The Lunar Frontier

Vol. 1

The North Pole of the Moon

rstockman@usbnc.org

Table of Contents

1.

Launch

Saturday, 29 July, 2028

A big, silvery, pock-marked beauty.

And there was no one on it.

Will Elliott had stood, had stared at the moon, and had thought the same thing hundreds of times. Now he could add: *but soon it'll have people.*

He smiled, very pleased, excited, at the realization.

He stared at the gibbous moon another moment longer, then turned to his garbage bucket and pulled it down the driveway, in the smothering heat of an August evening in Houston. He left at the edge of the street and walked back up the driveway, noting the tall grass of his lawn in the moonlight, and stopped to look at the bright orb again. A reddish light near it caught his eye and he focused on it: Mars. *The red planet, vast and potent, and there was no one on it.* Perhaps he'd start looking at Mars and thinking that, some day. He turned back to the moon briefly.

"Will, what are you doing; moon gazing?" shouted Lurleen, his wife, from the garage door. "Come on, come inside."

"I'm coming." He turned back to the house. Once inside the garage, he pushed a button to talk to the house computer. Lurleen just liked to shout "housie!" but he generally preferred the intercom mode. "Could you mow the lawn tomorrow morning?"

"Yes, I'll schedule that," replied the house computer. "The weather forecast says partly cloudy, so the mower won't have enough sunlight to do the whole thing at once."

"That's okay, send it back inside for a battery recharge, then send it back out to finish the job."

“Alright. Will. I’ll do it.”

“Can you move the schedule up to once every five days? It’s been unusually rainy and the lawn is growing faster than usual.”

“Alright, I’ll adjust the schedule.”

“Thanks.” Will closed the intercom and walked into their living room. The wall screen was filled with the image of the Northstar 1 launch. Vapor trailed from the triplet of first stage boosters of the Thunderbird rocket and was highlighted by the reds of a setting New Mexico sun. He sat on the couch next to Lurleen, who was busy on her tablet computer and seemingly ignoring the countdown.

“So, do you think it’s used?”

“Huh? Oh, the Thunderbird? The first stages would be, but I don’t know about the second stage. They haven’t been able to reuse them very often.”

“And Swift is charging NASA for a new rocket, but giving them used ones?”

“Used Thunderbirds and used Polaris capsules. The NASA contact didn’t specify new or used and they knew Swift would recycle equipment. Swift’s launching stuff for $1,600 per kilogram and charging $3,000. He needs to make a profit to develop the Mars system.”

“That’s right, he’s a Mars fanatic.”

Will shrugged. “If it weren’t for Zeke Swift, we wouldn’t be going back to the moon. Congress would have shut down NASA if Swift hadn’t cobbled together a consortium of companies and governments to pay for it and if NASA had stuck to its multi-billion dollar plan to nowhere.”

“I’m not sure we should be going back to the moon.”

Will turned away and decided to ignore that comment. He was on the short list for the next flight, even though he had been in the astronaut corps only a year.

It was t-minus 60 seconds. They sat, silently, watching the countdown to zero.

The three first stages flamed alive at once. A plume of flame and smoke shot to the right side of the vehicle while all the engines rose an optimal burn. Then the vehicle was released and it began to rise rapidly into the sky. Will stood, causing Lurleen to scowl at him; he had to express his excitement somehow and he knew she would not appreciate any exclamations.

"Go, Kimball," she said with some appreciation, for she knew the commander, Heather Kimball, slightly, and had been immensely impressed by her.

"And Roger, and Sergei, and Pete, and Paulette, and Kenji," added Will, for he knew all six—two Americans, a Russian, a Canadian, a French woman, and a Japanese—fairly well, because he had trained with them.

"I wonder what Madhu thinks of Roger's flight," she wondered.

"Call her up and ask."

"No, not now."

At T-plus 90 seconds, the outer two boosters, drained of their fuel, fell away, and the central first stage continued firing. The long-distance telescopic cameras could only show a small dot; the image switched to a simulation complete with extensive data on the side. Lurleen turned back to her tablet.

The central first stage fell away and the second stage lit up. In less than ten minutes, they were in orbit. Will breathed a sigh of relief.

"The used equipment worked fine," said Lurleen.

"It did indeed, but you never know," said Will.

His smart phone vibrated with a message. He pulled it out as the wall screen switched back to the New Mexico spaceport, where the two side boosters were heading to landing pads so they could be checked out and refueled. It was a video message from his mother, Katherine Elliott. Her face flashed on the small screen; she was sixty years old, with silvered hair and enthusiasm in her voice. “Wasn’t that a great launch, Will? I’m sure you were watching. Your friends are on the way to the moon! What a great day this is. Fifty-five years and no one on the moon, but now we’re going back.”

Will rose from the couch and walked into the kitchen; he didn’t want to gush where Lurleen could listen disapprovingly. He hit reply. “Mom, I can’t begin to tell you how happy I am,” he began, surprised to hear himself choking up a bit. “This . . . this . . . is so momentous, and it’s permanent, not flags and footprints, not a short visit. It’s the difference between Palmer’s sighting of Antarctica in the early nineteenth century and South Pole Station; the moon will have inhabitants. Of course, it won’t have citizens or children; it may never have them, but who knows? It’s an important place, a fascinating place. It’s a piece of the puzzle for understanding ourselves; actually, it’s dozens of puzzle pieces. And I’m part of the team to find the pieces and figure out where they fit. It’s overwhelming.”

He hit send and immediately she beeped for a live exchange, so he activated it and her face appeared on the screen.

“You’re right, Will, and I’m so proud you’re part of it; that in a way, I’m a part of it. I suppose Lurleen is more worried about sharing you, about losing you. But I’m not because this is right. And she’ll understand eventually.”

"Thanks mom, I sure hope so." He felt a tear forming in one eye, but he wasn't sure whether it was in gratitude for her comments or in the hope they would prove true. "Where's dad?"

"At work; he had to go in tonight. But he's proud, too, even though he can't say it right now."

"I know he is. Well, I'd better get back to the launch, and my phone keeps vibrating; people are messaging me and tweeting about the launch and I need to say something."

"So, you're speaking at the Houston Bahá'í Center about exploration tomorrow morning?"

"That's the plan."

"Great. I'm glad you could fit that into your schedule. They'll love it, I'm sure."

"Thanks, mom. We'll talk tomorrow afternoon. Bye."

"Bye."

He closed the live circuit and walked back into the living room.

"How's your mom?" asked Lurleen.

"Fine, though I never asked, actually."

She nodded and he sensed disapproval, or perhaps a bit of jealousy. He turned to the messages. One was from Mission Control: *Can you come in tomorrow? Your proposal for an excursion to the impact melt exposure in Cernan Crater has been approved for late September, when the sun angle will be right, but we need to flesh out the details right away. We need to add plans for side trips to the rim of Borealis ZZ Crater and the floor of Armstrong FJ Crater. That'll strengthen the justification and offer significant scientific return.*

He looked at the screen. That meant no presentation at the Houston Bahá'í Center, and no Sunday afternoon at home with Lurleen. She'd be pretty unhappy.

He debated. *Okay, I'll be in by 9 am*, he texted back.

2.

Aldrin Pad 2

Wednesday, Aug. 2, 2028

Lurleen hurried into the house to get the phone, cursing that they had bothered to add a land line to the house computer. Almost no one ever called the house phone. She was a bit out of breath when she picked up the handset. “Hello?”

“Hello, Lurleen? This is Madhu; Madhu Anderson. How are you?”

“I’m fine, but I apologize I’m a bit out of breath. I just dashed in from the garage.”

“I’m sorry to call the house phone, but I didn’t have your cell. I want to invite you and Will over for a landing party tomorrow, noon to 3.”

“Oh, I’m sorry, but I’m at work all day on Thursday.”

“That’s too bad. This is so big; you sure you can’t take a long lunch and come over?”

“I . . . might be able to do that. Are you sure you want a house full of people for the landing? I mean, what if something goes wrong?”

“That’s the best time to have the house full of people, Lurleen! No, I need community. I’ve invited a bunch of friends from church as well as astronauts and spouses. Jane Page is coming, and Sarah McCord. Niki Theodoulos will be there; her husband Pete’s on board.”

“I haven’t met her.”

“She’s very nice; she’s one of Canada’s emerging experts on zero-gravity medicine, and she’s switching to low-gee medicine now that we’ll have crews in lunar gravity for three to six months at a time. She and I are trying to find a collaboration; I work on space food and nutrition, you know. In low atmospheric pressure and zero gravity, food tends to taste bland. But anyway, I thought you’d like to meet Niki; you’re in the medical profession, right?”

"Sort of; hospital administration. I doubt I can make it, but thanks so much for inviting me, Madhu. I appreciate it. I'm impressed you're so calm about this. I'd be scared to death about Will going to the moon."

"He's in line, too, isn't he?"

"Yes, he's among the final cut for Northstar 2 that goes up in February."

"That's what I thought. Say, let's get together for coffee some time; maybe Saturday when you're free?"

"Thanks, I'd like that very much. Will will be at work anyway! They texted him Saturday night about an expedition he proposed and he's been working thirteen hours a day every since."

"He's dedicated. That must be hard for you, but don't worry; it'll work out. Alright, Saturday at noon at the Moon River Cafe, assuming all is going well on the moon of course."

"Okay, that'd be great."

"Excellent. Please keep them in your prayers."

Lurleen didn't know what to say to that; she was agnostic. "I . . . will do that."

"Thank you Lurleen. Bye."

"Bye." Lurleen hung up the phone, wondering whether she should have said yes to the party. The problem was that she didn't fit into the two groups that would be there: the astronaut and space people, whose singular focus on exploration baffled her, and the evangelicals from Madhu's church, whose unscientific faith baffled her even more. But she wondered what made Madhu, an Indian American married to an Anglo from Oklahoma, tick. And maybe Madhu could help her with her own dilemmas.

Silvery, pockmarked, and incredibly close: Kimball had trouble taking her eyes off the finely textured, gray landscape rolling past the window of the lander. The shadows below were getting longer and longer as they approached the lunar south pole at an altitude of two hundred kilometers. There were teleoperated rovers, or TROVs, down there, and a small automated station with a solar power mast sticking up into semi-permanent sunlight on the rim of Shackleton crater, and a very small water processing facility with a water tank next to the solar mast. But they weren't heading there; they would land at the North Pole and its billions of tonnes of water in the permanently shadowed areas on the floors of craters. Half a world away.

"Thirty seconds to descent burn," reported Pete Theodoulos, the lander pilot. Three seconds later the cap-com at the Johnson Spaceflight Center in Houston replied, "copy that, you are go for deorbit burn."

"Here we go," added Kimball. She was commander, but since she wasn't the pilot and the computers did all the work anyway, she had no role. She moved her head slightly to look out another window of the lander, over to the left. She could just barely see "the Depot," a station in lunar polar orbit consisting of a docking node three meters in diameter with docking ports on five of its six cubical facets. The sixth facet sprouted a large solar power array capped by an ion engine to maintain the orbit against the perturbing influence of the moon's bumpy gravitational field. A Polaris capsule docked to one facet provided emergency accommodation and a redundant earth return vehicle; the Polaris that had brought them to the moon was docked opposite it. The Thunderbird-H third stage that had launched them from low earth orbit and braked them into lunar orbit was docked at a third port opposite another Thunderbird-H that had transported satellites to lunar orbit and had considerable spare propellant left. The docking node contained a fuel refrigeration and exchange system that would maintain the hydrogen in

cryogenic liquid form and would transfer part of the hydrogen and oxygen to the empty Thunderbird-H, so that either stage would be able to propel them back to Earth in either Polaris. Once they could convert lunar water into hydrogen and oxygen fuel, the Depot would always have lunar-made propellant for the return trip to Earth. Finishing the set-up of the propellant manufacturing system was one of their principal objectives.

"In ten," said Pete, snapping her back to reality. He began a countdown, and when he reached zero the lander's five engines awoke with a muffled roar. Weight returned, but it wasn't much; the acceleration was just half a gee. The six of them were sitting upright like airplane passengers, rather than reclining in couches.

In twenty seconds, the engine fell silent again. They all had watched the screen, which displayed their actual and intended position, velocity, and acceleration as two superimposed graphs; the green and red lines had been on top of each other the entire time, as desired.

"We're on our way down," said Pete. "Landing occurs in a bit over half an hour."

"Is everyone ready?" asked Kimball, looking at the others, who nodded one by one.

"An historic international mission," commented Kenji Takamasa. He was their cryogenics expert and an employee of the Swift Company, as well the Japanese representative on board.

"Five nationalities," agreed Kimball, a touch of ambivalence in her voice.

"No, six," replied Pete. "My parents were Greeks and I was actually born in Greece, so I have Greek citizenship, as well as Canadian."

"If you define 'nationality' broadly, you can add Kazakh and Jewish to Russian," added Sergei Alievitch Landsberg, their Russian pilot and fix-it expert.

