MARS FRONTIER

Vol. 2

Columbus Two

Table of Contents

1.

Landing

April 16, 2038

It all happened very fast.

The shuttle *Hadriaca* fell like a rock toward the Martian surface. It cut through the thin Martian atmosphere, almost unaffected, but the thickening air near the rapidly looming surface rubbed the heat shield a bright red, pressed the three crew deeply into their seats, and assaulted their ears with a whine.

Bang! The mortar fired the drogue chutes into the supersonic slipstream, jerking the *Hadriaca* upward and slowing it further. Another thousand kilometers per hour of velocity ebbed away. *Poof!* The drogues detached as the three main parachutes popped out and blossomed like silver mushrooms silhouetted against a pink sky. Another thousand kilometers per hour of velocity was rubbed off.

Pit in the stomach. The parachutes, completing their job, blew away and for a few seconds the *Hadriaca* fell freely, as father Mars sought to bring it to his bosom. Then there was a deep-throated rumble and roar as the shuttle's five oxygen-methane engines lit up, spitting a hundred meters of orange-tinted blue flame. The shuttle pitched vertical as the final deceleration brought it to a halt and the six landing legs deployed.

"Here we come," said Sebastian Langlais, pilot and Commander of the Columbus 2 mission. The ship settled toward the central bull's eye of landing pad 3, the computer making minor adjustments based on the radio beacons.

Bump! The ship settled onto its legs and the flames went out.

“The *Hadriaca* has landed safely at Aurorae,” said Sebastian rather matter-of-factly.

Will Elliott, Ethel MacGregor, and Shinji Nagatani watched the whole landing sequence on the wall screen of habitat 1’s great room. After nine months of looking at each other, they’d finally have new faces to gaze on! As the *Hadriaca’s* engines fell silent, they applauded.

Will pushed a button. “Congratulations, *Hadriaca*, and welcome to Mars.”

“Thank you, Aurorae,” replied Langlais formally.

“I’d better get going,” said Shinji. He was already wearing his pressure suit, minus helmet and gloves. Will and Ethel nodded a goodbye as he headed for the docking unit. Docked to one of its pressure doors was a ranger, a vehicle rather like a humvee. Shinji entered, closed the hatches, undocked, and drove off.

“I sense mixed feelings in you,” Ethel said to Will.

He looked at his wife of ten months. “It’ll be a great relief to see new people. But I worry about how well the eight of them and the three of us will integrate. And Langlais is so. . . stiff. I hope we can get past the façade.”

“I worry about that, too. He hasn’t been willing to talk to us about our duties.”

“Which is crazy. We’ve asked for ten months.”

“I can understand his desire for face-to-face, live communication, though. Think how hard Columbus 1 was.”

“It was. But in the end we were pretty close.”

“Everything was fine in the end. We’ve got a year and a half together; plenty of time for the eleven of us to become a team. Don’t worry.”

“I hope you’re right.” Will smiled and kissed Ethel on the cheek.

They watched the ranger head toward the *Hadriaca*. It had landed five kilometers away, on the other side of Boat Rock, a massive pile of fluvial sediment, volcanics, and crater ejecta that protected them from a crash or explosion.

Shinji reached the *Hadriaca* in ten minutes. He circled the shuttle, focusing cameras on the vehicle to reveal any venting gasses. There were no plumes or discoloration to see, so Will gave him permission to park five meters from the exit ramp. Shinji put on his helmet and gloves and began to depressurize the cab.

About the time he finished, the shuttle’s airlock door opened and two figures came out. A third followed a few minutes later. They descended the ramp, stepped onto Mars, cheered, and began to walk around excitedly. Shinji stepped to greet them; they shook his hand, slapped him on the back, and exchanged greetings. When the third person exited, he left an airlock full of air-tight suitcases and plastic boxes. While Mars’s new inhabitants practically danced off the excitement of landing, Shinji stacked their suitcases and boxes into the space behind the ranger’s seat.

Finally they stepped inside the ranger. It was a tight squeeze for the four of them. Shinji closed the cab and began to pressurize the interior while driving everyone back to the Outpost, where he backed the ranger against the airlock and docked to it. From inside, Will used a remote manipulator arm to latch the transfer tunnel safely into place.

The airlock door opened and the three arrivals stepped inside the outpost. The first was Sebastian Langlais, a 46-year old German. His blond hair was streaked with gray, but his blue eyes flashed with energy and excitement. “Vill Elliott, it’s goot to see you again.” Will had forgotten Langlais’s German accent.

“It’s been almost four years, Sebastian. Welcome to Mars.”

“Thank you.” They shook hands very formally. “I’m looking forward to your service under my command.”

“Ah, thank you.” Will wasn’t sure what to think of that. Sebastian turned to Ethel to shake her hand and Roger Anderson came out next. A 42-year old Texan, on the tall side for an astronaut, his brown eyes peered at Will in a way that was more respectful than friendly.

“Will,” He said, extending his hand. They shook; a bone-crushing exchange. Will looked at Roger Anderson’s eyes and felt the man’s rivalry. It triggered a natural rivalry in him. Roger had published a reply to one of Will’s papers about lunar mantle fragments and had often asked pointed questions during the last six months of Columbus 1’s geological operations. Anderson was a damn good planetary geologist and knew it.

Will returned the gaze. “Roger. Welcome to Mars.”

“Thanks, this should be a fascinating mission.”

He moved on to Ethel and the third person came out of the ranger, Roger’s Indian-American wife, 41-year old Madhu Gupta-Anderson. Will had never met her before; she was a new addition to the astronaut corps. He was surprised by how long her gorgeous black hair was; more than regulation for sure. She smiled warmly and shook hands.

“It’s really nice to meet you, Will. I’m looking forward to working with you.”

“Thank you. I’m pleased to meet you, Madhu.” Will smiled back

Madhu moved on to shake hands with, then hug Ethel. “I’m very happy to meet you.”

“Thank you, I’ve looked forward to meeting you as well.”

Madhu reached up and touched Ethel’s hair. “By the way, I have a full set of professional hair-cutting shears.”

“Marvelous! We’ve been without a really good barber for nine months. I’m afraid we look rather shaggy.”

“Nothing we can’t fix,” replied Madhu with a smile.

“Can someone help me?” exclaimed Shinji, appearing in the hatch with a large plastic-wrapped box.

Will reached out and grabbed one end. “Sure.”

“Those are your wedding presents,” said Langlais.

“Oh? Thank you!” Will pulled the box through the docking tunnel, then carried it across the docking unit and into Habitat 1. The others reached through to grab suitcases and boxes as well and carried them inside the habitat, a flying-saucer-shaped inflatable structure twelve meters in diameter and seven meters high.

“Which is my room?” asked Langlais.

Will took him into a semicircular lounge in the left hemisphere. It had seven doors along its curved outer wall. “Shinji’s in the next to last room. The room past his is the sick bay. Roger and Madhu are upstairs with us.”

Sebastian nodded. “Alright. I’ll take this one, then.” He walked to a doorway near Shinji’s room, but separated from it by one empty room. He entered a pie slice of hab two and a half meters deep and almost two and a half wide on the habitat’s circular outer edge, with a single porthole window facing the southwest. He pulled his suitcase inside

and closed the door. Will watched, disappointed he hadn't been able to set a time he and Sebastian could talk.

It didn't take Sebastian long to unpack. Ethel had made an attractive armoire from plastic sheets covered with fake mahogany finish. His eight sets of clothes went in quickly. He placed a few books on the shelf and pictures of his wife and two teenage sons on his desk. He pulled out his attaché—a computing and communications device—set it up on his desk, and checked for messages. Sure enough, his wife Angela had videomailed him. "Dear Sebastian, I'm so relieved you're down safely," she said in German. "We all watched it on t.v. What a beautiful landing! Best wishes, honey. We all love you."

"It was great, dad, please bring me a Mars rock!" added sixteen year old Helmut. He spoke in English; the family had been in Houston for four years. He looked off screen, then moved over to accommodate someone else.

"No, Kristoff won't come to the camera right now," Angela said to Helmut. "I'm sorry, dear. We're so proud of you! Send us a quick message when you can. Bye."

Sebastian smiled as his wife's picture faded. Kristoff still wouldn't talk to him; the thirteen year old was profoundly hurt that dad would be away for two and a half years. It hurt Sebastian, too; it was an aspect of life over which he had no control, and it was hard for him to accept anything he couldn't control.

He touched the reply icon on the screen and turned toward the attaché's camera. "Thanks, everyone. It's good to hear from you, but I noticed the email address didn't end in '.mars' again. Now that we've arrived, you need to add that so the message will reach us via the right internet node.

"I didn't have time to get scared, but if I hadn't been the pilot I might have been! The atmosphere is so thin, spacecraft fall through it like a rock. It always looked like we would crash in a matter of seconds. I'm not sure it looks that way on camera, though. I don't know how to describe Mars to you; being here is indescribable! It's hard to believe we can fly through a hundred million kilometers of *nothing* and land four meters from the center of a bullseye in the Valley of Dawns, which is itself whirling around the sun at its own incredible speed. Yet here I am safe and sound, in my room, breathing Earth air and bouncing along in Martian gravity. The ground outside feels kind of like a sand dune; your boots sink into it a bit, and they make a crunch. The air is pinker than I thought; it's been dusty here lately. I'm going to miss white clouds.

"Anyway, I need to catch my breath, then walk around this place and start organizing everything. Kristoff: all my love to you, and best wishes with the soccer game tomorrow. Helmut: don't forget your chemistry exam next week. Angela: I miss you more than ever. But I hope you will all be proud of me, because Columbus 2 will be the greatest scientific achievement in human history. That is my goal. I hope it'll make our separation worth while. Bye."

Sebastian closed the message and sent it. Then he turned the chair toward the porthole and took the luxury of staring at Mars for a minute.

Meanwhile, Will and Ethel helped Roger and Madhu move their six items of luggage—he was amazed they had been able to bring so much—from the great room to their apartment. The great room, their main gathering area, occupied the northern third of the habitat. Off it was the galley, bridge, and repair area; the stairs to the upper level were in the southeastern corner near the far airlock. The great room had four windows and

three skylights, which let in ample sunshine and provided a view of the escarpment twenty kilometers to the north. Each habitat accommodated six people. The six crew of Columbus 1 had used two such habitats and the eleven crew of Columbus 2 would have three. But the extra space was not a luxury; it provided redundancy in case one of their living areas depressurized and much-needed interior space to wander in or be alone in. It was an important antidote to cabin fever.

"Which way to our place?" asked Madhu.

"This way," replied Ethel. "We just finished building it last month." She pointed to the stairway that led to the upper level. All four grabbed a suitcase and carried it up.

The upper level originally had been a balcony opening onto the great room. It occupied two thirds of the habitat, but half of it had a ceiling too low to walk around in, so was used for storage only. Will and Ethel had the right half of the space with the adequate ceiling; Roger and Madhu the left. Their rooms were separated by a tiny room with a toilet, another room with a sink and a shower accessible to either couple, and closets. The rooms had been enclosed using metal support beams and plastic sheeting made of Martian materials, with plumbing and wiring added. It was Ethel's greatest construction effort to date.

Roger and Madhu looked at their room, which had a double bed, a table, a chest of drawers, two chairs, and bare grayish-white walls. "This has a lot of potential," said Madhu.

"We didn't add the wallpaper," said Ethel. "We had run out."

"We brought our pattern from Earth," said Roger.

“I think you’ll like it,” added Madhu. “It’s quite different.” She opened the door to the common bathroom and looked around. The sound of flowing water came out of a loud speaker; white noise to increase privacy. “I gather everything is set up and functioning?”

“Yes, Will and I have been using it for ten months. The plastic walls and floor have held up pretty well.”

“I’m looking forward to a lengthy shower and a chance to wash my hair thoroughly. I gather today—I mean this sol—we can take long showers?”

Ethel nodded. “This sol everyone can take as long a shower as they want. We’ll store the waste water for processing later. Once we have the third habitat and the two new greenhouses set up, we’ll have plenty of recycling ability.”

“We have to cover the new habitat with an ice layer for radiation protection, and it could be fifty tonnes of bath water as easily as clean water!” added Will. He pointed to the stairs and Roger nodded; they went down to get the remaining two luggage cases.

Ethel looked at Madhu’s hair. “Your hair’s beautiful.”

“Yes, and it’s almost twice as long as regulation permits. But it fits inside my pressure suit just fine. Don’t tell Sebastian, but I’ve decided I’m not cutting my hair while here on Mars. I’m growing it long.”

“I’m sure he’ll notice eventually.”

“He will, he’ll complain, and I’ll ignore him.” Madhu smiled.

Will and Roger returned with the remaining luggage. “It’s too bad the four of us are jammed together up here when there’s so much room in the other habitat, and there will soon be a third habitat,” said Roger.

“We didn’t have a bathroom to install for you,” replied Will.

“But one’s arriving later today, so we can build you a different apartment once the other basic tasks are done,” replied Ethel. “Will and I could convert this room into a living room. The big task is reinforcing Habitat 2’s attic with metal support beams all the way to the basement area. The three of us didn’t have time, and during dust storm season we had to conserve power, so we couldn’t make the materials.”

“I suppose we could remove a wall and convert two private bedrooms into one,” said Roger.

“But we’d have to cut the fabric and that would alter the habitat permanently,” said Madhu. “I suppose we want to avoid that. Besides, here we have a real closet.”

“Can I come up?” exclaimed Sebastian. They all replied affirmatively, so he hurried up the stairs. “So, this is married housing. You have a lot of space.”

“Not that much more,” replied Ethel. “These rooms are double the size of a single, though they do have closets.”

“But we’re staying long-term,” added Will.

“Long term? Just two missions. No one’s staying long term yet, it’s not in the mission plan.” He looked around. “Between the balcony up here and the basement underneath, we have an amazing amount of space inside these habitats.”

“We can roughly double the nominal space,” replied Ethel. “But it takes about six months of work, using our current technology and staffing, to set all of it up.”

“So, four habitats could house about forty-eight people?” asked Roger, impressed.

“Theoretically, but with no backup and a lot of cabin fever,” replied Ethel.

“That’s beyond specs,” added Sebastian dismissively.

“I have a solution for cabin fever; traveling outside,” said Roger. He looked at Sebastian and Will. “I know we’re not scheduled to do any serious geology for a few weeks, but surely we can do some sooner?”

“We could go to the escarpment,” suggested Will. “If you wanted a real quick adventure, we could hike up Little Colorado Canyon. We could go halfway and check the station there. If the oxygen tanks are in working order, we could recharge and continue up to the end of the canyon.”

“You finally made it up to the highlands, right?” asked Sebastian.

Will shook his head. “We got most of the way, but we have never finished the hike to Xanthe Terra. Some time, we need to improve the dirt track enough to drive a buggy up.”

“That’s not scheduled,” said Sebastian. “We’ll follow the mission plan. Columbus 1 sometimes deviated from it drastically, and that produced chaos in Houston. They’re Mission Control, not us. I’m sure we’ll modify the mission plan somewhat, but we’ll accomplish the nominal mission first.”

“Of course,” said Roger.

“There’s one other delicate matter,” added Sebastian. He turned to Will. “I assume you and Ethel plan to be extremely careful about avoiding pregnancy?”

Will was startled. “The answer is so obvious, the question is almost foolish. This is no place to bring a child into the world.”

“I quite agree,” said Sebastian tersely, irritated by Will’s tone. Will looked at Ethel; she was startled by the question. Madhu and Roger were unsurprised. “Well, I’m

heading to the bridge," said Sebastian. "The *Elysium* reaches apoapsis in six and a half minutes and needs permission to land." He headed down the stairs.

"He doesn't make a very good first impression," commented Ethel after he had left.

"Who does he think he is?" added Will.

"You'll get used to him," replied Roger. "I appreciate his meticulousness."

"I ignore him half the time," commented Madhu.

"That's because you were added to the training late," replied Roger. "The rest of us have accepted his approach to things. If we're all on the same page, this mission should go smoothly."

"I hope so," replied Will. "We'll let you settle in; we have things to do around the outpost."

"See you later," added Ethel. Will and Ethel headed out of the room.

Roger and Madhu were alone in their new room. He looked around. "Well, here we are. Did you ever think you'd see Mars?"

Madhu chuckled. "Being on Mars and feeling Mars around you are so different from anticipating and thinking about it."

"Isn't it?" Roger sighed. "Eighteen months. Quite an adventure."

"And we're together. That's the miracle; I never expected it!"

"We put your name forward at just the right time. Will and Ethel broke down more barriers than they know." He moved close to Madhu and she leaned toward him. They kissed.

A bit over an hour later, the shuttle *Elysium* landed at the Outpost carrying Monika Yevtushenko, their Russian exobiologist, and Armando Cruz, their American physician. Shinji drove over and brought them back to Habitat 1. Everyone welcomed the newcomers warmly. “Armando, we haven’t seen you since the launch of Columbus 1!” exclaimed Will.

Armando laughed. “Wasn’t that something? I floated around Columbus 1 with all of you twelve hours before the burn, and if you remember, I said I’d apply for Columbus 2 even if my wife killed me!”

“And here you are,” added Ethel.

“Yes, after a rather terrifying landing! But so far my wife is managing the separation alright; one kid’s in college, the other one will be next year, and my flight pay can almost cover the tuition!” He looked at Will and Ethel. “Columbus 1 was quite a social struggle. I hope we can do better on Columbus 2.”

“So do we. At least NASA has accepted the idea of married couples.”

“Roger and Madhu are *so* grateful for the two of you. They aren’t the only couple arriving, either.”

“Good,” said Ethel. “I think it’s easier to be here if you have a partner. Mars is a stressful place!”

“I’m so glad the two of you are married. Congratulations.”

“Thanks, my friend.”

Ethel leaned over and kissed Will. “We’re very happy.”

“We had a first year without any separations; that really helped,” said Will. “I feel like I know Ethel better than I ever knew my first wife.”

“I feel the same about Will and my first husband,” agreed Ethel.

“A happy marriage is the key to half of one’s success in adulthood,” exclaimed Armando. “Freud was asked what adults should be able to do well, and he said ‘love and work.’ Staying here, you were able to accomplish both at once.”

“For now,” said Ethel. “Two more years may be all we can handle.”

“There’s always the matter of children; I won’t quote Freud about that, but as a doctor and father I highly recommend them.”

Ethel smiled. “Maybe some day.”

Just then Shinji entered the habitat with Madhu, who was asking him about the greenhouses. “I’m anxious to take over the management of them as soon as possible,” she said. “Maybe before the *Apollonaris* lands this afternoon, we can go to the *Hadriaca* and get the plant and animal cabinets. The tilapia are not doing well. I think the tank you’ve got ready in Greenhouse 2 will be much better for them.”

“Sure,” said Shinji. “We’ve got four hours before they land.”

“Can you show me around the sick bay?” asked Armando. “I want to see where we can put the new equipment. Maybe we can use one of the extra bedrooms.”

“Glad to,” replied Shinji.

Just then Monika came out of her room. “Shinji, can you show me the biology lab? I’ve got lots of equipment on the way and we’ll need to plan what goes here and what goes in the new Mars Life Science Facility.”

“It should all fit in the facility,” replied Shinji, feeling pressed. He turned to his fellow physician. “Armando, let me show you the medical area, since it’s right here; then

I can show Monika the bio lab in Habitat 2; then Madhu and I can take care of the tilapia."

Madhu nodded. "That works for me."

"Okay, I'll unpack a bit more," added Monika.

Four more hours passed before the *Apollonaris* descended from Phobos, where it had been updating the fuel manufacturing facility, checking the scientific instruments, and conducting additional exploration. On board were the last three members of the expedition: Érico Lopes, a Brazilian geophysicist and computer expert; Paul Renfrew, a Canadian engineer and expert in using and maintaining Prospector telerobotically operated vehicles or "unmanned rovers"; and Carmen Segovia, a Spanish pilot and mechanical engineer. Roger drove over to fetch them; he couldn't stay in the habitat any longer. The arrivals walked around for a while, exulting in their landing on the Red Planet, then piled into the ranger.

"Habitat 1 is full, so the three of you will be in Habitat 2," said Roger.

"Good," said Érico. He smiled at Carmen. "Shall we be next door neighbors?"

She nodded in anticipation.

They drove to the Outpost, docked, and moved into their rooms. Soon all eleven human beings were walking around the Outpost, exploring the two greenhouses and two habs, then gathering in the great room to chat. Will and Ethel started to cook a big supper of imported frozen meats and other delicacies they had run out of, combined with fresh vegetables. Madhu helped; it took three of them because everyone else was socializing.

As the sun set, Roger and Érico came inside; they had walked to the top of Boat Rock, explored the crack separating it from Face Rock, and hiked along the base of Layercake Mesa. Habitat 1 filled with the smells of cooking. Ethel found a particular wedding present—a beautiful linen tablecloth that would go well on the long dinner table—and spread it. The food went on a buffet table and they all lined up to fill their plates, then sat to eat and talk. The great room filled with laughter, more than it had ever heard before, for Mars now had almost twice as many humans as it had during Columbus 1. Will looked at Ethel with a smile; it was thrilling to be part of a crowd after years of relative isolation.

"So, Érico, how was Phobos?" Will asked. The Brazilian was seated across the table from him.

"Fascinating, though in some ways it was anticlimactic, after our visit to 2029KM20."

"How was that?"

"Also fascinating. It wasn't as big as Phobos, but it was completely new, and had an interesting collisional history."

"We flew by a little asteroid on our flight out; fifty meters across."

"But you got the effort started," said Paul Renfrew. "And thanks to your effort to set up the Phobos fueling facility, on our trip home we'll be accompanied by a Lifter full of fuel, so we'll be able to land on 2015GH6."

"The transportation system's proved itself and there are twenty thousand rocks with flying between Earth and Mars to visit," noted Will. "What do you guys think of Martian gravity?"

"It's nice in a pressure suit," said Érico. "Traction's almost the same as on Earth."

"I'm still getting used to some tasks, like picking up spoonfuls of soup," said Paul. "You can spill pretty easily!"

"You go slow," agreed Will.

Ethel tapped him on the shoulder. "I think it's time for the transition," she said.

Will looked around. Everyone had finished eating and were drinking after-dinner coffee or tea. "Okay." He stood and looked to Sebastian, who had been waiting. The two of them walked to the end of the buffet table, where a small ship's bell stood in its frame. Will picked up a small metal baton and tapped the bell twice quickly, then repeated it. Two pairs of rings pealed out.

Everyone immediately stopped talking and turned toward them.

"As outgoing Commander, it is my pleasure to welcome all of you to Mars," began Will. "This is the second time the Outpost's bell has been rung. Before the Columbus 1 crew left Earth, Commander Laura Stillwell, an officer in the United States Navy, obtained the bell for formal and official occasions. The only occasion that came along, however, was a wedding. We would have rung it to mark the transition in command from Laura to me, but NASA, in its infinite wisdom, did not finalize the decision until Columbus 1 had left Mars orbit.

"For the last nine months, three of us have lived here at Aurorae. We've been running scientific tests on rock and soil samples, writing research articles, developing the greenhouses, and carrying out routine maintenance. I can't tell you how thrilled we are to see Columbus 2 arrive this sol. It's not just a matter of supplies. We had run out of coffee and tea, we were getting tired of rabbit and chicken, our underwear and socks were filled

with holes, the filters were getting old and were no longer filtering out all of the Martian dust we were tracking in, and the rangers were in need of new parts. But what you've really brought us is human company. The outpost is filled with laughter again. We hope the next eighteen months will see a lot of happiness and fellowship here, as well as lots of accomplishments. It took Columbus 1 about six months after landing to begin to gel as a team. It was painful, but also quite exciting to watch it happen. I pledge all my effort to help us build a strong, unified, collegial, fun-filled team. And now I turn the commandership over to Sebastian Langlais. Sebastian, not only do I wish you great success, but I pledge you my loyalty." Will reached down and picked up a leather-bound book Laura Stillwell had brought. "This is the Commander's Log. There are two pages of entries in here about the major events of the outpost. I've added half a page more, including a paragraph about the landings this sol. Commander Langlais, I now turn this book over to you."

"Thank you, Commander Elliott." Sebastian took the book and everyone applauded. The two men shook hands. He opened it briefly to glance at the entries, then put it down on the table next to the bell. "My friends, Mars now has eleven personnel and we have eighteen months of work. I echo Will's wise comments about the importance of building a strong, efficient, unified team. I hope we can accomplish that quickly during the set-up phase. The shuttles have landed 31 tonnes of equipment, consumables, and spare parts. We have six weeks to unload and deploy them, then two automated cargo vehicles go into Mars orbit with 31 more tonnes of stuff. But we have twice the personnel of Columbus 1, so we'll finish the work faster.

“Then the science phase begins. The Outpost needs two to three people full time to keep it running. The members of the Columbus 1 crew can handle the bulk of that task, freeing the newcomers for exploration. We’ll keep the vehicles exploring as much as the specifications allow. We’ll advise Mission Control about some very important decisions: do we send out two vehicles or all three; how long will they stay out; do we explore north, west, south, east, or a combination thereof. The mission plan provides fascinating choices. As long as we work closely with Houston, we will do well. The results will surpass Columbus 1, I am sure.

“Now, I understand we have a program of entertainment. Madhu?”

Sebastian stepped down and everyone applauded. Will glanced nervously at Shinji and Ethel; they had never been asked to spend most of their time at the outpost.

Madhu Gupta-Anderson stood at her chair. “We do have a few brief acts. Érico has promised to sing, and I am pretty sure I have convinced Sebastian to play the violin. As you may know, he has brought a Stratavarius. And by popular demand, I will perform a classic south Indian dance. After that, I suggest Will and Ethel pull out their wedding presents and open them. We can watch and applaud.”

Everyone nodded. Will looked at Ethel about that suggestion and she nodded as well. But there was a worry in her eyes.

2

Delegation

April 17-18, 2038

The next sol the two rangers headed to the shuttles to continue unloading them. On the landing sol—April 16, 2038—they had hauled two tonnes of consumables and personal property to the outpost. The next morning they unloaded the heaviest items—Habitat 3 on board the *Hadriaca* and the Mars life science facility on board the *Apollonaris*—and hauled them to the outpost on their wheeled trailers. While some crew returned to the shuttles to unload equipment, others turned to inflating the two structures.

"I don't know what we would have done without all the preparation you and Ethel did," Roger said to Will that night. They were catching their breath after hauling the new mass spectrometer through the airlock and setting it in Habitat 2's Geology Lab.

"We learned a lot when we set up Habitats 1 and 2, and we had nine months to bulldoze and prepare the holes for Habitat 3, the life science facility, and the greenhouses. Ethel was able to manufacture metal I-beams, verticals, crossties, screws, and plastic panels. And we knew the order to do things in."

"I'm amazed that we can already walk through the greenhouses and into Habitat 3!"

"Inflating the Hab is easy and quick. Reinforcing its walls and floors with hard plastic panels and metal supports, snaking in the plumbing for water and sewage, attaching the life support and pumps, adding wallpaper to make everything pretty and reduce the danger of fire, arranging the furniture: that's three person-months of work!"

“Not to mention setting up the greenhouses and the life science facility. Taking the well-developed soil in Greenhouses 1 and 2, bulking them up with new materials, and spreading the mix among four greenhouses will take a lot of time!”

“At least we’ve been composting and bulking up the soil for months,” added Will.

Just then, Carmen stepped out of a bedroom in her bathrobe, walked across the geology lab—into which all of Habitat 2’s bedrooms faced—and entered another bedroom. Will nodded a hello to her and she nodded back, then he turned back to the mass spectrometer. But Roger was uneasy. “She’s sleeping with Érico. They were together on the flight out, too.”

Will nodded, not wanting to discuss the matter further. That displeased Roger. “I wish people would follow the old regulations, even if they don’t seem to apply very well, not to mention common decency. Carmen’s married, after all.”

Will was startled by that. “I’m not one to pry into these things.”

“Oh? You and Ethel rejected the behavior of Commander Laura Stillwell and Assistant Commander Sergei Landsberg.”

“I wouldn’t say ‘reject.’ We didn’t emulate them. When you have a crew of only six, the Commander and Assistant Commander can’t take off for the night and leave everyone else. Their affection for each other was not as much of a problem as their occasionally clouded judgment and their avoiding each other after they broke up.”

“If they’d followed plain biblical morality, the whole mess could have been avoided. I gather you’re a religious person, as a Bahá'í, so I know you understand that.”

“I do and I agree, but Bahá'ís don’t push their moral values on others. For example, we don’t drink alcohol, but if you have a beer I won’t get upset with you because I don’t expect you to follow that particular ethical principle.”

“But what about adultery? I wouldn’t be quite so upset if she were unmarried, but that isn’t the case.”

“You can always talk to them or to Sebastian.”

“Sebastian?” Roger laughed. “He’d kick me out of his office!”

“Well, there you go. I won’t kick you out of anything, but there’s nothing I can do, either.”

“I suppose,” growled Roger.

The next morning Ethel gave Paul Renfrew a thorough tour of the plastic and metal-making facilities, since he was now in charge of them. “For a small facility, this equipment has really been quite good,” she said. “Over two years I’ve made eight tonnes of plastic sheets and special items, like cups, sample bags, and soil trays for the greenhouses. The metal working facility has been used less, but that’s been enough to make three tonnes of metal beams, pins, forks, etc. When we run either one, we draw so much power we have to run the fuel cells in the shuttles. That won’t be necessary once we set up two more solar power units.”

“How familiar are you with the cargo manifest?”

“I helped finalize it. The new metal processing unit and metal-working tools should complement the carbonyl unit well and greatly increase what we can do with the metal we make. Set-up will take about a month. I’m very interested in using the new

chemical synthesis unit; it'll greatly broaden our capacities. I've never been satisfied with the glues we could make here because of the fumes they emit. But now we have enough extra oxygen to purge the contaminated air. Being able to make more advanced chemical feedstocks will greatly increase the capacity of the plastic making unit."

"It's very exciting," agreed Paul. "The new industrial facility will allow us to house these units in a much more convenient space. We'll have plenty of room for items to cool and be stored, too."

"That will help a lot."

"I can't imagine how you made all the plastic sheets in a space barely longer than the sheets! I gather you really want to be involved in running them?"

"Definitely. I've really enjoyed it. You can see how much I like construction."

"Good. Because I was sent here to do several jobs. One was to run the plastic and metal-making units. Another was to repair and run the Prospectors. Prospectors are my passion; my doctorate was in robotics. So I'm perfectly happy letting you handle chemical, plastic, and metal synthesis and fabrication. If we have someone devoted full time to that area, we could make a lot of useful items."

"Definitely. The greenhouses' needs are nearly inexhaustible. The new equipment on its way includes better catalysts, so we should be able to make higher quality plastics. The metal synthesis equipment allows a much wider range of production, tighter control of the characteristics of the resulting metals, and the new lathe allows more precise cutting. In a few months we'll have some very powerful capacities and the power output to run them; we just need the human resources."

"Well, I think we now have that."

Ethel smiled. “Thank you, Paul, you’ve made my day! I was concerned that my responsibilities would be limited.”

“I wouldn’t want that. We’ve got eleven people here; we need to use all of their abilities. We need plastics and metals *and* as much time as possible devoted to the Prospectors; I can’t run all eight of the functioning ones, and there are two broken ones to recover and repair. So I’m glad to give you the work you want, because it’s not what I want to do!”

