MARINERS

Vol. 9

Mutualistic Democracy

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2.

1.

A New Year

Jan. 2088

Cathedral Square was packed for the New Years celebration; most of Titan's 2,000 people were there, sitting in chairs facing the stage or in the restaurants lining the square, watching the festivities, while the kids ran around among the grass and trees of Cathedral Enclosure, the 200-meter wide tunnel carved in the moon's cryogenically frozen ice crust and brilliantly illuminated by electric light generated by Titan's geothermal and wind energy.

The Titan Philharmonic Orchestra was approaching the end of its new symphony, "Rings of Saturn," when Amy Elliott leaned over and said to her husband Marshall, "Are you sure?"

He nodded. "Yes, I'm sure."

"Alright." She looked around at the crowd, most of whom had arrived in the years and decades since Saturn-1 had reached the ringed planet and set up the first settlement there, on Titan, in May 2070, almost eighteen years earlier. Some of the first-timers were planning to head back to Mars in three months with their adult or nearly-adult children. It was a turning point for the now-independent commonwealth.

The orchestra played the closing finale of the symphony and the crowd erupted into vigorous applause. Saturn's residents were highly skilled and trained; most of them could play a musical instrument, and the orchestra, which was not professional, nevertheless was quite good. They began to leave the stage as Father Okonkwo, the settlement's Catholic priest, who doubled as Director of the Titan Center for the Arts, walked up to the stage.

"Weren't they incredible? And to think, we just heard the debut of a new symphony tonight, one the Denver Philharmonic has agreed to add to their spring schedule! It shows you

the talent we have here, composing music at the same time they're analyzing geophysical data or improving our computer model of Saturn's weather!

"It's now 24:05; less than 34 minutes remain to December 30, before we usher in January 1, 2088, Marsian time. We will turn to lighter music and entertainment, but first our Chief Minister, Marshall Elliott, will deliver the traditional New Year's eve address. Marshall."

Elliott rose from his seat near the stage and walked to the podium. "These New Year's eve addresses have to be short, because who wants to listen to the chief minister drone on when we're about to celebrate a new year! But it's always useful to look back to see where we've come in order to anticipate where we are going to go.

"It's been quite an eventful year. Saturn-7 arrived with 580 people, and since then we have had 150 more births--a one-year record--raising the population of the Saturn Commonwealth to 2,434. Nannybots have been quite helpful, but they can do only so much! Perhaps tonight's celebrations will bear fruit, as it were, nine months from now."

There were some chuckles in the audience. "The big development this year was the establishment of Rhea Borough, the Commonwealth's third. Enceladus has 250 people and Rhea 100, and in two and a half months Iapetus Borough will be established as well, initial population 75. Saturn-8, when it arrives in 2089 with another 600 people, will allow their expansion and the establishment of a borough on Mimas. We will see whether these boroughs prove simply to be comfortable stations for doing geology, with personnel rotating through them regularly, or whether they will develop identities and long-term populations of their own. We don't know. We do know that the Commonwealth is going through another important milestone in its development when it moves from remote study of the entire system with an occasional human presence to an ongoing human presence on every major moon. This is a very exciting change."

More applause; he paused a moment. “Here on Titan, we started the Cathedral tunnel complex almost 12 years ago, in April 2076. Cathedral Main is 200 meters long; Cathedral East and West branch from its end and both now run 500 meters; Cathedral North, between the two, is now 200 meters long; and Cathedral South has branched off of West and runs southwest 200 meters. Altogether we now have 1.6 kilometers of these magnificent, verdant tunnel enclosures with soaring 150 meter ceilings and we’re set up to clear an additional 100 meters every 18 months on all four tunnels. We have figured out how to live on this moon sustainably and comfortably; its geothermal and wind energy is sufficient to power a civilization of tens of millions of people, if we can figure out how to get them here. That’s a problem for the next century!

“We have also broken out of our isolation from Titan’s landscape and atmosphere, first, by completing the Dacha 20 kilometers north of here, near the Likoma geothermal complex, and with the rapid construction of the Observatory on Eagle Pinnacle a short elevator ride from here. I am told that the latter averages 20 visitors per sol and more on the weekend, and the number of people going outside to walk on the hiking trails has soared. I’m very pleased by the connection we are now making with the land around and above us. It’s a healthy development.

“Finally, a week ago the Saturn Council voted to explore a new way to arrange our elections, based on Mars’s new election law. We hope to have a proposal ready for popular consideration in the next month or so. Most likely, we will divide Titan Borough into three districts of about 700 people each. Each will hold its own Future of Saturn forums and elect two members to the Saturn Commonwealth Council, who will also serve as members of the Titan Borough Council. Enceladus, Rhea, and eventually other boroughs will have 1 representative on the Commonwealth Council each until they grow beyond 500, when they will elect a second

representative as well. Mars is now calling this neighborhood-based election system ‘mutualistic democracy,’ something we will want as well.

“Finally, I want to thank all of you for the trust you have put in me for the last twelve years. I was elected your Chief Minister in March of 2076; nearly 12 years ago. In that time we started Cathedral; converted Enceladus into a permanent outpost with a substantial carrier and the ability to serve as our interplanetary spaceport and manufacturing center for C-50 drums; renewed the aerostat in Saturn’s atmosphere and even sent down a repair crew; conducted extensive geological research on Titan; used crewed missions and automated rovers to explore all the major moons, several of the moons associated with the rings, and several outer moons; our population quadrupled; and of course we achieved independence on November 2079. It’s been quite a remarkable twelve years, but no person can or should remain in charge and responsible forever. Saturn has some truly remarkable and talented individuals, and it is time that they have their chance to apply their energy and creativity to moving this Commonwealth forward. Therefore I am hereby announcing my plans to depart for Mars on Saturn-7 on March 15, two and a half months from now, and I will resign as Chief Minister on March 1. The Saturn Council now has time to select my replacement, and I have time to assist him or her in the transition.”

“No!” exclaimed someone in the audience. Many people erupted into speaking at once, so Marshall paused to let the surprise pass. “The Commonwealth of Saturn has natural and human resources that are unparalleled in the outer solar system. We lack the deadly radiation belts and massive gravity of the jovian system, which renders most of the major moons uninhabitable and the Helium-3 in Jupiter’s atmosphere unreachable. We have marginal solar power, wind power that is unavailable in the Uranian and Neptunian systems, and three moons with geothermal energy. We are closer in than the ice giants, with a one-way travel time to Earth

or Mars of 12 months. Our talented people have opportunities the other outer worlds lack. Consequently, the future of the Saturnian system is bright. I will most likely return; I'm not sure I can keep myself away from Titan, to which I have given over twenty years of my life. I look forward to remaining in touch with all of you and marveling at all the things you will accomplish. Thank you."

Marshall stepped away from the podium as the entire audience rose to their feet to give him an enthusiastic ovation. He nodded in thanks and went to his seat, where he had to nod several times before he could sit. "That was great!" said Amy, squeezing his arm and then kissing him.

Father Okonkwo returned to the stage. "I think we are all still in shock, Mr. Chief Minister Marshall. We love you and deeply appreciate your dedication to this Commonwealth. We have been able to go from strength to strength partially as a result of your energy and vision. We will seek your wisdom from a distance and look forward to the day when you return. And now, how do we turn to a celebration of the new year? The Titan Jazz Ensemble will get us moving."

He stepped off stage as the jazz players prepared to perform. Will Elliott, their 18 year old son, hurried over to his parents. "That was a great speech, dad! Such a fitting close of your service."

"It's not over yet; I have 2 months to go, and a major change in our election system to shepherd through the legislative process. I'm glad you were happy with it, son. Have you made up your mind yet?"

"Yes; I'm going to Mars, too."

"You are! Fantastic!" said Amy, hugging her son.

"I'm really glad. Relieved. I'd hate to leave you here by yourself, as mature and capable as you are, Will."

"Thanks, dad. In the last two weeks, since I had my first conversation with Dr. Kersley, he and I have exchanged some emails, and we had lunch earlier this sol. He only teaches three history courses and they're all fairly basic. If I want to consider majoring in history, I have to take a lot of courses from Martech-Aurorae and probably from Earth as well. This spring semester, I'll get half my courses face to face here and finish them up remotely as we head for Mars. I can take a full summer semester from here, remotely, and that'll finish up everything I can get from Dr. Kersley. In the fall, we'll be closer to Mars and I'll take courses remotely from there. When we arrive I'll have half my Bachelor's done and will be able to decide where to focus my study, and if I want to take more courses on the geology of the Saturnian system, I can take them remotely from Mars. The advanced Saturnian geology courses are filled with students from all over the solar system."

"On Mars, you'll be able to interview the old timers a lot more easily, too."

"Yes, and I want to get to know grandpa while I still can. It's very strange to think I'm named for the 'George Washington of Mars.' I have to understand what that legacy means. That's something I can only do there."

"Very true. I'm glad you're going to get to know my father. I miss him and I'm looking forward to reconnecting as well. And I'm excited about your Marsian and mariner history project. I'm surprised we haven't had a major Marsian historian yet."

"Dr. Kersley says that's because Martech has been importing historians to teach all the aspects of terrestrial history, in order to guarantee that Marsian society stays connected with its terrestrial legacy. It has experts in the history, literature, and languages of various regions of

Earth and various time periods, but they have continued focusing on their subfields; they rarely have branched out to study Marsian history, literature, art, even language. But in the last six years Mars has grown from almost 60,000 to over 260,000. It now needs experts in its own history, language, literature, and arts."

Marshall nodded. "I'm sure you are right." He looked around at the growing crowd of people standing nearby, wanting to talk to him. "We can talk more later, I had better speak to these others now."

"It still seems strange that we don't have a December 31," said Lech Bukowski to his wife Joanna as they headed down the spiral ramp from their flat to the ground level. "Here it is New Year's Day here, and back in Pittsburgh it's still December 31!"

"I know," she said. "Our January 1 is supposed to fall after January 1 happens, Universal time on Earth, but it started a few hours before. I guess they have to throw in a leap sol or something."

"I think I heard that, too. I hope it'll be a December 31!"

"No, I think it's just an extra February 29 later this year."

"Oh, of course." Lech was disappointed.

They stepped out of their apartment building and walked to New York Circle. It was full of people, booths selling breakfast items, and a crow of people watching two jugglers. After they crossed the street, a woman greeted them. "Welcome to the New York Circle Neighborhood's first neighborhood party, and Happy New Years! What are your names?"

"Lech and Joanna Bukowski. I'm surprised we are greeted by a person instead of a robot!"

“This is a neighborhood party, so everything is being done by volunteers. My name is Mandy Carr. If you could, please write your names on name tags; we want everyone to be able to get to know each other.”

“Oh, sure.” Lech handed a name tag to Joanna and started writing his name as well. “You are from this neighborhood, right?”

“Probably. We live there.” Lech pointed to their building.

“Yes, that’s part of our district. The population density is pretty high, here. Those buildings there are another neighborhood.” She pointed to a cluster of buildings on the northeast side of the circle. “You can see their celebration up Haudenosaunee Avenue, 200 meters.”

“Everyone’s celebrating this sol.”

“Yes, 208 neighborhoods in Aurorae, averaging about 700 each. We only had 5 weeks to pull these together after the Council approved the electoral redistricting and budgeted money for four neighborhood gatherings before the midterm elections this November. We’re doing as much as possible with volunteers. Could the two of you serve as greeters for an hour at some point between now at 5 p.m.? We still have some empty slots.”

“Yes.” Lech looked at Joanna. “How about 2 p.m.?”

She nodded; Mindy made a note. “Thanks. I have your phone number, so I’ll be sure you get a text. Enjoy the New Year’s celebration.”

“Thanks.” Lech and Joanna finished their name tags and walked into the square. They stopped at a booth for hot coffee and pastries, all free, and sat at a table to eat. “Can we join you?” asked a young couple.

“Yes, sure,” said Lech. “I think we’ve met before; Lech and Joanna Bukowski.”

“I think you’re right. I’m Oskar Langlais and this is my wife, Maryam Islami.”

"Yes, we have met," said Joanna. "In fact, here on the Circle when Maurice Brandt was speaking. You're a journalist, right?"

"Yes, I cover the arts and culture for *Mars This Sol*, so these neighborhood gatherings are the subject of a story I'll write tonight. I may even do a few video interviews later this afternoon. But right now, we're eating breakfast!"

"What do you do, Maryam?" asked Lech.

"I work in the Ministry of External Affairs, focusing on the United States."

"What do you think about the groundswell of support for decreasing partisanship in elections?"

Maryam nodded. "It's a very good sign, if more states can be persuaded to adopt ranked choice voting and pass legislation allowing for districts to be drawn by nonpartisan commissions. It's the only way that American democracy will start to function. There was a recent study about the impact of the dysfunction on the American economy and by extension, the world economy. It's clear, based on the right-wing attempts to discredit our electoral system, that Mars is having an impact as an example of a well-functioning government. It's very gratifying."

"And now this attempt to improve our system further is also getting a lot of attention," added Oskar.

"I understand this is an attempt to get back to an older experience," said Lech.

"Yes, sort of," replied Maryam. "Oskar left Mars for Ceres when he was four, so he doesn't have any memories, but I left for Earth when I was seven, so I have some. Aurorae had 2,500 people and the other outposts were under 700. I remember my father--who was Ambassador to Earth--explaining that our communities were small enough so everyone could get to know most of the other adults, especially the ones who were active doing important tasks. And

I remember big public events--like New Years and Mars Day and the Future of Mars Forums--were exciting events when everyone seemed to be there. There was an excitement in the air."

"I bet." Lech looked around. "We don't have everyone here, yet."

"This event will go on until the evening," said Oskar. "So people will come and go. I'm glad to see that the organizing committee was able to arrange for some booths. We have face painting for the kids, lots of restaurant booths, and later we'll have some art booths and some boutique stores opening booths. The neighborhood will be well represented."

"And all 208 neighborhoods will have booths like this, and entertainment! It's pretty impressive!" said Joanna.

"Well, remember this is New York Circle; it has a lot of stores," replied Maryam. "Some neighborhoods might have only one. But a typical neighborhood does have a half dozen or dozen people who paint, or make quilts, or do pottery, or do something else. For them, these quarterly neighborhood gatherings are a huge opportunity to sell their products and acquire a reputation."

"And I'll be reading some of my poetry from the stage at 11:30," added Oskar. "I've even received poetry grants from the Ministry of Culture; I'm a professional poet. All the singers, jugglers, musicians, and actors on the stage this sol are from the neighborhood. It's a fantastic expansion of Marsian art and culture. And the experience will be useful when there are rehearsals for the North America Enclosure Festival in June. That'll last Frisol evening through Sunsol evening and will be quite an extravaganza."

"And expensive," said Joanna.

"The Festivals--there will be five of them--will require tickets," said Oskar. "The government subsidy will be smaller, as will the business donations."

"I think we'll find that we really need these neighborhood gatherings, and the large festivals," said Maryam. "There aren't many large cities on Earth that have a strong sense of civil pride and neighborhood identity, but we will! It'll change the feel of this place."

"I think you're right," said Joanna. "I recognize some of the people here from the restaurants and stores, but it'll be nice seeing their names on the name tags and talking with them. This place is safe, so there's no danger in having a conversation with a stranger."

"Exactly," said Oskar. He looked at Maryam. "We should go. We need to walk around here, then go visit several other neighborhood gatherings before I go on stage."

"Alright." Maryam rose and extended her hand. "Good to meet both of you."

"Thank you, good to meet you as well," said Joanna. "Ciao."

"Ciao!" Oskar and Maryan walked away. Lech looked at the booths. "Well, let's walk around. I see the Bahá'ís have a booth about virtues classes for kids, and the face painting looks like fun."

"It does. I see that young lady over there is setting up a booth for her glass sculptures. I'd like to see those."

"Then we'll stop there, too!"

Marshall was nervous as he entered the meeting room for the Saturn Commonwealth Council. The Council had six representatives from Titan, one from Enceladus, one from Rhea, and himself, the Chief Minister. They were all his friends; the Council had a close working relationship, and like his father, Marshall worked hard to keep it that way. As soon as he walked in, everyone rose and began to applaud.

"Oh, thank you," he replied, surprised.

"We're sorry you're leaving!" exclaimed Sydney Kilgore. "As you said at New Year's eve, it's been twelve years! Good years!"

"Very good years," added Tomas Racan, who had been on the Council as long as Marshall.

"Thanks, I appreciate your kindness. I have really enjoyed the challenges of working here, too. But twelve years is enough. My father retired after eight years as Chief Minister and I feel bad setting a precedent for twelve years. Healthy governments require turnover of the Council's memberships and of the top leadership."

"But what will you do on Mars?" asked Iris Geyer.

"I don't know. I can certainly serve as a consultant for the Mariner League and perhaps I can be added to the commissions coordinating the Pluto, Sedna, Makemake, or Helia expeditions. I am already the representative on the Mars Council for the Marsian residents of the Saturn Commonwealth and if I'm actually on Mars, I'll be more effective. I'd like to actually get to know Mi Sanda and the other people on Mars we actually interact with, plus the American, Chinese, European, and Indian ambassadors in Aurorae. So I can do quite a lot there supporting our priorities and the priorities of the outer solar system in general. Strong support from Aurorae may be the key for our continued growth out here."

"Mars has more or less committed to keep Phobos at 5% their total size, and Ceres at 1 perent," noted Guillaume van der Velde. "It's be good if we can manage a commitment to be one percent as large as Mars. Two percent would be even better."

"One percent is 2,690, and that's very close to where we are now," noted Gwanya Kwok. "Mars is growing so fast, it'll be hard to stay at one percent. That'd be an increase in our population by 1,200 next year!"

"But that might be possible," said Marshall. "As they switch the immigration to Mars to carriers, their corvets could be converted to passenger flights to the outer solar system. The speed is going up, too; if the new 5,000 second specific impulse gaseous core engine goes into production in another year, a one way trip to Saturn in 8 or 9 months will be possible." He sat in his chair at the head of the table. "Anyway, we have a fairly light agenda for this meeting. Cathedral South is about to start a new 100-meter section and plans for additional housing in the Titan-1 C-200 are ready for approval. All is moving forward on the Iapetus Drum also. We have a report about the new electoral system to consider, and I suggest we discuss when we will elect the next Chief Minister. I'll remain in office until March 1, but it would be helpful if my replacement is elected sooner--in the next few weeks--so I can assist with the transition."

"That makes sense," agreed Iris, and the others nodded.

"I have a report about the electoral system," said Tomas. "Guillaume, Sydney, and I will have the exact wording of the legislation ready for discussion in two weeks. We're taking the language approved by the Mars Council back in November and modifying it to fit our situation. Everyone has a flat in Cathedral. Some prefer to live in Titan-1 and only spend the weekends in Cathedral, but since everyone has a place in Cathedral, we can use it as the primary basis for creating three electoral neighborhoods. They'd be Cathedral Main, Cathedral East, and Cathedral West, of course. As soon as people live in Cathedral North and South, they'd be added to East and West respectively. As the population increases and the housing expands down the various tunnels, the boundaries can be adjusted."

"That's easy," added Guillaume. "All three electoral neighborhoods have natural locations to hold their own festivals and Future of Saturn forums."

"How strange, for us to be divided into three separate festivals," said Christine Niehaus.

"We could schedule them at different times, so everyone could attend all three," said Marshall. "On Mars, that won't work because Aurorae is so big, people need the chance to get to know people in their own neighborhood. But here, that's not an issue."

"Are we really going to make this change?" asked Oscar Pereira. "Because as big as Titan is, the population is not yet too large for people to get to know most of the really active people."

"I think we need to," replied Tomas. "This place was much closer-knit twelve years ago when the total population was less than a thousand. I remember. If we can get that feeling back, it'll strengthen the government immensely."

"I agree," said Sydney. "Maintaining a sense of community is essential for our success out here, a billion kilometers from anyone else."

"It's definitely more urgent on Mars than it is here," said Guillaume. "I remember what Mars was like when I was a kid. It was much, much closer place than it was when I left to fly here."

"But we do need it here," repeated Tomas.

"Yes, I agree," said Guillaume.

"I gather, then, that at this stage in the proposal, it has strong support by the Council? Right?" Marshall looked around the circle and one by one, everyone nodded. "Good."

"But we still have a long way to go," said Guillaume. "We need the exact legislation and the map of the new districts."

"You'll have them in two weeks," said Tomas.

“Good,” exclaimed Marshall. “My suggestion, for what it’s worth, is that we vote tonight to determine who the next Chief Minister will be, as of March 1. That’ll create a two-month transition.”

“It’ll also make you a lame duck,” said Christine.

“I suppose, but in two months we won’t pass any major legislation except the electoral reform bill, and that seems likely to move forward. If both the current and the incoming Chief Minister are in favor of something, that doesn’t make me a lame duck; it just means there are two votes in favor.”

“I think this is a generous offer by you,” said Sydney.

“Thank you.”

“How shall we vote?” asked Iris. “Adel and I will have to vote by email.”

We can send the votes to the Council’s AI,” said Marshall. “It can preserve all the votes and count them up.”

“What’s the name?” asked Guillaume.

“Tethys; like the moon,” said Marshall. “Are we ready to vote now? The Council has nine voters, so there needs to be at least five votes for someone to become the next Chief Minister.”

“I’m ready,” replied Sydney, and a chorus of voices expressed the same sentiment.

“Alright,” said Marshall. He pulled out his communicator, typed a connection to Tethys, and looked at the others. “Shall we have silence while we contemplate the vote?”

“Yes,” said Sydney. She closed her eyes as if to pray about her choice. Marshall smiled when he saw that and did the same; Bahá'ís always elected in an atmosphere of silence and prayer. He said a quick prayer, then turned to his communicator and typed in a name.

It took less than a minute. When everyone began to look up and look around the room, Marshall said “Tethys, has everyone voted?”

“Yes, all nine votes have been cast.”

“Did someone receive at least five votes?”

“Yes. Guillaume van der Velde received seven votes.”

Marshall smiled; Guillaume looked surprised. He reached over with his hand. “Good luck, Guillaume. I look forward to working with you to make the transition smooth.”

“Ah . . . thank you. I’ll need a week or two to transition someone else to my current position. I’m scheduled to teach our course on Saturn’s Rings starting next week!”

“We have plenty of time,” said Marshall.

18.

2.

New Plans

Feb. 2088

"Good morning, everyone," said Helmut as he entered the meeting room for the Cabinet. "Everyone says the first round of neighborhood festivals went quite well. What did everyone think?"

"Very successful and a lot of fun," agreed Crystal Kern, Minister of Space Exploration. "I'm in Liberty neighborhood and we had a grand time, with several musical groups including a cowboy band, square dancing, and lots of good food. I met quite a few people who lived near me."

"We had a good time in the Bolivar neighborhood in South America enclosure," agreed Lily Estrella. "I actually heard a lot of Spanish in the street, too! Most of the time, everyone just speaks English."

"I'm told that in 'China Town' in Cathay Enclosure, Chinese was the main language spoken," said Baozhi. "I live in the Southeast Australia 1 neighborhood, a very nondescript name for the place. Everyone speaks English, of course, and we only had one business in our neighborhood, so the festival was pretty low-key and ended early. But a committee formed to propose a name for the neighborhood, so that was good. I heard, also, that Phobos had 13 neighborhood meetings, but they spread them out over three sols so they could use the same social spaces. A lot of people attended more than one, which made it harder for the festival to form social bonds among the people of a particular electoral district."

"That was a problem in North America, too, I'd say," agreed Irit Goldberg. "Haudensaunee was closed and five neighborhood festivals were held at once along it, which

actually produced one continuous party. People walked along it and mixed. Next time, more of the festivals need to be moved to other intersections."

"I think that was a common problem," said Helmut. "Our enclosures were not designed to provide the social spaces for so many neighborhoods. But even so, people mingled with neighbors, socialized, and I gather some volunteer organizations were able to recruit, including the neighborhood associations."

"Most neighborhoods now have formal associations," added Rory Mayerovitch. "I've been looking at the names; they are a lot of new people who have not been active in civic affairs before. So that's good."

"It sounds like the electoral colleges will be exciting conferences," said Helmut. "So, what do we have? Irit, what reports do we have of the latest round of nuclear explosions?"

"They went well," Irit replied. "Three 50-gigaton events; the biggest ones we have set off, yet, three kilometers under the top of the permanent cap. All three blew craters 25 kilometers in diameter and 4 kilometers deep, which are now filled with boiling lakes of liquid water that should freeze over in another week or two, but will release heat for over a decade. We vaporized about 450 cubic kilometers of carbon dioxide, which will increase the atmospheric pressure by about four percent. We have now pushed it up 6.5%; quite a measurable amount in a decade."

"And at a rate that will continue to increase," said Helmut.

"Yes; three 50- or 60-gigaton explosions next spring will probably be our max, because the gale-force winds are extreme."

"We even felt the shaking here!" said Mi Sanda.

Irit nodded. "We did. The plan in subsequent years is to set off a second barrage of three or even four 100-gig blasts right before the southern autumnal equinox, after the dust storm

season is over, to release another pulse of gas and maintain higher temperatures as the sun sets and winter begins. We should be able to push up the atmospheric pressure by ten percent every annum and completely destroy the permanent caps in about ten or fifteen annums. That increase should be sufficient to generate the equivalent of an entire Martian atmosphere of outgassing from the regolith. It appears that by 2110 or so, the atmosphere will be about three times as dense as it is now."

"But we'll have the problem of the refreezing of the atmosphere every winter," said Baozhi. "It's time to start a solar mirror project. Phobos was the major producer of solar sails and can go back into that business very easily. With some technological development, they should be able to produce solar sails 10 kilometers across. Think what 100 of them could do! All they need to do is raise the wintertime temperature five degrees Celsius and the cap would continuously evaporate all by itself."

"That requires 500 to 1000 mirrors of the size you mention," said Helmut. "Still, Phobos could do it over a decade or two. Let's appoint a blue ribbon commission to review the most recent design study and make a recommendation. Baozhi and Crystal: can you put together a plan?"

"Yes," they both said at once. "This is very important," added Baozhi. "Phobos is now at a size where it can handle such a project; in fact, it needs such a project if it is to grow. A thousand people can create the necessary infrastructure of solar power systems and manufacturing plants in one annum to start turning out about four hundred square kilometers of solar sailing material per annum.That'd be five such mirrors. As efficiency grows and the plant expands, however, it'll soon be able to turn out ten or twenty such mirrors per year. If we can get

production up to fifty such mirrors, in ten annums we can produce five hundred of them, which will be enough to maintain the winter temperature minimum above the freezing point of CO2."

"Especially if we've turned out enough halocarbons by then," added Irit.

"Yes," agreed Baozhi. "It's quite exciting; we're getting very close to the point where we can tip Mars into a permanent estival. We can accelerate the project immensely with the proposed asteroid redirect project. I think you've all heard about the new report, which has identified three objects that can be steered onto a collision course with the north and south polar caps within the next twenty Earth years. Their average energy release is about 1,000 gigatons each; a truly immense number, and one capable of vaporizing the entire remaining cap and keeping it vaporized for over a decade."

"Yes, but there are a lot of problems," noted Crystal. "We can make 100-gigaton laser-triggered fusion bombs for maybe 10 million redbacks each, but redirecting an asteroid would cost a billion redbacks in gaseous core engines, plus the vehicle, the hydrogen, and continuous monitoring. There is a very small risk it'd miss the poles and endanger an outpost. Ideally, the incoming asteroid needs to be fragmented before it reaches Mars so that it produces dozens of smaller craters rather than one large one, and fragmentation is very unpredictable, so again an outpost could be endangered. And our bombs explode underground, releasing the heat there; impacts release it into the atmosphere, and a certain fraction of the atmosphere is actually blasted into space. Earth has gotten used to the idea that we can set off huge fusion devices, but asteroid redirect raises the idea of asteroids as weapons against terrestrial cities."

"Earth has gotten used to Marsian fusion bombs; it can get used to asteroid redicret," replied Baozhi. "Ultimately, redirection of Kuiper belt objects that are mostly water and other volatiles will be essential for terraforming Mars because this world has lost too much of its gas.

Gaseous core engines are getting cheaper, and this new design capable of a specific impulse of 5,000 seconds will make them more efficient than ever. The ability of Ceres to produce carriers full of hydrogen will get cheaper, too. For that matter, it may be feasible in thirty years to manufacture carriers a kilometer long and wide, send them to the Saturnian system via gravity assists, fill them with nitrogen from Titan's atmosphere--which masses 2,500 times more than Mars's!--and bring the nitrogen here, again mostly via gravity assists, to bulk up our atmosphere."

"That's theoretically possible, yes," agreed Crystal. "But a cubic kilometer of liquid nitrogen would add less than a billion tonnes of mass to an atmosphere of 25 trillion tonnes; in other words, an increase of less than one twenty-five thousandth. Not very practical."

Baozhi scowled at her. "We're talking about 22d or 23d century technology. Same with asteroid redirect; it's a project we can start now to gain experience for future decades."

"Well, we now have a report that baselines the idea," said Helmut. "Unlike siphoning off Titan's nitrogen, we have a technological scenario."

"Which at least opens a way forward."

"Yes, it does; eventually. Right now, let's focus on the manufacturing of solar mirrors, Baozhi."

He nodded.

"Anything else?" asked Helmut. "No? Then thank you, everyone, and let's get to work."

The cafeteria of Martech-Titan was crowded for lunch; it took Will Elliott a while to find his friends. As soon as he sat, Trey said to him, "So, will you help me convince Emin to come to Mars with us?"

Will sat and looked at Emin Mehmetoglu, who seemed to be amused. “I don’t know; what’s the issue?”

“My mom and sister are going back, but my dad’s staying here.”

“Oh; I’m sorry.”

“The split’s been coming for a long time.”

“What do you want to do?”

“I’ve become intrigued by chemical engineering. It’s amazing how many compounds we can make and how useful they can be. The Chemical Fabrication Department here can make 35,000 different substances and routinely make several thousand every year.”

Will took a bite of his sandwich and thought for a moment. “So, are you interested in making them, or discovering new ones to make?”

Emin stopped sipping his soup to think about that. “Well, up here the chemists have to do both. No one is a pure chemical researcher. Even on Mars, the chemists are doing practical work as well.”

“Practical, yes, but with a lot less drudge work,” commented Trey.

“The robots do most of that.”

“Most, but not all,” said Trey.

“I think there’s a different issue to consider,” said Will. “Your parents are going in different directions. Which one do you want to be with? And for how long? Where do you want to live?”

“Yeah,” said Emin, nodding. “That’s the big issue. I love them both and I’m close to them both.”

“Is your dad planning to stay here?”

"For now, yes. Of course, right now he's commander of the Rhea Outpost, so when mom leaves, I'll be alone on Titan, but I have plenty of friends, and besides, I'm an adult now and I can take care of myself! Dad has a girlfriend, but she's not sure she wants to stay. But they are sure they don't want to go back to Mars now, now that he's commander of Rhea, and besides, they don't want to be on the same ship as my mom."

Will nodded. "Tight quarters for a year. Understandable."

"Frankly, I'd like to leave this God forsaken iceball. The last few years have been rough at home and I'd like a clean break. But I'm not sure I want to be in tight quarters with my mom and sister for a year, either."

"You don't have to," said Trey. "The ships aren't full and there's a lot of room on board. Will and I are rooming together."

"You're going back, too?"

Will nodded. "I may be back in five or ten years; I don't know. But I want to explore the history department in Aurorae, and they have a great range of planetary science courses there, plus I can always take the Martech-Titan courses from there. I know the profs here already."

"That's true. Interesting point. Why history, Will?"

"Because I like it. I've started interviewing my grandparents there and the other old timers and they have an interesting story to tell. I just came across a newly published article about Marsian history written by a professor at the University of Kentucky in the United States and its interpretations are all wrong. It's rather shocking and quite neo-Marxist. Dr. Kersley and I are meeting morrowsol to discuss it."

"Are you going to trash it in print?" asked Trey, with a smile.

Will smiled. "Maybe I will."

"How are you going to finish up your semester, blasting off for Earth in the middle?" asked Emin.

"We'll go to class every day via live video," replied Trey. "By May 1 when classes end, we'll be 10 light-minutes away, so the time delay won't be too bad. When the fall semester begins, we'll be about halfway to Mars and about 45 light-minutes from both, which will be a pain."

"There's an MIT student in my Saturn Atmospheric Physics course and he's 90 light minutes away, but he records his questions and they're played at the beginning of the next class," said Emin. "I suppose at the end of the fall semester you'll be closer to 20 light minutes from Mars."

"Yeah, not too bad," said Will. "I'm taking three or four classes on board the ship, too, because there are about 70 Ph.D.s heading back to Mars!"

"And thirty of us kids," added Trey. "We'll have a Martech campus all to ourselves! Marshall Elliott's teaching a 'Topics in Planetary Science' seminar where we can all research and present our own topics. There will be a lot of seminars of that sort. The voyage will be pretty boring otherwise."

"My dad's planning to do a lot of writing and my mom has a book to finish," added Will. "My sister Millie will have special 9th grade classes all summer. There will be all sorts of music lessons and music courses available, too. I may take a keyboard course."

"They're still working out what will be available," added Trey. "People are still signing up to head back and we'll be in school until May, anyway, so there's time to work out who can teach what and who wants to take what. But it looks like we can accelerate our schooling and get as many as ten courses finished over the summer and fall."

"Oh, that's impressive," said Emin. "And you say I can get my own room?"

"Of course! Saturn-7 consists of three galleons docked together. They brought 500 people here and are returning to Mars with 120 people. We'll be rattling around in all that space!"

"Plus there's a zero-gee gym," added Will. "We'll learn how to play striker."

"Interesting," said Emin. "I'll talk to dad about that tonight. Maybe I'll go back after all."

"I'm afraid your plans to reshuffle a lot of the leadership has increased the number of people leaving on Saturn-7," Marshall said to Guillaume, as the latter walked into his office.

"Well, I want my own team in place." Van der Velde sounded a bit defensive.

Marshall nodded. "That makes sense. We need some turnover to stay fresh. Come, sit down." Marshall moved out from behind his desk and they sat in comfortable chairs facing each other. "Sydney was ready to resume full-time research on the Saturnian atmosphere anyway; they have wanted to rotate the directorship for some time."

"I think that's true of most of the positions I'm reshuffling. But as you said, you really can't reshuffle yourself very easily when you're Chief Minister."

"You can't; you'd be tempted constantly to comment on your successor's decisions. So, what are your plans? You've had a month to think about your administration."

"I have some plans developing." Guillaume considered. "One thing we never did with Cathedral is establish different climates; it's all warm all the time. But Uranus has two climatic zones in Avalon and that has proved popular, and now Neptune is thinking of doing the same. I asked Sydney and her atmospheric team to make a different kind of model; one of the air in Cathedral. They suggested a fifty meter high building disguised as a hill across the front of Cathedral North. One side of it could even have windows and be residential, but the other side

would just be a hill, and on the north side it could have sledding and maybe even skiing in the winter--"

"Have you ever skied?" asked Marshall. "I did one winter in New England. You can't do much on a 50-meter hill, even in terrestrial gravity!"

"I see. Well, we could make it higher; a lot higher, since Cathedral is 150 meters tall. Anyway, the idea is to separate Cathedral North from the rest of the tunnel system with a tall building/hill, possibly with a transparent barrier above, and start a standard set of seasons. People wanting to live in the 'temperate zone' could walk through tunnels to avoid the cold and ice if they desired. A building 50 meters high, 100 meters long, and 200 meters wide could hold a lot of agriculture. We could do something similar with Cathedral South; perhaps a monsoon climate."

"That's a good idea. If Cathedral North's floor were at different levels, also, there could be different minimum temperatures and various microclimates. I like that idea."

"We'll have to hold hearings, but this is the time. Saturn-8 leaves Mars next month with 800 people; two corvets! It looks like immigration is reaching a higher number."

"And what will we do with them?"

"I've been thinking about that, too. There were good reasons to settle Titan--big, an atmosphere, fascinating inorganic chemistry, geothermal energy and wind power. There were good reasons to settle Enceladus; we need an outpost toserve as our interplanetary spaceport, it has low gravity and it has geothermal power. Rhea has less of a justification; it is the second largest moon in the system and has wisps of geothermal energy that we may be able to start using in 2 years. Beyond that, justification for permanent outposts is less clear. What probably makes more sense is a mobile outpost; a 50-meter drum able to house and feed 50 to 100 people, with a

solid-core nuclear engine on top attached to two power reactors and a series of chemical rocket engines around the sides or on the bottom. It could go to Iapetus for a year or two, fly back to Enceladus for personnel turnover, then fly to the rings to visit various moonlets there for five or ten years, receiving new personnel every six months or so. If we had two or three of them hopping from moon to moon, visiting one of the inner moons every few years when new geological questions arise, we'd maintain a very robust exploration program without isolating our population in lots of small moon outposts."

"And each one would be considered a borough?"

"Yes. It could have a permanent population and a rotating population."

Marshall nodded. "I like that idea. What about the outer moons?"

"We're still counting them! I could see a mission to Albiorix or Siarnaq to characterize the Gallic or Inuit families, but the rest need automated rovers. So far, they appear to be from all over the outer solar system, so there's a lot of work to do to study them. If one is particularly interesting, yes, we'd visit it."

"Those are good plans."

"We also need to expand our study of Saturn itself. The new drop sondes will have much tougher shells and should make it several hundred kilometers before they're crushed. The aerostat needs new radar and ultrasound equipment. The new field of atmospheric seismology holds a lot of promise for studying the interior. There's *so much* we can do. If we grow to 5,000 or even 10,000--which is possible in the next 10 to 15 years--we'll be a stable, permanent community. No need for people to retire to Mars."

"I agree, and you can count on me to push the point in the Mars Council."

"Marshall, I'd like to appoint you Ambassador to Mars for the Saturn Commonwealth. What do you think?"

"Hum." He considered. "That may be possible. I'd probably have to resign from the Mars Legislative Council, though, and it may preclude me from holding any Marsian government positions, such as a government minister or President of Martech. Let's think about that for a while, Guillaume. Either way, I'll be a strong advocate for Saturn."

Guillaume nodded, obviously disappointed. "Alright."

"Why does he always call when we have to leave?" said Changying, looking at her communicator.

"Who?"

"Nick McDonald."

Ted glanced at the clock on the wall. "We have time. Let's listen."

Changying nodded and pushed play. Nick's face appeared on a wall screen nearby. "Good sol, Changying and Ted. Thought I'd send you another quick update; learnings for the Helia project, I hope. All is well; in fact, morale is up. We're getting some interesting flyby data from the first probe we launched, which just passed Chiron last week. Our geologists are in heaven; they have an entire little world to map, detailed reflection and absorption spectra, radar, and over a thousand laser strikes that provide detailed compositional data. That'll keep them busy a year at least, at which point our second probe will be passing an obscure centaur just past the orbit of Neptune. After that, we'll be getting data from one flyby probe or another every six months and we'll be extremely busy. You guys will definitely want to have a dozen or more probes with you

to study Kuiper belt objects, not to mention Helia's various planets and asteroids, as the latter are found and cataloged.

"Now that Sedna 1 is finished, we are working on Sedna 2, which was our C-100 hydrogen tank for the departure burn. After a long debate we have agreed to set it up as a temperate climate space, with a 120-sol summer, 30-sol spring and fall, and a 30-sol winter. Some people actually want to move in, as long as their housing is located against the Sedna-1 bulkhead so they can walk to the latter without dealing with winter weather. The temperate climate zone underdecks in Sedna 1 will be shrunk in size and partially converted to regular food production, but we have to be careful because if we store too much food against emergencies, we will deplete our supply of CO2, nitrogen, and water. Another lesson for Helia: bring plenty of volatiles.

"Finally, the 'sludge' problem is still not solved, even with the fancy recycling equipment we have brought along. Chlorine, for example, is disappearing; the amount of salt that goes into our food and ultimately into our waste water stream is larger than the amount of salt we are recovering. We're recovering most of the sodium, but not the chlorine, and we still haven't figured out where it is accumulating; maybe it's reacting with organics in the soil in the ag units. Pluto reports a similar problem. Iodine is also disappearing, and manganese. Our chemists are writing up a detailed report for Martech and they are establishing a task force to investigate. This might be a big problem for you over 30 years. We're also going through our supply of computer chips faster than predicted, and a minor outbreak of a flu-like illness has defied our effort to determine the cause. Lots to worry about on a long voyage, but we are managing pretty well.

"Best wishes with your work; I admire your passion. Keep in touch. Ciao."

"Interesting," said Ted. "It sounds like the sludge problem is less than it was for the Seron, though. They were running through supplies of lots of elements much quicker than expected. They couldn't even recycle all the sodium!"

"I'll look forward to reading those reports," said Changying. "There must be a thousand ways a closed-cycle ecology can collapse after 30 years, and we haven't even identified them all yet, let alone solved them."

"Let alone having two or three solutions for each problem." He put his arm around her back. "You worry too much."

"I have to, and now I have even more reasons to worry. Shall we reply?"

"No, later. You'll want to spill our little secret."

They closed up their office and headed to Lech and Joanna's flat, which was right across New York Circle from the headquarters of the Helia Project. Ted's parents were already there and the robotic food delivery had just delivered their souvlaki with rice and vegetables.

"So, what's new?" asked Ted, as they sat.

"We're working on the funding package for B-75s, but it's all screwed up," replied Lech, frustrated. "Marfab plans to make 100 of them because of the efficiency of scale that produces, but so far there are commitments to purchase only 23 of them! Not enough people are willing to consider agriculture as a career, partly because of the uncertainty over future production. Agmar doesn't want any at all because they want to farm up to two levels under the Africa and Asia Enclosures. That's 28 million square meters, which can feed nearly 500,000 people, which is far more than we'll need for several annums. But their commitment has caused other problems. Margen can't provide the necessary electricity to light the underground agriculture--10 million kilowatts, about the power demand of New York City!--and Marbuild is scrambling to figure out

how to remove the heat so the ag levels don't cook themselves. The money the cooling units will require and the lessened demand for surface agriculture means the construction of Demeter-1 and 2 can be delayed, unless the power can't be provided on time. The bank is caught in the tug-o-war over funding!"

"It sounds like a mess Helmut has to step into," said Changying.

"There's a big meeting scheduled for Frisol with him and all the relevant parties. Everyone is bringing their cost estimates. Meanwhile, small business is likely, again, to lose out, because it can't always have the efficiency of large operations."

"Maybe we can now afford a bit less efficiency," said Ted.

"Especially if all the costs are considered, such as the system for extracting nitrogen and argon from the atmosphere," said Changying. "So, mom, how's school?"

Joanna smiled; she always liked it when Changying called her "mom." "About the same, but I have a new project. The school district has asked three of us who are recent arrivals and senior citizens to put together a course about Earth culture. They don't want the young arrivals to do it; they don't have enough experience. We'll do most of the work over the summer. They want the committee to grow and include people from at least six different regions of the world, and we're supposed to work with Martech's academics as well."

"That sounds like fun!" said Ted. "It's a big responsibility!"

"Yes, it is; we're excited. They also want us to meet with recently arrived teenagers; they have assembled a list of 100 of them. Capturing their reactions to the change in culture when they arrived will be part of the curriculum. The kids here have a lot of trouble understanding Earth and we're hoping the class can explain it to them."

"That's a really cool assignment," said Changying.

"What about the two of you?" asked Lech. "How are the plans to go to Phobos for two weeks?"

"Canceled," replied Ted, and he smiled. He looked at Changying.

She smiled back. "I can't be flying for a while. I'm pregnant."

"Oh, you are!" squealed Joanna. She reached over and hugged Changying.

"Congratulations!" exclaimed Lech. "What fantastic news! And it didn't take long!"

"No; I guess we're not radiation damaged!" replied Ted. 'We're thrilled."

"The baby is due at the beginning of October," said Changying. "That means when we leave for Helia--if we leave for Helia--he or she will be eleven."

"That's probably a good age. Any older and they will feel torn from their friends and the life they've come to know," said Joanna.

"They'll be about 41 when we arrive at Helia," said Ted. 'That's a sobering thought."

"Assuming we make it," added Changying. "I've already been worrying enough about the voyage to have trouble sleeping at night. Now that can only get worse."

"You'll do fine," said Lech. "I am amazed at the work the two of you are putting into the project. You're becoming experts about every detail!"

"We have to," replied Changying. "It's the only way we can ask the right questions to the real experts."

"And now you'll start a family of your own," said Joanna. "Be sure that you can count on us.'

"I know, Joanna, and thank you," said Changying. "But if there's a time to pour time and energy into a child, it's the next few years while work on the project is at a fairly low level. By the time the kid is five or six, the intense work will begin."

"I'm sure it will all work out fine," said Joanna. "This is something you need to do for yourselves and for your marriage. It will bring you great blessings. Believe me."

Changying nodded. "I believe you."

Helmut could tell that the meeting would be tense as the various stakeholders arrived, nodded nervously at each other, and did not speak: Festus Rattigan, the Director of Margen, the semipublic agency responsible for producing Mars's electricity and methane; Henry Smith, Director of the Marsian Chamber of Commerce; Ramesh Prathan, Director of Marbuild, responsible for doming over portions of the Martian surface and converting Martian range into Marsian polder; and Tina Jain, Director of Agmar, the semi-public company that grew most of Mars's food. Helmut looked at Rory and Zhang Baozhi for a bit of encouragement. "Alright, let's get started. Baozhi will review our projected population increase, because that determines food supply."

"Thanks, Helmut." Baozhi pressed an icon and a population projection chart appeared on the wall screen. "The time has come to make reliable population projections long term; in other words, plan immigration farther in advance. We are assuming that we will add one C-200 and 60,000 immigrants every columbiad for the next four columbiads, that is, 2089, 2091, 2093, and 2095. Thus, immigration will be 122,000, 180,000, 250,000, and 310,000 for each of those columbiads. Currently demographics predict that each arriving group increases its numbers by about 30% every columbiad for three columbiads; thus we are projecting 50,000 children born from 2087 to 2089, then 70,000, 130,000, and 165,000. This means the Marsian population will grow from 269,000 at the beginning of last year to 441,000 by early 2089, 691,000 by 2091, 1.07 million by 2093, and 1.55 million by 2095." He paused so that everyone could gasp and then

contemplate the numbers. “Note that in 2093, the population increase from about a million to about a million and a half is a 50% increase, whereas in 2089 the increase is 64%, so the increases should become more and more manageable, even if they are unimaginably huge by our current standards. We’re talking about seven years from now.”

“So we have to get real about the problem we face,” continued Helmut. “Based on current standards of 200 square meters of polder per person, we’ll need 300 million square meters inside domes, 6 times as much as we have today. If the domes soar 1,000 meters above the ground--even 100 meters--the quantity of nitrogen and argon we’ll need to extract from the atmosphere is enormous. If they are all shielded by three meters of water built into the dome, we’re talking about 900 million tonnes of water. On the other hand, if we build underground agriculture, the current high-efficiency farms need only 60 square meters per person, but they require about 30 kilowatts per person; so to feed 1.25 million more people, we’d need 37 million kilowatts of power production, and all of that will become heat that has to be expelled into the exterior. Can we do it? Yes, of course. Is there a cheaper way? I am sure there is.”

“The sort of power production you're talking about, Helmut, will make other things possible as well,” noted Festus. “For example, if we had 5 million kilowatts available for production of halocarbons, we can raise the average surface temperature by 10 degrees Celsius in twenty years.”

“I know, Festus. But it’ll be easier to provide Thaumasia and Tithonium 5 million kilowatts if we aren’t producing 37 million for agriculture, and it’ll be cheaper as well.”

“So, you want cheaper, lower agricultural domes?” asked Ramesh. “We can do that. But you can’t provide all the food a person needs on 60 square meters; more like 80.”

"I know, because sunlight is partially blocked by dust storms or is seasonally low. If we use the sunlight we have and supplement it with lights, the 37 million kilowatts of increased power drops to maybe 10 million."

"But it'll be needed precisely when dust storms reduce solar power," objected Festus.

"If the agriculture were all underground, electricity would have to supply 100 percent of the light during dust storms. If the agriculture is on the surface, you only have to supply fifty percent. It's still better."

"We still have a huge standard of 200 square meters per person, though," said Ramesh.

Helmut shook his head. "That standard made sense when we were small. We needed big open spaces. But cities typically have 10 or 15 square meters of park area per person. With our huge domes, we can grow upward a lot more than three stories. Once Africa and Asia and the equivalent large spaces in the other outposts are finished, we'll have enough large dome space to accommodate the housing and work space for 1.5 million people, if we were to fill them with people. I think we should lower the per-person standard to 50 square meters of non-agricultural space and 75 square meters of food production space and plan accordingly. The food production space does not need high domes or water shielding. We may want to design some of them with high domes so that they can become residential in the future, but the shielding would be added later."

"So, are you proposing a lot of B-75s? Because they require intensive use of electricity if you fill them," said Tina. "They're also too small to automate as fully as we would like."

Helmut nodded to Rory. "We don't think they're the perfect solution, either," said Rory. "I've spent quite a bit of time, over the last few weeks, talking to engineers at Martech. Our domes are made out of complex plastic sheeting that can withstand Marsian standard pressure

and that is extruded in sheets 30 meters wide and as long as we want them to be. If you've ever seen the extruding machine, you know it's a bit over 10 meters in diameter and the sheet it extrudes is shaped like ¾ of a circle. The sheet is then laid flat to cool and taken to the enclosure, where it is knitted to the rest of the dome. But if we knit the sides together at the production site, we'd have a tube 10 meters in diameter and as long as we want it to be, and it is extremely cheap to make. Knit the ends together around an airlock, install it outside in a metal cradle for it to rest in, add a floor 10 meters wide with soil at the mid level, and you'd have a very cheap greenhouse for growing anything. Add reflectors to double the sunlight in the morning and afternoon, and you'd have plenty of light. They can be designed with water tanks or even rocks in the sublevel to store extra heat during the day that will radiate away at night, so there is a minimal thermal regulation problem."

"My brother tells me he has people who want to build houses in the sublevels of his B-75s," added Helmut. "I suspect one could even sell the space for cheap housing! Or one could install additional agricultural levels and light them electrically if the power is available, which might be the case when the atmosphere is clear. Sell the power more cheaply then, with a contract that it'll be cut off or will triple in cost during dust storm season."

There was silence as everyone contemplated the proposal. "It'll be rather ugly," said Ramesh, and Festus nodded.

"Ramesh, not everything has to have a soaring dome tall enough for the Empire State Building," replied Helmut. "We have plenty of height already for a very large city. What we need now is breadth. Each square meter inside your soaring domes costs at least 250 redbacks per square meter. A 'sausage' greenhouse 200 meters long and 10 wide, 2,000 square meters, including the metal floor and the reflectors, can be made for 300,000 redbacks; 150 redbacks per

square meter. I suspect you can make large agricultural enclosures for about that. We need them as well."

"Correct," said Ramesh.

"Agmar prefers large enclosures," reiterated Tina.

"I know, but I think you can adopt your robotic techniques to the sausage greenhouses quite well," replied Helmut. "As for ugliness, I remember when I came here, we had greenhouses of all sorts of sizes. I suspect some of them are still used. There's nothing wrong with covering the desert with lines of greenhouses. It's cheaper than the alternatives."

"We still need underground agriculture for the next columbiad," warned Tina.

"We have to complete the existing plans for the upcoming columbiad, but we hope to be making greenhouses by the end of this year," replied Helmut. "And we plan to recommend to Marbank about the funds to provide for greenhouses, B-75s, and domes. We'll also propose new area standards for residential and agricultural use."

"That'll have to go to the Mars Council," noted Tina.

"Correct."

"With this population projection, we'll need a whole new urban plan," said Ramesh. "It means that Aurorae will grow to about 750,000 people over seven years.."

"Now you're talking, Ramesh!"

"The plan to add a C-200 every columbiad seems simple and prudent," said Baozhi. "It'll keep Phobos and Ceres very busy with a routine task they will get more efficient at over time."

"Just don't switch to C-300s," exclaimed Henry. "They'd accommodate what? One hundred twenty thousand?"

"Probably 150,000," replied Helmut. "We don't know; there's no official design. What we have now is a plan to expand the population logically and routinely. What we need is a plan here, on the ground, to accommodate them all. The mix of high domes, low domes, and greenhouses still has to be determined. Don't worry, Ramesh, you won't be confined to just low domes from now on. Baozhi is pulling together a planning commission and we want all of you on it, or someone you nominate, plus a dozen other experts. We need a plan to grow Mars to 1.5 million people by 2095, and we need the basic outline in six months."

"This is much bigger than the problem we thought we would be discussing this sol, then," said Tina.

"And we now know when Mars will have a million people; 2093!" added Ramesh.

"Continue the projection forward and you reach over 2.5 million by 2100," said Helmut. "If we freeze immigration at half million per columbiad, Mars will have over 100 million people by 2200. That's where we're going. Any questions?"

There were none; people were still contemplating the information. "Excellent, because I have an important family matter. If you want to discuss the matter further, Baozhi and Rory will stay."

"Thank you, Chief Minister Helmut," everyone replied. Helmut nodded in thanks, rose, and hurried out of the room. He pulled out his communicator and called Clara. "Any news?"

"Yes, Oskar and Maryam and the baby are on their way over right now."

"Great, I'll be right there." He hung up. "Geena, please call me a private taxi for Australia Enclosure. I'm heading for the Andalus transportation center right now."

"It's on the way," replied his AI.

Helmut hurried across Andalus Square and down into the transportation center underneath. A robotic taxi pulled right up next to him and he hopped in. In a few minutes he exited the Transportation Center in Australia Enclosure and hurried home. Everyone was gathering: Sebastian, Clara, Kristof, his wife Irma, his daughter Nicola, her daughter Nina, Maryam's mother Nadia, Charlie, Sirikit, Andrew, Angela, plus the proud parents and their newborn. Helmut hurried right over and Maryam offered him the little boy.

"Welcome to the world, little Ruhi," he said, hugging the baby to his bosom. "He's beautiful."

"Three point 6 kilos at birth," said Oskar.

"And how are you doing?" asked Helmut to Maryam.

She smiled. "Exhausted and sore, but I'm recovering."

"Good. He looked to his father, still sitting in his electric wheelchair. "So, another great grandchild."

"I'm not sure I'll make it to the next one!"

They all laughed. Helmut looked at his new grandson. "What a world you'll see," he said.

3.

Departures

March 2088

“Thanks for coming outside with me,” said Trey, as he and Will stepped outside the Observatory in their cryosuits.

“Sure. I thought you were accompanying me, actually. I wanted one more look at our icy-orange world.”

They headed up East Summit trail. ‘I’m going to miss this place.”

“I will, too. Do you think you’ll ever be back?”

“I don’t know. It'd be easy to say ‘yes, of course, I love this place.’ But life can take unexpected turns.”

“Yes, we’ll fall in love with Mars.”

“Or a woman who doesn’t want to come here! Do you think you’ll ever be back?”

Will considered. “If I become a geologist, fifty-fifty. If I become a historian, probably not.”

They reached a particularly steep stretch of the trail. “Did I ever tell you that I made this stretch of trail?” said Trey. “It was last summer, just before the Observatory opened, and they were building the trail. They let me use the roaster on the ground, here.”

Will looked down at the black, concrete-hard trail surface. A roaster had an oxygen tank and sucked in air--which had methane in it--to blast a flame against the ground, thereby melting the ice and reducing the tholin to carbon. “Looks like you did a really good job. The slab must be ten centimeters thick!”

"They said I worked too slowly and made it twice as thick as it had to be, but they weren't upset."

"The carbon black gives a good grip!"

"Say, did you hear Cam has decided to come to Mars?" asked Trey.

"Yes, he told me last night at the going away party. And Isis got cold feet and is staying."

"I suspected she would. I'm glad Emin's coming, though I don't know why our room had to become a triple. There's plenty of space on board."

"Maybe we can move around after trans-Mars injection. I suspect his dad had something to do with it." Will knew Adel had called his dad and asked him to watch out for Emin.

"I bet he doesn't want Emin in a room by himself."

"Brian told me last night that he hasn't been able to sleep, thinking about leaving."

"Well, he's in love with Isis! So much for that relationship."

"They've been chums since kindergarten," noted Will.

"Puppy love. I'm looking forward to meeting some women who don't feel like sisters."

Will chuckled; all the kids on Titan had known each other since birth. "Me, too. Martech's Freshman class has 400 kids! And we've met a few of them online."

"Marsians and mariners; we're an interesting bunch," said Trey. He hurried up the last thirty meters of the trail until it reached the top of East Summit, where he stopped to gaze at the view to the east, down Teays Canyon toward Acheron Flumina and the dunes and the methane playa lakes of the lowlands beyond.

"You can just about see Saturn," said Will, pointing to a fuzzy blog in the hazy orange sky.

"I'll miss that, too." Trey stared at the brightened patch of haze. "So--are you scared about going?"

"Scared? No!"

"Well, I am." He paused. "This place is all I've ever known; well, Titan and Enceladus. Mars is a big, different place."

"Well, *Earth* is a big, different place. Mars is small and a bit different."

"You know what I mean. Compared to Titan, Mars is big and different."

"And we don't know what faces us there. That's the real unknown."

"Yes. That doesn't scare you?"

"No; I accept it, I guess. And I suppose I trust it."

"You've always been open to what comes your way. I worry about it."

"And I'm going back to Mars with my entire family, where I have grandparents and cousins. You're going back by yourself, where you have no family. I think that's pretty brave."

"Dad and mom say they'll return to Mars in two years when Daisy graduates high school. That's the plan, anyway. I didn't want to stay here for college, then have them leave. I'd have to do grad school here, and I'm not sure I want to do that, and besides, I'd be graduating with my undergraduate degree while en route to Mars!"

"That would be a bummer. But look, you're always welcome to hang out with my family. I suspect mom and dad will be helping all of us. And there are thirty of us going back! We'll take care of each other. And it's not like Mars is a dangerous place. It's a great place. I think we'll all have a great time together."

"I wonder whether we can all be placed in the same dorm together."

"We can ask. We're all on the same galleon together. Dad's calling it 'Marthech-Interplanetary.'"

Trey chuckled. "What does your dad think of Guillaume's ideas? The inauguration speech went over quite well."

"I think so, too, and so does dad. It was nice of Guillaume to ask him to give the send-off speech for the Iapetus Outpost. They depart two sols before we do."

"What's your dad going to do, now that he's out of office?"

Will shrugged. "He doesn't know, and he isn't worried about it. He wants to rest and think for a while."

"Well, he's got a year!"

"Exactly, the flight will be a chance to take a long vacation. And then . . ." Will shrugged. "We'll see. He doesn't seem to be worried about it. It's not like he's searching the Marsian job websites!"

"Trey chuckled. "No, I suppose he wouldn't do that. And how's your exploration of history going?"

"I'm . . . leaning toward it. Dr. Kersley is helping me write a response to that crazy paper about the rise of Marsian democracy, and my grandfather has been writing a lot of stuff and sending it to me about the period. Actually, I think he's sending me pages from his unpublished memoirs. I'll finish it up on the flight. I've decided if I publish it, I'll use the name 'Bill Elliott.'"

"Bill? No one calls you Bill!"

"I know, but once we're on the flight to Mars, I'm going to ask everyone to call me 'Bill' instead of 'Will.' My grandfather is Will Elliott and I don't want to be confused with him, not as a historian, and not once I'm on Mars where everyone knows him."

"Bill. . . that's going to be hard to get used to!"

"Well, you can continue to call me Will if you want."

"What about the older people who call you 'Willie'?"

He shook his head. "No way! I'm an adult now; that's going to stop. But I doubt my mother will change."

"No, probably not."

Changying was late to the office because of morning sickness. Ted went in early to open things up and answer communications and she arrived about 11 a.m. Her first communication was with Nick McDonald. "Sorry I'm late, but the morning sickness is beginning to hit me hard," she began. She had told Nick about the pregnancy the next sol after they had told Lech and Joanna, some two weeks earlier. "Thanks for letting us know about the recommendations from Martech's space exploration team about ecological balances and stored food reserves. They seem to have hit on an optimum solution, though it involves an awful lot of dried food! But I suppose that's the best way to maintain the maximum flow of essentials through the ecosystem. We'll file it away for future reference. Ciao." She turned to Ted. 'Did you see the report?"

"Yes; I skimmed it, knowing you'd read it in detail."

"I did indeed. But I think we'll need a different approach, if we modify the initial demographic profile."

"Yes; more initial children will change the calculations. Did you listen to Yuri Severin's videomail?"

