of interior Washington state and British Columbia: hot and dry in the summer, cool to cold in the winter. Spring had begun in Mars's northern hemisphere on November 2, 2056, almost exactly four months earlier, and in another two months the sun would be as far north in the sky as it got, producing long shadows in Aurorae Outpost's domes and minimizing insolation; by raising the insulating blankets on the eastern and western sides of Columbia and decreasing the reflectivity of their interior surfaces the sunlight falling inside could be cut considerably, causing temperatures to drop and winter to set in. The cold would be intense but brief—six weeks—and there would be snow. Then as the sun approached the equator again, the period of daylight would be lengthened until the sun passed over the equator on November 20, 2057, and Columbia would be in midsummer. The movement of the sun into Mars's southern hemisphere would bring long shadows and cold temperature again, producing two annual terrestrial climatic cycles every Martian year or "annum": every 669 sols or Martian days and 687 Earth days.

Columbia's cylindrical condominiums were in blocks separated by fields of wheat, corn, and vegetables, sown to give four to six crops per annum, irrigated and fertilized for maximum yield. As a result, its 2827 square meters housed 100 persons and fed 25.

A tunnel led him to Colorado, where cylinders were set amidst Ponderosa pines, aspens, and wheat fields, then to Shenandoah, a fifty-meter dome—the older ones were smaller—which had the climate of the southeastern United States. It was purely

agricultural, filled with wheat fields and rice paddies that also raised fish, with groves of peach and pecan trees. From there he crossed Oregon—another agricultural dome filled with vegetables and soybeans, with a patch of cotton—to Cochabamba, a 75-meter residential dome at the outpost's northeastern end. He stepped into the Deseret Store's temporary tent—temporary for two years!—grabbed a breakfast cart, and filled it with the usual items his family ate. Then he paid and pushed it straight home.

Ethel was up and in the shower; Marshall, 17, was dressed and ready to head off to high school even though he had an hour; Lizzie, 14, was still sound asleep and rose only after three loud summons. They ate, chatted about the day, and discussed their plans with Paul after he arrived in three sols. Then at 8 a.m. they all headed their various ways, Will upstairs to Mars Control and his office. Before he discussed the sol with Anisa—her image staring at him quizzically and alertly from a screen of her own on his desk—Yevgeny and Alexandra Lescov arrived for their 8:15 a.m. appointment.

"Good sol," said Alexandra. "Sorry we're early; we were up to monitor the aerobraking and got the sol started early as a result."

"That's alright; I did the same. I watched the aerobraking from Cathay. It was incredible to see."

"We sat in bed and watched it on t.v.," replied Yevgeny. "We might get up to watch the *Intrepid* in two weeks, though. Is it worth the hassle?"

"Oh, I think so! But let's sit and get started." Will pointed to his meeting table and rose from behind his desk to join them. "So how does the arrival schedule look?"

"The *Simud* definitely will not be available for use," replied Yevgeny, who was in charge of Mars-space transport. "We've got to pull out engine 3 entirely to repair the

hairline cracks. Normally, that would take our entire repair staff a month. Right now the staff is occupied with routine maintenance and fueling to keep the fleet flying."

"So, that's one less shuttle."

He nodded. "I told everyone at our staff meeting yestersol that we'll take our time and get everyone down safe and sound. In the next two months we have to haul 400 people down and 70 up. That's 17 passenger shuttle flights; we've got six passenger shuttles; they can fly once every four or five sols depending on maintenance; so we have plenty of time. We've got to deorbit 250 tonnes of cargo and haul up 200 more; we have to make six flights with two cargo shuttles; so we have plenty of time. Three passenger flights and one cargo flight will go through Dawes, which will reduce the pressure on Aurorae Spaceport. The last passengers coming down are the ones certified to handle in-space cargo transfer and refueling."

"Is your crew getting any sleep over the next two months?"

"Sleep, yes, but little else. We've got everyone in the Exploration and Emergency Corps pressed into service; 150 folks are working in the Spaceports."

Will turned to Alexandra. "And just about everyone else is working for you."

"I think so," she agreed. "Agriculture's on half staff; the hospital has postponed routine work. But the Gallerie will open the sol after tomorrow and everyone's flat will be functional. They won't be painted, but they'll have lights, plumbing, and beds."

"I guess that'll do."

Alexandra shrugged. "The complexity of this operation got away from us. Fifty percent is a huge expansion of population. The budget cuts in terrestrial support hurt. The bigger problems come down the road, though. The caravel *Epsilon* was scheduled to be in

orbit by now. Basic interior work will take four months before a construction crew can fly it to Earth. We're now looking at a launch date for the inflatable shell of early May, which means it won't be ready for flight to Earth until early September, which is way too late to get it there before the next opposition."

"Has anyone talked to Lufthansa about the problem?"

"I don't think so."

"There is a solution," said Yevgeny. "Fly the *Epsilon* to Earth on a hundred-fifty sol trajectory arriving eight weeks before the next opposition. That gives them enough time to fuel it, load it with passengers, and fly it back."

Will shook his head. "They'll say we intentionally missed the deadline to force them to pay more in fuel, and to steal tourist tickets from them."

"A terrestrial departure two months before opposition is too late for a quick and easy trip back through the inner solar system," pointed out Alexandra.

"Then let's give them the *Courageous* instead," said Yevgeny. "It's the same size and more or less the same layout. The modifications can be made by our thirty-five personnel heading home on it next month. It'll employ them on the flight."

Will nodded. "That'll work, if Lufthansa accepts."

"Full disclosure," said Alexandria. "I don't mind admitting I didn't shepherd this as well as I could have. There are lessons to learn so we do better next time."

"My bigger concern is crowding," said Yevgeny. "The four hundred people arriving in the next two months will strain our shuttles to the maximum. I'd rather spread the six hundred or so arrivals next columbiad out over four months, even five."

“I agree; we need to use the entire launch window, which means a wider range of departure and arrival dates, and some flights that are fairly long,” said Will. “The hundred-fifty sol trajectory to Earth before opposition allows residents to go back to Earth pretty cheaply for ‘shore leave.’ That’s a valuable benefit.”

“It’s been sixteen years since we saw Earth,” said Yevgeny, looking at Alexandra. “And twenty-two years for you. We’ll stay until Boris is all grown up, of course.”

“Yes. Marshall’s old enough to go to university on Earth in two years, and Lizzie will follow three years later. Our time here could end soon. I can’t imagine moving back to Earth, though. This is home now.”

“And it’s pretty exciting, compared to retirement next to a golf course in a warm climate,” added Alexandra.

“I suspect two decades of occasional golf up here has ruined terrestrial golf for me anyway!” laughed Will. “Not that I ever played the game much. I suppose I’ll never see Earth again and will lay my bones in Memorial Park in another twenty or thirty years.” He signed. “Well, we all know what we have to do. My sol is full of calls; we don’t get six-minute communications delays with Earth very often. Let’s get to work.”

2

Homecomings

Mar. 4, 2057

Two sols later, the first two shuttles descended to Mars with twenty-four passengers each. They fell through Mars's thin atmosphere like wingless stones, rubbing off three quarters of their five kilometers per second and converting it to incandescent air, then blasted off the remainder with rocket flames. Once the giant capsule-shaped vehicles had landed on clay landing pads scattered across the Martian desert south of the Outpost, mobilhabs—big pressurized two-story vehicles—rolled up, docked, and received the passengers via pressure tunnels. Less than an hour after landing, the new arrivals were inside Aurorae Outpost's garage, which served as an arrival hall.

Paul Nuri arrived on the third passenger shuttle, which landed on the third sol after the *Courageous* arrived in Mars orbit. When his mobilhab pulled into the arrival hall, Ethel, Marshall, and Lizzie were waiting.

"Paul, over here!" shouted Marshall, waving. Paul was easily recognizable from the many videomails exchanged over the years; 182 centimeters or six feet tall, massing 75 kilos or 165 pounds, 27 years old, he had the black hair of his Iranian father and the light brown skin of his mother, whose father had been African-American and whose mother was Scotch and Mexican. Marshall shared a similar skin color via Will, but had brown hair and blue eyes from Ethel; he was also three inches or seven centimeters shorter, a bit thinner, and ten years younger.

The cousins recognized each other immediately. Paul hurried over, pulling his suitcase. “Alláh-u-Abhá!” he said to Marshall, using a common Bahá'í greeting.

“Alláh-u-Abhá,” replied Marshall, and they shook hands, then embraced. “It’s good to meet you!”

“Thank you, good to meet you, too! Are you going to take me outside some sol?”

“Sure; are you certified?”

“Yes, I’ve spent time on the moon.” He turned to Ethel. “Auntie Ethel, it’s nice to meet you face to face.”

“Yes, after twenty years of video.” She hugged her nephew. “Welcome to Mars.”

“Thanks. It’s really great to be here; very exciting.” He turned to Lizzie, fourteen but already becoming a beauty. “Hello, cuz.”

“Hi, welcome to Mars.” They embraced as well.

“It’s good to be here. Where’s Uncle Will?”

“At home. If he had come down here, he’d have to greet everyone and we’d never get away,” explained Ethel. “Shall we go there, or to your flat first?”

“There; I gather my flat’s pretty bare.”

“I’m afraid so,” replied Ethel. “But that won’t stop the electricity, water, and communications bills from arriving.”

“They’ve already been emailed to me!”

“Let me get your suitcase,” said Marshall, picking it up without further comment. They headed out of the arrival hall and across “South Main Street” into Yalta Biome.

“I recognize the Patio from all sorts of programs,” said Paul.

“It’s becoming the university cafeteria,” replied Ethel. “Martech’s moving in here to give the hospital more room in Catalina. It’ll still be a public cafeteria, though.”

They walked across Yalta’s central “yard” and through the connecting tunnel to Riviera Biome. “You’re in the north building, right?” asked Paul. “When does Mars Control move to Andalus?”

“Six months; they have to install the new communications equipment that arrives in three months on the cargo vehicles,” replied Ethel.

They entered the building and turned toward the first floor apartment on the west side. “Are you moving, too?”

“No plans,” replied Ethel. “The Mars Commission Board voted to build a ten million redback residence for the Commissioner, but Will turned it down. He said there’s no guarantee the next Commissioner would live here, so it’d be a waste.”

“Besides, the Chief Minister should have a residence, once there is one,” added Marshall. The front door opened automatically and they stepped into the living room.

Will was waiting on the couch and rose. “Paul’s finally here! Welcome to Mars!”

“Thanks, uncle.” They hugged. “I haven’t seen you for so long, I don’t even remember seeing you!”

“You were four. It was Christmastime, 2034. I was supposed to be back on Earth in the late spring 2035 and would have seen you then, but the lifter carrying four of the Columbus 1 crew to lunar orbit lost an engine, so David Alaoui and I were stranded on the moon for three months.”

“They almost scrubbed Columbus 1, too,” added Ethel. “NASA didn’t want to take any chances. If they lost Columbus 1, the whole project might have been canceled.”

“Mom was really disappointed; she had a birthday present for me and was never able to give it to me.”

“Oh, that’s right! I have it for you!” Paul turned to his suitcase, opened it, and rummaged around until he found a small wrapped present. Will took it with obvious delight and carefully unwrapped the paper, so as not to damage it; Mars didn’t have wrapping paper, so it would be reused. He pulled out a small picture frame with a portrait in it. “My favorite picture of dad!”

“Really? Let me see grandpa,” said Lizzie, coming over. Will handed her the picture but continued to look at it.

“It was taken in 2029, a year before he died. Twenty-seven years ago. It’s easy for me to remember because Paul was just a few months old. I was just twenty-eight at the time. It was quite a shock.” A tear appeared in his eye, thinking about his dad.

Ethel put a hand on her husband’s shoulders. “So Paul, do you have your doctorate yet?”

He nodded. “I defended my thesis on the *Courageous* by videolink; that was a weird experience! It’s on the geochemistry of Imbrian melts. Alas, I won’t be at Brown for the graduation, but the diploma has been sent to Martech on one of the hippogryphs.”

“Good; we’ll add you to our graduation in June,” said Will. “Is Tim Foote still there?”

“He just retired, but he’s still around. When I saw him in September he told me to say hello and tell you they use Elliott and Anderson’s *The Geology of Mars* in three courses a year!”

Will laughed. “He was a good prof. I should send him an email; I haven’t been in touch with him for years.”

“So, what will you do here?” asked Ethel.

“Exploration Corps, I hope. My job here is field geologist; my first trip’s down Kasei in June. Meanwhile, I’ll be doing construction and getting a few construction certificates. I’ve applied for the Phobos construction team and might apply to a geology team there or Deimos.”

“Asteroid Belt?” asked Marshall.

Paul nodded. “I hope so. This is the place to be. Some of my experience with Mare Imbrium’s volcanics is relevant to the study of Vesta.”

“Talk to Kurt Hollingworth,” said Will. “He’s deep into Vesta igneous processes. Very interesting; low gravity, low pressure, and low water content, so the rocks and minerals are different than on Earth.”

“I’m already in touch. We’re meeting next week.”

“He knows how to make contacts,” said Ethel. “Tharsis volcanic processes are relevant as well. Have you talked to Roger?”

“No, but I want to.” Paul turned to Marshall. “What are you thinking of doing?”

“Maybe geophysics. They say there’s a lot of work on Mars that applies universally.”

“Yes, that’s true. Did you have a good birthday?”

“It was a really small celebration because my presents arrive next week!”

“Pesky transport,” added Lizzie.

"I've got something for you, too," said Paul. He reached back into his suitcase and pulled out a larger, flatter present. The boy opened it with excitement. "Oh, wow, tee shirts!" He held them up; one was from Brown University, the other Wesleyan University, Paul's undergraduate school. "They're perfect! I need tee shirts for work."

"Good, I'm glad they'll be useful."

"Thanks, Paul." Marshall looked at his older cousin with admiration.

"What a great present," said Will. "And I know Marshall wants to show Paul all over the outpost, not to mention all the geology trails in the area and up by the Dacha. But now let's get him some lunch, since I doubt Paul's eaten in about twelve hours, and put his stuff in his efficiency, and then let him decide whether he wants to rest, since people usually don't sleep much on the flight down."

The shuttle *Pavonis* also brought Kristoff Langlais to Mars. Sebastian waited in the arrival hall for his tall, blonde, 32-year old son and waved when he stepped out of the mobilhab.

"Kristoff, you're finally here," he said in German. They hugged. "Welcome."

"Thanks, dad, it's great to be here. It's good to see you again."

"Two and a half years. I wish Helmut were still here and that you could meet Clara and little Charlie. But they'll be back, if all goes well."

"How are they doing?"

"I just talked to them three sols ago. The flight is fine and everyone's happy. The crew has settled into a routine. We'll call them later, if you want; they're five light-minutes away."

"Yes, let's do that." He looked around. "Arrival Hall: It looks like the video."

"How was the flight down?"

"Routine; long, boring weightlessness interrupted by crushing weight and frightening roars, illumined by the awareness that equipment failure probably meant instant death."

"That's spaceflight for you. It has to be tolerated if you want to do anything interesting, though."

"Exactly."

"I'm starved. Let's drop off your things at my place and go to the Gallerie. I'm sorry I mentioned to Alexandra you were arriving."

"Apology not accepted, dad! Even a lousy room is better than your living room couch!"

"Your bed is there, so it's more comfortable than that. Just think of the money you'll save on water, electricity, and mortgage."

"I don't care about that as much as the impact on my love life, dad."

"I'm sorry. Humor your father and stay with him for a month. I'm lonely."

"Well, find a girlfriend."

Sebastian laughed. "Kristoff, perhaps this will surprise you, but I am getting *old*! In fact, at age 65, I happen to be the oldest person on Mars! I don't think there are any single women near my age."

"So what! But let's not talk about this, let's walk. Your flat's in Columbia; I bet I can lead you there."

“Then I’ll let you.” They headed for the exit and Main Street South, where they turned left. “How was the flight from Earth?”

“Packed; 150 people in a flying saucer 30 meters across. We slept in three different time zones staggered by eight hours. When you went to the cafeteria for breakfast, others were eating an early supper and yet others a midnight snack. One result was that classes were scheduled at all sorts of odd times and repeated at other odd times. But I got certifications in space repair specialist and flight life support/gas recycling specialist and did the classes for mobilhab repair specialist and waste recycling specialist.”

“Not bad; you kept yourself busy. Any interesting women on board?”

“Well, there was Veronique; Belgian, Ph.D. in chemistry, coming to do plastics fabrication. She was nice. And Nadia was interesting: Tunisian, Ph.D. in Internal Medicine, doing a Space Medicine and Mars Medicine internship. And I can’t forget Millie from Shetland.”

“What did she do?”

“Anything I asked her; but that’s another matter.” He smiled.

“Well, I hope you’ll settle down some time. Clara’s really great, and Charlie’s a marvelous little boy.”

“I know, I know. Maybe some sol, dad. Don’t worry about it. Mars has a reputation for being a family-oriented place, but it also has quite a singles scene.”

“It does, but it rotates through the singles. They arrive, date, and marry.”

“That’s true; of many of them.”

"Yes, but time's passing, and the biological clock ticks quicker here than on Earth because of the radiation. A third of the couples seek help for fertility and twenty percent of the children are the result of in-vitro fertilization."

"Mostly twins, to save time. I know how the birds and bees work here, dad."

"Well, let's not start out by arguing. I'd like to get our relationship started on a different foot this time around." They continued down Main Street South, a six-meter wide tunnel that ran the length of the Outpost near its southern edge. "Have you checked when you start work?"

"No; they'll email me. I'm assigned to Ceylon Agridome; tropical fruits and nuts. They were able to accommodate my doctorate, but I suspect it'll get boring fast."

"The arrivals are always on the bottom of the ladder, but there are opportunities for advancement every two years. You may want to consider business; they'll be privatizing construction this columbiad and agriculture was privatized last columbiad, though almost no one acted on the opportunity."

Kristoff shrugged. "Maybe. A business would be a good chance for independence, but it's also more work than I want to do right now."

"Suit yourself," replied Sebastian, not wanting to nag his son any more.

The hydroponics were lush beyond description. Helmut had visited farms in North America and Europe and knew the enormous difference. There, land was farmed based on economics. Vast areas were left unused because farming them was not economical. Fields yielded one crop per year even when two could usually be grown because the risk was not judged to be worth the investment. Only areas with large numbers of

impoverished farmers or lavish government subsidies saw almost every square centimeter utilized.

Marsian farms were a sharp contrast because land cost six million redbacks per hectare to pressurize and enrich, even after twenty years of research and experience. But even there, inefficiencies existed because of the use of sunlight for photosynthesis and for aesthetic reasons: when people wanted to surround themselves with greenery, the space was designed for their benefit, not the plants'.

Not so on the caravel *Giovanni Piazzi,* named for the discoverer of the first asteroid. There was one small concession to aesthetics: four folding chairs and a folding table were available, one could place them next to any combination of plant growing cabinets one wished, and one could open the plant cabinets to enjoy the greenery. Cabinets containing genetically modified "superspecies" trees were the most popular. The product of research at the Space Agriculture Center in Seville, Spain, and Aurorae, the trees never grew taller than two and a half meters, the height of the cabinet; could use half the sunlight of Earth trees twenty hours a sol and grow twice as fast; were self-pollinating and ever-bearing. So far, four varieties were available: *pomears* bore two varieties of apples and pears; *persikas* produced peaches, apricots, plums, cherries, and nectarines; *citroneas* bore orange, lemon, grapefruit, and lime; and *cashemonds* had almonds and cashews. Visitors appreciated their lush greenery and sometimes helped themselves to their bounty. The trees were illegal in many terrestrial nations, for fear they'd crowd out the less efficient native species.

Otherwise, the efficiency of the hydroponics was measured in cubic centimeters of space, grams of water and nutrients, and watts of power. Depending on the species

used, each person needed between twenty-five and one hundred-three cubic meters of hydroponic volume, between ten and thirty-five kilowatts of power, and between 500 and 2000 kilograms of hydroponic materials: plastic cabinets and trays, water, carbon dioxide, nitrogen, phosphorous, iron, styrofoam growing medium, etc. They left Mars with 110 cubic meters of available space per person, fifty kilowatts of solar power—which would decline to twenty-five at Ceres—and 1,500 kilograms of materials, which were lost to space at the rate of about half a percent per month.

Helmut contemplated these facts and wondered what the hydroponics would be like four years hence as he picked strawberries. The strawberry cabinet was the standard dimensions: 1.95 meters wide on the bottom, 1.3 meters wide on top—to accommodate the curvature of the floors—2.45 meters high, and 1.6 meters deep. It had 30 trays spaced 8 centimeters apart: 1 centimeter of styrofoam growing medium, six centimeters of vertical space for the plants, and 1 centimeter for the overhead tray and the strips of light emitting diodes that fed the plants with exactly the frequencies of light they needed at exactly the right intensities. The seventy-six square meters of ever bearing plants packed into the cabinet produced a third of their daily demand; some of the production of their four cabinets was frozen against the sol when the lower power output at Ceres forced cutbacks.

The strawberries were his last stop. All afternoon he had been picking everything on the chef's list, plus anything else that the computer said was ripe. That required moving plant cabinets, because they were four deep. He had to weigh everything on a fancy, expensive scale that automatically adjusted for the local gravity—which changed every centimeter around the ship—and store it in a refrigerated cart he had with him. He

never had to worry about bugs and plant diseases; every plant was perfect and clean enough to eat.

"That's the last one, Genie; how much did I pick?" Helmut asked his virtual personal assistant, who replied via his tablet.

"Six point six kilos; that's 1.3 kilos more than the kitchen needs for breakfast. You finished ten minutes early; congratulations. You just got an email from your father. He says he and Kristoff want to call at 5:15 p.m. and wonders if that's a good time."

"Yes, email him that we'll take the call then, and copy it to Clara. She should be available." He looked around. "If we're done, let's go." He reached down and began to push the long, narrow cart—about the size of an airplane food cart—down the narrow aisle between cabinets. He turned the corner and pushed it a few more meters to the elevator, which was waiting for him; Genie had summoned it. "Can you get it to the second floor? I want to stop on the third floor and see Clara."

"Sure," replied Genie.

The elevator dropped a floor and Helmut got out, leaving the cart to find its way to the kitchen under Genie's guidance. He opened a pressure door and crossed into sector 5. The curved floor took him past geology labs, mostly set up. Sector 3 and 4 held their engineering and repair shops; sector 2, right above his quarters, more hydroponics; sector 1 held the control area. Captain Vickers had his office there, a large room contained six stations for controlling Prospector telerobotic rovers—all six were in use at the moment—and one side of the control area was the bridge. Clara was the chief day officer, which meant she was responsible for monitoring the entire ship at the time. In an emergency, the six Prospector stations could be pressed into service as well.

"Did you see that dad and Kristoff are calling at 5:15?"

"Yes. Thierry's usually on time, so that shouldn't be a problem."

"Good. I'm on my way down right now." He walked to the elevator between sectors 1 and 2 and pushed the button, descended one level, then walked to their quarters. It was much cheerier than it had been when they had first seen it nine months earlier: the walls were a pleasant blue that graded from dark near the floor to light near the ceiling, several large pictures were hung, and the large 3-D screen was always on with a scene from the Canadian Rockies, giving the impression that it was a picture window with a stupendous view outside. At the moment the scene showed the sunlight and cumulus clouds of late afternoon. In addition to two pseudo-wood armoires, the room had a large desk and a double bed that was folded up into a couch. Charlie was in his cubicle off of theirs; that sol Martha Vickers had been watching him while helping Caitlin with her homework at Helmut and Clara's desk. Charlie usually stayed in his room much of the time because of its excellent radiation shielding; Caitlin's room was on the other side enjoyed equal protection thanks to of the several tonnes of water nearby. After exchanging pleasantries with Helmut, the Vickers went their way. Clara arrived a few minutes later.

Sebastian and Kristoff called right on time. When the tablet signaled an incoming signal from Mars, they projected it onto the big screen. Because of the five-minute communications delay, they could not carry out continuous, live conversation.

"Good sol to all of you," began Sebastian. "Kristoff arrived here this morning, so we figured we should give you a call as soon as you're off duty; if I remember right, Clara's on the day shift this sol, right? We've been thinking about you a lot this sol. I

showed Kristoff your flat and he wishes he'd rented it after all, even if it would have ruined his budget. We've been walking around the outpost, looking around, meeting people, and we went to Silvio's for two hours to buy furniture before the crowd arrives and purchases everything. Both Silvio's and Deseret have a whole new line of furniture, Clara, that you'll like very much. It looks almost exactly like wood. Well, I'm rambling; here's Kristoff."

Kristoff moved into the center of the view. "Hello Helmut and Clara, and of course little Charlie! It's been a long time since we talked; over a month since you called me. I finally got here this morning after waiting at Embarcadero for transport for two sols. The flight out wasn't bad, though I don't envy you spending four years in a caravel. I suppose it's a lot more comfortable with 27 than with 150, though. You have a cute flat. I wish I could afford seventy-five square meters; my efficiency flat, when it's finally available, will have twenty. I'm supposed to have a fridge and two-burner electric stove, but now I hear it might be six months before they're available! The construction delays here are the worst ever.

"They opened the Gallerie this sol, not only the food area but both stores. Andalus Square is now full of people; you'll love it. The outpost has a 'city' feel to it. Overall, I'm impressed by how big and 'modern' this place is. The consumer choices are pretty limited, but they really aren't bad. Someone starts production of bottled water in a few months, of all things.

"My work starts in three sols; I start out part time because the rest of my sol is devoted to safety classes and orientation, and I have to get certified to use a Mars pressure suit. I'll be busy with classes and certifications for about four months before I

can settle into a routine. I'm also adjusting to all sorts of little cultural details, like the quality of the fruits and vegetables—much better than in the U.S. and more like Europe—and the tooth paste and shampoo, which has a quality more like North Korea's, and in wretched looking containers. I'm getting used to redback prices and how to call friends on my tablet. They need to do more briefing about that stuff on the flight out! I guess every flight out they add more classes, but this was a shorter flight than before, and the classes never make as much sense in the abstract as they will when you need them.

"Anyway, how are all of you doing? Over to you."

Helmut looked at Clara. "He's in a good mood."

"And more communicative than usual; I suppose that's your dad's influence."

"Yeah, dad has always tried to keep Kristoff close, so he can keep an eye on him, and Kristoff has done better when dad's monitoring him, too." Helmut hit the reply icon. "Good sol, Kristoff, and welcome to Mars! Sorry we aren't there to give you a face-to-face greeting. No soon do we leave, than you arrive. It's too bad the exigencies of launch windows forced us to miss each other by two months.

"I suspect we are more comfortable than you were on your flight, but maybe not that much. One third of our volume is taken up with hydroponics; they make us self-sufficient in consumables, but at a huge cost in terms of interior volume, mass, electricity, and cooling systems. Our life support systems mass more than yours did. Another third of the ship is occupied by scientific and medical labs. So we only have a third of the ship for housing a sixth as many people as on your flight, and we're all on the same time zone. Fortunately, social relations are pretty good; Martha Vickers, our counselor—she's a psychiatrist but avoids the term—works hard to keep everyone on

good terms. Charles, her husband, the captain, is pretty effective as well. We also keep ourselves busy. We have robots to do most of the work in hydroponics, but we won't use them until we reach Astrea. I just spent all afternoon picking strawberries, fruits, and vegetables. The bridge is full of people driving Prospector-550s, which are the new series of robotic rovers operating on Astrea and Ceres. They'll soon be on Flora and Hebe as well. We're already pretty busy working on the worlds we'll visit over the next four years.

"We're looking forward to seeing you when we get back! It'll be good to have the family together again. We feel privileged to be on this adventure, to 'boldly go where no man has gone before' as the old Star Trek program said. The Asteroid Belt has thousands of worlds to visit, so this is sort of the solar system equivalent of Star Trek. We want to do this first mission right so there will be dozens, if not hundreds, more missions in the future, not to mention outposts and eventually small towns like Aurorae.

"It's good to hear from you, Kristoff. Let's be in touch more often. Enjoy getting settled; enjoy Mars! Talk to you later."

3

Inaugural

Late Mar. 2057

Will was amazed by the crowd inside the Gallerie. “Wow, it’s really noticeable how many more people we have here!” he said to his family as they stepped through the stucco-covered Moorish columns of the Gallerie’s grand entrance.

“It is,” agreed Ethel, looking around. “And what a beautiful space! I suppose once the plants get established, it’ll be even prettier.”

“I like the high ceiling and the balconies,” said Liz. “There are flats up there too, right, dad? It’d be fun to live in a mall.”

“Yes; thirty-six flats,” said Will. “They’re on the third level, and they were snapped up fast in spite of the price. I like this space very much, but I’m a bit concerned that we put a European public square next to an American mall.”

“Oh, don’t worry. They’re really two different sorts of mall spaces, since the square will never have cold weather or rain. I like them both,” said Ethel.

“Well, let’s wade into the crowd,” said Will. “Kids, we want you sitting at the head table with us for supper, so don’t go join your friends. We’ll be sitting down about 6:30, so you have half an hour to hang out.”

“And we can get our food anywhere?” confirmed Liz.

“Yes, and no one pays, because I have to pay for all 800 people tonight. It’ll cost the Commissioner’s budget about 150,000 redbacks, but it’s worth it.”

"Okay, see you later," said Marshall, and he headed straight for his friends in the Deseret Cafeteria. Will spotted a group of Arabs clad in traditional clothing; the men wore fairly long robes, though they appeared to be of a fairly light cloth, and the women were covered with loose clothing except for their faces and hands. He noted one woman seemed to be wearing high heals, which surprised him. He knew trying to speak to her would not be appropriate, but he decided he would walk over to the group, which was clustered around a table of halal hors d'oeuvres. As he approached one man turned to him. "Commissioner Elliott, I am Prince Bilal ibn-Majid Abbas. We are very pleased and honored to meet you."

"Thank you, Prince Bilal." Will extended his hand; the Prince looked at it awkwardly, then shook hands very quickly. Will pretended not to notice. "I want to welcome you and your group to Mars, and this seems like a perfect opportunity. I trust the flight was comfortable?"

The Prince pulled out a handkerchief and wiped his right hand automatically. Then he shrugged. "It was short, and I suppose it was a thousand times more comfortable than nineteenth century trans-Atlantic passenger voyages. We can thank Alláh for that at least."

"And you arrived on the surface just two sols ago."

"Indeed, we were one of the last groups to leave Embarcadero. I've made an appointment to meet with you Monsol morning about our situation here; our quarters are very limited."

“I look forward to the discussion and apologize in advance. As I am sure you know, we have been in crisis for about six months because of finances on Earth, and they have affected our construction schedule.”

“I understand that; the revolution in my country has seriously destabilized world petroleum prices. Let us all pray that the difficulties in Khaliestan will be resolved to everyone’s satisfaction. But meanwhile, we paid good money—what we were asked to pay—and have not gotten what we were promised.”

“We will discuss it. I was hoping to meet with you because our physicians are concerned to examine one of your community members, who, we understand, discovered she was pregnant during the flight from Earth.”

“Yes; Halima, one of my wives. She is fine and we have a physician among our numbers, Dr. Fatima Hussein, who is monitoring her health closely.”

“Excellent; we can discuss the question of her certifications for space and Mars medicine on Monsol, then. I am very happy to see all of you here.”

“We are looking forward to this dinner and thank you for making sure we have food that meets our needs. We are anxious to become fully involved in the community here and pull our weight, like everyone else. Please help everyone understand that just because we are religious people, we are not dedicated to the Mars endeavor any less. Khaliestan’s royal family, praise Allah, has supported the sixteen of us, as have many Khaliestani businessmen. We are proud to be a part of the effort to settle this world and to contribute to its culture. Technology has resolved many of the issues that would have limited our involvement in the past. Our women are free to move about the Outpost as long as they are properly chaperoned, and last year a leading shaykh issued a fatwa

stating that robotic chaperoning was sufficient so long as the husband gives permission and can obtain a detailed report from the robot. All of our women have virtual personal assistants, and they have been programmed to serve as chaperones as well. So our women do not need to be confined for their own comfort."

"Excellent; I'm glad to hear it," said Will, looking at Prince Bilal's face to see whether the prince showed any awareness that his statement sounded patronizing and chauvinistic. On the contrary, the Prince appeared relieved that a potentially embarrassing problem had been solved. "We have heard that many of the women in your party are immensely talented and highly trained. We are sure they will contribute significantly to this place."

"That is our desire. By the way, who do we talk to about obtaining land here in Al-Andalus for a mosque?"

"Ruhullah Islami, the Commander of Aurorae Outpost."

"I see." The Prince looked disappointed. "We definitely want a mosque separate from the Shi'ah community here."

"We will place no restrictions on any group. The only restrictions are purely practical: if there is no land left in Andalus, it will be difficult to purchase any; if there are no building supplies available, it will be hard to build a mosque. Right now there are requests for places of worship from six religious communities. I doubt more than two of them can go forward this year, and maybe two more next year. The earlier requests have priority."

"I see. It is useful to know the criteria for selection." He said it as if his group should have been told months earlier.

“We want to be fair to everyone, and we are delighted to have a more and more complete representation of humanity here.”

“Thank you. Allow me to introduce you to my colleagues.” The Prince led Will around the circle, introducing him to engineers, physicians, geologists, chemists, an economist, and to their shaykh, an older man with a graying beard and a warm, hospitable smile. But he did not introduce any of the women, except to add that the party also included a gynecologist, several seamstresses, an architect, a teacher, a historian, and a nurse. Will was surprised to note that while the men appeared to be mostly in their forties, the women appeared to be in their twenties.

Will thanked them all and gradually took his leave. He headed straight for Alexandra Lescov, who was across the room by the wine. But on the way, Ruhullah intercepted him. “So, you met the Khaliestanis. How did it go?”

“Reasonably well. They were very polite, but distant.”

“Yes. I was watching. I’m glad you didn’t try to shake hands with the women.”

“No, I know better than to offer. But I was surprised Prince Bilal wiped his hand after we shook!”

“He seems pretty conservative in some ways. You’re a non-believer; in fact, as a Bahá'í you’re worse than a Christian, you’re a *kafr,* one who has taken partners with God. They probably believe that it is lawful to kill you, though I am sure they wouldn’t think about trying. That’s one teaching of Islam I repudiated when I was twenty years old.”

“What happened then?”

“I was at university and that year I started to look at everything differently. Let me give you another tip about interacting with them. Never offer them food or drink with

your hands; just point to it and let them help themselves. There will be issues of whether you are unclean and can contaminate their utensils."

"That *is* conservative. He assured me, with great generosity of spirit, that their women could walk about the outpost freely, as long as they carried their tablets with them with the virtual personal assistant software running, because the VPA is programmed to serve as a chaperone."

"A chaperone?" Ruhullah smiled. "That's a novel solution. We Iranians are so much more liberal than that. Our women don't even cover their hair up here!"

"Yes, Emily Scoville Rohani dresses much more conservatively than the Marsian Shiite women. But I've got to go talk to Alexandra, see you later."

Ruhullah nodded. "Ciao." And he went his way.

Will pushed through the crowd looking purposeful and it worked; no one tried to stop and talk. Alexandra saw him coming. "What is it?"

"Are we giving our paying customers priority in completing their housing?"

"Paying customers? Not much."

"Well, we should. They paid us for housing; our people didn't. Prince Bilal Abbas is meeting me Monsol to complain about that."

"Then we have a few sols to make amends. We should have met our financial obligations. I'll get on it tonight, after the banquet ends."

"Thanks. You're a million."

"I know. Ciao."

Will looked around for his kids. Marshall was nearby talking to Corazon, who was flirting with him. He seemed to be ignoring it; at 14 ½, she was just hours younger

than Liz, making her the fourth child born on Mars. Marshall had known her all his life and tended to treat her like a sister. When he saw his father he walked over, escaping his admirer. “Did you know Deseret can’t sell coke any more?”

“Yes, they’ve got the exclusive contract for Pepsi and Aurorae Foods—our old cafeteria—has Coca Cola. They both have to make commercials. Maybe you can arrange to be in one.”

“Maybe that will be interesting, but *no one* wants to hang out in the caf.”

“Well, now everyone gets to hang out in the Gallerie and buy some things from one and some from the other.”

Marshall pointed across the space at a large olive-skinned man. “Dad, that’s Mark Pike ‘the Spiker’ right?”

“Yes; New York Yankees.”

“Can you introduce me?”

“Sure. I think he can give you an autograph. He’s carrying around little cards, and I doubt very many people up here have asked.”

“I don’t know whether I want an autograph.”

“Well, ask anyway.”

Marshall nodded. They walked over to what, Will judged, was probably the largest human on Mars. Pike was not that tall, but he exceeded the six-foot-two/185 centimeter limit, and his musculature made him heavier than anyone else as well. He turned to the Elliotts as they approached. “Good afternoon, Commissioner.”

“Good afternoon, Mr. Pike.” They shook hands. “This is my son, Marshall.”

“Oh, of course! I’ve heard of you.” He shook Marshall’s hand, using a less crushing grip than with his father.

“I’ve heard of you, too. I’ve never met a professional athlete before. Could I have your autograph?”

“Oh, sure.” Flattered, Mark Pike reached into a pocket and pulled out a card with his picture and a signature. On a planet where few people carried pens or paper, it was the easiest way to give an autograph. Marshall looked at it and put it in his pocket. “Do you watch a lot of baseball, Marshall?”

“Well; no, we watch a lot more basketball and soccer up here.”

“It’s a shame; it’s a great game!”

“Well, I have to admit I don’t know how to play baseball, and it’s complicated enough so it’s hard to follow on television if you don’t know how to play.”

“That’s true, and there’s no place here that’s big enough. But I suppose people could play it outside. The other sol, up at Olympus, a couple of us batted a few balls into the caldera; it made a great backdrop for a commercial! You sure can hit a ball a long way in a pressure suit, once you get used to it.”

“A group of guys tried playing baseball outside a few years ago,” agreed Will. “There are problems that have to be solved before the game will catch on. Pressure suits make pitching and running pretty hard, but almost everyone can summon a brief burst of energy to hit a ball hard, so pitchers end up throwing easier balls to hit, they go farther, then everyone has to run a long way to catch the ball and throw it back. After two innings the score was 35 to 30 and they quit because everyone was exhausted!”

“Soccer must be impossible, then; so why do people watch it on tv instead?”

“Because it’s simple to understand. You don’t have to play it to follow the game. Besides, soccer’s the big sport on Earth and everyone here follows their national teams. If it’s any consolation, we don’t follow cricket up here very much, either.”

Pike laughed. “I guess. I’ve seen two mini-basketball courts inside here, so far, and I tried playing with a few others; you get used to the higher basket pretty quickly.”

“So, did you enjoy Olympus Mons?”

“Yes, it was spectacular! Except for the reddish dust, it’s almost like being on the moon. We were on top most of a sol, plus a sol-long trip up and another one back down to the airstrip. North Pole Station was absolutely fascinating; like nothing you can see on Earth.”

“I heard about the skiing.”

Pike smiled. “I guess it was worth a try! Terrestrial skis are way too stiff at one hundred below Celsius, and CO_2 snow just ain’t as good, not late in summer anyway. I’m not sure the shots will be useful in a commercial. But I suppose those things could be overcome if there were commercial reasons to do so.”

“Which there won’t be for some time. And you’ve been to Cassini and Dawes already?”

“Yes, we started there. Fascinating places. Now my group is here for four sols, mostly up at the Dacha, then we have a sol-long excursion to the chaotic terrain west of here, and a three-sol trip to Tithonium Station to see the escarpment where it’s highest. Then we head to Phobos, and then back to Earth.”

“A whirlwind tour of Mars in one month. I hope you enjoyed it.”

“Oh, yes; worth every penny, though fifteen months is a long time to be away. And we weren’t inconvenienced with partially completed accommodations, like the arrivals.”

“No, we made sure your accommodations were the best.”

“I just wish we’d see Deimos as well.”

“Maybe some sol we can add it, but you haven’t missed anything; it looks the same as Phobos!”

“Yeah, but it’s another world I can say I’ve walked on.”

“I hope we can arrange it in 2059.”

The intercom crackled. “Dinner is served,” announced a female voice.

“Good; let’s go,” said Pike, and Will nodded. But they headed in different directions, to different buffets; Will preferred to support Aurorae Foods. As they approached a line Marshall whispered “So dad, how much did he pay to come here?”

“I’m not sure in redbacks; currencies have been fluctuating a lot, lately. Including one month on the moon, about twelve million redbacks, depending on when he paid.”

He and Marshall entered the line behind Yoshiyaki Suzuki, head of the Zen monastery; Henry Smith, President of the Deseret Company; and Victor MacLeod, the number two person in the Green World Community. “Gentlemen, good sol,” Will said to them. “Doing business?”

“There’s always a deal to make,” replied Smith. “These guys are our big produce suppliers.”

“How are your arrivals doing?”

“We’re making sure they all go through safety classes and pay attention closely,” said MacLeod. “No more depressurization accidents at Aram. The Green World Community will be a model where safety is concerned, I assure you.”

“Dr. Rivers didn’t come?”

“No, he sent me. I’ve been here a month. We’ve got twenty-four new arrivals and they’re enthusiastic. Aram will be the third largest settlement on Mars, once we head down Meridiani Trail in two weeks.”

“And you’re breaking ground on more enclosures. Yoshi, how are the new monks?”

“We’ve integrated them into the community right away. The harder part is helping the dozen Japanese technicians and engineers integrate into Mars, since they’re neither part of our community, nor part of the Commission. Complicating the effort is the housing situation. We’ve moved all twelve of them into the monastery’s guest housing while their rooms are finished.”

“We appreciate that; it takes some pressure off of us. I don’t think this mess will happen again, Yoshi.”

“I hope not,” said Henry. “Our twelve new Mormon arrivals are rather disappointed. They’re saying we should establish a construction company.”

“Maybe you should. We have to push privatization and commercialization up here more. That’s one of the themes of my keynote tonight.”

“It’s one we’ll appreciate. Any additional advice about the Mormon Temple?”

“Henry, I have nothing to do with the Borough Government, and in a few months I’ll have little to do with Mars government. It’s—”

“Will, you’re incredibly influential here and always will be.”

“And I choose not to interfere with matters that the borough has to decide. The Bahá'ís want a piece of land and a temple too, remember.”

“I know.”

They had reached the food, so the conversation stopped. Afterward Will and Marshall walked to the head table where they were joined by a few special invitees; Ruhullah Islami, Commander of Aurorae Borough; several of the wealthier tourists who had invested in Mars; Roger Anderson, Director of the Exploration Corps, his wife Madhu Gupta, an artist, and their son Sammie, Marshall’s best friend; and Yuri Severin, captain of the first caravel to arrive. They had a pleasant conversation while eating Martian salmon—a recent addition to their diet—and several dozen other possibilities. Finally, Will judged that the majority of the 800 people had finished eating, so he walked up to the stage nearby.

“Good evening, everyone,” he began. “It has become a tradition for me to open the cultural program following the inaugural dinner with a ‘state of Mars’ keynote. I would be remiss if I did not begin by welcoming our new residents to Mars. Let’s greet the arrivals.” He paused to lead the crowd in applause. “Currently Mars has 1,028 human beings on it. That’s a very significant, historic landmark and worthy of applause.” He led everyone in applause again. “The first six human beings arrived here 21 years ago. Our expansion has been powered by improvements in technology, a thirty-fold decrease in flight costs from Earth, the discovery of significant gold deposits, the export of propellants from Mars and its moons, the sale of Martian land to tens of thousands of individuals, the promise of settlement of a new world, the dream of unachievable utopia,

and billions of redbacks in expenditures by nearly every national government on Earth. In a few weeks when 45 of our companions and 35 tourists leave Mars our population will fall below the one thousand mark, but the drop will be temporary; based on the 49 children born on Mars last columbiad, we can predict that about 79 will be born in the next twenty-six months, raising our population close to 1,100 in early 2059. Assuming we receive about 500 people that year, our population will exceed 1,600; by 2061 it should be 2,300, by 2063 3,200, and by 2065 4,000.