“I’ll consult with the experts in Houston and draw up a plan for manufacturing over the next eighteen months.”

Paul nodded. “Yes, Sebastian will insist on that.” He turned and headed to his work area while Ethel turned back to her equipment. So many possibilities! The sunwing hanger had to be extended to accommodate a third aircraft. That required about a tonne of additional metal parts. Will had talked about making a large metal water storage tank insulated under a meter of regolith to improve their water supply. There was even the possibility of making pressurized buildings.

She was still thinking about the possibilities that evening when Will, Roger, Sebastian, and Monika returned from a day-long field trip to Little Colorado Canyon. Sebastian had grudgingly permitted it because it was Sunsol. They raved over the natural beauty of the place during supper, held in the new dining area in Habitat 3.

“I had no idea that Mars was *beautiful*,” exclaimed Roger. “It’s like Earth!”

“What, the moon’s not beautiful?” asked Monika, who, as an exobiologist, had been there only briefly for Mars training.

“It’s very different. Softer, rounded; very little cragginess, few cliffs, and no canyons.”

“Oh, I don’t know,” said Will. “I saw some pretty spectacular slopes on the moon. Tycho’s rim is very impressive. The Mountain of Perpetual Sunlight is dramatic.”

“Perhaps.” Roger was irritated by the contradiction. “I’m glad the Outpost is in an area with dramatic scenery. The escarpment is a spectacular thing to look at.”

“It is,” agreed Will. “You should see it in Gangis, where it’s even higher. That’s one reason I think we should explore up canyon as well as down canyon; the escarpment in Melas and Ius is up to six kilometers high!”

“We’ve already got some sunwing reconnaissance there,” replied Roger, shaking his head. “No, our destination must be northward: Chryse and the old ocean bottom of Acidalia Planitia. We need to haul a driller along and see whether it penetrates into ocean sediments or even ice. That’s the place to find life, alive, frozen, or dead.”

“Don’t forget the methane emission in the central Mariner Canyons,” replied Will. “It may reflect residual spring activity and life, too. I’d favor exploration in both directions, and maybe southward as well; we need to penetrate through the chaotic terrain and reach the southern highlands. Then vehicles can range freely to Argyre and Hellas, and maybe the south pole itself.”

Roger shook his head adamantly. “Columbus 2 is heading north.”

“Don’t you think some consultation and give and take would be helpful?” asked Will, his voice rising. “We don’t have to put all our eggs in one basket. We can explore a substantial distance northward, but still travel eastward and southward as well.”

Roger looked at him, then shrugged. Sebastian leaned forward. “Will, we can talk about this later. But Roger is in charge of exploration. He makes the call.”

“Oh? I was unaware of that,” replied Will, surprised.

“I haven’t made the administrative chain clear? Roger’s in charge of exploration. Madhu’s in charge of the greenhouses and Paul of manufacturing.”

Will nodded, trying not to look too surprised. Ethel had no problem looking surprised. Everyone else was silent. There was very little talking for the remainder of the meal.

Will and Ethel left Habitat 3 and went back to their room on the balcony of Habitat 1. Before they could talk, there was a knock on the door.

“Shinji. Come in.”

Their Japanese friend entered. “Will, I don’t know about you, but I’m furious. I haven’t been this angry in years. I’m ready to go tell Sebastian off.”

“I almost wanted to, too.” Will shook his head.

“Have we been totally disenfranchised?” asked Shinji. “I don’t even know what I’m supposed to be doing. I can’t do medical work because Armando wants the sick bay. Monika controls the Bio Lab now, so she controls Mars life science. And Madhu is in charge of horticulture.”

“We’ve got to straighten that out,” said Ethel. “It’s ridiculous. There are only eleven of us here; we don’t need to have four serving as bosses. Everyone can report to Sebastian. Shinji, I think you should be able to choose what you do. You’ve been here two years, after all; you have seniority!”

“The irony is that the people with seniority are the people with no say,” said Will. “We’re being treated like we’re an appendage to Columbus 2.”

“Which is no way to get people to stay more than one cycle!” exclaimed Ethel.

“I don’t think NASA wants people to stay more than a cycle or two,” said Shinji.

“I’m lucky,” continued Ethel. “Paul told me that he’d leave metals, chemicals, and plastics completely to me because he wants to run the Prospectors.”

“And he’s good at that,” added Will. He looked at Shinji. “I guess we have to go talk to Sebastian.”

“Tomorrow morning after breakfast?” suggested Shinji.

Will nodded. “Sounds good to me.”

The next morning the three of them were quiet at breakfast. Will yawned several times; he had not slept well.

Sebastian was the first one to finish breakfast and hurried to the bridge in Habitat 1. A few minutes later, Will and Shinji followed. The Commander was already hard at work reviewing the outpost’s inventory, dictating notes to secretarial assistants on Earth.

“Sebastian, we need to talk to you about something,” Will said.

Langlais scowled, irritated to have his careful work interrupted. “Maybe you can make an appointment for 11 a.m.? I’ve got a line open to the inventory manager in Houston. We’re reviewing the database and cleaning it up. The inventory here was in real disarray.”

“There was practically nothing left to inventory, and we knew where all of it was,” replied Will.

“Be that as it may, now we have to maintain a careful and detailed inventory, and I’m in the middle of the task.”

“This is rather important.”

“Eleven o’clock.” Sebastian said insistently.

“Alright.” Will and Shinji turned away, and as they walked to their work areas they grew more and more angry. It was impossible to get any work done while waiting. They returned almost three hours later, at eleven. This time, Sebastian was conciliatory.

“I’m very sorry I couldn’t meet with you earlier, but the Inventory Manager had to leave the office at 10:40 a.m. our time. It was our last chance this sol to work together. Now, how can I help you?”

“I’m not sure where to begin,” replied Will. “Aurorae is an outpost of eleven people; it isn’t a town of eleven thousand or a city of eleven million. In my experience, efficiency is enhanced by having relatively little administrative structure. So I’m not sure we gain by having directors of exploration, manufacturing, and horticulture.”

“And I’m the prime example of the problem, because my work has always fallen in three areas: horticulture, medicine, and Mars life science,” added Shinji. “Right now I have three different bosses, and they either want me to serve as their laboratory technician or go work for someone else.”

“Has anyone actually said they want you to serve as a lab technician?”

“Not in so many words.”

“We do have a problem. The eight of us trained together and divided up all the mission’s tasks before the three of you decided to stay. We discussed that last summer.”

“But Sebastian, there are now eleven of us, not eight. The tasks have to be divided up fairly among all of us,” objected Will.

“That’s my job, of course.”

“We didn’t say it wasn’t,” replied Shinji, irritated.

“Alright. What do you want to do?”

“Life science is what I like the most. We don’t normally need two physicians. We can manage with one horticulturalist supplemented occasionally by outside help.”

“I’m sure there’s plenty of work for two exobiologists.”

“Of course, and now we have the equipment.”

“I’ll talk to Monika. She’ll remain in charge of the facility, but in practice it has to be shared equally by both of you.”

“Thank you, Commander,” said Shinji. “But what about Will?”

“I’m not sure what Will’s problem is.”

“We had a discussion last night, with Roger,” replied Will. “I don’t want to be unreasonable, Sebastian. I don’t have any objection to Roger’s goals. But I am concerned that he thinks he can make all the decisions without listening to anyone else. We have to explore the Marineris canyon system, not just escape from it. NASA could have set up the outpost in Chryse if it had wanted to focus on northward exploration. And I don’t see why there isn’t time for both.”

“There might not be,” said Sebastian. “The exploration team has to follow the standard exploration protocols. If it’s going to push to the edge of the northern layered terrain, it has to clear a route four thousand kilometers long; maybe five thousand when you add twists and side trips. That’ll take our entire mission at fifteen kilometers per sol

and every other month off! Furthermore, we're two months past northern spring equinox, so we must start as soon as outpost setup is finished."

"We have to accelerate the rate of exploration. With three sunwings we can fly supplies to the expedition; we can even rotate crew. Expeditions can go for longer than a month. With three vehicles there's greater safety and three bulldozer blades will make faster progress on clearing a route. The conestoga represents a significant increase in living space, comfort, and lab capacity. A continuous expedition could get to the northern layered terrain in nine to twelve months."

"But the sunwings aren't passenger rated and we don't have permission to stay out longer than a month. Mission Control would have to approve changes to the protocols. I'm not opposed to minor changes; without them we can't even get to the layered terrain, just to Acidalia Planitia and the old ocean bottom."

"I can see that the ocean bottom should get some priority; Martian life is the issue driving exploration. But don't forget that the central canyons have an escarpment over six kilometers high. That's quite a gash in the crust; quite an exposure of geological time. We may learn more about life on Mars by finding earlier fossils there."

"It's a gamble," conceded Sebastian. "The extended mission profile includes a expedition to Ius Chasma. But it's Roger's decision and my call. I assume you want to participate in the missions? Otherwise, I could reassign you to the Outpost. You could help with horticulture or play a supporting role."

"Of course I want to participate! Ethel and I have talked about trips of several months duration. If she comes along to do repairs we could stay out even longer."

“Commander, you’re slipping back into the idea that we should just play a supporting role,” noted Shinji, gently.

Sebastian’s eyes flashed. “It is my prerogative to decide who does what task. The eight of us had initiated our working relationship a year before the three of you decided to stay here. It’s hard to accommodate you now.”

“Considering we have seniority here, it would be helpful if you could reconsider some of those relationships,” asserted Will.

“There is no seniority on Mars; we’re not settling this place, just visiting. As for work assignments, I’m Commander and I decide,” replied Sebastian abruptly.

3

Expedition

mid April to late May, 2038

It was pointless for Will to stay angry at Sebastian and Roger; it wouldn't change anything and there was too much work to do. After thorough discussions with Houston—but none with the other residents—Sebastian surprised everyone by announcing a plan for reorganizing the outpost. The great room of Habitat 3 became their main space for eating and socializing; its kitchen was enlarged accordingly. Part of Hab 1's great room became a facility for running Prospectors and part was added to the bridge. The former geo-bio lab was partitioned to create an expanded medical facility. Two bedrooms became medical offices and a third became an examining room; Shinji and Sebastian moved their bedrooms. Hab 2's great room became the new geology facility, with some of its bedrooms converted into offices; part of its geobio lab became a horticultural lab. A team reinforced the balcony of Habitat 2 and enclosed a two-room apartment for Roger and Madhu, leaving Will and Ethel with the two rooms on Habitat 1's balcony. Everyone wallpapered their rooms with a fresh design.

Setting up Habitat 3, the life science facility, the new greenhouse, four new docking units, airlocks, and one transfer tunnels, plus modifying Habitats 1 and 2 took the eleven of them five weeks, barely beating the nominal six-week schedule. The automated cargo vehicles were not due to arrive at Mars for another week, so the crew turned temporarily to scientific and other tasks.

Roger agreed to a three-sol expedition southward to the chaotic terrains that Will led. It was an ideal chance for him to introduce the arrivals to Martian field geology. When they returned, the first automated cargo vehicle had aerobraked into Mars orbit and the *Elysium*, crewed by Sebastian and Paul, was ready for launch to retrieve the contents. After the shuttle blasted off, two rangers towing portahabs headed eastward for another three-sol expedition to the mouth of Gangis Chasma, and they pushed farther eastward along the northern escarpment of Aurorae for an additional thirty kilometers.

They returned just before the *Elysium* landed. It brought fifteen tonnes of cargo, including their first conestoga, a special eight-wheeled, six-tonne vehicle similar to a terrestrial mobile home. Its loft sleeping cubicles, main cabin, hygiene area, and rear science lab normally accommodated four, but could support eight in an emergency. Thoroughly tested on the moon, it was an exciting addition to their exploration capacity.

But the inflatable vehicle and its telescoped chassis was immensely complicated to set up. Rolling it out of the cargo bay was impossible at first because one tire had cold welded to the braking system. Inflating the vehicle expanded it to its full size, but for two frustrating sols they couldn't get the chassis parts to align and bolt in place. Its cabinets, furniture, and loft sleepers took two weeks to install. Its automated docking system with steerable, inflatable ribs proved very tricky to use properly and leaked air.

While they assembled the conestoga, the *Apollonaris*, with Carmen and Érico on board, blasted off to pick up the second automated cargo vehicle's contents. They endured three sols of stubborn problems transferring the cargo pallet to the hold of the *Apollonaris.*. After they landed at the Outpost, four sols were consumed unloading the cargo.

When they had everything set up and connected, the eleven of them couldn't help parading from one end of the Outpost to the other. It was up to seventy-eight meters long and thirty wide, big enough to allow a lot of walking around, with plenty of spots for solitude. Anchoring the southern end was Habitat 1, with Habitat 2 north of it, then Habitat 3. Each circular habitat had an airlock on its eastern and western sides, to which were attached docking units. Greenhouses 1 and 2, transparent Quonsets twenty-two meters long and eight wide, connected the first two habs together on their east and west sides respectively via their docking units; Greenhouses 3 and 4 did the same between habs 2 and 3. Extending northward from Habitat 3's eastern docking unit was the industrial facility: two docking units, three meters squares to which the chemical, plastic, and metal processing units were docked. A plastic transit tunnel ran northward from them to the east end of the Mars Life Science Facility, an inflatable Quonset twelve meters long, six wide, and six high. Another plastic tunnel connected the LSF's western end to the western docking unit of Habitat 3, giving it entrances at each end.

They still had weeks of set-up to complete, but the work no longer required everyone. That night after dinner Sebastian rose and said, "It's now May 28. On Earth, the spring semester is ending. Every planetary geologist and exobiologist who can is heading for Houston, Paris, Moscow, Brasilia, or Tokyo. Industrial engineers, horticulturists, and space medical researchers are on their way as well. Are we ready for them?"

"Horticulture is ready for them," replied Madhu. "When we arrived, Shinji and Ethel had prepared enough soil to set up Greenhouse 3 immediately. Greenhouse 4 will be operating by the end of the summer. A team of twenty scientists in Seville is ready to

follow growth experiments with ten different plant species, and we've started growth experiments with tilapia and rabbits."

"How are the tilapia, anyway?" asked Ethel.

"They're recovered from the cramped environment and artificial gravity of the ITV and growing pretty well."

"Ethel and I are going to need help," said Paul. "We have to put together sunwing 3 as soon as possible. The hanger has to be enlarged to accommodate it, which requires a lot of metal and plastic parts and filling more sandbags to build up the hanger's walls. Sebastian, we'll need your help when you're here. We'll need three people full time."

Sebastian nodded. "We'll assign you a third person whenever we can, but you'll also have to handle routine maintenance. Standard exploration protocol is to send out six people in three vehicles; we don't have permission to reduce it to five. That raises the question, where will we go?"

There was silence while Roger looked at Will and Will looked at Roger. Finally Will said, "Most of the scientists in mission control want a northward expedition and this is the season to go, so I support that plan."

Roger beamed. Will raised a finger. "But there is a caveat. We need to try new exploration strategies that can cover more ground. With them, a northward expedition is possible with enough time left for a southward or eastward expedition. Without them, we'll barely finish the northward trek."

"No caveats," said Sebastian, shaking his head. "We have to stick to standard procedures. No short cuts on safety."

"Sebastian, the exploration protocols are based on the experience of Columbus 1, when we innovated new strategies. If we hadn't done that, we'd still be using lunar protocols based on a two-week day-span and we'd be heading for Gangis."

Sebastian scowled. Roger said, "What strategies do you have in mind?"

"We tried month-long expeditions on Columbus 1 and they worked well. But it's really a modification of the two-week expedition protocol developed on the moon, which called for everything to be back at base before nightfall. There's no reason expeditions can't go out for two or three months. The rangers and portahabs are immensely reliable. In the month-long trips we averaged one shut down of a fuel cell out of six on one ranger. Once we had to shut down one wheel motor out of six. If we send six people along we'd have robust repair capability."

"How about limitations of fuel and supplies?" asked Roger.

"We've got new capabilities. The water extraction tents didn't work very well for Columbus 1, but the new water extraction equipment is supposed to be better. If the new regolith oxygen extractor works we may be able to obtain much of our oxygen as we go and haul more methane. But even if they don't work well, we now have three sunwings that can airdrop 250 kilogram blocks of ice and packs of food. We can make plastic packing materials to protect them from the impact. And we can send a solar power unit along. The new ones can be set up more quickly and even if they are less efficient at higher latitudes, they'll still make between 1,200 and 1,800 kilowatt hours per sol."

"Is that enough for an expedition?" asked Madhu.

"Approximately. A ranger, bulldozing for eight hours and driving four hours more, consumes five hundred kilowatt-hours. I'd send two; one to pull a portahab and

one to pull a supply trailer. A portahab needs one hundred kilowatt-hours per sol for its life support systems. I'd send one. A portahab needs one hundred kilowatt-hours per sol for its life support systems. I'd send one. That raises daily consumption to eleven hundred. A conestoga needs five hundred kilowatt-hours for driving eleven hours and running life support. So now the total's sixteen hundred kilowatt-hours per sol. Prospectors only need ten kilowatt-hours per sol. We can haul a solar power unit, spare methane and oxygen, water and supplies, and three Prospectors on a trailer. The Outpost will have four buggies and a portahab for local expeditions."

Sebastian face was expressionless; Will couldn't tell whether he was considering the ideas of preparing a rejoinder. Roger said, "You operated the rangers only five hours a sol on Columbus 1, and this plan calls for twelve hours."

"On Columbus 1, whenever there was extravehicular activity, route-clearing stopped. Both rangers sat while two or more of us explored. But with three vehicles, the conestoga can stop with the explorers—two or three people outside and one inside to provide emergency backup and run the Prospectors—while one ranger pushes the trail forward and the other follows with the portahab and cleans up the trail. When the explorers finish their EVA, they'd jump into the conestoga and catch up. That doubles the trail-clearing time.

"I'd divide each sol into three periods of three and a half hours each. Each crew would spend two periods bulldozing the route and the third stopping to explore or do chores. The result will be a higher quality trail—probably one rated for forty kilometers per hour—and thirty kilometers of new trail per sol, rather than fiften. Assuming six sols

of exploration a week, that's 180 kilometers per week. The 4,000 kilometers to the northern layered terrain can be accomplished in twenty-two weeks of field work."

"You're calling on people to work ten and a half hours a sol, though," said Sebastian.

Will shook his head. "Not necessarily. Driving will require seven hours times three drivers or twenty-one hours. If we have two pairs of people outside for three and half hours each, that's fourteen hours more. That's a total of thirty-five hours; divided among six people, that's less than six hours each. Food preparation, sample logging, reports about each stop, etc., will push the total to about eight per person."

"And where will the solar power unit be, all this time; deployed in the trailer?" asked Roger, skeptically.

"At a home base. We'd set it up, run it remotely for a week, and let it make oxygen and methane. Leave the extraction tent there to extract water and oxygen from the regolith. After a week, one ranger would go back with the trailer and portahab. It'd travel the 180 kilometers of new route in five or six hours and pack up the home base. The next morning it'd drive back to the other vehicles, refuel them, and they'd set up a new home base."

"That'd work," said Érico, impressed.

"It's cobbled together from various elements," snorted Sebastian.

"Most of the elements have been suggested before," replied Will. "They aren't in the protocols. But most of the items in the protocols now weren't there when Columbus 1 landed. Committees on Earth can brainstorm all sorts of scenarios and draft all sorts of proposals, they can test them at Devon Island, but we're the people feeling the vibrations

of the steering wheel in our hands and the ache of fatigue in our bones. We're the ones to decide what works here in practice. I'm not proposing that we try them all at once. We should try new strategies one by one and gradually develop a new set of protocols best suited to our resources."

"Are you assuming that once the mission sets out, it doesn't return until it reaches its destination?" asked Ethel. "Because it could be quite a hardship living in a portahab and a conestoga for six months, even with the bigger space the latter provides."

"No," replied Will. "I'm assuming we'll use the sunwings. Every fifteen hundred kilometers we'd fly down a half tonne of solar panels, a water tank, a methane tank, an oxygen tank, a fuel cell, and a Sabatier reactor. It'd take four flights. The crew will set them up as an 'oasis.' That way when the expedition has to drive back to the Outpost, it can refuel every fifteen hundred kilometers. It would take a vehicle three sols, driving at forty kilometers per hour during daytime, to travel fifteen hundred kilometers. So two vehicles could return to rotate crew, then turn around and drive back, refueling as they went. It would be even faster and easier if the sunwings are rated for human use. A sunwing could fly two people fifteen hundred kilometers in about ten hours."

"It'd be a long relief flight from the northern layered terrain!" exclaimed Roger.

"Faster than on the ground. A four-thousand kilometer flight would take twenty hours. They could always land halfway in between at an oasis, stretch, and do routine maintenance for a few hours. The sunwing's cabin is big enough for standing and sleeping, so it wouldn't be too bad."

Roger looked at Will respectfully. Sebastian was more cautious. "That's an intriguing proposal. As you say, many of the elements have been suggested."

“We have to test them. The real key is the sunwings. Now that we have three of them and two have flown flawlessly for two years, we know they’re reliable. Sunwings could provide the expedition with all the methane and oxygen it needs; four flights a week. The solar power unit is a much better option, though, and a flight every week or two to ship fresh vegetables to the expedition and haul samples back to the Outpost for preliminary analysis is a better use of them.”

“Sunwings 1 and 2 need a lot of maintenance,” reminded Ethel. “Both of them have two nonfunctioning motors, and two other motors on one sunwing and three on the other are partially nonfunctional. But we now have the spare parts to fix them.”

“And sunwing 3 has new high-efficiency solar panels providing twenty-five percent more power,” added Paul. “It can haul more cargo at a higher speed.”

“All three sunwings will be in good condition in a month,” agreed Sebastian. “Even if the expedition sets out tomorrow, it won’t need a sunwing flight for several weeks.” He looked at Roger. “What do you think?”

“We should try the ideas one at a time. I’d send out the conestoga, two rangers, a portahab, and a trailer with the solar power unit, just as Will suggests. We can try the new water and oxygen extraction equipment as we go. The crew rotation plan should be tried.”

“What I ask is that if these strategies work, we devote some time to exploring either eastward or southward,” reminded Will. “Columbus 2 shouldn’t just be about exploring lowlands. It also has to explore the canyonlands or the southern highlands. We should try to reach some volcanics as well.”

Roger laughed. “So, do you want to drive onto the Tharsis Plateau?”

"Keep in mind that Columbus 3 might," persisted Will. "We can make it easier for them. We have to think long term."

"I'd leave the long term planning to Houston," exclaimed Sebastian. "But I agree, with this, Moonman: if the northern expedition reaches its goals and there's still time, we'll go southward or westward. The geologists on Earth will be chomping at the bit for an expedition in about three sols, so let's focus on preparing for a trip northward down Simud Vallis to Chryse. The route needs to be reviewed; the new data from the sunwings may require changes in the route or the proposed stops. The rangers need maintenance, the conestoga needs breaking in, and there's a lot of packing to do. We need to decide who's going. We'll settle when and how they rotate back later. I'll tell the geologists in Houston they can start on the route review and will put together the crew manifest. Ethel and I can work on rangers 1 and 2. Paul, can you set up the trailer with the solar power unit and supplies? Roger and Will, can you update the supply manifests?"

Everyone nodded. Sebastian smiled a slight, wan smile. "Great. We have a plan."

The meeting began to break up. Will and Ethel headed for their room to watch a bit of television and relax before going to bed. They walked to Habitat 1 through the greenhouses, which were now enclosed in thermal blankets for the night. They didn't speak until they reached their room.

"Did you notice that Sebastian asked the men whether they could do certain tasks, but told me what to do?" she said.

Will was startled by her comment. He thought for a second. "You're right. That was sexist."

"I'm afraid so. But at least he decided to try your ideas."

“I was wondering which would win out inside him: his desire for great accomplishments or his anal desire to stick to the book.”

“I’d be careful, Will, showing him up in front of everyone else.”

“Well, someone has to have vision!”

“I wish they had made you Commander; but then, NASA doesn’t want us to be too innovative because they’ll end up in a support role.”

“That’s the problem; they’ll lose control.”

“I’d like to go along on one of the expeditions, especially if the crew stays out more than a month.”

“We could have our own ranger.”

“That might be interesting,” Ethel considered. “Good scenery, too.”

“Yes, though northern Chryse gets pretty flat and boring.” He shrugged. “Let’s drop this subject, turn on the t.v., and relax.”

4

Chryse

early June, 2038

Four sols later, Expedition North 1 set out. Roger and Paul led in a ranger; Will and Shinji followed in a ranger pulling the portahab and trailer; Érico and Carmen drove the conestoga. They proceeded at forty kilometers per hour until they reached the end of "Route 1," which took three hours; Columbus 1 had cleared only a hundred-twenty kilometers of trail to the east.

They immediately tried the procedure Will had proposed: the lead ranger, which had a bulldozer blade 4 meters wide, bulldozed a trail, stopping and backing up to clear it better when necessary; the second ranger smoothed it and widened it on the left side; and the conestoga followed behind, cleaning up rocks and irregularities with its light bulldozer blade. They proceeded at walking speed. The Martian surface consisted of rolling stone fields with scattered small dunes and craters; obstacles were easy to avoid. The ssunwing had already photographed potential routes at a resolution of ten centimeters and a NASA team, using a program that digested the pictures and proposed a tentative route, selected the straightest path that avoided boulders and craters. The lead ranger's passenger served as navigator, directing the driver to the right or left based on the optimum route projected onto the screen in front of him. In an emergency a vehicle could drive as fast as sixty kilometers per hour on the trail, though the maximum design speed was forty. Once the trail was well photographed and smoothed, vehicles could drive themselves robotically up to thirty kilometers per hour; slower than a human driver, but they could continue day and night.

They didn't stop for lunch; there was no need because each vehicle had two on board. Will turned the wheel over to Shinji and pulled out sandwiches. At 2:15 they reached a kilometer-sized crater that had punched a deep hole in the bedrock. The expedition stopped long enough to drop off Roger, Will, and Érico; Carmen remained in the conestoga to drive the Prospector accompanying them; Paul and Shinji continued clearing the route in the two rangers.

The three men activated their helmet cameras so that anything they saw was broadcast back to the geologists on Earth, then trudged up to the crater's rim, describing as they went. The hole was about the size of Arizona's Meteor Crater and of similar depth; it had the remnants of an early Hesperian pond on its floor, including grayish salt deposits. Will pointed. "We can get down to the bottom over there. Follow that broad slope down, past the cliffs; then around the next cliff; then follow that natural ramp to the floor."

Érico nodded, but Roger kept looking, then pointed. "This is closer. We won't have to walk half way around. The slope's a bit steeper, but we can manage it."

"The Prospector won't, though," noted Érico.

"It'll catch up," replied Roger.

"Okay," said Will, reluctantly.

They started down. "How many craters like this have you been in?" asked Roger.

"Maybe twenty on Mars and twenty on the moon."

"About the same total as me," said Roger. "It's possible to do more exploring here. On the moon, you can't do anything two weeks a month and you have to worry about radiation exposure."

“You have to watch that here as well, but less,” replied Will, wondering why Roger was making small talk. He stopped and flipped his binoculars down in front of his eyes to scan the various layers exposed on the opposite side of the crater. “These are pretty standard strata. They’re basically the same ones we see in the walls of the craters near the Outpost. This part of Aurorae was scoured pretty deeply, then back filled with flood deposits.”

“Conglomerates, arkoses, and occasional sandstones,” said Érico.

“In a few places there are interflood deposits: volcanic ash, sand dunes, and crater ejecta. But they’re rare,” said Will. He pointed. “Right there, for example; that white streak is probably an ash fall. Very rarely we’ll find interflood shales.”

“With microfossils?” asked Érico.

Will nodded. “Usually. Any standing body of water seems to have had an ecology, even if it froze solid often. Even the flood waters had microorganisms in them. Sift through the fines in an arkose and you’ll find microfossils. We didn’t figure that out for almost a year, though; we didn’t recognize them.”

“Let’s check out the ash layer,” suggested Roger.

The three of them carefully walked down the slope to the whitish layer, a mere centimeter thick and about twenty meters long. They also spotted a lens of interflood deposits twenty meters long and up to two meters thick; it consisted of ash, some ejecta, a weathered regolith layer with a caliche deposit formed on top, and some eolian dust. They dictated descriptions of the deposit, broke off pieces, examined them, and described what they saw.

“Nothing fancy or unusual,” said Roger in conclusion. “Let’s head to the floor.”

The three of them headed down to the floor. The lower twenty meters of the wall showed signs of erosion from water weeping from the bedrock, probably ice melted by the impact. The crater floor was a thick, hard layer of salt, polished in places by wind erosion, buried by dust in other places.

"Fascinating," exclaimed Érico. "Nothing like this on the moon."

"This is uniquely Martian," replied Will. "This crater represents an ideal type. In this area, the bedrock is pretty dry down fifty meters and is still too dry for water to flow until about one hundred meters depth. Craters that punch deeper than that end up with deposits of sediment mixed with a little salt on the bottom. Shallower craters have dry floors. But this crater punched just a bit below the ice table, so the water seeped in slowly and gently, carrying almost no sediment. So we have a deposit of nearly pure salt."

Roger reached down and looked closely at an area that had been polished by the wind until it looked almost like ice. He pulled out his rock hammer and a chisel and carefully cut out a large piece. Then he lifted it out.

"What's that for?" asked Will.

"Madhu wants a collection of particularly beautiful samples," explained Roger. He sounded embarrassed. "She wants to do some art work using Martian materials; maybe a mosaic."

"Really? That's a great idea," said Will. "The Outpost could use some artwork."

"We think so. But let's not discuss this with Sebastian."

Will smiled. "So, you have a bit of rebellion in you, too."

"He's too pragmatic at times, and I think he'll like the result, especially if she does the work on a Sunsol."

Will nodded and picked up the scattered, broken pieces of halite. They were unusually beautiful, with a slight yellow or tawny brown tint to them. He put a few in a pocket. Roger put several big chunks of halite in the Prospector's sample drawer and smaller bits into the x-ray crystallography, infrared absorption, and alpha scattering instruments to get analyses. They headed back to the rim, the Prospector dutifully following behind. Roger led them up the route Will had recommended.

They spent a half hour walking the crater's ejecta blanket, picking up samples and reconstructing a bit of the impact history. A few small bits of meteorite were found, indicating that the impactor had been chondritic. Then they stowed the Prospector, entered the conestoga, and drove down the trail, clearing it one last time. They caught up to the two rangers just before sunset.

Ranger 1 backed up to the automated docking port in the rear of the conestoga. Shinji docked his portahab to the conestoga's other airlock, next to the driver's seat, with Will's exterior assistance, thereby connecting all the vehicles together. Paul popped frozen dinners into the microwave and soon the six of them sat to eat.

"We had a good sol," concluded Roger. "We cleared twenty-six kilometers of trail and explored a good geological site. Tomorrow we'll have at least two more hours for bulldozing. So it appears we can follow the strategy Will suggested; thirty kilometers a sol of cleared route and at least three hours of EVAs."

"A few more sols, and we'll know whether it's too much for us," said Will.

"I don't see a problem," said Érico. "There should be enough time to record and stow the samples."

“This is quite exciting, I think,” added Carmen. “I’ve been bitten by the bug! Who would have thought six people could just drive across Mars?”

“We’ll see whether the fuel base idea works,” noted Will.

“And whether the vehicles remain reliable enough,” cautioned Roger.