"No, I'll listen to that now." She glanced at the screen and pushed on the icon for his videomail. At age 75, Yuri was one of Mars's old veterans; the Russian had been commander of

Mercury station for a while, had headed Uzboi outpost, and then had been the commander of Saturn-1 and Saturn's first elected Chief Minister. He was now in retirement in Aurorae and occasionally stopped by to chat. His face popped up on the screen.

"Good sol, Ted and Changying. Thank you for sending me your proposal for greater demographic diversity of Helia at launch. I agree with you completely and think you need to go even farther than you have. Launching a crew that is 90% in their late twenties and early thirties does generate some problems. First of all, they'll all start their families more or less at once; on Saturn-1, literally a quarter of our personnel were busy with babies when we arrived! You won't have that, but you will have the subsequent problems of suddenly having to provide them all kindergarten, or first grade, or high school. It requires a constant reshuffling of human resources. Smoothing out that demographic bulge is important. Furthermore, when so many personnel are all in the same cohort, they all expect promotions and such at the same time. You will be better off with some kids that have just finished college and aren't even married yet, and some people in their late thirties and forties who have brought children along, even teenagers. And don't try to avoid couples who have decided to be childless or singles who aren't planning to marry or start families. They might be able to adopt, if that becomes necessary, and they'll be able to devote more time to the expedition than parents.

"I'd even advise that you include people in their 50s and 60s who might not make it all the way to Helia. Their passing will open the way for others to be promoted, and every community needs grandparents. It's part of the cogwheeling of the generations. So if you are aiming to recruit 1,800 adults and have a population that will build to 3,350, I wouldn't hesitate to include 100 or more unmarried or older people and 500 or so children. If your vehicle is

designed to support that many in year 30, it should be able to support them in year 1 or year 10 as well.

"I hope that helps! See you soon. Ciao."

"That does help," said Changying, looking at Ted.

"I agree. We should ask Nick about that."

"I'll plan to, but he has mentioned the baby boom going on and the problems that's causing." She turned to other emails, videomails, and reports that had arrived, and within an hour there was another message from Nick. "He couldn't have gotten my videomail yet."

"This must be separate. Play it." Ted walked over to watch; he always enjoyed Nick's messages.

The wall screen flickered and Nick McDonald's face appeared on the screen. "Good sol! I thought I'd sent you guys a personal message, completely separate from the technical reports and concerns we've been exchanging lately.

"Maggie and I were delighted to hear that you guys are pregnant. Your earlier hesitation reflected our hesitation as well, and we've enjoyed the little bulletins about your ups and downs. We had always vowed we wouldn't have children; our careers were more important, as was our passion for exploration. We almost decided to settle down with a family about ten years ago when we were passed over for major positions in Neptune 1 and Neptune 2--that was a big disappointment--but we were rewarded, as it were, with this assignment instead.

"But now that we're on our way and things are quiet--or at least routine--we've been rethinking our plans, in spite of the fact that we are both 49 years old. We have stored frozen embryos from twenty years ago, when we first arrived on Mars, and they're on board with us, so I think we'll give family life a try! We're not telling anyone else--certainly not our parents--but

you guys are special and we've really appreciated your more personal communications. And we have to tell someone, so you get to hear it! But don't tell anyone, of course. We'll see how it goes, and I'll let you know! Ciao."

"Wow!" said Ted. "That's amazing!"

"They're starting late, but we would have been almost that old, if we had waited until the flight began. I'm glad they're not waiting."

The Enceladus C-100 had a unique design. First, because the moon had 1% gravity, the "down" end of the cylinder was usable, so it was a big parabolic bowl with a central opening for the elevator connecting it to the moon, surrounded by a sloping, grassy expanse for theater and art productions, followed by "Enceladus Circle," a plaza with tables where everyone could sit and eat together. Second, the outpost only had 500 people, so their housing, work spaces, and horticulture were crowded around the parabolic bowl, leaving 70 meters of the 100 meters largely undeveloped, so it had a soccer field, a pond all the way around the circumference, grassy areas, flower and vegetable beds, and a forest/orchard of fruit and nut trees. Enceladus was anticipating exporting produce to Titan at some point, including fine wood.

Enceladus Circle was unusually crowded that sol, with the 50 departing members of the Iapetus Outpost, the 123 passengers heading for Mars, and the entire population of the outpost. As soon as the dinner was finished, Iris Geyer, the CEO of the borough, rose and introduced Marshall Elliott. He walked carefully to the podium near the elevator through its rapidly decreasing gravity. He had to wait for the powerful applause to subside. "Thank you, everyone. I very much appreciate your kind demnstratin of respect for me and the accomplishments I was able to oversee over the last welve years. We--you--achieved a lot for the development of the

Saturn Commonwealth. We have laid a solid foundation for growth. If the rumors about the growth of Mars over the next seven years are correct, I think we can expect Saturn to at least double to 5,000 people in the next six years."

That generated applause. "That foundation for growth experiences two milestones over a few short sols. Most important, Saturn-8 left Mars last week; two corvets and 800 people, the largest immigration wave ever, and a fairly young immigration wave, one which will probably produce 500 or 600 children over the next few years. That fact alone tells you that we'll probably hit 5,000 by 2094, and we may reach 10,000 by the beginning of the new century.

"The second milestone, obviously, is this mission to Iapetus, departing morrowsol, which will explore the geological history of that fascinating world in depth, study the equatorial ridge in detail, and gather more information on the formation of the crater Nevelon and the apparent extra-solar origin of its impactor. With it, Saturn Commonwealth moves to having a fourth outpost. We remain the largest outer-system community, and the one with the most outposts. We now have a vigorous program of planetary geology. Chief Minister Guillaume plans to send out a migratory 'Ring Outpost,' a C-50 drum in two years that will visit the moons and moonlets making up the ring system. A similar migratory base is being planned for the surface of Titan. As our population grows, our ability to do science here will continue to expand.

"And then there's the departure of Saturn-7 in seven sols, which isn't a milestone in itself, but presents us with an important lesson. The 120 people returning to Mars were here twenty years and represent only a quarter of the original arrivals. At least half are planning to stay permanently, and as the Commonwealth gets bigger, the percent who plan to stay--who will want to stay--can only grow larger. Mars used to lose ten to twenty percent of its arrivals after a few years because people made temporary commitments. Now, such temporary plans are

unusual. We will see the same here. Indeed, I think we will see people coming back in the future. I hope to do that myself. Until then I say to all of you: farewell. Set goals, move forward to accomplish them, and above all else, develop a distinctive culture and civilization. Become another distinct home for humanity. If we do that, people will want to come, we will grow, and our contribution to the human story will only become more important. Thank you."

Marshall returned to his seat to a standing ovation. Iris Geyer returned to the podium. "Thank you, former Chief Minister Marshall. Our gratitude to your wise and careful leadership for twelve years cannot be expressed in words. You didn't mention your many accomplishments: proposing Cathedral, pushing for the development of Enceladus, helping to establish the Mariner League, proposing legislation in the Mars Council as our representative, resolving innumerable clashes of priorities, and doing it all with humility and patience. We could not have been more fortunate to have you as our last pre-independence leader and our first post-independence leader. We will miss you. Please do come back and bring us even greater wisdom and advice."

"The one problem of eating breakfast outside in the Columbia tunnel entrance is that you get used to Tritonian gravity, and then have to go back inside the drum and deal with the gee," said Jiaying, as she and Jamison Rideout stepped out of Columbia 1.

"Well, it's Sunday. You'll have all day to adjust; or we can just stay out here, read, and relax." He paused to look around and take a deep breath of fresh air. The lava tube entrance to Columbia cavern had been enclosed and pressurized for two years. The floor--250 meters square--had been covered by insulation, metal plate, and soil simulant for almost that long. For several months, thick insulation covered by metal plates had been bolted to the ice walls all the way to the top of the cavern 250 meters over their head. And for over a year, a heavy plastic

barrier stretched over the entire cavern at the 100 meter level. Powerful lights on the roofs of Columbia-1 and Columbia-2 and arrayed around the space illuminated the entire area with 40,000 kilowatts of light, ⅔ the level on Earth. With 15 hours of light per day, enriched carbon dioxide in the air, and plenty of water, the result was an astonishing amount of verdure. Vines climbed the walls 10 meters above the ground and added another meter every 2 months. Hundreds of tree seedlings were growing in an orchard and forest on one side of the drums; the other side had wheat, corn, soybeans, sorghum, berries, and vegetables that provided most of the outpost's food. Between Columbia-2 and the bulkhead separating the lava tube from the actual cavern was a large area of grass with picnic tables arranged in a line along the edge of the future forest or located in little semi-private bays. Several families were sitting and enjoying a breakfast in semi-privacy, but their favorite table--with a bamboo grove on one side and an impressive thicket of reeds on the other, next to a very shallow pond--was available. They stopped at the strawberry patch, which robots renewed with new plants every month or two, and picked a bowl-full of berries. Jamison washed them off while Jiaying foraged in the vegetable garden and brought them some fresh pea pods and two big tomatoes, and they found two oranges on a nearby tree. Their basket had bread, soy-cheese, butter, jams, and of course big cups of coffee. They sat silently preparing their breakfast and were very pleased with the result.

"This is a great way to start a Sunday," said Jiaying, popping a strawberry in her mouth.

"I would add 'the weather today is great' but when isn't it? It's almost too good."

"People want change. I suppose when we have an area of the main cavern terraformed, we can set it up to have winter."

"I think so. I checked the atmospheric pressure gage while you were in the bathroom this morning. The main cavern is now up to 0.2 standard Marsian pressure; 0.1 terrestrial standard. In

another six months it'll be up to 0.3 and at that point we can oxygenate the area closest to the bulkhead."

"Well, once the robots finish installing the thermal curtains."

"That'll be done in six months, too, including the 110-meter ceiling. And about that time, the C-200's outer walls will be finished as well."

"I'm still not convinced we need the C-200 any time soon. The two drums can easily house 500 people, and with this area and 'Area 1' around the C-200, we'll have 250,000 square meters terraformed. That's more than enough."

"The C-200 is needed because of politics. If Proteus has carriers, we need carriers as well. And we will need it eventually; the drums will get pretty full if we have more than 500 people. I'm hoping when the next immigrants arrive next year, we'll get permission to expand to 600 or so. Then we will need the C-200."

"And it'll provide redundancy."

Jamison nodded. "Against a thermal breach that freezes this ecology, but once Area 1 is enclosed as well, that'll be less of a danger."

"Have you heard anything more from Patel about how many we can expect?"

"No. I think that'll be decided after the Future of Neptune forums." He sipped his coffee and ate some bread with cheese. "I heard from Nick yesterday."

"Oh? How's the Sedna project going?"

"Pretty well. They're converting their liquid hydrogen tank into a temperate climate area, and they're getting flyby data from their probes every few months. Five more years to get to Sedna, though."

"A long, boring flight. I guess he and Maggie are happy they didn't get Neptune-2 after all!"

"I think so. He never would have gotten command; Mercedes always had the inside track for that. But he told me something interesting. Startling, even."

"Oh? What."

Jamison paused for effect. "They've decided to have a baby via in vitro."

Jiaying gasped. "No! You're kidding me!"

He shook his head. "They have five years of peaceful cruise ahead of them with no heavy-stress events; a good time to raise a kid. They'll reach Sedna about the time it starts kindergarten."

"That's true. They're both 49."

"I know." He looked at her steadily.

"You're not going to bring it up again, are you."

"Yes, why not? No one can accuse us of having a kid so that we can stay on Triton. Because I'm the elected CEO of the borough, I can't be rotated. We're here for a while; our lives are stable; Triton is basically settled and has an expansion plan; this world will require hundreds of scientists studying it for decades. We've been together five years, now, we know each other. It's a good time."

"I suppose you want to marry me, too."

"I've said that to you several times. Yes, I think we should get married."

She laughed a little laugh, but then got serious. "Well . . . you have a good point. My various excuses have sort of run out."

"I think so. We have good circumstances. And with modern medical technology, it isn't too late."

"No, but the kid will start college when we're in our late 60s!"

"So what. When I finished grad school, one of my professors was in his sixties and he had just fathered a child. The other graduate students thought it was crazy; but he's still alive in his late 80s, and that kid must be in his 20's by now."

"Good point." She smiled. "Alright. You give me a ring and I'll marry you."

"A ring? Is that another excuse?"

"Maybe."

"Because I have a ring for you, you know? Not on me, but after breakfast I can give it to you."

She smiled. "Alright. You give me the ring and I'll marry you."

"And we'll have a child?"

"We'll have to talk to Dr. Rosen about that."

4.

Big Plans

April/May 2088

"Good news; it missed the cable," reported Tom Shepherd.

Bill Hollingworth scrutinized the tv image on his screen, which showed Tom, in a space suit, walking on the outside of Themis's dome, a jet of water escaping next to him. "It must have been pretty close."

"The micrometeoroid missed the cable by about a centimeter. The hole in the dome is only 5 millimeters. I think I can plug it pretty easily."

"Proceed."

"Acknowledged." Tom pulled out a special tool from the storage pouch resting against his chest, which already had a dome patch installed in it. He reached down to poke the tool through the little hole, which itself almost shut off the water jet. He pushed a button on the tool and umbrella-like, the patch expanded . He pulled the tool up against the hole so that the patch covered it, waited a minute for the quick-glue to dry, then detached the tool. "Done. The leak is stopped."

"Good work, Tom. "Come on in. How much water did we lose?"

"We'll have to run a computer program to be sure. I'd say, maybe five tonnes."

Bill nodded, the dome surrounding Themis had two million tonnes of water in it, so the loss wasn't serious. He watched Tom slowly reel in his tether until he reached the North Polar docking station, where he entered the airlock. Once he was safe, Bill breathed a sigh of relief. Someone had to go outside about once a month to deal with something. The outer dome--Themis had three--was a never-ending source of worry. They had started repair work on their

manufacturing unit so they could produce new sheets of material to supplement what they already had.

He glanced at his communicator and was surprised he had a videomail from Earth. He pushed play and saw a familiar face--Alan Quint's--appear on the screen.

"Good day, Bill. It's been a long time since we talked. Some months ago, my father forwarded to me your email to him and I've been thinking about it ever since. You may not know this, but our visit to Themis caused me to explore the Green World Union, and two years ago I joined it. We're the largest offshoot of Tree Rivers' movement; 100 members moved to Aram last columbiad and 250 more plan to go this coming year, which will be really great for Aram. My interests have turned to Themis, however. I've thought very often about the beauty of that little world, and its great fragility. Your plea for assistance has really worried me, and as you may know, I have made quite a lot of money on drug rehabilitation programs, both the new drugs and the software.

"I have been exploring a solution for your problem that will also make my dream possible--the establishment of a new asteroidal colony that will be larger than yours. One problem Themis has is that the work to maintain the dome and ecology is exhausting for 100 people, but with only 30 hectares, Themis is too small to support too many more. You might be able to handle a total population of a thousand, but what I have in mind is bigger than that, and the Green World Union has tens of thousands of members willing to emigrate to a place where we can be an independent entity. So I have approached the Large Structures Fabrication Department on Ceres and it turns out they can manufacture a C-300--that is, a cylinder 300 meters in diameter and 300 meters long--fill it with propellant, and launch it from the surface. At first I inquired about a C-300 filled with liquid hydrogen and gaseous core engines, but that

proved way too expensive. The gaseous core engines alone would cost a billion redbacks, and to push the vehicle off the surface of Ceres it would need dozens of very large chemical engines--several times larger than the largest chemical engines ever built, in fact. Ceres would also not have the ability to produce the nearly 4 million tonnes of liquid hydrogen, which alone would cost eight billion redbacks and take maybe ten years to produce.

"But it turns out that a C-300 filled with hydrogen and oxygen propellant--roughly a million tonnes of hydrogen and 6 million tonnes of oxygen--is feasible. The chemical engines to push the C-300 off Ceres and on a trajectory to Themis would cost about 200 million redbacks to design and manufacture and the propellant can be made over three years for about 500 million redbacks. The C-300 would reach Themis with enough hydrogen and oxygen left to raise its perihelion from outside Venus's orbit to about the orbit of Earth, and its aphelion can remain close to the orbit of Mars. This would reduce the thermal load you are dealing with and make Themis a better destination for ships transiting between the planets. Furthermore, once the C-300 is empty, the cylinder's side walls will provide 28 hectares of interior surface--almost the same as Themis--and of course a second or a third level would double or triple that. Docked permanently to Themis, it would permit a population of up to tens of thousands of people, would provide a safe backup to Themis in case its dome were breached, and would provide a huge area with terrestrial levels of gravity. The increased population would also bring more technology and more financial resources. It would make possible the excavation of large underground facilities on Themis, for example, which would increase your total surface area, and the material removed could be used to provide the C-300 with metals and soil.

"What do you think? Themis, obviously, would change; it'd be half of a big partnership. Perhaps it could be one of two boroughs of an independent Themis nation, something that is of

limited efficacy right now because of your small size. It may be a scary transition; I can understand that. But knowing how difficult your situation is, it may be the only way you can survive at all.

"Talk to your Council and get back to me with this proposal, please. The sooner a C-300 can depart Ceres is about five years from now, and it'd take over a year to reach Themis. So we are talking about 2094. Meanwhile, I'd be willing to come to Themis with my father's caravel and bring ten million redbacks of supplies and an initial immigration of dozens or scores of people. The launch window from Mars opens in January and I need time to plan and get to Mars. I look forward to hearing from you. Bye."

Bill sat, paralyzed by the message. It was salvation; but it was also a kind of doom, because there was no way 100 people could keep control when a thousand immigrants were added. It was survival of the dream, but in an altered form. He'd have to take the message to the Council immediately. But he also knew they had no choice.

Ted and Changying had a lot of trouble finding Dr. Stanley Mansale's office. They assumed it was in the cavernous reach of Martech's Department of Martian and Planetary Geology, but upon arrival they learned he was on the other side of the campus in the Astronomy Department, so they were late to their appointment with him.

"We shoul have guessed you'd be over here," said Changying, when they finally arrived at his office. "Observations of Helia are telescopic, after all. I had no idea Martech had an entire group of people observing extra-solar planets."

"Oh, yes, and we're pushing the field forward quickly," replied Stanley, a thirty-ish man with black skin and very curly black hair. "And as you might imagine, Helia is the poster child,

because it is so close by. Even so, there are a lot of mysteries that your project will resolve definitively, and that will help us characterized extra-solar planets much better."

"I'm afraid planetary geology and physics are areas we are not very familiar with," said Ted, as he and Changying sat. "And we've been so busy over the last two years, we haven't kept up with the latest research on the Helia system."

"Well, I proposed a briefing to you, and I'll be glad to provide it now," said Stanley. He sat in a comfortable chair facing them, with a small table between them. "Lacey, please project my first slide." His AI dutifully responded and the entire flat surface of the table--which was also a screen--lit up with a series of images. "Well, here in the middle, of course, is Helia; 112,000 kilometers in diameter, about 85% the diameter of Jupiter, but over 30 times as massive. It's a brown dwarf that burns deuterium and lithium to produce its light, and it's a deep red color to the human eye; Helians will have to get used to living in a very different type of natural light.

"Orbiting Helia are four planets, and the first three can be compared to the first three Galilean satellites of Jupiter, or to Venus, Earth, and Mars. They are similar to the Galileans in that they are in a Laplace resonance with each other--"

"Their orbital periods are multiples of each other," said Changying.

Stanley smiled. "Exactly. You know something about planetology after all! Helia 1 orbits the central star every 11.1 hours, Helia 2 every 22.2 hours, and Helia 3 every 44.5 hours. This means they tug on each other and distort each other's orbits, which changes their orbital period around Helia; but Helia pulls back on them because they are tidally locked, and if the orbital period changes a little bit, the rotational period is out of sync with the revolutionary period and Helia gets them back in sync again. This causes them to spiral inward, but very, very slowly; billions of years. If anything, that's good, because Helia has been fusing its deuterium and

lithium for 500 million or so years and it's just about out, so over the next 500 million years it'll start to cool. The planets won't move in enough to totally compensate, but it'll help."

"And all that gravitational tugging generated geothermal heat," added Changying.

"Yes, exactly. The planets are quite young anyway and therefore they have a lot of internal radioactive decay going on, but the heat that radioactivity produces is greatly exceeded by tidal heating, especially in Helia 1 and to a lesser extent Helia 2. Helia 3 should have some, as well, but it's less. We'll get back to that.

"The other useful analogy is Venus, Earth, and Mars, and it isn't bad. Helia 1 receives about twice as much sunlight from Helia as the earth receives from our sun; very similar to Venus. Helia 2 receives 72% as much light as Earth and Helia 3 receives 37% as much light, which is about the same as Mars. However, the relative sizes of Venus and Mars, compared to the Earth, are reversed in the Helia system. Helia 1 is 6,000 kilometers in diameter, similar in size to Mars, and because of its small size it has a fairly thin atmosphere of nitrogen and carbon dioxide; we think about 0.3 bars, or 30% as dense as the Earth's atmosphere. As a result, its greenhouse effect is not extreme, and it has areas near the poles and near the terminators that are fairly comfortable. Helia 2 is larger; 10,000 kilometers in diameter, about half way between Earth and Mars, and consequently it has a thicker atmosphere, probably about 1.2 bars or 1.2 times as dense as the Earth's atmosphere. Its more powerful greenhouse effect makes up for the fact that it gets three quarters as much sunlight as the Earth. It's fairly temperate in some areas. Finally, Helia 3 is farthest. It formed in a cooler part of the solar nebula and therefore captured more material. It's about the size of the Earth, has a thick atmosphere--about 2 bars--and a strong greenhouse effect, and is also fairly temperate."

"So, Helia has three planets in the Goldilocks zone!" exclaimed Changying, surprised.

"You might say that. Remember, the planets are tidally locked and always keep one face toward Helia, so their back sides never see the sun and are cold, dark and, covered by ice. You don't have three planets to settle, but three half planets! And in fact, not all of the planets are habitable. For Helia 1 it's probably about 10-15%, in areas where the sun is low in the sky, but that's still 13 to 18 million square kilometers; roughly the size of North America! For Helia 2, it's the front half nearest the subsolar point, but half of that is covered by water, so it's about 20%. For Helia 3, it's the equatorial islands and shorelines of the main ocean near the subsolar point, where the continuous sunlight is equal to 75% of earth's insolation. Together, the three have about the same inhabitable area as the continent of Asia."

"Enough for billions," said Changying.

"But you still don't have a map, right?" asked Ted.

"Only a very crude one, because we can't resolve things smaller than 500 kilometers across. That should change in a year or two when we get time on the Ceres 150-meter optical telescope. We have some techniques that should allow resolution of 5 kilometers per pixel. We already can pinpoint volcanoes on the dark side of each planet with about that precision if they are in a part of the planet that rotates out of view; as soon as they rotate out of sight, we know, and that allows us to pinpoint them within a few kilometers."

"How many volcanoes have been identified?" asked Changying.

"These are very volcanic places, like I said, because they still have a lot of heat left from formation, they have a lot of radioactive materials that on Earth have decayed away, and they have a lot of tidal heating. Observations and geophysical modeling suggest that even Helia 3 has 3 or 4 times as many volcanoes as the Earth; Helia 1 has about twenty times as many. But on all three worlds, there are large, stable areas where one can live."

"So, we'll be able to find a place to settle?" persisted Changying.

"Yes, certainly. I'm from Vanuatu; it's a small Pacific nation north and east of Australia, and our entire country is a string of volcanic islands. We're the most volcanic country in the world. We manage fine. With modern technology, we can identify places that are stable long term. The volcanism is actually useful on the dark side of each planet, where it is probably responsible for much of the melting of accumulating ice. The near sides have water, but a lot of the water is locked up as glaciers on the dark side."

"Do we have any sense of elevations?" asked Changying.

"No, other than 'sea level.' That'll be very hard to obtain. We'd like to know whether there are any protocontinents, but it may be too soon for them to have formed. Earth had very little differentiation into continental and oceanic crust until later in its history."

"Have you found any evidence of life?" asked Ted.

Stanley shook his head. "No, but it may be too soon. The system is half a billion years old; life appeared on Earth about half a billion years after formation. We certainly can't expect to find the absorption spectrum of chlorophyll, for example."

"It sounds like terrestrial plants, released on these worlds, could oxygenate the atmospheres," said Changying.

"Yes, genetically modified plants that store a portion of their oxygen for their own use can grow under the existing conditions on all three planets, especially plants that propagate via underground roots or runners. Assuming water is available widely over the entire front side, each planet could have breathable levels of oxygen in just a few thousand years. But that will also eliminate the greenhouse effect that makes Helia-3 comfortable and could compromise the

climate on Helia 2 as well. Detailed climatic modeling will be necessary after the population has settled and explored the entire solar system."

"What about Helia 4?"

"It's an ice giant rather like Uranus, but smaller, and receives a bit less sunlight than Jupiter. A Caltech team just found three moons orbiting it."

"I didn't hear about that," said Changying. "No other planets? Asteroids?"

"No other planets have been found so far, but there appears to be an asteroid belt--or maybe a ring--340,000 kilometers from Helia and inside the orbit of Helia 1. We've picked up some very tiny reflections, so the largest object there is maybe 25 or 30 kilometers across. The sunlight there would be about the same intensity as Mercury's, so it'd be a very hot place, and the reflection spectra we're picking up indicate a lot of metal. There's a big gap between Helia 3 and Helia 4, so conceivably there may be asteroids there as well. Beyond Helia 4, the modeling suggests the primordial cloud was too thin to form planets, but there may be Kuiper belt objects."

"That makes sense." Changying looked at the fuzzy images. "It's a shame we can't image them better."

"Give us time! I'm studying the system full time. There are a dozen or two others working on it as well, here and on Earth."

"I take it, the Helia system is your passion,' said Ted.

Stanley nodded enthusiastically. "Indeed it is! In fact, my wife and I plan to apply for the Heli mission. She's a physician.'

"We will certainly need physicians," said Changying. "What's her specialty?"

"She's been taking several; oncology, low-gee problems, and internal medicine. Do you know when the Commission will open the application process? And will people with children be able to apply?"

"We still don't know when we'll start the application process, but I hope we'll start it soon. Frankly, Ted and I have started an informal process already; we're in touch with several people who want to be on the flight. As for children, I'm pregnant, so we are assuming children will be welcome. If we wait until everyone is on board and we're underway, we will have a huge baby boom and that causes other generational problems. We're better off allowing applications involving both parents and their children. We're designing the Helia, tentatively, for 1800 adults and the ability to accommodate 3300 to 3600 people."

"Let's keep in touch," said Ted. "You and your wife would be the perfect age to be on the flight; by the time we leave you'll be close to 40 and in a position to be managerial. We'll probably seek a lot of people in their late twenties and early thirties at the time of departure, but they're teenagers or in their early twenties now, so they can't apply yet."

"I see what you mean about ages. Anyone who's 30 now will be in their early 40s at departure and in their early 70s on arrival. I suppose you want people in their mid twenties at the time of departure, who will be in their mid 50s at arrival time. But anyone in their 50s when we leave will be retired and possibly in poor health when we arrive."

"Exactly," said Changying. "We may have some people in their 50s and 60s, but no more than 5-8%. When we arrive, we will be witnessing the marriages and children of the children born near the beginning of the voyage. So our vessel needs to be large and have the resources to potentially hold even more people than 3600. So, you're interested in going?"

"More than interested! Helia is my main research interest and my wife is completing her residencies with the needs of the Helia population in mind."

"Good," said Changying. "Let's meet, all four of us, next week over lunch and talk further. Ted and I are now in the position that we need what I am calling a 'cabinet'; people who can help flesh out aspects of the plan. We have consultants, of course, but we pay them and they advise. I'd rather start to get advice from people who are also committed."

"Well, we're committed!"

"Good; so are we!" said Changying. "How about Tuesol at noon?"

"Yes, I am sure that'll work for Marisol. Your offices are in New York Circle, right? There are a lot of good places to eat there."

"Yes, let's be in touch that sol to choose one. Now we have to go," Changying rose and offered her hand. 'Thanks for the briefing, Stanley. I was very impressed."

"My pleasure, I assure you." They shook hands, then Changying and Ted headed out of Stanley Mansale's office.

"He's perfect," said Changying. "And his wife can give us lots of medical advice."

"I agtee. We got a lot more this sol than a briefing about Helia. It is time we started to assemble our team, even if we can't pay them yet."

"We can probably start to pay them, too. I wish the Helia Commisison would meet. We need to light a fire under them."

"We need to get new people on it, who will take the project more seriously. We're eleven years from launch!"

"I'll talk to Crystal Kern. If the Marsian Minister for Space Exploration doesn't make Helia a priority, no one will."

“She’s pushing a big expansion of asteroid belt exploration right now, but she should have time for us,” complained Ted.

Just then, both of their communicators buzzed with an incoming message. Puzzled, they both stopped and pulled out their communicators to look.”

“The neighborhood newsletter.” Changying shook her head. “And I see I have a meeting tonight of the Neighborhood Committee.”

“I thought you wanted to be on the committee.”

“I sort of do; I want to see how this new organizational arrangement will work. Helia will be big enough for 3 to 5 neighborhoods, after all, if we use this new system. Which we’ll probably have to; if it works, eleven years from now everyone will be used to it.”

“It certainly has increased our awareness of neighbors. When we walk arond New York Circle, people recognize us and say hello, and vice-versa.”

“Yes,that’s kind of nice, but I am still not sure how I was invited to serve on the committee.”

“I suspect my mom and dad nominated you. Remember, the newsletter asked for nominations about a month ago.”

“And they found my social media posts, and my page on Gallery.”

“Everyone’s on Gallery, and now it allows you to click through and see everyone else in your neighborhood who's on Gallery. Very convenient.”

“Yes, but I have pretty high privacy settings!”

“I think they may have found some of your information via my Gallery page.”

“Ah. Yes, your privacy settings are lower. The next neighborhood festival is two weeks away, so I hope they have it mostly planned. I can’t jump in and solve problems.”

"Well, if you read the neighborhood newsletter, you'd know the plans are mostly in place. They're probably already planning the July and October festivals and talking about what they can contribute to the September festival for all of North America enclosure. I thought the January festival was very nice."

"Yes, it was. Planning festivals is not exactly what I want to do as a volunteer, but I suppose it'll be fun."

"And maybe you'll find other things you can propose, as well," suggested Ted.

The bell rang indicating the end of the fourth quarter and the other team whooped their victory. Bill Elliott continued his float to the nearest wall and proceeded to walk round and round the striker court's circular wall so that he could join his other five team mates. One couldn't line up in zero gee; one would float away. But one could walk round and round, the centrifugal force keeping your feet on the surface, and that way both tema lined up and walked past each other, slapping hands.

"Sorry," Bill said to Trey and his dad, Chad, who shrugged.

"We'll do better next time."

Bill nodded and floated out of the court; the door was at the end of the cylindrical court near the scoring hoop. He was surprised to see his dad there, watching. "Hey!"

"Hey. Sorry you lost. I only saw the last half of the game."

"Then you saw all the hoops. It was 2 to 1."

"I saw them all, but I see you took a good shot."

"Yes, but missed. Striker really requires comfort in zero-gee. It's really hard to score when you can only hit the ball, not hold it, and you can't anchor onto anything."

"That's the idea." Marshall looked at the transparent hard plastic cylinder, 20 meters long and 10 in diameter. "This is a really nice striker court."

"It looks like the ones they use on Phobos; I've started watching games. Have you ever played?"

"No. When I was a kid, striker didn't exist; Phobos was a tiny outpost, sometimes not even inhabited. When I was 17 I got to go there on a geology field trip and by then it was building caravels and galleons, so it had almost 300 people, and they were beginning to develop zero-gee sports."

"And now Phobos has six professional teams."

"And millions of fans on Earth. So, how are you doing? We haven't seen you in two sols! You want to get an ice cream or something?"

"Not now; I'm all sweaty. But we can talk here." Bill floated over to a nearby window out of the way and grabbed a guardrail there. The window distracted him.

"It's amazing to look out onto empty space, isn't it," said Marshall. "We gaze at infinity."

"It is kind of amazing, though I think I like views on Titan or Enceladus better. I like to see rolling countryside to the horizon. Anyway, I am fine. Chad and Trey invited me to join their striker team and this was my third game."

"You've picked up the moves pretty fast!"

"Not really; I'm very clumsy in zero gee. The first time I played I almost got motion sickness. But I've been watching lots of games on Phobos and that has given me a good idea how to move."

"How's school?"

Bill shrugged. “Fine. We’ve been underway just a month and the time delay hasn’t built up too much, yet. Oh, by the way! My paper was accepted for publication!”

“Really? Congratulations! Was that the third draft?”

“I suppose fourth; Dr. Kersley really did a lot of rewriting. I offered to make him coauthor, but he said no.”

“That’s something to watch out for. Sometimes advisors want to make you the second author, even if you did the bulk of the work. Dad will be so proud.”

“I sent him a copy of the paper when I submitted it and he wrote a long email praising it. The paper described me as a ‘history major at Martech’ so I guess that’s what I am! I can always double major.”

“You can, but don’t do something like that for someone else’s stake. If you want to do history, do history!”

“Thanks, dad! I’d be the third geologist in a row and I don’t want people to think I’m turning away from a family legacy.”

“The only family legacy is service, Willie, just remember that.”

“Okay, but please don’t call me ‘Willie.’”

“Oh, sorry; ‘Bill.’ I’m not used to that.”

“I know. You and mom can always call me ‘Will’ anyway. That’s alright.”

Marshall laughed. “Okay, I appreciate that.”

“How are you doing?”

Marshall shrugged. “I guess fine. Your mom is immersed in her book on plant genetics, which includes email and videomail for hours a day. She now has a position in the Plant Genetics Department at Martech. They’re thrilled to have her, too; she made a lot of important

contributions to the techniques to improve the efficiency of photosynthesis, and now she's started work on enhancing the ways plants store oxygen. The Planetary Geology Department will have me, of course, but I haven't made any important contributions to the field for ten years. In fact, I haven't made any contributions at all for the last five! So I've been doing some reading; the latest research on Mars, the Pallas research to support the upcoming Ceres-Chinese joint mission to that asteroid, and the research in Triton. . . all of it is interesting, but none of it grabs me. It's making me wonder whether I still want to do geology!"

"What else would you do?"

Marshall shrugged. "I don't know. I suppose I have to wait and see what comes along. I am intrigued by the Helia Project, so perhaps I'll contact them, though I do wonder whether it's premature, not to mention the ethics of taking children away from all of humanity and to an uncertain fate. Any mistake or failure, after all, and they're doomed, and no rescue will be possible."

"But don't they need a Jupiter gravity assist to get there?"

"Yes, but that's available every 12 years, and waiting 12 years for better technology would not be a terrible thing. Several times my father said in speeches that perhaps Mars would lead humanity to the stars before the twenty-first century was over. I have to wonder whether people are taking that idea too seriously." He shrugged. "But maybe not; I don't know. There are closer targets, and missions are already on their way to Pluto and Sedna. The Indians want to send a C-100 to Makemake and that's been delayed again and again. I emailed Surender Subrahmanian this morning and asked him what he knows about the project."

"How would he know? He's been focused on tholin chemistry."

"Makemake has tholins as well and he knows the researchers studying Makemake's surface. It's an important object for detailed study because it also has a large moon, so a trip there will study two objects, and they appear to be quite different. We need missions to Quaoar and Haumea as well; automated probes at least, if not human missions. They're all close to the same distance as Pluto, too, so they aren't too hard to reach."

"It sounds like you have already fallen into planning!"

"I guess I have. I'll have to dig up the research on trans-Neptunian objects. There are now thousands of them known and we have good data--and important research questions--on a lot of them."

"Good. Kersley and I exchanged emails this morning and he suggested that I resume my interviews with grandpa and his friends. I replied that I really wanted to wait until I reached mars, so I could interview them in person, so he suggested I interview instead."

"Me? Why?"

"Dad, you've been called 'the first Marsian' because you were the first child born there; the first one born off Earth, in fact."

"I know, and for a long time the rumor circulated that I was part alien!"

"I know. Kersley once said to me that you should be writing your memoirs. You were the first kid to grow up on Mars and you became the Chief Minister of the Saturn Commonwealth."

"I'm too young to write memoirs. I'm just 48."

"I don't think you're ever too young to write memoirs. It's a question of whether you have anything to say, and I think you have a lot to say."

Marshall considered that a moment. "Interesting idea. I'll think about it."

5. Eight Year Plan

Aug-Sept. 2088

Bill Hollingworth stopped to wipe the sweat off his brow. He looked up at the sun shining through Themis's dome 100 meters overhead. "Thank God we're not at perihelion," he said to the others.

"Well, you're the one who got us into this situation," said Jeremy, his 13 year old son.

"Now, Jeremy," said Suzanne, his wife.

"Turn up your jet pack and it'll cool you more," recommended Cynthia Clarke. She reached down and picked up a huge bundle of cut brush and weeds--weeds grew very tall in Themis's near-zero gravity--and tossed them into a big bag, which bounced away and then rebounded, because it was tied down.

"I think we're just about finished," said Bill. "We've cleared another half hectare today."

"How much more?" asked Jeremy.

Bill looked around. "We need five hectares and we're halfway there. We'll extend the existing gardens; wheat, corn, vegetables, grapes, peaches, citrus, and berries."

"This uses up a lot of the plateau!" complained Jeremy, who had poked around every nook and crany of Themis and knew it intimately well.

"Well, there's still plenty of wilderness, especially in the Badlands. We'll probably never manage to clear it, even if there are a thousand people using this place," replied Suzanne.

"The six of us are finished with our share, anyway," added Bill. "And my jetpack is almost out of battery power, so we should head back and charge the jetpacks up so another crew can come out and continue the work." He pulled out his communicator to see if anyone had

messaged him while they had worked for the last two hours. There was an email from Alan Quint, which he quickly read.

Dear Bill: Still haven't heard from you about whether you can provide us with gravitied housing when we arrive in June. It looks like the caravel will have 127 people on board, so we'll need about 5,000 square meters. I know that's an awful lot, but we'll need to send the caravel back to Earth by September or October 2089 at the latest, and we'll need to stay somewhere. The caravel will be really crowded, too, with that many people, especially since we'll be bringing some animals and some new crop species and they'll take up a lot of space. We'll definitely need something as soon as we arrive. Please, please, respond to this email. Alan.

Bill shook his head, angry and helpless at the same time. He held the screen up so Suzanne and Cynthia could read it. Cynthia was furious. "The son of a bitch! Does he have any idea what he's asking for? Our 30-meter rotating housing took 2 years to complete and it has only 3,000 square meters of space!"

"Well, we have the *Materra* and *Patares* and each of them have 3,000 square meters as well, so we have 9,000 altogether," said Bill.

"Yeah, and it's all claimed!" replied Cynthia. "You had enough trouble convincing everyone to accept Quint's proposal. So now do you want to ask them to cut back on housing and work space?"

"There are some things we can do," said Suzanne. "We can move some work outside into microgravity, and there are storage areas that could be emptied."

"I think we can manage a thousand square meters that way," said Bill. "If we start on another 30-meter rotating enclosure, we could at least get it finished enough to spin it by June."

"I don't know about that," said Cynthia, who was head of fabrication. "That would only make 1,000 square meters more. I doubt we'd have time to add a second or a third level, which would add another 2,000."

"He said animals," said Jeremy. "What are they bringing?"

"Cows, pigs, and rabbits," replied Bill. "They'll all need to stay in gravitied spaces as well, as the zero-gee would be bad for their health long term. He also plans to bring turkeys, which we can chip and release."

"If they have babies, the babies won't have chips and we'll never find them in the Badlands," said Jeremy.

"If they start to overeat the vegetation, we can hunt them," said Bill.

"And he said 127?" noted Cynthia. "We number only 120. That means in the next election we'll lose control."

"We already knew that would happen," responded Bill defensively. "If we keep people out, this place will have a major gas leak eventually, we'll have to evacuate, and Themis will be abandoned. This is the only way."

"I suppose," said Cynthia, shrugging.

Bill looked at Suzanne and Jeremy; they were finished with their questions. So he clicked on a reply icon and "record" so his oral response would be converted to text.

"Thank you for your message, Alan. I haven't been delaying my response; I've been trying to determine what is possible, because every message I get from you asks for something new. We've been exchanging messages for months and here it is August. The residents of Themis are quite grateful that our population will grow and Themis will survive, but our means are quite limited here, so it is difficult to determine what we can actually do. We've been clearing

land to double our farming area to 10 hectares--a third of Themis, half the dry land, and most of the Plateau, except the part your family owns--and that is taking us a lot of time. Mars can feed people on 100 square meters of polder and interplanetary vessels have it down to 45 square meters, but we need at least 300 square meters. We don't have optimum sunlight or water, and we have weeds, which no one else has; we also have insects. We're going to start planting as soon as possible and we'll accumulate surplus, but it will behoove you to bring backup supplies.

"As for 5,000 square meters: July is twelve months away. If we build a 30-meter rotating vessel that's 15 meters high instead of 10 meters, that'll give you 1,500 square meters, and we can probably find another thousand in our existing facilities. That, plus the 3,000 square meters on your caravel, will have to do. Once your people are here and our population doubles, the construction work can go much faster. We have the power and the metal to make 5,000 square meters by September or October--fifteen months--but we'll need your people to help. That's the best we can offer, Alan. We only have so many resources available to us."

"Any other questions about Pallasites?" asked Hideki Takahashi, looking at his fellow students in the "Topics in Planetary Science" seminar.

"Thanks, Hideki, that was a great presentation," said Marshall. He looked at the other nine students in the class and they applauded.

"Not bad, for someone planning to become a minister," quipped Emin to his friend.

"You got to know your audience," replied Hideki with a smile.

"You do; and you could easily do both, which is always a good strategy if you're planning to sign up for a small mission," noted Marshall. "Well, all ten of you have now given your presentations and we have four weeks left to the semester, so what shall we focus on next?"

"What are your thoughts about the Baozhi Zhang Commission's Eight Year Plan for Mars?" asked Trey.

"What are yours?"

Trey hesitated. "I asked first."

"I'm surprised it's being called the 'Baozhi Zhang Commission' when it's just a government commission and it's the government's Eight Year Plan," commented Bill, frowning.

Marshall looked around. "How many of you have read the Plan; or maybe I should say, the summary?"

Eight hands went up, out of ten. Marshall nodded. "Impressive. Probably better than the Marsian public. I was up all night reading the entire 400-page report. It's quite shocking to think that Mars, in eight years, will grow to 1.55 million and Aurorae alone will have 700,000 people. Mars already has a GDP bigger than Luxembourg and a space program, separate from immigration, that rivals the U.S. and exceeds everyone else. Phobos will be the largest human settlement off a planet, unless lunar immigration accelerates markedly. And Mars's capacity to tackle large projects is mind-boggling."

"But they're projecting a decrease in polder from 200 square meters per person to 125," noted Hideki.

"That's alright," said Marshall. "That's because of all the intense agriculture that is planned. They'll still have to increase the pressurized enclosures from about 50 square kilometers to about 200. Marsian cities won't be noticeably more crowded."

"What about all the big plans, though?" asked Trey. "The Phobos mast, the polar mirrors, the asteroid redirect?"

"They have to be considered one by one. The Phobos polar mast is a good idea. Phobos needs huge amounts of electricity and any spot on the surface, besides covering the surface with solar panels, has sunlight only half the time. A two-kilometer mast at either pole gets into perpetual daylight and you can put as many square meters of panels up there as you want, in Phobos's micro-gravity. The polar mirrors have been considered a long time; the proposal is actually over a century old. It's a great project for Phobos and can accelerate the melting of the poles quite significantly.As for asteroid redirect, I'm not so convinced about that one. The timeframe is quite long; 30 to 50 years. The reliability of the targeting of the polar caps needs to be considered very carefully. And then there's the issue of how much terraforming to do; targeting the poles that way may terraform Mars more than is currently contemplated."

"I was wondering about that," said Trey. "The summary said the current climate change goals can be met by 2110; 22 years from now. But asteroid redirect wouldn't even start until a decade later."

"Correct. The current goal is to increase atmospheric pressure 3 to 5 times and to raise the polar minimum temperature in winter by at least five degrees Celsius. That'll prevent the cap from reforming and pulling the carbon dioxide back out of the atmosphere. The latest models suggest that regolith desorption will release more gas than anticipated and that an atmospheric pressure approaching a tenth the Earth's atmospheric pressure is possible. Longer term, if the Martian global temperature is raised 10 degrees Celsius, even higher pressures are possible, but the cost of raising the global temperature, and keeping it up, grow exponentially. Asteroid redirect may be a cheaper solution."

"But it'll scare a lot of people," said Bill.

"Yes, and maybe too many, scared too much; or maybe the risks are manageable and educating the public is possible."

"But there's still the threat to Martian lifeforms," said Hideki.

"Not at an atmosphering pressure of 0.1 or 0.2 bars; ten or twenty percent the pressure of the Earth's atmosphere. That would create a permanent estival and would be good for them. Liquid water on the surface would be rare, but it would occur--the equatorial regions would have transient ponds--and the thicker atmosphere would block ultraviolet and cosmic radiation, so Martian lifeforms would be free-ranging again. But the plan also calls for an expansion of Marsoform research and spreading Marsoforms widely, and that'll be controversial, because they'll compete for resources and they'll release oxygen into the atmosphere, which will poison Martian life if it builds up too much. If an atmosphere with a fifth the Earth's pressure were possible, domes could be made much simpler and lighter, although they'd be battered by more violent winds and sandstorms, so it isn't all as good as you might think. The Category 5 storm Mars is dealing with right now is suggestive; since they've started nuking the poles, there have been category 5s two annums out of five."

"I noted the report doesn't say much about the outer solar system," said Emin.

"What does it say?" asked Marshall.

"That immigration to Saturn, Uranus, and Neptune will be increased to 700 every other year for the next four years, then 1,000 every other year the last four years," said Emin. "But they didn't specify what those commonwealths would do."

"That's because that's not their business," said Marshall. "Those numbers mean Saturn will go from 2,300 to at least 6,500. What would we do with that many?" He looked around the room; no one responded at first.

"We'd have to excavate another kilometer or two of tunnels at Titan Outpost, maybe Enceladus would need another C-100, and we'd have outposts on maybe six moons instead of four," offered Trey.

Marshall nodded. "What else? Centaurs?"

"We'd send out more probes to them," said Emin.

"How many would you recommend?"

The students looked at each other.

"Those of you that have read the summary; what other gaps do you see?"

That generated a long silence, but Bill knew his father's interests. "There's nothing about the Kuiper Belt and beyond."

Marshall nodded vigorously. "Yes, I'd call that a gap. We now have two communities heading there, to Pluto and Sedna. The latter, based on the orbiter and the rover, appears to be partially extrasolar; the isotope ratios are just different enough to suggest it formed at the outer edge of the solar nebula where there was a different supernova component. That's important. There are over one hundred thousand Kuiper Belt Objects over 100 kilometers in diameter, and they aren't all the same. We need several hundred probes and a permanent human presence out there to do a good, thorough study. We need to start studying the scattered disk, beyond the Kuiper Belt, and the Oort Cloud beyond it. Eris is an obvious choice. What about the inner solar system?"

"Nothing at all," said Emin. "I was surprised and disappointed there was no plan to assist Mercury."

"The most neglected planet in the solar system," agreed Marshall. "What do you think of this: for the next four weeks, we'll study the future. Next week, everyone should bring a

15-minute presentation about items they'd include in an eight-year plan for exploring the solar system."

"Does it have to conclude in eight years?"

"No, just start."

"You know, I don't even know the history of space exploration very well," said Trey. "When did we first land on the Earth's moon? 1965? 1970? Or was it 1980?"

"It was 1970," replied Marshall, "No, I take it back: 1969. Bill, what do you say to giving us a presentation summarizing solar system exploration up to now?"

"Sure."

"What will we cover, after next Tuesol?" asked Hideki.

"We'll drill down and go beyond a scattered collection of ideas. Maybe in four weeks we can actually put together something worthy to be posted to the web as a class project. All of you are mariners; the solar system is in your blood and is your destiny. You need to think about what we're going to do with the territory."

"So, how are you sleeping?" asked Helmut. He could see that Maryam, who was holding baby Ruhi, had bloodshot eyes and had not yet managed to eat any supper.

"Things are a bit better," replied Oskar. "Now that he's four months old, his sleep cycle is settling in better."

"He still wakes us up at least twice every night, though," said Maryam.

"Oskar was worse," said Clara, with a smile.

"So was Andrew," added Sirikit, which caused Andrew, almost age 9, to stop eating his pasta and look at his mom. "Human beings have to learn practically everything, dear, including when to sleep," she explained to him.

"We hope he'll be sleeping better when Maryam goes back to work in October," said Oskar. "I'm working from home a lot more, so she can sleep."

"I'm curious," said Sirikit. "Has *Mars This Sol* said anything about Baozhi referring to the Eight Year Plan as 'the Baozhi Zhang Commission Report'?"

"No, not yet. We're debating whether that was a slip of the tongue or whether it's a pattern. We're careful to call it 'the Eight Year Plan'."

"Not a slip of the tongue," replied Helmut. "I think you will find he used that phrase at least three times."

"That's hardy electioneering," said Charlie.

"I'm not so sure," replied Sirikit. "We're less than three months from the election."

"And he is going around and promoting the report," added Maryam. "The Mars Council has to meet to approve it, but they won't meet until after the election."

"It is raising eyebrows." Halmut paused, wondering whether to say any more. "I'll tell you something absolutely confidential because I know I can trust all of you, and because I feel a serious ethical dilemma. This morning, Crystal Kern came to me and she was absolutely furious. 'Baozhi has started to campaign for First Minister. He has no right to call the plan his. We all contributed to it. You contributed to it in particular. He's just the coordinator of the team. You should do something.' I said 'I agree, it's not his plan, but he is the spokesman for it. Someone needs to sell it to the public and he was chair of the commission.' She said 'You should sell it, not him, because you are the Chief Minister. The plan was your idea. The eight-year duration

was your idea, and it sounds like a plan for an entire eight-year Baozhi administration.' I said I was planning to sell it as well; Rory has scheduled me to speak about it morrowsol, in fact. She said 'You should tell him not to electioneer.' I told her it wasn't my job to do that, at least not yet. She wanted to say something and I said no, you'll look petty and it may make you look like you are electioneering against him. So she left my office very dissatisfied."

There was silence for a moment, then Clara said, "I think she'd make a better Chief Minister than Baozhi. So I sympathize with her."

"I . . . probably agree with you. Crystal has done a good job as Minister of Space Exploration. She has set solid, achievable goals, she has pushed for efficient use of funding, has shot down projects that were pure research with no necessary application to an existing project, and she's a good manager and effective people person. Baozhi can be hard to get to know, can be demanding at times, and can get attached to projects for their own sake, like this asteroid redirect idea that he won't let go of. Of course, Will Elliott was often seen as driven by idealizd goals and was difficult to talk to, so I can't blame Baozhi too much."

"Free Space Media is already speculating that you won't seek reelection and is reviewing potential replacements," said Oskar. "It puts *Mars This Sol* in a difficult position because it boosts Free Space Media's ratings. Lester Glaysher posts something almost every sol. And believe it or not, Maurice Brandt hasn't forgotten us. From his New York office, he writes rambling commentary about Mars three or four times a week."

"I thought he was running for senator fron New York?" said Sirikit.

"Yes, he's doing that, too."

"Free Space Media is really trying to divide us and pull down our system," said Marshall. "They've become a tool of the American right wing."

"And they're on a resurgence again," said Maryam. "We're tracking their efforts to interfere with our elections."

"What worries me is their effort to overturn American electoral reforms," said Sirikit. "They want to ban ranked choice voting and write-in ballots, so everyone has to choose between two candidates only, and they want to allow extreme gerrymandering. The polls show the Presidential and congressional elections will be close."

"They almost always are," replied Helmut, shaking his head.

"So, what are you going to do?" asked Charlie.

"Well . . . obviously, when my second term ends in November, I'm not going to seek a third term. Will set the precedent of two terms of two annums each and I'll respect that. Besides, I'm very tired and I need to do something else. Obviously, I'm not going to endorse anyone as a successor; that's against our system of no campaigning. So I guess I'm going to do nothing about Baozhi."

"He wouldn't be a bad Chief Minister," agreed Clara.

"I agree, too, but I think someone does need to talk to him," said Sirikit. "He's skating right on the edge, and if he pushes further, someone else will push a little further. I smell ambition, don't you?" She looked right at Helmut.

"Yes," he conceded. "But Sirikit, we aren't Baha'is like you. We don't worry as muvh about personal ambition."

"Maybe you should," she replied. "Government service has to be about serving the public and the nation, not about yourself. Ambition to serve others is fine, but ambition to serve yourself distorts the purpose of government, leads to corruption, and will reduce the credibility of the government. Once you reduce its credibility, you get increased partisanship and decreased

effectiveness. So I don't see a harmless slip of the tongue in calling the commission and the plan his. I see personal ambition."

"What would you do, though?" replied Helmut. raising his voice in protest.

She thought. "Ask Will to talk to him."

"Ah. Yes, I'll do that."

When Oskar and Maryam came out of the transportation center under New York Circle, they were surprised to see a table with fliers and Lin Changying sitting behind it. "What are you doing?" asked Oskar, surprised to see a Co-Director of the Helia Commission publicizing something.

"This is a table for the Neighborhood Committee. We're alerting people about a hearing to discuss the growth of Aurorae and particularly the growth of New York Circle. The Baozhi Commission's plan to expand Aurorae from 150,000 to 750,000 has a lot of people concerned."

Oskar was surprised. "Why? That's a five-fold expansion. Aurorae had 30,000 people--a fifth as much--seven or eight years ago. That's the way things go."

"I agree, but we're trying to encourage people to speak up, get informed, and get educated. The only way Aurorae can expand that much is to create a north-south growth axis to complement the east-west axis the city already has, and as you probably know, the axis is supposed to go through New York Circle. That makes this spot the center of an expanded Aurorae. But the existing design can only accommodate 400,000 people. It's not just the population aspect of the design; the transportation center can't handle 750,000. These are the issues people are talking about."

"They are issues that require education and patience," agreed Oskar. "The city of Aurorae has to update its growth plan; that's not the job of the Commonwealth's commission. No doubt they'll make a new plan to grow to several million. When they do, they'll need to add a few more north-south and east west growth axes. South America enclosure can be the center of another north-south axis, for example; it has the tunnels to accommodate underground transportation lines. No doubt they'll do the same with Africa and Asia. Then they can add another east-west axis north of this one, and another one south of it."

"Not some suburbs?"

"Think of the other chains of enclosures as suburbs, but you want them close so people can go back and forth easily via multiple transportation tunnels."

"People are also concerned about the Baozhi Commission's decrease from 200 square meters per person to 125."

"They say non-agricultural space per person will be a bit more, but again, that's the Commission, not the city."

"Surely, the Neighborhood Committee knows the difference between the Commonwealth's planning and the city's?" asked Maryam.

"Yes; I'm mentioning issues people are talking about. As you note, no one has proposed solutions to them, yet. But for us, the big question is what they'll do to New York Circle."

"That's legitimate," said Oskar. "It will change New York Circle because it'll eventually be the center of a city of 400,000 people. That's the city's current plan. It's in the middle of an east-west axis. And there are plans to add some tall buildings here; the space exists, and some of it is used by people as park land right now. But New York Circle won't remain the center of

Aurorae forever. This is the third center Aurorae has had, after all; first it was Andalus, then Australia, and now North America is emerging as the city center."

"The current city plan, however, makes it the center of an east-west city," noted Changying. "In the next two years, they'll have to add a north-south axis right through here, and New York Circle will be the transit intersection. That'll require a lot of expansion of underground facilities."

"That needs a hearing," agreed Oskar. "I think they planned for that expansion, though, and left the space underground. When is the hearing?"

"This coming Sunsol afternoon. You should come, Oskar; clearly, you know quite a lot."

"Well, I was born in Aurorae and came back when I was fifteen, so I know the history of this place. Maryam was born here, too. Yes, I'll plan to come. But Changying, please don't call it the Baozhi Commission. He has used that term a few times, but it is the Eight Year Plan of the Commonwealth government's commission. As Minister of Development, he was asked to chair the commission. But obviously he didn't develop the entire plan."

"Good point; thank you. I'll remember that."

"Remind others, too," said Maryam. "I'm hearing that title used quite a lot."

"I'll be sure to mention it on Sunsol," added Oskar. "We need to keep personalities out of elections as much as possible. Elections need to focus on the needs of the community, not on people."

"I'm still getting used to that idea, myself. One reason I volunteered for the Neighborhood Committee, after I was asked to join it, was because I want to understand how Marsian governance works. We need to establish a healthy community on the voyage to Helia."

"And that means people have to sacrifice their own interests for the community, especially in a thirty-year voyage out of the solar system," agreed Maryam. "I'm surprised you have time for this work, though."

"We're not leaving for Helia for eleven years. We have a lot of the preliminary design of the ship, but every six months the design shifts because of technological developments. The Helia Commission Board meets about once a year, currently. So Ted and I have a lot of flexibility right now."

"I see you're pregnant. Sounds like a good time for a family."

"Yes, and I see you have a little one! How old is he?"

"Four months: Ruhi. His name means spiritual." Maryam smiled.

"That's lovely. We're having a daughter in October and we're very excited. The four of us should get together some time. Ted and I live in that building." Changying pointed northeast.

"And we're there." Maryam pointed west. "I suppose when they complete various highrises going up over the next year, they'll have to redraw the district boundaries!"

"Yes, the area from here up Haudenosawnee Avenue to Quebec Circle and down Cherokee Avenue to Atlanta Circle will gain 25,000 people. At that point, North America will be have 50,000 people."

"Well, based on the current plan," replied Oskar. "They're leaving some farmland that could fill up later, and they could add more floors to some of these buildings; they're designed for it."

"Well, we had better not allow that!" said Changying. "Creating neighborhoods has caused unexpected problems for the planners!"

"I think so," agreed Oskar. "Yes, let's get together for lunch or supper some time. We'd like to get to know you better."

Will Elliott wanted his meeting with Baozhi to be spontaneous, not planned. There was a way to do it; most sols, the Minister of Development ate lunch in the food court of the Emporium, a former mall now converted into government offices. Will sat at a table near the elevator with a coffee and waited for him to appear. When Baozhi Zhang arrived, Will waited a moment, then waved.

"Good sol!"

Baozhi was a bit surprised, since he had never sat down with Will before and knew him only visually. "Ah, good sol, Mr. Chief Minister Will! How are you this sol?"

"Pretty good, and you?"

"Not bad; very busy, as I am sure you are aware, with the new plan. There are lots of details to flesh out, and a fair number to defend against critics."

"Ah yes, I remember those sols all too well, and I am glad I no longer have those responsibilities. Can you sit with me for a moment? I want to compliment you about the effort."

"I think so; thank you." Will pointed to a chair nearby and Baozhi sat.

"It's bold and creative; I am very impressed. We've been going from one columbiad to the next for way too long; it's high time we plan six or eight years in advance, even if the plan has to change."

"The point is to set a ceiling of sorts to growth," said Baozhi. "Some things simply have to be planned six years in advance, like orchards and vineyards, not to mention factory expansion. We can't easily plan other things that far in advance, like demand for Phobosian

goods in low Earth orbit. But if we have a ceiling on overall immigration, we can move some expansion from Aurorae to Phobos or vice versa."

"Who came up with the eight-year timeframe?"

"I think it was Helmut's idea."

Will nodded; that's what Helmut had told him. "It's ambitious, to plan four annums--two elections of the Chief Minister--in advance. In the past, we've planned and then busted through the ceilings!"

"I know, and we could do it again, but I don't think we will very much because immigration is becoming immensely complex. AI isn't smart enough to plan everything. It's easy enough to plan for the expansion of Aurorae to 200,000 people and put in two levels of two-lane underground roads connecting the enclosures. If you expand to a million, however, that transportation system becomes inadequate and has to be replaced, which is immensely expensive. Even the hyperloop system will max out when the population reaches several million and will have to be expanded. We're already seeing that problem with the methane and oxygen pipelines built into the hyperloop tracks; they aren't big enough to move enough power to Aurorae from ideal sites for solar and wind power. So growth simply will have to slow down because infrastructure will reach its limits."

"That's true. Not long ago there was a calculation that we could cut the percent of GDP going to immigration in half, to 15%, and the combined cost of immigration and health care would still be lower than it is in many terrestrial nations. I was also impressed by the new projects; the solar mirrors, the Phobos mast."

