# *MARS FRONTIER*

## *Vol. 2*

### *Columbus Two*

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# Landing

April 16, 2023

High above Mars, the shuttle *Hadriaca* fired its engines briefly. It pulled away from Columbus 2, a complex of three interplanetary habitats and a shuttle in orbit around the Red Planet. A few minutes later a second Mars shuttle, the *Elysium,* separated from the complex as well.

For twelve hours the *Hadriaca* fell towards Mars until it finally blazed through the thin upper atmosphere, burning off a significant amount of its speed, nearly circularizing its orbit and changing its plane slightly. Three hours later it dipped into the atmosphere again, one last time, slowing and heading toward the surface like a glowing meteor, carefully directed by Commander Sebastian Langlais toward a spot on the sunrise terminator a bit north of the equator. The shuttle dropped quickly and slowed in the thickening air until its drogue chutes, then its three main parachutes popped open. A minute later they detached from the shuttle on Langlais's command and the three main engines roared alive, steering the shuttle toward its preprogrammed landing spot and burning off its remaining velocity. The landing legs extended and the vehicle momentarily hovered above the surface, then dropped onto it, bouncing a bit on its legs. The first three members of the Columbus 2 crew had arrived at Aurorae Outpost.

Inside the outpost, Will Elliott, Ethel MacGregor, and Shinji Nagatani watched the entire landing on the big screen in habitat 1's great room with rising excitement. 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.

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

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

“Thank you, Aurorae,” replied Langlais in a formal tone of voice.

“I guess I had better get going, ” said Shinji. Unlike Will and Ethel, he was wearing a pressure suit, minus helmet and gloves.

“See you later with the new arrivals,” said Will.

Shinji nodded and headed for the airlock. Outside was a “docking unit,” a square room three meters across with pressure doors in each of its four sides; docked to one of the doors was a ranger, a vehicle rather like a truck or humvee, ready to be driven to the shuttle.

“I sense mixed feelings in you,” said Ethel to Will, after Shinji had left.

“Yes, you’re right. It’ll be a great relief to see some 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 break down the façade and get to know him.”

“Oh, don’t worry. It’ll be fine. Think about how hard Columbus 1 was.”

Will smiled. “Yes; the six of us had a lot of difficulties. But in the end we were pretty close.”

“It really worked out, in the end. We’ve got a year and a half together; the eleven of us will become a team, also. Don’t worry.”

“I think you’re right.” Will smiled and kissed Ethel on the forehead. They had been married ten months, now, a romance that had sprouted during Columbus 1.

They watched the ranger heading toward the *Hadriaca* on the cameras. The shuttle had made for a cleared landing area about five kilometers away, on the other side of Boat Rock; that way the massive pile of fluvial sediment, volcanics, and crater ejecta would protect them from any crash or explosion. It had landed within the inner ten-meter bull's eye they had spray-painted on the Martian desert floor; that's how precise the landing had been.

Shinji arrived at the *Hadriaca* in a few minutes while its crew was completing their power-down and checkout. He circled the shuttle at a distance, focusing the cameras on the vehicle to reveal any venting of gasses. There were no plumes or discoloration to see. Finally he had permission to move closer and parked about five meters from the ramp that led from the *Hadriaca* to the Martian surface. Shinji put on his helmet—he was already wearing his gloves—and began to depressurize the cab.

About the time he finished, the shuttle's airlock door opened and two figures came out, followed by a third a few minutes later. They came down and stepped onto Mars, cheered, and began to walk around excitedly. Shinji was able to step out as well about the time the third person exited; the latter left an airlock full of air-tight suitcases and plastic boxes. While Mars's new inhabitants practically danced off their excitement of landing, Shinji packed their suitcases and boxes into the space behind the ranger's seat.

Finally, they shook his hands, slapped him on the back, and stepped inside the ranger. It was a tight squeeze; the cab was 2.4 meters long and thus could hold four people across it, but the seat was moved forward about as far as it could be to hold the suitcases as well. Shinji closed up the cab and began to pressurize the interior while driving them all back to the Outpost, where he backed the ranger against the airlock and

docked to it again. Will controlled a remote manipulator arm from inside to make sure the transfer tunnel was latched properly in place.

Inside, Will and Ethel waited. The airlock door soon opened and the three new people stepped inside the outpost.

The first was Sebastian Langlais, a 46-year old German, the new Commander of the Mars expedition. His blond hair was streaked with a lot of gray, but his blue eyes flashed with energy and excitement as a result of their arrival. He stepped out.

“Vill Elliott, it’s good to see you again.” Will had forgotten Langlais’s strong German accent.

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

“Thank you, we’re very happy to be here.” They shook hands.

“Long trip?”

“It felt long.” Sebastian turned to Ethel to shake her hands 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 less friendly but respectful fashion.

“Will,” He said, and extended his hand. They shook; a bone-crushing exchange. Will stared at Anderson’s eyes and felt the man’s rivalry. It triggered a natural rivalry in him, also. Anderson, after all, had disagreed with one of Will’s papers about lunar mantle fragments that he had found during one of his lunar south polar expeditions. And he had often asked pointed questions during the last six months of Columbus 1’s geological operations. Anderson was a damn good planetary geologist and he knew it.

Will returned the bone-crushing grip and smiled. “Roger. Welcome to Mars.”

“Thanks, glad to be here.”

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. He was surprised by how long her black hair was; more than regulation, he was pretty sure. She smiled warmly and shook hands.

"It's really nice to meet you, Will. I'm looking forward to collaborating with you."

"Thank you. Pleased to meet you, Madhu." They shook hands and she was genuinely warm and friendly. That made him feel better.

Madhu moved on to shake hands with, then hug Ethel. "I'm 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'm the mission barber, and I have an entire set of professional hair-cutting shears."

"Oh, marvelous! We've been without a really good barber for nine months, now. 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 door with a large plastic-wrapped box.

Will reached out and grabbed one end. "Sure."

"Those are your wedding presents," said Langlais.

"Oh? Thank you!" exclaimed Will. He pulled the box through the airlock, then turned and carried it into the habitat. The others reached through and grabbed suitcases and boxes as well, carrying them inside the habitat.

"Which is my room?" asked Langlais.

Will took him around a corner into a small, semicircular room with a series of doors along its curved outer wall. “Shinji’s in the far room, there; the room next to his is the medical unit. Since Roger and Madhu are upstairs with us, the two habitats have fourteen rooms and only need to accommodate seven, so we should leave every other room empty for privacy.”

Sebastian nodded. “Alright. I’ll take this one, then.” He walked to a door near Shinji’s room, but separated from it by one empty room, and opened the door. He entered a room 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, nodding.

Will walked back around the corner to the Great Room, their main gathering area. The bedrooms did not face the Great Room, so that the noise of socializing didn’t interfere with the sleep of anyone going to bed early; the bedrooms faced the Geo-Bio lab, which was actually empty, since they had been using the great room of Habitat 2 as their Geo-Bio lab instead. Off of the Great Room was the kitchenette, the bridge, and the repair area. Each habitat was large enough to accommodate six people, eight in an emergency; 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 gave them much-needed interior space to wander in or be alone in. The space was an important antidote to cabin fever.

Roger and Madhu were carrying more boxes into the Great Room; Ethel followed with one of their suitcases. “Where’s our place?” asked Madhu.

“This way,” replied Ethel. “We just finished building it last month.” She pointed to the stairway that led to the smaller second level that was squeezed under the habitat’s upper pressure dome. Then all four of them grabbed a suitcase and carried them up.

The upper level originally had been a large balcony opening onto the Great Room. The Great Room occupied about a third of the entire floor area of the habitat, leaving only two thirds for the upper level, and half of that had a ceiling too low to walk around in, though it could serve as storage and some of it was usable for sitting. The usable space was an oval seven meters long and four wide; Will and Ethel had the right half, Roger and Madhu the left half. Their rooms were separated by a tiny room with a toilet, another tiny room with a sink, a shower accessible to either couple, and closet spaces. The entire area 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 small room, which was pretty bare. “This has a lot of potential.”

“We didn’t add the wallpaper,” said Ethel. “We had run out, but you’ve brought more.”

“We’ve already selected our design,” 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 have held up pretty well, I think.”

“I’m just looking forward to a lengthy shower and a chance to wash my hair thoroughly. I gather we can take long showers here?”

Ethel nodded. “Today—or maybe I should say ‘this sol’ which is what we use instead—everyone can take a long shower, and once we have the third habitat and the two additional greenhouses set up, we’ll have almost unlimited access to water. We’ll have a lot of recycling ability.”

“We have to cover the new habitat with an ice layer for radiation protection, anyway; it could be fifty tonnes of bath water as easily as clean water!”

“Yes, that’s true.” Ethel looked at Madhu’s hair. “Your hair is beautiful.”

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

Ethel smiled. “I’m sure he’ll notice eventually.”

“It’ll be a long time! Sebastian’s not very alert about women’s hair.”

The two women walked back into the bedroom. Roger had put the suitcases on the bed; Will had helped.

“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 we do now, so we can build you a different apartment once the other basic tasks are done,” replied Ethel. “Will and I could convert your bedroom into a living

room. The big task is reinforcing Habitat 2 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 somewhat, so we couldn't make the materials."

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

"Yes, 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 up here. You all have a lot of space."

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

Sebastian nodded, looking around. "Between the balcony up here and the basement underneath, we have an amazing amount of space inside these habitats, though I suppose it's not all usable."

"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 up all that space."

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

"Yes, theoretically, but with no backup, and a lot of cabin fever," replied Ethel.

"I have a solution for that; 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?”

Will shook his head. “We got most of the way to the end, but we have never gone back and 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. “I want us to start by following the mission plan closely. Inevitably, we’ll depart from it; if Columbus 1 proves to be a model, we’ll do about twice as much as was scheduled in the nominal mission. But let’s start with the nominal mission, and that means devoting the next six weeks to developing the Outpost.”

“Alright,” said Roger, disappointed.

“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 not.

The awkward moment of silence was broken by static on the public address system. “Attention,” exclaimed Shinji, over the habitat’s loudspeaker. “The *Elysium* is nearing apoapsis and requesting permission to land.”

"Already!" exclaimed Sebastian. He raised his voice to reply to Shinji. "I'm on my way to the bridge!"

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A bit over an hour later, the *Elysium* landed at the Outpost carrying Monika Yevtushenko, their Russian exobiologist, and Armando Cruz, their American physician. Monika was a pilot and flew the vehicle. Shinji drove over to the shuttle to pick them up. They welcomed the two newcomers very warmly. "Armando, we haven't seen you since launch!" exclaimed Will.

Armando laughed. "Wasn't that something? I still remember floating 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.

"And so far, my wife is managing alright; one kid's in college, the other one will be next year, and my flight pay can almost cover the bills." He looked at Will and Ethel. "I'm so glad you're married. Congratulations."

"Thanks, my friend." Will shook Armando's hand.

Ethel leaned over and kissed him. "We're very happy; and the first year's always the worst."

"But at least we've had a first year together; that's really helped, I think," said Will. "I feel like I know Ethel better than I ever knew my first wife."

"I feel the same," said Ethel, nodding.

“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.’ So 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 can’t quote Freud for you about that, but as a doctor and father I highly recommend them.”

Ethel looked slightly embarrassed. “Maybe some day.”

Just then Shinji entered the habitat with Madhu, who had stopped to ask him a question 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, and I think the water 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.”

“Oh, can you show me the sick bay?” asked Armando. “I want to see what you’ve got, and where we can put the new equipment.”

“That won’t take long,” agreed Shinji.

Monika came out of her room at that moment. “Oh, and Shinji, can you show me the biology lab? I’ve got a similar interest; 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. “We’ll need the space to expand the Geology lab.” He turned to his fellow physician. “Armando, let me show you the medical area; then I can show Monika the bio lab in habitat 2.”

"Okay, I'll unpack, then," said Monika, and she turned back to her room.

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Four more hours passed, then the *Apollonaris* descended from Phobos, where it had been updating the fuel manufacturing equipment, 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 get them; he couldn't stay in the habitat any longer. Soon all eleven human beings living on Mars were walking around the Outpost, exploring the greenhouses and labs, unpacking their possessions, and gathering in the great room to chat. Will and Ethel started to cook the big supper that was planned that evening using a lot of imported, frozen meats and other delicacies they had run out of, as well as lots of Martian vegetables. Madhu came to help; it took three of them because everyone was hanging around and asking questions.

The sun set. Roger and Érico came inside; they had used the afternoon to walk to the top of Boat Rock, explore the crack separating it from Face Rock, and hike along the base of Layercake Mesa. Habitat 1 began to fill with smells of cooking. Sebastian and several others hauled the table and chairs in Habitat 2 to Habitat 1's Great Room, so they all could sit together. Ethel went and found a particular wedding present and opened it, because she already knew it was a beautiful linen tablecloth that would go well on one of the tables.

The food came out on a long 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 heard before, for Mars now had almost twice as many crew on it as it had 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 2009KM20 on the flight out."

"Oh, that's true; I had forgotten. I apologize, I'm sure that's not something to forget!"

"Definitely not! It wasn't as big as Phobos, of course, but it was completely new, and it was a stony asteroid with interesting geology."

"I guess most Columbus missions will be timed to visit an asteroid from now on," exclaimed Will. "We flew by a little one; fifty meters across."

"If we return to Earth on schedule, we'll visit 2015GH6," added Paul Renfrew. "It's pretty big; six kilometers long, and probably a loose collection of rocks. The Mars missions can do a lot of asteroid exploration, now that the transportation system's tested and there are twenty thousand orbits of rocks in the computers."

"You guys will be accompanied by a Lifter full of fuel, too," noted Will. "So it'll be much safer."

"And we can thank you guys," added Érico. "Columbus 1 broke the ground."

"What do you guys think of Martian gravity?" asked Will.

“I’m pretty well adjusted, now,” said Érico. “It’s pretty nice, in a pressure suit. You have almost normal terrestrial traction.”

“I’m still getting used to 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. Most were drinking their coffee or tea. “Okay.” He stood and looked to Sebastian, who had been watching Will. He stood as well and the two of them walked to the end of the table with the food, 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 actually the second time the Outpost’s bell has been rung. When Columbus 1 was making its final preparations, Commander Laura Stillwell, an officer in the United States Navy, obtained the bell for our 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 Stillwell to me, but NASA, as you probably know, did not formalize the decision until Columbus 1 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, generally catching up on an immense backlog of research, developing the greenhouses, and carrying out routine maintenance. I can’t tell you how thrilled the three of us 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 getting pretty old and 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 need 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 we arrived here 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 also pledge my loyalty to you." Will reached down and picked up the Commander's Log, a special 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 take a look at the entries, then put it down on the table next to the bell. "Well, my friends, Mars has eleven people on it, and we have eighteen months before departure. I echo Will's wise comments about the importance of building a strong, efficient, unified team. I hope we can accomplish that task quickly. We have a six to eight week construction period ahead of us. Thanks to abundant Martian hydrogen, the shuttles this sol arrived with the Mars Life Science Facility, two greenhouses, a third habitat, and tonnes of consumables and spare parts.

Two automated cargo vehicles go into Mars orbit in a month with a new Sunwing, metal and plastic making equipment, scientific instruments, a conestoga, and many other useful items. We'll have half as much equipment to set up and twice as many personnel, so we should be able to do the work faster than Columbus 1.

"Then the scientific work begins. The Outpost needs two or three full-time people to keep it running. We should be able to keep the vehicles exploring almost constantly. The new conestoga is much more spacious than the portahabs. As you know, we will have some very important and complicated decisions to make at that point: do we send out two vehicles or three; do we keep them out constantly or rotate them; do we explore north, west, south, east, or a combination thereof; do we emphasize the 'Prospector' telerobotically operated rovers or human exploration. We face some fascinating choices. I think the results will go down in history.

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

Sebastian stepped down and everyone applauded. Madhu Gupta-Anderson stood at her chair. "We do have a few brief acts. Érico has promised to sing for us, and I am pretty sure I have convinced Sebastian to play the violin for us. As you may know, he has brought a Stratavarius here! 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 and she nodded as well. It would be an evening everyone would remember.

# 2

# Delegation

mid April through early May, 2023

The next day the two rangers, with trailers attached, headed to the shuttles to continue unloading them. On the landing day—April 16, 2023—the rangers had managed to haul 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 went back to the shuttles with the rangers to unload equipment, others turned to setting up the two inflatable structures.

Unlike Columbus 1, Columbus 2 arrived after considerable local preparation had been done. During their nine months of running the outpost, Will had excavated the foundations for both structures and Ethel had manufactured the metal and plastic parts needed to complete them. As a result, once the two inflatables had been wheeled into place, all the crew had to do was add air. Habitat 3 was the same size as the others: shaped roughly like a flying saucer, twelve meters in diameter, with a domed top and a curved bottom giving it a maximum thickness in the middle of seven meters. It had to be inflated into a bowl-shaped depression and Will had been very careful to get the dimensions exactly right and cover the surface with a layer of soft Martian dust and sand; Habitats 1 and 2 had been placed in hastily excavated depressions and later they had to devote a lot of time to filling gaps underneath the structures. Inflating the habitat into its final shape was quick and easy; in a few hours they had filled the interior with oxygen, nitrogen, and argon and they could walk around inside. But vast amounts of work

remained after the simple act of inflation. The habitat had some one hundred independent inflatable “ribs” to keep it stiff if it suffered from a puncture, and each required careful inflation with Martian air. Once inflated, the floors and walls were all in place, but they were soft and tended to sag underfoot or deform from the pressure of a hand; they had to be stiffened with hard plastic panels. But the panels Ethel had made were rather flammable and an unattractive gray, so Columbus 2 had brought a special flame-proof cover layer that they could apply, and it was decorative as well; they called it “wallpaper.” Finally, the floor of the main level had to be stiffened with horizontal and vertical metal beams that Ethel had made with the metal carbonyl unit so that it would be firm underfoot and strong under the weight of furniture, equipment, and people. The “balcony” level required similar reinforcement to be used, and the basement level needed walls. Finally, life support equipment had to be installed and pipes laid to carry water, air, and sewage. It was a solid month of work for three people.