"Oh, are you part Jewish?" asked Paulette. "So am I, and part Polish as well."

"So, we're up to nine nationalities!" said Kimball. "I suppose I shouldn't claim to be part English, part Scottish, part Scots-Irish, part German, and a bit of Italian. I'm sure Roger has a similar story where background is concerned."

"Space: the new ethnic salad bowl," agreed Pete.

"But back to your comment about historic, this mission is also very ambitious, considering how much trouble we've had with the equipment," added Paulette Lamarque, who was a robotics engineer. "The work is behind schedule even before we land!"

"It turns out, people have to be here to fix things," replied Sergei. "They underestimated the difficulty."

"Well, they underfunded the effort," growled Kimball. "Let's face it, Swift's budget was a tenth what NASA or ESA would have spent. That saved the tax payers tens of billions and got us back to the moon; it might not have happened for another decade otherwise. But it also means less research and development ahead of time."

"And more elbow grease," agreed Pete. "I don't know about you, but I'm glad to be providing the elbows. It's an incredible privilege to be on this flight."

"It is," agreed Paulette, to a unanimous set of nods.

"Can we have a moment of silence together?" asked Roger. "It seems appropriate."

"Alright," agreed Kimball, a bit reluctantly. Roger bowed his head and closed his eyes, praying silently to himself, *Dear Jesus, protect and preserve this crew, make our effort successful, bring us home safely, and help us to do all of this dedicated to you. Amen.* He moved one hand to a breast pocket where he had placed a tiny Bible.

The others didn't bow their heads or close their eyes; usually they looked out the window, for the magnificence of Tycho crater was rolling by underneath them at that moment.

Kimball felt distinctly uncomfortable by Roger's religion, yet he tended to bring it up periodically anyway. When he raised his head and opened his eyes, she felt relieved.

"We have to do this together, folks," she said. 'The world is watching and listening. A three month mission, extendable to as much as five months if we are comfortable with the longer stay and it is safe. A station to set up, humanity's first toehold on the moon. A propellant manufacturing and space transportation system to establish so that future missions are three times cheaper than ours. Detailed characterization of the frozen deposits in the permanently shadowed areas. Preliminary exploration of the immediate vicinity of the station. A chance to operate everything, and frankly, a chance to break it, because that's the only way to make it operate well. We have a lot on our plate."

"And all this is a prelude for Mars, unless we get killed," added Kenji.

They all nodded at that. Pete glanced at the chronometer. "Three more minutes, and the waste disposal area has to be closed and stowed."

"I'll wait until after landing," replied Paulette. "I prefer to pee in gravity!"

They laughed and turned to their own thoughts. Roger looked out the window again—they were coming up on the northern end of Mare Nubium—and he wondered how Madhu was holding up in their house with their friends. Paulette was thinking about all the people in France cheering her on and how her inclusion in Northstar 1 was an important patriotic achievement. Kenji wondered how many people were tuned in, because it was in the middle of the night in Tokyo. Sergei thought about his wife and two young children and hoped the landing would go well.

Down in Houston, Madhu Anderson and Niki Theodoulos were with a few other astronauts and some church friends, trying not to look nervous. In the Northstar Control Room—

in its own small building on the grounds of Johnson Spaceflight Center, but owned and operated by the Swift Company rather than by NASA—Zeke Swift sat watching everything from the back of the room with Dorinda Stetson, the Administrator of NASA. “Kimball gave a good summary of the mission to the crew,” Swift said. “Not only do they need a reminder every week or two, but the public needs to hear it.”

“But her criticism about the mission being underfunded was right, too,” replied Stetson. “As you know, we are reluctant partners.”

“You are indeed; but remember, because of this project, you beat the Chinese. And Pete was right; when you save money down here, you need more elbow grease up there. The life support systems are fine, the transportation system has been proved, but the tasks of taking cryogenic ice, excavating it without breaking the equipment, hauling it to a processing plant, and processing it on the moon in space conditions are daunting. We’ll figure them out over the next six months or a year. Maybe Northstar 2 will need one or two extra launches to get the hydrogen and oxygen propellant for moon landing and Earth return in place. Maybe not. The budget can accommodate it.”

“But can your Mars budget accommodate it?” she asked, with a smile.

Swift shrugged. “I have other aces up my sleeve. We’re going to Mars in seven years, Dorinda. Seven.”

She was startled by that prediction. “We’ll see whether NASA joins that effort.”

Swift smiled. “You can’t afford not to.”

“I suspect you’re right. How much is your estimate now?”

Swift paused to calculate. “We need another two or three billion. If NASA did it, you would have already spent sixty billion instead of two, and the remaining Mars effort would cost a hundred billion more.”

“Well, that’s one way to calculate it.”

“Dorinda, I mean no offense. You could have done just the equipment we’ll use for forty billion. But the lobbying to add this and that, include jobs in all fifty states if possible . . . that’s the problem. I love the idea of space jobs in all fifty states. Give me the hundred billion and you’ll have jobs in all fifty states, but you’ll also have human beings on Mars, Mercury, Venus orbit, Ceres, and heading for the Galilean moons of Jupiter.”

“Don’t underestimate my ability to focus NASA, Zeke. You’ve shaken up everything and we’re realigning. Wait and see what we can do, too.”

Swift smiled. “Good.”

Dorinda looked around the VIP area. Her aides looked startled by her comment. Just then Swift’s smart phone beeped with an incoming text from Mission Control regarding the TROVs, which were the property of Peary Resources, a separate company of which he was CEO. He read it and hit reply. “Tell them yes, whatever they want to do,” he replied. He glanced at Dorinda, who was distracted, and decided he wouldn’t tell her that NASA’s carefully choreographed landing would have a surprise.

A few seconds later, there was jubilation down in the TROV control area. “They said yes, folks!” exclaimed Will. “Landing’s in fifteen minutes, but we’ll have at least an hour after that to get in place. Let’s start planning our moves.”

“It’s actually not a lot of time to move five TROVs in a safe manner,” added David Alaoui, a French astronaut who had arrived just a month earlier for training.

"You're right," said Will, noticing the fellow for the first time, because he hadn't been running TROVs before. "But if we set them to avoid each other and we move at half a meter per second, it should be pretty simple."

"True," replied David. He turned to a TROV control station; Will headed for the station next to him. There were five TROVs and six operators present, but five of the six were astronauts, so they got priority.

The TROVs were parked in various places, all of which were protected from any blast if the lander crashed, but were close enough so they could rush in to see or help. His TROV—it was the one he used to explore the area most, a Prospector-450 series geological TROV—was parked not far from the "geology shed," an open structure with sample storage and ample equipment for sample analysis. It was two hundred meters from Aldrin Landing Pad 2, so he wheeled it around and headed down the road—they had packed down the regolith into a smooth surface and nuked it with microwaves to fuse it together—at a full meter per second. Alaoui was looking at the image in front of him—he had not yet put on his three-d helmet—and Will saw he was confused.

"You're next to the shelter, about three meters from the airlock."

"I know, but I thought I saw a United Nations flag here when I was controlling a Prospector three days ago."

"Ah—yes, it's on the other side of the airlock, I think. Swift's a real fan of the U.N."

"So am I."

Will looked at David a moment, surprised. "So am I," said Will, with a smile.

David took that as permission to go find the flag and grab it. He wheeled the TROV forward four meters and turned; sure enough, the flag was on a three-meter pole resting against

the side of the inflated shelter. He reached over carefully and picked up the pole in his left manipulator.

"There it is," said Rick Page, an astronaut the same age as Will and an expert on space vehicle repair. He was there to consult about repairing landers and thunderbirds on the moon, and had fallen into Will's plan quite readily. Will pointed his TROV's camera southward along the twenty degrees west longitude line and spotted the lander coming in fast, spouting a long, pale blue flame of burning hydrogen. He stopped moving the TROV to watch the landing.

The lander's engine had just come on, three and a half minutes before landing, to burn off 1,600 meters per second—about three thousand miles per hour—of velocity. One terrestrial gravity was a surprise to Kimball after five days of weightlessness. She looked out the window at the lengthening shadows of the moon's north polar region, then at the screen that displayed the image from the targeting camera. North Ridge was the battered rim of ancient Peary crater. Two younger craters, Whipple and Hinshelwood, were punched into its crest, thirty kilometers apart, with the North Pole located right between them. Whipple Crater, on the east end, was 16 kilometers in diameter, over 3 kilometers deep, and filled with volatiles. Its rim overlapped with Peary Crater's North Ridge to form Armstrong Plateau, and was in sunlight about ninety percent of the time. Armstrong Pinnacle was the highest point, stuck up into perpetual daylight, and had their main solar power arrays. As one moved westward along North Ridge it decreased in altitude away from Whipple until one reached Aldrin Saddle, a long, lower stretch of the ridge; it then rose again toward Hinshelwood, an old crater with some volatiles. Their facilities were on Armstrong Plateau. Two kilometers farther along the ridge, at the beginning of Aldrin Saddle, were a series of landing pads, including #2.

There was really nothing for any of them to do; even Pete, as pilot, just watched the computerized systems follow their programming. Northstar 1 began to throttle back on its engine power a minute before landing, as it approached its destination. It turned more and more vertical as it neared the pad; once it was fifty meters above it the engine throttled way back to allow the vehicle to descend. The exhaust flame kicked up a great cloud of dust and steam. Ten seconds later there was the slightest bump and the engine went off.

"Mission control, we have landed," reported Pete.

"Northstar 1 is on North Ridge," added Kimball.

"Congratulations, Northstar 1!" replied the capcom.

Mission control and the TROV control room erupted in cheers. Will jumped to his feet and began to slap the hands of everyone else in the room, including a startled David Alaoui. Up in the VIP area, Zeke Swift shook hands with Dorinda Stetston, then gave the NASA Administrator a startled hug. In her living room, Madhu Anderson emitted a little yelp of pleasure and relief. She looked at Niki Theodoulos and the two hugged, tears pooling in their eyes. Even Lurleen, in her office in the hospital, watched the landing on her tablet and sighed in relief. A complex, expensive mission had succeeded.

"Vodka!" exclaimed Sergei, in the lander. He pulled out a bottle.

"Where did you get that?" asked Kimball, startled.

"A secret stash."

She considered a moment. "Very small amounts until tonight in the shelter; we can't make any mistakes."

"Champagne?" exclaimed Rick Page almost at the same moment, in the TROV control room.

“Sure!” chorused Jerry McCord and Sebastian Langlais, American and German astronauts and geologists.

“No thanks,” replied David, who may have been French, but was also Muslim.

“Ah; I’ll pass,” replied Will, who as a Bahá'í shouldn’t drink alcohol. He wasn’t all that active as a Bahá'í—his research took all his time—but if the Muslim wasn’t going to drink, he decided he had better not, either.

“Suit yourself,” replied Rick with a smile, pulling out some plastic cups. Will took two and walked to the fountain to fill them with water, for David and himself.

“To human exploration of the moon!” exclaimed Rick, and the five of them clinked their plastic cups together in a toast. Then they turned to their TROVs. All of them had long treks to get to the pad, and they didn’t have much time.

The five astronauts inside the lander cabin downed their vodka quickly—Pete was too busy monitoring the automated shutdown of the propulsion system—slapped each other on the back, then started to suit up. A curtain across the capsule gave the women privacy from the men and vice versa. The moon suits were a thin, stretchable airtight material that clung to the skin tightly when an electric current was applied to it, which helped the skin itself retain the body’s internal pressure; turn off the electric power and over a few minutes the suit relaxed, allowing one to peel it off. A diaper accommodated a half day of urine; thin, highly absorptive long johns absorbed sweat and kept the suit clean, dry, and odor-free. Tough pants, a coat, boots, and gloves worn over the suit protected it from tears and scuffs. A collar connected to the helmet, which had a computer and communications built into it. A portable life support system backpack carried ten hours of oxygen, powerful batteries, and a heating/cooling system that connected to tiny tubes in the long johns.

In an emergency one could suit up in ten or fifteen minutes, but 45 to 60 was usual, and they took their time to get it right. All connections were checked three times; diagnostics were run to test everything. Ninety minutes after they touched down, they began to depressurize the lander cabin. Finally, Kimball was able to open the doorway-shaped hatch and step out onto a narrow "porch."

She turned to survey the breathtaking view that unrolled before her. Aldrin saddle was hundreds of meters above the surrounding moonscape and provided an impressive view, which was undimmed by atmospheric haze and thus was sharp to the horizon. The shadowed areas appeared black; the sun-illumined terrain was bright to the eye, though in fact it was no brighter than a freshly plowed field on Earth. Particularly striking was the lack of color; the moon was a gray world, the only color being small crystals that were invisible unless one's eyes were within centimeters of them. It was as if someone had dumped beach sand on a desert on earth; the contours were usually soft and rounded, though it was pocked by craters of every size.