"But continued growth of this magnitude will be possible only if several conditions are met. First, transportation costs must drop. Preliminary indications are that this is possible. Second, exports must increase. Gold exports cannot continue to grow, indeed it is likely their value will fall because of the exhaustion of the richest deposits and because the automation of gold mining on Earth, based on our technology, may push up production there and cause the price of gold to fall. The average resident of Mars can support him or herself economically if he or she generates several tonnes of exports per columbiad. This is not likely to be practical for everyone, though a significant expansion is possible, primarily to the moon, low earth orbit, Mercury, Venus, and the asteroid belt. Our expansion is very much tied to their expansion. Third, terrestrial costs must be cut. In four years our total population will exceed the size of mission control twenty-one years ago. We're just about at the point where we will not need a mission control on Earth; we'll be able to carry out that task ourselves from here. Fourth, support services provided by universities and corporations may need to be restructured or cut back; above all, other sources of financing may be needed, especially for technologies useful to Earth as well. Fifth, we need to become more efficient and productive up here; that means we must

privatize more operations, especially construction and agriculture. A shift from the Commission doing everything to dominance by the Marsian government and private industry seems to be inevitable. Sixth, we need to expand our Marsian economy, which means making more consumer goods and providing more of our own services, rather than importing them from Earth.

"These six principles will define many of our priorities this columbiad. The revolution in Khaliestan, the huge increase of the price of petroleum on the world market, and the subsequent economic downturn, are a warning sign of troubles ahead. Mars must diversify, expand, and continue to move toward financial independence. It is difficult to say how far these six principles will take us toward that goal. It appears predictable that governments will continue to decrease their subsidy, which is now one third what it was in the 2030s. The Lunar Commission receives a quarter of the government subsidies it received two decades ago. The picture improves considerably, however, when one includes subsidies to the Lunar and Venus-Mercury Commissions and the Jupiter Project that benefit Mars directly. That shows the direction of things to come.

"In addition to these six economic and administrative priorities, we have several other goals to pursue this columbiad. A significant change will occur four months hence when the clerk of the Borough of Aurorae will assume full time responsibilities as the outpost's de facto mayor. Simultaneously, the Commissioner will recommend to the Mars Council, whose members will increase to thirteen, and the Landowner's Assembly someone to serve as Chief Minister; once they approve, the Chief Minister in turn will select ministers of his cabinet, who will be approved by the Mars Council. This change is historic and marks a devolution of significant political power to the Martian electorate."

Will had to pause because of spontaneous applause. “A major effort will be devoted to improving surface transportation. The Commission will recommend to the Mars Commonwealth Authority a plan to widen and upgrade the Aurorae to Cassini trail system, which is carrying the bulk of Mars’s surface cargo and passenger traffic and which connects together all of the planet’s outposts. Several particularly rough spots will be smoothed and widened and areas of soft ground will be firmed up through freezing or by moving the trail. This could speed surface transportation twenty percent or cut fuel use by a similar amount. A similar upgrade will be recommended for the Marineris Trail as far as Tithonium-Candor, which has chromium ore and gold. Construction of oases and an upgrade from Aurorae north and south to the poles will also be recommended, since more and more transportation moves along the Polar Trail.

“Caravel production will grow from two to three. In the last three weeks we have been in consultation with both private companies providing transportation to Mars and have reached an agreement that they will service the Earth to Mars to Earth run with one caravel each, starting next columbiad, and the Mars Commission will service a Mars to Earth to Mars run with two caravels. This raises the number traveling to Mars to about 600 and splits them into three groups arriving over four months. The Mars Commission’s vehicles will have a limited number—sixty, in 2059—of berths available for Mars residents to return to Earth for one month of shore leave, then come back to Mars.”

That was greeted by gasps of surprise and scattered applause. “Our goal will be to make the number of round trip berths ten percent of the total between the planets. Ships leaving Mars have an advantage: they leave about the normal time for a Hohmann trajectory to Earth, but a 145-sol trajectory takes them to Earth about the normal time for

a six-month trajectory back to Mars; furthermore, Phobosian fuel is half the price of lunar fuel and the ship can carry enough to Earth for the slower flight back. Those taking shore leave will be fully employed in both directions, especially in orientation and training of arrivals.

"Finally, one must mention dozens of other accomplishments that are certain for the next columbiad: the hundreds of collaborations with universities, companies, and individuals over physics, astronomy, Martian geology and biology, engineering, ecology, genetic engineering, and agriculture; the great expansion of bioarchive space that will continue; the arrival of a Japanese ecosystem, our first from Asia; plans to set up a tropical Atlantic ecosystem, the cost of which would have been prohibitive a decade ago; the reorganization of Martech and Mariner Hospital; further development of silane as a fuel for vehicles and aircraft; further research on a second generation, rocket powered, Martian aircraft; and further collaboration with the Chinese and American governments over research at the Martian north and south poles, as a preparation for crewed missions to Jupiter's Galilean satellites. Our tasks are numerous, our efforts ambitious, our collaborations impressively diverse, and the results should be historic and a source of great pride for all of us. Good luck to all of you; work hard, be creative, and live well. Thank you."

4

Directions

Late Mar. 2057

The sun slanted horizontally across Andalus Square and reflected fiercely off the silvered insulating blanket covering the west side of the dome. The Bahá'í community of Aurorae—all 22 of them—were gathered for dawn breakfast at a circle of tables about ten meters from the entrance to the Gallerie. Among those present were the Elliott family; Ananda Thanarat, Kim Irion, and their two children, aged 4 and 7; Enrique Delrio and his wife Lara, who wasn't a Bahá'í, and their children, who were considered part of the community; Tomas Racan and his fiancé, who was investigating the Bahá'í Faith; and two couples who had just arrived on Mars, Jalál Sabetian and his wife Simin, Australians of Iranian origin, an engineer and physician respectively, and Mariella Arroyo and Naoto Ozawa, Filipino horticulturalist and Japanese ecologist respectively, who had become engaged just before leaving Earth and were scheduled to get married in two weeks.

"Another sol, another fast," said Ananda, pushing the remnants of his tea aside as the sun peeked above the horizon. Kim downed the last half of her coffee cup with a quick swallow. During the Bahá'í Fast—March 2 through 20 of every year—Bahá'ís abstained from all food and drink from sunrise to sunset. The children and non-Bahá'í spouses, being exempt, continued to finish their breakfasts.

"Ananda, anything new about the temple?" asked Enrique.

Ananda shook his head. "Not yet. I'm meeting with Alexandra tomorrow. But we're third in the queue and she doubts they can handle more than two per columbiad."

“Makes sense. The workload right is really heavy, even with the new arrivals.”

“And we’re starting the new course on the Book of Certitude on Wednesol, right?” asked Ethel.

Ananda nodded. “That was the decision at the Assembly meeting yestersol. And that Mariella and Naoto will coordinate devotions Frisol evening.”

“We need to leave soon; I have to get to the hospital for early morning appointments,” said Simin. “So perhaps we should say our prayers.”

“I’m glad everyone could make it this sol,” added Tomas. “We’re so busy, that’s pretty unusual.”

Tomas, Ananda, and Marshall began to move chairs into a circle for prayers. Meanwhile Prince Bilal and his two wives emerged from a nearby building and headed for the Gallerie to eat breakfast. He saw the Elliotts and Simin Sabetian and nodded to them, then detoured over.

“Good sol,” he said. “I’ve noticed your little group eating breakfast out here every morning for the last four or five sols.”

“This is the Bahá'í community of Aurorae,” replied Will. “And this is the eighteenth sol of our fast, which is a bit like Ramadan.”

“I see.” His friendliness was replaced by an aloofness, almost a hostility. He glanced at the diverse group, nodded, and turned away. His wives had waited outside the entrance; as soon as he entered the Gallerie they followed right behind him.

“I’m afraid my cover has been blown,” said Simin, sadly. “After a month of delicate negotiations, Halima finally came to the hospital for an examination and evaluation, because her pregnancy has had a few complications. I think the hospital must

have implied that I was a Muslim, so they insisted she see me. Bilal came to me right before I went in with Halima and said ‘are you a Muslim?’ and I replied ‘I am a lover of Allah and His prophet,’ which seemed sufficient for him.”

“We’ll have to work on them,” said Ethel.

“Good luck,” replied Jalál, skeptically.

“Will, can you ask Ruhullah to talk to them?”

“No, because he’s Shi’ite and Bilal’s group regard Shi’ites with suspicion. But Rostam Khan and Husni Hijazi are both Sunnis and have good relations with Prince Bilal. I’ll talk to them.”

“None of the Khaliestanis have come to the interfaith program or supported it in any way,” noted Ethel. “In the past, that has been a medium for overcoming prejudices.”

“I’ll suggest to Rostam and Husni that they get Bilal to support the service next time the Muslims sponsor it,” agreed Will. He rose and helped finish the circle of chairs. Then they all sat briefly together for two prayers, and everyone headed home.

Ethel headed to work immediately; she had to run the metal carbonyl separators that sol. Will went home to wash, shave, and make sure the kids headed to school. Then he hurried to the office. He had half an hour before a meeting with his heads of staff. Among his messages was one from Olaf Norlander, the new Commander of Concord Station. Norlander had been on Mars for Columbus 4 in 2042-43, and subsequently had served as Commander of LeMonnier, Europe’s lunar station in Mare Serenitatis, and Magellan Station in Venus orbit.

“Good morning, Will,” he began. I want your advice about establishing a civil authority here on Mercury. We’re about the same size as Mars when you passed the

Aurorae Declaration; Concord now has 24 people and one couple will have a baby in three months. Oxana and I are leaning toward making a long-term commitment to this place as well; we'll probably have our two fertilized embryos shipped here on the next flight and if so, we'll be parents of twins in about two years. Others are thinking seriously about starting families here as well.

"We're very optimistic about our future. I doubt we'll catch up to Mars, but if we stay fifteen years behind you, we'll do well! The science here is unlimited, water and gasses are abundant at the poles, solar energy is limitless, and robotic technology is conquering many of the limitations that high heat and solar radiation impose on human exploration. We completed the 'Interpolar Trail' a few months ago by robotic bulldozer and a crew drove the whole thing—during nightspan with night vision equipment—so we can now access the South Pole. There's talk of clearing an Equatorial Trail because three months ago we discovered a fantastic gold deposit on the edge of Caloris. If it's as large as we think, we may be able to mine it profitably and set up quarters in the mine, so we may have a human station near the equator pretty soon as well.

"The gold discovery was timed perfectly; in the last year we've received four solar sailers with 120 tonnes of cargo, which have absolutely revolutionized our situation. We have a sailer permanently stationed in orbit to haul fuel and cargo from low Mercury orbit to Portal Station at L2. We haven't opened land for sale to individuals and companies yet, though I'm hoping we'll do that this year.

"Looking forward to your ideas. Bye."

Will pondered the request a minute or so, then hit reply. "Greetings, Olaf. I suppose if there's one suggestion I'd make, it's that whatever declaration or Basic Law

the Mercurians set up should anticipating both local and planetary authority. Don't define the boundaries of a 'Concord Borough' yet. Declare everyone residents of Concord Station and give its civil authority jurisdiction over the entire planet until such time that other stations are established and a 'Mercury Council' is needed. That will smooth that transition.

"Beyond that, it's not clear where Mars is going, so I'm not sure I can advise. Mars and Mercury will be dependent on Earth economically for a long time. On the other hand, there are plenty of poor nations on the Earth that exist partly on foreign aid. Nauru only has a few thousand citizens; Mars will exceed its population in a decade or two. So we may be looking at something resembling sovereignty in our lifetime. That's hard to believe, but it's possible.

"I'm very impressed by Mercury's progress. I gather the Caloris gold will be very hard to mine profitably, but the deposit is rich and your transport costs are coming down impressively. I look forward to establishing a regular exchange with you, just like I had with Patrice. Call any time. Bye."

Will sent the message and pulled up the agenda of the meeting, then headed to the Council room. Huma Mubarak, the only flesh-and-blood secretary on Mars, was in the room setting up the conference call that would bring in several people on Earth and elsewhere on Mars: Louisa Turner in Houston, Vice Commissioner for Public Relations; Pierre Messier in Paris, the Vice Commissioner for Terrestrial Operations; Pete Theodoulos, Vice Commissioner for Terrestrial Space Operations; and Emily Scoville-Rahmani, Commander of Cassini Outpost. The three folks from Earth would have limited participation because of the thirteen-minute communications delay that sol.

The Mars members were slowly arriving: Alexandra Lescov, Director of Construction; Yevgeny Lescov, Director of Mars Space Operations and Exports; Lisa Kok, Director of Environmental Management; Érico Lopes, Lieutenant Governor of Mars and in charge of the university, hospital, security, and air and surface transportation; Yuri Severin, their newly arrived Director of the Emergency Corps; Rachel Evans, their new Director of Safety; and Roger Anderson, Director of the Exploration Corps.

"Good sol to everyone," Will said, when the images of all four people were on screen and all six staffers had arrived. "We've now received half our arrivals and the tourists are mostly done with their surface tour. Everything seems to be going well. Roger, your people ferried the tourists around Big Dusty; how did it go?"

"The comments were overwhelmingly positive," replied Roger. "We move them eight at a time with three support staff, which didn't overtax accommodations anywhere. It was a bit rough on North Pole Station, which had to remove half of their personnel, but they got paid handsomely for it. Our two Sunwing-Es were very busy, but not excessively. The big complaint was lack of a visit to Deimos."

"Safety," replied Yuri. "Deimos will require considerable development or the tourists will have to be trained first."

It is a serious problem," said Rachel, frowning at Yuri for his intrusion into her area of responsibility.

"I've already started exploring solutions for the safety issues," added Yuri.

"How much investment did we get from the tourists?" asked Roger.

"At least seventy million redbacks," replied Will. "Mr. Liu is still considering a two hundred fifty million redback investment in gold production at Tithonium."

"Maybe we should give businessmen a tourist discount," quipped Alexandra.

"We should consider a retroactive discount for investors. Let's make a note of that." He glanced at his tablet; his automated secretary had already captured the idea. "Alexandra, what's the housing situation?"

"The major problems are over. Most plumbing and electrical problems were resolved the first week. We had enough basic furniture and the special order stuff will be finished later this week. Everyone painted or wallpapered their own spaces with little assistance from us. We now have the additional staff to make sure the remaining arrivals face a better situation. Next columbiad, we need to make it clear that everyone will get a basic space painted off-white and no furniture. They can buy everything ahead of time over the web or on the sol they arrive and put it together themselves."

"The 'crisis' was overblown," insisted Lisa. "It was a crisis of expectations."

"I'm not so sure," replied Will. "We did not do what we promised, and we still don't have all the work spaces set up. How will this impact construction?"

"It won't significantly," replied Alexandra. "We don't need more residential domes, even with 500 coming."

"What about the plans for building places of worship?"

Alexandra shook her head. "Will, I think you have to get involved because they'll appeal my rejection anyway. All the plans are grandiose; they want buildings to seat a thousand worshippers when there won't be need for such buildings for a decade or more. The only practical plan is the Nigerians' and they're doing most of the construction themselves. The Mormon temple's design is the most advanced, but even they won't have the plans finalized for a year."

“How many places of worship can you build per year?”

“I don’t want to build any! With all our shortages, it’s a waste of resources. I don’t care if the Mormons or Bahá'ís or Catholics can shell out twenty million redbacks.”

“Alexandra, we have a secular society, but it is not opposed to religion. We support the arts because they add to this place in an intangible way. Not everything here has to serve functional or scientific purposes.”

“I agree, but there’s a big difference between shelling out a million redbacks a year to support the arts and expending one hundred million redbacks to build six places of worship. In a few years we’ll be in a much better position to build places of worship. Meanwhile, there’s plenty of space that can be used for worship and religious classes part time. I wish these religious communities, which speak about love and tolerance so much, would overcome their differences enough to share facilities!”

“Here, here,” agreed Lisa.

Will looked at Roger. “Maybe we had better talk to the religious communities.”

Roger nodded. “Alright.” He was the other active religionist in the group.

“My bigger concern is the possibility of privatizing construction; that could cause major disruptions,” added Alexandra.

“The same would be true for agriculture,” added Lisa.

“Then let me lay some matters to rest,” replied Will, irritated. “We already have privatized agriculture. The Zen monastery is farming their dome and the Green World Community sells their produce to Deseret. Aurorae has ten hectares of farmland that the Commission owns and we have no one proposing to buy and farm it. If someone wanted to buy it, we’d have to see what was reasonable. I doubt that the Commission will be in

the business of agriculture in fifty years, but we are now. As for construction, the Nigerians are already building their own church and the Zen monastery built its own facilities, with their own and Nigerian labor. So construction has also been privatized. If someone wants to build housing and work space, we'd accommodate them if we could. No one has come forward to do that, yet. The Commission won't be in the construction business in fifty years, either. We may even have sold our caravel-building effort to Boeing or Airbus. Who knows." There was a moment of silence in the room.

"Sometimes I think you're set to dismantle the Commission, Will," said Yevgeny.

"Well, in a sense I am. The Earth doesn't have an Earth Commission. Virginia no longer has a Virginia Company, Massachusetts a Massachusetts Bay Company, India an East India Company. The Mars Commission is a vehicle to take Mars to its destiny, which is to become a nation in its own right and a member of the United Nations. And we have the potential to become another United States or China: a large, populous nation, one that can help lead humanity to whatever destiny it has. I don't know when we will become a nation or when we'll become a big nation. The latter is centuries in the future but the former may be just decades. Many South American nations achieved independence with governing populations of a few thousand. We'll never become the fifty-first state of the United States or an overseas department of France; we're too isolated."

"You've always had a utopian streak, Will," commented Roger.

"Roger, this is not utopianism. I have a young man in my house who is a citizen of both the United States and of Europe but has no idea what that means. He doesn't have an American or a European identity; he's a Marsian. Sammie's 16 and is the same. Érico,

Corazon's 14 and Paolo's 9; are they half Brazilian and half Spanish, or something else? Alexandra and Yevgeny, Boris is six; will he think of himself as Russian in another decade? Lisa, Anna's 13; what is her national identity? Emily, will your Amina think of herself as half British and half Malaysian? We have 166 children here and the number roughly doubles every columbiad. We owe it to them to create a Marsian national identity."

"But this world won't be self-sufficient for some time; maybe a century," noted Yevgeny. "That's the reality, Will."

"And it is the reality of dozens of nations on Earth that they are dependent on foreign aid. The United States developed in the nineteenth century as an independent nation with extensive private European investment. We're moving along a similar path. The Commission will have a role in this place for some time; decades. But that role is destined to change as Marsian institutions and the Marsian economy develop and mature. That's the vision that's been forming in my mind over the last four or five years."

"You're describing a situation those of us who don't live at Aurorae are already familiar with," exclaimed Emily. "Cassini, Dawes, Meridiani, and Thymiamata are all dominated by businesses, not by the Commission."

"Your argument makes sense, Will," said Yevgeny, who had been listening carefully. "We'll still need astronauts; but that's our Exploration Corps, isn't it?"

"Yes," agreed Roger. "The Exploration Corps is the source for most of the crew of the Asteroid Belt Commission, over half of the personnel that have applied for the Jupiter missions are part of our Exploration Corps, former members are on Mercury and the

moon and in Venus orbit, and many of the astronauts working on the moon have applied to come here."

"The space program within a space program," agreed Will. "Mark my words: the first humans who go to Alpha Centauri will be Marsians. The nations of the Earth are mired in domestic troubles, pension funds that can't cover retirements, huge prison systems, and social welfare. We're building a society with a young, highly educated, highly motivated workforce that will have a low crime rate, a low need for welfare, and whose retirement pensions can be covered by the vastly larger, young, immigrant workforce. Our people will have vast experience with space exploration. We can and will have reasons to put a large fraction of our economic output into space exploration. In fifty years we will be leading humanity's expansion into space, and that will fire up young idealists, stimulate immigration and further investment. That's my vision of our future."

The room was silent. "But we have a long way to go," said Érico. "Right now we cover only one third of the expenses of Mars through exports. We can't expand gold production much more, which means we can't afford to double our population very many more times."

"We need a task force to look into that problem," suggested Yevgeny.

"Make it so, Yevgeny," said Will. "You're the expert on exports. We have a new economist up here, Dr. Hun-jai Park, and Silvio has a lot of practical experience. Put together a team and write a report."

"Okay. It'll take a few months."

Will nodded. “We should probably get back to the agenda. We have video reports from Pete and Pierre. Let’s listen to them and email them questions.” Will reached down to the screen of his tablet and pushed an icon.

Pete Theodoulos appeared on the large wall screen. “Good morning everyone. In the last month I’ve spent a lot of time with representatives of Lufthansa Space Express, United Spacelines, a new company called Rocketways that offers cheap flights to low earth orbit, the Lunar Commission, the Gateway Task Force, and others. We’ve been charting ways to expand passenger transport between Earth and Mars without overtaxing facilities or causing bankruptcies. The result is an agreement that Lufthansa and United will each fly one caravel, leaving Earth four to five months before opposition, reaching Mars after 150 Earth days. After a thirty-sol stay here, the caravels will return to Earth via the inner solar system. Each caravel will accommodate twenty tourists in first class and 110 passengers in economy class at a cost of five million redbacks per person in the latter and eight million in first class.

“We’ll fly two caravels to Earth 220 days before opposition, arriving there 70 days before, and departing for Mars on a 150-day trajectory 40 days before opposition. Arrivals will be spaced out over at least two months. We can fly people to Mars for 3.5 million redbacks each, assuming we pack 150 people into each ship, including 15 berths on each for ‘shore leave’ people. These prices should slowly decline over the next few columbiads.

“This means the twelfth columbiad will see 520 arrivals, including fifty returning shore leavers, for a total of 490 new people. Our two caravels will be based on Phobos and Deimos and will serve as additional accommodation there between flights. In future

columbiads we will add more flights at other times. We estimate that if we had five groups of three caravels each arriving four weeks apart, our current fleet of Mars shuttles would require only a modest expansion to deorbit about 2,000 arrivals per columbiad. Cargo would arrive mostly via solar sailer spread out over the entire columbiad, so that the demand on the shuttles is constant. At our current rate of expansion, we could reach 2,000 arrivals per columbiad in four or five columbiads.

"Finally, our negotiations with the Venus-Mercury Commission have borne fruit. They will soon make a decision whether to purchase three caravels, one permanently stationed in Venus orbit, one arriving, and one departing every nineteen months. This will allow expansion of Magellan Station to about fifty personnel and a significant expansion of Venus surface exploration. Once that purchase is complete—they'd buy one per year—they will consider purchasing two more for the Mercury run, which would allow expansion of Concord Station to one hundred people and exploitation of the gold deposits at Caloris. We should hear from them in a month or two. Back to you."

The screen went blank. Will shifted back to the conference call arrangement with the screen split four ways. "Good news."

"Question," said Emily. "If the Mars-bound caravels arrive at Gateway a month before their departure, how will we ever get everyone up to them in such a short time?"

"Gateway will be expanded to hold some people for a week or two before the caravels arrive from Mars," replied Will. "The Lunar Commission has agreed that we can fly up to one hundred fifty personnel to the moon up to six months in advance, where they will complete their training by running Peary and LeMonnier. The round trip

between the moon and Gateway is three days, as opposed to seven between low earth orbit and Gateway, so it'll be easier to get people on board from the moon."

"How much will that cost?"

"It will cost us, but the Lunar Commission has to fly staff to the moon every six months and pay them, and they'll split some of those costs with us. We've also agreed to purchase all the tourist hotel beds on the moon for the two months before trans-Mars injection. That means we can fill the lunar tourist flights; we'll do some training at Peary. As soon as our people leave the Lunar Commission will launch replacement personnel, then tourists two weeks later."

"We need the caravel contract," said Alexandra. "We've finally grown large enough to accommodate both caravel construction and housing and dome construction."

"We have to be much more careful about dome construction and maintaining a reserve of space for safety, which means cutting back on caravel production if necessary," said Yuri. "That's my job."

"We can maintain higher standards and the schedule; we got almost two hundred more construction specialists this time," said Alexandra. "Construction's been growing faster than any other segment up here for the last four columbiads, and that will continue for some time."

"But can you handle 470 new arrivals in twenty-six months, maybe 600 a columbiad later, then perhaps 820?" asked Will.

Alexandra scowled. "When I arrived here this place had thirty people, and now we have almost a thousand. Back then I would have had no idea how to get where we are this sol. Your language implies a lack of confidence and I don't appreciate it."

There was silence in the room for a moment, then Will nodded. “You’re right, I apologize. I’ve been expressing the same frustration about the construction problems that many others have expressed. But I need to remember the big picture—you’ve very skillfully brought us to where we are this sol, and we have a magnificent facility.”

“Whenever expansion runs close to fifty percent per columbiad, there will be problems,” she added, more calmly. “If the growth rate is reduced to thirty percent, we’d handle it much better.”

“People have been calling for a slower growth rate for some time,” added Yevgeny.

“Maybe we can slow it down,” agreed Will. “But there’s also the question of cutting back on terrestrial support, which means moving some of those jobs here. That’s Pierre’s report, so let’s hear it.” Will pushed a button and the screen changed again.

“This is only a preliminary report; we need to do much more research,” began Pierre. “Twenty-two years ago, when Columbus 1 was about to depart for Mars, Project Columbus had a very large, essential, support staff scattered among the participating nations to strengthen political support and financial investment in the project. Since then, some support centers have grown and others have shrunk. Shuttle support has shifted to the moon and Gateway. Ground support teams for rangers, conestogas, mobilhabs, and pressure suits are the employees of the companies that do the manufacturing at the lowest price. Seville does extensive space-related agricultural research, but increasingly it can be done at least as well on Mars, the moon, Mercury, and the asteroids. Many of the personnel at Seville would come to Mars if their families could accompany them. That is true of Moscow as well, though the Center there is doing more and more work to support

the use of domes in cold climates on Earth, which are increasingly popular. Houston's role as mission control is becoming obsolete as Aurorae takes over that responsibility.

"Support centers elsewhere have proliferated in the last fifteen years as more nations have joined the Commission. The price of Brazilian, Indian, even New Zealand participation has been the establishment of a support center in those countries. We now have fourteen new support centers. They do outreach to the local population, support small Mars museums, and do some Mars-related research. We would get much better value for our money if these centers were shrunk to support their public relations function, the museums were more self-supporting, and the research done at the centers were moved to Mars or contracted to universities. National subsidies should be used to purchase local products that are needed on Mars, not to pay for support centers.

"The long-term projections of petroleum supply and demand suggest that an era of very high petroleum prices has begun. Khaliestan's revolution has pushed prices up impossibly high; they will decline. But world production peaked in 2049 and prices started up before the revolution. The transition to solar, wind, and nuclear power, which has been underway for decades, will take several decades more and may cause severe economic disruption. Government support for space exploration as a percentage of economic output has been declining and will probably continue downward. So the Commission has to look increasingly toward economic resources on Mars and in space and to commercial investments to continue its work. Back to you."

The screen returned to its four-fold division. "Thanks, Pierre. None of us had any idea your report would relate to the discussion, which has taken some unexpected turns."

“So, there’s fat to cut on Earth, if we can afford to move the personnel and some family members here,” said Alexandra. “But it costs a lot more to support a worker here than on Earth.”

“Yes and no,” replied Yevgeny. “We pay a worker more here, but all the salary on Earth goes into the terrestrial economy; here, when they buy a flat, they pay for the construction team and when they buy food they pay for the domes and agriculture.”

“And we still have a poor knowledge of the Marsian economy,” added Will. “Now that we have an economist up here, we need to get him busy studying it.”

“I have a concern,” exclaimed Érico. “Right now, we recruit our Mars personnel from among our terrestrial support staff. But as we get larger here and the support staff on Earth shrinks, we’ll have recruitment and training problems.”

“We’re working on that,” replied Will. “We’ll do more training on Earth, the moon, the flight out, and after they arrive here. We also plan to do a lot more university recruitment.”

“Support the university Mars Clubs,” said Érico. “They’re a great investment. We should expand the Mars camps for high school students.”

“We’ll make a note of that,” agreed Will, nodding. “I see comments are now arriving from Earth, so let’s hear them.” He pushed some buttons on screen.

Pierre Messier spoke first. He cautioned against shrinking terrestrial support too quickly or precipitously, noting that it could threaten some essential research and impact on safety. Pete Theodoulous reinforced him with concerns about cutting back on mission control in Houston, which supported their work at Gateway. Yuri agreed and emphasized safety concerns.

After forty-five minutes of further discussion of cutbacks on Earth necessitated by the current fiscal crisis, they listened to Louisa Turner's report on public relations. The tourists had generated a lot of human-interest stories; she urged the idea of a contest to give away one tourist berth to a young Mars supporter. They discussed the matter further and made assignments.

"What else do we have to discuss?" Will asked in conclusion.

"I'm concerned about several things," said Lisa. "Privatization and devolution will change the way things are run here in significant ways. I'm not a politician, so I have no plans to put myself forward to the public. If Environmental Management is moved from the Commission to Aurorae Borough, I'm concerned that the environment will cease to be a majority Commission concern. Frankly, I am far less comfortable about these changes than I have previously indicated. And I've felt helpless to do anything about them."

"Thanks for saying something; let's address the problem in a reasonable way," said Will. "First, you have the most difficult situation because you will retain responsibility over Aurorae's environment and as such be an employee of the borough; will continue to be responsible for bioarchive and ecological research and thus be a Commission employee; and will have concerns about the overall safety and efficiency of the ecosystems that keep all of us healthy, and thus will have responsibilities to the Commonwealth through Rachel. The only way that complicated situation will work is if the Commission and Commonwealth Authority work together closely. If they become competing or opposing power centers, it could be a disaster. Environmental Management here could compete against the Seville support center, for example, or it could be

neglected. Working closely together means a lot of joint meetings." Will looked around. "What else? Are we finished? I guess so. Thanks, everyone. Pierre, Peter, and Louisa, if you have anything else for us, it'll be emailed to everyone for discussion." He reached down and pushed a button, ending the line to Earth and Cassini.

The others around the table rose, except Érico. "I have one concern to voice quickly," he said. "This revolution you're leading, Will; will Pierre and Peter support it? It will drastically contract their roles."

"I'm not altogether sure how much you all support it! No, that's not fair; I think everyone was frank, and that's the way it has to be. We have to trust Pierre and Pete, but we also have to make this change palatable to them and to everyone else. Pierre would really like to come here, but he has children. Maybe they can fly here with him in a few columbiads. Peter Theodoulos has been here already and can come here any time, but he's ambitious; he wants to be head of the Lunar Commission or the Mars Commission some sol. And maybe he will be. The governments will require a lot of lobbying; it won't just be a question of pledging that any money given by them is spent in their economies. Right now they're getting patents, scientific publications, and prestige. We'll need to build up our publicity of discoveries and inventions made here by their citizens."

"In short, it'll be an uphill battle," said Alexandra.

"Well, it won't be our first," replied Will.

5

Temple Site

late April 2057

The air inside Punjab Dome was chilly on Will's bare hands, even though the sun was overhead. The visor of his respiration helmet was slightly fogged; it was irritating and he didn't feel like holding his breath long enough to take it off and clear it. He looked down the two-hundred-meter length of the space, which was covered by regularly spaced "haystacks" of dirt. Then he turned and watched the crews installing metal forms for the concrete walls along both sides. Where there were no forms, he could see the tops of the thirty-meter long nickel-steel pilings that had been driven diagonally into the Martian ground every half meter like giant tent stakes, angled toward the center of the dome so that the weight of the enclosed dirt would help hold the dome down. The interior pressure already exerted one hundred tonnes per meter of upward force. The piles locked together underground, forming a barrier that slowed leaked air. A second set of nickel-steel piles just outside the first were angled outward. The double palisade of pilings had been frozen into the ground by injecting steam into the regolith through the piling's hollow cores. Then Kevlar cords that ran through the dome had been placed into the hollow cores of the pilings and permanently anchored into place with concrete. Finally, the top five meters of piles had been welded together by robotic welding units to render their joins air tight.

Punjab had been pressurized with Martian air last week. Huge compressors worked continually to maintain pressure because the warmed air seeped into the ground under the dome and gradually worked its way down and out. This was not altogether bad;

it warmed the subsurface so that when they added water it would freeze several meters below the surface, forming an airtight ice table with a water table above it.

Will walked to the northern "downhill" end of Punjab. There he walked around a "haystack" of coarse sand, which would soon be spread out on the ground to form a water-permeable layer. He laboriously climbed to the top of a haystack of future agricultural soil, a careful mix of sand and clay-size particles, washed of their salt and ready to be spread and have organic matter and fertilizer added. From the top he could see beyond the three-meter high nickel-steel perimeter wall.

West of the dome margin he could see pressure-suited teams placing a plastic pressure skirt over the fifty meters of ground between Punjab and the next dome, Zanzibar, and burying it under a meter of reg. The skirt would capture any escaping oxygen so it could be channeled back into the domes. Remotely controlled excavators were excavating two routes for standard five-meter tunnels between the domes. At the edge of the far side of the skirt zone, four automated pile drivers fifty meters high were forcing pairs of piles into the ground to hold down the eastern edge of Zanzibar; their pounding was just barely audible through the thin Martian atmosphere. A man ran four steam injectors above four nickel-steel piles that had reached their final position. Robotic earth-moving equipment was excavating a hole two hundred meters long, seventy meters wide, and three meters deep, where the interior of Zanzibar Dome would be located in eighteen months' time. A twenty-meter tall dirt sifter was processing all the regolith removed by the excavators, sorting it by size, crushing some size fractions, separating it magnetically to recover meteoritic nickel-iron, then pouring each separated fraction into

its own neat heap for future use in Zanzibar, making heaps just like the one Will had climbed.

He could also see a bit into the next dome north of them, “Punjab North,” which was seventy meters long and wide. It was destined to serve as a buffer on the north side, protecting Punjab from depressurization. In a few years much of Punjab’s topsoil would be removed and the dome converted to housing, but Punjab North would remain agricultural.

He turned around and walked to the southern end of Punjab, trying to picture the place in a few years, first filled with rice paddies to stop air leaks and improve the soil, then other agriculture, then apartments and work spaces. The western side, facing the future Zanzibar Dome, had metal doors blocking the two future pressure tunnels installed and ready for use.

At the southern end he glanced at the foundations for Punjab South, which was to be another agricultural dome. He turned to head back to the pressure tunnel and airlocks leading to Cathay when he saw Alexandra Lescov approaching him.

“I heard you’re visiting,” she said. “I’m supervising the work in here this morning. Any questions?”

“No. It looks good. When do you plan to flood the place?”

“Two or three weeks. The Martian air has to thaw the ground another meter at least. We waited way too long with Cathay.”

“I see you’ve started on the first construction in Cathay.”

“Yes, three sols ago, and the excavations down four meters did not hit frozen ground or water, so we established a very deep water and ice table. We’ll house three

hundred people there in 2059. By the way, did you hear that Roger has finally brought about a compromise among the Christian groups about a church?"

"No! How did he do that?"

"He sent me an email at 6 a.m. this morning, just before he left for Pronilus Mensae for two months. I guess he worked on them until midnight after almost three weeks of on-again, off-again discussions. I was surprised he didn't copy the email to you; maybe he forgot because he was so tired. The Universal Church of Jesus Christ and the Creator will build the large church they have already started, but they will build a temporary wall across the middle of the space—their sanctuary is long. The Catholics will rent the rear half from them and will even construct a façade of their own design on the far end. This creates two sanctuaries, each able to seat about 200 people. The Protestants will rent space from either group, depending on worship schedules; the Universal Church meets pretty much all Sunsol morning while the Catholics hold mass Satursol night. The two stories of basement will have classrooms for children and adult religious education and they will be shared as well."

"That should work pretty well. No one gets even 100 worshippers on Sunsol. There are already three Protestant groups, too; two could fit in the adult education spaces. Only one is large enough to use an entire sanctuary. What about the Mormons?"

"I told Henry Smith they wouldn't get anything built by us this columbiad; resources are just too tight. He was pretty upset and pointed out that last columbiad, Deseret was housed in a tent for over two years because we were unable to build anything for the store. I suggested he set up the tent as a temple. He wasn't amused."

"No, I can imagine."

“What about the Bahá'ís?”

“The Spiritual Assembly met three nights ago and after some sad but not resentful consultation decided to request that construction begin before April 2060.”

“That’s over three years. I suspect we can handle that.” Alexandra smiled. “Did I ever tell you about my visit to the Bahá'í House of Worship outside New Delhi? It was so beautiful; I was immensely impressed. Even though there were a thousand tourists wandering around, there was a sense of peace I’ll never forget. I’d like to see something like that built here.”

“It would take a pretty big dome! We want something more modest for now. I once visited the temple site outside Moscow for prayers with the Russian Bahá'ís. It was beautifully landscaped. It had a sense of peace as well.”

“I didn’t know you could pray outside; I’ve always associated religions with buildings!”

“Oh, many religions pray outside. Bahá'ís all over the world pray at temple sites or even in city parks sometimes.”

“Then maybe the Aurorae Bahá'ís should start by purchasing a dome, landscape the interior and build something in it later. I’d like that, actually; I’d really like a peaceful place. The agricultural domes are too practical, the bioarchive domes are too hard to enter and leave, and the public spaces are too crowded.”

Will smiled. “You know, that’s a great idea!”

Alexandra pointed. “I know the perfect spot. Andalus Southwest. It’s a seventy-meter buffer dome. The excavations for it will be finished next month and the dome is scheduled for installation in six months. Andalus Southeast will be next to it and

will be built at the same time. Both are zoned for agriculture or bioarchive, but that just means no permanent residents. The space between them and other domes will be zoned for underground housing. I recommend southwest because it overlooks the notch."

"How much will it cost?"

"Five million redbacks."

"We probably can afford that," said Will. "That's a great suggestion! Thanks, Alexandra!"

The idea of a "Bahá'í garden" spread around the Bahá'í community fairly quickly and was the subject of many informal conversations. Paul Nuri was a particularly big fan.

"Will, what do you think of the idea of a sort of 'living temple'?" he asked one sol over lunch. "We could pour a concrete floor in the center of the dome about thirty meters across and plant flowering hedges and bushes all the way around to form the walls. The dome itself would serve as the roof."

Will chewed his sandwich and considered. "That'd be cheap and innovative, and 'Marsian,' but we still need an auditorium and some classrooms."

"Well, then dig a foundation, build a basement, and set the 'living temple' on top."

"That's possible, I suppose. We could even set it up temporarily and build the walls and roof of a permanent temple inside the hedges later."

"Yes, I suppose that's possible," said Paul, not so pleased with the suggestion. "Grandma's very excited, by the way."

"I know, she's called me twice about it! She's calling everyone she knows."

"It's too bad we can't use it for the interfaith services we already hold," said Ethel.

"Why not?" asked Marshall, who was looking across the Gallerie at Corazon Lopes. She in turn was glancing at him and smiling.

"We could pray together, but we couldn't have a sermon or instrumental music. You can't include them in worship in a temple."

"But at least we can get something quickly and cheaply, and if we can maintain the gardens, it can look beautiful as well," said Will. "So, Paul, how's work?"

"We're setting up two geochem labs for new equipment that arrives next month, one for studying mantle inclusions, the other for studying fossil gas bubbles in polar ice cores. Unfortunately, they need me for the latter." He sighed.

"The new equipment can measure CO_2, CO, nitrogen, methane, sulfur gases, and oxygen levels to the parts per trillion range," said Will. "We should be able to reconstruct pressure and composition of the atmosphere back millions of years."

"Oh, farther!" exclaimed Paul. "Stanfield now thinks we can develop techniques that will work even on Noachian polar sediments. We should be able to reconstruct the atmosphere's history almost back to the beginning, especially if we analyze isotopes caused by cosmic rays hitting the dust particles. The sulfates and sulfides will tell us volcanicity and water vapor content as well. And now the folks at Concord want the same equipment to measure sulfate deposits in the Mercurian ice deposits in order to reconstruct Mercury's varying levels of volcanic activity. Of course, I'd rather be reconstructing the geochemical evolution of the outer mantle. I'll probably get the chance to do that some time as well."

Just then Corazon rose from her chair, looked at Marshall, raised her empty glass, then headed toward Deseret cafeteria. Marshall immediately looked at his empty glass, stood, and went to get a drink as well. They talked for a minute next to the fountain.

"So, when did he start to like her?" Will said to Ethel, surprised.

"She saw the Brown University t-shirt and called him 'college man,'" replied Paul. "That did it."

"So, that's why he's been wearing his two college t-shirts almost every sol for a week," said Ethel.

"It's not because I gave them to him!" replied Paul, smiling.

Marshall returned to the table with a half-full glass of milk. "So, Corazon ain't so bad after all," Will said.

Marshall looked at his dad. "I never said she was bad."

"And she likes college t-shirts," added Ethel.

"Yeah," agreed Marshall, trying not to look engaged in the question, but he glanced at Paul. "We're taking the same literature course and were talking about the novel we're reading right now."

"You should study it together; you'll learn more that way," said Paul.

"I suggested that to her."

"I studied with high school girlfriends, too," said Will. "The trick is to focus on the book and not talk about a hundred things." He glanced at his watch. "I'd better go, I have a very busy afternoon. I have to make a dozen calls to Earth and hope to get some responses, all while I drive to the Zen monastery and deal with problems. The dozen Japanese arrivals have all relocated there."

“Are they upset with conditions here?” asked Ethel.

“That isn’t clear. The plan all along was to build a Japanese development up there; the monastery ordered the dome and building bubbles early, so they’ll be available in a few months. Services like transportation to Aurorae eight times a sol were scheduled to start soon thereafter. But when housing conditions were substandard last month, the monks took in six of them, then the other six moved in as well. Now they all plan to stay, which means they want the housing and transportation started sooner, which is just about impossible because the vans for the transportation system haven’t arrived. So I anticipate drinking a lot of green tea and I hope to arrange a compromise.”

“Thank goodness it’s relatively easy to sit crosslegged in front of a low table in Martian gravity,” quipped Ethel. She glanced at her watch. “Since you’re leaving the table a bit early, this is the chance for Lizzie and me to find a wedding present for Mariella and Naoto at Silvio’s. He got a small but impressive array of goods last month.”

“He told me he’s making a huge profit on fancy women’s lingerie,” said Will.

“Well, we won’t buy them a skimpy lace bra and negligé for the honeymoon!” replied Ethel.

6

The Park Report

late May 2057

Early February saw the arrival of the first automated cargo vehicle with forty tonnes of medical supplies, badly needed spare parts, and high-priced consumer goods that were profitable after covering extra fuel costs. An unmanned Mars shuttle rendezvoused with the ACV at Embarcadero, docked to its cargo module, and transferred to it a cargo module destined for Earth: gold, platinum-group metals, argon, nitrogen destined for the moon, methane, deuterium, scientific samples, and fossiliferous rocks for sale to the public. The Embarcadero crew refueled the shuttle and it descended to Aurorae. Then a hippogryph propulsion module filled with liquid oxygen and methane from Phobos pushed the ACV and forty-tonnes of cargo into an interplanetary orbit that would intersect the Earth's atmosphere in twelve months.

A week later an empty water transport aerobraked into Mars orbit. The Embarcadero crew was ready with one hundred twenty tonnes of water from Phobos and Deimos, which was soon on its way to Earth. Embarcadero's sixteen crew had constant work for the next six months. Every week something arrived: an ACV, a water transporter, a hippogryph, a shuttle, or a solar thermal tug bearing water, liquid oxygen, or liquid methane from the moons. Two refurbished Mars shuttles aerobraked from Earth bearing cargo. By mid July, 800 tonnes of cargo would have arrived from Earth and 1,000 tonnes—half water—would have been sent back. Then the positions of the planets would be unfavorable for almost two years.

The 900 residents of Mars were busy in hundreds of different ways. The arrival of new people always meant a review of safety procedures and the inauguration of new safety rules. Domes practiced depressurization emergencies. The arrivals had to practice dozens of things, from working outside to repairing life support equipment. Many people planned their next twenty-six months, negotiating with different departments to set up schedules when they would work in construction or agriculture or participate in a scientific expedition. The alternation of duties made life more interesting and allowed people to accumulate certifications, which were necessary if they wanted to apply for the Exploration Corps or for a mission to an asteroid, Venus, Mercury, or the greatest of prizes: a future mission to Jupiter, which was still at least six or eight years away.