The Mars life sciences facility was almost as much work. It was the length of a Habitat—twelve meters—and six meters wide. It was essentially an inflatable Quonset hut, with a slightly curved floor and a wall and ceiling that formed a semicircular profile, punctuated by three windows on each side. A flat floor of hard plastic panels had to be installed, with short plastic supports every two meters to hold it above the curved bottom. The airspace beneath—no more than half a meter high—would house pipes and wires.

One shuttle had brought a greenhouse, a tough, airtight, transparent plastic cylinder twenty-two meters long and six wide. Another would arrive on one of the automated cargo vehicles. Will had excavated curved depressions for them and the first one was set up quickly. But transferring soil to the two new greenhouses from the two

existing ones, setting it up in plastic frames, adding Martian regolith to bulk it up, and starting plants growing would take months.

Also on board the shuttles were solar power units. Like their two predecessors, each one was a transparent cylinder thirty meters in diameter and thirty-two long, with two strips of solar panels opposite each other. One strip of panels ran through the length of a silvered area that covered half of the cylinder; it was kept facing toward the sun at all times by rolling the cylinder along the ground. The silvered areas reflected sunlight onto another strip of solar panels that ran along the middle of the opposite side of the cylinder; that strip of panels had silvered wings to reflect any stray light back toward the panels in the middle of the silvered side. The result was that nine hundred sixty square meters of area that constantly pointed toward the sun—and was exposed, on average, to four hundred eighty kilowatts of solar energy—reflected all the energy onto ninety-six square meters of high-efficiency solar cells, generating a continuous one hundred sixty kilowatts of electricity. Since the intense sunlight made the panels quite hot, compressed Martian air was circulated against their backs to cool them and capture about one hundred sixty kilowatts of heat as well.

Columbus 1 had drilled a series of wells into the bedrock under Aurorae and after two years the six shafts had penetrated almost four hundred meters. The rock they passed through was porous and about five percent ice by mass. About a year after arrival they had capped the shafts tightly on top with Martian concrete; this meant they could pump compressed Martian air down several shafts after it was heated by the solar power units. The hot air penetrated the pores in the rock, heating it, melting the ice, and evaporating the water; when the cooler air escaped up the shafts it was humid, and by condensing the

water they could harvest as much as four tonnes of water a week. After over two years, tens of thousands of tonnes of rock were heated up to fairly high temperatures and were thoroughly dried out; the heat steadily escaped horizontally, melting ice and making a pool of liquid water at the bottom of the shafts that they could pump up if necessary; and if the Outpost needed spare heat during duststorms, when the solar power units were useless, they could pump it out of the ground. By adding two more solar power units, they had even more energy available for harvesting water and storing heat. Two people were able to set them up in four days.

Two wind turbines were on their way on the automated cargo vehicles, due to arrive in Martian orbit in a month. Each had blades twenty meters long; in a forty-kilometer per hour wind, as was typical on the top of Boat Rock every afternoon, they had a power output of three kilowatts. Normally, six occasional kilowatts of power was not worth worrying about; but in a dust storm winds typically blew steadily at fifty kilometers per hour or more on the mesas and gusted often to 100 kilometers per hour or more, and at a hundred klicks the wind turbines could make twenty kilowatts each, plenty to run the outpost at emergency rationing power levels.

Sebastian decided to make the new Habitat 3 their main habitat for eating and socializing. Only Paul Renfrew lived there and he liked to stay up late, which was just as well, since the habitat tended to be noisy. In a fit of generosity Sebastian agreed that pairs of single rooms could be merged by cutting away the wall between them, so the six private bedrooms in each Habitat became three. Removing the walls in such a way that they could be replaced later was tricky, but could be done; they spent several days on the task, then wallpapered the larger rooms with fresh patterns. Sebastian also agreed that

Roger and Madhu could have a two-room apartment of their own on the balcony level of Habitat 2, which left Will and Ethel with the two rooms on Habitat 1's balcony. While the wallpapering went on, another team reinforced the balcony of Habitat 2 and enclosed the apartment there.

Setting up Habitat 3, the life science facility, the new greenhouse, the docking units, the airlocks, and tunnels to connect them together took about two weeks of continuous work by all eleven of them. Modifying Habitats 1 and 2 took another week. As a result, by the end of the third week after the arrival of Columbus 2, set-up work began to wind down. They had beaten the nominal schedule, which was to be expected because it assumed minimal work and maximum delays. The automated cargo vehicles were not due to arrive at Mars for two more weeks, so the crew turned temporarily to scientific and other tasks. One 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, in conclusion. "Over two years I've probably run the plastic making facility the equivalent of two months, which has been enough to make about eight tonnes of plastic sheets and special items, like cups, sample bags, soil trays for the greenhouses, etc. The metal working facility has been used even less; maybe the equivalent of one month, and that's been enough to make three tonnes of metal beams, pins, forks, etc. When we ran either one we have to draw a lot of power, so much that we ran the fuel cells in the shuttles and used up their stored fuel to make enough power. Now, with four solar power units, that won't be necessary. But with the new equipment coming next month our power needs will grow again."

“How familiar are you with the cargo manifest?”

“Pretty familiar; I’ve scoured the website. 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 can make. Set-up will take a month or so. I’m very interested in getting a chance to use the new chemical synthesis unit; it’ll greatly broaden our capacities. I’ve never been satisfied with the glues we could make here, for example. Now that will change. And of course, being able to make more advanced chemical feedstocks will greatly increase the capacity of the plastic making unit.”

“It’s very exciting,” agreed Paul. “And the new industrial facility will allow us to house these units in a much more convenient fashion. We’ll have plenty of room for items to cool and be stored, too.”

“That will help a lot.”

“I’m sure; I can’t imagine how you made all the plastic sheets you did in a space barely longer than the sheets! I gather you really want to be involved in running them?”

“Oh, definitely. I’ve really enjoyed it. You’ve seen how much I like construction.”

“Good. Because as you may know, 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 is in robotics. So I’m perfectly happy leaving you to the tasks of chemical, plastic, and metal synthesis and fabrication of items from them. And I know if we have someone devoted nearly 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, which means stronger ones. 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 work would be rather 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; we’ve now got eight functioning ones, plus two broken ones that we need to recover if we can. So I’m glad to give you the work you want to do, because it’s not what I want to do!”

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

Paul nodded. “Yes, Sebastian will want that.” He turned and headed to his work area in Habitat 3 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 metal 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. They raved over the natural beauty of the place during supper.

"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 exploration training.

"It's very different. Softer, rounded; very little cragginess and few cliffs. You can get lost in a boulder field, but never in a canyon."

"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 every day."

"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! Think what a Sunwing can photograph."

"We've already got some Sunwing reconnaissance there," replied Roger, shaking his head. "No, our destination must be northward: Chryse, then the old ocean bottom of Acidalia Planitia. We need to haul the driller up there 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 hydrogen 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 from here. Then vehicles can range freely to Argyre and Hellas, and maybe the south pole itself."

Roger shook his head adamantly. "Maybe eventually. Columbus 2 is heading north."

Will grew angry. "Don't you think some consultation and give and take would be helpful? 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, ultimately."

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

"I apologize if I didn't make the administrative chain clearer. Roger's in charge of exploration. Madhu's in charge of the greenhouses and Paul of manufacturing. I'm in charge of the spaceport."

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

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

"Oh, Shinji. Come in."

"Will, I don't know about you, but I'm furious. I don't think I've been this angry in several years, in fact. I'm ready to go to Sebastian and tell him off."

"I almost wanted to do it, too." Will shook his head.

“So, have we been totally disenfranchised?” asked Shinji. “I don’t even know what I’m supposed to be doing here. 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’m comparatively lucky. Paul told me that he’d leave chemicals and plastics completely to me; he needs time to run the Prospectors.”

“And he’s good at that,” added Will. He looked at the others. “Well, I guess we have to go talk to Sebastian about this.”

“Tomorrow morning after breakfast?” suggested Shinji.

Will nodded. “Sounds good to me.”

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

Sebastian was the first one to finish breakfast and hurried to the bridge in Habitat 1 at the other side of the Outpost. A few minutes later Will and Shinji followed. They had decided Ethel’s situation was alright and she wouldn’t join them, so as not to look like

they were ganging up on Sebastian. The Commander was already hard at work reviewing the outpost's inventory, dictating notes over the videophone to secretarial assistants on Earth.

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

The German seemed to grasp a potential problem immediately, but that did not provide him with an incentive to act. "Maybe we can make an appointment for 11 a.m.? I've already got a line open to the inventory manager in Houston. We're both reviewing the database and cleaning it up. Unfortunately, when I arrived the inventory was in real disarray."

"When you arrived, there was practically nothing left to inventory, and we knew where all of it was," replied Will, rather pointedly.

"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 sounded insistent.

"Alright." Will and Shinji turned away, and as they walked to their work areas they grew more and more angry. Indeed, it was impossible to get any work done while there. 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 on the inventory. 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.”

“Oh? I’m sorry, I didn’t realize. Has anyone actually said they want you to serve as a lab technician?” asked Sebastian.

“Not in so many words, no.”

“Shinji, what do you want to do?”

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

“Okay, and I’m sure there’s plenty of work to go around for two researchers.”

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

“Then I’ll talk to Monika for you. I’ll tell her that the two of you are equally project scientists and you must be treated that way from now on.”

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

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

“We had a bit of discussion last night, with Roger,” replied Will. “I don’t want to be unreasonable or anything, Sebastian. I don’t have any objection to Roger’s goals, either. 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."

"We still have to decide what exploring schedule we want to maintain," said Sebastian. "So there probably is a question of whether we can do both. If a team is going to push to the edge of the northern layered terrain, they have to clear a route at least four thousand kilometers long; probably five thousand, when you add twists in the route and side routes. That'll take a long time at ten kilometers per day and every other month off! In fact, it can't be done."

"We have to improve the rate of exploration," agreed Will. "With three Sunwings we can now fly supplies to the expedition; we can even rotate crew. Expeditions can go for a lot longer than a month if they want. With three vehicles there's greater safety and three bulldozer blades means 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."

"If the Sunwings are finally passenger rated, if people want to stay out longer than a month, and if Mission Control approves changes to our standard routine. If not, we can't even get to the layered terrain; just to Acidalia Planitia and the old ocean bottom. And we don't go anywhere else."

Will shrugged. "I can see that the biologists should get some priority; Martian life is the issue driving exploration right now. But don't forget that in the central canyons we've got an escarpment over six kilometers high to study. 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. "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! And Ethel and I have talked about longer trips, up to two months at a time. If she comes along—she could do repairs for the trip—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. And the eight of us had divided up tasks and initiated our working relationship before the three of you decided to stay here. It's a little hard to accommodate you now."

"Considering we have seniority here, it would be helpful if you could reconsider some of those relationships," said Will, irritated.

"Well, I am Commander here and that matter is up to me," replied Sebastian abruptly.

# 3

## Expedition

mid to late May, 2023

Will Elliott had relatively little time to get angry at Sebastian and Roger. As a compromise, Roger agreed to a three-day expedition southward to the chaotic terrains, which Will was happy to lead. When they returned, the first automated cargo vehicle had aerobraked into Mars orbit and the *Olympus,* crewed by Sebastian and Paul, was ready for launch to retrieve the contents. After the shuttle blasted off, the two rangers towing portahabs headed eastward for another three-day expedition to the mouth of Gangis Chasma, and they actually pushed farther eastward along the northern escarpment of Aurorae for an additional thirty kilometers.

They returned just before the *Olympus* landed. It brought fifteen tonnes of new cargo: metal working equipment, additional plastic and chemical making equipment, six Prospector-200s (200-kilogram robotic rovers), a wind turbine, and spare parts. It also brought their first conestoga, a special eight-wheeled, six-tonne vehicle similar to a terrestrial mobile home, much larger than the ranger and portahab combination—8 meters long, 2.4 meters wide, and 2.4 meters high. Unlike their portahabs, the conestoga had a built-in driving cab, with an airtight hatch between it and the rest of the vehicle so that it could serve as an airlock. Two loft sleeping cubicles over it opened on the conestoga's main cabin, which had a "dinette" area (table and seating for four), a couch, and a galley with a three-burner stove, oven, microwave, two-basic sink, and fridge. Behind it was a hygiene area with a shower stall and a cubicle with a toilet and sink. The rear 2.5 meters of the vehicle was a scientific lab with loft sleepers for two and an exit hatch; the room

also served as a pressure suit donning area and airlock. Normally accommodating four comfortably, it could support eight in an emergency. Thoroughly tested on the moon, the conestoga was an exciting addition to their exploration capacity. An even larger vehicle, the Mobilhab, which had a second story, was slated to be deployed on the moon in a matter of months and would come to Mars in two or four years.

As exciting as it was, the conestoga was immensely complicated to set up. It was an inflatable vehicle with a telescoped chassis so that it could fit in standard six-meter cargo bays. Even rolling it out of the cargo bay was complicated because the tires proved unexpectedly locked. Inflating the vehicle expanded it easily to its full size, but bolting the extended chassis together was complicated; for a long time they couldn't get the parts to fit. The interior was filled with cargo and the cabinets, furniture, and loft sleepers required extensive installation.

The conestoga also came with an experimental automated docking system for surface vehicles. The flexible plastic tunnel that connected two hatches up to a meter apart came with a dozen inflatable ribs; differential inflation of them could steer the docking collar right or left, up or down, and in or out. The driver could use cameras to align the collar precisely and extend it into the docking receptor of the other hatch, then lock it in place. The seal was never perfectly airtight; the tunnel would deflate in an hour or so. But in practice that was sufficient for transfer of personnel between vehicles without pressure suits, since the hatches were kept closed.

While they worked on the conestoga, the *Apollonaris,* with Carmen and Érico on board, blasted off to pick up the cargo of the second automated cargo vehicle. Carmen and Érico had trouble transferring the cargo to the hold of the *Apollonaris,* even with the

remote-controlled arm on the Interplanetary Transit Vehicle or ITV still in orbit, and needed an extra day to do it. They also transferred methane and oxygen to the automated cargo vehicle—which had an empty mass of only two tonnes—so that it could fly back to Earth for reuse. Then they landed at the Outpost.

Another four days were consumed with unloading the Sunwing, the glass making equipment, the construction equipment, a docking unit, tunnels and connectors, a greenhouse, scientific instruments, and spare parts. The conestoga, finally set up, was taken out for a test drive. The manufacturing equipment deorbited by the two shuttles was set up at the northern end of the Outpost, bringing it into its final configuration for Columbus 2. Anchoring the southern end of the outpost was Habitat 1. Habitat 2 was north of it. They were connected together by greenhouses 1 and 2 on the eastern and western sides of the habitats respectively. Extending northward from Habitat 2 were Greenhouses 3 and 4 on the eastern and western sides, respectively, and they connected Habitat 2 to Habitat 3. Extending northward on the east side of Habitat 3 was the industrial facility: two docking units, each three meters across, each with two “doors” to which a chemical, plastic, or metal processing unit could be docked. At its northern end, the Mars Life Science Facility ran due west, and at its western end was a simple plastic tunnel that ran southward to the western side of Habitat 3.

When they had all the modules connected and set up, the eleven of them couldn’t help parading from one end to the other. The Outpost now consisted of three habitats, four greenhouses, a life science facility, an industrial facility, and two pressure suit donning and cleaning facilities. It was seventy-five meters long and sixteen wide, big enough to allow a lot of walking around, with plenty of spots for solitude. A pattern was

set that could be expanded almost infinitely; a Habitat could be added to the Outpost in many places, connected to the other modules via at least two escape routes to provide safe evacuation.

They still had weeks of work to set everything up, but the work would not require eleven people. That night Sebastian gathered everyone after dinner. “It’s now May 28,” he said. “On Earth, the spring semester is ending. That means 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, also. Are we ready for them?”

“The greenhouses are in good shape and are ready for experiments,” replied Madhu. “Thanks to Shinji and Ethel, when we arrived there was enough extra soil in preparation that we were able to set up Greenhouse 3 almost immediately. Greenhouse 4 will be ready by the end of the summer. So the greenhouses are ready for various experiments that originally were scheduled for the fall. I’ve got a team of twenty scientists ready to follow growth experiments with ten different plant species, and we have growth experiments involving the tilapia and rabbits.”

“How are the tilapia, anyway?” asked Ethel.

“They’re recovered from the cramped environment and artificial gravity of the ITV and they’re now growing pretty well.”

“Ethel and I are going to be extremely busy and will need help,” said Paul. “Both Sunwings will be deployed right away to scout out possible exploration routes and we have to put together Sunwing 3 as soon as possible so we can test it. The hanger has to be enlarged to accommodate a third one. The work requires a lot of metal and plastic parts

and filling more sandbags to build up the hanger's walls. The industrial engineers will want to see the new equipment tested. Sebastian, we'll need your help when you're here. We really will need three people full time."

Sebastian nodded. "I was assuming we'd assign you a third person whenever we can, but you'll also have to handle a lot of routine maintenance. Because the ideal arrangement is to send out six people in all three vehicles; certainly we need to send at least five. And that raises the question, where will we go?"

There was silence while Roger looked at Will and Will looked back at Roger. Finally Will said, "Roger wants to head north and most of the scientists in mission control want an exploration in that direction as well, so I will drop my objection to it."