She turned further to the right and was startled to see that the lunar ranger that had approached the pad to carry them to the shelter was flanked by all five TROVs, three on one side—one of which was holding a United Nations flag high, as if it were a flag of truce—and two on the other side. She smiled at that. "Who sent the TROVs to greet us?" she said, and in response, suddenly all five of them raised their right manipulators and bent then at the elbow to form a salute.

"Shit, who ordered that?" exclaimed Stetson in mission control, upset.

"The UN flag; that's a nice touch," responded Swift with a laugh.

"Nice touch? You just offended half the population of the United States!"

"This is not an exclusively U.S. mission, Madame Administrator," reminded Swift.

Kimball, meanwhile, started down the ladder; the porch was three meters above the ground. She leaped down the last half meter. “The human presence on the moon resumes,” she pronounced. “We come on behalf of all mankind, to develop this world for the benefit of we, the people.”

“At least she got in that reference to America,” muttered Stetson.

Kimball moved aside for Kenji Takamasa, the Swift Company’s employee, to descend next. Paulette Lamarque followed, because the European Space Agency had been the next largest contributor to the project. Sergei Landsberg and Pete Theodoulos followed, and Roger Anderson was last. All six were now down. They pulled out flags representing their nations—Kenji carried a Japanese flag and a banner representing the Swift Company—and they posed a moment for photos, into which David Alaoui managed to stick the United Nations flag by moving his TROV closer to Kenji. Then they stowed the flags so that they could raise them later.

Knowing Roger Anderson’s private email address, Will quickly emailed him: *Hey Roger, I’m controlling the TROV on the far left. There’s a crater over here, just fifteen meters across, but it has a patch of permanent ice on the floor; want to take a look?* He didn’t know Roger really well, but he suspected the only official geologist on the expedition would agree. Sure enough, a moment later Roger walked over.

Will used the manipulator to point to the crater. It was strange to see his friend just a meter away in three dimensional virtual reality, but with a three second time delay because of the distance. Roger looked at him and he could see a smile on his face through the gold-colored glass. Roger walked over to the crater and Will rolled along next to him, though he stopped at the rim; it would take too long to descend. Roger hopped right down, turned on his helmet headlamp, and pointed it at the frozen gasses. Vapor began to rise from the deposit as the lights

heated up the deposit. Roger picked up a small rock and used it as a scraper to obtain a sample, which he brought close to his helmet out of curiosity. Then he carried the stone with the scraped up snow back to the others so they could admire it before the sunlight evaporated it.

"The stuff we've come to harvest," said Kimball. "Right here just twenty meters from the landing pad. The precious water that we need to live here and build our interplanetary transportation system." She took the rock and held it up to her helmet camera, so that hundreds of millions would have a close up view.

After that, the six of them scattered to reconnoiter the area for a half an hour. The geology was hardly pristine; TROV wheel marks crisscrossed Aldrin Saddle and its sloping flanks. The whole area had been explored telerobotically over the last few years. Even so, the humans were anxious to get their moon legs and see the world they had yearned to visit for nearly half a century. It was a big, silvery, pock-marked beauty, and now it had people on it.

3.

A New Friend

After they walked around the landing site and got their moon legs, the Northstar 1 crew returned to the lander to retrieve their airtight garment bags, climbed into the ranger—a vehicle about the size of an SUV, with six large heavy tires and two manipulator arms in front—and drove two kilometers to the shelter, which had been partially set up robotically. They docked, entered through the circular hatch in the ranger's front, moved in their personal belongings, microwaved a big turkey dinner, set up some of their furniture and the bath areas, drank the rest of Sergei's vodka with their dinner, and went to their rooms to set them up and sleep.

The five TROVs followed them to the shelter, where the drivers plugged them into their recharge stations, then the drivers were finished for the day. As they prepared to leave the TROV control area, Dorinda Stetson came in, followed by a reluctant Zeke Swift. "That salute was a great idea," she said. "Whose was it?"

They all hesitated, then Will Elliott raised his hand. "Elliott; I should have known. Was the UN flag your idea, too?"

He hesitated. The others looked away. Then David Alaoui said, "No, that was my idea."

"But he looked at me as if he wanted permission," added Will. "I take some responsibility for that."

"You should see the news outlets and the social media. Everyone uses two sound bites: Kimball stepping onto the moon 'first woman walks on the moon,' and the TROVs saluting the six astronauts, U.N. flag in hand. The P.R. guys are apoplectic. The right wing media is going

crazy. The message is being drowned out." She pointed her finger at Will. "You've been here long enough; you should have known better. This had to be approved—"

"It was," interrupted Will, calmly. "We texted the owner of the TROVs."

Swift smiled slightly. "They did indeed, and I said they could do whatever they wanted."

Dorinda glared at Swift, shocked. Then she turned back to Will, fury undiminished. "Nevertheless, you are a NASA employee. You've been briefed about staying on message, using the talking points, and asking permission for anything that impacts the message. This had a huge, adverse impact on the message. You are docked a month's pay." She turned to David. "Dr. Alaoui, I suggest you keep in mind that NASA does have some say about whom its partners can nominate to serve on Northstar missions." She turned and walked out. Swift paused, decided not to say anything, shrugged, and walked out as well.

"Bitch," said Rick Page.

"Well, she has a point," replied Will.

"Thank you for taking some of the heat," said David to Will. "I should have known better."

"I should have known better, too, but don't worry about it. She's overreacting. Would you like some lunch? I'm starved."

"Lunch? It's 5:15 p.m.!"

"Well, it'll be lunch for me."

"Sure, but let me buy; she docked your pay, not mine."

"Okay." Will nodded at that. He was nervous that David presumably was a Muslim. He was a Bahá'í and Muslims sometimes had a prejudice against Bahá'ís; but he had a hunch David wouldn't mind, and he had no intention of bringing it up, anyway. David finished shutting down

his TROV station and the two of them headed out into Houston's tropical heat. The cafeteria was a short walk. "It's a lot hotter here than in Paris," observed Will. "Is that where you're living?"

"Yes, we have a house in Ris Orangis, a suburb southeast of Paris, but right now my wife is back in Fez, Morocco, with her family, while I'm here. It's a lot easier for her to deal with two small boys when there are grandparents and aunts around."

"Yes, that would help a lot. And your name is David? I guess Daoud is your Muslim name, though."

"You are correct, my name in Arabic is Daoud, but I rarely use it, even in Morocco. You see, my mother was a Christian French woman; my father was a Moroccan Muslim. They actually named me David. If I tell a Moroccan my name is Daoud, they assume I'm Jewish, because only Moroccan Jews use that name. And David is just easier in the west."

"Yes, I'm sure; anti-Muslim prejudice." Will shrugged. "But Daoud is a perfectly good name."

"It is. Some of my friends use it." He said it in such a way to suggest Will could use it, too. They entered the cafeteria. "And you're Will, not Bill?"

"I was Will to my parents and in grade school, I was Bill when I was a rebellious teenager, but when I started college I went back to Will. Only strangers call me Bill."

"I'll remember that." They got in line and loaded up with the "moon steak," which seemed to just be Salisbury steak, "harvest moon" macaroni, "lunar legumes," which seemed to be "California mix" vegetables, and for dessert, moon pies. "At least they don't have moonshine," quipped David, as he paid.

"They do this every week or so," replied Will.

They sat at a table. "How long have you been in the Astronaut Corps?"

"Almost a year; you?"

"Two years. Of course, in France there's only a half dozen of us. For less than a year, you're driving TROVs like an old hand!"

"I was a graduate student in Planetary Geology at Brown University; my Ph.D., awarded two years ago, was about volatile distribution in north polar craters based on their morphology, age, and latitude. We had a contract to use a Prospector-300 TROV and I drove it a lot to do the necessary 'field geology' for the dissertation. My dissertation was the first one based on TROV field work, in fact."

"I heard about it. My dissertation focused on the geochemistry of lunar highlands crust and differences between the front and back sides."

"I've read it," said Will, nodding.

"That's right; people call you 'Moonman' don't they?"

"I suppose because I spend too much time on lunar geology. It's a passion; my wife calls it 'my second wife,' unless she is calling herself 'the second wife,' anyway."

David smiled at that. "This is a hard profession to be in. If you want to fly, you're under enormous pressure to prove yourself worthy. It breaks up some marriages."

"I've seen it," agreed Will, nodding. "But I just *love* lunar geology."

"It is fascinating. You're a candidate for Northstar 2, aren't you?"

"I'm on the short list; they'll report the results in two weeks." Will took a bit of the steak, thought about the short list, and suddenly said, "And you're on the short list, too, aren't you!"

"I am," confirmed David. "I'm told I have a pretty good shot, too, because they've agreed to include two Europeans, and they need more geologists up there."

"They certainly do; this mission has only one. I suppose Northstar 2 will have one, also, but who knows."

"Well, I'm not a cutthroat sort of fellow; don't worry about that," said David. "I'm impressed that they'd include you on the short list, with less than a year in the Corps."

"Usually you don't fly for several years; but then, I'm the 'Moonman.' I guess the passion pays off."

"Well, good luck. I hope we both get to fly. I rather enjoyed the salute you arranged."

"That was fun. People treat TROVs like they're delicate things, but they're really pretty resilient, and now that people are up there, we don't have to worry about getting them stuck in loose material or tipping one over! The crew can fix them! So I thought the salute would be a nice touch."

"It was. Of course, an awful lot of things up there *are* broken."

"Sad, but true. Two TROVs are stuck in permanent shadow and have to be rescued. One solar mast is just half deployed. One experimental cryogenic processing unit is totally jammed. The Thunderbird-Hs in orbit need fuel. The shelter's interior is a shambles, there's no radiation protection in place, and the life support system has maintenance issues. Northstar-1 will be working their tails off cleaning up the mess."

"More geology left for Northstar-2!"

"That's for sure. But the potential is enormous, and we'll get there. Once we're making fuel on the moon, one ordinary Thunderbird will be enough to send a Northstar to the moon, rather than a Thunderbird Heavy. In a few years, the Earth-moon transportation system will be fully reusable and tourists will go to the moon for thirty or forty million each. Think of how much Peary Station can expand then! A dozen, two dozen, three dozen personnel, roads

southward to Mare Frigoris and Imbrium, landers able to hop to the equator for a two week expedition and back . . . pretty soon the Moon will be a permanent research site, just like Antarctica, with a dozen small stations and a hub, probably Peary, serving as the lunar McMurdo . . ."

"You *are* the Moonman."

"Well, I'm not inventing this. There are thousands of technical memoranda, research studies, and private proposals outlining this *ad nauseam*. The potential has been sitting and waiting for over a half century since Apollo. We know generally what to do on the moon, and now we have a way to get there. It's a question of political will."

"Ah yes, political will. We can be thankful Dr. Swift has brought the price down ten or twenty fold."

"Yes, but it would have come down eventually, and it has a long way to go, still. We're lucky to be born at the right time."

"I agree." David ate more of his meal. "Have you ever been to France?"

"Yes, a few times, include on my honeymoon two years ago. I've even been to Morocco; Casablanca, Rabat, and Marrakesh. I was fascinated."

David looked at him closely. "With the right clothes you could pass for a native, too."

Will smiled. "Thank you, I'd enjoy that! Yes, my dark skin doesn't quite look native French, though there are plenty of Frenchmen darker than me."

"Including my father, but you aren't always accepted. I can assure you of that."

"I'm sure." Will hesitated a moment. "You have a good eye. My father's African American, though fairly light skinned. My mother is half Scotch-Irish and half Mexican, born and raised in the USA, of course."

“So, you have the blood of three continents running in your veins.”

Will nodded. “I do. My mother must have some Indian blood, though she’s not sure. I’m the product of the so-called melting pot. That’s not always easy, either.”

“No. I see we are both minorities.”

“Indeed we are. How did your French mother meet your Moroccan father?”

“University. Her parents were very liberated and very liberal, or thought they were until she introduced them to my dad. They didn’t accept the marriage for six years. But by the time I was old enough to be aware of things like that, they were reconciled. They were good grandparents to me.” David looked at Will’s plate; they had both finished their food, but still had some soft drink in their glasses. He raised his. “To Northstar 2.”

Will smiled at that and raised his glass as well. “To Northstar 2.” They clinked glasses and drank. “I was a bit surprised Sergei had a bottle of vodka with him.”

“The Russians love it. When I was on ISS2 for three months, they had it there, but secretly. But at their Mir International Industrial Facility they didn’t hide it at all. I’ve never tried it.”

“Nor I.” Will considered his next sentence. “I don’t drink alcohol because I am a Bahá'í.”

“Oh really? I had a Bahá'í friend in my undergraduate years at the University of Strasbourg. Good people. I am grief-struck by what my fellow Muslims have done to Bahá'ís. The persecution is not right. As far as I am concerned, it is contradicted by the Qur’an’s call for everyone to respect the religion of others.”