By late May the arrivals had been on Mars one to three months and things were settling into a routine. Thoughts were turning toward the elections in early June. "I'm amazed the Commission will devolve so much authority to Marsian elected institutions," Kristoff said to Sebastian one sol in late May. They were eating supper with Yuri Severin. "In a few weeks we'll elect a borough council *and* a Mars Council!"

"It strikes me as a lot of bother," said Yuri. "I guess I'm used to the moon."

"If it weren't for the isolation, the lunar model would work here as well," said Sebastian. "The moon has a highly transient population and no children. But there are pressures on the Lunar Commission to be more responsive; landowners want a voice and many people want funding for sports and the arts, especially dance. It's inevitable that the moon will have a Landowner's Assembly. The thousand or so semi-residents who want a voice can buy a piece of land."

“Isn’t it rather strange that big corporations have a vote here, though?” asked Kristoff.

“They’ve invested billions,” replied Yuri.

“And the Landowners Assembly has less authority than the Residents Council,” added Sebastian. “The Commissioner will nominate the Chief Minister; the Residents Council and the Landowners Assembly approve. The Chief Minister nominates judges and ministers to run the government departments; the Council approves them, but not the Assembly. The Council can originate spending bills, but not the Assembly.”

“How many members?” asked Kristoff.

“The Council currently has eleven, but the election will be for thirteen. Each borough gets one representative per hundred representatives; Aurorae goes from six to seven and Cassini from one to two. Dawes, Meridiani, Thymiamata, and Aram have one each; they have between 25 and 50 residents.”

“And the Council for the Borough of Aurorae goes from five to seven?” asked Yuri.

Sebastian nodded. “Yes; boroughs elect three officers—a clerk, chair, and treasurer—then two representatives when the population exceeds one hundred, two more when the population tops 500, two more when it exceeds a thousand, and two more each per two thousand residents until a maximum of 15 is reached. That’s not specified in the Fundamental Law—the Constitution—that’s legislation, which makes it easier to change later if we get much larger settlements.”

“And the clerk will now actually do something,” said Kristoff. “That should make the election interesting.”

"I wouldn't say the clerk does nothing now," replied Sebastian. "He's in charge of the school system and security. But on July 1 when the new officials take office, the Clerk will also be in charge of environmental management and the position of Commander of Aurorae Outpost will be abolished. The Chair's role will be ceremonial, unless the clerk has a heart attack."

"The creation of the position of Chief Minister is much more exciting and important," said Yuri.

"Yes," agreed Sebastian. "When the Mars Commonwealth Authority started, it could authorize the sale of land or its sequestration into natural parks. Then it acquired authority to encourage arts and culture, then last annum it acquired authority over health care. Then after the dome leak at Aram, the Commission appointed an accident commission and it recommended an expansion of Commonwealth authority, especially over safety and emergency management, and recommended that the Commissioner not serve as Governor as well."

"I'm amazed Will agreed," exclaimed Yuri.

"He's very detached about power," agreed Sebastian. "The decision to create an independent Asteroid Belt Commission was his idea. He pushed the strengthening of the Commonwealth in spite of government opposition."

"It weakens their role," said Kristoff. "What does the Commission have left?"

"Spaceports, Phobos and Deimos, interplanetary transportation, all mineral rights, and a veto in many Commonwealth decisions," replied Sebastian. "The Commonwealth basically runs the planet, but cannot have a foreign policy. Phobos and Deimos will go to

the Commonwealth eventually, I'm sure, and mineral rights, and spaceports; interplanetary transportation's already being privatized and the veto will get abolished."

"Does the court actually do anything?" asked Kristoff.

"Oh, Silvio's busy," replied Sebastian. "He has already sentenced two people to 'rustication' back to Earth—both subsequently served prison time there—ordered two people to serve thirty sols of home confinement, levied a dozen fines, settled four lawsuits, and finalized eighteen divorces."

"I'm amazed."

"Getting back to Elliott, though," said Yuri. "I've only been here three months—plus a month a few years ago—but my impression is that the less authority he has, the more influence he has. Does that make sense?"

"I think you're right," agreed Sebastian. "He's a strong communicator, he listens well, he's honest, he empowers others, and he's careful not to reveal too much. He's probably going to be remembered as the George Washington of Mars."

"I'm glad no one has to run against him," said Kristoff.

"He will never run for office," added Yuri. "I get the impression he wants to retire in another five or so years."

"He seems to have a fear of campaigns," replied Sebastian. "Some of that is his Bahá'í background; they forbid campaigning or even mentioning of names in their own internal elections."

"Is that where the informal ban on electioneering comes from?" asked Yuri.

"You mean no one here campaigns?" asked Kristoff, surprised. "I was wondering why I hadn't heard anything about parties or blocks or candidates yet."

You won't either," said Sebastian. "There's quite a lively set of 'Future of Mars' web-based Forums open to residents and landowners where all sorts of ideas are debated, and next week people will be able to place posters on designated walls on Andalus Square stating their ideas. And starting Satursol afternoon there will be a 'Future of Mars' meeting in the square every week, 2-4 p.m., with a live feed on the *Mars This Sol* Multimedia site. If you want to know who to vote for, you listen to or read everyone's positions. You will see tendencies, too, toward more socialism or more capitalism; more immigration or less immigration; running behind them are issues of more consumer goods, more government services, etc."

"So, what if I stood up and announced my candidacy for the Council?" asked Kristoff.

"Go ahead and find out," replied Sebatian. "A few people will stand up and say that you are interfering with their human right to vote for anyone they want; it used to be only the Bahá'ís said that, but now a wider range of people do. Their argument is that if there are two or three public candidates, people won't vote for anyone else because they know the person won't win. They say that violates the human right to vote one's conscience. I find it a strange argument, but maybe my reaction is culturally based.

"Others will look at you and wonder whether you're really an egotistical politician. Someone else will pull you aside and say if you want votes, you don't say so, you stand up and propose some specific idea or solution and get known that way, or you do some service people hear about. But don't propose an entire platform, because that looks like a campaign, and people will wonder whether you will feel beholden to implement a platform even if it becomes clear it isn't the best thing for Mars—"

Kristoff laughed. “You mean it’s better to be vague than be specific?”

“In a way; it is better to claim expertise in a small thing than in everything. The argument makes sense: on the Earth right now, governments are elected by gigantic machines that sell influence for campaign contributions, tailor their message to get elected rather than to do what is best, and then lie about themselves and smear their opponents. It is almost impossible for the voter to determine what’s really best because of the lavishly financed professional deception.”

“That’s true,” agreed Yuri. “But surely if there are no candidates, that means anyone elected stays in office forever?”

“We have had one or two spontaneous turnovers, but it’s hard to say why. On Earth, even after candidates spend millions against each other, there isn’t much spontaneous change either. So let’s do away with the screaming and yelling, let’s do away with the selling of influence and the buying of votes, and vote based on character and expertise.”

“I suppose this means you can’t attack officials either,” said Kristoff. “But what if they’re corrupt?”

“You arrest them,” replied Yuri.

“We don’t attack scientists personally about their science, so why attack government officials; decisions and policies should be judged on their merits, not by their authors.”

“Maybe,” replied Yuri skeptically. “I suppose an informal election system is possible for a few hundred people, maybe even a few thousand, but I doubt it can last.”

"I wonder about that, too," agreed Sebastian. "People are too susceptible to corruption. But as long as Will is alive, it will be hard to introduce campaigning because he'll denounce it with all the moral force of an Old Testament Prophet."

"Interesting," said Yuri. "I have to go to work; we have a 1:30 head of staff meeting." He rose and picked up his tray. "Ciao." Sebastian and Kristoff nodded and replied in kind.

When Yuri arrived, staffers were gathering in the conference room. The report about growth was the sole item on the agenda. "I want to introduce Dr. Hun-jai Park to everyone," began Yevgeny, with a smile. A nervous Korean man, aged 32, smiled slightly. "Hun-jai has a Ph.D. in economics from M.I.T., and he taught there several years. He specializes in space economics. He was hired by the Commission three years ago and we urged him and his wife to relocate to Aurorae. We're delighted to have him here, working for the Commission and teaching at Martech. He'll give part of the report that he, Silvio DiPonte, and I put together over the last six weeks." He nodded to Hun-jai.

"Please excuse me if I look nervous, because I am. This is a dream job and I feel quite inadequate to do it."

"Oh, don't feel inadequate, Dr. Park; we're all very impressed by your credentials," replied Will.

"Thank you, Dr. Elliott, I appreciate your words of encouragement. In a way, our study has no hard conclusions, because it is too difficult to predict developments over the next seven columbiads or fifteen years—to 2072. I was speaking to Dr. Elliott a few weeks ago about our progress and he made a very interesting comment to me: that the struggle on Earth right now is a struggle to define an international order, and since no one

knows how to define it, no one has the power to force a consensus, and no one wants to change their ways, we have terrorism, war, and economic and social chaos. From a practical point of view, it produces huge uncertainties over the value of currencies, the handling of government debt, and the relations between states and regional blocs. I think the Commissioner's analysis is right, and it has huge implications for Mars. It means consensus on the Mars Commission will remain difficult to achieve and government commitments will remain unreliable; those conclusions are not in the written report.

"It also means that it is hard to put numbers on anything. The United States dollar has experienced an average of five percent inflation in the fifty-seven years since the turn of the millennium and is now worth a sixteenth as much. The euro's value has dropped twenty fold. The price of gold, which was about $300 per ounce in 2000, is now $50,000 per ounce, a twelve-fold increase after inflation is discounted. The redback's value rises and falls as well because of the fluctuation of the value of things on which it is based: its basket of currencies and the value of gold and other important exports. It currently stands at ₹1000 redbacks per ounce of gold. We will assume that the price of gold will remain at that level for the next fifteen years; problematic, but we have to assume something. Uncertainty will cause hoarding and drive up demand; prosperity will increase demand for jewelry and industrial uses and will also maintain a high price. At that remarkably high value, gold production should be able to grow to 350 tonnes per columbiad, even though the concentrations we are pursuing are lower every year. This is a big planet, and the rich and very rich lodes should be available for several decades. At that rate, equal to 34 million redbacks per tonne, and subtracting the half that goes to private companies, that's almost 6 billion redbacks per columbiad for the Commission.

"We also project exports of platinum-group metals and deuterium to average 30 million redbacks per tonne and to increase to 100 tonnes per columbiad, bringing us another $3 billion redbacks per columbiad. Demand for fossiliferous Martian rocks has dropped and its value has dropped, so we aren't even counting it in the calculations.

"The export value of argon, methane, water, hydrogen, Martian beef, and manufactured goods is largely set by launch costs. When the Space Shuttle and twentieth-century boosters were replaced by the Falcon and the first generation of twenty-first century boosters, launch costs dropped tenfold. By the time of Columbus 1 they had halved again. The Swift shuttle and its cousins have brought down launch costs five fold since then, so they are now sixty redbacks per kilogram, a hundredth what they were in 2000. We project another halving of launch costs by 2072.

"At the time of Columbus 1, transportation of cargo and personnel to the Martian surface cost four times more than the launch to low Earth orbit, but the Sunfire solar thermal engine has reduced the multiplier to two, and solar sails will reduce the multiplier for cargo to 1.5. Since Sunfires require hydrogen propellant—very expensive for us to extract here and ship to Earth orbit—we no longer supply our own launch hydrogen. Since solar sails can virtually rendezvous with Deimos and Phobos, they are by far the cheapest way to supply Earth-moon space with water and methane. Hence we should definitely expand our exports of volatiles, but at 60,000 redbacks per tonne, they will never earn us much money.

Two other major sources of income will continue: government subsidies and private investment, currently two billion and one billion redbacks per columbiad respectively. We anticipate the former to drop and the latter to grow, so we are assuming

they will continue supplying us about three billion redbacks. We are projecting equipment exports—three caravels per columbiad now—to grow from three hundred million redbacks per columbiad to about a billion. Taking all this into account, the model predicts a rise in income available to Mars from roughly 9 billion redbacks next columbiad to 13 billion in 2072."

"Wait; you mean that right now only one fifth of our income comes from governments?" asked Érico, surprised.

"It's a quarter this columbiad, but it'll drop to less than a twelfth in fifteen years," replied Park. He changed the image on the screen. "There are many ways to calculate expenses per person. The current average salary is 330,000 redbacks per columbiad per employee, but 70% of it is spent on Mars on housing, food, clothing, and other locally produced items, so that money covers the salaries of others. Personal income goes round and round. As our population grows, the percentage of personal income coming from the Commission will shrink and the amount supporting commercial employees will grow."

He changed the slide again. "Two major expenses of the Commission are support services—everything from Mission Control in Houston to physicians interpreting medical tests in New Delhi—and research and development. Both can be moved to Mars or privatized. Terrestrial support services can decline from three billion to half a billion per columbiad. You may ask why we should move someone to Mars and pay them five times as much to do the same work they could do on Earth. The answer is that they contribute to our skill pool and economy. Growing this place makes it more efficient; if we double our population, domes and buildings cost less per square meter, we can afford more sophisticated equipment and thus make more sophisticated materials, we have the space

to plant a wider range of crops, we can make more and import less per person, we can export more sophisticated and complex products, etc.

"We've developed an economic model to project the current situation into the future. The average person now costs three million redbacks to fly here, including the average of 1.5 tonnes of cargo, mostly sophisticated equipment, that must accompany them. We think that cost will halve. Maintaining them requires 300 kilograms of replacement equipment and medicines per columbiad, the cost of which will decline from 36,000 redbacks to 15,000. They also import 150 kilograms of consumables per columbiad, most of which comes out of salaries, not out of our budget. Both of these figures are averages; they're low when someone arrives and rise because of the need to replace equipment, because salaries rise with increasing seniority, and because the average settler eventually produces 0.8 children—1.6 per couple—who also need imported consumables. Our report includes a five-page appendix where the calculations are explained in great detail."

Park flashed an amusing slide showing a puzzled man. "The first obvious, intuitive conclusion is that if the cost of transport declines by about fifty percent in the next fifteen years and volume increases fifty percent, we cannot afford to increase the number of arrivals much more than three-fold. In a sense, this report could be subtitled 'The Limits to Growth.' This year, the transport and provisioning of 350 people cost about 1 billion redbacks, a small fraction of our 9 billion redback budget, but expansion requires upfront costs in new equipment and infrastructure. As the Marsian population grows, their salaries and import of necessary cargo will grow to a substantial fraction of our budget. Our current expenditures on terrestrially based research and development and

other services can be reduced sufficiently to expand transport capacity to 500 in 2059, but we will need to rethink terrestrial operations drastically to expand it to 650 by 2064, maybe to 800 in 2067 and 950 in 2071. Pete's report two months ago spoke of the possibility of 2,000 people arriving here in a few columbiads. That will be very difficult to accomplish.

"Even with an immigration of 950 per columbiad, in fifteen to seventeen years we will hit our economic limit, unless gold income increases or is supplemented by other significant sources. We figure in 2073 our population will reach about 9,000, at which point costs on Mars will grow to about four billion redbacks and the import of necessities will reach 5,000 tonnes. No one knows how we would handle a load that high without substantial investment in equipment that our high costs will prevent. Immigration at that point will have to slow. Presumably by then we will have more exports, but it's too soon to say of what.

"Mars will gradually change. The rate of population growth will drop from fifty percent per columbiad to twenty percent. Construction will occupy a smaller segment of our economy. There will be more resources for constructing space vehicles and for commercial ventures. The percentage of our population under age 18 will climb to a third. If subsidies from terrestrial governments decrease as predicted, our population will feel increasingly independent. Over time, a larger fraction of our population will have deep roots here. Consequently, the issue of full sovereignty can be expected to grow in importance.

"All this assumes stability in the price of gold and other major exports, which history shows to be a dangerous assumption. A major decline in gold prices will

precipitate a major financial crisis. But this projection is the best we can make right now. The report will need to be updated every columbiad."

Park paused, so Will asked a question. "Even 9,000 people on Mars in our lifetimes is more than we would have ever dreamed. Never mind it's much less than Pete had suggested. Have you projected the numbers farther into the future?"

"Making projections is an amusing exercise, but the uncertainty grows too large to produce a meaningful result," replied Park. "If growth per columbiad continues with 950 arrivals and 750 children, over 19 additional columbiads—which takes us to the year 2100—the Martian population would rise to 40,000. If you add the third generation—which would kick in at about 500 children around 2090—it'd be 50,000 by 2110. I'm not sure how that many people will support themselves. Possibly robotic factories will make imports less necessary. If natural growth continues, our population would rise to about 400,000 before the death rate equals the birth and immigration rates, some time around 2200."

"Too many variables," said Alexandra. "So, when do we get independence?"

The others in the room laughed, but they all paused to consider it seriously. "From the sound of things, we'll have 10,000 people here in less than twenty years," said Will. "And their economy will be about thirteen billion redbacks per columbiad, with only a one billion redback government subsidy. That sounds like time for sovereignty to me!"

"And we'll all probably be alive," added Yevgeny. "That's amazing."

"What recommendations do you have?" asked Will.

Park changed slides again. "First, we need to cap immigration at 500 for two columbiads. Second, we need a very thorough study to determine what manufacturing

capacity should be developed to reduce imports. The long-term increase in imports is our biggest potential problem; if it can be reduced, population growth can be sustained without financial crises. Robotic manufacture of goods is rapidly expanding on Earth and has a lot of potential for making us less dependent on imports.

"Third, we need to find new exports, even if they are office furniture and Martian steak for hotels in low Earth orbit. Tourism is the largest economic engine for launches to low Earth orbit right now. The moon is number two. Number three is Mars; number four is satellite services; number five is Mercury-Venus. We can sell to all of them. Fourth, we need to foster the commercial sector here because they will increase local manufactures and exports better than central planning can. Fifth, we need a master plan for growth. When Mars has 10,000 people, will 9,000 of them live in Aurorae and only 1,000 in the other outposts? Will Mars have six outposts of roughly equal size? The latter arrangement will require a huge investment in ground and air transportation. What other outposts should be established, and why? When should we allow individuals or families to retire to their own land outside outposts? There are lots of issues to consider.

"Sixth, we need to reexamine our system for selecting immigrants. We had focused on people with Masters or Ph.Ds but no children; they had skills, were mature, and could start families here. Then we added to that group spouses with valuable skills. More recently we added veterans of spaceflight who were past child-bearing years and were willing to work here until retirement, and possibly stay. We need to consider two more groups. Family members and relatives of people already here will help root families and will broaden our skills base, especially with non-space related skills and lower skilled workers. The other group with enormous potential are younger people with just

Bachelors degrees. They will be very motivated to come here, will work for lower wages—for several years, until they work their way up—and we will save money on them even if we pay for their further education. They will develop the skills we need and will mature into very committed citizens."

"Fascinating," said Will. "I like your ideas. Regarding your second point, increasing exports, we need to look into platinum-group metals much more carefully. The price of petroleum has been steadily increasing as the readily available supply slowly drops, the switchover to a hydrogen economy is accelerating, and the use of fuel cells is exploding. They use platinum and palladium catalysts. Many electronic devices use those rare metals as well. The price of platinum and palladium has been going up sharply."

"It may help," said Park. "I've talked to various people about the demand and price of platinum. They all agree it will remain expensive. But our production costs are very high; much higher than gold's."

"But we still make a profit," replied Will. "So we can anticipate commercial interest."

"The cost of extracting platinum-group metals from nickel-iron will decline as we get larger," noted Yevgeny.

"It has a future," agreed Will.

"We need to search systematically for ataxite or chondrite-enstite impactors," suggested Roger. "They are enriched up to ten-fold in platinum-group metals."

"Can we detect them remotely?" asked Alexandra.

He shook his head. "Unlikely. We have to find them through field geology and chemical tests on meteoritic fragments."

“Are we sure there are any to be found?” asked Yevgeny.

“Yes. About 1.5% of the small nickel-iron fragments we find in the regolith are ataxite. We’ve got 144 million square kilometers of surface and it has been pounded by impacts for 4.5 billion years. The platinum-rich impactors are there; we just have to find one large enough to exploit profitably.”

“Then we should start looking,” said Will. “My other comment is about point number five and the size of outposts. It’s an issue for the Commonwealth. The Commission should set some long-term growth goals and put plans in place to pay for them, but the Commonwealth has to decide where the people will go.”

“But the Commission’s money will fund their settlement,” said Yevgeny. “And many will be Commission employees, so we’ll want them where we need them.”

“I’m not saying the Commonwealth dictates to us, just that our plans have to accommodate the wishes of the people. Mars already has public opinion. The sols when we could set up a new factory anywhere we wanted are coming to a close. Come July, we’ll need to consider zoning issues.”

“And other outposts will want to make counter offers to sweeten the deal and attract more workers,” added Emily, from the video screen. “Cassini will certainly want to drum up business. I’m glad Dr. Park raised the issue of centralization of settlement. I know everyone in Aurorae thinks everything should be there to save money, but the rest of us disagree.”

“It sounds like this world will soon get more lively,” commented Will. “We’ll need to release a version of this report to the public in a week or two, as soon as it’s edited. It will fuel a lot of discussion during the election.”

7

Elections

late June-early July, 2057

Will re-read the newspaper article Louisa Turner had sent him one more time, shaking his head. “It’s that bad, huh?” asked Ethel from her side of the bed.

“I’m afraid so, though it should be easy to refute. It claims to be an exposé of the ‘Park Report’; that we’re planning to flood Mars with cheap, uneducated labor in order to push toward independence, and that I ordered changes to be made to make the report more palatable before its release to the public.”

“And?” asked Ethel.

“I did ask for changes, because Park, even if his Ph.D. is from M.I.T., still writes in Korean English. A few sentences made no sense at all. Reexamining our immigration criteria is one of six recommendations at the end, and it mentions favorably other changes in the criteria we have made in the past, such as increasing the immigration of veterans. It does recommend increasing the immigration of lower-skilled labor and paying for their graduate educations. There are no direct references to the issue of independence in the report, though one implication of the report is that full sovereignty may be a matter of two decades away.”

“Is the report about independence or immigration criteria?”

“No! That’s what’s crazy; it’s a fascinating projection of our future growth based on economic factors. Well, the way out of the mess is pretty simple, I think.” Will hit reply. “Thanks, Louisa, for waking me up; this is the sort of emergency I have to deal

with. It seems to me we can handle this simply and decisively before things get out of hand. Release the report, incoherent sentences and all, and say that an edited version is on its way. Can you also draft a list of major points, so no one misses realizing that the report centers on a lot of important issues that have nothing to do with the claims in the leak? That's the real tragedy of this leak; it distorts a fascinating and useful report that the Martian public must read and digest. I hope the leak encourages careful reading. Oh, one more thing; have you any idea who might have leaked the report? We need to deal with that, too, if we can. Over to you." Will sent the message and crawled back into bed, to get fifteen minutes of sleep while waiting for her reply.

But sleep was difficult; the fact that someone had attempted a clumsy leak disturbed him. He had just drifted to sleep when the tablet in their bedroom beeped with an incoming message. He leaped out of bed and activated it. "Hi Will; I apologize again for waking you, and I'm glad you don't mind. I completely agree with your plan. In fact, while waiting for you, I've been rereading the report and adding footnotes clarifying the meaning of a few sentences. I think I can have it in reasonably good shape in half an hour; the incoherent sentences are relatively few. My assistant has already been working on a summary, so I'll get her to finish that in the next hour. We have some time; it's 9 p.m. here in Houston and before dawn in Europe. The Indians, Chinese, Australians, and Japanese are used to waiting for the sun to rise in Houston. I'll email the document and the summary to you in about three hours; by then you can get up at a half-decent hour. We'll still have it out before the morning news cycle in Aurorae and in Europe. And yes, I'll get a copy to *Mars This Sol,* so they can release it. Bye."

He acknowledged her call and went back to bed. But sleep was fitful; he finally got up for the morning, feeling grumpy. At breakfast in the Gallerie, Dr. Park approached him. “Good sol, Will. Is there anything I can do about this newspaper article? I woke this morning with email messages from a dozen reporters.”

“Forward them and any potential replies to Louisa Turner. She’s coordinating the response.”

“I forwarded the calls to her. I see the report is already released; that’s the best response. I’m glad she added a few footnotes with edits. I am not offended by editing.”

“Good. Thank you. If any of her edits aren’t quite right, she can make further changes. Have you any ideas who might have done this?” And Will looked at him very closely to see how he answered.

Park’s face looked completely innocent. “No, I can’t imagine who would do this, or why; it was a pretty ineffective, foolish effort.”

“Yes; it looks pretty amateur. I don’t see why you shouldn’t respond as well, just involve Louisa in the decision and what you say.”

“Alright; thank you, Will. Have a good sol.”

Will nodded. “Ciao.” He looked around the Gallerie and wondered who was talking about the story. The occasional glances his way, followed by embarrassed nods, suggested many were.

Three tables away, Kristoff Langlais was sitting with his friend from work, Julian Bedford, and with Veronique Dermont and Rahula Peres. Julian was drinking orange juice and reading the New York *Times*. “Oh, the story’s really weak, after all,” he said shaking his head.

"Well, it sounds like the sort of thing big bureaucracies do," said Veronique.

"Which?" asked Rahula between bites of corn flakes.

"Flooding a place with cheap labor to depress the market."

"But they aren't proposing to do any such thing," repeated Julian. "You can read the report itself, if you want; there's a link here. They're proposing to diversify the labor market. There are still some tasks robots can't do so well that people don't want to do; they need more cheap labor for those jobs."

"That makes sense," agreed Rahula.

"If that's really what they plan," added Veronique, suspiciously.

"We'll find out at the Future of Mars Meeting on Satursol," added Rahula.

"Whatever," replied Kristoff, as he ate French bread and soy cheese. He looked at Veronique. "Tonight, too?"

She shook her head. "People do have other plans sometimes, you know."

"Like what?"

She shook her head and didn't answer.

"So, how's Ceylon?" Rahula asked. He was from the real "Ceylon."

Kristoff shrugged. "I doubt it looks like your home much. We've really got the productivity up. Have you seen the kumquats? They're our new addition to the Martian food supply."

"Yes, I saw them. Actually, I was in Ceylon a few sols ago, and it *does* remind me of Sri Lanka; of a plantation there, that is."

"That's about right." Kristoff grabbed the last piece of bread on his plate, then picked it up. "Ciao, y'all," he said and headed for the nearest place where he could bus

his tray. Then he scanned the crowded Gallerie for the face of someone else. He spotted Millie Whitmer with a few friends by the entrance. He walked over. “Good sol,” he said to her. “How are you?”

“Not bad. I’ve got a really crazy sol, though; we have to change all the fuel cells and motors in a van. You?”

“Pretty good. The mangos need me this sol. But I’m going to the Frisol program tonight here; I hear Nancy’s dancing flamenco. Do you want to have dinner, then go?”

Millie smiled. “Thanks, but after the sol I’m facing, I’ll probably just take a bath and go to bed.”

“On Frisol?”

“Yes. I wish I could do the work Monsol instead, but the van’s needed tomorrow. It’s been laid up for six months; once one motor and fuel cell died, they pulled out the good ones to keep other vehicles operating.”

“Okay. Good luck.”

“Same to you and the mangos. Ciao.”

“Ciao.” Kristoff headed out of the building, frustrated.

Mars had never had a space like Andalus Square for public events before. Its chairs filled quickly for the Future of Mars Forum; the “blue sky and cumulus clouds” screen was moved into place over the dome to moderate the intensity of the sunlight and make it a pleasant place to sit and watch. At 2 p.m. Will Elliott stepped onto the stage.

“Good afternoon, Marsian voters,” he said. “This is the first time we are holding these forums for everyone with a connection to Mars. Voters have gathered at all outposts

to discuss the future of Mars live and by video. Landowners are tuning in all over the Earth, and some will email questions and comments. Questions that never get discussed in public this week will be placed on a web page and some may be discussed next week at the second of three forums.

"In early July we will elect the officers and members of our outpost Councils and the members of the Mars Residents Council and Landowners Assembly. It is a long-standing practice that no one runs for the Councils. People sometimes yearn to be elected. They are free to stand up and say what they think should be done for Mars. A few have stood up and asked people to vote for them; interestingly, none of them has been elected. Some voters are reticent to vote for someone who appears to have personal ambition. Others are suspicious of platforms, for candidates may feel beholden to their promised actions even if better plans later emerge through discussion and give-and-take. Yet other voters believe strongly in their right to vote their conscience. Perhaps the approach we have taken can best be summarized as follows: that Marsian voters should vote for Council members based on perceived character and experience, rather than based on ideology, platforms, or plans to revolutionize Mars. The resulting leadership so far has been flexible and dynamic. The leadership is not polarized and in consequence, neither is our society; a very important achievement in a setting where extremism and terrorism cannot be risked. Perhaps the residents of spaceship Earth need to realize the fragility of their environment and pull back from the brinks they constantly find themselves facing.

"I am chairing this Forum for one simple reason: I am the only person on Mars you cannot vote for. It would be a conflict of interest for the Commissioner to serve on a

Council or as an officer. I hope the result of this afternoon will be new ideas to move our society forward, and clues as to who might do an excellent job leading us.

"The first four speakers have been selected randomly from the list of persons who have indicated they wish to speak. After that, the floor is open for general discussion. After each speaker, if you wish to comment, dial the appropriate number on your communicator. When we call on you, we'll activate the communicator's line so your voice will be fed into the public address system. Johnny Lind is the first speaker."

Johnny rose with his phone in hand, a list of points glowing on its little screen. "I want to express my fascination that a report as detailed and intriguing as the Park Report has been made public. The bizarre effort to leak parts of it has simply made its calm and level-headed conclusions more widely read. Above all, I want to stress the value of a slower rate of population increase. The eleventh columbiad saw it grow almost fifty percent. Considerable difficulty resulted. Some still lack furniture. Some are still sleeping in monk's cells. There was no time to verify the functionality of electric switches and bathroom pipes. The twelfth columbiad will be just as bad if the population grows by fifty percent again. I urge a slower rate of growth two years from now; perhaps thirty percent. The results will be better for everyone." Johnny sat to scattered applause.

"Since the subject has come up, Alexandra, have you any comment?" asked Will.

Alexandra Lescov rose and spoke into her communications device. "Allow me to take this opportunity to apologize to everyone who was inconvenienced. Financial cutbacks affected our support facilities on Earth and forced us to make major adjustments in our work schedule. Consequently we were not able to have everything ready. But one result is a new work tracking system with more powerful priority setting software. We are

confident that we can grow forty percent in 2059. After that, based on the conclusions of the Park Report, our growth rate will slow, to thirty percent in 2061, twenty percent in 2063, and eighteen percent in 2065." She sat; the audience seemed satisfied, even though the numbers she gave included immigration only.

Will called on Yuri Severin next. "I had planned to speak about exploration, but instead I want to address our policies for selecting immigrants. The plan to employ large numbers of people with Bachelors degrees—partly because it's cheaper to educate them here and pay them a pittance—greatly disturbs me. Mars should not follow the American capitalist model of development, a model that has produced a severe disparity of wealth, perpetual poverty, and incredible self-centeredness in Earth's wealthiest nation. Mars is a much more equitable society, one that balances socialist and capitalist tendencies. The Commission is a great social leveling force. If it continues to shrink in influence, the Commonwealth needs to replace it as a balancing force. Many European states have a healthier balance than the United States. They should be our model. This issue becomes even more important as we move closer to independence."

That provoked comments from the audience. The number wanted to speak suddenly shot up. "Father Greg," said Will, calling on the next speaker.

Greg Harris, one of the few Catholic priests who was married and had children and still able to perform his priestly duties, rose. "I wanted to address an aspect of the Park Report as well. I am fascinated by the two references to sovereignty and independence. I've been on Mars thirteen years and have watched it grow from under one hundred to almost one thousand. I'm still dazed at the thought that in fifteen years we'll number close to ten thousand and will be contemplating 'independence.' This is a matter

we'll be discussing at great length, over and over, for some time. So let's remember a few principles. First, this is a highly emotional subject. There are no scientific criteria for determining when a place or a people are ready to assume responsibility over themselves. A small, highly educated, united group of people extremely isolated from the rest of humanity could be ready far sooner than a larger population with less developed institutions and more extensive ties with the rest of humanity. On the other hand, a small population heavily dependent on the financial subsidies of others may not be in the position to determine their own destiny.

"Second, we need to keep talking with each other when we disagree. Some will want sovereignty now; others, never; some won't care. Most societies achieve independence after violent upheavals. We can't afford that; revolution may produce depressurization. We need to view sovereignty as a process with many steps to it, some of which we have already taken, some of which we are taking in the next few weeks, some of which will stretch out over decades.

"Third, we need to recognize that even if we try to create a coherent, managed process, it won't proceed as we expect. There will be roadblocks, unexpected breakthroughs, unforeseen changes in public opinion on two planets, and throughout the entire process there will be the messy interactions of emotional, unpredictable, and sometimes unstable human beings.

"Finally, let me suggest some vocabulary. Let us speak of 'sovereignty' and not 'independence.' No person or nation is truly independent. We are all dependent on each other. Nations are steadily recognizing their interdependence and delegating sovereignty to regional and international institutions. The European Union now has an outer ring of

‘associate’ members, including Russia and several other former Soviet republics, that stretches to the Pacific. The Latin Union will soon have a Parliament and a common currency. There’s speculation about a loose “Atlantic Union” that encompasses the Latin and European Unions, Canada, and Mexico. If that happens the United States may join. The African Union may finally adopt a common currency. The East Asian Common Market is contemplating the same series of steps. By the end of this century we can easily imagine a ‘World Union’ replacing the United Nations and encompassing all these unions, plus many bits that have been left out so far. Mars will have to participate in such unions as well and will be interdependent on the rest of humanity.

“We face some very exciting years ahead. But let’s make sure our debates build up our community, not weaken or damage it.”

There was applause as he sat. Will recognized Silvio DiPonte. He stood. “I want to speak as one of our businessmen here to thank everyone for the support for business they expressed two years ago when they called for universal health insurance. It made an immense difference in terms of encouraging business; all of us were able to do more hiring. We now have three large businesses, four small ones, and dozens of part time businesses where people make goods for sale on their spare time. But the private sector still encompasses a small fraction of the Marsian economy and if we want that economy to grow stronger, it has to have more large businesses. In this respect my view is diametrically opposite to Yuri’s; and I am not an American, nor do I advocate American capitalism or individualism. In fact, I come from one of the countries that has the mixed Socialist-capitalist economy and society that he praised. Some decisions have to be made on an economic basis; that’s the reality of life. The settlement of this world ultimately

will be driven by economics. Investments will not be made if profits are absent. I see no reason for anyone to object to the creation of an additional class of immigrants. Our total immigration is rising from 300 to about 500; if that higher number includes 100 people with Bachelors degrees, it will still encompass a hundred more people in the existing categories. Businesses need semiskilled workers and we have precious few of them now. Furthermore, we need to allow a greater flow of people through different jobs; workers start low, work their way up, and then many retire from the Commission and start businesses. Mars has at least sixty people who are millionaires in terms of redbacks. Most people who have been here more than ten years have achieved this status. New legislation should encourage them to retire from the Commission and start businesses."

He sat to scattered applause. Will glanced at his tablet; thirty people had indicated a desire to speak. "Four speakers have raised four issues: the rate of immigration, capitalist versus socialist economic models for our society, the issues related to sovereignty, and the need to encourage business further. A lot of hands went up from Yuri's comments, so let's discuss that issue first. Suzanne van de Velde."

She rose. "I am sympathetic to both Yuri's and Silvio's perspectives, but I think our situation is quite different from Earth's. Air is not free here; everything has to be supplied and can be lost in an instant. I lost my husband almost eight years ago when he lost his air in an instant. We have to have community here, and that community has to have common services and rewards to create solidarity if we are to survive. Since I arrived eleven years ago, the disparity in income has steadily grown. Eleven years ago, the smallest private flats were 25 square meters and the largest family flats were 60. The numbers are now 16 and 120. Arrivals start out farther and farther behind every

columbiad as taxes and fees are tacked onto starting salaries. Meanwhile, veterans with seniority receive more and more every year. If we have more businesses, we'll have more lower-income workers, slower salary increases, and some business owners who are *very* rich. And soon enough we'll have unemployment, too. This is not my idea of community or solidarity, and frankly it makes me worry about our survival." She sat to applause.

Will recognized Henry Smith, President of Deseret, their largest business. "I am as concerned about survival as anyone, but I do not understand why you are linking the stability of our society with absolute social equality. No society that has ever existed has been absolutely equal. We have always had some economic disparity here and always will. In fact, this is the first time I've heard anyone suggest we should abolish any disparity! The history of efforts to create economic equality in societies is tragic. I think we should be thankful that after twenty-one years, Mars has relative economic equality; the lowest-paid worker receives maybe a fifth or a sixth as much as the highest paid worker. In the United States, even in relatively socialist Europe, the disparity is a hundred times wider. If the disparity grows to ten to one I think we'd still have something to be proud of, and I doubt we'd be closer to some sort of revolution. As for business owners making profits, few of us are making much money, but if we do some of us will plow the profits back into society in the form of investment, charitable gifts, and endowments. In short, don't paint capitalism as immoral; it has produced more prosperity for more people than any other system created by humanity."

He sat to applause and the number of people wanting to speak suddenly jumped again. Will inwardly groaned. Capitalism versus socialism, individualism versus communitarianism: the arguments had existed for thousands of years in different forms.

Much of the afternoon would be devoted to ancient subjects. He called on Anne Hollingsworth, an Australian, who pleaded for more privatization and support for the resulting businesses. Then Xiaopeng Cai spoke about a mix of government and private efforts, but stressed the need for a strong government. That triggered a reply by Tatiana Gavrilova, who called for minimal government and maximal creativity to maximize growth. Will recognized a landowner named Walthiere Kaas whose video message stressed landowners as a kind of business and who begged for more services at affordable prices, and more royalty payments for minerals harvested from private land.

Three more people addressed the matter in favor of privatization and commercialization; one more was opposed. An hour had passed, the audience was bored, so Will called for discussion of the issue of sovereignty instead.

That was more interesting and less predictable because no one had spoken in public about it before. Everyone was in favor, but some felt it should come sooner and others later; some felt it had to be earned; some felt it was their birthright. A Finn waxed about Mars being the next United States and a Filipino compared it to the "Middle Kingdom" (China).

They had time for a few more brief comments, so Will opened the floor to new subjects. Albert Baert startled everyone. "I'm concerned about the cameras and microphones in our flats," he said. "I know they're there in case of emergencies, to find trapped and injured people. I know they're not turned on except in emergencies; and as everyone knows, I work in a control room—the Asteroid Belt Commission's—so I know how effective the protocols are at protecting our privacy. But we don't have cameras and microphones in skyscrapers on Earth, in luxury hotels, or expensive condominiums.

When this place was experimental, cameras and microphones were wise. But now they aren't necessary. Some of our structures are over twenty years old and haven't leaked. We haven't had a fire; not yet, anyway. I think the time has come to reconsider our monitoring system."

He sat. There was scattered applause and everyone pondered the idea. Several hands went up and there was a discussion. Finally, Will suggested that the new Authority would have to debate the issue and pass regulations about the matter.

Ruhullah Islami spoke about the unfinished business of setting up the Mariner Institute of Technology—MarTech—as an independent, endowed university, and about endowing Aurorae Hospital. Hans Muller, owner of Muller Mining, spoke from Earth about the role of terrestrial corporations in developing Mars. Finally, Daichi Furukawa, one of their veteran Japanese residents, spoke about the diversity of Mars and the strength they had drawn from it.

The crowd began to disperse. Érico and Alexandra came up to Will. "I think you let the business versus government discussion go too long," said Érico. "The rest of the discussion had an edge to it."

"I think you're right," agreed Will. "But we did learn that a majority favors more privatization and more businesses, and everyone is pleased that the words 'sovereignty' and 'independence' are being discussed."

"I don't agree with Father Greg that we shouldn't use the word independence," said Érico. "No one uses it to mean total independence."

"I understand his point that 'independence' implies a violent revolution in many people's minds, though," said Alexandra. "Everyone is afraid of that happening here."

“We’re going to live to see independence,” said Will, wonder in his voice. He saw Yuri Severin across the square talking to Suzanne van de Velde. “I want to talk to someone, so I’ll see you both later. Ciao.” He headed to Yuri, who had just finished talking to Suzanne. “Yuri, I was very interested in your comment about the role of economics in our decisions,” Will said. “I hadn’t realized you had such strong feelings about the matter.”

“Well, this is the place to express our feelings, isn’t it? I didn’t feel it was appropriate at a staff meeting.”

“Please feel free in that setting as well. I want my people to be frank, even to blow off steam if necessary. We’ll feel better and make better decisions together.”

“Thank you. It’s no secret that many Russians of my generation are very sympathetic toward Marxism. It’s generational thing; our parents rejected it, so we’re attracted to it. It embodies a basic fairness toward all persons. It levels extreme differences.”

“Thank God we don’t have economic extremes here, and I hope we never will. I think there are ways to moderate both capitalism and socialism. Let’s hope we can find a third way, in between them.”

“Good luck; no one else has ever found it!”

“True. Have a good sol, Yuri.” Will turned away, then added, “Oh, Yuri, have you any idea why anyone would want to leak a biased version of the Park Report to the media? I’ve been asking everyone who knew about the report.”

Yuri looked surprised, but perhaps it was guilt; Will wasn't sure. "I can't imagine," he replied. "Sorry." Then he turned away and headed across the square. Will watched him go, suspecting he had uncovered the leaker and his motivation.

Two more "Future of Mars" Forums followed over the next two Satursols, with similar opinions expressed to smaller crowds. The election was on Sunsol, July 4, 2057. Everyone could vote via their tablet, using a password emailed to them earlier. At midnight the results automatically appeared on the election website.

"Interesting," said Will to Ethel. She was already laying in bed. "For Aurorae Borough: Ruhullah Islami, Clerk; Lal Shankaraman, Treasurer; Alexandra Lescov, Chair; and four council members, John Hunter, Eve Gilmartin, Enlai Tang, and Ernesto Gomes."

"Eve and Ernesto? How unexpected. Enlai's new, too, and I'm glad Ruhullah was elected Clerk. But no Madhu."

"She didn't come to any of the three forums and she told people she was tired of serving. For Mars Council, the same four borough council members plus Alexandra Lescov, Yevgeny Lescov, and Érico Lopes."

"And none of them are Clerk or Treasurer; that's good, they already have a lot of responsibility. Electing Érico is a sign people might want him to serve as Chief Minister."

"I think so. Good diversity, too." Will leaned over and kissed Ethel. "It's looking good for Mars."

8

Inauguration

mid July 2057

Marshall peeled off his pressure suit with a sense of relief. He had been working construction all afternoon; they had repaired two pile drivers, done some routine maintenance on a regolith sifter, and had shifted the steam pressure hoses to two new piles along the eastern perimeter of Zanzibar. With the sun slanting low across the Aurorae Valley, it was time to rest his aching muscles and fill his empty stomach.

He headed into the showers to wash off six hours of sweat, then dressed quickly. It was a quick ten minute walk to the Gallerie. It was already beginning to empty of people; families were going home to let the kids run around or watch television for another half hour before it was bedtime; people working the evening shift had gone to work. But Corazon was still there in the alcove where the older kids often ate, possibly waiting for him, since she knew he would arrive late. Sammie was sitting next to her, and that was nice as well, since they were best friends. But then as he came out of Deseret Cafeteria with his tray, Marshall saw Sammie reach over and playfully pull Corry's hair. And that he didn't like.

"Evening," Corry said to him.

"Good evening," he replied, a bit coldly. He was irritated but didn't know whether he should say anything. He sat across from her and as far from Sammie as he could.

"How was work? Sounds like it was tiring."

"It was; we had a lot of hard tasks to do."

“I prefer working for Deseret,” said Sam. “No pressure suit to wear.”

“I’m not much of a cook,” replied Marshall. “It’s fun watching the domes take shape, too. We’ve driven in most of the eastern perimeter of Zanzibar and we’ll have it frozen in place by September.”

“I wish I could work,” said Cory. “Another three months.”