Roger beamed; he was happy, not relieved. Will raised a finger. "But there is a caveat. I think we need to consider new exploration strategies that can cover more ground. If we adopt them, a northward expedition is possible with enough time left for a southward or eastward expedition. That's what I want to propose."

"What strategies do you have in mind?" asked Roger uncomfortably.

"We tried the month-long expedition on Columbus 1 and it worked well. But it's really a modification of the two-week expedition strategy developed on the moon, based on the length of the lunar day. The rangers and portahabs have proved immensely reliable in the Martian environment. In the month-long trips we had to shut down one fuel cell out of six on one ranger and once we had to shut down one motor out of six. If we send six people along we'll have more robust repair capability. There's no reason why expeditions can't go out for two or three months."

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

Will shook his head. “We’ve got new capabilities that can overcome those limitations. We tried water extraction tents on the expeditions and they worked in a limited way, but the new water extraction equipment is supposed to be much better. But even if they don’t work well enough, we now have three Sunwings that can airdrop 250 kilogram blocks of ice and food. We can use plastic packing materials to protect them from the impact. The new water extraction tent comes with a new regolith oxygen extractor and if it works as expected we may be able to extract the oxygen for breathing and burning methane as we go. And our energy situation will be very different if we 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 every sol.”

“Is that enough for an expedition?” asked Madhu.

“More or less. A portahab needs one hundred kilowatt-hours per sol for its life support systems. I’d send one. A ranger needs fifty kilowatt-hours per hour for its engine while bulldozing and twenty kilowatt-hours when just driving. If it’s operated for eight hours bulldozing and four hours driving, each ranger needs about five hundred kilowatt-hours per sol. I’d send two; one to pull a portahab and one to pull a supply trailer. A conestoga needs five hundred kilowatt-hours for driving eleven hours plus life support. The total’s sixteen hundred kilowatt-hours per sol. The Prospectors need ten kilowatt-hours per day. The trailer will carry the solar power unit, spare methane and oxygen, water and supplies, and three Prospectors. The Outpost will have four buggies and a portahab for local expeditions.”

“How would we use three vehicles?” asked Roger. “And you operated the rangers only five hours a sol on Columbus 1; why are you suggesting seven hours now?”

“On Columbus 1, whenever the expedition involved extravehicular activity, route-clearing had to stop. Both rangers sat while two or more of us walked around and explored. But with three vehicles, the conestoga can stop with the explorers—two people outside, one in the conestoga to provide emergency backup and run the Prospectors—while one ranger pushes the trail forward and the other follows with the portahab and trailer and cleans up the trail. When the explorers finish, they can jump into the conestoga and catch up. I’d divide the day into three activity periods of three and a half hours each. Each crew would spend two activity periods bulldozing the route and the third stopping for exploration or doing 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. 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; less than half a year.”

“You’re calling on people to work ten and a half hours a day, 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 about six hours each. Food preparation, sample logging, reports about each stop, etc., can be accomplished in two or three hours a day times six people.”

“And where will the solar power unit be, all this time?” asked Roger, skeptically.

"At a home base. You set it up, leave it, and let it make oxygen and methane for a week. You also set up the extraction tent and let it heat and repeatedly wet the regolith in order to extract water and oxygen from it. Then you send one ranger back with the trailer and portahab. It travels the 180 kilometers of new route in five or six hours and packs up the home base. The next morning it drives back to the other vehicles and they set up a new home base."

"That should work," said Érico, impressed.

"It's a plan cobbled together from various proposals," snorted Roger.

"It's true, the elements are published in different places," replied Will. "But I'm not proposing that we try it all from the beginning. Nor am I proposing we run all of this past mission control. Instead, I am proposing that we try different pieces of the plan at different times; we experiment and gradually develop a plan suited best 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 am assuming we will use the Sunwings. When the expedition reaches the first fifteen hundred kilometer mark, about eight weeks after it starts, Sunwings will fly down a half tonne of solar panels, a water tank, a methane tank, an oxygen tank, a small fuel cell and Sabatier reactor, and a few other basics. It'll take four flights. The crew will set up 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 reach the Outpost. So two vehicles could return for rotation purposes, then turn around and drive

back about ten days later, refueling as they went. But it would be even faster and easier if we can get the Sunwings 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 almost twenty hours. They could always land halfway in between at an oasis and walk around for a few hours. The Sunwing's cabin is big enough for standing and for sleeping, so it wouldn't be too bad."

Sebastian looked at Will respectfully. "This is a very intriguing idea. As you say, the elements are all published. But no one has put them all together."

"That's because no one has dared. They aren't here; they're not sure what's really feasible. The only way to find out is to try the different elements. The real key is the Sunwings. Now that we have three of them and two of them have flown flawlessly for two years, we know we can rely on them. The Sunwings actually could provide the expedition with all the methane and oxygen it needs; the expedition would need 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 the Sunwings."

"Sunwings 1 and 2 still 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 the new high-efficiency solar panels and therefore has thirty percent more power," added Paul. "It can haul more cargo, and at a higher speed."

"We'll have three functioning Sunwings in another month or so," agreed Sebastian. "Even if the expedition sets out tomorrow, it won't need a Sunwing flight for a few weeks." He looked at Roger. "So, what do you think?"

Roger hesitated. He looked at Will. "We should try some of 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 ideas should be tried, too."

"What I ask, remember, 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 and searching for fossils and maybe current life there. It also has to explore the canyonlands more or explore the southern highlands. If we can, we should try to reach some volcanics as well."

Roger laughed. "So, you want to drive up to Tharsis?"

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

Roger looked down, irritated by Will's lecturing.

"Okay, I get the picture," said Sebastian, and it was clear he was a little irritated as well. "I agree, Moonman; if the northern expedition reaches its goals, we've got to go either southward or westward. The geologists 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; there may be new data requiring changes in the route or the proposed stops. The rangers need routine maintenance, the conestoga needs breaking in, and there's a lot of packing to do. We need to decide who's

going and when we'll rotate whom back here. I'll get the geologists in Houston started on the route review and will put together the crew manifest and rotation schedule. 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 work on the supply manifests?"

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

The meeting began to break up. It was now 7:30 p.m.; getting late. 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 and were getting chilly anyway. 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. Sebastian doesn't strike me as someone enlightened about the role of women."

"I'm afraid not." She looked at him skeptically. "How long do you think you'll be away?"

"I don't know. If the Sunwing's working, maybe I can get back for a week every month. More likely, I'll be out two months, back two months, then out two months. We're not talking about four month rotations, like in earth orbit, or six month rotations, like on the moon."

"That's true. And I could go along on one of the two trips, too."

"We could have our own ranger."

"That might be interesting," Ethel considered. "I would enjoy more exploration. There are always interesting repair challenges."

“Good scenery, too.”

“Yes, though northern Chryse gets pretty flat and boring.” She shrugged. “I guess that’s the best we can do.”

# 4

## Chryse

early June, 2023

Four days 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 only took three hours; Columbus 1 had traveled westward quite a long way, but had cleared only a hundred-twenty kilometers of trail to the east.

They immediately took on the procedure Will had suggested, which was also the procedure recommended in one of the technical reports: 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 about the speed a man could walk. The Martian surface had very few gullies and generally consisted of rolling stone fields with scattered small dunes. The Sunwing had already photographed the potential routes at a resolution of ten centimeters and the photographs had been placed on a website, allowing a team of NASA scientists, using a program that digested the pictures and proposed a tentative route, to select a path that avoided boulders, small craters, dunes, and other obstacles. The lead ranger's passenger served as navigator, directing the driver to the right or left based on all the various proposals projected onto an aerial photograph on the screen in front of him. In an emergency a vehicle could drive as fast as sixty kilometers per hour on the trail they had already cleared, though the maximum design speed was forty. Once the trail was well

photographed and smoothed, vehicles could drive themselves under software control up to thirty kilometers per hour; slower than a human driver, but they could continue twenty-four hours a day.

They didn't stop for lunch; there was no need because each vehicle had two on board. Will had been driving, but he switched with Shinji and pulled out the sandwiches instead. At 2:15 they reached a kilometer-sized crater that had punched a hole in the sediments of Aurorae. They stopped long enough to drop off Roger, Will, and Érico; Carmen remained in the conestoga with them; Paul and Shinji continued clearing the route in the rangers.

The three men activated their helmet cameras so that anything they saw was broadcast back to the geologists on Earth, dictated descriptions of the scene around them, 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 ancient 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 on top; 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."

"Okay," said Will, reluctantly.

They started down. "So, Will, how many craters like this have you been in?" asked Roger.

"Oh, I don't know. Maybe fifteen or twenty on Mars and a dozen on the moon."

“I’ve been in about a dozen on the moon, also,” said Roger. “It’s possible to do more exploring here. On the moon, you can’t do anything two weeks every 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 the binoculars down in front of his eyes. He scanned the various layers exposed on the opposite side of the crater. “These are pretty standard strata. They’re basically the same as 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 was frozen solid most of the time. 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. In a few minutes they were able to recognize 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 all dictated descriptions of the deposit, then broke off pieces, looked closely, 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 shock 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. "Actually, this crater almost represents one of the ideal types. 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. Craters that punch much deeper than this 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.

Roger sounded a bit embarrassed. "Madhu wants a collection of particularly beautiful samples, and this is beautiful. 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. Sebastian’s too pragmatic, sometimes. But I think he’ll like what he sees once she has the materials to make something small.”

Will reached down 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 them in a pocket. A chemical analysis of them might be useful.

The three of them headed back up to the rim. Roger led them up the route Will had recommended, which seemed like a small concession to him.

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 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 and docked to the rear of the conestoga. Shinji released the trailer from his portahab and backed it up until it docked to the conestoga’s other airlock, next to the driver’s seat. Paul popped frozen dinners into the microwave and soon the six of them sat to eat.

“Well, we had a good day,” said Roger. “We cleared twenty-six kilometers of trail and explored a good geological site. And tomorrow we’ll have at least two more hours for bulldozing. So it appears we can follow the strategy Will suggested; thirty kilometers a day of cleared route and at least three hours of EVAs.”

“A few more days, 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, too.”

“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 supply holds up,” noted Will.

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

The conversation paused while everyone considered the hidden dangers of their effort. 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 as well. And she does ceramics; she hopes she gets the chance to make objects of Martian clay while she’s here.”

“And mosaics?”

“Probably she’ll try mosaics on the ground, outside, where there’s room. Between the greenhouses there’s a big strip of ground and it’s easy to see, so she might beautify one of those areas. Or maybe she’ll make a rock garden near the base of Face Rock. It’s too soon to say.”

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

“Me, too,” added Will. “I know where we saw various rock deposits and can help supply her with different colors, if she wants to make mosaics.”

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 hematites, silver and metallic 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 list 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 surprised and a bit defensive. “Well, there’s really nothing to tell.”

“You’re a geophysicist, I know, and you’ve spent time on the moon; where did you get your degree?” Will asked, oblivious of Érico’s reaction.

“The University of Fortaleza; it’s a major scientific and technical university in Brazil,” he replied, looking more relaxed. “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 her hand, but looked slightly embarrassed. “You may not know that Brazil now has the world’s eighth largest economy; we’ve surpassed the United Kingdom and our economic output is approaching that of Italy and France. So I think Brazil’s presence here is permanent.”

“Excellent,” said Will.

“This is what we need more of,” commented Roger. “If more countries made permanent commitments to send one or two astronauts here, or even three, this place would gradually expand.”

“I think Canada may make a commitment,” replied Paul. “It sounds like we’re about to make a permanent 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, but I can’t picture the place.”

“It’s a bit bigger than the Outpost, but more crowded,” replied Érico. “It has four habitats strung out along the crater rim, and generally there are eighteen people there. But it has only two greenhouses, and they’re buried to protect them against micrometeorites and solar radiation, with mirrors to reflect sunlight inside. We’re in better shape here, I think. They also have less plastic and chemical manufacturing equipment because there’s so little carbon in the volatile deposits.”

“I heard that the human waste on Columbus 1’s ITVs went to Shackleton,” said Will.

Carmen nodded vigorously. “The carbon and nitrogen, of course! They ship it up from the Earth orbit, too. The oxygen and hydrogen is used for fuel.”

“Exploration is also following a different strategy,” added Roger. “While they’ve finally cleared the Shackleton-Aristarchus Trail, it’s not used much because it takes four days to drive it; the round trip takes up more than half of the lunar dayspan. So most of the time expeditions set out by lunar hopper and arrive at their destination in about an hour. A pair of hoppers can deliver two conestogas and four crew, they explore for two weeks, then fly back to Shackleton for nightspan. The result is good coverage of the moon, but creation of very few permanent routes.”

“That’s changing, though,” disagreed Paul. “The Lunar Commission is planning to clear a route all the way around the lunar equator, and two more connections to Shackleton via the far side and Nectaris. That way automated fuel and supply vehicles

that can drive during nightspan can be positioned at the landing site when the hoppers arrive."

"I've heard about Lunar Route 1," agreed Will. "I wonder whether we'll build Mars Route 1 first?"

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

Will frowned. "Why do you say that? We explored thirty kilometers today, and we have solar power units to make our energy. Mars is 21,000 kilometers around the equator; at 30 per day, that's 700 days."

"But I doubt you think we'll clear the route in less than two years!"

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

"Maybe." Roger shrugged. "Of course, if our President continues to get his way, Columbus 3 will bring two nukes. 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 as well." He referred to "our President" deferentially, which made Will uncomfortable and Érico visibly irritated.

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

"So? We do need them! We can't use these SPUs 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 the 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 really *have* an environment.”

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

There was silence; no one dared get into a political argument in a small space, especially since it was clear that Érico was a left-winger, Will was on the liberal side as well, and Roger was conservative. Finally Shinji turned to Paul and changed the subject. “So, you plan to stay two cycles?”

Paul nodded. “I made the commitment. So has Monika. Are you planning to stay a third cycle?”

Shinji shrugged. “I don’t know. I doubt it.”

“I could be convinced,” said Érico.

“Really?” said Carmen, surprised. She sounded a bit worried.

Érico nodded. Will smiled. “The place grows on you. Ethel and I may stay longer, too. We like this assignment.”

“Really?” Roger was surprised. “I think I’ll like Mars, but I want to go back to the moon after this. It’ll bring a whole new perspective.”

“It will; but I’ve decided that my marriage is more important,” replied Will. “Here 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 a happy marriage at the same time.”

Roger looked at Will, surprised, then pointed a finger at him. “That’s the first time I’ve heard a good reason to stay here!” he exclaimed.

# 5

# Home

early to mid July, 2023

The Sunwing's passenger cabin was much smaller than Will had imagined. In order to minimize its wind resistance, it was extremely narrow, 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 could and often was piloted remotely. The seats were followed by a galley with a microwave oven, a tiny refrigerator chilled by Martian air, and a sink. Finally, there was a tiny bathroom, just an enclosed room with a plastic pot. For sleeping, the seats could be folded flat to form one bed and a hammock could be stretched along the cabin above. The 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, even primitive, but the cabin massed only one hundred kilos while accommodating up to two hundred kilograms of payload, including two passengers. Roger and Will climbed into the cabin in their pressure suits through the rear opening, then zipped up the opening and sealed it carefully. They pressurized the cabin. Then the Sunwing took off using jets of heated carbon dioxide gas while its propellers turned at maximum power.

Out the forward windows they watched the sunwing become airborne. In a few minutes they had climbed to several hundred meters, allowing Ethel, who was flying the plane remotely, to tell Roger and Will they could now 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 headed downward for the Outpost's landing area. In a few minutes it was on the ground and they disembarked, stiff from sitting too long.

Armando and Sebastian drove out to pick them up. 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 made of parachutes. 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. "And that's not easy in the tiny cabin."

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

Roger nodded; Will was staying at the Outpost for six weeks and would rejoin the expedition later.

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 hurried over and they kissed very warmly.

“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. The two of them sat together in their new “living room”; Roger and Madhu’s old bedroom.

“What a luxury, having this space of own,” said Will. “When did you finish Roger and Madhu’s new room?”

Ethel laughed. “Two days 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, you know; I made some paint last month.”

“Any color?”

“I can experiment; probably. We need some pictures on the walls. There’s still plenty of poster paper and colored ink, so we can get on the computer and select a picture or two to print out. I was thinking you and I can take some time off—three days—and set up this room special.”

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

She nodded. “The *Hadriaca*, I think. But I was scanning the web the other day 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 on a vacation day because Sebastian said no.”

“He did?”

She nodded. “He wants us to concentrate on science; that’s what will be remembered in the history books.”

“Oh, I don’t know. If we lay the groundwork for this place to expand faster, that’ll go down in the history books, too. How’s he been doing, here?”

Ethel shrugged. “Alright, I guess. He’s fastidious about details and his vision is focused on one thing: lots of science so that Columbus 2 will go down in history. He’s pleasant enough to talk to when he gives you the time.”

“That’s about the same as before. I saw the expanded Sunwing hanger.”

“That took a while. I suggested he and I expand it enough to accommodate a fourth Sunwing, in order to save time later; he said no. It would have added about a week of work, so I can’t blame him.”

“But it would have saved about ten days, I bet.”

"Yes. We also reinforced Habitats 2 and 3 so that the balcony levels could be used, and built an apartment for Roger and Madhu. Sebastian helped a lot; he's quite good at construction. All the supplies are now stowed and inventoried, and all the industrial equipment is set up and tested. Armando and Madhu have both new greenhouses set up, have transferred soil into them from the other two greenhouses, and have replaced the transferred soil with new reg, so we now have four functioning greenhouses with rather thin but heavily fertilized soil. They planted all four greenhouses, though Greenhouse 3 is mostly experimental plots. And Monika has been working twenty hours a day in the Mars Life Science Facility; Armando told me she had identified two more species of microorganisms and found one extremely well preserved cell that allowed her to conclude that Martian lifeforms were prokaryotic."