“Thank you, I quite agree. I have always felt a bond with my Muslim friends; we share a lot of values in common.”

“I suppose that’s true,” agreed David, though less positively.

They rose from the table and bussed their trays. As they were stepping outside, Will said, "Do you need a ride anywhere?"

"To my hotel, though I can walk. It's not far."

"I'll drive you; it's on my way home, if it's the usual one where they put visitors."

"So I understand. Say, is there a good place around here to go jogging?"

"Just about anywhere; it's a pretty area, fairly wealthy. I usually go out very early, 6 a.m., before it gets hot. Do you want to come with me tomorrow?"

"Sure, that'd be great."

4.

Whipple Trail

Thursday, August 3, 2028

Heather Kimball didn't sleep well, their first night on the moon. There was a lot to do, as Commander, and she didn't want to make any mistakes; sad experience told her that as a woman, she would be judged more quickly than a man would be. She stayed up late reviewing task lists, sending dozens of queries to the planners in Houston, and tweaking daytime assignments to produce small improvements. She didn't turn to setting up her room until 1 a.m. Houston time, which was the time zone Peary Station would keep.

Yet she rose at 7 a.m. to make sure the automated systems were working to make the morning coffee. "The Shelter"—officially, Lunar Habitation Module 1—was an inflated cylinder 6 meters in diameter and 24 meters long, lying horizontally in a trench that the ranger had slowly and laboriously excavated under terrestrial control. The lower level, which had a curved floor and flat ceiling, had airlocks and areas to clean and don suits at each end; in between were storage, exercise, and TROV control areas. The top level, with a flat floor and curved ceiling, had two pairs of rooms on the left end, each 2.25 meters long and 3 meters wide, facing each other across a 1.5 meter wide corridor; a 6 by 6 meter common room with galley and stair well to the lower level; another set of four rooms; and a 6 by 6 meter science and health room, with another stair well. Kimball's quarters were in the left hand pod of rooms and served as her office as well. The room next to her was Sergei Landsberg's; across the hall was Paulette Lamarque's quarters. The fourth room was occupied by a bathroom and storage cabinets. Pete, Roger, and Kenji were in the other pod of rooms, which had its own bathroom and storage space. Each room

had its own window to the outside; the ones on Kimball's side of the shelter had a view of the Earth balanced perpetually on the southern horizon.

When she stepped into the common room, she found Sergei Landsberg talking to his wife and sons at the big table, so she walked to the other side of the commons to pour herself a coffee, put breakfast items in the microwaves, and pull out a few more items from storage. When he finished, she walked over. "How are Olga and the twins?" She sat and put down the coffee cup too quickly, spilling some. "Oh, damn!"

"The gravity takes some getting used to. At least we have some."

"I definitely prefer it over weightlessness," Kimball agreed. She walked to the kitchenette and grabbed a towel to mob up the spill. "I took a nice shower last night. What a relief."

"That must have been 2 a.m. I think I heard the water running."

"It wasn't quite that late." She nodded toward Sergei's tablet.

"Oh, Olga and the boys. The boys miss me, but being able to boast to the other kids at music camp that their dad is the first Russian on the moon is more important, for now. They can't wait for ninth grade to start. Olga's proud, but irritated by the 3.5 second time delay in our conversation. She joked I should call her back when we're at perigee."

Kimball smiled at that. "That'll save a bit more than a tenth of a second."

"She knows; as I think you know, she's a physicist. Maybe when the kids are at university, she can devise an experiment and we can come here together. I miss her."

"I bet."

"Where's your family, Kimball? Tennessee?"

Kimball nodded. "My parents are dead, but my brother's living in the house where we grew up, outside Knoxville. We talked last night."

"Talked, or texted?"

She shifted uncomfortably in her chair. "Texted; he was proud of me and I texted him back. He has a good life there, as an English professor. He's a good guy."

"I'm glad to hear it." Sergei looked at the commander and wondered again why she never let people call her Heather and why she had never married. She was enigmatically private.

"So, you got the daily assignment?" she asked. "I plan to send them out every evening, but we were so busy last night, I couldn't."

"If we could review the day over supper and consider tomorrow's assignments, that'd be even better; plenty of time to discuss assignments. I already have a counter offer for you."

"Oh? What?"

"I'd like to go down into Whipple with the ranger and try to retrieve the Prospector-450 stuck there. The manipulator arms should be able to pick it up or grab it enough so that we can tow it out of the permanent shade. I just checked; its computer still responds to commands. It even moved its right arm for me."

"That's a long way. Whipple's deep!"

"But the Prospector's only half way to the bottom. About ten kilometers from here, and the trail is well established. I think I can do it in two hours, and we may be able to bring back some volatiles. We don't have that much water to put in the radiation envelope."

"That's true. I'd like to get us up to at least 24 tonnes of water in a month; that'd give us ten centimeters of shielding, enough to protect us from solar flares quite well."

"We need to get the radiation shield's thickness up to a meter; that's 240 tonnes of water. We can do that at 24 tonnes a month, but the sooner we start, the better. That still leaves four of you to work on shelter set up."

"True, but Kenji wants to tackle the broken electrolysis unit, Roger wants to get started on geology right away, and I want to double the height of the solar mast on Armstrong Pinnacle so we have more power."

"And Paulette wants to fix the Prospector, so we have six TROVs. If she comes with me, we can be done in two hours. She'll be able to turn to the TROV right away and I'll do some extra work tonight inside, if you want. I don't mind."

Kimball scowled. "Well, we can be flexible; it's our mission. And the ranger should go down to Whipple to get some of the volatiles there, to put through our system. We want to see whether we can recover some of the colder fractions."

"Sure, we can try that."

"Okay, let's do it."

"Great."

Kimball and Sergei walked back into the galley to bring the breakfast items to the table. Before they finished, the other four arrived from their rooms and helped set the table. Sergei told Paulette about the ranger ride.

"That'd be great," she said. "The sooner we fix that TROV, the sooner the Houston team can use it to help us."

"I'm jealous," said Roger. "I can't wait to get out and see the area."

"We have about four days of heavy set-up work," said Kimball. "That's today through Sunday. But if we get a fair amount done by Saturday evening, we might be able to take Sunday off completely. That'd be a good time for a pleasure trip."

"We don't need the TROV that badly," said Pete. "And the Houston staff can drive the ranger into Whipple to get ice while we sleep; we don't need to do it. Have they tried to pull the TROV out?"

"Repeatedly," replied Paulette. "I suspect an EVA will be necessary, Sergei."

"Okay, I can do that. It won't take long to get the Prospector onto a trailer."

"I was also counting on the ranger for part of this morning to move the water tanker over to the shelter," added Pete. "We have ten tonnes of water in storage; that's enough to shield most of the sunward side of the shelter with a layer of water 10 centimeters deep, which is pretty substantial shielding against solar radiation, and useful against cosmic radiation."

"We can do that first," said Sergei.

"Alright," agreed Pete, though he sounded disappointed he couldn't stop the excursion.

Kimball pulled out her communicator and reviewed work assignments for the day, adjusting Sergei's and Paulette's appropriately. They agreed to review work assignments together briefly at every breakfast and supper, then chatted about family reactions to their safe landing. It had gotten excellent media coverage and was the headline item in most news programs worldwide.

Finished with breakfast, Sergei and Paulette headed to the north airlock, to which the ranger was docked, while Pete headed to the south airlock to suit up. The ranger was their only large surface vehicle for people. It was 2.5 meters long, wide, and high, with a low circular hatch in front under the windshields and a tall doorway-sized airlock a meter wide in the rear on the "passenger" side. The vehicle could be docked to another vehicle or shelter via either. Three bucket seats half a meter wide on the "drivers" side of the ranger could be moved all the way forward or backward to create open floor space or could be laid flat to form beds, separated by

curtains. The middle seat could be raised to the height of a table so that the other two seats, laid flat, could serve as benches. Bins in the high ceiling provided ample storage space and some radiation shielding. In front of the airlock on the "passenger" side was a small microwave oven, one-burner stove, refrigerator, and sink. A toilet could be moved into the airlock for privacy and then rolled out and attached to the waste disposal unit; a bucket of warm water could be taken into the airlock for bathing. Each of the vehicle's six metal mesh wheels had its own fuel cell power supply and electric motor that could be accessed from the cabin, making it almost impossible for the vehicle to break down. The station also had two "buggies," four-wheeled vehicles the size of a golf cart for two persons, to provide short-distance transportation.

They partially suited up, undocked from the shelter, and drove several hundred meters to Cryo Plant Number 1, parked on top of "Scott Mound," a low rise named for an Apollo 15 astronaut. The cryo plant was still perched atop a special cargo lander with large wheels on its landing legs so the vehicle could move to avoid shadows. Its landing propellant had been stored in seven different tanks, which were now available to store hydrogen, oxygen, and other gasses recovered from the ices: carbon dioxide, carbon monoxide, ammonia, and methane. A robotic transport vehicle brought a load of ices to the cryo unit, heated them slowly so the volatiles gasified one at a time, and fed them to the storage tanks. An electrolyzer unit broke water down into hydrogen and oxygen; a cryogenic refrigerator liquefied them. Finally, on top of the cryo unit, a solar mast extended upward 15 meters and turned to keep 75 square meters of solar panels pointed at the sun, sufficient to generate 25 kilowatts of continual solar power. The six-tonne unit had been landed with a two-tonne transport vehicle able to scrape up ice-rich dirt and pour it into its closable top, Theoretically, the system could make 110 kilograms of hydrogen/oxygen

propellant per day or 40 tonnes per year, almost enough for two round trips to lunar orbit and back, but inefficiencies so far had reduced production to half that.

Attached to Cryo Plant 1 was a water tank on a trailer, full with ten tonnes of water. They backed up to it and used the manipulator arms built into the roof of the ranger to disconnect it from the cryo plant and hitch it to the rear of the ranger. It was a delicate task and at one point they almost gave up and went outside to do it by hand, but they finally attached the trailer to the hitch. In a few minutes they pulled it to the shelter, where Pete waited. He attached a hose to the trailer and started a pump inside the shelter to move the water into one of the compartments in the shelter's outer envelope.

Pete waved to them, so they waved back. Paulette put the ranger in gear. "Here we go," she said. "I'm surprised that took an hour."

"Everything takes longer, up here."

She nodded and turned the ranger around and headed back to Scott Mound. The trail continued beyond it up the side of Armstrong Pinnacle, where Cryo Plant 2 was located, and past Schmidt Pinnacle another half kilometer away, where Cryo Plant 3 was set up. From there, the trail turned toward an embayment in the rim of Whipple Crater and down a crude, bulldozed ramp.

They were now on Whipple Trail, which descended to the snow and ice at the crater bottom. The sun was coming straight at the part of the rim they were on, so they were in sunlight for several kilometers. The trail had been very carefully carved into the rim over two years, using small rovers to make the first forays and larger ones later, with the ranger's bulldozer blade finishing the job under terrestrial control. There was nothing to see in the pool of blackness below them; the sunlight around them was too bright. But once they dropped into the shadow,

Paulette turned on the headlights. As their eyes adjusted they saw more and more below them, illumined by reflected sunlight and starlight.

The moonscape around them was dark, rolling regolith with a consistency of beach sand mixed with pebbles and rocks. It was quite obvious when they entered the zone of permanent shade; the regolith lightened with a skim of frost on it, a skim that grew thicker and whiter as they descended into colder areas. The crater floor below them resolved as a bright white patch in the starlight, a layer of ices mixed with dust and meteoritic debris several meters thick. Because much of the deposit had been formed a few molecules at a time, it was fluffy and sometimes had fluffy "icicle" structures sticking as much as half a meter upward. Whipple's hundred square kilometers of floor contained close to a half billion tonnes of volatiles, enough to last a spacefaring civilization for centuries; and it was only one of hundreds of cold traps in the north polar zone.

"It's beautiful," said Sergei.

"It is," agreed Paulette. "I suppose they went to the effort to make this trail because of the beauty and the huge potential. There are a lot of little cold traps right up on the plateau, and they have excavated only a little from them."

"I wonder about that. Swift is usually efficient."

She pointed to the display, which showed the surface temperature. "We're approaching the minus 150 Celsius point. We need to stop, activate the heating systems, and make sure they're functioning right."

"Are you hungry? It's just about lunch. Let's pop some dinners in the microwave."

She nodded. "Good idea."

Paulette stopped the ranger and activated the wheel heaters; the metal mesh was in contact with the ground and was prone to damage at very low temperatures. Meanwhile, Sergei opened the tiny refrigerator built into the passenger side of the cabin, pulled out two frozen dinners, and popped them into the microwave. He raised the central seat and laid it flat to convert it into a table between the two of them and set out cutlery while she reviewed systems and talked to mission control briefly. When the microwave beeped, he pulled the dinners out and uncovered them.

"I wonder what we'll make out of these plastic trays?" he mused.