The conversation paused while everyone considered the possible dangers. Finally Will said, “So, Madhu is an artist? Does she paint?”

Roger smiled. “Paint? Yes. And she dances; you saw her classical south Indian dance at the arrival dinner. She plays the flute and sitar. And she does ceramics; she wants to make objects of Martian clay.”

“And mosaics?”

“That, too. She wants to try big mosaics outside where there’s room. Between the habs there are big strips of ground that are easy to see, so she might beautify one of them. Or maybe she’ll make a rock garden near the base of Face Rock.”

“That would be great,” said Carmen. “I’d like to help her.”

“Me, too,” added Will. “I know where we can find rock deposits with all sorts of colors.”

Roger smiled. “That would be great. If she had dozens of kilos of stuff—black basalt, orange eolian dust, white salt, yellow sandstone, brown shale, greenish and bluish copper ores, black and reddish hematite, silver nickel-iron meteorites—she could make some pretty big mosaics. Once she has a design, she can execute it pretty quickly.”

“We should make a map of good materials as we find them and pick them up on the way home,” suggested Paul. “This world has an amazing range of rock colors.”

“It’s not just lunar gray,” agreed Érico.

“Then let’s do it,” said Will. “It won’t take us much time.” He turned to the Brazilian. “Érico, I still know very little about your background.”

Érico was startled. He hesitated. “Well, there’s really nothing to tell.”

“You’re a geophysicist and you’ve spent time on the moon; where did you get your degree?”

“The University of Fortaleza; it’s a major scientific and technical university in Brazil. I was very fortunate that my country wanted a presence on the moon, then Mars.”

“He’s too modest,” exclaimed Carmen. “He’s really brilliant.”

Érico put his hand on hers, but looked slightly embarrassed. “You may not know that Brazil now has the world’s sixth largest economy. We’ve surpassed the United Kingdom, Italy, and France. So Brazil’s presence here is permanent.”

“Excellent,” said Will.

“If more countries made permanent commitments to send an astronaut or two or three, this place would gradually expand,” commented Roger.

“I think Canada may make a commitment,” replied Paul. “We’ve made a commitment to keep one astronaut on the moon.”

“I’ll have to go to Shackleton’s website some time,” exclaimed Will. “I know they’ve added habitats and industrial facilities since I was there three years ago.”

“It’s bigger than the Outpost, but more crowded,” replied Érico. “It has four habitats and a nominal crew of eighteen. But it has only two greenhouses, and because they’re buried to protect them against micrometeorites and solar radiation, they aren’t as appealing as the greenhouses here. Shackleton has no plastic and chemical manufacturing because there’s too little carbon in the volatile deposits.”

"I heard the human waste on Columbus 1's ITVs went to Shackleton," said Will.

Carmen nodded vigorously. "Of course! Otherwise they have to ship carbon and nitrogen up from low earth orbit."

"Exploration is following a different strategy," added Roger. "They've finally cleared the Shackleton-Aristarchus Trail, but it's not used much because it takes four days to drive it. Most expeditions set out by lunar hopper and arrive at their destination an hour later. A pair of hoppers can deliver two conestogas and four crew, they explore for two weeks, then fly back to Shackleton for night span. The result is good coverage of the moon, but few permanent routes."

"That's changing, though," noted Paul. "The Lunar Commission is planning a route all the way around the lunar equator and two connecting trails to Shackleton, via the far side and Nectaris. That way automated fuel and supply vehicles that can drive during night span can be positioned at the landing site when the hoppers arrive."

"Lunar Route 1," said Will. "I wonder whether we'll build Mars Route 1 first?"

Roger laughed. "I doubt it! We won't circumnavigate this world for decades."

Will frowned. "Why do you say that? We explored almost thirty kilometers this sol. Mars is 21,000 kilometers around the equator; at 30 per sol, that's 700 sols."

"But I doubt you think we'll clear the route that fast!"

"No, but I think it'll be done in less than a decade."

"Maybe." Roger shrugged. "If our President gets his way, Columbus 3 will bring two nukes." Roger glanced at Érico to make sure he was irritated by the phrase "our President." "Then a shuttle could fly to any spot on Mars with a nuke and a couple tonnes

of water and make all the fuel it needs to fly home a month or two later. At that point we'll be freed from dependence on trails."

"Assuming we need nukes," replied Carmen. "Mars has done fine without them."

"But we do need them! We can't use the solar power units in the dust storm season. Why should we be setting up and taking down a big, bulky solar power unit when a 1-tonne nuclear reactor on a cart can do the same thing with less hassle?"

"Because nuclear power's a risk to Earth during launch, a risk to our health here, and a risk to the Martian environment as well," replied Érico.

Roger scowled. "They can design nukes to survive launch accidents just fine, if we follow procedures the nukes are no danger to us, and Mars doesn't have an 'environment.'"

"Spoken like a right winger, just like your President," complained Érico.

"No, you're being irrational," replied Roger.

There was an uneasy silence; no one dared get into a political argument in a small space. Finally Shinji turned to Paul and changed the subject. "So, you plan to stay two cycles?"

Paul nodded. "Monika and I made the commitment. What about you?"

"I don't know. I doubt I'll stay."

"I could be convinced," said Érico.

"Really?" said Carmen, worried.

Érico nodded. Will smiled. "The place grows on you. Ethel and I would like to stay longer."

“If NASA lets you,” said Roger. “They made it clear to us they don’t want anyone staying more than two cycles. They don’t want ‘settlers.’ ”

“Really? They’ve never said that to us!”

“It was part of our training program,” replied Roger. “I like Mars, but I want to go back to the moon after this. It’ll bring a whole new perspective.”

“It will, but my marriage is more important,” replied Will. “Ethel and I won’t be separated for six months at a time. That’s the main reason we’re staying; we can do our work and build our marriage at the same time.”

Roger pointed a finger at Will. “That’s the first time I’ve heard a good reason to stay here!”

5

Home

early to mid July, 2038

The sunwing's cabin was smaller than Will had imagined. In order to minimize wind resistance it was barely wider than a passenger. It had two seats with built-in airbags for crash protection, one behind the other, though they could face in either direction. The front seat usually faced forward toward the windshield and the control panel, though the sunwing often was piloted remotely. Behind the seats was a galley with a microwave oven, a tiny refrigerator chilled by Martian air, and a sink. A tiny bathroom occupied the rear. For sleeping, the two seats could be folded flat to accommodate an air mattress and a hammock could be stretched above them. The cabin's walls and floor were airtight fabric that yielded slightly under one's weight. One normally flew in the sunwing cabin wearing one's pressure suit minus helmet and gloves for safety.

It was extremely simple, but the cabin massed only one hundred kilos and could accommodate up to three hundred kilograms of payload, including two passengers. Roger and Will climbed in through the rear opening, zipped it closed, and sealed it carefully. They strapped in and pressurized the cabin. Then the sunwing took off using jets of heated carbon dioxide gas while its propellers turned at maximum power.

They watched the ground drop away. In a few minutes they climbed to several hundred meters and Ethel, who was flying the plane remotely, told Roger and Will they could take off their helmets and gloves. They did so and chatted on and off during the five-hour, thousand-kilometer flight back to the Outpost. It was an hour before sunset

when the sunwing began to descend to the Outpost's landing strip. In a few minutes it was on the ground and they disembarked, stiff from sitting too long.

Armando and Sebastian drove out to meet them. The four of them stowed the sunwing in the hanger for the night; over the last five weeks the hanger had been widened so that three sunwings could be packed into it tightly under its roof of parachute material. They tied down the flaps and climbed onto two waiting buggies.

"So, how was the ride?" asked Sebastian over the common frequency.

"Pretty tight," replied Will. "It's like flying over the Atlantic cheaply in a jet with no empty seats."

"Oh," Sebastian groaned.

"We stood and jogged in place a lot," added Roger.

"Still, a five-hour flight beats a thirty-hour drive," exclaimed Sebastian. "I guess we'll fly back down in a few sols, Roger."

Roger nodded; Will was staying at the Outpost for six weeks.

The sun was almost touching the horizon as the buggies stopped outside the Outpost. The four of them climbed off and walked into the airlock. Once the pressure equalized, they opened the doors and entered the station. Madhu and Ethel were waiting for their husbands.

"Welcome home!" exclaimed Ethel. Will reached for her and they kissed.

"It's good to be home." They gazed into each other's eyes, then kissed again. "I've missed you."

"I've missed you, too. Videophone calls just are not enough."

"No, they aren't. You look well."

"Of course, I'm happy!"

Sebastian and Armando stepped out of the airlock behind Roger and Will, carrying the two husbands' luggage. The six of them walked into Habitat 3 where a big stew of vegetables, rice, and beef was cooking; the smell was heavenly. They all filled their bowls and sat to eat and talk. After a lively exchange about a variety of subjects—including lots of stories—they all headed to their rooms.

The next morning, Will ran over to Habitat 3 to pick up breakfast for Ethel and himself. They sat together in their new "living room"; Roger and Madhu's old bedroom.

"What a luxury, having this space of our own," said Will. "When did you finish Roger and Madhu's new room?"

"Two sols ago! Madhu was thrilled."

Will looked around the bare room. "The wallpaper's interesting."

"She has interesting taste. Their new room has their second choice wallpaper. We can paint this; I made some paint last month."

"What color?"

"Almost any. We need some pictures on the walls, too. There's still plenty of poster paper and colored ink, so we can select a picture or two on the computer and print them. I was hoping we can take some time off and set up this room specially."

"We need more furniture. Where did this little table and the chairs come from; a shuttle?"

She nodded. "The *Hadriaca*. But I was scanning the web the other sol and came across a fairly simple chair design that I can make out of plastic, so I think I'll do that at some point. It'll probably have to be a vacation sol because Sebastian said no."

“He did?”

She nodded. “We’ve had several interesting exchanges. He asked me about my work schedule; he wanted to cut metallurgical and chemical research to half time so I can concentrate on repairs and maintenance, freeing staff for more exploration. I complained that we need to continue the work in order to lay the foundation for future Outpost expansion and he said ‘there won’t be any more expansion for a while. NASA doesn’t want more than four people staying for a second cycle and the maximum arriving each cycle is eight, so the Outpost only needs to accommodate twelve, and it can do that now.’ I was surprised by that and said that regardless, my work schedule is already laid out in the mission plan. That seemed to end the conversation.”

“Interesting. A few weeks ago Roger told me NASA had decided they don’t want anyone to stay more than two cycles.”

“They definitely don’t like all your ideas; they want the creativity to reside on Earth and the action on Mars.”

“That’s too bad! I won’t stop proposing ideas. I saw the expanded sunwing hanger.”

“That was a big project. I suggested we expand it enough to accommodate a fourth sunwing, in order to save time next cycle. He said no, there won’t be a fourth sunwing.”

“Sounds like NASA plans to rest on its laurels and stick to a small Mars outpost.”

“They’ll save money.”

“It’s disgusting; this is an entire world to explore! It holds all sorts of clues to the history of life on Earth!”

“Don’t worry about that now. He wants us to concentrate on efforts that’ll be remembered in the history books.”

“But if we lay the groundwork for this place to expand faster, that’ll go down in the history books, too. How’s he been as a boss?”

Ethel shrugged. “Alright, I guess. He’s fastidious about details and his vision is focused on one thing: lots of science firsts. He’s pleasant enough to talk to when he gives you the time. He’s quite good at construction; he helped a lot with Roger and Madhu’s apartment. All the supplies are now stowed and inventoried and all the industrial equipment is set up and tested. Armando and Madhu have greenhouse 4 set up, have transferred soil into it from the other greenhouses, and have replaced the transferred soil with new reg, so we now have four functioning greenhouses. Greenhouse 3 is full of experimental plots. Monika’s been working twenty hours a sol in the Mars Life Science Facility; Armando told me she had identified two more species and found one extremely well preserved cell that allowed her to conclude that Martian lifeforms were prokaryotic.”

“No cell nucleus?”

“Right. Tell me more about the trip. I suppose the conestoga makes it much more comfortable.”

“Oh, yes. It drives well and the systems work well. The new bulldozer blades for the rangers are awesome; they push through rocks and reg like they’re not there.”

“Paul told me the repairs have been routine, but the vehicles consume a lot of power.”

“Yes, more than we can make with the solar power unit, but the sunwing brought down additional solar panels and sometimes brings methane. The panels are a pain to set up, but they make the difference.”

“And Roger’s alright to deal with?”

“I suppose. He doesn’t like to admit someone else might have a better idea, but if you’re clever, you can work around that. If you suggest a route we could follow to the floor of a crater, he’ll take us along a different route instead, but then he’ll lead everyone back along your route. I noticed that after I made suggestions on two occasions, so a third time I proposed a ridiculous route down and he accepted it for the return trip!”

“You did?”

Will smiled a mischievous smile. “We got along fine most of the time. It turns out he’s keeping an eye out for natural materials that Madhu can use to make mosaics. If you help with that, he loves you. I think he’s a bit embarrassed; he stresses how scientific he is as a researcher. We’ve already collected about a half tonne of stuff Madhu can use, including a really interesting ventifact Roger found last week. The sunwing goes down this morning and it’ll bring cataloged samples and natural art materials back.”

“She mentioned the mosaics to me. I gather she talked to Sebastian about it and he said she had to do the work on her own time.”

“I’m not surprised.”

“Was Monika happy to see Paul?”

Will laughed. “Oh, yes! They kissed and hugged for about five minutes. She’s staying in the front of the conestoga with him.”

“Not with Carmen?”

“No. Carmen’s in the back of the conestoga with Érico.”

“Interesting! None of them are married?”

“Paul and Monika are divorced, Érico’s single, and Carmen’s separated. I think we should do some match making. Paul and Monika are both 37; Érico’s 36 and Carmen’s 35. They make half decent matches, too. Paul and Monika have already committed to stay two cycles and Érico said he’s thinking about it. I’d like to snag all four of them for Mars.”

“I suspect all four of them are negative about marriage, so it may be hard to convince them. I’d like to see Madhu and Roger stay. I’ve already been working on Madhu.”

“Really? Great minds think alike!”

“I guess so! Are you thinking about staying a third cycle? I was, until Sebastian said it was against policy.”

“I was, too. I wouldn’t worry about the so-called policy too much. They can always save money by flying fewer here on Columbus 3. It’s a lot cheaper to retain people on Mars than replacing them.”

“But they don’t want long-term people here; they want personnel who will do what they’re told!”

“Too bad; do you think they’ll tie us up and drug us to fly us back to Earth?”

“No.” She didn’t like his tone and changed the subject. “I’m glad your relationship with Roger is working out. I was afraid that would ruin Mars for you.”

“No, I’ll carve out a niche alright. Shinji’s managing pretty well, also; expeditions keep everyone busy with a variety of tasks.” Will took another bite of bread with fresh

strawberry jam on it. “The food’s so much better here; the fresh baked bread is really nice.”

“The wheat’s growing very well.”

“We should probably go downstairs pretty soon. Some time this sol, I promised Roger I’d figure out where we’re going to put all the samples we’ll collect over the next two years. We’ll have fifteen or twenty tonnes. The basements of the three Habitats will be strained to store them all; we’ve still got seven tonnes of samples from Columbus 1! What we really need is an unpressurized storage facility with shelves where we can put tonnes and tonnes of rocks.”

“Oh?” Ethel looked interested. “I’ve been thinking about ways to build exterior structures as a prototype for building pressurized structures of local materials. How big a storage area are you talking about?”

“Pretty big; fifteen tonnes of samples, based on Columbus 1’s collection, will take 500 to 750 square meters of shelves, and stacking the shelves six high means one hundred square meters of floor space. If you add a third for access to the shelves, you’re talking about 130 square meters.”

“A bit bigger than a habitat, then. Something ten meters wide, thirteen long, and two or three meters high. We can make it of metal or plastic sheeting reinforced with metal cables and beams, with regolith piled against the outside for insulation and to make pressurization possible.”

“I’d make it twice that large to accommodate expansion. You really think you can do that?”

“Of course! There are a dozen designs on the Columbus website. Theoretically, we already have the equipment to make the parts for pressurized buildings, complete with windows. Of course, windows and doors are very complicated to make from scratch, and we can’t make life support equipment; just structures. But we have some spare life support equipment.”

“Fascinating. Maybe we should put together a proposal.”

“I’d send it to the construction people before showing it to Sebastian; he’d veto it as a waste of resources. The next six weeks will be relatively quiet; we’ve completed most of the set-up work. I’m scheduled to drive Prospectors four hours a sol, and something like this would give me a real break.”

“Then let’s talk to the construction people. Both of us fly north to join the expedition in six weeks. We could do a lot by then.”

“Good.” Ethel looked at her watch. “Wow! It’s after 9 a.m. I’d better go take a shower. Can you get me a new stick of deodorant? I’m just about out.”

“Sure.” Will was dressed, so he headed out the door of their living room. He hurried down the stairs and through the greenhouses to Habitat 3, in whose basement the bulk of the supplies were stored. He quickly found the deodorant Ethel used. He also grabbed a new tube of toothpaste for himself; the tube he had opened two weeks ago had a funny taste, probably because it was three years old.

He returned to their suite, shaved, and showered. Ethel had promised to produce more plastic sample bags and they were urgently needed, so she went to do that for the rest of the morning. Will prowled around the Geology Lab in Habitat 2 and reviewed the huge backlog of test requests. Now that they had the ability to measure isotopes to the

part per billion range, there was much less need to haul samples back to Earth, but a ten-fold increase in requests for tests on Mars had resulted. It was a serious problem; a technical service staff was needed. Over a hundred samples were in the queue for either potassium-argon or rubidium-strontium age dating. He'd have to do most of them himself.

He devoted the morning to selecting the most urgent requests and setting up the samples so that they would be automatically fed into the machine when it was ready for them. He set up the microscope to photograph a dozen samples in high detail sequentially, then set up the x-ray crystallography machine to scan a half dozen samples. By the end of lunchtime, he'd have to set up all the machines with a whole new batch of samples, if he had time. Instead, he and Ethel spent the afternoon selecting art to decorate their living room and chose a shade of paint for the walls. They also examined furniture designs; Ethel wanted to be creative in making furniture for the living room. It made them late for supper.

Sebastian was late for supper as well. As he left his room, his attaché beeped with an urgent incoming message from Earth. He sighed; no time to eat yet. It was a videomail from his older son, Helmut. "Hi dad. I suppose I shouldn't burden you with this, but they caught Kristoff smoking pot at summer camp today. Mom's at the police station right now trying to bail him out. I'm sorry to tell you, but I'm stuck at home by myself and it's getting late here! I guess I'll just go to bed, but the house is so big and quiet I had to talk to someone. So I plan to stay up until you call back, okay? I'm sorry to tell you, like I already said. There's so little you can do. Kristoff's doing all these things because you're away; he sort of said that to me yesterday. I told him it won't bring you back faster and

he got mad at me. I really don't understand what's happening; he seemed fine when you left. Anyway, I'm fine, I got all my work done for the science project and I'm looking forward to hearing about the latest Martian geology you've done. Bye."

Sebastian stared at the screen, then sank his head into his hands in grief. Kristoff had been a good kid until a year and a half ago, when puberty and the shock of realizing his father would be away for almost three years hit him at once. For two minutes, he couldn't even think what to say to Helmut, but then he realized his sixteen year old son was waiting. He hit the reply icon and turned to the screen. "Thanks for telling me, Helmut. I'm sorry this is so hard on you. You are a strong, capable, mature young man and I'm really proud of you. I hope you can help Kristoff because this is a really difficult, scary time for him. I'll be sure to videomail him even though he probably won't respond. I love him very much, just like I love you, but it is so hard to convey that by videomail. I wish I could talk to him about Martian geology or send him some pictures. We'd have something to share in spite of the distance. But I can't get home until February, 2040, and there's nothing any of us can do about that. My heart bleeds about that, son, it really does." His voice choked up. "But, anyway, here are some photos from a trip the other day. They have captions. Take a look and we can talk about them later. Bye." Sebastian went to a web site of a recent field trip and grabbed a dozen particularly interesting pictures, which he attached to the message, then he sent it. He also composed a quick videomail to Angela; he needed her side before videomailing Kristoff.

He felt so helpless, and Sebastian *hated* to feel helpless. At least he had control over Columbus 2, especially the mission's inventory, which he had been assiduously reorganizing. He headed for Habitat 3's great room for supper.

“We stayed in bed until noon,” Roger was saying, as Sebastian entered the habitat. “Our two new rooms are quite nice.”

“I wish the rest of us had the space you couples have,” noted Armando. “I wonder where Sebastian is; the meal’s getting cold.”

Just then Sebastian strode in. He headed for his seat, sat, and began to fill his dish. “How much toothpaste can we use here, anyway?”

Madhu was surprised. “What do you mean?”

“The supply is down by five tubes in the last month. That’s ten percent of our supply.”

“We sent three to the expedition a few weeks ago,” said Armando.

“And I was running out; I grabbed a tube two sols ago,” added Madhu.

“I grabbed a tube this sol because I was running out,” said Will.

“That’s five. Do you couples really need two tubes? Can’t you share one?”

“Unsanitary,” said Armando.

“Well, they kiss!”

“I think we have enough tooth paste for all of us to have a personal supply,” replied Ethel calmly.

“Two people using separate tubes does not cause the total amount of tooth paste to be used up faster,” noted Will. “It just means each tube lasts twice as long.”

“But once the tubes are in your bathrooms, I don’t know how much is left. If they’re in the inventory cabinet, I know.”

“Do you really need to know how many tubes we have?” asked Ethel, irritated. “After all, there were several tubes left over from Columbus 1 when you arrived, and you arrived with extras.”

“In fact, those old tubes from Columbus 1 should have been thrown away,” added Will. “One of the tubes sent northward to the expedition was an old one and I got it. The taste was funny.”

“So what if it’s old?” replied Sebastian, raising his voice a bit. “It can’t go bad. Microorganisms won’t grow in it. We should use up the old stuff and preserve the new stuff. There’s no guarantee all of Columbus 3’s supplies will arrive safely. If there’s a crash, the Outpost might end up with half the toothpaste it needs and the staff would have none for a year.”

“I’m sorry I sent the old ones down,” Armando said to Will. “The toothpaste boxes were separate originally, but someone who didn’t know mixed the boxes.”

“I should lock the supply cabinet and have people ask me for supplies,” growled Sebastian. “Armando, is there any way we can mix the old and new toothpaste together to eliminate the bad taste?”

“It might work. I’d have to try the old toothpaste and see how bad it is. Mission Control might be able to advise us.”

“Adding a little artificial sweetener might do the trick,” added Madhu. “Or possibly some artificial flavor. We could make some banana ester quite easily, for example.”

“Banana flavored toothpaste?” replied Armando, shaking his head.

“Could we save the old items for emergencies?” asked Ethel. “Rather than doctoring the old toothpaste now, we could set it aside and doctor it later if we really needed it.”

“Let’s not let old things get older,” replied Sebastian. “Use the old things now while they’re still okay; save the new things for later.”

“I suggest Armando and I look through everything from Columbus 1,” said Madhu. “He’ll check the medications and I’ll check the edible items. We’ll determine the status of everything and consult with the folks in Houston. They should have recommendations about all these items.”

“Okay, but they want us to throw things away, and I won’t do it,” said Sebastian. “Keep that in mind.”

“Okay,” agreed Madhu.

There was silence in the room for a moment. “This is excellent pasta, Madhu,” said Ethel. “I am so grateful to have an expert here to cook for us.”

“Thank you,” said Madhu, with her typical warm smile. “I’ve got a pretty good rhythm going, now. I harvest the greenhouses in the morning and do the bulk of food preparation before lunch. That leaves me with a long afternoon for planting and experiments, and supper preparations are quicker.”

“How are the potatoes coming?” asked Armando.

“Pretty well; I think we’ll have a good harvest. The rice isn’t doing so well, though. The experts have some ideas and I think we’ll do better next time.”

“Are the tilapia living in the rice paddy?” asked Will.

Madhu nodded. “And that may be part of the problem. We’re still not sure.”

There was another lull in the conversation. “By the way, did everyone see the news of the Swift shuttle launch?” asked Will.

“No; I was cooking,” replied Madhu. “How did it go?”

Will nodded. “It was a good launch; no problems.”

“What did NASA say?”

Will shrugged. “What can they say? Mr. Swift has built a cheap, reusable craft and for decades NASA said that was impossible.”

“They’re angry the technology for the Mars shuttle contributed significantly to his success,” revealed Sebastian.

“Really?” said Madhu.

“The second stage is basically a Mars Shuttle scaled up fifty percent, with some improvements.”

“How cheap will it make launches?” asked Madhu.

“The cargo version launches eight tonnes to orbit at a tenth the current cost,” replied Will. “The passenger version hauls twelve people up for 1.5 million dollars each.”

“And they’ve already got two hundred paid passengers; one year’s worth, with one launch every three weeks,” added Ethel. “That’s without a destination to visit.”

“I suspect after six months of bad press, NASA will allow Swift to add a hotel to International Space Station 2,” said Will. “Then pressure will build to allow tourists from the Swift shuttle to transfer to flights to Shackleton.”

“What will it do to our launch costs?” asked Roger.

“NASA says it won’t save any money,” replied Sebastian. “But that’s not true.”

"Transportation to the moon is already cheaper using lunar hydrogen and oxygen," added Will. "To compete, the ion tugs are switching from xenon to argon, which is vastly cheaper. Ultimately, transport costs to Mars must drop drastically."

"They'll keep this place the same size and slash its budget to half, then a quarter," exclaimed Sebastian. "Our loss will be the moon's gain, because it'll get hundreds of tourists every year. We're too far away for tourists."

"Just as well; I have ambiguous feelings about tourists on the moon," said Roger. "There are now hotels in Antarctica with casinos. The service staff outnumbers the scientists! I'd hate to see that happen to Shackleton."

"I have ambiguous feelings, too," agreed Will. "But if NASA phases out expendable rockets in favor of the Swift shuttle, the cost of the Columbus missions could drop ten fold. This place could double or triple in size *and* they'd save money."

"That's not our business, though," admonished Sebastian. "We're scientists, not politicians."

"But can't we do more to foster expansion?" asked Will. "We need to talk this place up more; it's far more complex geologically than the moon and it once had life. It deserves a large, serious commitment to exploration. The Outpost needs expansion; we need water storage facilities and we should try to construct pressurized buildings."

Sebastian shook his head. "Don't waste your time blogging or Twittering about the glorious future of Mars. The best way to build up this place is to accomplish a lot of science. Scientific success will necessitate expansion of staff. We have to visit more places and run more Prospectors. Paul can run a Prospector several hours a sol from the conestoga. Let's explore, explore, explore. That'll expand Mars."

6

Building

mid July, 2038

Will and Ethel watched the sunwing jet into the air and climb into the pink morning sky. It banked northward and headed for the expedition, some 1,200 kilometers north of the Valley of Dawns. Ethel waved to Sebastian and Roger, even though it was unlikely either of them would see the gesture.

“There they go,” she said to Will on a private channel. “So, we’ve got six to eight weeks before they return.”

“Unless Sebastian comes back for a few sols on one of the supply flights.”

“He won’t; he’ll get into the exploration. I still can’t believe he appointed you interim commander of the Outpost.”

“I was surprised as well. But I suppose since he’s European, he had to appoint an American.”

“I wish we didn’t have to think that way.”

“I agree. It won’t be six weeks with unchanging staff, though. Armando will go down to replace Shinji in two weeks, and Paul will be back here in four. At some point Roger will be back, too.” Will turned to the sunwing hanger, which was nearby. “Let’s look at the hanger. I want to think about construction options.”

“Sebastian did give a green light for an unpressurized sample storage building,” agreed Ethel. “We’ve tried every construction technique on the hanger.”

Will nodded and they walked to the hanger sixty meters away. It had only one sunwing in it at the time. They pulled back the flap of parachute material and entered.

Since the parachutes were a translucent white, it was bright inside the hanger; it was twenty degrees Centigrade warmer than outside, which they soon noticed through their pressure suits. Will carefully walked under the sunwing and reached the hanger's sixty-five meter long back wall; 2/3 as long as a football field. The wall had taken months of intermittent work and represented a history of their construction experiments.

At the side they had entered, the hanger was excavated into the Martian ground in order to make its floor flat. They had used both rangers to bulldozer the regolith out of the way and build a berm on which they raised a wall of unmortared fieldstone. Will had done much of the stacking of the rocks; he had a knack for it. Fines had sifted into the cracks between the rocks and helped fill them up.

Ten meters of fieldstone wall was followed by plastic sandbags; a lot of work to fill, but they made a tighter wall. Fifteen meters of sandbags were followed by plastic sheets held in place by vertical iron beams they had buried in the ground and frozen in place. It had proved much faster to build because the rangers could push regolith—carefully—against the lower meter of the plastic sheets outside to hold them in place. But the blank white plastic wall was flimsy and ugly.

Thirty meters of plastic was followed by ten meters of duricrete, a substance made by mixing Martian dust with water and letting it set inside plastic forms. It had more strength than plaster of Paris, partly because it had crystallized and frozen at the same time; had it been able to crystallize without freezing it would have been stronger. The orange-red-brown wall looked like concrete.

They turned the corner and walked along the twelve-meter side wall, which was made of Martian concrete. They had taken duricrust—the hard crust that formed on the

Martian surface when water percolated upward through the regolith—crushed it, washed the salts out of it, and roasted it, dehydrating the calcium and iron sulfates. They mixed the result with sand, added water, and let it set in forms. The result was not as good as terrestrial concrete, but it wasn't bad.

"Which would you recommend?"

Ethel pointed at the orange-red section. "The duricrete is fastest, easiest, and can be the strongest. Based on this effort, the engineers at the Institute for Space Construction in Moscow designed a mixing device we can make. We'd fill a hopper with dust—preferably loose dust that's been heavily irradiated with ultraviolet, so that it will undergo the most hydration reactions—and blow it through a pipe with heated air and just the right amount of water into a form. The form has to be reinforced and airtight enough to retain some air pressure so the mix can set slowly, above the freezing point of water."

"Can we make walls for a building that could be pressurized at some point in the future?"

"Hum. Perhaps. Many pressurized building designs are based on unpressurized designs, but they have thicker duricrete walls, more metal reinforcing rods, and a plastic coating on the inside wall to make them airtight. The main reinforcement they have is dirt, piled up against the walls and roof and frozen in place."

"We've got hundreds of tonnes of spare water."

"Let me talk to the construction experts in Moscow; they can give us a design to follow. They don't necessarily talk to Houston, either."

"I'll handle Houston and Sebastian."

"Be careful not to deceive them, Will. You'll ruin everything."

“I won’t deceive them, don’t worry. I want a design for an unpressurized building that can be pressurized later. Sebastian authorized an unpressurized building for rock samples. I’m willing to do my ordinary work at all sorts of odd hours in order to help with this augmented design. We need to build a pressurized building! Mars will never expand if it has to import all its pressurized space.”

“I agree. We know the rough size of the building, so you can start excavating the foundation. That’ll take three or four sols. By then I’ll have a design from Moscow.”

The next three sols were quite busy for Will. He ran a buggy—about the size of a golf cart—with a little bulldozer blade every sol for as many hours as he could; it was not easy to operate the machine in a pressure suit, but all the pressurized vehicles were on the expedition. He postponed breakfast every morning so that he could get an hour of lab work done starting about dawn; the various tests on rock samples ran autonomously for as long as three hours, so he was able to get a substantial amount of work done in the morning while he ran the rover. Before and after supper he worked four hours more in the lab. The arrangement gave him about six hours a sol outside. Unfortunately, the hard physical labor required a lot of eating and a lot of rest.