"No cell nucleus?"

"Right. How was the trip? I suppose the conestoga makes it much more comfortable."

"Oh, yes. It drives well and the systems work well. And the new bulldozer blades for the ranger are awesome; they push through rocks and reg like it's not there."

"Paul told me the repairs have been routine also. But they 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 us methane. The panels are a pain to set up, but they make the difference."

"I gather Roger was alright to deal with?"

"Yeh, we got along fine. It turns out he's keeping an eye out for natural materials that Madhu can use to make mosaics. If you help, he loves you. I think he's a bit embarrassed, since he stresses how scientific he is as a researcher. We've collected about a half tonne of stuff Madhu can use already, 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. Roger has been a pretty easy Commander to deal with. If you suggest a route we could follow, he takes us along a different route instead, but then leads everyone back along your route. He doesn't like to admit someone else might have a better idea, but if you're clever, you can work with that problem."

"Sebastian's more subtle and more stubborn," noted Ethel. "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. When Sebastian and Roger go back and Shinji flies back here, I suspect they'll bunk together in the portahab."

"Interesting! None of them are married?"

"No. Paul and Monika are divorced. I think we should do some match making. Paul and Monika are both 33; Érico's 29 and Carmen's 28. I think 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 the Outpost."

"I suspect all four of them are negative about marriage, though, 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 already thinking about staying a third cycle? I have been."

"Yes, I have, also. This is a great place."

"Once you get used to it, at least! I'm glad your relationship with Roger is working out. I was afraid that would ruin Mars for you."

"No, I think 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 this expedition collects. I suspect we'll have fifteen tonnes of samples in another year or so. The basements of the three Habitats will be strained to store them all; we've still got seven tonnes of samples from Columbus 1 in storage! 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 in case we want to pressurize the interior.”

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

“Of course! There are a dozen possible designs on the website. Theoretically, we already have the equipment here 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 Columbus 2 brought some sample doors and windows, and we have some spare life support equipment.”

“Fascinating. Maybe we should put together a proposal to submit to Sebastian and Mission Control.”

“I’d love to. And the next six weeks will be relatively quiet; we’ve completed a lot of the extensive set-up work. I’m scheduled to drive Prospectors six or eight hours a day, and something like this would give me a real break.”

‘Then let’s plan to make the proposal. We’re here six weeks before both of us fly north to join the expedition. We could do a lot of work in that time.”

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

“Sure.” Will was dressed, so he could go out. He rose and 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 up 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 the presence of isotopes in Martian samples to the part per billion range, there was much less need to haul samples back to Earth and a ten-fold increase in tests requested on Mars. It was actually a serious problem; if the Outpost were to continue expanding, a technical service staff was needed. Over a hundred samples were in the queue for either potassium-argon or rubidium-strontium age dating. Will would have to do many 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 to be tested, 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 was willing to be quite creative in making furniture for them. It almost made them late for supper.

"We stayed in bed until noon," said Roger, after hearing Will and Ethel had been working on their suite. It almost sounded like a boast. "Our two rooms are quite nice."

"I wish the rest of us had the space you couples have," noted Armando. "Though having the space of two bedrooms does help. I wonder where Sebastian is; the meal's getting cold."

As if he had summoned the Commander, the door suddenly opened and in walked Sebastian. He was looking cross. "How many toothpaste tubes 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 days ago," added Madhu.

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

"That's five. But 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,” added 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. After all, 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 they’d have none for a year. We need to be very careful with our supplies.”

“I’m sorry I sent the old ones down,” Armando said to Will. “But the toothpaste boxes are mixed together. They 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. 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. If we consult with Mission Control, they 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.”

“Fine. Ask Mission Control, then. I want to avoid throwing things way that can be useful. Earth’s a long way away; it’s not like we can run to the supermarket when we need supplies.”

“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 grow older,” replied Sebastian. “Use the old things now while they’re still okay; save the new things for later. If we do any doctoring, it’ll be minimal.”

“I suggest Armando and I look through everything from Columbus 1,” said Madhu. “He’s a physician and I’m a dietician. He can check the medications and I can 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 don’t want to,” 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 pick vegetables and such 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. They'll be a nice balance to all the wheat. 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 done something for a billion bucks that NASA has said for decades is impossible or incredibly expensive. They're embarrassed in front of the entire world. They'll deny the success as long as they can."

"They're probably angered that the technology for the Mars shuttle contributed significantly to his success, too," added Sebastian.

"Really?" said Madhu.

Will nodded. "The second stage is basically a Mars Shuttle scaled up fifty percent; it has the same dimensions, but uses liquid oxygen and hydrogen fuel."

"How cheap will this make launches?" asked Madhu.

“Once they have a cargo version, it’ll be able to haul only eight tonnes into orbit at a time, but at a cost of eight million bucks, so the cost is $1,000 per kilo. The passenger version hauls twelve passengers, and the tickets are slated at 1.5 million dollars per person.”

“And they’ve already got a one year waiting list, at a launch every three weeks,” added Ethel. “That’s about 200 private passengers and 300 million dollars in sales, and they’re staying in orbit only twelve hours.”

“It’s a matter of time before Swift builds a destination for them,” said Will. “A huge amount of work has gone into inflatable habitats. I suspect after about six months of bad press, NASA will relent and allow Swift to add to the International Space Station 2, or build near it. At that point tourists will go to orbit for three days.”

“What will Swift do for our cargo transportation?” asked Roger. “Right now the ion tugs are incredibly expensive. It’d be cheaper to use chemical rockets with hydrogen and oxygen hauled up by Swift.”

“NASA denies that, of course, and says the Swift shuttle ultimately won’t be cheaper. But lunar fuel is already undercutting the ion tugs, so they’re working on adapting the engines to use argon instead of xenon. The technology has matured.”

“Argon’s pennies per kilo instead of xenon’s seventeen million dollars per kilo,” added Ethel. “Too bad the cargo flights to Gateway will take nine months instead of six, though.”

“The argon takes more power,” conceded Will. “But the new solar arrays make more, and last longer.”

“Pressure will build to allow passengers from the Swift to transfer to flights to Shackleton,” she added.

“Well, tourists,” replied Will. “NASA says they can’t man-rate the craft and thus won’t use it for their own crew.”

“Tourists for the moon for about three million bucks?” exclaimed Sebastian, surprised.

“No; the estimate is that the ticket will be seven million, when you include cargo and accommodations,” replied Will. “But it’ll come down over the next decade as the technology matures and the ion tugs get cheaper. Shackleton and the transportation system won’t be able to accommodate any number of private passengers for at least another year. They have to add a habitat and expand the fuel making facilities because they’ll have to add at least two more flights per year. And there will be the issue of using the Swift shuttle to launch lunar cargo.”

“At a sixth the cost of the current system!” added Ethel.

“Twelve passengers per time? That’s a lot of tourists. And I suppose once they have a tourist habitat on the moon, they’ll want to keep it as full as possible, which means importing a few staff and hauling tourists there once or twice a month. That’s about 200 lunar tourists a year.” Sebastian shook his head in amazement.

“And billions of dollars in revenue! Just remember, if they can haul that many tourists to the moon per year, the cost will fall and the scientific staff will also expand,” said Will. “Eventually university profs of geology will be able to get grants to go to the moon for summer vacation and Sabbaticals. Nations that have promised to keep one or two astronauts on the moon per year will be able to pledge three or four instead.”

“It’ll be a long time before there are 200 tourists per year on the moon, though,” said Roger. “I have ambiguous feelings about it, Sebastian. There are now hotels in Antarctica and tourist service staff now outnumber the scientists.”

“I have ambiguous feelings, too,” agreed Will. “But I can see a lot of advantages. If NASA caves in and phases out expendable rockets in favor of the Swift, the cost of the Columbus missions could drop six fold. They say even Columbus 3 could be half as costly and Columbus 4 could be a quarter. The Swift first stage could launch one of our shuttles in place of a second stage, which would save a lot on launch and repair costs. That may mean this place will double in size.”

“And there won’t be any tourists here for a long time; the round trip isn’t practical,” added Sebastian. “I suppose that’s an advantage to us. Not only is this world bigger than the moon; it’s far more complex geologically, and now we know that it once had life. It deserves a large, serious commitment to exploration.”

“But couldn’t we be doing more to prepare for expansion?” asked Will. “The Outpost can be built up more. We can construct more water storage facilities, for example, and experiment with constructing pressurized buildings.”

“Maybe,” replied Sebastian, skeptically. “I think the best way to build up this place is to accomplish a lot scientifically. Scientific success will fuel expansion of staff. So the folks here have to be running the Prospectors. Even the staff on the expedition can do more with Prospectors; Paul has found he can run a Prospector several hours a day from the conestoga. Let’s explore, explore, explore.”

# 6

# Building

mid July, 2023

Will and Ethel watched the Sunwing jet into the air and climb into the pink morning sky. Then it banked northward and headed for the expedition, some 1,200 kilometers north of the outpost. Ethel automatically 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.”

“Probably. Sebastian said he might come back for a few days on one of the supply flights.”

“I bet he’ll get into the exploration and won’t bother. I’m still surprised he appointed you interim commander of the Outpost.”

“I was a bit 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. It’s silly.”

“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 weeks, followed by Monika. At some point Roger will be back, too.” Will turned to the Sunwing hanger, which was nearby. “Say, let’s go look at the hanger again. I want to think about construction options.”

“Sebastian did give a green light for an unpressurized geology building for sample storage,” agreed Ethel. “The hanger has used every technique imaginable.”

Will nodded and they turned toward the hanger, which was a scant sixty meters away. It had only one Sunwing in it at the time; they pulled back a flap of parachute material forming the roof and front wall to enter. Since the parachutes were a translucent white, it was bright inside the hanger; it was even twenty degrees Centigrade warmer than outside, which they soon noticed through their pressure suits. Will walked under the remaining Sunwing and reached the hanger's sixty-five meter long back wall; it was nearly as long as a football field. Representing a history of their construction efforts, the wall had taken months of intermittent work to complete.

At the end 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 that helped support the back wall, which was built of unmortared fieldstone. Will had done much of the stacking of the rocks himself; he had a knack for it. Fines had sifted into the cracks between the rocks and helped fill them up.

Ten meters of fieldstone 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 to hold them in place. But the blank white plastic wall was ugly.

Thirty meters of plastic was followed by ten meters of duricrete, made by mixing Martian dust with water and letting it set inside plastic forms. It had a bit more strength than plaster of Paris, partly because it had solidified and frozen at the same time; had it

been able to solidify without freezing it would have been stronger. The wall looked like concrete, but was orange-red-brown, just like the dust it was made of.

Finally, they turned the corner and walked along the twelve-meter side wall, which was made of real concrete. They had taken duricrust—the hard crust that forms on the Martian surface because of water percolating upward through the regolith—crushed it, washed the salts out of it, then roasted the remainder, dehydrating the calcium and iron sulfates. Then 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 of the wall. "Of everything we've tried, the duricrete is fastest and easiest. The engineers in Houston have proposed a mixing device that I think we can put together from items we have here. We'd start with a hopper, which we'd fill with dust, which would flow under gravity into a pipe in the bottom. Warmed Martian air and a spray of water would flow into the pipe, mix with the dust, and blow the mixture into a form, gradually filling it. The form would have to be airtight enough to build up some air pressure so the mix could set slowly, above the freezing point of water. The form would have to be reinforced with metal ribs."

Will nodded. "It sounds a little like a snow maker at a ski resort."

"Yes, it's similar. We have the compressors, the solar power units make plenty of heated Martian air, we have the piping, we can make plastic and metal forms, and we have something we can use as a hopper. The big problems, after we put the pieces together, are making sure the hopper stays full of dust and making sure the mix is right. Too much dust and it'll be too cold and dry; too warm and the water will vaporize. Too

much water is less of a problem. We'll have to open the form periodically to check how we're doing, too."

"Can we make walls for a pressurized building?"

"Will, we only have permission to build an open building."

"I know, but duricrete walls could be pretty thick, strong, and airtight."

"Yes, they could be. The walls of a pressurized building would be thicker and we'd have to spray them with a plastic coating to make them more airtight. A pressurized building probably should have heavier piles of regolith outside to counter the interior air pressure, and if the regolith pile were frozen hard it would be even better."

Will shrugged. "We've got plenty of water; hundreds of tonnes of it. That's not a problem. Could we make duricrete walls thick enough to hold in air pressure?"

"And get away with it?" Ethel considered. "No. A duricrete wall for a pressurized building should have iron reinforcing rods in it and should be thicker. But we could eliminate the reinforcing rods and build the walls thicker, and tell Houston that we're constructing something that later could be pressurized. Actually, I think we could justify some reinforcing rods for safety purposes. Let me talk to the construction experts in Houston; I don't need to run any of that past Sebastian."

"Okay. I'm willing to do my ordinary work at all sorts of odd hours in order to help. I really think we need to build a pressurized building. Mars will never expand if it has to import all pressurized space. We've got to learn how to build here."

"I agree. We know the rough size of the building, so you can start excavating the foundation with a buggy. That'll take three or four days. By then I'll have a better idea how to make the walls."

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The next three days were quite busy for Will and Ethel. Will ran the buggy—a small, one-person vehicle about the size of an all-terrain vehicle—with a little bulldozer blade every day 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. Meanwhile, 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 for as long as three hours autonomously, 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 day 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 day to make the materials while exchanging emails and voice mails with the construction experts in Houston. Among the dozens of designs available to her on the web was a design 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 covered by two meters of regolith. The weight of the reg overhead 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. An ice layer in the middle of the reg gave it concrete-like hardness. A spray-on plastic sealant would reduce the air leakage through the duricrete walls, which had a light network of reinforcing rebars. The rebars could be woven together in units inside the suit donning facility in standard atmosphere, which

could then be depressurized and the units could be hauled outside for installation; that simplified construction.

The morning of the fourth day of work, Will and Ethel awoke to find an email from Houston giving the complete plan; the web site's plan had been tentatively modified to fit their situation. 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 Houston, and they've recommended a design that we can accomplish in about eight weeks. We've either got all the equipment needed or can press into service some equipment designed for other purposes. The folks in Houston are already hard at work testing construction techniques for us."

Sebastian hesitated. "This was approved by Dr. Mann?" Rafael Mann was the head of the construction team.

"Yes, we've been in touch with him several times every sol about it."

"But this is for an unpressurized building?"

Will chose his words carefully. "Yes, but the building can be outfitted for pressurization as well. It's the design the team recommended." He didn't add that he and Ethel were the members of the construction "team" initially advocating the pressurization aspect. The folks in Houston had become keen on it as well; it was an important development for Mars settlement.

“I see. Well, I just hope you can do this and the regular duties we outlined before I left.”

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

Sebastian hesitated. “Okay, have it your way. I’m looking forward to seeing this so-called unpressurized building. 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. Sebastian seems to have 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 a few minutes later. The call had made them a bit 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. “Interesting news. Mission Control sent the final design for the Geology Storage Building during the night. They copied Sebastian as well.”

“And he said no?” asked Madhu.

“No; he asked whether it was a pressurized building and when we said yes, and that Houston was recommending 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, of course. The walls and roof are heavy enough to hold in air pressure; the key is piling regolith on them and building them so that they distribute the various forces adequately. Iron rebars inside sixty centimeters of duricrete will do it.”

“How much eolian dust will you have to move!” she asked.

“About two hundred fifty tonnes,” replied Ethel. “But we can do that in seven weeks at the rate of four tonnes per day. We’ll need to pile a lot more on the roof and against the walls; maybe two thousand tonnes. 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 about four years.”

“That’ll help a lot,” said Monika.

“Meanwhile, we can leave a large open area in the middle of the building where larger structures can be assembled,” added Ethel. “We can assemble things inside without a pressure suit, then depressurize the building and open the doors to carry the thing outside where it can be used. I really am very limited in the suit donning area.”

“I bet,” agreed Madhu. “So, I guess we can still 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 this will make a statement, at least to me. How can I help?”

“We could use a lot of help,” agreed Ethel. “The main way all of you can help is to structure your time inside so you can keep an eye on the plastic and metal making equipment while you’re doing other duties. 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 physically place them in the machines, turn the machines on, and afterwards turn the machines off and remove the samples.”

“That’s easy; I can do that,” said Armando. “I need to spend about two or three hours a day 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 down with the expedition for the last two weeks, I was amazed how tired and weak I felt at first. I’m not getting enough exercise.”

“Your bones are decalcifying as a result,” 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 a good reason to be outside walking around with a fifty-kilogram pressure suit weighing down my legs.”

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

“Then you can count on me for four hours a day. 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 day,” 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 in seven weeks.”

“I’m counting on it,” replied Will.

# 7

## A Contribution

early Sept., 2023

The five people at the Outpost put in a very dedicated and hard-working seven weeks. With Madhu and Monika helping with 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 logged over forty hours per week in their pressure suits and often worked half a day on Sunsol.

But 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 3 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 thin nickel-iron bars 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 two tonnes of water, and added heat 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 days. Hauling eight tonnes of eolian dust to the site took most of a day. Assembling everything inside the form took a day, and filling the form took a day. The first week, they barely poured a second section and felt very frustrated by the slowness of the work. Sebastian called to complain that nominal work was falling behind.

The second week, however, went better. Hauling the dust took one person—Will—so the pillars and rebar curtain manufacturing work could proceed simultaneously. Will could do most of the set-up work by himself as well. On those days, 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 days. The next week—working from Sunsol to Sunsol, so they had seven and a half days—they almost completed work on three sections.