"The mast has been on the wish list for a decade and the polar mirrors have been on the drawing board at least as long."

"I get the impression that you are in favor of more climate modification than is currently planned."

"Yes. Privately, I think we need to go for terraformation eventually, so we need to lay the groundwork now. And I'm in favor of educating the Marsian public about partial oxygenation of the atmosphere. If we get to the point where we can actually make planetary-scale modifications, we can dome off the Tharsis calderas to maintain low-pressure, oxygen free environments for Martian lifeforms. They don't need the entire surface of the planet. They don't have any of the surface right now, after all."

"Well, good luck with that! That's a long-term educational effort. I think you might indeed have opportunities to serve the Marsian public in roles that will enable you to shape this world's future. You are a strong and experienced administrator and a person of vision. We must be people with an ambition for Mars; not for ourselves. Clearly, you love Mars and want to see our nation grow and become an example to humanity. I think anyone with a love for the Marsian nation must examine themselves daily and consider whether they are acting for Mars, or for their own aggrandizement. Many times, these two ambitions align, but they don't always, and then we must always do what is best for Mars, even if it isn't in our best interest. That's very difficult. But the success of the Marsian experiment rests on it, Baozhi. If personal ambitions start to dominate our politics, we will be doomed to repeat the problems that beset terrestrial nations."

Baozhi frowned. "I think I agree, Will. Clearly, there are many times when one can't serve Mars without the permission of the people to do so, so one needs that permission. There's nothing wrong with that, is there?"

Will paused. "Sometimes, it is best to let the will of the people express itself without any manipulation, however subtle. Yes, we must acquire the permission to do things on their behalf,

but we must gain the responsibility by demonstrating our worthiness. That means being honest about our philosophy for Mars, our long-term vision for Mars, and giving thanks to others whenever it is due. I think the Eight Year Plan Commission, or the Commonwealth Planning Commission, is a good example. We don't normally name our commissions after people."

"Oh, is that the issue?" Baozhi considered. "I agree, that may not have been the wisest thing for me to say, Will. But I've only said that once or twice."

"You may want to rethink that number. I'm relieved that you recognize the issue so quickly, Baozhi, and I really appreciate that you said so. You are capable of leading this world without self aggrandizement; in fact, you'll do a better job without it."

"Considering no one can endorse anyone for a political position, I'll take that for as close to an endorsement as I can get!"

"Please don't, because I might say something similar to a dozen others. I am happy to praise people and rarely will point out what I consider to be their personal weaknesses. We all have those as well."

"We do, and I will take it as a compliment of some sort that we did discuss one of my weaknesses this sol."

Will nodded. "Yes, that's true, because I might not do the same with the dozen others I could compliment."

Marshall looked at the complex table of lists and costs projected onto the classroom's main screen. "You know, I think this is pretty good!"

"You did half of it," said Emin.

"No, not really. I did edit your projections and suggestions, but you all did the research. You dug up the old plans, the website proposals, the publications by experts, and you called on the ideas of the other scientists on board; and we have quite a collection of experts on the flight."

"They contributed as much as we did!" exclaimed Trey.

"Do you feel you understand this proposal for an eight-year solar system exploration plan?"

"Well, yes! Of course, we debated and argued about every detail!"

"We did indeed. So you all get an A for this course, 'Topics in Planetary Science.' Exploration of the solar system is a topic in planetary science."

"I'm particularly pleased that we came up with a 'Helia 2' mission," said Celeste. "It could make rescue of Helia 1 possible, if they have a problem."

"I agree, that's a nice innovation," said Marshall. "Hideki, your work on Mercury is particularly important. I'm so glad you had an uncle there who gave us access to internal planning web pages! They have great ideas and they're crying for support. Mars could do so much more, too."

"And it wouldn't cost that much," added Hideki.

"Venus really requires a lot more terrestrial support," continued Marshall. "Their technological needs are unique."

"But even then, Martech has been providing them with a lot of engineering and technological development," noted Bill. "No one can manage without Martech, and it'll need a lot more projects if it grows as much as Mars does over the next eight years."

"I don't know how much more it can grow," said Trey. "It's already a very large technological university."

"Oh, it can grow; believe me," said Marshall. "And the strategy is to grow the satellite campuses, like in Dawes, Cassini, Phobos, and Uzboi, where new, small departments with young professors can tackle new challenges and innovate. I'm surprised the Eight Year Plan doesn't call for the expansion of many of the departments at Martech-Phobos. It's a campus with readily available microgravity! It does significant engineering work already, but it needs to be bigger."

"So, what do we do with this project?" asked Bill. "Create a course website?"

"Yes, but I think we should publicize it, too," said Marshall. "You've covered all the bases. You've taken the immigration goals for each of the Commonwealths and matched them with reasonable plans, and you've taken some of the technological projections--especially in the area of propulsion--and applied them to the various exploration projects. The combination actually doesn't exist anywhere."

"But surely a million-redback budget and a task force of experts, and six months, could do better," said Trey.

"Of course. But I think the contours of their plan will resemble yours. The basics will be fleshed out much more. And if you are interested, we can create a 'Topics in Planetary Exploration 2' and continue this project in the fall semester, starting next week. That will give us the chance to flesh this out in much greater detail. We can also enlist more of the expertise on board. We could easily line up a dozen guest speakers. In fact, we might even want to make the lecture series a public event for everyone. Then when we meet in class, we can talk about the presentation and what its implications are."

"You're determined to make sure this trip isn't boring!" quipped Celeste.

Marshall laughed. "I guess I am, and thanks to you guys, the summer has flown by. We're half way to Mars already."

6.

Elections

Oct.-Nov. 2088

"So, is the U.S. going to block any emigrants?" asked Sirikit to Maryam.

Maryam finished chewing her salad and held off taking another bite of lunch so she could consider what diplomatic insights she could share with her sister in law. "We think it's an empty threat. It's hard to say, because even though President Omar has been friendly toward Mars, Saunders has proved to be a formidable candidate, so Omar has to play a complicated game. He has all the power of misinformation and right-wing media behind him and thirty percent of the American public feels Omar is illegitimate. Fortunately, that's not enough to win an election."

"It isn't, but thirty percent is enough to create a close race, when independents are included. The US has no mechanism to demand that Mars pay for the education of every emigrant, and any lawsuit after they've left Earth is unlikely to succeed. China tried this, ten or so years ago."

"It's just election propaganda. They're too late; *Hesperia* and *Arcadia* left Earth last week and the *Cimmerium* and the *Utopia* are filling fast for their departure on December 1. So, what insights can you share with me from the Martech Economics Institute?"

Sirikit sighed. "The news continues to be good for us and bad for everyone on Earth except the ultra-wealthy. Gold prices are high and will stay that way because of uncertainty. PGM prices are moderate but demand is permanently up, so we can make a lot of revenue there. And unfortunately, the extremes of wealth and poverty are good for the space economy. Low Earth orbit is seeing a wave of investment in research, development, and manufacturing.We need

to chase a lot more terrestrial investment in our economy and particularly in Phobos, because we have to keep up with LEO."

"Mars Central Bank has been talking to us about allowing more strategic investing--partnerships--and allowing in more foreign investment. But as you know, money really isn't the problem; the bank can create it with the snap of a finger, and does so to cover the costs of each columbiad."

"Yes, I was referring to strategic research partnerships. The Economics Institute has called for an adjustment in the Eight Year Plan to expand Martech, particularly Martech-Phobos. There's no reason why the bulk of all zero-gravity research can't be done there. If we have the best labs and equipment, we'll get investment from universities and governments on Earth. But that will come with strings: if a product is developed there, the partners will want to invest in manufacturing as well. We should allow that. The Central Bank can use its credits in other ways."

"True. Ironically, that's an idea from the plan created by Saturn-7 Planetary Science Class."

"Yes, and because they have put together a series of lecturers, they're actually getting interplanetary coverage! They didn't expect that."

"I wonder whether it'll come up in the Future of Mars Forums this weekend? Sometimes it's easier to talk about expansion elsewhere than to deal with the controversial details at home."

Sirikit nodded. "I'm actually a bit worried about the Future of Mars Forums. Aurorae will have 207 of them; the entire Commonwealth, 384. All we need is trouble or serious confusion in one of them and Free Space Media will cover it thoroughly. And since all of them are being broadcast over the web, the video will be publicly available."

"Free Space Media has been very critical, but at least they don't have a stringer here, so they're quite limited in what they can do."

"Their main audience is terrestrial; they're trying to undermine the Marsian example. And with our elections, coincidentally, coming just days before US elections, we actually can have an impact on Earth this time."

"External Affairs is watching closely." Maryam put down her empty tea cup. "I had better get back to the office. It's nice to be back to work, even if it is just three sols per week!"

"How's Ruhi doing with the teething?"

"He's miserable, but he's beginning to enjoy real food." There was a beep on her communicator indicating a news item, so she pulled it out. "Ah. The twin 50-gig explosions in the north polar cap went off as predicted."

"Good. That'll accelerate springtime down there. When are the three 50-gig explosions under the south polar cap? Two weeks from now?"

"Yes; October 27, I think, right after the northern spring equinox on the 24th, before our elections on the 30th, and before the US elections on November 2d. They say we may feel the shaking."

"Of the explosions, or the elections?" asked Sirikit, with a smile.

Maryam laughed. "We'll see."

The 500 chairs for New York Circle's Future of Mars Forum filled all the grassy spaces and overflowed onto some sidewalks and plazas. As the sun sank behind the tall buildings west of the circle, the neighborhood's residents began to gather. At precisely 5 p.m., a woman walked up to the podium.

“Welcome the the Future of Mars Forum for New York Circle, also known as Aurorae District 204. My name is Daphne Schaefer. I live in South America Enclosure and was asked by the Aurorae Electoral Commission to chair your session this evening. We plan to meet for about 90 minutes tonight to discuss matters related to the neighborhood, the enclosure, and the Commonwealth. Your district already has a discussion board about these issues and it already has a substantial number of threads. I encourage you to visit the discussion board every evening over the next week, leading up to the election on Sunsol, October 30. We will begin with a welcome video from Chief Minister Helmut.”

She pushed a button on the podium and the screen behind her flashed alive with Helmut’s face. “Greetings, my fellow Marsians. I have the privilege of welcoming you to this Future of Mars Forum because I am completing my second term as Chief Minister and will retire from that role after the election. Thank you for participating in this key event in Marsian democracy. As you know, we do not nominate anyone, campaign for them or endorse anyone for elected public office. The responsibility of deciding who to vote for falls wholly on you. We have broken our boroughs into manageably small electoral districts so you can meet the majority of adults in your district, can form your personal opinions about their abilities, and can vote based on your own personal information. This is also your chance to stand up and express your ideas to your fellow residents, or write them down and post them to the district’s message board. Some people even create elaborate websites stating their views and ideas. That is fine, as long as they never, anywhere, ask anyone to vote for them. We draw the line on appeals for votes; that action can get one disqualified. This partially protects us from personal ambition, which can distort the purpose of someone’s service in government and lead to corruption of one form or another.

"Your electoral district is meeting either Frisol, Satursol, or Sunsol evening. The week that follows is a time for exchange on the neighborhood discussion board, then on Sunsol, October 30, we will vote, from midnight to midnight. We are to vote based on our individual conscience, unswayed by the opinions and comments of others, and based on our judgment of the person who best combines experience, good judgment, honesty, open-mindedness, and selfless devotion to service to the Commonwealth. We vote not on claims someone makes of what he or she will do, but on the person's character. Hence the importance of starting our electoral system with a small group and face to face relations.

"Your neighborhood will elect one person to the electoral college for your area. For most boroughs, such as Dawes and Uzboi, the entire borough is a single electoral college region. In contrast, Aurorae has nine electoral college regions, each with 23 neighborhoods, and each electoral college will meet for an entire day to discuss the future of the borough and the Commonwealth, then elect one person to the Aurorae City Council and three to the Mars Council. Those bodies, in turn, will elect the mayor of the city and the Chief Minister of the Commonwealth, in mid November.

"Therefore, your vote starts a very important representative process. It is a peaceful process, a consultative process, a process that has been called scientific politics because the words we speak and the ideas we advocate must stand up to evidence and be weighed by professional judgment. It is a process where we are free to be wrong and to change our mind. It is a process that should be free of spin and debating points. That collegiality and mutuality begins with your forum, right now. Best wishes from me and my entire administration that your deliberations will be fruitful and friendly."

Helmut's face disappeared from the screen and everyone applauded. Daphne pushed a button that revealed a five-digit number. "Text this number to indicate you want to speak," she said. "Your name will appear on the screen here in the order of the request. When your turn comes up, your communicator will become your microphone. Automated cameras surrounding this area will project your face onto this screen as well." There was a pause while people began to text to the number. A name popped up on the screen. "Martin Chin."

Changying looked at Ted, disappointed. Martin, a software developer, was by far the more prolific blogger in the neighborhood, and she did not particularly like his comments. Martin rose and activated his communicator while the robotic cameras found him and projected his face on the screen.

"Thank you, Daphne. Anyone who has read my comments on the neighborhood discussion board or on my Gallery page knows that my main concern is the development of New York Circle and the rising value of property here. This area was designed to be the high-density, high-rise urban core of Aurorae. The Commonwealth Tower is already 20 stories high, but at its northwest corner a second tower is scheduled to rise 40 stories, and when it reaches the top of the Commonwealth Tower it will be used to continue that structure up to the 40th floor as well. Together, those towers can house over 2,000 people! And four other skyscrapers are scheduled to be built in this area in the next two columbiads. How will these buildings be divided up into neighborhoods if their populations are over a thousand each? The towers need a redesign. This entire area will soon be massively crowded, with huge numbers of people coming and going through the transpo center under this circle every sol. They say our property values will go up, and that itself is a concern; who would be able to buy here, and why should some areas of Aurorae become richer than other areas? But what if the overcrowding lowers property values

instead? I think our representative needs to demand changes from the city planning authority. The towers need to be re-thought." Martin sat to a scattering of applause.

Oskar, seated with Maryam and the baby next to Changying and Ted, was irritated and texted "respond" to the number as well, even before Daphne was able to explain the procedure. She immediately called on Oskar, who rose.

"I've been following Martin's comments, and I appreciate his concern, but I think there are other facts to consider. First, the Commonwealth Tower currently is ⅔ office space, not residential space. As you may know, *Mars This Sol,* where I work, occupies the entire second and third floors. The buildings are designed to be an equal mix of housing and office space and each will therefore have about 750 people, and thus will be their own neighborhoods. And that's fitting; the residents of each building need to be able to meet and get to know each other in order to manage the building properly.

"As for transpo being overcrowded, it was designed to handle far larger crowds than it currently has. The north-south route goes under the east-west route and is still little used. There is room to add more elevators and escalators and there are already four exits from transpo, two of which are little used because the high-rises on those sides of the circle haven't been built yet.

"Finally, as for property values, anyone who has been here any length of time knows the older enclosures have less expensive housing and the larger, newer enclosures have more expensive housing, That pattern has already been established. I'm not sure there's anything that can be done about that; not that I have heard anyone propose, anyway. I see no reason to worry about the housing values here falling. When you bought here, you were informed that the area was undergoing a five-year development project, that its population was going to rise considerably, and the value of your property would probably rise as well. We were informed; we

all knew that. Why should you change it now, when some people planned on that information being true?"

Oskar sat to applause. Daphne looked at the list of names on the screen. "Aisha Thibault."

The Algerian-French woman rose. "The difficulty I have is that I don't know how to evaluate the Eight Year Plan's priorities. I'm one of those small businessmen everyone says should be encouraged and supported; I run the tailor shop at 103 Martin Luther King Avenue, which is a task that no one has yet roboticized completely! I am excited by the idea that we'll expand to a million and a half people in eight years. I am also puzzled by the detailed solar system exploration plan the Saturn-7 graduate students completed and wonder why the Eight Year Plan has so little about it, when Mars seeks to be the center of expansion out into space. I was particularly surprised that the plan included a second Helia mission! Furthermore, I used to hear the idea that Mars would lead an interstellar mission before the end of this century, but that has disappeared. Maybe the Helia mission fulfills that proposal."

Changying immediately rose. Daphne smiled. "You'll need to type in the number to be connected to the sound system."

"Oh, right." Changying typed in the number and waited for her face to appear in the screen. "The solar system exploration plan was put together by undergraduates, not graduate students, which makes it even more remarkable. I was surprised by the idea of a Helia 2 mission also, but it is a good idea if it can be afforded; and in a decade it probably could be afforded. Expansion into the solar system is Mars's destiny. On the Earth, nations have two forms of power, called hard power and soft power. Hard power is military in orientation and still is a high priority for the large nation, who spend a significant fraction of their GDPs in weapons. Soft

power, on the other hand, is the product of generosity. Mars has no military; it only has soft power, which comes from its generosity. The entire solar system is in need of support for it to grow and develop, and all the nations of the Earth are supporting those Commonwealths, so if we want to play a role, we have to support them as well.

"So that's why we give space exploration a priority. The Eight Year Plan allocated Marsian money to it, but did not detail goals, because the other Commonwealths are all independent. They need to set their own goals. The Saturn-7 Solar System Plan was an independent proposal and they drew off the existing websites of the various Commonwealths; they didn't invent goals for the other Commonwealths as much as gleaned their existing goals from published sources and put them together. So the Saturn-7 plan is a useful supplement of the Eight Year Plan. What really surprised me about the Eight Year Plan is that they didn't even specify the details of Mars's own space exploration plan; how many missions it would send out to the asteroid belt, for example. I could understand that they wouldn't specify the goals of Ceres, even though it is a Martian borough, but all of Mars? At any rate, the Saturn-7 plan has that as well.

"Finally, an interstellar mission: Helia does fulfill that goal, even though it is only 6 light days away, rather than 4 light years. Proxima Centauri is incredibly far away and any method of getting a probe there will either cost the entire GDP of a large terrestrial nation or will take a thousand years. However, in ten years we'll have a much better idea of what fusion engines can do. Right now they don't have the power to generate the high specific impulse necessary for speeds that approach a fraction of the speed of light. It should be possible to create engines that can produce 1 percent of C, which would get a probe to Proxima in 400 years. In another 30 or so years, maybe we can produce engines that will reach 5% C and a probe can reach Proxima in

80 years. Considering that waiting 30 years will shave over 300 years off the travel time, it is better to wait."

She sat to appreciative applause. "Thank you," added Abu Bakr.

"Next up: Julio Schultz."

The Chilean psychologist rose. "Thank you, Daphne. We are just now beginning to hear about the city's expansion plan, but as a psychologist I am concerned about two things: population density and dome height. I think I understand the plan to reduce our area per person to 125 square meters, but I am concerned about a sense of space, and that's a function of sight lines and dome height. Our existing enclosures have that; Africa and Asia will have them even better. But I gather the expansion plans to accommodate 750,000 people in Aurorae will not."

"Who can respond to Dr. Schultz's question?" asked Daphne. No one immediately responded, but finally Oskar texted in, and she called on him. He rose.

"I feel like I am participating too much, but *Mars This Sol* just published a story last night about the expansion plan. Briefly, the east-west axis, which is now 18.8 kilometers long, will not get any longer for some years, and expansion to the west is capped by large agricultural areas, so it will only lengthen to the east. The "continental" enclosures--Australia, Europe, South America, North America, Africa, and Asia--together are 9.25 kilometers long and have 24 square kilometers of polder. If they are built up to the population density only a bit higher than most major cities on Earth--22,000 per square kilometer--they can hold 530,000 people, and they can still have room for agriculture for about 200,000 people.

"The next priority is creating a north-south axis running through North America Enclosure and New York Circle, followed by another north-south axis 3 kilometers to the west, running through Europe Enclosure and Place de l'Etoile. Later, an axis can be added to Africa

and to Asia, to the east. Each axis will consist of an enclosure 1 kilometer wide, 4 kilometers long, and only 250 meters high, but that will still create plenty of 'headroom.' Domes that soar 750 to 1,000 meters require the extraction of immense quantities of nitrogen and argon from the Martian atmosphere, and the lower height will save a considerable amount of money.

"Between the axial enclosures, which will have underground transpo lines, is a 3-kilometer wide strip that will be filled by a triad of 'suburban domes' a kilometer long and just 100 meters wide, so they will soar only 50 meters into the air. They can be built quickly and cheaply. Initially most will be agricultural, but later they can have water shielding added to the domes and they can be converted into neighborhoods. The 'suburban domes' will be longer to the east and west of the axial enclosures. They will create a strip of enclosures 9 kilometers long and 4 kilometers wide to the north of the 'continental' enclosures and another strip to the south of the 'continental' enclosures, adding 64 square kilometers to the city. That'll be enough to house another 500,000 people and feed 600,000 people.

"If the city needs to expand more than that, a new east-west axis will be added north of that development and another one south of that development as well, and then the north-south axis will be expanded another 4 kilometers to the north. What all these additional enclosures will be called is anyone's guess, because we've run out of large places to name them after! Like avenues and streets on Earth, they'll have a wide variety of names. The design can be expanded northward nearly to the base of the escarpment and southward as far as is desired."

"If I can follow up on that," said Julio. "One nice thing about North America enclosure is that most buildings are the same height and are connected together to form open, flat farmland. Down on the street level you'd never know that up on the roofs, the enclosure is rural, even bucolic!"

"That won't change much," replied Oskar. "Some of the parks at street level will be built on, so we'll lose them, but they will have park space on their roofs. Our avenues are actually parks, since vehicle traffic is underground. Later this year, 6 hectares of farmland will be converted into a botanical garden, so our total park space will increase."

"Thank you," said Daphne. "Victoria Mulunda."

The Congolese horticulturalist rose. "I have a question and a comment. My question has to do with our elementary school; my son just started first grade there and it is a great school. Do we know whether there are plans to expand it, or build other schools nearby as the population grows? I think it is designed to double its first floor size and to accommodate second and third stories. Does anyone know?" She looked around at the crowd, particularly Oskar, who seemed to have a familiarity with the design. He shook his head.

"I think you can look that up," said Daphne. "This is one disadvantage of these smaller neighborhood gatherings. At a city-wide forum, someone would look it up instantly and know. What's your comment?"

"I'm not convinced that the agricultural design is adequate. Eighty square meters per person for food production assumes a category 5 dust storms every 2 or 3 annums, but we may be moving into a far more active dust storm climate, as the Martian atmosphere thickens. The solution is either more farmland or electrical lights, and both of those have problems. We need to be sure to store up at least six months of food for the entire population of the planet, or we'll have a famine."

"Have you expressed this concern to Agmar?" asked Daphne.

"Yes, and I will document it carefully. There are shortcuts, such as raising a smaller variety of crop species that are more productive per hectare."

"Thank you. Priya Kaur."

The Indian physician rose. "You noted that the Eight Year Plan only assigns a percentage of GDP to space exploration. That is also true of health care, and it does not explore the need to expand mental health care. As you may know, we have had a few suicides over the last two years among some of our younger generation. This requires a greater priority. I think the Helia mission needs to think extensively about mental health. You'll be confined in a single vessel for thirty years and your kids will feel an immense pressure to continue the mission as well as their parents."

Changying rose to respond and Daphne nodded, so she raised her voice so she could be heard without connecting to the sound system. "Thank you, Dr. Kaur. We have been thinking about that issue quite a lot and we want to cross-train as many of our medical personnel as possible, so they can handle a wide variety of specialties. We hope as many of our physicians as possible will also have some counseling training. As a result of our contact with the Ministry of Health and with Mariner Hospital, we are aware of their concern about the suicides. I'll be glad to put you in touch with a few people there, people you may already know, though. I think you'll find a sympathetic ear."

Daphne called on the next speaker, who expressed a concern about the loss of park space as more high rise buildings went up. The woman after him commented about the sizeof the wave of immigration coming and the problems of housing and furniture shortages, which had already started to pop up. After three more speakers, Daphne thanked everyone and wrapped up the program.

"I think that worked out pretty well," said Changying, as she, Ted, and Ted's parents headed out of New York Circle.

"You were able to speak up quite a lot," said Lech. "I'm so proud of both of you!"

"It's good to see that you had the answers because other than the report from *Mars This Sol,* no one else had them!" added Joanna.

"These small forums are going to be a bit frustrating, because there won't always be people around to provide answers," said Ted. "But the recording will be analyzed and answers will be provided by the neighborhood committee."

"If we have time to find them!" said Changying. She paused for a moment, so they all waited for her while she put her hand on her stomach.

"What is it?" asked Ted.

"A contraction; a pretty big one, too."

"You are overdue by a sol."

"Yes, but first babies often are overdue." She started to walk forward again, but as they reached their apartment, she paused for another one. "Oooh."

"That's just three minutes after the other one," said Joanna, surprised.

"I know. Maybe they'll pass; but maybe not. We'll see."

"We may be heading for Mariner Hospital, then," said Ted.

"Well, election sol has finally arrived!" exclaimed Will Elliott, in a breakfast videomail to Marshall. "I sort of miss the huge Future of Mars forums that we used to have, but even with repeated forums, Mars just had too many people for them to be an effective election event. Ethel and I went to our local forum last weekend and no one seemed to have any ideas what to ask about. I ended up answering a few questions because there was no one there who could or would. The chair, who came from Neighborhood 101, isn't supposed to answer questions; the idea is

that the people in the district do everything. Even though there seemed to be a paucity of useful questions, overall a lot more questions were asked than in any previous pre-election forum, so by that measure, certainly, the change was worthwhile. I'm excited by the idea that Marsians are electing delegates based on face-to-face relationships and a certain personal sense of the person;s character. I suspect the Mars Council will look quite different from the current Council..

"Ethel and I have just voted, but I suppose you haven't yet. Are you still considered part of the Saturn jurisdiction for electing the representative to the Mars Council from the Marsian citizens residing in that Commonwealth? I suppose you are. We look forward to hearing from you. Ciao."

The screen went blank. Marshall looked at Amy. "We didn't experience any Future of Mars or Saturn Forums at all, and I sort of miss them."

"It'll be strange, voting without one, especially since we don't know everyone on Enceladus."

Marshall nodded, took a sip of his coffee and a bite of toast while he considered his reply, then hit the reply icon. "Good morning, dad. No, we haven't voted yet, and we didn't participate in any of the Future of Saturn forums. There were six of them: one of each of the three neighborhoods on Titan, plus one each on Enceladus, Rhea, and Iapetus. The Titan neighborhoods elect 2 members to the Saturn Commonwealth Council each and three to the Titan Borough Council each; the other three moons elect one rep each to the Saturn Commonwealth Council, for a total of nine representatives. Before we left, we agreed that the representatives elected to the Commonwealth Council would also constitute the electoral college to select Saturn's single representative to the Mars Council. By law, Martian citizens in interplanetary space vote as residents of their departure port, so we vote for the Enceladus

delegate to the electoral college. We'll take care of that later this sol. We're going to keep our eye out for Bill in order to remind him and his friends vote! This will be their first opportunity and we want to be sure they get in the habit!

"Otherwise, nothing new up here. We have been amazed at all the attention our Eight-Year Solar System Exploration Plan has been getting. Every sol, some media outlet is calling for an interview. We even heard from Free Space Media, though the kids decided to refuse to speak to them. This week they're looking at electoral representation and whether Marsian citizens residing in another sovereignty ought to vote in Marsian elections. Next week we return to exploration, with presentations about Mercury and Venus resources.

"That's it. looking forward to your private analysis of the election results. Bye."

The contractions stopped after a little while, but every sol they returned and finally on Thursol, Changying went to Mariner Hospital to give birth to Yvette. She was home by Frisol and since she was on maternity leave, she turned to the neighborhood discussion board, adding comments to various ideas. On Sunsol they voted early and spent the rest of the sol with Lech and Joanna, with a three hour rolling videomail exchange with Changying's very proud parents in Shanghai.

On Monsol morning, before Changying got up, Ted turned on *Mars This Sol* while making them coffee. "My God, Changying, you were elected delegate!" he exclaimed, hurrying into the bedroom.

"What? Really? That's impossible!"

"That's what it says on the *Mars This Sol* website! You received 127 votes!"

"Why? And I can't be running around attending an electoral college meeting, I have a baby!"

"I'm sure I can come along to help with Yvette, or maybe mom can. I'm sure she'd be thrilled to do it."

"She would be." Changying shook her head and a tear appeared in her right eye. "I wanted to see how the process worked. I never thought I'd actually be voted for!"

"Well, the process worked, then! The idea is to vote for people who *don't* want to be elected, not people who do!"

"That's true," she said, feeling a bit better. She got up, picked up Yvette, and walked into the kitchen, where Ted had breakfast ready. She nursed Yvette and ate while they watched *Mars This Sol's* election coverage. Jacaranda Chamberlain, the news anchor for most big events, had Will Elliott as her next guest.

"How do you feel about this election, Chief Minister Will? How'd it go?"

"From what I can see, it went very well," he replied. "First and foremost, participation in voting was up significantly, which suggests that people are more comfortable voting when they know people personally. A major complaint of our previous system was that we had gotten too big for people to know who to vote for, especially in Aurorae. Second, someone added up all the comments made on the neighborhood discussion boards and in their Future of Mars Forums and it was probably 100 times as much as previously. People's voices can now be heard more easily. No doubt the new administration will crawl the boards and the recordings of the forums via robotic software to acquire a master list of comments and questions. It's comparatively easy to sift through everything and follow up on good suggestions or respond to questions. That's good service to the people. Third, we now have a pool of nearly 400 delegates throughout the Commonwealth, people who have been chosen by their peers for their loyalty and service to Mars. I've been skimming through the list and looking people up. We have a wide variety of

ages, races, religions, and vocations. The diversity is very impressive; it's a real cross section of Marsian society. I could see the government periodically surveying them or inviting them to comment on certain ideas, in order to get feedback."

"There have been criticisms of the new system. It's not well suited for Thaumasia Outpost, for example, which has 1,000 people; just a bit too small to have two neighborhoods, but it does have two representatives to the Mars Council."

"That's why, for outposts with less than 5,000 people, they can decide how many neighborhoods they will create. Also, they can either elect their two representatives directly or elect a five-member Borough Council and give it the responsibility to select the representatives. That problem is even bigger for the borough of Elliott, which has only 300 people, but nevertheless they get 2 representatives on the Mars Council. The entire adult population votes for five members to serve on the borough council, and the council selects the reps."

"So, we have the electoral colleges meeting next weekend to elect the representatives to the Mars Council. Do you anticipate any changes? What should we be looking for?"

"The electoral colleges represent new territory for our democracy and I am quite excited by them. Every borough except Aurorae has a single electoral college, Aurorae has three because the delegates need to select nine members of the city council and 30 representatives for the Mars Council. If there were one electoral college the delegates would have to select 39 people to vote for, which can get very difficult in the absence of nominations and mentioning of names. With three electoral colleges for the eastern, central, and western portions of the city, the 69 or 70 delegates in each college meet for two sols, so there's plenty of time for everyone to speak and get to know each other, and they vote for three city council members and 10

representatives. That's much easier to do, involves intense face to face activity, and lots of time to get a sense of character."

"Do you think we should expect a big turnover in the membership of the Mars Council?"

"I do, Jacaranda. The new electoral law specifies that no one can be a member of a borough council and the Mars Council, unless the borough has fewer than 5,000 people. All the larger boroughs have people serving actively on both bodies. The delegates will be told to vote for the 3 city council positions and the 10 Mars Council positions on the same ballot, so inevitably some people will be selected to serve on both bodies, and they will have to choose. But I can make one prediction: we are going to have a strong and capable Mars Council, because we have a remarkable set of people elected to serve as delegates."

"Thank you, Chief Minister Will."

7.

A New Chief Minister

Nov. 8, 2088

The two hundred seven delegates filled the chamber of the Mars Legislative Council for their first Satursol morning session of the convention of Aurorae's three electoral colleges. After a morning of discussion of the nature of servant leadership and the qualities of a true leader, capped by a keynote address by Will Elliott, they all headed to the lobby for a catered lunch. Will Elliott went through the buffet line and as he was seeking a table to sit at, he spotted Changying at a table with five others in a quieter corner of the room with Yvette sound asleep in a bassinet next to her.

"May I join you?" asked Will. "How is little Yvette?"

"Blessedly, she is sleeping a lot this morning, in spite of the noise. That was very kind of you to send a card."

"I was very happy to do so. I've enjoyed getting to know you and Ted. How's he doing?"

"Very well. Managing Helia without me at the moment, but Helia is sort of in suspended animation at the moment, so that's fairly easy."

"Why's that?"

"Because we're still about four years before the vessel design is finalized, construction begins, and the crew is selected. The project's budget is a million redbacks a year. We did a lot more the previous three years, but that's because we were actually participating in Project Sedna and Project Pluto and were assisting them, then we made a flight to Ceres. We have no projects like that, at the moment."

"So, it's time for this little project here." Will pointed to Yvette.

"Yes, it's a good time for her. And so far--she's just two weeks old--she's sleeping most of the time, so she was able to come on this excursion. This afternoon, however, my mother in law is coming here to watch her in one of the offices."

"That's good. You need to concentrate on the convention, especially after this meal, when the three electoral colleges will start to meet separately. I see from your badge that you are in the western region." Will looked at the other five people sitting at the table, who were a mixture of delegates from all three regions.

"I hadn't realized that we'd all start out together," said Changying. "But it was nice to get a sense of the 207 of us . And now we'll just meet with our own group, so we can get to know each other over these two sols."

"Deciding who to vote for is a very tricky business," said Will, looking at the others. "You can never really know the character of another person; not even your spouse. But you can get some sense of their personality and their drive to serve, shall we say. We are all wrapped up in our own egos; that's a perpetual battle inside ourselves. But the thing that makes human beings great is their ability to transcend themselves. We are social creatures designed to work together and cooperate; if we couldn't do that, we'd have never built culture or civilization, let alone achieved spaceflight. Leaders are people who overcome their ego and help others do the same, so that we can build something together."

"You said something this morning that intrigued me," said a black man named Sven. "That when we have a choice between doing something good for ourselves and doing something that is good for Mars, we have to do the latter. But most of the time, decisions are not that clear cut."

"Correct; that particular test is rare. But whenever we have to make any decision, we have to ask ourselves, 'what's the principle involved? What's right?' And this is a crucial question for several reasons. First, if we do the right thing, we retain the moral high ground and a clear conscience. We can explain what we did and why, and we have a chance that others will accept our decision and the approach it was based on. Second, if we do the wrong thing, if that becomes exposed we will be inclined to deny the error, and that undermines our credibility, the moral stand of our office, and the credibility of the government in general. Third, doing the wrong thing and denying it encourages others in government to do the same thing, so it erodes the morality of the entire governing process."

"And that gets us to the situation the United States is currently in," exclaimed Betty, an older Asian woman.

"Exactly. The United States elections occurred almost a week ago, we're pretty sure who won but there are efforts to reverse the victories in several states, and so far how many people have been killed in riots and terror acts? Sixteen?"

"Seventeen, including Congressman Sneider, assassinated just this morning," said Changying.

"Not to mention the bombing of the right-wing media site, Jaguar News. No one was killed, but the building collapsed and they're off the air," said Trevor, a white man with a British accent.

"Both sides are committing violence against the other," said Will. "It's the same in many other countries, too."

"You note that even if we do the right thing, we might not be able to persuade people that it was right," said Rabia, a Pakistani software designer. "What then?"

"Sometimes, even when you do your best and do the right thing, it doesn't work. You all may recall that once upon a time, Mars had two legislative chambers: the Mars Legislative Council, elected by the residents, and the Landowner's Assembly, whose members were elected by all land owners, including large corporations. I felt that Landowner's Assembly couldn't be eliminated; we had made a promise to them that they should have representation. But once Mars became an independent nation, the people would not accept the Landowner's Assembly. I tried to defend it and educate the people, but they would not be persuaded; Mars was now independent. So I changed my mind; as an independent nation, we needed a different arrangement. That was very controversial, but I felt the ethical principles had changed. Some people were angry at me for years that I had supported the land owners."

"And I suppose the land owners were angry at you afterwards," said Changying.

"Some, but they proved quite forgiving. The ones who lived here still had representation through the Council, the ones on Earth understood that they didn't have a right to interfere in the business of another country, and the corporations had other ways to lobby anyway."

"Do you think we can avoid the creeping collapse of values that we see on Earth?" asked Sven.

"I think we have to be alert and vigilant, and if we are, we'll turn out fine. Values do change over time. They can change for the better as well as for the worse. Mars does much better than most terrestrial nations because as a culture we talk about ethics a lot. Leadership and ethical treatment of others is taught in high school. We have a consensus on many basic values that is lacking in most terrestrial societies. We even have a broad consensus among the religious communities here. Sometimes people say our electoral system was inspired by Bahá'í values, and that is partially true, but it is also true that the Christian communities have agreed that

campaigning for office very frequently is a violation of the commandment against lying and bearing false witness. Churches on Earth still don't understand that, but they are beginning to recognize it as well. The Buddhist community here is beginning to see campaigning as a violation of the call for right speech, and the standards of discussion at the Future of Mars Forum meet the standard of right speech. We are beginning to see Buddhist philosophers and ethicists echo this position. I think our electoral system is the wave of the future, just as American democracy proved to be the wave of the future three hundred years ago. It takes time. The key is creating a new culture of leadership, and that's what Mars is doing. That's what this morning was about."

"So, here's a question I've been wrestling with," exclaimed Luis, a Bolivian horticulturalist. "Should I vote for myself?"

"You should vote for the people who are most qualified in your mind, and if that includes you, then you should vote for yourself. Absolutely."

"I'm more worried about figuring out who to vote for!" exclaimed Betty.

"Well, here's another thought," said Will. "When there are too many possibilities, ask yourself why you would not vote for someone. Consider this: you all represent one seven hundredth the population of Mars. That's a fairly select group. Probably half of you, if accidentally thrust into the position of Chief Minister, could grow into the job decently. Most of you are qualified to serve on the Mars Council and the Aurorae City Council. So if you feel helpless, you can literally vote randomly, as long as you are avoiding people who strike you as being too much out for themselves and not able to admit that they were wrong. Also, ask yourself whether the person strikes you as someone who will treat everyone fairly, regardless of their background, race, ethnicity, and gender. And if you need to vote at least a little randomly,

be sure to consider racial and gender balance. Note that 65% of the delegates are male and 52% are white, even though the Marsian population is 50% male and 42% white. That's not representative. It is your collective responsibility to correct that."

"Thank you for emphasizing that in the session," said Luis.

"And thank you for helping me with my dilemma," added Betty.

Your comment that we are the next wave of social organization makes me wonder what will replace us," said Sven.

"Well, give us another century! Because we are small, our example isn't very influential. If Mars greets the year 2200 with one or two hundred million people, which appears increasingly likely, and if Earth continues to sink into anarchy, our example will become more and more powerful. But no place remains the cradle of innovation forever. Soon there will be large communities in low Earth orbit, on the moon, and in interplanetary space, and any of them could wrestle leadership from us. Who knows?" Will turned to Changying. "Even Helia might be the harbinger of the next wave of civilization."

"Who knows?" said Changying, with a smile.

Satursol afternoon, the delegates from western Aurorae met in a large room in the Emporium building and discussed a series of questions about the growth of the city, followed by free consultation on the subject and a dinner just for the 69 of them. Sunsol morning they reconvened with breakfast and focused on the future of Mars. After a catered lunch, they turned to the solar system from 2 to 4, then had a break and an hour of open consultation on any subject. After supper they convened one last time to vote, something they did electronically using special computers just for them, not connected to the internet. The results were tabulated instantly. Then

they said goodbye to each other, having gotten to know each other fairly well in just two sols. Changying headed straigh to Lech and Joanna's, where Yvette and Ted awaited her.

"Congratulations!" exclaimed Lech and Joanna simultaneously as she stepped into the apartment.

"Thank you!" exclaimed Changying. She turned to Ted for a warm embrace and a kiss; she needed the encouragement and empowerment. "As one person said to me, right after the vote was announced, 'it's not congratulations. It's thank you for your service.'"

"Oh, I suppose that's true," said Joanna, nodding.

"Well, congratulations anyway!" replied Lech. "My daughter in law is going to be a member of the Mars Legislative Council! And she arrived here barely four years ago!"

"It feels like a decade, already," she replied, looking at Ted.

"I'm glad they didn't elect you to the city council," said Ted. "I suppose they knew you didn't have the time."

"They're not supposed to consider whether I have time or not," replied Changying. "Each person is supposed to vote based on who they think has the experience, judgment, and character to serve. But I'm glad they decided I wasn't qualified! The Mars Council will be demanding enough."

"When does the Council convene?" asked Lech.

"Next week, and it's first item of business is the selection of the next chief minister. I'm glad I have a week to think about that vote. I'll need it."

8.

A New Chief Minister

Nov. 15, 2088

Will Elliott straightened his tie. “How’s that?” he asked Ethel.

She leaned over and nodded. “Good. Don’t forget your cane.”

“I really don’t need one. Not ywt.”

“The doctor recommended it. We may fall more slowly in Martian gravity, but our bones are also weaker and break more easily.”

“I know. You bring your cane, too.”

“Of course.”

Will’s communicator ringed. “Don’t answer it, we’ll be late.”

He glanced at it. “It’s a videomail from Marshall.” Ethel hurried over as he pushed the button.

Marshall was wearing a tie, also. “Hi, dad. I just submitted my vote as Saturn’s representative to the Mars Council. It really wasn’t easy; I studied resumes and position papers and news items for several hours. I do hope you’ve talked to Baozhi about his tone. It’s not clear to me who should be Chief Minister, and of course you will keep your opinion to yourself, at least until the voting is finished. I doubt I’ll get a chance to vote again because we’re still 15 light-minutes from Mars and the voting will go too fast for us off-worlders to participate. I indicated they should count my vote for the first round only; I have no idea how it might change later.

“By the way, our ‘Topics and Planetary Science and Exploration’ seminar will be this evening instead of this afternoon, because of the convening of the Mars Council. We’re going to

have a summary presentation and analysis of the data for Chariklo based on Saturn Commonwealth's orbiter and lander, and the paper will also list other centaurs that Saturn can target for probes in the next ten years. There are quite a few, and some of them can be stopping off points for a second or even a third target. I worked with the presenter and he really improved his presentation well. I'll send you the link if you want to watch it. Ciao."

"He's doing such a good job with that class," said Ethel.

"He's the reason the course's Eight Year Solar System Exploration Plan is so good. The media outlets are figuring that out, too. Let me record a quick response." Will approached a screen right outside the bathroom and asked his AI to record a videomail back. "Hi Marshall. Yes, send me the link and I'll enjoy watching. One of these sols, I wouldn't mind talking to your course! And I agree, the vote for Chief Minister is going to be difficult. Yes, I've had a conversation with Baozhi. There's no obvious first choice. It worries me, but I'm sure we'll manage fine. We can exchange notes about the vote later. Can't wait for you and the family to arrive. Ciao." He sent the message.

"Now we're really going to be late."

"They'll probably start late anyway; the lunch break always tends to run over. Let's go." Will started for the door.

"Your cane!"

"Oh, that's right." Will reluctantly grabbed the cane and headed out of the house.

"I'm informing the taxi that you're on the way," said Zoe, Will's AI. They exited the building, crossed Australia Square to the transpo center, and climbed into the automated taxi. Andalus Square was close and a quick ride.

When they entered the chamber of the Mars Legislative Council, they saw that the meeting had been gavelled to order. Michael Feldman, Mars's Chief Rabbi, was reciting a prayer in Hebrew to open the meeting. Will and Ethel waited for him to finish, then headd for their reserved seats on the left side of the chamber, where Jacquie Collins and Helmut Langlais were seated, with the Supreme Court and various ambassadors seated behind them. Jacquie and Helmut nodded in greeting as they sat with them in the front row.

The newly elected Speaker of the Mars Council, Mikhail Shtokman, rose from his seat up front. Will noticed that he looked nervous, and well he should; he was a distinguished Marsian, had served as Minister of Space Exploration under Jacquie Collins, had been Speaker of the Council for the last two years and had led it well, and had been running the various propulsion programs on Phobos and Deimos for the last five years. He was an obvious candidate for Chief Minister. "Thank you, Rabbi Feldman. Having spent the morning on basic tasks necessary to organize the Council--electing the Council's officers and ratifying its rules--we now turn to its first item of business, the selection of our next Chief Minister for the next two annums or Martian years. Could the clerk of the Council step forward and read the relevant procedure."

Anika Matadeen, who was also a representative of Dawes borough and that place's Development Officer, stepped forward with her tablet and began to read the two pages of instructions. Will used the time to look over the Council, which had 86 representatives from Mars's seventeen boroughs plus 11 representatives for the Commonwealth's expatriate citizens, from Mercury to the Pluto and Sedna missions. Only two of the expatriate representatives were actually present; most lived on the world they represented and voted only when the pace of the proceedings and the speed of light made it possible. But Will was surprised to see Sirikit

Thanarat-Langlais and Charlie Langlais seated with the representatives. He reached over to Helmut and pointed.

Helmut leaned over and whispered. “They’re the two representatives of Ceres Borough, appointed by the Ceres Council.” Will touched his hand to his ear piece and a moment later the ear piece repeated Helmut’s whisper, but louder so he could hear. He nodded.

“Good for them. They’re good choices. How are you doing?”

Helmut nodded. “Nervous about the rest of my life, afraid of the boredom, and relieved of all the stress.”

Jacquie reached over and took his hand. “That sounds right; that’s how I felt. But it’ll work out great.”

“I’m kind of young to retire.”

“You’ll be busy, believe me,” said Will. He leaned back over to Ethel and calculated Helmut’s age: 66, and he had been on Mars or Ceres 40 years. He was one of Mars’s veterans. Jacquie was ten years younger.

“Thank you, Chief Clerk Matadeen,” said Mikhail, the reading of the procedure being finished. “Do I hear any discussion?” He looked around.

“I move we commence the vote.”

“Second!”

“Discussion? . . . No? All in favor?”

Hands went up; it appeared to be unanimous.

“Very well. Everyone has a tablet at their desk wired to the chamber’s central computer, which is not connected to the internet; we are in an electronic bubble here. The tablet has an app that will allow you to vote, and it will send an email to the central computer to store your vote.

Once the voting is over, the central computer will connect to the internet and email all of your votes to you, allowing you to verify them and allowing a recount, if that proves to be necessary. Please write the name of the person you wish to vote for on the tablet's screen with the stylus provided. The tablet will convert your handwriting into a specific name and ask you to verify your choice. The process is very quick; once all votes have been cast, the results will be displayed on the screen above my head. Does everyone understand?" He looked around. "Very well, please commence voting."

Silence fell over the chamber as everyone pulled out the tablet, turned on the app, and considered their vote. Some wrote a name down immediately; others thought several minutes before completing the task. The display screen showed the number of votes that had been cast; Will's eyes strayed back and forth between the display screen and the voters. some of whom were pondering very seriously.

Finally the last person voted and the "vote completed" flashed on the screen. Shtokman said "let us see the results," and the vote flashed onto the screen. Seven people had received at least 2 votes, but four were distinctly ahead of the others: Crystal Kern 22, Baozhi Zhang 21, Mikhail Shtokman 16, Helmut Langlais, 11, and Lily Estrella 10.

Conversations erupted across the chamber. Crystal smiled up in the public observation balcony; Baozhi, also in the balcony, looked glum. Mikhail tried to look professional and unmoved. "Why did they vote for me? My two terms are up!" said Helmut to Jacquie and Will.

"I think it's a vote for 'anyone else.'" said Will.

"This is worrisome," said Jacquie.

"They'd all be good choices, at least," said Helmut. "Lily has been in charge of all the immigration waves and she has managed the problems very, very skillfully."

"I'm very impressed by Crystal," added Jacquie. "She has coordinated our space program very well."

"And Mikhail is a skilled negotiator. He has brought consensus to the Council," said Will. They looked at each other; no one had praised Baozhi.

Shtokman let the talking continue for a few minutes, then called for another round of voting. Everyone quieted, thought, and wrote down names. This time, only two offworlder representatives were able to vote, because they were present; thus the total number of votes was 88, and 45 votes were required to be elected Chief Minister. The results were Crystal Kern 28, Baozhi Zhang 28, Mikhail Shtokman 15, Helmut Langlais, 12, and Lily Estrella 5.

"Well, at least there aren't any single and double votes for people any more; there's some movement," said Jacquie.

"But there are still people voting for me. I wonder whether I should say something?" said Helmut.

Will considered. "That's up to you. There is precedent for Chief Ministers saying they don't want to be considered further; Jacquie and I both said that. It removes some freedom from the voters, but it also protects choice, because otherwise someone might be reelected many, many times."

"True." Helmut thought a moment, then stood and raised his hand. The Speaker recognized him. "I do not wish to serve another term as Chief Minister." Then Helmut sat and shook his head. "That was hard."

"I know," said Will and Jacquie simultaneously.

Shtokman let the members talk another minute, then called for another round of voting. There was silence and it took quite a long time for everyone to vote; obviously, people were

wrestling with their own concerns. Then the vote was finished and automatically tallied: Crystal Kern 30, Baozhi Zhang 29, Mikhail Shtokman 19, and Lily Estrella 10. “Well, that’s a little progress,” said Will.

“We won’t get a Chief Minister, however, unless this becomes a choice between two people,” said Helmut. “And no one’s going to drop out.”

Shtokman called for another vote, and it was quick this time: Crystal Kern 31, Baozhi Zhang 31, Mikhail Shtokman 18, and Lily Estrella 8. “Mr. Speaker, may I make a suggestion?” exclaimed Ananda Thanarat, one of the Marsian old timers and a representative from his neighborhood. “May I request a minute of silence? Some may wish to pray or meditate, but even those who don’t do those things can use the silence to reflect deeply about their choices.”

“That sounds like a good idea,” agreed Mikhail. “A minute of silence.” He glanced at the chronometer on the wall.

Will bowed his head and prayed. Jacquie and Helmut bowed their heads as well, but probably not to pray. A profound silence fell on the room. Then when the minute was over, Shtokman called for another round. The result: Baozhi Zhang 34, Crystal Kern 33, Mikhail Shtokman 15, and Lily Estrella 6. “Well, that’s a bit of movement,” said Helmut.

“Maybe,” replied Will.

Again, there was discussion throughout the room for a minute. “That minute of silence might have helped,” noted Shtokman, “So let’s try it again.”

“Pretty soon we’re going to need a bathroom break!” said someone, and everyone laughed.

“Let’s try again,” added another representative.

The comments brought a positive mood to the room as another minute of silence began. Then the voting began. The result: Baozhi Zhang 37, Crystal Kern 36, Mikhail Shtokman 13, and Lily Estrella 2. “Now it’s becoming a two-way choice,” said Jacquie.

“As soon as the people voting for the others realize it,” agreed Helmut.

Another minute of silence and another vote: Crystal Kern 39, Baozhi Zhang 39, Mikhail Shtokman, 10. Jacquie nodded approvingly; Helmut looked worried.

“Let’s finish this up, folks,” said Mikhail, presumably signaling that people should stop voting for him. “Another minute of silence, please.”

The silence felt tense and ran long as people debated in their minds who to vote for. Finally, the last person voted and the results flashed onto the screen: Crystal Kern 43, Baozhi Zhang 43, Mikhail Shtokman, 2. “Oh my God,” said Will. “This could be a tie.”

“For a while, anyway,” said Jacquie.

“Crazy,” said Helmut.

“One more time, folks,” urged Shtokman. He did not call for a minute of silence, so some people began to vote right away, and the way the number voted went up quickly, it was clear that most people had made up their mind. The total number of votes stalled at 85 for over a minute, when the last three voted: Crystal Kern 44, Baozhi Zhang 44!

The three former Chief Ministers looked at each other with alarm. A roar of talking broke out in the chamber. “But he’s not completely honest,” said someone.

“She doesn’t have the experience,” replied someone else.

“Sexist,” whispered Jacquie to Will and Helmut.

“No campaigning, please!” exclaimed Mikhail. “Please, stop all talking! This is a time, as Ananda observed, of inner reflection, even prayer. We can’t be badgering each other about our

votes; it's not appropriate or legal. Let us have silence, so we can prepare ourselves for another round. Two minutes of silence this time." He returned to the speaker's podium and bowed his head.

So did quite a few of the representatives. Others sat still and closed their eyes or moved into a yoga position. The atmosphere, this time, felt solemn, even meditative. Will said the Bahá'í prayer "The Remover of Difficulties" several times in the two minutes. Then Shtokman asked everyone to begin voting. It took a long time, but finally the result flashed on the screen: Baozhi Zhang 46, Crystal Kern 42.

The Council chamber filled with applause, though some of it sounded polite. "Finally; nine rounds," said Helmut. He looked up at the balcony. "Baozhi's coming down."

"And Crystal is leaving," said Jacquie. 'I don't blame her. They'll always favor the man."

"Except in your case," noted Will.

"Crystal has other concerns," replied Helmut. "She perceived some of Baozhi's actions as electioneering, and said so to me."

"And she was right," replied Jacquie. Will nodded in agreement.

A moment later, Baozhi exited the stairs on their side of the chamber and headed to the former Chief Ministers on his way to the podium. He stopped and shook hands with all three. "Congratulations, Baozhi, you can count on my support and assistance," said Will.

"Thank you, Chief Minister Will."

"Congratulations, and I am sure you'll do a great job," echosed Jacquie.

"Thank you."

"I look forward to working with you," said Helmut. "We'll make a smooth transition, I'm sure."

"Thank you." Baozhi had a big, giddy grin on his face as he shook hands with Helmut. Then he headed to the podium, where he was greeted by a wave of applause.

'Thank you, my fellow Marsians," he said. He pulled out his communicator and glanced at its screen; he had prepared remarks. "This is an auspicious time for Mars. The wave of arrivals for the twenty-sixth columbiad begins to break on our shores in barely a month, and when it ends, Mars will have received 122,000 new citizens, raising our population to over 440,000 people. In the next eight years our population will more than triple and we will exceed 1.5 million. Meanwhile, because of explosions at both polar regions over the last year, as winter comes to the northern cap this year, about a quarter less carbon dioxide will freeze out of the atmosphere than usual. Here at Aurorae, the air pressure, which usually dips to 750 pascals in northern winter, will dip no lower than 850 this time. For the first time, we have had a significant and measurable impact on this planet's atmospheric pressure. I pledge that we will continue that progress. Indeed, it is time to consider what the next step in terraforming this world should be. We can create an atmosphere at least a tenth as dense as the Earth's atmosphere and one that is at least one percent oxygen, the threshold for plants to exist outside." He paused for applause and there was some, but some people clearly worried about the native Martian life forms. "My administration will also turn to the large-scale manufacturing of solar mirrors to maintain a higher winter temperature at the poles, an effort that, combined with halocarbon production over the next ten years, can push the average atmospheric pressure up to 1,000 pascals, or 1% of the Earth's atmosphere. We will accelerate the use of fusion explosions to vaporize the permanent CO2 caps, which alone will raise the pressure to 1,800 pascals and will start the process of desorption of CO2 accumulated in the regolith. We will commit to spreading Marsoforms over larger areas where the pressure is sufficient for them. We will continue to balance the growth of

the Central Highlands with the Capitol region. We will expand our metal highways and pipeline infrastructure to meet the growing needs of our population. We will triple the polder we live on. We will complete the construction of a functioning fusion engine. Finally we will triple the size of the outer solar system settlements in the same timeframe as we triple our own population. Phobos will quadruple in size as it becomes deeply involved in zero-gee manufacturing; it will acquire a polar power mast, a zero-gee station, and it'll even get a micro-gee botanical garden where people can enjoy huge trees and natural beauty.

"In short, Mars will achieve greatness. There is much we will accomplish, and the effort begins this sol. I pledge every fiber of my being to advancing our world and spreading civilization throughout this solar system and beyond. Thank you."

Baozhi was rewarded by strong applause. He nodded to the legislators in thanks, then stepped down. "This Council is adjourned!" announced Shtokman.

"A good speech, though I don't particuolarly like the 'Mars wll achieve greatness' part," said Helmut.

"It was mostly boilerplate from the 'Baozhi Eight Year Plan'," said Jacquie.

"Jacquie, I appointed him the head of that commission because he was Minister of Development, who is the logical person to head it," said Helmut.

"I understand, but he didn't draft the entire plan. I bet some of it was your idea."

"Yes, and the ideas of others."

"The plan doesn't call for the tripling of the outer solar system settlements or the quadrupling of the size of Phobos," noted Will. "That's new. I'm not even sure you can quadruple the size of Phobos in eight years."

"It's physically possible; Phobos has enough nickel-iron and volatiles, for example, and we can provide equipment from Mars and other resources from Ceres if necessary," replied Helmut. "But it is not yet clear what the 50,000 people would *do.* Some would provide services, some would be zero-gee researchers and asteroidal geologists in an expanded Martech campus, and some would be construction people, ship builders, and solar mirror manufacturers. But we'd need to increase the number doing zero-gee and micro-gee manufacturing to about 15,000. That requires a lot of partnerships with terrestrial businesses, a lot of terrestrial financing, and faster cheap transportation of products to Earth. That's the hard part."

"As for tripling the sizes of the outer solar system settlements, that requires recruiting a lot more people and devoting a lot more vehicles to transporting them," said Jacquie.

"The controversy, however, will come from the plan to accelerate terraforming," said Helmut. "Martian life forms have a pretty strong lobby."

"Baozhi likes to think big," said Will.

9.

A Bad Sol

Nov-Dec. 2088

"It's hard to describe the atmosphere of the election," Changying said to Ted, Lech, and Joanna that evening. "The 88 of us were a consultative body trying to reach a consensus without speaking; it was strange! Since you couldn't debate the candidates, as it were, you had to discern the direction of thought of the group from the votes. Sometimes it felt like a snake of 88 pieces, writhing helplessly. We had to vote 9 times; it took an hour and a half! But gradually we reached a consensus on two candidates, then finally on one."

"It might have been better if the two of them were both given ten minutes to state their case," said Lech.

Changying shook her head. "At first I thought that, but now I'm not so sure. Baozhi is an assertive personality. Crystal isn't. That would automatically give him an advantage, and being an assertive speaker is not a criterion for being a good Chief Minister. Frankly, that route probably would have taken longer, because other people would have wanted to speak up. There were comments about Baozhi being dishonest and Crystal being inexperienced. There would have been a lot more like that, and the atmosphere of the Council would have been soured for the legislative work we have to do. Instead, we left feeling good. There were times when the Council felt . . . almost like church. There was a solemnity, a sense of almost sacred purpose. A lot of Marsians have learned yoga, and a lot of the representatives moved into a crosslegged position on thei chairs during the minute of silence."

"Interesting," said Joanna. "And at the same time, Michigan state police were using tear gas to force occupiers out of the state capitol, and six people were killed."

"I'll take yoga and silence any sol," said Ted.

"So, we have a new Chief Minister," said Lech. "What's Baozhi like?"

"You heard his speech; that was Baozhi with his hair down," said Changying. "He was telling you exactly what he wants to do. He exaggerated, or maybe he decided to be more honest than in the Eight Year Plan, which does not quadruple Phobos or triple the outer solar system settlements or terraform Mars. I suspect he stated the real goals he wants to set. 'Greatness' goals."

"The greatness comment didn't go over very well," said Ted. "Commentators on *Mars This Sol* downplayed it."

"I'm not surprised," replied Changying. "It comes off as puffy, exaggerated patriotism, and Marsians generally don't like it. They don't need to, isolated away from Earth, and besides, a lot of them are nerds. I think he'll be good for project Helia, though. It's the sort of grandiose project he favors."

"Did you vote for him?" asked Joanna.

"Not until the eighth round; I preferred Crystal. She's solid, organized, and has vision. I suspect she contributed most of the space exploration part of the Eight Year Plan. I hope she continues as Minister of Space Exploration."

"But aren't things rather stalled at the moment?" asked Lech.

"Yes, but it's hard to change that, with the launch over ten years in the future," said Ted. "We have to watch the technological developments and see how they shape the design of the vehicle."

"When is the inauguration?" asked Lech.

"A bit over two weeks; December 1," replied Changying.

"Were you serious about quadrupling the size of Phobos over eight years?" asked Calvin Grant, Chief Executive Officer of Phobos Borough.

"Absolutely," replied Baozhi, looking at Calvin's image on the screen in front of his desk. "It's a crucial step in Mars's role in the solar system economy; it may be the most important step we can take, in fact. Swiftville is primarily for rich people seeking a safe haven or a vacation destination; it has room for at most a few hundred zero-gee researchers. Martech-Phobos already has almost that many and could easily grow to have tens of thousands of researchers. It's not just a big, rotating cylinder 500 kilometers above the earth; it can have as many cylinders as we want, as much solar power as we want, it has plenty of radiation shielding, it's one an entire miniworld that people can explore on weekends, and it has a community with schools and bridge clubs and great restaurants. . . a much nicer place to live. We can attract terrestrial investment to develop its research capacities and then we can manufacture many of the new products we develop there. Once this fusion propulsion system is ready, we can ship things to Earth much faster, too."