"Once we set up a plastic recycling unit, we'll be making them into all sorts of things," Paulette replied. She closed the line to Houston and turned to look at her dinner. "These aren't too bad, but after three months, they'll get tiresome."

"They're too American. I want some good Russian food." He paused. "And good French food would be welcome, too."

"Yes, definitely."

"So, how's Jacques?"

She looked at him, surprised he brought up her boyfriend. "I don't know; I haven't talked to him for over a month. We broke up; remember, I told you about it?"

"I remember," he confessed. Jacques had stayed in France; Paulette hadn't been there for six months.

"How's Olga?"

He sighed. "Always complaining. I'd rather not talk about it on an open microphone." He reached over and pushed an icon on the control screen so that their audio didn't go back to Houston. Their video did, and the data from their ear pieces that monitored vital signs, but at

least they had some privacy. “She never says ‘how are you?’ or ‘I love you’ or anything like that. It’s always ‘can you please pay the boys’ school bill later today?’ or ‘I wish you were here to help with the boys,’ etc. They are a handful, but she could at least ask how I’m doing. This expedition is stressful as well as exhilarating.”

“Very true; both at once. Jacques was good with the talk, but he had his physical needs and little interest in my needs.”

“That’s a problem in many relationships.”

“It is. One can be very lonely in a relationship.”

“True.”

She took a bite of her food, put down the fork, then ran her hand under the tray table to touch Sergei’s leg. He smiled back at her. “We work long hours up here, but we also have our rest time.”

“We do, and I could use some rest.”

“Me too. Perhaps tonight.”

She nodded and picked up her fork again to finish her meal. They had spent time together before; she was glad the relationship would resume.

They finished eating quickly, reactivated the audio, and resumed their trip. The TROV had been working its way toward the very coldest areas of the crater floor when it had gotten stuck in a deep, loose deposit of volatiles three months earlier. It was at the 90 Kelvin line, a spot colder than Saturn’s moon Titan.

“No one has ever been in an environment this cold before,” noted Sergei, as they approached the TROV.

“But the equipment is rated for it for at least 60 minutes, so we should be okay.”

"We won't stay; get the TROV and go. Why did the wheels stay stuck?"

"They spun and dug themselves into a ditch. That made a little progress, but all the contact with the cold materials damaged the heating elements in two of the wheels. They cooled off and got frozen into the regolith. The ranger and its manipulators are the only things strong enough to pull it out." She pointed to the swirling fog in front of them. "We have to turn down the headlights, they're sublimating the ammonia, methane, and carbon monoxide ices." She turned them way down so they could barely see where they were going and the fog disappeared.

"Wow," he said. "What's the composition down here?"

"Up to ten percent CO_2, plus some parts per thousand methane, ammonia, hydrogen sulfide, and CO, and some parts per million of many other compounds, some of which are nasty, like cyanide. The coldest traps have frozen nitrogen ice and adsorbed hydrogen and helium gasses as well. Fascinating stuff, really, since it can give us a good idea about the average composition of comets, once we can model the deposition and loss mechanisms. It can provide a settlement with all the organic molecules it needs. The problem with the headlights is selective heating; the ices reflect the light, but the dust doesn't, and the metal mesh wheels transmit a lot of heat as well."

Sergei pointed to a ghostly image on the infrared display screen. "There it is."

"Yup, we're just about there."

Paulette slowed the ranger as they approached the stricken TROV. They circled it to view it on all sides and noted that their own wheels were slipping as well, though not too much; the ranger massed 4 tonnes. Paulette moved farther out, scouted the terrain a few minutes, and approached the TROV from a side that appeared rocky; the wheels didn't slip at all. She turned around and backed the ranger toward the TROV so that the trailer would be in the right position.

She stopped when the trailer was just a few centimeters from it and turned to Sergei, who had moved into the middle seat and activated the manipulator controls.

He took his time moving the arms into place, circling the TROV with them from above so he had lots of views of the various handholds from the cameras built into each arm. The cameras behaved funny, probably from the cold, but they worked adequately. After a careful examination he moved both arms in, one at a time, and closed on the handholds built into the top of the TROV.

Sergei took the joystick and moved the arms upward. They couldn't budge the TROV. He gradually increased the force over several minutes and still nothing happened.

"We're at 110% of maximum strength," said Sergei, finally. "We can't go any higher."

"If we can't lift it, we can always drag it free," suggested Paulette. "The manipulator arms can attach the chain."

"Okay, let's try that." Sergei released the manipulators and moved one to the back of the ranger where there was a chain. It wasn't rated for 90 Kelvin, but if it snapped, they could always replace it later; besides, the chain would take several minutes to cool off. He moved as fast as he could and in less than 2 minutes he had the chain's hook anchored in a handhold on top of the TROV.

Paulette put the ranger in gear and moved it forward slowly. The chain tightened and began to pull on the TROV. After a few seconds of resistance, it popped free of the icy dust deposit.

"We did it!" exclaimed Sergei. Then he looked at the image more closely. "Oh damn, two of the wheels ripped off the TROV!"

“Metal fatigue. There’s probably nothing we could have done without going outside and pointing heat lamps at the dust slowly, for an hour. Our suits aren’t rated for exposures of that length, not in these conditions.”

“Ninety Kelvin? The max is fifteen minutes.” Sergei considered. “I can suit up, go out with a heat lamp and a rock hammer, chip the wheels free, and come back inside in less time than that. At least we’ll have the wheels. They’re probably repairable.”

“I agree. Suit up while we consult Houston.”

He nodded, stood, moved the middle seat out of the way, and stepped into the back space behind the seats where he had room. He was already wearing his long johns and his spacesuit; it was a matter of pulling on over garments to keep in his body heat, putting on the life support backpack, and snapping his helmet into place. That took a while, and meanwhile Houston consulted with various people and approved the plan, with a few modifications.

He was ready to exit. He rolled the portable potty out of the airlock, stepped in, and closed the door. It took several minutes to evacuate all the air; at cryogenic temperatures, they didn’t want any water or carbon dioxide to freeze on moving parts. Finally, he was able to step out.

Paulette had picked up the TROV and put it on the trailer, so all he had to do was walk to the spot where it used to be and hack the wheels free. He grabbed a powerful lamp stuck magnetically to the roof of the ranger, turned it on, and walked to the wheels, which were easy to see. He had to point the light away from the ground, though, because it kicked up so much sublimated gas and entrained dust that visibility was a problem. He started by whacking the ground with the rock hammer.

It bounced off, much to his surprise. Ice was as hard as concrete at these temperatures. He turned the powerful light on and moved it so close to the wheel, it was almost touching it. The result reminded him of a pot of violently boiling water; gas spread out rapidly in all directions. He held the light in place for fully a minute, then whacked again.

It was as if he had done nothing. Perhaps a few millimeters of ice were gone, but there was a lot left. He put the light almost against the wheel again and left it. While he waited, he became aware of a funny bubbling feeling under his feet as the boots heated up and boiled off gasses underfoot. It made his feet feel a bit like the puck on an air hockey table. Cold was beginning to spread through his boots, too.

After two minutes, progress; the ice was noticeably less. He whacked under the wheel with the rock hammer and chips flew. He whacked several more times and the wheel broke free, attached to a chunk of ice. It flew several meters across the ground and stopped. He picked it up with tongs and put it in a cotton bag; plastic bags would shatter at this temperature, but not cotton, for some reason.

He turned to the second wheel and repeated the process, but waited three minutes the first time before removing the light. He whacked.

The steel head of the rock hammer shattered. Shards flew in all directions; some hit his leg, but they didn't cut his heavy clothing. That made him realize he was getting cold. He looked at the rock hammer more closely and decided he could still try hitting with the shaft, but he'd need to give the light more time. He put it down close and waited.

Bang!

He actually heard the explosion through his arm. The lamp shattered; his arm pushed backward by the force. He jumped back.

"What the—?"

"The lamp probably volatilized CO_2 or another volatile under an ice cap; it popped the cap," explained Paulette. "That's the danger of that approach!"

"That's for sure." He reached down and touched the wheel, which had been broken by the small explosion, but was also knocked loose. He picked it up with his tongs.

Then he realized that his right foot was becoming very, very cold, very, very fast. Surprised, he looked down and saw nothing unusual. He picked up his foot and tilted it.

No treads! The entire bottom of the boot had fallen off!

"What happened?" He looked around and saw the treads stuck the ground where he had been standing for four minutes, until the explosion forced him back. "I've got to get inside immediately!" he exclaimed. "The treads have broken off my right boot. My foot is not exposed, but there's less than a centimeter of material between my skin and dirt at 90 Kelvin."

"Hurry inside!" said Paulette.

"I'm coming right now!" Sergei grabbed the cotton bag and dashed inside, leaving the broken rock hammer and light.

5.

Saturday Lunch

Saturday, Aug. 5, 2028

"If that had happened to Will, I think I would have just about died," exclaimed Lurleen to Madhu Anderson, as they sat down to their lunch at the Moon River café. Its view of Clear Lake, however, was most un-Moon-River-like.

"I would have been pretty worried," conceded Madhu. "But that was a wait-and-see situation, not an instant death situation. Do you know what I mean? The lamp wasn't generating enough heat to make a big explosion; it was more like the power of several popcorn kernels popping at once, but it was enough to shatter the lamp and kick it backward. The tread separation was the big surprise, but his foot wasn't frost bitten or anything like that. If he had had to run a kilometer without the treads, that would have been serious. But the airlock was just three meters away."

"And the shattered rock hammer?"

"I asked Roger about that. He was monitoring the whole thing in the shelter; he was the day officer and an EVA generally requires monitoring from the shelter. He was worrying about the rock hammer because their heads are known to chip or shatter even under terrestrial conditions. Nothing that works normally in terrestrial conditions, work normally in 90 Kelvin. Nothing. He talked to Sergei afterward and Sergei admitted that he was worrying about the rock hammer as well."

"So now they can't go outside at all."

"Not for a few more days, while the boot failure is investigated. But they have nearly a month of shelter setup to do, anyway. Have you been inside the mockup? The thing arrived

vacuum packed as a cylinder 3.5 meters in diameter and 5 meters long. It inflated into a cylinder 24 meters long and 6 meters in diameter. The western end cap and both airlocks were packed with appliances, furniture, and life support equipment. Cargo lander 4 brought 4 tonnes more; lab equipment, a fully equipped sick bay, four TROV operation stations, and storage cabinets. The two construction robots inside were operated 24 hours a day, 7 days a week for three months from Houston, but they could only do so much. They are maybe a fifth as fast as human beings. They set up the life support, kitchenette, one bathroom, and the space suit donning areas. Everything else needs to be set up. They even need to reinforce the floors and walls with hard plastic panels because they're just plastic sheets stretched taut."

"Rather like a trampoline; I heard that on the news. I'm glad they'll be busy. But what about radiation? That worries me, too."

"In the upper level of the shelter they're exposed to about the same amount of cosmic rays as in low Earth orbit; it's safe for a cumulative exposure of 18 to 24 months. In the lower level of the shelter the exposure is a third less because of the dirt around it. If there's a solar storm, they're completely safe in the lower level; much more so than in low earth orbit. The shelter is designed with water tanks built into the outer covering. Right now they're filled with air, but they can accommodate 300 tonnes of water, which will surround them with a meter of water. That will cut out much of the cosmic radiation exposure."

"That's good. Will and I want to have children in a few years. Aren't you worried about Roger being . . . affected?"

"He froze some sperm before his first launch to low Earth orbit. He's 32; I'm 31. We plan to wait another five or six years before starting a family. We might even wait ten years; by then he plans to retire and stay on Earth."

"I wish Will would do that." Lurleen sighed. "He's 27; I'm 26. Maybe we could wait ten years . . . but I'm not sure he'll want to retire by then! He's crazy about the moon!"

"I know; Roger calls him 'the Moon Man.' He has a pretty unique talent. A genius, really. How many papers has he published?"

"Oh, I don't know. I really don't pay attention, it's not my field at all and I can't read them. It seems like he's author or coauthor of one paper a month, though."

"What drives him? Is he anti-social?"

"Will?" Lurleen laughed. "No, he's about as social a man as you can meet. He *loves* to be around people. He loves to explain things to them; he's a natural teacher. In fact, you can't shut him up."

"That's true, I've noticed that. Roger's a touch that way, too, but Roger sees himself as a natural leader, not as a natural teacher. He likes the spotlight. He's good at it, too. Starting tomorrow, he'll be conducting a live Bible study every Sunday morning at 10 a.m. Central time from his room. Right now you can see the Earth right out his window; it'll be his backdrop! He's starting with Genesis 1 and 2. He aspires to be Commander of a future mission; maybe Northstar 3 or 4 or 5. I suspect he'll be appointed, too."

"Will would be good at that, I bet, but he has no concern about it." She laughed. "It'd interfere with his research on impact melts in a lunar polar environment! Apparently the heat and water produce some unusual minerals. Lately he's been in the TROV control room 10 or 11 hours a day, six day a week. While the other guys are moving water or cryogens or supplies to the shelter, he's been rolling around the plateau and North Ridge looking at small craters, either old ones with snow on their bottoms or fresh ones with none."