Then the Sunwing returned to the Outpost with Paul; Sebastian had given him a two-week rest. By the next morning Monika had him recruited to assist. The fourth week saw them complete three sections more and almost a fourth as well. 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 as well, and half the metal sheets for the roof had been made.

Week seven was a race against time. Metal 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 metal

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 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 at least 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 2's airlock to the entrance of the Geology Storage Facility. Sebastian walked in with Will and Ethel following. He strolled slowly and looked around. Daylight poured in through four doorways, one in each wall, 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." He reached out and touched a pillar and 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 a bit like a bunker."

"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?"

“All of them?” asked Ethel. “Probably four weeks, maybe five. We have to make the metal supports, the metal nuts and bolts to hold everything together, and mold the plastic shelves. The shelves have to be pretty strong, too.”

“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, yet.”

“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. When you return from the expedition, you can build the shelves then.”

“We were hoping to have a few days 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 in this case 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 all got 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 put in.”

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

“Well, I suppose you were. But you still went against my order. So I’m docking both of you two weeks of vacation.”

The last words echoed over the earphones. Will and Ethel both looked at Sebastian, shocked. He shrugged. “Remember, I’m in charge of Columbus 2, not the construction consultants in Houston. Will, you were on the moon in the early days. NASA learned the hard way that the person in charge of a mission should be its Commander. Even the people in Houston work for him, not the other way around. Otherwise you have inefficiency on the moon or Mars, which is the place you can least afford it.”

“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 what you’re saying, but the job of inspiring the extra work is mine, not yours, Will.”

“Then maybe you should start,” replied Ethel.

Sebastian turned to her, angry. “I’d advise against insubordination.”

Ethel looked at him, angry, then turned away.

“Well, I guess the tour here is over. 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 long twelve to fourteen hour trip.”

“Okay. I assume you’re going in this airlock? Then Ethel and I will go in the other; it’s closer to Habitat 1.”

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

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They had a very unhappy evening. 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, by comparison; because Madhu had become a friend of Will and Ethel, 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 of vacation and ordered you to the expedition!” exclaimed Monika. “He can be crazy sometimes! 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 instead," 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 day left before flying north to the expedition, and it's our sol off, so we decided last night that we would dedicate it to completing the Geology Storage Facility."

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

"Why not?" asked Will. "It's Sunsol. This sol'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 of a project when you see it? 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. “I happen to love Mars, too, though. 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.” She turned to Ethel. “Roger and I will be out to help in about ninety minutes.”

“What?” said Sebastian, startled.

“You can count on me, too,” said Armando to Will.

Monika nodded. “Me, too. I’ll devote this sol to finishing the building. With six of us working, I think 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 this place’s future, something that will stand long after all of us leave Mars.”

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 cloud eastward away from most equipment. 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 warm water, it would make a smooth duricrete floor for the inside.

Then, to their surprise, another figure came out of the Outpost. It was Sebastian. They all stopped work to watch him approach. He switched to the common frequency everyone's radio was tuned to. "Look, I'm sorry," he began. "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. "Well, 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 day off."

# 8

## Castle Rock

early Sept., 2023

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

Will and Ethel looked out their windows and watched the progression of terrain. The sunwing had left the Outpost at dawn and, after a thirteen-hour flight, was closing on the landing area on the edge of Acidalia Planitia. The early spring sun was still in the sky, illuminating the area with its slanted rays.

"I'm ready to drop the food package," Ethel reported 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, who was 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, with this software. 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 mud flows formed when the wet ejecta had behaved like a slurry.

Will watched over her shoulder, fascinated, as Ethel flew the Sunwing southward a kilometer, dropping them lower to the ground, until she banked 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 hot $CO_2$ jets came on to cancel out their last hundred fifty kilometers per hour of horizontal velocity. When they touched down there barely a bump.

Ethel cut the power to the props and began to shut down the systems. Four figures in pressure suits were outside watching. She waved 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 won’t have time to catch up; 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, but my return flight will be all night,” 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, even if it’s only for two weeks. Y’all don’t discover something important in my absence, now!”

“We’ll try not to,” replied Will, jokingly. “I suppose we had better get our luggage and help out.”

He and Ethel reached inside and 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 dangerously close to full. It came off fairly easily and she hauled it to the ranger, where she had seen 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 to zip up the cabin and checked everything out for takeoff. They brought in with them their suitcases and 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 they could manage in an emergency. At zero, Sebastian activated the carbon dioxide jets and the sunwing rose vertically three meters, then began to accelerate diagonally as its propellers began to spin at maximum speed. In less than a minute the aircraft was flying.

"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 dehydrated tv dinners!" replied Érico.

The three vehicles approached each other. Ethel lined up her ranger with the conestoga's rear airlock and backed toward it, and in a few minutes managed a hard dock; then the other ranger approached the conestoga's north side and docked the 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 finally reported.

"Good." 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; at least 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.

"I've never heard this called Castle Station before," said Will.

"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; hence the name of the station," replied Érico.

"We've been here ten days," 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 here 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 through three hundred meters of sea bottom sediments, with no end in sight. We can only drill a hundred meters more. It's been fine-grained clay, mixed with occasional volcanic ash falls, crater ejecta, and boulders rafted in by icebergs. The clay has been two to four percent organic matter, with zillions of partially preserved microfossils."

"You must be in heaven."

"You can't imagine it!" she replied.

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

“Saturated,” replied Paul. “Nothing is dry, like in the equatorial regions. Castle Crater’s floor is pretty fresh; the crater is about five million years old. It’s mostly a block of permafrost. We’ve installed the water harvesting tent and we’re getting up to one hundred kilos of water a day.”

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

“No loss; we have plenty here!” replied Paul. “We’ve been using lower power settings on the recycling units and throwing the gray water away. And the farther north we go, the more water there will be lying around.”

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

“I was thinking we’d leave 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 are rotated 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 faster on the flat plain, I bet,” said Will.

Érico nodded. “There are very few rocks. We can push the route northward as much as fifty or sixty kilometers per day under these conditions.”

"Wow." Will thought a moment. "And from here we're three hundred or so kilometers from the southern edge of the winter cap, and two thousand kilometers from the edge of the permanent cap."

"The route is already extended to the area that gets snow in the winter; but of course there's no snow there now. If we can continue the pace of fifty klicks a day, it's another forty days to the permanent cap unless the dune fields slow us down significantly," agreed Érico. "This three-vehicle system for exploring has worked out very well. The machines have been reliable, the solar power has worked out well, the Sunwings can move us around 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. "And before we landed, we heated it up! The other pot has more of the same. We've got half of Mars's first rice harvest here."

"Martian rice?" asked Carmen, surprised.

"The paddy's beginning to be productive," said 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."

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The next morning Érico, Carmen, Will, and Ethel said goodbye to Paul and Monika and headed north on the route. Ethel and Carmen rode in the conestoga and took the lead;

Érico and Will followed behind. The route was smooth and clear and they drove along 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 a five-hour drive.

"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 was tens or 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, and the soft surface is peppered with rocks tossed here from meteor impacts, and half the area is blanketed with eolian deposits! It looks totally different."

"It is amazing. I think I much prefer the canyonlands and the rolling highlands, though. There's practically no geology to do here, except to stop at a crater and see what it punched through."

"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 what that means. I mean emotionally; he's always understood that intellectually, of course. I'm beginning to wonder whether he's thinking about staying an extra cycle."

"What did he say?"

"He was always saying that his two years on Mars would allow him to return to the moon and even the Earth and look at them in total different ways. That hasn't changed, but now maybe he's thinking that four years will give him even better perspective than two."

"Good! The more who stay, the better, as far as I'm concerned. Are you thinking about staying?"

"Yes, definitely. As I said at the Outpost, this place is growing on me. Are you leaving with Columbus 2?"

"I don't think so; Ethel and I are leaning toward two more years. What about Carmen?"

"She's thinking about staying. Which raises interesting questions about whether we should get married, since if we return to Earth, it will 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."

"That was our concern, too. You might be able to work together at ISS-2 or the moon, though. 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, I think. If Brazil had been able to send two astronauts to ISS-2 at the same time, we might have sent up a couple years ago. But Brazil only has 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."

"Yes, 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 want 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, too. It's just not clear what the point of actually getting married would be."

"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 ever have children; it is much better to raise them in a stable emotional environment, with both mom and dad around. So to me, marriage is not imposing 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 is 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. “You know, the Outpost could be a pretty pleasant place to live for quite a long time—say, a decade—in a few more years. What it needs is more people; say, 20 or 30 people. If half the arrivals stayed six years, the Outpost would have sixteen; if twelve came each time, it’d have twenty-four. And the cost of keeping the 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. How long would that take?” Érico calculated. “About a year. Not bad. But someone would have to spend a 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 fly eight here.”

“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 about this place. Sebastian has been very tolerant of our interacting 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. 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 to reach the end of the route. After eating they started bulldozing the route 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's definitely leaning toward another two years here."

"Érico told me the same thing. I think their attraction to each other has reinforced it, too; if they go back to Earth they'll have to choose between each other or their careers."

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

“He’s hesitant, though. I could see that. But 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 the future here. We both think it’s a good idea to educate the public more about Mars. We need to be more active about selling this place to our various nations.”

“I agree, and that’s something practical Sebastian would support. You should talk to him.”

“I will.”

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The next morning the four of them ate breakfast together. Just as they were finishing, they decided to call Sebastian together. Will set up an attaché—a combination computer and videophone—and they punched in Sebastian’s number. The communication and navigational satellite in orbit automatically relayed the call to the Outpost, and his attaché began to ring.

“Good sol,” he said, using the greeting that had become standard on Mars. 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, and we want to share it with you,” replied Will. “Érico and I were talking about it yesterday; he and I talked to Ethel and Carmen last night, and all four of us talked about it this morning. Here it is September 6$^{th}$; 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 play with. So it occurred to us that it is time to go on the media offensive and educate the public 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 stroked his chin, thinking. "I see your logic, and it makes sense. Of course, we should run this past NASA and the other agencies. But admittedly, by the time we did and they made a decision, it'd be conjunction already. And we do have some latitude in our access to the media."

"Some people will get mad at us for doing this," said Will. "Roger would have a better idea of who than anyone else here. We could also ask Laura Stillwell and David Alaoui for the reactions in Houston and Paris; they'll definitely know."

"Those are good ideas. You know, my suggestion would be to keep this low key. Érico can get away with more than the Americans and Europeans; so can Paul, as a Canadian, and his comments will be carried in the U.S. as well. Shinji already has pretty wide latitude speaking to the Japanese press."

"I may have more latitude as well," noted Ethel. "Because of my seniority here and because I haven't been commander."

"That's true. You could even be interviewed by British press with Will, too." Sebastian nodded. "I like the idea, I really do. The eleven people of Columbus 2 are doing at least twice as much as the six of Columbus 1. This place needs a decent number of personnel; twenty would be great, fifty would be even better. Otherwise, we'll never

explore this world decently. The new commercial shuttle will reduce launch costs five or six fold, and that reduces the cost of flying people and cargo here five or six fold as well. The agencies need to keep their financial commitment constant rather than their personnel commitment! So let's start out carefully, gradually, see how the first few go, then point out to our public information agencies how well these coincidental interviews went. How does that sound?"

"Great," replied Érico. "I'll arrange something informal with one of Brazil's big morning news and variety shows. I know the female anchor."

"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 look for something the week later. I agree that we need to do more to support expansion. Now, how's the exploring?"

"We cleared sixteen kilometers in half a day and had time to explore a crater," replied Érico. "Even with a ranger and a conestoga, we should do at least thirty klicks a day."

"There's not much to see, and not many rocks to move," agreed Sebastian. "Good. By the way, when Érico and Carmen rotate back here in two weeks, only Armando will come down. We can run the expedition with five, for a while. I'd really like to have 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, concerned. "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 for eight weeks, remember. And I plan to return in about six weeks. Roger will be back too, but I’m not sure when. The expedition will manage just fine with five.”

“Okay,” replied Will, concerned.

“Look, this whole plan was yours, and it has proved to be brilliant,” said Sebastian. “We’re staying in the northern polar region until just before conjunction; that’ll leave time to explore the layered terrains, the permanent ice, maybe do some drilling, etc. It’s going to be an incredible accomplishment and will go down in history. Then we’ll all be back here at the Outpost for a month or so at conjunction, and we’ll *all* take a nice vacation. Then we’ll have about seven months left and we’ll explore south and east, as you wish. Five people will be plenty.”

# 9

# Icefields

Oct. 15-Nov. 18, 2023

They dug into the steep slope with shovels through the equatorward-facing layers of wind-blown dust. It was one of the first polar layered deposits they had encountered, and places where the wind had eroded off the edges showed pronounced layering.

"If we only knew how old it was," 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 also suggest this deposit is a few hundred thousand years old."

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

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

"What's this?" he asked.

"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! Water on Mars! The first ice we've encountered here!" 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.

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

“The layer’s about seven centimeters thick,” reported Will, to the geological team on Earth that would be watching them 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 more gray-white than 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.”

“Clearly, the permanent cap is bigger than it appears from orbit,” replied Paul, examining the ice. “Say, it’s five p.m. Let’s take the ice inside so Monika can check for microorganisms. We can have some supper, then we can still come back out to explore if we want; 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 and a very pleasant discovery. 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 interrupted the surface and punched through the subsurface was there something of interest, and even that was largely the same each time. The dunes also made progress slow. The ice was exciting, by comparison.

"I'm much 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 as well," 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 much 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 day, and some navigational capacity, unless we get north of 85 or 86 degrees."

"Before we get that far north, 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 icefields there for life. We'll need to clear a landing circle there—it's the last one scheduled—and that'll take a few days. 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. 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 noticing 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-looking face appear on the screen of his attaché.

"Good day, Dr. Elliott. We remain deeply impressed by the expedition you are currently leading into 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 also furious that you arranged the interview yourself. 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; 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 another two years. 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 tours of duty. 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 is worrisome. So we would request that you and Ethel carefully 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; Érico and Carmen 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, even 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.”

“Indeed. His reasons didn’t make much sense to me. We’re healthy, and they can always study the long-term effects of the Martian environment after six years.”

“Seniority; that was an interesting comment. Columbus 2 was made rather complicated when the three of us who were already here were essentially demoted. 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 of talking to you, I’ve become convinced 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, wouldn’t you say?”

"Sometimes; she may have been a fairly good Christian, but she wasn't always as kind as she should be! No, I think more kindness is called for 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."

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The next morning, having calmed down and thought about the situation, Will was ready to respond to Lassen. 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 unplanned interview on the *Good Morning* show. If an opportunity like that arises outside the usual channels, I'll be sure to talk to public information 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 quite 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 the limits reached by some astronauts. Our medical treatment here has been excellent; the new MRI has enabled us to take semiannual body scans, which clearly indicate no precancerous or cancerous conditions developing. Furthermore, the testing that can be done here really 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 our typical days on this expedition—significantly reverse the decline. We've talked to the two physicians here on Mars many times and they are confident that with the equipment we now have here, 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 had to worry that his prolonged absence was indeed impairing the 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 edge to navigate and low cliffs to steer around, 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, in other places smothered with loose dust that threatened to bog down a vehicle. While Will drove the conestoga and Shinji drove a ranger, Monika and Paul followed 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 did not leave 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 Carmen drove, Paul often did the same between observations.

In midmorning they stopped long enough to rotate drivers and 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 they found a safe route to the top. Assisting them was a sunwing, which had flown overhead and photographed the entire area several days earlier. It was two hundred kilometers ahead of them photographing their future route.

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

"Good evening, Will," said Lassen, no doubt referring to the time in Houston. "As you might imagine, we're rather disappointed by your response. I hope you can 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 water at the surface, or at least near the surface. I understand Paul and Carmen found a nice, fairly intact chondritic meteorite about two hours ago; a 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 heated up a bit."

"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 actually dropped a bit 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 like a plausible dream. 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 next year. I can manage to run the MES until you can return. You would be a 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 sat, staring 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 an innocent; he has no idea how 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 does have a role to play 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 could do a good job."

Ethel nodded. "You know, she really could 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. 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. "Good. 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 dirty dishes before preparing supper. Ethel started to drive one ranger, while others drove the other ranger and the conestoga or handled other tasks. They also stopped for their afternoon three-hour exploration, which Will was scheduled to skip so that he could prepare 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. Clearly, the pressure was mounting. He told Ethel about it that night.

"I got a call from the assistant director of ESA, Claude Dubois," she added. "To his credit, though, he sounded extremely uncomfortable with the message he was relaying. So this is coming from NASA, and ESA may be a reluctant participant."

"Interesting. I explained the proposal to Kimball, you know, and she sent me another response later this afternoon indicating she was thinking very seriously about the idea. So we may have solved Clarke's problem!"

"That's a small victory, I guess. But I'm not sure what we'll do about this NASA thing."

"I know."

Just then, Will's attaché beeped; it was a local videophone call. He looked at the screen. "Sebastian." He pushed "connect." "Good evening, Sebastian."

"Good evening. Say, what's this issue about you and Ethel returning to Earth with Columbus 2? I got a very strange message this sol from Lassen, who almost never asks me to do anything, requesting me to urge you to accept their recommendation that you and Ethel not pursue a third term on Mars. Their reasoning made no sense."

"I got a call from Lassen last night, our time, asking us to return. He said it was for the sake of our health, for seniority reasons, and to avoid the problems of poor communication that can result over time when people no longer can actually see each other face to face."

Sebastian scowled. "That's what they said to me, too. I asked Armando about the radiation and medical research aspects and he was surprised."

"Sebastian, I received a call from Dubois this sol," added Ethel, stepping closer to the attaché so he could hear her better and see her. "He was very uncomfortable and asked me to consider returning to Earth as well."

"This is foolish. If people want to stay here for a while, let them! A replacement costs hundreds of millions to fly here. I hope they don't think they're saving money or something."