"Yes, Baozhi, but there are bottlenecks. We'll need to devote 10,000 construction workers just to build the infrastructure you're talking about. Phobos 1 through Phobos 6 can accommodate 16,000 comfortably, but we also have to maintain space to accommodate people in transit to Mars. Another C-200 to hold 5,000 more people will cost 1 billion redbacks and take 750 workers two years to build. And we're not getting cylinders or raw materials fast enough from Ceres for the growth you project."

"We need to transfer some of the construction people destined for the surface to Phobos, so you have more of them, and we need to start building C-300s instead; they'll hold 15,000 people at least."

"They'll practically poke right up above the rim of Stickney. Do you know how many thousands of tonnes of nitrogen gas the atmosphere of a C-300 needs? All that will have to be hauled up from Mars or flown in from Ceres."

"Phobos has some nitrogen, we can fly some up from the surface, and Ceres can get some to Phobos about three years from now, so we have to plan carefully."

"Baozhi, another problem: you keep talking about zero-gee research, but in reality we have mini-gravity research here. The new 200-meter shaft we've excavated only gives us 4 minutes and 20 seconds of zero-gee. Even in Phobosian gravity, things do fall to the bottom."

"I know, Calvin, but how about this: an elevator shaft from Stickney down 11 kilometers to the very center of Phobos, where gravity really is zero."

"We've talked about that. One hundred million redbacks a year for two years to excavate such a shaft, not to mention the facilities that have to be built at the bottom. You're talking about half a billion."

"Fine; let's do it! Half a billion is a small investment to make to acquire permanent access to unlimited amounts of zero gee at the end of a ten-minute elevator ride. We're talking about settling 38,000 more people on Phobos in eight years. That'll require three C-300s at six billion redbacks each plus designing the larger size of vessel. We're also talking about building a ten-kilometer solar power mast at the north pole to get outside Phobos's shadow and enough solar panels to generate a thousand megawatts of power; that's another billion redbacks right there. But 50,000 people will generate a GDP of 25 billion redbacks at least. We don't do this immediately, but if we start on the power mast, the shaft to the center of Phobos, and the design of the C-300s, in three years when material and nitrogen can arrive from Ceres, we'll be ready for a big expansion. That'll give us time to line up contracts also. I've already asked the

Chancellor to appoint a task force to plan for a major expansion of Martech-Phobos; I mean to 1,000 researchers in 4 years and 2,500 in eight. That kind of commitment will get the attention of biotech companies, manufacturing companies, and others who want to use zero-gee."

"Assuming we can recruit them from Earth. I'm not opposed to your ideas, Baozhi, but I do want to make sure they've been thought through carefully. It isn't just a matter of money; we need people to do the work, but we need infrastructure to accommodate the people, and the infrastructure requires people to build it . . . You know that. Maybe you should meet with Derik Nassery, our new Development Officer? Give him a clear vision of what you have in mind and he'll figure it out."

"And you'll be involved?"

"Yes, of course! This is too big for the Development Officer to handle by himself. By the way, do you know who you'll appoint as Minister of Development yet?"

"No, not yet. I've been Chief Minister Elect only four sols. These decisions take time."

"I'm sure. When will you be announcing your choices?"

"As soon as possible; in fact, I have an interview with someone right now, so I had better close this connection."

"Alright, thanks Baozhi. I like the way you're thinking about Phobos. We really do need to seize the opportunities available to us."

"Exactly, I have no intention of letting a single opportunity pass us by. Thanks, Calvin."

'Thanks, Baozhi. Ciao."

"Ciao."

He closed the connection and looked out the door of his office--he was still using his office as Minister of Development--to see whether Irit Goldberg had shown up. Not seeing her,

he turned to email. Attorney General Indira Kumar, who had been attorney general since Will Elliott was Chief Minister, had tendered her resignation. That surprised him; she was highly respected, extremely competent, and only 60. Rory Meyerovitch, Helmut's chief of staff, had sent in his resignation letter earlier that sol as well. It felt a bit like everyone was jumping ship on him.

He heard a knock on the door and looked up; it was Irit Goldberg, minister of the Martian Environment. "Good sol, Irit, please come in." He stood up from behind his desk and pointed to a chair to the right side of the desk; he planned to continue sitting behind it.

"Good sol, Mr. Chief Minister elect Baozhi." She smiled and said it slowly, respectfully, but he wasn't sure if her tone had an ironic twist to it. They shook hands and she sat in the chair next to him.

"Thank you, Minister of the Martian Environment Irit," he said. There had always been a bit of awkwardness or even tension between them, and he hoped to get over that. "I want to compliment you for all the work you've done for the Martian environment. You've overseen the designation of 10 million square kilometers as national parks and national deserts, planned areas of development where land could be sold to investors along our metal highways and trails and designated other areas as natural areas or parks, and of course your coordination of the work to bring about partial terraformation has been superb. No one could have done it as well. So, I am offering you the post of Minister of the Martian Environment for another four year term."

"Thank you, Baozhi. I'd be thrilled to take the position. But I need to understand your vision for Mars a bit more because we have to be on the same page about it. As you know, I almost never use the term 'terraform'; our goal right now is to bring about an estival over a twenty-five year period where the atmospheric pressure will increase roughly three fold. We're

taking our time because of the potential negative climatic effects. We've already seen a statistical increase in global dust storms, and if they increase severely, the metal highways will have serious dust problems and will require retrofitting, the enclosures will need more robust dust-clearing facilities, the solar energy farms will need to compensate, etc. There are a lot of knock-on effects that potentially can cost billions. We're in the process of creating a plan to deal with them."

"Good; that's what we need, because we can compensate for the negative effects. There are positive effects as well; shuttles will be able to aerobrake more and we'll need less fuel for landings. We're eight years into the thirty year plan to bring about an estival. I think we can complete that plan in eight more years; we know how to do it and the resources available for it are expanding fast. Production of halogens is set to double in the next year and we can double it again in another four years. Solar mirrors can maintain polar temperatures high enough to prevent refreezing of the atmosphere and we can accomplish that in eight years. I want to start our thinking on the next phase, because we'll need a smooth transition to it. It appears that the regolith has enough CO2 to increase atmospheric pressure to 10 kilopascals; a tenth the pressure of the Earth's atmosphere. The question is how we'll get it out; it requires heat. But once it comes out, the additional greenhouse effect will help keep it out, and at that increased pressure there will be transitory liquid water bodies, which means the dust will be partially consolidated into caliche, which will reduce the dust storm activity, and the water will break down superoxides and perchlorates and release some oxygen into the atmosphere."

"Yes, I know about all of that, Baozhi, it's my field. Yes, Mars has enough CO2--potentially--to have an atmospheric pressure of 10 kilopascals. Yes, water will create caliches that will consolidate some of the dust. But there will still be plenty of dust to create huge

dust storms, probably bigger ones than we get now, and the perchlorates will produce other toxic chemicals when they break down. What we need is a huge acceleration in research about all these phenomena. We don't know what our intervention will do. Thickening the atmosphere is not an end in itself. If it produces a gray world of gray skies and cuts solar power in half, cuts sunlight for agriculture in half, the increase in atmospheric pressure won't be worth it. We'll live in gray enclosures where the sun is barely seen and our farms will be powered by nuclear reactors."

"We have eight years to accelerate the research. I'll put it in the budget."

"Good, but remember, these are home-grown researchers. We can't inport them from Earth, like we can aerospace engineers. We have to attract graduate students and oversee their doctorates, then give them positions. We don't even know all the positions we need at the moment. We can't snap our fingers and double the size of a department in two years."

"I see." Baozhi said gravely. He was getting frustrated. "Irit, I'm giving you the chance of a lifetime to oversee the greening of a new Earth. What work could be more important than that? This world has the potential to have a population of billions. It could have rivers and an ocean again, and the tops of the volcanoes, where the air is thin and cold, can provide a permanent estival for Martian life. We can have this world for us and still leave space for them. A lot of us think that is our destiny."

"I . . . think that is our destiny as well, *if* everything we've been discussing works out. Mars hasn't had an atmosphere of 10 kilopascals for over a billion years; it will take advanced engineering to get it there and keep it there. It may take billions of people just to maintain it. And 10 kilopascals might not get us the conditions for partial terraforming that we want, either. We have to go forward deliberately; we have to know what each step will bring about. That can't be

rushed. And you can't rush public opinion, either. Not everyone wants the green Mars you talk about. If you drive out to the Marsoform field that Jefferson Woolsey has been patiently expanding and nurturing for sixteen years, you'll see a lot of dead Marsoforms. Nothing is going to rot them away; they're going to sit, black, dead, and frozen, until they're buried by the dust or are slowly sandblasted into atoms over a million years. In short, they're an eyesore." She shrugged.

"I see. So, will you take the job, or not?"

She considered, then shook her head. "No, not under these circumstances. We need to be on the same page. You're asking me to implement a vision that, so far at least, I can't endorse. If I can't endorse it, how can I implement it?"

Baozhi nodded. "I see. Alright, I'll look elsewhere. Thanks for coming in, Irit."

"Thank you, Baozhi." There was a tear in one of her eyes; she had hoped he would come around, just as he had hoped she would. She stared at him, to give him another chance. Then she rose, turned away from him, and hurried out of the office.

He sat, a bit shocked that the interview had gone so badly. Her stubbornness made him angry; everyone seemed to agree that partial terraforming, terraforming to a significant degree, was possible, maybe even to 20 kilopascals if they could keep the temperature up high enough. Martian life had been extinct on the planet's surface; only a few dozen species had survived frozen in ice. Without humanity, complete extinction would have been their fate eventually. Giving them a few square kilometers where they could thrive was a gift to them, and they didn't need the other 125 million square kilometers of Dusty Red. If Mars has ten million people by 2150, it'd have the economic base to get the pressure up to at least 10, maybe 20 kilopascals, and

20 kilopascals was a magic number; it was the partial pressure of oxygen on the Earth's surface. It meant people could go outside with coats, gloves, and scuba gear.

Restless and irritated, Baozhi rose and walked down the hall. He passed the offices of the other key people in the Ministry of Industrial Development--some of whom would be moving with him to the executive offices in less than two weeks--and around a corner to a large conference room. Lily Estrella was there at a large square table where some thirty people were seated, with another thirty visible on a large screen up front. It was her daily planning session for the immigration wave. He watched for a moment; she was quite amazing at remembering every detail and constantly encouraging people to work as a team. With sixty thousand people arriving over the next few weeks, there were lots of bottlenecks to fix, lots of little problems to resolve before they became big problems.

He continued down the hallway and went through doors to the balcony overlooking Andalus Square. He stood for a moment, catching some fresh air, then went back inside. As he was approaching the conference room, Crystal Kern came around the corner.

They nodded uneasily at each other, then Baozhi said, "Crystal, we should talk about the Ministry of Space Exploration. You've done a great job of running it for the last eight years, which has put us in a strong position to expand--"

She shook her head. "Baozhi, I won't work with you. I won't work for you. The way you behaved over the last few months was . . . inexcusable."

He was shocked. "I beg your pardon? What I do that offended you so much?"

"You were blatantly campaigning for the position of Chief Minister. You kept it just subtle enough so no one would complain about it; you were very clever that way. It was wrong and it worked, because it got you elected."

"How dare you accuse me of such a thing!" replied Baozhi, raising his voice. "I didn't do anything wrong at all! I promoted the Eight Year Plan! I had to; it had to be sold to the public! There was nothing wrong with that!"

"You called it your plan and promoted yourself as well, when in fact a lot of us contributed to it! I contributed the entire space exploration section, but I never got any recognition for it! What you did was wrong and unfair!"

"And you sound like a sore loser, Crystal! The representatives voted for me over you, so get used to it! I don't want jealous people in my cabinet anyway!" He turned to stomp away, but when he did he saw people coming out of the meeting room. The meeting was breaking up, and they would have heard the entire exchange. Embarrassed, Baozhi strutted back to his office. Lily Estrella was right behind him.

"Baozhi, you can't treat Crystal that way. She's upset and needs to calm down. But yelling at her that way, accusing her of jealousy; that just makes it worse."

"Look, I don't need your help to handle other ministers. Crystal accused me of something, and a few dozen people would have heard her; she humiliated me in front of them. That's not right! I was not campaigning or promoting myself, I was promoting the plan! If people don't believe me, that's just too bad!"

"Look, go apologize to her and maybe you can get her back. She's a great Minister of Space Exploration."

"If she wants to serve, she needs to apologize to me, not me to her!"

"Please don't be so stubborn, Baozhi. If we're going to work as a team, we need to be flexible. Sometimes that means apologizing, even if the other person is the one who should apologize. You're right, she started it, but--"

“There is no ‘but.’ If she doesn’t apologize to me, she’s out. There are plenty of people who can be Minister of Space Exploration.”

“Well, for the sake of the team, please reconsider--”

“No, I’m the head of the team, remember, not Crystal. I set the terms of functioning of the team, and if people don’t like that, then I don’t want them on the team. That includes you, Lily.”

She was startled and angered by that ultimatum. “Baozhi, I can’t operate that way, it isn’t me. We have to work together or this administration won’t succeed.”

“Look, I’m going to be Chief Minister in less than two weeks, and I define what constitutes success; not you, not the media; me.”

“Alright, suit yourself, but are you going to run all the ministries yourself? Good luck with that.” She turned and walked out of his office.

10.

Off to a Bad Start

Dec. 2088

Bill Elliott popped up the last slide of his presentation about lead-uranium isotope ratios in 2065BE1903. “Conclusion: It’s an ambiguous situation. Questions?”

There was a silence as the dozen students in the class pondered the ambiguity of the situation. “Very interesting,” Trey finally ventured.

“Could the error bars be wrong?” asked Celeste.

“Anderson et al said that’s what they were,” replied Bill. “I haven’t seen anyone question them.”

“The issue, then, is whether the other elemental compositions are in error,” said Eman. “It sure looks like an object from the solar nebula.”

“Not if it’s 4.9 billion years old,” replied Hideki.

“What do you think?” Trey asked Marshall. “Could the solar nebula have come from a cloud that lasted several hundred million years?”

Marshall smiled and looked at the students, hoping someone would answer for him. Unlikely,” he finally replied. “Al26 was a major source of heat in the early solar nebula and its halflife is 700,000 years, so a supernova added it to the solar nebula right before it began to collapse, and that supernova would have added other material to the nebula. Hence this object was produced before the solar system began to form.”

“But why are the isotopic ratios the same as other asteroids?” asked Trey.

“We don’t know. Maybe two stars of about the same mass went supernova a few hundred million years apart? It’s a mystery.”

"It's too bad the rover-probe died before it could collect and analyze more samples," said Bill. "This is one of the big mysteries in current asteroidal science."

"Which raises a different question for us," added Marshall. "Should this be a priority target in the next eight years?"

The students looked at each other, then began to nod. "If it's that big a mystery, yes," said Trey.

"Especially with the Helia mission," added Celeste. "Extrasolar research is hot. There are several other extrasolar objects that have been explored. It's time to send another probe to 2065BE1903."

"Of course, that probe was senrt by Jupiter, and we don't have much to say about their priorities," said Trey.

"Well, we have included them in our so-called plan,"replied Marshall. "And 2065BE190's orbit crosses into the asteroid belt, so Mars could send easily claim the right to send a probe back."

"I think there might even be an existing probe out there that could be repurposed to visit 2065BE1903," said Bill. "I can run Astrolabe on the trajectories and see."

"Yes, do that," agreed Marshall. "Alright. Class is just about over, and we only have three more left to the semester. As I said, we won't be convening next semester; we'll be less than ten light minutes from Mars and I want all of you taking courses through Martech, so you can start adjusting to the place. But I'll be available to help, at least until early March."

"Did you watch the inauguration this morning?" asked Trey. "What did you think?"

"I did," replied Marshall. "It was quite nice, with good music, a great poem by Oskar Langlais, and Baozhi's inaugural speech was quite good; he seems to have pulled back from

some of his positions that caused controversy. I actually like some of his ideas; they've been floating around for a decade or so and were always considered way beyond Mars's capabilities, but a Mars of 50,000 people is a lot more limited than a Mars of 1.5 million. People have been talking about a station at the Mars-Phobos L1 point and a cable connecting it to the outpost at Stickney. It'd be cheaper than a shaft to the middle of Phobos, but that L1 point is pretty unstable because Phobos's gravity is so weak. We've already drilled down 3 kilometers. An 11 kilometer shaft two or three meters in diameter really wouldn't be that difficult to make, it'd allow us to explore a cross section of the moon, and when we get to the center we could expand our facility there almost infinitely. So I favor that."

"But starting real terraformation?" asked Celeste.

"I don't know. I'd have to immerse myself in the science first. Clearly, it'd be a lot dustier world."

"Well, they already call it 'Dusty Red'," noted Bill.

"Admittedly, the controversies didn't come up in the inauguration," said Trey. "But they're all over social media."

"Quite correct," said Marshall. "Baozhi was dealing with a public relations disaster even before he was inaugurated. Don't tell anyone I said that, by the way. But clearly it's true. It appears there was pent up resentment against him among his fellow cabinet members because of his behavior before the election. A lot of the so-called 'Baozhi Plan,' a term he *did* use a few times, really came from Crystal, Lily, and Helmut himself. They were modest; Baozhi wasn't. Crystal almost was elected Chief Minister, so she's mad she followed the rules and he didn't. You can't blame her there. But Baozhi's fight with her was witnessed by two dozen people, and they have talked about it, and a few overheard his altercation with Lily and talked about that as

well. Now everyone knows the plan wasn't just his and the public feels like it was misled by the Chief Minister. They're also upset about his unprofessional behavior; politicians can get away with it on Earth, but not on Mars. That's a very bad situation."

"How can it get resolved?" asked Bill.

Marshall shook his head. "The right thing for Baozhi to do is truly apologize and resign and let the Mars Council choose a replacement Chief Minister. Maybe they'd re-elect him because he was contrite, and then he wouldn't be tainted. It'd be a risk for him, but it would be the right thing for him to do for the sake of Mars. *Mars This Sol* had an opinion piece to that effect two sols ago, and I think they are right."

"It's too bad grandpa can't tell him that," said Bill.

Marshall looked at his son. "Let's just say that I can neither confirm nor deny that grandpa has talked to Baozhi about it."

"I see," said Trey, with a chuckle.

"Look, what is said in this room, stays in this room," said Marshall. "The big issue right now is whether Lily Estrella will stay on as Minister of Immigration through the current wave. Sixty thousand immigrants arrive at Phobos in two weeks. I think things are already getting gummed up. The house I've put a contract on won't be ready until a month after we arrive. It was scheduled to be ready a week before we arrived. That's a big change. Some of the furniture is available; some of it is delayed as well."

"Who's supposed to replace her?" asked Celeste.

"Her deputy, Bijan Lohraspi. Fortunately, he knows what's going on. But Baozhi still has no Minister of Space Exploration or of the Martian Environment. I gather neither of those ministers are willing to return."

"This is more chaos than Mars ever has, it seems to me," said Bill.

Marshall nodded. "And the Marsian public is not happy."

Changying was not happy.

She glanced at Ted, then turned back to Crystal Kern, visible on her wall screen. "We need someone on the Helia Commission that we can count on to push it, both as a priority and financially. You know the project and you have the contacts in government. You really would be ideal, and now you have the time."

Crystal shook her head ever so slightly. "I do have the time, Changying, but I don't have the other things you want. Remember, I am out of the government. Baozhi still doesn't have a Minister of Space Exploration. I'm *persona non grata*; anything I say will be looked at with suspicion by Baozhi. My involvement will look like a slap in the face to the current government, too, like I can't let go. You're better off waiting until a Minister of Space Exploraroin is named, and ask him or her to serve, or to name someone."

"Have you any idea who might be chosen, and when?"

Crystal smiled. "No. Several people have called me and asked about my experience with the job for the last 4 annums and my experience with the new Chief Minister. Perhaps that's why they have turned it down."

"I see. You did a really great job, Crystal, and were very supportive of Project Helia."

"I wish I could have done more, but the project is still eleven years into the future, so obviously it doesn't have a high priority. But the key technologies that are necessary are falling into place. The latest reports from the Sedna and Pluto missions are that the recycling systems

are working quite well and that the resource margins are good. In another three years we'll be very confident of the resources needed for a thirty-year trip."

"Exactly. The fusion engine technology is maturing well, also, thanks to US, European, and Chinese research. They're all sending additional scientists to Phobos this columbiad to speed the work. We're very optimistic. We really need you!"

"No, I don't think so. You and Ted are a great team; I'd just be a third wheel. You need a strong commission and it needs US, Chinese, and Marsian representatives. I gather a new NASA rep is on her way and will arrive in late January. You should have a Marsian rep by then."

"I suppose, but we'd like the Commission to have several independent members as well who are experts, not national reps. The national reps will handle the politics and money; the independent members will bring expertise."

"Maybe I could do that in six months, but right now I can't be effective in any role, Changying. Let's talk about that later."

"Alright." She was disappointed. "Thanks for taking the call to discuss my email, and I will call you back in six months or so. I really appreciate all you've done for us in the past."

"It was a delight and privilege. Best wishes with the Helia project. It's bold and important. Ciao."

"Ciao." Changying closed the connection and turned to Ted. "Now what?"

"She's right; we're pushing this too hard. We should wait another month, until there's a Minister of Space Exploration and we can meet with her or him."

"I want to build our independent members, though. I see three groups of members: national representatives, people with prestige and experience in exploration, and technical

experts like Stanley Mansale who will actually go on the mission. We need the first and second groups before we invite the third, and we can start building up the second now."

"Will Elliott said no because of age and Jacquie Collins felt it wasn't her thing. Helmut will say no; he needs a break anyway."

"I know."

They thought for a moment. "Say, here's an idea," said Ted. "What about Marshall Elliott? He's on his way to Mars, has no job, is a favorite son--everyone knows who he is--and the Eight Year Space Exploration Plan his course put together has gotten a lot of favorable notice."

Changying nodded. "Brilliant! Ted, you're a genius! Kung Fuzi, when does Saturn-7 reach Mars?"

"March 10," replied her AI.

"But you can call him now. How far away are they now?"

"Four point seven light minutes," replied the AI, knowing they wanted to know the communications delay.

"A video mail, then. Kung Fuzi, can you send a videomail to Marshall Elliott on board Saturn-7?"

"Yes, his email address is available."

"Excellent." She beckoned Ted to move closer to her. "Ready?" she asked.

"You're doing the talking."

She nodded and clicked on an icon on her desk screen. "Hello, Marshall Elliott. I don't think you know us; I an Lin Changying and this is my husband, Ted Bukowski, and we are the two principals for the Helia Project. At the moment, the Helia Commission has lapsed. The US

NASA representative has headed back to Earth, there is no Chinese rep, and until Mars has a Minister for Space Exploration, there is no Martian rep. We still have European, Brazilian, and Indian reps, but without the other three we can't meet. The national reps, however, are only a part of the Commission; we want to expand it to include experienced spaceflight professionals who can advise us at a high level. Therefore, we were wondering whether you would be interested in serving on the Commission."

She paused, thinking of her next sentence, so Ted said, "With your experience, you really are ideal. You've overseen construction of a C-100 on Enceladus and C-50 drums on Rhea and other moons, you've overseen the launch of automated probes to other moons in the Saturn system and to centaur asteroids in the vicinity of Saturn, you've helped to conceive and design the Cathedral tunnel complex, and of course you know about planetary geology and exploration of other worlds. It'd be hard to find a better person to invite."

"And you've been an executive of an entire self-containd community; that's invaluable," continued Changying. "I hope you are able to join the commission. Please get back to us in a sol or two, if you are interested. Thank you. Ciao."

She pushed the send button and the videomail headed to Mars's deep space network and was beamed to Saturn-7 in a millisecond. Marshall was watching the news on *Mars This Sol* when it arrived 4.7 minutes later. Disgusted by the sad news coming from Earth--the US Presidential election was still not settled, votes were being contested by both sides, deo=monstratins were becoming confrontations and riots in some places, militias that had disarmed were rearming, and the stock market was falling--he turned off the news and listened to their videomail. "Huh," he said.

"Sounds appealing," said Amy, who was sitting across the room.

"Yes, it does."

"It'll give you something to do when we arrive, at least."

"True. I'll qualify for a small government honorarium for service on a recognized board."

"You'd better run it past your dad first, it might be a political minefield."

"That's what I was thinking, too. Ivy, can you forward this videomail to my father, and add the text line: 'Dear Dad: What do you think? Is this politically complicated? Please let me know. Love, Marshall."

"It's sent," replied his AI instantly.

"Thank you. And let's record a videomail back to them." He turned to the screen on his desk and the word "recording" appeared. "Dear Changying and Ted: Thank you for thinking of me. Yes, I have heard of you; you're doing excellent work. Give me a sol or two to think about it, and I'll get back to you. Ciao."

11.

A New Job

Dec. 2088

Will Elliott said he saw no problem with the request, but Marshall didn't reply right away; instead, he read up about the Helia Project in detail. After three sols, he was ready. "I apologize for the delay, but I wanted to think thoroughly about the request," he began. "I do have a series of questions, so perhaps we should have a brief exchange about them this sol, if you have the time.

"First: I am curious about the proposed size of the vessel. We have C-100s and C-200s, but there are no designs for a vessel 150 meters in diameter. Why did you go with that dimension? And why did you decide on a population of up to 3,150? That seems like such an odd number. Related to these questions are the mass of 20,000 tonnes for the organic materials, plastics, and metals forming the interior of the vessel; 6 tonnes per person. The *Pluto* has a mass allocation of 3.5 tonnes per person and the *Sedna,* 4 tonnes per person. Why such a generous allocation? What propulsion system do you plan to use?

"You're never going to come back: what are the ethics of that fact? Is it ethical to take children on a voyage of no return? How will you develop criteria for recruitment of residents; of citizens of another solar system? Do you want a follow-up mission or even a cargo mission in subsequent years? What is the current estimate for Helia's total budget? The latter number appears to be absent on all the official records and web pages I've been able to find. And last, why 2099, if advanced propulsion systems exist that allow a direct flight to the Helia system?

"I think those are enough for now! I look forward to hearing from you subsequently. Ciao."

Marshall hit send and the videomail rode a laser beam to the Marsian deep space network, then the Marsian internet to Changying's computer. She listened carefully. "He's testing us."

"Why do you say that?" asked Ted.

"The ethical question: it has the same answer for Helia that it had for Saturn-1 twenty years ago! Well, I'll reply." She read a transcript of the videomail, highlighted a few questions, and began to collect notes on them. Then she was ready to respond. "Thank you, Marshall, for your thoughtful questions. I think they get to the heart of the project, actually.

"The place to start is the crew size. Saturn-1 had 300 adults and as you know, there was, first, creation of a job list, then recruitment of personnel to fill the jobs. Uranus, Neptune, Pluto, and Sedna all involved similar lists, which got longer and more detailed over time. Our list involves 1800 adult job positions, including a poet, an historian, barbers, beauticians, even surrogate mothers. It is heavy on scientific and engineering specialties because those skills are easiest taught face to face.

"We then assume 1.5 children per couple, which is 1,350 children. Some of these could be adopted; we will have a sperm bank and an egg bank and an embryo bank with us, so we will have even more genetic diversity than the 1800 adults would imply. Initially, we thought we'd start with no more than 200 children and let the rest be born en route. Now, we don't care; we will allow families with children as old as 12 or 13 on board and may allow older ones as well.

"So that's where 3,150 comes from. But that won't be the maximum population on board, because after 30 years, not many of the original adults will have died, but the children will have married and started families as well. Our population may very well grow to almost 5,000 by the

time we reach Helia. Hence the 20,000 tonnes of stuff; that's only 4 tonnes per person. Frankly, it may not be enough.

"As for the size, a population of 4,000 people--to take an even number--will need about 480,000 square meters for housing, work spaces, agriculture, and recreation. A cylinder 150 meters in diameter and 200 meters long--100 meters of which will be the liquid hydrogen tank for the departure propellant, so it won't even be usable until we head out--has 100,000 square meters of cylinder wall, so we will need 5 levels to provide us with the space we need, 6 levels if we want to be able to accommodate 5,000 people. If we used a cylinder 100 meters in diameter, we'd use up 30 meters of the interior and have only a 70-meter open space. That's not a lot of headroom. A 200 meter cylinder would provide 170 meters; lots of headroom in the central open space, but the mass of the central atmosphere gets pretty large, and if we want to keep an entire spare nitrogen atmosphere against possible leakage, that's a lot of mass. So 150 meters diameter seems best. That gives us headroom comparable to the Cathedral tunnels on Titan.

"As for the ethical questions, I'd again refer to Saturn-1. You all were heading 1.5 billion kilometers--far beyond any place humans had gone before--in two caravels, at the same time the Earth was engaged in a nuclear war and there was the possibility you'd have to abandon your mission and return to Mars, or get stranded in the Saturn system with no possibility of rescue. In spite of those conditions, the 300 crew had 72 babies during their voyage, including your oldest son! That was optimistic; that was confidence in the situation. We won't leave Mars until we are confident we have life support systems capable of supporting us for thirty years. We can take plenty of spare reactors, plenty of spare uranium and plutonium, plenty of raw materials, plenty of technology, and with six airtight levels we should be safe from all but the largest catastrophic failures. We'll get to Helia, and our babies will be the crew. We'll have at least 4 caravels and

galleons along for local exploration, transportation to move the population to our permanent surface settlement, and serve as lifeboats if necessary. So we have the confidence that we will succeed. Recruiting people for this adventure should not prove difficult. It wasn't difficult for Saturn-1, either.

"As for propulsion, that's still the unknown, but fusion propulsion is looking better and better. The Phobos test facility has now run a fusion engine at 20,000 ISP for three hours.We'll need an ISP of 12,000 and a duration of several weeks. The 2099 launch date is based on the need to fly to Jupiter and use its gravity well if we are using gaseous core nuclear with an ISP of 5,000 seconds and VASMIR propulsion subsequently. If the fusion engine works, we could skip Jupiter and fly any time Mars is in the right position.

"Finally, cost: that depends on what you include. The fusion propulsion system will require at least 20 billion redbacks of investment, but will be useful for a much wider range of projects than just ours. The cylinders and the liquid hydrogen will cost about a billion redbacks. Fifteen billion redbacks have been spent, over the last ten years, on the designs of C-50s, C-100s, C-200s, and the designs of the specific models on Phobos, Enceladus, Miranda, Proteus, Triton, Ceres, Sedna, and Pluto. The Helia carrier will benefit from all that work. Life support and environmental management; how much has been spent on those systems in the last 50 years? Thirty billion redbacks at least. The actual construction of the Helia vessel will be accomplished by the crew itself over 2 or 3 years; their salaries during that period will amount to about a billion redbacks per year.We'll need perhaps four billion redbacks of reactors, gaseous core engines, solid core nuclear engines, caravels, galleons, medical equipment, and other specialized equipment. Those are our current estimates, based on the Pluto and Sedna missions.

"As for follow-up missions; I noticed that your student-led Eight-Year Solar System exploration plan included a second flight. That may be a good idea. But right now, I'm aiming to get a first flight flying! Ciao."

She hit send and it winged its way to Saturn-7 on a beam of light. Marshall listened to her reply, then skimmed the automated transcript again. "What do you think?" asked Amy, curious.

He nodded. "She does a good job. I like her style; she doesn't cover anything up."

"So it would seem."

"Yes, so it would seem." He considered, then hit reply. "Thank you so much, Changying and Ted. I have more questions, but I'll ask them after I arrive. Meanwhile, yes, I agree to serve on the Helia Commission."

"I appreciate this opportunity to talk further, Will," said Baozhi, as Will Elliott arrived at the Chief Minister's office. Baozhi pointed to Marjeeling tea already brewing for them, and they sat in comfortable chairs opposite each other, in front of Baozhi's huge desk.

"It's good to see you again, Mr. Chief Minister," said Will as he sat. "Five weeks after the US elections, and still no determination who is President."

"The losers won't concede. I was impressed by your opinion piece in the *New York Times.* How do you manage to write so well!"

"I was blessed by a liberal arts education. It has served me well, and since I completed my duties as Chief Minister eight annums ago, I have done little else but write. I now have a lot of experience! I've been interviewed by two television prorams lately, also."

"Good; keep hitting them with truth. I have a bit of a problem; by recalling all of Mars's ambassadors for quick face to face consultations, we have no one on the ground. The

ambassadors have had to issue all their statements from the flight. We'll spend all of next week in intensive discussions about the best diplomatic strategies to take. They can stay two weeks, max, then they have to head back on a fast flight. So I'm afraid I can't think about anything else during that time period."

"Launch windows can't be manipulated. I think it was a good idea to get everyone here, though, as you begin your term. I think Jacquie did the same, but Helmut never did."

"But he did spend entire sols on videomail with them when the planets were at opposition. I sat in on one of those marathon conferences."

"So, you have a Minister of the Martian Environment."

"Yes; Dr. Bruce Korlevic, a young guy and an enthusiastic terraformer. He's already rethinking priorities so we can study the major problems, such as releasing carbon dioxide adsorbed to the regolith, worse dust storms, the impact of decreased insolation, and protection of our hyperloop system."

"Good; but as you know, this is a very controversial direction to move in. You've already been denounced by the Friends of Mars Outdoors."

"Yes, and frankly, I don't care. The polls show the majority of the population think it is our destiny to have a breathable Marsian atmosphere some sol. It'll be a long time but it appears we could thicken the atmosphere to 15 kilopascals in another century or two, and that's sufficient for scuba equipment."

"I agree the public can be brought around, but it's important how it's done. No one wants to see Martian life extinguished."

"It won't be. There are Marsoforms living in the anaerobic soil conditions inside Elysium enclosure! They're going to coexist with terrestrial life. But I understand your point; there's no reason to stir up opposition when it can be avoided."

"Exactly. This is a hard job; people will always question your judgment, second guess your decisions, and sometimes they can be jealous and nasty. It takes a toll."

"Fortunately, I have a pretty thick skin!"

"You have to. I think criticism of the immigration situation will decrease now, also, with Bijan Lohraspi moving swiftly to get everything back on track."

"I'm meeting with the immigration team as well, to make sure the bottlenecks are resolved. I sometimes wonder whether Lily Estrella sabotaged the situation."

"I . . . don't get that impression. Chaos was caused when it wasn't clear who was in charge, so decisions that had to be made immediately got postponed. That can cause things to snowball out of control quite quickly. Once Bijan asseted control, everything began to straighten out."

"Even so, she talked to people and undermined the process."

"I won't dispute that, but remember: now that you are in charge, problems will be blamed on you, regardless of the cause. It comes with the territory.'

Baozhi nodded. "How very true."

"Any luck with the Minister of Space Exploration?"

"No. I asked John Kasahara; he said he would prefer to stick to coordinating asteroidal studies, and he can't move off of Phobos because his wife has a job there in the fusion propulsion project. Jimmy Khan, also, said he was more effective as chief designer of spacecraft, and I think that's true. I was tempted to contact Helmut, but he wants to rest. I did contact Mikhail

Shtokman, who was in charge of all our near-Earth operations twenty years ago and more recently was in charge of Martian spaceflight control. But he'd have to resign from the Mars Council, so he declined."

"He enjoys being Speaker, and he's effective," agreed Will.

"John also said he talked to Crystal and she discouraged him from taking the job. So she's been sabotaging the effort! And of course, every time it comes out that someone turned down the job, I look like a fool!"

"I know! That happened to me, too. Keep looking."

"I really can't, I'm running out of people and once the external affairs diplomats arrive from Earth, I have to focus on them for two weeks. So it may have to wait."

'That'd be too bad. I think you'll have to look for someonewho's not involved in the politics and institutions here; someone who is independent. Maybe an outpost CEO or former CEO."

"I suppose that's possible. They have experience running a large organization. Calvin Grant would be good, but he enjoys running Phobos."

"Yes, someone like him."

"Alright, I'll see what I can come up with." He glanced at the chronometer on his desk. "I've got to prepare for my 2 p.m. meeting."

"Well, I hope this has been helpful, Baozhi. Any questions, any concerns, any time you just need a listening ear: let me know. I'll be here for you."

"Thanks, Will, I really appreciate your support and assistance. It does make the burden easier. Before I was elected, I had no idea how lonely this job can be. But you, Jacquie, and to

some extent Helmut have been a Godsend. Really." He rose, so Will did as well. They shook hands, then Will departed.

The office door closed and Baozhi was alone. He retreated behind his desk to think about the discussion. Will really wanted to help, but Baozhi really didn't want to talk about the areas where he needed help the most; he preferred to learn at his own pace and serve as his own advisor. Otherwise, there was embarrassment and a chance he'd lose face.

But Will had given one very useful piece of advice: look beyond Mars's space personne for a new minister. And as he thought about that idea, a name popped into his head so sreoingly he almost wondered whether Will had subtly planted it: Marshall Elliott. He was arriving at Mars with twelve years of highly successful administrative experience, which included Saturn's own small space program, and he had just steered a group of 18 and 19 year olds toward making an eight-year solar system exploration plan. Baozhi hadn't read it, but had heard some favorable comments. "Betty, take a videomail for Marshall Elliott aboad Saturn-7, please," he said to his AI. "How far away is Saturn-7?"

"A bit over 4 light minutes. It arrives March 10."

"Thank you." Four light minutes; that really wasn't a bad delay at all. He turned to face the camera embedded into the nearest screen. "Good sol Marshall Elliott, this is Chief Minister Baozhi. I was very impressed by your eight year solar system exploration plan; surely there was more experience behind it than the age of the majority of the planners suggests! How would you like an opportunity to carry out some of it? As you undoubtedly know, my new administration needs a Minister of Space Exploration, and you come highly recommended. Would you be interested in the position? Let us talk further about it. Ciao."

He hit send and the message wafted its way through space to Saturn-7, where Marshall listened to it, shocked. He walked into the bedroom to play it to Amy. “Thisis amazing. I’m in a bit of a shock.”

“Maybe he’s getting desperate? No offense, my dear. On the other hand, you are former chief minister of the Saturn Commonwealth, with 12 years of administrative experience. That’s a pretty strong resume.”

“Yes, I suppose it is, but your little joke may also be true; he may be running out of people. I had better ask dad. Ivy, please forward Baozhi’s videomail to my father. Add this: “Dad, what do you think of this offer? Did you suggest it, by the way? Let me know. Love, Marshall.’”

He sat with Amy and they ran through the pros and cons. The list was mostly pro: Marshall needed a job, still didn’t have one, and one could not get a better offer than being in charge of a tenth of Mars’s GDP! The cons were mostly unknown. Will responded quickly. “No, I didn’t suggest your name. I was just having tea with Baozhi a little while ago and I suggested he start looking beyond the usual folks running aspects of the space ministry, like spacecraft design and asteroidal studies. I suggested a CEO like Calvin Grant. Baozhi must have thought of you himself. As I think about it, I think you’d make a great Minister of Space Exploration! You have the skills, the experience, the vision--the eight year plan shows that!--and qualities like patience. I suspect working with Baozhi does take some patience. He’s not a bad boss, but he seems to be insecure and prone to quick judgment, and we’ve already seen he has a tendency to support grandiose ideas. Yes, I think you’d be a perfect person to do it. As such, you’d be one of the five most powerful people on Mars: The Chief Minister, the Speaker of the Mars Council, and the Ministers of Immigration, Industrial Development, and Space Exploration.

Unfortunately, they're all men; under Helmut, two were women. Yes, my advice would be to take the job. Ciao."

Marshall looked at Amy, wide-eyed, and she looked back to him the same way. "What do I do?"

She shrugged. "Take the job. How will the Mars Council confirm you?"

"I suppose over video, with a 4-minute time delay built in! I'll need a prepared statement about my philosophy and approach."

"Fortunately, you have the eight-year space exploration plan."

"And I have other ideas as well, that didn't go into the plan," added Marshall. He glanced at the screen in front of him, then sighed. "Ivy, please record a video message for Zhang Baozhi." He stared at the screen, then began. "Good sol, Mr. Chief Minister Baozhi. Thank you very much for the offer; I am very flattered that you'd consider me. I am very interested in the job. I suggest that I write up a statement about the approach I would take to the position and send it to you first. I will need such a statement for the Mars Council's hearing, after all. If my approach is acceptable to you, I will be honored to take the job."

12.

Healing Sectarian Wounds

Jan. 2089

Alan Quint felt the hyperloop car begin its deceleration. He looked up from his screen; the hearing to approve Marshall Elliott was not very interesting anyway, with long blocks of questions followed by a long block of responses, sometimes with a minute or two of dead time while everyone was waiting for the communication to go through. He looked at the wastes of the Aram plateau, with exposed layers of sandblasted rock, scattered boulders, old scars of impact craters, and clusters of reddish-brown sand dunes stretching to the horizon. Tree Rivers had chosen the place because of the biblical associations with its name, not because it offered any particularly valuable resources. But as Aram outpost hove into sight, he sat up straight to look more closely. Its twenty-two cylinder domes marched across the landscape, first three pairs of smaller ones, then a quartet of larger domes, then two quartets of even wider, longer domes, then finally a crowning quartet of the four largest domes Aram had made, 150 meters wide and 500 meters long. All of the domes were lushly green, with vegetation cramped up against the sides; 68 hectares of earthly oasis in stark contrast to Aram's cinnamon wastes. They were built on a perceptible slope, also, so the domes all drained downhill to the mother dome at the end, next to Genesis crater where the residents lived.

The hyperloop began to brake sharply as it rolled into Aram station. The car barely fit; once it stopped, the station's rear door closed and air rushed in. In one minute the light over the car's exit door turned green and Alan exited, suitcase in hand.

"Welcome, Alan, welcome! I'm Victor MacLeod, We're so glad to finally meet you face to face!"

"Thank you, Victor." He shook hands with the Chief Executive Office, then turned to his companion. "Partrick Stern, I presume? I recognize you from our videocasts."

"You are correct, Mr. Alan. Welcome to Aram." Alan and Patrick shook hands as well.

"We need to exit the station, so this hyperloop can continue on its way," said Victor. "How was your trip on the hyperloop?"

"Pretty pleasant, and the scenery is spectacular. It's hard to believe you're a thousand kilometers from Aurorae! I left there just an hour ago!"

"It is hard to believe; people call hyperloop transport 'flying.' They're still straightening the route and installing bridges and tunnels, because the Hyperloop should be able to get here in a lot less than an hour. And your flight from Phobos?"

"I gather it was routine. Never having experienced it, I would not have known. The shuttle was absolutely packed, as you can imagine with 60,000 people at Phobos awaiting flights to the surface. People are all over the four Phobos C-200s, trying to escape cabin fever of their two very crowded C-100s, taking spacesuit lessons and experiencing Phobos . . . it was quite a remarkable experience. I wish we could have flown in from Earth two weeks earlier, but I was delayed departing Earth."

"Yes, I gather you were mobbed by people wanting to come here."

"And go to Themis! That was the big problem. I was finally able to convince Mars Immigration Authority to allow me to accommodate 175 on my caravel. That's 26 coming here and 149 going to Themis. Unfortunately, your people won't be arriving for two weeks; that was the soonest they could get a flight from Phobos."

"I know. They're flying to Meridiani, too; it's twice as far away as Aurorae, but the flights are less crowded." Victor pushed open a door and they exited the station. The corridor

was short and led straight into Genesis Crater, 150 meters in diameter and exquisitely landscaped. Alan stopped to admire the beauty. “Wow! You know how to manicure a place!”

“Beauty is a central idea in our religion; our variant that is,” said Victor. “Genesis crater is now 25 years old. It has trees 20 meters tall! The soil is rich and mature. Vines have climbed all the cliff edges of the rim. The pond at the bottom has fish and is great for swimming. And as you can see, the housing is disguised; mostly, all you see are the windows!”

“Built into the rim.”

“Or built in front of it and landscaped over. We need to be partially underground because of cosmic radiation. We’re rather crowded, thanks to the arrival of 250 settlers two weeks ago.”

“Our first new arrivals in six years,” added Patrick.

“It’s a great relief to have settlers coming here from Earth again,” said Victor. “And we are immensely grateful for the 20 million redbacks you raised to cover their costs. it’s a revolutionary situation for us.” He began to lead Alan down a ramp that spiraled down the crater rim to a Swiss chalet style guest house halfway to the floor.

“I was delighted to help. I want to see all the branches of the Green World Movement to be re-healed and united again.”

“So do we, Alan. We feel terrible that things developed as they did when Tree died.”

“Everyone does. Of course, I’ve been a member only three years. When dad took my brother and me to Themis, we were immensely impressed by the vision that Rivers had.”

“He was a remarkable visionary, regardless of the nature of his inspiration.” Victor led them to the guest house’s front door and opened it. He led them into a comfortable living room with a big fireplace and a stack of real firewood. “This is your place while you are here; it’s all for you. The master bedroom is in the back on the right. but let’s sit and talk. Lemonade?”

"Yes, thank you." They all sat and Victor poured three glasses of fresh-squeezed lemonade from a pitcher that had been waiting for them.

"I'm sure you witnessed a certain amount of chaos in Aurorae when you arrived. It's a big city, 145,000 people before the immigration wave arrived, growing to 200,000, and I don't know where it is at the moment. I was in town for the Mars Council meetings last week--this sol I'm attending by video--and couldn't believe all the people milling about, pressing into restaurants, lining up at stores, sitting in parks talking enthusiastically to strangers, power walking the enclosures to get a feel for their new home . . . it's quite extraordinary and a bit overwhelming. Here at Aram, things are much quieter. Even the arrival of 250 new settlers, raising our population to 572--nearly doubling our population--has been a much more subdued event."

"I'm surprised. Hundreds want to move here even now, but there's no money to pay for their emigration. I was glad to pay, but I can do only so much. We have to generate more revenue for Aram."

"We've been very concerned about that, but so far, we have had to receive subsidies from the Commonwealth government to maintain our enclosures. We haven't built a single new enclosure for eight years! We produce enough food to feed 5,000 people, plus we export wood and wine, but those items barely keep us going. We're hoping these new 'suburban domes' they're creating, cylinders 100 meters in diameter and up to 1,000 meters long, will be cheap enough so we can start to buy and install them. The current system involves pile driving to anchor a dome over a patch of ground--rather like staking a tent--burying the dome's skirt, and freezing the ground underneath to make it airtight. At Aurorae and other big outposts they even dig the ground up, process the material, lay a welded metal floor, and put the processed reg back.

These ‘suburban domes’ will just be prefabricated plastic cylinders that you lay on a clean metal cradle and inflate. They should be much cheaper to set up. And the Commonwwealth government is subsidizing farmers to start their own agricultural cylinders, so we can get funding. We hope to double our farmland in the next few years and really start to green this plateau!”

“Excellent. I gather the land here is pretty fertile, too. I’m willing to help out further, also. In addition to paying for the immigrants, I’ve also provided you with 50 million redbacks to purchase new equipment.”

“Yes, and we are immensely grateful. Thank you. We wish, in fact, that rather than building up Themis and adding a C-300 to it, you would move here and build up Aram. A billion redbacks will go a lot farther here than in deep space. It’ll get you a lot more results here. We have a solid community, a system for working together, and a purpose. What we need now is money to expand.”

“You do indeed,” agreed Alan. “And I can offer a deal to you. I am not planning to settle in Aram permanently, though I will be glad to come here from time to time; I have permanent use of my father’s caravel, after all. And I do want to see Aram grow, because the reorganized Green World Creed--as we now call our movement--has 20,000 members, and I think we could easily recruit a thousand to move here. I am hoping that Themis and C-300 docked to it will accommodate a population of 10,000. That effort is becoming clearer, as is the cost: 1.3 billion redbacks. But my stock in Everclean is now worth 2.8 billion, and it keeps going up every year. There are so many people with addictions, now--nearly ten percent of the U.S. population--and our new anti-addition treatment is so effective, money is simply pouring in. I can borrow against my stock to pay for the C-300! Themis will be permanently funded by stock in that and other

companies I invest in. Aram can be part of that financial arrangement as well, as long as it is part of the religious arrangement."

Victor frowned. "What do you mean?"

"As you may know, eight months ago at the annual meeting of the Green World Creed I was elected President of the organization, and in my acceptance speech I called for the reestablishment of the office of prophet, though with a slightly less lofty title: Bishop. This became a motion on the floor which carried and I was named Bishop of the Green World Creed. I subsequently convinced Flora Rivers to retire from the prophetic office she claimed--but few people cared about any more--and that brought some of her faction back into the movement. The two remaining movements had also united in that the 'Green Earth Coalition' found it difficult to retain members and purpose when it was a purely secular, terrestrial ecological organization. The rest of the Green World Community was beginning to run out of steam as well; it's hard to function essentially as a 'Tree Rivers Church' for very long, with an empty prophetic office. So now the office is filled again. As you know, we have reestablished the weekly water blessing. I gather it hasn't been held here for thirteen years."

Victor nodded. "That is correct. When Tree Rivers died--almost exactly thirteen years ago--we split into similar factions that appeared on Earth. We didn't have any followers of Flora here, but my colleague Victorino, who was Tree's personal assistant and chief of staff, began to claim prophetic powers in Tree's place. That split the community and the Commonwealth had to send down mediators. They insisted on an election, which I won. Victorino's prophetic claim was thus rejected and within a year, Victorino and over one hundred others left. Some returned to Earth and others got involved in agriculture at the various other outposts. Victorino got cancer and died about five years ago. The rest of us us here were of two schools of thought; some of us,

like the Green Earth Coalition, wanted a secular commitment to ecology, while others favored continuing Tree's memory and his religious principles. We didn't split over the issue, however, because we had to work together here to survive."

"But why not hold the water blessing?"

"Because the secular ones no longer believed in it. They might be more willing now, though; we have all grown fond of the way it was while Tree was our prophet."

"Well I propose we reestablish the water blessing. Morrowsol morning we all go down to the mouth of the Gihon, dip out water, and anoint everyone. To it, I can add water from the Columbia--Tree's favorite river--the Mississippi, and the Ganges. I have half a liter of each in my luggage. But if we do it, I must occupy the position Tree held in the ceremony, and I will wear my red bishop's vestments."

Victor was startled by that. "Why?"

"Because I want to reunite the various factions of the Green World Community as the Green World Creed. I am now bishop over all the remnant factions on Earth and I want to do the same here, and on Themis. But that means accepting my authority as bishop. I have no plans to change the creed or the rituals Tree created. They are powerful and unifying. I think they are capable of bringing in millions of followers. But we have to have unity, and with that unity also comes the fortune I have dedicated to the cause."

"I see." Victor was startled by the turn of events. He looked at Patrick, who was as surprised and uncertain as he was. "Here's my suggestion," he finally said. "It is not up to me or Patrick to accept you as bishop. The entire community must do it. I am sure the 250 immigrants who just arrived from Earth are familiar with your leadership, but the rest of us are not. I suggest

you address the entire community tonight after supper. Make your case. Then we'll see how many show up at the mouth of the Gihon River morrowsol morning for water blessing ."

Alan nodded. "Very well. That's a good plan. Will the two of you officiate with me?"

Patrick and Victor looked at each other, uncertain, then Victor nodded, followed by Patrick. "Yes."

Marshall completed his closing statement to the hearing before the Mars Council, then stepped out of his office and walked to the cafeteria nearly. It was crowded with almost 150 people--far exceeding the legal capacity of the space--watching the live hearing as it was broadcast back from Mars. Marshall's closing speech was about to come back over the live channel to them.

He stood against the back wall and listened to himself summarize his philosophy about space exploration, the essential mix of human and automated projects, the need for further use of nuclear power and artificial intelligence to run powerful systems at a great distance, the centrality of Mars's role, and the need to separate technological development funding from the funding of actual projects, in order to insure more efficient use of resources. When he finished his statement, the entire room broke out in applause. "Great speech, Marshall!" shoulted someone.

"Thanks," he replied, causing those who hadn't realized he had slipped into the room to turn around and applaud further.

On the screen, the camera turned to Mikhail Shtokman, Speaker of the Council. "Thank you, Marshall, for these lengthy three sols of testimony. I can say I am impressed, and I think that is true of the entire Council. Your grasp of where we are today in space, where we have come from, and where we are going is complete and quite persuasive. Your experience running

the Saturn Commonwealthis also distinguished. I believe we aere ready for a vote. May I entertain a motion?"

"I move we confirm Marshall Elliott as the Minister of Space Exploration."

"Second!" Several people offered a second.

"There is a motion on the floor. Is there discussion?" Mikhail looked around. "No? No discussion? Very well, I call the motion. Please signify with your voting controls." He paused to let people vote; this way the out-worlder representatives, who probably had already submitted their votes, could be counted as well. There was a pause and the camera turned to the large wall screen. The vote appeared: yes, 90; no, 2.

Everyone in the cafeteria erupted in applause. "One of our own!" exclaimed someone.

"Congratulations, Marshall!" said someone else.

"Thanks!"

"Speech! Speech!"

"Alright." Marshall walked across the cafeteria toward the screen. "Thank you, everyone, for your support. The Marsian Commonwealth is now twelve annums old and its capacities have increased 80 times in that period. Clearly, we need new plans. We are on the verge of a fusion propulsion breakthrough that will revolutionize transportation, an ecological breakthrough that will us to grow food without the plants they come from, and a space industrial breakthrough on Phobos. We have a plan to expand Mars's population systematically and a plan to move Mars toward an estival. It's a very exciting time to be on Mars! And we all have a role to play in Mars's future. Thank you."

It was short and spontaneous, but everyone applauded anyway. He nodded in thanks, then headed out of the cafeteria. Amy came out and gave him a hug. "I knew they'd confirm you!"

“Thank you. Now I have a huge responsibility, and it really starts now, before we even arrive!”

“That’s alright. You’ll manage. We’ll manage. I can take over the work to plan our arrival; our housing furniture, etc.”

“That would be really helpful. I want you to get your book done.”

“It’s just about done, so don’t worry about it.”

Marshall’s communicator vibrated. He pulled it out. “A videomail from Baozhi.” He pushed play.

“Congratulations, Marshall. You did a great job in the hearings; I was very impressed; so articulate, and with the perfect Marsian accent to boot and an incredible Marsian pedigree! Very impressive for everyone. I’m looking forward to working with you. You are a great asset to this administration. Ciao.”

Amy frowned; she had been looking at Baozhi’s facial expressions closely. “He’s jealous.”

“You think so?”

“Oh yes! The reference to the pedigree especially, and the accent.”

“I can’t help the accent, it’s genuine! In fact, us kids were the first ones to have the Marsian accent. We heard so many versions of English around us, in movies, and on the internet, that Fatima Hijazi molded our pronunciation to match English spelling when we learned how to spell in kindergarten and first grade. He has no right to complain about that!”

“Well, watch out. You can’t help being the first child born on Mars or being the son of the ‘George Washington of Mars’ either. He may be regretting that he invited you. So be careful.”

Alan Quint--Bishop Alan Quint--was fairly well received after dinner that night. It helped that nearly half the audience were recent arrivals who were familiar with him, and that they had already talked about him quite a lot to the veterans. It also helped that he pledged $100 million redbacks over the next two years to improve Aram's infrastructure.

The next morning, nearly everyone came to the edge of the "Sea" a salt water body 70 meters across in "Enclosure 1." The Gihon bubbled up from a deep pool that connected via a siphon to a deep pool in Enclosure 3, flowed 50 meters, and discharged its small volume of water into the Sea near the eastern side of the enclosure. The Pishon, Aram's other small river, similarly entered from Enclosure 2 due west of Enclosure 1 via a siphon that connected straight to "the Lake," a body of similar size to "the Sea" but of fresh water. Between the two was a grassy expanse dominated by a large monument to Tree Rivers; he had been cremated on the floor of Genesis Crater and his ashes buried under the monument. Because of the size of the crowd, they met next to the monument.

Alan Quint had practiced the wording of the water blessing all night because it was different on Mars than on Earth. He raised his hands. "We have much to be thankful for this sol; the gift of life, of fecundity, of richness all around us." He reached down and dipped his hand into the Gihon. "Of pure water." He raised his hands again. "And of fresh air." He reached down and grabbed a handful of dirt. "Of the richness of the soil of father Mars." He plunked a blade of grass. "Of the green of Mother Earth, cladding the body of Father Mars." He raised his hands toward the east. "Of the blessed light of the sun, the giver of life to all of us, for we all run on sunshine." He raised his hands straight up. "Father Mars, Mother Earth, bless our work. We thank you for this rich, verdant, thriving Aram outpost. We thank you for the gift of trees for building things, creating art, and warming us when we are cold. We thank you for leaves, which

feed the animals. We thank you for roots, which sink deep into the ground to find Father Mars's rich nutrients. We thank you for the gift of oxygen that Aram's plant life have made for us. We thank you for the sun, the engine that powers it all." He lowered his hands and turned to the others. "Father Mars and Mother Earth have indeed blessed us. Let us commune with them now snd receive their blessings." He dipped a large container into the Gihon and drew out water. He reached down to three half-liter containers. "This contains water from the Columbia River. I now add it to our blessing water. May the spirit of that river strengthen and energize us." He poured it into the container. "And this contains the water of the Mississippi. I now add it to our blessing water. May the spirit of the Mississippi bring us wisdom and endurance." He poured it into the container, then raised the third. "This contains water from the Ganges. May the spirit of the Ganges lead us straight." He added it to the container. "Now, everyone form a single line and come forward to receive your blessing. When you are finished, we will form a circle around the monument. Let us begin." He dipped a sponge into the container, as did Victor and Patrick. People formed three lines and one of the three men, Alan robed in red and Victor and Patrick robed in green, touched their sponge to the person's forehead. It was a quick, simple ritual. When it finished, the three of them joined the others at the monument. "Let us pray," said Alan, raising his hands. "Oh spirit of the great prophet Tree Rivers, your people are gathered around you this sol seeking your guidance and blessings. We love and honor you in your absence, we remember your words and the rites you taught us, and we are determined to spread your wisdom to all of humanity. Help revive our unity, cement our hearts together, and strengthen us to work for your Cause. Amen."

"Amen," repeated everyone. Alan glanced at Victor and caught his look of surprise, because no one had added a prayer at the monument to their worship before.

Alan raised his hand again. “We are a new people, reunited in our dedication to the prophet’s memory and recommitted to his work. Let us cross the Gihon together in love and unity and get started in our daily work.” He reached out to take the hand of Victor and gestured that he should take Patrick’s hand. Everyone began to grasp the hands of their neighbors. Then Alan Quint started forward.

“Let us follow our bishop!” exclaimed Patrick.

Alan walked straight to the Gihon--which was only two meters wide and half a meter deep--stepped into the water and waded acoss, then exited onto the grassy ground on the eastern bank. His shoes and the bottoms of his pants got wet, but it did not matter.

The entire crowd followed him, one by one, holding hands and wading across the river. “We have become a new people,” concluded Bishop Alan. “Go forth to your daily work.”

“Attention passengers. Flight 110 to Phobos will commence boarding in ten minutes.”

Alan Quint looked around Gate 4--Aurorae Spaceport only had four gates--at the others. There were three of them waiting; himself and two flight attendants. He looked at the younger one, an attractive woman in her thirties. “Looks like the flight will be pretty empty this sol.”

She nodded. “All our business is down, Phobos to Aurorae. No one wants to go up because with the immigration wave, they can’t get a seat to come back down!”

“Yes, of course.”

She looked at his red robes. Alan had started wearing them regularly when he was in public after his trip to Aram had been successful. “What are you; a Catholic Bishop?”

“No; I’m Bishop Alan Quint of the Green World Creed. We’re the community at Aram and on Themis.”

"Oh yes! My husband and I spent a very pleasant weekend at your guest house, once. I knew you emphasized ecology and nature, but I didn't realize you had bishops."

"We do now. The Green World Creed is a revival and reform of the prophetic movement Tree Rivers started over thirty years ago. I was consecrated bishop in British Columbia last year and came here to meet the followers in Aram and explain to them our new arrangements. I'm happy to say they all accepted the arrangement and recognized me as their bishop." This, he knew, was not completely true; there had been skepticism of his claims at the evening meeting and many had attended the water blessing out of curiosity, then had crossed the Gihon with the crowd because everyone else was doing it."

"We had fifteen members on the flight two sols ago, I remember."