"So, they're letting him do geology?"

"Of course! If they object, he proceeds to explain in detail what his research project is, and he's very articulate. It usually works. And if he goes to the moon, he's not going to sit in the shelter; he'll be outside as often as possible, studying impact melts and soaking up radiation."

Madhu frowned. "Lurleen, what are you afraid of?"

"What do you mean?"

"Will's an astronaut; he has to fly. Didn't you understand that when you married him?"

"When I married him two years ago, he was finishing up his Ph.D. at Brown. He told me he wanted to be an astronaut, but I didn't take it seriously. What are the chances of anyone becoming an astronaut? And they're usually military types; I didn't think they'd accept a geologist! But they did, and I was very surprised. It was all very abstract, except for the fact that he was devoting himself twelve hours a day to lunar geology. He even stopped being active in the Bahá'í community; he used to be pretty active in Providence, but after we moved to Houston he barely goes to any Bahá'í events."

"It's hard to be active in anything else, though, especially now when they're scheduling the crews for Northstars 2 and 3. He'll probably fly on one or the other. Everyone in the Astronaut Corps is trying to be as active and as visible as possible, to maximize their chance of selection."

"But he doesn't seem to be worrying about that, either. It's as if he knows he'll be selected and is just going about his business."

"I suppose, considering he's the Moonman, he can expect to fly soon anyway. But back to my original question: what are you afraid of?"

"Me?" Lurleen thought about it. "Certainly, I'm afraid of losing him. I love him very much, even if he can't give me the normal life I hoped for."

"Ah, that's it, then," said Madhu. "You wanted an ordinary life. Well, Lurleen, an astronaut can't give you that. He'll be away three to six months at a time. That's guaranteed."

"I know, but when he's here, he's barely around, too! I'm lucky to have a Sunday with him. I want a husband, Madhu. It's a real problem."

"I don't know what to say, except to note that the divorce rate in the Astronaut Corps is pretty high right now. They're married to space as well as to us, Lurleen."

"How can you take it?"

Madhu shrugged. "Well, Roger's plan to retire helps. We're planning to start a family, though later than my parents would like. I've got my work, and he usually is pretty good about saving the weekends for me. Maybe you can persuade Will to stay home on Saturdays. And I wish I could go, too, frankly. I'm sure I'd pass the mental and physical exams. Maybe they'll need a food specialist on the moon or even Mars, some day."

"They're not going to need a hospital administrator up there any time soon!"

"No, that's for sure. It's telemedicine for the moon; they'll be getting a DaVinci operating system in another year, and the world's greatest specialists are all three light seconds away. So I suggest you find something to devote yourself to; ideally, something Will can help you with, too."

Lurleen shook her head. "I can't imagine that there's something like that we can do together."

"Well, look." Madhu took another bit of her lunch. "You're welcome to come to our church, too. Church is a pretty important part of Roger and my life together. It gives us a powerful something in common. It's part of the covenant between us."

"Thanks, but that won't work for us. Will's a Bahá'í; he was raised a Bahá'í, and even if he isn't doing a lot with it, now, he's a Bahá'í to the bone. It's the way he looks at the world. As for me, I'm an agnostic. I don't know what I believe and I have never found churches to be very interesting or fulfilling. Bahá'í meetings are mildly interesting and their hearts are in the right place, but I could never make the kind of commitment they make."

"Well, think about it. If he's accepted to Northstar 2, what are you going to do?"

Lurleen shrugged. "Congratulate him, I guess."

"That's good. Be supportive."

"I will. And I'll ask him to store some sperm, too. I'm not sure what he'll say about that."

"Well, it'll be an interesting conversation!"

6.

A Day at the "Office"

Early Sept. 2028

"Plagioclase?" growled Will to himself, though loud enough for the TROV driver next to him, John, to hear. "The entire crust up here is made of plagioclase! Pete needs to be more specific. It looks like Labradorite to me, and that's significant!"

"Why?" asked John.

"Because most of the plagioclase feldspar in the lunar highlands in anorthite, the high calcium type. The opposite kind, albite, is high in sodium. In between there are 4 intermediary grades, and labradorite is right in the middle; its half calcium and half sodium in composition." He looked more closely at the image from Pete's helmet camera he had frozen on his screen, then pointed. "You can see a bit of iridescence in the sample, which is characteristic of labradorite." Will pushed an icon on his screen, to open a text message to the exploration crew. He pushed on Pete's name and recorded, "Pete, it looks like the sample has iridescence. Is it labradorite?" Then he pushed the send button. The system converted his voice message into a text and sent it to the cap com, who apparently forwarded it to Pete. A few seconds later, Pete said, "I should have been more specific. This sample appears to have extensive labradorite. Can we get a laser zap of the outcrop?"

Will maneuvered his TROV over to the outcrop, pointed the laser at the spot where Pete had broken off a chunk of rock, and called up the firing controls. A moment later, a laser flash hit the outcrop and produced a very tiny, hot spot. The TROV's infrared spectrometer captured the emission and ran it through a computer. Up popped a chemical analysis. "It's labradorite," confirmed Will in a text to Pete.

"What would they do without us?" comment John, who was moving over to another outcrop nearby to zap it as well.

"It's Pete, mostly; he has just enough geology training to know something, but not enough to know what to conclude. Roger, in contrast, is very good; just about the best."

"They should send more geologists!"

"I certainly agree." Will hadn't told John, who was a graduate student in engineering, that he was on the short list for Northstar 2; John tended to treat him too deferentially as it was, because Will was an astronaut. He wished that David was helping that day, but it was Friday and David took Friday—the Muslim Sabbath—off.

Just then a text popped up onto Will's screen from Pete: *Thanks, Will, for that call, but I was in the process of figuring that out anyway. Give me a bit more space.*

That surprised him. He stared at the screen for a moment, then typed a response so John wouldn't hear it: *ok.*

"Hey John, can you support Pete a moment?" he asked. "I want to check out the thirty-meter crater. It's about forty meters to the northwest."

"I know the one. Okay."

Will clicked on the icon for the Capcom and reported his plan, which was immediately approved. He wheeled over to the crater at half the speed of a walking person, which was its maximum speed; when a crew was around one could take chances that one couldn't take when no one was around to rescue the TROV. He stopped at the edge and scanned the crater floor—it had a skim of snow on the bottom—recorded the temperature, and zapped the snow, which showed that it was pure water ice. He zapped a rock outcrop on the far side and waited for the spectra to come back; it was impact melt. Interesting. He dictated a series of notes, then headed

to another crater ahead of the geology team, where he could provide support, now that he was over his hurt.

Dorinda Stetson groaned when she saw that the call was coming from Zeke Swift. He had called her weekly since Northstar 1 had landed at Peary Station, generally to review the situation. Neither of them needed the conversation; both were getting daily briefings directly from the same people at Northstar Control. She wished she had never shared with him her private video address.

She opened the line. "Good morning, Zeke."

"Good morning, Madame Administrator. How are you doing today?"

"Pretty well, and things seem to be going better up at Peary."

"No more boot malfunctions, that's for sure, the broken TROV will be fixed soon, they've partly set up the shelter and its basic shielding, and the first geology expedition went well. Yes, it's been a good month. Are you just about ready to announce the crew of Northstar 2?"

"Yes; after Labor Day. They'll be able to provide direct support for Northstar 1 in and around training and will be the principal source of planning for their mission. They also have to make a few field trips together; Kilauea, Meteor Crater, and possibly Antarctica."

"Good, practical training. I called you to let you know in advance about the announcements at my press conference at noon today."

"You're holding a press conference?" Her heart sank.

"Didn't your press people tell you? I informed them five days ago. You'll like the first piece of news: Peary Resources, Inc., has secured an additional $300 million in funding, some

from me, some from a group of investors in Qatar. It involves no technology transfers; they're business partners only. We already have a Thunderbird Heavy launch in the budget, so now we will have money for two. One Thunderbird Heavy will launch the equipment to double the capacity of the low Earth orbit and low lunar orbit fuel depots. The other will launch a cargo lander able to transport more water to lunar orbit, and the cryo plants and other equipment to double lunar surface production."

"Really? Congratulations."

"Thank you. This will greatly facilitate the supply of propellant for the 2030 Jupiter probe, which, as you know, is now fifty percent overweight. You get it into LEO and we'll refill the fuel tanks at a good price; fourteen hundred dollars a kilo."

"Well, you don't have any competition at that price, or you won't by 2030 anyway, so that sounds attractive. Send us a proposal."

"It'll be on its way next month. My second announcement involves Northstar 6; recall that the contract for oversight and coordination with NASA lasts through Northstar 5 only, and after that I am free to contract with other nations and corporations to supply them seats to the moon, in addition to any seats or flights or equipment you wish to purchase. Again, no technology transfer is allowed, just purchase of seats. We're finalizing a contract for a lunar hotel; the first tourists will go up on Northstar 6, which we're tentatively scheduling for June 2030. It'll overlap with Northstar 5. I've already sold seats to Qatar and India and it looks like China will send two 'tourists'."

"Well, that's within the contract. I hope the price is good."

"We're projecting that each lunar flight will cost about 100 million by then and we're selling the seats for 30 million each. It looks we already have one tourist, also."

"Congratulations, Zeke. The lunar transportation system is developing quite fast."

"Thanks, Dorinda. Yes, the system is maturing quite well. Reusability was the key question. We've now shown we can aerobrake lunar water transports into low earth orbit, and in another year we can probably do it in a few weeks rather than a few months. The technology for converting water into propellant in zero-gee is mature, and we're getting the kinks out of fuel transfer. Unless something blows up, we're in good shape. Which gets me to the third announcement: Swift Company will aim to complete its manned Mars lander for launch in 2033, with the goal of placing crews on the surface during the 2035 launch opportunity."

Dorinda Stetson's face darkened. She was afraid of exactly that. "Zeke, you *can't* do that to us."

Swift was an immensely patient man, but it was clear that his patience was under strain. "Madame Administrator, I mean no offence to you, NASA, or my adopted home country by doing this. Really, I don't. But consider the situation dispassionately, please. The Thunderbird Heavy gives us 35 tonnes to low earth orbit with reuse of the stages, 55 tonnes without return of stages to the earth's surface. The Thunderbird-H hydrogen/oxygen stage allows us to push 18 tonnes to translunar trajectory, 15 to Mars. If we use Thunderbird-H technology on the Thunderbird second stage we can put 60 tonnes into low Earth orbit and over 20 tonnes to a translunar trajectory. Using low earth orbit refueling with lunar fuel, we can push just about any mass to a trans-Mars trajectory that we want. If we add a lunar fuel depot at the L1 point between the Earth and moon, we can push men and cargo there, refuel the stages, and send them to Mars with existing technology; easily and *cheaply.* We don't need nuclear engines or VASIMR."

Mr. Swift, the radiation burden is too high for chemical propulsion. In another decade we can develop a big enough space reactor to power a VASIMR and get crews to Mars in a month or two."

"Madame Administrator, the radiation threat is a boogeyman. The nuclear engineers who want you to spend a hundred billion on space nukes are insisting on it so you have to build their technology. Your Jones Commission that studied a Mars mission was influenced by them. That's why it pronounced a Mars mission too expensive and said it had to be postponed to the 2040s. I am not bound by the Jones Commission."

"But what about surface power? You need a nuclear reactor to be sure you have power during dust storms."

"No, that's not necessary either. It'd be nice, but it isn't essential. The sun is never blocked. I have my experts, too, Madame Administrator. As for the interplanetary transfer vehicle, it is straightforward to expand our Polaris capsule—double its size—and add an inflatable hab to it for the interplanetary legs. That's now old technology. Thunderbird stages can be landed on Mars just the same way we can return them to the Earth's surface, and that technology can be used to develop the Gryphon cargo and human landers."

"You love mythical beasties, don't you."

"Actually, I do. Gryphons are part eagle, part lion; they're pretty cool. Gryphon development will take five years. The inflatable surface shelters and surface vehicles will be adaptations of the lunar equipment. We have thirty years' experience with reliable, long-lived life support systems in low earth orbit, and on Mars we'll have access to water and air we can use. The technology development prices we've been quoting in the media are holding up quite well."

"Mr. Swift, the National Aeronautics and Space Administration will not permit you to trump us this way. Mars has been our destination for most of two decades and we're making progress toward it. The recent sample return mission has helped characterize the Martian surface conditions quite extensively. The revised Mars project should be submitted to Congress next year and will get us to Mars in 2042 or 2044."

"Madame Administrator, we are very grateful for all the technology development and cutting edge science NASA has sponsored. The Redstar mission—that's what we're calling it—will benefit immensely and crucially from it. But Redstar will be landing a precursor mission, to test the hardware and place advance resources and emergency return capacity, in 2033-34. Human beings will follow two years later. We have been immensely careful in all our contracts, where use of proprietary technology is concerned, and our lawyers have revisited the issue again recently. You have no legal grounds for stopping us."