Meanwhile, Ethel ran the metal and plastic making equipment twelve hours a sol to make the nickel-steel rebar and plastic sheeting while exchanging videomails with the construction experts in Moscow and Houston. Among the dozens of proposed designs was one for a duricrete building twenty meters long and ten wide, with a row of three pillars down the middle to support a roof of welded metal sheets. If four meters of regolith was piled on top, its weight counteracted the three tonnes per square meter of

upward pressure from the interior air; the pillars guaranteed the roof would not collapse if the building lost pressure. Ice layers gave it concrete-like hardness. The duricrete walls would have a light network of reinforcing rebars which could be woven together in units inside the suit donning facility, then carried outside and installed.

The morning of the fourth sol of work, Will and Ethel awoke to find an email from Moscow giving the complete plan. But they noted with a sinking heart that the email had been copied to Sebastian. He called Will a few minutes later.

"Will, good sol. What's this email I just received about a building? Is this the Geology Storage Facility?"

"Yes. We've been in consultation with the construction experts in Moscow and Houston and they've recommended a design we can complete in six to eight weeks. The folks in Moscow are already hard at work testing construction techniques for us."

Sebastian hesitated. "This was approved by Dr. Mann?" Rafael Mann was the chief construction engineer in Houston and liaison with the Institute for Space Construction.

"Yes, we've been in touch with him many times about it."

"But this is for an *unpressurized* building?"

Will chose his words carefully. "Yes, but the building can be retrofitted for pressurization as well. It's the design the team recommended and it fits the Outpost construction section of the mission plan." He didn't add that he and Ethel were the members of the "team" requesting the pressurization option.

"I see. Well, I just hope you can do this and the regular duties we outlined before I left. Because this is an ambitious design; it can't be done in six weeks part time."

“Sebastian, we’ll get everything finished, don’t worry.”

Sebastian hesitated. “Okay, have it your way, Moonman. I’m looking forward to seeing this so-called unpressurized building of yours. Have a good sol.”

“You, too. Bye.”

“Bye.” Will closed the circuit with relief.

“Congratulations; you did it,” said Ethel, who had been listening.

“Thank you. I think Sebastian decided to look the other way. Maybe he’s curious to see how we do both, so he can give us more work!”

“I wouldn’t put it past him!”

They headed down to breakfast. They were now late; Armando, Madhu, and Monika were already eating. Monika had just gotten back from the expedition two nights before.

“Good sol,” said Will, greeting everyone. “Good news. Houston sent the final design for the Geology Storage Building last night. They copied Sebastian as well.”

“And he said no?” asked Madhu.

“No; he asked whether it was an unpressurized building and when we said yes, but it could be pressurized in the future, and that Houston was supporting it, he growled and said he’d be interested in seeing it.”

“And that we had to be sure to get our regular work done,” added Ethel.

Madhu was surprised. “Really? He’s slipping.”

“You’re going to build a pressurizable building?” asked Monika, surprised.

Will nodded. “It can be either. The walls and roof are heavy enough to hold in air pressure with regolith piled on them.”

“How much eolian dust will you have to move?”

“Two hundred fifty tonnes,” replied Ethel. “We can do that in seven weeks at the rate of four tonnes per sol. We’ll need to pile two thousand tonnes of reg on the roof and against the walls. But the buggy and the reg blowers can do that pretty efficiently.”

“And until we add the weight, we can use the building without pressurizing it,” added Will. “It can accommodate all the rock samples we’ll recover for four years.”

“That’ll help a lot,” said Monika.

“Meanwhile, we can leave a large work area where larger structures can be assembled in a shirt-sleeve environment,” added Ethel.

“That’ll be much better than the suit donning area,” said Madhu. “I guess we can thumb our noses at Sebastian in a creative way by helping you.”

“I’m not sure that’s the right reason to help!” exclaimed Will.

“Let me clarify. Sebastian’s too anal. He micromanages. So I want to help because it’ll make a statement. How can I help?”

“We could use a lot of help,” agreed Ethel. “One way you can help is to structure your time inside so you can keep an eye on the plastic and metal making equipment. Madhu, when you’re in the greenhouses you can run into the manufacturing facility in a matter of seconds, so you can help monitor the equipment while I’m outside.”

“And I need help with the geological analysis,” added Will. “I can set samples up and log them into the computer, but I need someone to place them in the machines, turn the machines on, and afterwards turn the machines off and remove the samples.”

“I can do that,” said Armando. “I need to spend about two or three hours a sol running medical tests, but the rest of the time when I’m doing medical work I could do it in the Geo Lab.”

“That would really help,” agreed Will.

“I’d like to get outside and help with the construction,” said Monika. “When I was with the expedition, I was amazed how tired and weak I felt at first. I’m not getting enough exercise.”

“Your bones are decalcifying,” added Armando. “You really do need more exercise, Monika.”

“Especially if I’m going to stay,” she added. “I signed up for four years, but my health is not cooperating. I need to be outside walking around with a fifty-kilogram pressure suit weighing down my legs regularly.”

“We can give you a reason to do that!” exclaimed Will.

“Then you can count on me for four hours a sol. I’ll extend my workday from nine hours to eleven. With Paul away, I really don’t have much to do.”

“Thank you, that’ll help a lot!” said Ethel.

“I think we can keep the two of you outside six or eight hours a sol,” suggested Armando. “I’ll rearrange my schedule and postpone a few tasks that were optional. If we cut back to the ‘nominal’ work, I bet we can get that building put up before Sebastian returns.”

“I’m counting on it,” replied Will.

7

A Contribution

early Sept., 2023

With Madhu and Monika helping run the manufacturing facility, iron and plastic parts steadily poured out for the construction. Armando helped Will keep the geology lab running. Will, Ethel, and Monika each logged over forty hours per week in their pressure suits, including half a sol on Sunsol.

The effort paid off. At the end of the first week the foundation area was cleared and leveled and a trench for the walls had been excavated by the “reg blower,” a device with spinning toothed wheels that accelerated sand and gravel up a chute and threw it, rather like a snow blower. A duricrete-making system had been put together from various parts. A plastic tube was run from the solar power units to the construction site immediately east of Habitat 1 to bring 150 degree Centigrade Martian air from the solar heaters to the site.

On Monsol of the next week they completed the first form—a metal-framed box five meters long, sixty centimeters wide, and two and a half meters high, with plastic walls on the inside. It ran from one nickel-iron reinforcing pillar to the next, with a woven curtain of nickel-iron rebar joining them together. In a marathon sixteen-hour session that they completed under floodlights, they blew eight tonnes of eolian dust into the form, accompanied by four tonnes of water, and added heat from the wells all night. The next morning the duricrete was rock hard. It was a success!

But the Geological Storage Building required sixteen such sections. Making and weaving together the nickel-iron bars for each pillar and the curtain connecting them to

the next pillar took two sols. Hauling eight tonnes of eolian dust to the site took most of a sol. Assembling everything inside the form took a sol, and filling the form took a sol. The first week, they barely poured a second section and felt very frustrated by the slowness of the work. Sebastian called to complain strenuously that other tasks were falling behind.

The second week went better. Hauling the dust took one person—Will—so assembling the pillars and rebar curtain could proceed simultaneously. Will could do most of the set-up work by himself as well. On those sols, the work manufacturing bars and assembling them could be done inside by Ethel and Monika. The second week, they managed to create and pour a section every three sols. The next week—working from Sunsol to Sunsol, so they had seven and a half sols—they almost completed work on three sections.

Then the sunwing returned to the Outpost with Paul; Sebastian had given him a two-week rest and wanted to experiment running an expedition with only five members. By the next morning Monika had recruited him to assist. The fourth week saw them complete three sections and almost a fourth. They were finally rolling along. When Paul left at the end of week five, fifteen of sixteen sections were finished. By the middle of week six, the walls were finished; all eighty meters of them. By the end of that week the five support pillars along the middle of the building had been poured and half the metal sheets for the roof had been made.

Week seven was a race against time. Metal roofing beams had to be riveted together in the suit donning area, carried to the building, and welded in place; then metal sheets had to be laid between the beams and welded down by a worker in a pressure suit.

The roofing beams had to be welded to the support pillars in the walls and in the middle of the building as well. They managed to complete the metal roof just a few hours before the sunwing bearing Sebastian and Roger landed at the Outpost. There was no time to manufacture or install the heavy metal pressure doors, run electrical wiring, or manufacture and spray on plastic sealant. But the shell was complete.

Surprisingly, Sebastian was quite interested in the building. He stretched his legs by walking around the outpost, passing through every habitat and greenhouse in the process, then called Ethel and Will to ask for a tour. The three of them suited up.

It was a mere three-meter walk from Habitat 1's airlock to the entrance of the Geology Storage Facility. Sebastian walked in with Will and Ethel following. He strolled around and looked at everything. Daylight poured in through four doorways, but not a ray of light penetrated through the metal roof; it was tight and reflected sunlight off its shiny, slightly silvery surface. "Orange-red walls; orange-red duricrete," Sebastian said. "Not my favorite color, but I suppose it'll grow on me."

"Think of it as cinnamon with a little paprika thrown in," suggested Will.

"Yuck! That would taste terrible!" Sebastian reached out to touch a pillar. He ran his gloved hand over the smooth surface, admiring the work. He stepped back to the door and felt the width of the duricrete. "My congratulations; you really exceeded anything I thought you could do. This is very impressive. Very, very impressive."

Will wasn't sure what to make of Sebastian's compliment. "It's built like a bunker, though."

"I suppose that's unavoidable, especially when you did all the extra work to make it pressurizable. How long will it take to build the shelves?"

“Four or five weeks,” replied Ethel. “We have to make the metal supports, shelves, nuts, and bolts.”

“Not something you can do before you go to the expedition, then,” said Sebastian. “Well, that’s alright. The shelves can wait. We don’t have a huge pile of samples to store on them.”

“Actually, we do,” replied Will. “The basement of Habitat 2 is full and there’s a tonne of bagged samples in Chryse to fly up here.”

“We can accommodate them in various places for now; if nothing else, we can leave them in the sunwing hanger. You can build the shelves when you return from the expedition.”

“We were hoping to have a few sols off before flying down,” said Will.

Sebastian shook his head. “I’d be willing to be flexible normally, after seeing such a magnificent effort, but you really didn’t have my permission to build this. Before I left, I told you that this should be a building for outdoor use. Instead I got a building that could be pressurized, which took about twenty person-weeks of extra work. You got all the nominal workload done, and I commend you for that; but usually we get about twenty-five percent more work done than in the nominal schedule. So while you all were busy building this place, I was dealing with complaints from the scientists that our Prospector exploration and scientific analysis of samples had slowed down. I also had a complaint about all the overtime the construction consultants in Moscow put in.”

Will was surprised. “Perhaps you should have called us up about the matters. We were unaware of the complaints.”

"I suppose you were. But you went against my orders. So I'm docking both of you two weeks of vacation."

Will and Ethel both looked at Sebastian, shocked. He shrugged. "Remember, I'm in charge of Columbus 2, not the construction consultants in Moscow and Houston. Will, you were on the moon in the early days. NASA learned the hard way that the Commander has to be the person in charge of the mission. Otherwise you have inefficiency and chaos."

"Sebastian, if you want to talk about efficiency, by your own admission we just managed to accomplish about sixty percent more work in the last eight weeks than nominal. That's a lot more than the usual twenty-five percent extra."

"I understand, but the job of inspiring extra work is mine, not yours, Will."

"Then maybe you should start," replied Ethel.

Sebastian turned to her, angry. "I'd advise against insubordination! I'm the Commander, not your husband!"

Ethel looked at him, angry, then turned away.

"Do you have any other questions about the building?" asked Will.

"No. Tomorrow's Sunsol; I suggest you get a good rest. You'll have half of Monsol morning to pack for the flight to the expedition. It's now a twelve to fourteen hour trip, depending on winds."

"Okay. I assume you're going in this airlock? Then Ethel and I will go in the other."

Will and Ethel walked away from Sebastian as fast as they could and headed for their room.

The dinner in Habitat 3 was big and pleasant enough, but they refused to speak to Sebastian, and the tension was felt by everyone else. It was pleasant to see Roger; Madhu had become their friend, so Roger was drawn into a circle of friendship as well. Armando, sensing that something had happened, asked what was wrong, and Will told him a short version of the events that had transpired.

The next morning, they went to breakfast early. Armando and Monika were there; they were early risers. “I can’t believe Sebastian docked you guys two weeks vacation and ordered you to the expedition!” exclaimed Monika. “He’s crazy! Crazy and arbitrary!”

“Maybe we’ll appeal to mission control,” said Will. “It’s a possibility.”

“This is the first time we’ve felt like we should just leave and go back to Earth,” added Ethel.

“Of course! Yours was a labor of love!” exclaimed Armando.

Just then Madhu entered the room. “Good sol,” she said.

“You’re up early,” observed Monika.

“Roger’s hungry, and he wants *me* to bring *him* breakfast in bed! I reminded him it’s supposed to be the other way around, but he just laughed.”

“You’ve been here all this time, and he’s been in the field,” replied Ethel.

“I suppose.” Just then Sebastian entered the room. Madhu looked at him and nodded a good sol, then looked back at Ethel.

“I’m surprised you’re up so early. Sunsol is your day of rest,” he said.

"Not this sol," replied Ethel. "Will and I have one sol left before flying north to the expedition, and it's our sol off, so we decided last night that we would dedicate it to the Geology Storage Facility."

Sebastian looked shocked. "No, you can't do that."

"Why not?" asked Will. "It's Sunsol. It's our sol off."

"But you should be resting for the trip."

"We'll rest *on* the trip," replied Ethel. "What else is there to do in a small cabin for fourteen hours, but sleep, read, and watch television?"

"But I don't want you to work on it any more."

Will looked at Sebastian. "Look, it's our sol off. Our time is our business, not yours. You can't order us not to work on the building."

Sebastian scowled. "What's wrong with you, Will? We're here to do science and explore. That's the great human adventure, not building buildings."

"What's wrong with you, Sebastian?" retorted Madhu. "Can't you see love when it's right in front of your eyes? Don't you think love of this place has to be tapped and directed instead of defeated or ignored? Your problem is that Will and Ethel love Mars, and you don't understand!"

Sebastian was startled by her comments. He turned to her. "No, I don't understand love of this place."

"Fine," said Madhu. "But I happen to love Mars, too. This is a fascinating place, and this Outpost is Mars's future village, town, city, capital city. But I suppose you can't see that, since NASA doesn't believe in 'settlement.'" She turned to Ethel. "Roger and I will be out to help in about ninety minutes."

“What?” said Sebastian.

“You can count on me, too,” added Armando.

Monika nodded. “Me, too. I’ll devote this sol to the building. With six of us working, we may get the roof covered with reg by sunset.”

Sebastian looked at them, shocked. “This is crazy!”

Armando looked at him. “Yes, it is pretty crazy. But we’re not just building a building, Commander; we’re making a contribution to Mars’s future, something that will stand long after all of us leave.”

Armando picked up his cup of coffee and sipped. Sebastian looked at them all, one by one, astonished. Then he took his breakfast and walked back to his room.

Once they finished their breakfast, Will and Ethel suited up and headed outside. They began to run both reg blowers, kicking regolith onto the metal roof and a great cloud into the air; fortunately the wind blew the dust away from the outpost. With any luck, by sunset they’d have about thirty centimeters of reg in place, the minimum amount for adding water.

Armando and Monika soon joined them and began to string electrical lines along the roof’s metal rafters. Periodically they wired in a power cord that dropped down along the wall to a dozen centimeters above the floor, where a plug would be put later.

Madhu and Roger made their appearance next. They drove off in the two buggies to get eolian dust from a nearby drift; mixed with water, it would make a smooth duricrete floor.

Then, to their surprise, another figure came out of the Outpost: Sebastian. They stopped to watch him approach. He switched to the common frequency. “Look, I’m

sorry. I had no idea this building meant so much to everyone. I can understand the idea that people want to make a contribution to this place, in addition to contributing to humanity's knowledge. That's not a foreign idea to me. So. . . what can I do?"

Will was surprised. "We have a third reg blower; you could operate it."

"Good." Sebastian looked around until he spotted it. "Okay, I can do that. We'll work this sol until sunset, then we'll rest tomorrow. The sunwing flight can be delayed until Wednesol; that'll give you an extra sol off. And I'll restore your vacation."

8

Castle Rock

early Sept., 2038

The sunwing soared over a cinnamon Mars, heading northward. The canyonlands and chaos of Aurorae were replaced by the channels and eroded mesas of Chryse. The water-rubbed remnants and depositional bars of boulders and gravel grew smaller and farther apart as the sunwing headed north, downhill toward Mars' ancient ocean floor. Finally, it was flying over the smooth wastes of an ancient marine plain and its lithified abyssal muds.

Will and Ethel looked out their windows and watched the progression of terrain. The sunwing left the Outpost at dawn and, after a thirteen-hour flight, was approaching the landing area on the edge of Acidalia Planitia. The early summer sun illuminated the area with its slanted early evening rays.

"I'm ready to drop the food package," Ethel announced over the radio. She sat in the pilot's seat up front, where the windows gave stereoscopic views of the terrain below.

"We copy," replied Roger, in the conestoga below.

Ethel looked at the bullseye roughly traced on the ground and glanced at the computer screen, which displayed a schematic of the sunwing's trajectory and the release point. She was approaching that point. When the screen showed that she was at the right spot she pulled a small lever.

The sunwing lurched upward; it was 100 kilograms lighter. She looked at another screen that displayed the ground from a camera beneath her seat. The package plunged

downward, its airbags deploying. It landed in the bullseye, bounced back into the air, then landed again.

“Good shot, Ethel!” exclaimed Roger.

“Piece of cake. I’m swinging around for landing, now.” Ethel banked the sunwing eastward. They caught a quick glimpse of the 500-meter crater next to the landing area which had punched through the Noachian muds and into permafrost; its ejecta blanket was dominated by lobes of frozen mud formed when the wet ejecta landed and flowed like slurry.

Will watched over her shoulder, fascinated, as Ethel flew the sunwing southward a kilometer, dropped them lower to the ground, banked it again and headed northward one last time, approaching the landing area and slowing the sunwing, ailerons extended. There was nearly no wind. The landing area was flat and smooth. The retrorockets came on to cancel out their last two hundred fifty kilometers per hour of horizontal velocity. When they touched down there was barely a bump.

Ethel cut the power to the props and began to shut down the systems. She waved at four figures in pressure suits and they approached.

The outside crew placed rocks under the wheels to stabilize the sunwing so that a gust of wind wouldn’t move it while Will and Ethel depressurized the interior and removed the pressure seal over the zippers in the rear. Finally they were able to remove the clamps and carefully, slowly, unzip the two layers of pressure membrane, then the outer layer as well. Will, then Ethel pushed out and stepped onto the ground.

“Welcome, welcome!” exclaimed Shinji. He reached out to shake their hands; they hugged him instead.

“It’s good to see you, Shinji! You’re a sight for sore eyes!”

“I’m sorry we can’t talk now; we don’t have a lot of time before sunset,” replied Shinji. “I hope it was a good flight?”

“Yes, very comfortable,” replied Will. “She drove and I slept.”

“The view was spectacular; I spent most of my time looking out the window,” added Ethel.

“I wish I could see it; maybe Phobos will shed enough light to see something,” replied Shinji.

Roger hurried up, suitcase in hand. He shook their hands as well. “It looks like you’re ready to go!” said Will to Roger.

“I am; it’ll be good to be home. Y’all don’t discover something important in my absence!”

“We’ll try not to,” replied Will, jokingly.

He and Ethel reached inside, pulled out their suitcases, and hauled them over to the nearest ranger, then returned—walking stiffly, after sitting most of the day—to help with the sunwing. One pair of oxygen and methane tanks had been changed; the other pair was proving difficult, but Paul was hard at work on it. Ethel grabbed her tools attached to her belt and removed the sunwing’s plastic waste tank, which was close to full. It came off fairly easily and she hauled it to the ranger, where she found the replacement. She attached it and checked the fittings. Meanwhile, Will climbed back inside and changed the water tank so the new passengers would have something to drink. Roger and Shinji said goodbye to everyone, then climbed in and zipped up the cabin. They brought with them one hundred kilograms of samples.

In fifteen minutes everything had been changed and the sunwing was ready for launch. They removed the stones blocking the wheels. Sebastian, who was piloting the sunwing remotely from the Outpost, gave a countdown to liftoff; neither Roger nor Shinji were certified to fly it, though Roger could manage in an emergency. At zero, Sebastian activated the methane and oxygen jets and the sunwing rose vertically three meters, then began to accelerate diagonally as its propellers spun at maximum power. It was airborne.

"Thanks a lot, guys!" exclaimed Roger. "See you again in a few weeks!"

"Enjoy the flight!" replied Ethel. She switched frequencies. "No one cook anything; we've got a surprise for you."

"Great! We're tired of rations!" replied Érico.

The three vehicles approached each other. Ethel lined up her ranger with the conestoga's rear airlock and backed toward it. In a few minutes she achieved a hard dock. Then the other ranger approached the conestoga's side and docked its portahab against the door there. In the conestoga, Carmen pushed a button that pressurized the rear tunnel, enabling people to walk from vehicle to vehicle without a pressure suit. They had a convenient nightly base.

"The tunnel's now pressurized," she reported.

"Thank you." Ethel turned to Will; he already had the two pressure cooker pots in hand. "This is going to be interesting, an expedition made up of three couples."

"Yes, until Érico and Carmen rotate back to the outpost in two weeks and are replaced by Armando." Will opened the hatch. He and Ethel stepped into the tunnel to the conestoga, closed the door behind them, then opened the other door and stepped into the

conestoga at the same time as Carmen and Érico. They greeted all four of the others at once.

"Welcome to Castle Station!" exclaimed Paul.

Monika was next to him. "It's so good to see you here!" she added.

"Thank you; we're glad to be here." Ethel embraced Monika; they had become good friends. Will and Paul embraced as well, as it had become the thing to do during welcomes. Then Will embraced Carmen and Ethel embraced Érico.

"Where does the name 'Castle Station' come from?" asked Ethel.

"There's a rock on the rim of the crater that looks a little like the turret of a castle, so we're calling the crater Castle Crater," replied Érico.

"We've been here ten sols," noted Monika. "It deserves a name. This has been a good base of operations. We've pushed the route another three hundred fifty kilometers farther north, but the two vehicles pushing farther north have always come back because the ranger here has been busy with the drills."

"I hear the drill casings are coming up with fossils?" asked Will.

"Absolutely!" exclaimed Monika, enthusiastically. "The drill has penetrated three hundred meters of sea bottom sediments, with no end in sight. It's been fine-grained clay, mixed with occasional volcanic ash falls, crater ejecta, and boulders rafted in by icebergs. The clay has been one to two percent organic matter, with zillions of partially reserved microfossils."

"You must be in heaven."

"You can't imagine!" she replied.

"The sediments are wet, too, I hear," added Ethel.

“Saturated,” replied Paul. “Nothing is dry, like in the equatorial regions. Castle Crater is only five million years old. The ground here’s solid permafrost. The water harvesting tent’s yielding up to one hundred kilos of water a sol.”

“No wonder we didn’t have to save the water in our fuel cell exhaust,” said Ethel. “We could fly higher and faster because we could throw it away as it was produced.”

“No loss; we have plenty!” replied Paul. “We’ve been throwing gray water away rather than recycling it, to save energy. And the farther north we go, the more water there will be lying around.”

“When do we set out, anyway?” asked Will. He looked at Érico, who was commander of the expedition until his departure, at which point Will would take over.

“Tomorrow,” replied Érico. “Ranger 1 and the conestoga will drive straight to the end of the route, then push it farther north, making very short stops for geology. Ranger 2 and the portahab with Paul and Monika will stay here to monitor the drill. In two weeks when Carmen and I rotate back to the Outpost, both vehicles will drive back here. The expedition will pack up Castle Station and all three vehicles will head north. We’ll do a little more postponed geology, then push the route as far north as we can in the next month or two.”

“You’re moving fast on the flat plain,” said Will.

Érico nodded. “Sixty kilometers per sol! There are very few rocks and the permafrost cracks have been too small to slow us down.”

“Wow,” said Ethel.

“The southern edge of the winter cap is three hundred kilometers away, and the edge of the permanent cap is two thousand kilometers,” noted Will.

"The route is already cleared into the winter cap, but of course there's no snow now. If we can continue at fifty klicks a sol, it's forty sols to the permanent cap, unless the dune fields slow us down significantly. This three-vehicle system for exploring has worked out very well. The machines have been reliable, solar power has been adequate, the sunwings can rotate personnel and deliver supplies, and the six of us have had a lot of fun together. It's really been great!"

"I'm glad to hear it," said Ethel. "And I'm very happy to be a part of it."

"So, what do you have for us?" asked Carmen, pointing at the pressure cookers.

"One of Madhu's rice dishes, complete with chicken and vegetables," replied Will. "The other pot has more of the same. We've got half of Mars's first rice harvest."

"Martian rice?" said Carmen, surprised.

"The paddy's beginning to be productive," replied Ethel. "Oh my God, Will; we promised to sent pressure pots back to the Outpost on that sunwing!"

Will chuckled. "They have two left, there; that'll be difficult! We'll have to send the pots back on the cargo flight next week."

The next morning Érico, Carmen, Will, and Ethel said goodbye to Paul and Monika and headed north. Ethel and Carmen rode in the conestoga; Érico and Will followed in the ranger. The route was smooth and clear and they drove at sixty kilometers per hour, the maximum speed of the vehicles, occasionally slowing down when the computer warned of bumps or curves. At that rate, the end of the route was six hours away.

"It's incredible how flat it is here," said Will. "Like parts of the American great plains; not a bump or roll, except for an occasional crater."

“Actually, it’s flatter than any plains on dry land; it’s more comparable to the abyssal plains at the bottom of the oceans,” said Érico. “Just think, once there were hundreds of meters of water over our heads here, and this was a quiet water depositional environment with mud sifting down through the water, disturbed only by an occasional boulder rafted in by an iceberg. And now look at it, 3.9 billion years later; the water is long gone, the mud is rock split by permafrost cracks, the surface is peppered with rocks tossed here from meteor impacts, and the area is blanketed with eolian deposits! It looks totally different.”

“It is amazing. I think I prefer the canyonlands. There’s practically no geology to do here, except when a crater has punched through the strata.”

“That’s true,” agreed Érico. “The poor state of preservation of the fossils is disappointing, too; we were hoping to find frozen intact organisms. Even so, this work grows on you, doesn’t it?”

“Yes, very much so. Mars grows on you. Not a tiny or simple place; a geological jigsaw puzzle almost as complex as Earth, and that’s saying a lot. Much more complex than the moon.”

“Yes, definitely. Even Roger’s beginning to realize that. I mean emotionally; he’s always understood it intellectually. I’m beginning to wonder whether he’s wishing he could stay another extra cycle.”

“Good! The more, the better. Are you thinking about staying?”

“I’d like to, but NASA may not want too many of us to stay; it messes up the flight plans of the interplanetary transit vehicles.”

“How serious were they, when the trainers talked about crew staying only two cycles, and growing this place gradually to a peak of a dozen or so?”

“I got the impression the policy was controversial; some wanted to go slow so they could keep the place under control and others leaned toward letting this place grow naturally and semi-autonomously. There’s a third faction too, though, the politicians who want to slash Mars funding in favor of social programs. That’s part of the problem; they’re exerting pressure.”

“I’ve got to email some of my contacts and get a better feel for the situation.”

“Do you want to stay?”

“Yes, Ethel and I would like to stay. We want Mars to grow as fast as possible. What about Carmen?”

“She’s thinking about staying. Which raises the interesting question whether we should get married if she can get a divorce. If we return to Earth it’ll be very hard for both of us to stay in our respective astronaut corps, and hard for either of us to transfer to another astronaut corps or enter the private sector.”

“That was our concern, too. You might be able to work together at ISS-2 or the moon. A married couple just served together at ISS-2; it was a first.”

“Yes, a ‘scandal.’” Érico shook his head. “You Americans have strange notions about romance and sex. If Brazil could send two astronauts to ISS-2 at the same time, we might have sent a couple years ago. But Brazil has only one six-month slot per year at ISS-2, and the same at Shackleton. There’s pressure to eliminate the position at ISS-2, too. I doubt Carmen and I could coordinate things to be there at the same time.”

“A good reason to stay here, then.”

“Exactly. In two years, and certainly in four years, we’d have enough money in the bank to return to Earth and retire if we wanted to. Of course, we still don’t know whether we want to get married.”

“That can be a difficult decision to make. Ethel and I are very happy together and very happy here. It has worked out very well.”

“I’m glad to hear that! The two of you are role models of sorts for us. We’re both young enough to stay here a while, then go back to Earth and start a family. We get along very well. It’s just not clear what the point of actually getting married would be. Carmen’s marriage just caused her grief, and now it’s a barrier.”

“I think the two of you make a good couple; you are very comfortable together. I suppose the answer to the question why get married, in my mind, is that it is simply a promise of commitment. It means you will try to make the relationship work even when it might be difficult. That’s particularly important if you have children; they need a stable emotional environment. To me, marriage is not an unreasonably set of expectations; it is simply a public way of saying you are partners throughout life’s challenges.”

“Yes, I understand that; but it’s still not clear to me that it’s necessary if you aren’t planning to have children.”

“Knowing the other person is committed to you can be pretty comforting.”

“Yes, I suppose.” Érico seemed unwilling to argue with Will. “All the research shows the pendulum is swinging back toward marriage, at least in Brazil. After bashing tradition, people are now embracing it.”

“The same in the States,” agreed Will. “The Outpost could be a pretty pleasant place to reside for quite a long time—say, a decade—in a few more years. What it needs

is more people; at least 20 or 30 people. If half of each mission stayed six years, the Outpost would stabilize at sixteen personnel. If twelve came each time rather than eight, it'd have twenty-four. And the cost of keeping twenty-four here wouldn't be much more than it is now because we're getting close to raising all the food we need."

"Think what we could do with twenty-four!"

"And three more vehicles; we could run two expeditions at once."

"We could set out to clear 'Route One' all the way around the equator, from the eastern and western ends. It'd take about a year. But someone would have to spend two billion importing more equipment, and no one's willing right now."

"I know. The space agencies have been hesitant to commit permanently to Mars, so far. It's still not clear Columbus 3 will even have eight personnel."

"Brazil has said it won't send someone, though it might on Columbus 4."

"And the various Mars societies have a bad relationship with the space agencies."

"Of course. They're seen as unscientific, and the space agencies are claiming scientific justification for exploring this place. It's a shame, too; they're natural allies."

"I wonder if there's anything we can do to bridge the gap," mused Will. "We're the ideal group to do it, after all."

"We should talk more to the media. Sebastian has been very tolerant of my interaction with the media. It's too difficult to control; Sebastian isn't an employee of NASA and the Portuguese-speaking media wants to talk to me, not to NASA!"

"There are more restrictions on me, as a NASA employee. I've been pressured not to blog, or say anything in the social media. But you're right, the non-Americans have more freedom."

“Well, I’ll see what I can do. I have several very sympathetic contacts in the Brazilian and Portuguese television networks.”