"Correct. Some have volunteered to join my flight from Phobos to Themis, which departs in three sols." "Volunteers" was not quite accurate; two veteran Aramites had decided to come with him because they were unhappy with the other residents, and thirteen of the 250 people he had paid to move to Aram had become disillusioned by their unequal treatment by the veteran residents and had decided to leave. At least at Themis, they would outnumber the veteran residents.

"You're flying to Themis? How? A private flight?"

"Yes, the Creed possesses a caravel. Delta-v, 4.5 kilometers per second; flight time, five months."

She nodded. "Not bad. Well, good luck with your visit there."

"Thank you." He'd need it; the caravel was now illegally overcrowded, and he hoped no one would notice. There would be people sleeping in the corridors, the life support areas, and even the cafeteria.

Alan glanced at the flight board; the flight attendant turned to an email. Then Alan's email beeped with an incoming videomail from Marshall Elliott. He had emailed the new Minister of Space Transportation three times; he was finally replying! Alan pushed an icon to send the audio to his ear piece.

"Good Sol, Bishop Alan. I'm sorry I won't make acquaintance with you, but I arrive at Phobos on March 10, five weeks after your departure for Themis. I apologize I didn't reply to your first and second messages, but I needed the time to do some research. This will be a wrap up of all three.

"I spoke to Jimmy Khan yestersol and he summarized your meeting with him. Marcraft is happy to design a C-300 suitable for 10,000 people with a glass end to allow natural sunlight to provide the interior lighting, with mirrors to gather enough insolation for the entire interior and louvers to prevent micrometeoroid impacts. Jimmy is quite excited about that aspect of the design. The rest of the interior--the floors, wiring, piping, etc.--is routine design, since we already have several designs for C-300s, and I am sure Marcraft would charge you a standard rate if it follows an existing plan. As you probably know, Marcraft and the Division of Spacecraft Design at Martech are not part of the Ministry for Space Exploration but are a semipublic company and a university department respectively, although the Minister is an *ex officio* member of both Boards of Trustees. The question of payment for the research and development for the insolation system remains to be determined--it'll run several hundred million redbacks--but it is a legitimate function of the Ministry of Space Exploration because it has wider application. It probably does not have much use on Phobos or Ceres because of the sizes of the mirrors needed; remember, a C-300 has a 70,000 square-meter end to admit light but the cylinder walls are 283,000 square meters, so you'd need to admit exactly four times the intensity of sunlight at

earth's distance to shine a terrestrial level of light on the cylinder walls. That would be difficult to do on Phobos or Ceres because of their distance from the sun and their rotation. But in Earth orbit and Venus orbit, it would be possible; indeed, I'll contact the Venus Commonwealth to find out whether they'd like to arrange for partial funding of the system, and Swift might kick some in as well.

"So, that answers your question about the solar energy system. We will have one additional requirement regarding the interior design; if we are to provide the design, we must also provide inspectors to make sure it is executed properly by your construction team. You may want some of the work done at Phobos; it'll cost you, but it will guarantee quality. As you know, thirty-three years ago, Aram suffered a series of depressurizations that resulted in the death of several residents and a near collapse of the borough. I remember it well; I was sixteen at the time and followed the news closely, and my father was in charge of Mars. The Mars Authority had to rescue people and step in afterward to guarantee construction standards. It was a huge mess and very expensive. We are all holding our breath about Themis, which by all accounts is barely maintaining its domes, which are aging fast. If they have a failure right now, it could cost someone a hundred million redbacks to mount a rescue mission that would result in the abandonment of Themis and the death of its ecosystem. The Commonwealth cannot let people build anything they want by whatever standards they want to follow, and then serve as that group's insurance policy. Independent inspectors, chosen by us to review all aspects of the construction of your C-300, is one of our requirements for support of your project.

"I think that answers all of your questions. Yes, we will contract with you to design a C-300 and Ceres will contract to provide you with the cylinder and the propellant you want. Ceres wants the work. Their factory to build solar panels is starting a major expansion next

month and will allow them to produce a thousand megawatts of continuous power within two years. At that point, they'll have the ability to produce and sell you the hydrogen-oxygen propellant that you want. They can already build a cylinder 300 meters in diameter and 300 meters tall and will have the personnel to complete that job, plus one C-100 per year or one C-200 every 18 months, which they need to be able to do for demand in Earth orbit and at Phobos. Martech is designing clusters of chemical engines capable of lifting a full C-300 off the surface of Ceres, so all the pieces will be in place to complete one by 2093.

"I look forward to additional conversations with you about this project, preferably after the end of April, because I need time to get settled into my new house and my new job. I'm excited about this new development for the settlement of the solar system. You will be doing the heavy lifting, thanks to your fortune, to create the first significant deep space habitat. That will accelerate the day when it will be economic to build many such deep space habitats. Mars is very much in favor of this development and wants to position itself to support this new capacity of the human species. Ciao."

Alan watched Marshall's face fade from the screen. He wasn't happy about the inspection requirement, but he saw the advantages as well; the depressurization event had badly tarnished Rivers' reputation. That was not something any prophet--or bishop--wanted to happen.

13.

Home, Sweet Home

March 2089

On March 10, Saturn-7 finally caught up with Mars in its race around the sun. Saturn-7 turned one of its two gaseous core nuclear engines toward the direction of flight and fired it. An hour later it was in orbit around Mars and closing on Phobos. Four hours later, a second, short burn circularized its orbit, just ten kilometers from the moon, which began to pull it in. Low-power chemical engines provided the remaining propulsion as it carefully headed for landing pad number 6 just west of Stickney crater. Two hours later it touched down on the metal pad, to which its metal landing legs were attracted magnetically.

Bill, who was with his parents for the landing, grabbed his two suitcases. “No, sit down,” said Marshall. “Let’s not hurry.”

“Why?” Bill was eager to see Phobos.

“We need to wait until everyone else has gotten off. I think there will be media representatives waiting to interview me.”

Bill frowned. “So?”

“I’m trying to minimize publicity. There’s no reason the arrival of the Minister of Space Exploration should warrant coverage. Everyone knows when Saturn-7 is landing.”

“Do you know whether there’s someone waiting to interview you?” asked Bill.

Marshall nodded. “I asked Jacaranda Chamberlin privately and she said yes.”

“You have her email address?” said Bill, surprised.

“She was married to my cousin Paul; Paul Nuri, your great aunt Molly’s son. They divorced not long after arriving on Mars.”

"That's right, we'll meet great aunt Molly," said Milly.

"Yes, but she's 90 and frail," replied Marshall.

"So why don't you want to be interviewed?" said Milly.

"Because the Minister of Space Exploration is not a famous position, or all that important. I probably can't avoid the interviewer, but this way they have to wait, and at least no one else will be around to watch."

"We don't think they'll be able to interview dad when we land at Aurorae because no one knows which shuttle we're taking," added Amy. "Remember, we're staying here eight sols so dad can do business with people here? We were supposed to be heading to Aurorae morrowsol, but we were able to swap seats with four other passengers and delay our landing. If anyone ask you when you'll be landing at Aurorae, just say 'I don't know.'"

"Okay," said Millie, and Bill nodded.

"So, everyone's excited to see Phobos?" asked Marshall.

"I want to see the 'Spirit of Mars' statue," said Millie.

"We'll go see it," promised Amy. "There are several places where there is an excellent view of it."

"Phobos 2 has an incredible observation deck," said Bill. "And there's a view of it from the Stickney Marriott."

"You've been doing your research!" said Marshall. "We left Phobos when we headed to Saturn, remember, Amy?"

"I sure do! And how many people lived here then? A few hundred, manufacturing caravels. And now it has what? Ten thousand?"

"It's supposed to have 13,000 when the immigration waves are finished," said Bill.

"We won't recognize the place," said Marshall. "For that matter, we won't easily recognize *any* of Mars, either. Aurorae had 3,000 people; barely more than Titan has now. Most of the boroughs have populations bigger than that, now! I almost feel like Rip van Winkle, who woke up after 100 years!"

"You've seemed nervous all sol," said Amy.

"I am. I feel like an impostor; am I a Marsian or a mariner? If I'm a mariner, what right do I have to be Mars's Minister of Space Exploration? I haven't lived here almost 23 years; nearly half my life."

"I'm not sure there's much of a distinction between 'Marsian' and 'mariner,'" commented Bill. "I feel like I'm both. I've never been to Mars before, but it has been a constant presence in my life since I was born and now it's a subject of my career. So I guess I'm a mariner who feels Marsian. I'm both."

"I'll ask you how you feel in another month, when you begin to feel the differences."

"At least we'll see your father, mother, sister, her husband, and their kids," said Amy. "When we left, we had no idea whether we'd be back soon enough to see your parents."

"Yes, that's a blessing. I'm looking forward to seeing them and having them actually see Bill and Millie."

"Can we go now? I want to see Phobos!" said Bill. "Especially since you've agreed Millie and I can skip classes this sol."

"Just this sol," said Amy. "School's the priority. But we'll have plenty of time to see all four carriers, the museum, the agricultural cylinders, the Spirit of Mars . . . everything. Dad will be busy, but I'll take you."

"And I'll come along when I'm not in meetings," added Marshall. "I promise! Okay, let's go."

Everyone picked up their suitcases--they each had two very large ones--and headed out of the cabin. They headed to the center of the spinning caravel, out through the ventral exit into the zero-gee gymnasium--which now had a barely detectable gravitational pull from Phobos--into the dorsal entrance into the second caravel, and across its axis to its ventral exit at Phobos's ground level. They floated down a tube that usually had an elevator in it, but in Phobos's gravity it was faster to float down the 5 meters instead, and ended up in a lobby under the landing pad. It led to a transpo tube where a maglev car awaited the passengers. It was the last one; two others had already departed. Sure enough, a reporter was waiting.

"Dr. Marshall, can I ask you a few questions? I'm Jay Powers, BBC."

Marshall grabbed a guardrail in order to stop himself in the zero gee. "Sure, Jay, how can I help you?"

"Well, let me start by saying welcome to Phobos and the Marsian Commonwealth! How do you feel, returning home for the first time in twenty-three years?"

"It's great to be back to Mars. We all will miss Saturn, and I for one would like to return there at some point in the future--it's a great community and it's doing great things--but I'm looking forward to seeing my parents and enjoying time with them. Video just isn't the same."

"What's your biggest challenge, as Minister of Space Exploration?"

"I'd say, coordination. There are fifty nations on Earth with space programs, plus six commonwealths in the inner and outer solar system, and Mars has two departure points: Phobos and Ceres. Exploring the solar system is fascinating, complex, and very rewarding. We learn new things about the history of our worlds and the evolution of life every year. We have some

exciting new technologies coming online in the next few years that promise to revolutionize conditions, too. I hope we can accomplish as much as we can with the resources available."

"What are your goals here on Phobos?"

"It's our arrival port and I plan to stay for a few sols to speak to borough officials, the propulsion research teams, the shipyard, the department of planetary science, and the asteroidal studies subdepartment. I need to get a feel for their priorities and plans."

"It sounds like you have a full schedule, then."

"Indeed, and I had better get going now, my family and I need to get to our hotel and settle in."

"Of course. Thank you for your time."

Marshall nodded and said "ciao," and they headed for the car. "That was easy and painless," whispered Amy.

"Yes. Let's hope the boss has no objection to it."

Eight sols later, the family having seen everything there was to see on Phobos, and Marshall having talked to everyone he needed to talk to, they headed to pad 3 for the 1 pm flight to Aurorae, the second flight of the sol. The second immigration wave had arrived at Phobos just a month earlier and not everyone had reached the surface, yet, so the flight was full. The family had seats in level 1--the bottommost, which meant they got on first before the other levels--which minimized people bothering Marshall.

They settled into their flight couches and strapped in. A half hour later was a very brief burn that launched them off Phobos and set their orbit to one that would intersect the Martian atmosphere in three hours. A pleasant float, with chances to look out the ship's few porthole

windows at the growning face of Dusty Red, was followed by instructions to strap in for seven minutes of atmospheric entry, descent, and landing. The Prometheus oriented itself horizontally with its nose angled upward as it dipped deeply into the Martian atmosphere. Gee forces built up to 1.5, then decreased as the ship traded its velocity for distance. Finally it turned to orient itself upright and came down onto a landing pad on a tail of orange-tinged blue flame.

"That was fast!" said Bill. "When we returned to Titam from Enceladus, we were flying through the atmosphere for over an hour!"

"Well, Titan has a real atmosphere!" replied Marshall. "We entered Titan's atmosphere at 400 kilometers altitude and had been slowed to a slow fall by 300 kilometers up. Mars's air can't slow us practically at all until we're at 60 or 70 kilometers!"

"I bet it takes a lot less time to get to orbit, then," commented Millie.

"Exactly," said Marshall.

"Ladies and gentlemen, welcome to Aurorae," announced the captain. "We have touched down on landing pad 4. You may unstrap yourself and put your seats in an upright position. Be patient while the exit gantry swings into place and makes a hard dock against the exit portal at your level. Please be sure to take all your belongings with you as you exit the vehicle. Thank you for flying Marspace and have a good sol."

Bill excitedly unstrapped himself and stood up. Marshall glanced at him patiently and took his time; he wanted to slow Bill down, though admittedly Marshall was extremely excited to be home as well. He stood as well, luxurating in the feel of Martian gravity. It felt *home,* even after 23 years.

They grabbed their now-heavy suitcases while ten exit gantries swung against the side of their ship and doked to ten doors. The gantries then filled with air and their docking was tested.

Finally, after the five-minute process of docking and inflating was complete, the door on level 1 swung inward. Forty-five people rose from their seats, grabbed their luggage, and headed for the door. The line moved slowly across the gantry to the elevators; while waiting, Bill stared out the windows at the stonescape below, illumined by the setting sun. “I can see why they call it ‘Dusty Red.’”

“That’s for sure. So much powdery dust; it’s actually a problem, and if we thicken the atmosphere it’s going to be a bigger problem.”

“So I hear.”

They waited their turn for a chance to ride to the ground 30 meters below, though some took the central spiral ramp instead. Once at the ground level, they walked down a ramp and into a corridor that took them to a transpo station that served all four passenger pads. Bill looked around. ‘No reporters, dad.”

“Good, I guess we fooled them! Look for the bus for Australia and South America.”

Bill pointed. “It’s on the other side.”

A bus-sized car, capable of holding 100 passengers, awaited on their side of the metal road; its destination was Cochabamba Station. But a second bus was arriving on the other side of the road at stop 2 at that very moment, and it said “Australia.” They climbed on and once it was full, the doors closed tight and latched and the bus rolled into an airlock that was just a few centimeters larger than it. As a result, depressurization did not take much time. Soon the bus exited and accelerated down a metal road along the south side of Boat Rock. Bill was fascinated by the view; so different from Titan’s tholin-crusted ice.In a few minutes the bus slowed, descended underground, and passed through another airlock. From there, it entered the city’s

underground road system. In another minute it pulled into Australia Central's transpo station. "We're staying on until we get to Place d'Etoile," reminded Marshall.

"I thought grandpa and grandma lived here in Austalia," said Millie.

"They do, but we're going to Liz and Mike's. Grandma and grandpa are too old to be entertaining a bunch of people and cleaning up afterwards."

"I see."

About a third of the bus got out, immigrants at their final destination being welcomed by a great crowd of sponsors and relatives. Then the doors closed and the bus pulled back into the main transportation artery. The tunnel led, in a kilometer, to another transpo station labeled "Etoile."

"Here we are," said Marshall. He grabbed his bags and kept an eye on Millie, to make sure she was managing with hers. They stepped out of the bus and straight into a crowd of people holding signs indicating the immigrant they were awaiting.

"Marshall! Marshall!" He heard the voice of his sister Liz and looked for her in the crowd, uncertain he'd recognize his 46 year old sister, who had been half that age when he left. but she was unmistakable; her face was fuller, as was her figure, but she was still Liz. Mike Tobin, her 47 year old husband, was with her, as were two young adults; their 18 year old twins, Jason and Shayda.

"Hey Liz!" he replied, and he hurried over to her, sometimes pushing a bit through the crowd, the rest of the family right behind him.

"It's so good to see you!"

"It's great to see you!" They hugged, excited to see each other in the flesh after two-plus decades. Amy was right behind and Marshall hugged Mike. "Great to see you, too, and looking forward to really getting to know you!"

"The feeling's mutual!"

He turned to the kids. "Jason and Shayda, I presume. Let me give you a hug as well."

"Good to finally meet you, Uncle Marshall!" they replied. He hugged them as well, and he was so moved that he had tears in his eyes. "My kids, Bill and Millie."

"Great to meet you!" said Bill, having already hugged Auntie Liz and Uncle Mike in the interim. He shook hands with both cousins.

"You're staying with us, by the way," said Jason.

"What?"

"Shayda and I have an apartment near Martech. You'll be a lot more comfortable."

"Oh, thank you! That's great!" Bill already liked his cousins. It was good to have family members the same age!

"What about me?" asked Millie.

"You'll have Jason's old room," replied Shayda.

"We'll help you with your bags," said Jason, taking one of Bill's. Shayda took one of Millie's; the parents were doing the same. "So, you're going to be at Martech, too."

"I *am* at Martech; this semester I've been taking 4 courses, two of them by video and two that are completely online. Previously I was at Martech-Titan; I'm transferring 54 credits."

"You're a junior, then."

“Come to think of it, I am! I was scheduled to have a dorm room, but they changed the rules this semester because of a shortage of space; if I wasn’t present at the beginning of the semester, I couldn’t have a room. And they have no vacancies mid-semester.”

“No. And I gather the house your dad tried to get fell through.”

“Yes, everything got behind schedule, so they couldn’t hold vacant houses and canceled the contract. So we’re temporarily homeless!”

“That’s alright, there’s plenty of room at my parents, and at grandpa and grandma’s, and maybe at Paul’s as well. We’ll manage.”

“This immigration wave is pretty screwed up, compared to two years ago,” said Shayda. “The public is pretty upset. There are all sorts of petty shortages, combined with big ones like delays in furniture and housing.”

“Baozhi never should have fired Lily Estrella. She knew how to manage immigration,” added Jason.

They were walking up a ramp to the surface. Suddenly they came out of the transpo station and Bill was surprised to see a beautiful circle, 240 meters across, with a neat park of trees and flowers in the middle and 5 or 6 story buildings of classical French architecture all around. “Wow, this is pretty!”

“The Etoile is one of the prettiest spots in Aurorae," said Shayda. “Twelve streets diverge from here and each extends to the edge of Europe enclosure. They help you remember geography as well; Brussels, Luxembourg, Amsterdam, Berlin, Zurich, Milan, Rome, Marseilles, Madrid, Lisbon, Bordeaux, London.”

“Mom and dad live at 357 Luxembourg.” Jason pointed to the nearest street and they headed down it. They had gotten slightly ahead of the parents at this point.

"Wow, these are really beautiful buildings!"

Shayda nodded and lowered her voice. "And really expensive; some of the most expensive housing in Aurorae, though they have small units as well as big ones. But if you've been here twenty-five years--or longer, like mom--you can afford it."

"That's what they say; wealth has more to do with how long you've been here, than anything else."

"It's mostly true, but not always. I'm studying economics. She's the scientist."

"Physicist, please; it's the only *real* science," teased Shayda.

"Oh my. I'm studying to be an historian."

"Really? I thought you were a geologist, like your dad!" said Shayda.

"I'm that, too. it's my fallback."

Jason laughed at that.

They crossed the street--it was mostly used by pedestrians, with an occasional golf cart or bicycle, as all vehicles were banished underground--and entered the lobby of 357 Luxembourg. The four of them stepped into the elevator--the parents would have to wait--and they headed up to the fifth floor. When they got out, they approached 5A, a flat with a terrace and windows on the street. They opened it and entered the house's living room. Will and Ethel Elliot, Molly Nuri, Will's sister, and her son Paul sat waiting for them. They rose and Bill immediately recognized the proportions of his own face in that of his namesake.

"Welcome," said Will, his eyes fixed lovingly on Bill, then Millie.

"Thanks, Grandpa." He went over and hugged Will, then greeted his grandma and hugged her, then went down the line. "I've only seen you once or twice, grand auntie Molly."

"Yes, and it'll be nice to get to know you, Willie." They hugged and he decided it wasn't the best time to ask her to call him "Bill."

"And I don't even know how to describe our relationship!" he said to Paul, who laughed.

"Ah . . . second cousin once removed, I think."

"Of course!" They hugged as well.

At that moment, the four parents arrived and chaos erupted as everyone was hugging and talking at once. "Everyone sit down!" suggested Liz. "We have enough seats! The food should be here in a few minutes. Let's get the luggage out of here and into the bedrooms."

"It's a good thing we decided to get a big place, eight years ago," added Mike. "At the time we thought it might be possible for dad and mom to move in, so we got a place that basically has two master bedrooms. Shayda won the coin toss; Jason got the third bedroom, which was also pretty comfortable, I might add. Now Marshall and Amy get Shayda's old place and Mollie gets Jason's."

"Where are they living now?" asked Amy.

"We have a two-bedroom flat of our own in Australia," replied Jason. "And Bill's going to stay with us. Less crowding in the bathrooms here."

"Good idea," said Marshall. He rose from thechair he had just sat in, and everyone trooped into the back of the house to see the big, comfortable bedrooms. That only left Bill's two suitcases in the crowded living room. "I suggest that my robot carry Bill's stuff to your apartment," suggested Will.

"Good idea," replied Jason. "Argo, will you assume control of grandpa's bot and carry Bill's luggage to my place?" he asked his AI.

"Yes, sure," came the reply to Jason's earpiece. The robot, which had been standing like a statue, came alive, walked to the suitcases, picked them up, and headed for the door. As it opened the door, a robot with dinner arrived. "Excuse me," the robot said as it passed the meal delivery bot. Then the bot entered and placed the large bag of Chinese food on the dining room table. Mike began to spread it around. "Come help yourself!" he added. "It's five minutes after sunset, so we can break the Fast!"

"Let's have a prayer first," reminded Ethel. She pulled out her communicator and looked up a Bahá'í prayer for breaking the fast. She, Will, and Mollie had not been fasting; they were in their late 80s and early 90s, and fasting was not required after age 70. Marshall and family hadn't fasted that sol, either, because they were traveling. But everyone else had been.

Prayer over, they lined up to take paper plates and load them up with various rice and noodle dishes, then sit in the circle of chairs to eat. Bill sat next to Will, with Marshall on Will's other side and Paul past him. Shayda sat on their side of the room, which otherwise coincidentally was all male.

"I'm so glad to actually be with you, face to face," said Will to Bill. "I really enjoyed your interview questions and was very impressed by the paper you published. I take it this is the first of many research projects of Marsian history you want to undertake."

"Yes, it is quite amazing that no Marsian has written a history of Mars. There are two popular works written by terrestrial writers, but they aren't historians and their accounts don't go very deep. The piece I replied to was one of the few scholarly articles on the subject."

"Did you ever hear from the author?"

"Yes; he wrote and thanked me for the additional information."

Will smiled. “Good! Scholarship should be collaborative, and it should be collegial as well. Have you settled on history as your major?”

“Yes, though I can probably double major in geology as well. I’ll have enough courses.”

“Good. Did you know that I started out majoring in history, then switched to geology? It served me very well because working in the humanities forced me to become a good writer, and my ability to write was crucial in my service as Commander of Aurorae Outpost, and later as Assistant Commissioner. Because of the time delay, a clearly written email--or a clear script of a videomail--became my principal communications medium with Earth. Whenever I was working with the media, also, I’d add ‘and if you want to ask me this question, here’s my response,’ and journalists tend to be lazy; they are happy to ask the question and play your recorded response! It helped me keep ahead of everyone, which otherwise was difficult because I was not part of the spontaneous discussions.”

“That’s interesting. I’ve never seen that in print anywhere.”

“I mention it in my memoirs. I told you that I’ve been writing them, on and off, for sixteen years, now. Maybe this summer you can help me with them. I could use a partner.”

“I’d love that!”

“Good. Have you thought about a senior thesis, yet?”

“A little, but I still need to finalize an advisor here at Martech and run the ideas past him or her.”

“Bill was very helpful in organizing the Eight Year Solar System Exploration Plan and writing up parts of it, dad,” said Marshall. “He is really a good writer.”

“Yes, I am impressed as well. So, how much of the plan are you planning to implement?”

"It's fortunate that we developed the plan when we did. Saturn-7 had 25 or 30 Ph.D.s on board who provided expert advice; it wasn't just me and the students. Samantha Augustine, who is the Director of Exploration for the Uranus Commonwealth, emailed me and said we had developed a perfect extension of their plan. She and I have exchanged five or six emails since, which has resulted in modification of their cargo imports and a refinement of their plans to explore the Uranian moon and the centaurs that cross the planet's orbit. Neptune's plans are pretty simple; they haven't changed. But some of the ideas about robotic exploration of Io appear likely to be added to the Jovian system's long-term plans."

"You even included plans to expand the neutrino telescope on Metis!" said Mike, surprised.

"One of the students emailed the project leaders on Callisto," said Marshall. "She gave them access to several unpublished proposals, and as you know, one of them is being implemented."

"Yes, your plan ended the delays."

"Oh, I didn't know that!"

"It's impressive how, even before you were the Minister of Space Exploration, you were already serving in that role," said Will proudly.

Marshall felt the pride and teared up a bit. "Thanks, dad. I'm so glad we'll have some time together. I missed you."

"I missed you, too. Videomails are just not enough."

"No, they aren't. And I'm going to need your advice about how to handle personalities."

Will considered. "I think you'll do fine. I am still having lunch with Baozhi twice a month. The worst of the trouble is over. It takes time to get comfortable in that job; to gain

confidence and to relax. I think he's just about there. He has gotten personally involved in the immigration problems and they should be ironed out in another month or so, once everyone has come down to the surface and gotten housing, furniture, and a job."

"It messed up our housing plans," said Marshall.

"I know, and fortunately you can stay with family. A lot of people don't have that option, so they're stuck on Phobos, living in the carriers that delivered them, until their housing is ready. But they're only a month behind and they're catching up fast. Certainly by the end of April, things will be getting back to normal."

"The housing is almost finished; it was the furniture that got delayed the most," said Mike. "I have a friend who works for Domus, a new housing construction company, and he said they finished their immigrant housing and have started on 'relocation' housing; in other words, the second houses people like to buy after they've been here five or more years."

"Really? That's what we're looking for," said Marshall. "I didn't see any housing available from Domus. I looked."

"Their immigrant units are all taken, and their second housing units are probably not on the market, yet. After supper we can go look, if you'd like."

"Sure!"

"You'll still have a furniture problem, but I suspect you can borrow stuff from us temporarily," said Will. "Could someone get me a cup of decaf?"

"I'll do it," said Bill, jumping up. Everyone had pretty much finished dinner and he eyed the large chocolate cake that the bot had brought. As he was carrying a tray of coffees back to the others--it occurred to him that others were ready as well--the door opened and Will's service robot strode back in, walked back to a niche in the wall, and went rigid. As he finished

distributing the coffees, the doorbell rang. Liz walked over and opened it. “Hey, Jacaranda, come in!”

“We wanted to welcome the new arrivals!” said Jacaranda Chamberlin.

“I suggested they stop by for dessert,” added Paul. “I thought Tracy and Samantha would like to meet their cousins.”

“Hi, I’m Tracy!” said one, and the other fraternal twin immediately raised her hand. “And I’m Samantha!”

“This is Bill and Millie,” said Amy. The two kids rose and shook hands with Paul’s daughters, who were second cousins-not removed. They were attractive, dark-skinned women, aged 26. “It’s good to meet you both,” said Bill. “What do you do?”

“I’m in journalism, like mom,” said Tracy.

“And I work for Marbuild in inventory,” said Samantha. “We make sure Marbuild has all the supplies it needs to build the enclosures.”

“Important work,” said Bill.

The girls walked over to greet their grandmother, Mollie. Jacaranda turned to Marshall. “So; a good flight?”

“Yes, both Saturn-7 and the Prometheus this sol. It’s good to be home.”

“It’s good to have you back, Marshall. No problems at the spaceport?”

“No, no journalists, and the BBC reporter at Phobos was nice.”

“Jay’s a good guy. When are you settling in?’

“I’m not going to work for a few sols, but I’m doing email. We’ve got to get ourselves settled first.”

"Yes, I hear you have no housing. We're doing yet another report about that problem, but I won't interview about it, don't worry! I'm sure someone would like to interview you about your reactions to this place. How many people did Aurorae have when you left? Three thousand?"

"Something like that. But I'd prefer to avoid publicity right now."

"Why; Baozhi? Forget about that! We've been interviewing all the ministers about routine matters because the public needs to get to know them. They need to get to know you as well."

"I think they already do!"

She laughed. "Yes, but they know the stereotype; the first baby born on Mars. Someone needs to walk around the city with you and catch your reactions, your comparisons with the olden days, comparisons with Titan, etc. I hope you can do it."

Marshall nodded. "Alright."

"Good. I'll ask Oskar Langlais; he has his own story of leaving and returning. I bet he'd have some insightful questions, and it would shift the theme of the piece as well."

"That sounds good."

14.

Settling In

(late Mar/Apr. 2089)

Bill was up half the night talking to his cousins; they even went to an all-night diner at 4 a.m. for breakfast together before going to sleep. The next sol was March 19 and the last sol of the Bahá'í fast, but because they had had a 4 a.m. breakfast they all slept til noon and only had a few hours of daylight before they could break the fast at sunset. They spent the afternoon walking all over Aurorae and Martech, talking.

Right before sunset they went to the break fast and holy day observance for Sector 38, for the Bahá'í fast ended with Naw-Ruz or Bahá'í new years, which was a holy day. Two percent of Aurorae's population was Bahá'í, or 4,000 people, so they were divided into sectors of 50 or 60 people each and met in rented spaces. Sector 38 rented a room in Martech, since it was close to the university and filled with university people. Bill enjoyed introducing himself with just his first name and meeting many new people who had no idea who his father and grandfather were. After the holy day observance there was a Naw-Ruz party and even more people came--holy days attracted many friends of the Bahá'í community, and parties even more. Bill, Jason, and Shayda were up late once again.

When Jason woke up Bill at noon, he suggested Bill shower and get dressed in the next half an hour. "On Naw-Ruz, the Bahá'í temple is open all day and there are prayer services every two hours, but more important, everyone goes and hangs out."

"It's a lot of fun," added Shayda. "The temple and gardens are in Andalus Southwest, which is only 70 meters across; way too small for everyone. But the Bahá'í community owns Andalus Southeast as well and the two are connected by three tunnels, so people go back and

forth. There's free food in Southeast, music, talks, and plenty of space to sit on the grass or at picnic tables and talk."

"So, we're going there for breakfast, basically?"

"Yes," said Jason.

Bill hurriedly washed and got ready; Jason and Shayda had already used the bathroom. Once he was ready they walked across Martech to Andalus, then to Andalus Southwest where the Bahá'í House of Worship was located. The 70-meter circular dome had a 30-meter house of worship in the center, surrounded by a 20-meter fringe of gardens filled with tropical flowers. But every square meter of grass had someone standing on it; every meter of stone wall had someone sitting. So they headed to southeast, which was mostly grass with trees and beds of luxurant flowers lining the edge. They got in line for some free food--it was a gigantic potluck--and loaded their plates, then sat at a table to eat.

"Hey Bill!" He looked up and saw his father waving and walking over. "Haven't seen you for over 24 hours!"

"We're doing fine!"

"Yes, I see. I'm glad."

"We've been showing him around," volunteered Jason.

"Good, I'm glad. When you're done here, I want to show you something. Did you notice when you walked through the man tunnel from Andalus there was a door on the left that said 'National Spiritual Assembly Offices.'?"

"Ah . . . I think so."

"Well, that's where I lived! That was my parents' house, starting when I went to university, and where I lived when I came back. And you know the gardens of the temple; I was

their first gardener! The summer before I went to university on Earth the Bahá'ís had just bought the dome and it was bare ground. We had a design from a landscape architect and I built the first stone walls and set up the first gardens. There wasn't even a temple then, just a prayer area."

"That must have been back in the days when we could all fit in the temple at once," said Shayda.

Marshall chuckled. "Yes, that's for sure. Now there are so many Bahá'ís here, it takes seven services to provide everyone a chance to participate in one. By the way, the 2 pm service will include the choir and get there at 1 to get a seat. I'm told they sang beautifully."

"I'm a bit blown away," said Bill. 'On Titan we had, what? Sixty Bahá'ís? And Aurorae has 4,000!"

"We're two percent of the population," said Shayda. "We used to be three percent, but the more recent immigration waves have had a lower percentage of Bahá'ís."

"The assembly purchased southeast about ten years ago because we got too big to even stand together in southwest," said Jason. "It was agricultural, until then."

"So, have you been walking around?" Bill asked his father.

"A little, but dad and mom and Liz and I spent the entire afternoon together at mom and dad's place. That was really nice. Your mom got together with some old friends, too."

"That's good," said Bill. "Millie seems to have got attached to grandma."

"Yes, they really hit it off. I'm glad we have this weekend with no school or work. We needed the time. I'm glad you've gotten to know some special cousins, too." He looked at Jason and Shayda.

"We're delighted, too!" said Shayda.

"Good. I'm going to relax and enjoy this sol, because morrowsol starts the quest for a place to live!"

The next morning--Monsol--at 8 a.m. Marshall, Amy, and Milly headed for Milly's new school in Australia Enclosure, a short walk away. She had been with the eighth grade class all year and now she was excited--and a little anxious--to meet her teachers and classmates face to face. She didn't want her parents to escort her to the classroom, however, so they waved goodbye at the front door. "I'm glad she's got three months with the kids before summer," said Amy, as they headed back to the Etoile. "They'll have a graduation ceremony together.'

"And then she goes to high school, and we have no idea where that will be. I have to get going on housing."

"Mike gave you the name of his friend at Domus; why not call him." Amy pointed to a bench nearby at the corner of two streets.

"Alright." They walked over and sat. Marshall pulled out his communicator and said to his AI, "Please video call Albert Remsberger."

"Certainly." There was a pause, and ringing sounds, then a man's face appeared on the screen. "Good morning, I'm Al's AI. How may I assist you?"

"I'd like to speak to Al. My brother in law, Mike Tobin, suggested I call. I'm looking to buy a house."

"Certainly, Dr. Elliott, hold on a second." There was a pause, then the still image of a man was replaced by the real face. "Good sol, Dr. Elliott, this is Al Remsberger, Vice President for sales. It's kind of Mike to make the referral; we play in a men's basketball league together. What are you looking for?"

"A house, three large bedrooms, a large living room and dining room so we can entertain--I've learned that skill from my father--two smaller rooms for offices, perhaps a family room, and an average sized kitchen. That's what, 250 or 300 square meters?"

"Yes, that's about right. We have something almost finished that's about that size, but nothing ready to buy."

"No one has something ready to buy, so that doesn't surprise me! We had a contract on a house back in January, but since we weren't arriving until March, they canceled the contract!"

"Correct; the Immigration Ministry issued an emergency declaration back then in order to free up housing for immediate use by arrivals. We can complete a place with those specifications in less than a month because we are now moving to our larger housing units. But you can't get furniture."

"We can borrow furniture from relatives. Is there something we can see?"

"Yes, certainly! Come by any time. Our headquarters is at 10 Ayr Valley North. Walk up Australia First Street to its northern end and you'll come to the entrance."

"Oh, that's convenient. We just dropped our daughter off at Australia Intermediate at Second and 30th Avenue."

"Then you're very close; less than five minutes away! Come on up."

Marshall looked at Amy, who nodded. "Okay, we'll be right there, Al. Thanks."

"Ciao."

"Ciao." He closed the line. "Let's go see."

"Definitely."

They backtracked to the school, continued west to First Street, and followed it to 241st Avenue, which hugged the northern end of Australia enclosure. A large sign pointed to a ramp

toward a tunnel labeled “Ayr Valley.” “There we go,” said Marshall. They descended two stories to the “street level” where there were lanes for large automated vehicles, smaller delivery carts, parking areas, and sidewalks for people. First Avenue continued to an open pressure door, then on past, where it became “Ayr Valley.” The sidewalk continued as well and as soon as they crossed the pressure door’s threshold they saw Al standing near a door marked “Domus Construction, 10 Ayr Valley.”

“Welcome, Dr. Marshall and Dr. Amy!”

“Thank you!” They paused to shake hands with Al, who was in his mid forties, like Mike. He pointed to the door and opened it for them, leading them into a large reception area. “Do you want to see the model, or the real thing?” He pointed to a diorama.

“Sure, we can start here,” said Marshall, walking to the diorama.

“This is a theoretical model; Ayr Valley has its own unique twists. As you can see, it is an airtight plastic cylinder 100 meters in diameter and 1,000 meters long, though the model only represents 200 meters of it. We start by excavating a depression about 20 meters deep, install reinforced steel concrete pillars to support the structure and do some back filling, lay steel pipes for the cooling system in the 50-meter-wide area between cylinders, then install the curved metal cradle on which the plastic tube goes. Then we place the tube, inflate it, clamp it tightly to the cradle, and install a metal sleeve inside the plastic tube to protect it from water and corrosion. We cut holes in the metal sleeve and the tube right above the concrete pillars so they can be extended upward inside the tube to support the structures we build. At that point, our billion-redback additive manufacturing process gets started. Basically, we assemble a machine 100 meters wide on top and 40 meters high in the tube. The pieces used are 10 by 5 meters in dimension, so they can fit through the tunnels. nce assembled, the assembler machine gets started. It can place rebar

and pour the concrete around it, print nickel steel walls and pipes, it can even print drywall! It takes six people to run because you're constantly replacing filters and checking print heads. You have to wear breathers because the machine generates a lot of carbon monoxide gas; this cylinder has to be inflated initially with nitrogen, no oxygen at all because CO is flammable. The machine can go the length of the 1000 meter cylinder in four to eight months, depending on the complexity of the print job, and print everything. Then we take the machine apart and move it to the next cylinder, ideally one just a short distance away. It's quite amazing."

"Expensive, but it saves money in the long run," said Marshall.

"Exactly. In ten years, it can print housing and work spaces for about 45,000 people. We finished Ayr Valley North 1 just last month and it already has a thousand people living in it."

"What's the capacity?" asked Amy.

"The zoning calls for 500 meters of housing and 500 meters of agriculture in each cylinder. That can accommodate 2,150 people; three neighborhoods of 750 each. The agriculture can supply 600 people on the surface and more underground, depending on how many levels of agriculture are installed. A cylinder 100 meters in diameter and 1,000 meters long has 785,400 cubic meters of volume, but we put the top floor level 30 meters up from the bottom, so we are using only a third of it. If you install floors 3 meters apart through the entire bottom part, you'd have enough work, housing, and agricultural space for over 5,000 people! But you'd also have massive amounts of heat to deal with, and huge electrical demand. Fortunately, we're next to Martech and they have contracted for 200,000 square meters of the subsurface, and we use most of the rest for our construction work. So under your house, there will be a lot going on. You'll never hear or feel it, but you'll have the comfort of knowing that the cost of Ayr Valley is amortized across a lot of users."

"Good; and I'm sure it's better for the bottom line as well," said Marshall, with a smile. "Can we go up and see?"

"Of course, this way!" He pointed to an elevator and they walked over to it. "This is a public elevator; there's one every hundred meters along Ayr Street. The surface is 20 meters up. By the way, we made Ayr Street's right of way 30 meters wide so that there is, currently, a 10-meter wide shoulder on both sides, and next year a farmer plans to install an ever-bearing peach orchard on both sides, so the street will be brightly lit 16 hours per sol and should be quite attractive."

"That sounds beautiful," said Amy. "I'm a plant geneticist and horticultural specialist; I love agriculture."

"Then you'll love Ayr Valley."

The elevator reached the top floor and the door opened and they walked out onto a middle space. "Wow, I see why you call it a valley!" said Marshall.

"Exactly; it gives a homey feel to it. The housing rises four levels on both sides in terraces of varying width. What you can't see from here is that ten percent of the upper surface consists of light wells that go all the way down to the first floor. Altogether, the valley floor is 92 meters wide; there's a 30-meter common space here in the middle and each lower level of the buildings is 30 meters wide as well. The lowest level has a lot of small apartments that either front on this common area or on open-air alleys or on light wells, and if any of them want additional rooms in the future they can add a lower level. The top level--the fourth floor--is eleven meters wide and people up there have the entire roof as their private lawn and garden. If you want lots of entertainment space, that can't be beat."

"Radiation protection?" asked Amy.

Al pointed up. “The dome has two meters of water built into it. It’s a quadruple layer dome; the outer layer protects against ultraviolet and dust storms, the next layer holds in the air pressure, the third layer is a moisture barrier to protect the main dome from degradation, then you have two meters of water bags, then the inner dome layer, which can also hold in air. The terraces all have a meter of soil, for added protection.”

Amy nodded. “That’s good.”

Marshall pointed to the western side of the valley, where a reflector was reflecting sunlight in. “So, we get extra insolation.”

“Yes; that reflective barrier tilts eastward in the morning to reflect sunlight into this valley, then in the afternoon it tilts westward to reflect extra sunlight into Blyth Valley to the east. Altogether, it increases the light in here about thirty percent, so ordinary terrestrial plants--those without genetic modification for low light, that is--can grow quite well. The CO_2 content in here is 1,000 ppm, which speeds up plant growth as well.”

“What’s the climate?” asked Amy.

“Blended. Down here, the park along the center will experience two winter seasons per annum of 30 sols each when the temperature dips to freezing every night. But up on the third and fourth levels, the nighttime temperature won’t drop below 10 Celsius; they’re in a tropical climate. The agricultural area on the northern half of the cylinder will never have frost.”

“What about dust on the dome?” asked Amy.

“These B-1000s have a brand new anti-dust system. The space between the cylinders is 50 meters wide and because of the reflectors, it almost never gets any sunlight, so it’s fairly cold. There’s a water reservoir underground there that receives excess heat from the cylinders through one set of pipes, and Martian air is circulated through the reservoir through another set of pipes,

cooling the water. The air is then expelled into the atmosphere. During storm season, the air jet, which exits from holes on top of the reflector, is directed against the dome to blow dust off of it. The air intake is heavily filtered, so only clean air is circulated through the cooling system and blown against the dome."

"Clever," said Amy. "That's much better than the system for Australia and the other big domes."

"Yes, cleaning them is almost impossible."

Marshall looked at the common space. "So, how is this common space used? I see areas with trees, areas with flowers, a basketball court. . . is it a park, basically?"

"Yes, exactly. Ayr Valley 1 North is designed for 2,150 people and has 15,000 square meters of park space; picnic tables, a tennis court, a basketball court, a playground, and plenty of open space for kids to run around. It even has a barbeque area; there's enough air in here to accommodate the smoke. That's another reason for agriculture to fill half of it, it greatly reduces the environmental control burden."

Marshall pointed northward along the common area. "Show us the flat."

"Sure, it's 300 meters this way and up on the top floor." Al led the way, northward along the sidewalk. "As you can see, the vegetation's not completely established, yet. In another six months, though, it'll be beautiful. There's a park maintenance fee, but there's only one employee; almost all the work is done robotically."

"Why 'Ayr' Valley?" asked Marshall.

Al smiled. "Good question. Five valleys run northward from Australia and they're alphabetized; Ayre, Blyth, Cleve, Dawn, and Esk. The alphabet will continue for the valleys that extend northward from Europe, then South America, etc., until 26 valleys have names. Then the

alphabet starts again, with two-syllable names; these are all one syllable. Except for Dawn, they're all named for places in Australia."

"Of course," said Marshall, smiling.

"The next one north of this one will be Ayr Valley North 2, then 3, then 4. After Ayre 4, there's supposed to be a big, 1000 meter wide, east-west enclosure, then I suppose there will be an Ayre North 5, etc. Who knows how high the numbers will go!"

"Aurorae could have millions of people," agreed Marshall.

Soon they came to a wider spot on the common area. The sidewalk bent to the west and ran past a convenience store, a restaurant, and a beauty salon. On the east side was a large playground for the kids, then a semicircular amphitheater 40 meters across with bleachers rising against the eastern building, with a stage. "This is Ayre North 1 Center; a few services on the left and a common area for meetings, theater productions, music, etc., on the right, plus space for an elementary school. There are three neighborhoods in the cylinder, so they'll have to hold their meetings on different nights."

"This is so cool, to have this!" said Amy.

"A lot of amateurs come here and perform on weekend evenings." Al pointed. "Here's the entrance to the unit I want to show you." He turned left to a spot where a wide open-air alley cut into the building twenty meters. The second and third story flats had balconies that overlooked the alley rather than the common area--the second story balcony was actually a glass-enclosed sunroom--and a spiral ramp ascended at the end of the alley in front of the elevator. They took the elevator to the fourth floor. The elevator door opened on an open-air balcony that ran northward, to the right. "This is the door for the flat I'm suggesting," Al said, pointing southward, to the left. "The balcony runs along all the fourth-floor flats to the north, but

the balcony to the south is private because there's another elevator on the other side. Genie, please open the door to 325D."

The door unlatched and he opened it. They entered a balcony 4 meters wide and 20 meters long that looked to the left straight down on the amphitheater opposite. On the right was a living room that was all glass, a big empty space 10 meters wide and 11 meters deep, with a floor of dark vinyl-wood. Amy was immediately drawn inside, eyes wide. A wide stair led up to the roof. "We'll go up there in a minute, let me show you the rest." Al led them into the living room. He pointed to the rear left. "The kitchen isn't huge, but people don't cook much nowadays. This corridor goes to four rooms." He led them back. "First, a smaller bedroom on the left, with windows on the front balcony. Then the Master bedroom, with its own bath and windows on the front balcony. Finally, the second smaller bedroom in the rear part of the house, with no window on the front balcony, but with its own small sun area." He led them into the small bedroom and its small, private garden, which immediately charmed Amy. "Finally, a den, which could be divided into two small offices with separate doors." He pointed to the den and they stuck their heads inside to look.

"Let's go up," said Marshall, anxious to see the rooftop terrace. Al nodded and led them up the stairs and opened the door onto an area that was 11 meters by 20--a very large space--and all covered with tiles except the corner over the private garden, which had a transparent plexiglass floor.

"What would we do with this much space?" asked Amy.

"We could do lots of things. We could have a garden in one area. If we want to entertain, lord, we could have a hundred people up here!"

"It has excellent privacy, too. It has walls all around," noted Al. "We can also install hedges. And if you want to garden, there's a service that can provide you anything you want seasonally, up to and including small fruit trees."

Marshall laughed at that. "No, I'm thinking of a few pots with tomatoes and such. And we're against the outer wall of the cylinder here, so we could plant climbing things; morning glories, grapevines, all sorts of things."

"You know, I wonder whether Bill would be willing to take the den for a bedroom," said Amy. "He probably won't live with us very much, anyway, he'll be in the dorm this summer, and I suppose he'll get an apartment of his own eventually. It's as big as the bedroom. Because I was thinking that you and I could use the bedroom with its own garden as two offices, especially if the wall were modified to open the space up."

"We could do that," said Al.

"Interesting idea. And Al, the walls aren't really painted."

"Correct; they just have a coat of primer. You tell us the colors and we'll paint them."

Marshall looked at Amy; she was smiling. The place was a good fifty percent larger than the other place they had considered, and the rooftop terrace had enormous potential. "How much?" he asked.

"One point seven million."

He nodded. "When can you have it ready?"

"Modifications will take a few sols, and we have to make a final inspection."

He looked at her again; she nodded. "How about one point five?"

Al paused. "The lowest I can go is one point six."

"Alright, you have a deal," said Marshall.

That night Marshall paid for everyone's supper, then they watched a three-d walk-through of the house. "Wow, that's nice," said Liz. "I see why they call those cylinders 'suburban.'"

"How much?' asked Mike.

"One point six."

"This place was 1.1."

"I like the mix of urban and agricultural," said Amy. "There's a lot of wisdom to it. It will reduce the burden on environmental management."

"All these enclosures are managed by the city," said Will. "They inspect, maintain, and manage their environments, paid for by our taxes. It's the only way." He looked at Marshall. "If you need anything, let me know.."

"Thanks, dad, but we've got a good down payment and our salaries can cover the mortgage fine."

"So, who gets the bedrooms?" asked Bill.

"I already told Millie she could have the larger of the two," said Amy. "She's got at least 4 ½ years at home and you're going to be in a dorm."

"Hey, am I still a member of the family or not?" protested Bill.

"Of course you are," said Marshall. "But your sister deserves some priority, Bill, because she's living there full time."

"Which one do you want?"asked Amy.

Bill sighed, frustrated. He looked at the images again. "Could they build a bedroom for me up on the terrace?"

"No," replied Marshall. "That's above the radiation shield."

"If it's against the back wall, and considering there are two meters of water overhead, the radiation load shouldn't be bad."

"You're young."

"Honey, we want that space for an entertainment space," said Amy.

"The whole thing?"

"Yes," said Marshall.

"That's a good idea," said Will, nodding.

"The bedroom with the garden space is actually pretty big, with the garden space included," said Marshall. "It has a plexiglass ceiling; it's like a giant skylight. The glass wall and sliding glass door could be removed."

"But all that light would wake me up in the morning."

"A curtain," said Amy. "Either where the sliding glass door is, or something across the skylight."

"Or there's the den," said Marshall. "It's 2.5 by 6 meters; 15 square meters. The bedroom we're talking about is 5 by 4, which is 20 square meters, if you include the garden part. The front bedroom Millie gets is 5 by 4 also."

Bill looked at Millie, who stared back at him smugly. "Alright, if the glass wall is removed and the garden is included in it, and if I can have a curtain so the sunlight doesn't wake me up, it'll be alright."

"Good," said Marshall. I think it's a special room, frankly. Your mom and I will split the den into two offices; they can put up a wall and install a door."

"I'm glad that's resolved," said Will. When will you move?"

"Ten sols; maybe a week. We'll see," said Marshall. "My next priority is settling into my office and meeting my staff."

The next sol, Marshall met Oskar Langlais, walked around the city with him, and reflected on the changes he saw. He and Amy signed the paperwork to buy the house. Finally, toward the end of the sol, Marshall went to Andalus Enclosure and to the second floor of the Gallerie where the Ministry of Space Exploration was located. He met briefly with each of his leading staff: Halima Mubarak, the Assistant Minister; Julio Ozawa, the chief of staff; Qing Bedford, Director of Automated Exploration; and William Wairimu, Director of Human Systems. As their multinational names indicated, they were all native born Marsians, mostly in their early and mid thirties. He moved some items into his office and announced a head of staff meeting the next morning.

Marshall, ever mindful of his father's insistence on giving hospitality at all times, brought pastries to the meeting the next morning, which put everyone in a festive mood. "I saw your video interview with Oskar Langlais this morning," said Halima. "It was very interesting."

"We spent a lot of time in the old side of the city where I had a lot of reminiscences," said Marshall. "It was particularly nice to see Catalina Biome, where we lived when I was young. Then we went to New York Circle, and wandered through Africa and its four major town centers, and finally walked across the huge fields of Asia enclosure, which will be completely transformed into a city for the arrivals of the next columbiad. It was an emotional trip."

"All of us have had similar experiences, though the place was much bigger for us when we grew up here," said Julio.

"Well, not for me; I spent some of my childhood in Dawes, and it had a hundred or two at most," said Qing.

"But for all of us, the transformation we've seen also was incredible," said Halima. "I appreciate that you expressed it for us."

"And so did Oskar," added Julio. "He was one of our schoolmates."

"I am so impressed that the Ministry of Space Exploration is run by the second generation, and the young second generation at that," said Marshall. "Exploration is in your blood. I've spent the last two months reviewing the budget, all the ministry's projects, getting a sense of all the responsibilities you have, and my visit to Phobos was particularly useful. So, let's get started. Qing, yestersol I asked you about Project Hermes; can you fill in the others?"

"Sure. It was easy to look up, but I also dug through old archival documents. Project Hermes was started twelve years ago and was closed ten years ago on the grounds of cost. The idea was to produce advanced solid core nuclear engines of an appropriate size for automated probes. Thrust would be 1 to 5 tonnes and the Isp. 1,000 seconds. The reactor would also produce up to 50 kilowatts of power for the probe. It would be used in the asteroid belt and the outer solar system to transport and power rovers. Once it refueled itself from ice on the surface of the asteroid--the rovers would be capable of digging and mining ice--it could take off and orbit the asteroid and beam power down via laser to the various surface assets."

"We dearly wanted something like that in the outer solar system," said Marshall. "What was the estimated price tag?"

"At least 500 million to develop the engine and 50 million to produce each unit. We can do better than that, now."

"Exactly, and our resources are so much greater now, and ten years ago there were problems with international cooperation, which we now have. I'm guessing we could develop a slightly larger version--10 tonnes of thrust and 100 kilowatts of power output--for about 500 million redbacks. Any guesses?"

"That sounds about right," said William. "And New Hanford could turn out, say, two dozen engines for 250 million total. They need a bulk order to save money."

"That's what I'm thinking," agreed Marshall. He looked at Qing, who shook his head.

"This is out of my expertise."

"I know. Currently, the Director for Automated Space Exploration coordinates budgets for Phobos, Ceres, and international projects, but is not in charge of development funds. The Director of Human Systems is primarily in charge of technological development because human missions are planned by the university science departments; we just supply the ships and some of the non-science crew. So I am wondering whether we ought to split the Human Systems Department more formally into two subdepartments, one for technological development and the other for human missions, and the development of a new Project Hermes would fall under technological development. I'd call it the Astronautics Research Agency."

"That's fine with me; it is more or less split that way already," said William.

"So, that's one change I'd make. The other change related to the Astronautics Research Agency is to coordinate and prioritize research better. In the last few months, videomailing people and seeing them face to face on Phobos, I've heard a lot of complaints about research funds being planned poorly. Of course, 'poorly' sometimes means someone other than you got the funds! But I think it is time to reevaluate the system we have for deciding who will get funding."

"In our defense, because we've been doubling every three or four years, it's easy to tell people 'just wait a few years' because the money will be available then," said Halima.

"Remember, all of us have been here just a year or a year and a half," reminded Julio.

"I know; there was quite a turnover of heads of staff last year. Since we're all fairly new, we can brainstorm new ways to organize the ministry. The other thing I think we need to do--and very quickly--is organize some sort of conference to coordinate efforts."

"A space exploration conference?" said Halima. "We did that four years ago and it was very helpful. It especially helped to bring Phobos and Ceres together.

"I know, Saturn was part of it," said Marshall. "They were rivals for funding then and still are. The Mars Council convenes in June to approve the budget for the next annum and in May we have to submit our budget to Baozhi. That's a little over five weeks, so there is no time for a formally planned space development conference. What I was thinking was something smaller and more informal, so it can be planned quickly: a round-robin of videomails among the Chief Ministers of the various Commonwealths, plus the Governor of the Jupiter Special Administrative Region, to discuss our various priorities and needs. Call it a 'Space Summit'."

"That would be easier to pull off," agreed Halima. "We'll need a plan of our own to share, however, and currently we have two: Baozhi's eight year space exploration plan, which is pretty sketchy, and your plan, which is much more comprehensive."

"The first one, as you said, is too sketchy; the second one was developed without the detailed information you all have. So I think we need a third plan that draws on our knowledge. Halima, can you work on that with me?"

"Sure."

"Qing, since the bulk of an exploration plan involved automated missions, I'd like you to consult with Phobos and Ceres and create a single plan for automated exploration, and get that to Halima. William, you pull together the joint plan for crewed exploration; that shouldn't take too long. But I need to talk with you about this new Astronautical Research Agency. I'm also planning to approach Baozhi about a Development Agency that will coordinate our work with the other Commonwealths. Julio, I'll need your help with that."

"It sounds like you'll need more heads of staff!" exclaimed Halima.

"I think we will," agreed Marshall. "I'll work on that, too."

"So, we have a budget of 20 billion redbacks," said Julio. "It employs a lot of people. How much of it can we change?"

"I don't know, but a lot of our workforce has multiple skills and experience, so I suspect we can do some shuffling of priorities. Certainly we can plan for larger changes once the next wave of immigrants arrive in 2091. We have to create jobs for them, after all! I suspect closer work with the outer solar system commonwealths, Ceres, and Phobos will automatically change some of our priorities. So let's start with the budget we have now, project it into the future two years, then start modifying. William, can you ask Marcraft for an exact cost estimate for restarting Project Hermes? Halima, can you review all the different agencies and efforts that exist to help the other Commonwealths, so we have a list of programs and people that need coordinating?"

"By when?"

"Next Frisol; that's a week and a half. We'll meet again at that time. Julio, we need to plan a one-sol retreat for all the headquarters staff, maybe in about a month. Once we have some

roughed out priorities, we need to get everyone on board and get their ideas as well." He looked at them. "Anything else? If not, let's get to work."

"Thanks, said Halima, as they all rose from the table. Marshall stopped to talk to William for a minute--he was clearly concerned about the changes coming to his department--then headed to his own office. Baozhi was there, waiting for him.

"How was your head of staff meeting?"

"It was good. I have some new ideas for reorganization and I'll get them to you once they're a bit firmer."

"Excellent. Did you discuss the polar mirror project?"

"No, that didn't come up, but it's in the budget."

"Good. I recommend expanding the funding for it as fast as possible. We need to heat the poles and thicken the atmosphere."

"Yes, I'm sure we'll make it a priority."

"Good." He stood there a moment, uncertain what to say. Then he added, "I saw your interview with Mars This Sol this morning. It was touching. But I really don't want to see my heads of staff in interviews like that."

"I was asked directly and I said yes because I was told that all the heads of ministries had given similar interviews."

That surprised Baozhi; he considered. "Yes, but they were all in November and December, not March."

"I see. Well, I have no plans for additional interviews."

"Alright. Good." Baozhi rose. "I look forward to hearing about reorganization and new priorities in space. That's what we need."

15.

Space Exploration Summit

Marshall, Amy, Bill, and Millie were lucky; Domus Housing Corp.was able to make the modifications they wanted quite quickly, and just five sols after signing the purchase contract, they were able to move in. They were part of a steady flow of 100 or more immigrants into Ayr Valley every sol, as Prometheus Shuttles continued to bring people down from Phobos. Because they had had time to acquire some furniture, the place was not completely bare, and they were able to borrow furniture temporarily from Liz and Mike, as well as from Will and Ethel. After several hours of robots hauling things in and arranging them, the place was beginning to look pretty comfortable.

They all arose the next morning for a quick breakfast. “So, you’re happy with your room?” Marshall asked Bill.

Bill thought a moment. ‘Yeah, actually it’s kind of cool having a big skylight, and the curtain around the head of my bed was sufficient to keep the light out of my eyes. Fortunately, there’s not too much light for the first hour because the sun isn’t high enough to hit the terrace.”

“Yes, the time we’ll get the most light is the evening when the sun is in the west and reflecting off the reflector east of the valley,” said Marshall. “I’m glad we don’t have a flat on the east side of the valley!”

Amy looked at Millie. “We’ve got to leave for school in ten minutes, dear. Now, do you want to walk it yourself, or shall I come along?”

"I can do it myself. I just walk down Ayr Street, through the airlock and onto First Street, then I go up to the surface and continue down First Street until I turn onto Thirtieth Avenue, and I can turn only one way because it ends at First. My school is at Thirtieth and Second."

"Use your AI and you can't get lost," said Bill. "I can walk you, if you want, because there's an entrance into Martech at Twenty-Fifth Avenue."

"A little early for your 10 o'clock class," said Amy.

"That's alright."

Mollie nodded. "Okay, that'd be nice if you can walk with me."

"Sure."

Marshall looked at Amy, pleased his son had agreed to accompany his sister. He finished his toast. 'We really don't have much to eat in the house, yet."

"No. I'm making a list and I'll see whether the store downstairs can deliver. It appears to be pretty big."

"They probably can. I wonder whether they sell lattes!" said Marshall.

Bill laughed. "They probably do, too!"

"When the kids leave, why don't you and I go check out the store?" suggested Marshall.

"Alright."

Everyone finished their toast, fruit, and drink, whether it was coffee for Marshall and Bill, tea for Amy, or orange juice for Millie. Then they all followed the spiral staircase down four stories to the ground level and tne parents said goodbye to their kids.

"This is a really big store!" said Amy, as they walked in. It was essentially a small supermarket, with a wall of freezers full of frozen items and several aisles of canned goods and boxed items, with a section continuing toiletries and over the counter medications. There was no

one tending the store--which was not unusual in the era of AI--but it opened up onto the restaurant, which had several dozen people eating breakfast and a woman in front of the bakery counter.