"Short of an act of Congress."

"Do you think Congress can be persuaded to do that? Let's see; Swift Company, six astronauts to Mars in 2035, price tag: half a billion dollars each, then half that two years later. NASA: four or six astronauts to Mars, or maybe just two astronauts, 2042, or maybe 2044, or maybe the 2050s, price tag: at least a hundred billion, but if it stretches into the 2050s, who knows?"

"Without us, who would pay?"

Swift looked embarrassed by that question. "The Qatari investors in Peary Resources asked us how much a seat to Mars would be and when we said a half billion, they indicated they probably could come up with that. Qatar spent two hundred billion on the World Cup a decade

ago, remember? If I approach India, don't you think they'd agree to an astronaut or two? France is always willing to do something independent. And then there's China."

"That would hit the technology transfer wall!"

"No it wouldn't, if they're just paying customers. The technology we're talking about has already taken taikonauts to the Mir Industrial Orbit Facility. No one objected."

Stetson stared at Swift, speechless. His face was impassive; he was never one to gloat when he had won. That made her even angrier. "Well, Mr. Swift, I appreciate your calling me before you make the announcement. We'll be sure to watch the press conference."

"I'll email you a set of the Powerpoints and the video. It's always good to speak to you, Madame Administrator."

"Thank you, Mr. Swift," she replied ambiguously. She reached over and pushed the disconnect icon. Once the screen was blank, she called in her assistant. They had to call the White House, a group of key Congressmen who had jobs to protect in their congressional districts, and several influential lobbyists. She had some aces up her sleeve.

7.

Labor Day Weekend

Early September 2028

"Welcome to Houston!" said Lurleen, as Molly Elliott Nuri and her husband, Dr. Taraz Nuri, came out of the concourse and entered the public part of the airport.

"Thank you, Lurleen!" said Molly, embracing her sister in law. "It's good to be here; we've never been to Houston before!"

"It's a great place," replied Will, embracing his sister. He turned to his brother in law. "Taraz, good to see you again."

"Thank you, Will, Alláh-u-Abhá." He exclaimed the Bahá'í greeting with great warmth.

"Alláh-u-Abhá," replied Will. They started by shaking hands, but Taraz embraced him instead. "Where are mom and dad?"

"Coming," replied Molly. She pointed; Katherine and Stephen Elliott were approaching the exit of the concourse just then.

Will smiled. "Welcome mom and dad!" he said, and he moved forward to embrace his mother, then his father.

"Thank you, dear," said Katherine, giving him a kiss.

"Good to see you again, Will," said Stephen, embracing his son. Will nodded and was surprised to see how white his father's curly hair had become, and how he had developed jowls. His father was only 64. Katherine was 59 and dyed her hair, so she looked reasonably young to Will.

"Come on, let's get your luggage," said Will. "So; you can stay just four days, but that's better than nothing."

“My cardiology conference lasts three days, then we have to fly straight back to Bolivia,” said Taraz. “I’m sorry I can’t spend more time with you, but I have to attend some of it.”

“Will can’t stay away from work more than four days anyway,” said Lurleen.

“I’m not sure we can handle the heat and humidity much longer, either,” said Stephen. “I suppose we won’t be outside much, though.”

“No, we’ll stay inside, go to restaurants, walk around the mall, and go to the Museum of Fine Arts,” said Lurleen. “There’s plenty to do in air conditioning.”

They reached the luggage carousel. The luggage was just beginning to come out. A young man approached them. “Dr. Elliott, right? Can I have your autograph?”

“My autograph?” Will was startled; no one had asked him for it before. “I suppose; why me?”

“You’re a model to me, Dr. Elliott. Your blog about lunar geology is so detailed, so fascinating; I want to go to the moon, too, and maybe to Mars after that!”

“Good for you! What’s your name?”

“Charlie Vickers. Here, can you sign this?” He handed Will a piece of paper.

“Sure. Will pulled out a pen and wrote a message of best wishes to Charlie, signed and dated it. They shook hands.

“Thanks!” The kid smiled and hurried off.

“How often does that happen?” asked Stephen.

“That’s the first time, dad! I was astonished. I had no idea anyone was interested in my blog!”

“What sort of blog?” asked Taraz.

"I make an entry every few days about the geology we're finding in the vicinity of Peary Station. I've been making it for about a year; I'm driving TROVs—telerobotic vehicles—almost every day."

"Ah. Over my head!"

"I'm sure your cardiology is over my head as well."

Taraz nodded. "It's pretty specialized. But our practice in Santa Cruz, Bolivia, is almost primitive, compared to the things people are doing here in the States! One of the reasons I've come to this conference is to try to find some specialists willing to come to Santa Cruz for a month or two and show us what they do."

"Persian Bahá'ís," added Stephen.

Taraz nodded. "They may be the easiest to persuade, but I'll try to persuade anyone I can!"

"I hope you can," said Katherine.

Lurleen turned to Molly. "And how's your teaching at Nur University?"

"Pretty good, but I'm still learning more Spanish than my students are learning English!"

"No, your Spanish is better than that," replied Taraz, patiently.

"It's very good," agreed Katherine. "We were there for the last month."

"And you're both Bolivian and Persian, right?" asked Lurleen.

Taraz nodded. "My two sets of grandparents settled in Bolivia and Peru, respectively, right after the Iranian revolution, and my parents grew up there from a young age, so I'm third generation Iranian Bolivian!"

The luggage arrived, so they stopped talking to pick it up, then headed for the car. "So, last time I saw you, you weren't an astronaut," said Taraz, as they walked to the parking garage.

"That's true; it was your wedding, and we wouldn't have talked about the astronaut corps then anyway! I'm not sure what to say. The confirmation letter came through in June, just a month after your wedding. It was a thrilling moment; I don't know how to describe it. It was a confirmation of my intended life direction, you know? We moved here last August, so we've been here almost 13 months. I threw myself into the task and never looked back."

"What an amazing confirmation. A blessing," said Taraz, though he noticed Lurleen's scowl and Katherine's look of worry. "So, I am curious, Will: why did you want to be an astronaut?"

"Why . . ." Will considered. "That's an interesting question. It's not fame or anything; it feels more like destiny. I have always been fascinated by the origin and development of worlds, entire worlds. As a doctor, maybe you can appreciate the challenge of understanding how a human being develops from a fertilized egg to a fully capable, functioning, and beautiful adult. The Earth and the moon have stories of origin and development that are just as rich and fascinating. And their stories are part of our story too, because we are here because of the way they developed. Learning how the Earth-moon system developed is learning a part of our story. That's the big picture, Taraz."

"Fascinating." He looked at Will with a new appreciation, for he had never expected an answer like that. "But why the moon, then, when the story of the Earth isn't understood yet?"

"Because there's more new information to learn about the Earth on the moon than there is on the Earth, believe it or not. There are almost no rocks—no record—of the Earth on the Earth before about 3.8 billion years ago, so the first 750 million years of Earth history is virtually a blank. How do we fill the blank slate? From the moon. We have the record of what happened on the moon and can infer that similar events happened on the Earth. But even more important,

every large impact on the Earth threw terrestrial rocks into space, and some of them landed on the moon. We anticipate finding thousands—millions—of tiny, smashed chunks of Earth on the moon. The estimate is twenty tonnes of tiny Earth fragments per square kilometer! We should be able to recover a lot of information about the formation, evolution, and development of the Earth. We will probably even find evidence that tells us about the origin and development of life itself on Earth. We have only the sketchiest idea about that so far; the rocks from that era have been entirely destroyed."

"So; the origin of life." Taraz was impressed again.

"Well, actually, we may have to go to Mars for that, because life probably originated on Mars as well; in fact, it may have originated there and traveled to Earth on a piece of Mars blasted into space by an impact. Most of Mars dates from the era that has been erased on Earth, so there are centuries of research about the origin of life to do there. These three bodies complement each other remarkably well. They're like three jigsaw puzzles with missing pieces, but all three together have all the pieces. It's really amazing."

They got to the van that Lurleen had rented for the weekend and put the luggage in the trunk, then climbed inside. Since everyone was listening to Will, she got behind the wheel. "So, would you like to go to Mars, son?" asked Stephen.

"Maybe, dad," replied Will. "Right now I'm learning the moon, and there is a lifetime of work to do to understand it. But Mars is fascinating, too."

"What do you think of this plan Mr. Swift announced yesterday?" asked Taraz. "It seems to be getting a lot of bad publicity."

"I was at Johnson Spaceflight Center this morning, talking to some people in Mission Control," replied Will. "Very interesting. Many of us are excited that Swift is proposing to work

another miracle. Let's remember that when he first developed the Thunderbird, everyone said he'd fail and go bankrupt. Then he said he'd make it reusable and they said he'd fail. He wanted to go straight to Mars and couldn't get enough government and private support to develop the system, but the moon was a bit easier and cheaper and he was able to persuade a coalition of governments and businesses to pony up the cash or guarantee the loans to create the Northstar system. He developed the Thunderbird for a twelfth the cost of a NASA booster of the same capability. He was able to develop Northstar for two billion, which was twenty or thirty times cheaper than NASA's estimates. Because of that, NASA had to abandon its plans and use Thunderbird rockets, Polaris capsules, and Northstar landers, though they saved face by getting overall control over the system for the first five launches. They were furious, but they had no choice; otherwise, they would have lost their primacy in space.

"So now he proposes to go to Mars for four billion dollars more; again, about a twentieth the cost of a NASA project, and in half the time. NASA is going to be shown up again. What are they going to do? The same thing as the first time: fight him, threaten to sue him a thousand times over every little thing, smear his plans, undermine confidence in his capabilities, lobby against him in Congress . . . and then in the end, most likely, they'll pay him and save face by getting Mission Control here."

"So, can he do it?" asked Katherine.

"Definitely. He doesn't need a lot of new technology, and he can test some of the new technology on the moon."

"But what about this morning's announcement of the Lyra Launching company that they'll build a reusable rocket in the next five years that will put stuff into earth orbit for $300 per pound?" asked Lurleen.

Will smiled. “That’s interesting, isn’t it? Lyra has been working on their rocket several years and it may very well do that. There are at least two other boosters that should also achieve $300 to $500 per kilo and will be launching in the next five or six years. Once that happens, Swift won’t be able to launch into space for $1,000 per kilo and charge $2,500; he’ll have to cut prices to compete. Long term that’s good for everyone; tourists will go to low earth orbit hotels for less than $1,000,000 and to the moon for perhaps 2 or 2 million. The moon will develop fast. Mars will be reachable for several tens of millions per person and that will come down, too. Of course, Swift won’t be able to make the big profits he can make now and plow them into new technology, mainly the Martian transportation system. But he won’t need to if he gets governments and private investment instead, and he will get them; the rumor is that India and France are interested.”

“NASA will never let them get to Mars first,” said Katherine.

“Exactly,” said Will. “But meanwhile, I suspect someone in NASA headquarters leaned on someone at Lyra to make an announcement now; first, to distract from Swift’s announcement, and second to undermine the profits they are projected to make before they have those other sources of funding.”

“Ohhhh . . .” said Taraz, understanding.

“Nasty,” said Stephen.

“Well, what can I say? Institutional survival will bring out the worst of behaviors.”

“Why does NASA have to spend so much?” asked Molly. “It’s an obscene amount.”

“Actually, it’s not obscene at all; Americans spend more on pet food, on potato chips, and on landscaping their cemeteries every year, than on NASA,” replied Will. “It is just more visible than those choices. The problem lies with Congress. To get votes, NASA has to spend money in

as many Congressional Districts as possible. When NASA announces a new project, every research center wants a piece of the pie, so they want the project designed to maximize their share. But you can't design a project based on where you spend your money; it creates huge inefficiencies. That's why when NASA projects are proposed, their initial budget projection collapses, the price of the project balloons five or even ten times, then it gets canceled after some of the money has been spent. Swift doesn't have that problem; he takes a project, figures out the cheapest and simplest way to achieve it, and raises the money accordingly."

"But Dorinda Stetson has said she's committed to making NASA a lean, efficient organization," said Lurleen, as they merged onto the highway.

"Yes, and she is trying," agreed Will. "But the lobbyists will oppose any attempt to close research centers. The best we can hope for is that a larger share of NASA money is set aside for space entrepreneurs like Swift, and that they are given a central role in moving outward."

"Swift wants to settle Mars, right?" asked Stephen.

"That's what he says. Those costs won't come down for decades. Meanwhile, the system he's developing can easily be used to send a manned facility to Venus orbit to study that planet. We have the long-term life support capacity now; it'd be safe. With minor changes it could even be used to land astronauts on Mercury; the gravity is similar to Mars and the conditions at Mercury's poles are similar to the moon's poles. The larger asteroids could be visited. Even Jupiter isn't out of reach."