“The big fifteenth birthday,” said Marshall, smiling at her. “What present will I give you?”

“I already know what I want to give you,” said Sammie, with a secretive smile.

“Really?” She was surprised. He nodded.

Marshall said nothing. They talked about the intramural basketball league—both Marshall and Sammie had been accepted even though they were ten years younger than the other players—and whether Cochabamba would win the championship, or whether Bangalore or Andalus would make a big comeback. Then there was the concert in London in three Earth days by a teen heart-throb named Wally.

“Well, I’ve got to get home,” said Corry. “Mom is waiting to help me with homework for that engineering course I’m taking through M.I.T.”

“How’s it going?” asked Marshall.

“It’s tough to keep up with the freshmen! But with mom’s help, I’m picking up most of the course.” She rose. “See you all tomorrow. Ciao.”

They watched Corry bus her tray and head out of the Gallerie. After she had disappeared into the darkness of Andalus Square, Marshall turned to Sammie and said “You know, she’s my girlfriend.”

“Huh?”

“My girlfriend.”

“What, you’re going steady or something?”

“Yes, we are. If you want a girlfriend, there’s always Lizzie.”

“She’s always doing ballet!”

“Not always, she eats here like everyone else.”

“I think it’s up to Corry who’s her boyfriend. Maybe we should ask her if she has a boyfriend.”

“Go ahead,” though Marshall was not so sure what she would say. He rose. “I’m done with supper, so I’ll see you around.”

Sammie was upset that his friend was leaving. “Boy, you’re sore. Ciao.”

Marshall didn’t want to leave, but he had no choice now. He took his tray to the disposal area, then went outside. The sun had set and it had grown almost instantly dark, but Andalus Square was brightly illuminated. Looking up, one had the impression one saw stars; in fact a black insulating cover had been pulled over the dome to keep in the heat and it had scattered reflective white “stars” painted on it.

He headed across the square and out the eastern street that lead to Bangalore. Once in Bangalore he detoured a bit and walked past Paul’s cylinder. The light was on in his cousin’s flat. He picked up his tablet and said “dial Paul Nuri, please.”

A moment later the phone was ringing. “Hey Marshall. How are you?”

“Pretty good. I heard you were coming back from Kasei this sol.”

“We drove in about 2 p.m. I was looking for you at supper.”

“I was working outside until 7. I was walking by and saw your light was on.”

“You want to come up? You’re welcome.”

“Thanks, I’d like to.”

“See you in a minute, then.” Marshall closed the line and walking into the building. The cylinder was ten meters in diameter and four stories high, with a steep ramp that went to the top. Each level had four flats of 18 square meters each; pretty small. He went up the ramp to the third floor and followed a narrow hallway back to flat 3C. Paul had the door open for him already, so he walked right in. It was a simple quarter pie slice of the floor, with a bathroom occupying one corner. The rest of the space was one room. With the bed folded into the couch, it looked like a living room.

“Hey, good to see you!” said Paul, extending his hand to Marshall. They shook, then hugged as well.

“How was Kasei?”

“Incredible! We left here nine weeks ago, traveled up Little Colorado Canyon and then along the North Escarpment Trail as far as Ganges, then turned north and began to clear the Kasei Trail across Xanthe. The most dramatic time was the two weeks when we dynamited and bulldozed a route down into the chaotic terrain. I think the sunwings dropped twenty tonnes of ice blocks so we could freeze some unstable parts of the ramp. Then we spent two weeks working our way across the chaos—it was a lot of work—and cleared our way down Kasei Vallis until we hit the trail that had been cleared up from the bottom. We drove on down, stopping to check some geological sites that were missed before, then drove back here in four sols.”

“That’s fast. So now there’s a completed trail?”

“All the way, with an emergency shelter half way. It’s an amazing landform; incredible cliffs and flood features. I learned a lot.”

"I bet. I wish I could have gone. But dad says next summer when I'm eighteen I can apply for any surface expedition I want."

"Good. Do you know about Martech's Phobos course that starts in September? It'll be quite a thorough study, and includes a field trip to Phobos over Christmas vacation. I bet you could go; you'd be just weeks short of your birthday then."

"I wonder. I could probably get in; I took a course last summer and did okay. But I bet dad won't let me take the field trip."

"Oh, why not; you'd be practically an adult. I can talk to him."

"No, don't; I'll talk to him myself first."

"Okay. How much more do you have to finish before you can start Martech?"

"If I really work hard next school year, I can graduate in June. It'd be a year early. I started first grade in the fall of 2046 when I was six and a half but when Sammie was five and a half; we're eleven months apart in terms of age, but we're the oldest kids here, so we were put in one grade together."

"I see. But you've taken extra classes?"

"Everyone does because school goes all year, and the summer involves a lot of special distance-education courses. Sammie's almost as far ahead as I am."

"So, you're going to Martech?"

Marshall shrugged. "I really don't have much of a choice, do I? Especially since Martech has reciprocal arrangements with just about every major university on Earth. I can take anything up here."

"That's true, but university's a lot more than taking courses." Paul smiled nostalgically. "There are the friends, the football games, the midnight movies followed by

a twenty-mile drive for supper; or longer, I had friends who once drove to New York City for supper and drove to Chicago for the weekend!—the freedom." He sighed. "You should go back to Earth for university. You'll never really understand the place unless you visit it."

"I have a free round trip; the Commission's promised one every fifteen years."

"Well, I'd go to Earth."

"There aren't any flights back to Earth next year."

Paul shrugged. "Go to Martech a year, then transfer. I don't think you'd have trouble getting accepted. What do you want to major in?"

"Probably physics. It seems like everyone doing really serious geology up here has a physics degree. And it would allow doing lots of different things; atmospheric research, for example. Polar stuff's all the rage right now."

"It's the foundation for research on Ceres, the Galileans, Titan, the other outer moons; the Martian poles are a cheap analogy."

"Not a very good one for the Galileans and Titan. I think I'd like to get into the Exploration Corps and maybe apply for an asteroid mission, or even an outer solar system mission. In ten years I'd be the right age."

"Yes, I think so." Paul nodded. "It could be a very exciting future. But you didn't look so excited when you stepped in the door."

"No, I'm bummed out. Sammie was flirting with Corry. I told him she's my girl and he said we should ask her."

"What would she say?"

"Well, I don't know. That's why I'm bummed!"

Paul nodded. “I understand. Ask her some time and find out. It’s the only way. Did I tell you that Jacaranda has applied for Columbus 12?”

“No; has she heard anything?”

“Not yet, and it’s been nine months, so we’re getting worried. Her training’s in the media and there’s more and more need for that up here. They’re thinking of shifting most of *Mars This Sol* to Aurorae next columbiad. If they do, she’ll probably get a slot.”

“Great! And you guys will get married?”

“Probably. Nothing’s official yet. But the separation has been going well; we’re emailing each other daily. Sometimes you can be more honest that way.”

“That’s ironic.”

“It is.” Paul settled back in his chair. “Now, the pace of my work shifts drastically. The next three months I’ll be extracting fossilized atmospheric gas samples from the new cores from the north polar ice field and analyzing them. Very tedious, exacting work.”

“Boring.”

“It will be, but not all science is exploring catastrophic flood valleys. The tedious stuff is usually more important.”

“I don’t have the patience for that kind of work.”

“You will, don’t worry. It comes over time.”

Marshall’s tablet beeped. He glanced at the screen. “It’s mom.” He pushed a button. “Hi mom. I’m visiting with Paul right now.”

“Oh, is that where you are. It’s almost 9 p.m., so I thought I’d better check.”

“I’ll be right home. He just got back from Kasei this afternoon.”

“Good. Tell him to come over tomorrow night after supper for ice cream.”

Marshall looked at Paul, who nodded. “Okay, he’ll be there.”

“Great. See you soon, dear.”

“Bye.”

“Bye.” The screen went blank. Marshall rose. “I’m glad you’re back. I needed some encouragement.”

“Any time. See you tomorrow night.”

“Good. Good night.”

Kristoff looked at his father’s face closely. In the bright light of Andalus Square, he could see a lot of lines and sags in the skin. “You know, you look really tired.”

“Well, the *Giovanni Piazzi* is approaching Astrea, so they’re incredibly busy getting ready for the rendezvous and landing. And there are a zillion last minute details to finalize in the design of the *Henrich Olbers* before they ‘lay the keel’ in December; every time they finish a caravel they come up with ‘simple’ improvements. Lately I’ve been sleeping four hours a night.”

“That’s not enough. Get more staff, or delegate more. You’re not getting younger.”

“I know, and neither are you.”

“But I still have plenty of time to enjoy life; you’re using up your retirement.”

“Which I’ve earned, and can use as I please.”

“Okay, point taken, dad.” Kristoff scowled a bit; he had begun to feel a bit guilty lately about his relaxed, enjoyable lifestyle. The fact was that he really didn’t feel a reason to work harder; he wasn’t driven like his father or brother.

A small ship's bell rang out on the stage in front of them. Kristoff looked up; Will Elliott was ringing it in pairs of little taps, ring ring. . . . ring ring. . . . ring ring. . . . It was quite a sight because behind the table and adjoining podium was a gigantic Martian flag as a backdrop: a large red field with two white half circles on the top and bottom of the left side, representing the polar caps, with two yellow stars between the poles representing Phobos and Deimos and a circle of six green stars in the middle representing the six boroughs. From the V.I.P section in the first row Kristoff could see little details, such as the thin black book on the table next to the bell. The crowd seated on rows of chairs filling Andalus Square fell silent. "What is it?" asked Kristoff.

Sebastian smiled. "Laura Stillwell, Commander of Columbus One, brought the ship's bell from the U.S. Navy, where she was a commissioned officer. It was used to mark very solemn occasions; Will and Ethel's wedding, the transfer of command to Will when Laura left, then the transfer of command to me when Columbus Two arrived. I doubt it has been used much since, because Will's been in charge for twenty years!" He chuckled.

"Though as Mars and outpost commander, then just Mars commander, then Mars governor, then High Commissioner of the Mars Commission," said Kristoff.

Will rang the bell six more times, then looked up at the crowd. "Good sol, fellow residents of Mars. This sol—Sunsol, July 11, 2057—will go down in history as the beginning of substantive self-government on Mars. Therefore I want to mark this occasion by transferring to the new governing authority of the Mars Commonwealth the Commander's bell that Laura Stillwell brought here in 2036. It has been rung for a few weddings and a few transfers of command, but since then has gathered dust in my office."

He reached down and picked up the black book. “Commander Stillwell also brought a captain’s log to Mars. She and Sebastian made a few entries, then I made a few as well to mark major occasions. It is mostly filled, but more pages can be added. I would now like to turn these two items over to the sole constitutional officer of the Commonwealth, Judge Silvio DiPonte.”

Silvio rose from his seat to warm applause. He wore his judge’s robes and thus looked like a constitutional officer. He came to the stage and shook hands with Will, who left the stage. Silvio rang the bell six times as well.

“This sol we swear in the new governing authority of the Mars Commonwealth,” he began. “The commander’s bell will be rung at the beginning and end of the ceremony. In the logbook I am now placing a copy of the Fundamental Law of Mars, our proto-Constitution.” He paused to hold up a folio and place it inside the logbook. “I will now call the members on stage. Since Érico Lopes was elected Chief Minister yestersol and the Chief Minister, according to the Fundamental Law, has a seat on the Mars Council, the seat Érico was already occupying was vacated. It was filled by the person with the next highest number of votes. Therefore I would like to invite on stage the following fourteen members: the seven representatives from Aurorae, Eve Gilmartin, Ernesto Gomes, John Hunter, Lisa Kok, Alexandra Lescov, Yevgeny Lescov, and Enlai Tang; the two representatives from Cassini, Emily Scoville-Rahmani and Scott Curry; the representatives of Dawes, Meridiani, Thymiamata, and Aram, Gerhard Bach, Cornelius Beyer, John Stanwood, and Victor MacLeod; and Chief Minister Érico Lopes.”

Applause rose as the fourteen stepped forward, four women and ten men, the heads of the hospital, the university, the construction department, the exports department,

Cassini Outpost, the Consolidated Mining Operation at Cassini, Dawes Outpost and the Muller Mining Operation, and Meridiani Outpost. Ethel leaned over to Will. “Ethnic diversity isn’t too bad, but there aren’t enough women, and most of them are members of the establishment.”

“I’ve chosen more women leaders than the voters did, and the ones they’ve chosen were among the ones I chose. Actually, I’m not sure I like the ethnic diversity; there are no Japanese, and they’re beginning to be a large group here. And I wish some of the prominent outsiders were on it, like Madhu, Father Greg, and Silvio.”

“Silvio disqualified himself to keep the judiciary and legislatures separate and Father Greg respected the Vatican policy that priests cannot serve. We already know about Madhu. But we now have Mormon, Japanese, and Nigerian businessmen here. Some of them should get elected in a few annums.”

“Everyone up there has been on Mars more than a decade,” noted Will, nodding.

They turned back to the stage. The fourteen members of the Council had arranged themselves in a single line across the platform. “Please raise your right hands and repeat after me,” said Silvio, and he proceeded slowly, phrase by phrase. “I, Silvio DiPonte. . . . do assume the responsibilities and privileges of membership in the Mars Council of the Commonwealth of Mars. . . I pledge to defend and uphold the Fundamental Law of Mars . . . and serve the people of this world.”

They repeated after him, then he walked down the line and shook hands with all fourteen of them, while they shook hands with each other and the audience applauded.

“Érico Lopes, please step forward,” Silvio said. “Please place your left hand on the logbook and the Fundamental Law, raise your right hand, and repeat after me.” Érico

nodded and repeated the oath of office: “I, Érico Lopes, do assume the responsibilities and privileges of the position of Chief Minister of the Commonwealth of Mars. I pledge to defend and uphold the Fundamental Law of Mars and serve the people of this world.”

When he finished Silvio rang the bell six times very solemnly, then the entire audience erupted in applause. Érico, tears streaming from both eyes, bowed slightly and smiled.

Then the Aurorae Orchestra, which had played two pieces before the ceremony and was scheduled to play a patriotic sounding tune afterward, struck up with the informal, unofficial anthem instead. The entire audience rose and began to sing:

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

From Tharsis Montes to the Hellas Basin,

From the cratered highlands to the Mariner valleys,

This land was made for you and me.

9

Land

mid July 2057

The muted roar of the engines continued and continued and continued. “Daddy, how much longer?” asked Charlie Langlais.

“Ten. . . no, nine more minutes,” said Helmut. At age 3 ½, Charlie still had no sense of time. The engines had been firing forty-six minutes now, but at very low power; the tenth of a gee against the wall made the floor, which had 0.4 gee of centrifugal force, pushing down on it, feel like a steep ramp. Helmut pointed to the rocky surface visible on the screen. “Look how much closer Astrea is now.”

“Wow! Is that where we’re landing, by the crater?”

“That’s right. Let’s see what the ship looks like from down below.” Helmut pushed a few buttons on his tablet and the scene shifted to a camera on a Prospector on the asteroid’s surface. The bottom of the saucer-shaped spacecraft had three orange-blue flames shooting out of its bottom; two of their five engines were shut down. The engines were firing on low power so that gravity remained as ordinary as possible.

“Dad, can we go see the toilet?”

“You used the toilet just before the engines came on!”

“No, I mean I want to look at the water because it’s tilted!”

“Oh.” Helmut had explained that the engines tilted the water level and made the toilet unusable. “No, we have to stay strapped in our seats until the engines are finished.”

“Why?”

“Because it’s not safe to walk around while the engines are firing. They change where down is.”

“How much longer?”

“Seven minutes.”

Charlie nodded. He was thinking about something. Then he said “And will mommy come down here when they stop?”

“Not for an hour or so. She has to make sure everything’s shut down. Martha and Caitlin will come here to be with you while mom works in the Control Room and I go outside.”

“Why can’t I come outside in a hopper van?”

“I told you, not today. Maybe in a few weeks; we’ll see.”

“But why?”

“Charlie, no one has ever been here before. This isn’t Phobos. We have important work to do and we have to start right away. Dharmapala and I are setting up the drill. Thierry, Zach, Adam, and Jack are deploying solar arrays. Captain Vickers and the Chens are conducting the first geology mission. Then the sun will set. When it comes back up I’m going on a geology expedition with Dharmapala and a few others. In a few weeks we’ll be sending out two geology expeditions at once all the way around the asteroid, to its poles, into the deepest craters; everywhere.”

“I know, daddy,” said Charlie, though he often said that when he didn’t want to hear any more. Helmut contemplated the object they were just a few kilometers away from. Astraea’s 43,000 square kilometers could take years to explore completely, though in six months they would reach the highlights. Its gravity was about two percent that of

earth; once the ship was landed they would barely notice that their 0.4 gravities was "tilted" a little, enough so that a marble, placed on the floor, would roll consistently "downhill" toward Astrea even though the centrifugal rotation was making "down" to be at right angles to the ground. Astrea was not expected to produce any surprises. They had been exploring it by Prospector for over a year, already had a small robotic fuel making plant set up, and had several hundred kilograms of samples from four different localities.

Just then the engine sound changed, and with it the gravity. Charlie looked around "Is that okay?"

"Yes, as the fuel is burned up the ship gets lighter. They just shut down engine number three. Only two are firing now."

He nodded. "Are we going to have supper the usual time?"

"Yes. Nothing is changing because we're landing." Though, Helmut reflected, a lot of things *were* changing. Rather than having two hundred tonnes of methane and oxygen fuel on top of the ship to shield them from cosmic rays, they'd have an entire asteroid underneath; and in six months time they'd have five hundred tonnes of oxygen, methane, hydrogen, and water on top as well, assuming they were able to make all the fuel they needed for the trip to Ceres. They'd also have less power because Astrea blocked the sunlight half the time, and simultaneously the drilling and exploring would demand more power than they used while cruising. They'd leave for Ceres with lots of water on board, which they'd have to convert to hydrogen and oxygen fuel during the cruise.

Then they heard and felt the two engines throttle back. Helmut looked up at the screen; they were skimming above the surface of the asteroid at just a few hundred

kilometers per hour. Up to this point, an engine failure would have resulted in a flyby rather than a crash; but now the velocity was almost completely adjusted to equal the asteroid's, so it would pull them in. Sure enough, the screen showed that they were tilting around in order to land. The engines continued to fire at a very low level.

"Here we go, Charlie," said Helmut. The altitude meter was dropping. . .100 meters. . . 90. . . 80. . . 70. . . 60. . . 50. . . 40. . . 30. . . 20. . . 10; dust began to get kicked up as the flame blasted the loose surface. Then the engines shut out entirely and for a moment all felt normal. Then with a very slight bump they could feel the landing.

The loudspeaker crackled. "The *Giovanni Piazzi* has landed on Astrea," announced Charles Vickers. "The landing was perfect."

"Yeah!" said Helmut, applauding, and Charlie did, too. He removed his safety harness and took off Charlie's as well. "Let's go check the toilet!" said Charlie. He jumped up and ran in the bathroom. "Oh, the water isn't tilted any more!"

"No, the engines aren't on any more."

"But I wanted to see it!"

"I'm sorry, but we can't get up when the engines are firing. Maybe I can strap a tablet to the wall so we can watch it by video next time." Charlie didn't seem satisfied, so Helmut added, "Come on, let's go set up your room." He took Charlie's hand and they walked back into the main room—Helmut and Clara's bedroom at night and their living room during the day—and then into Charlie's small bedroom. They unlatched the toy chest and the closet with its toys. Everything had to be secured for the engine firing.

There was a knock on the door, then Martha and Caitlin entered. "How did all of you do?" asked Martha.

“Pretty well, but Charlie wanted to see the water in the toilet tilted when the engine was firing and was disappointed when he looked afterward.”

Martha smiled. “I’d like to see that too, some time, Charlie. Maybe we can video it next time.”

“No, I want to see it.”

“Let’s see what toys you want to play with. In a little while, after Caitlin and I finish her arithmetic lesson, we want to draw with you.”

Charlie turned to Helmut. “Dad, I want to go with you!”

“You can’t, I have to go outside. But you’ll have fun here with Caitlin and Martha.”

Charlie grabbed his father’s leg and cried. It took several minutes of patiently talking and pulling for Helmut to get away. “It’s the arrival,” said Martha. “He can feel our excitement and anxiety.”

“I’ll be back for supper,” said Helmut, knowing it would probably be a late supper. They had a lot to do.

He headed to the elevator and up to the central axis. When the elevator stopped his centrifugal weight had ebbed to almost nothing and Astrea was pulling him “down” against the wall. He pulled himself out of the elevator and “up” using handholds, since two percent gravity was not much of an impediment; “just enough for pissing,” someone had once remarked. The “top” of the central axis connected to the egress facility, a cabin fifteen meters in diameter and five meters high on the top center of the flying saucer. The cabin’s roof was studded by three docking ports where vehicles could dock. The interior

had two spacesuit donning facilities and a garage where four hopper vans were parked amid deflated and stacked solar arrays and tonnes of other gear.

The spacesuit donning facilities were a chaos of people putting on suits in low gravity. Twelve people—almost half the crew—were going out. Three were already outside installing a ramp to get everyone and the hopper vans conveniently and safely to the surface. “Don’t use the gravity, folks,” the word came back from them. “It’s too low. Follow Phobos and Deimos norms.”

Helmut was almost the last one to go out; only Commander Vickers, who had been busy in the bridge longer than expected, was left. Zach and Thierry had already jumped down to finish the ramp so everyone else followed and started on their tasks. Helmut tried walking along the ramp, but he found it tricky even with the electromagnets in his boots turned on. So he deactivated them and fired the jets on his backpack, soaring twenty meters into space and then fairly quickly coming back down. It gave him a nice view of the caravel’s circular top with its central egress cabin, the pathway around it, and two pathways to the edge, one with a ramp. The rest of the top of the saucer was covered by two semicircular “tank sheds,” metallic enclosures four meters high with micrometeoroid-proof roofs. The sheds contained their tanks for hydrogen, oxygen, methane, and other cryogenic liquids.

He set his feet on Astrea, watching powdery dust rise from the regolith as his boots crunched in. He did what everyone else did; reach down and pick up the first rock he saw. Iron-magnesium silicate; not an unusual sight on an asteroid made of stony material like Astraea. The regolith would be a mix of local fragments and of the objects

that fell on it, which came from all the asteroid types. Because of its size, Astrea had a fairly thick regolith; photographs of crater rims showed layers.

"Okay, everyone, gather round!" It was Vickers' voice. Helmut looked up and saw Charles landing about thirty meters away. He had chosen his location carefully; a camera shot toward the ship would show a crater wall a hundred meters away, making quite a nice scene.

The crew jetted or shuffled over and formed a line. "No Mars flag?" someone asked over a private line, so that the billion people on Earth wouldn't hear.

"We have the flags of all the sponsors," replied Charles. "Is everyone ready?" They were, so Charles took the United Nations flag and stepped forward. "Seven months ago the *Giovanni Piazzi* left Embarcadero Station, Mars, for the asteroid belt on behalf of all humanity. Today we have achieved our first landfall: Astrea, a moderate-sized world in the inner belt. Today we claim this world for humanity and the Asteroid Belt Commission. Perhaps some day Astrea will have residents and will contribute to the culture and technology of the human family. In their name, we plant these flags. First, the flag of the United Nations." Charles drove the flagpole into the loose regolith, lifting his feet into the air when he did so. He carefully lowered himself back to the ground.

Then others stepped forward, one by one, with the other flags: the United States, the European Union, Russia, China, France, Germany, Japan, India, Canada, and Brazil. Finally, Helmut, as one of the youngest on board and the father of a Mars-born child, had the privilege of planting the Marsian flag.

Kristoff arrived at the Gallerie quite late for supper; sometimes work in Ceylon Agridome made him late. He was disappointed to see that his friends, especially the women he liked to see, had all left. Both eateries still had food, though, so he grabbed supper, ate it quickly, then went out to prowl around and see whom he would see. The outpost had benches and chairs, usually under a building overhang or a cluster of trees, and it was quite common to see people sitting outside the door to their flat socializing.

He cruised around the square saying hello to various people, but no one he wanted to sit and chat with. He crossed into Columbia, but headed out of it quickly because it was winter there and quite chilly; snow was "forecast" for the wee hours of the morning. Colorado already had its coat of snow, so he avoided it and stuck to "North Main Street," a tunnel that was always warm. He stepped into Cochabamba and was hit in the face by warm, slightly humid air; there was no winter there.

Both Millie and Nadia had moved to Cochabamba recently; the continued construction of houses in Andalus and now in Cathay had allowed some to move into larger flats, triggering a reshuffle of housing that would continue up to the eve of columbiad 12's arrivals. So he was hopeful he'd find someone to chat with and perhaps even spend the night with. But the lights were off in both their places, so he headed to the university in Catalina and Yalta.

Just before leaving Cochabamba, though, he passed Rahula Peres, sitting on a bench under an orange tree, looking dazed; or maybe like he was meditating. Kristoff stopped, and Rahula looked up. "Are you okay?"

"Yes, I guess." Rahula paused. "I just asked Cindy Uribe to marry me, and she said yes."

“Hey, congratulations! When’s the wedding?”

“We didn’t set a date; probably a couple months. I’m sorry if I look out of it, but I’m dazed; I’m thinking about life, the future, marriage, responsibilities, children, what we’ll do here . . . so many decisions to make together . . . it’s exciting.”

Kristoff was startled and baffled by his friend’s reaction. “You don’t look excited!”

“I am but my mind is racing about everything. And I’ve got to go home to tell my mom, and both of us have to call dad.”

“A funny time for him to hear this, especially after walking on Astrea all day.”

“Exactly! I’m not going to ask him permission to marry her now. It’ll take him a few sols.”

“You’ll ask permission?”

“Yes, of course. My mother and father’s marriage was arranged, you know. That sounds strange to a lot of people here, but it’s still very common on Sri Lanka.”

“Really? But he’s not expecting to decide for you, is he?”

“No, of course not. He and mom and I sat together after we arrived here and they said I could marry someone of any background I wanted, it was my choice. Almost everyone here marries someone of a different background, after all. But they still wanted the right to give permission. I said yes.”

“Do you think your father will object? She’s pretty Catholic.”

“I don’t think so. Dad’s grandfather was Catholic; my mom’s aunt was a nun. Our family name, Peres, is Portuguese. But our Peres family has been on Sri Lanka for almost five hundred years and is thoroughly indigenous.”

“Not only is almost everyone here marrying someone of a different nationality; most people even on Earth are partially mixed.”

“More that they’ll admit, sometimes,” agreed Rahula. “The new President of France is of Russian background and the Chancellor of Germany is a quarter Turkish. Anyway, thanks for asking. You must be excited about the Astrea mission, too. Your dad and brother have worked very hard.”

“I haven’t seen dad for several sols. He’s always in mission control. But he’s very proud of the mission and especially of Helmut. I’m proud of him too. He’s really accomplished a lot.”

“He planted Mars’s flag this afternoon.”

“He did? I didn’t see the ceremony; the cassava was demanding my time.”

Rahula laughed. “Cassava? We never planted that in Sri Lanka!”

“The Nigerians wanted it, so we planted it in Ceylon as an experiment. It’s growing pretty well.”

“Good! I guess I don’t look dazed any more. I better head home and talk to mom.”

“Good luck. Ciao.”

“Ciao.” They both headed their own ways. Kristoff entered Catalina, but found it completely empty, so he crossed into Yalta Biome. Veronique lived there, and the outpost’s former commercial center was now a hangout for singles. People with musical instruments often played at night at the snack bar. He spotted Veronique, but in a circle of about a dozen other women who were sitting around Cindy Uribe. Nadia and Millie were

there as well. He could hear fragments of conversations about wedding dresses, hairdos, and receptions.

He didn't want to approach the circle and break up their fun, so he walked across the biome. It occurred to him that his father loved hot chocolate and probably hadn't had one in a week. So he headed for Andalus to buy one and take it to Mars Control.

Alexandra Lescov hurried to the access door of Andalus Southwest. "Sorry to keep all of you waiting," she said when she arrived.

"We just got here, too," replied Ethel, who was accompanied by the nine members of the Aurorae Spiritual Assembly and by Will.

"Good." Alexandra turned to the door. "Unlatch door to the Andalus Southwest Tunnel, please." The door dutifully unlatched and she pulled it open. They all followed her inside. "Quite something to watch the video from Astrea," she said to Will.

"Yes. It's nice to be able to watch without feeling responsible," he said. "After two sols of exploring and setting up, they seem to be off to a very good start."

"Yes, they do." Alexandra pointed to the tunnel around them. "Nothing unusual here," she said. "A standard nickel steel pressure tunnel six meters wide and high, twenty meters long, with pressure doors at the beginning, middle, and end. You can drive a van on the false floor, which has air and water pipes beneath. The hatches on the right and left sides, half way down, are pre-built access ways to underground interdomal facilities, if any are ever built." She pointed to the side doors as they went down. They walked to the end. "Please open the pressure door leading into southwest Andalus dome," Alexandra said, and a moment later the door unlatched.

She opened it and they slowly filed inside onto a gravel path that led all the way across the square seventy-meter dome. Two branches paths led to either side. The interior was warm. Off the path the bare ground was muddy, with puddles and ponds. “It doesn’t look like much right now,” said Alexandra. “The sides of the dome consists of two rows of metal ‘piles,’ two per meter, driven twenty-five meters down, one set angled toward the center of the dome and one set angled outward, frozen into the reg, connected by welded sheet metal plates down five meters, covered by five centimeters of insulation that includes three airtight membranes. The floor is ‘open bottom,’ meaning there’s no plastic membrane. We pumped heated and compressed Martian air in here for an entire month, which warmed the reg above freezing down four meters. Then we added half a tonne of water per square meter—2,000 tonnes altogether. There’s still some on the top, but it’ll be absorbed in a week or two. It has frozen the regolith at the bottom, reducing air losses to almost nothing

, so we oxygenated the atmosphere in here three sols ago. The dome has the usual insulation blankets with silvered reflecting bottom surfaces and the standard ultraviolet and infrared blocking membranes; the infrared blockers are set to raise the interior to 25 Centigrade.”

“Temperature control during duststorms?” asked Tomas Racan.

“You’ve got it. The dome has an infrared curtain that stops 95% of infrared radiation. If we raised curtain over the dome right now, this place would zoom to over 40 degrees Centigrade in two sols. Actually, it’s partially raised right now; see it?” She pointed to the western side of the dome, which had a darker blue tilt than the eastern side. “The ground in here’s still pretty cold, so the dome’s trapping more heat to warm the

ground. During a dust storm, the dome's master thermostat partially raises or lowers the IR curtain. It can also pump out ground water, cool it, and pump it back into the ground to maintain air temperature at the expense of soil temperature. You've got about 30,000 tonnes of regolith under you that's above freezing; that's a lot of heat."

"Life support equipment?" asked Kim Irion.

Alexandra shook her head. "You don't need it unless people plan to live in here. This dome has 100,000 cubic meters of air; that's thirty tonnes of oxygen, ten tonnes of nitrogen, and five tonnes of argon. If you had five hundred people in here for an entire sol, they'd only consume 1.5% of the oxygen. You could bring in 200 kilograms of firewood and have a bonfire and the oxygen level would still be safe. The dome has an air input line controlled by environmental management. The outtake line will remove excess air if the carbon dioxide content falls below 0.3%, which doesn't take long on a sunny day when there are a lot of plants. There's also a separate carbon dioxide input line."

"And we'll produce a couple of tonnes of oxygen per year?" asked Ananda.

"That depends on the plants. The oxygen goes back into the outpost's environmental management system."

"And that access door on the eastern side; is it an emergency escape route?" asked Ethel, pointing.

"It'll provide access to Andalus southeast once it's completed in two or three months. Right now the tunnel goes ten meters to a second pressure door. It'll provide an emergency shelter in case of depressurization."

"And what about irrigation and topsoil?" asked Enrique Delrio.

“There’s a water pipe in the tunnel, so you have a water supply, but you’ll have to decide what sort of irrigation system you want; you can have a central system that dispenses water evenly to the entire floor from the apex of the dome, or drip irrigation. You’ll need to install desalinators. We already have ten wells installed with sensors that monitor the ground water level. The ground water will grow increasingly salty as chemical weathering of the regolith takes place. It will poison trees with long roots and corrode the pilings, so you must install desalinators to pump out ground water, desalt it, and store it in a tank for reuse as irrigation. It’ll need to be topped off periodically as well because some of the water will be used up as minerals hydrate. The tanks also can heat the water; the sensors will tell you how far down the ice table is and you can control that by irrigating with warmer or cooler water.

“As for topsoil, we haven’t provided any. You can buy some; we usually recommend at least three centimeters, but if you buy treated sewage sludge or compost you can buy half as much topsoil.”

“This is complicated!” said Kim.

“It gives you an appreciation of the work that goes into an agridome,” agreed Will. “And the volumes they require.”

“The thirty tonnes of oxygen require 150,000 kilowatt-hours of electricity to make from water,” noted Alexandra. “That’s only seventeen kilowatts continually for a year, though. The oxygen we need for expansion now comes from photosynthesis. Two thousand tonnes of water sounds like an awesome amount, but we extract over one tonne of heavy water from it, which is worth three million redbacks. We’re now geared up to make these things.”

"Are there any kinds of plantings you would recommend?" asked Ananda.

"Ask Lisa Kok, but I'd suggest clover. We have a strain that is nitrogen fixing and does well in unimproved or poorly improved reg. It'll provide a thick, attractive, slightly aromatic ground cover quickly; it can be cut and harvested for animal food; and when it flowers you can be paid for bees to be brought in and make honey. It's a good multiple use plant."

"Then we're not depriving the outpost of needed space," said Ananda.

Alexandra shook her head. "No, the situation has changed a lot in the last few years. This dome has 4,900 square meters; it could feed forty-nine people. When we were receiving thirty or forty people per columbiad we would have never spared a dome like this. The dome would have cost a lot more to make, too; our earliest domes were forty meters across and cost forty million redbacks each! But the larger flights have necessitated a great expansion in our dome-making capacity and costs have fallen. We need domes like this to provide redundancy to our agriculture; if we ever lose a dome in some sort of accident, we'll press this one into service as a backup. We can't easily divert space in the bio-archive domes because of species contamination problems. By providing the outpost with a sort of park, you're doing us a favor."

"We're providing a service," agreed Tomas, smiling. "That's what I like about this idea the most."

Alexandra looked at the others who had not spoken. "So, what do you think?"

"Oh, we're taking it!" replied Ananda. "There's no question; the Assembly made the decision last night. We've got the money in the bank. Our plan is to landscape the

place over six to twelve months and open it as a spiritual park next spring. It'll be a place of contemplation, quiet, and enjoyment of nature. No picnicing, though."

"That sounds nice," said Alexandra. "Andalus Southeast will be the bioarchive 'Hilo' for a Hawaiian tropical ecology. You can go to the website to complete the paperwork and deposit the check in the Commission's bank account; the paperwork gives the details. I gather the Assembly is already legally incorporated as a nonprofit. The borough is now in charge of environmental management and safety and charges an annual 100,000 redback fee for those services, plus a 40,000 redback property tax, but I suppose you're exempt from the latter. Once the paperwork is complete, I'll have my assistant change the voice print codes on the doors to let all nine of you in, plus anyone else you want."

"Great." Ananda extended his hand. "Thanks for the tour, Alexandra. We appreciate it."

"Delighted." She shook hands with him, then with the other eight.

They all turned to head back out. As they were walking down the tunnel back to Andalus, Will stopped at the access doors half way and tapped on them. "Ethel, what do you think of the idea of buying the interdomal area here?"

She stopped. "Why? Our current house is fine."

"Well, I wouldn't mind a bit more space, this would be closer to work once the Commission's offices move into Andalus, and we have plenty of money."

Alexandra overheard the comment and stopped as well. "Our new standard oasis domes are ten meters by twenty and only cost a hundred thousand, plus another hundred

thousand to dig the hole, inflate them, and bury them. They should be installed in pairs for safety."

"Four hundred thousand buys us 400 square meters," noted Will. "Of course, building a house that big would cost several million more."

"We don't need it, but I'm willing to think about it," replied Ethel.

10

Ups and Downs

early Aug 2057

By Sunsol, the paperwork was finished and Andalus Southwest belonged to the Bahá'í community of Aurorae. They gathered for a special devotional program in the dome, sitting on folding chairs borrowed from various homes and public places.

"This place hasn't dried up very well," said Ethel, after the prayers and songs were over and they were eating some cookies. She kicked the ground. "It's still muddy."

"When Alexandra said a few sols more, I don't think she was speaking literally," replied Will. He looked around. "It's still hard to believe we own this. It's larger than the entire outpost was five years after arrival. It's larger than the first four biomes combined!"

"Which cost hundreds of millions to design, manufacture, and set up," added Ethel.

"Why didn't bioarchive get this?" asked Ananda.

"They don't need it, believe it or not. They have enough right now and they are planning to use most of the six smaller domes associated with Cathay, Punjab, and Zanzibar," replied Will.

"I was thinking that we might want to move as many meetings here as possible," said Ananda. "The evacuation shelter is large enough for two classes, and the entrance tunnel could be used for another. People can walk to Andalus Square to use bathrooms for now."

Kim grimaced. “So ugly and inconvenient. Don’t you think we should at least wait until we can get a portable john? And maybe a few tents?”

“And some plants; these are not enough!” Tomas pointed to three potted geraniums and a potted rose that various people had bought. “Lisa Kok said that the quantity of flowers we need in here is not available. We’ll have to buy seeds, raise flowering plants, collect their seeds, and use them to plant the rest of the space.”

“We may want to make some of this space into a flower farm,” said Ananda. “We could sell the flowers. For that matter, I wouldn’t mind planting some ever-bearing strawberries, peaches, and a few other fruit trees; we’d have our own supply of refreshments.”

“We should hire someone to design the gardens professionally,” noted Will. “The concrete dome edge could be covered by terraces and maybe even waterfalls.”

“Who’s going to plant all this?” added Tomas. “We’re all working. Maybe the youth could do it?”

“What youth?” replied Marshall, startled. “I work, too, when I’m not in school, and Lizzie’s pretty busy.”

“This is a real problem,” agreed Will. “This place is so busy and work-oriented, no one has time left for anything else. We don’t have volunteer associations. We may have to hire some workers to help us.”

“But can we find workers to hire?” asked Ananda. “That’s why I’d favor moving our meetings here right away. If we all stayed an extra hour to garden, we’d build community and beautify this place.”

“When will we build a temple in here?” asked Tomas.

“That may be a while,” replied Ananda. “The Construction Crew has no spare workers to build it. For now, we can consider the entire dome a House of Worship.”

“Well, it isn’t nine-sided, the way houses of worship are supposed to be,” said Tomas. “And there’s the issue of the use of this place. Houses of Worship have a lot of restrictions on how they can be used. People will want to be married here; they’ll have to follow Bahá'í marriage laws to be married on our property, though. One friend even asked me whether we planned to allow barbeques in here!”

“People will misuse this space,” agreed Will. “We should encourage the borough government to set up some small picnic spaces with barbeque facilities in some of the larger agricultural and bioarchive domes. Otherwise people will come here to picnic.”

“If we build something, the sacredness of this place will be more apparent,” said Tomas. “Let’s start with the basement where we could hold classes. People would be less inclined to picnic if there was a building in the middle.”

“Let the Assembly decide,” replied Ananda, cautiously. “I like your ideas, Tomas, but we can’t decide these matters now.”

That seemed to end the discussion; Ananda was the Assembly’s secretary and tended to be listened to because of his experience. People finished their cookies and walked around the space to absorb the fact that they now owned it. Then people began gradually to leave. Will, Ethel, Marshall, and Lizzie were among the last. They walked home about 1 p.m.

“This should be a quiet afternoon,” said Will. “There’s coverage of Astrea on t.v. in another hour; a team’s exploring the Grand Chasm.”

“I plan to get the laundry ready for the automat,” said Ethel. “Then I’ll join you.”

"I'm going out exploring with Sammie at 2 p.m., if that's okay," said Marshall. "But first, dad, I wanted to talk to you about something."

"Sure; what?"

"A couple weeks ago Paul told me that he was planning to take the Martech course on the Geology of Phobos this fall, and he encouraged me to apply for it as well. So a couple sols ago I talked to Dr. Stroger. It's a joint Martech/Caltech course; 14 students here are signed up and 25 in California. He said there's room for me, and I did alright taking the Martech course last summer, so he approved me for signing up. Since it's set up for distance-learning, if any of the classes conflict with a high school class, I can attend the latter and make up the missed class by video."

Will smiled. "Fantastic! Congratulations! That's a great addition to your academic record. It won't be easy, though, and since you're now almost eighteen they won't cut you as much slack as they did last year."

"I know; Dr. Stroger said as much. I'll have to take the final exam and write a research paper. I'll get a letter grade not a pass/fail. But dad, there's more. I asked him whether I could take the field trip to Phobos. He said I'd need permission from you and mom, since I'm not yet 18, and I'd have to be space certified."

Will was startled. "This is a distance-learning course for Caltech students as well, and they won't be going to Phobos. Why do you want to go?"

Marshall was taken back by that. "Dad, of course I want to go to Phobos! Who wouldn't! Who'd ever pass up an opportunity like that!"

“Well, you’re not 18, and you won’t be before February of next year. Besides, how would you get space certified here? We’ve never done that before because everyone arrives here space certified.”

“I asked Yevgeny Lescov about that yestersol. He said they’ve anticipated the need to certify us kids at 17 ½ and recertify people who haven’t flown into space in the last decade. I’m already certified to wear a pressure suit. He said he could set up a class for me on Satursol mornings, September through November, with several hours of reading as well, and I said I’d do it.”

“Oh.” Will looked away. He looked at the ceiling for a moment. He didn’t want to look at Marshall. He didn’t want his son flying in space. “You’re not 18, son. You’re still too young. Look, in seven months you’re going to be an adult. Let’s not rush it. Enjoy your youth while you have it.”

Marshall scowled. “Dad, don’t be ridiculous! I want to go to Phobos in December for two weeks; isn’t that a great experience for a youth?”

“Well, I’m not going to give permission.”

“What? Why?”

“Because you’re under age, that’s why. Wait until you’re eighteen.”

“They only offer this course once every two or three years!”

“And two or three years isn’t that long to wait.”

“Dad, *why* won’t you give me permission? You aren’t granting me a privilege as son of the Commissioner; Dr. Stroger said it’s an existing policy because they know Sammie and I are coming along, as are two hundred other kids. It’s a routine thing.”

“Marshall. . . let’s not discuss this more, okay? I’ve told you my position. You’re still a kid. Enjoy it and don’t rush adulthood, okay?”

“No, that’s not an answer!”

“Well, it’s my answer.”

Marshall’s face turned red. “Well . . . . damn you, then!” He turned and stormed out of the house, slamming the door.

Will sat on the couch, shocked by his mild-mannered son’s reaction. Ethel had watched the whole thing. She looked at Lizzie. “Dad and I need to talk.”

“Okay.” Lizzie went to her room and closed the door, where she still could hear. Ethel came and sat on the couch with Will. “He is just a boy.”

“His reaction proved it, wouldn’t you say?”

“He owes you an apology.” She let silence pervade the room for a minute. “Permission is something we are allowed to give.”

“I know.”

“You’re afraid you’ll lose him, aren’t you?”

“Well, yes, I suppose I am!” exclaimed Will, raising his voice. “There’s one chance in two thousand that the Mars shuttle will either blow up on launch or crash on landing. And there was the time David Alaoui and I were exploring the rim of Tycho and he slipped down a 20 degree slope and I had to rescue him in a stiff pressure suit in lunar gravity with only an hour of spare oxygen. And the time Shinji and I were sound asleep in a van up at Nirgal and at 4 a.m. a pressure seal failed. And the time I fell down in Chryse and slightly cracked my helmet.”

Ethel nodded. “And the time I was riding from Peary to Gateway and the lifter blew one of its engines; we had to limp to orbit. And the time I overheated a carbonyl synthesis unit, it hit 150% of its maximum rated pressure, and if it had exploded it would have killed me. And the time Paul Renfrew grazed a boulder, lost control, the ranger depressurized and he died. And the time Guillaume van de Velde’s sunwing lost part of its wing and crashed. And the six or seven accidents with injuries we have up here per year.”