"Excuse me, do you know whether the store delivers?" asked Amy.

"Yes, we do, but we only have one delivery robot at the moment, because of shortages. But a branch of Aurorae House Cleaners opens in that space over there next week--" She pointed to an empty commercial space next to the store--"And their robots will provide delivery service at supper times, evenings, and early mornings. Meanwhile, you can come to get something at any hour; the store never closes."

"That's convenient, and it's good to know about Aurorae House Cleaners. Everyone says we should get cleaning service from them. What do you have in the restaurant?"

"Let me introduce myself before answering your question. My name is Eun-Ae Kim; call me Anna, that's easier. My husband is Ju-won, but people call him John. We're from Pusan, South Korea, and we just arrived on Mars in January with our son, who is a geochemist at Martech. We own the store and the restaurant and live in the flat right behind them, so we're always here. I am also the valley's entertainment director; basically, that means I control the schedule for use of the theater area. You may have noticed the screen at the door to the store lists upcoming entertainment. The stage can be reserved from 6 to 8 p.m. any night by anyone and we already have musicians booked for tonight and Wednesol night.

"As for the restaurant, Ju-won and I will start cooking the evening special about 3 p.m. Generally, we have three home-cooked specials every night and it is better to reserve ahead of time, because we run out. There's usually one dish that's Korean or Chinese. The others may be Italian, Greek, Latin American, or Indian; we ran a restaurant in Pusan and have a lot of

experience. But in addition to the three specials, we have a menu of about twenty other complete meals, so we can provide quite a variety. Those other items are pre-prepared cold and delivered here at 3:30 every afternoon; all we need to do is pop them in the oven. The French bread and pastries are delivered every morning at 6 a.m. and are excellent for breakfast, along with a variety of coffees and teas we have available."

"That's quite impressive," said Amy. "I had no idea you could do so much!"

"Well, robots help, and we purchase pre-prepared, fresh meals from a contractor. The store can automatically reorder its inventory; a robotruck arrives to restock the shelves every night. If there's something we don't have, tell us and we'll add it to our inventory list. Our goal is to be the heart of Ayr Valley, and what's better for that than food?"

"Is this place big enough to support a store?" asked Marshall.

"The city thinks so. Business is slow now, but once all the flats are sold and everyone discovers what we have, we think we will do fine. We're less than a five minute walk from everyone, after all!"

"The city has a surprisingly large number of stores with restaurants,' said Marshall. "So much better than when I was a kid here!"

Anna was surprised. "You grew up here? There must have been a lot of changes!"

"Oh, yes." He extended his hand. "Marshall Elliott. I was born here. In fact, I was the first person *ever* born here."

'Yes, I've heard of you! And you live here in Ayr Valley?"

"Right upstairs. We just moved in yestersol."

"I saw the movers. Well, welcome! As I said, we seek to be the heart of the community. We want to see Ayr Valley develop a feeling of community. Our store and restaurant want to be

at the center, with the entertainment across the commons every evening. The city is encouraging it strongly, too. To make sure small stores can compete with large operations and can be established in all the neighborhoods, the store and restaurant space is provided to us free. Your mortgages help to pay for this space. That way, every neighborhood or group of neighborhoods can have small businesses. I don't know whether you knew this, but we even have a community center; a group of meeting rooms next to the restaurant. So clubs can form and meet, for example."

"That's great!" said Amy. "I didn't know the city had such arrangements."

"I believe they're new. Anyway, I need to check the tables; we can have the robots do only so much! It's good to talk to you, have a nice sol!"

"Thank you, you too! It's good to meet you, Anna."

Anna Kim hurried over to a table. They watched her talk to the customers. "She's a great hostess," said Amy.

"She is. We have to be sure to support this place. It sounds like we can get just about any food we want here, any time."

"They even have ice cream by the scoop! Bill will love that!"

"He will, and they have lattes. It's too bad I already drank my coffee. We'll have to send someone down every sol to pick up lattes for everyone."

"And we need to get the cleaning service! Shall we buy some groceries and head back up?"

"No, I have another suggestion: let's walk around more. We've never seen the northern half of the village."

"Alright, good idea. We can shop on our way back."

Marshall nodded and they headed out of the store and turned left, to continue up the valley away from the main entrance. They passed a large playground and a set of vacant windows on the eastern side of the common area, one of which said “future site of Ayr Valley 1 Elementary School.”

“I guess this place is big enough for an elementary school,” said Marshall.

“Normally there would be several hundred elementary school kids in a population of 2150. Of course, the immigrants, who are the bulk of the population in here, haven’t had their children yet.”

“No. We have to get to know our neighbors! This is going to be an interesting place to live!”

“I’m liking it more and more all the time.”

They continued up the path. The buildings closed in on the commons, narrowing it to only 20 meters; then there was another embayment in the housing on both sides, widening the common area to 50 meters, with another elevator and spiral stair providing access to the upper levels. After they passed that area, the apartment blocks assumed their usual width of 30 meters facing each other across a 30-meter commons, until they reached the northern end of the housing. The second half of the cylinder was agricultural, but the floor was five meters higher. They ascended a very steep grassy slope and peered through a plexiglass barrier at a high rice paddy.

“Well, we couldn’t have walked through there even if we had access,” said Marshall.

“No.” Amy peered at the paddy. “I see tilapia in the water; it’s an efficient farming arrangement. And look at the vines climbing both walls, toward the balcony up above. Vine crops are adapted to lower light levels than many plants.”

"The reflector on the west side is really reflecting a lot of light against the eastern side right now, anyway."

"Yes, but that'll last only a few hours. Look at the lines of planters every three meters on the side of the cylinder! They're getting maybe 10,000 extra square meters of growing area that way."

"And I see lights on the bottom of the balcony."

"Oh, yes; so, they can supplement the sunlight. Good."

"And look at the spiderbots. They're always amazing to see, tending the plants and harvesting. I haven't seen them for years, since our flight to Saturn."

"I remember." Amy pointed to the two balconies about fifteen meters above the rice paddy. "Let's see whether we can get up there."

Marshall nodded and followed her. There was a staircase that ran up the northern side of the west building, connecting to patios and terraces and rights of way that ran along each level. When they reached the fourth level they passed a house similar to theirs, but a bit smaller, with a terrace facing the agricultural area. The stairs continued past the house and rose another 3 meters to a balcony that was level with the base of the dome. It was open to pedestrians, also. "This is nice!" said Amy. "The balcony must be 10 meters wide and runs all the way to the far end of the cylinder!"

"We can even look outside." Marshall stopped to look out through the dome, though the outside was distorted by three layers of nomex and kevlar and two meters of water, and all he could see was the solar reflector standing like a wall. The Martian sky was fairly dust-free that day and normally would be blue on the horizon, fading to black overhead, but because of a small

amount of blue dye in the sterile water, it was blue overhead as well. Will pointed overhead. “I suppose in a dust storm, with a lot of dust in the air, the sky will look purple?’

Amy laughed. “I suppose!”

“There’s a lot of light up here,” he noted, looking around, because the reflector, west of them, was reflecting the morning sunlight onto them and over their heads to the opposite terrace and the rice paddy below.

“That’s why this place can have almost 120 meters of farmland when the dome is only 100 meters wide; the balconies get extra light from the reflectors,” said Amy. “I suspect most of these crops are genetically modifed to be photosynthetically efficient in low light. This is a very well organizd and efficient farm. I’ll have to email him or her and complement them on the design.”

They continued north along the balcony. A five-meter wide strip of it was planted in corn; the other five meters was planted with young grape plants that were just beginning to climb their arbors. Marshall and Amy walked between the rows. There were two or three spots where there were benches and a table as well; it was nicely set up for solitude. For the last half of the walk, the grapes were replaced by short red raspberry canes that were already spreading and becoming dense patches. When they reached the far end, there was a walkway to cross over to the eastern side of the cylinder, so they crossed and followed the eastern balcony back to Ayr Valley 1 village. It had blackberries and a large roped off area where strawberries were ripening.

“I love walking through agriculture,” said Amy. ‘I’ll have to make this loop every day.”

“I might even want to jog it. I need to find a good jogging route.”

“In a big city like this, you can choose a different route every sol of the annum!” chuckled Amy. “Say, I know you’re going to work in a little while, but your mom and I plan to

go to the Persian rug store this afternoon. She wants to buy us a big Persian rug for the living room."

"Aurorae has a Persian rug store? God, those must be expensive!"

"They are, but apparently the cost of flying them here is only twenty percent of the original retail price anyway, so they aren't that much more. Still, I think she's thinking of spending *a lot* on a big rug. They can run 20 or 30 thousand."

"Well, you can try to discourage her, but I am sure she really wants to make our house beautiful for entertaining. She knows how valuable it can be to build relationships."

"And she's much better at it than I am!"

"Well, nowadays it isn't that hard, because no one cooks anymore! So don't worry, you're a great hostess."

"But you don't want to come to the store."

"No, I anticipate a lot of videomails this sol. Do we still have the landscape designer coming at 5 p.m.?"

"Yes, and some living room furniture arrives at 3:30. Did you see the landscaping preliminary designs? I liked all of them."

"They know how to lay out beautiful gardens. As long as they don't convert too much of the roof into garden."

"Don't worry about that, the roof is way too big for any reception you can throw!"

Marshall chuckled. 'I suppose that's true."

They stopped at the store to load up on groceries and they met Ju-won/John, who was just as friendly and sociable as his wife. Marshall carried four cloth bags of groceries upstairs--they

had to buy the bags--then kissed Amy goodbye and headed to his office in Andalus. He stopped at Julio's office first. "Sorry I'm late. Anything I need to know about?"

"The US ambassador called and left you a voicemail, saying he wasn't really qualified to represent NASA's needs at the space exploration summit."

"We really need someone to get NASA's point of view. Anything from the Administrator of NASA?"

"Not yet, but you know how much things are in disarray right now, with lingering uncertainty over the legitimacy of the President. I'll send a reminder email to his administrative staff."

"Thanks. Do we have all the comments from the Commonwealths?"

"Yes, Mercury's just arrived. I've glanced at the transcripts briefly. I see Baozhi's opening message to them was played on *Mars This Sol* this morning."

"Good; I was hoping it would."

"They were very good comments."

"Yes, I agree." Marshall had drafted the talking points, but wasn't going to mention that. "Let's get everyone together in the conference room right now and listen."

"Alright."

Marshall waved and headed for his office, then to the conference room. That sol was scheduled for a rolling, dayspan-long conference of representatives of the various commonwealths about their exploration plans and needs. Most were on Mars time, with 24.6 hour sols, except Jupiter, Venus, and Mercury, but they had scheduled the conference so that Aurorae time and Universal time on Earth were aligned that sol.

It took just two minutes for Halima, Julio, Qing, and William to arrive in the conference room. Marshall popped up the menu of his videomail and found that most of the participants were the Chief Ministers and not their Directors of Space Exploration, though no doubt the latter were copied as well.Neptune and Uranus had responded first; they must have been up quite early, because their messages took the longest to arrive.

“My fellow Chief Ministers, I’m so glad we are able to meet in this virtual discussion,” began Chief Minister Mercedes Patel of Neptunia. “I want to thank Chief Minister Baozhi for his warm opening remarks. I very much appreciated his comment that if Mars is the cradle of Mariner civilization the various settlements are its advance guards. We very much feel like advance guards. I also want to thank Dr. Marshall for his elegant summary of Mars’s preliminary plans and issues for us to consider.

“I think it’s safe to say that we are in an unusual situation compared to the rest of you in that the Neptune system has very few moons. We’re glad we have Triton, but when it arrived, it destroyed everything else! We’ve visited all the inner moons bigger than 20 kilometers and plan to return to them every five years or so, as new research questions arise. They’re all smashed residue from the original set of moons and we’ve begun to sort out what came from what; we’ve identified, we think, remnants of four, possibly five, earlier worlds. At some point, we’ll station automated, atomically heated and powered rovers on them, but that will require imports from Mars. The big research questions we have all focus on Triton, and it will be the center of our geological study for centuries.

“Then there are the outer moons, many retrograde and captured from elsewhere in the solar system. All of them are immensely far away, so they have to be explored with automated equipment. A Hermes engine would be immensely helpful to visit them more quickly. We’d need

four such engines, two stationed on Proteus to send missions to the prograde moons, and two stationed on Triton to visit the retrograde moons. Proteus needs more nuclear power because producing hydrogen requires a lot of it. We don't have a lot of spare hydrogen after supporting three round trip flights per year to Triton. Triton has discovered another geothermal reservoir and in a few years they will have a significant power surplus. We don't need a larger version of Hermes for flights between Proteus and Triton because we use gaseous core engines; the delta-v is enormous because Triton, remember, is retrograde.

"At this time, we are not considering projects to send automated probes to centaurs and other outer solar system bodies. The reason is the flight times; several years, except for occasional centaurs that pass within a few hundred million kilometers. Space is fairly empty out here. What we do need, however, is 750 to 1,000 additional immigrants every two years, and technological advice from Martech about terraforming Columbia cavern on Triton. We're very excited about the possibilities there, both because the cavern can be pressurized and because the local geothermal energy is sufficient to heat and light it. We have attached a separate document listing our priorities and the sorts of assistance we need. Ciao."

The screen went blank. Marshall looked at the others. "I'm surprised they aren't planning at least some probes to centaurs in the next eight years," said Qing.

"I think it's a matter of time," said Marshall. "Neptune is the newest settlement and they're still settling in. Visiting Sao and Laomedeia are priorities for them because they may be scattered remnants of the original satellite system, but they are way out; too far for a crewed mission."

"Neso is as far from Neptune as the Earth and Mars are at a close opposition," noted Halima. "And the preliminary research indicates that it and Psamathe, which are remnants of the same original body, come from an interesting centaur."

"Let's hear Anand John Tian's comments from Uranus," said Marshall.

"Good sol, everyone. Our exploration priorities are pretty basic and predictable. First, we are not going after centaurs because of the long flight times. That may change in ten years, however. We have a dozen moons that are quite far out, with travel times of two to four years to reach them. Most of them are captured centaurs and are retrograde, so the energy to reach them is quite large from Proteus, and we have no massive moons to use as gravitational slingshots to decrease the delta-v significantly. But the delta-v isn't so high that chemical propulsion is out of the question, and we can print all the engines we want, so we are quite content using hydrogen-oxygen propellant at the moment, supplemented by our Peregrine if necessary. It flies down to Uranus only once a year to pick up Helium-3, so it's available to serve as a nuclear first stage. Chemical propulsion is fine to reach the fifteen inner moons, we've visited all of them with crews, and we plan to place automated stations on all of them in the next ten years. Chemical propulsion is fine to visit the other four larger moons. The five big moons are our focus, and they'll take a century to explore thoroughly.

"But one way the Hermes can be useful for us is in sending exports to Earth and Mars. Right now our Helium-3 heads to Mars on the return flights of the passenger ships, but once we start exporting PGMs, we'll need a way to send them straight to Earth. We'll probably use the Peregrine as a nuclear first stage to cut the travel time down significantly, but we could use a Hermes engine for that as well. We also need more support for our PGM mining operation on Portia; another nuclear reactor and modifications to the mining equipment so it can handle the

extreme cold. Portia has emerged as a key part of our exploration and development strategy for two reasons: its exports can make us money, long term, and because it produces huge surpluses of metals that we can use in construction. We want to put drums on Ariel, Umbriel, and Oberon in the next five years so we have permanent facilities on each world, even if they are inhabited intermittently. Needless to say, we want to start receiving 750 more immigrants every two years!

"I think that's it. I look forward to comments from the others and thank Dr. Marshall for arranging this little summit. Ciao."

Marshall smiled. "There's an unexpected use."

"They really don't need much from us, that's out of the ordinary," said Halima. "They have a reasonably compact satellite system and a small supply of PGMs."

Marshall nodded and clicked on Guillaume Van de Velde's message.

"Thanks for arranging this meeting, Marshall. Saturn would benefit greatly from a Hermes nuclear stage because we have over one hundred moons to explore, with new ones still being discovered occasionally. But one thing you didn't mention about Hermes is whether you plan to install LOX augmentation. That was part of the original design and is very important. Water is only 1/9 hydrogen by weight, after all, so use of the oxygen for propellant will make refueling much easier and quicker. The ISP for hydrogen heated by a nuclear core and then combined with oxygen in an afterburner is 700 or 750, depending on the amount of oxygen used, half way between the pure chemical and the pure nuclear options. Everyone needs that possibility.

"Our priority currently is to place drums on all the major moons; there are five of them, other than Titan and Enceladus, and we now have drums on two. Assuming we can get a 750

immigrants every two years, within ten years we should be able to maintain permanent stations on all of them, stations that will be moving to the point where they need a C-100 or a C-200.

"Inside the major moons are a dozen or so inner moons, the number being larger if you count the smaller ring-shepherding satellites. The rings have millions of objects in the hundreds of meters size range, after all. We have now visited all the significant inner moons and plan to place automated rovers on them all in the next few years. We are fortunate that they can be equipped with very large solar concentrators; they can manage without nuclear power, though it does make the exploration faster and more efficient. In the next four years we'd like to import twenty or thirty nuclear batteries able to put out as much as a kilowatt of power.

"Then there are the outer moons; 75 or more, most of which are arranged in three large families and orbiting up to 26 million kilometers out. Many are retrograde, also, which necessitates nuclear propulsion, either using the Peregrine as a first stage or using a Hermes. I suspect we could use three or four Hermes every two years to reach the outer moons.

"Finally, there are the centaurs; we've already sent probes past two and we have landed a rover on one. We used the Peregrine as a nuclear first stage. We could use at least two Hermes.

"I should conclude by noting our expanded project for exploring Titan. We have completed a Mobilhab and are testing it on short expeditions. It'll go out on a Titan circumnavigation trip next fall once we have completed a second vehicle. They are nuclear powered and Martech is still helping us with the design.We hope to keep the two of them out on a permanent expedition, with crew rotated via Peregrine, which can fly in Titan's atmosphere quite well. We need the parts to build a second Peregrine, to be sure we can support these surface expeditions. We anticipate making many discoveries about Titan in the next few years. We're also worried about our aerostat; the reactor is reaching the end of its life and the Helium-3

extraction equipment has improved greatly. Assistance from Mars for a new aerostat would be very helpful."

"Wow; expensive requests," said Halima.

"But he's right about the aerostat, and we can expect similar requests from Uranus and Neptune in a few years," said Marshall. "We'll need to put two hundred million per annum into our budget and ask all three outer solar system Commonwealths to start investing in technology and infrastructure as well."

Marshall clicked on the videomail from Jiang Liu. He was not Chief Executive of the Jovian Special Administrative District; the Chinese had decided they had better not set a precedent. Rather, he was their Nobel-prize winning astrobiologist and often represented the Callisto in events of this sort. It was also the only solar system settlement to keep its clocks synchronized with Beijing's.

"Good day, everyone, from Callisto. I have been asked to summarize our plans, which are quite extensive over the next four years. Callisto outpost itself is growing from approximately 1,000 people to 2,500 people over the next eight years and will build its own C-200 based on a novel design of our own. Immigration will be coming straight from China using a pair of corvets transporting 750 people, which will make one round trip every 25 months. The new Chinese space exploration strategy bases most of its efforts here. We anticipate sending out two crewed expeditions and two automated probes per year to the outer asteroid belt and the Jupiter Trojans. I have attached a list of our proposed destinations. We are also dispatching two probes per year to our outer moons; we are in competition to see whether we have more moons than Saturn! The Himalia, Ananke, and Carme groups have been pretty well characterized and their origin and fragmentation histories have been reconstructed, but the Pasiphae group has resisted our efforts

so far and thus is the focus of our research. It is not clear that the Hermes engine is of much additional value to us because we can use gravity assists from the Galileans to set up our probes on the right trajectory, with a small chemical engine kick at perijove to send them on their way. That's also true of our asteroid probes. Our crewed expeditions use existing large solid core nuclear thermal engines or gaseous core engines, all of which were developed jointly with Mars and other partners on Deimos.

Our small number of inner moons all have automated rovers on them, and Metis, as you know, is the focus of considerable research. The outpost there is gaining a new launching and landing pad with an elevator to lower the caravel to an underground hanger between flights. This will allow more flights with Callisto and an expansion of the outpost to up to 75 personnel. The neutrino telescope there will be expanded over the next few years and should provide much more detailed data about the interior structure of Jupiter as well as a better map of neutrino sources in the universe.

"Surface exploration of Callisto is still ongoing, with 25 scientists dedicated to the task, a number that will increase by half in the next eight years. The automated bases on Ganymede, Europa, and Io are also being expanded and a permanent buried outpost on Ganymede will be completed. While we have regular sample return flights twice a year from the inner three Galileans to Callisto, there is still some work that benefits from being there. That is still not possible on Europa and Io because of the intense Van Allen Belt radiation, but we want to work with Martech and Venus to develop better automated systems for cybernetic exploration. Thermal conditions on Io can resemble Venus, so there is a valuable synergy there.

"Our work on bionts continues and we are collaborating closely with Saturn, since their prebiotic 'life' closely resembles Callisto's and Europa's, but less so the Ganymedean forms.

This is a major puzzle. Increasingly, we think there was independent, parallel evolution of Titan and Europa's bionts, with Callisto acquiring its bionts from Europa later. Interestingly, Triton and Titania's biological evolution is more limited, and we're planning a big conference with them to explore the differences in conditions in the early solar system. Elysium outpost's research on Martian lifeforms has also been helpful, since there are some rocks on Mars that appear to reflect the biont phase.

"So that summarizes our work, which is quite exciting."

William scowled. "So, they're going to pay Shanghai Institute of Technology a billion redbacks to look over Martech's C-200 designs and propose minor changes? That's stupid."

"And they could use the Hermes, even with gravity assists," added Julio. "Callisto has plenty of solar power and makes plenty of hydrogen already.That's politics speaking."

"I don't like the way the Chinese have been pulling away from us over the last six months," said Marshall. "This is the first time I've heard they plan to make Callisto their main base of operations."

"I was surprised, too," said Halima.

"And I wonder whether Baozhi can stop it," added Qing.

The videomail from Mercury was next. "Good morning everyone, this is Chief Minister Paul Pokorny of the Mercury Commonwealth. I think my contribution to this meeting will be quick because we don't have any asteroid missions; there are very few that come anywhere near us and this close to the sun, solar storms are extremely dangerous. The bulk of our work involves exploration of the planet's surface during sunrise or sunset when there is no excess heat; the planet rotates at only 10 kilometers per hour, so it is easy to travel long distances in the terminator zone. We are in the process of establishing an outpost on the rim of Chao Meng-Fu

right at the South Pole because the southern hemisphere is difficult to explore from the North Pole. The Caloris Gold Mine is reopened, also, so we now have three outposts, although Concord is by far the largest, with 1,200 people. We are collaborating closely with the other Martech Planetary geology departments, the newly established Marius University on the moon, and many universities on Earth on our surface exploration, and there are no additional plans needed at this time. The biggest limitation is population; it is difficult to recruit people to come here, even though we have a very comfortable living area and a great community. Your assistance with that would be helpful.

"The only other assistance we could use is a supply of liquid hydrogen from Ceres. We use chemical propulsion to fly from the surface to Portage Station at the Mercury-Sun L2 point, and chemical propulsion works fine for that purpose; the delta-v is 4.5 kilometers per second and hydrogen-oxygen propulsion gives an exhaust velocity of 4.4. If we used solid core nuclear to get to Portage, we'd have to split several times more water to make the necessary hydrogen. But hauling hydrogen from Mercury to Portage to provide it with the propellant needed for interplanetary flights using gaseous core nuclear requires a lot of flights. A supply from Ceres would be far more convenient. That's our big request. Ciao."

Marshall looked at the screen, puzzled. "I don't think that works very well," said William. He pulled out his communicator and did some calculating. "First of all, Mercury needs what; two or three hundred tonnes of liquid hydrogen per year? Even a C-50 drum holds about 8,000 tonnes of liquid hydrogen. I suspect a gaseous core huclear engine would burn two thirds of that to move the remaining 2500 tonnes to Portage. So Ceres would have to break down 72,000 tonnes of water to provide Mercury with 2,500 tonnes of liquid hydrogen, and it'd be close to a ten year supply."

"It doesn't strike me as cost effective," agreed Halima.

"They have several advanced Prometheus shuttles," said Marshall. "And they have all the solar power they could ever want. I don't think that's practical, either, but we may want to keep it on a wish list. Let's hear Venus, now." He pushed an icon on his screen.

"Good morning, this is Chief Minister Patrice Beaudoin of the Venus Commonwealth. This is my first opportunity to speak to many of you, since I was elected Chief Minister in November, Pauline Augustine has retired from the post and is now in charge of the Eirene Project, which is bringing a C-200 named Lakshmi full of liquid hydrogen and the asteroid 2061DXR, now named Eirene or 'Peace,', to Venus orbit. As you probably know, Lakshmi rendezvoused successfully with Eirene and captured it securely back in October, and in January it fired its gaseous core engine for several days, burning through over half of the Lakshmi's liquid hydrogen, but now 2 million tonnes of a 65-meter stony-iron asteroid is on its way to Venus. It'll go into orbit next February and we will then rendezvous with it. At that point, Venus will have a real moon, named for one of Aphrodite's attendants, and our floating outpost will have an ample source of resources, and we'll convert Lakshmi into housing and move in. Needless to say, that will occupy most of our human resources for several years. But after that--perhaps by 2094--we will be in the position to begin launching missions to Earth and Venus crossing objects. We are in discussions with both India and the European Union about stationing crews here permanently.

"Otherwise, Venus surface and atmospheric exploration remain our priority. Daedalus 1B, which joined Daedalus 1A in December 2086, has worked out well. Daedalus 1C was delayed but it went down a few months ago and has been added to the facility. That has allowed us to raise the crew to eight. Daedalus 1D joins it late next year. By 2095 or 2096 Daedalus will have

seven balloons arranged in a hexagon, capable of feeding and housing 42 people. It's now extracting one tonne of deuterium per year from the Venus atmosphere, which we export to Earth. If we had the storage capacity, it could capture and store 100 tonnes of ordinary hydrogen; it now can capture and store 20 tonnes, which means a Daedalus can fly down without the fuel it needs to return to orbit. We hope to raise the capacity to 100 tonnes, once we have enough balloons to keep that mass in the air. We also need a larger Daedalus passenger compartment; ideally, it should be able to accommodate 10 people in very tight quarters or three tonnes of cargo, both up and down. That's a big expense, but Saturn needs it also for its passenger flights between Titan and Enceladus.

"I won't speak much about our surface exploration, but we now have eight active rovers on the surface and we are flying samples up to Daedalus for analysis on a regular basis. I heard Jiang Liu note that Io's surface conditions can be as hot as Venus's. I agree, there is synergy between us, and Martech can help both of us. I hope that it can become a budget item. Ciao."

"Again, the rovers on Io are designed by Chinese universities. They share some patents with Martech, but there's very little collaboration," said Qing. "I suspect there will be even less, now."

"And I am curious about the idea that Europe and India would base their missions to Earth-crossing asteroids at Venus," said William. "But I guess that's good for Venus, and they need the support."

"I agree," said Marshall. "In a way, they're perfect for it; they're large enough, and with their various captured asteroids, they can do excellent exploration training."

"So, we have no reports from the Chinese and American space exploration agencies," said Halima. "That's not helpful."

"I think we do," said Marshall. "I asked Ted and Changying to reach out and also summarize the Helia project. We have a videomail from them as well." He pushed on the icon.

"Good sol, everyone, Changying has asked me to deliver this videomail from us," said Ted. "We have three reports, both very short. We have no report from the Chinese space agency. Changying made queries and was told that Chinese commitment to the fusion propulsion research on Phobos was solid and continuing, and that their crewed missions would be based on Earth and Callisto, with occasional exceptions where they will support Chinese scientists setting out from Phobos, Ceres, and other venues. That has always been their policy.

"I've emailed all my contacts at NASA headquarters and NASA's various regional research centers. Because the United States still has two people claiming to be President and there's so much turmoil, and Congress has been unable to approve budgets--people are working without a budget--no one with any authority will commit to anything. But if I email contacts at JPL or Goddard or Langley, I can get informal responses. The U.S. is still planning to launch two or three crewed missions per year to near earth asteroids and to asteroid belt objects and their commitment to the fusion propulsion program, carrier development, rover development, etc., will continue. The Los Alamos people say they want to collaborate on the Hermes engine, so it is quite likely we'll get U.S. involvement. I was emailing someone at the Indian Space Agency and they expressed interest in Hermes as well. You can be sure the Europeans will support Hermes as well.

"As for Helia, we will certainly want several Hermes engines. We don't know how we will use them in 40 years, of course. But there are other things we would like to see budgeted. The time has come to make a major commitment to the design of the vessel. We feel we are ready for it, and need to hire a Director of Construction.

"We also think the time has come to establish a Department of Helia Studies. There are a few researchers working on Helia full time, like Dr. Stanley Mansale. It would facilitate their work if they had a standard budget and an organization within Martech. Many of the scientists joining the department might also be among the people heading for Helia, also. We would also like to set up a Department of Helia Biology because queries we have made indicate that we need to start developing lifeforms able to survive and thrive in high carbon dioxide, low-oxygen conditions. We will learn more about the conditions on Helia-1, Helia-2, and Helia-3 as we approach closer and closer to them, so we will need to develop genetically modified species on the flight. The sooner we get started, the better.

"Finally, the Helia Commission needs to be reinvigorated. We plan to turn to that shortly."

"There's more from Helia than I would have ever expected," said Julio.

"Yes; Ted has some good points," said Marshall. "We do need to fund those two departments so that the research can get started, and those are fairly small financial commitments."

"Especially considering that the people who would transfer to those departments are already funded," said Halima.

"Ted did some good research for us with the NASA regional centers," added Marshall. "He's right; we'll probably get funding for Hermes, and NASA funding for crewed and automated missions has been fairly steady."

"So, what now?" asked Halima. "Are we preparing a response for Baozhi? For you?"

Marshall shook his head. "Baozhi will make another closing statement on Wednesol. The responses will come from all of us, not just from me."

"Safe, after Baozhi was upset about your interview," said Qing.

"How did you hear about that?"

"I overheard his comment to you; I was walking by your office at the time."

"That wasn't the reason I had in mind. Each of us has an area and they need to get used to speaking to all of you; to all of us. Halima has been collecting specific requests for assistance that don't fall in our usual purview, like creating departments and providing liquid hydrogen. William will respond to new technology requests and crewed missions, and Qing to automated missions that are planned."

"I've looked over the Chinese list of possible asteroid belt projects, and there are overlaps with Ceres's lists," said Qing. "That needs to be resolved."

"Or they'll become a race to see who goes to which place first!" said William.

"Let's take an hour or two and write up our responses, ideally with back-of-the-envelope calculations about cost," said Marshall. "Then we'll record our joint response."

16. Ambitions

May 2089

Walking the length of the agricultural half of Ayr Valley 1 and back every morning became a habit with Amy, sometimes with Marshall if he wasn't in a hurry to get to the office. One morning she was surprised to discover the corn in the west balcony gone; it had been harvested and the stalks removed. A week later, soybean shoots began to pop out of the ground. After another week, the entire strawberry patch in the east balcony was gone--the plants had been in tightly packed square plastic containers--and by the next sol an entirely new strawberry patch had been placed, which was beginning to flower. Then one morning in early May she was surprised to see the rice paddy drained and robots wading through the field, catching stray tilapia. A young woman was observing, so when Amy approached her she said, "Fascinating, isn't it? This half cylinder is constantly changing."

"Yes, it is. It has to, in order to maintain its high efficiency."

"I've been following it closely because I'm a plant geneticist and ecologist. Do you know the owner?"

"I am the owner. Nicola Langlais." She extended her hand.

Amy smiled. "Very pleased to meet you! And my, so young! How did you do this?"

"My father, Kristoff Langlais, has been farming here for thirty years, so it's in the blood. He's the third largest producer of food on Mars, after Agmar and the Aram community. I help him run his operation, but this is the first farm of my own."

"Can you make a living on this much space?"

"No. I have 55,000 square meters in here, between the floor and the two balconies, and I also own the level below, though I use that for storage right now. I'll get 12 tonnes of rice and 2

tonnes of tilapia from the paddy 5 or 6 times per annum, plus other crops up here, but the mortgage on the space and the equipment consumes 95% of the surplus income, and will continue to do so for 20 years! Fortunately, a third of the mortgage and equipment purchases were covered by a government grant and another third were an interest free loan and the interest on the rest was pretty low. That's how it works up here; if you want to expand food production 30 to 50% every two years, you need some pretty aggressive policies! There's also a production efficiency bonus. I could get a bit more rice per hectare without accommodating the tilapia, and a lot more tilapia per hectare without accommodating the needs of the rice, but the combination yields more per hectare and I get a subsidy for that. That's why the walls are covered with vine crops and the balconies have short crops under or shaded by taller crops. It produces more overall."

"Interesting. I didn't know that; I haven't lived here for over twenty years. I was in charge of bioarchive on Titan for ten years, then I did work on photosynthetic efficiency of chloroplasts for several of our food crops."

"All of these crops have improved photosynthetic efficiency. It's amazing what we've been able to do here. Blueberries the size of cherries! Strawberries the size of peaches! And all with incredible flavor! My peach trees are ever bearing; the raspberries, too, once they start in a few months. And of course, all this is illegal on Earth, lest they overwhelm the native species."

"How many robots do you have?"

"A dozen, just for this space, and I'm acquiring half of Blyth Valley next door when they inflate it next month. You see the robots down there in the paddy? They're catching the tilapia that got trapped when the paddy drained. But 95% of the tilapia drained into the reservoir I have the first level down, and they'll be harvested there. Some of the rice straw and the other plant

matter will go downstairs to the mushroom area; the rest will be mixed with the mud of the rice paddy, along with fertilizer for the next crop."

"When will you replant?"

Nicola shook her head. "We don't have to; the rice will regrow from its roots. It comes to harvest faster that way."

"Of course. I'm delighted to have run into you! Good luck with your farm!"

"Thank you; I love this work, and more and more people are getting involved. We now have 100 farmers in Aurorae and I hope we'll have a thousand in a few years. If you're interested, let's stay in touch. My AI says you must be Amy Elliott, based on your profile on Gallery, which has you living in Ayr Valley and coming from Titan."

"Exactly right, Nicola! I'd love to stay in touch, I love farming."

"Contact me in mid June, when I've started moving into Blyth Valley, and I'll give you a tour."

"Thanks, I will. Ciao."

They waved goodbye and Amy continued on her way around the northern end of the cylinder, then back south. On her way out of the valley to go to her office in the Department of Ecology, she stopped quickly at Kim's Restaurant. Ju-won was in the store. "Good morning, John, what are your dinner specials today?"

"Thank you for asking, Dr. Amy. We will have a complete Turkey dinner with gravy, rice or mashed potatoes, carrots, squash, and French bread. White wine is optional. Our second choice is an excellent meatless cheese lasagna with asparagus and squash. The third choice is rice with bourbon chicken. For dessert, Tiramisu, apple pie, or chocolate cake. They all come with bread, a choice of soups, and salad."

"I'll order six turkey dinners with two each of the three desserts, six salads, and bread. Can you deliver it at 7 p.m.?"

"Yes, that should be fine, we have access to all of Aurorae House Cleaning's robots at that time! My AI has been listening and has recorded the order, I am sure. Are you having guests? We can provide your dinner on special china rather than paper plates for a little extra."

Yes, I'd like that as well. "Thanks, John. Have a great sol."

She hurried off to the office, but she had Nicola and her farm on her mind all sol. She was intrigued that Aurorae now had 100 farmers; she looked it up and sure enough, there were, though only ten were female. All of them planted multiple crops. Kristoff Langlais was indeed the largest, with over a million square meters of land. He was dwarfed by Agmar, however, which had eighteen million square meters of farm, orchard, and animal facilities.

She headed home a bit after five, knowing that Marshall's guests--their first guests, aside from family--were arriving at 6:30. She checked the house quickly and was pleased that the cleaning robots had done their job well; they'd be back at eleven to wash the dishes and clean up after dinner. Marshall wasn't home until 6:15, which made her nervous, as did Millie's insistence she wanted to eat in her room and Bill's general lack of interest in the guests. But when the doorbell rang at 6;30, they dutifully appeared anyway.

"Come in, Ted and Changying, thank you for coming!" said Marshall. "I hope you had no problem finding the place."

"No, our AI led us straight to the 300-block elevator on Ayr Street, then we came up and wow! What a beautiful valley!" said Changying.

'Yes, it's a bit of a shock if you start at the street level underground," agreed Marshall. "Let me introduce you to my wife, Amy; my son, Bill; and my daughter, Millie."

‘Pleased to meet you!” just about everyone said at once, and a flurry of hand shaking followed.

“This is a beautiful house!” said Ted. “You’re perched up on top, looking down on everything!”

“Exactly! Come up on the terrace and take a look!” Marshall led Ted and Changying up the stairs to the terrace level. The landscaping company had finished their work just a few sols earlier. Several large potted orange trees were clustered together to make a shady spot near the stairs; the northern, southern, and western walls were lined with a garden almost a meter wide with a variety of flowering tropical plants; the eastern side of the terrace, however, just had a shoulder-high plexiglass barrier. After walking around the terrace, everyone walked over to the east side to admire the view.

“This has to be one of the prettiest places to live in Aurorae,” said Changying.

“We’re impressed. The northern half of the cylinder is all agricultural, too, with a few walking paths.”

“Is it expensive?”

“There are smaller, cheaper flats available farther down and more expensive ones up high. Most of the people here are new immigrants.”

“I see why there are thirty more of these ‘valleys’ scheduled to be opened by the twentieth seventh columbiad,” said Changying.

“Domus is opening six,” said Amy. “But there are several private companies opening some of the others, and I guess Marbuild will complete half of them.”

Changying pointed at the stage below. “I see people are setting up for a program.”

"Yes. Tonight there's a new musical group, the 'Ayr Valley Band' who will play popular songs," said Amy. "There's nothing morrowsol, but the sol after there's folk dancing. We'll often come up here after supper and listen."

"Why here?" asked Changying. "Go down there, sit with your neighbors, and chat while you listen! That's why the Mars Council allocated 20 million redbacks for local arts and cultural events. A place is being set up for every 2 to 4 neighborhoods where people can gather every 2 or 3 evenings to gather, get to know each other, talk, and enjoy art."

"Millie and I got down most of the time!" said Bill.

"We have gone down, and you're right, we should go down more often," agreed Marshall. "It's a nice gathering. Kim's restaurant has ice cream, popcorn, pizza, and other snacks. I'd guess there are a hundred or two people in the audience each time. We have three 'neighborhoods' here and the evening programs really do help bring us together.'

"And the Kims; they're really marvelous, warm people," added Amy.

"Let's go back down," suggested Marshall. "The eastern reflector is reflecting a lot of light at us. I think this terrace won't be very usable for the next half an hour, until the sun sets."

"It is pretty bright up here, until the sun is low enough that the western reflector will shadow the eastern one," said Changying, turning to the stairs. They went down and Amy gave them a tour of the rest of the house. Then they sat in the big living room chairs that had finally arrived just a week earlier.

"Tell us how Helia is going?" said Amy.

"Pretty well," replied Changying. "The first phase of planning appears to be ending and we are moving into the second phase, where the design is nailed down, the first personnel are

recruited, the various departments are set up one by one, the Commission begins to meet regularly, etc."

"Where do you start? What departments?" asked Bill, curious.

"We start with three: a department to study the Helia system, a department to explore the genetic modification of plants necessary for life on the planet we select, and a construction department to finalize the design of our vessel," said Ted. "Subsequently we'll create an environmental design department to plan the vessel's ecology, then we need an inventory department to plan the equipment we need for the voyage."

"And lots of other departments and supdepartments," added Changying. "We're still figuring all that out, but the Pluto and Sedna missions provide excellent models. We were actively involved in their final phases and are still in regular contact with their commanders."

"How long will it take you to get to Helia?" asked Millie.

"About thirty years; we're still not sure," said Changying. "It has a lot to do with the propulsion system we select. Fusion, advanced ion, and gaseous core are all undergoing improvement and we're still not sure which will be best."

"We'll know in a year or two. Or three," replied Toed, with a smile.

"Well, I have good news for you," said Marshall. "We submitted our space exploration budget for the next annum, July 2089 to April 2091, to the Chief Minister's budget officer this sol. It includes 15 million redbacks for the Helia Studies Department, 15 million for the genetics department, and 200 million for the design effort."

"Fantastic!" said Changying.

"Thanks!" said Ted.

"Of course, that's just step one," said Marshall. "Step 2 is the merging of the various budget proposals to a single executive branch budget proposal, and step 3 is its approval by the Mars Council."

"I'll see what I can do about that!" exclaimed Changying, who was a member of the Council.

The doorbell rang at that moment. They looked and saw a robot waiting to bring in their dinner. "Come in!" exclaimed Marshall, knowing his AI would respond by unlocking the door. The robot rolled in and they all rose from their chairs and walked to the table.

"They're all the same," said Amy. "So everyone can take their own plate and sit. Let me grab the soup, the bread, and the drinks." She grabbed those items and placed them on the table while the others grabbed their plates of steaming hot food.

"This is very nice," said Changying. "I didn't know you could order food on china!"

"I didn't either until this morning. Maybe it's typical of just Kim's restaurant."

"No, I think most places will do it," said Bill. "I was looking at menus the other sol. But you have to return the plates and silverware!"

"The robots will take them back later," said Amy. "So, what are you doing, in terms of genetics?"

"We're not sure, yet," replied Changying. "We're still looking for a team to put it together. Helia has three planets that are more or less within the Goldilocks zone; in other words, where liquid water can exist, at least somewhere in the world. Helia 1 is the smallest and Helia 3 the largest, so the atmosphere is the thinnest and greenhouse effect is weakest where there is extra insolation and strongest where the sunlight is weakest. They all have atmospheres of nitrogen and carbon dioxide and lack oxygen. Theoretically, they are more habitable than Mars."

"That was probably true of Mars, Venus, and Earth, 4 billion years ago," observed Marshall. "How much sunlight?"

"About the same range also, but a bit lower, and much redder."

"Plants can handle the lower levels, and there's been some research on modifying chloroplasts to utilize longer wavelengths," said Amy.

"But plants need oxygen," said Changying.

"Yes, but they produce their own in photosynthesis. The trick is making sure they retain enough for their own processes. That's what cactars do."

"We gather that a lot of the research on Marsoforms has laid the foundation for Heliaforms," said Ted.

"I'm sure that's true," said Amy.

"Do you know any young Masters or doctoral candidates we can talk to?" asked Changying. "We want to talk to professors, too, but we're looking to recruit young ones who will start doing the research and then agree to join the flight."

"I see." Amy thought for a moment. "I've only been on Mars since late March; less than two months. So I am not the best person to talk to. The Marsoform team is huge; I think there are 200 PhDs, graduate students, and support staff. I suggest you go straight to the top and talk to Jefferson Woolsey himself. He can refer you to specific professors who have graduate students whose work might be going in the directions you need."

"Thanks, that's very helpful," said Ted.

"So, are you already recruiting crew? I thought you wereen't leaving for ten years!"

"Yes, our official departure date is 2099," said Changying. "But we might manage an earlier date. We want to start recruiting people now, when they are very young--graduate

students, maybe even undergraduate students--to get them started on the research and experience we need. The departments will be the key; institutions where they can take courses and do research. That way, when we leave, they will be ready."

"I see," said Bill, nodding.

"I think an earlier departure may be possible," said Marshall. "Seven years from now, maybe even six."

"How much will the project cost?" asked Bill.

Ted shrugged. "Depends on what you include. Gaseous core engines have been undergoing refinement for fifteen years at the total cost of perhaps thirty billion redbacks. Fusion propulsion will cost at least fifteen billion to develop over ten years, but it isn't just for us. Carrier design, environmental design and management; these have cost similar amounts over an even longer time period. But think of all that as the foundation that's already paid for. The carrier shell, propellant, propulsion system, internal systems, health care system, education system, reserve supplies, industrial infrastructure: all that will cost many billions, maybe ten or twelve billion. But about half that cost is the salary of the personnel on board, who will tke the raw materials and the equipment and actually build the ship."

"You mean, the people who will fly on it will also build it?" said Bill, surprised.

"Of course!" replied Changying. "If they build it, they'll be able to repair and maintain it!"

"Yes, I can see that.'

"What are your interests?" asked Ted.

"Me? I'm double majoring in planetary geology and in history, but my plans are to become a historian of Mars. We have no one researching and writing regularly on the history of

Mars, and that history is now 53 years old. This world has over 400,000 people now! It has an advanced society, a unique culture, even its own dialect and accent. It needs its own history."

"That's true. Of course, the Helia project will need a historian as well!"

"Do you have a historian on your personnel roster?" asked Marshall.

"We have two people in the humanities, field unspecified," replied Ted. "If they can do geology or a science as well, that's even better. We want people who can do more than one thing."

"Well, I'm not interested," said Marshall.

"Could you help to introduce us to some of your friends, though?" asked Changying. "We don't have much access to undergraduates."

"You mean, a campus meeting?"

"Yes, that'd be good," said Ted.

"Sure, I could call on some of my friends. I think they'd like to hear about Helia. Of course, this would be a no-pressure presentation."

"Of course!" said Changying.

"That's good," said Marshall. "I'd like to get a briefing about the planets, some time."

"Dr. Stanley--Stanley Mansale--plans to give us one next month," said Changying. 'You'd be welcome to come along."

"Thank you, I'd welcome that." Marshall took another bite of his turkey, chewed, and thought. "You know, I have a suggestion. Helia-1, 2, and 3 are not very exciting names. You need to name these planets. That will excite and inspire the publi a lot more."

"We've hesitated because we didn't feel we have the right to do it," said Changying. "That's up to the International Astronomical Union."

"True, but they have a policy that extrasolar planets just should have designations by number because we now know of over a hundred thousand of them. You can't give that many names. The Helia project needs to give them names for your own sake; for your public relations and politics. If you do that, the IAU won't complain; in fact, they probably could be convinced to adopt your names, especially if the discovery team goes along."

"That's a great idea," said Ted, nodding. "You're right, that'd convey the project to the public."

"You need that," said Marshall.

"You should make the naming contest," added Bill. "That'd really generate interest!"

"But what if we get a lot of silly and ugly names?" asked Ted.

"Don't accept them," replied Marshall. "If you have a big enough contest, you'll have thousands of names to choose among. You'll get some great choices."

"I agree, I think we will!" said Changying, with a smile.

When Marshall entered the cabinet meeting room, he could feel the tension. Ministers all looked nervous about their brief presentations about the budget. Baozhi had already met with each of them individually and had reviewed their proposals, so that meant they were nervous about input from their peers. Unusually, they had not seen more than short summaries of each others' budgets, mostly focused on the upcoming Martian year or *annum*: 687 Earth days, 668 sols, 22.5 months, which barely took one to the end of the next columbiad, its flood of immigrants and their needs.

"Boris, why don't you start," said Baozhi. Boris Lescov--son of Alexandra Lescov, Marcraft's first great designer, now retired--was a physicist, and many wondered why he was qualified for the job.

"Sure; two slides will do it." He pushed an icon on the screen in front of him and a table appeared. "We're in a better position to ramp up our efforts than many departments because a small increase in budget and human resources can go a long way. There are no changes to the fusion detonations this November 10, when two 50-gigaton fusion nukes will be detonated under the southern cap just as spring begins in that hemisphere. We have moved them to the austral vernal equinox to keep them as far from dust storm season as possible; it begins January 1, 1990.

"But half an annum later, when the northern spring begins in September, 2090, we propose to set off three nukes under the northern cap, and they will be 60 gigs instead of 50. The northern hemisphere's summer is much less dusty, so we will see what results. At about the same time, when the southern cap is slipping into winter, we'll set off at least one 60-gig to help stave off refreezing of the carbon dioxide. Then when austral spring returns in September 2091, we'll set off three 75-gigaton devices. That's as far as we have planned, but we anticipate continuing to increase the number and size of the nukes.

"We're also doubling the size of halocarbon production at both Thaumasia and Tithonium, which will require bringing a total of 2 million kilowatts of more power online. We'll also build new liquid methane and oxygen storage tanks, so that when power drops during dust storms, we'll have reserves. This appears to be necessary, based on meteorological models.

"Finally, slide two: we are budgeting for a doubling of the size of the cactar planting, both here and at Tithonium, and at the latter we plan to start melting the existing ice deposits and heating them with solar mirrors so they will evaporate into the air. We're pretty sure cactars have

now been suffuciently modified so that they can obtain their moisture from the air if the air is moist enough, and if the air is moist, the nighttime temperature doesn't drop as far. Tithonium's atmospheric pressure is almost double the pressure at datum, also.

"That's it."

"I can't imagine the environmentalists will be happy," said Bijan Lohraspi, which caused Baozhi to scowl.

"Is there a plan to get this through the Council?" asked Marshall. "Because all the members have seen the predictions from the meteorological models. If we double the atmospheric pressure, we get thirty to fifty percent more global dust storms."

"Well, it is a model," replied Baozhi. "And we can accommodate that increase if we build methane and oxygen storage facilities. A severe storm can be handled by shutting down halocarbon production and using that extra production capacity--three million kilowatts in normal times--to supplement other power sources."

No one said anything in response. Marshall wanted to ask about the 1,000 idled workers and the possible shortage of artificial lighting for agriculture, but knew better than to bring them up.

"Bijan, give the immigration plan," said Baozhi.

Bijan, the Minister of Immigration, nodded. "We now have everyone settled in from the 26th columbiad and all furniture and housing is complete. The plan for the 27th columbiad has changed little from two years ago. We will use our three C-100s, the *Utopia,* the *Arcadia,* and the *Cimmerium,* carrying 20,000 people each, our one C-200,the *Hesperia,* carrying 60,000, and add another C-200, the *Ausonia,* transporting 60,000, for a total of 180,000 immigrants. A C-200 arrives in Earth orbit in the next few months with all the liquid hydrogen we need for the

launches. Because the C-100s have proved totally reliable and their gaseous core propulsion systems will be expanded to guarantee increased safety, each vehicle will depart Earth by itself, rather than in pairs. Opposition occurs on March 6, 2091. The carriers will depart for Mars every two weeks starting in early December and will arrive starting March 15. The flight times will vary from two to four months; longer than in earlier columbiads, but this is a very poor opposition. The arrivals will be distributed to the outposts more or less the same way as previously, except for Phobos, which will grow to 20,000 people. Our population, which now stands at 442,000, will grow to about 730,000 when one includes children born from 2089 to 91.

"To house and feed everyone, housing will be completed in Africa and most of Asia. The use of 'hills'-- huge buildings that look like hills--has worked out well in the design for Zanzibar Town and will be part of the design of the other 'villages' in Africa and Asia. They will concentrate the 'footprint' of the housing, leaving more of the surface for agriculture. There will also be considerable underground farming. Demeter enclosures 1 and 2 south of them will be completed by 2090, for agricultural purposes only. They'll enclose 14 million square meters of polder, able to feed nearly 200,000 people by themselves. The big innovation will be the production of 'valleys,' cylinders 100 meters in diameter and 1,000 meters long, each able to house 2,250 people or three neighborhoods and feed about 1,000. The B-1000 cylinders are now being mass produced, which greatly reduces their cost, and the robotic systems for setting them up are becoming pretty sophisticated as well. If we can produce 30 'valleys' for Aurorae, we can house 67,500 people or ⅔ of the immigrants settling here. All the other outposts are begging for B-1000s and we should be able to start this new construction process at all of them in three years. Note that two cylinders, one purely agricultural and one with a neigborhood, would be more or less self sufficient in consumables.

"For the 28th columbiad, we are proposing a new approach: introduction of a C-300 capable of transporting 120,000 people. It would be divided into 2 or 3 airtight sections for redundancy. Ceres would manufacture it. Phobos would make another one for use on the moon to house its growing population and give them a much more spacious living area. This means the 28th columbiad would transport not 240,000 people, but 300,000 people to Mars."

There was silence over that announcement. "People are upset about all the chaos this time," said Bijan. "How will you convince the Mars Council to do that?"

"We must try," said Baozhi. "Earth continues to sink into chaos. We must grow, and as fast as possible."

"That argument, as we know, has always been highly controversial," said Marshall. "I'm not sure the Council would go for that."

"We must try," replied Baozhi. "I'll throw all my weight behind it. I'll meet every member of the Council personnally if I have to."

"How many square meters of polder per person will we have after the next columbiad?" asked Simin Thabeti, the Minister of Health.

"One hundred twenty square meters per person," replied Bijan. "A big decrease, yes, but it is sufficient because the enclosures are so large and agriculture is so much more efficient, with the new genetically modified crops."

Simin nodded. "True, but not everyone wants to go outside. For the people who have to stay inside, the noticeable increase in crowding will be very upsetting."

"I'm not sure they'll notice, except maybe on Transpo," said Baozhi. "Public spaces are still a significant fraction of the city, especially with vehicle traffic routed underground. I walked around Africa enclosure yestersol. It's quite pleasant and open."

"Yes, but it hasn't reached its maximum population," replied Simin. "Half of it still needs to be settled. Right now, it's very pleasant, but when it's full, it'll feel a lot more crowded. Does the budget include money to create neighborhood centers and community programs?"

"Yes, it even increases the money for them to 50 million redbacks," said Baozhi. "Local perograms have been immensely popular and good for building local ties. Setting up a locus of community activity for every 3 or 4 neighborhoods has proved effective; they have a critical mass of people to support local businesses and local social activities and still allow people to meet enough residents of their own neighborhood so they can vote reasonably well from personal experience.'

"And a lot of people who are hospitable and good at organizing others are elected," added Marshall. "That's my impression, anyway."

"I think so," agreed Baozhi. "Marshall, summarize the space exploration plan."

"Certainly," said Marshall. He turned to his communicator and put up a slide. "I'll start with Mars's own priorities before turning to our support for other settlements. In the next two years, Ceres and Phobos will both launch two crewed missions into the asteroid belt, Phobos focusing on the inner belt and Ceres on the middle to outer belt. Currently we have eight missions out and ongoing; they average 4 to 5 years and visit 2 or 3 asteroids. We are also providing some support for four missions primarily sponsored by other nations. We are coordinating our missions with three other nations that send out their own missions to asteroids inside Mars's orbit or in the asteroid belt, and we coordinate with China, which sends out missions from Callisto to Jupiter Trojans, outer belt asteroids, and centaurs whose orbits come within Saturn's orbit. Our ten missions--the eight that are out and the two that are about to go out--have a total of 300 personnel, including 110 scientists. Altogether, our asteroid sciences

departments at Phobos and Ceres had 250 faculty and they go out, on average, 4 to 5 years every 10 to 12. The pilots, environmental control staff, engineers, AI tech support, and horticulturalists on the missions number another 500 personnel; ground support add another 200. They are dedicated to their work. I mention this because the scale of our exploration effort is larger than all other nations combined.

"Then there are our automated missions. Phobos and Ceres both send out two per year using a standard rover and science package, chemical kick stage, nuclear battery, and ion engine. Typically, the probes visit three asteroids in a seven-year period before they expire. A lot of the probes involve multinational financing and personnel.

"There are no plans to increase the number of crewed missions for the next four years, but after that we will need to reevaluate because of progress on propulsions systems. Right now, chemical systems are used for the crewed missions because of the limited energy supplies the ships have. If they dissociate water, chemical propulsion uses all the hydrogen and a substantial fraction of the oxygen, whereas a solid core nuclear engine only uses the hydrogen, so it requires far more water to be broken down. This is another reason LOX augmentation for nuclear propulsion should be re-developed.

"That's the exploration side. Now, turning to the technological development side, there are two big projects that are new. One is the Hermes project. After extensive discussion with our nuclear propulsion department, we have determined that we can start development of a solid core nuclear engine with updated technology in three months. We will start with the design for the Peregrine solid core nuclear engine, which is only six years old, and miniaturize it to produce a smaller, lower-thrust version. We should have a prototype on Phobos in another six months. After a year of testing, especially of LOX augmentation and of use of the nuclear core for power

generation, we will be able to start production, and we are budgeting to produce 40 engines. It appears we will have to pay fifty percent of the development cost; the U.S., China, India, and Europe will split the rest. We anticipate that even the crewed missions will be able to use them; a caravel would use a cluster of four engines for departure from Mars, but even one will be sufficient.in the Belt. With LOX augmentation, caravels would have approximately fifty percent more delta-v at their disposal than chemical propulsion can provide.

"The other big project is the solar mirror project. It's hugely ambitious. To warm the polar cap by five degrees Kelvin in the winter, we'd need a mirror 250 kilometers in diameter located 200,000 kilometers from Mars. Such a mirror would have an area of 50,000 square kilometers and mass of at least 200,000 tonnes. Simply designing a structure to hold such a mirror together is an immense engineering challenge. Phobos has a long history of manufacturing solar sails, but they have been only ten square kilometers in size, and the manufacturing ability has been mothballed for almost ten years. We think an entirely new system is needed to produce large areas quickly. The equipment to extrude the plastic enclosure for the 'valleys' produces a sheet of tough, multilayer plastic 328 meters across and 1,000 meters long. A version of that system could extrude aluminum-coated mylar 4 microns thick and more than 1,000 meters long. It could then be transported to its final spot 200,000 kilometers from Mars and deployed. We think a machine of this sort can be designed, built, and made operational in two years and it could probably produce 20 square kilometers a year."

"Except we'll need a lot more than that," said Baozhi. "If we want to have 50,000 square kilometers of mirror, at 1,000 square kilometers per year it'd still require 50 years. Twenty square kilometers is virtually nothing."

"But we have start somewhere, build the machine, test it, improve it, build a second model and have two of them etc. We also must build a mylar manufacturing facility on Phobos. We can make mylar out of materials on Phobos, but the aluminum will have to be flown up from Mars."

"How long before we can produce a thousand square kilometers per year?"

Marshall was stymied. "That question currently is too difficult to answer well. I think we can get production up to 100 square kilometers per year in a few years. Remember, we are also producing halocarbons at Thaumasia and Tithonium and they'll do at least half the work of raising the polar temperatures, so the mirror can probably be much smaller."

"But even if we need 25,000 square kilometers, 100 square kilometers per year would take 250 years. We have to do better than that."

"I know, but it will take time to develop that capacity, even with a crash program. In the next columbiad, Phobos's population will swell to 20,000. We can create 1,000 jobs for this program. I suspect at the twenty-eighth columbiad we can double them. Producing and deploying 1,000 sequre kilometers of mirror per year will take several thousand people. We'll get there, Baozhi.

"Our other large research project is improvments of fusion and gaseous core propulsion. Gaseous core propulsion is now able to produce 5,000 seconds of specific impulse, which is about 170,000 kilometers per hour of exhaust velocity. We might be able to raise it by another 500 seconds in various ways, but the main focus of the research is stability and reliability of the engines and reducing the amount of radioactivity they spew into space. Fusion propulsion is definitely possible, but we need lighter engines with greater thrust and very long lifetimes. It appears a reliable 25-tonne thrust engine that will mass 100 tonnes and produce a specific

impulse of 10,000 to 15,000 seconds can be developed in four to five years. The Helia project will need at least five or ten of them; a flight to one of the outer planets, at least two. The budget for fusion engine development is growing from 1 billion a year to 2 billion next year and probably 3 billion subsequently, including substantial engineering work done in the US, China, and France.

"Turning now to support for other settlements, there are three large projects: an improved aerostat design, an expanded Peregrine shuttle, and the design and construction of the Helia vessel. Saturn's aerostat is functioning well, thanks to a crewed visit and an upgrade of its balloons three years ago, but its reactor is reaching its end of life. Replacing its core is possible, but very difficult, because it provides the heat to keep the aerostat aloft. Probably the best course of action is to design an aerostat two that is larger and has two reactors, larger and tougher balloons, greater Helium-3 production capacity, and other improved features. Ideally, it would be deployed and operational a few years before the first aerostat dies. Uranus and Neptune will need the aerostat 2 design as well, just a few years later. We're talking about a 1.5 billion redback commitment during 2090-91.

"The Peregrine 2 mostly needs to be bigger. The Peregrine can transport at most six people from Venus orbit down to the Daedalus; they want a capacity of ten, and an expansion of the cargo capacity from three tonnes to ten. The enlarged Peregrine will also work much better to move people around on Titan and to launch then into Titan orbit, where a caravel can transport them to Enceladus. It can also transport more Helium-3 and can allow safer crewed access to the aerostats in the atmospheres of Saturn, Uranus, and Neptune. The enlarged Peregrine will need at least fifty percent more liquid hydrogen propellant capacity and a more powerful Peregrine

engine. The design for the enlarged vehicle and more powerful nuclear engine will run about a billion redbacks, also in 2090-91.