"And we're getting less radiation here than in low Earth orbit," added Will. "Do they think we want to come home and take a desk job?"

"They probably do," replied Ethel. "Sebastian, this sol Will got a call from Robert Clarke of the Mars Exploration Society, asking him to consider the position of President of MES."

“Really. That would sure help MES. Considering NASA’s rocky relationship with MES, I’m surprised they suggested it.”

“It was Lassen; and he is an old friend of Clarke,” replied Will. “Sebastian, maybe you’re the best person to end this foolishness.”

“By putting my foot down?”

“Exactly. I assume, Sebastian, you won’t sedate Ethel and I, tie us up, and throw us onto a shuttle?”

He laughed. “No, we won’t do that. Alright, I’ll call Lassen back and tell him to butt out and be thankful he has such hard-working, patient, and self-sacrificing employees. I think they don’t want to give you the Commandership of Columbus 3, Will.”

“I think that’s true; maybe the pressure is coming from the candidates for Commander or their bureaucratic friends.”

“Okay, I’ll take care of this. You all made forty-seven kilometers this sol?”

“Yes, we did very well. No interesting discoveries, though.”

“That can’t happen every day. Okay, good night.”

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They continued northward. The next day they began to suffer problems with the communications and navigational satellites, which were so close to the southern horizon that reception was degraded. The global positioning still worked, but intermittently; they had to reduce the amount of video they were sending and receiving, which meant less television at night. But once they moved a sunwing to a high altitude station a hundred kilometers south of them to serve as a relay, communications improved considerably.

Two days later, global positioning finally stopped altogether. The satellites, which were in an orbit just lower than Phobos, were now below the horizon permanently. The sunwing could still relay video, and they began to use their shortwave radios, which could 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, that Lassen has said to leave you alone.*

"But 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 now. 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 must be there right now. This email didn't come to us via Earth; it came straight from the moon."

"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 folks who are friends in Houston."

Ethel shook her head. "Cloak and dagger stuff isn't good, but I guess all organizations have it, sometimes. At least they haven't bothered us any more."

"Which suggests this message is real, and not bogus. We don't know."

"True."

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 day the going got harder; there was very thick dust to roll through and the air was filled with it, so visibility was poor. They were approaching the retreating edge of the seasonal cap, so winds were high. They stopped to set up another recharging station and found that the solar power unit could not produce much 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 to them. They regretted not having a portable wind turbine to augment their power.

They headed back south briefly for three hundred kilometers to a spot out of the wind belt to clear their last landing area. It allowed Roger and Sebastian to arrive and Paul and Monika to head back to the Outpost, making a two-hour stop at Castle Rock to fix a broken piece of equipment there. Armando and Érico flew down the next day and Shinji went home; the two men stopped at Chryse Station to reconnect a solar panel that had been left there 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 caught up to the retreating seasonal cap. They all went outside to look at the Martian 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 a cliff and rolled to its base. "Permanent ice on Mars! You just have to go to 79 degrees north to reach it!"

"We won't be hauling it to the equator any time soon," said Sebastian. "Who would have thought we'd get here. Our goal was to reach fifty north by the middle of next year. Here we are, six hundred fifty kilometers from the north pole."

"But that's another trip." Roger looked at the ice cliff. "The rest of the trip is blocked by hundreds of escarpments like this one."

"At least we have swung around the side of Borealis Chasma," noted Will.

"We'll drive east to its mouth, too," said Sebastian. "The sunwings show a short route up Borealis Chasma is possible. I wish we could get to the pole. But I guess that'll be the job of another expedition. We've got about eight days more to explore up here. Then we have to head back to the Outpost."

# 10

# Conference

late Nov. 2023

The six people in the three vehicles watched the rolling rockfields of Aurorae Chaos with rising excitement. They had just covered 5,400 kilometers—a bit more than the width of the United States from Maine to San Diego—in nine days. 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 at a gentle twenty-five kilometers per hour while everyone slept. Every day they stopped for at least three hours to explore or repair equipment; there were oases with solar panels, oxygen, methane, water, a landing circle, and a communications system at 25, 50, and 71 north that needed maintenance. The exploratory stops helped resolve some riddles at a few sites and tied up loose threads.

As they approached the Outpost, Will and Ethel were surprised to see two slowly turning wind turbines on top of Boat Rock. They were the first visible signs of habitation. A few minutes later the entire Outpost became visible on the northern slope at the base of Boat Rock, including the Geology Storage Facility, which appeared to have a thicker coating of reg over it than when they had left nine weeks earlier. The greenhouses were noticeably 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. Will and Ethel were a bit startled; they had no idea there was such depth of feeling between the two of them.

Érico and Carmen were welcoming Sebastian and Roger, who were stepping out of another airlock about six meters away. 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?”

“I’m not sure what to say,” replied Will. “Five thousand klicks is a long drive, so we’re rather tired. It’s a privilege to see that much of Mars, though it was a lot of magnificent desolation.”

“Well, 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. “That’s for another time, I guess.”

“This place has really developed!” exclaimed Will. “The wind turbines are really exciting to see!”

“We got them up last month,” said Érico. “They’re making only a few kilowatts, but they’re an interesting experiment. I hear you could’ve used them at seventy-six north!”

“Oh, yes! It was incredibly windy when we were there; the carbon dioxide cap was still sublimating and bulking up the atmosphere. The meteorology unit we left will soon tell us how windy it is all year round.”

“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, where they’ll stay frozen. 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 the last 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 looked at Madhu, who was walking by. “Good to see you.”

“Oh, thanks, Will. It’s good to see you, too. Did you enjoy the trip?”

“Yes, it was an incredible experience. We’ve totally blown away the Ganges Chasma expedition of Columbus 1. This is in an entirely different league.”

“And it’s the beginning of real planetary-scale exploration,” added Roger.

Ethel touched Madhu’s shoulder. “How are the greenhouses?”

“Oh, go look! You won’t recognize them. We finally got the salts washed from the soils and the nutrients in them are balanced. The soils have healthy microbiologies established in them and are getting richer all the time. The rice paddy is very productive now, too, which means lots of tilapia. And 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, where they had their personal possessions, grabbed them, then headed through Greenhouses 1 and 3 to their apartment.

Greenhouse 3 had the rice paddy and they were so startled by what they saw and felt around them that they stopped after closing the airtight door behind them. Warm, humid air hit their faces as soon as they entered; it felt like the tropics. The rice paddy filled five meters of the six meter width of the greenhouse; they had to squeeze past on the right side.

“I had just finished making the liner when we left,” said Ethel. She reached down and felt the heavy plastic sheets, which she and Madhu had meticulously glued together in late May to make a series of large tarps. The rice paddy was simply a square stone wall—Will had helped pack the stones together—almost a meter high, with tarps laid over it three thick, with fifteen centimeters of soil added on top of them. The water was only twenty centimeters deep, but that was enough for rice and fish to thrive. Ten meters long, the paddy could produce two hundred kilograms of rice a year and half that much fish.

The other half of the greenhouse was planted in fruits and vegetables. Pots made of Martian plastic placed along the edge of the rice paddy held four dwarf orange trees, two lemons, two limes, two mangos, and two date palms. None of the trees were mature enough to bear fruit, but they were growing fast. The rest of the greenhouse was divided into squares about two and a half meters across, each of which had hard plastic bottoms resting on top of rocks to keep them off the greenhouse's plastic floor, which was cold because of its contact with the subfreezing ground. The squares also had hard plastic sides holding in twenty centimeters of soil. Each had its own species; the eight of them had tomatoes, corn, cantaloupe, eggplants, peanuts, soybeans, lettuce, and cucumbers. The last meter of greenhouse before they passed into Greenhouse 1 had several tall, odiferous composting units and a pungent rabbit house.

Greenhouse 1 was equally lush, but less humid and tropical. They walked down the middle between the squares of potatoes (2), wheat (2), peas, beans, carrots, strawberries, herbs, rye, watermelon, lentils, more soybeans, spinach, broccoli, and cauliflower. Chicken and turkey coops lined the two ends, with grapevines growing up them and apple, peach, pear, and plum trees growing between them. Everything was growing with great vigor except the strawberries, which had finished bearing. After three months of soaking up sunshine, the strawberries would be hauled 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 artificial snow for six weeks, gradually warmed and given more sunlight, then brought to the greenhouse to bear again. That way two squares of strawberries could be rotated through the same spot

in the greenhouse, and they bore fruit two thirds of the year between them. Greenhouse 2 was staggered to bear fruit during the gaps.

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 as well; 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 day off?” Will said to Sebastian.

“Speak for yourself,” replied Érico from the sink, where he was running a potato peeler.

Sebastian nodded. “I didn’t say anything because it goes without saying. I’ve been thinking of declaring a week off for almost everyone, but I suppose we should work most of the next week; that’s all the time we have left until conjunction.”

“What sort of communication will we have with Earth?” asked Will.

“The ESA’s Cytheria 3 Venus orbital platform has better capacity than Cytheria 2 did during the last conjunction, but since they’re running a sunwing in the Venus atmosphere and it uses up a lot of bandwidth, we’ll be rather limited; the equivalent of one video channel. We can also relay audio and data via the Heliosat 4 solar observer unless it has to monitor a storm.”

“That’s about what we had during the last conjunction.”

“Well, you went on vacation. I figured that’s what we should do, too. But meanwhile, we need a nice, long staff meeting to evaluate what we’ve done and what we need to do.”

“Here, here,” said Roger. He and Madhu strode in and were in time to hear the last comment.

“I’d like to review our plans for the rest of the mission, up to blast off,” suggested Érico. “The nominal mission is almost accomplished.”

“There are plenty of extra accomplishments to consider,” said Sebastian. “I have an updated list from Mission Control.”

“I’d like to propose a slightly longer timeframe,” said Will. “Not just until blastoff, but until Columbus 3 arrives. Ethel and I will be here. Paul and Monika had pledged to stay before leaving Earth, so we know we’ll have four here. If we have any more, we may have a staff sufficient for exploration, and we’ll certainly have a staff sufficient for further work on the Outpost. It’d be wise to plan the next phase of Columbus 2 in the light of the phase that follows.”

Sebastian hesitated, then nodded. “That makes sense, especially after our subtle media campaign.”

“We’re definitely staying,” confirmed Érico.

“Good.” Will looked at Roger; he made no indication of his plans.

“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.”

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They had a truly grand time that night; the most energetic celebration Will had ever seen on Mars. Madhu orchestrated an artistic program that included a skit by three of them, a dance by her, and a singalong. There was even a spontaneous creation of a song by Will and Roger,

*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 11 p.m. everyone headed back to their rooms. Érico headed to Carmen's, where they often spent part of the night together. "I haven't had that much fun in a long time," he said to her.

"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."

He turned to her. "I love you very much also, Carmen." And 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 this before. I know about your sad childhood. But there are millions of happy marriages, you know. 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. But I 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 see it as 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 can resume this discussion tomorrow.”

“I hope so,” she replied. He headed out the door. She watched him go, feeling hurt.

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They gathered the next morning, as planned. Sebastian invited Mission Control to attend remotely, in spite of the time delay—a round trip between Earth and Mars at the speed of light took forty minutes—and in spite of the fact that 10 a.m. at the Outpost was 8 p.m. in

Houston. It seemed that every time they had something important to do that could not wait, the time was inconvenient on one planet or the other.

"Let me run through a rough agenda," Sebastian began, as they all settled onto couches and chairs moved into Habitat 3's Great Room. "First, we need to ascertain the human resources we'll have here from the launch of Columbus 2 back to space until the arrival of Columbus 3 nine months later. Second, we need to consider what we'll do from January 15, 2024—two weeks after conjunction, when our communications return to normal—until August 16, when trans-Earth injection is scheduled. Third, we'll quickly outline tasks for the mission extension, from August 16, 2024 until Columbus 3's arrival, scheduled for May 15, 2025. Fourth, we'll 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?"

Everyone nodded. Sebastian looked around. "Okay, who's staying? Let's start with our oldest residents: Will, Ethel, and Shinji."

Will nodded. "Ethel and I have decided to stay."

Sebastian turned to Shinji, who shook his head. "I'm planning to return to Earth on Columbus 2."

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 tentative commitment to stay, when NASA asked all of us for volunteers."

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; maybe another two years is all we need. I want to keep looking. We’ve identified ten probable species of microfossils. More importantly, we’re looking at an era in the evolution of life that has been completely erased by geological processes on Earth. This is eobiology: it’s a whole new field. This is some of the most exciting research of the century. I’m planning to stay.”

“Alright,” said Sebastian. “I’m planning to leave; I have a family that needs me on Earth. It’s not practical for me to stay any longer. 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 think what I want to do is stay two more years and marry Carmen.”

Carmen’s jaw dropped. Others expressed astonishment or surprise. “Marvelous; you are welcome,” said Will.

“We need you here,” echoed Ethel.

Carmen looked at him directly. “Do you mean that, Érico?”

“Of course I mean that. I stayed up all night thinking about it.”

She had been sitting on the next couch over; she rose and walked to him, and they hugged and kissed.

“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 rose and walked over to shake hands with both of them. Everyone else followed and business was suspended for several minutes. Everyone was very happy about the announcement; most knew Carmen wanted to marry him, but he had been holding out. 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 got up from the couch where Madhu and Érico were sitting to make room for Carmen. Sebastian turned to Madhu. “What are your plans?”

“Roger and I talked about the matter for about two hours last night. I have really enjoyed my horticultural and dietician’s work, and Roger has been 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. So 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 enough to carry out a substantial exploration and industrial schedule,” noted Will. “The nine months will be as vigorous a period as the eighteen months when Columbus crews are here!”

“This raises the issue of visiting Deimos, though,” exclaimed Sebastian. “We’re scheduled to spend six days there, doing routine maintenance on the fuel making facility and collecting samples.”

“I was thinking about that, because I’d like to see Deimos,” replied Roger. “There are four Mars shuttles here. Two could fly to Deimos, then rendezvous with the ITVs; then one could return here with those of us wishing to remain.”

“That’s possible. It’s 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. I guess the three of us will rattle around in two ITVs for six months.”

“It’ll give you plenty of living space,” replied Ethel.

“One problem I can see,” noted Shinji. “The Outpost will have eight crew, but no physician. But all of you 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 provide medicines. As long as no one needs an appendectomy, we’ll be okay.”

“Everyone get their teeth cleaned and checked before Shinji leaves,” suggested Roger.

“We’ll have to check the inventories carefully; we may have some shortages to anticipate and avoid,” said Sebastian. “Direct radio contact with earth ends in five days and resumes four weeks later. How will we spend seven months of 2024, before three of us head for Earth?”

There was a pause, then Érico spoke up. “I’d like to see us return to the north, at least for 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.”

There was silence for a moment. “It sounds good, but it has too many practical difficulties,” said Roger. “We’ve found that between the low sun angles and the dust, solar panels and solar power units don’t work well at all up there, and the conditions may continue to be too windy for sunwings to land north of 71 north. The autumnal equinox is mid February; conditions at the pole will be deteriorating by the time conjunction ends and by the time we reach the pole it’ll be sunset. Then remember that the pole has no communications or navigational signals. We’d have to guess on the pole’s location. Finally, the polar layered terrain is too rough for easy travel.”

“We headed north just before the summer solstice, in late spring, and used up the entire summer season reaching the polar region and exploring it,” noted Will. “That’s really not bad.”

“Maybe in another Martian year we can return,” suggested Roger.

“Okay, so 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 to see us 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. It’s pretty rough, with lots of landslide deposits and boulders in places. But there are places the Martian crust has been gashed open for six kilometers of depth, and since we’ll be traveling along the bottom of the wound, we can retrieve samples from the talis piles at the base of the escarpment from the entire exposure. The sunwings have already been photographing the canyon walls in detail and making laser reflection studies of the rock

composition. We also know of several major sedimentary deposits that probably have lots of microfossils."

'That's a good argument," agreed Roger. "The only modification I'd make is that I'm in favor of a penetration of the southern highlands as well, and clearing a route that will eventually reach the Martian South Pole. And once the autumnal equinox passes on February 10, we'll have about forty days before the dust storm season begins. I'd rather see us head south first, then return here if the dust storms break out."

"That might be wise," agreed Will. "In forty days we can penetrate about 1,200 kilometers, and with relatively little refueling we could return straight here on full tanks. It'd let us explore much of the Great Southern Waterway. If we pushed 2,000 kilometers southward, we'd follow it through the Argyre mountain ring, which has some of the planet's oldest crust, and onto the Argyre Basin, which had a sea and then glaciers. From here, we could make a similar trip eastward in spite of the dust storm."

"We could even try three or four shorter trips from here, including one to the east and one to the south," added Monika. "The chaotic terrains east of here need study; they have some ancient lake deposits and some recent channel deposits."

"Mission control recommends all three of those possible routes," agreed Sebastian. "I'm in favor of partial explorations along all three, also; during dust storm season you have to stick close to the Outpost."

"I agree," said Will. "If the sunwings can't take off or land, we have no emergency resupply capacity or emergency evacuation capacity."

"Ethel, how are the vehicles doing, anyway?" asked Sebastian.

“Not bad,” she replied. “We need to spend about two or three days doing routine maintenance on each of them, but they’ve come through the ordeal well. 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. “The motors we removed can be repaired, too. The fuel cells sometimes can, but we can always fix them up to supplement energy resources here, and shift the good fuel cells here to the rangers.”

“We should be able to reach Nirgal Vallis, at least. That means crossing the chaotic terrain south of here, the transition area, crossing through Holden Crater and its lake deposits, and making detours into the unmodified highlands. We still have no data on the cratered highlands, so a mission of that sort is very significant,” said Will.

“I agree,” said Roger. “That’s doable before the dust storms start.”