“Good idea.”

They postponed lunch until they reached the end of the route. After eating they started bulldozing the trail forward across the vast, flat, stony plain. They steered by global positioning coordinates because there were no reliable landmarks. About 3 p.m. they reached a two-kilometer crater and went out to explore. They came back inside at sunset, docked the conestoga and the ranger together for the night, and ate a late supper.

“I had a fascinating conversation with Carmen,” said Ethel, as they prepared to go to bed in the front part of the conestoga. “She’s really enjoying the exploration and the research she’s doing. She’d like to stay another cycle, if NASA can be convinced.”

“Érico told me the same thing. Their attraction to each other has reinforced it, too.”

“They live on different continents, but here they live in the same place. Carmen really loves him. I think she wants to marry him.”

“But what about her marriage?”

“Maybe she’ll seek a divorce. The marriage is over.”

“He’s hesitant, though. I don’t think we should push the matter.”

“I’m not going to push, but a few hints won’t do any harm.” She smiled puckishly.

“Érico and I were talking about Mars’s future. We both think it’s a good idea to be more active about selling this place via the media.”

"I agree, and that's something practical Sebastian would support. You should talk to him."

"I will."

The next morning, as the four of them finished breakfast, they decided to call Sebastian together. Will set up an attaché and they punched in Sebastian's number.

"Good sol," he greeted them. Then he saw the four faces crowded around the screen. "What's happening? I never get a call from four at once."

"We have an idea we want to share with you," replied Will. "Érico and I were talking about it yestersol; he and I talked to Ethel and Carmen last night, and all four of us talked about it this morning. Here it is September 6th; we're three and half months from conjunction and four months from the final decisions about the composition of Columbus 3. Columbus 2 is going well by everyone's measure and there are no 'scandals' for the journalists to exploit. So it occurred to us that it is time to go on a media offensive about Mars. We can strengthen our various space agencies in their efforts to finalize the funding for Columbus 3 and possibly strengthen the commitment to development of a permanent human outpost here. Almost all of us have contacts in the media we like and get along with well."

Sebastian frowned. "I know some of us have leeway with our national media, but I'd be careful about an informal campaign. The agencies and their media people will feel undermined and circumvented. That'll have consequences, too."

“But Sebastian, we have an incredible exploration story to tell, and the media people are not fully exploiting it,” said Will. “They say the public has gotten tired of it. I’m not so sure. This is the time to shore up support for Columbus 3 and 4.”

“This place has to grow,” added Érico. “It needs 20, 30, even 40 people, not the sixteen NASA keeps talking about. The Swift shuttle may make that possible without an increase in funding.”

“The agencies need to make a constant funding commitment, not a constant personnel commitment,” added Ethel.

“I agree, but this is the sort of thing that should be run past NASA and the other agencies. Admittedly, by the time we did and they made a decision, it’d be conjunction. And we do have some latitude in our access to the media.”

“Some people might get mad at us for doing it,” said Will. “Roger would have a good idea of who will be upset in Houston. I could also ask Laura Stillwell and David Alaoui for the reactions in Houston and Paris.”

“Good idea; talk to your friends from Columbus 1. Érico has latitude to talk to the Brazilian media.”

“What I do is email the media office that I plan to contact my friends at a certain television show, and they email back ‘great.’”

“Then do it. Shinji has some flexibility regarding the Japanese media, and Paul has a great relationship with the Canadian Space Agency’s media office.”

“They’ve given Paul complete freedom with his blog, on Facebook and Twitter, and other social media,” added Will. “He has said before that if I have ideas for uploads, I should write them down and he’ll do it.”

"Great; that gives us access to the social media," said Érico.

"I'll contact the United Kingdom's space media office," said Ethel. "I have flexibility because of my seniority here and because I haven't been commander."

"You could even be interviewed with Will on the British tv. The English interviews will spread around on the web, too." Sebastian nodded. "Okay, this is worth a try if we're careful and if this doesn't slow down your other work. The eleven personnel of Columbus 2 are doing twice as much as the six of Columbus 1. This place obviously needs to grow. NASA's rigid cap on growth is outdated because of our accomplishments and because of the Swift shuttle. It needs to be reconsidered, and I'll tell them that. So let's start out carefully, gradually, and see how the first few go. How does that sound?"

"Great," replied Érico. "I'll email the female anchor of one of Brazil's big morning news and variety shows. She's a friend."

"Good; do it. I'll suggest Shinji do the same for early next week. Ethel, you aim for late next week; I'll ask Paul to look for something the week later. Now, how's the exploring?"

"We cleared sixteen kilometers in two hours and explored a crater," replied Érico.

"There's not much to see, and not many rocks to move," agreed Sebastian. "When Érico and Carmen rotate back here in two weeks, only Armando will come down. We'll run the expedition with five again. I want six here at the Outpost; we need to do more with the Prospectors and we have a lot of maintenance, horticultural, and manufacturing work to do."

“But Sebastian, we can do Prospector stuff here, and six gives us more redundancy,” replied Will. “You’ve got plenty of medical equipment there and lots of safety in the habitats. We’re the ones on the front line.”

“Will, I know; I was there. And I plan to return in about six weeks. The expedition will manage just fine with five.”

“Okay,” replied Will, concerned.

“This exploration protocol of yours has proved to be brilliant,” said Sebastian. “We’ll stay in the northern polar region until just before conjunction; that’ll leave time to explore the layered terrains, the permanent ice, and maybe do some drilling. It’s going to be an incredible accomplishment and will go down in history. Then we’ll be back here at the Outpost for a month at conjunction, and we’ll *all* take a nice vacation. Then we’ll have seven months left and we’ll explore south or east.”

9

Ice Fields

Oct. 15-Nov. 18, 2038

They shoveled through the equatorward-facing layers of wind-blown dust covering the steep slope. It was the first polar layered deposits they encountered, and places where the wind had eroded off the edges showed annual laminae.

"If we only knew how old it is," said Paul as he dug.

"Some day we'll figure it out," replied Will. "But we know from the cratering history of this area that the surface is constantly renewed, and the climatological models suggest this deposit is a few hundred thousand years old."

"It's too young for microorganisms," agreed Monika. There was a note of frustration in her voice; she hadn't found anything alive yet. All the microfossils were at least middle Hesperian in age, some 2.5 billion years old.

They dug and dug. And then suddenly Will's shovel hit something hard; he heard scraping and clinking sounds through the handle. He stopped, puzzled, then pushed the clods of consolidated dust out of the way. The tip of his shovel was white.

"I just hit something, too," exclaimed Carmen. The others watched as they continued to dig downward.

Up came a chunk of ice. Looking down into the hole, they could see more white.

"Look at that! The first ice we've encountered on Mars!" exclaimed Will.

"We'll have to keep samples; it may have life in it," said Monika. She pulled out a sample bag and dropped chunks of ice into it with a pair of tongs.

They resumed digging and very quickly uncovered an extensive layer of ice. A powerful whack with a shovel broke through it.

“The layer’s about seven centimeters thick,” reported Will, to the geological team on Earth that would be watching in about twenty minutes. “The ice looks consolidated and old; large crystals, as opposed to frost or snow. It has significant quantities of dust in it, so that it’s gray-white.”

“Here’s a fairly dark crystal,” added Paul, holding a chunk up to the camera on his helmet.

“This has to be a remnant from the last climatic cycle when this pole was cold and the deposits extensive,” said Carmen.

“We’re at what; 64 north?” asked Will. “We’re still 14 or 15 degrees south of the permanent cap.”

“The permanent cap is bigger than it appears from orbit,” replied Paul, examining the ice. “It’s five p.m. Let’s take the ice inside so Monika can check for microorganisms. We can have supper and can come back out to explore; sunset’s about 10 p.m.”

“Good idea; we can clear and photograph this exposure later,” said Will. They all headed for the vehicles, where Shinji was cooking supper and Ethel was running a Prospector on the other side of the planet.

It was an animated supper; the ice was a big surprise. They had been crossing flat wasteland and extensive, rolling dune deposits for five weeks since Will and Ethel had flown down to join the expedition. The terrain was monotonous; only when a crater punched through the surface was there something of interest, and even that was the same

each time. Dodging lines of dunes slowed their progress. The ice was exciting, by comparison.

“I’m in favor of pushing on northward, but I suppose this raises the question of whether we should,” noted Ethel, as they all drank tea in the conestoga.

“One could use the discovery to argue the opposite,” noted Carmen. “We have now entered old, eroding, ‘fossil’ layered deposits. We have to explore the currently active ones to understand the old ones.”

“The bigger issues are logistical,” replied Paul. “The solar power unit can’t be kept facing the sun as easily and has to deal with dusty air, so it generates half as much power. We’re not pushing rocks out of the way anymore, but we need to use more energy for driving in sand and for heating. The satellites will be unusable once we pass 70 south, which means no communications or global positioning.”

“We’ll still have the ITVs and Deimos, though,” said Will. “We’ll have communications through them about two thirds of the sol, and some navigational capacity, up to 85 or 86 degrees north.”

“Before we get that far, we’ll have to deal with cliffs,” said Paul. “The layered terrain has some pretty steep slopes. I doubt we’ll want to go very far into it.”

“It isn’t clear we’ll have the time, anyway,” added Will. “It’s October 15. In six weeks we have to head back to the Outpost. That’ll get us to the edge of the layered terrain with a week to spare, but not to the pole. So the edge of the layered terrain is the logical destination.”

“I agree,” said Monika. “We need to sample the ice fields there for life. We’ll need to clear a landing circle—it’s the last one scheduled—and that’ll take a few sols.

Then Roger and Sebastian can fly in to participate in the glorious end of the expedition, and we can drive back home."

Paul nodded, then Ethel and Shinji. "Good; it's a consensus; we'll drive to the edge of the active layered terrain. I'll report it to Sebastian and Houston tonight," said Will.

The supper gradually broke up as everyone prepared to go to bed. After brushing his teeth, Will checked his messages. In addition to an email from a journalist, thanking him for the lengthy interview—the subtle educational campaign had been going very well, with no one yet complaining about the coordination of efforts—he found a videomail from the director of NASA's Mars Exploration program, Dr. Harold Lassen. He pushed play and saw the man's tired face appear on the screen of his attaché.

"Good day, Dr. Elliott. We remain deeply impressed by the expedition you are currently leading in the northern polar regions. No one could have imagined that we would get so far so early in our efforts to study the Red Planet. The quantity of data obtained since your landing on the planet three and a half years ago is greater than the predicted amount after a decade of exploration. It is almost impossible to imagine what we'll obtain in the next three years, which will probably see the exploration of the canyonlands and some of Tharsis.

"But I didn't call about exploration. There are two quick matters requiring your attention. The first concerns your fascinating interview on the Good Morning show three days ago. It was very well received; ratings were strong and our public information people tell us it made a very favorable impression on the public. But the public information department is furious that you accepted the interview without asking them

first. That is what they are for, after all. We have noted quite a streak of interviews coming from Mars in the last few weeks and we've contacted our fellow agencies about it. The social media traffic has noticeably increased as well. None of it has been coordinated. It leaves the impression that Mars may be pressuring governments for more money, and that impression could prove counterproductive.

"The second matter requires careful thought. On the Good Morning Show, you mentioned your desire, and the desire of Ethel, to remain on Mars two more years. The agency has discussed this matter and feels strongly that it is not advisable for you to stay any longer. There are several reasons for this. First, your radiation exposure has passed the recommended limit. Second, four years with limited medical care is risky. We need you back here so we can get a better idea of the long-term impact of the Martian environment on the human body. Third, while we want to encourage four-year tours of duty, at this time we do not want to encourage six-year stays. It raises issues of seniority, residency, and cultural sensitivity; it is difficult to remain in contact with one's national culture from Mars. Furthermore, the face-to-face relationships that make communication smooth and efficient are stretched badly enough after two years of separation; more than four years can produce alienation. So we request you and Ethel to reconsider your desire to remain. We can arrange the transfer of either of you to the American or European Astronaut Corps, if you want to live and serve together upon your return. There are plenty of vehicles to carry you back to Earth, and plenty of people who will stay at the Outpost; Paul and Monika remain committed to a four-year tour of duty.

“Thank you again for all you’ve done for the exploration of Mars. Your contributions are of epic significance. We’re sure your contributions will continue in very important ways from earth. Goodbye.”

Ethel had come over to listen. She looked at Will; he looked at her. “Wow.”

“Wow, indeed.” He thought a moment. “I don’t know whether I should be angry, pensive, or defiant.”

“His reasons don’t make much sense. They can study our health remotely just fine and they’ll need to study the effects of a six-year stay some time.”

“Seniority; that was an interesting comment. I suppose that means they don’t want to make me Commander.”

“Probably. The communication and cultural sensitivity arguments struck me as bizarre. They seem to be reaching.”

“I agree.” Will paused to think. “Tomorrow morning I’ll send them a reply, declining the request.”

“I’d make it polite.”

“Oh, very polite! I’ll be kind and respectful. I’ll even apologize profusely about the interview, to give them something.”

“Good. In the last few years, you’ve convinced me that while sometimes firmness is called for, kindness is essential. It’s your Bahá'í principle of consultation.”

“And your Presbyterian grandmother’s sense of Christian courtesy?”

“Sometimes; she may have been a fairly good Christian, but she wasn’t always courteous! This requires more kindness than she would usually muster.”

“Okay; I’ll be careful, then.”

"It sounds like we have to be more careful with our media campaign. You better tell Sebastian."

The next morning, having calmed down and thought about the situation, Will was ready to respond. After breakfast, he stepped into the cab of the conestoga to record a message in private.

"Good sol, Dr. Lassen. Thank you so much for your message yesterday. Ethel and I have spent some time thinking about it, and we much appreciate your speaking to us.

"First, I must apologize to you and to the public information people for the interview on the *Good Morning* show. They called me and I said yes without thinking about O. P. I. If an opportunity like that arises outside the usual channels, I'll be sure to talk to them immediately. As you probably know, the Brazilian and Japanese space agencies have been pretty loose with their astronauts here, and all of us know each other very well. Columbus 2 has clicked well as team. This made me improperly lazy, where public relations are concerned. I'm glad to hear the result was good for the agency, though. In the last few months there seems to have been a flurry of human interest in the Mars mission. I hope that has been of benefit and has strengthened the public's support.

"Second, Ethel and I have thought quite a bit about your recommendation that we return on Columbus 2. We're glad to report that our radiation exposure, even with a flight back to Earth, is still within tolerable limits. Our medical treatment here is excellent. The new MRI has enabled us to take semiannual body scans, which clearly indicate no precancerous or cancerous conditions. Furthermore, the testing that can be done here allows extensive study of the effects of Martian gravity on the human body. As you

know, the results have matched the models that have been developed as a result of zero-gravity and lunar gravity studies; our skeletal strength and cardiovascular function have been impaired less than in either of the other two environments, the decline arrests at a certain level appropriate for the gravitational field here, and strenuous exercise—such as is required by EVAs—significantly reverses the decline. The two physicians here are confident that with the equipment we now have, we are gathering excellent data.

"The seniority issue is more serious. Allow me to assure you that Ethel and I are happy to join and fully participate in any team that is sent to this world. We neither demand, nor even expect, positions of responsibility here. We will serve the team while we serve the goal of exploring this world, in any reasonable capacity.

"I hope that sets your minds at ease about Columbus 3. Have a good sol; er, day. Goodbye."

He reviewed the tape and decided he had been as polite and courteous as possible, but he did wonder whether his prolonged absence from Earth was impairing communication. He hit send and got started with his work.

Soon the three vehicles separated. Will and Ethel took the lead in the conestoga with Will driving and clearing. The ancient layered terrain was more difficult than the rolling, dust-covered plains they had been crossing for the last month; whenever they came to the edge of a layer there was a steep slope to climb and low cliffs to avoid, with lots of broken debris to push out of the way. The flattish tops of the terraces were largely free of rocks—except for meteorites, which were easy to spot—but they had been eroded by the wind in funny ways, sometimes with teeth-chattering grooves to smooth over or endure. Other places were smothered with loose dust that threatened to bog down a

vehicle. While Will drove the conestoga and Shinji followed to smooth the trail with a ranger, Monika and Paul scouted around in the other ranger, sometimes smoothing the route a bit, but just as often dashing off it to investigate rocks, pits, or small cliffs. They rarely left the cab; detailed close-up observations and photography, coupled with samples picked up using the ranger's remote-controlled arm, were usually sufficient. A particularly significant site could be revisited later when they drove back to the Outpost. Ethel, meanwhile, operated a Prospector in Isidis Planitia on the Martian equator. While Monika drove, Paul often did the same between observations.

At midmorning they stopped long enough to dock the conestoga and ranger together so Will could shift to Shinji's vehicle. Ethel, Paul, and Will drove; Shinji rested a bit, then began to prepare lunch; Monika drove a Prospector in Amazonis except when her ranger stopped for observations. They were delayed about fifteen minutes by two more terrace edges, but each time Houston's proposed route to the top was safe. Assisting them was a sunwing, which had photographed the area several sols earlier. It was two hundred kilometers ahead of them photographing their future route.

The three vehicles docked together for lunch. Will saw that two messages had arrived from Earth, so he excused himself and went into the cab to play them. Ethel came along.

"Good evening, Will," said Lassen, no doubt referring to the time in Houston. "As you can imagine, we're disappointed by your response. Please reconsider the situation further in the next few days. Meanwhile, congratulations on finding the ice layer; everyone here is thrilled we've actually seen Martian ice near the surface. I understand

Paul and Carmen found a nice, fairly intact chondritic meteorite about two hours ago; the sample will be a nice addition to the return flight. Bye."

"Boy, that was a pretty simple concession," said Ethel. "I'm surprised."

"They're not finished. I suspect you'll hear from ESA, and maybe the language will be stronger."

"Could be."

Will clicked on the icon for the second message. A moment later the face of a man in his late fifties appeared on the screen, one he did not immediately recognize.

"Good afternoon, Dr. Elliott. I'm not sure you'll recognize me; my name is Robert Clarke, President of the Mars Exploration Society. I was just talking to your boss, Dr. Lassen, yesterday, and he suggested I call you. It is not yet public knowledge, but I will be stepping down as President of the Mars Exploration Society in the next few months, or possibly in a year, depending on how quickly we can line up a successor. The last few years, as you can imagine, have been tough on the MES. Many conceive that our purpose was achieved when Columbus 1 landed on Mars three years ago. Our membership has dropped and there is a widespread feeling we have become irrelevant. After all, we set out to send astronauts to Mars ourselves, if necessary, decades ago, and that never happened.

"We think it's time for the MES to take a new direction: to stress continued exploration and colonization of the Red Planet. It is, after all, the only world in this solar system outside of Earth where human life is reasonably possible, and the only world where terraformation seems plausible. Unfortunately, my health does not permit me to seize the new direction aggressively. Hence we are searching for a new director, one who

can build our ties with the space agencies exploring Mars and with the scientists actively pursuing its study. In the last decade, frankly, we've seen an imbalance in our membership and priorities. We have too many dreamers who want to project their personal fantasies onto Mars, whether they are anarchists, communists, or religious utopians. This has alienated both the professionals involved in Mars exploration and the middle class consumers whose taxes pay for the exploration. We need to pursue both serious science and mainstream acceptance.

"We're hoping you might consider the position of President. Dr. Lassen informs me that you will almost certainly be returning to Earth in eighteen months. I can manage to run the MES until then. You would be the perfect person for the position; you have widespread name recognition, you have obvious management capabilities, you have extensive experience on Mars, and you could bring a vision to the organization that would be unique, because of your unique experiences. I hope you consider the suggestion very carefully. Please let me know what you think. Goodbye."

Will stared at the blank screen after Clarke's face disappeared. "The nerve of Lassen to tell Clarke to call me. I'm tempted to call Lassen and tell him off! And Clarke is innocent; he has no idea he's been used."

"Don't blame Clarke; he's trying to solve a problem."

"I don't blame him. The offer is even tempting; if we planned to return to Earth, that is."

"I can see that it would be. The MES can play a role in Mars exploration, too, if it could be reorganized and realigned."

“It really could be useful.” Will thought. “Say, isn’t Heather Kimball planning to retire from the Astronaut Corps? She applied for a position on Columbus 3 and they turned her down because of her radiation exposure. They don’t even want her flying to the moon any more. She’d do a good job.”

Ethel nodded. “She’d be good. She’s highly respected by everyone, her management skills are amply demonstrated, she has a flare for public relations—”

“And I bet she’d be good at fund raising,” added Will. He turned back to the attaché and hit reply. “Good sol, Dr. Clarke. Thank you very much for the fascinating and very attractive offer. I wish I could help, but there’s only so much we can do from here. You see, the rumor that Ethel and I are planning to leave is not true. Our current plan is to stay at least two more years. But you may wish to contact Commander Heather Kimball. She is planning to leave the Astronaut Corps at some point soon, we think, and she would be an excellent President of the MES. I think it would be difficult to find someone more qualified than the first women to set foot on the moon. Whenever we do return to Earth, we may offer our services to the MES. Best wishes. Goodbye.”

He hit send; the videomail was on its way. Ethel nodded. “I’ll call Heather later this sol and tell her we mentioned her name to Clarke.”

They headed for their various tasks. Will filled the sink with water to wash the lunch dishes before turning to supper preparation. Ethel headed for the ranger she would be driving for the afternoon. After three hours of driving the expedition stopped for a three-hour exploration, which Will skipped so that he could finish preparing supper. It also gave him privacy to answer a confused email from Kimball about a call from Clarke, and to respond to an email from Laura Stillwell, the Columbus 1 commander, who had

also been asked to call him and urge him to come back to Earth. He was polite but a bit franker to her and asked her what was going on. Clearly, the pressure was mounting. He told Ethel about it before bed.

"I got a call from the assistant director of ESA, Claude Dubois," she added. "To his credit, he sounded extremely uncomfortable with the message he was relaying. So this is coming from NASA. ESA seems to be a reluctant participant."

"Interesting. I explained the proposal to Kimball and she said she was thinking very seriously about the idea. So we may have solved Clarke's problem!"

"That's a small victory. But what will do about this NASA campaign?"

"I don't know. I hope Heather will advise us."

Just then, Will's attaché beeped; it was a local videophone call. He looked at the caller i.d.: "Sebastian." He pushed "connect." "Good evening, Sebastian."

"Good evening. How are you? I gather you've had a busy day."

"I have. Did you hear from Lassen?"

"I did. What did he say to you?"

"He called last night and asked Ethel and me to return to Earth on Columbus 2. He said it was for the sake of our health, for seniority reasons, and to avoid the poor communication that can result when people no longer can actually see each other face to face."

"What did you say?"

"No. We were very polite, of course. The reasons don't make sense."

"Sebastian, I received a call from Dubois this sol," added Ethel, stepping closer to the attaché so he could hear and see her better. "He was very uncomfortable and asked me to consider returning to Earth."

"They're ratcheting up the pressure."

"I got a call from Robert Clarke of the Mars Exploration Society this sol as well, asking me to consider the position of President of MES."

"Really. That would sure help MES."

"Sebastian, this is politics. They don't want Mars to acquire the experience or creativity to have ideas of its own."

Sebastian sighed. "Look, Will, don't make this difficult. Just agree to return to Earth on Columbus 2."

"Sebastian: *why*? It's irrational and foolish to insist that someone leaves a place because they've accomplished too much. I haven't asked to be Commander; in fact, I haven't been. I've made it clear I'll accept any position here that's given to me. I'm not an unreasonable person; I've persuaded people in reasoned ways rather than coerced them. So what's the problem?"

"I think you just put your finger on the problem: you're too smart, too creative, too articulate, and you love Mars too much."

"But Sebastian, really, is that a problem? Should it be a problem?"

"It shouldn't, but it is. A certain number of managers don't know how to handle it. They want a nice, conventional setup: they draw up a nominal mission, an extended mission if the nominal mission is accomplished, and afterward they review it all,

brainstorm, and plan a new nominal mission. But if the Mars crew wants to change it or innovate a lot, they're powerless."

"No they aren't. They videomail, email, send proposals, write reports, and we all consult back and forth."

"You're right; if they're good, that's what they'd do. But a large number of managers haven't adjusted to the communications problems posed by the distance. Look, Will, make this simple. If they order you to resign, then resign."

"But they haven't ordered me, Sebastian. I assume you won't sedate Ethel and I, tie us up, and throw us onto a shuttle?"

"No, we won't do that. And I assume if NASA orders you to return, you'd obey?"

Will thought a moment. "We would."

Alright, I'll call Lassen back and see what I can do. I reluctantly agree: they should be thankful they have such hard-working, patient, and self-sacrificing employees. One issue may be the Commandership of Columbus 3."

"Maybe the pressure is coming from the candidates for Commander or their friends. But I repeat: I am not asking to be Commander."

"Okay, I'll talk to them. You made forty-seven kilometers this sol?"

"Yes, we did very well. No interesting discoveries, though."

"That can't happen every sol. Okay, good night."

Will didn't sleep well that night. The next sol they continued northward and no one called. But they had some communications problems; the satellites were too close to the southern horizon. They had to reduce the amount of video they were sending and

receiving, which meant less television at night. The global positioning system worked only intermittently. Once they position a sunwing to serve as a high-altitude relay station, communications improved considerably.

Silence from NASA and ESA continued. Two sols later the global positioning stopped altogether. They had detailed surface photography, though, so they navigated via landmarks. The sunwing could still relay video and they began to use their shortwave radios, which broadcast at frequencies that reflected off the Martian ionosphere and reached the Outpost.

That evening Will received a surprising and cryptic email from Neal Stroger: *Will, I've been asked to relay a message to you; Lassen has decided to leave you alone.*

"Who's Stroger?" asked Ethel.

"Neal was at Shackleton when we arrived for training, but left a week later. He's youngish; maybe 30 or 32. He would have been late twenties, then. He's an Air Force officer who joined the Corps, then went to graduate school in lunar geology."

"Oh yes; impact melts!"

"Exactly. He was poking into every big crater he could get into, studying impact melts on their floors. He must have a Ph.D. by now."

"But why him?"

Will pointed to the return address. "It was sent from Shackleton. Stroger's on the moon right now. This email didn't come to us via Earth."

"Less likely to be detected by NASA. Sneaky."

“Yes. That tells me whoever wanted to let me know that NASA has relented, didn’t want NASA to know they told me. Maybe Laura. Maybe a few other friends in Houston.”

Ethel shook her head. “Cloak and dagger stuff isn’t good, but all organizations have it. At least they haven’t bothered us lately.”

“Which suggests this message is real, not bogus.”

They had no more to say about the message, so they went to bed. The next morning they continued northward. The five of them had a standard routine going, by then.

The next sol the going got harder; the ground was covered by thick, shifting dust and the air was filled with it, so visibility was terrible. They were approaching the retreating edge of the seasonal cap; winds were high. They stopped to set up a new station but the solar power unit produced very little power. The powerful winds made sunwing landings impossible as well. On the other hand, the winds made sunwing cargo drops easier; the sunwing could almost hover over the surface, flying into the wind, and drop packages gently. They regretted not having a wind turbine to augment their power.

They briefly drove south for three hundred kilometers to a spot out of the wind belt to clear their last landing area. Roger and Sebastian arrived and Paul and Monika headed back to the Outpost, making a two-hour stop at Castle Rock to fix a broken piece of equipment there. Armando and Érico arrived the next sol and Shinji went home; the two men stopped at Chryse Station to reconnect a solar panel and make sure the station was stocked for the return trip.

After receiving a tonne of methane and oxygen from the Outpost via sunwing, the six continued north, and in early November they reached the retreating seasonal cap. They suited up to look at the snow. Snowballs, however, were impossible to make; the snow was too cold. With the wind, it was even difficult to stay outside very long.

Finally, on November 18th, they approached a glittering cliff of white; the active northern layered terrain, where permanent snow and dust mixed and were present all year on the surface. They stopped to get out and investigate.

"We did it!" exclaimed Roger, picking up an ice chunk that looked like a whitish rock that had broken off the cliff. "Permanent ice on Mars! You just have to go to 79 degrees north to reach it!"

"Who would have thought we'd get here," said Sebastian. "Our goal was to reach fifty north by the middle of next year. Here we are, six hundred fifty kilometers from the north pole!"

"The north pole's another trip." Roger looked at the ice cliff. "The rest of the way is blocked by hundreds of escarpments like this one."

"We'll drive east to the mouth of Borealis Chasma," said Sebastian. "A short trip up it is possible. I wish we could get to the pole, but that'll be the job of another expedition. We've got about eight sols before we have to head back to the Outpost."

10

Conference

late Nov. 2038

Six people in three vehicles watched the rolling rockfields of Aurorae Chaos with rising excitement. They had covered 5,400 kilometers—a bit more than the width of the United States from Maine to San Diego—in nine sols. With pairs of drivers, they kept the vehicles going at forty kilometers per hour during most of the daylight hours; at night, after docking together for supper, the vehicles separated and drove themselves automatically at a gentle twenty-five kilometers per hour while everyone slept. Every sol they stopped for at least three hours to explore or repair equipment. At 71, 50, 30, and 12 north there were oases with solar panels, oxygen, methane, water, a Sabatier reactor, a landing circle, a meteorology post, and a satellite antenna; they stripped the oases to minimum size, since no expedition planned to visit again soon, and packed most of the equipment onto the sunwings to fly it to Aurorae.

As they approached the Outpost, Will and Ethel were pleased to see two slowly turning wind turbines on top of Boat Rock. A few minutes later the entire Outpost became visible at the mesa's northern base. The Geology Storage Facility appeared to have a thicker coating of reg than when they had left nine weeks earlier. The greenhouses were distinctly verdant, even from a kilometer's distance.

The vehicles backed against three airlocks on the eastern side of the Outpost and docked to them. In a few minutes the crew exited to an excited welcome.

"Welcome home!" exclaimed Monika to Will and Ethel, as they stepped out. She gave them both a hug; Shinji was there to shake hands. Then the next airlock over opened

and Armando stepped out, followed by Paul. Monika turned to him. “Welcome home, my love!” she said, and they embraced and kissed passionately.

Érico and Carmen welcomed Sebastian and Roger as they stepped out another airlock. Madhu was there as well; she and Roger embraced and kissed warmly. Will and Ethel walked over to the other group and Érico turned to them.

“I’m sorry I missed the rest of the trip to the layered terrain, but only so many could go. How was the return journey?”

“Five thousand klicks is a long drive, so we’re rather tired,” replied Will. “It’s a privilege to see that much of Mars, though it was a lot of magnificent desolation.”

“It was a lot of boring desolation with moments of magnificent desolation,” corrected Ethel. “Fascinating in its own way, though. Not many people can say they’ve been from almost pole to equator on any planet.”

“Though we haven’t really been to the pole,” noted Érico.

“The wind turbines are exciting to see!” exclaimed Will.

“Oh, you saw them!” said Carmen.

“They’re pretty easy to spot, with twenty-meter blades,” said Ethel.

They make only kilowatts each, but they’ll make twenty during a dust storm when solar power is minimal,” said Érico. “You could’ve used them at seventy-six north!”

“And how! It was incredibly windy; the carbon dioxide cap was bulking up the atmosphere. The meteorology post we left will tell us the wind power potential.”

“I’ve got to see that place,” exclaimed Érico.

“Some day,” said Carmen.

They all headed for the habitats. Monika said to Paul, “So, where are my samples of polar ice and regolith filled with living organisms?”