“Exactly.”

“And your mother and father let you go. So did my parents.”

“We weren’t seventeen.”

“We also weren’t Marsians. This is like getting your driver’s license, Will, and not much more dangerous.”

He thought about that. “Well, I suppose that’s true. I just wish he’d wait.”

“Would you have waited?”

“No, I suppose not.” He sighed. “Alright, I’ll talk to him again.”

“I was impressed he had done all the research.”

“Yes, that’s true.”

Ethel rose and went to get the laundry. By the time she had it all collected together and had dictated instructions about individual pieces—they were all bar coded—the robotic laundry cart had arrived outside the door to pick up the load. She piled it in and sat to watch the Astrea mission with Will. Then they listened to the news and walked to the Gallerie for supper.

Marshall didn't come home until 9 p.m. He went straight to his room, so Will had to knock on his door.

"Can we talk?" he asked.

"Sure." Marshall sounded hesitant. Will entered.

"I think we both owe each other an apology. I'm sorry I was so stubborn. Your mother and I talked and we agreed your plans were carefully thought through. I . . . was just frightened we'd lose you."

"Dad, I'm only going to Phobos!"

"I don't mean in the sense of you moving out of the house, I mean we don't want you to die. Space travel has its risks."

"Oh. Yes, I know that. And I'm sorry I said whatever I said. I actually don't remember what I said, but I was angry and I expressed it. I . . . apologize."

Will felt a tear in his eye. "Thank you, apology accepted. Mom and I will sign a permission form. You can fly to Phobos."

"Thanks, dad! I can't tell you how grateful I am."

"Just be careful."

Sebastian Langlais looked over the complicated spread sheet covering three of the four screens in his office right off Piazzi Mission Control. They told the story of the ship's various inventories. Solar power was 2% lower than expected, but within margins. The well the crew was drilling was scheduled to produce water three days early; good news. Hydroponic productivity was 30% lower than in flight because of the lower solar power supply, but was 10% higher than the minimum. As planned, they had eliminated cotton

and flax production entirely; they had enough fiber and vegetable oils to make such things as paper—they could never eliminate their need for that!—tampons, soap, shampoo, and other essentials for the duration of the surface mission. Volatile consumption was much higher than expected because 'Phobos norms' mean they were jetting around the asteroid instead of walking, and with a much higher gravity than Phobos, jetting used a lot of gas. But exploration was following the plan pretty closely. They were running three Prospectors on the surface almost continually, one geology team was exploring the landing area and another team was traveling around the asteroid by hopper-van. The additional satellites they had put in orbit around Astrea had generated a flood of data, including some surprising reflection spectral results.

Sebastian examined the table line by line, auditing everything. He no longer worried about inventories as much as he used to, but he still concerned himself with it more than Commander Vickers wanted or appreciated. A similar line by line examination of the financial spreadsheet guaranteed that no budgetary detail escaped him. Overruns produced emails requesting explanations.

But it was 4 in the afternoon and he had been working on such details since 7 a.m. with only a short lunch break, and with only five hours sleep before. When he finished examining the spread sheet he stood and was surprised to feel faint, then dizzy. He quickly sat in his chair and realized that he was having a burning sensation in his arms and chest.

Heart attack? His cholesterol was fine. He had no heart blockages. His blood pressure had been high, but he had been taking medication for it. But as he sat there, consciously probing his body with his thoughts, he felt a tightness of breath as well, and a

touch of nausea. This was not normal. “Call the hospital please, Julie,” he said to his virtual office assistant.

There was a brief pause, then a too-perfect image of an efficient telephone operator. “Mariner Hospital.” He groaned; in his haste he had gotten a virtual receptionist. “This is Dr. Sebastian Langlais, and I think I am having a heart attack. Please connect me to a physician.”

“Right away, Dr. Langlais.” The tone was calm but urgent. No doubt his medical records were already being found and his location was being determined. He pushed the communicator into his ear to make sure it had a good contact; in milliseconds it would be asked to report his pulse and breathing rate, estimate his blood pressure, take his temperature.

The tablet’s image changed and Shinji Nagatani appeared. “Sebastian, what are your symptoms? We’re pulling up vital data right now.”

“Shortness of breath, a feeling of nausea, burning in my arms.”

“And you’re in Andalus? That’s a long way to walk.”

“I can’t walk it.”

“You shouldn’t. I’m getting your pulse now; it’s not normal. We’ll send the ambulance. Is there anyone nearby who can help you?”

“Yes. I’ll call Albert Baert; he’s running the Control Room right now.”

“Sit tight, we’ll be right there.”

Sebastian leaned back in his chair and called for Albert, who hurried over and sat with him. Shinji was indeed there, in only two minutes, complete with a nurse and a stretcher; they gave him a shot, helped him get on, and rushed him down the ramp to

Andalus Square, where a van, set up as an ambulance complete with flashing lights, was waiting. A quick drive up the North Main Street Tunnel and Sebastian was at the hospital, where it soon became clear that he was having a heart attack.

Irma Baeker, the chief nurse, immediately called Kristoff; that was not a call they left to virtual assistants. He ran over to the hospital.

"Can I see him?"

"Not right now," replied Irma, speaking with her crisp German accent. "They're stabilizing him. His heart is under severe stress; there must be a blockage. They're administering drugs to decrease the stress, then they'll determine the extent of the blockage and administer drugs to dissolve it. Don't worry, they have everything they need; we have no shortage of medications."

"Have they ever treated a heart attack on Mars before?"

"No, this is the first one, but the physicians have treated them on Earth and they've kept up with the medical advances of the last few years. We also have cardiac support teams available in Houston and New Delhi, and its mid afternoon in New Delhi right now, so they're available."

"I should call Helmut; no, I'll wait until there's news. No reason to worry him too much."

"I'm not sure who's running the Asteroid Belt Commission or the Ceres Project right now! What can I get for you? Some coffee?"

"No, nothing; I couldn't take anything."

"Sometimes a drink will help, like water, or maybe a pastry. Let me know; I'll be right here." Irma pointed to a desk in front of the doors to the emergency area.

"Thank you," replied Kristoff, smiling. She was charming as well as supportive. He sat in a chair in the waiting area and stared at the wall. "He works too hard," he finally said.

"Many people up here do," replied Irma. "They believe in something, and that partly compensates. But it is hard to balance all the demands of life, isn't it?"

"Yes, it is," agreed Kristoff.

Up on Astrea, Helmut was unaware of his father's situation. He was sitting in the front passenger seat of hopper-van 2, which was coasting from the *Piazzi* to a geological site near Astrea's north pole. Hopper-vans were simple devices; they were ordinary vans as would be used on Mars or the moon, a pressurized vehicle with six wheels able to support two people easily for several weeks or up to four in an emergency, but with three small rocket engines mounted in front and three more mounted in the rear, supplied by several large oxygen and methane tanks on the van's roof. The six engines gave the squat vehicle redundancy and stability and the propellant gave it a total delta-v of about 5,000 kilometers per hour, plenty for taking off, coasting to the far side of Astrea, landing, and returning to the mother ship. Equipped with six extremely large tires with long metal cleats to ensure traction in the asteroid's low gravity, the hopper-van could also roll slowly across the surface.

Hopper-vans 2 and 3 coasted about a half hour to reach Astrea's north pole and landed on the crest of a flattish ridge, where sunlight would keep the van warm. The four crewmembers had just climbed out of the vans and had to study alternating layers of ice and regolith in the inner slope of a crater when Helmut got a videomessage from Kristoff.

“Helmut, this is Kristoff. I’m sitting in the waiting room at Mariner Hospital right now. Dad’s in the emergency room undergoing cardiac stabilization. He’s had a minor heart attack; his heart hasn’t stopped or anything, they caught the problem before it got that serious, but they can’t predict what will happen next. They think there’s blockage; they’ll check that next, then administer drugs to dissolve the plaque if that’s the problem. So I’m just sitting and waiting. He works way too hard; he’s been getting four or five hours of sleep per night. I wish he’d retire or at least slow down. Anyway, call me back. This is getting pretty nerve-wracking. I wish you were here. Bye.”

“Oh God,” Helmut groaned. He glanced at the chronometer; the message had taken sixteen minutes to reach him, so his reply would take sixteen more. His father could already be dead. And in the spacesuit he couldn’t tape a videomessage, only an audio one. “Please reply, audio, private line,” he said to the suit. “Kristoff, thanks for calling. I’m outside, but I guess I had better head inside a van so I can talk better. I’m here with you, as much as I can be anyway. Let me know how dad’s doing. Bye for now. Send message, please.” He switched to the public frequency. “Hey guys, I’ve got a family emergency. I need to go back inside the van so I can talk more easily. Can you do without me?”

“Sure,” replied Thierry. “Is Charlie okay?”

“It’s not Charlie or Clara; it’s on Mars. Kristoff’s in the hospital and I’ll know more later.” He decided he had better not mention who was ill.

“Go ahead,” replied Thierry, who was in charge of the polar expedition. “We’re scheduled to be here twenty-four hours; should we leave early?”

"I'll tell you later. Bye." Helmut closed the line and looked at the van fifty meters away. He cautiously, carefully planned his arc back to it so that the trajectory was neither too long nor too short, taking a laser rangefinder reading to ascertain the exact distance and velocity needed first. He didn't want to make a mistake because of his worries.

He landed just short of the van and slowly walked to it; one had to go very slowly in 2% gravity. He entered the airlock and was quickly inside. He pulled off the spacesuit and called Clara.

"I didn't expect to hear from you," she said.

"Have you heard? Dad's in the hospital; he's having a minor heart attack."

"Oh my God. I wonder who's running Mission Control? I suppose Albert."

"There are only three or four of them there anyway; there's not much they can do to help us. I'll forward Kristoff's message to you. I haven't told anyone."

"I better tell the Commander, though."

"Yes, let Charles know, but let's let him tell the others."

Kristoff got very little sleep that night; the hospital gave him a bed in the room next to his father, but after several hours of procedures, Sebastian mostly slept. Helmut rested even less; after eight hours the mission was cut short and the two hopper-vans returned to the *Piazzi,* partly because mission support was weakened. Clara stayed up with Helmut most of the night, waiting to hear, though there was no news.

The next morning Sebastian felt a bit better. "Dr. Feldman just finished examining him and said he can have a few visitors now," Irma told Kristoff at 6:30 a.m. when the shift changed.

“Thank you. You were here all night?”

“Of course. I don’t usually do a night shift after a day shift, but we have patients overnight less than half the time. I was on call. So were three others; your father had excellent care!”

“Plus two teams on Earth. I’m very impressed.”

“Well, it costs a lot to fly people here, so they get the best medical treatment,” she replied with a smile. Kristoff nodded and crossed to his father’s room.

Sebastian had an oxygen line clipped to his nose and an i.v. in his arm, but otherwise looked fairly alert. “Good morning,” he said. “You’re up early.”

“I was sleeping across the hall! This is a family friendly hospital.”

“They have spare beds. Have you been talking to Helmut?”

“Of course. They’re waiting to hear any news; they’re very worried.”

“Everyone is,” He sighed. “I almost feel like I could get up from the bed and walk home. I’m not sure whether I can’t because of the heart or the medications.”

“They sedated you.”

“Of course! They had to. They injected a pretty powerful plaque dissolving agent into my system, and watched very closely for bleeding; it’s the biggest side effect. You’ll have to talk to Arieh and Shinji about the results. I’m still a bit out of it.”

“I’ll talk to them. Don’t worry, dad; I’m here for you.” He looked at his father and they exchanged a powerful feeling of love without saying anything. Sebastian felt a tear in his eye.

“Thanks.”

They didn't say anything else for a moment. Then Shinji came in. "Good morning. Is this a good time to talk?"

"Just give me the summary for now; Kristoff wants the details."

"Okay. I can give you the details this afternoon. The long and short of it is that you developed two blockages in your coronary arteries and that we have dissolved about twenty percent of each; we're scheduling you for a scan in about an hour to verify. There appears to be no permanent damage to the heart muscle, so with some adjustments you should recover fine."

"How long do I have to stay here?"

"I'd say a week. This procedure is routine on Earth, where you'd be out in two or three sols, but the cardiac centers there do hundreds or thousands of patients per year. We're doing one per decade. The medication to dissolve the plaques and to grow new arteries can be taken orally, but we want to observe you to make sure everything goes fine."

"And when will I be back to work?"

Shinji looked at him closely. "A month, Sebastian, and no sooner. I mean it."

Sebastian shrugged. "Okay. Doctor's orders. I guess I can follow the *Piazzi* on television."

"I'll help, dad," added Kristoff.

"Good. Thanks. I guess it'll be time for us together."

11

Jetwing

Sept. 2057

Will Elliott walked slowly around Mars's first turbojet. It was an interesting contraption; it superficially resembled turbojet aircraft on Earth and sunwings on Mars, but was different enough from both to make him doubt that the design could work. The fuselage was a simple cylinder 2.5 meters in diameter and twelve meters long, constructed of kevlar and other high-strength, light-weight plastics over a frame of strong but light carbon nanotubes. The rear was surrounded by a massive air intake funnel that extended a meter beyond the entire fuselage, culminating in a turbojet engine that ran on carbon dioxide and silane.

The wings were huge as well. The leading edge started about three meters back from the front of the fuselage and extended outward and backward forty meters to each side. For takeoffs and landings, their width could be increased to as much as seven meters, but once in the air the flaps could be pulled back to halve the average width, minimizing drag. Ten meters from where each wing joined the fuselage, it sported a huge air intake for a second and third turbojet engine. A small carbon dioxide and silane rocket engine, pointing downward, was located below the cockpit.

"Up to five tonnes of freight," said Will, glancing at the fuselage. "That's hard to believe. There are still no profitable supersonic cargo transports on Earth."

"This wouldn't be profitable on Earth, either," replied Donald Wilder, their chief aeronautical engineer. "But it won't have any competition here."

"Except from trucks," replied Will. "Robotic trucks are getting cheaper and more capable all the time, and if they're powered by silane they can go a long way between fill-ups."

"The jetwing will principally be used to carry passengers anyway, and since they'll never be full, they'll carry cargo as well. And the development costs are being covered by the Commission, so they won't be included in any determination of prices for people and cargo."

"Just like the silane truck engines," agreed Will. He had both pride at their aeronautical accomplishments and lingering doubts about the wisdom of the investment. No doubt Mars would need efficient, long-range, fast, reliable jet aircraft at some point. But much of the research was so different from anything done on Earth that they faced a mountain of costs in achieving something safe and reliable. The Commission had sunk an amazing 2.5 billion redbacks into Martian aircraft designs in the last six years.

Will wasn't going to express his doubts to Wilder, though; the man was too valuable and too fickle. "How many test flights are you proposing?"

"The first series will include six. The second and third series will take place after modification of the design and will probably involve at least five flights. Phase three flights can actually be service to other outposts, but the Sunwing-Ds will be the usual scheduled vehicle."

"But the jetwing will allow a new flight schedule, right?"

Wilder nodded. "Call that 'Phase Four.' One vehicle could fly from here to Meridiani, Dawes, Cassini, then back; the other vehicle would go around the circle in the opposite direction. At 1,500 kilometers per hour, Cassini is only four or five hours from

here. A jetwing could complete all those stops and return here between sunrise and sunset."

"What does the maintenance schedule for the turbines look like?"

"Not too bad. The billions of research have mostly been sunk into turbines that can survive a bath of hot silicon droplets and particles. The turbine blades are tough enough to withstand the erosion from the hot silicon and to self-clean as silicon deposits build up. The wings are based on the sunwing design, modified for the supersonic speed based on wind tunnel tests on Earth, and the fuselage is reasonably straightforward."

"And it can use existing runways."

"Yes. Its wings are smaller than the Sunwing-D and it can carry about five times as much mass because it uses rocket assistance in takeoff and landing. In between, it flies about five times faster. The tanks can hold up to two tonnes of liquid carbon dioxide, and after burning the CO_2 during takeoff the vehicle can refuel the tanks during flight, using power drawn from the solar cells covering the wings."

Will nodded. "Very impressive. Of course, the people and spare parts to maintain them will cost one million redbacks per year, and if they fly 250 passengers and 200 tonnes of cargo per year each, the cost is 500 redbacks per passenger and 2 redbacks per kilo for freight. When you add fuel, insurance, overhead, and other costs like the fifty-million redback cost for each vehicle, those numbers quadruple."

"Well, thank God our salaries here average five times as much as on Earth," replied Wilder, unwilling to let comparisons disadvantage his creation. "Fortunately, this place is going to grow and demand for jetwings will increase rapidly."

That was also questionable, but Will wasn't going to argue. "Let's see what she can do," he replied.

They turned and headed back to the ranger. While it drove back to the outpost on autopilot, they stripped off their pressure suits. In twenty minutes they were in Mars Control, where Wilder's team of three was finishing their check out.

After resolving a few minor problems, they activated the three turbojet engines. Thrust built up normally as they gave it more fuel; finally they turned it and taxied it down the runway. Once it was moving at two hundred fifty kilometers per hour the belly-mounted rocket fired and lifted the craft into the air, then the rocket pivoted backwards and accelerated the vehicle to its minimum air speed, which was six hundred kilometers per hour with a light load. The jetwing rose lightning-fast into the sky and responded well to commands. After flying it twenty kilometers east, pushing it upward to 5,000 meters, then bringing it back to the landing strip, they fired the rockets to slow the craft and cushion its landing, set it down on its wheels, and rolled it back to the hanger.

"A simple first test flight, but that's all the goals called for," said Wilder to Will.

"Congratulations," replied Will, and they shook hands. "I look forward to the future tests."

Kristoff headed for the Gallerie for supper after a long sol in Ceylon Polder. He arrived only a half hour after the peak of business, so the food court was near capacity and all the businesses were open. He had to wait in line three minutes at one point to get Aurorae Foods' special, roast turkey with stuffing, rice, and vegetables. Someone had once quipped that Mars's only traffic jams occurred in the buffet lines. Deseret's

Special—spaghetti bolognese with large but unsuccessful meatballs of tofu—was one reason for the long lines across the food court at Aurorae Foods.

Finding a table was hard. He headed for his father's usual spot and found Lisa Kok there instead, with her unmarried "husband" of sixteen years, Karol Havlicek, and their thirteen and a half year old daughter, Anna, one of Mars's older children. The next table over was Eammon O'Hare and Irina Lesz and their five children, aged eight to almost thirteen. Lisa saw Kristoff coming and said "You just missed him. He went back to Asteroid Control; they had a minor anomaly in the garage on the *Piazzi*, two hopper vans had a fender-bender."

"Oh. This sol was his first full sol back at work after the heart attack."

"Yes, he said it went very well. They gave him a standing ovation when he arrived."

"That's nice. He's been going crazy at home."

"You've been with him a lot, too, but I'm amazed how little your work suffered."

"I had to rearrange my priorities. By the way, I think we can try a different arrangement of the species in Ceylon to utilize the insolation cycle better."

"Several people have said that, but no one has made a proposal."

"Well, I will!"

"Good, I'll look forward to it."

"Great. I can get it to you in a few weeks. Ciao." Kristoff headed across the floor to the area where various friends hanged out at mealtimes. He was surprised to see one alcove walled off temporarily with the sign "Site of future private dining room." One of Chief Minister Érico's many minor changes.

His single friends tended to sit at four or five tables near the entrance to Deseret, a convenient stroll to the cappuccino machine. He nodded to Millie, Nadia, and Veronique, who were all busy talking to each other and a few other friends. The table had an empty chair, but it was piled with some shopping sacks, so he kept going. The next table included Rahula Peres, his fiancé, and a few other acquaintances, but that table was full as well. A table nearby, however, had Irma Baeker, so Kristoff headed there. "Can I join you?"

"Oh, sure, Kristoff. How are you?"

"Pretty good. I had a good sol at work and my boss is now interested in some ideas I have. My dad's first sol back at work went well, by the way; I heard that he got a standing ovation."

"Really? I'm glad. He's a great man and I'm relieved he recovered so fast. The growth of new arteries in his heart is going very well; better than normal. He'll have the heart of a 30 year old after this."

"Sounds like something a lot of people could use."

"Indeed! There's a lot of talk about converting this therapy into a routine procedure at, say, age 60. It'll add ten years to the average person's life."

"He's been making some changes to his lifestyle, too; he's cut back on hours and delegated more. For that matter, I've been making some changes, too."

"Well, that's good. It's never too soon or too late to reexamine one's life and reorient parts of it. I've been thinking about my career lately as well, and whether I want to pursue some new directions."

"Really? In nursing?"

"No; chemical engineering. I've always been interested in it, and a friend of mine has been describing some of the needs here. I can take two courses and qualify for assistant work, then they'll cover the other courses I need to get a Masters."

"Educational benefits up here are good. I've become fascinated with tropical ecosystems lately; it's amazing how complex our systems are and how well understood they are. The computer models are becoming very sophisticated and allow us to predict the effects of various changes in the inputs. I think we can raise Ceylon's productivity at least five percent by using the sunlight more efficiently. If we can increase the insolation with mirrors in the interdomal areas, we can increase productivity even more."

"That's worth pursuing. But life's not just tropical ecosystems, or chemical engineering either."

"True, but tropical ecosystems are a bit easier to handle sometimes!"

Irma laughed. "That's true, but ultimately not as important to a well-rounded life."

"That's true," he agreed.

Several weeks after its first flight, the jetwing was one of the topics of discussion between the Mars Commission and the Mars Authority at the first meeting of the heads of staff of the two organizations.

"The jetwing project generated a lot of questions yestersol at the monthly 'quiz the Chief Minister' forum," exclaimed Érico. "But I couldn't answer them, so I have to pass them on to you."

"I saw," said Will. "A lot of people think the jetwing is a boondoggle; that it won't be economic and will cost way too much. I have my reservations, too. But

long-term, we definitely need it. And NASA is covering most of the research costs, so that they can control the technology."

"That's a good, frank summary," said Érico after a moment of silence. "But 2.5 billion redbacks: that's twice as much as we spent developing the caravel! Some might say that maybe the political process should have delivered something more useful."

Will nodded slightly. "This was indeed a highly political process. The only way we could get a nonrevocable license to the technology was to let NASA lead and pay forty-nine percent. It might have been cheaper for us to develop it ourselves, but we didn't have access to the engineers, even on Earth, because of technology transfer laws. It won't be the last big technology partnership we accept. We're still working on getting more nuclear power."

"Do we know what the jetwing's passenger and cargo rates will be?"

"A round trip between here and any of the outposts will be 2,000 to 3,000 redbacks per person; twenty times the cost of an airline ticket on Earth. Freight and passenger prices will be set partially based on the demand for each. If people want to travel between the outposts for free, they can still sign up to ride on the robotic trucks as monitors."

"What does this say about development of the other outposts?" asked Andries Underwood, Director of the Authority's new Surface Transportation Ministry. "If 85% of the population is located in Aurorae, there isn't a huge need for jetwings, or ground transportation either for that matter."

"The Commission has always taken the position that development can not be confined to a single place because no one place has all the resources we need. It may be

that 50% or 80% of the Marsian population is located in one place for various economic reasons. But that does not mean that a robust transportation network is unnecessary; on the contrary, it may be essential to provide them with raw materials. Our commitment is to development anywhere in the Tithonium-Aurorae-Dawes-Cassini corridor."

"Alright that helps," said Andries. "Because last month the Surface Transportation Ministry was hit by a ten percent increase in the price of oasis equipment; shelters, solar power systems, wind turbines, etc. This raises the question how we should complete our plans. Your comment suggests we should cut back on the development of the Polar Highway, since it's not on the corridor."

Will nodded. "I apologize we didn't anticipate the price hike. Our economic team recommended that with the creation of the Surface Transportation Ministry, we should no longer charge just our expenses, but include a profit. This is necessary to be fair to private businesses that might eventually want to supply equipment to you. We considered giving a larger subsidy to the Authority to cover the increase, but our economic team did not recommend that; rather, it thinks the Authority establish a corporate income tax. Such a tax would be relatively low because it would apply to the gold exports as well."

"It would also apply to Silvio's, Deseret, and our other companies," replied Érico. "That's the problem. The Aurorae representatives of the Mars Council worry about taxing fledgling businesses and the representatives elsewhere worry about taxing gold companies and sending the local profits to Aurorae. Most members of the Mars Council favor a continued subsidy from the Commission."

"I understand those arguments," replied Will. "But the Authority will have more independence if it has its own sources of income."

“Meanwhile, the higher equipment costs have already kicked in,” said Andries, looking at Will. “Should we drop our plans to improve the Polar Highway?”

“Ask me; I’m your boss,” said Érico, quickly. “Concentrate on the Tithonium to Cassini corridor.”

Will nodded. “We’ll eventually need improved access to the northern lowlands, but not now. We must have a good road to Tithonium because of its gold and chromium.”

“But Will, do we have to follow Earth business models so closely?” asked Érico. “If you had spoken to me first, I would have said that if a private company were to offer to supply the Surface Transportation Ministry, we would have asked them for a no-profit bid and compare that to the Commission’s contract; if it were cheaper, then we would have granted then the contract and a profit.”

“Well, I’ll remember that next time.”

There was an awkward silence for a moment. Then Andries said to Will, “Are you still planning to complete the development of a phase 2 silane motor for trucks?”

“Yes,” replied Will. “We’ll fly twenty silane motors here for use in robotic trucks in 2059. That’ll give the trucks 2.5 times more range and eliminate refueling problems on the Meridiani Highway. Are we finished with surface and air transportation? Because Yevgeny has an important report.”

Érico looked at Andries and Rachel. “We’re ready to move on.”

Will turned to Yevgeny, who began. “The Park report recommended that we identify more potential exports. One result: we must expand Phobos. Look at this table of cargo transportation costs.” He projected a long table onto the screen. “We can ship from the Martian surface to low Earth orbit for 50 redbacks per kilo, cheaper than the 70 that

cargo costs from the Earth's surface, and we can ship something from here to the lunar surface for 70 redbacks per kilo, as opposed to 90 from Earth. Solar sailers will cut the costs to 45 and 55, respectively. But two thirds of the cost comes from the shuttles, lifting cargo from the Martian surface to orbit. Phobos or Deimos doesn't have those costs. They can send cargo to Earth orbit or lunar orbit by solar sailer for just 5 and 10 redbacks per kilo respectively, and twice that by hippogryph cargo vehicle. Venus and Mercury are only slightly more. Those are prices no one will ever match.

"In short, the cheapest production point in the entire transportation system—in the entire solar system!—is Phobos and Deimos. We should be supplying the moon, Mercury, Venus, and low Earth orbit with everything we can. Costs from the earth's surface to orbit will continue to decline, but so will our launch costs to Martian orbit and the cost of producing fuel on Phobos.

"The first obvious export to try is food, so we are recommending putting greenhouses on Phobos. If we could export 1,000 tonnes per columbiad—which may be possible in eight to ten years—food could earn us 10 million redbacks. It doesn't sound like much, but it'll pay to expand the place and it will establish the importance of the moonlet. Light manufacturing on Phobos using locally produced plastic has the potential to bring in maybe 100 million and would reduce the manufacturing costs of caravels. We have had workers on Phobos almost continually for three years, staying in the caravels they are building. We recommend building a caravel to serve as a permanent outpost. We already have one completed caravel on Phobos, destined to be shipped to Earth in about a year, and we have to complete another caravel in that same time period, so Phobos can accommodate an agricultural team now."

“Of course, you haven’t included the costs of raising food on Phobos,” pointed out Lisa. “Our costs on the Martian surface average 5 redbacks per kilo.”

“Phobos will be more expensive because the domes have to be protected from micrometeoroids and solar flares,” replied Yevgeny. “But that would be true on the moon and low earth orbit as well.”

Lisa nodded. Rachel said, “There will be safety issues to consider.”

“I’ve already started to look into them,” said Yuri.

“And so will I,” replied Rachel, raising her voice. “For these ideas to coalesce into a safe plan, there’s a lot of work to do. Caravels were not designed to serve Phobos housing—”

“Sure they were,” interrupted Yuri. “They’ve housed twenty-seven people safely for nine months, seven months to Astrea and two months on that asteroid’s surface, and it’s no different from Phobos.”

“That’s the Asteroid Belt Commission’s safety standards. We don’t have to copy them. Then there’s microgravity agriculture; there are no safety standards for it. And how will you produce plastics in microgravity? No equipment has been designed to do that, even for use in Earth orbit.”

“We’d put the equipment inside a spinning facility based on a caravel,” replied Alexandra.

“And there are no standards for that, either,” pointed out Rachel.

“Point well made,” said Will, raising his hand. “There’s a lot to do.”

“This means Phobos would move toward borough status,” said Érico.

"Probably," agreed Will. "It'll be similar in size to Meridiani and Thymiamata. It's time to build a large, enclosed drydock there, so that huge structures can be assembled in a shirtsleeve environment and under a radiation shield. It'll become the place anything big is made."

"I'm beginning to sense that the limits to immigration that the Park Report identified are receding," said Érico.

"Partially," replied Will. "Yevgeny, can you speak about the contract with the Mercury-Venus Commission?"

"Sure. We will soon sign a contract to sell them five caravels over six years, 2059 through 2064. The Asteroid Belt Commission will be purchasing a second caravel; it'll be one of the ones we send to Earth next year for passengers. NASA wants two caravels for 2063 for their first expedition to Jupiter. The Chinese want one in 2060 and another one in 2063; we're still completing the negotiations."

"And we can fill the orders," added Alexandra. "With Punjab completed early next year and Zanzibar late next year, we can feed 500 more arrivals, and by adding housing to Andalus and Cathay we can lodge them. This time we will be ready."

"Aram will have 57,000 square meters of farmland by then," added Lisa. "Cassini and Dawes are expanding to 20,000 square meters each. So we have plenty of space for bioarchive. Last week I heard a rumor that Muller Mining, in order to develop Dawes and Cassini further, was proposing a series of European ecosystems archived at the two outposts. So I telephoned Gerhard Bach, who is very close to Muller. He confirmed the rumor. Cassini may get 'Rhine,' a Franco-German project to duplicate the ecology of

Alsace and Lörrach. Dawes would get ‘Tagus,’ a project to duplicate the ecology along that river in Spain and Portugal. Muller Mining would pay for up to half of the costs.”

“Oh, is that what’s going on?” said Will. “Very interesting.” He looked at Érico. “That’s everything we have to discuss. Have you anything to add?”

“No. Our big concern was the jetwing.”

“I’m glad we clarified it. I think the transition to the Authority has gone fairly well. I like the changes you’ve made. You’ve struck a good tone; asking people to call you ‘Chief Minister Érico’ is a good mix of formal and informal.”

“It worked for Father Greg, so it seemed like a good compromise,” agreed Érico. “Yes, the transition is working out. Thanks, everyone, for coming.” He rose.

“Thanks, everyone,” added Will, unsure whether Érico should have adjourned the meeting.

People began to say goodbye to each other. As Will head down the hall, Lisa caught up to him. “Can we talk?”

“Sure. About what?”

“Let’s get outside first.”

“Alright.” He pointed to the new conference room and offices. “Very nice. They’ll be very comfortable when we move in.”

“How long?”

Will shrugged. “Eighteen months; early ’59 I suppose.”

They started down the spiral ramp. “And what about our current offices?”

“We’ll keep Mars Control as a backup facility and lease out the offices.”

They stepped off the spiral ramp and walked into the bright sunlight of Andalus Square. Lisa turned to Will. “It’s the new administrative structure. It’s driving me crazy. I have to shift personnel between agriculture for the borough, and bioarchive and research for the Commission. I have to keep costs in two separate budgets. My relationship with the environmental research folks in Seville is confusing because I wear two different hats. And reporting to you versus to Ruhullah is hard, too. Priorities are going to clash eventually, just as they did this sol.”

“The new arrangement is not working as well as I had hoped,” said Will. “But you are a highly trained and highly respected professional. You divided responsibilities between agriculture, research, and bioarchive before and juggled the schedules of the specialists. That hasn’t changed; it’s just that now you are running two parallel, interpenetrating organizations. As for Seville, they’re essentially a contractor; sometimes they’re under contract to support agriculture, sometimes research or bioarchive. Either way, they do what you tell them to do. Pierre Messier is devoting most of his time right now to realigning the Seville facility. The Spanish government will probably support it as an agricultural research facility. There’s hundreds of millions of dollars of agribusiness using the bubbles we developed, especially in colder climates. They’re playing with carbon dioxide levels and all sorts of other variables. Seville is ideally suited to support that research.”

“Are any of the experts coming here?”

“We’ll fly as many of them here as we can, families included. We’ll give them up to eight years to immigrate and we’ll continue to employ many of them under contract

during that time. You may have a very good reason to persist in your two jobs; your staff may soon double and acquire some very talented people!"

"I hope so. But devolution and privatization create a lot of uncertainty. I keep thinking I should resign as head of the Borough's agricultural facilities and just do bioarchive, but with Cassini and Dawes both acquiring bioarchive facilities, I wonder whether the Commission will be in the bioarchive business in a few years. Then I consider resigning from the Commission and just do the borough's environmental management and agriculture, but maybe the borough will privatize those tasks in a few years. I feel like I have no job security. I'm not even sure I have respect any more!"

"Well, I respect you highly. Your doing complicated and essential work, and very effectively. Just keep doing what you're doing. Let's plan on talking again in a few weeks and see how it's working, alright?"

"Okay," she said reluctantly.

"Good. Anisa will set up an appointment. We'll be sending a team to Phobos to set up agriculture in a matter of months. Think who you'd send."

"Just what I need; more work for too few people. Okay, I'll talk to Yevgeny more and help define the agricultural objectives. Thanks, Commissioner Will."

He laughed. "I guess I'll get addressed that way now as well! Ciao."

She waved and headed northward across the square, to cross the Gallerie, get a cup of coffee, and walk along North Main to her office. Will headed to East Street, thinking about the meeting. Érico had been difficult, Andries critical. Rachel and Yuri had clashed about safety issues again; Yuri continued to treat her like an impediment and had been carrying out his own safety reviews, in spite of Will's warnings. He'd have to

arbitrate another difficult meeting between them. Lisa had never been comfortable with her split responsibilities. Alexandra was unhappy about privatization of construction.

He sighed. Sometimes he yearned for retirement.

He walked down East Street toward the tunnel to Bangalore. He couldn't go to the office yet; he needed a walk. When he reached the church building he stopped and looked in the open door. The interior was coming along quite impressively.

As he was looking in, Rev. Friday Nah saw him and beckoned. "Come in, Dr. Elliott, come take a look!"

"Thank you," replied Will. "I'd love to." He stepped in and walked around the interior, which was quite attractive. "Where did you get the statues of the saints?"

"They're made in Nigeria. Do you like the stained glass windows?"

"Yes; is it real stained glass?"

"No, it's paint on transparent plastic, but it looks very good."

"It does! Impressive artwork. But your daughter is very talented."

"Yes, she did it all. She's down in the subbasement right now, painting the last window. The hard part is the design; the rest is almost paint-by-numbers!"

There was a man up front doing some detail work on the altar. Will pointed. "He's the construction expert, right?"

"Yes; my brother in law, Simeon Afigbo."

Will nodded and walked over to Simeon, who saw the Commissioner coming and stopped working. "Good sol, Dr. Elliott," he said.

“Good sol, Mr. Afigbo. I want to congratulate you on the fine work you’ve done on this church. I’ve been watching it go up for ten months, now, and now that I can see the interior I must tell you that I am very impressed.”

Simeon smiled. “Thank you. It’s taken us a very long time! But we all work for a living. I just got off third shift and I’m spending six hours here before I go sleep.”

“Your community has achieved a remarkable monument to determination and sacrifice. A building this size is not easy to build; it’s even harder when it’s built by part time workers. And it’s a work of art as well.”

“That’s the only way to build; construction is art.”

“You must come to the dedication,” said Reverend Nah.

“I’d be delighted,” replied Will. “This is the first place of worship finished in the Outpost.”

“Please invite us when you finish your Bahá'í House of Worship,” added Nah.

“Everyone will be invited. But it won’t be for some time. Mr. Afigbo, I have purchased some land under the skirt between Andalus and the Bahá'í Dome, and I want to build a house there. I want to buy two ten by twenty meter oasis shelters and have them buried there. Would you be interested in the contract to build my house?”

Simeon was surprised. “Yes, I would. But why don’t you contract the Construction Department to build it for you?”

“It’s a conflict of interest. The Commission offered to build me a residence here, but I declined. Besides, I want to encourage private enterprise.”

“Are you sure we can get the construction materials? It isn’t easy. The Construction Department doesn’t give us much priority.”

“Well, perhaps that can change.”

“Then let’s talk about it.”

“Good. I’ll talk to Ethel and get you a description next week.”

12

Transitions

Late Nov/ early Dec. 2057

The long-range cameras on Deimos revealed a flower-like object. Petal-like sails of aluminized film extended outward from the cargo pallet as much as a kilometer; the eight sails each had a slightly different angle in order to push the twenty tonnes of cargo precisely in the direction desired. In Earth orbit the three square kilometers of solar sails experienced twenty-seven newtons—about six pounds—of solar pressure on them, but at Mars the force was less than half as much.

Will squinted at the screen, but was unable to see the tiny dot in the center where the cargo rested. Rostam Khan was hard at work checking out the systems on board the cargo capsule. A moment later he pressed a button and smiled. “Cargo separation has occurred,” he announced.

“Excellent,” replied Will. “It’s too bad we can’t see anything.”

“No, it’s too far away,” replied Rostam. “One hundred thousand kilometers beyond Deimos. The cargo capsule will aerocapture in a sol and a half. The sailer will enter an elliptical orbit and lower its apoapsis to Embarcadero’s in a bit over a week.”

“What are you shipping back?” asked Sebastian Langlais, who had been invited in to observe.

“Thirty-five tonnes of water,” replied Will. “It’s bound for Gateway. It’ll arrive in a year.”

“And what’s the shipping cost?” asked Sebastian.

“About five redbacks per kilo to go from Deimos to Gateway.” Will laughed. “Half the price of shipping it from the lunar surface!”

Sebastian laughed as well. “Who says you can’t ship coals to Newcastle. The arrival is timed well; we’re running out of some consumer goods. You’ve ordered five more sailers, right?”

Will nodded. “Two of them are already on their way here with twenty tonnes of stuff; they’ll arrive in twenty-two months and twenty-three months, respectively. Our plan is to order twenty-six sailers eventually and send one from Earth each month, to spread out the work load. Some will have more cargo and some less to spread out their arrival here to about one every month or two. We have to plan a long time in advance, unfortunately, until sailers get larger and can travel between the planets in about one year, instead of two.”

“But it’ll save a lot of money, for things that can stay in space that long at least. We’re looking into purchasing sailers for cargo transport in the asteroid belt. We want to send a mission to Pallas, but it’s in such a high-inclination orbit it’s hard to get anything to it. With a sailer we can ship stuff to Pallas from Deimos, and if we ever build a base somewhere in the belt it can use sailers to provision exploratory missions from it.”

“With a three to five year lead time,” agreed Will. “Sailers are ideal in the belt because the asteroids have such weak gravity.”

“That’s what we’re hoping,” said Sebastian. “Both the strength of the sun’s gravity and the strength of sunlight fall off by the square of the distance, so their relative proportion stays constant. You just have to be patient.”

“Exactly.” Will sighed. “I wish we had developed this technology ten years ago. It would have saved us a lot of money. The design works best for trips to Mercury. We had several problems with our sailer as a result, but we figured out how to solve them.”

“I heard,” said Sebastian. “A historic sol. It cuts shipping costs by what; a third?”

“About that, which means we can grow,” said Will. “Transportation between planets no longer requires propellant.”

Will quickly looked around the room as he and Érico waited for their host to appear. It was elegant but simple, a common combination in Japanese architecture: it had simple, plastic wood-grain walls, a flat stone floor (which was really concrete), comfortable cushions to sit on in front of low tables, and several paper screens with elegant Japanese paintings on them.

“Very nice,” said Will to Érico quietly, who nodded.

“Good taste.”

“I’m glad we’re not late after all,” added Will. “The sailer’s arrival delayed our trip up here.”

“No, we’re okay.”

Just then their host, Ichiro Otsu, appeared with Yoshiyaki Suzuki, the chief monk of the Zen monastery. Will and Érico rose. “It’s very kind of you to invite us,” said Will. “You have a beautiful place.”

“Thank you,” replied Ichiro. “Chief Minister Érico, Commissioner Will, welcome to New Tokyo. We are honored by your visit.”

“And very happy you could make it,” added Yoshiyaki.

“Thank you. Your hospitality is legendary,” Will replied to both of them. “I am immensely impressed by the work you have accomplished up here in nine months.”

“Our resources are getting bigger and bigger all the time,” replied Ichiro. He looked around and out the window at the rice paddy. “This dome was an immense amount of work, but the monks were experts at construction. Please be seated. May we pour you tea?”

“We would love some,” replied Will. He sat cross-legged on a cushion in front of the low table, silently thanking God that it was easier to sit cross-legged in Martian gravity than it was on Earth. He was getting stiff in middle age. Érico looked a bit awkward, but followed Will’s lead. They sat silently while Ichiro very formally poured green tea for them and offered sugar and even milk, which surprised Will. This was not a tea ceremony.

“I am impressed that you have managed such a beautiful facility, in spite of all the shortages and misunderstandings,” said Érico.

“Thank you,” replied Ichiro. “We have not wanted to be difficult or to appear to be complainers. But we have found that both of you, and Alexandra, have encouraged us to speak up, and we were grateful for that.” He pointed out the window. “Our dome is a hemicylinder seventy meters long and seventy meters wide, just like the Bahá'í dome near Andalus. It is supposed to be the central cylinder of nine so that we have our housing surrounded by eight other domes to provide added safety. I’m sure we’ll have eight more eventually. Meanwhile, the dome was rated for habitation by virtue of its quality construction and because it straddles the tunnel between the monastery and the Dacha, providing us with multiple evacuation routes. By the way, that door leads downward to

the tunnel; it's the closest evacuation route." He pointed to a door with an "emergency exit" sign over it.

"You know, instead of building nine hemicylinders in a square, you may want to build them in a line, above the tunnel, all the way to the Dacha. I bet the ones close to the escarpment would be quite valuable."

"Interesting idea," replied Ichiro, though he didn't really seem interested in it.

"The twenty-four of you did most of the work, right?" asked Will.

"We hired seven Nigerians; the men and women who helped on the monastery," added Yoshiyuki. "And by doing the bulk of the work ourselves, we saved a lot of money. Of course, it also means the Japanese colony has not yet been able to make much of a contribution to Mars. But that will change next year when we shift our human resources to engineering and manufacturing."

"In fact, we are anxious to get involved," continued Ichiro. "As you know, our numbers include six mold-makers who are highly expert."

"Alexandra is hurting terribly because they haven't been able to start work," agreed Will.

"It was a waste that they had to spend the last nine months running pile drivers and regolith steamers rather than making specialized molds." Ichiro shrugged. "But what can one do? Once we had made the decision to locate ourselves up here, by the monastery, it became unavoidable. There is a very limited labor market here; we could not hire replacement workers. And the Construction Department had a terribly difficult time providing us with materials. We had to go down to Aurorae and remove the toilets

and sinks in the flats we had agreed to purchase in order to install them up here. We're still paying mortgages on housing that is now unusable by anyone."

"Once the materials that had to be removed are replaced by new ones, you can put them on the market and recoup your investment."

"Of course. We've started consolidating one-room efficiencies into two and three room flats and reselling them for a ten percent profit to newly married people or residents wanting more space. Don't worry; we're no longer upset about the housing mess when we arrived."

"When given lemons, make lemonade," added Yoshiyaki. "It should be an old Zen saying, even if it isn't."

"It epitomizes our approach in the last ten months," agreed Ichiro. "The Japanese public has followed our project very closely and the investors have been very pleased with the impact on Japanese pride and culture. In fact, they want to send sixteen more migrants this columbiad, and they want to send more women and couples so that this colony has a future." He leaned over the table at his guests. "But one thing would help the effort greatly. We would like to see the monastery and this dome, complete with the surrounding terrain, be declared a borough. That would give us the sort of standing and institutions that Aram has."