"The Helia vessel design will cost about 150 million, the work split between Martech and Ceres. Ceres will build the shell and send it to Phobos, full of liquid hydrogen, liquid nitrogen, and several tens of thousands tonnes of metal cargo and it should arrive in 2095. Once the cargo, hydrogen, and nitrogen is offloaded, construction on the interior can start any time the crew has been assembled, because the Helia crew itself will do the construction. If all 1,800 crew has been selected, their salaries will run about a billion redbacks a year until they depart from Phobos, at which point they will be an independent human community and we will cease to pay them. Construction of the interior and setting up its environment and ecology will take about 18 months--."

"So, in other words, the *Helia* could depart for its destination in six or seven years?" said Baozhi, unterrupting.

Marshall nodded. "The issue is the selection of a propulsion system. If they are going to use gaseous core, they need to fly to Jupiter and get a gravity assist, and Jupiter will be in the right position in late 2099. If they are using fusion, it'll have a high enough specific impulse for them to depart for Helia just about any time."

"Hence the importance of developing the fusion engine," said Baozhi. "And we badly need fusion propulsion for transport in this solar system; for flights between Earth and Mars any time, one-year flights to Uranus, 18-month flights to Neptune and Pluto. It'll really open up the solar system."

"It will," agreed Marshall.

"Then I want fusion pushed particularly hard. That and solar mirrors. It would be fantastic if we could launch the *Helia* in less than eight years, as part of the eight-year exploration plan and as an accomplishment of this administration."

"If this administration gets reelected in four years," noted Simin.

Baozhi nodded vigorously. "Of course, we'll get reelected, and we need to plan as if it will happen. We're going to accomplish great things, and we're going to make Mars even greater than it ever has been; greater than it has ever dreamed it'd be! If we import 180,000 in 2091, 300,000 in 2093, and 420,000 in 2095; if Mars has 110,000 children by 2091, 150,000 more by 2093, and 240,000 more by 2095: Mars will have a population of 1.8 to 1.9 million people when this administration ends! I don't think we can even imagine now what a Mars of that size can accomplish. Our eight-year plan has detail for the next two or three years, then it becomes an outline. That's inevitable, but we will flesh it out with many great accomplishments. Wait and see; we will accomplish things for which every human being alive can be proud."

16.

Finding Crew

June 2089

Will took his time trudging up four flights of stairs. Finally, he and Marshall reached the balcony level overlooking North Ayr Valley 1's agricultural area. "I made it!"

"I wasn't sure you could, dad."

"The low gravity helps, and I took my time." Will smiled. "Not bad for 88!"

"I guess so! You can see why Amy and I like this route."

"Yes, it's very nice to walk under trees and be able to gaze down on a field. What's growing down there; rice?"

"Yes. The owner harvested it just last week and reflooded it, and now the roots are putting out another crop. Right under the field she has a space 5 meters high where she stores the rice paddy's water when it's drained out of the paddy; she catches the tilapia raised in the paddy there. The rice straw and other plant debris is composed in her mushroom farm. The rest of the space is a low-light garden where terrestrial shade plants grow. Then there are all the peach trees along North Ayr Avenue; they're hers as well. Amy was talking to her the other sol. She said once all those areas were set up, she'd have 150,000 square meters in this cylinder--including the seasonal fruit trees along the commons between the two buildings--and it was actually enough, theoretically, to feed all 2,000 people in this valley! I was amazed when she said that."

"That's impressive," said Will. "Who's the owner?"

"Nicola Langlais, Kristoff's daughter."

"I know her. She's smart. I hope we can find more farmers like her." Will pointed to a bench under the fruit trees nearby. "Let's sit."

Marshall nodded and rhey walked over to the bench, which was in a pleasant sunny spot. “So, how are you holding up?” asked Will.

“Alright, I think. Baozhi is really unhappy about the public reception of his proposed budget, especially the plan to import 300,000 people in 2093. It sounds crazy, but at that point we’ll have 800,000 people already, so it represents an increase of less than 40%, and we’ve had bigger increases than that.”

“But the larger immigration waves get more and more complex and more csn go wrong,” said Will. “I can understand the hesitation. People don’t trust him, either, because he screwed up this immigration wave.”

“I know, but you can’t tell him that.”

“I tried, but he didn’t want to hear it.” Will shook his head. “He and I aren’t having lunch any more. He has decided to strike out on his own.”

“That’s too bad, because he doesn’t listen to the cabinet much. He is insisting we put together a plan to produce a thousand square kilometers of solar reflectors per year within 2 or 3 years. If we ramp up production gradually, increasing it 50 to 100% every year, we can get there in five or six years, the demand on the budget will be spread out, and we’ll learn from small mistakes rather than big, disastrous ones.”

“How many people would it take to produce and deploy a thousand square kilometers per year?”

“We’d need a manufacturing facility on Phobos that costs 4 or 5 billion redbacks and employing maybe 2,000 people. We’re actually not sure, yet. We’d also need to fly about 2,000 tonnes of aluminum every year from Mars to Phobos, so we’d need a facility at Thaumasia or Tithonium to process that much aluminum. The mirror would need to be built in sections and

that's a huge mathetical problem, to assess all the forces from gravity and light pressure, balance them, and keep the mirror stationary. It's not easy."

"Then there's the increase in the detonation of fusion devices under the permanent cap. There are some people who are simply furious."

"I am amazed by the depth of their fury," said Marshall. "Two cabinet ministers are thinking of resigning."

"I don't blame them. But I think they need to stick it out. Baozhi might get all of these measures through the Mars Council. They're awfully ambitious goals--perhaps too ambitious--but the Chief Minister has a pretty good track record."

"Well, Mikhail Shtokman sounded lukewarm, when he met with the cabinet the other sol."

"That will make it harder." Will slowly rose. "We had better get back to your place. Ethel will be ready to go home, and you have a meeting to attend. What was it, again?"

"You're welcome to come. Ted and Changying are hosting a gathering to talk about the Helia project at Martech, aimed at the students. Bill is helping by inviting his friends."

"Maybe another time. I don't want to become the center of attention. I Bill thinking of going?"

"No, he's just helping out. He's planning to get a Ph.D. in history and stay here."

"Good, I'm delighted by his plans. I've really enjoyed talking to him/ What's he doing this summer? I've been thinking of asking him to work with me on my papers."

"Dad, he'd be thrilled by that."

"Good, I'll ask him, then."

They walked back down the long flight of stairs to the commons, then along the commons to Kim's restaurant and up the elevator to Marshall and Amy's apartment. There, Will and Ethel called for an autotaxi. Marshall rode the elevator down to Ayr Street with them, then hurried to Martech.

He was just in time. The room, which had a capacity of 50 people, had about 15 students, plus a few Martech faculty. Bill nodded to his father; he looked a bit disappointed. Marshall nodded back and sat in the back in order to avoid becoming a distraction. He noted that Ted and Changyng had brought along 8-month-old Yvette, who was crawling on the floor near them.

Changying rose. "Good Satursol afternoon, everyone, and thank you for coming. We will have three brief presentations thistle, by the future chairs of our planetary science and biology departments, then by Ted Bukowski about the status of the mission. So, first, allow me to introduce Dr. Stanley Mansale. Stanley."

The young Vanuatuan-Marsian rose. "Thank you, Dr. Changying. Everyone, please call me Stanley. I'm delighted to see so many of my students here, even though we are now on the summer break.

"I also see Dr. Marshall is here and I want to acknowledge him, because the Ministry of Space Exploration has extended short-term funding to us to establish these two departments, and the budget the Mars Council will begin to debate on Monsol allocates ten million redbacks per annum for each department. We are very excited that this research can begin with solid funding on a long-term basis, instead of being a research interest of scattered faculty members. The Department of Helia System Science is located within Martech's Division of Space Sciences, along with Mars Studies, Asteroidal Studies, Icy Moon Studies, Outer Planet Studies, Stellar Systems Studies, etc. We have been carved out the latter because our research, currently, is

telescopic, but as the department grows, it will include people drawn from all the disciplines found in the Division of Space Sciences.

"I think most of you know the basics of the Helia system already. Helia is a 500 million year old star, spectral type L7.5. It has burned up all its deuterium--that tends to last only a few tens of millions of years--but it was born fairly rich in lithium and lithium-hydrogen fusion is still occurring, which will power Helia for at least another 100 to 200 million years. It's a stable star with no serious flare activity. To the eye it will look magenta--deep reddish-purple--with cloud bands formed out of various metal oxides in the outer atmosphere of the star. It is just two hundred-thousandths as bright as the sun. It is located a mere 1000 Astronomical Units from here--150 billion kilometers--in the constellation of Sagittarius.

"It has four known planets, numbered 1 through 4 respectively, plus we now have evidence of an asteroid belt orbiting inside Helia 1. Planets 1, 2, and 3, are, currently, in the Goldilocks zone where liquid water is present. They receive 197%, 72%, and 37% as much sunlight as the Earth; by comparison, Venus receives about twice the light of Earth, and Mars, 43%, so they are very comparable. But in this system, the greenhouse effect works favorably; Helia 1 is the smallest, 7,000 kilometers in diameter like Mars, and has the thinnest atmosphere and the least greenhouse effect, while Helia 3 is the largest, 14,000 kilometers in diameter, 110% the size of Earth, and has the most atmosphere and the most greenhouse effect. If Mars and Venus could have formed in the orbit of the other, we'd have a much more habitable solar system right now!

"We still can't image any of the planets in detail, yet; a pixel is about 500 kilometers across. But that's sufficient to learn important details about the surfaces of the planets. We have also recorded stellar occultations behind the planets, which have allowed us to measure their

diameters precisely. We also have detailed spectral observations of their atmospheres, so we can say this:

First: all the planets have atmospheres primarily of carbon dioxide, with substantial nitrogen, and all of them have clouds of water vapor covering one half to three quarters of the surface. Helia 3 had the least cloud cover, Helia 1 the most. The Earth, by contrast, is two thirds cloud covered at any particular time. The atmospheric pressures are 0.3, 1.2, and 2.0 times the pressure of the Earth's atmosphere; all of them are habitable to humans. Oxygen is less than 0.1 percent in all three. There is no evidence of chlorophyll in the spectral lines, although there are substantial amounts of organic compounds.

Second: all the planets have bodies of liquid water on their sun-facing sides. Helia-1 may be 30% ocean covered on the sun-facing side; Helia 2 and Helia-3, 60% and 80% respectively.

Third: All three planets are largely ice-covered on their sides facing away from Helia. Remember, these planets are tidally locked; one side has perpetual sunlight and the other, perpetual darkness. But heat does circulate around to the back. There is evidence of strong winds and certainly there would be strong ocean currents. We don't know how thick the ice sheets are, but we can infer that glaciers, perhaps continental-type ice sheets, will flow into the front side.

Fourth: All three planets have volcanism, especially Helia-1. The three are locked in a Laplace resonance whereby Helia 1 orbits the central star in 11.1 hours, Helia 2 in 22.2 hours, and Helia 3 in 44.8 hours; almost a perfect 1:2:4 resonance, just like Io, Europa, and Ganymede. Helia itself rotates once every 6 hours. Maintaining this tidal resonance generates a lot of internal friction. We can see volcanism best on the dark sides; nearly every pixel has the heat signature of a volcanic center. But I assure you that volcanism does not render a world uninhabitable, just interesting! My native land, Vanuatu, has many volcanoes.

"Fifth: we have watched the dark sides of all three worlds for transient flashes that would indicate meteors. We can't observe small shooting starts, but anything over a meter in size would be detectable. Our preliminary estimate is that all three worlds are being bombarded at about 10 times the rate Mars is today. That's still a lot less than terminal bombardment at the beginning of this solar system. The settlers will want to maintain planetary protection, but should not face any serious dangers on a time scale of a century or two.

"Finally: Where on each of these worlds would we want to settle? We still can't make maps, so the answer has to be very general. On Helia-1, subsolar illumination would be pretty intense and we think the surface temperature runs close to 50-60 Celsius on average, with excursions even higher. That's why it has 75% cloud cover but little ocean coverage. A spot where Helia is about 14 degrees above the horizon will receive the same amount of sunlight as the surface of the earth, though it'll be continuous, in other words, half the intensity over twice the time. The spot would also have to have a pleasant temperature, which means avoiding blasts of frigid air from the back side or heat from the subsolar point. For Helia-2, a spot where Helia is 35 degrees above the horizon would furnish the same amound of daily illumination. For Helia-3, the subsolar point would furnish 74% as much daily illumination as the Earth receives and nearly twice as much as Mars. If that spot were on a large landmass on the equator surrounded by ocean, it could be quite pleasant. In short, all three planets could serve as our home, and most likely Helia civilization will expand to all three of them over time.

"Let me close with a summary of Helia-4; it's much farther out, receives slightly less light than Jupiter, has a diameter 50% greater than Earth and a mass about twice Earth's, so it is probably an Earth-like body similar to Helia-3 but with a thick hydrogen-helium atmosphere. It

appears to have 3 substantial moons--at least a thousand kilometers in diameter--but we're still not sure. Helia-3 might have a moon as well.

"Before we have questions, let me turn the floor over to Dr. Cynthia Nguyen, the chair of our new Department of Helia Biology. Cynthia."

There was warm applause from the audience for Stanley's presentation as Cynthia rose. "Good sol everyone, and thank you for coming. I particularly thank my undergraduate and graduate students for coming tonight. I am Dr. Cynthia Nguyen. I arrived here two columbiads ago from Australia; my father is Vietnamese and my mother, Malaysian by ethnicity, and both were born in Australia, as was I. The 'Helia Biology' Department is also located in the Space Sciences Division, but it really has two sides to it; one, to search for and characterize any life in the Helia system, and two, to produce genetically modified plants and possibly animals able to survive on Helia-1, 2, and 3.

"We do not anticipate being able to nail down definitively whether life has arien in the Helia system for some time. Most likely, if it arose anywhere--Helia-3 is the likely cradle because it would have cooled and stabilized first--it would have spread to the others via meteorites blasted into space. Helia-2 is only 600,000 kilometers away at minimum distance and Helia-1 about 900,000 kilometers away, with transfer times between these worlds measured in hours rather than days. Life might even have originated on more than one of them and is now found cohabiting on these worlds. We won't be absolutely sure until we arrive and study the worlds from orbit, which we'll need to do for at least a year or two. We'll also need to determine what organics exist on each planet, also; there's a good chance cyanide compounds exist for example, in which case we will want to settle in an area clear of them such as a recent volcanic area. Finally, we'll want to develop a plan to preserve the native life. We may want to leave one

of the three planets uninhabited by us, or we may want to create a large biosphere reserve on Helia-3's moon if it has one. Exactly what ethical obligation we have to bionts is still debated, and that may be all we will find in the Helia system, since it is only 500 million years old. One-celled organisms with a cell membrane and DNA or equivalent are less likely to exist there.

Once those issues are resolved, we will turn to the issue of terraformation, and it will turn primarily on the spread of plant life and oxygenation of the atmospheres. Conversion of CO2 to oxygen and organic material, over the long term, will decrease the greenhouse effect and cool all three worlds; good news for Helia-1, but bad news for Helia-3. That will need to be one consideration when we site our initial settlement.

"Genetic modification of plant life for the Helia system will face two major challenges: the lack of available atmospheric oxygen, and the spectrum of the ambient light. The first is the lesser issue because of all the work done on cactars, which have a hollow central cavity where they can store oxygen they produce. Most terrestrial plants can be modified to create such a cavity; some water plants, like water hyacinths, already have a flotation organ where the oxygen can be stored. They also reproduce by creating buds that break off and make new plants. Many plants spread underground via their roots, or like strawberries, across the surface with runners. Finally, even seeds can be modified to store a certain amount of oxygen in them in the form of oxygenated chemical compounds. We suspect that dozens of plant species can be modified on the flight to Helia and prepared for release into the environment. They may be able to oxygenate the atmosphere to the one percent level within a century, depending on the quantity of inorganically produced carbon compounds in the ground that will start to break down once oxygen is available.

"The more difficult problem is photosynthesis, which utilizes light of 400 to 650 nanometers in wavelength. Helia's energy output is minimal on wavelengths shorter than 600

nanometers--red light--is strong at 700 nanometers, and is strong in the near infrared. Chlorophyll B's absorption peaks at 630; Chlorophyll A at 680; neither absorbs anything past 700 nanometers. Work making photosynthesis more efficient, which Martech's plant genetics department leads in, has not tackled this problem. It has improved chlorophyll A's ability to utilize ultraviolet light, so there is a foundation to build on. Most likely, we will need to create a third form of chlorophyll or augment it with another compound that is sensitive to light in the 650 to 800 nanometer range. That's ten or more years of work.

Beyond that, after arriving in orbit around Helia 1, 2, or 3, extensive work will be needed to determine what other characteristics the plants will need. Will the planets' regoliths have too much arsenic or selenium? Will there be poisonous compounds like cyanide in the soil? As Stanley suggests, we may be best off working with a sterile volcanic island first, but we really have no idea. Most likely, we'll try to send some probes ahead of us to pass through the Helia system several years before we arrive, to provide us with as much advance information as possible. But when we will depart from Mars we'll be substantially in the dark."

Everyone applauded Cynthia, who then turned to Ted. "We have good news, where the mission planning is concerned," said Ted. "The fusion engine being developed on Phobos is very promising, and development work will be accelerated over the next two annums. We now think a reliable engine will be ready by 2096. The new budget that the Mars Council will review, starting Monsol, includes monies for the final design for *The Helia,* a vessel 150 meters in diameter and 100 meters long, with a liquid hydrogen tank about 100 meters long for the departure burn and another tank about 50 meters long for the arrival burn. After the departure burn, the fuel tank for the departure burn will be available for additional living space. The vessel will be built by Ceres, filled with hydrogen, and launched to Mars in late 2093, arriving at Phobos in mid 2094. The

living portion will be drained of whatever hydrogen remains in it, the first contingent of the Helia crew will move in, and they will construct the ship. If the fusion engine is ready, the vessel will launch toward Helia in December 2096; seven and a half years from now. For those of you who are university freshmen, that's just about the right amount of time to get your doctorates." He paused and looked at the students, who shifted uncomfortably in their chairs. "We will be recruiting approximately 1,800 adult personnel. They can be married or unmarried, with or without children. As you can see, Changying and I have a daughter, Yvette, who will be coming along. She will be approximately 38 years old when we reach the Helia system. We do not yet have an application process, but it will be formalized in 2091. Until then we will hire people as needed, and the hires will automatically be considered for the flight.

"We will need just about everything imaginable on board, from brain surgeons to storekeepers. The Helia community will be an independent commonwealth as soon as it departs Mars, with its own central bank and currency, a university, a bioarchive, and everything else it might need. It will have two 100-meter habitation chambers, each 150 meters in diameter, one tropical and one temperate in climate, with multiple lower levels for other environments. It will be designed to accommodate a maximum population of 5,000, representing the departure generation, a second generation as large, and a third generation 78% as large as the second, some of whom will be born after arrival anyway.

"I think that's everything. Questions?"

Several hands shot up immediately. Changying pointed to one. "Do we know whether these planets have magnetic fields to protect their atmospheres from Helia's solar wind? How radioactive are the planets, considering they formed only 500 million years ago?"

"Good questions," replied Stanley. "We know their masses; Helia-1 is denser than Mars and has about thirty percent more mass, so it must have a large nickel-iron core, and based on the planet's age, some of it should be molten. Helia-2 and Helia-3 are even bigger and denser. All three planets rotate pretty quickly, too. So we infer that they all have magnetic fields, though Helia doesn't generate much solar wind anyway. All three of them will provide robust protection against cosmic radiation. All three of them will have higher natural radioactivity; for example, Uranium-235 has a half life of 700 million years and it is mostly gone on Earth, but most of it will still be present on the Helia planets. There is a good chance all three worlds will have natural ground-water-moderated fission reactors."

"How will the vessel land?" asked another person.

"It won't," replied Ted. "The *Helia* will remain in orbit or perhaps will be landed on a moon or asteroid. We will need a nuclear shuttle like the *Peregrine* to fly people and cargo back and forth. We'll bring several of them along."

"How will you guarantee that the ship will be able to stop when it reached the Helia system? If it overshoots, how long would it last?"

Changying smiled at that question. "We will be sure to have a variety of backup systems to guarantee arrival, including the ability to dump half the living volume and much of the mass so we can get into orbit. The ship will probably have 100 to 150 years worth of uranium on board for energy production, and that would probably be the biggest limitation."

"What's the escape velocity and surface gravity of Helia-3? It seems to me it is the least habitable planet."

"You are probably correct," replied Stanley. "Its surface gravity is 1.1 times Earth's and the escape velocity is 45,000 kilometers per hour. Of the three, I'd bet on Helia-2 currently. Its surface gravity is 0.75 and its escape velocity is 33,000 kilometers per hour."

"What will the population do in another 100 million or 200 million year when Helia dies?"

"I wouldn't worry about that," replied Changying. "We're talking about millions of generations into the future. Humans may not even look the same. The surface the first settlement is built on may not even exist a million years into the future, let alone 100 million years; that's twice as far into the future as the dinosaurs are in the past! All three planets have enough geothermal energy to sustain civilizations and Helia-4 has enough deuterium and Helium-3 to provide fusion energy for billions of years."

"What sort of civilization do you seek to create?" asked Hideki Takahashi.

That caught Changying by surprise. "Well, we'll start out with mariner civilization. The vessel, for example, will probably have 3 'neighborhoods' and each will elect three representatives to a Helia Council. But a new civilization is guaranteed to arise over time because we will be a separate branch of human civilization; the first 'type 3' civilization, in fact. Remember the classification system of civilizations; type 1 are confined to their home world, type 2 are confined to their solar system, and type 3 have spread beyond their solar system."

"Do you anticipate that a Helia 2 mission will be sent later?"

"We have no idea," replied Ted. "But the more sent, the better. The Helia system can accommodate billions of people."

"What will the planetary science researchers do, during a thirty year voyage?" asked Omar, one of Bill's friends.

"They won't be bored," replied Stanley. "In addition to continued telescopic work on the Helia system, and the probes we will send ahead of us, every few years we will pass relatively close to an object in the Oort Cloud, and we will send flybys past as many of them as we can. We'll all be able to continue research on asteroids or icy moons as well, just like our colleagues at universities on Earth."

"Other questions?" asked Changying. There were none. "Thank you, everyone. Please help yourself to some of the refreshments. Let's talk informally."

Everyone applauded vigorously. Bill turned to his friends, with whom he was sitting. "That was fascinating. Thanks, Hideki, for your question. I do wonder what sort of world they will create."

"Well, go along and be their historian!" suggested Hideki.

Bill shook his head, "No, I have plenty of history to do here already."

"I'm intrigued," said Omar. "An entire new solar system to study, and an entirely new civilization to build; quite an opportunity."

"I don't know," said Celeste. "I doubt they'll really develop *that* new of a civilization. I'm happy to let someone else go off into the wilderness."

"Like the wilderness of Saturn?" asked Trey.

"Well, it's a familiar wilderness, anyway," she replied.

"I am intrigued, also," said Trey. "But not enough to sign up."

"Well, I'm willing to sign up!" said Hideki.

"Really?" said Celeste, surprised.

Hideki nodded. "I want to learn more, especially about a Type 3 civilization."

"Do you want to make it a type 3 civilization for Christ?"

Hideki was taken aback. “Whatever civilization they make needs to be ethical and, dare I say, spiritual? Because the yearning of people is for meaning, and that will be true in Helia as much as Mars or Titan.”

“God is no farther away in Helia,” added Bill.

Trey scowled at that; he was not spiritually inclined. “Let’s go get a coffee,” he suggested.

“The caf? I’ll join you in a minute,” replied Hideki. He waved to the others and walked over to Ted and Changying, who were talking to Cynthia and Stanley. The four of the were reflecting about the meeting, but turned to Hideki immediately.

“I want to know more,” Hideki said.

“What’s your field?” asked Changying.

“Religious studies, philosophy, and ethics. I’m studying to be a Christian pastor.”

“Christian? Which group?”

“United Church of Mars; basically, all Mars’s Protestants. But I plan to get chaplaincy training, too, so I’ll be qualified to do spiritual support for anyone.”

“How old are you?” asked Changying.

“Twenty. I just arrived from Titan three months ago.”

“Oh.” That impressed her. “What do you want to know?”

“What can I do? I want to help. Like, for example . . do you have any summer positions? Because I have time.”

Changying looked at Ted and they considered. “We probably can arrange for that,” said Changying. “Why don’t you stop by the Helia offices Minsol afternoon.”

“No, dear, you’ll be in the Mars Council meeting.”

"Oh, that's right, and it's supposed to be a long meeting. How about Tuesol at 5 p.m., then? Tuesol's deliberations are supposed to end by 3 p.m."

Hideki nodded. "I'll be there."

Changying almost didn't make it to the Tuesol afternoon meeting with Hideki. Two sols of lengthy deliberations about the budget wore her down. When she entered the office, she found Ted and Hideki waiting. "I apologize I'm a bit late. This has been a very difficult experience."

"I watched it online," said Hideki. "Those Council members ridiculed Bijan Lohraspi!"

"It was inappropriate," replied Changying. "I was there. Cesar Alvaro is a long-time trouble maker who was banned from the Mars Council because of electioneering until this most recent election. His withering criticism was inappropriate."

"I felt bad because it became clear that Bijan and Boris had not proposed the immigration and polar cap efforts themselves," said Ted. "It was clear that Baozhi had set the goals, and they were just the ones to carry them out."

"But now the Mars Council is questioning the Helia project!" said Hideki.

"Suspicion has become contagious," said Changying. "Don't worry, I'll have a few things to say about Helia, probably morrowsol. Now, Hideki, Ted and I talked about your request, and we can offer you a summer internship position."

"Yes, thank you, Ted told me. He said you were interested in utopian literature!"

"Yes, exactly. There have been thousands of utopian experiments on Earth. You asked what sort of civilization we want to create. We don't know. Martian civilization has some significant innovations compared to Earth, rather like the innovations in government that America pioneered and that spread around the world. There's far more research than can be

accomplished in a summer, but a summer will give us a sense of the options that were considered in the past."

"I suggest you interview some scholars," said Ted. "That might get you--us--more information quickly."

"Yes, that's a good idea. Most communitarian experiments were religious, remember."

"I know," replied Ted. "But we are curious about their innovations as well."

"So, you said you were studying to be a pastor for the United Church of Mars," said Changying. "I've never understood how it works."

"Because some say it doesn't! It's more of an umbrella organization than a denomination. Just about every Protestant church on Mars--there are close to 100 now--is a member. Each church elects a lay person as a representative, plus the pastor is a representative, and they attend two different 'chambers,' rather like a bicameral legislature, which meets every two annums. They elect a bishop to run the entire organization, and he can issue statements if they are approved by a nine-member executive board that the chambers also elect. So that's the organization; it's a bit like the Episcopal church in the United States, but the bishop has less authority, and each congregation owns its own building. Each church has its own theology and practices. Some baptize by immersion and some by sprinkling; some baptize infants and some baptize only those who have had an experience with the Holy Spirit. Some have communion with wine every week or two, others have communion once a year at most or maybe not at all, and might use water or grape juice. Their attitudes about the reliability of the Bible and the way it guides life also varies. The main advantage it gives us is that the Protestants--18% of the population, or about 80,000 people--have a single united voice, roughly equal to the Catholics,

who number 82,000. If we were divided into separate Protestant groups, none would have more than 15,000 or so, and our multiple voices would not carry much weight."

"It seems to me that you don't carry a lot of weight anyway," said Changying. "And if you have 100 churches with 80,000 members, that's 800 per church, but I've never seen a church big enough to hold that many!"

"True. Protestant and Catholic churches rarely get more than 10% or 15% attending on a Sunsol, and the churches are built to hold maybe 400 at most, except for the Aurorae United Church Cathedral, which is Episcopal in tendency and seats 1,500. But I disagree about weight. We are fairly united on moral issues. Mars has essentially no abortions and no poverty, so they don't stir disagreements among us. A few years ago, the Bishop issued a statement favoring a gradual process of thickening the atmosphere, and that remains our position. The current plan violates the gradual process we have endorsed. We also advocate an immigration rate of no more than 30% per annum. That has been violated a few times, and the new plan violates it again."

"What does the church do?" asked Ted.

"We write to all the Mars Council members who have a church in their territory, which is all of them," replied Ted.

"So, will Helia have a church?" asked Changying.

"Based on the current statistics, if it has 2,000 adults--to take a round number--it'll have 360 Protestants, 370 Catholics, 140 Buddhists, 140 Hindus, 120 Muslims, 120 Confucinists and Chinese religionists, 60 Bahá'ís, 40 Mormons, 20 Jews, 10 people who belong to various tribal religions, and 520 people with no religion at all. What those numbers look like after a 30 year voyage is anyone's guess. Isolation may do some strange things to us."

"That's one reason we want a large crew and a big interior space," said Ted. "Two hundred people have enough genetic diversity for this flight, but we want a substantial community, a space that's big enough to not feel claustrophobic, and enough experts along so we're not hurting for expert advice. And it appears the Mars Council will approve a budget that will make a 150-meter cylinder that can arrive fron Ceres in 2094.

"Then we'll have two years to prepare it," said Hideki. "That's an exciting prospect."

"It'll also be hard work," said Ted. "But it will be sacred work, if I may use that word, because once we take off, our carrier will be our home; it'll be sacred space, in a sense."

"It will be, even before anyone consecrates it," agreed Hideki. "That's an interfaith ceremony to plan, once we complete the ship; a formal consecration ceremony involving all the religions."

"It sounds like you need to make recommendatind for various ceremonies and rituals, then," said Changying.

Mikhail Shtokman did not look forward to his meeting with Chief Minister Baozhi Zang. When he entered the Chief Minister's office, he could see Baozhi was not looking forward to it, either.

"Come right out with it," said Baozhi. "Don't mince words."

"Alright," said Mikhail, without even sitting, because Baozhi wasn't sitting, either.

"It's Frisol late afternoon and the Mars Council has now had five entire sols to debate the budget. I can say with some certainty, based on a poll we did, that it will not pass as is. The immigration plans for the 28th columbiad need to be scaled back, the release of carbon dioxide from the poles needs to be continued at the present rate, and money is not available for producing 10,000 square kilometers of solar mirrors by 2096. Those are the sticking points."

"I see. But we really feel those points are essential for the growth of Mars and development of its status as the center of solar system exploration and the solar system's economy. If you bring me a budget without those points as we wrote them, Mikhail, we will veto the budget. We want the points approved exactly as is. Please go back to the Mars Council and make that clear."

That startled Mikhail. "You realize, of course, that no budget in the history of an independent Mars has ever passed as written. There have always been changes, sometimes drastic ones."

"I know; I've been part of the budgets pretty much since the beginning. I've always found the process an exercise in timidity or flattering of various egos. The Chief Minister is the person who knows Mars's capacity the best and should decide what goals to set."

"Baozhi--"

"Chief Minister Baozhi, please."

"Mr. Chief Minister, Mars operates on consensus. No one knows everything; no one can know all the potential this world has. That's why the budget is reviewed and approved by the Mars Council.This is the wsay it always has been; as they say, we depend on each other for our oxygen."

"I understand, and oxygen aside, I'd like to see us move down another path; a bolder path.'

"And where will we get the money?"

"The Central Bank can create money."

"But it can't create human resources."

"No, but that's what the big immigration is for! We need people here, in order to terraform this world enough to bring about an estival, to build the mirrors and the halocarbon factories and fusion devices, to explore the solar system thoroughly, to support low Earth orbit and terrestrial economies with zero-gee products . . . we can do all these things with the people."

"Everyone knows that, Mr. Chief Minister, but immigration waves that are too large are not just inconvenient; they are disruptive. If you proposed the use of a C-300 in 2095 instead of 2093, the Council would have less reason to oppose now--it'd be in six years, rather than four--and the percentage increase would be less because the base population would be larger."

"But why do we need the larger population base? We need more people here, and in 2093 rather than 2095!"

"Well, you and Bijan both testified before the Council and the majority isn't convinced. I'm not here to argue with you, but to explain the situation. There's a similar compromise possible with the nukes; rather than raising the number and yield of the spring device, increase the number detonated in the winter to prevent refreezing of the CO2. The atmosphere will be one third thicker than it is if we just prevent the formation of the seasonal dry ice deposits."

"I know, and we will increase the fusion devices used in the winter somewhat; but the big push will be mirrors and halocarbons."

"I'm telling you that I don't think it'll pass."

"And what if I veto? You'll have to start over and the legislative session will be prolonged."

"Yes, it will, but I doubt you'll raise the support for your budget that way. You'll probably decrease it instead. And remember if it gets below ⅓ of the vote total, it can trigger a recall."

"They wouldn't dare!"

"I'm telling you, Mr. Chief Minister, that you have gone beyond the norms, and if you continue, they might go beyond the norms as well."

Baozhi was startled by that comment and was silent for a minute. Then he nodded. "Alright, this is helpful, Mikhail. I'll think about the situation; but I am still inclined to veto if I can't convince the Council. I appreciate it that you have come here to inform me of the mood in the Mars Council."

"That's my job. Have a good sol, Mr. Chief Minister."

"Thank you, you, too. Ciao."

Mikhail walked out of Baozhi's office. Baozhi closed the door of his office sat, and put his hands on his head. He was simultaneously, saddened, disappointed, angered, and frustrated. Saddened because he had been unable to convey his vision adequately. Disappointed because the Council had not understood it. Angered, because they were going to vote against it. Frustrated, because he had been unable to get the help he wanted from the Cabinet. He felt like crying and smashing something at the same time.

But he couldn't let emotion overwhelm him; he had to act. He called an immediate cabinet meeting. Most managed to reach the meeting room before he did. "Here's the situation," he began. "Mikhail Shtokman just stopped by and told me that our budget is likely to be rejected. We have the weekend to turn things around. I'll deliver a speech tonight about its importance; *Mars This Sol* will probably broadcast it live. I want all of you to contact your friends on the Mars Council and ask them to consider the importance of this budget very carefully. It represents Mars's future. It accelerates the goals already set. It doesn't make the atmosphere thicker and dustier than we already expected; it just completes the goal of bringing about a partial estival

sooner. It brings our population to the two million mark sooner. These are good, worthy goals; they're goals we had already planned to reach!

"So please, emphasize that we are not breaking norms or sowing chaos. We are simply doing something every Chief Minister and administration has done for the last 24 years; we are aiming bigger, we are trying to achieve something faster, we are accelerating Mars's progress! That's all! What's difficult to understand about that?"

"And what if they respond that we should compromise and slow down the acceleration?" asked Marshall. "Every administration has accelerated plans, as you say; but every administration has also compromised to get as much as they could."

Baozhi shook his head. "No, no compromise this time. This is really the minimum amount. We probably should push for even more. Imagine how much faster Mars would grow if we used a C-300 next year and a C-400 in four years? Four of them could transport a million people every columbiad! Automation makes immigration cheaper every columbiad. Mars could easily have a billion people by 2200; think of that! Mars is destined to be the largest single nation in humanity and we can lead our species to peace and stability. Our future is at stake. The future of humanity is at stake! We need to inspire the Marsian population to sacrifice to being to about and inspire the Mars Council to get out of the way and help lead."

"The polls, though, are not good, especially where immigration is concerned," said Bijan.

"I know. I'll work on the public tonight and all of you work on the legislators over the weekend. This is very important; we will veto any modified budget. Your jobs are on the line." His last sentence hung in the air, startling everyone.

"We'll do what we can," replied Boris, and everyone nodded.

Marshall went back to his office, made a list of Council members he knew, and drafted an email to all of them. His AI, Ivy, would do the rest, consulting with the person's AI about various possible times and checking with him about them. He made a list of times starting Satursol afternoon, after Baozhi's speech. After talking to Anika Matadeen from Dawes Outpost and Rodrigo Moreno of Uzboi at the restaurant of the Aurorae Hilton, where they were staying during the Council's legislative session, he walked to the Liberty Marriott, where Erico Lopes had a room. He met him in the lobby and at first he didn't recognize Erico. His thick, tightly curled black hair had retreated to a white fringe surrounding his bald top, and his dark skin was wrinkled.

"Uncle Erico! I haven't seen you for over twenty years!"

"How nice to hear yoiu call me that! And I haven't seen you for twenty years, either! And now you're what . . 49?"

"Exactly, 2 ½ years older than Corrie. How's she doing?"

"Pretty good. Her son is in Martech; I suppose Bill will run into him. And Paolo's 41 and has two teenagers. He lives in Uzboi. Carmen and I have been in Cassini for 25 years, now." He smiled. "I'm 81. I can't believe it! Carmen just turned 80."

"The first generation is getting so old! Dad's 87. Sebastian's 97 and I guess he's housebound, now. I haven't visited him."

"I saw him two weeks ago. He has robotic care 24.7 hours per sol; he can't even get out of bed without help. His mind is still sharp, but he tires easily. If you go to visit him, don't plan to stay more than half an hour. So, how was your time on Saturn? And how is your new job as Minister of Space Exploration?"

"It was quite a priviliege to arrive on Saturn-1 and watch the entire settlement grow and strengthen, to become an independent Commonwealth and then be the first Chief Minister for twelve years. Fascinating and exhausting. And since we left, Saturn-8 has arrived and the population is almost 3,000! Guillaume and I exchange videomails every week or two, partly because of my old job and now, partly because of my new one. As for the Ministry of Space Exploration, it's a big step up, in terms of budget and complexity. It's very exciting and exhausting."

"Well, you're up to it, I'm sure. And now we're talking about the next step for Mars; the latest budget. I heard Baozhi's speech. He has a grand vision for Mars, just like every Chief Minister. That's great; I appreciate it. But it's very easy for one's vision to go beyond various limits. One limit is human and financial resources, and he is probably pushing those limits too far. The other limit is the willingness of the people.. That limit can be moved; consider the twenty-fifth columbiad, when we increased our population far more than anyone thought was possible, popular opinion favored it, and it worked out. The proposal for the twenty-eighth, bringing in 300,000 people, is a smaller percentage increase than in the twenty-fifth. But Baozhi lost the people's confidence with the mess he just made with the twenty-sixth, and his speech won't change that. He's not a great communicator."

"No, he isn't, and he probably can get some lessons."

"Marshall, you have to encourage him to compromise. Mikhail and I talked Frisol. I encouraged him to go talk to Baozhi, which he had already planned to do, and he told me afterward that Baozhi said he'd veto the budget if it was modified. I am baffled by this attitude. Our government has three branches! The Chief Minister and the Mars Council have to agree on the budget because this is a responsibility that exceeds the vision of one person. The Council is a

pain to deal with, it can be fractious, it can be a center of egotism, but it is an essential part of the consultative process. Mars is not a one-man operation. It can't be. And Baozhi has been here thirty-two years! He was Mayor of Phobos! He should know this!"

"He has a vision and he feels it's right. He has told us he won't compromise, but no one has presented a specific plan to him."

"It's not hard to develop one. Postpone the C-300 by one columbiad and no one will object; the percent increase in population will be small enough by then. Move the really big nuclear explosions to the winter season when they will prevent refreezing of the atmosphere; that'll push up air pressure permanently by thirty percent. Stick to the current round of fifty-gigaton fusion devices in spring to liberate more permanent cap at the same pace that was planned, or even slow them down a bit, because the computer models suggest those huge releases of gas are a trigger for global dust storms. Expand production of solar mirrors and halocarbons at a higher rate because they'll eventually eliminate the need for wintertime nukes entirely. Put more resources into maintaining the square meters per person; reducing it from 200 to 120 is not popular, even if people won't be affected seriously by it. Expand Phobos with an extra billion or two redbacks of imported equipment from Earth, so it can compete with LEO. Accelerate fusion propulsion research and speed up Helia. Baozhi will love those additions."

"He will, and perhaps he'll find them sufficient; I don't know. But it's very tricky for anyone in the cabinet to argue with him. He doesn't take it well."

"Your father told me he was jealous of you." Erico pondered a minute. "I know your father and Helmut have both been meeting with him, and those sessions ended a month or so ago. Maybe I should try, and maybe Jacquie can help. I was a chief executive of Mars, too, back in the preindependence sols."

"I suspect it'll help if there's an actual compromise on the table."

"And one that is not public; that will cause him to lose face, and that'll cause other problems. Okay, that's helpful. I'll talk to some key legislators over the weekend and see what we can pull together."

"I talked to Anika Matadeen and Rodrigo Moreno just a little while ago and they also urged compromise. I said I'd do what I could. Anika also emphasized increasing solar mirrors and halocarbons. Rodrigo suggested that a C-300 be built for Phobos first, using metal from Uzboi so they wouldn't have to wait for Ceres to send one."

"Okay, they're both key players. I'll talk to them, and Cesar Alvaro--we can't avoid him, even if he is nasty at times--and a few others. Who else is on your list?"

"No one, but let me know if you want me to help."

"No, I don't want to jeopardize your relationship with Baozhi. Leave the rest to me."

"Alright. Thanks, Uncle Erico."

"Thank you for all you're doing. Your father is my model for how to handle this situation. I think we've all learned a lot from him."

"Yes, and so have I."

"Good. We'll see what we can do."

Marshall slept better that night. Sunsol morning, Boris called him rather frantically because he heard about the compromise budget and found that he was being lobbied to support it. He felt he had to inform Baozhi. Marshall said nothing about his own knowledge of the effort but said it was best to just keep contacting legislators and mphasizing they should trust the Chief Minister.

But now he had a new worry; if Baozhi heard about the compromise, that would make him angry.

That fear was swept away by the *Mars This Sol's* evening news program, which described the compromise in detail and noted that Erico was putting it together. "Someone leaked," he said to Amy sadly.

"But who?"

"Maybe Cesar."

"Or maybe Baozhi himself, if he has already heard!"

Marshall laughed ironically. "Yeah, that's possible, but he would have heard who was organizing the effort as well. That's a lot of information."

"Maybe *Mars This Sol* acquired some of the information in their story."

"Maybe." Marshall asked Ivy to call his father. "So, did you see the news?"he asked.

"Yes, about the budget compromise? I'm glad Erico's working on one. He's the most senior member of the first arrivals in the Mars Council."

"Except the negotiations with Baozhi haven't started yet and he told the cabinet he'd veto any budget compromise. This is a leak."

"Oh. That's not good." Will said nothing for a minute. "I'm not sure I should get involved. Baozhi is tired to talking to me."

"I suggest you talk to Erico. I think he's coordinating things."

"Good; he's a fresh face, he's very respected, and he's on the Council."

"Any advice for me?"

"Just be very careful. Baozhi will want your support, even if he's losing."

It was late Tuesol evening before the revised budget--it wasn't a compromise budget because Baozhi refused it--was ready to go. Erico, Mikhail, and Anika met with the Chief Minister one last time and he declined their offer. The entire cabinet gathered Wednesol afternoon to watch the vote, live on *Mars This Sol.*

"Sixty-seven to thirty-two," said Baozhi, shaking his head angrily.

"Veto proof," added Boris.

"You shouldn't have dared them," added Bijan, who had felt particularly frustrated by the position he had been put in.

"That wasn't a dare! That was my position, simple as that!" Baozhi rose from his seat and paced around the floor. "They have no imagination. They're not willing to take risks for this world's future. Small-minded people, no creativity, no boldness! Mars will suffer from their position."

"What are you going to do?" asked Marshall. "That's probably the more important question. If you veto, they'll override, and that may be worse for the administration."

"Don't you think I know that?" said Baozhi, looking at him angrily. "You got your slice of the pie! They increased resources to space!"

"They followed science," said Marshall. "We know from the meteorological models that big nukes during early spring, especially in the southern hemisphere, increase atmospheric dustiness and aggravate global dust storms. Shifting them to the winter keeps the CO2 from freezing out of the atmosphere and injects more permanent cap into the atmosphere at a time when it doesn't make the weather worse. Once the mirrors and halocarbons are sufficient, wintertime nukes will just liberate CO_2. That's a win-win for everyone. The mirrors were your idea, too, and it was a good one. The Council thought so when they increased the funding."

Baozhi stared at Marshall angrily. “You know, we could have gotten more if we had been willing to compromise,” complained Bijan. “One legislator told me that we could have gotten a C-300 in 2093, rather than 2095. By then, the immigration wave would have amounted to 30% of the population total, and that’s well within historical expectations.”

“But I wanted it in 2093, and 2095 is so far off, we can still get it. I needed the bargaining chip!”

“But we didn’t get the bargain,” said Bijan. “I’d sign the bill; they’ll just embarrass you with an override.”

“I know! The bastards.” Baozhi shook his head. Then he turned to Bijan and Boris, who were seated together, and both looked frustrated, even angry at Baozhi. “Gentlemen, these were your budget areas that were rejected, so I want your resignations on my desk by tonight.”

“What! What did we do? The ideas that were rejected were yours!” protested Boris.

“You’ll look petty,” warned Bijan. “On Mars, we don’t fire people when their ideas fail, we help them succeed the next time!”

“You heard me.”

“You’ll have to fire me!” said Bijan.

“And I will,” warned Baozhi. Marshall looked at Bijan, not daring to speak, hoping that a pleading look in his eyes would make him back down. Bijan saw him and looked away. A moment later, he rose and left the meeting room.

“I guess we’re finished with this meeting,” said Baozhi.

18.

Sources of Authority

June 2089

"I had no idea it'd be so green," said Jon Vaccaro, the captain of *The Queen of Heaven,* Alan Quint's caravel.

"It really is beautiful, after five months of floating in interplametary space," agreed Alan. He pointed. "That area is 'the Farm,' where they raise their food. It looks noticeably bigger to me; they expanded it westward."

"They have to feed us now as well," said Jon.

"Yes, that's why. It looks like the Sea is a bit higher than it was when I was here in '82. Or maybe that's a rice paddy. They had been on Themis six years at that point; now it's 13. In between, they've only had one visitor. They're very isolated."

"Growing up, I was always fascinated by the idea of islands," said Jon. 'Well, this is a real island; an oasis in the middle of literally nothing."

"Three hundred twelve meters in diameter, 30 hectares of surface, 15 of which is 'Plateau,' 7 is 'Badlands' because it is filled with crevaces and cracks, and 8 is 'the Sea.' Just 100 meters of air between the average surface elevation and the bottommost dome. I think the forest has really grown up."

"The trees down there look pretty big," agreed Jon.

"I think so. How long before we dock? Everyone on board has severe cabin fever."

"It'll take 90 minutes."

"ASAP." Alan headed out of the bridge and bak to his room, where he showered and put on his bishop's robes. He recorded an entry in his diary. Just as he finished, he felt a slight jolt as the caravel docked. He rose and headed for the ventral airlock.

There was a mob there when he arrived; 164 men and women, waiting to get off. "I'm sure some of us will have to sleep up here tonight. Our mansion at the Overlook can accommodate almost 100, if the second story is finished; they haven't updated me. Their main housing unit, the hab, may have room for the rest of us."

"Come on, they have the equivalent of three caravels, and you're the boss!" said Treyvon King. He had had a bad case of cabin fever for the last month.

"I'll negotiate what I can."

"We outnumber them!" reminded Treyvon.

Bishop Alan nodded and stepped into the elevator with Jon Vaccaro and Clementine Davenport, their chief environmental control officer. The door closed and they were reminded to hold on. The elevator lurched downward--with more speed than Themis's gravity could reverse--so they had to hold the railings to keep their heads from bumping the ceiling. When the elevator stopped, the doors opened and they saw the greeting party: Chief Minister Bill Hollingworth, 40; Cynthia Clarke, the Head of Fabrication; and Irene Langlois and Tom Shepherd, the Chief Day Officers.

"Greetings and welcome back to Themis," said Bill to Alan, extending his hand. Alan, who had just set his feet down on the metal floor, was still a little unsteady in the nearly zero gee, so he used Bill's gesture to steady himself.

"Thank you, I'm delighted to be back."

"We should move out of this area, because I'm sure your people want to come out. Let's descend to the ground."

"We need to talk."

"I thought we'd go to the Overlook and sit there."

"Good plan," said Alan.

The seven of them squeezed into another elevator, one that took them 130 meters from the docking area to the ground. When the elevator door opened, Alan was surprised by teo things; thei air was hotter and more humid than he expected, and it smelled. The smell wasn't bad; it was organic, though perhaps it had a touch of rot in it. "I assume you all have magnets in your shoes," said Bill. "If so, always keep a foot on the metal walk and of course one hand on the guardrail. The gravity here is a ten thousandth of Earth's; we understand. But you'll gain proficiency at walking in this gravity. You'll want flying lessons as soon as possible, too. We now have fanpacks that can blow you around, but they need practice." With that, Bill set out westward, past the *Materra,* the *Patares,* and the Hab where Themis's 120 people lived. The first two were caravels so covered with sand bags and vine crops that they just looked like a wall of plants. The hab, with its seven years of growth, also looked like a natural landform. Two large tanks storing liquified gasses were similarly covered over.

Then the trail, which had bent southward, entered forest. Alan was surprised by the trees. "Some must be 20 meters tall! Are you running out of carbon dioxide?"

Bill laughed. "No, we still have plenty of CO2. Our problem is too much oxygen; the atmosphere has 15% more oxygen than the Earth's atmosphere. We're extracting it and sending it up into the outer domes or liquifying it and putting it on one of these tanks. We probably should start to vent it, because it's a fire danger, and in the case of our tanks, an explosive danger."

"No, don't vent it; we'll need it! Every tonne of gas here is one less tonne we need to haul in for the C-300!"

"Well, the outer layers of the dome are just about as full as they can be, especially layer 2, which is also full of water, and that's important because of the issue of flammability. The tanks have to be kept cold and we're having trouble maintaining the temperature of the entire biosphere here, and that affects the tanks. The water layer is now at 60 Celsius, and of course half the heat is radiated back in and thus has to be expelled back to the water layer again. The radiator units are not as efficient as they used to be. Neither are the solar arrays, and their power output is essential for maintaining the thermal balance." Bill shook his head.

"Well, we've brought you new panels and parts to repair the radiators. And a lot more. We need to build a fairly elaborate docking apparatus, so that the C-300 can attach to Themis."

"What are you going to call the C-300?"

Alan scowled. "'Themis,' of course."

"The same as the world?"

"The 'world' will be the asteroid and the C-300."

Bill, surprised, said nothing.

In a few more steps, they reached the Overlook and the Quint's "mansion." It was a "tuna can" 20 meters in diameter and 10 high, now covered with vines and surrounded by a garden of neatly manicured flowers. Just as they reached the mansion, the first contingent of passengers from *Queen of the Heavens* arrived; they had been walking along the path faster. Bill and Alan's party took the ramp up to the top of the mansion and looked in through the plexiglass top at the spinning interior. "Two floors; good," said Alan. "That will give us a lot more space."

"But they'll have to bring their beds and other furniture from the ship. There are only 120 of us, here, and no spare furniture."

"Have you divided the second floor into rooms?"

"We haven't finished the task, but we have installed the bathrooms."

"Why not?"

"It takes just about all of us to keep our ecology going; environmental control, food production, general maintenance, etc. We've extended our work hours to 55 per week and we still weren't able to get everything done."

"What were you able to get done?"

"Let's sit down and talk."

Alan shook his head, angry. "Alright. Jon, Clementine, can you review the existing quarters and style people? Can your team help?"

"Of course." Bill looked at his colleagues and nodded. They all headed down the ramp, jumped onto the rotating floor, and followed another ramp to the outer wall of the tuna can, which was now a floor. Alan looked around at the garden level, which was an open metal deck 30 meters in circumference, with the Quints' old yard furniture, still covered. They descended one level to the top floor, which was new; Quint saw a corridor with rooms on each side of it, each of which had a skylight. He glanced at it briefly, then they continued down to the bottom level where the Quints' residence was located. They entered a large salon with very nice furniture that had been brought on the ship last time, with a kitchen and dining area on one side and a corridor leading to four large bedrooms on the other. The corridor continued into a dormitory area.

"Let's sit." Alan led Bill back to the first bedroom, which had an office off of it. They sat. "So, what did you complete?"

Bill sighed. "Let's start here, with the mansion. The bottom floor has ten dormitory rooms, as planned; it's finished. The top floor has 12 of the 24 rooms completed and enclosed; the rest is an open dormitory room. We also have room for 12 in our hab. "

"So, where will my people stay?"

"The mansion can accommodate 44 in the dorm rooms. I suggest that the open area accommodate 30 more and the garden level can accommodate 30 or 40 more. Add the ten in the hab and that's maybe 120. The rest can stay on the *Queen of Heaven,* which will be quite comfortable if it is housing only 40 or 50."

"So, no work at all on a new hab for us?"

Bill shook his head. "No, that has simply not been possible. We have created some of the sheet metal and metal framework."

"I see. So, we'll have to do a lot of that work ourselves."

"We'll do as much as we can."

"What else?"

"Food production. We've cleared and plowed three more hectares of trees and grass and plowed it, and we've planted it. We've also taken a hectare of the Badlands, leveled it and pushed the debris into the sea, and created a one-hectare rice paddy, and we'll be harvesting the rice next month. The paddy has also been a very valuable resource for the fish in the Sea. Last week there was a huge ammonia release into the Sea and it killed thousands of tilapia. We dropped everything and harvested as much of the fish as possible while they were still fresh and

we'll be eating a lot of tilapia over the next month. The paddy has a reservoir of tilapia that we can release back into the Sea to rejuvenate the population."

"Don't you have a bubbler in the Sea?"

"Yes, and we turned it up to the most powerful level. It created foam that was up to half a meter thick on the top of the Sea; a bubbler does strange things in microgravity. It took several days to reoxygenate the Sea and eliminate the ammonia, but that was long enough to kill the fish. It shows you how fragile our ecology is, here."

"So, is there enough food for us?"

"We've been rationing some food items for the last two months and we have built up enough to feed everyone until the crops come in, starting in two weeks. Please understand that our situation is a lot more complicated than the situation on Mars or on your ship. We have a lot of plants here that become weeds when they pop up in the gardens, especially the vines. With the low gravity, seeds blow anywhere, even vegetable seeds. And we intentionally introduced a dozen species of insects; some of them, sometimes, will eat the crops. Then there are the birds; we have a lot of wild turkeys right now. It's hard to kill them because we can't use guns, without risking the dome."

"Typical of Tree Rivers; he wanted environments as natural as possible. What about the spiderbots?"

"We need spare parts to repair some of them. The few we have left are working 24 hours a day, but they also have to do maintenance. We have to do dome repair several times per week and the spiderbots do a lot of that."

"I see. How much rationing will be necessary?"

"Basically, no generous first servings and no second servings. We have a lot of tilapia that we did not anticipate, so we'll be eating a lot of tilapia. Dairy products simply can't keep up with such a big addition to our population; there will be shortages of milk and butter. Because of the need to plant food crops, we haven't been able to plant soy. The badlands probably have a lot of grapes right now--they grow wild in the woods there. But the spiderbots are busy and can't go after them."

"So many problems." There was sarcasm in his voice.

"If the population were increasing thirty perent, even fifty percent, we could handle it. But it's going from 120 to 260 and we were at the point, a year ago when you said you'd come here, when we had at most ten spare personnel. The dome and environmental management were exhausting. There are a dozen different ways an accident can destroy this world in a day or two ns we're constantly anticipating problems and nipping them in the bud. We didn't want you to arrive at an abandoned, airless, dead world."

Alan said nothing in response, for a moment. "So, do you accept me as bishop?"

Bill was surprised by that question. "As Bishop of the Green World Creed; of course."

"Well, then, as bishop, I should be overseeing all plans and decisions, from now on."

"I see. Themis has a Constitution, you know. The Constitution specifies that we elect a Chief Minister and a Council every Martian year. The last election was in early November and the next election will be in October 2090, 16 months from now."

"I know you have a Constitution. But I am proposing to spend 2 billion redbacks to bring a C-300 here, and that will revolutionize the situation. It will guarantee the survival of Themis; you won't have to worry about the dome constantly or storing gasses. The C-300 will also have 300,000 square meters of interior surface; if it has two or three levels, it'll have two or three

times as much. It won't have problems with bugs, birds, and weeds, and it'll have terrestrial gravity. Themis can become, essentially, a national park. Your community can even continue living on Themis, if you want, or you can have housing inside the C-300. But if this is to happen, I need to be in charge."

"I see. So, are you prepared to take your C-300 to another asteroid and terraform it? Your family personally owns 5 hectares of Themis, but we own the rest. If you are proposing to take Themis away from us, we might as well say no, go find your own asteroid, and take our chances. It's not like we have no outside resources. We might yet be able to receive donated materials to repair the dome. It's not like it's going to pop in the next year or so. We can maintain it. It takes a lot of our human resources, but obviously we are dedicated to maintain the dome."

"So, are you saying we should leave? Head back to Earth, and take the supplies we brought with us?"

"No, that's not what I said. I simply countered your demand for control with our own demand for control. We must be communities that follow the rule of law; communities of give and take, of consultation, of partnership. Demanding to take control is not the best way to go."

"Well, you demanded control as well."

"No, I referred to the Constitution and the rule of law. We are a sovereign community controlling its own sovereign world. At the moment, you are our guests. Guests don't usually arrive, offer 2 billion redbacks, and demand control."

"That's true. Do you want the infusion of 2 billion redbacks, or not?"

"Yes, if we retain a modicum of control over the combined world. Greater Themis, as it were, needs to be a constitutional world with an elected Council that includes us. Decisions about the asteroid need to include us. Your caravel can feed maybe 50 people. Themis has the

ability to feed several hundred and we know how to do it; your people don't. We have the equipment to convert nickel-iron meteorite into construction materials; you don't. I can meet with the Themis Council and propose that its size be expanded from five to nine. Our Constitution does allow expansion of the Council membership and allows the Council to fill vacancies between elections. That can include you and three others. I am the elected Chief Minister and that will continue until the next election. And then we can argue endlessly on the Council about directions and details."

Alan was not happy by that. "That's no way to treat your bishop."

"As I said, I recognize you as bishop." Bill didn't add that he didn't consider himself a member of the Green World Creed; indeed, most of the inhabitants of Themis had abandoned the faith. "That means you deserve a certan amount of respect," he added.

"I see." Alan considered. "I'm not inclined to accept your conditions."

"Then you can leave; or we can have a big fight for control and possibly destroy this place entirely, while all of humanity is watching. We have a very popular reality program, remember. If the dome is compromised, we'll have to retreat into the *Materra* and the *Patares,* and if we feel we need to leave this world we'll have to destroy the dome to get the ships out, because there is no airlock big enough for them. We don't want that to happen. Neither do you. So we are back to a compromise."

"I have two billion redbacks and you have a terraformed world."

"Exactly."

"Alright. Fine. I'll tell you which four of us to add. Does the Council have a second in line?"

"No, a vacancy in the office of Chief Minister is filled by a vote of the Council members."

"Can you create the office of Assistant Chief Minister?"

"I . . . think we can."

"I want that position as well. Don't worry," he added with a smile. "I'm not planning to bump you off."

"No, I am sure no bishop would do that," replied Bill, with a wry smile.

"Good. We have an agreement, then." He rose. "Let's go see how the arrivals are doing."

"Alright." Bill stood and followed Alan out of the office. He glanced at his hands, which he had kept hidden under the desk. They were still shaking. He stuffed them into his pockets, and they'd stay there until the shaking stopped.

Jamison Rideout fell asleep with his baby sleeping on his bare chest.

When he awoke. he realized that he was relaxed in a way he rarely felt. He looked at the curly hair of his little son, nestled under a blanket against him, with his hands cradling the boy in place. He decided to fall back asleep on the couch.

Jiaying awakened him half an hour later. "It's time for lunch."

"Oh. I had better get dressed."

"I'll feed Christopher meanwhile."

Jamison rose and headed into the bedroom to put on a shirt while Jiaying nursed their newborn. Once she finished they headed out of Columbia-1 to the plaza between it and Columbia-2 where everyone ate. Triton borough now had 400 people, which was the maximum the two drums could comfortably hold. The moon's gravity was rather low for dining

comfortably--it was half of Luna's--but they had all learned not to pick up their drinks too quickly. It was Saturday, so people were coming and going at different times. Jamison and Jiaying headed for a table where several friends were sitting.

"Let me take the baby for you!" said Yua Khan, as they sat. "My babies are so much bigger now, they don't even want to sit with us!" She glanced at a nearby table where Fahim (8) and Hina (5)--their son with a Pakistani name and their daughter with a Japanese name--were laughing with other kids.