Sebastian looked around. “So, any objections?”

“Fine with me,” said Érico. The others nodded.

“Okay, we have an exploration plan to propose to Houston; head south as far as Nirgal, and maybe as far as Argyre; then head west toward Noctis Labyrinthis. What do we have to do around here?”

“We have an oxygen surplus problem,” said Madhu. “I hate to vent it into the atmosphere. The greenhouses are now very productive and they make a lot of oxygen. We need a tube to the well, so we can pump it underground. The estimates are that we can recover eighty percent of it.”

“Mixed with CO2, right? Useable for what?” asked Sebastian, skeptically.

“For heating. I can put only so much organic material into the soil. The rest we can store, and during a duststorm if we need extra heat, we can pull the oxygen out of the ground and burn the plant waste. The fact that the air coming out of the ground is 25% carbon dioxide won’t matter.”

“How ready are we for a big duststorm?” asked Armando.

“No problem,” replied Sebastian. “The wells penetrate several tens of thousands of tonnes of porous rock, and it’s been heated as high as one hundred twenty centigrade. We’ve been pumping hundreds of kilowatt-hours of heat into the rocks every day for two years and most of it can be pumped back out; plenty to keep the outpost warm for months. So I’m skeptical about pumping oxygen into the pores in order to burn ten or twenty tonnes of leaves and stems. I think we should do it as an oxygen reserve, though. As for electricity, we have four shuttles with 150 tonnes of oxygen and methane, and each tonne can make 4,000 kilowatt-hours of electricity and 1,000 kilowatt-hours of waste heat. We can run the Outpost on six hundred kilowatt-hours per day, so a tonne can run the Outpost about a week.”

“We have almost two years of emergency electricity, then,” said Armando, nodding.

“And we don’t yet have capacity for more than a tonne of oxygen underground,” pointed out Will. “Twenty cubic meters of rock has a mass of sixty tonnes and has about one cubic meter of pore space filled with ice. Heat the rock up and you can extract a tonne of vaporized ice, but the cubic meter of pore space can only hold about a kilogram of gaseous oxygen. We haven’t yet extracted a thousand tonnes of water from the ground.

Of course, the rocks have pore space that never had water in it, so we can probably store two tonnes of oxygen underground right now."

"But you're storing the oxygen under low pressure; we can compress it," noted Madhu.

"We need equipment from Earth to do that first," replied Ethel. "Will was assuming storage at a tenth of an atmosphere of pressure. With better compressors and sealing of the shaft, we could store the gas at ten times as much pressure; maybe twenty times as much."

"What I'd favor is construction of a water storage facility," suggested Will. "It doesn't have to be fancy; we can bulldoze a berm of reg in a square and cover it with plastic to suppress evaporation. We could extract the water from the ground and store it in a frozen pond. That frees up lots of pore space underground and would allow us to store more oxygen there."

"A second well a few hundred meters away could store methane," added Paul. "It'd take years to build up substantial underground storage, but it would cost nothing."

"Better to store ethylene than methane," replied Ethel. "We can pump liquid carbon dioxide into the ground first to cool the rock down somewhat, then pump liquid ethylene down. When it boils, we can reliquify the gas and pump it back down. We can store 800 kilos per cubic meter of pore space, which is much denser than gaseous methane."

"The Sabatiers can make ethylene fine, too," noted Paul.

"I have another idea," added Madhu. "If we make a pond, as long as it's capped by two meters of ice, it could have plankton and fish."

Sebastian raised his hand. “Hold on, we’re racing ahead. All these ideas are on the website, right?”

“Yes,” said Paul and Madhu almost simultaneously.

“Good; they’ve been studied. Routing oxygen underground can be done pretty easily, right?”

“A day or two of work for one person,” agreed Paul.

“And the berm?”

“Depending on its length and height, it would take a ranger with a bulldozer blade maybe a week,” said Will.

“What about plastic sheeting for a ceiling?”

“I can make it in a few days,” replied Ethel.

“Not a lot of time, then,” concluded Sebastian. “The drills are working fine, too. We should start that second set of shafts, where we can store ethylene some day.”

“That won’t take a lot of staff time,” said Will. “An hour every day or two. But the shafts will take six months.”

“We can get them started now,” said Sebastian. “This is the sort of work that can be started and stopped depending on other priorities. What else? Do we need to do more chemical, plastic, and metal work?”

“We’ve carried out most of the experiments,” replied Ethel. “We use the equipment when we have to make things for expanding the facilities here.”

“If there’s any expansion we need to complete, it’s the Geology Storage Facility,” said Will. “We need to manufacture and install the doors and see whether we can

pressurize it. If we can pressurize it with Martian air and if it holds the air adequately, then we can use 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 needs to be our priority during conjunction. What else?"

"We have to check the shuttles again," noted Ethel. "The rangers and the conestoga will take two person-weeks to maintain, including repair of parts we've removed."

"There's one other thing I'd like to devote time to," said Madhu. "I want to lay out a large rock design between the greenhouses. 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, partly. But I'd like to think that art is worthy of more than a volunteer effort."

"Hum." Sebastian considered. "Okay, we'll schedule it in as well. What else?" No one had other suggestions. "Alright, let's turn to the mission extension, if there's anything specific to say about it. I assume anything we're planning for the next eight months applies to the extension as well."

"One priority for the long term is 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 be able to find a route we can clear for the vehicles."

“And 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 set?”

Sebastian nodded. “The two reactors are being manufactured now. The rangers and the second conestoga will incorporate a lot of improvements based on our experience here, and the spare parts will improve the other vehicles as well. Columbus 3’s cargo will include another habitat and two more greenhouses.”

“I’d suggest they send four more greenhouses,” suggested Madhu. “We’ll have the crew to support them and the bigger crew will need more food.”

“They will have to rethink Columbus 3,” agreed Sebastian. “If there’s something I’d recommend to them, it’s that they send more younger persons. The eight people here will have seniority, and that means the newcomers have to stay and 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 entire plan for the Columbus missions, in fact.”

“We are moving things along much faster than expected,” agree Will.

“As you probably know, Columbus 3 is being actively reconsidered,” said Sebastian. “It looks like more nations want to send astronauts here than the ITVs can

accommodate. Twenty nations have now sent astronauts to the moon and they are ready for a new measure of international prestige." He looked at the others briefly, as if he were about to reveal a secret. "I was told last week that NASA has set a price for participating in Columbus 3: three hundred million per person."

"That's about half the cost of Columbus 1," noted Will, impressed.

"The possibility of finding life here 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

late Dec. 2023-early Jan. 2024

Will and Érico stopped their ranger by the new water supply reservoir on their way over to the Geology Storage Facility. Conjunction or not, the geologists were still doing some exploration; it just involved very short half-day and day trips. The two of them, Roger, and Paul had just spent the morning hiking 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. Roger and Paul were following in the other ranger, which was pulling a portahab.

The water supply didn't offer much to look at. They had taken a minimalist approach, building a dam across the bottom of a long gully-like depression near the well. 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. A sheet of plastic, supported by plastic poles every few meters, covered the reservoir and kept in the water vapor. Once they built up a block of ice next to the dam, three meters high and three wide, they'd add another plastic sheet upstream and build another parallel layer of ice. Under the accumulating ice they had laid a coil of plastic tubes. In about a year they'd have enough ice to run warm air through the coils and melt a pod of water underneath, which would allow them to pump water out easily and introduce plants and animals if they wanted to.

Will had been driving the ranger in his pressure suit. He stopped, opened the driver's side door—the interior had been unpressurized—and stepped out, followed by Érico. He lifted a door flap and walked under the plastic ceiling.

"Good; a steady trickle," he said.

"It's warm under the plastic; only minus twenty centigrade," noted Érico. "The water has actually warmed the place up."

"I still think we should have used the air and water under here as the heat exchanger. The steady flow of heat from the well would keep the water under 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."

"Yes, I agree, I guess. I've become rather skeptical about the idea that Mars still has indigenous life."

"Well, 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. That was the weakness of their system; 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 turned and headed out. "Let's just hope the suspense lasts a few more years," added Will. "The possibility of life is providing much of the publicity and more than half the funding for Mars exploration."

They stepped back into the ranger. Will slid into the driver's seat; Érico sat next to him. They headed toward the Geology Storage Facility, up the slope at the base of

Boat Rock. “You’re right about that. Brazil may actually commit to sending someone every cycle. My presence here has generated a lot of publicity and made the Brazilians feel proud of their country.”

“It sounds like quite a competition is heating up, actually. I never would have expected that the decision of eight of us to stay would have been 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, anyway, 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 supporting and encouraging interracial marriage.”

“Were your parents from different races?”

Will nodded. “My father is black and my mother, white. But it really wasn’t too difficult for me because in the Bahá'í community there were a few other families who had a similar mix, or were European-Persian or Persian-Latino.”

“My background is mixed as well; maybe you can tell from my skin color.”

“I guessed that was the case. I really know nothing about your childhood and upbringing.”

Érico smiled, a bit embarrassed. “I guess I can tell you the details. Carmen knows as well, 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 geology teacher I had in high school." Will applied the brakes. "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 make the building easy to see. Two of the four openings were blocked 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 over a common radio frequency at a very low power, so that when someone approached someone else, they knew. "How was the trip?"

"Good. We think we can 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. What I need you guys to do this afternoon is start on the third airlock. We've got the parts completed, and we assembled them quickly 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 days 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. Then putting together the first airlock took a long time. But now we know what we’re doing.”

“That’s true,” agreed Will. “We can spot weld all the big pieces by the end of the day, I’m sure.”

“All the little pieces were put together inside, where we didn’t have pressure suits to hinder us,” 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 in the sand, in the order of their use. Each one was carefully labeled as well, so there would be no confusing. The actual doors were already on their hinges and the valves that let air in and out had already been installed and tested. They did that work inside the manufacturing facility where they didn’t need pressure suits and 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 days earlier. After a few minutes of reviewing the parts and the procedures they followed, the announcement that lunch would be ready in twenty minutes came over the common radio frequency. They all headed to Habitat 3 for a chicken, vegetable, and potato soup. It was one of their first uses of native grown potatoes.

“Hey, everyone, there’s good news,” said Sebastian to the whole group, after they had eaten a few minutes. “This morning—afternoon, European time—the French announced that in addition to their continued support for the European Space Agency’s Mars commitment, they would make a commitment 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. “We’ve now accounted for nine berths. Right now, we can only fly eight people to Mars at once.”

“That’s changed as well,” replied Sebastian, smiling. “NASA has announced that it will add a third ITV to Columbus 3, the backup unit now reaching completion. Furthermore, they are willing to accommodate up to two additional crew on the two Mars shuttles. Columbus 3 will have at least twelve crew, 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 capacity of 24, though.”

“They must be counting on us to complete this pressurizable building, then,” said Ethel.

Sebastian nodded. “Absolutely true. If the automated cargo vehicle carrying Habitat 4 were to fail, we’d have 22 people here 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, after all."

"Iran and Indonesia might be possibilities as well," added Sebastian. "It'll be interesting to see."

"When are we going to get a Mars Commission, anyway?" asked Ethel. "NASA led the exploration of the moon for six years before bowing to international pressure and putting everything under an international body. It seems to me they need to abolish the Columbus missions 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 rather than a three-day flight between the two bodies at any time. 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.

# 12

## Emergency

early-mid Feb. 2024

Will used a small hammer to pound 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 inside 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 coat 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 2024 calendar on the nail. It was printed on the same electronic paper as the 2023 calendar had been; he had put the latter into their electronic paper printer to reset the pixels embedded in the paper.

It hung over his “desk,” a dark green plastic table with drawers in the sides. He wondered when he’d be able to sit at it without a partial pressure suit. So far the facility had been pressurized two weeks, but only with Martian air. The first few days 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, after all. 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, a paint with 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 a very convenient arrangement; it had already saved them time finding samples for analysis.

And now that the building was finished, he was leaving it; the next exploratory mission began the next day. He walked around the facility one more time, admiring all the work they had done. It had been very difficult to build. Then he headed outside.

He was about to go inside the outpost when he saw motion out of the corner of his eye. Madhu was working on her art. Will headed over to see it instead.

“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, either. It’s a lot of fun.”

“I bet. I’m glad we’ve got some art here, also.”

“It’s very important. I have a plan for the entire slope up here, with a sculpture garden and more mosaics.”

“What about between the greenhouses?”

“I’m working on it; I need a design first. People can’t walk between the greenhouses; it’s off limits. 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.”

“Well, I don’t think we’ll grow that fast! But I do wonder what this place will look like, a 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 see some of 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 take one’s life support unit off one’s back. Ten minutes later they walked into Habitat 3’s Great Room.

“I’m still not convinced we have to change it,” said Ethel, shaking her head. She was sitting at the table with Sebastian; they were pouring over a computer screen covered with 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’ve changed one on the moon. It was a Lifter, but the Lifters’ pumps and engines are just a small version of the Mars shuttles’. I’ll show you how to do it; a useful skill, since I’m leaving.”

“True.”

Will approached them. They looked up. “I guess it’s suppertime,” said Sebastian, surprised.

“You’re changing a fuel pump?” he asked.

Sebastian nodded. “In the *Hadriaca.* The readouts indicate there’s an electrical irregularity.”

“Didn’t I hear a faint alarm bell, an hour ago?” Alarm bells were broadcast over a common radio channel and often were picked up by people in pressure suits, if they were close to the Outpost.

Sebastian nodded. “Slow pressure loss in Greenhouse 3. Paul’s inspecting the outside for the leak right now.” Air leaks tended to leave a frost deposit around them, so were relatively easy to spot.

“Oh, there’s a bit of news,” Ethel said. “India has declared a desire to fill the fourteenth slot in Columbus 3’s crew. So 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. “And 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 that I never expected to miss. Skiing, too. I almost was tempted to try skiing when we were up 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 day to avoid cabin fever. But there’s always exploring. Is the expedition ready to go?”

Will nodded. “We packed this afternoon; everything’s in the vehicles except us and our personal belongings. We’ll be ready to roll after breakfast. Houston sent a revised route map this sol that extends all the way to Nirgal Vallis. Sunwing 2 is still photographing the area so that the route can be extended and supplemented.”

“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.”

“The Sunwings don’t do as well at the altitude of the highlands,” noted Sebastian. “They can carry only one passenger at a time, or no more than 200 kilos of cargo. Rescues will have to rely on a Mars Shuttle. We may want to use automated rovers to deliver supplies, too; they’re less affected by the weather.”

“I love the idea of your reaching Argyre, especially if you bring back the broken Prospector there,” said Ethel. “But three months is a long time, Will.”

“I know, dear. But it’s still less time than a tour of duty at ISS or Shackleton, and the dust storm season may make it shorter, anyway.”

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The next day Will, Shinji, Érico, Carmen, Roger, and Paul set out in pairs in the two rangers and the conestoga, respectively, heading south across Aurorae Chaos. The first day they followed an existing route they had cleared about a year earlier across the wide, flat valley and into the broken, chaotic southern borderlands of Aurorae. The next two weeks were the hardest ones they had ever experienced because the ground was so rough and difficult to cross. The bulldozer blades, already battered and repeatedly repaired, were badly damaged and required frequent welding to keep them working. One kilometer-long stretch of boulders took a day to pass through; Sunwings could identify individual rocks down to five centimeters in diameter, but had no way of knowing which rocks were bedrock or frozen in place and which were loose enough to push easily. That stretch had a lot of rough rock that simply could not be cleared, a serious obstacle for automated vehicles. Astronauts at the Outpost would have to take over and drive the unmanned vehicles through several spots in the chaotic terrain.

The biggest challenge was getting out of the chaos and up onto the highland terrain. Three days 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. But at the end they were on the rolling central highlands of Mars, ground formed over four billion years ago and battered into a bumpy mass of overlapping craters and sequential ejecta blankets, then eroded by snow, rain, wind, floods, and more meteors.

They spent three days exploring runoff arroyos formed by snowmelt just a few hundred thousand years earlier when Mars had had a steeper axial tilt, warmer poles, and a wetter climate. They found evaporite deposits and occasionally shale strata with microfossils, one only 1.5 billion years old; life on Mars had lasted longer than they had

previously thought. They hiked to the bottoms of craters to study the exposed layers in the crater walls and sample buried environments. They spent a week crossing Holton Crater, a huge ancient lakebed, and studied the sandy terraces left by waves pounding an ancient beach. They stopped one day a week to rest a bit, do their laundry, and repair broken equipment; there were constant maintenance problems with all machines, especially the two rangers, which were now older and in need of more care.

By mid February they reached the mouth of Nirgal Vallis, as hoped. It was the beginning of the dust storm season, but no storms were threatening them yet. They stopped to set up the solar power unit and clear a Sunwing landing circle, which took two days. Two Sunwings landed in close succession, bringing them water, fresh food, and spare parts, then departed with samples. Monika was anxious to get started with her study of the fossiliferous rocks.

They explored up Nirgal Vallis for a hundred kilometers or so, studying fresh gullying on the pole-facing slope—some of which still had buried residual snow from the last Martian high-tilt epoch—and identifying deposits that could help them date successive floods that had coursed down the canyon, which had cliffs up to a kilometer high and which was up to ten kilometers wide. Since there was no way to pass over the cliffs, they returned to Nirgal Station, then retraced their route northward for a dozen kilometers to investigate some low areas that had received sediment from Nirgal; it, too, would help them reconstruct the history of the feature. Then they returned to Nirgal Station to refuel; the solar power unit had made a fair amount of methane and oxygen fuel, and an automated rover drove up Route 2 from the Outpost with a tonne of

additional fuel and 500 kilos of solar panels. They now had enough to push on to Argyre Planitia and, with modest refueling by automated rover, 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 he did every night, then a bit before eleven he and Shinji headed to the portahab and turned out the lights to sleep.