Will and Érico were both surprised, even startled. "Have you talked to the people at the Dacha about this? They're only a kilometer away."

"No, we haven't, and we understand the Dacha will be expanded; it's occupied so intensively that people are often staying at the monastery and walking over. That's why two people live there all the time, I suppose."

“Correct,” said Érico. “The Dacha is property of the Borough of Aurorae. It’s way too small to accommodate the crowds; sometimes sixty people want to stay here on the weekends, but it can only hold sixteen. We plan to double it.”

“I suppose you know how we have been defining boroughs so far,” added Will. On the equator, they are squares fifteen degrees of longitude long and fifteen degrees of latitude wide. Each has about 750,000 square kilometers. The Dacha, like the Outpost, is 7 south and 37 west, in the middle of a square. Have you thought about that issue?”

“We have, and we wonder whether other boundaries are possible. For example, if Aurorae Borough were shifted southward seven degrees, we could be on the northern edge of a new borough. Or perhaps we could settle for a smaller piece of Mars, or a different boundary.”

“The boundaries are set by the Authority now,” said Érico. “That means changes have to be approved by the Council and Assembly and signed by me and by Will. There are many landowners north of here who might object to finding their land in a different borough.”

“We also have the interesting situation that domes in two boroughs are connected by tunnel,” noted Will.

Ichiro shrugged. “That’s hardly a problem. They aren’t touching each other, after all.”

“I’d be more concerned about boundaries being changed and changed and changed,” said Érico. “It sets a bad precedent. It would encourage any group of investors to define their own borough, presumably with its own tax laws and other arrangements.”

Ichiro looked at Érico. “In other words, like Earth.”

“Perhaps, but I wasn’t making a favorable comparison.”

There was an awkward silence in the room. Érico sipped his tea, looking steadfast.

“Perhaps we’re looking at this from the wrong perspective,” said Yoshi. “Our purpose is not to set up a corporate tax shelter to maximize profits; it is to set up a structure that will encourage the Japanese public to see this as their Martian project.”

“We don’t need a borough the size of Aurorae,” added Ichiro. “Maybe a hundred square kilometers will do it.”

“I can see it now,” said Érico. “Aurorae fifty years from now will look like a Swiss cheese. There will be, say, Industrial Town A and Industrial Town B in their own little boroughs, and two hundred kilometers of road between them that has to be maintained by the Borough of Aurorae.”

Ichiro stared at him. “So, would you prefer that we move down the highway five hundred kilometers to Gangis and set up our own borough there? We can.”

“I have no such preference,” replied Érico.

“I have long wondered what Aurorae will look like in a century,” exclaimed Will. “Three quarters of a million square kilometers is about the size of Texas or France. It could have several million people. I suppose at that point the borough will have incorporated villages and cities within it. Perhaps we need to think of the problem that way.” Will looked at Érico and Ichiro. Neither looked pleased by the idea.

“I didn’t know villages existed in the Marsian legal code,” said Ichiro.

“They don’t; not yet.”

"We'd have to enact legislation," speculated Érico. "I suppose they wouldn't be able to pass their own taxes, but perhaps they'd have authority over their life support systems."

"What about their own school system?" asked Yoshi.

Érico considered the idea, then shrugged. "Maybe."

"No one would want small children transferred a long way by van," suggested Will. "And instruction in Japanese makes sense for them. But older children could handle the safety concerns of a van better, would benefit from participation in a common high school, and would acquire the language skills they'd need as adults here."

Ichiro said nothing. Érico shifted in his chair. "Let's have more tea," suggested Yoshi. He poured more tea and the conversation continued.

Ethel cast a glance at the controls of carbonyl fractionator #3. The carbon monoxide flow was low; probably a stuck valve. A moment later the computer spat out its analysis; she was right. She sent the information to Helene Kouao, the young Cote d'Ivoirian who was the repair technician on duty at the time. Then she turned to the robotic harvester controls and studied an irregularity in the voltage of an electric motor on harvester number 2. After that she turned to the temperature at the top of carbonyl fractionator #4, which had been running too high all day. She adjusted it again.

Helene came in. "I think we'll have to shut down fractionator 4 a few sols early. The temperature controls are really flaky this sol."

"I'm afraid you're right." She sighed. "That'll cut into production quite a lot."

"It's not easy to keep this operation going at full capacity."

"No. There's no such thing as a free lunch, is there?"

Helene nodded and stepped back out of the control area, leaving Ethel to contemplate the difficulties of producing large quantities of platinum-group metals at a profit on Mars. It had been difficult lately; they had had unexpected equipment trouble. While platinum was an extremely valuable substance, and the process of extracting it from meteoritic nickel-iron was straightforward, it was also complicated to implement. The effort began with five truck-like harvesters, each with a six-meter wide line of twelve four-meter high diamond-tipped excavating wheels. They would roll across the flatlands of the Aurorae Valley twelve kilometers east of the outpost, digging up the top two meters of an ancient lag deposit where a catastrophic flood had deposited particularly dense rocks, mostly ancient fragments of nickel-iron meteorites. The excavators fed the material to a crusher, then it went through a magnetic separator that sent the nickel iron fragments to a trailer; the rest went back into the hole, where another unit smoothed it. A huge cloud of dust blew steadily downwind—away from the outpost—and a track of disturbed ground resulted, which fortunately did not look very different from the normal terrain around it. The robotic separators ran constantly except when they had to return to Aurorae's main garage for servicing, which usually was one sol per week; one was always being repaired, which took two full-time workers. Every hour each fifteen-tonne harvester processed 200 cubic meters of regolith, extracting between six and fifty tonnes of celestial bounty that had rained down on Mars 4 billion years ago.

At that moment, two trailers were almost full with fifty tonnes of nickel-iron fragments. A robotic truck with two empty trailers was on its way; once it arrived Helene would telerobotically transfer the full trailers to the truck and the empty trailers to the

harvesters, refuel the harvesters with a tonne of liquid oxygen and methane, and resume her maintenance work on the fractionators while the truck drove itself and the raw material back to the outpost.

The processing facility could receive as much as seven hundred twenty tonnes of meteoritic metals per sol; in practice it received closer to six hundred fifty. The four carbonyl fractionation towers had a capacity of seven hundred forty tonnes per sol, half of which was tower number 4, their newest. Hot carbon monoxide gas converted the finely crushed metal fragments into iron, cobalt, and nickel carbonyl gas, which rose to different heights in the tower, cooled, and condensed into liquids. The liquid metals were poured off into molds of various shapes, then heated to dissociate the carbonyl back into solid metal and carbon monoxide gas, which was recycled. Every sol the six hundred fifty tonnes of raw material became 546 tonnes of iron, 98 tonnes of nickel, and 5 tonnes of cobalt, plus 4.8 kilograms of platinum, 3.4 kilos of ruthenium, 2.7 kilos of palladium, 2.4 kilos of osmium, 2.2 kilos of iridium, 1 kilo of silver, 0.65 kilos of rhodium, and 0.64 kilos of gold, more or less; the quantity of rare metals varied. The mining, concentrating, transporting, and processing consumed a continuous 4,000 kilowatts of electricity and 3,000 kilowatts of heat. About a tonne of water and two tonnes of oxygen were byproducts of the process.

The result was a large and growing pile of iron and nickel—almost a quarter million tonnes per year—that they could never use. They molded it into sheets, beams, rods, and any other customized shape; the construction department's metal rolling plant took sheets, heated and shaped them, and private contractors hauled off for free anything

they could use. They accumulated 14 tonnes of rare metals every columbiad, worth about 500 million redbacks on Earth.

The operation required eleven full-time staff on Mars and eight on Earth. The Marsians worked ten-hour shifts five sols per week; someone was always at the controls—that took 2.5 shifts per sol—plus two specialists were available to do maintenance on the fractionators 1.5 shifts per sol, and two specialists maintained the harvesters 1.5 shifts per sol. Every staff person could do at least two of the three jobs, which helped prevent boredom. Ethel spent half of her time at the controls and the other half of the time on paperwork and meetings, since she was in charge of the entire operation. Sometimes she helped maintain the fractionators as well. The terrestrial staff provided human resources, accounting, marketing, record keeping, and legal affairs such as signing contracts for transporting the product. In addition, ten more construction workers were engaged full time to build fractionator number 5, which would increase their output thirty percent in 2059. Finally, the Board of Directors, which met twice a year, commanded a large fee.

Mars Metals, Inc. had recently been making a steady profit of about 14% on investment; the equipment had cost a lot to develop and fly to Mars, it required constant maintenance, and the metals were expensive to fly to Earth. By investing ten million redbacks of their own money, Will and Ethel made 1.4 million redbacks a year of profit; other individuals and corporations made much more, and the Commission made the most because it owned half of the company. Ethel also made sure all the Martian staff owned shares and acquired some of the profits as well; as a company vice president she had

persuaded the Board to establish a profit sharing plan, and sometimes she made personal interest-free loans to staff to help them buy in.

A potentially worrisome development was the beginning of competition. In the last few years the gold mining operations had been working deposits with less and less gold. Those that dealt with alluvial gold deposits—about a quarter of total production, the rest were mining hydrothermal deposits and sometimes were excavating deeply into the planet—were also encountering significant quantities of nickel-iron. Starting in 2059 they would be separating the nickel-iron from the alluvium and fractionating it as well, producing metal products for Cassini Outpost and recovering three to five tonnes of platinum group metals per columbiad. Fortunately, demand on Earth was strong as fuel cells with platinum catalysts came into widespread use in automobiles.

As a result, many Mars residents invested in Mars Metals and the gold mining companies. The work gave her constant pleasure as well as numerous challenges, for she got to work with people and with her hands at the same time.

She was reflecting on how enjoyable her job was and watching over the operation when her private communications line buzzed. She turned to the tablet and saw that it was an urgent videomessage from her sister. She ordered the tablet to play the message.

Gina's face appeared, looking anxious, perhaps a bit in shock. "Ethel, about half an hour ago I called dad and didn't get an answer, so I drove over to see how he was doing. He didn't answer the door so I let myself in. He was still in bed and . . . well, Ethel, he seems to have died in his sleep last night. I'm sorry to break the news this way, but I'm just not sure how to say it. I'm a bit overwhelmed and shocked myself. It's been

twenty years since mom went and it was beginning to look like dad would last forever. I'm . . . sorry to look this way when I called you. Just get back to me, okay? Bye."

Ethel stared at the screen, in shock herself. Her father, James Ian MacGregor, was 92 years old. He had had a bad heart for twenty-five years and had resolutely yet successfully ignored it all that time. But he had been getting much weaker in the last year, as he himself was wont to explain to her in excessive detail whenever they talked. Just yestersol they had exchanged messages and he had complained about a cold and having trouble sleeping.

"Oh, daddy, I'm sorry I never saw you again face to face," she said aloud to herself. She had last visited him in June 2035, twenty-two years earlier. A tear came to her right eye. She had not expected to see him again, but she had not thought he would pass soon. She closed her eyes and could picture his face, hear his voice. She said a little prayer. "Maybe we can be closer now, since there is no distance between our souls," she added, talking to him instead of to God. She looked at the screen, then hit reply.

"Hi, Gina. I'm here; let me know what I can do. I just said a prayer for daddy. We talked yestersol—yesterday—and he had said he had felt a bit under the weather with a cold and was not sleeping well. I'm . . . in shock, but that's to be expected, right? Your explanation was fine, don't worry about it. Do you know which funeral home you're calling? Or maybe you have to call the police first; I don't know what the procedures in Edinburgh are any more. We had such a great dad, Gina, and we were blessed having him around so many years. I guess he's now free to be with mom, his mom and dad, and everyone else in the next world. Let's keep up the conversation. Bye."

She sent the message and turned to her tablet to call Will. At that moment he and Érico had just left New Tokyo Dome after finishing their discussions with Ichiro and Yoshi. “Will, I appreciate your vision, but it frustrates me a lot at times,” Érico was saying as the van began to drive them to Little Colorado Canyon and down to the outpost. “We barely have enough people to have boroughs, and you’re suggesting we establish villages! Do a thousand people really need three levels of government? Sure, a decade or two—or three!—from now, they’ll all be useful. But now?”

“I suppose it makes your job more complicated, but we do need to plan ahead. The Japanese want a sense of ownership of their facility. This gives them the autonomy they need while preserving overall coordination and, above all, central tax collection. Like you said, we don’t want one place to become a tax shelter while everyone else has to pay the costs of running this place.”

“I agree, this helps preserve some important principles, but you’re talking about a lot of time and effort to get a bill passed the legislature. And you’ve also changed the perception of everyone about what a borough is; that takes time as well.”

“I’ve always imagined a borough to be like a county, or a state or province. I thought it was possible boroughs would have no further divisions, but unlikely.”

“Maybe so, but most people here don’t imagine that boroughs will have subdivisions! And now we have created them. This isn’t all good. I don’t like the idea that ethnic groups can go out and make their own enclaves rather than assimilating. That’s potentially dangerous to this world’s unity.”

"Perhaps, but we'll have to maintain a certain amount of assimilation some other way; economic pressure is probably best. That, and the Constitution, are the main things that keep the United States together."

"I don't like that vision of Mars, Will. Our civilization needs to have some substance to it, and not be a hollowed out expression of a piece of paper."

Will was tired of arguing with Érico; now that his friend was Chief Minister, he had become considerably less deferential. But perhaps that was just as well.

Then his tablet beeped. It was Ethel; he answered. "Hello."

"Will, I just got a call from Gina. Dad passed away in his sleep last night."

"What? Oh God, I'm sorry, honey! How are you doing?"

"Fine; I'm in shock about it. I suppose the grief will hit later. Gina's in shock too, but we're talking our way through it."

"Good. I'm on my way back to the outpost from the top of the escarpment. It'll take forty minutes for us to reach Aurorae."

"Okay. I'm still at work; as soon as I can find someone to take over, I'll head home. Gina has a lot of planning to do and I want to help. I don't think she even knows what funeral home to call."

"We should plan a memorial service up here, too. I'll be there as soon as I can. Meanwhile, I'll say a prayer for him."

"Thank you. Bye."

"Bye." Will closed the circuit. Érico looked alarmed. "Your father in law?"

"Yes. He was 92; quite a long, remarkable life. I wish I had actually met him, but after talking to him over the videophone twice a week for twenty-one years, I feel like I

knew him pretty well. He was a dignified fellow; very proper, very polite. But he had a sweet side, too."

"It's amazing how close one can feel to someone one has never met. So, Will, is he 'closer' to you now, or farther?"

"You mean, you're slipping and asking me a theological question?" Will smiled, amused. Érico was unreligious. "His soul is neither closer to us, nor farther away, because it is in a placeless place. It is now freed from a body. I suppose you could say he is farther away, because his soul no longer has a material anchor in this world; or you could say his soul can now be closer because it lacks that anchor."

"Hum. Interesting," replied Érico, not convinced.

Several sols passed. In the United States, Thanksgiving came and went. In Scotland, James Ian McGregor was laid to rest. The following Sunsol the Bahá'ís dedicated their weekly devotional program to him.

Many of Will and Ethel's friends came to show their respect. The Bahá'í dome was green and sweet-smelling for the gathering, which was held under an open sided tent pitched in it. Afterward, people walked around the dome or stood and talked to Ethel.

"Ninety-two years; he did very well," said Roger to Ethel and Will. "My parents are both gone now. They made it to their mid eighties."

"That's respectable as well," said Ethel. She sighed. "Eighty is now just twenty-five years away, if I make it."

“If any of us make it,” agreed Madhu. “Though I suppose we will. We can deal with heart attacks, as Sebastian found out a few months back, and we can deal with cancer pretty effectively.”

Ananda approached. “Thanks, Ethel, for giving me the privilege of speaking,” he said. “I hope my comments were helpful.”

“Thanks Ananda, they were perfect.” Ethel leaned over and gave him a kiss.

“They were excellent; very appropriate,” agreed Roger. “And congratulations, Ananda, I hear you are appointed a Bahá'í leader.”

“Thank you, though I wouldn’t put it that way; I was appointed a servant. It’s a big job, being Mars’s first Auxiliary Board member.”

“What will you do?” asked Madhu.

“Well, we don’t have any clergy, as you know. My position is to advise and above all to encourage the Bahá'ís. I can’t tell them what to do. I’m no longer on the Aurorae Spiritual Assembly, the governing body of the Bahá'ís here, which coordinates everything. I remind them what we are supposed to be doing, encourage them to act, and I stay current with the guidance and advice of the Universal House of Justice, our international coordinating institution.”

“And sometimes we ask him to speak; he always has been a good speaker,” added Ethel.

Roger looked around. “This place is coming along. The lawns are green with grass and you’ve started on flowers.”

“Next week we’ll be excavating a hole in the middle,” added Will. “We’ll be pouring a nine-sided foundation thirty meters across for our Bahá'í Center. It’ll be underground for a few years and we’ll build the House of Worship on top of it later.”

“I have some ideas about these gardens,” added Madhu. “Would you like to see them, some time?”

“Sure!” exclaimed Ethel. “I’ve always been very impressed by your garden designs.”

“This has to be different from my exterior gardens, since you want plants in them. But I can accommodate that. It’d be nice for the Bahá'í gardens here be distinctively Marsian.”

“We’d like that, Madhu,” replied Will. “Bahá'í gardens and buildings are supposed to reflect the local culture.”

She smiled. “Good, then I’ll offer some suggestions.”

“So, are you back to work and everything?” Roger asked Ethel.

She shrugged. “I only took off parts of three sols. There’s a very nice grief support group coordinated by Suzanne van de Velde and they’ve invited me to lunch next week. Father Greg’s been over for tea twice, and all my friends have been really marvelous.” A tear appeared in her right eye. Madhu smiled and the two of them hugged. “Thanks,” she said to her friend.

“What are friends for,” replied Madhu.

“Helping each other get through life’s bumps,” replied Ethel.

13.

Voyages

Jan. 2058

Charles Vickers looked at the countdown display. T-minus 5 minutes and counting. He glanced at the view of Astrea on the screen. The sun had just risen over the Piazzi, bathing the familiar craters and hills around it in horizontal light. They were about to head eastward across the solar system to Ceres.

He looked at Clara, Helmut, and Thierry, who were running monitors in the bridge. “So, did we have fun?”

Clara was startled by the Commander’s levity. “Yeah. Astrea was a blast,” she said jovially.

“It was pretty good,” agreed Thierry. “Of course, we’re out of fiber, low on paper, have had to simplify our horticulture, and had no time for maintenance.”

“We’ll be using the cruise to Ceres well,” agreed Charles. He turned to Helmut. “Great geology.”

“Incredible; a lot of things we’ve seen on Phobos and Deimos, some things we expect to see on Ceres, and some unexpected things.”

“And all the detailed chemical analysis we can do on the cruise will reveal the collisional histories of several asteroid families, I’m sure,” exclaimed Charles. “Coming up on . . . t-minus 2.”

“All life support systems are go for launch,” reported Thierry; they were his area of responsibility. “Everything is secure for engine firing.”

“Propellant tank pressurization is coming up,” added Clara. She was watching the propulsion system; their five engines were pressure fed and thus did not need pumps to move the liquid methane and liquid oxygen to the combustion chamber.

“Communications links with Mars are go,” added Helmut. “We’ve got a direct link open and a relay through the lifter on its way to Ceres.” The lifter was closer and therefore could receive a larger volume of data; it would store all data from the launch in case an accident wiped out the ship entirely. Charles nodded; he was looking over summaries of all systems on board.

“I think my favorite moment here was when Charlie rode in the hopper-van to Mount Waltama,” he said.

Helmut chuckled. “He enjoyed the trip and the view. He’s going to be a geologist, I think. Too bad we can’t get him in a spacesuit yet.”

“Give him time,” replied Charles. “Coming up on t-minus one.”

Clara nodded. “Ignition system is activated. Tank pressure has now reached launch condition. We’re ready to go.”

“Initiate automatic engine firing sequence,” said Charles. Clara nodded and pushed a few buttons. It was now a matter of waiting, watching, and aborting the sequence if something strayed from normal.

“One destination down, three to go,” said Charles. “I think Ceres will be my favorite, though.”

“It’s an entire world of its own,” agreed Helmut. “Big, geologically complex, fascinating. I can’t wait.”

"Let's hope six months is enough to get study of it started," said Charles. "And that someone can be persuaded to fund further research."

"Just keeping the ABC funded is tricky," agreed Thierry. "The asteroid belt doesn't seize the imagination the way planets do."

"Let's not be pessimistic," said Charles. "Here we go." He watched the countdown clock run through the last ten seconds. At t-minus one they heard a rumbling as the engines began to come on at low power; but even at low power the ship rose slowly off the surface of Astrea. Then the power built up and at t-minus zero they reached the intended engine thrust. The *Piazzi* rose quickly off Astrea, its rolling gray surface fell away, and they headed into space toward Ceres.

The departure of Marshall's geology class from Phobos was gentle, almost anticlimactic. They all strapped into their seats and heard a brief hiss of the shuttle's engines; one couldn't call it much else. There was a slight, momentary feeling of weight as the ship accelerated by about 200 kilometers per hour in half a minute's time. Marshall looked down and saw the moon moving slowly away.

First the landing pad appeared, a big circle of steel anchored firmly to the moon that held onto ships magnetically. As they rose, a bump on the nearby horizon resolved itself as "the Knob," a round butte of relatively intact chondrite bedrock where the entire class had spent their first afternoon. Beyond the Knob was Twin Craters, a pair of relatively fresh impacts that dug holes 150 and 175 meters in diameter respectively. East Twin—the larger of the two—was also the deeper, almost 50 meters. He watched closely and spotted the two caravels parked there at the base of the high eastern cliff, which

shielded them from any possible troubles at the spaceport. The two vehicles had been their home over the last month, and they had spent some of their spare time on interior construction of the vessels. Though both were slated to depart the moon in less than a year's time, East Twin was the permanent location of Renfrew Outpost, as the moon's permanently staffed facility had been recently designated.

Neal Stroger leaned over to look out of Marshall's window. "There's Renfrew," he said. "I wonder how big it'll grow to be."

"I wonder too," agreed Marshall. "The fact they can raise food for a fraction of the transportation costs of anyone in the solar system is intriguing."

"That's their geopolitical advantage," agreed Neal. "You really enjoyed your month up here, didn't you?"

"I sure did! It was really incredible. So much to see and learn, and I really enjoyed everyone's company, too."

"Well, you fit in well, in spite of your age." Neal looked at him. "You realize you're not a boy any more, Marshall. You're a man now. Your eighteenth birthday may still be a month away, but you proved yourself on this trip."

Marshall smiled, embarrassed. "Thank you. I guess it was a rite of passage, of sorts."

"I think so. You'll be starting up with Martech in the fall, right?"

Marshall nodded. "I graduate from Mariner High School in June; the first graduate. Sam will be one course short and will graduate at the end of the summer."

"And he'll be in Martech as well, come September. Good. If you want my advice, it'd be to go to Massachusetts Institute of Technology for your undergraduate

degree. They've got the physics and geophysics you need and they have an incredibly good liberal arts education as well. You can study anything there. Of course, the weather's better at Stanford or CalTech."

"Stanford's still rebuilding after the big quake, though," said Marshall. "Paul suggested MIT as well. He said Martech would be fine, but I should experience Earth."

"He's right." Neal nodded. "That's part of my reason for recommending MIT. The Boston area has one of the most incredible student scenes on Earth, you're a few hours from New York, you can get to Europe fast from the airport there. . . it's a good location."

"Your degree's from MIT, right?"

"Undergrad and grad." Neal smiled reminiscingly. "It was a great time in my life. I met Rosa there; she was working on her degree in nuclear engineering."

"I wonder if I can get in."

"Get in? You can guarantee getting in."

Marshall was surprised. "How?"

"By getting a good mark in this course, which won't be easy; most of the students have at least one Masters degree and know how to write the final research paper. But I also tell all my students if they need help, they should ask me, and if they want to submit a draft of the paper to me, I'll give them advice. I think if we meet three or four times and you submit a draft to me, you can do it. And then you have a solid mark in a hard course that is recognized by Caltech as well as Martech; remember, I'm on the faculty there, still, and this is a joint course. That's how we accredit everything; we have

all our courses jointly sponsored with an accredited institution. And then if you ask me to write you a recommendation, I will be in a good position to do so."

"Really?" Marshall was excited by the scenario Neal had laid out. "Alright, I'll arise to this challenge you've thrown my way!"

"Good! That's the spirit! Let's plan on meeting next week to review your initial outline. Assuming we survive the return home, of course." Neal was accustomed to mentioning the possibility of death in connection with spaceflight; it was one of his personality traits that no one appreciated.

"Alright; next Thursol. I could stop by around 4 p.m."

"Perfect."

Marshall turned back to the window to watch Phobos recede into the distance and think about the offer. He needed a mentor and he liked Neal. Neal's geology was not as oriented around physics as much as Marshall liked, but he could pursue geophysics later. Right now he had to prove himself.

The shuttle began to turn ninety degrees in order to fire its engines again, a more powerful burn of 500 meters per second that would lower the vehicle's periapsis into the Martian atmosphere. His mind was still racing about MIT when the countdown began. The engine came on and they experienced normal Martian gravity for two and a half minutes as the shuttle's engines did their work.

Phobos began to recede from them rapidly as the shuttle began its three-hour plunge to the atmosphere six thousand kilometers below. Marshall began to think of Earth. *Earth.* He had wondered about the place; occasionally he had felt a desire to see it; but now the curiosity fanned into a flame. He closed his eyes and tried to imagine

domeless green to the horizon under a cloud-studded blue sky. He couldn't quite picture it. He had seen thousands of photographs, watched hundreds of hours of t.v. shows set on Earth, had even been on dozens of three-d virtual reality tours of cities and other special places. As a result he could picture the United States Capitol, the Leaning Tower of Pisa, even the crater of Hawaii's Kilauea Volcano. But for some reason he could not picture rolling forested hills under a blue sky.

Then there were rain and snowstorms, the smell of sea salt, the crash of thunder—he could picture the flash of lightning easily because he had seen it on Mars during dust storms—and the soaking green heat of a tropical rainforest. He wondered about them. There were malls, huge crowds, new cars, and water skiing.

And there was the relentless pull of terrestrial gravity; could he ever adjust to it, or would it exhaust and debilitate him? The doctors said all the Mars-born kids could go back to Earth; their bones averaged fifteen percent weaker than normal, but they'd gain calcium once there; their hearts would adjust gradually. The biggest danger was the onslaught of thousands of germs and the consequent need for dozens of inoculations. He'd be ill a lot, the first year. That was something he did not look forward to.

Finally, there were social issues; how would his peers regard him? As the ultimate country bumpkin, utterly ignorant of many basic aspects of terrestrial culture; as the ultimate sophisticate, raised in the most international of cultures; as a social and sexual curiosity? His father had already reminded him more than once that the tabloid press, right after his birth, had carried numerous photographs of two-headed babies and alien babies labeled "Marshall Stephen Elliott." He already had a reputation on Earth that he didn't even know or understand. That was weird to contemplate.

He was still thinking about all these matters as the shuttle reached the Martian atmosphere. In a matter of minutes it went from floating weightless in space to being a plasma-wrapped entry vehicle blazing across the early morning sky, plunging toward the desolate, ruddy surface of his home world. Gee-forces rose and rose until they were a breath-catching 2.5 times higher than terrestrial normal. Then the engines blazed alive and burned off the last speed that the thin Martian air was unable to rub off. The shuttle settled onto the surface on a tail of flame.

The engines cut back sharply, g-force waned, and there was silence followed by a slight bump. They had landed. Outside Marshall's window was the hull shape of Boat Rock, with the northern escarpment looming above and twenty kilometers beyond it. "Welcome to Aurorae Outpost," exclaimed the captain, who added, "Welcome home."

They all began to unstrap themselves, stretch their legs, and adjust to a steady gravity after hours of fluctuating forces. They grabbed their luggage and began to form a line while scraping noises outside told them that a passenger conestoga was docking to take them back to the outpost.

It took about fifteen minutes to get the pressure tunnel set up, and then they all exited the vehicle and entered the conestoga. Soon it was on its way to the Arrival Hall, a place he had been in many times before, but never because *he* was arriving. The conestoga drove through an airlock and right into the hall, facilitating unloading. As Marshall stepped out he saw his father waiting for him.

"Welcome home, Mr. Elliot," said Will, and Marshall couldn't help think of Neal's remarks about how he was now a man. He didn't feel any different, though.

“Thanks, dad.” He leaned over and kissed his father. Will reached down. “Let me carry your bag.”

“No, that’s okay, dad, I can manage.”

“No, I insist. How was the trip?”

“Oh, wow, it was incredible! The whole thing, launch to landing, was amazing.”

“And Phobos?”

“Spectacular. Who ever said small worlds are boring and gray! We spent two afternoons exploring the steep northern slopes of Stickney. The stratification is incredible. We rappelled into one of Stickney’s fractures. Did you see the ice layer we found on the floor of one of the north polar craters?”

“Yes; it was quite a surprise, too. It may be a recent product of our drilling; there’s a fracture that runs from the bottom of a well to the surface in that area.”

“Yes, that’s the theory; it’s just water vapor we created that escaped our control.”

“Probably. More analysis is needed to pin it down. We lose about twenty percent of the water and carbon dioxide we make from carbonaceous chondrite.”

They crossed South Main Tunnel into Riviera Biome. Marshall looked around. The place was still decorated for New Years, with banners and electric lights strung across the central yard. “Nice to be home again. How are the plans for the new house?”

“Moving along. I met with Simeon yestersol. We’re going with two standard enclosures.”

Marshall stopped. “Two? That’s twenty by twenty; dad, that’s a quarter the size of this entire biome!”

Will smiled. “I know. But we need two escape routes and there is only one tunnel to connect to. With two enclosures, one can connect to a neighboring tunnel. We’ll have four hundred square meters of space.”

Marshall laughed. “But right now we have only 100, and we have one of the largest houses here!”

“That’s right. And we’re going to have a *bath tub,* not just a shower stall.”

“But no one has them.”

“Not true; the Construction Department made them years ago for the Dacha. By ordering one, we’ll have to pay for the new molds and equipment, but they will be available to make bathtubs for others. We’re going to have a private garden also; there will be several big windows in the regolith overburden. Your bedroom will have its own bathroom; you and Lizzie will effectively have private apartments.”

“But I don’t know whether I want a private apartment.” Marshall paused to think about the implications of his father’s generosity. Meanwhile, they entered their flat and stopped in the living room. He looked around at the familiar scene, where they had lived some ten years, and wondered whether it was getting old and shabby or whether it was just well-loved and well-worn. Will sat on the couch, so Marshall sat opposite him. “How much is this going to cost?”

Will didn’t answer right away. “Probably about eight million redbacks,” he finally said. He saw Marshall’s shocked look and smiled. “Do you know how much we’re worth? Mom and I are at the top of our salary scales and we’ve invested in all the mining companies. We could pay it off from our salaries in a bit over two years. Our current residence is worth 1.5 million. We can pay cash for it if we want.”

“Dad, people here will be furious! They’ll be shocked! This will be terrible for your reputation!”

“Perhaps. I’ll need to do some explaining. But look at it this way. We’ve already given six million redbacks to the Van de Velde Foundation; they’ll be funding one arrival this columbiad. We’ve given five million redbacks to the Mars Bahá'í Temple Fund and will give more. And we still have a lot of dough. We could invest more of it in mining companies or construction; I’ll probably invest in Simeon’s construction operation. We could invest more of it in Martian land, though that doesn’t produce much return. Otherwise, we have to invest it in stocks and bonds on Earth. Investing it in a big house is an excellent investment. We’ll get our money back eventually and we’ll drive the creation of new products that will benefit everyone.”

“That’s good, but people will still be upset.”

“I can’t help that. In another two months I’ll have been here 22 years. In May I’ll be 57 years old. I’ve been working hard and under immense stress for two decades. And that’s a long time to accumulate surplus; the first five years here we had nothing to spend our salaries on, and since then our salaries have always been higher than our expenses. I think I’ve earned a little comfort. Besides, I turned down an offer by the Commission to build me a formal residence. I don’t think the Commissioner should have such a residence; eventually the Chief Minister should have that honor instead. And I’ll use the house a lot for official business; I plan to cater a lot of dinners.”

“Dinners?”

Will nodded. “One of the gardens will be set up for dining. A lot of business can be done over a meal.”

“You’re good at that.”

“I wish I had time to cook meals; I’m pretty good at that as well. Anyway.” He looked at his son head to toe. “You look more relaxed; maybe a bit more confident. I take it the trip was important.”

“Definitely. A sort of rite of passage. I was one of the guys; another man in a space suit.” He listened to the word “man” as it came off his tongue and wondered what his father would say. Will smiled.

“Good. I was worried it would be too much too fast. When I was young and confident, I thought one should just try things and shouldn’t hold back. Since then I’ve learned that one can try too hard and get discouraged and disillusioned. Timing is everything. But maybe I worried too much.”

“I really learned a lot. Neal—Dr. Stroger—was very encouraging. He and Paul both said I should go to MIT for my undergraduate degree. Neal got his degrees there and said he’d write a recommendation if I did well on the final project.”

“MIT? What’s wrong with Martech?”

“Nothing. But I want to see Earth, and the profs at MIT cover the subjects I’m interested in.”

“They do; but Earth. . . I really don’t want you to go to Earth!”

“Dad! I’ll be eighteen in a month! And I have a round trip flight to Earth; I’ve been here long enough. I want to see Earth.”

“I know, I understand, but Earth is a big, dangerous, complicated place, and you have no experience—no idea—what the place is really like.”

“It’s not that bad, and I’ve seen plenty already; not just tv shows either, but the human behavior up here.”

“True, but you haven’t seen all the human behavior that’s occurring up here; believe me. And the range of things that happen on Earth is much bigger. It’s not an easy place to negotiate socially. And then there’s money, buying things, renting things, driving cars; all sorts of things you don’t know about and no one here can really tell you about.”

“Well, I’ve got cousins, and there are the Bahá'ís!”

“Thank God for that. Look, I don’t want to argue with you about this. We already tried that. You’re not as old as you think, where going to Earth is concerned. It isn’t that simple. Why don’t you wait a while; complete your undergrad degree here at Martech and go to MIT or Caltech for a doctorate.”

“Jeez, dad!” said Marshall, exasperated. He shook his head trying to contain his anger. He paused, then said “Look, dad, I’ll start out at Martech this fall when I’m 18 ½, but half way through the semester I’ll leave for Earth, assuming I can get a space on the caravel that’s going. I’ll get to Earth a bit late for spring semester, so I’ll have six months to go live near grandma and get adjusted, then I’ll start at MIT in the fall of 59. I’ll be 19 ½ by then. This all assumes I’ll get in.”

Will was impressed that his son had controlled his anger about a threat to some central life plans. Unlike their previous confrontation, Marshall had not raised his voice; he had offered a rational appeal instead. “Perhaps you are ready. But your mother and I have to talk about this.”

“Okay. Fine with me,” Marshall replied, though doubt and worry crossed his face. “I’ve got to write a superior research paper for Neal. I spent a lot of time looking at

the stratifications in the north crater wall of Stickney. He told all of us there is excellent remote sensing data of the wall as well, and no one had mapped it and interpreted the results. So I'm going to look into that as a research topic."

"Sounds good. It should tell us about Phobos's impact history, and the history is pretty complex. It might even add clues for when Phobos separated from Deimos."

"If that theory is correct."

"Yes." Will looked at his watch. "I'd better get back to the office. It's good to have you home."

"Thanks, dad. It's good to be back."

It wasn't until evening when Will was able to tell Ethel about the conversation. Since the kids didn't eat supper with them, they talked about it over coffee, while sitting with Roger and Madhu.

"I don't like it, either," said Ethel. "He could get taken advantage of all sorts of ways."

"That's what I'd worry about," agreed Madhu. "He's not used to handling cash or people borrowing money from him, for example."

"So, he loses a couple hundred and learns," replied Roger. "He's not dumb. He may make a few mistakes, but I doubt they'll be serious. And both of you have sisters with families to watch him."

"He's already talked about staying in Stamford near mom for a few months, where Molly and Taraz can keep in touch," agreed Will. "The bigger concern I have is the celebrity factor. Handsome, smart, articulate, and the first child born on Mars: that could

open a lot of doors I'd rather not see opened. And all it would take is one contact with someone who would make suggestions; that he be interviewed on television, appear in a commercial, meet some powerful friends at a party . . . whatever."

"He probably won't meet people like that at a nerdy school like MIT," commented Roger.

"Maybe you could ask Louisa Turner to watch out for that," suggested Madhu.

Will shook his head. "No, that wouldn't be appropriate. We'll have to count on Molly and Taraz. They have a little experience. Paul was interviewed by local media outlets before coming here."

"I wish I could go and watch out for him, for the first month anyway," said Ethel.

"That would be a better solution, but it's not practical," said Will. He paused. "On the other hand, if the Commissioner were to fly back to Earth, he could get a lot of business done and watch number one son."

"All the way back to Earth? For a month, plus a year in space?" said Ethel.

"It'd be a grave inconvenience. But it would have advantages. I haven't met any of the people on Earth I work with. That degrades our communication. My role in external affairs and diplomacy is sharply limited and that impacts on our government subsidies. It's hard for me to intervene in internal disputes; for example, right now we're hitting severe resistance to our plans to spin off the Seville agricultural research center. There are times only the Commissioner can do things, or he loses power. There are some areas I am not as powerful, if one wants to use that word, as I should be."

"Of course, if you went to Earth to do all those things, you wouldn't have time to watch Marshall," said Ethel skeptically.

"I'd have to do a bit of both."

Ethel shrugged. "Call Pierre and Louisa about it; I know that's what you want to do."

After supper Will videomailed both Pierre Messier and Louisa Turner about the idea. It wasn't until the next morning when he got a response.

"Will, I hope you can do this," said Louisa. "I checked with Pete Theodoulos. You'd have twenty-two days on Earth. In that time we could get you to at least twelve of the countries involved in the Commission, maybe more; we'd charter a private jet. We could get you on television an hour or more a day and could arrange dozens and dozens of interviews; some of that could be done as soon as you're within a half million kilometers of Earth. Pierre says he could arrange meetings with important officials, receptions . . . all sorts of functions. You could help resolve several internal issues, especially the closing of support facilities. If all went well, we'd get excellent publicity and more financial support for the Commission. I suppose it wouldn't be practical for you to come back every columbiad, but every other columbiad the Commissioner should visit the planet he isn't on! Let me know if I should call Ethel and help persuade her. Bye."

Kristoff looked into Lisa Kok's office. It was the third time he had stopped by to see her in two sols. This time she was in.

"Good morning," he said. "Can I take thirty seconds of your time?"

"Sure. How are you doing? I've been very impressed by your work in Ceylon lately. You seem to have hit your stride."

“Yes, since dad’s heart attack I’ve been looking at my work more seriously. In a way, that’s why I’m stopping by. I’m curious about the Phobos agricultural project.”

“We’ll be sending two or three folks up in late February or early March. We’re setting up two cylinders initially—regolith-based agriculture—then a hydroponic cylinder a few months later. We’ll expand depending on which type does better. Why, are you interested?”

“Yes. I like Ceylon, but I want a bigger challenge. Phobos will be different.”

“It’ll be a lot of work; the work week there is seventy-two hours, not fifty. The pay will be 175% more than here, though.”

“I can handle the longer hours; I suppose there isn’t much else to do up there.”

“Not much, and not a lot of single women, Kristoff. We hope to have some exports late this year, so it’ll be intense. But your work lately has been impressive. If you want to be considered, say the word.”

“Consider me.”

Lisa nodded. “Okay, you’re on my short list. I’ll let you know next week.”

14

Ecology

Early March 2058

Kristoff pulled on the joystick and moved his “cherry picker” closer to the genetically modified wheat seedlings. He reached down from the cherry picker’s bucket, took several pale leaves, and put them in a sample bag. They were still uncertain what it was in the Phobosian regolith that made the plants unhealthy, but these blades looked particularly yellowed. Then he took a soil sampling tool, extracted a bit of crumbled regolith from the ground, and inserted a sensor, which told him the soil temperature was 20 Centigrade and the moisture level was normal.

He pulled on the controls to raise himself above the crop, then pushed the joystick to move himself another three meters along the cylinder to look at some pale leaves there.

His tablet, which was carefully velcroed to the counter in front of him, rang. It was Irma Baeker from Aurorae. He could use a break. He activated the call. “Hi, Irma, how are you.”

Her face appeared on the screen; she looked perky, energetic, her brown hair carefully coiffed as always. “Hey, I’m great! Just the usual; work, rest. How are *you*? I haven’t talked to you since blastoff.”

“Oh, God, I’m sorry! It’s been ten sols, too; it’s hard to believe I’ve been up here that long. Well, I don’t know where to start. I’ve been working twelve hours per sol; that’s standard. But we’ve actually got wheat seedlings popping up in two cylinders now!

Considering that ten sols ago there was nothing at all except inflatable greenhouse cylinders packed in boxes and prepared beds in the crater floor, it's pretty amazing."

"How's that possible! The wheat can't be very big!"

"Oh, of course not. Germination started late yestersol in this cylinder and has just started in the other one. Here, I'll give you a tour." He grabbed the tablet and pulled it free from the velcro. He pointed it down the cylinder to the far end so the camera could take in the scene. "This is agri number one; a sausage twenty meters long and ten in diameter. It's a real cylinder, not a semicylinder like we make on Mars, so it has a curved floor, but in Phobosian gravity it really doesn't matter; we can grow on the bottom third of the floor. The top third is transparent to let in sunlight; the zone in between the two is covered by regolith to reduce cosmic radiation."

"But what about micrometeorites?"

"There's a solar reflector overhead and it has a kevlar blanket on top. It doesn't cover the cylinder completely, but the chance of a micrometeoroid impact is almost nothing anyway."

"Cheap and basic."

"That's right. I'm glad I didn't have that job, all we had to do was inflate the cylinders, blow in the regolith, water, and seed it."

"Now, where are you right now? I get the impression from the picture on my screen that up is to the right!"

"Oh, sorry." Kristoff rotated the tablet 90 degrees to fix the orientation. "Yes, I'm actually horizontal right now, not vertical! Phobos has seven ten-thousandths as much gravity as Earth, so I 'weigh' 47 grams—about as much as a chocolate bar!—rather than

sixty-eight kilos. Basically, I'm weightless. In a big cylinder like this I could get stuck floating in the middle or could bounce into the crops, and I wouldn't have anything to hold me in place that would let me pick or dig. So we have a track running along the east side of the cylinder and riding the track is a 'cherry picker'; basically, it's a basket up to my waist that I stand in and that my waist is strapped to, leaving my torso and hands free. I can move the cherry picker with a joystick and can use it to hover above any part of the crop I want."

"Ah; clever. I'm no expert, but the wheat looks a bit yellow."

"Yes! Very good! The reg's never undergone chemical weathering before, so once it's exposed to liquid water its chemistry changes. It'll be a year before we can start growing crops that we can eat; this wheat is genetically altered to extract arsenic, selenium, and a few other undesirable elements from the future 'soil.' The reg is producing salts as well, so we're constantly adding water and pumping off the extra liquid to desalt and recycle it. We expected the problems, but we're taking samples to verify the entire weathering process as it occurs."

"Impressive. And I suppose the salts can be broken down into elements and sold, since Phobos is 'closer' to low earth orbit and the moon than anything else, in terms of energy. It sounds like you're having fun."

"Oh, a blast so far! It's isolated and the work's intense, and the social life is very limited, but this is my work. I'd rather have genetically altered wheat depending on me for a while than mangos in Ceylon agridome."

Irma laughed. "Yes, you were always talking about being needed by a different fruit of the sol! Sounds like the trip was a good decision."

Kristoff smiled. “Yes, so far. I would have never done this a year ago, but priorities change.” He shrugged.

“I guess so.” She looked at him admiringly. “I don’t know if I told you, but I’ve signed up for a chemical engineering course. It just started yestersol.”

“So, you’re making the switch?”