"No, they have their friends," said Jiaying. She handed Chris to Yua. "How has Hina taken to kindergarten?"

"She's still adjusting, but her entire cohort moved up from preschool and that helped a lot," said Yua.

"And she wants to learn to read, now, so that's coming along," added Rahmatullah. "How are the three of you doing?"

"Still adjusting, also!" said Jamison. "He sleeps 20 hours a day, but they aren't always the right 20 hours."

"I'm still sore," said Jiaying.

"That'll last a while," said Yua. "Is he nursing pretty well, now?"

"Yes, finally."

"I'm glad we finally did this," said Jamison. "He's so cute."

"But we aren't having another one," reminded Jiaying. "I do agree, though, it was the best decision we made together."

"And now you're staying here in Triton for at least a decade," said Rahmatullah.

"We've done our duty, serving on Proteus and various other moons," replied Jamison. "We can now settle down. What's new with the C-200?"

"The loading of all the major structural elements and construction materials into the inner cylinder is going well. We may be finished by the end of next week, assuming the last items are completed."

"How long before the C-200 is finished?" asked Ritchie Patel, the 19 year-old son of the Chief Minister, who was spending his summer on Triton.

"It's another six months at least," said Rahmatullah. "Once we have the larger and heavier elements inside, we'll install the tops of both cylinders and get rotation started; that'll take 5 or 6 weeks. After that, we'll install a second floor, so the entire cylinder will have a lower level for storage, agriculture, etc. Then we'll install housing and such for 1,000 people and set up the rest as parkland, until it's time to increase the population. Some people will be moving in by February."

"Any idea when we'll move the cafeteria inside?" asked Jiaying.

"Maybe March or April. We'll set it up where there's 0.2 gee."

"I hope I'll get to see inside, but I'm leaving on the last flight in December," said Ritchie. "Mom and dad just said I could stay the fall semester."

"Isn't it harder to take your courses by video?" asked Yua.

Ritchie nodded. "But I have my own little apartment here, a job, friends, a girlfriend . . . I rather like the freedom!"

"That explains why so many of the younger generation have opted to serve here," said Yua.

"Oh, exactly," said Ritchie. "There are only a dozen of us, but 10 of us are here! Wait until your children grow up; the Tritonians will want to move to Proteus, and the Proteans to Triton."

"How is your summer research project?" asked Rahmatullah.

Ritchie nodded. "Good, thank you for asking. I'm mapping frozen nitrogen lakes and running them through software that determines their likely activity, once sunlight shines on them. That helps model Triton's variable atmosphere."

"Valuable work," agreed Jamison. "Have you thought more about your major?"

"Oh yes, definitely! Trans-Neptunian objects! I'm living on one, the largest one, in fact."

"Of course, Triton is no longer a TNO, having been captured by Neptune," said Rahmatullah.

"Yes, I concede that, but it formed beyond Neptune; we're sure of that. The Chinese will reach Pluto next year and I'll plan to follow their work closely."

"We have friends on the Sedna mision," said Jamison. "Nick and Maggie McDonald. In fact, I owe them a videomail. I can introduce you, if you'd like."

"Really? Yes, I'd like that very much. My mom offered to introduce me, also, since she knows Commander Nick, but I'd rather get an introduction from you. The advance work on Sedna has been very interesting and quite significant."

"They're sending out probes to do flybys of a dozen TNOs, and the results of the first two flybys have been fascinating. Who would have expected cryovolcanism on an object just 300 kilometers in diameter! There's quite an international team working on the data from 16684. I suspect you could get added to it."

"Especially if you work with Andy Jordan," added Yua, who was a geologist. "He's been interested in 16684.

"Good, maybe I should talk to him, then."

"But let me introduce you to Nick." Jamison looked at his plate; he had finished lunch except for a single potato slice. He speared it and ate it. "Let's walk into the cavern. Nick just sent me a video of his little girl running around in the new section of their hab, so I want to take a picture of Chris and show him the cavern. And I can show you as well. Alright?"

"Alright!" Ritchie was practically ready to jump up from his seat.

"Good." Jamison reached over to Yua and took Chris. Jiaying looked at him funny; she didn't like the boastful nature of his videomail. He smiled at her in return and rose from the table.

The airlock leading to Columbia cavern was 100 meters away and they followed a path along the orchard and the bamboo to the pond, then around the pond to the smallest airlock, which was designed for foot traffic. The medium and large airlocks were for small rovers and large trucks bearing ore and raw materials respectively. On the other side they entered a curtained off section of the grand cavern, which was over 2,000 meters across and up to 250 meters high. The front area was 200 meters deep, followed by the construction site for the C-200, followed by a heavy insulated plastic curtain, which ran to the right and left-hand walls, about 300 meters in each direction. The resulting 400 by 600 meter slice of the cavern occupied 200,000 square meters. The air was warmed and oxygenated all the way up to a multi-layer transparent plastic barrier 10 meters below the icy ceiling. Only 10 percent of the floor had insulation and metal plate on it, and only half of that had artificial soil and vegetation. They sat on a grassy area that had been planted up against the outside of the C-200, leaning against the

metal wall, and Jamison played the videomail Nick had sent him the evening before, which showed him, Maggie, and their little daughter Tessie in the newly terraformed hydrogen tank of the *Sedna,* which had been emptied during launch from Mars. He listened and Ritchie looked closely at the little 3-d image on Jamison's communicator, because he was fascinated by the interior. "They've fixed it up nicely."

"Yes, but all the housing is against the inner bulkhead instead of spread out, for radiation and evacuation reasons. I prefer the way we set up Seron 2, with stairstep housing and private patios."

"We have huge amounts of interior space and we can go outside. They can't."

Jamison nodded and adjusted Chris on his lap, then hit the reply icon and held the communicator in front of him. "Good sol, Nick and Maggie! Thanks for the videomail last night of Tessie walking. Your new enclosure looks really beautiful. I'm leaning against the outside of our partially completed C-200, on the grass, and I thought you'd like to see our progress on the cavern." He pushed a button to turn the camera around and gave them a slow pan of the enclosed area. "As you can see, we still have a lot of ice to deal with! The insulated floor is fine, but the exposed ice is so cold, there isn't a trace of melting, and the air is still chilly; I can't keep Chris in here very long." He switched the camera to face him and the baby. "He's now 10 days old and sleeping a lot--except when we want him to--and he's now nursing pretty well. I've actually taken a leave of absence from my job as CEO of Triton Borough; who would have thought that possible? We love this little guy! I wish we hadn't waited so long. I'm still worrying about how to handle career and family life, but now I realize--I feel--the eternality of that struggle. Humans have been raising babies and working since the beginning, and it has never been easy. At least

the drudgery of both work and family have largely been shifted to robots. So Jiaying and I will explore life as we deal with the challenges of both.

"Say, I want to introduce you to someone: Ritchie--Richard--Patel, who's here this summer as a geology intern. He's finished a year of Martech-Neptune and is interested particularly in TNOs. Ritchie will email you separately, but he's here right now." Jamison turned the camera to Ritchie, sitting next to him.

"Greetings, Dr. McDonald. Over lunch I was telling Dr. Rideout how I want to dedicate my career to exploring TNOs, and it helps to live on what is probably the biggest one. This summer I've been researching nitrogen lakes and their cryovolcanic activity and I've been following your flyby of 16684 very closely. I'd love to be in touch with you about some of the evidence for aqueous cryovolcanic activity. I'll write you separately."

He nodded and Jamison turned the camera back on himself. "Well, that's the news here. We're exploring several new cryovolcanic provinces here on Triton and have a better sense of the history of water-based cryovolcanism. Reconstruction of its history before it was captured by Neptune is slow, since there's so little crust from that era left, but we have two new papers coming out next month about it. Those should interest you, and they complement research about the evolution of Nereid and Proteus. Otherwise, we're still shaking our heads about the budget debacle on Mars. Thank God it's nothing like the ongoing political paralysis on Earth! Half the old democracies are tottering toward dictatorship because of the collapse of consensus. I feel glad we're here in Neptunia, though I suppose we'll face our own crises too, eventually.

"Anyway, thanks again for the message. Keep in touch. Ciao."

Alan Quint was sure to wear his bishop's robes as he headed into the Hab to find Bill Hollingworth on Monday morning. He intentionally arrived during breakfast because Bill had been impossible to locate the day before. He suspected Bill was avoiding him. Sure enough, Bill was eating with his wife Suzanne and 14 year old son Jeremy. Alan looked at Suzanne worriedly, as she was the daughter of Greenley Rivers, Tree's brother. "Good morning, Bill. I want to talk to you about a few things."

Bill looked up. "I'm almost done with breakfast; can it wait?"

"Yes, but only 5 minutes or so. I have a lot to get done."

"So do I. Shall we talk here?"

"No, in a private spot."

"Alright."

Alan stood and waited while Bill, seemingly, savored every bite. "By the way, why is today Monday, but it's Sunday on Earth?"

"We've never been able to get Themis's rotation to match Earth's exactly, and as mass shifts around here, rotation speeds up or slows down slightly. I think right now 1 rotation with respect to the sun averages 23 hours, 59 minutes, and some seconds."

"I see. I want that fixed."

"I'll tell you what the simplest fix is. Because Themis is so small, no part of it is ever really dark; no darker than an extremely cloudy day. Here at the North Pole it's always light because of light reflecting off the dome. So the easiest solution is to ignore the actual rotation rate and switch to a terrestrial clock. Because our orbit is extremely elliptical, the sun can get ahead or behind the clocks by an hour anyway."

"That's too untidy.'

"Then we have to put Themis into a circular orbit. Have you the propellant for that?"

Alan shook his head. 'Come on."

"Alright." Bill shoved a final, large mouthful of potatoes and eggs into his mouth. He rose and headed out. 'My office is in the Patares; shall we go there?"

No, we can just stand outside."

He nodded and headed up the ramp to the exit, then across the plexiglass and down to the ground. He accomplished the latter with a jump, as the gravity was too low to be of much good when one descended a ramp. Alan turned on the magnets in his shoes and used the ramp anyway. They took the metal path to the *Materra*, which was closer, leaned against its side, and Bill said, "What can I do for you?"

"Several things. I noted that you didn't attend the water blessing yesterday. In fact, most of the original residents didn't."

Bill was uncertain what to say. "I'm sorry, but it was on a Sunday morning, and most of us enjoy sleeping late on Sundays. We've had a rough couple of months."

"This was an extremely important ritual for the community, done once a month. I want everyone there."

"So, are you creating a religious test?"

"You said you accepted me as bishop."

"I said I accepted you as bishop of the Green World Creed. I didn't say that was my creed. Most of us here knew Rivers well, remember, especially Susanne and me. I can't say that we still follow him. We do appreciate his teachings, but they are more a spirituality to us than a creed."

Alan looked at Bill in shock. “I simply don’t understand. How could you build and maintain this world, without believing.”

“We arrived as believers in Rivers as a prophet. We now accept his approach to nature as our spirituality, and if we believe in anything, we believe in Themis as our home.”

Alan was speechless at first. “Is that why it took two weeks to modify the membership of the Council?”

“Yes, exactly. If I had tried to force the change through, it would have failed. I didn’t have to convince just the Council; I had to convince the population. I’m pleased it took only two weeks. You and three of your people are on the Council and you are Assistant Chief Minister.”

“I want more space for my people. We’re extremely cramped on the *Queen of the Heavens* and in my mansion. We have less than 5,000 square meters of space while your people have 9,000. It’s not fair.”

“And we promised to build you a 30-meter Hab and were unable even to start, because of necessary maintenance to keep the dome intact. We’ve taken in 30 of your people at great personal difficulties, because we were occupying our space and we are families, not single people. And the 30 haven’t always been, shall we say, nice to us; there’s tension. Furthermore, the animals you brought we have transferred to the *Materra* and *Patares*, which freed up space on *The Queen of Heaven.* We now have 50 square meters per person; you have 40, although your people eat here with us, some of our common space is actually used by both groups. That’s the best you’re going to get for now.”

“You’re including the upper terrace of my mansion, which is not very comfortable space for sleeping at all because it’s never dark.”

"That can be fixed with some tarps. Look, Alan, your people have mostly been sitting around for the last two weeks. A few have tried to help on the farm. Most have been exploring Themis, discovering crevices and ravines in the badlands, learning to fly, and enjoying shore leave. My people know how to farm, maintain the dome and our environmental systems, and do construction. It's time your people joined those teams. We can't give any of those responsibilities to your leaders because they don't know them. I'd like to sit down with you and your officers and create teams to handle those tasks. We rotate responsibilities here, too, so that everyone knows how to do at least two jobs well. That's essential. Rather than complain that we dragged our feet reorganizing the Council, rather than complain you don't have enough space, let's create teams for food, the dome, the environment, and construction, create work schedules for everyone, and get started."

"I want my officiers in charge of some of those teams."

"Did you hear what I said about rotating? Our teams don't have permanent leaders, we rotate that responsibility."

"But you do have someone in charge of agriculture, the environment, and construction!"

"We do; they're the overall experts. Does anyone on your ship know enough about the environment maintenance issues of Themis or the agricultural system or how to build a rotating hab to take responsibility for them? No. In six months, maybe they will."

"I see. Very well. Six months we'll try it your way."

"Thank you."

Bishop Alan Quint turned away, frustrated and angry, wondering how he can engineer a coup and really take charge. Bill Hollingworth watched him leave and wondered how he could

thwart Alan's ambitions and remain in charge of his home world.

19.

Place des Fondateurs

Aug. 2089

"Wow, it's hot in here!" said Amy, as Nicola Langlais led her into Blyth North 1 Valley.

"They still don't have the thermal controls functioning right." Nicola looked at her communicator. "Thirty-three Celsius."

"It's been hot in Ayr North lately, too."

"That's because they share one common heat expulsion system. They should have it fixed in a few sols. The irony is that we should actually be in the coldest season in these valleys because right now the sun is as far north as it gets and Mars is at aphelion, so here on the equator we are getting minimum sun. But these domes trap solar heat so efficiently, they'll get too hot without a cooling system."

"That was not a problem we had on Titan. All our underground tunnels had to be heavily insulated. Amy walked to the edge of the balcony and looked down on the main field. "So, where do you get your topsoil?"

"Agmar has a subsidiary that does nothing but sift and wash reg, add organic matter and fertilizer to it, and sell it to us. My main field and the growing areas here in the balcoinies will receive six centimeters of artificial soil and over the next few years I'll add organic waste from my farming operation in order to bulk it up to 10 centimeters. The trees will sit in pots with about half a cubic meter of soil each." She pointed to the southern end of the field. "You see how much higher the plexiglass barrier is, between the field and the settled portion of the valley? This farming area will be much more tropical than Ayr Valley. The main field will be planted in sugar

cane. The two walls, which will be in partial shade, will have cacao plants and vanilla vines, which are excellent tropical shade plants."

"Sounds like you'll be growing chocolate bars in here."

Nicola laughed. "Yes, basically. I'm still not sure what I'll plant up here on the balconies. They'll be pretty warm and humid."

"If you can give me some climate parameters, I can give you some ideas. I ran several tropical bioarchive biomes on Titan. You'll want things that don't grow too tall and get a lot of sunlight. There are some remarkable tropical grape varieties. I don't know what fruits and berries have robotic maintenance and harvesting software, however."

"I can handle that. I'm helping my father manage his million square meters of farmland and we have figured out the efficient ways to use robots. Spiderbots, in particular, are now so cheap that you can employ them to prune and shape your plants, which maximizes use of sunlight. They can remember every bean or pod or berry and will remember what was almost ripe yestersol, which speeds up harvesting. It's really amazing."

"Software that feeds us efficiently and cheaply here puts hundreds of millions of farmers out of work on the Earth."

"I know, but what can you do? We can't import people who just pick crops."

"Fortunately, many of the crops we grow here can't be grown on Earth anyway, because of laws restricting genetic modification, so some of our software can't be used there."

Nicola shook her head. 'That's less and less true. Many of the laws are being repealed, and sometimes that's just as well; if we can feed the Earth's population on half as much land, that's more land for parks and nature reserves. Some island nations, also, are allowing use of

crops that could compete aggressively with their wild plant species and they're using some islands as nature preserves."

"Anyway, I'll get you a list on Thursol; give me two sols."

"Any charge?"

"No; I'll make this part of my research. In fact, I've been looking for a new research area. I'm thinking of making Marsian polyculture my new area of focus. Because of robotics, we can do polyculture that involves intensive intervention, which is not so practical on Earth. It's amazing that we can feed a person on 60 to 80 square meters of surface, depending on light levels."

"The private farmers really could use research of that sort. There are a few agronomists who help us, but many of them work professionally for Agmar, so we get the crumbs!"

"I know. Agmar has a huge research team. This is yet another example of how we say we want more privatization and private businesses, and then we don't support them."

Amy turned southward, to look at the half of the valley that would be settled. The western side was three quarters finished, but it didn't resemble Ayr Valley; there were two open areas on the slope. The east side was still a gaping hole, revealing the cavernous space underneath the buildings. "What are they doing, over there?"

"The sloping areas? Blyth is designed for 2,150 people, just like Ayr, but it'll have six stories of buildings instead of four, and that leaves space for two strips of forest on each side of the valley. It'll be pretty."

"We actually have only 1,800 at the moment because some of the residents are new immigrants, and they're either unmarried, or married and don't have kids yet. These numbers are an approximation."

"Yes, of course. I very much like the 'valley' design. This place will be open for settlement by October. It'll include two tunnels to North Ayr, so people can support Kim's store and restaurant and attend events in the theatre until Blyth has enough people to support its own services. And they've already started on North Ayr 2 and will start excavating for North Blyth 2 in September. North Ayr 2 will feature a lake in the middle, the west 'bank' will be forest, and the east 'bank' will hold ten stories of housing."

"That'll be interesting to see. I gather they're developing all sorts of designs for these valleys."

"North Ayr 1 may start to look rather boring in a few years!"

"What do you know about the proposal to lengthen the valleys?"

"It's still speculation. Last month's legislative battle brought focus on the reduction of the number of square meters per person from 200 to 120. The 120-meter figure refers to 'sunlight surface'; these valleys, 100 meters wide and 1,000 meters long, count as 100,000 square meters, but with 2,150 people in it, that comes out to 47 square meters per person. So these valleys are part of the 'problem.' The housing area, though, with four stories of construction, provide 40 square meters per person, including some commercial space, even though it has only 50,000 square meters of 'sunnlit' surface. The central commons area, 30 meters wide and 500 meters long, provides 15,000 square meters of 'park' which is a bit less than the 10 meters per person, but the walkways along my terraces and the walkways along Ayr Street raise them to 21,000 square meters, which is the standard. As for agriculture, I have 55,000 square meters of farmland, including the terraces and the 'park' pathways along them--we can double count--plus a sixth of the 'park' because it has my fruit trees, plus 20 meters along Ayr Street underground, which is artificially lit for my peach trees, plus one level under the farmland. They add 67,500

square meters. So altogether I have 122,500 square meters, which is 57 square meters per inhabitant. So there will be a small deficit in food production once the valley reaches its full population, but not more than about 10-15%. Frankly, if I were willing to pay for the electricity, I could open up several more underground levels--most the space in these cylinders is empty--and could feed 5,000 or more people. It shows what we can do on Mars, maintaining a population density as high as many terrestrial cities *and* feeding everyone."

"So, are they thinking of lengthening the cylinders to close the deficit? Or subsidizing electricity? Because a food deficit is also an oxygen deficit and a waste surplus."

"I wish they'd subsidize electricity, because my bill is pretty high! They're also thinking of reducing the population of future valleys to 1,500. The urban planners object to that because they want three neighborhoods in each valley, and they object to lengthening because transportation routes and other infrastructure are lengthened. More likely, they'll leave them as they are, or zone the area south of the big enclosures for agriculture. I think there's a good chance for the latter option."

"Interesting." Amy considered. "Even the big enclosures are pretty well designed, with big strips of agriculture that people can look out on and walk along."

"And the area under the farmland is filled with offices and work areas, thanks to very cheap metal carbonyls. We really do live in an amazing place." Just then her communicator beeped. She pulled it out, then gasped. "Oh my God!"

"What is it?"

"Sebastian just passed! That was a text from my dad!"

"How old was he?"

"Ninety-seven! He had been suffering physically, the last few months. Amazing, that he lived so long! But we'll miss him!" Nicole's eyes filled with tears. Amy walked over and hugged her.

"God bless him. He's in a better place now."

Some Marsians did not know that the second commander of Aurorae Outpost was even alive; a few didn't even know he had been living on Mars. Nevertheless, Sebastian Langlais's death was big news and all of Mars paused for three sols while he was remembered on *Mars This Sol* and other media outlets. Baozhi gave a statement of condolence and remembrance; Will and other old timers were interviewed extensively about him.

The state funeral was held in Andalus Square, attended by one hundred guests and a thousand members of the public. Sebastian was not religious, but Helmut felt that respect for the religious nature of the occasion necessitated readings from the world's scriptures, a sermon, and speeches by Baozhi and Will. Afterward, the funeral procession proceeded to Europe Enclosure, the casket and the older members of the procession riding while everyone else walked behind; quite an impressive sight. The Place de l'Etoile, the central public place in the enclosure, was 240 meters across and had a circular road around it from which 12 streets radiated, and within the circular street was a circular park set up with a central space for a grand monument, rather like the Arc de Triomphe in Paris, for which the place had been designed. Just the sol before, the Aurorae City Council had renamed the Place de l'Etoile (Star Place) as the Place des Fondateurs (Founders Place) and had designated the spot near the center where Sebastian was to be buried.

The three Elliott men had very different experiences, as they watched Sebastian's casket being lowered into the ground while a bagpipe played a haunting tune. For Will, it was an errie

experience, who knew that this was where he and Ethel would rest one sol. He had seen the design for the monument to be built on the site, vaguely reminiscent of the Arc de Triomphe itself but consisting not of a single arch, but six of them forming a hexagon with a vault above the central space, the six supporting pillars being appropriately thin for Mars's lower gravity. It was elegant and uniquely Martian. The vault would include a museum, ample windows, and an observation deck on top. He stood on the spot at the very center of the future pavilion, next to the spot where Sebastian was interred, and had the strange certainty that he was standing over his own future grave. It made him shiver and he stepped away, which puzzled Ethel, until she looked around and nodded.

For Marshall, the funeral was a blast from the past; half the official guests had been on Mars during his childhood. Seeing them all gathered together was both a reminiscence and a reminder that that generation would soon be gone, and many of them would be buried in the Place des Fontateurs.

For Bill--who had not been on the official guest list, but who managed to crash the official funeral by staying close to his grandfather--it was a poignant historical event. He knew all the names and had met half of those present. It made him realize that he had to hurry if he wanted their recollections.

The bagpiper completed his tune and the crowd began to disperse. The one hundred guests headed to an elegant restaurant facing the Place des Fondateurs that Helmut had leased for the reception afterward. It was a mix of old timers, family friends, government officials, and diplomats. Marshall was about to start walking over when Sam Anderson hurried over. "Hey, my brother! Haven't seen you in decades!"

"Sam!" Marshall exclaimed, delighted to see his boyhood friend, the second child born on Mars, just eleven months after he had been. They hugged. "I saw you across the crowd, but couldn't get there. I was hoping we'd talk!"

"We have a lot of catching up to do! I had wanted to get together with you during the Mars Council sessions, but I was pretty busy, and so were you."

"Yes, I saw you in the chamber when I testified in favor of the budget."

"You did your best, too. You were pretty persuasive."

"Not persuasive enough."

"Well, you were working with difficult material! I'm so excited for you; Minister of Space Exploration!"

"And you're Mayor of Thaumasia, and it's pretty big now; what, 2,000 people?"

"Almost. We produce a thousand tonnes of perfluoromethane per sol--a fraction of what we will need to produce eventually to warm the planet with the greenhouse effect--plus a lot of rare elements that are found in the pegmatites exposed in Mars's only collisional plate boundary. You should come up sometime and go hiking, there's some spectacular geology!"

"I bet there is! How's Mindy and Victor?"

"They're here; I'll introduce you. Victor's 19 and at Martech. My mom is pretty frail, as you may have noticed; at 91, I think she's Mars's oldest resident now."

"Bill's twenty and he's here as well. We'll have to have you over for dinner."

They had been walking while talking and walked into the restaurant at that moment, where they were pleased to see they were seated at the same table. Will, Ethel, Erico, Carmen, and Madhu all were seated together at a table next to the family; seeing an empty chair, Bill quietly sat with them as well. Will told the others of his experience at the pavilion. "In a way, I

am relieved Sebastian is there first," he said. "Because if I had died first, they might have named it Place Elliott, and I don't like that."

"They'll put you in the middle anyway,' observed Erico.

"That was the spot where I had the strange feeling."

"I think they need to move Roger here," said Ethel.

"That would be nice," agreed Madhu. "When he passed, there was no Europe Enclosure."

"I like the design for the monument," said Carmen. "A simple triumphal arch suggests a military victory, and let us hope there will never be a real war on Mars. A pavilion feels more inclusive."

"Yes, it faces in all directions," agreed Ethel. She sighed. "This sol, I feel old."

"Yes, the funeral makes one feel old."

"Well, we are!" replied Madhu. "It makes me think of all the ones who have already passed away. Armando, Paul, and Monica have predeceased us, Erico and Carmen; we're all that's left of Columbus 2."

"Yes, I've been thinking a lot about David Alaoui, Sergei Landsberg, Laura Stillwell, and Shinji Nagatani on Columbus 1," said Will. "Ethel and I are the last ones."

"But what a world we've seen," said Ethel.

Just then, Helmut came over. Bill hastily rose to let him sit. "I think we gave dad a grand send off."

"We did. I'm glad it was a state funeral. Sebastian deserved it," said Will.

"Thank you for your kind words, Will. Your story about Sebastian watching the inventory like a hawk was quite funny and it captured father's precision."

"It was quite a consequential character trait," said Ethel. "Because I ended up taking some old, damaged birth control pills, and Marshall was the result!"

"I didn't include that part!" said Will, with a smile.

"I heard that from dad; he felt bad afterwards that he had accused you of intentionally getting pregnant so you could stay on Mars."

"NASA and ESA were pressuring us to leave after the second columbiad," said Will. "It was a fortunate development, but it was unintentional."

"I was terrified of getting pregant because no one knew whether healthy children could be born on Mars," said Ethel. "But, fortunately, they can be."

"If radiation exposure is minimized," agreed Helmut. "I'm afraid we found out, with Oskar, that that is important."

"And now he's married and has a child," said Ethel, with a smile.

"Ironically enough, married to a granddaughter of Madhu, Erico, and Carmen," added Helmut.

"And I won't say we've slain the specter of radiation-induced cancer, but we do have it under control, more or less," said Will. "I've now had four cancers cut out of me."

"Me, too," said Madhu. "Remember that spot on my lung, when Sam was a baby?"

"At least Martian gravity is gentler on our joints," noted Ethel.

"We've both had three cancers removed," added Carmen. "We have a longer life expectancy than the average terrestrial!"

"Which reflects the nature of our society," said Will. "People are at the center, as individuals, families, and communities. Work hours, work style, and corporate expenditures are

shaped accordingly. And our governing system seeks to minimize egotism, so that government centers on service."

"I'm sure you'd attribute our success to spiritual values, but legislation and training in ethics, group decision making, and teamwork have been the key to create the appropriate culture," said Helmut.

"Well, spirituality is the secret sauce," replied Will with a smile. "All the religious communities on Mars agree on these values."

"I wish our leaders all did," exclaimed Helmut, rather forcefully. He looked at Baozhi, talking to someone about ten meters away. "I regret that I asked him to lead the eight-year planning effort. I'm very disappointed. He nearly triggered a constitutional crisis."

"And firing Boris and Bijan was completely uncalled for and inappropriate. It made him look like a vindictive child," added Erico, lowering his voice.

"Well, the polling shows that the public agrees with you," said Will. "I don't think any Chief Minister's support has slipped to 30% before. I'm disappointed as well. But we need to encourage and assist him. He's been in office less than 8 months. His two-annum term has 37 months left."

"It does," agreed Helmut. "But Will, I met with him daily during the transition and weekly afterward. You met with him weekly. Jacquie met with him several times. He regards himself as 'his man.' He doesn't listen."

"I met with him twice, too," added Erico. "And I know Alexandra met with him at least once. I don't understand him. He was a good administrator when he was mayor of Phobos borough."

"He was," agreed Helmut. 'That's why I made him Minister of Industrial Development. But talk to people on Phobos and they'll tell you he didn't consult with his staff much; he set the direction and they fell in line. And he was highly constrained because Phobos's budget was set by the Chief Minister. He could lobby for more resources, but he couldn't drastically shift resources around."

"My impression, though, was that he was a pretty good team leader back in 2073; my last year as Chief Minister," said Will. "But that's right before he became mayor."

"My impression always was that he was hard to work with because he had definite ideas how things should be done," said Helmut. "And he wants to do things in as grand a way as possible, also, so he'll go down in history."

"The best way to do that is to build a team," replied Will. "Anyway, I don't want to backbite. As I said, we need to help him grow."

"But Will, he doesn't want your help, or mine," persisted Helmut. "Frankly, I'm worried about Mars. Situations like this prove the cynics right and generate more cynics. Mars needs to remain an example of an ideal, and the Chief Minister is an important part of that. Lily Estrella would have been a much better choice; she has vision and she's warm and genuine. Baozhi does not deliver a good speech and is not good with people. Consider his eulogy this sol. It lacked inspiration."

"Not everyone can be warm and genuine," replied Will. "His speeches don't grab me, either, but that's not a danger for Marsian society. Threatening to veto the budget and then firing ministers when he doesn't get what he wanted: that's a danger to Marsian society. I suspect he regrets both actions. If we work on him, he can get better."

"You're ever the optimist, Will," replied Helmut.

"It's optimism that has gotten Mars where it is," Will replied.

20.

A New Name

Sept./Oct. 2089

Bill looked around his bedroom one more time. He had left the sheets and blanket, but had taken the fancy bedspread his mom had bought him recently. His desk was bare, except for a pad of paper, which he nearly never wrote on, anyway, since the desk's entire top surface was a screen. Out in the little garden part of his bedroom was three potted miniature roses his grandfather had given him, but they were staying; the dorm's window was small.

He opened a drawer of his dresser and found two pairs of socks he had left. He debated, then took one pair. He might need the other pair, in case he spent the night back at home. He stuffed the socks into his suitcase and zipped it up.

"That's everything," he announced, as he stepped into the living room.

"Good." But his mother's face did not look like she meant "good." "Are you sure we can't come along and help you settle in?"

"I'm sure, mom. It'll only take me half an hour to unpack, anyway; there's not that much stuff for me to move."

"I know, but . . . well, never mind." There was a tear forming in one eye.

Bill felt a tear in his eyes, too, but that actually irritated him. "It's not like I'm moving to Earth, or even to Cassini! I'll be just a 15 minute walk from here!"

"I know."

"You're coming home for Sunsol dinners," said Marshall, though it was with a tone half-way between declarative and interrogative.

“Of course, I won’t miss them. It’s family.” They alternated the dinners between Marshall’s and Liz’s, Will and Ethel always came, and once a month either Will’s sister and her son Paul and his family, or George Tobin, Mike’s cousin, came with his wife and son. The interrogation made him feel worse, so he looked away. “Don’t worry, I’ll be back. And once I;m settle in, you can come by.”

“And you know where my office is,” added Marshall. He rose from his chair and gave Bill a hug. Mille followed and she looked particularly distraught. “I really liked it when you walked me to school.”

“I enjoyed it, too. Maybe when school starts up, I can do that again, or walk you home sometimes. My afternoons are more flexible.”

“I know, you like to sleep late!” she said, with a smile.

Amy approached her son. “I know you’re not going to Earth or Cassini. but this feel big!” She hugged him, too. “Let’s figure an evening, like Wednesol, when you can come home for supper, so the four of us have some time together as well.”

“Okay, I can do that.” He turned to his dad and sister. “Bye bye.” Then he picked up his suitcase and walked out of the door onto their balcony overlooking Ayr valley. It was Sunsol evening; there was a musical group performing in the theatre and many people were eating a late suppeer on their balconies, listening to the music. Near the elevator, an autocaet--a robotic golf cart--awaited. He added the suitcase to the boxes of stuff he had already piled in the back and jumped onto the seat in front. ‘Okay, let’s go to Joseph hall,” he said.

“On the way,” replied the cart’s robotic voice. It rolled over to the elevator, then rolled in when the doors opened. The elevator descended all the way down to Ayr Street, then exited the

elevator, took the corridor to the street, and accelerated down it, the pressure door to Australia enclosure automatically opening as it approached.

Marshall didn't pay much attention to the trip; he was thinking about why his departure felt so monumental. He had lived in a room of his own on the Saturn-7 flight, after all, and sometimes he didn't see his family for three or four sols. Their fancy Ayr Valley condo had barely begun to feel like home; they had moved in a bit over three months earlier. But moving out so definitively, to a university dormitory and another mental world; that did feel like a big break.

The cart manuevered into an elevator and the elevator doors opened in the courtyard created by Joseph, Renfrew, and Lassen Halls. It rolled over to Joseph and stopped. "You have arrived at your destination," a robotic voice said.

"Thank you." Bill climbed out and unloaded the suitcase and two large boxes of possessions from the back. "Thank you," he said, and the cart said "thank you" as well and rolled away. One thing he did not have to worry about was theft, so he picked up his suitcase and went up the spiral ramp at the building's eastern end one level to the second story. He entered the dorm and proceeded down the corridor to 216. He stopped outside the door and it immediately unlocked.

It wasn't a very large room; four meters long and three wide, with a single window, a bed, desk, chair, and closet. It had been refurbished recently because it was an old building--built in 2043, the first large airtight structure built on Mars of local materials--but had just been added to Martech for overflow dorm space, the Freshman class being much larger than expected. Bill put his suitcase on the bed and immediately someone was at the door.

"Bill, you're right, this is a good choice!" It was Hideki Takahashi, who had moved into the room next door.

"Good, I'm glad you liked it. It's a historic building and the museum is using just the first floor for now. Martech is having trouble getting students to move in, but the rooms here are slightly bigger than most dorm rooms, and they have *windows.* Who ever heard of that at *subterranean* Martech? Is anyone else moving in?"

"We have the entire floor! Trey, David, Celeste . . . this is going to be little Titan!"

"Fantastic! I was hoping we'd get to all be together."

"There are a few others; Trey was in a dorm and some of his buddies are moving in here, too. But Titanians will be the majority. It'll be so much fun!"

"It'll be a blast! I'm so glad you were able to arrange this, Hideki."

"Hey, I have the entire Project Helia student mailing list. This was nothing; a little side project! Do you need help?"

"Yes, I have two more boxes outside."

"Okay. let's get them." They headed back toward the stairs. "Are you taking any geology at all, any more?"

"Not this semester. I am taking physical chemistry--organic chemistry next semester--but that's it for the sciences. I'll be in a twenty-first century literature course, a historical methods course--which is actually a graduate level course--and sociology. Are you doing geology and religious studies?"

"Basically, one of each, but I'll be in sociology with you! I need it for the Helia project."

"How's that working out?"

"I *love* the work! I'm continuing during the school year, but fewer hours per week. We're having a big event in two weeks; we're giving the latest reports about the project, announcing the names of the planets, and recruiting students to join the project, of course."

"Fantastic, that sounds interesting."

"Will you attend?"

"Yeah, sure."

They picked up the boxes and brought them up to Bill's room. Hideki headed back to his room and Bill began to unpack. It didn't take too long. He had some dishes, a hot plate, clothes to hang up, a bed to make, and things to put on and in his desk. The walls were giant screens, as was standard, so Bill had to decide what color to make the walls and what images to project onto them. The exception was the wall right in front of his desk, which had a built-in large screen with three cameras, to provide 3-d imagery.

He sat at his desk and set up his communicator to communicate with the various screens. He set the walls on a light blue and projected a view of Teays Canyon onto the wall over his bed. At that point, he heard someone come down the corridor and stop at his door. He looked up. "Grandpa!"

"I was wondering whether you had moved in yet," said Will. "So I thought I'd take a look." He looked at the room. "I like the picture."

"Teays Canyon; there's a nice hiking trail. You lived in Joseph Hall, didn't you?"

Will smiled. He looked up and down the corridor. "Yes, we did. We moved in when your dad was about 2. In fact . . . . He looked up and down the hall again. "I think this room next to yours was our living room! So this room--your room--was your father's bedroom! That's amazing!"

"Wow, that *is* amazing! He had this entire room when he was . . . 2?"

"Well, we had two closets--armoires--in here for our clothes. Ethel and I had a double bed and a desk in our room on the other side of the living room; there was no additional room for closets!"

"That makes sense." Bill looked around his room again. "Wow."

"I didn't realize this was a dorm."

"It's a new usage of the space."

"I guess the museum wasn't able to use this space yet. They have expansion plans, but no one wants to tear out these walls. They're part of the original design. Your grandmother did a lot of the welding of the nickel-steel rebar inside these walls. I hauled trailer loads of duricrete, sand, and other materials and helped to pour the duricrete. This building was an incredible amount of work. Incredible." He looked around at it again.

"Did you have robots?"

"No, we had to do the work ourselves in pressure suits, if you can imagine!"

"Sounds like another thing for us to talk about."

"Yes, we never talked about our first construction efforts. There are a lot of subjects we never touched on. And I've gotten to the point where talking about it has become easier than writing it."

"Then we can talk. I'd love it."

"Good. We should set a regular time, if you can."

"Oh, I can!"

"Good. There's another way you can help me, Bill, if you're willing." He paused. "My doctor says I shouldn't go for walks by myself any more, I should take my robot. But the robot

can't go everywhere I want to go. Sometimes . . . I want to go to Baltic Enclosure and climb to the top of Boat Rock. It's a long way up and I have to go a bit slow, but I can still get to the top. But the robot can't manage that."

"Oh, sure, I'd love to walk with you! I need to get more exercise, too!"

"I'm not sure I'd call it exercise, to walk with me; I'm slow and can't go as far as I used to be able to go. I was jogging until I was about 80, believe it or not, but I can't do that any more."

"Even so, I'd be glad to walk with you. I have a class at 10, starting next week, but I could go out at 8 with you."

"That'd be great, I'd really love that. What sol?"

Bill thought. "Tuesol or Wednesol, maybe?

"Yes, that'd be good. Let's start this Wednesol."

Marshall leaned toward the wall screen to examine a detail of the plans for the Helia. He used his fingers to enlarge the area against the bulkhead and internal details like pipes and wiring popped into view. He touched a pipe and the diameter, mass, and purpose of the pipe appeared. Down at the bottom of the screen, a list of pipes, their purposes, lengths, andmasses appeared, each with its own id number. He moved his finger into the intertank area between bulkheads and the contents of each storage room in the intertank area appeared, again with a detailed inventory.

"So thorough," he mumbled, and Julio Ozawa, his chief of staff, nodded.

"If they decide to move a pipe or a wire, also, everything updates automatically, and the AI immediately searches for potential design flaws; leaks that can damage wiringm for example."

"Jimmy Khan and his people have the most sophisticated design software I have ever seen. I just wish we could be more certain about the propulsion system, since that affects the specific impulse, which determines the fuel consumption, which determines the tank sizes."

"Fortunately, most of the design is unaffected by those issues. We've already assumed we can build and fill tanks large enough."

"Though with this large interior design and large mass, that would be nearly impossible with gaseous core, even with an Isp of 5,000. Let's face it, this design requires fusion engines and an Isp of over 10,000, and such engines have to put out an immense amount of power for a very long period of time, and then they have to be restarted 30 years later to make the orbital insertion burn around Helia."

"Fotunately, that's a much smaller burn, since all three of the inner planets are moving around Helia at a pretty high velocity."

"Still, even so . . . I want a meeting with Ted, Changying, and the fusion propulsion team early next week to discuss this issue. I still haven't seen a good solution to that design problem, and that's a very old design problem. We need a delta-v of over 500,000 kilometers per hour to get to Helia in 30 years and a delta-v of 350,000 kilometers per hour to get into orbit. We still can't do that! Can we do that reliably in seven years? That's what Baozhi will ask me."

"The fusion propulsion project is now over 2 billion redbacks per year. It's a huge multi-national effort."

"I know, and they'll say that to you, but that's the answer to the wrong question."

"I agree. I'll set up the meeting."

"Thanks." Marshall waved goodbye to Julio and turned to communications. Baozhi had asked for a report about the feasibility of asteroid redirect, and the astronomers had produced a

list of possible candidates. One stood out as particularly promising; a 2-kilometer body consisting of ice and frozen gasses orbiting just beyond Neptune, total mass about 4 billion tonnes. A half-kilometer per second change in its velocity--achievable with a very large cluster of gaseous core engines expelling one percent of the asteroid's hydrogen--would cause it to encounter Neptune, whose gravity assist could send it to Jupiter, whose gravity assist could send it to Mars 40 years in the future. The deflection would have to tke place in 2094, five years into the future. Of course, 4 billion tonnes of water, carbon dioxide, methane, and ammonia didn't amount to much; the Martian atmosphere massed 2.5 trillion tonnes. If the asteroid collided with the south pole, it'd instantly liberate nearly all the water and carbon dioxide stored there. But forty years from now, most of the CO2 might have already been liberated. Besides, the number and size of the gaseous core engines needed was immense, and the human crew that went along would number several hundred. It was a 20-30 billion redback project.

But Baozhi would want to consider it, anyway; that was his nature. With a sigh, Marshall forwarded the report to the Chief Minister. He was already thinking of questions to ask, like 'do you want to devote 5 billion per year to this, or to solar mirrors and halocarbon production?' or 'do you want to do this and cut back on our support for Saturn, Uranus, and Neptune?' This was not a project for which Mars could expect help from Earth.

He felt momentarily paralyzed, knowing that the report would generate a personal confrontation with the boss. He tried to keep those at a minimum, because as much as Baozhi listened, he still hated bad news.

A new videomail popped up on his screen, from George Tobin, his brother-in-law Mike's cousin. That was unusual; they didn't communicate, except to exchange news and ideas at the family dinners. He hit play.

"Good sol, Marshall. I hope you are doing well and aren't too overworked! I'm calling because earlier this sol I exchanged videomails with Bill Hollingsworth. As you may know, I am Themis's lawyer and sometime lobbyist here in Mars, unpaid in both cases I'm afraid. He is having a very difficult time with Alan Quint, the so-called bishop of the Green World Creed. This is a variant--a sect--of the movement Rivers started. Quint has arrived at Themis with 167 personnel--they out number the 120 people already there--and they have strongarmed Bill and the Council into expanding the Council from 5 to 9 and added Quint as Assistant Chief Minister. The other four original Council members are very resentful and oppose everything Quint wants, which makes Bill the swing vote; a very difficult position to be in. But the bigger problem is that about half the new arrivals don't have any relevant skills. Quint recruited based on willingness, not on experience. They have to learn farming--zero-gee farming--and construction, because housing is badly overcrowded. They want to do work on the dome, which can involve space walks--very glamorous--but they aren't licensed and certified for that, and definitely don't want to do farming. They also will need to build a large docking facility for the C-300, but it won't arrive for 3 more years. They can't plant and harvest fast enough with the current available workforce to feed everyone without depleting resources, like the tilapia in the Sea. Meanwhile, dome repair is suspended. Bill is tearing his hair out over the mess.

"I know there's nothing you can do about all this, but if there is something someone can do, it may be worth considering. I see safety issues. We have nearly 300 people on a little domed-over asteroid struggling to maintain temperature, pressure, oxygen levels, and food supplies, tens of millions of kilometers from anyone else. Tree Rivers never should have been allowed to send them to Themis, although I admit there were no laws to stop him, and he was fairly responsible.

"That's the news from Themis. Let me know if you have any questions or want me to communicate back to Bill. Ciao."

Marshall watched George disappear from the screen and then stared at it, thinking. He had talked to Quint back in January, before he had reached Mars, and they had discussed the C-300. He had even specified that the work would have to be performed properly and reviewed by inspectors. So safety was indeed an issue, and the dome could be included at that point.

"Ivy, can you open the paperwork for the Themis C-300?" he asked his AI. "Hey Julio, can you come back in here for a minute?" he added, as his chief of staff's office was next door.

"What is it?" Julio entered just as the C-300 information began to appear on screen.

"Let's take a look at the Themis C-300 specifications. I just got a worrisome videomail about the place."

"The information is coming in rather slowly about it. Ceres has completed the design for the shell, but there has been a lot of back-and-forth about the contract with Martech to design the interior."

"Back and forth?"

"Quint wants the materials included to build an interior able to hold 10,000 people; that's about 25,000 tonnes of metal and plastic. But he wants a design to accommodate only 500."

"Oh? Is that a phase 1? What about the other phases?"

Julio shrugged. "Your guess is as good as anyone's."

"Why didn't you mention that to me?"

"The latest set of emails waas just two weeks ago and we haven't done a big review of projects since. It's on my agenda to talk to you about it."

"Good. I don't have the authority to block the work, but I did specify that we would want the design and its implementation inspected fully. We can halt Marsian involvement in projects on the grounds of safety."

"The design probably includes proprietary equipment as well, and you have to sign the export licenses."

"That's right." Marshall turned to the design specifications, and the more he read, the less happy he was. "This is all minimalistic. He wants as large a structure as he can buy--something we don't even have design and construction experience for--and he wants to decide himself how to fill it."

"I think that's right. He has no idea that if a misplaced wire gets wet because of a pipe leak and shorts and starts a fire, the entire structure can be ruined."

"He doesn't want to spend any money!" Marshall shook his head. "Contact Jimmy Khan and ask for a thorough safety evaluation of these plans. He has probably been gently pushing Quint and Quint has been stringing him along, hoping that the physics of launch windows would force us to approve the C-300 or force Ceres to lose the huge contract. No more. Get me a report and I'll talk to Quint myself."

When Bill entered the lecture hall, he was surprised and impressed by the number of people who had showed up for the Helia meeting. The room, which held 350 people, was almost full. Most were undergraduates, but some were graduate students, and there were a few professors as well. Hideki was sitting up front with the other planners of the meeting and was beaming with pleasure. Bill walked up to him. "Congratulations! How did you do it?"

"I've been working on this all summer; lots of individual emails to people. There are people planning to watch the livestream, too, as far out as Neptune!"

"Fantastic! Congratulations again! I was talking to my grandfather this morning and he was very happy to hear about this meeting and the way the plans are moving forward. He was very supportive. He might even show up."

"Really?" said Changying, who was sitting next to Hideki. "Do you think he'd like to speak?"

"No, he'll probably slip into the meeting and sit in the back. He wouldn't want to become the center of attention."

"I see," said Changying, nodding.

Bill nodded and headed up the stairs to the back of the auditorium near one of the doors, in the hopes Will would sit next to him if he showed up. Hideki scanned the crowd, excited by the numbers, but mindful of the difficult exchange of emails he had had with his parents earlier that sol. As he looked, another message came in from his mom: *Hideki, you are an adult now and we respect that. But as you know, we have never understood your desire to become a Christian minister, and now we might lose you forever if you go to Helia. We'd rather you come back to Titan as a minister than that. Please remember your family. We love you.*

A lump rose in his throat as he put his communicator away. It was the same sentiment they had expressed to him for months, practically every sol. No amount of reminding that their parents hadn't wanted them to leave Japan had changed the argument, either.

He saw Changying rise; the meeting was about to start. "Welcome, everyone, to this evening program about the Helia project. We plan to offer programs like this three times a year, at the beginning of the fall semester, the beginning of the spring semester, and the beginning of

summer. We will always start with news, then focus on a big theme. We have two important new items tonight. The first is progress on the design of our vessel, which will be 150 meters in diameter and 150 meters long until we depart this solar system, when we will be able to occupy the empty hydrogen tank, which will double our interior volume. Martech's Spacecraft design division has just about completed the details. We will have the ability, after trans-Helia injection, to duplicate our housing and agricultural space in the empty tank, which means we will be able to accommodate a growing population over our 30-year trip and will have built in redundancy in case of damage to either half. The design, furthermore, is elegant and will give us a lot of open space; space for people literally to lose themselves, if they wish. That's absolutely essential, for the vessel to remain comfortable.

"Our second announcement involves additional staff: Dr. Lindsey Douglas has agreed to be our Medical Officer. She has specialties in zero-gee medicine and radiation-induced cancers as well as experience as a primary care physician. We are very pleased that she has joined the team." She paused for applause. "The other addition to our team is Hideki Takahashi, our student liaison. He managed to produce this fantastic turnout we have today." That generated even stronger applause, because most of the audience knew him. "I now turn the program over to Ted, for additional subjects."

"Thanks, Changying. Cynthia Nguyen, our chief ecology officer and chair of the Department of Helia Biology. Cynthia."

She rose and walked to the podium. "Over the last several months, our work on chlorophyll has produced some very promising results. As you know, Helia produces a substantial amount of its energy in the 700 to 850 nanometer wavelengths, but chlorophyll is good to about 750. We have now developed a computer model of a chlorophyll molecule that

should be good to about 810 nanometers, called Chlorophyll-ir. Our next step is to synthesize the molecule and test it. If it works the way we think it will, we will then develop chloroblasts that produce it, along with Chlorophylls a and b. Finally, we will genetically modify plants to produce the chloroplasts. It will make plants a very dark green; they'll be distinctively different looking. This research has important implications for Marsian biology as well, as it will expand the range of light that plants here can utilize. The plant genetics departments here are also working on a chlorophyll-uv that can use more high energy ultraviolet light, with the goal of doubling photosynthetic efficiency again in the next ten years. We are moving into quite a remarkable biological world, friends. It's research that should allow agriculture without augmentation of the sunlight as far out as Callisto. Certainly, Ceres will benefit immensely, and long-distance vessels like the Helia will need smaller qualities of electricity to maintain their ecologies. Thank you."

Cynthia returned to her seat on the stage to applause. Just then, Bill saw motion near him and Will slipped into the seat next him. They smiled at each other. "Can we move up more? I may have trouble hearing, here," said Will.

"Sure." They rose and moved to the middle of the auditorium where there were two empty seats.

"Next, we have a report about the worlds in the Helia system, complete with their names," said Ted.

Stanley Mansale and Hideki Takahashi rose and walked to the podium. "As you know, over the summer we conducted a contest for names of planets in the Helia system," said Stanley. "People could submit as many names as they wanted and they could specify which planet it was being proposed for, or they could say the name could be used for any planet. We asked for names

that were no more than three syllables and easy to pronounce in most languages; an alternation between vowel and consonant was preferred, with no consonant clusters. People could also scan the list of proposed names and vote for the ones they liked the most. Finally, we had a committee of myself, Ted, Changying, Cynthia, and Hideki to vote on and finalize the names. These are the names we will use, and we hope the International Astronomical Union will accept them; they are the official naming body, after all.

"So, here we go." Ted pushed a button and a slide appeared showing Helia-1. "This is the best map of the innermost planet we can make, so far; each pixel is 500 kilometers across. The entire anti-solar hemisphere, because it never receives sunlight, is ice and snow; that's clear from the white color. But note the varying amounts of blue and brown, and lightness or darkness of the colors also suggests that a touch of white crosses onto the subsolar hemisphere. Over time we should be able to reduce the pixel size as we accumulate more light from the world and as we observe sudden changes in color as certain areas rotate out of sight from our telescopes. The intensive brown near the subsolar point reveals its dryness, but even there, we estimate the central pixel is ten percent water by area. Most likely, the southwestern edge of the subsolar hemisphere has a large finger of ocean that extends to the rear hemisphere; you can see that several pixels on the back side are bluish-white, indicating the presence of ice and open water. An island or peninsula near the edge there would have the moderating effects of ocean currents to reduce icy blasts from the back and may be pleasantly inhabitable. As for the name. . . ." He paused for Hideki to continue, and he pushed a button so that it appeared under the crude map.

"Aretia," said Hideki. "This word comes from the Semitic root for 'earth' as it appears in various languages."

Stanley nodded and projected an image of Helia 2. “This world, as you can see, has a lot more water; perhaps half of the front side, and maybe a third of the rear side, the rest of the back being glaciated of course. We can’t resolve the land versus sea on the front, but we suspect there are lots of islands and peninsulas along the edge. It may be that this world has a global dichotomy, with the front side lower than the back, but we can’t be sure, yet. This is suggested by the pattern of volcanoes, which seem to concentrate along the terminators. And . . .” He pushed a button to add the name

“Tersia,” said Hideki. “From the Indo-European root that gives us ‘terra’ and ‘thirsty,’ probably originally referring to dryness.”

“Thank you.” Stanley projected the third world. “As you can see, this world is 100% blue or partially blue in front and there’s a lot of blue along the edge and across onto the back, suggesting this is an ocean world with small continents. There are three large clusters of volcanic activity on the back side, and the front side has a cluster north and east of the subsolar point, an area where the brown suggests about 30% of the pixel is land. That’s be a good area for settlement. As for the name . . .”

“Boralia, from the Latin word for ‘north’ indicating the coldness of Helia-3,” said Hideki.

“Finally, there’s Helia-4, and not much to see.” Stanley projected the image. “As you can see, we have crude bands of white and gray with some pastels; rather like the cloud bands of Jupiter. This is a super earth with a very thick hydrogen-helium atmosphere. It may have a surface, but most like there’s a global ocean covering it, possibly with an ice shell. We’re calling it . . .”

“Ultia,” said Hideki. “Reflecting its distance from Helia and the fact that it is the last planet.”

“Unless we fnd another one,” added Stanley. The audience laughed, then applauded as they returned to their seats.

Ted rose. “Our last speaker tonight is Hideki Takahashi, who so successfully brought together this crowd tonight. Hideki.”

The 20-year-old rose and walked to the podium. He had said he’d thank everyone for coming, but Ted had introduced him as a speaker, and it occurred to him he had something to say. “I want to thank all of you for coming tonight,” he began. “Most of us, in this room, are the next generation of explorers. For me, my parents are my role models. They worked hard, acquired the education they needed, and left Japan for Mars. Other than videomail, they’ve never seen their family again; quite a sacrifice for a close-knit family. They moved to Titan and were among the first crew to arrive in the Saturn system. I was born during the two-year flight. On Titan, they built both a close-knit family and a warm, collegial, supportive community. There, videomail to Japan took two hours, round trip, but they stayed as close as they could.

“Now we are contemplating a similar step: departure from the solar system, settling a new solar system, and a thirty-year voyage that will take us nearly 6 light-days from here. Nevertheless, our videomails back to our old home will ride a laser beam to it, and our families’ stories will ride a laser beam back. The world will watch us with fascination as we settle Aretia, Tersia, and Boralia, spread out over those worlds, cover them with vegetation, and build an entirely new civilization; a three-world civilization rather than a one-planet civilization. Our children will discover sacred places and places of great beauty, will build big cities and impressive monuments to the founders, and will terraform all three worlds. It’s quite a story, and tonight we can see some of the end in the beginning. I hope many of you will sign up and join the adventure.”

Hideki sat and the audience rose to give him a standing ovation. Will practically jumped from his seat and applauded. “I couldn’t have said it better myself,” he whispered to Bill.

Plot Summary

Autumnal Equinox: Dec. 24, 2087

Jan. 1: Marshall announces plans to leave for Mars; Willie wants to go to school there or maybe on Earth. Guillame van der Velde is the new Chief Minister; Major fusion bombs explode at south polar cap

Dust Storm Season begins: Feb. 15, 2088

Feb/March 2088: First district fairs, Feb. 1; Drum heads to Iapetus; Saturn 8 leaves for Mars; Saturn-9 leaves Mars for Saturn; Baozhi proposes crashing small asteroids into the polar cap as well as solar mirrors to heat them; Changying pregnant; Oskar and Maryam have baby in Feb.; meet some of the Titan kids heading back to Mars; recruit some of them for Helia; they try to recruit Willie as well. Trey Sutton, Celeste Kwok, Hideki Takahashi; maybe 30 of the 80 high schoolers return to Mars. Meet Victor Anderson, born in May 2070; 777 children born on Mars, 2070-71; launch of Saturn-8 and Iapetus borough

April/May:Tad Lind leads an expedition to Portia for PGM mining; how are things on Earth?; Ted and Changying get briefing about the Helia system and recruit the planetologist for Helia; report from Saturn-7; C-300 to Themis?

June 15: Second round of district fairs

Dust Storm Season ends: July 10, 2088

Aug. 2088: Ceres-Chinese mission departs for Pallas; Baozhi's plan for expansion of Mars over the next eight years is published and is a shocker and is popular. It includes manufacture of polar heating mirrors and erection of a power mast at Phobos's north pole. But it also has some controversial aspects, like asteroid redirect and it implies total terraformation as an ultimate goal.

Early Oct: Changying and Ted's baby born; another round of 30-gig explosions in the south polar region

Vernal Equinox: Oct. 24, 2088

November-Jan. 2088; District elections, late Oct.; electoral district elections; Zhang Baozhi chosen Chief Minister; also US presidential election; he asks Marshall become head of Space Exploration even though he hasn't arrived, yet; Alan Quint heads to Themis via Mars with first set of immigrants

Opposition 26: Jan. 31, 2089

March 10 2089: Saturn-8 reaches Mars; Marshall is an instant celebrity; Baozhi is becoming controversial with his ideas; the columbiad is not going well;

April/May: Plans for 27th columbiad discussed (Phobos to 20,000, Ceres must grow as well); Baozhi has ideas about space exploration and C-300s; larger and more frequent nukes; accelerating mirrors and halocarbons; accelerating B-1000 deployment;

May/June: Marshall talks to Changying and Ted, recommends naming the planets; introduces them to Bill, Bill mentions his friends. Changying and Ted meet with the friends. Hideki talks to Changying, expresses interest in Helia; she is skeptical but he convinces her.

Quint arrives at Themis; McDonald family has baby; Neptune family has baby; another meeting with the geologist; meeting with a plant geneticist who lays out the new possibilities;

Sept.: Bill moves into the dorms; Name Helia's 4 planets (Aretia; Telluria; Boralia; Ultia; start recruiting personnel, including Ritchie; controversy over asteroid redirect and the possibility of food shortages if there is a Category 5 global dust storm (Baozhi doesn't want to scare the public)

Autumnal Equinox: Nov. 10, 2089; big nukes up north to maintain a lake all winter

Dust Storm Season begins: Jan. 1, 2090

C-200 on Triton opens for business, Feb. 2090

April 2090: Ayr Valley has winter partly because of dust storm

Early 2090: Ceres-US mission departs for Vesta

Dust Storm Season ends: May 27, 2090

2090: Lakshmi reaches Venus with 2061DXR "Eirene," a mixed stony-nickel-iron body 65 meters in diameter, mass 2 million tonnes

Vernal Equinox: Sept. 11, 2090

Marsian midterms, late September; Baozhi is recalled, Marshall elected Chief Minister of Mars; US midterm election, November 2090

Opposition 27: March 6, 2091; 27th columbiad, 180,000 arrivals

Autumnal Equinox: Sept. 28, 2091

Dust Storm Season begins: Dec. 19, 2091

Dust Storm Season ends: May 14, 2092

Vernal Equinox: July 29, 2092

March-ish 2093: Sedna project arrives

Opposition 28: April 11, 2093

Autumnal Equinox: Aug. 15, 2093

Dust Storm Season begins: Oct. 6, 2093

Dust Storm Season ends: Feb. 28, 2094

Vernal Equinox: June 16, 2094

Opposition 29: May 26, 2095

Autumnal Equinox: July 3, 2095

Dust Storm Season begins: Aug. 25, 2095

Dust Storm Season ends: Jan. 20, 2096

Vernal Equinox: May 3, 2096

Autumnal Equinox: May 20, 2097

Dust Storm Season begins: July 11, 2097

Opposition 30: July 31, 2097

Dust Storm Season ends: Dec. 5, 2097

Vernal Equinox: Mar. 21, 2098

Autumnal Equinox: Apr. 7, 2099

Dust Storm Season begins: May 29, 2099

Opposition 31: Oct. 18, 2099

Dust Storm Season ends: Oct. 23, 2099

Vernal Equinox: Feb. 6, 2100

Autumnal Equinox: Feb. 23, 2101

Dust Storm Season begins: Apr. 14, 2101

Dust Storm Season ends: Sept. 9, 2101

Titan northern spring equinox: Aug. 11, 2009; (+29 yr 5 mo 17 days); Jan. 28, 2039; July 14, 2068; Dec. 31, 2097. Northern summer solstice is late Feb. 2077

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