Paul laughed. “The samples are in plastic bags inside the sample case on the portahab’s roof. Don’t hold your breath about life.”

“Oh, I know,” she replied matter-of-factly. They had not yet found anything that had been alive in at least 2.5 billion years. “I’m glad you’re back.”

“I’m glad to be back, too. I missed you.”

“A lot?”

He nodded. “A lot.”

She smiled, pleased by his answer.

“It’s true; he kept mentioning your name in his sleep,” said Shinji.

Will turned to Madhu, who was walking by. “Good to see you.”

“Thanks, Will. It’s good to see you, too. Did you enjoy the trip?”

“Yes, it was incredible. We’ve totally blown away the Ganges Chasma expedition of Columbus 1. This trip was in an entirely different league.”

“It’s the beginning of real planetary-scale exploration,” added Roger.

Ethel touched Madhu’s shoulder. “How are the greenhouses?”

“Go look! You won’t recognize them. We finally got the salts washed from the soils and the nutrients balanced. The soils have healthy microbiologies and are getting richer all the time. The rice paddy is very productive, which means lots of tilapia. The rabbits, chickens, and turkeys are reproducing faster than we can use them. I’ve expanded into the tunnel connecting to the Mars Life Science Facility.”

“Really?” Will looked at Ethel. “We’ll have to take a look.”

“We’ll walk through the greenhouses on the way to Habitat 1,” she replied. They returned to the conestoga, grabbed their personal possessions, then headed through Greenhouses 1 and 3 to their apartment.

They were so amazed by Greenhouse 3 that they tarried at the entrance a moment. Warm, humid air hit their faces as soon as they entered; they were in the tropics. They looked past six seedlings in big plastic pots—four fast-growing dwarf oranges and two lemons—to see a rice paddy filling the entire six-meter width of the greenhouse. “I just finished making the paddy liner before we left!” said Ethel. They stepped up to the fieldstone wall edging the paddy—Will had helped to pack the stones—and she reached down to feel the triple-thick plastic sheets that held in the mud and water. “It’s held up really well.”

“So lush!” exclaimed Will. He pointed. “And look at all the fish!”

“The tilapia are happy,” she added. “Fifteen centimeters of mud and twenty centimeters of water is all it takes.”

“How much food?”

“The paddy can produce two hundred kilos of rice and one hundred kilos of tilapia per year.”

They stepped onto a metal gangplank that crossed the middle of the paddy and walked over the ten meters of greening rice. They stepped down amidst plastic pots along the other side holding two limes, two mangos, and two date palms. The other half of the greenhouse was filled by planters of hard plastic two and a half meters square. Like the paddy, they rested on metal grills over rocks to keep them off the greenhouse’s frigid plastic floor. Their twenty centimeters of soil held one crop: tomatoes, corn, cantaloupe,

eggplants, peanuts, soybeans, lettuce, and cucumbers. The last meter before they passed into Greenhouse 1 held three tall, odiferous composting units and a pungent rabbit house.

Greenhouse 1 was equally lush, but less tropical. They walked between the two planters of potatoes, two of wheat, and one each of peas, beans, carrots, strawberries, herbs, rye, watermelon, lentils, soybeans, spinach, broccoli, and cauliflower. Chicken and turkey coops lined both ends, with grapevines climbing up them and apple, peach, pear, and plum trees between them. Everything was growing with great vigor except the strawberries, which were ready for retirement to the basement of Habitat 2, where artificial sunlight would be gradually diminished over a month and the temperature around them would drop; then they'd be covered with snow for six weeks, gradually warmed and given more sunlight, then brought to the greenhouse to bear again. That way two planters of strawberries could be rotated through the same square of greenhouse floor, bearing fruit half the year between them. Strawberries in Greenhouse 2 bore fruit the other half.

They entered Habitat 1 and walked to their apartment. After unpacking, they headed for the great room in Habitat 3 to join everyone else. They passed through Greenhouses 2 and 4 to see them; they had almost the same crops and were equally verdant. They took a peek at the two-meter wide pedestrian tunnel to the Mars Life Science Facility; it was lined with pots full of herbs and self-pollinating vegetables, making walking rather difficult.

Érico, Carmen, Sebastian, Shinji, and Armando were already in the great room; the first two were busily cooking while the other three sat drinking coffee. "I take it that we have the rest of the sol off?" Will said to Sebastian.

"Speak for yourself," replied Érico from the galley.

Sebastian nodded. "Yes. I'd like to declare a week off, but I suppose we should work most of the next two weeks until conjunction."

"What sort of communication will we have with Earth?" asked Will.

"Very limited. For the entire month of December the Earth is on the other side of the sun for Mars *and* Venus. That means the Heliosat 4 solar observer and the Mercury orbiter will have to relay data between Venus and Earth as well as between Mars and Earth. We can also bounce data off the Vesta and Jupiter orbiters, but that'll be slow."

"We went on vacation during the last conjunction."

"That's what we'll do, too."

"Are we planning a long staff meeting to evaluate what we've done and what we should do during our remaining eight months here?" asked Will.

"I hope so," said Roger. He and Madhu entered in time to hear the last comment.

"The nominal mission is almost accomplished," agreed Érico.

"I thought we'd meet briefly to consider the various extended mission options," said Sebastian. "I have an updated list from Mission Control."

"I'd like to propose a longer timeframe," said Will. "Let's consider our schedule until Columbus 3 arrives. Ethel and I will be here, and Paul and Monika pledged to stay, so—"

"That's not part of Columbus 2," replied Sebastian. "You can plan the extended mission later."

"But Sebastian, we may have more than four. I'd like to start tomorrow by finding out who plans to stay. If we have six, we'll have enough for exploration. It'd be wise to plan the next phase of Columbus 2 in the light of the phase that follows."

Sebastian hesitated, then nodded. "I see. Okay."

"When do we meet? We'll be partying all of tonight," noted Érico.

"We'll make it an all-day event tomorrow," replied Sebastian. "Well, by 'all day' I mean 10 a.m. to 5 p.m. No reason not to sleep late tomorrow."

They had a truly grand time that night; the most energetic celebration Will had seen on Mars. Madhu orchestrated an artistic program that included a skit by three of them, a dance by her, and a singalong. Will and Roger spontaneously created a song,

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

From the Hellas Basin, to the cratered highlands,

From Tharsis Montes to the Mariner Valleys,

This land was made for you and me.

Which made everyone laugh, even Sebastian. About midnight everyone headed to their rooms. Érico headed to Carmen's, where they often spent the night "I haven't had that much fun in a long time," he said.

"Not on the moon, that's for sure. Four to six month stays tend to be very serious and hard working. I can't imagine what a vacation on Mars will be like."

"A strange idea; but we've been working eight months straight. We need a break." He looked at her. "Tomorrow the first topic we'll discuss is who's staying an extra two years. I'd like to say yes."

She looked at him, thinking. “Good, I’d like to say yes, too. I want to be with you, Érico. I like this place very much, I love my work, and I love you. Tomorrow I plan to email Pablo for a divorce. I know he wants one; remember that email I got?”

“From your friend, saying he’s living with another woman?”

“Exactly. There’s no reason for us to stay married; it was over for eight months before we left Earth, and nothing since has changed the situation.”

“I love you very much, Carmen.” He embraced and kissed her.

She pulled back slightly. “Yes, but you know what else I mean.”

“Carmen, you know my concerns about marriage. It’s not easy for an orphan adopted into an unhappy family—”

“I know, I’ve heard about your sad childhood before. But there are millions of happy marriages. Look at Will and Ethel, or Roger and Madhu. Or my parents.”

“I know, but I have to go on my experience.”

“No, you don’t! You’re one of Brazil’s top scientists, the first Brazilian on the moon, the first Brazilian on Mars. You’re a bright, capable man, and a very sensitive one. You don’t have to prove yourself to anyone. I just want to know I can count on you.”

“Of course you can count on me! Haven’t I been here for you for the last year?”

“Yes, but let’s make a commitment, a *real* commitment. Is that too much to ask?”

“Well, maybe not—”

“Then let’s get married.”

Érico opened his mouth, but he didn’t say anything. It was as if he were paralyzed; unwilling to say yes and not wanting to say no.

Finally Carmen shrugged. “What can I say? We’ve been here before.”

"We have." He turned toward the door. "I guess we'll resume this discussion tomorrow."

"I hope so," she replied. He headed out the door, sad and pensive. She watched him go, feeling hurt.

Sebastian rose early to finish planning the meeting. He started by making his usual round of the Outpost, to inspect every hab and greenhouse, then returned to his room to organize the agenda. A flashing icon told him Angela had just videomailed him. "Good morning, dear. It's 'morning' here too, but just a bit after midnight, whereas I suppose you'll get this after breakfast! We've had a pretty good day. Helmut got the highest mark on a major test in his physics class. The teacher was *very* impressed. Even Kristoff is doing well right now; he got an A on his eighth grade science paper because he did it on African violets, and as you know, he has become fascinated by them! I'm buying him every variety I can and it seems to have given him something positive to put his energy into. I'll email you a list of varieties you can buy him for his birthday, if you'd like. As for me, work was a real drag today; the trouble with my bossy office mate is continuing. I think he's going to quit, so I can wait him out. Good luck with your big meeting today! Bye."

He had to smile at that; she was always cheerful, even when she was suffering about something. It made him feel better, too. He hit reply and taped a quick response, with sections for each boy, then sent it and turned back to his work.

Sebastian headed for Habitat 3's great room a few minutes before 10 a.m. He invited Mission Control to attend remotely, in spite of the time delay—round trip

communications between Earth and Mars at the speed of light took forty minutes—and in spite of the fact that it was 8:25 p.m. in Houston. It seemed that every time they had something that could not wait, the time was inconvenient on one planet or the other.

"Let me propose an agenda," Sebastian began, as they settled onto couches and chairs. "First, we need to ascertain the human resources we'll have here from Columbus 2's departure until the arrival of Columbus 3. Second, we need to consider what we'll do from January 3, 2039—two weeks after conjunction, when our communications return to normal—until August 15, when trans-Earth injection occurs. Third, we need to outline tasks until Columbus 3's arrival, scheduled for May 1, 2040. Fourth, let's consider cargo and staffing recommendations for Columbus 3, based on our experience and plans over the next year and a half. How does that sound?"

"Sebastian, what will NASA think about all this independent mindedness?" quipped Roger.

"They'll get used to it; they have to. And remember, they're listening." Sebastian looked around. "Okay, who wants to stay? I put it that way because NASA may have its wishes, but it needs to know our wishes as well. Let's start with our oldest residents: Will, Ethel, and Shinji."

Will nodded. "Ethel and I are staying."

Shinji shook his head. "I'm returning to Earth."

Will and Ethel looked disappointed, but they were not surprised; Shinji had never expressed a wish to stay a third cycle. Sebastian turned to Paul and Monica. "Back on Earth both of you made a commitment to stay."

Paul nodded. “I made the commitment, and my time here has reinforced it. I’m staying two more years.”

“Me too,” added Monika. “We haven’t found life yet, but I want to keep looking. Maybe another two years is all we need. We’ve identified ten species. We’re also looking at the era of the origin of life that has been completely erased by geological processes on Earth. This is *eobiology* and *eobiochemistry*: whole new fields. It’s some of the most exciting research of the century.”

Sebastian nodded. “I’m leaving; I have a family that badly needs me on Earth. Armando?”

“I’m in the same situation. My wife can tolerate one cycle, but not two.”

“Érico?”

The Brazilian paused to consider his words carefully. “I want to stay two more years and marry Carmen.”

Everyone was surprised; Carmen’s jaw dropped. “Marvelous,” said Will.

Carmen looked at him directly. “Do you mean that, Érico?”

“I mean it. I stayed up all night thinking about it.”

She had been sitting on another couch; she walked over and kissed him.

“So, Columbus 2 will have a wedding as well,” said Sebastian. “This is becoming a trend. Carmen, I take it you’re staying as well?”

“Of course!”

Will walked over to shake hands and hug with both of them. Everyone else followed and business was suspended for several minutes. Finally Sebastian said. “Let’s

plan to have a special dessert and a bottle of wine at lunch, shall we? Meanwhile, we need to return to the subject at hand."

Everyone returned to their places. Roger moved from the couch where Érico was sitting to make room for Carmen. Sebastian turned to Madhu. "What are your plans?"

"Roger and I talked about the matter last night. I've really enjoyed my horticultural and dietician's work and Roger's in geological heaven. Another two years will allow both of us to solidify our contributions to this place and return to Earth with valuable experience. We want to stay."

Sebastian was surprised. "That means Columbus 3 will return to Earth with only three crewmembers! The Outpost will have a staff of eight while waiting for Columbus 3's arrival!"

"That's more than Columbus 1; enough to carry out a substantial exploration and industrial schedule," noted Will.

"But what about Deimos?" exclaimed Sebastian. "We're scheduled to spend six sols there, exploring and doing routine maintenance on the fuel making facility."

"We have three Mars shuttles," replied Roger. "Two could fly to Deimos, rendezvous with the ITVs to transfer samples, then one could return to the Outpost with crew."

"It'll be dust storm season, though; we'll have to be prepared for delays in landing." Sebastian considered. "We have three ITVs in orbit, and NASA's counting on two returning to earth this time. The eight of you will have one problem: you won't be able to return any time you want. There may not be enough berths."

"We'll cross that bridge later," said Érico.

“One problem,” noted Shinji. “The Outpost will have no physician.”

“But all of us have emergency medical training and we have the equipment to provide the data to doctors on Earth,” added Ethel. “We’ll be able to set bones and dispense medicines. As long as no one needs an appendectomy, we’ll be okay.”

“Everyone get their teeth cleaned and checked before Shinji leaves,” said Roger.

“We’ll have to review inventories carefully; we may have shortages,” said Sebastian. “Direct communication with earth ends in ten sols and resumes twelve sols later. How will we spend the remaining months before three of us head home?”

There was a pause, then Érico spoke up. “I’d like to see us return to the north for at least two months to explore the layered terrain more, initiate drilling, and reach the North Pole itself. The latter would be quite an exciting and historic achievement.”

“I’d like to finish our northern exploration too, but I don’t think it’s practical,” said Roger. “Between the low sun angles and the dust, solar panels and solar power units don’t work well up there, and usually it’s too windy for sunwings to land north of 71 degrees. The autumnal equinox is mid March. Conditions at the pole will be deteriorating by the time conjunction ends and by the time we reach it, it’ll be sunset. And the pole has no communications or navigational signals; we’d have to guess its location. Finally, the layered terrain is too rough for easy travel.”

“We used up the entire summer season reaching the polar region and exploring it,” noted Will. “That was a significant achievement.”

“Maybe in another Martian year we can return,” suggested Roger.

“I take it that’s a consensus,” said Sebastian. “Which way do we go next? West?”

“That’s Will’s suggestion,” said Roger. “And I’d support it.”

“I’d like us to clear a route the length of the Mariner Canyons, all the way to Labyrinthus Noctis,” said Will. “That’s almost as far as the northern polar terrain. There are very rough spots, with lots of landslide deposits and boulders. But there are places the canyons are six kilometers deep and we can retrieve samples from the entire exposure. The sunwings have photographed the canyon walls in detail and made laser reflection studies of the rock composition. We know of several major sedimentary strata that probably have microfossils.”

‘That’s a good argument,” agreed Roger. “The only addition I’d make is that we should start a southward route that will eventually reach the South Pole. Once the southern spring equinox occurs, we’ll have about forty sols before the dust storm season begins. I’d rather see us head south first, then return here if the dust storms break out.”

“Then I suggest we start with a very quick westward trip,” replied Will. “We could move the refueling oasis at Gangis farther west and expand it, then go south, then when we return from the southern expedition it’d have plenty of fuel for a Marineris expedition, regardless of dust storms. A forty-sol southern expedition could explore the Great Southern Waterway maybe as far as Argyre. Its rim has some of the planet’s oldest crust and the Argyre Basin had a Noachian sea and Hesperian glaciers.”

Roger nodded. Monika added, “If there’s a very heavy dust storm, we could conduct shorter trips from here, including one to the east and one to the south. The chaotic terrain east of here has lake and channel deposits.”

“We’ll have to see what the dust storm season brings,” said Sebastian. “We’d have to conduct short trips if the storms prevent emergency sunwing flights. Ethel, how are the rangers and the conestoga?”

“They came through the northern expedition pretty well. We need to spend a week doing maintenance on each of them. I had to replace a total of four fuel cells—each has twelve—and three motor and braking units.”

“So, we have plenty of spares.”

She nodded. “I was able to fix some of the motors on the trip and can repair the rest here. The fuel cells will work well enough to provide supplemental power here. We can shift good fuel cells here to the rangers.”

Sebastian looked around. “So, any objections to a quick trip west to set up a refueling station, then an expedition south as far as Nirgal and maybe as far as Argyre, then an expedition west toward Noctis Labyrinthis?”

“Fine with me,” said Érico. The others nodded.

“The latter will take us into the period after Columbus 2 leaves,” noted Will.

“Okay, we have an exploration plan to propose to Houston. What do we have to do around here?”

“Because of the greenhouses, we have an oxygen surplus problem,” said Madhu. “I hate to vent it into the atmosphere. We need to pump it underground. We should be able to recover eighty percent of it.”

“Mixed with CO_2, right? Useable for what?” asked Sebastian.

“If we need extra heat during storm season, we can pull the oxygen out of the ground and burn plant waste, or we can use it with the shuttles.”

“But we don’t have the equipment to compress the gas underground, so the wells can’t store more than a tonne or two of oxygen anyway,” pointed out Will. “We need to store liquid oxygen in the tanks of the old landers, too.”

“I’d favor construction of a water storage facility,” suggested Will. “It can be simple; we can bulldoze a dam across a low spot of ground and cover the area with a plastic sheet to prevent evaporation. If the top freezes over, the liquid water underneath will be insulated.”

“If it’s capped by two meters of ice, it could have plankton and fish,” added Madhu.

That idea’s on the website, right?” asked Sebastian.

“Yes,” said Paul and Madhu almost simultaneously.

“Good; it’s been studied. How much work will the dam take?”

“Less than a week, depending on its length and height,” said Will.

“What about a plastic cover?”

“A week or less,” replied Ethel.

“We can get it started and finish it around other tasks,” said Sebastian. “Do we need to do more chemical, plastic, and metal work?”

“The new equipment is fully tested and working well,” replied Ethel.

“We should complete the Geology Storage Facility,” said Will. “We’ll have to manufacture and install the airlocks and pressurize it with Martian air. If it holds the air adequately, then we can pressurize it with oxygen and nitrogen.”

“Alright,” said Sebastian, nodding. “It sounds like the Outpost will need all the space it can get, if it’ll have sixteen personnel pretty soon. The Geology Storage Facility can be our priority during conjunction. What else?”

“There’s one task I’d like to propose,” said Madhu. “I want to lay out a large mosaic between the habs. I’ve got the materials and I have a design in mind.”

Sebastian was surprised. “This isn’t something you can do on your vacation?”

“Sure. But I’d like to think that art is worthy of more than volunteer effort.”

“Hum.” Sebastian considered. “Eight months ago, I never would have taken such a proposal seriously. But we’re building a long-term presence here; I won’t say ‘settlement,’ but something approaching it. Okay, we’ll schedule it as well. What else?” No one spoke. “Alright, what about the period between Columbus 2 and 3?”

“One priority would be finding a route from Noctis Labyrinthus up to the Tharsis Uplift,” said Roger. “We need to devote some sunwing time to high-resolution photography of that area. We should discover a path we can clear.”

“And we need to fine a route leading eventually to the South Pole,” added Will. “After that, we’ll need to consider routes eastward across the highlands to Isidis, Hellas, and Amazonis.”

“It’s strange to think that in the third year of exploring this world, we’re talking about the circum-equatorial route,” said Ethel. “Didn’t someone predict that was a decade away?”

“Columbus 3 will speed everything up if it brings those reactors and additional vehicles,” said Roger. “Are those still scheduled?”

Sebastian nodded. “The two reactors are undergoing final assembly now. The rest of Columbus 3’s cargo is uncertain; if the Outpost’s crew had been ten or twelve, some argued for saving money and just shipping consumables. But if the crew will expand to sixteen, they’ll need at least one more ranger, another conestoga, another habitat, and two greenhouses.”

“I suggest they send four more greenhouses,” replied Madhu. “The bigger crew will need more food.”

“They’ve ordered two new rangers and a Conestoga and they’ve even upgraded the design based on our experiences,” said Roger. “So I hope they agree to send them!”

“They’ll have to rethink Columbus 3,” agreed Sebastian. “I hope they can send younger persons. The eight people here will have seniority, so the newcomers will have to work their way up.”

“Thank you!” replied Will.

“They need to send people who want to stay, and for that, couples are better than singles,” added Ethel. “They need to rethink the Columbus mission statement, in fact.”

“We are moving things along much faster than expected,” agree Will.

“Columbus 3 is being actively reconsidered,” said Sebastian. “The proposal to cut the arriving crew to six was defeated because plenty of nations wanted to send astronauts and because the cost has dropped to three hundred million per person.”

“That’s a third the cost of Columbus 1!” noted Will.

“The possibility of finding life is enticing more participation,” added Monica.

Sebastian looked at his attaché. “It looks like we have five video messages from Mission Control. Let’s turn to them. I bet they’ll have lots of comments about our ideas.”

11

Conjunction

mid Dec. 2038-early Jan. 2039

Will and Érico stopped the ranger by the new water supply reservoir. Conjunction or not, the geologists were still exploring; but the trips were short. The two of them had been part of a team that had hiked up Little Colorado Canyon to visit the automated oasis half way up and survey a possible route for driving to the top of the canyon.

They pushed the plastic tarps back to take a look at the reservoir. It didn't amount to much; they had built a dam across part of a depression near the wells and covered the low spot with a tent of plastic sheets. The warm, moist air coming out the well passed through a heat exchanger that cooled it to just above the freezing point to condense out the water, which trickled down an insulated pipe to the reservoir. The water quickly froze to make a mound of ice. Under the accumulating ice they had laid a coil of plastic tubes. In about a year they'd run warm air through the coils and melt a pond of water underneath an ice cover, which would allow them to pump water out easily and introduce plants and animals if they wanted to.

"Good; a steady trickle," Will said.

"It's only minus twenty centigrade under here," noted Érico, looking at his suit's exterior sensors. "The water has warmed it up."

"I wish we were expelling the heated air straight into this space. It'd keep the water here above freezing, and we could try to introduce a simple ecology."

"I don't blame Monika for objecting; it could cause the release of terrestrial species able to survive in Martian hot springs."

“I’m skeptical about the idea that Mars still has indigenous life.”

“The chances are fading every year.” Érico reached over and grabbed the pipe. He broke off the icicle that had accumulated between it and the ground and moved the pipe a few centimeters. Someone had to stop by at least once per sol to move the pipe or it would be embedded in the growing ice block it produced.

They headed out of the depression. “The possibility of life is providing much of the publicity and more than half the funding for Mars exploration, so let’s just hope the suspense lasts a few more years,” said Will.

They stepped back into the ranger and drove toward the Geology Storage Facility. “You’re right about that,” said Érico. “Brazil may commit to sending someone every cycle. My presence has generated a lot of publicity and made the Brazilians feel proud of their country.”

“It sounds like competition is heating up. I never would have expected that the decision of eight of us to stay would be received so positively. It’s expensive, after all! I guess it suggests that this place is more habitable, more pleasant than expected.”

“You and Ethel, I think, are largely responsible for that. You set a positive tone for the Outpost, you’ve stressed community, and you’ve been a model couple.”

“Thank you. It’s our personalities, I guess; we both love to play host. Or parent.”

“You do. Your parents are Bahá'ís, right?”

“Yes. So am I, though here I’m the only Bahá'í on the planet, so there is no community to be a member of.”

“We don’t have much religion here, except for the interfaith service you and Ethel planned when Paul’s cousin died. There aren’t enough of us, I guess, and we’re not a highly religious bunch.”

“I don’t know about that. Roger is Southern Baptist and he reads his Bible; I’ve seen him. When we were room mates on the trip to the northern polar deposits, we were sort of watching each other and seeing who prayed more!”

“Who won?”

“It was a tie, I think.”

“I know some Brazilian Bahá'ís. Very nice people; articulate, socially conscious, though I was surprised they weren’t more politically active. I was very impressed that they didn’t seem to have any prejudice toward me because of my darker skin. Brazilians pride themselves on being free of racial bias, but the fact is that lighter skinned peoples earn more than darker skinned peoples, on average. The Bahá'í group I met, though, was a real mix.”

“We strongly emphasize unity in diversity, even to the extent of encouraging interracial marriage.”

“Your parents were from different races, right?”

Will nodded. “My father was black with some Cherokee and my mother’s white with some Hispanic. But my background really wasn’t difficult for me because in the Bahá'í community there were a few other families who had a similar mix.”

“My background is mixed as well; I suppose you can tell from my skin color.”

“I guessed that was the case. I really know nothing about your childhood and upbringing.”

“I guess I can tell you the details. Carmen knows, but no one else. My mother was a Brazilian of nearly pure African background; very black, or so I am told. She apparently was raped by a Brazilian of Portuguese background, and being a strong Catholic—among the few—she decided not to have an abortion, but put me up for adoption. I was adopted by a struggling middle class family whose skin was a bit darker than mine. It was not a good match, but who would have known it at the time? Anyway, I left home at age fifteen, and after four years on the streets, as a result of friendship with a remarkable college professor—I started taking night classes at a very inexpensive college, and he was my science teacher—I was encouraged and empowered to apply to one of Brazil’s most difficult universities. They accepted me and to this day I’m still not sure how it happened. But from then on, everything got better.”

“Mentors can be very important. I don’t know whether I’d be here today if it weren’t for a high school geology teacher.” Will stopped the ranger. “Here we are.”

They opened the doors—they were still suited up—and walked over to the Geology Storage Facility. In the last two weeks, a lot of progress had been made. The walls and ceiling were now buried under three meters of regolith, mixed with water and frozen hard as rock. White parachute cloth had been draped over the mound and anchored to keep the water from evaporating and to make the building easy to see. Two of the four openings were closed by metal airlocks built by Ethel and Paul out of locally refined metals. Ethel was busily welding inside one of the airlocks; they entered the building through one of its openings and saw her.

She looked up when she heard them approaching; suit radios were set to broadcast the rustling sounds that suits make, so that when someone approached someone else, they knew. “How was the trip?” she asked.

“Good. We think it’s possible to build a ramp up the first cliff in the Little Colorado Canyon with the use of some explosives,” replied Will. “Paul and Roger headed straight over to the manufacturing facility to make some of the equipment.”

“I know; I talked to them. This afternoon I need you guys to start on the third airlock. We’ve made the parts and assembled them inside to test the tolerances. If you can fit everything in place and spot weld it, we can complete the welding tomorrow.”

“You mean the third airlock will be finished by tomorrow?” asked Érico, surprised.

Ethel nodded. “And the fourth two sols later. Most of the time has been consumed making the parts, and we made the parts for all four airlocks at once, plus a spare set. Putting together the first airlock took a long time. But now we know what we’re doing.”

“We can spot weld all the big pieces by the end of the sol, I’m sure,” agreed Will.

“All the little pieces were put together inside where we didn’t have to wear pressure suits,” added Ethel. “We still have a few minutes before lunch; you might want to start looking at the parts.”

“Okay,” agreed Érico. He and Will walked back outside and began to walk along the parts that Ethel had very carefully laid out on a plastic sheet on the ground, in the order of their use. Each one was carefully labeled as well, so there would be no confusion. The actual doors were already on their hinges and the valves that let air in and

out had already been installed and tested. Ethel did that work inside the manufacturing facility where she could easily use very small screw drivers and power tools.

It was a familiar job; the two of them had set up and spot welded airlock 2 three sols earlier. They began to review the parts and the procedures they followed when the announcement that lunch would be ready in twenty minutes came over the common radio frequency. They didn't have much time, but they decided to use it as best they could.

Sebastian was making his daily walking tour of the habs and greenhouses when he heard the lunch announcement in his ear piece. He continued to Greenhouse 2. He was not alone; Shinji and Madhu were leaning over the pot of an orange tree.

"What is it?" he asked, approaching.

"A miracle," replied Shinji.

"Or a prank," added Madhu.

"A dangerous prank," said Shinji. He pointed to a small plant with pink flowers growing in the pot.

"What is it?" said Sebastian, worriedly.

"*Saintpaulia Ionantha*."

Sebastian looked closer and frowned. "It looks like an African violet, to me."

"That's what I said," replied Shinji.

"The bigger question is, how did it get here?" said Madhu. "I can't imagine any of us brought the seeds on purpose or even accidentally. All plant seeds and cuttings brought here were inspected a hundred times to prevent biological stowaways."

"Germs, let alone African violets." Sebastian shook his head. "That's bizarre."

"If I was a religious man, I'd go so far as to call it a miracle," repeated Shinji.

"Well, I'm religious and I wouldn't," replied Madhu. "But it is bizarre."

"Report it to Mission Control. They'll investigate and spend ten million bucks developing new sterilization procedures," said Sebastian. "And pot it so we can enjoy it."

"We could use a few more flowers," agreed Madhu.

"I've got to write my son about this; I'll see you at lunch," said Sebastian. He suddenly realized that he had a great reason to videomail Kristoff. He hurried back to his room, pulled up Kristoff's private email address, and began to record. "Hi, Kristoff, this is dad. You wouldn't believe what I just saw in Greenhouse 2. Make a guess, okay? I'm going to count to ten." He closed his eyes and counted quickly aloud in German. "Are you ready with your guess? *An African violet.* Isn't that amazing? We did not officially bring African violets here, and they're fickle things to cultivate, but we have one growing in the pot of an orange tree in greenhouse 2! It's got a pink flower with streaks of violet in it; really pretty! We were all shocked. I suppose there will have to be an investigation to figure out how the seed got here, so don't tell anyone because it isn't official yet. But I know how much you love African violets, so I had to be sure to tell you first.

"I hope you are well! I hear you got an A on your science paper. Good for you! Email it so I can take a look. I hope you have a good day! I love you. Bye."

He sent the message and hoped Kristoff would reply; the almost fourteen year old hadn't communicated with him even once since the landing. Sebastian headed for Habitat 3. Everyone was seated and enjoying a soup of chicken, vegetables, and potatoes made from their first harvest of Martian spuds. They all discussed the African violet and laughed about it, though worry was an undercurrent. Finally, as they were finishing lunch, Sebastian said, "Hey, everyone, there's good news. This afternoon, European

time—this morning for us—the French announced that in addition to their continued support for the European Space Agency's Mars commitment, they would commit to send three French astronauts to Mars every opposition."

"Three!" exclaimed Carmen, surprised. "What does that do to the European quota of two?"

"Augments it. There will now be five Europeans coming to Mars every two years. The United States, in response to the announcement, says it plans to raise its national commitment to four."

"But what about the other nations?" asked Paul, startled. "That accounts for nine berths, but we can only fly eight people to Mars at once!"

"That changed as well," replied Sebastian, smiling. "NASA has announced that it will add a third ITV to Columbus 3. Furthermore, they are willing to accommodate up to two additional crew on the two Mars shuttles. Columbus 3 will have at least twelve crew and maybe as many as *fourteen.*" Sebastian let that sink in.

Will cheered. "Fantastic! If fourteen come and eight stay, the Outpost will have 22 people! That's barely below our future capacity of 24, though."