She nodded. “I like nursing, but we still don’t have many patients, and I’d like to try my hand at some of the plastics research they’re planning; plastics that work well in high ultraviolet and cold, plastics good for space, etc. We finally have the luxury of doing the research that meets *our* needs, instead of relying on corporations or universities.”

“That’s exciting, though you’re so good with patients, it’s a shame you won’t be working with them any more.”

“I will, but part time only. The hospital still doesn’t need full time nurses unless they’re engaged in research; we typically have no patients at all two sols per week. I’m really not that interested in medical research.”

“Most of us aren’t,” quipped Kristoff.

“How many people are up there right now?”

“Renfrew Station has thirty-five. There are three of us doing agriculture, six doing station maintenance and support—they helped us set up the cylinders—and twenty-six doing construction on the *Heinrich Olbers*. Ten of them are living in the *Olbers,* which is connected to the *Endeavor* via pressure tunnel.”

“Thirty five’s more than I thought. So, social life shouldn’t be too bad.”

“We have fun on Satursol nights; there’s usually live music, sometimes karaoke, a movie, and beer. But only Satursol night. Monsol through Satursol we’re up at 6 a.m., at

work at 7, we take a half hour break for lunch, and break for dinner at 7:30 p.m. Sunsols we sleep late and do laundry!"

Irma laughed. "Yeah, when I visited Meridiani it was that way, too. At least you guys earn twice as much money."

"Yes, everyone's thinking about how much easier life at Aurorae will be when they go back! But I may stay a while; microgravity agriculture hasn't been researched very much. If we can figure it out, we can sell lots of food."

"It is an interesting problem. But keep in touch, okay? I enjoyed our conversations."

"I will; I did, too." He smiled. She obviously liked him. He was not so sure how he felt about her, however.

"Good. It's your turn to call me, now; the ball's in your court."

"Okay, I'll call next week. And thanks for calling, Irma. I enjoyed it. It's nice to be remembered."

"I'm sure. You've volunteered for a pretty interesting project, but you've left friends behind. Well, I'd better get to the Gallerie before everyone's gone. Bye."

"Bye." Kristoff closed the circuit and smiled for a while. He hadn't heard from Nadia, Veronique, or Millie; nor from Rahula or his male friends, either. It was nice to be remembered.

"Girlfriend?" He was startled; he turned and saw Dr. Marci Carnegie, his boss, floating in the tunnel connecting to agricylinder number 2. "I came in here a minute ago and heard a female voice on your tablet."

"Oh. No, she's not a girlfriend; just an acquaintance."

"Oh. I'm finished in number two; the shoots coming up there are yellow, too. I've collected some good samples."

"I've got one area left to sample and I'll be done."

"Great. I'm on my way to the station for supper. See you there." She launched herself across the cylinder and grabbed a rope along the western ceiling to keep herself going the right way.

Kristoff finished taking samples, then drove the cherry picker across the cylinder to the end. He climbed out and began to pull himself down the tunnel, handhold to handhold, at a pretty fast pace; no one was coming in the other direction, so it didn't matter how much he floated about as he went. He reached the axis of the *Endeavor,* which was the main unit of Renfrew Station; it would continue that role until the time came for it to fly to Earth, at which point a new caravel would have been landed for setup. He turned ninety degrees, enjoyed the one percent gravity of the *Endeavor's* rotating axial corridor, and stepped into elevator #3 to descend to the agricultural labs, where he deposited his samples; their third team member, John Wainaina, would analyze them later tonight. Then he went to the mess hall, which was crowded, noisy, and boisterous.

He really wanted to call his dad; for some reason, Irma's call had triggered the desire. So after a delicious supper with pleasant company, he headed to his room—which was almost as big as his flat on Mars—to call his dad.

"Kristoff, good to see you. How are you?"

"Pretty good; the work's really enjoyable up here and we're making pretty good progress on agriculture in Phobosian regolith."

"That's good news. Biologists were predicting all sorts of problems."

"We're encountering them, too, between the movement of liquid in microgravity, gas convection problems, and trace elements in the reg. It may be that hydroponics will prove better than artificial soil in spite of the problems with controlling liquids in microgravity. We'll be installing a hydroponics system in cylinder number three in April. But it's really exciting being here, seeing Phobos, and doing this work; it's really rewarding."

"Good, I'm glad to hear it. How does it compare to working in Ceylon?"

"Better; for now, anyway. No one stays on Phobos forever, though maybe some people will stay a year or so. And the horticultural specialists on Mars rotate from ecology to ecology every year or two."

"It's good variety and experience."

"So how are you? What's new?"

Sebastian shrugged. "Not much new. I spend two hours per sol asking governments to honor their pledges; it's a drag. Deseret has a new bedroom desk-closet-chest of drawers combination that's very efficiently designed and I'll probably order one for my flat, assuming they'll assemble and deliver it, since I'm not inclined to do either and I have no sons to prevail upon. The bridge game is shifting from Tuesol to Thursol nights. So, everything's normal."

Kristoff smiled. "Have you talked to Helmut?"

"We exchanged messages last night. Charlie has a mild cold, which has everyone baffled, since no one on board has had a cold for over a year! It shows how these germs can lie dormant a long time. So they think everyone might get it now."

"Are they relaxing yet?"

"No! Six months of intense exploration means they now have six months of heavy maintenance, plus a lot of analysis. They just analyzed some samples from the Waltama mountain complex and were surprised by the isotope ratios; the impact that threw it up was enriched in siderophile elements more than expected, which means it came from the inner solar system, and probably was from early in the planetesimal accretion process. So they've sent in a few Prospectors to explore the area remotely while the transmission delay isn't too bad. Now they're kicking themselves for exploring the area so lightly."

"No one will be going back soon, I'm sure."

"Probably two decades. We're trying to draw up a long term exploration plan for the 100 most significant objects in the belt, but heck, I can't be sure there will be funding for the third mission! At least 2059 sees the launching of ten automated orbiter/lander probes and 2060 will see twelve, all by different nations. In a decade we'll be managing a telepresence on fifty or sixty objects at once, possibly from the belt itself."

"I'll give Helmut a call tomorrow. I hope Charlie gets better quickly."

"He will. I'm glad you're showing so much concern. I appreciate the call."

"I'll try to call more often, dad."

"Good, I'm grateful for that. You seem to be . . . changing some priorities."

"Yes, you could say that. I was just talking to Irma; she called me. It was nice. She said it was my task to call her back next time."

"Oh? Will you?"

"Yes, next week. I think I will."

Will was sticking his tablet onto his belt to leave his office—he was late for an appointment—when Marshall suddenly showed up. “Dad, I got into MIT!”

“Really? Congratulations!” Will walked over to the door and gave his son a hug.

“Thanks, dad. It’s so exciting. Of course, the letter says I’m supposed to show up on campus in September for orientation!”

“I think they’ll understand. They have quite a distance-learning system; you probably can get started that way.”

“Neal said there’s no problem; I ran into him on the way over.”

“I hope you thanked him again for the good recommendation.”

“Oh, yes!”

“I’m proud of you, Marshall.” Will hugged his son again. “Now, if you want to talk, walk with me; I’m late for an appointment in Andalus.”

“I’ve got to get back to school, but I can walk a little ways. I guess we had better get our reservations in for the flight back.”

“Yes. I have mine in, but you need to get yours in immediately. There are still berths. I’m looking forward to showing you around Earth.”

“If you have any time!”

“I plan to make time. The jet they’re chartering to fly me around has room for you. I’ll pay for you to come along.”

“How many cities?”

“It isn’t finalized yet, but we’re talking about the U.S., Canada, Mexico, Brazil, six or seven countries in Europe, Russia, Pakistan, India, China, Japan, Indonesia, Malaysia, Australia, and New Zealand. I’ll visit some of them just a few hours; the jet

will have private quarters for me and a dozen others. The U.S. will include six days in Connecticut and five more touring around."

"I thought you were staying in Connecticut a week."

Will shook his head. "Louisa wore me down; we're looking at six days, and that includes some time visiting New York and Boston."

"So, I can visit all those countries with you?"

"Yes. Think of it as a graduation present. God willing, we'll build in a few hours of sightseeing every day."

"How much will that cost?"

Will shook his head. "You don't want to know." They came through the building's revolving door and stopped. "You've got to go that way; I have to go this way. See you tonight; and congratulations again."

"Thanks. I won't see you at lunch?"

"No, I'll be outside over lunchtime." Will waved to his son and turned to walk quickly to Andalus, very pleased and proud. He still wished that his son wasn't going, but the boy had made a bold choice and was carrying through with it quite well.

In a few minutes he reached Andalus and entered the new Borough Building or "Town Hall." The exterior wasn't completed, but the offices and meeting rooms were, so Ruhullah Islami and his staff had recently moved in. Will headed for the second floor and the Clerk's Office. He caught up with Lisa Kok as she reached Ruhullah's office.

"We arrived at the same time," she said. "I'm glad you're late, too."

"There's always too much to do." They stopped and Lisa knocked. Ruhullah himself opened the door.

"Come in. It's good to see you both. How are you doing this sol?"

"Very well. Marshall just heard that he's going to MIT next year."

"Oh, congratulations!" exclaimed Ruhullah. He pointed to the table. "Sit down. What marvelous news! Well, if you think it's marvelous, anyway."

"Yes, I'm pleased. I wish he wasn't going, but he made the decision and we're supporting it; he's eighteen now and a pretty mature kid. I think he'll do fine."

"I'm not sure I'd be so supportive if Anna decides to go back," said Lisa. "Of course, she's still got four years. Marshall's the oldest and has set the pattern for the other kids here."

"Maybe," replied Will. "We'll see."

"I guess I can be thankful I don't have any kids to grow up and head off into space," said Ruhullah. "My parents weren't happy about it, even if I was the first Iranian on Mars." He glanced at his watch. "We should probably get started."

"Yes; I have a lot to do this sol," agreed Will. He leaned back in his chair. "I thought the three of us should meet about environmental management and ecological research. We're trying to reorganize the Space Ecological Research Center in Seville so that it can focus on terrestrial agricultural research instead and become independent of the Commission. The negotiations are long and complicated because Dr. Gustavo Sanmartín, the director, has close ties with Spanish government officials and has been using them to obstruct the plans. He wants the facility to grow and do agricultural research for Earth and space. It looks like I'll have to spend two or three days in Spain just to straighten out the mess. It also means we've had to make our plans here more elaborate. We're now talking about establishing a Center for Space Ecological Research as a part of Martech.

We'll encourage the top twenty or thirty researchers in Seville to relocate here over the next six years *with their families* and utilize excellent facilities with garden space at Aurorae, Phobos, and Embarcadero, and advanced lab facilities. We'll recognize their years of service in Seville as if they had served here, so that advances them on the seniority and salary tracks. But this obviously affects Aurorae's environmental management system, which will be tied into the new research facility, and our existing research effort. If we do this, Lisa, I would make you Director, and would count on you to plan the Center and its facilities within a ten-year budget outline."

There was silence. "Wow," said Lisa. "How much are we talking about?"

"Twenty-five to thirty additional researchers with doctorates plus an additional support staff of about fifty. Based on bioarchive and our horticultural area, I suppose that means about 10,000 to 20,000 square meters of experimental farm plots and 2,000 square meters of office and lab space. That's a new budget of about twenty million redbacks per year."

She nodded. "That's about right, based on what we have now. With that kind of facility we could do a lot of research on low-pressure agriculture, establishing terrestrially-derived ecologies 'outside,' zero-gravity and microgravity ecologies, etc."

"We could do Galilean satellite analog research at the Phobosian poles," said Will. "Possibly Titan analog research at the Martian poles. We could make Mars a research center for settling the outer solar system."

"And you've invited me to the discussion because it would involve our existing environmental management staff," added Ruhullah.

Will nodded. “Exactly. We have eighteen horticultural specialists who are feeding the eight hundred fifty of us at Aurorae, plus three professional ecological researchers, plus six ecologists doing Bioarchive. They already possess immense capacity and would form the core of the new Center. The new people would triple their numbers and add primarily to our professional research capacity. A lot of our horticultural specialists have doctorates and could eventually be promoted to researcher status at the Center.”

“I’ve been wondering whether a new arrangement might not be smoother,” said Ruhullah. “The borough could contract out some of its environmental management services to the Center and to private corporations rather than doing everything itself. If we did that I would not have the hassle of managing our air, water, and food supplies on a daily basis, just the pipes that redistributed the air and water. But the Center would have to bid for the contract.”

“I’d prefer that arrangement,” said Lisa. “Because I wouldn’t have to worry when you are my boss and when Will is.”

“Lisa, in this new arrangement you’d be your own boss, because the Center would be an independent agency affiliated with Martech. Some of the researchers would teach classes occasionally; they’d all have faculty status. The Commission would make a long-term commitment to support the Center and purchase its research, but it would contract with other agencies as well, such as the agencies setting their sights on Jupiter and Saturn.”

“What long-term research would the Center do?” asked Ruhullah.

“Oh, that’s easy,” replied Lisa. “We have a dozen projects we want to pursue that we can’t because of resources. We can do a lot of research on genetically modified

species that would scare the pants off of ecologists on Earth; plants able to photosynthesize several times more efficiently, for example. Release them accidentally into Earth's ecology and they'd drive native species to extinction. But they're exactly what we need here; even more so in the outer solar system where sunlight's pretty thin."

"I see," said Ruhullah.

"And there's the t-word no one speaks around here, too," added Will. "Terraformation. If we have to use artificially manufactured greenhouse gasses to raise the surface temperature and pressure, it'll be a thousand years before our economic basis is big enough to make a noticeable impact. If we can genetically engineer microbes to do it, the entire picture changes."

"Surely we're a century away from doing anything noticeable, though," said Ruhullah.

Will nodded. "Probably. We may be a century from deciding whether it is ethical and prudent to terraform Mars. But the debate will partially hinge on information the Center will gather."

"But can we be sure the Commission can make a permanent commitment to such research?" asked Lisa.

"The Commission can't afford not to. Ecology makes our lives here possible. The ongoing commitment over twenty years has totaled several billion and has made our biomes, agridomes, and bioarchive facilities possible. If this place is to grow, the commitment can't decrease." He looked at Lisa. "So what do you say? Are you interested?"

"Interested? Of course!"

"I thought you would be. Ruhullah, can we count the borough in?"

"Yes, of course. I think a contractual arrangement for farming is better for everyone. It means the Center will have competition, though."

"We can handle that," said Lisa.

"Good," said Will. "Lisa, I need a proposal. Work with Enlai Tang and a group of your choosing about it. Enlai will bring the university's concerns into the process and can raise issues about how to foster exobiological research as well. Because we haven't found Martian life, exobiological research has suffered a contraction. This Center could help revive it, since many folks interested in new ecologies are interested in exobiology."

"Okay. Martian biology also gives us clues how to create an ecology that can function in the current environment. When do you want something?"

"A preliminary outline in a month; it can be slides. The detailed plan needs to be ready for debate next year."

"Okay, we'll do it," she said. She smiled; she was obviously excited.

"Excellent. Now I need to go to my next appointment, otherwise I'd hang around and chat further. Thanks, Ruhullah, for hosting this."

"Oh, any time. Ciao, Will."

"Ciao."

15

Graduation

June 2058

The courtyard of Catalina Biome was filled with a large crowd, even if Mariner High School's first graduation involved only two students. Will gripped Ethel's hand tightly, as if his pride in his son would burst forth otherwise.

"I have the unexpected burden of saying a few words to our graduates," said Father Greg, after Marshall and Sammie had processed in, wearing caps and gowns, and had seated themselves rather embarrassedly up front with Principal Fatima Hijazi. "This graduation was inevitable but somehow was unexpected: it is the first high school graduation of Mars-born children and marks the time when they join their parents as Marsian adults. For twelve years these two young men have been the focus of many of our hopes and dreams; first, that children could be born here and grow up to be healthy adults; second, that we could build a society where they were safe, protected, loved, and nurtured by everyone. I submit to all of you that these young men have demonstrated that our hopes and dreams were not empty. They are healthy, happy, remarkably capable, and good-hearted. They have been given a first-rate education in spite of isolation, lack of peers, and lack of some resources, like a big high school. The proof of their educational success can be measured in their high grades, the fact both of them have taken college-level distance-learning courses from prestigious universities as high school students, and the fact that one of them will be leaving us for one the Earth's best institutions of higher education.

"We can also be proud of the quality of their characters. Both are active in their religious communities. Both have done service here to the rest of us. Both are disciplined, inquisitive, and articulate. So far, folks, our graduates suggest that the Marsian social experiment has been a success.

"But life is not easy. They will inevitably face hard times and difficult choices in their lives. We will need to continue to guide and nurture them, just as they will nurture us and guide the next generation of Marsians. And we must work hard to help the children who are following them, for every year the number of children here increases. There were two of them, but in the last year, 90 members of the class of 2076 were born.

"So let us recommit ourselves this sol to a strong education and a vibrant Marsian society. Let us consider what we can do to strengthen our public schools. And let us assist these young men to become full members of Marsian society."

Father Greg stepped down to strong applause. The Aurora Chamber Orchestra played a tune, then Will rose to speak. Finally, Principal Hijazi spoke about Marshall and Samuel briefly, then had each one come forward to receive his diploma. Everyone applauded; Will cried.

Afterwards, both young men were surrounded by a circle of well-wishers. Will went over to Sam, who looked so much like his father. "Congratulations, Sam," he said, shaking his hand. "I'm very proud of you. How are you feeling?"

"Pretty overwhelmed! This isn't anything like I had imagined. I've seen photos of graduations on Earth, but when there are only two students it gets pretty intense!"

"That's true." Will chuckled. "And you're going to Martech in the fall?"

"I start in two weeks, though my summer load will be light."

“You’re not waiting. Good. I’ll see you around.”

“Yes. Ciao.”

“Ciao.” Will turned and walked over to his son, who was shaking hands with one or two last persons. Then he joined his father and mother.

“I guess we can go home now.”

“Okay. It seems funny to go home and watch t.v. after this,” said Will.

“We can go to the Gallerie for ice cream,” suggested Lizzie.

“Let’s do that,” agreed Ethel.

They all headed for the biome’s western exit. “Sammie’s taking a course at Martech this summer,” said Will.

“I’m tempted,” replied Marshall. “But if I work I can earn what will be a small fortune on Earth.”

“You know, it’d be good if you can devote some time to service,” exclaimed Will. “The Bahá'í temple property needs someone to take care of the gardens and advance the work on the basement of the temple. You know construction and can do the latter.”

Marshall looked at his father. “Dad, this is my last summer here for some time!”

“All the more reason to get in some service,” replied Ethel.

“Look, we can’t hire many people to work on the temple site; no one’s available,” replied Will. “This place has full employment. You have the skills and you really should get in some service to the Faith while you’re here.”

“I can always serve the Faith by working for a summer in some jungle on Earth.”

“Yes, you could, but please consider doing some service here this summer. It’s your decision, not ours.”

“Okay,” said Marshall, nodding.

“Look, Marshall, I plan to spend fifteen hours a week on the gardens this summer,” said Lizzie. “Kim’s bringing Mahidol. We plan to do quite a lot. If you finish off the basement, we’d be able to use the place.”

“Okay, I’ve got the idea,” he replied.

They entered Andalus Dome and crossed the square, which was fairly full of people that Satursol afternoon. The square was quite beautiful now that the façades of the buildings were finished and the landscaping was mature. One could see scaffolding behind the line of buildings that marked new construction; Andalus was getting flats to accommodate 150 more people for the next wave of arrivals.

They entered the Gallerie and bought ice cream at the new ice cream store. Marshall received yet more congratulations from people who had not attended the graduation. When Will and Ethel left, he remained to socialize with friends, some of whom had been on the Phobos flight.

“Well, we’ve raised one of the two all the way to adulthood, dear,” said Will. “It’s hard to believe we’ve been here that long.”

“It’s hard to believe we’re that old!” she added. “Lizzie has three more years of high school, then we’ll have an empty nest. That’s going to be hard.”

“Maybe she’ll stay and attend Martech.”

“I hope so. When we had these kids, I never thought one of my chief concerns would be that they might move to another planet and be millions of kilometers away.”

“I know.” Will said nothing else; he had been thinking a lot about the sol when Marshall would be staying on Earth and he would be returning to Mars.

They walked home in silence. Ethel busied herself with cleaning while Will checked his tablet. It was Tuesday on Earth; he had a lot of messages. One was from Hans Muller, owner of the largest commercial operation on Mars. He always enjoyed talking to Muller, whose Ph.D. in Classics brought elegance to his speech.

"Good sol, Will," Muller began. "I trust you and your family are well. I read that Mariner High is holding its first graduation this sol and on the list of graduates was one Marshall Stephen Elliott. Congratulations to you and to him for twelve years of hard work, and an exciting plan to attend MIT.

"I always find it very difficult to call you because I hate to communicate via messages. I much prefer the opportunity to build rapport through small talk; in that sense, even talking about the weather has its symbolic value. Perhaps I should switch to the old-fashioned letter in its electronic manifestation; it fits my style better. But who has time to write a letter nowadays?

"I called because I wanted to discuss Cassini Outpost. As you know, I've long been concerned that the Commission does not give Cassini or other outposts—beyond Aurorae—the priority they are due. Cassini now has over 100 people, including nearly a dozen children. When Aurorae was that size it already had Martech, Mariner Hospital, a spaceport, and all sorts of other facilities Cassini still lacks. I understand that Mars needed its first university and hospital and at the time Aurorae was the only place to put them, and that Cassini is a few hours' flight from these facilities. But Cassini has a bright future; its gold reserves alone equal those of all the other outposts combined, and that doesn't consider its silver, copper, the uranium a few hundred kilometers away, and the platinum-group metals it will soon start extracting from ubiquitous meteoritic material.

"Essentially, I'd like to see Cassini graduate to the next larger size of outpost, and more of Cassini's gold wealth go to its own growth. Consequently I would like to make a proposal. First: Muller Mining will give forty million redbacks to the establishment of an ecological and agricultural research facility at Cassini if the Commission matches it. I understand you are establishing such a Center, partially by encouraging scientists in Seville to emigrate. Why not move the Center to Cassini? Cassini needs green space and a vigorous agriculture, and such research will lend it both.

"But that's not all. I am willing to donate twenty-five million redbacks over three years, if the Commission will match it, to establish a Muller campus of Martech at Cassini. The campus should be devoted, in addition to ecological research, to research on Martian ore formation and utilization, and the requisite engineering to make recovery profitable. All the mining companies working on Mars have a good reason to support such a research facility. I think we can raise quite a bit of money from them.

"It's a lot of money, but the company's making good profits and I feel a responsibility to return some of it to Mars. I'm now 62; I have to think about where I want my fortune to go and how I want to be remembered. So we need to talk further. I hope we can spend at least half a day together when you're on Earth to talk about the future of Mars, because I have lots of ideas.

"So come to Munich! Bring your son along. I hope we can talk about these and many other ideas. I look forward to hearing from you. Bye."

Will thought about Muller's offers a minute. They complicated plans for an ecological facility. Then he hit reply. "Hans, it's great to hear from you again. I'll talk to Louisa right away about adding Munich to my itinerary. I think we have one day in

Europe held in reserve, so it may be possible. I don't know how much of that time I can give you; the demands on my time are incredible. I'll have to travel back to Earth every other columbiad; or maybe I should say that whoever is Commissioner will have to travel either to Earth or to Mars every other columbiad.

"I probably will bring Marshall along, so you'll be able to congratulate him personally. We're immensely proud of him. We're just crossing our fingers that he comes back to Mars.

"Regarding your generous offer to establish the Muller Campus of Martech at Cassini, I am sure the Commission's Board will be thrilled and can allocate matching funds. We wanted to upgrade the educational facilities there this columbiad, but the budget was too tight. A focus on Martian ore formation and recovery is logical. We need to think of something to put at Dawes that will expand that facility as well. We are building up their spaceport and upgrading the Meridiani and Cassini-Dawes Trails to improve transportation in the central highlands, but Dawes needs an anchor other than mining.

"Concerning the ecological and agricultural research facility at Cassini, our plans to expand the facilities at Aurorae are in a fairly advanced stage. We already know who is coming to Mars next year and who will come two years later, and they are already preparing to live in Aurorae. Cassini is more sophisticated than Aurorae was just a decade ago, but expectations have risen. We will need to conceive of a facility that has a mission that fits Cassini; otherwise it might not achieve its potential and the staff might 'leak' back here. So I am in favor of your offer, but I am not sure how to implement it.

"We're always very grateful for your support for Mars. Without your commitment our gold exports would be half what they are; you've invested in the technology that has made it possible to maintain our level of gold production in spite of declining gold concentrations. Naming a campus after you is the minimum we can do, Hans. So I'm looking forward to continued discussions. Bye."

On Monsol Will met with Lisa Kok to appraise her of Muller's offer and gage her reaction. They considered various possibilities and decided that ultra-low pressure agriculture was a logical candidate for Cassini, primarily because no one from Earth had been doing the research. A team of young biologists, enjoying the freedom and independence that Cassini offered, could accomplish the breakthroughs needed to make low-pressure agriculture feasible.

Lisa returned to her office to outline a plan and Will made his weekly inspection tour of the outpost. He wandered through all of the new domes. Aurorae was almost doubling its size and gaining 5 hectares, or 50,000 square meters, of pressurized space this columbiad; Cathay, Punjab, and Zanzibar, which were 70 meters wide, had three sections each with a total length of 340 meters. The nine sections required a construction crew of sixty and the plastics and metals needed were fabricated by sixty others. Will visited Vandevelde to see how fabrication was going, and got a report about the caravels.

Before heading to his office he stopped at the site of his new house to see how Simeon Afigbo and his team were doing. The two enclosures had been placed two months ago, pressurized, connected to each other and to the access tunnels, and backfill was placed against their sides and cemented in place. They were now two tubes twenty

meters long, ten wide, and six high, with a strip seven meters wide along the crest of each open to the sky and sunlight. Simeon's team of five had already made extensive progress on the first enclosure, which was divided into thirds: the front third was a formal living room; the middle third was a garden, onto which the living room opened fully; and the rear third was a kitchen and private dining area. The second enclosure would have bedrooms for everyone, offices for Will and Ethel, and a family room. Will was pleased to see how much was done; they'd be able to move in before Will and Marshall left for Earth. Will made a few decisions about the placement of lights and the color of a hallway wall, then headed back to his office.

He had just sat at his desk when he received a video call. He opened the line.

"Hello?" Then he saw Brian Stark's face appear on the screen. "Hey, Brian, how are you this morning?"

"Pretty good, Will; and you?"

"Not bad, not bad. Haven't talked to you in a long time."

"Well, there hasn't been anything to talk about. My work has been routine and I suppose yours has been as well."

"If it's ever routine! But yes, I know what you mean."

"Say, I thought we should talk a bit, but I don't want people to see me come to your office . . . is there any possibility you can swing by my flat in Cochabamba? I'd like to update you about some things. Preferably this morning."

"This morning? I've already got an awful lot to read and respond to."

"Well, take a break and come have coffee with me, preferably in the next hour or so, because I have to get out to New Hanford this afternoon. It's kind of important."

"Okay." Will looked around his office. "I can come now, I suppose."

"Great, I'll put on the water."

"Fine, see you in a few. Ciao."

"Ciao." Will closed the circuit, wondering what Stark had in mind. He was one of their more laconic residents, but it was his job to be that way; he was running the United States Navy's New Hanford Nuclear Research Facility, a top-secret facility twenty kilometers east of Aurorae. It enriched uranium for use in space nuclear reactors, thereby protecting the Earth's politicians from the embarrassment of have a spacecraft carrying nuclear material blow up in the Earth's atmosphere during launch. The uranium would do negligible harm to the Earth's environment, but radioactivity was such an emotional subject that such an accident would create enormous controversy. A similar accident on Mars would have far less impact because the Marsians were a technically educated population living on a largely barren world. Consequently, all uranium for use in space reactors and atomic engines now came from Mars, and the export had a bright future. The actual size of New Hanford's output was classified and Stark was unable to discuss it with Elliott, but Dr. Adel Mehmetoglu, the official inspector for the International Atomic Energy Agency, audited the facility twice a year and provided a copy of his inspection report to the Mars Commission.

Will contemplated these facts as he walked to Cochabamba. He searched for Stark's cylindrical building, then headed up to the entire top floor that was Brian Stark's flat. It was musty smelling and unkempt.

"Excuse the mess," Brian said as he escorted Will to the couch and cleared a space for him. "And please don't suggest I need to get married in order to clean this place up. Women find the comment sexist."

"I'm sure they would be as turned off by the comment as by the place."

Brian laughed. "I'm sure they would be. My ex-wife would be horrified by the mess, but I'm free of anyone's naggings, at least. I have special imported coffees; want to try a raspberry mocha?"

"Sure." Will sat and looked around the living room while Brian ground up some beans and put them into the coffee maker, which was another exotic device Will didn't see very often. He watched the coffee drip into the pot. Brian offered no small talk until he poured two cups and brought them over. He handed Will his cup and sat in a dining room chair facing him. Will sipped. "Interesting flavor. You'll have to invite me over more often."

"Maybe I will. Have you ever heard of Dr. June Addison or Dr. Reginald Pearson?"

Will frowned. "No."

"You are excused. Rosa Stroger probably knows about the work of both of them, though. They're both coming to Mars; June confirmed over the weekend, Reggie early last week. June got her Ph.D. in nuclear engineering when she was just 23; she's a wiz, especially with the mathematical side of things. She's been at Los Alamos for the last seven years working on all sorts of secret projects, including gaseous core nuclear fission engines. Reggie's Canadian by background but is now a dual U.S. citizen and has a Ph.D. in nuclear physics. His very impressive resume includes faculty positions at Stanford and

MIT and a stint at the Lawrence Livermore Lab. He's an incredibly capable engineer; he can take any idea and make something that will do it."

Will raised his eyebrows. "Sounds like you're upgrading your operation."

"We've got sixteen new folks coming next year, ten with doctorates and six working on doctorates. It's an entire department of Nuclear Physics and Engineering for Martech, if it'll have them. They're coming to set up and calibrate some new automated uranium enrichment equipment; we're getting a major upgrade and the only way to test it is with a highly capable engineering team. Most of them have pledged to stay one columbiad only. But June and Reggie recruited the others because all of them are disillusioned by U.S. nuclear research and feel stymied by various understandable safety regulations and less understandable political problems. This is an incredibly capable team, Will. New Hanford doesn't have the financial resources to tap all their talents, though I have some flexibility. The ones with doctorates have permission to take on faculty positions while working for us, which means they can be faculty at Martech. The doctoral candidates are all students of the ones with doctorates, so they can be Martech graduate students."

Will frowned. "What do you have in mind?"

"There are two projects they could tackle. First, this team is capable of designing and building a research reactor out of Martian materials, with minimal imports. We still can't refine zirconium, cadmium, and hafnium here, but we could import those metals if necessary and make the alloys and reactor parts."

"Cassini's carbon dioxide centrifuge can separate some zircon as a byproduct of gold production, so zirconium and hafnium can be obtained here," corrected Will. "We just haven't done it yet."

"Even better. Of course, sixteen people can't make a power reactor themselves; they'd need a team backing them. I asked Reggie whether he could design and build a 200,000 thermal kilowatt reactor here on Mars and he said he probably could with about 100 people working under him for two or three years."

"That's interesting," said Will, trying to be noncommittal.

Brian scowled. "Come on, Will! We're talking about 50 million redbacks. Subsequent reactors would be half as much. Aurorae, Cassini, Dawes. . . they could all use 50,000 electrical kilowatts. That's the capacity to extract sixteen tonnes of platinum group metals per year, worth 150 million redbacks. Think of how much water you could pull out of the ground with 150,000 thermal kilowatts of 'waste' heat!"

"But Brian, we don't need that much water. We're already intentionally wasting water in the outpost's system in order to use all the water we're already pulling out of the ground for deuterium production. And 50 million redbacks buy a lot of solar power production, even when you include backup storage for dust storms. We can now make a solar power unit that turns out 150 electrical kilowatts and 150 thermal kilowatts for a quarter million redbacks, and the cost is dropping. That's less waste heat than your reactor, but more electricity for the same price, and more reliability; the solar power units are down less than a reactor would be."

"Not when you include dust storms. That's a third of every annum."

“Perhaps, but we also have a lot more flexibility because we don’t have to produce a vast amount of extra power capacity or make our entire power supply dependent on one piece of equipment.”

“Will, then we’ll ask Reggie to make 10,000 or 20,000 kilowatt reactors instead. One at each outpost would give you a base level of power output that you could always count on. And the polar stations could use them.”

“When personnel stay there all winter, they bring two portable 150 kilowatt reactor or one with methane and oxygen tanks as a backup. What would they do with 10,000 kilowatts?”

“Then we can look into making smaller reactors, like the six we have here now.”

“Look, Brian, I’m not trying to be difficult and I’m not against nuclear power. Thank God we have the six reactors we have. But they cost us an arm and a leg. If this place had gone all-nuclear we would have spent a billion on reactors that was unnecessary. Wind and solar cost us significantly less.”

“And how would this place do during a really big dust storm?”

“We’d have significant energy rationing; we’d have 20% of peak power use. But we’d still come out ahead economically.”

“Then let’s look at a plan that would address that problem at a reasonable cost. I asked Reggie about a research reactor; they have to be large enough to produce plutonium and other useful isotopes. But we can make smaller ones instead. New Hanford’s going to need a big reactor eventually, and then we’ll be in the position to sell you power and water.”

"And how would you get the water to us in huge qualities; an insulated pipeline, or huge trucks?"

"How about two pipes, one for methane and one for oxygen? We'll use the waste heat to vaporize underground water, we'll electrolyze it to extract the deuterium, methanate it, and send the methane and oxygen to Aurorae by pipeline."

"You've got big dreams." Will shrugged. "But I won't close any door. Let me know what you can propose. I'd aim for reactors in the 10,000 kilowatt range and a cost per kilowatt that's not too much above what we pay now."

"I think you're short-sighted, Will."

"You said two projects; what's the other?"

Brian smiled. "A gaseous core nuclear engine."

Will laughed. "What? No one on Earth can afford to build them and you want us to make one via skunk works? Brian, you're losing it."

"Not at all. There's been a string of studies over decades. Some have even used supercomputers to simulate engine operations; they've gotten quite sophisticated. The Chinese have done a lot of laboratory work, prompting the U.S. to do some as well. But the engines can only be tested in space. Earth orbit is out; environmentalists will freak out because they exhaust highly radioactive uranium or plutonium, and the security types are wary that the tests will occur in the full view of spy satellites. The moon is the alternative everyone proposes, but getting the equipment and engineers to the moon is expensive and there are satellites around that could watch. Last year the Chinese sought to purchase twenty thousand square kilometers of the lunar back side just beyond the south polar zone

for a ‘research reservation’; it was for testing gaseous core engines, among other things. But the Europeans and Americans vetoed the plan.”

“Very interesting,” said Will, not admitting he had heard about the Chinese plans. “But where can we get the money to do it? We’re talking about billions, all to develop an engine of uncertain value.”

“That’s the history of space propulsion systems, isn’t it? All sorts of things have been proposed and many have been tried. So far, chemical, ion, and solar thermal propulsion have dominated. Solid core nuclear works well, but the Mars Commission decided it was too expensive for its transportation, so it hasn’t used it much.”

“And that’ll certainly be true of gaseous core,” added Will. “We’re looking at transportation costs of three million redbacks per person next year, five million for those coming on the faster trajectory. The cost of hydrogen and oxygen from the moon and Phobos keeps declining. A billion-redback gaseous core engine can’t pay for itself at those prices, unless we’re hauling thousands here every columbiad, and that doesn’t appear possible in the next decade or two. We don’t even know whether the use of gaseous core engines will be permitted in Earth orbit.”

“That’s true; but that means all ships departing for the outer planets will have to leave from Mars,” replied Brian. “Will, listen to the proposal before you dismiss it. June says she can manufacture a thirty-tonne gaseous core test engine in two years with a team of one hundred engineers. There’s no rocket on Earth that can lift thirty tonnes into orbit right now, which means the parts would have to be assembled on the moon. But Mars shuttles, refueled in low Mars orbit, could lift an assembled thirty-tonne engine to Deimos, where it could be landed on the back side of the moon near the north pole. That

means no one on Mars can photograph the operation, nor can any satellites currently in Mars orbit. We'll have to import some parts and alloys from Earth, but June thinks we can make the rest here. Deimos already has a hydrogen supply; we'd need to add a few tanks. It's a perfect test site, and reasonably inexpensive as well. Mars can test gaseous core engines better than anyone else."

"But who will pay? The governments represented in the Mars Commission all will know about the budget allocation."

"The United States will pay separately. The nuclear-powered variable specific impulse magnetoplasma rocket is developed and being tested. It'll carry a crew to Jupiter just fine, but it's complicated, it needs a lot of testing, and it takes a long time to accelerate. The Chinese plan to use solid-core nuclear to get their folks to the Galileans and they're scheduled to launch in 2063; two years before the U.S. The U.S. will probably speed up their timetable to launch in 2063 as well. VASIMR is superior for voyages to Saturn and beyond, but for Jupiter, solid core nuclear works just fine. Better than both would be gaseous core nuclear."

"It would be; it's got up to ten times the exhaust velocity of chemical engines. But thirty tonnes; that's a big engine."

"Yes, you can't make them small, even with plutonium. Not yet, anyway."

"There's no way we can afford both projects."

"I know; not until this place grows further. But with its population doubling every four years, it won't be long before you'll need both projects to employ everyone."

"Are you sure you can convince the U.S. to pay?"

"No, but I'm heading back to Earth to lobby for it on the same ship as you. We may be able to work together." Brian sighed. "Politics has made nuclear power very complicated. Several times the Congress has spent billions on radiation-proof testing facilities, then dropped the projects before they reached fruition. Bright people are attracted to the field, then leave. We can offer a permanent solution to the problems if people will trust us with the research."

"And our capacities here are expanding incredibly fast," agreed Will. "In a decade we might have 3,000 or 4,000 personnel. They'll have excellent training and they'll be their own electorate; they'll be able to vote how to spend their own tax revenues. We'll have graduated to a very different sort of place."

"We'll be doing our own nuclear research by then, whether Earth likes it or not," agreed Brian.

Kristoff floated quickly through the four agricultural cylinders to the proximal end. The fourth one was largely bare ground with yellowed shoots sticking out of the processed regolith; the third was a lush, green hydroponic unit growing trays of wheat and rice; the last two were reasonably mature regolith units growing soybeans and cotton respectively. Both the regolith and hydroponic systems had proved effective, though the former required four months of soil preparation. Phobosian agriculture was a success.

Kristoff finally reached the end of the last cylinder and headed for his office to write reports for a few hours. He preferred to do his agricultural work when the cylinders were filled with natural sunlight; artificial light was not as good for most observations.

In a few minutes he was back inside the rotating caravel, where his office was located on the fourth floor. He decided to start by calling Irma Baeker, though. He owed her a call; he had meant to call her the night before and hadn't. She would be working tonight as well, so morning was the best time to call.

Her phone range three times, then the screen filled with an image of her. "Hello, Kristoff, how are you this sol?" she said, cheery as always.

"Oh, pretty good. You're on duty this afternoon and evening, right? I figured this was a good time to call. I've been working since 7 a.m. and will work in the cylinders again late this afternoon."

"Oh? Why; sunset?"

"Yes. It caught me by surprise, too; it was like someone turned out the lights. The backup lights came on, though."

"I'm amazed the plants don't mind."

"No, 3.8 hours of light followed by 3.8 hours of darkness doesn't seem to bother them at all. It bothers me a bit, since every sol we have light and darkness at a different time. But the vast majority of workers here never go outside and never see the sun for more than ten minutes anyway, so they don't care."

"Yeah, it makes sense to keep Aurorae time. So, is it the same old-same old up there?"

"Pretty much. No news, really. The greenhouses are going great and we're dealing with various problems from the microgravity, like water percolation. It looks like we'll have some crops to export in a few months. Not a lot, but some."

“That’s good news. Down here it’s the same old as well. No news, really. Oh, the hospital is concerned I plan to leave before the columbiad ends so they offered an incentive to stay in the form of more flexible hours. That was nice.”

“I bet.” He sighed. “No, nothing really new, but I enjoy calling and hearing your voice. Sometimes it’s nice to share boredoms.”

She laughed. “Don’t put it that way! Life is routine, not boring!”

“Alright; share the routine, then.” He looked at her face on the screen and realized that over the last three and a half months of exchanging trivial videocalls every two or three sols, something that was not trivial had developed. “You know, you’re a really special person,” he said, surprised about what he was saying. “Very caring and compassionate; I really appreciate our friendship.”

“Thank you. I’ve enjoyed these calls as well. You’re much deeper than I thought.”

He laughed. “Deeper? Do I come across as shallow?”

“Well, Kristoff, you have a reputation as a playboy, don’t you think? A smart one, but still.”

“Playboy? Hum, I suppose I do have that reputation. Maybe it’s just as well we’re communicating by videocall, then!”

She laughed. “Perhaps. So, it’s dark outside right now; how will you spend your time?”

“There’s plenty to do in the office; our work involves endless report writing. Fortunately, I can dictate notes as I observe and those are automatically transcribed. And every sol I get a detailed and lengthy email from a monitoring team on Earth who tell me

which plants look sick in infrared and which have a spectral signature showing poor chlorophyll in their leaves. I'm always busy."

"And that's what you like most." She giggled.

"Well, I do like my work! And you seem to like nursing better than you admit."

"Hum. I think you're right about that. I talk about switching fields, but working with the people gives me immense pleasure."

"You'll enjoy the chemists as well."

She laughed. "You're right; I do. They have a good sense of humor. Say, I'd better get going, I promised Marsha I'd eat lunch with her at 11:45."

"Early. Okay. The ball's in your court now, right?"

"Yes, it is. I'll call you tomorrow or the sol after."

"Great. Until then, keep laughing. Ciao."

"Ciao."

16

Ceres

Late June-early July 2058

Father Greg looked glum. That was the inevitable conclusion of his friend, John Hunter, when John arrived for his lunch in the Gallerie with his two sons, 7 year old Maaka and 4 ½ year old Wicahpi-luta.

"Greg, you look tired," he said, preferring to be delicate.

"Thank you, but I'm not," replied Greg, taking another sip of his coffee.

"Worried or depressed would be more exact," replied Anna, who was eating and keeping an eye on their two kids, 7 year old John and 5 year old Esther.

"Oh." Hunter didn't want to pry; he said nothing more.

"The church is sending another priest," added Anna a minute later.

"Really? Does that mean you won't be a priest any more?"

"I don't know," replied Greg. "But everyone has to admit that a married priest with two children isn't exactly what the Vatican favors, and Father Hinga's supposed to be pretty conservative."

"That will be interesting for the parish," said John, who was not Catholic but knew the parish was pretty heavily dominated by liberals. "I suppose they can be pleased to have such a high ratio of priests to laity."

Anna laughed. "Do you realize, John, that in some dioceses in the United States there are three churches per priest? And this is after closing a lot of churches because of low attendance at mass."

“Well, if no one goes to mass, the church won’t need many priests anyway,” said John. “Is Cassini a parish now?”

“It should be; we’ll make it one in the next year I’m sure,” replied Greg.

“Maybe we should move there,” commented Anna, joking.

“Father Hinga might visit it to give communion once a month. It’s not an entire planet away.”

“True. Greg, I don’t think you should worry about it,” said Anna. “We love the church and the church gave you a marvelous opportunity to serve because of very unusual circumstances. Those circumstances are coming to an end because Mars is finally growing enough to become ‘normal.’ We should be thankful for that.”

“Oh, I agree,” said Greg. “I have plenty to do up here, with or without my collar. But there will be grief in the transition; I will grieve, and the flock will grieve.”

“I can’t help the flock, but I’ll help my friend any way I can,” said John, reaching out and touching Greg’s hand.

“Thank you. You are a good friend.”

“It’s been a long time too,” added John. “You and I have been up here fourteen years. And in that time you’ve done just about everything here. You got special training as a hairdresser and aesthetician before coming here and ran the laundry as well!”

Greg laughed. “How true. I said then that I was a servant to everyone, and a servant I will remain.”