At 4:15 a.m. the portahab's interior lights suddenly came on and the alarm began to blare loudly.

"What the hell?" said 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 definitely dropping, even though the computer would have activated an emergency cabin flood with life-saving oxygen. Without oxygen, one had about fifteen seconds of useful consciousness.

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, fortunately. Shinji opened the other hatch and they entered the conestoga.

Almost simultaneously, Roger and Érico had jumped out of their beds 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 suddenly given way,” 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. “That might have been a factor.”

The videophone light began to beep; it was an urgent call from the Outpost. Sebastian would have been wakened automatically by the computers. Roger reached over and pushed the activate button. “We’re here, Sebastian. We’ve had a catastrophic air leak in the portahab, but Will and Shinji got out just fine.”

“Is the situation under control?”

“No; the portahab’s still losing air, and pretty soon the water inside is going to start boiling.”

“I’m overriding the life support controls to pump in carbon dioxide from outside,” noted Paul.

“Look, first step is to suit up and go inside,” said Will. “We need to secure the inside 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, it could. 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, maybe a day of looking if we can’t find the leak.”

“And then what?” asked Shinji.

“Push on southward,” replied Will. “We’ll have trouble sleeping for a few days, no doubt. But 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. All of us have fallen over on EVAs. Paul fell two meters off a rock outcrop in Chryse. Two years ago I even cracked a helmet when a sample shattered under the blows of Laura’s rock hammer. 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 systems on suits partially failing as well. This is a dangerous job. That’s why we train. We’ll work our way through this one, too.”

“Yes, he’s right,” said Roger, reluctantly. “Let’s at least pretend to try to go back to sleep.”

“I agree,” said Will. He looked down at his right hand and noticed for the first time that it was shaking. It would be hours before the adrenaline was flushed from his system  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, 2024

After three days of extra stay at Nirgal Station, the expedition resumed its southward travels, but use of the portahab was restricted. Excessive dust buildup around the seals of the hatch leading to the cab had caused a seal to crack, which meant the hatch had to be specially sealed with a plastic coating and it could not be opened and closed until they reached the Outpost and overhauled it. Anyone driving the ranger that pulled the portahab could not enter it. They cleaned around the seals of all the doors to prevent the problem from recurring. And no one slept in the portahab at night for several weeks to make sure it held air.

At least the weather held. In three more weeks they found the Prospector that had finally broken down, after two years of exploration; they strapped it to the roof of the conestoga so that it could be repaired at the Outpost and reused. Ten days later—the end of March—they reached the northernmost edge of the floor of Argyre Planitia. They spent three days examining ancient seabed deposits, beach deposits, and subsequent eskers and other glacial features. Then, even though there was still no dust storm, they headed back to Aurorae.

In a week's time another expedition set out westward along the Mariner Valleys, much to Will's delight. After a month, he rotated home for a month, then he returned in late May for the last five weeks of further westward exploration. They had some very dusty days and some small dust storms, but no serious weather problems; global-scale storms were not annual events. While they didn't reach the end of the canyon, they

managed to explore most of the way. They returned to the Outpost loaded down with samples of all sorts, including intrusive deposits they had found exposed in the escarpments. Since careful study would tell what temperature and pressure conditions prevailed when the magmas cooled, the samples were high priority to return to Earth.

It was a dusty day when the expedition returned to the Outpost, for Marineris was subject to more dust and localized dust storms than most areas on Mars. The result was a very colorful sunset, more so than what was typical on Mars. 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; in Will's case, it was filled with 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. I'm afraid there won't be any more long explorations until after Columbus 2 leaves."

"That's alright; we've done enough exploring for a while!" replied Roger. In the last fourteen and a half months, he had been out almost the entire time.

"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?” She looked at him, surprised.

“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. 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 days. 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 then.”

Will shook his head. “No, don’t do that. It might be minor, or 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 flies home. And they really haven’t helped his stuffed up nose, either.” She kissed him. “You’re a sweet dear.”

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The next morning they went down to breakfast a bit later than usual. Most staff were taking the day off, since they had just returned from a long absence. Sebastian immediately spotted Ethel, though. “Can you meet with me in maybe 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 days from now.”

Ethel nodded. “Okay, but can we do it in two hours? I have a quick appointment with Shinji first.”

Sebastian debated. “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 day 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 seems crazy.”

“Well, you were away; but we got a lot done by video, and weddings are easier to plan here than on Earth. It has to be simpler.”

“Yes. Thank goodness you were already married here; we already have some of the things we need.”

“It’ll help.” Ethel didn’t mention all the spare wedding gifts that she and Will had received that they were now distributing to others to give to the couple.

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 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 and surprised 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 day! Well, I wasn’t taking them when Will was away, or not for two of the three months. But I started taking them again a month 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.”

“In retrospect, 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, but said nothing. He turned to Ethel, who said “I’m pregnant.”

“What?” he was incredulous.

“I’m pregnant; that’s why I was feeling tired and a bit nauseous in the 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 could all be comfortable and private.

The three of them walked from Habitat 2 to Habitat 1 through a greenhouse, and fortunately they didn’t encounter anyone. They went up the stairs and entered Will and

Ethel's living room; it had a couch for two that Ethel had made herself of metal and plastic covered with pillows of parachute material filled with soft foam plastic peanuts and covered with a blanket they had received as a wedding present. The two of them sat there. Shinji pulled up a chair.

"You said we had options. What are they?" Ethel was sounding more composed.

"Well, one option that 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 tonne or two 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 and landing 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 and could carry it out in a week or two. Most likely, you'd be able to resume duties in a day or two. 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 would be predicted, 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 than Mars, suggesting that this environment is closer to Earth. 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 rem or 2,500 millirem 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 roughly 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 oxygen and ethylene storage reservoirs, we have enough water to cover this habitat with ice. In a few years we could cover all of them with ice.”

“The design would allow a meter of ice,” said Ethel. “The ice shell could be made in such a way that it would support most of its own weight.”

Will looked at her. “But this is an awfully small place to raise a child.”

“Children are raised on houseboats that have 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, and you’d be carrying a baby or a toddler to the greenhouses or the other habitats anyway. 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 make simulated cows milk from soy already, 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 some 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 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? Do you want this child to become a medical experiment?”

“I suppose 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 inevitable, or caused by the radiation exposures both of you have already had.”

“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 shielding against flares, the radiation hazard would be managed adequately. Under those circumstances, a six year old could probably be accommodated.”

Will looked at Ethel. “So we’re talking about at least a decade, most likely.”

“And we may be here eighteen more 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 we know you won’t be the last. We have three married couples here.”

“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 won’t be a friend. If you keep the child, NASA will be baffled and angry.”

“As Érico once said to me, we Americans have never dealt with sex very well.”

“This may create more enemies than friends,” agreed Ethel. “Which is bizarre, since children should bring people together.”

Shinji shrugged. “Even an accidental pregnancy on Mars is a political act.”

“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 opened the door to 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!”

“Oh, 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 I think 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 married to a wonderful husband. 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 just doesn’t have the justification, I think.”

“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 day-to-day contribution. After four years here, we will 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 “Ten a.m. here. It’s about 11 a.m. in Scotland now, 6 a.m. in Connecticut, and 5 a.m. in Houston. 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—easy to do, they had them memorized—and recorded the videomail. Both houses were equipped with videophones and both subscribed to videomail service. The messages would probably be noticed quickly, too, but the round trip communications time between the two planets was about twenty-five minutes, so no answer was possible for some time.

They recorded a quick message, reviewing their options and their tentative decision to keep the baby, then sent the message. 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 get 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 day 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 your taking. And doing.” Sebastian looked at Will. “So 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 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 here 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 might 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, almost mumbling because it seemed unnecessary to mention. “Who knows?”

“We’ve taped a message to my mom and Ethel’s dad, but they haven’t replied yet.”

“This secret won’t keep very long. Too many microphones around the Outpost are live. 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, 2024

Will's mother called back first, in spite of the early hour; she rose fairly early, whereas Ethel's father was out on his daily walk and shopping trip. They were both surprised, supportive, and worried. That summarized Will and Ethel's feelings as well. Conversations by exchange of video messages continued on and off for two hours.

Will headed to the Great Room long enough to grab lunch for Ethel and himself, then retreat back to their cozy apartment, where they could eat without looking their friends in the eye. There was nothing to say yet. He nodded to Shinji, who seemed to understand what that meant. Sebastian made a few humorous remarks that were supportive; uncharacteristic, as he rarely showed his humor.

Having finished eating, Will began to draft an email to send to Mission Control. Ethel looked over his shoulder and they 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 too much or blaming someone else. Sebastian read it over and offered no comment except "send it."

Then half the afternoon was consumed by a rambling video meeting between Will, Ethel, Sebastian, Shinji, Harold Lassen (Director of Mars Mission Operations), Jerry McCord (capcom and commander of the future Columbus 3 flight), two assistant directors, and a public information officer. They felt drained when it finished, and it was suppertime. "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.

The four of them left Will and Ethel’s living room and headed for supper.

Everyone else had arrived and had started eating when they entered. The four of them had facial expressions that were immediately noticed by several people. “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, actually; 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 pregnant. We found out this morning and were in a state of shock and disbelief for quite some time. The whole experience still feels surreal, I might add. 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 the baby.”

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.

“One result of their decision to keep the baby: I will stay on Mars two more years,” added Shinji. “I want to make sure the mother and the baby are as healthy as possible.”

“What are the risks?” asked Carmen.

“It’s hard to say,” replied Shinji. “We really don’t know. Madhu, how do the rabbit babies do?”

“The vast majority are fine,” she replied. “Of course, statistically I’d say 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 lacking health care, or in an urban slum. But the chances aren’t as good as in the hospitals where your nieces and nephews are being born, either.”

That sunk in and they all pondered it. “This is a pretty small place for a child,” commented Madhu.

“Maybe NASA will enlarge it,” replied Will. “By the time the child is four, Columbus 5 will have arrived. 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 later Barbie dolls!”

“It’s cheaper than flying in a replacement crewmember,” replied Ethel.

“Do you really think you can do this?” asked Roger, skeptically.

Will looked at him. “Yes, we think we can. It’s a matter of faith, you might say. 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. “I think a child is just what this place might need. A bunch of adults living without children isn’t natural, either 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 a such.”

“I agree,” said Sebastian. “I’m commander here only for another month, but Shinji has put his finger on the situation. We can all argue about this 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 the Mars project any more. If anything, this will make Mars more attractive to the middle class families that make up most of America’s taxpayers. There’s nothing NASA can do about this development; certainly, 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’s happened, it can’t be reversed.”

“So, let’s make the most out 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; Roger as well. Finally, with some hesitation, Érico got up and hugged his two friends.

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Will and Ethel did not sleep well that night; there was too much to think about, sometimes 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, mostly 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—the settlement—of Mars. He didn't really know what to think of that and knew he'd just have to adjust. But he wished he knew the decision they had made 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 strange and hard to evaluate. 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 the stars and recited every Bahá'í prayer he had memorized, which took some time. 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 went to get her breakfast; she almost threw it up. Finally, feeling a bit better physically, 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 yesterday’s appointment, but we can talk any time.”

“Really? You’ve got media interviews this sol.”

“They start at two; 2-5 p.m.”

“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 that.”

“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. Yesterday it was all adrenaline and reason.”

“Not all; there were a few tears.”

“Yes, there were a few of them, too. But this sol, frankly, I’m feeling depressed. It’s a huge, wrenching change to my life. My career will never look the same and trying to make a place in my life for a new role. . . well, 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 day.”

“That might work. And I suspect we can arrange some other childcare help as well. Or maybe I should say that some other help can be arranged, since I won’t be here to do it.”

“I’m sure others will help.”

“Do you want to hear the strange rumors?”

“There are strange rumors?”

Sebastian smiled. “Well, of course. The *American Enquirer* has been publishing stories all along 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, though she was uncomfortable. “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. In that sense, we’re international celebrities, and we have to deal with the same pressures as movie stars. At least we’re isolated here.”

“Another reason to stay.”

She nodded. “Definitely. Well, what do you have?”

Sebastian turned to his desk and grabbed a three-page memo. “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 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 days.”

“They are predictable.” Ethel stood up. “Well, since I can’t be helpful here, I guess I’ll go back to our apartment to prepare 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 turned 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 leaned over and 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; clothes rarely worm around the Outpost. “What’s up?”

“Oh, not much. I’m just 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, though? 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, Érico. 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.”

“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 headed out of his room.

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The test of the *Hadriaca's* engines was scheduled for three days later in the afternoon, so that 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." The total amount of data

on the shuttle's systems accumulated at a rate faster than it could be transmitted to Earth even if the entire communications capacity of the Outpost was dedicated just to that task; so the data had been stored on the Outpost's computer for rebroadcast. Sebastian triggered that. 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, either."

"I agree," said Ethel. "This fix is beyond our capacities. Better to fly the shuttle unmanned to orbit on two engines. We could still use it to haul cargo to the interplanetary habitats."

"It can serve as an emergency vehicle for the flight home, too. The shuttle needs a heat shield for that, not all three engines. 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. We've got four shuttles here, so we'd still have a backup. It would be complicated, though."

“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 handling television interviews after three days. 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 feature 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, 2024

Madhu pulled Carmen's veil back a bit on her head. "Oh, you are such a beautiful bride!"

"Thank you." Carmen looked in the mirror, the only head to foot mirror in Habitat 2. "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. "We've *got* to pressure Mission Control to 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 investigate where the groom is."

"I'm hoping 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 Geo-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 the Great Room, which was set up for the ceremony; the reception would be in Habitat 3, where they usually ate. They had decorated the room very nicely; the couple would get married under a white arch covered with vegetation and woven with daisies, the only 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 go get him?"

"I think so. It's time."

"Okay." Armando through the airlock and into Greenhouse 1 on his way to Habitat 1, where the groom was dressing. Will, Sebastian, and Paul were there as well. Armando stuck his head in the open door. "It's time, I think."

"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. "My wife is divorcing me, and that will be finalized in another two months. If Monika can be convinced, maybe we will get married. 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. Mission Control seems convinced the problem with the *Hadriaca* is not systemic. We'll be flying a Deimos mission at the same time Armando and I fly to the ITVs. That way either manned shuttle can rescue the other. The *Hadriaca* will haul up Mars rocks and other samples—on two engines—then boost one ITV on trans-Earth injection. I don't see a problem."

"Well, don't worry, I'm not backing out," replied Érico. "I'm ready."

“That’s the spirit,” said Will.

Érico headed out the door and toward Greenhouse 1. The other men followed behind the groom, who 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 the habitat; through the geo-bio lab’s open door, the women saw and heard them arrive. Érico stood at the back, waiting for his bride to appear; the others sat. Shinji and Roger arrived from Habitat 3, where they had been busily preparing the meal.

Carmen came out of the Geo-bio lab, followed by the other women. The latter passed her and went to sit with their husbands. Érico smiled as Carmen approached him 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]

Plots, Columbus 2

The Latins speak to each other a lot in Spanish, so in retaliation some speak to each other in Russian, and it causes trouble

Brazilian and Roger get in a fight over the Olympics

Roger and Will are geology rivals

Sebastian cuts back on Mars build-up efforts in order to focus on expeditions and science

Ethel and Will work on a pressurized shelter secretly because Sebastian opposes the effort

Brazilian and Will are both mixed race and become friends

Debate on Earth about size of “permanent” Mars commitment

French decide to send three astronauts to Mars every cycle. They sent two to the moon as well. Other nations follow: Russian, 2; Canada, 1; Japan, 1; China (eventually), 2; Brazil, 1; India, 1; EU, 1. The ITVs must be expanded so that 16-20 can be sent per cycle.

Colonization Society raises the money to send one

Sebastian overcontrols inventory, but does not maintain it well. Ethel gets pregnant because of 4 year old birth control pills. Sebastian warns them to be careful, too!

Launch of private, inexpensive ($1,000/kg) shuttle. Tourist flights to ISS for $1,000,000 each.

## Mars Frontier, Volume 2: Summary



Three shuttles land with eight new personnel. One shuttle went to Phobos first. Will and Ethel meet Madhu for the first time. Roger is anxious to get outside and explore; Sebastian is anxious to follow the mission plan closely. 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, 2023



Habitat 3, a greenhouse, two solar power units, and a few other things are set up in three weeks. Ethel talks to Paul, who gives her control over the metal and plastic making facilities so he can concentrate on the Prospectors. But Shinji feels unneeded. 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, 2023



The automated cargo vehicles aerobrake into orbit and two shuttles flew up to pick up the cargo. They set up the rest of the Outpost. Then they met to plan their first expedition. Will agreed to 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, 2023



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, 2023

Will and Roger fly home after five weeks of exploring. Will will stay six weeks (it ends up being eight, however). 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 $1,000 per kilo. Tourism to LEO will boom; it is projected to start on the moon in a few years.
Date: early to mid July, 2023

6. Building 71

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, 2023

7. A Contribution 81

When Sebastian and Roger return, 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., 2023

8. Castle Rock 90

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 agrees to it. The expedition will continue until conjunction (in three and a half months).
Date: early Sept., 2023 (Sept. 6 at one point)

9. Icelands 106

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, 2023

10. Conference 124

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. 2023

11. Conjunction 146

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. 2023-early Jan. 2024

12. Emergency 154

Will and five others prepare to depart from the Outpost. In a month or so, they reach the mouth of Nirgal Vallis and explored up the valley, then continued 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. 2024

13. Surprise 165

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, 2024

14. Test 184

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 days later, Érico agrees to the wedding.
Date: early-mid July, 2024

15. Wedding 197-99
Érico and Carmen get married.
Date: about August 8, 2024