"They must be counting on us to complete a pressurizable building, then," said Ethel.

Sebastian nodded. "Absolutely true. If the automated cargo vehicle carrying Habitat 4 were to fail, the outpost would have 22 people in three habitats. It's possible; we'd also have the Mars shuttles, conestogas, and rangers. But it leaves no redundancy if one of those three habs got severely damaged and had to be abandoned. Consequently, the crew coming here will be strong on construction skills. A design for a new crew

accommodation and work building will be complete by the time they arrive. If progress on the building is sufficient, Columbus 4 won't need to include any habitats; just windows, life support equipment, and other objects we can't make here easily."

"Incredible," said Roger. "So we have commitments for nine, between the Europeans and the Americans. Russia and Canada have promised one each."

"And Brazil; that's what I hear through the grapevine," added Érico.

"Japan will probably send someone; that's thirteen," said Shinji. "I wonder whether a fourteenth will materialize? Argentina or Chile could decide to compete with Brazil, or India could make a commitment."

"China may want in, too," added Will. "They've now joined the Lunar Commission."

"Iran and Indonesia might be possibilities, too," added Sebastian.

"When are we going to get a Mars Commission, anyway?" asked Ethel. "NASA led the exploration of the moon for sixteen years before bowing to international pressure and putting everything under an international body. It seems to me they need to abolish the Columbus project and just send reinforcements to a Mars Outpost, under an international Mars Commission."

"I agree," said Will.

"I suspect NASA feels that's premature," replied Sebastian. "Though I agree, and I suspect the French announcement will put NASA under pressure to accommodate partners more fully. Of course, we're in a different situation than the moon, with one resupply window every two years. Separate national bases are not practical here the way they are on the moon."

“At least for another decade,” replied Will. “Cheaper and faster transportation between the Earth and Mars may change that situation.”

“It’s beginning to look like this place has quite a future ahead of it,” agreed Sebastian.

There was a lull in the conversation, so he rose to get a cup of coffee. As he was walking back to the table he heard a beep in his earpiece. A video message had just arrived from a family member on Earth. He excused himself and walked to Habitat 3’s control area where he could watch.

Much to his surprise, it was Kristoff. He was surprised to see how much his boy’s face had filled out and matured. There was fuzz on his upper lip and chin and as soon as he spoke, Sebastian could hear that his voice had changed. “Hi dad. I can’t believe it; an African violet. Violet with pink, huh? I checked some websites and I don’t see any wild subspecies with that combination, but there is a hybrid with that color. I’ve attached the web page. Maybe that’ll help trace down who might have had the seeds on their clothes, or something. Can you take a picture of it and send it to me? I’ll do some more research if you want. I’ve seen that kind in the stores, but I don’t have one. Since you have one, it’d be fun to have one, too. Well, that’s everything. Bye.”

Tears flowed down Sebastian’s face. He replayed the message and studied Kristoff’s face closely, listened to every nuance of his voice. Finally, he clicked on the attached web page. It was exactly the same kind of flower. Perhaps a miracle had happened that day! He composed himself and clicked on reply.

“Kristoff, that’s the exact same flower. I’ll go take a picture in a minute and send it to you so you can see. I’ll definitely buy you one; I’ll order it in a few minutes and mom can go pick it up! I am amazed about this coincidence, aren’t you?

“Say, you know yesterday was conjunction. Right now Mars and Earth are on opposite sides of the sun; this message will be relayed to you via Mercury and may take a little while to arrive. But do you know what that means? From now on, every day we’ll be moving closer together. Blastoff’s less than eight months away now and I’ll be home in about fourteen. My trip’s more than half over, Kristoff. We’ve past the hump and it’s all down hill from now on. So let’s try to reestablish our relations, okay? Because I love you and miss you.” His voice broke a bit. “Bye.”

12

Emergency

early-mid Feb. 2039

Will carefully pounded a nail into the wall of the Geology Storage Facility. It went in quite easily; the duricrete had a hardness more than plaster of Paris, but less than concrete. He stopped when a centimeter still protruded. He unscrewed the top of a plastic jar and reached with his gloved hand to pull out a brush covered with a transparent, glue-like substance. He painted it around the base of nail very carefully to seal the hole he had made in the plastic sealant covering the wall. He watched it carefully a moment; he could see no evidence of a gas leak around the nail. He let the sealant set a moment, then hung a 2039 calendar on the nail.

It was displayed over his “desk,” an ugly dark green plastic table with drawers in the sides. He wondered when he’d be able to sit at it without a pressure suit. So far the facility had been pressurized to habitat standard pressure for two weeks, but only with Martian air. The first few sols they spotted quite a few minor leaks—mostly cracks in the duricrete—and sealed them. Lately, air leakage had been very little; the duricrete walls were surrounded by a frozen shell of regolith three meters thick. The one big disadvantage of the facility was its complete lack of windows, a disadvantage reinforced by its ugly orange-brown walls. But Ethel was promising paint in another month. It would have a plastic sealant in it to strengthen and thicken the sealant they had already applied. They also planned to manufacture a linoleum-like tile to cover the duricrete floor.

Will glanced at the shelves filling half the storage facility. He had spent much of yestersol and that morning finishing the job of transferring samples from the basement of the three habitats, where they had been scattered across the floors in numerical order. Now parts of the basements could be converted into rooms to make sure they had space for the additional people. The storage facility was very convenient; it had already saved them time finding samples for analysis.

And now that the building was finished, he would be leaving it; their next big field trip began tomorrow. He walked around the facility one more time, admiring all the work they had done. Then he headed outside.

He planned to walk three meters to the nearest airlock to go inside the outpost, but he saw Madhu working on her art near the base of Face Rock, so Will headed over there.

“What do you think?” she said as he approached.

He stopped to admire the giant image of a thunderbird, as she called it, a mythical creature that looked part American Indian and part India Indian, reflecting her two citizenships. She was placing pieces of red sandstone to make the stylized feathers; the black parts of the wing had already been made using fresh basalt, yellow parts with yellow sandstone, white parts with salt. Green copper ore and brown shale had been used to make an olive branch in his talons.

“Madhu, it’s really beautiful. I had no idea you had such a talent!”

“I’ve never had a chance to do this before. It’s a lot of fun.”

“I bet. I’m glad we’ve got some art here.”

“It’s very important. I have a plan for this entire slope, with a sculpture garden and more mosaics.”

“What about the spaces between the greenhouses and the habs?”

“I need a design. People can’t walk in those areas, but here they can stroll and look.”

“Interesting. This sounds like a long-term plan!”

“I guess it is. We’re staying at least two more years, after all.”

“Ten years from now, they’ll have to declare this a public park.”

“I don’t think we’ll grow that fast! But I do wonder what this place will look like, a half century from now.” She stopped and looked northward over the rolling, stony plain to the escarpment twenty kilometers away.

“I guess we’ll be sitting in our retirement homes and watching it on television. Are you going inside?”

“Sure; I guess it’s just about time for supper.” She grabbed some tools and came down the slope to him, and they both walked to the nearest airlock. It was easiest going inside in pairs; it helped to have someone to take off the life support unit.

Ten minutes later they walked into Habitat 3’s great room. Will could hear Ethel’s voice coming from the bridge. “I’m still not convinced we have to change it,” she said. Will looked in. She was sitting with Sebastian, staring at a large screen covered with technical readouts.

“We can always test it,” said Sebastian. “But when in doubt, I’d change it. Shuttle pumps are too important; you can’t afford a failure.”

“You’re an expert at changing these things, too,” said Ethel. “My experience with pumps is general.”

“I changed one on the moon. It was a Lifter, but the Lifters’ pumps and engines are just small versions of the Mars shuttles’. I’ll show you how to do it; a useful skill, since I’m leaving.”

“True.”

Will approached closer. They looked up. “I guess it’s suppertime,” said Sebastian.

“You’re changing a fuel pump?” Will asked.

Sebastian nodded. “In the *Hadriaca.* The readouts indicate an irregularity.”

“Didn’t I hear a faint alarm bell, an hour ago?” Alarm bells were broadcast over a common radio channel and often could be heard up by people in pressure suits if they were close to the Outpost.

Sebastian nodded. “Nothing to do with the shuttle, though. Slow pressure loss in Greenhouse 3. Paul’s inspecting the outside for the leak.” Air leaks tended to leave a frost deposit around them, making them easy to spot.

“There’s a bit of news, Will,” Ethel said. “India has pledged to fill the fourteenth slot in Columbus 3’s crew. They now have a full complement.”

“Amazing! So, this place really will have twenty-two people, next year.”

“It’s going to be crowded!” said Sebastian. “Even I’m beginning to wish I could stay. Maybe I’ll apply to come back when my boys are in university.”

“It *is* going to be crowded,” agreed Ethel. “After almost three years, I’m beginning to miss forests, swimming pools, beauty parlors, and a few other things.”

Will nodded. “Coca-Cola and pizza. That’s what I miss, and I never expected to miss them! Skiing, too. I was tempted to try skiing when we were near the North Pole, but I knew it wouldn’t work.”

“I miss my wife and boys,” said Sebastian. “Roger misses golf and plans to import a set of clubs on Columbus 3. The big problem here is the confined spaces. You have to go outside almost every sol to avoid cabin fever. But there’s always exploring. Is the expedition ready to go?”

Will nodded. “Everything’s in the vehicles except us and our belongings. We’ll be ready to roll after breakfast. Houston sent a revised route this sol that extends all the way to Nirgal Vallis. The extension to Argyre will be ready next week.”

“I wish you were rotating back to the Outpost,” said Ethel.

“Even if there’s no duststorm, we’ll be back in less than three months,” replied Will. “We aren’t going any farther than Argyre.”

“I’m still uncomfortable with our rescue capacity,” said Sebastian. “The sunwings can carry only one passenger at a time or a max of 200 kilos of cargo to the highlands.”

“We’ll have to rely on a Mars Shuttle to make a rescue,” agreed Will.

“I hope you reach Argyre and bring back the broken Prospector there,” said Ethel. “But three months is a long time, Will.”

“I know, dear. But it’s still less than a tour of duty at ISS2 or Shackleton, and the dust storm season may make it shorter, anyway.”

Ethel nodded a goodbye to Sebastian and rose from her seat. She and Will headed to the dining table, where they helped Madhu and Paul place the plates and silverware. Sebastian watched them go, then turned back to the screens in front of him. A videomail from Kristoff popped onto the upper right corner. He touched the icon to open the video and send the audio to his ear piece. “Hey dad, my science teacher is really happy about my paper about the African violet at the Outpost! He said he has never seen a 14 year old

do original research before! My survey of the ground personnel found two people with that breed at home, so I suppose one of them inadvertently carried a seed to work on her clothes. Thanks for helping me draft the survey; I had no idea there was an entire science to it. But I guess there's a science to everything!

"Oh, and we have a basketball game tonight against Clear Lake Christian Academy, so please think of me. Bye."

That made Sebastian smile. Kristoff loved basketball. He hit reply. "I'll think of you tonight your time. I'm sure you'll make some of the baskets; from what I saw, you're pretty good. That was a great science paper and your teacher should be pleased with it! Really exemplary. I told you that you could do it! But now you have to come up with another clever idea, and that's always the hard part. I'll be thinking about it. Bye."

The next sol Will, Shinji, Érico, Carmen, Roger, and Paul set out in pairs in the two rangers and the conestoga, respectively, heading south across Aurorae Chaos. They followed a route cleared a year earlier across the wide, flat valley and into the chaotic terrain of southern Aurorae, then plunged into the broken borderlands and cliffs that rose up to the highlands. The bulldozer blades, already battered, required frequent welding to keep them working. Three sols of pushing rocks by conestoga and by hand, swinging a pick, and ultimately setting a few explosive charges, proved necessary to clear a roadbed up a low cliff, and it was unclear that automated vehicles would be able to negotiate that stretch. But in the end they reached the rolling highlands, ground formed over four billion years ago and battered into a bumpy mass of overlapping craters and sequential ejecta blankets, eroded by snow, rain, wind, floods, and more meteors.

They soon found plenty of exciting geology: runoff arroyos formed by snowmelt just a few hundred thousand years earlier, evaporite deposits with useful salts, and shale strata with microfossils only 1.5 billion years old; life on Mars had lasted longer than they had previously thought. They spent a week crossing Holton Crater, a huge, ancient lakebed, and studied its extensive delta and its sandy wave-cut terraces.

By mid February they reached the mouth of Nirgal Vallis. They set up Nirgal Station with a solar power unit and a sunwing landing strip. Two sunwings landed in close succession, bringing them water, fresh food, and spare parts, then departed with samples. Monika, back at the Outpost, was anxious start studying the fossiliferous rocks.

They explored a hundred kilometers of Nirgal Vallis, a water-carved canyon ten kilometers wide and a kilometer deep. They reached fresh gullies on the pole-facing slope, some of which still had buried residual snow from the last wet epoch. They identified deposits that dated the successive floods that had coursed down Nirgal's floor. Since there was no way to drive out of the cliff-edged valley, they returned to Nirgal Station to investigate depositional features and to refuel; the solar power unit had been making methane and oxygen fuel. As an experiment, a buggy drove up the trail from the Outpost robotically with a tonne of methane and oxygen and 500 kilos of solar panels. They now had enough fuel to push on to Argyre Planitia and return to Nirgal Station.

The six of them had a big dinner that night, as was the custom when they were about to leave a station. Will called Ethel, as always, then a bit before eleven he and Shinji headed to the portahab and turned out the lights.

At 4:15 a.m. the portahab's interior lights suddenly came on and the alarm began to blare loudly.

“What the hell?” exclaimed Will, bolting upright from a sound sleep.

“Depressurization alarm!” said Shinji. “Head for the conestoga!”

“Right!” Will jumped out of bed and nearly collided with Shinji, who was sleeping in the bunk under his. They were both in their underwear, but there was no time to dress. Will could feel pain in his eardrums; the pressure inside the portahab was dropping even though the computer was flooding the cabin with life-saving oxygen.

They tumbled into the tunnel in the back of the portahab and pulled the hatch shut. The air pressure in the tunnel stabilized immediately; they had not jumped into the source of the leak. Shinji opened the other hatch and they entered the conestoga.

Almost simultaneously, Roger and Érico had jumped out of their beds in the conestoga and reached the airlock door. “You guys alright?” asked Roger.

“Just shaken,” replied Will. “Do you have something we can put on?”

“Sure,” said Roger. He led them into the cabin and opened a clothes locker. Paul was already sitting in the cab in his underwear, checking out the portahab remotely.

“I saw you guys got out right away; thank God,” he said. “I’ve turned off the oxygen flood. Interior pressure has already halved.”

“A seal must have failed,” said Will. “I’m surprised it went at night and not when we were bouncing around and bulldozing.”

“It’s about minimum temperature outside right now,” replied Paul.

The videophone indicator began to beep; it was an urgent call from Sebastian, who had been awakened by the computer. Roger reached over and pushed the activate icon. “We’re here, Sebastian. We’ve had a catastrophic air leak in the portahab, but Will and Shinji got out fine.”

“Is the situation under control?”

“No. The portahab’s losing air.”

“I’m overriding the life support controls to pump in carbon dioxide from outside,” noted Paul. “That’ll keep liquids from boiling and making a mess.”

“First step is to suit up and go inside,” said Will. “We need to clean it up so that it can be depressurized, then get clothing and pressure suits for Shinji and me. Then we have to find the leak and seal it up.”

Roger looked at him. “That could take a while.”

“Yes, but we can’t abandon the portahab. This should be fixable.”

“Should we scramble a shuttle?” called Sebastian.

“Negative,” replied Will. “It’s just an air leak. There are no injuries.”

“You should be checked out by Shinji.”

“Sebastian, there’s nothing to check out,” replied Shinji. “We got out when there was still plenty of air.”

“We’ve got to fix the leak,” repeated Will. “That’s one hour of work, but maybe a sol of looking if we can’t find it.”

“And then what?” asked Shinji.

“Go back?” asked Paul.

“Two thousand kilometers, and by the time we get home we’ll be sure the leak is fixed.”

“No, push on southward!” replied Will. “If the leak is fixable in a reliable fashion, there’s no reason for it to stop us.”

The others stared at him, digesting the situation. “Look, this isn’t our first accident,” continued Will. “All of us have fallen over on EVAs. Paul fell two meters off a rock outcrop in Chryse. Two years ago my helmet was cracked when rock fragments hit it. All the vehicles have had problems with carbon dioxide scrubbers, frozen waste tanks, failed motor brushes, or bad bearings. We’ve had problems with the suits, too. This is a dangerous job. That’s why we train. We’ll work our way through this one.”

“Will’s right,” said Roger. “Paul, let’s suit up, secure the portahab, and get Will and Shinji’s things. We can all sleep in here tonight and fix the leak in the morning.”

“I agree,” said Will. He looked at his right hand and noticed for the first time that it was shaking uncontrollably. It would be hours before the adrenaline was flushed from his system, too. He moved the hand behind his back and grabbed it with the other hand, so they would stop each other from shaking.

13

Surprise

early July, 2038

After three sols at Nirgal Station cleaning seals around all the doors, the expedition continued southward. Use of the portahab was restricted; the forward hatch that connected it to the ranger was sealed shut with a plastic coating until it could be overhauled at the Outpost. No one slept there for several weeks to make sure it held air.

At least the weather was good. In three more weeks they reached the Prospector that had broken down; they strapped it to the roof of the conestoga so that it could be overhauled at the Outpost. Ten sols later—the end of March and the normal beginning of dust storm season—they reached the northernmost edge of Argyre Planitia. They spent three sols examining ancient beach deposits, seabed deposits, and glacial features. Then they headed back to Aurorae.

After a week of rest, another expedition set out westward along the Mariner Valleys. After a month, Will rotated home for a month, then returned in late May for the last five weeks of further westward exploration. They had some small dust storms, but nothing serious; the storm season that year was mild. They explored 4/5 of the Mariner canyon system.

It was a dusty sol when the expedition returned to the Outpost. They had a big meal together, as was customary. At its end, Sebastian raised his wine glass.

“My friends, I thought we should break out the last bottle of wine for this occasion. I’d like to propose a toast: to Columbus 2. May the team be reunited some day, and may its accomplishments be well remembered by future generations.”

“Here, here,” repeated several. Then they all downed their glasses; Will drank carbonated water.

“We have four weeks to launch and five weeks to trans-earth injection,” said Sebastian. “Tomorrow we start our full-scale tests of the shuttles, to make sure they’re working properly, and we begin to set aside the sample inventory to fly back to Earth. There won’t be any more long trips until after Columbus 2 leaves.”

“That’s alright; we’ve done enough exploring for a while!” replied Roger. He had been out most of the last fourteen and a half months.

“I’m ready to stay home for a while,” said Will, and he turned to Ethel. She smiled, but not as enthusiastically as he expected. They hadn’t had much of a chance to talk yet, but he had noticed that she seemed tired.

A few minutes later the gathering began to break up. Will and Ethel walked home through the greenhouses, enjoying the greenery. “This place is a lifesaver,” said Ethel. “I’m really beginning to miss greenery.”

“Do you wish we were on Columbus 2?”

She thought a moment. “No, I’m glad we’re staying. But I’m not sure I can stay for a fourth cycle. Three may be enough.”

“Then we’ll head back to Earth on Columbus 3,” replied Will, with a shrug. “I’m content either way.”

“Really?”

“Yes. I want to be with you.”

“I’ve really missed you. In the last six months you’ve been in and out irregularly, and Sebastian always had reasons not to assign me to the expedition as well. I hope to go out with you more in the future.”

“I’d like that.” He leaned over and put his arm on her shoulders. “I’ve missed you a lot.”

“I’ve really missed you, too.”

They continued to Habitat 1 and walked up the stairs to their little two-room suite on the top floor. Will leaned over and kissed her passionately, and she kissed him back. Then she pulled away.

“Will. . . I don’t want to have sex tonight, if that’s alright with you. I’m pretty tired.”

“You seem tired. I was wondering whether you were feeling alright.”

“I’ve been feeling pretty blah, the last three sols. I was hoping it’d go away, but it hasn’t yet. This morning I almost felt nauseous!”

“That’s unusual. Did you talk to Armando?”

“No. Maybe I should talk to Shinji tomorrow. Now that he’s back I can go to him.” She shook her head. “I hope this isn’t related to Mars.”

“You’ve adjusted to Martian gravity in some unusual ways. But this doesn’t sound like osteoporosis or cardiac trouble.”

“I’m not worried about a calcium problem, but I do worry about my heart. I hope we don’t have to fly home because of it. I’m tempted to wait a month and complain to Shinji after launch.”

Will shook his head. “No, don’t do that. It might be a mild dust allergy.”

"This isn't like Armando's dust allergy. He's been taking so many pills lately, he's afraid the supply will run out before he leaves. And they really haven't helped his stuffed up nose, either." She kissed him. "You're a sweet dear."

The next morning they went down to breakfast a bit later than usual. Most were taking the sol off. Sebastian immediately spotted Ethel. "Can you meet with me in an hour? There's a new problem with the pump we replaced on the *Hadriaca.* I think the problem wasn't the pump after all, but the electrical circuits that supply the pump. I want to plan a ten second firing of the engines for two sols from now."

Ethel nodded. "Okay, but can we do it in two hours? I have a quick appointment with Shinji first."

Sebastian considered. "Okay. I'll put together more details of the plan, meanwhile, so we have more to discuss."

She walked to the table with the fruit, soy yogurt—Madhu had gotten very good at making it—toast, and home-made cereal. She filled her plate and joined Will, who had already gotten his food plus his morning coffee with soy milk and her tea.

"Are you going to help me with the wedding plans?" Carmen asked her as she sat.

"When? Right after lunch? I'd love to."

"You have the sol off, right?"

"I'm trying. Sebastian needs some help with the *Hadriaca*."

"I'd like to spend the afternoon with you and Madhu. The wedding's next week, and here we are finalizing the details! It's crazy."

"Well, you were away."

“I know, and my divorce decree was delayed.”

“We got a lot done by video, and weddings are easier to plan here than on Earth.”

“Thank goodness you were already married here; we already have some of the things we need.”

“It’ll help.” Ethel didn’t mention the wedding gifts that she and Will had received and that they were now distributing to others to give to Érico and Carmen.

They turned to other topics. After a leisurely breakfast, Ethel headed over to sick bay, where Shinji was waiting. She described her symptoms and her worries about cardiovascular troubles, then Shinji examined her. Then he gave her a urine test. It was positive. “No question, Ethel. You might want to call Will. You’re pregnant.”

“What?” she replied, shocked. “That’s impossible! We’ve been incredibly careful. I can’t have a child here!”

“Your options are limited; that’s why I said you should call Will. The three of us can talk, or the two of us and then you and Will.”

“I’ll call Will.” She turned to Shinji’s attaché lying on the table nearby and punched in Will’s number.

“Hello Shinji; oh, hello.”

“Can you come down to sick bay right away? I’ll explain when you get here.”

Will saw the worry in her face. “I’ll be there immediately.” He pushed “off” and was on his way.

“Are you sure I’m pregnant?”

“Oh, yes. The urine test is conclusive in itself, but the signs are all there. How long have you been pregnant, do you think?”

She thought. “Probably five or six weeks. But Shinji, because of the birth control pills, I haven’t had predictable or regular periods, so it’s hard to tell.”

“You’re taking your pills?”

“Every sol! Well, I wasn’t taking them when Will was away; not for two of the three months. But I started taking them again two weeks before he returned.”

“Hum. We should check the pills to make sure the dosage is right. You say you weren’t having predictable or regular periods; then you were having something.”

“Yes, in the last few months I have had a few very mild periods. I thought it was sort of strange.”

“I wish you had mentioned it to Armando, or even to me by video.”

“I guess I should have.”

There was a knock at the door, then Will opened it. He was panting; he had run over. “What is it?”

Shinji looked at him and said nothing. Ethel said “I’m pregnant.”

“What?” he was incredulous.

“I’m pregnant; that’s why I was feeling tired and a bit nauseous this morning. It was morning sickness.”

“But I thought you were taking the pills.”

“I was.”

“We’ll have to check them,” said Shinji.

Will looked at Ethel; she looked at him and she began to cry. He reached down to help her up and hugged her. A tear appeared in one of his eyes as well.

“It’s okay; we’ll get through this,” he said. “Why are you crying?”

“Because it’s such a shock!”

He let her cry. Shinji sat, unmoving, looking at the floor, trying to be unobtrusive. Will and Ethel were in his sick bay and they would need his advice. He waited, but he didn’t have long to wait. Ethel stopped crying in a minute or so. She looked around. “Will needs to sit, too.”

“Let’s move to our living room,” suggested Will, and he nodded to Shinji to come along. It was a good idea; they’d all be comfortable.

The three of them walked to Habitat 1 and went up the stairs to Will and Ethel’s living room. The two of them sat on the couch Ethel had made of metal and plastic, covered with pillows of parachute material filled with soft foam plastic peanuts and a blanket they had received as a wedding present. Shinji pulled up a chair.

“You said we had options. What are they?” Ethel was sounding more composed.

“Well, one option you *don’t* have is to fly back to Earth on Columbus 2. The radiation environment of interplanetary space is too harsh for a growing fetus, even if we wrapped your bedroom with a few tonnes of water and provisions. Also, right now the baby would be born in space, probably at International Space Station 2, because we’d reach Earth when you were eight months pregnant, and you couldn’t handle the three gees of atmospheric entry in that state.

“The viable options are two: keep the baby, or abort it. An abortion is a simple procedure; I’ve never done one and I doubt Armando has either, but they are not complicated or particularly risky. Both of us can learn the procedure through video and consulting experts. Most likely, you’d be able to resume duties in a few sols. You could even opt to fly back to Earth on Columbus 2 if you wanted.

"As for keeping the baby, there's always a danger of spontaneous miscarriage, especially in the first trimester. You're 37, so statistically the risks are greater than if you'd had the baby ten or fifteen years ago. We don't have medications to handle the possible complications of pregnancy; that was never anticipated."

"Something Houston *didn't* anticipate," said Ethel, shaking her head.

"It's impossible to say what the health risks to the baby are. Rabbits, chickens, turkeys and tilapia have been bearing young or laying eggs here quite successfully, and Madhu has published studies that show a higher loss rate of the young than on Earth, but we don't know why. There has been research on the moon as well which has indicated a greater rate of birth complications and health problems in animals there than the ones on Mars, suggesting that this environment is closer to Earth's. No child has ever been conceived in space before, let alone born there, so this could be a first. I've seen a study on the health of five children born to male astronauts and two children born to female astronauts. One child had juvenile leukemia, but statistically it's impossible to prove a cause and effect. The other kids are healthy so far."

"What about radiation?" asked Ethel.

"The radiation levels in these habitats, at 2.5 rems per year, are eight times the level on the Earth at sea level and are above the recommended dosage for children. But it's not clear from any research that such a level of radiation is dangerous. And we could cut the dosage in half if we added a meter of ice to the habitats. That was impossible to do in the past, but now that we are actively pumping as much water out of the ground as possible in order to create a water reservoir, we have enough water to cover all the habitats with as much ice as we want."

“The design allows a meter of ice,” said Ethel.

Will looked at her. “This is an awfully small place to raise a child.”

“Children are raised on houseboats with less space,” said Ethel. “And the danger of falling into the water is probably greater than any danger here.”

“I wouldn’t recommend raising children on houseboats, however, even if there are thousands of impoverished people doing it,” said Shinji. “A habitat is plenty big enough for a baby. I could see a four year old tearing through the Outpost and being fairly contented; it’s already pretty big.”

“And has lots of mysterious nooks and crannies,” added Will. “I suppose a pressure suit that could be controlled by a parent could be made for a child once they’re six or eight or ten.”

“Probably,” agreed Shinji. “But EVAs would have to be limited. The unshielded Martian surface has a radiation dosage of about eight rems per year.”

“Where would we get diapers and baby clothes? And baby food?” asked Will.

“Columbus 3 arrives in ten months, roughly when the baby is two months old,” said Shinji. “So you’d have two months to handle. Breast feeding is best for babies anyway, unless Ethel has a major problem. Madhu can already make simulated cow’s milk from soy and we could make a crude baby formula if we had to supplement mother’s milk. We’ve got plenty of pure vitamins in pill form, for example. The folks on Earth could give us a wide range of solutions.”

“We can make old-fashioned cloth diapers easily enough; we have plastics and plenty of old clothing lying around,” said Ethel. “We could make baby clothes, too.”

“It’s doable,” said Shinji. “I guess the questions you have to consider are, do you want to do this? Do you want this child to become a medical experiment? Do you want the hassle and controversy? Do you want your work here interfered with that much? Or put another way, should you give this new life a priority in your lives?”

“It would be an experiment,” thought Ethel.

“Especially if there are birth defects, and there could be. Furthermore, we’d have no way of knowing whether the birth defects were caused by the radiation exposures both of you have already had, or were present anyway.”

“At what age could a child fly back to Earth?” asked Will.

Shinji shrugged. “An unanswerable question. I wouldn’t recommend anyone under age eighteen flying in the ITVs as they are currently designed; the radiation exposure is too high during a solar flare. But in ten or fifteen years we might have three-month flights between Earth and Mars using nuclear engines, and that cuts the radiation exposure in half; with better magnetic shielding against flares, the radiation hazard would be manageable. Maybe a six year old could be accommodated.”

Will looked at Ethel. “So we’re talking about at least half a decade.”

“And we may be here eighteen years.” Ethel looked down and shook her head.

“How would we handle the child’s education?” asked Will.

“Kids get an education in the Australian outback via home schooling and the internet,” said Ethel.

“What about friends?”

“That would be a problem.”

“For a while, anyway,” said Shinji. “If you excuse the pun, children beget children. You could be the first couple with a child here, but you won’t be the last. We have three married couples.”

“And once Paul’s divorce comes through, he and Monika may get married as well,” noted Ethel. “But none of them have shown the least interest in having children.”

“Neither did we.”

“Once someone has a child, it may appear more practical,” said Shinji.

“How are we going to handle delivery and medical care here?” asked Will. “Both of the physicians are leaving.”

“Madhu has nursing training,” said Ethel.

“We’ll have to study that question carefully,” said Shinji, speaking slowly and deliberately. “If it is necessary, though. . . I’ll stay another two years.”

Ethel was startled. “You’d *do* that?”

He nodded. “I would. Armando has a family; he has to go back. But I just have my parents. I could stay another two years if necessary.”

Tears welled up in Ethel’s eyes. “That’s one of the most amazing sacrifices I’ve ever heard anyone make, Shinji.”

He shrugged. “Well, life has interesting twists and turns, doesn’t it?”

She leaned over and kissed him.

“This pregnancy will cause NASA absolutely to freak out,” exclaimed Will.

“Either way. If you have an abortion, the conservative right will be furious, and they’re running the U.S. right now. If you keep the child, they’ll probably ignore you and NASA will be baffled and angry.”

“As Érico once said to me, we Americans have never dealt with sex very well,” agreed Will.

“This may create more enemies than friends,” agreed Ethel. “Which is bizarre, since children should bring people together.”

“Even an accidental pregnancy on Mars is a political act,” replied Shinji.

“Convincing people it was an accident will itself be difficult.”

“I can assure people you were taking birth control pills. Oh, that reminds me. Let’s take a look at the bottle.”

Ethel nodded. She rose and entered the bathroom. She came back, looking at the label closely. Then she exploded. “Oh, God! These pills are four years old!”