Helmut was surprised that Ceres was a slightly reddish world. The ship’s long-range cameras were focused on Piazzi Station, located near the center of the crater Occator, the

site of their landing in fifteen minutes. The rolling, crevice-crossed floor was bounded by a 4,000 meter rim all the way around and a cryovolcano--Cerealia Tholus--in the middle, to the west of their landing site. Large areas of the floor of Occator were covered by bright salt deposits, products of a steady flow of subsurface water after the impact had factured the crust. It was Ceres's most fascinating area, and one that held clues of the dwarf planet's interior.

Helmut pointed to the screen. "Charlie, do you see the slight reddish color?"

The little boy, now almost four, leaned forward to study the screen. He nodded. "It looks a little like Mars!"

"Exactly. I suppose the color is from iron oxide, just like on Mars, too."

"Like home."

"Yes, like home." Helmut glanced at the countdown. "Hold on, Charlie, we're now ten seconds before main engine firing." He began to count down and Charlie followed along, though he really couldn't do numbers in backwards order and often counted wrong.

There was a low rumble and suddenly gravity came on, pressing them not toward the floor, but toward the wall. Charlie was used to the routine by now and said nothing. The force was the same as their normal gravity—Martian gravity—and thus did not feel oppressive. They sat and watched Ceres grow larger and larger on the screen and listened to the banter in the bridge, where Clara's voice mixed with the others. Helmut thought about the rolling, slightly reddish plain, which had formed when a "lava" of muddy water had oozed from the ground, frozen over against the vacuum of space on top, and spread out over the surface, creating a muddy, salty lake that gradually froze and evaporated

away over millions of years, leaving behind smoothed, oxidized, salty sediments. It was a geological process they had never seen before on an inner planet, but one that humanity would encounter on the moons of the outer planets. It intrigued him.

Helmut turned to watch Charlie who was excitedly alert to the experience around him. It was the boy's seventh major engine firing in his short life; he had gotten used to the rumble of the engines, the vibration of the ship, and the press of acceleration. Indeed, the boy seemed now to treat it like a part of life, which made Helmut reflect on what "normal" was.

The screen showed them dropping lower and lower until small craters and individual rocks could be seen. The plain was pitted, the pits being up to several tens of meters across and ten meters deep; they probably formed from the gradual evaporation of ground ice into space over millions of years. Helmut watched, wondered, and tried to imagine what the next six months would bring. Ceres had over three million square kilometers of land; it was almost half the size of the United States. Remarkably, as warm as its interior had gotten, the center had never melted; its volcanoes erupted water and gas, but not lava. Between eruptions of water and gas and cratering, the surface was diverse and rich in minerals.

The screen now showed fine details; small rocks, gravel, and small craters. The shadow of the caravel's landing legs appeared, stretched across the screen, then touched down with remarkable smoothness. The engines throttled back; they had landed.

"Welcome to Ceres, folks," said Charles. Helmut smiled and began to applaud.

"We made it, safe and sound!"

"We did. When do I get to go outside, dad? Can't you take me out today?"

“No, Charlie. Don’t worry, it’ll be a few weeks and we can take you on a flight somewhere.” Suddenly, gravity began to return; the caravel’s internal shell was beginning to spin. Helmut unbuckled his safety belts. “I’ve got to get up to the hub and suit up.”

“Oh, dad. . . .”

“You’re fine; Caitlin’s on her way over.” Caitlin Vickers, now thirteen, was able to take care of Charlie quite well. Helmut rose and walked to the door carefully because the gravity was still slowly waxing; it would be ten minutes before it reached normal. Meanwhile, the floor felt sharply tilted underfoot; Ceres made him weigh about two kilos in one direction, while centrifugal force make him weigh two and a half kilos in another direction perpendicular to the first. He held onto the handholds on the wall between the seats and the door to steady himself.

He opened the door. Caitlin was already heading down the corridor from the next room, where she and her parents lived, her velcro-covered shoes making a scrunch-scrunch as they pulled free from the carpeted floor. “I’m here for Charlie.”

“Thanks. See you all at supper.”

Helmut hurried along the corridor, using his hands on the “down” wall as much as his feet. He stepped into the elevator and went up to the hub, then walked more normally under Ceres gravity alone—the hub had little or no centrifugal gravity—to the space suit donning area.

Half the crew was suiting up. Charles Vickers had already gone outside and was preparing to plant the flags. There was a scheduled order when everyone was to go out; Helmut was sixth, or the second airlock group, so he had to hurry a little. A half hour

later he walked down the ramp from the roof of the caravel to the ground and felt the regolith crunch under his feet.

"Ceres," he said. It was a funny first statement to utter on the new world, but he said it with emotion, even a bit of passion. He had become quite intrigued by the place in recent months as they had gotten closer and the telerobotic Prospector 275s had become quick and easy to operate. He was assigned to the geology team this time, not to the drillers or the cargo unloading team, so he had the time to look the place over.

He took a few short hops to adjust to the gravity. They had practiced on the caravel's upper deck where gravity was only slightly more, so he was familiar with the necessary coordination to get around. One thirtieth the gravity of Earth took some practice, but it also had advantages; one could leap as much as twenty meters at a time. If one learned how to keep balance one could travel quite quickly and easily on Ceres, certainly faster than on Phobos.

While waiting for the remaining two airlock loads of personnel to disembark, he took a few tentative leaps, traveling only ten meters at a time, and each time nearly toppling over because his backpack and head wanted to continue forward after his feet had stopped. He had to convert a fall into an awkward run. He wasn't the only one; others were practicing in similar ways.

After several leaps, he aimed for a boulder and managed to leap almost perfectly to it; maybe it was luck, or maybe it was precocious skill. He whacked the boulder with his rock hammer—carefully, so that the force didn't knock him off his feet—and began to dictate a description of what could be described as a sedimentary rock, a mix of minerals,

salts, and water-weathered regolith. It was another datapoint supporting the theory that cryovolcanics had emplaced the plain.

"Okay folks, gather round!" exclaimed Charles on the common frequency. Helmut looked up and saw that everyone had come out. It was time for the flag placing ceremony. He carefully leapt over, traveling no more than about three meters at a time.

Charles placed the Marsian flag first, a rather surprising and controversial act. But the other flags followed quickly and soon there were a dozen of them set up, with everyone saluting them to the sound of an anthem-sounding piece that was not the national tune of any particular country. Two billion people were watching.

Then in fifteen minutes the ceremony was over and everyone turned to their tasks. The three crewmembers assigned to unloading the three automated cargo landers—the vehicles could be seen on the low hilly edge of the plain about two kilometers away—headed back to the caravel to unload one of their hopper-vans and drive it over to the nearest lander. Helmut and Adam Haddad leaped to the nearest thermokarst terrain to explore the roundish depressions. They landed inside one.

"Look at the overhang over there," said Helmut, pointing to a cliff-like edge about fifteen meters away. Most of the edge of the depression had an overhanging lip. Adam nodded and they leaped over to look at the hard, consolidated layer that supported the overhang, which stuck out a meter or two in places. He got there first and immediately headed underneath the rocky ledge to whack away at the softer material underneath.

"Watch out, you'll bring it down on yourself!" exclaimed Helmut.

"Then reach up and hold it; if it collapses, the couple tonnes of rock will weigh about 100 kilos, and it'll fall at 30 centimeters per second per second anyway."

“Okay.” Helmut did not like the arrangement, but he bent over slightly and put his hands on the bottom of the ledge. The material was crumbly, but strong enough to hold together under his hand.

Adam began to swing his rock hammer, chopping a hole into the soft material. Every blow tended to produce an equal and opposite reaction in his body and slide him around until he anchored himself against Helmut’s legs, which were firmly planted once Helmut began to push upward on the overhang. Low gravity made excavation difficult.

Adam dug for a minute or two, blasting loose chunks of whitish-grayish-pinkish sediment and regolith onto the floor of the depression, slowly cutting a hole almost a meter wide and high and a meter deep into the soft material. Finally the material began to turn harder and white debris began to fly.

“Ice!” he exclaimed.

“Yup, we found it,” said Helmut, smiling. “Interesting system for finding it.”

“Hey, it works. If we had tried to do this with a Prospector, even from orbit with no time delay, it would have taken weeks.”

“That’s for sure. Wow, you just broke off a good piece! Let’s stop and take a look.”

“Acknowledged.” Adam stopped swinging the rock hammer and crawled out from under the ledge, which Helmut let go of. The ledge remained in place; in Ceres’s minigravity, it would not break loose easily.

They wandered the floor of the depression, picking up the pieces Adam had scattered. The last piece was mostly ice; looking back at the exposed surface they could see an ice lens in the sediments. Adam took a series of pictures while Helmut set up a

tripod with a sensor unit on top. It would shoot the cliff with a low-powered tunable laser in infrared, visible light, and ultraviolet light, and record the spectral response.

Then they both began to pick up chunks, pull out numbered sample bags into which each would go, and begin to describe each piece in exact detail. Mars was twelve light minutes away, Earth sixteen; geological teams on each world were watching and listening, prepared to offer their advice.

As each piece was finished they would quiz each other about details, then put the sample in the bag and place it on the ground in a line. After twenty-five minutes and six samples, comments and questions began to come back from Mars, followed by Earth. They went back to the first sample and dialogued about it with each other and the remote teams. That process took another half an hour, at which point the laser scan of the cliff was complete and the analysis popped up on their screens. They discussed the high chlorine, sodium, magnesium, carbomtae, and ammonium content—clear evidence of water-borne salts—the frequency of rounded grains versus sharp and uneroded particles, the crude layering that was clearly visible in several places on the cliff, the slumping where a fossil ice lens had apparently evaporated, and other telltale clues about the origin of the depression from the sublimation of ground ice. In two hours they had done as much work as a Prospector would have done in a month.

Helmut glanced up at the sky. The sun was forty-five degrees above the western horizon. “We’ve got about an hour of sunlight left.”

“An hour and three minutes,” replied Adam, glancing at the small computer screen on the outside of his suit where a wristwatch would be. “Time for another depression?”

"I think so." Helmut looked around, then carefully leaped up eight meters onto the rim of the depression. Adam was right behind. Another depression caught their eye thirty meters away, so they leaped over and dropped down into it.

It was similar to the other one, except it was smaller—only twenty meters by twelve—it was oblong rather than round, and it had distinctive overhanging ledges everywhere. In some cases the overhangs were three or four meters deep and constituted small caves.

"Boy, the crust was strong here," noted Helmut. "I wonder whether we'll find tunnel-like caves, similar to lava tubes."

"You never know," replied Adam. "This landform is quite different from anything that can form on Earth or Mars."

"Definitely." Helmut looked around, then walked along the edge of the depression to study the overhangs. In some places one could see that a large ice lens had sublimated away and left a pocket; in a few places one could see that two or three ice lenses in a row had sublimated and produced a winding, tubelike cave. "We had better be careful driving and walking around on this plain. There might be hollows right below the surface that we could collapse into."

"You're right, as hypothesized."

"I think I heard Charles say something about that a little while ago," noted Helmut, who had been listening to Charles and Jack Alberghini over the radio discussing geology in another area of the plain. Helmut turned away from the edge of the depression to scan the floor and immediately a brownish rock at the bottom of a small crater caught his attention. Puzzled, he walked over. The small crater was just a meter across; its floor

was covered by brownish fragments, as if they were the remnants of the meteorite that had smashed into the ground at that point. He picked up a chunk and looked.

And looked again, surprised. He pulled out his rock hammer and broke a fresh surface, then placed the hand lens camera against it and looked at the image projected onto his faceplate. “Say, Adam, look at this.”

Adam skipped over and took the rock. He did the same. “I can’t believe it. This isn’t from here.”

“No. It’s not even from the asteroid belt, I think.”

“Hum. You’re right; it’s basaltic, but looks too weathered.”

“Exactly. If I’m not mistaken, this is a piece of Mars!”

“Yup, it sure looks like it!” Adam slapped him on the back. “You have all the luck! First you find a piece of Venus on Gradivus, then a piece of Mars on Ceres!”

“It’s funny, isn’t it?” asked Helmut. “Of course, my luck included a plane crash!”

“That’s true, I suppose you’ve paid for your luck.”

“It may sound funny, but this feels like an auspicious event to me,” said Helmut, pocketing the sample. “It’s as if Mars has welcomed us to this new, Mars-like world.”

Adam chuckled. “I know what you mean. It makes this place feel a bit like home, doesn’t it?” He looked around. “I’m going to enjoy exploring this little place.”

Will, Ethel, Marshall, and Lizzie approached the door of their new house. As they came down the Andalus Southwest tunnel, they could see that the doorway’s airlock door on the right side was open and Simeon was standing in it, waiting to show them around.

“Good sol, Simeon,” exclaimed Will. “How are you?”

“Excellent. We have everything finished.” The family stopped in front of the door, so Simeon extended his hand to everyone. “Ready for your flight back to Earth?” he said to Marshall.

“Just about. I’m almost finished with 100 hours of classes to be certified for interplanetary flight, and that’s taking a lot of time.”

“It does. That’s true, you never flew here, so you have to take all those classes!”

“So do I!” added Will. “I’ve never flown in a caravel. When I flew here twenty-two years ago, procedures were radically different. Even the suits have changed; they’re much lighter, more flexible, and smarter.”

“The solution is to stay here,” exclaimed Ethel. “Liz and I don’t want you to go.”

“Thirteen months is a long time,” added Liz.

“I know,” said Will. “But with any luck, the trip will pay for itself.”

“Are you raising money?” asked Simeon.

“That’s my main task,” replied Will. “We’re planning investor’s conferences, government support meetings, Mars future seminars, one hundred media events, and two hundred interviews. I hope I hold up!” Will pointed inside. “We can’t wait to see.”

“Then come into your new house.” Simeon stepped back and the family passed through a chilly tunnel three meters long. They entered straight into a formal living room ten meters wide and eight meters deep. It had an off white thick-pile carpet covering the floor and curved walls covered by wooden paneling. A long couch ran along part of the right-hand wall. A low wall with large windows separated it from the garden, which also was ten meters wide and eight deep. The windows had no glass or curtains; sunlight streamed into the garden area and diffused into the living room.

Simeon closed the two hatches, one at the beginning of the tunnel and one at the end. “You still need a lot of furniture in here, but you have a really beautiful formal entertainment space.”

“How many people can we have in here?” asked Marshall, amazed.

“We could easily have 100 over for dinner,” replied Will. “And I plan to have some large gatherings.”

“Catered, of course,” added Ethel. She walked across the living room and through one of the three open doorways into the garden. The others followed. It was still fairly fresh. The right and left walls were lined with large potted trees with a variety of flowers underneath; flowerbeds lined the other two edges as well. A large fountain in the middle had water trickling off the edges of an elevated round basin and dropping into a pool underneath, in which goldfish swam. The rest of the space was flagstones with a few benches. “My, this is beautiful.”

“It’ll be nicer once the plants get established,” replied Simeon. He pointed up. “The living room and kitchen areas have a meter and a half of ice and half a meter of regolith over them. You also have storage areas above the ceilings, and potential space for a little expansion. Come to the kitchen.” He led the family to the rear section of the enclosure, ten meters wide and four meters deep. Two doorways led in, and each had a real door closing them; in between was also a long window with a curtain.

“Oh, my!” exclaimed Ethel, looking at the kitchen. She wasn’t sure what to make of the ample counters, the six-burner electric stove, the two large refrigerators and the large double sink. “This is your kitchen, Will, not mine.”

"I admit, I'm the cook, and I'll be doing most of the entertaining," he replied. "Bathrooms at that end, right?" He pointed to the left side.

Simeon nodded. "There are two, in order to accommodate the guests, opening straight onto the garden. This open area is for a kitchen table; the family can open the curtain on the garden and sit at the kitchen table to eat meals together."

"That'll be new," said Lizzie.

"Let's move to the private side of the house," suggested Simeon. "The other enclosure has its own airlock to the Andalus-Cathay South tunnel." He opened the pressure door in the rear wall of the kitchen, which faced a hallway in the rear of the private enclosure. The two enclosures formed an "L" shaped house. They crossed into the other bubble, closed the pressure doors, and took the hallway to the family room, which had a large skylight in the ceiling, gray carpeting and light wood-paneled walls. "The family room is the middle third of this side of the house. The rear third is divided into two bedrooms for Marshall and Lizzie." He pointed to a door on the hallway and a door on the far side of the family room. "You each have private bathrooms and skylights. The front third of the house is a master bedroom for Will and Ethel, the master bath, and two small private offices. You have two skylights; this place has a lot of natural light, even if it is underground."

"This is so beautiful," said Ethel. She reached out and felt the plastic "wood" panels. "This looks better than real wood."

"It does," agreed Simeon. "The techniques have gotten very good."

"This really is something, Simeon," said Will. "Thank you."

"I hope it was worth waiting ten months! It took a long time to get the materials."

“I know, No one is equipped to accommodate private contractors.”

“They’re getting better,” replied Simeon.

Ethel walked into the master bedroom to explore the space; Marshall and Lizzie walked into their bedrooms. Will pulled out his tablet.

“Here’s the final payment,” he said, clicking on an icon and transferring three million redbacks to Simeon’s account. “Believe me, the wait was worth it. This place has over three times the space we have now. We don’t need this much space, but I want to be able to entertain. Next week the Mars Council meets to discuss legislation; now I can invite them all to my house for dinner in order to encourage them to get to know each other. I’ll be in the position to build social ties and strengthen this place in all sorts of intangible ways.”

“Eating and singing together are essential for good relations,” agreed Simeon. He smiled. “I was honored to do business with you, Will. I learned a lot from this project. It’s given me the confidence to tackle other projects.”

“Oh? What are you thinking about doing?”

“I’d like to install two enclosures and divide them up into halves or thirds for family housing.”

“That’s a good plan. The Construction Corps has gotten good at building basic housing for new arrivals, but they don’t do construction of larger units as well.”

“Exactly. The problem is funding; the bank will give me a small loan for basic housing, but not a larger loan to spend the extra money to build more expensive housing for the people needing the space.”

“Hum.” Will considered for a moment, “What if I made a private loan to you? I bet they’d be willing to loan you the difference.”

“That might solve the problem.” Simeon was excited about the possibility, but didn’t want to look too eager.

“You do good work, and I’d like to see more private construction up here. How much are we talking about?”

“Probably . . . about two hundred thousand redbacks. I have some cash on hand and can get a loan for another two hundred thousand. I can sell the space for about 5,000 redbacks per square meter. My wife’s putting together a website right now with walkthroughs of some standard designs. The idea is to get a contract for a specific design, then build it. That way we will be meeting specific needs.”

“That’s smart. Demand for family housing is still limited enough that you want to tailor your construction to specific customers. Tell you what, Simeon. You go talk to Silvio and find out whether he’ll loan two hundred thousand if I loan you the same. If so, draw up a promissory note we can both sign. In terms of interest, I only want to cover the current rate of inflation of the redback, which is 2 percent per year. I want the money back in three years. That will allow you to recycle it twice; to complete two enclosures, sell them, and complete two more. By then bank loans shouldn’t be a problem.”

Simeon smiled. “Thank you, Commissioner, you are very generous. I’ll draw up the note!”

“Good.” Will extended his hand. “Thank you again for your marvelous work.”

“Thank you.” They shook hands. Then Simeon handed Will the key cards to the two house’s two entrances, and headed out.

Ethel came back into the family room. “This place is really beautiful. I see you have the cards.”

“Yes, I wrote him a check to pay him. I also promised him a two hundred thousand redback loan so he could go into the business of house construction.”

“Oh? Good. Simeon seems hard working and very talented.”

“Exactly, and we need construction companies up here.” Marshall and Lizzie came out of their rooms at that moment, and both looked pleased. “So, shall we move in this weekend?”

Marshall nodded. “Sure! This is going to be nice!”

“I think we’ll like this new house very much,” agreed Will.

Kristoff rose and stretched that Satursol morning. The first thing that occurred to him was to call Irma. She answered the videophone right away. “Good sol, Kristoff.”

“Good sol, Irma. I thought you’d like to know that I’m coming back to Aurorae next week.”

“Oh? Aren’t you enjoying the work up there?”

“Yes, immensely; we’re scheduled to get two more cylinders soon, too. But one gets bored staying in one place too long, and I’ll have been up here five months. I figure it’s time to come back down for a few months.”

“It’ll be good to see you again.” She smiled.

“I’m looking forward to seeing you as well. I’ve really enjoyed our conversations. It doesn’t feel like we’re on separate worlds; it almost feels like we’re seeing each other every sol.”

“Well, we talk for half an hour!”

“True, but you know what I mean; it feels more real than just a videophone.”

“I’ll take that as a complement, then. I’ve really enjoyed talking to you, also, but seeing you will be better.”

“Definitely. If you’re interested, we could go spend some time up at the Dacha together.”

“Hum . . . well, Kristoff Langlais, I think we might need to have a conversation about the future first.”

“Oh.” Kristoff was taken by surprised by that; but she was right. “Okay. Let’s plan on that. I’m scheduled to return July 5th.”

“Excellent. We’ll meet at the Gallerie for some ice cream and a nice, long, face-to-face conversation.”

17

Departure

Early-mid-July 2058

The *Kasei* dropped from Phobos to Mars, blazed through the atmosphere, then landed on a tail of fire. Within fifteen minutes a conestoga loaded with its passengers was driving to Aurorae's arrival hall.

Kristoff stepped out of the conestoga on slightly wobbly legs and looked around for Irma. She was standing, smiling, waiting for him. He strode over, dropped his bag, looked into her eyes, then kissed her.

"Welcome home," she said to him.

"Thank you. It's good to see you, face to face, for the first time in six months."

"Where's your father? I thought he'd be here to greet you."

"We'll visit later. I told him you were meeting me."

"Oh."

He could feel her excitement to see him; she excited him as well. He picked up his bag with his right arm and put his left arm around her shoulder. "Let's go to my place."

That surprised her and she seemed hesitant. He started walking and she followed. But Kristoff realized that perhaps he had misinterpreted her signals. "I have a better idea. I'm starved; it was a long flight. Let's stop at the university cafeteria."

"Good idea," Irma replied, relieved. So they turned and entered the tunnel to Yalta Biome.

Kristoff left his bag at a table and went inside to fill a tray with breakfast. He grabbed coffee and cereal for Irma. “You remember our conversations,” she said, impressed.

“Oh yes, I remember you said what you eat almost every morning: coffee, cereal, a banana, and yoghurt. They had two out of four.”

“Well, it’s late for breakfast, anyway,” she replied.

He took a bite of some toast and jam. “It occurs to me that there’s one big difference between our relationship and the relationship I’ve had with other women. We’ve had to communicate by video for six months because of physical separation.”

“You know, I think it proved good,” she added. “It forced us to communicate more deeply in some ways.”

“Yes, and less superficially. I think you’ve taught me a lesson, Irma Baeker. Sometimes a physical relationship can be a distraction and block the pursuit of a deeper relationship.”

“It can be true,” she agreed.

“Looking back, I think it was true of most of my previous relationships. But with you I want more . . .” His voice trailed off.

She smiled. “I want more too, I think. Have you ever considered marriage, family, children?”

“Yes, I’ve always imagined I would get married some day, and I suppose start a family. Helmut’s very happily married and they have a son who is supposed to be quite a little boy; he’s taken to space exploration pretty well. What about you?”

“Yes, marriage and a family are goals of mine, though it’s hard to say when. It depends on finding someone else.”

“It takes two to tango,” he agreed. “We need to talk about marriage. Maybe we can go to the Dacha this weekend.”

She leaned forward. “There’s another way of looking at this. First you talk, then you decide to get married—or not—and if the decision is positive, you go to the Dacha together. One could even consider waiting and going to the Dacha on the honeymoon.”

“Yes, one could consider that.” He didn’t like that suggestion at all.

“At any rate, let’s talk about the matter.”

“How about tonight, over dinner?”

She shook her head. “I’m covering the graveyard shift at Mariner Hospital for the next five sols. That’s 7 p.m. to 7 a.m. I won’t have much energy until late afternoon.”

“Okay. I have a lot of vacation time coming to me, after six months of intense work on Phobos. Let’s plan on spending our afternoons together doing silly things; a hike outside or watching a movie.”

She laughed. “That would be good. Now you’re on the right wavelength. Are you planning to go back to Phobos?”

“There’s no specific date, but I’d like to. Lisa has asked me to help prepare for planting the vanilla; the seeds will arrive from Earth next spring. After that, I’d like to go back to Phobos. The cylinders there are maturing and we’re working out the bugs in the agricultural systems; it’s still more research than commerce. We’ll have about five tonnes of vegetables produced for export to the moon in the next few months. That’s nothing

compared to the potential. Phobos can become the breadbasket of the solar system. Phobos is now permanently settled; no more temporary crews."

"Oh? Borough status?"

"That's what they're talking about. Right now no one stays more than six months, but they plan to station a caravel there permanently. That means an outpost with 2,500 square meters of living space with Martian gravity and radiation protection; plenty to raise children. The demand for caravels and related habitable structures is proving strong; contracts for earth orbital facilities are coming our way. That's why agriculture is a practical side activity, there's housing for the farmers. Phobos averaged thirty residents over the last year, so it already needs fifteen agricultural cylinders just to meet its own food production. Lisa's contemplating fifty cylinders with 10,000 square meters of farmland—an entire hectare—managed by three agricultural workers and a team of robots in three or four years."

"Really? That's exciting."

"It is, so I'm feeling some pull to fly back up and contribute."

"And they need chemists and nurses, no doubt."

Kristoff nodded. "They certainly do."

The members of the Mars Council formed a line when the supper buffet was laid out on a table in Will Elliott's garden. They loaded up their plates with tilapia, rice, and vegetables, grabbed the special dessert pastries, filled glasses with carbonated fruit juice, and sat at the large table set up in the house's main room.

"You spoil us, Will," exclaimed Emily Scoville-Rahmani as she sat.

“No, I’m delighted to be hospitable. Besides, what legislative body should go without the chance to break bread together and socialize? It’s a crucial element in the social glue that makes a body like the Mars Council effective.”

“We could use the informal time together,” agreed Érico, looking at the others. “We’ve covered a lot of ground in the last two sols.”

“In terms of discussion, yes, though perhaps not in terms of decisions,” replied Alexandra Lescov. “We have a lot of difficult decisions to make.”

“Any decisions about the rights of workers working for private companies have huge implications for this place,” agreed Enlai. “We have to balance the needs of workers for comfort and safety against the needs of private companies for efficiency and competitiveness.”

“Let’s not undermine the modest prosperity our people already have,” cautioned Yevgeny. “New arrivals are definitely working a lot harder now than a decade ago, and getting less.”

“It’s one of the prices we are paying for having a larger population,” replied Érico. “Everyone’s salaries will rise fifty percent in three columbiads.”

“I’ve sensed a desire to protect Commission operations against the private sector,” added Scott Curry. “Regulations that raise the cost of private labor also serve to reduce the ability of companies to compete, especially in construction.”

“Scott, at the risk of repeating myself, I am not arguing for a minimum wage, unemployment insurance, time and a half for overtime, and such standard features of terrestrial life to protect my construction operation from competition,” said Alexandra calmly.

"I'm sorry if it sounds like an accusation, Alexandra, but in reality that is what you are doing," replied Scott. "Look at Cassini; it's dominated by the private sector, and it's doing fine."

"You're also mining gold and paying workers huge bonuses to work insane hours," said Alexandra. "Then they move to Aurorae and start families. Nothing we're proposing will prevent you, either."

"I'm sure you all can find a balance," said Will. "This is a difficult issue. The private sector has been growing slowly and we need to encourage it without making life harder for the workers. We also have to keep regulation reasonably simple; small companies up here can't hire six back office workers on Earth to fill out paperwork. Simeon Afigbo already has that problem."

"He'll probably have to hire someone else after this legislation is finalized," said Érico. "Because more personnel data will have to be kept in order to comply with regulations."

"He did a good job building this place, I'd say," exclaimed Cornelius Beyer, admiring the house. "I may want something like this at Dawes. But it would be almost impossible to get a house like this built there; the outpost's construction department can't do it and Dawes doesn't have a private contractor."

"Simeon might agree to do work," said Will. "He's now moving into what I suppose could be called middle income housing; not the cheap one-room flats for newly arrived workers, but four or five room houses for families of workers who've been here more than six years. And just this sol he and I were talking about workplace construction. Offices and manufacturing areas don't have to have windows. With the hundreds of

tonnes of nickel-steel being produced every month here and essentially thrown away, it makes sense fabricating big, airtight metal boxes and burying them."

"And we now have lots of interdomal spaces where they could go," added Ernesto. "How much cheaper would they be?"

"The steel's free and robotic welders are extremely reliable and thorough," replied Will. "Simeon can probably make a metal enclosure twenty meters long, ten wide, and five high for 50,000 redbacks. Interior walls, false floors and ceilings, lighting, water, and air can be added for about 50,000 more. That's twenty percent the cost of housing or work space inside a dome."

That caused a long moment of silence. "But you'll be getting what you paid for; bare bones space without windows," exclaimed Alexandra.

"It wouldn't be hard to cut a few holes in the metal roof and install plexiglass windows," noted John Hunter.

Will nodded. "At which point, cheaper housing for new arrivals would be possible, improving their quality of life."

"We can lower our costs," agreed Alexandra. "They've come down steeply in the last decade. We've been quite innovative and we're still innovating. But I suppose private construction contractors will make additional changes, and I welcome that."

No one was sure how seriously Alexandra meant what she said, and Will was mighty tempted to note that his house had taken months longer than necessary because Simeon couldn't get materials on time. So they changed the subject.

"Will, what do you think of this," said Érico. "Right now we hold elections once per columbiad, usually about three months after the last wave of arrivals. But the

columbiad is a measurement of time tied to the Earth. We're thinking of shifting the elections to the first weekend after the northern spring equinox. If we switch in three columbiads, the election would have fallen near the equinox anyway."

Will nodded. "Why not? By then, the arrivals should be a smaller percentage of our total population. I'd hesitate to disenfranchise thirty percent of our population for an annum, but if we plan this far enough in advance, I think it'd work."

"That's our thinking, too," agreed Yevgeny.

"Do you anticipate raising a lot of money on this trip?" asked Victor MacLeod.

"I hope so," replied Will. "We're planning an International Mars Development Conference in Berlin, to which hundreds of business representatives will be invited. I have various visits scheduled, including with Mr. Muller; Gerhard will be there as well."

Gerhard Beyer nodded. "I will."

"And both of us will attend the Landowners Assembly and Landowners Conference in Houston. It'll be the first conference of landowners, other than the Mars Exploration Society meetings. We'll be attending a special conference of the MES as well. We'll probably push up the sale of Marsian property, which will be good. I'll meet with the heads of every space agency and commission I can, to see what additional initiatives we can create."

"How much more can we get, though?" asked Lisa, skeptically.

"It's hard to say, but government support for Mars is now much less than it was when Columbus 1 was launched. Fortunately, costs have fallen dramatically per person and per tonne, and we have exports. Meanwhile, in the last twenty-two years the terrestrial economy has doubled and the huge costs of the retirement of the baby boomers

has passed. Americans are now spending twice as much every year on potato chips as on exploring Mars. Why shouldn't we get more governmental support? I'd love to see us get several billion redbacks more per year."

"Which would mean significant population growth," said Érico. "The Park Report's ominous prediction that our population will plateau in a decade will have been obviated."

"Dr. Park was right within the parameters he used to write the report," replied Will. "Maybe we can change the parameters."

"Permanently? You can't go to Earth every columbiad to drum up money," said Emily.

"I plan to go every two or three columbiads; that means I'll be spending one quarter to one sixth of my life in space. I think whoever is the Commissioner needs to travel to either Earth or Mars—if the Commissioner is based on Earth—every few columbiads. The travel may sustain a higher level of support. It may be wise for the Mars Authority to send someone to Earth during the columbiad when I'm not going, to keep up the interest."

"I don't particularly want to go back," said Érico. "My adoptive parents have both died and I was never close to my adoptive siblings. I have nothing to return to, except to see how much Brazil has changed."

"I'm thinking of going back for a visit," said Enlai. "My parents are getting very old and I'd like to see them one more time before they die."

"Those of us with kids will have to wait a while," said Emily. She turned to Will. "Is Marshall excited about the trip?"

"Yes, very. I just hope it goes well for him. We don't know how well he'll adjust to terrestrial gravity; he does fine in launches when exposed to several gees and his circulatory and skeletal systems are fine, but month after month of gravity may be very difficult. And in spite of about fifty vaccinations, he could get all sorts of colds and flu germs. Then there are all the problems that could arise because he doesn't know hundreds of skills, from whom to ask for directions to how to change a flat tire."

"I'd worry about that the most," said Emily.

Will nodded. "It is my biggest fear."

"You may have the same problems," commented Alexandra. "Twenty-three years of Martian gravity, isolation from terrestrial germs and a lot of new skills you never acquired."

"You're right, but I'll have handlers for my month on Earth. That's one reason I want to keep Marshall close, so he can benefit from the attention and services. After I leave, he goes to MIT—it now appears they'll accept him late in the spring semester to live on campus because he'll start with their distance-learning courses next week—and I'll worry."

Helmut leaped from the floor of the greenhouse and extended the wings attached to his arms. He used them to convert the vertical component of his leap into forward motion. He had to duck his head to avoid the greenhouse's plastic ceiling, but otherwise directed the energy of his leap reasonably well. He soared along the length of the greenhouse, slowly descending, but occasionally flapping his wings to keep himself off the floor and

to prevent himself from tipping toward one side or the other. At the far end he touched down, flapping powerfully to stop his forward motion.

"Wow, that was well done!" exclaimed Thierry, who was standing and watching. "But you need to watch your leap. Attempting to jump close to horizontal doesn't work and diagonal leaps are pretty tricky. It's usually easier to jump mostly straight up and use your wings."

"I had some trouble in the middle there, too; I yawed to the right."

"Yeah, you're still getting used to flight. The wings are a bit too big for Ceres's gravity, I think. I wish we had brought a canary along, or any kind of bird. We could have studied their flight in low gravity and gotten clues what to do."

"I'm glad Charles has agreed to make this greenhouse available for flight," said Helmut. "Our horticultural output is high enough without it."

"The bigger problem is getting work done! There's a waiting list to get in here."

"I want to bring Charlie in here. It's got a pretty good view of Ceres and he wants to see the place."

"Have you taken him on a ride in a van yet?"

"No; it's been five weeks since landing and we're still pretty busy."

"Busy! We're playing bird in here!"

"You know what I mean. We still have set up to finish, and the drill hasn't hit enough water yet. We have preparation for the big expedition to Mount Arteme around the other side to study mantle xenoliths."

"That should be quite interesting, if we really find pieces from close to the center of Ceres. I'm skeptical of the interpretation of the samples the Prospectors have found."

"So am I, but it would be valuable if true. But let's not waste our time chatting; it's your turn."

Thierry nodded and leaped into the air skillfully; he was their expert. It was like watching someone dive off a diving board, but in reverse; he went straight up, then gracefully soared horizontally. He flew the length of the greenhouse, executed a tight turn—no one else had perfected that maneuver—and flew back, landing right where he took off.

Helmut's turn. He jumped upward and managed a bit better to convert his energy into horizontal motion, flew wobbly to the far end, then tried to turn but ended up running into the side of the greenhouse. He slid down the side to the ground, then took off and flew back.

Half way back to Thierry he felt his communicator vibrate; a message from Mars. But he wasn't going to stop to listen; he had another ten minutes in the greenhouse. He and Thierry continued to soar back and forth.

As soon as they left, Helmut headed straight back to the *Giovanni Piazzi* via the pressurized tunnel. The message was probably from his brother, who had been messaging him daily in the last week. He headed to his quarters—Charlie was there with Martha and Caitlin at the moment—and played the message.

"Hi, Helmut, it's Kristoff." Helmut could see his older brother looked excited. "Well, I popped the question and she said yes. Yestersol when we talked extensively about marriage and our goals in life, she said that just making plans wasn't enough; she was old fashioned and wanted me to propose. So I went to Silvio's and bought her a ring,

obtained the biggest bouquet of flowers I could get—thank God I have horticultural connections!—and surprised her with them. Irma was very happy; she cried.

"I still can't believe this is happening! Irma's right; I was never letting women get close to me psychologically. I was keeping the relationship at a physical level. But now I see the deeper dimensions of a relationship that are possible. In the last four sols I think she and I have talked about twenty-five hours, about everything: life goals, values, and little things like how we like to have our flats set up. I never thought I could have a relationship with a woman like this; I'm still adjusting. Irma says if we hadn't been forced to communicate by video for six months, this would never have happened because she would have never gone out with me, and certainly I never would have built a relationship like this otherwise.

"Anyway, it's really amazing! I'm sorry you won't be around for the wedding. We plan to get married in January. After I finish my next assignment—establishing vanilla plants in Ceylon Dome—about June of next year, we plan to go to Phobos. It's getting bigger; by then it may have fifty residents. Irma can be nurse there part time while doing chemistry, which is the career she's switching into. The agricultural area is scheduled to expand a lot next year, so I'll have my hands full.

"I hope you're doing well. I hear the geology up there is better than expected and morale is high. Dad seems really pleased with how the mission's going. Of course, right now he's thrilled Irma and I are getting married; actually, I think he's a bit shocked! He had almost given up on me. But a lot has happened since he had his heart attack.

"I love you, Helmut. Call me back. Bye."

Helmut was tempted to listen again. He hadn't seen his brother so happy—almost giddy—in a long time, and he was not one to say "I love you." He could understand his father's shock. He hit reply.

"Hi, Kristoff, it's Helmut. Wow, what great news! I'm thrilled! I can't wait to tell Clara, she'll be delighted. We're sorry to miss the wedding, but I'm sure we can watch a live video feed. Next time you call, include Irma, so we can get to know her.

"This really is a big change for you; I can feel it, and I'm happy about that, too. Relationships are so fulfilling and empowering; you've already witnessed that. They can really change you. And children are even more amazing, though they can be exhausting and frustrating as well. I hope you and Irma discover that as well. Will Elliott keeps saying that's what people were made for, and I think he's right.

"Yes, everything up here is going very well. The geology has been really interesting, and we've converted a greenhouse cylinder into a flying area. I hear you all did that for a while on Phobos; you need a permanent aerodrome up there, believe me! It's really amazing to flap wings and feel them lift you. The tricky part is taking off and landing because you have to manage your momentum completely with the wings, or else you sprain something.

"Yes, morale up here is great. We've really clicked as a team. We've asked to extend our stay on Ceres by a month if we can make the fuel for a faster flight to Hebe. I love this place, Kristoff. The low gravity seems like a perfect compromise between a planet and a place like Phobos; it's easy to move around once you adjust, but there's enough gee to hold you down when working. The role of water in the surface processes is fascinating, and the interior is intriguing. The mineralization is extensive and unusual;

our mineralogist has already identified four new minerals. If a drill can get deep enough it might hit liquid water, so there's the remote possibility of microbial life. I wouldn't mind coming back here.

"Anyway, keep in touch, and introduce Irma to us! We should plan a Satursol video get together. Bye."

Two space travel bags sat on the sofa in the family room. A shaft of sun shone through the room's ceiling window and illumined the bags like a spotlight.

Will and Ethel came out of the kitchen and she noticed the light. "They look singled out," she said.

"They're packed and ready to go," replied Will. "Which one is Marshall's? I hate it when they're all the same color. Oh, this one's mine."

"Colors are not yet an option." Ethel shook her head. "I wish you weren't going."

"I'll be back in thirteen months, and we'll be in touch daily."

"I know." She sighed. "Every flight has one chance in ten thousand of failure. Four different major failure points on the flight to Earth: launch, transearth injection and cruise, aerocapture, and landing. Same on the way back."

"So, there are eight chances in ten thousand of failure. There haven't been any yet." He embraced her and kissed her. "I'll miss you, too, my love."

"Twenty-one years of marriage. A long time to be together."

"This is my last flight back to Earth, unless we both go back together some time."

"No more flights back as Commissioner?"

He shook his head. “The operation’s getting too big and I’m getting too tired of doing it. I wouldn’t mind running things another two or three years, but I think that’s it.”

“I get the impression no one would dare fire you, or nominate someone else for the job when your term ends. You may want to think about the freedom that gives you.”

“We’ll see what this trip brings. I’m 56; in ten years I may not feel well enough to travel in space.”

“I don’t know. There are seventy year old tourists flying to the moon! I’m not sure I’d like to go back to Earth. Dad’s dead, I haven’t seen my sister in twenty-three years and I suppose at this point I could go without seeing her ever again. I can take virtual tours of new buildings or virtual drives over new bridges and I’m not sure I like the crassness and shallowness of the consumer culture.”

“Yeah, I’m preparing to hold my nose, and I’ll probably be immersed in the middle of it in order to raise as much money as possible.”

Just then Marshall and Lizzie entered from the garden. He looked around. “I’m going to miss this new house. It’s been only a month, but it’s been great.”

“Don’t worry, we’ll use it well for entertaining,” said Liz, with a smile. She loved parties and had already had friends over several times.

“Even gatherings of the Council,” added Ethel, which she wasn’t looking forward to. She turned to her son. “I can’t believe the sol has arrived for your departure.”

“I can’t believe it either, mom,” he replied, surprised that his voice quavered a bit. He hugged his mother.

There were tears in her eyes when they separated. “My baby boy.”

“Mom! I’m 19 years old, weigh 79 kilos, and I’m 177 centimeters tall! I’m not a baby any more!”

“You’ll always be my baby.”

“Just be sure you come back,” said Lizzie.

“Oh, I’m coming back. This is where the science challenges are.”

“Here, and farther from the sun,” said Will.

“Maybe I’ll go there too. Later. I wouldn’t mind seeing Mercury and the moon.”

“Let’s not talk about departures,” said Ethel.

Will’s watch beeped. He glanced at it. “It’s t-minus two hours. We’ve got to go. The conestoga leaves for the *Kasei* in twenty minutes.”

“And it’s a twelve hour flight to Embarcadero?” asked Liz.

Marshall nodded. “We stay there a sol to make sure everything’s ready to go. A series of periapsis kicks for the *Courageous* with the Sunfire solar thermal engine, LOX augmentation for the trans-Earth injection, and a long Sunfire burn to shorten the flight. We cruise for 175 sols and aerocapture into an elliptical orbit around Earth, rendezvous with two Swift shuttles that head for Kourou and Kennedy respectively, and two days—not sols!—later we’re on terra firma.”

“I didn’t need the entire timetable,” Liz complained.

Will reached down to pick up his bag. “We had better get going.”

The others nodded. Liz picked up her brother’s bag for him, a gesture that surprised Marshall.

When they passed through the garden, Will glanced up through the transparent bubble at the clear, pinkish sky overhead. He glanced around the garden and savored the

trickling sound of the fountain, a sound slightly but noticeably different from terrestrial foundations because of the slower speed of the falling water. It was as if he would never see the place again, though he felt confident he would return. “I’m going to miss this place.”

“Home, sweet home,” said Marshall.

Then the four of them turned and walked through the living room to the airlock and the tunnel that led to Andalus.

Nov. 2, 2056: Vernal Equinox

Dec. 31, 2056: Earth to Venus, 4.4 km/s 86d; 27 Mar. 2057 Venus swingby to Mercury; May 13, 2057 arrival, 5.4 km/sec delta-v, 133d total

Jan. 24, 2057: Earth/Mars opposition
Tourist flight: Oct. 5, 56 depart Earth, 7.4 km/s; arrive Mars 3-5-57, 150 days, 7.0 km/s; depart Mars 4/11/56, 6.8 km/s; arrive Earth 12/1/57, 9.0 km/s, 234 d (14 months round trip). Other flights leave Earth mid Oct., early Nov., late Nov. (all c. 150 day flights, all can head back to Earth via inner solar system by mid June).

Oct. 18, 2057: Mars/Ceres opposition

Nov. 20, 2057: Autumnal Equinox

Jan. 8, 2058: Dust storm season begins

Jan. 23, 2058: Earth/Mars conjunction

May 24, 2058: Dust storm season ends

July 17, 2058: Earth to Venus; Oct. 2, 2058: arrive Venus; 14 Dec. 2058: arrive Mercury

Sept. 20, 2058: Vernal Equinox

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