“What!” Shinji jumped up and looked at the label. Then he nodded. “Our fearless Commander has mixed the inventory. Four year old toothpaste may be fine, but four year old birth control pills are not!”

“I’ll have to give him a piece of my mind!” Ethel shook her head angrily.

“You first; I’ll follow with extensive professional guilt tripping. I had insisted that the birth control pills stay in the sick bay and not be put in the regular supply storage area. But Sebastian preferred an ‘over the counter’ approach to what should be prescription medications; he didn’t want to take the chance someone wouldn’t come to me or Armando and ask for pills because they were unmarried. So he overruled me.”

“The anal retentive idiot!” exclaimed Ethel.

“I think I’ll go; I feel like I’m overstepping my professional sphere. If you have any questions, call me. This will take some time.”

“Thanks, Shinji.” Ethel gave him a hug. “You’re a great friend.”

“I try.”

Will hugged Shinji as well even though their friend was uncomfortable with it. Then he walked out of their living room. Will and Ethel sat on the couch.

“So, what do you think?” Will finally asked.

She looked at him “What do you think?”

He took a deep breath. “First, it’s your body, so the decision has to be one you are at peace with. Second, I have to support your decision, even if I disagree with it, because that’s the way it is in a marriage. And third. . . I think God has made us parents.”

She looked into his eyes. She looked frightened by the way he put it. Finally she said. “My Presbyterian grandmother would agree; you choose life in this circumstance, I think. I’m not an unwed sixteen year old who’s pregnant. I’m not a rape victim or a victim of incest. I don’t have a disease that will kill me if I continue the pregnancy. And I’m not dooming a child to feebleness or early death. There may be an increased chance of that, but it’s not clear how risky this pregnancy is. We didn’t plan to be parents, but maybe that’s what we are.”

“Could you have an abortion?”

She considered, then shook her head. “No, that would be horrible. It isn’t justified.”

“Can you handle the stress of being a Martian mother?”

“I don’t know. Can you handle the stress of being a Martian father?”

“I can try. We will be very different contributors to Mars exploration. Rather than two workers, we’ll be more like one.”

“On the other hand, Mars will have twice as many people.”

"They can do without our sol-to-sol contribution. After four years here, we have earned some parenting leave, and we can still do a lot of work." He paused to think. "So, are we keeping the baby?"

She nodded. "I think so."

"When do we tell my mother and your father? Do we want to wait? And we have to tell Sebastian and NASA. And at some point we have to tell everyone else."

"What time is it?" Ethel glanced at her watch, which displayed local and Houston time. "Ten a.m. here. It's 5:20 a.m. in Houston now, 6:20 a.m. in Connecticut, and 11:20 a.m. in Scotland. We can record a message for my dad and your mom now, then talk to Sebastian. That still leaves a few hours to plan what to say to Houston before they're awake enough to deal with it."

Will nodded. He walked into their bedroom, grabbed Ethel's attaché, and carried it into the living room. They programmed in both numbers and recorded the videomail. The messages would probably be noticed quickly, but the round trip communications time between the two planets was about twenty-five minutes, so no answer was possible for some time.

They reviewed their feelings, options, and the decision to keep the baby. Meanwhile, a message had arrived. Will pressed play; it was audio only.

"Ethel, we had a ten a.m. appointment to discuss the *Hadriaca's* electrical problem, remember? I need your input on this one; I've got a proposal drafted and ready to send to Houston by this afternoon. Bye."

"You never keep Sebastian waiting," said Ethel. She rose. "Shall we pay him a visit?"

Will nodded. They headed out the door, down the stairs, and along the length of Greenhouses 1 and 3 to Habitat 3, where Sebastian was in the bridge. Fortunately, no one was in the great room; the bridge had no door and therefore no privacy.

Sebastian saw Will and was surprised, but undeterred. He assumed they were there together to complain about the loss of part of her sol off. “Where have you been? We agreed on a meeting at ten. You’re the mechanical expert.”

“And you’re the inventory expert.” Ethel held up a bottle. “Do you know what this is?”

Sebastian squinted. “A bottle of pills.”

“Correction. A half empty bottle of pills. A half empty bottle of birth control pills. A four-year old half empty bottle of birth control pills. A four-year old half empty bottle of birth control pills that was mixed up with the new supply.”

Sebastian looked at the bottle, then looked at her with alarm.

“I’m pregnant, Commander.”

“Well, don’t blame me! I kept the old and new supplies carefully and rigorously separated. But from time to time, people pick up things, then put them down in the wrong place.”

“Birth control pills are not toothpaste and never should have been with the toothpaste,” replied Will.

“You have to watch what you’re taking. And doing.” Sebastian looked at Will. “What are you going to do?”

“Shinji just completed an examination and medical tests. He also ran through our options.”

Ethel looked around. “I want to sit; I’m weary.”

“Here.” Sebastian rose and handed her his chair, then went into the Great Room to grab chairs for Will and himself. The gesture seemed to mollify Ethel. “Look, I’m sorry this happened. What did Shinji recommend?”

“We have two choices; abort the baby, or keep it. If I were an unwed teenager, or a rape or incest victim, or someone doomed to die from the pregnancy, or if the child were doomed to die, an abortion would make sense. But none of those scenarios pertain. There’s a good chance we’ll have a healthy and normal baby. No one knows what those odds are, of course; but no one knows what the odds against us are, either.”

“Mars is a rough place to have a baby, don’t you think?”

“Yes, I do think. But is that a reason to have an abortion? The odds of having a healthy child are probably better here than they were in Scotland in 1700.”

Sebastian considered. “It might be a reason for some people. Morality is very subjective.”

“Perhaps. But Will and I are morally old fashioned, I guess you could say.”

“That’s your option, too. No one can—would—force you to have an abortion. That would not be ethically justified. Have you really thought this through? Don’t you need to take your time?”

“Some people would agonize about this for days, but I’m not like that.”

“Neither am I,” added Will.

“No, you aren’t,” agreed Sebastian. “Well, this has all sorts of implications. I suppose it means you’re stuck on Mars for a while. I doubt a baby can be flown through weightlessness and solar storms to Earth.”

“Probably not for a decade. Of course, the way things have been moving lately, that could mean only six years,” said Will.

“Maybe; or eighteen. This means humans are on Mars to stay. It means the Outpost, and Mars, has residents, not just itinerants. It means Columbus 3’s cargo manifest has to be rethought.”

“So does Columbus 2’s. Shinji said if we kept the baby he would stay to ensure adequate medical treatment.”

“Wow.” Sebastian pondered. “Okay. We can fly Columbus 2 with two crew, but don’t seduce Armando into staying, because my family’s expecting me!”

“Don’t worry,” replied Will.

“It means you’re off the hook with this memo, Ethel,” said Sebastian.

“We’ve taped a message to my mom and Ethel’s dad, but they haven’t replied yet.”

“This secret won’t last long. There are too many microphones around the Outpost. I suggest we get some sort of statement ready to email to mission control some time this sol. We should let everyone know this sol, either at lunch or dinner.”

“Dinner,” said Ethel. “This is too complicated to discuss rationally in less than two hours!”

14

Test

early-mid July, 2039

Will's mother called back first; she rose fairly early, whereas Ethel's father was out on his daily walk and shopping trip. Both were surprised, supportive, and worried. Surprised and worried: That summarized Will and Ethel's feelings as well. The exchange of video messages continued for two hours.

Will headed to the great room long enough to grab lunch for Ethel and himself, then retreated to their cozy apartment, where they could eat without looking their friends in the eye. There was nothing to say yet. Sebastian stopped by and made a few uncharacteristically humorous and supportive remarks.

After lunch Will drafted an email to send to Mission Control. Ethel and he debated how much to say. In the end, they settled on two short, factual paragraphs that made no attempt to sound defensive, either by justifying the event or blaming someone else. Sebastian read it over and offered no comment except "send it."

Half the afternoon was consumed by a rambling video meeting between Will, Ethel, Sebastian, Shinji, Harold Lassen, Jerry McCord (capcom and commander of Columbus 3), two assistant directors, and a public information officer. They were exhausted when it finished right before supper. "I know we're all tired, but we have to tell everyone at supper," Sebastian said. "This news will break pretty soon."

"Okay, let's go," said Ethel.

"Thanks for all your support, Sebastian," added Will.

The four of them headed for supper. Everyone else was already eating. Several people noticed their grave facial expressions. “I hate to interrupt supper, but I suppose this is news that can’t wait until we’re all drinking coffee,” exclaimed Sebastian.

That got everyone’s attention right away. Sebastian turned to Ethel and Will. “Will the two of you do the honors?”

Ethel nodded. “It’s a simple piece of news, one that is announced millions of times every day on Earth, and is usually greeted with great joy. But the situation is different here, I guess you could say. Will and I are having a baby. We found out this morning and were in a state of shock and disbelief for quite some time. The whole experience still feels surreal. It’ll take some time for this to sink in completely. Nevertheless, since it appears there is no reason to assume the baby will be born with two heads, and no reason to assume this will doom us, we have decided we have to take a chance and keep it.”

That created quite a murmur; “whoa!” and “wow” and “uh-huuuuh” could be heard. Then everyone stared, not sure how to react or whether to ask questions.

“I will stay on Mars two more years,” added Shinji. “I want the mother and the baby to be healthy.”

“What are the risks?” asked Carmen.

“We really don’t know,” replied Shinji. “Madhu, how do the rabbit babies do?”

“The vast majority are fine,” she replied. “Statistically the percentage that are not normal is close to five percent, rather than one percent on Earth. And maybe ten percent on the moon.”

Shinji shrugged. “There you have it. The best statistics we have. The chance of a healthy, normal birth is probably better here than in a poor rural area on Earth or in an urban slum. But the chances aren’t as good as in the hospitals where your nieces and nephews are born, either.”

They all pondered that. “This is a small place for a child,” commented Madhu.

“By the time the child is four, Columbus 5 will have arrived,” replied Will. “How big will it be then? Pretty big, for a four year old.”

“The imports will get interesting,” commented Madhu. “Infant formula, onesies, teething rings, and Barbie dolls!”

“Do you really think you can do this?” asked Roger, skeptically.

“Yes, we think we can,” replied Will. “It’s a matter of faith. But then, having a child is always a matter of faith, because you don’t know what will result. We’re just facing a few unusual unknowns.”

“I’d say so!” replied Roger.

“If we have the help of our friends, we can do it,” said Ethel. “The more uncles and aunts, the better.”

“I think this is great,” replied Madhu. “A child is just what this place needs! A bunch of adults living without children isn’t natural, socially or emotionally.”

“This is a step forward for the Outpost,” agreed Shinji. “Or maybe I should speak more impartially, as a physician and a psychologist: this can be a step forward for the Outpost, if we decide to make it one.”

“I agree,” said Sebastian. “We can argue about the decision, second guess it, and question its wisdom; or we can respect it and help our friends. There is no advantage to

the first path, in my opinion, because we don't know enough about the future to be sure it's unhappy or even that it's likely to be unhappy. This will probably work out."

"What will NASA say?" asked Roger.

"We just spent three hours on the videophone with them," replied Will. "The reaction really wasn't as bad as I thought; in fact, it ended up being positive. No one can demand that NASA shut down Mars exploration any more. This might make Mars more attractive to America's middle class tax payers. There's nothing NASA can do; they can't order Ethel to have an abortion, either morally or from the point of view of public relations. It's an accident, it happened, it can't be reversed."

"So, let's make the most of it," agreed Paul. "I, for one, propose a toast to our friends, the new parents."

"A toast?" asked Madhu. "I propose a hug!" She rose and walked to Ethel, embraced her, then embraced Will. Paul chuckled and rose to follow her. Shinji followed, then Armando and Sebastian. Carmen and Monika rose from their chairs to hug her and Will; then Roger. Finally, with some hesitation, Érico got up and hugged his two friends.

Will and Ethel did not sleep well that night; there was too much to think about, over and over. Will rose in the middle of the night, put on a coat, and entered Greenhouse 1. With a push of a button he rolled back the nocturnal insulation so that he could see the sky, at least for a few minutes before condensation on the cold plastic clouded it. Phobos and Deimos were both sailing overhead, almost full; the blackness was carpeted by stars. Life would never be the same. He knew vaguely how much time and energy children took. Gone were the sols when he could work thirteen or even fifteen hours before he slept.

But was that bad? It was a big change, no doubt. It was a new phase in his life. It was even a new phase in the exploration of Mars: settlement. He didn't know what to think of that and knew he'd just have to adjust. But he wished he knew whether the decision was right. Would their child, twenty years from now, be occupying the first grave in Aurorae Cemetery? Or would he or she be in a university on Earth, or attending "Aurorae University," or perhaps be on an exploratory flight in the asteroid belt?

The possibilities were hard to evaluate or accept. Some were frightening in the extreme; a deformed child requiring constant care would tie them up for their entire adulthood and would burden the outpost and NASA. Clearly, the only thing he could do about some of the possibilities was to pray. So he looked at the moons and stars and recited every Bahá'í prayer he had memorized. Then he went back to bed.

Ethel had no such option; she knew no prayers. She awoke the next morning feeling ill and it made her depressed. Will got her breakfast; she almost threw it up and that almost made her cry. Finally, feeling a bit better, she decided to pull herself together. She washed, dressed, and headed to the bridge.

Sebastian was surprised to see her. "I'm sorry I missed yestersol's appointment, but we can talk any time."

"Really? You've got media interviews this sol."

"They start at two."

"Well, you probably should prepare. I don't need your help."

"Sebastian, *please.* Helping you makes things feel. . . normal."

"Oh? You know, I didn't sleep well last night; I feel really bad about the mix-up with the pills. I want to apologize to you for it."

“Thank you, Sebastian, I appreciate it, but it really isn’t necessary. I’ve forgiven you for your role—not a central role—in this event. It was a chain of screw-ups that got me to this point, and some of them were mine. So don’t worry about it.” She sighed. “This sol it’s beginning to hit me emotionally. Yestersol it was all adrenaline and reason.”

“Not all. There were some tears.”

“Yes, there were some tears, too. But this sol I’m feeling depressed. It’s a huge, wrenching change to my life. My career will never be the same and trying to make a place in my life for a new role. . . it’ll take some time.”

“You’ve got about eight months.”

“Thank God for that. Meanwhile, I have nausea every morning to remind me of the changes coming.”

“Take two hours off, if you want, and work less.”

“No! That’s what I want to avoid! I want the next nine months to be at least reasonably normal. Then the baby comes and I’ll take maternity leave. Then Will and I will alternate taking care of the baby six hours a sol.”

“That might work. And the others will help with child care.”

“I’m sure.”

“Do you want to hear the strange rumors?”

“There are strange rumors?”

Sebastian smiled. “Of course. The *American Enquirer* has been publishing stories for years about how we’re in contact with aliens and we’re a funnel for alien technology

to the United States and Europe. Now their website has an advance copy of a 'scoop' demonstrating that the baby is an alien."

Ethel laughed uncomfortably. "Yes, there will always be those rumors."

"The serious ones will be harder to deal with. People will say you intentionally got pregnant and will offer a hundred motivations, some quite convoluted or conspiratorial."

"I know, and it's been weighing on me. We're international celebrities and have to deal with the same pressures as movie stars. At least we're isolated."

"Another reason to stay."

She nodded. "Definitely. Well, what do you have?"

Sebastian turned to his desk and grabbed a three-page memo on e-paper. "I ran this past Rick Page, head of the garage at International Space Station 2 yesterday, and he made a few minor changes to get the specs right. I haven't sent it in yet because once I heard your news, I decided no one would pay attention."

Ethel nodded and took the three pages. She read them and nodded. "As far as I know, this is right. Rick repairs a lot more engines and pumps than we do. The test you recommend is standard, too. And you're the expert, not me." She handed it back to him.

"I'll email it later this sol. They'll check everything, review the data we've collected, read the memo, and make their own recommendation, which will probably be the same. Then we'll get the software routine in an email in about three sols."

"They are predictable." Ethel stood up. "Well, since I can't be helpful here, I guess I'll go back to our apartment to neaten it, and then Will and I will run through the

emails the public information folks will inevitably send us. They're preparing a list of difficult questions and possible talking points for us."

She waved goodbye and headed back to the apartment. In Greenhouse 4 she walked past Carmen, who was sitting next to the rice paddy watching the fish swimming. Her eyes were red from crying. Ethel barely noticed the red eyes and stopped after walking past her. "Carmen? What's wrong?"

She looked up. "It's Érico. He's been spooked by your baby. He's not sure he wants to get married." She almost cried the last words.

"What? When did this happen?"

"This morning."

"I'll ask Will to talk to him."

Carmen stared, not sure what to say. Ethel gave her a kiss. "Don't worry."

Ethel headed back to the apartment and told Will. He headed for Érico's room. "Érico, are you there?"

A pause. "Is that you, Will?"

"Yes. Can I come in?"

"Sure."

Will opened the door and stepped inside. Érico was sitting on his bed wearing a tee shirt and shorts. "What's up?" asked Will.

"Not much. I'm wondering whether I should return to Earth, after all."

"Why?"

He hesitated. "Will, I'm not prepared to become a father."

"Who's asking you to become a father? Is Carmen pregnant?"

“Oh, no. We checked her bottle; it’s not four years old. But. . . well, as you know, my childhood was pretty rough. I wouldn’t want to wish such a life on a child.”

“Who says you would? This is Mars, not Brazil. There are no lousy orphanages or shoddy adoption procedures here. Carmen isn’t your mother and you aren’t your father.”

“I know, but. . . I don’t want to disappoint Carmen.”

“Do you think she’ll be happier if she doesn’t marry you?”

“Oh, I don’t know, Will.” Érico looked away.

“Well, I don’t know whether Ethel and I will be happier if this baby is born, either. But we’ve decided it’s better to take the chance than to kill it.”

“I salute you guys for that. It takes real courage.”

“And you don’t have courage? I’ve seen plenty of courage in you in the last seventeen months. You’ve traveled through hundreds of millions of kilometers of space, then across thousands of kilometers of Martian desert. Doesn’t that involve managing a lot of risks and having some faith in the future?”

He nodded. “People are the problem for me, not technology and science.”

“Well, you won’t find a better woman to help you deal with people than Carmen.”

Érico smiled. “That’s true.”

“It’s up to you, my friend. You haven’t had people problems with me or anyone else on Columbus 2. We’ve had people problems, but not from you! I can’t make up your mind for you. But just remember that your friends here love you and want the best for you, and for Carmen.”

“Thanks, Will. I really appreciate that. This is one of those inner demons I have to slay myself.”

"I understand." Will put his hand on Érico's shoulder, then left.

They tested the *Hadriaca's* engines in the afternoon so Ethel had the energy to participate fully. Besides, it was more convenient for the engineers in Houston; the Outpost's clocks were still three hours ahead.

The plan was to fire the engines for ten seconds, enough for the shuttle to lift off, fly upward a hundred meters, then come back down to a soft landing. The test involved throttling the engines up and down in order to test the pumps at various speeds. Sebastian and Ethel ran the test from the bridge in Habitat 3; there was no need to be on board.

The software routine had been carefully tested in Houston and sent to Mars for downloading onto the *Hadriaca's* computers. The two of them watched the countdown carefully, monitoring the shuttle's functioning carefully. The engines roared alive at t-minus zero and lifted the shuttle off the ground; then the computer aborted the liftoff and the engines powered down for an emergency landing after the computers switched off the questionable pump.

"Damn!" exclaimed Sebastian. "Test routine abort at t-plus 1.6 seconds."

"Pump 2 got to seventy percent of rated power," added Ethel. "Then it wouldn't go any higher and the computer shut it off."

"Run the full diagnostics," Sebastian asked, pointing. He pulled up the pump's data readout. "Transmitting full dataset to you now, Houston." He hit replay on the video camera and he and Ethel watched the aborted launch again.

"The routine could have included an abort override; the shuttle could have launched and landed safely on the other two fuel pumps," said Ethel.

“Yes, but we got what we needed. Pump 2 is flaky.”

“Now what?”

“I doubt we can fix it in the four weeks left before blast-off. We have the time to try. But I can’t guarantee the shuttle’s safety.”

“I agree,” said Ethel. “This fix is beyond our capacities. Better to fly the shuttle unmanned to orbit on two engines. It could still haul cargo to the ITVs.”

“It can serve as an emergency vehicle for the flight home, too. One engine is sufficient for trans-Earth injection and course corrections. But this may affect the flight to Deimos. I wonder whether Mission Control will be willing to launch three Mars shuttles, now that one has a problem.”

“We’ll have to carry out a thorough check of the engine to convince them it’s not a design flaw.”

“But nothing we can’t handle,” said Sebastian. He sighed and they turned back to the task of deactivating the shuttle’s systems. Finished, Ethel headed back to her apartment. She and Will were still taking television interviews. The public interest in the baby showed no sign of diminishing, though she and Will were getting tired of answering the same questions over and over again. At least NASA was giving them some new things to talk about; Columbus 1 would include nearly a tonne of supplies for the baby and a nursery, even though that meant a tonne less supplies for science, horticulture, and manufacturing.

Walking through habitat 2, she spotted Carmen and Érico in the great room, talking. They smiled and waved. “Ethel, the wedding’s on,” Carmen exclaimed, and Érico nodded. Ethel headed home with a bit more bounce in her step.

15

Wedding

about August 8, 2039

Madhu pulled Carmen's veil back a bit. "Oh, you are such a beautiful bride!"

"Thank you." Carmen looked in the only head to foot mirror in Habitat 2, which they had set up in the Bio Lab. "It does look very nice, considering it was made completely here."

"The lace Madhu donated really helps," said Ethel, admiring the gown. "You should see what this looked like when I wore it. From a distance it looked pretty good, but close up it wasn't so great!"

"The parachute material is now mostly replaced or covered," said Madhu. "Mission Control *must* send a real wedding gown!"

"Don't count on me needing it," replied Monika.

"I was speaking in generalities. This is the second wedding on Mars; it won't be the last."

Ethel glanced at her watch. "It's just about time. I'll find out where the groom is."

"I hope he's coming," said Carmen.

"Don't worry, Will and Sebastian won't let him back out now!" replied Ethel. She headed out of the Bio lab, which they had been using as the bride's preparation area because the bedrooms were so small. She poked her head around the corner into Hab 2's great room/ Geology Lab. They had pushed the geological instruments back against the wall and decorated the room for the ceremony; the couple would get married under a white arch covered with vegetation and woven with daisies, the only abundant flowers

they had at the Outpost. Two rows of chairs flanked a central aisle. Armando stood behind the chairs, fiddling with a camera.

"No groom yet?" she asked.

"No. Shall I get him?"

"I think so. It's time."

"Okay." Armando walked to Hab 1, where the groom was dressing. Will, Sebastian, and Paul were there as well. Sebastian was making a videomail, so Armando paused. "Yes, blast off is eight sols away," he said to his wife and two boys, whose faces were on the screen. "Helmut, you still have to thank Jerry McCord for his recommendation, so don't forget! I checked with him yestersol and he said he hadn't heard from you. Do you think there are a lot of kids who get into the California Institute of Technology after their junior year and get to skip senior year of high school? Not many! His recommendation was key, so you owe him! Kristoff, I'm sorry you didn't get into the junior scientists summer academy, but you can't win all the time. I don't want to hear that you've gone into a blue funk all summer over it and mope around the house all day! There are plenty of things to do, especially horseback riding; remember, you've got lessons this summer. Anyway, boys, I'll be home soon, so just hold on and I'll be with you again. Give mom a break! Bye." He sent the message and looked up

"'Blue funk'?" asked Armando.

"Yes, Kristoff gets depressed when he sets his heart on something and it doesn't happen. It has cost us thousands in counseling."

"Anti-depressants?"

"We may have to do that. What time is it?"

“Time for a wedding! The ladies sent me to fetch the groom!”

“Okay,” said Érico, sounding a bit nervous. He looked at the others. “So, you won’t talk me out of this?”

“Too late for that,” replied Paul.

“Hey, watch out; you may be next!”

Paul shrugged. “Who knows.”

“If you back out now, I’ll cancel your assignment on the Deimos flight,” said Sebastian, joking.

“We don’t even know for sure that there will be a Deimos flight.”

“Oh, there will be. The engine problem is not systemic.”

“Well, don’t worry, I’m not backing out,” replied Érico. “I’m ready.”

“That’s the spirit,” said Will.

Érico led the men out the door and toward Greenhouse 1. He was dressed in the fanciest suit on Mars; Sebastian’s, though he had given it to Érico as a wedding present. They crossed Greenhouse 1 and arrived in Habitat 2; through the bio lab’s open door, the women saw and heard them arrive. Érico stood at the back, waiting for his bride to appear while the others sat. Shinji and Roger arrived from Habitat 3, where they had been busily preparing the meal.

Carmen came out of the Bio lab, followed by the other women. The latter passed her and went to sit with their partners. Érico smiled as Carmen approached in her beautiful wedding dress, happiness radiating from her face.

“You are a vision of loveliness,” he whispered to her. He leaned over to kiss her, but she shook her head.

“After the vows, my love!”

“Oh, yes. Of course.” He offered her his arm and she locked her arm with his.

Shinji started the wedding march and they began to walk down the aisle.

[Completed Monday, Dec. 30, 2002; completed rewrite Sept. 18, 2008 and Dec, 6, 2008 and July 27, 2009]

Mars Frontier, Volume 2: Summary

Three shuttles land with eight new personnel. Will and Ethel meet Madhu for the first time. Roger is anxious to get outside and explore; Sebastian is determined to follow the mission plan exactly. Will asks Érico about Phobos. Madhu, Monika, and Armando ask Shinji to show them the horticultural, exobiological, and medical facilities they will be running. At the banquet, Will rings the Outpost's bell and begins the transition of command to Sebastian Langlais.
Date: April 16, 2038

Habitat 3, a greenhouse, two solar power units, and a few other things are set up. Paul gives Ethel control over the metal and plastic making facilities so he can concentrate on the Prospectors. But Shinji feels shorn of responsibility. Will clashes with Roger over exploration priorities; Will wants to go up-canyon but Roger wants to head north to the ancient sea bottom and the north polar terrains. Shinji and Will confront Sebastian over the issue of their getting respect because of seniority. Sebastian agrees that Shinji should be a co-equal exobiologist to Monika, but Will loses his argument about exploration priorities
Date: mid April through early May, 2038

The automated cargo vehicles aerobrake into orbit and two shuttles fly up to pick up the cargo. They set up the rest of the Outpost. Then they meet to plan their first expedition. Will agreed on the northern route, but argued for some new techniques that would speed up exploration. Everyone agreed to try them, one by one. Sebastian asked the men what they would do but told Ethel what she would do, which irritated her.
Date: mid to late May, 2038

The first expedition sets out to the northeast toward Chryse. They explore a crater. Roger is collecting samples Madhu can use in her art work; the rest of them agree to do the same. Roger and Érico clash over politics. They talk about the development of the moon versus Mars. Érico cautiously talks about his background. Carmen is obviously sweet on him and is surprised when he says he could stay three cycles. Roger wants to go home, but admits that staying keeps the family together.
Date: early June, 2038

Will and Roger fly home after five weeks of exploring. Will is scheduled to stay six weeks (it ends up being eight). Roger and Madhu have moved to a new apartment on the upper level of Hab 2. Will and Ethel discuss Sebastian's fastidiousness and his drive to concentrate everything on exploration. Will takes an extra toothpaste tube and that evening Sebastian complains. Over supper they all discuss the launch of the Swift Shuttle, which takes eight tonnes to orbit at a time for $1,500 per kilo. Tourism to LEO will boom; it is projected to start on the moon in a few years.
Date: early to mid July, 2038

Sebastian and Roger fly north to the expedition. Will and Ethel look at the sunwing hanger's construction and decide to propose a duricrete geology facility that could be pressurized. When Sebastian finds out, he grudgingly approves it, if they get their regular work done. Madhu, Armando, and Carmen agree to help to get the building finished in seven weeks, before Sebastian returns.
Date: mid July, 2038

When Sebastian and Roger return on Satursol, the shell of the building is complete. Sebastian gets a tour and docks Will and Ethel two weeks vacation for building a pressurizable building rather than a quick and simple outdoor building. He orders them to the expedition on Monsol. Sunsol morning, Will, Ethel, Armando, Roger, Madhu, and Carmen all go outside to work on their day off to finish the building. Seeing their determination and defiance of his approach, Sebastian comes out to help as well and relents.
Date: early Sept., 2038

Will and Ethel arrive at the expedition, which includes Paul, Monika, Érico, and Carmen. Paul and Monika stay at Castle Rock to run the driller while the other four push the route northward. Érico and Carmen clearly are in love and both are seriously thinking about staying. So are Roger and Madhu. The four of them talk about generating a stronger media presence and Sebastian cautiously agrees to it. The expedition will continue until conjunction (in three and a half months).
Date: early Sept., 2038 (Sept. 6 at one point)

The expedition encounters its first buried ice at 64 degrees north. Lassen tries to get Will and Ethel to return to Earth with Columbus 2, partly because Will's so good on television. They politely refuse. The ESA and Sebastian get involved as well. Robert Clarke, head of the Mars Exploration Society, calls and asks Will to consider replacing him. Will recommends that Heather Kimball be asked instead, and she accepts. The

expedition reaches 73 north and cliffs of permanent ice. They plan to head east to Borealis Chasma, then back to the Outpost.
Date: Oct. 15-Nov. 18, 2038

10. Conference 120

The expedition returns to the Outpost from the north polar terrains. Sebastian calls a conference the next day to plan the next year or so. They agree to explore southward until dust storm season begins, then explore westward toward Noctis Labyrinthus. If the storm gets bad, they'll make short trips from the Outpost only. Paul, Monika, Érico, Carmen, Roger, and Madhu all agree they want to stay; only Sebastian, Armando, and Shinji plan to leave.
Date: late Nov. 2038

11. Conjunction 139

During conjunction, the crew stays close to the Outpost, exploring Little Colorado Canyon; building and maintaining a water storage facility; assembling airlocks for the Geology Building. Sebastian announces that the French have decided to send three, the US four, the other Europeans 2, and that a third ITV is being added Columbus 3 to fly as many as 14 to Mars.
Date: late Dec. 2038-early Jan. 2039

12. Emergency 150

Will and five others prepare to depart from the Outpost. In a month or so, they reach the mouth of Nirgal Vallis and explore up the valley, then continue toward Argyre. A sudden failure of a seal at 5 a.m. depressurizes the portahab; they scrambled out in time. The expedition decides to continue south.
Date: early-mid Feb. 2039

13. Surprise 160

Will returns from the Argyre expedition, stays a month, then joins the Marineris expedition. It returns to the Outpost four weeks before blastoff and five weeks before TEI. Ethel's feeling funny. She checks with Shinji and finds she is pregnant; she's been taking four year old birth control pills. She and Will decide to keep the baby and videomail their parents, then tell Sebastian.
Date: early July, 2039

14. Test 177

They tell NASA, then the rest of the Outpost. Will can't sleep and goes to a greenhouse to pray. Ethel awakes depressed and goes to Sebastian, whom she insists helping in order to bring normalcy to her life. Ethel sees Carmen crying and finds out that Érico wants to

back out of the wedding. Will goes and talks to him about it. After the failure of a shuttle test, three sols later, Érico agrees to the wedding.
Date: early-mid July, 2039

15. Wedding 188
Érico and Carmen get married.
Date: August 8, 2039