"So, you see a revolution?" said Taraz.

Will nodded. "I think so. All the opposition you see in the media is because they're afraid he'll succeed."

“They love to shop,” Will said to his father, as they watched Molly, Katherine, and Lurleen walk into a department store.

“It’s the way they bond,” replied Stephen. “And I guess our way to bond is to sit and have coffee!” He pointed to a small coffee shop in a central intersection of the mall. They walked over and sat.

Will pointed to the television, which had a 24 hour news show on. “I don’t know what the world is coming to, when United Nations peace keepers are attacked and taken hostage like that.”

“I know. They’ll pull out of Equatoria after this incident, the civil war will intensify, and the mess will overflow into other African nations. It’s crazy.” Stephen shrugged. “Of course, Congress isn’t much better.”

“I know. That fist fight on the floor of the House of Representatives the other day was shocking. I don’t know what will happen with NASA’s fight against Swift.”

“Everything is becoming dominated by issues of money and power.”

The waiter came over. “What would you like, Dr. Elliott?”

Will was startled that he was recognized. “A medium nonfat latte, please.”

“I’ll just have Earl Grey,” said his dad. “And one of those blueberry muffins.”

The waiter nodded, pushed a button on his tablet to submit the order, and walked to another table. “Recognized again,” noted Stephen.

“Yes, twice, two day in a row.”

“You’ll need to start wearing dark sunglasses!”

“I suppose. I’ve talked to several of the astronauts who are better known and they say they aren’t bothered very much. But maybe the moon landings will change that, I don’t know.”

“So, how are you doing?” Stephen asked his son. “Are you happy?”

Will smiled at the reference to `Abdu'l-Bahá’s often-asked question. “Well, I suppose I am. I love my work, I have a loving wife . . . things are great.”

“Most people’s list wouldn’t start with work and end with the wife one item later. There would be children, hobbies, friends . . . the list would be longer.”

“Well, it’s too soon for kids; we’ve been married just two years and we’re still waiting to see how the astronaut corps will work out. And since I’ve just started with the latter, I’m pouring my energy into it. As for friends, we’ve both made lots of them at our work places.”

“You don’t have mutual friends, then?”

“No, not really, but we’ve been here only a year.”

“What about the local Bahá'ís?”

“I haven’t met too many of them, and Lurleen’s not very interested.”

“That’s too bad. I sense a lot of tension between the two of you.”

“Yes, it has been hard. She has never been happy about my joining the Corps, she’s not happy about me going into space, and she’s not happy about my long hours of work.”

“Do you blame her? She’s moved two thousand miles from home with a husband who’s a workaholic.”

“Well; yes, you have a good point.”

“Son, you can’t go on this way.” Stephen paused and looked at Will more intently. “Lurleen is a beautiful, talented woman, and I can’t wait to see what beautiful children you make together. I don’t just mean physically beautiful, either; the two of you can raise up spiritually beautiful children as well, because both of you have great personal qualities. But creating such a

relationship—such a family—takes a lot of time, attention, and energy. It is very rewarding. It's just about the most important thing you can do in life."

"I know, dad. But she doesn't make it easy, either. When I come home, she's resentful I was at work, even if it's nine to five on a Tuesday. The fact is, she doesn't get home until 8 or 9 p.m. sometimes, also. She said she didn't mind me accepting the invitation from the Astronaut Corps, but in fact she did."

"She wants an ordinary life."

"I think she'd say that, dad, but that's not the entire story." Stephen looked at him, puzzled, so Will continued, "She once said to me that what she really wanted was to marry a 'wife.' In other words, someone who could stay home with the kids while she pursued her career. She is very bright, very capable; a natural leader. Now, when two people who are bright, capable, and natural leaders get married, who's going to be the leader and who the follower? How do they establish a real partnership? What balances do they strike? It's not easy."

Stephen nodded. "Sounds like you need some marriage counseling. Your mother and I went to a counselor, you know, when you were 3 or 4. I had a new job, I was working 50 or 60 hours a week, she was stuck at home with two very small and active children and going crazy watching them . . . it was very difficult for her, and I wasn't helping at all. We needed some help to find a better balance."

"I could consider that. The problem is, right now I *have* to work long hours. This is the beginning, when everything is hardest and I need the most to make a good impression. Things will get better in a year or two, especially after I fly once and I'm established. This is a good time for her to work hard in her job, too; we don't have kids."

"That's true, but you guys have to come home and spend time together, also. Maybe you need to talk to her and coordinate long schedules better."

"We could do that, except both of us have emergencies, or things that seem to be emergencies, anyway."

"Well, both of you will have to sacrifice, son. That's part of what a marriage is all about."

Will sighed, unhappy about his father's observation, conceding the point reluctantly. He sipped his latte. "So, how are you doing?"

Stephen smiled. "I am blessed by a loving wife and an empty nest, so I can pursue my *pro bono* legal work to my heart's content! I think I'm on the verge of winning an important civil rights case. But it is very stressful, even if your mother does rub my shoulders and back every evening. I'll need to retire pretty soon. I'm 64, after all."

"I can't imagine you retired."

"Neither can I. That's not just a problem for me, but for you, too! I modeled this behavior for you, and you married a different sort of wife than I did. So keep that in mind."

"I will," Will smiled at that.

They turned back to the television and listened to the latest report about the UN Peace Keepers; three had been murdered as a negotiation point and twenty-five were still hostage. They finished up their drinks and rose to go find the women when Will's smart phone vibrated with an urgent message. He pulled out the phone; it was from NASA. He pushed the open icon.

To: all astronauts on the Northstar 2 short list

From: Northstar Mission Control

The flight team of Northstar 2 consists of the following: Sebastian Langlais, Commander; Will Elliott; Silvia Ferreira; Jerry McCord; Kalidas Sharma; Larisa Tatarinov. Congratulations

to all of them. This information is being held in confidence until Tuesday, September 5 so that the team members have time to inform their family. All team members and others on the short list (who will serve as backups) should report to Mission Control at 9 a.m. Tuesday for a welcome and press briefing.

"What is it?" asked Stephen, seeing Will's surprise.

Will turned the phone toward him so his father could read the message. "Wow, congratulations! You're going to the moon!"

"I am!" said Will, suddenly excited. "I am going to the moon!" Then he covered his mouth and looked around. Fortunately, no one seemed to hear him.

"What?"

"If this gets out, we'll be dealing with the press; that's why it'll be released on Tuesday." He looked at the message again. "I don't know Sebastian much; he's German, he's been running TROVs sometimes, but he left suddenly a few days ago with a family emergency. Silvia's Portuguese, an engineer, she was here over the summer and is still around. Kalidas is a TROV driver and repairman; a nice guy. From India. Jerry's American, can fix anything, and has a Ph.D. in geophysics. He should be pretty good with field geology. Larisa is very smart and articulate, Russian, speaks four languages I think, and is a cryogenics engineer."

"Lots of engineers."

"They're needed the most because we're making things, deploying things, and then fixing things when they break. No one knows how to build things that can operate reliably in a vacuum and in incredible cold."

"Well, Will, I am incredibly proud of you." His father put his hand on Will's shoulder.

"Thanks, dad." A tear welled up in Will's right eye. It meant a lot to hear that.

They started to walk around the mall looking for the women while Will described the training process, the process of planning for the mission, and the launch, scheduled for February 24, 2029 from the Swift Spaceport in New Mexico. They finally found them looking at perfume.

"Will has an announcement!" said Stephen, proudly.

"Really? You're in?" asked Molly.

Will nodded; she squealed. "My brother's going to the moon!"

"Congratulations, dear," said Katherine, embracing him.

"This is great news," added Lurleen, embracing and kissing him.

"Thanks, honey," he said to her, feeling genuine warmth in her comment.

"I need to text Taraz!" said Molly.

"Let me send him the announcement," said Will. "It's confidential until Tuesday noon, so that we don't get besieged by the press. Tuesday morning the flight crew is getting a briefing about handling the media. We need to keep it down so no one hears us."

They all looked around; a few others seemed to notice Molly's outburst, but they didn't seem to grasp the significance.

"We have to celebrate tonight," said Molly. "So, how long? Four months? Six?"

"Probably six. Northstar 1 has a three month mission, extendable to four or even five months. Northstar 2 is supposed to stay six months—to be exact, 192 days on the moon, 200 days from launch to return. That way, we'll overlap with Northstar 3 by ten days for transition. Starting in February, Peary Station is supposed to be permanently inhabited."

"And you'll be part of the second crew!" said Molly.

"That's right," said Will, smiling.

"What will you be doing?" asked Katherine.

"That remains to be determined. We'll refine the existing list of priorities and start planning "applications" to achieve them. There's already a very long list of possibilities; I've been proposing expeditions of various lengths for the last year, and some of them were ideas I had as much as four or five years ago. There's a big database of possibilities. Once Northstar 1 returns, we'll have to look at what it accomplished and refine the plans again. But the day by day work schedule will be constantly refined and reorganized; Commander Kimball is modifying it twice a day and spending two hours every night talking to Mission Control about it."

"Amazing," said Katherine. "Do you think we'll every have colonies on the moon? With residents?"

"The big question is the gravity and whether it's healthy, especially for children. We'll know that in a year or two. You wouldn't believe all the health tests we have to undergo!"

"My brother, the guinea pig," said Molly sympathetically.

"That's right."

"Let's cook a big meal in celebration," suggested Will. "I think that'd be more fun than going out."

Taraz skipped a plenary address at the cardiology conference to come home for the celebration. Will was an excellent cook and got very involved in every aspect of the meal, which his father helped with as well. When they sat to eat about 6, they had had three hours of fun together in the kitchen.

It wasn't until 10 p.m. when Will and Lurleen were finally alone. "I hope you really are pleased with this," said Will, while they got ready for bed. "I know it's not the sort of life you had hoped for."

“It isn’t, but I know how important this is for you. We won’t be young forever, and this is something you have to do now. We’ll be able to have children in another six or eight years, after you’ve been to the moon a few times.”

That surprised him; he had never promised to retire from the Astronaut Corps when he reached a certain point. “This is something we need to talk about. Both of us have demanding career plans, and that’s not likely to change at some point in the future. Right now, both of us can work fairly long hours, so if we can coordinate our time better, we should have more time together as well.”

“What? You keep getting called into Mission Control. What can you do about that? Besides, for the next six months you’ll barely be around, and the next six months after that you’ll be on the moon! The best solution, really, is for you to stay here a big chunk of time—several years—while we raise a baby or twins, then resume flying later if you still have the health and radiation quota for it.”

“A couple years? I don’t know whether that’s possible.”

“But that’d be fair, don’t you think? Because I may work long hours sometimes, but at least I’m here.”

“I see. You do travel sometimes, too, remember.”

“Not to the moon!”

“No, not that long or far,” he conceded.

“And another thing to consider,” she added. “You’re about to receive a hefty radiation dosage, and you’re 27 years old, something that could permanently damage your ability to father children. If you were to store sperm here before going up, it would hedge against genetic defects—”

"What? That's not a NASA recommendation. Where did you get that idea?"

"Madhu and Roger are doing it."

"I see. Well, he's been making a lot of flights to low earth orbit, which is more exposed. I don't see any reason to do the same."

"You don't, Will? Come on, I want to have a child with you, and I don't want it to be in bad health! Neither of us can afford the time to raise a handicapped child. As you said, we both have our careers!"

"Look, the flight to the moon lasts only four days, and once I'm there I'll be in a shelter that eventually will have a meter of water shielding it, and maybe a few meters of regolith as well. It's actually a pretty safe environment; much safer than low earth orbit. I won't get that much radiation exposure. Airplane pilots get a similar dosage."

"That's not what I understand."

"Well, we can talk about this more later," he replied. "Look, we can make this work. Astronauts aren't the only group that travels. While we're together, we can plan our time better so we can be with each other more, and while I'm away, you can really spend time at the hospital and get things done. We're not planning to have kids for a few years anyway."

"But when we do have kids, you need to be here!" she replied. "I can't raise them alone!"

"Alright, I understand," he said. "Let's cross that bridge when we get to it. Right now, let's work on improving our time together."

"Whatever," Lurleen replied.

8.

Beginnings and Endings

Tues/Wedn. Sept. 5-6, 2028

Sergei and Paulette were late for breakfast. Kimball was finishing up her omelet and staring at the last sip of coffee in her cup when Paulette appeared, followed by Sergei a minute later. She scowled at him; she was happy to pretend that it was a coincidence they both arrived about the same time—her ears had told her otherwise that night—but delaying the team meeting was another matter.

"I almost started without you," she said. She looked at the schedule that she had emailed to everyone. "Paulette and Kenji are fixing ice transporter 3 this morning and possibly this afternoon. Once it's finished, they'll be trouble shooting the cryogenic refrigerator problem on Cryo Unit 2. Pete is working on TROV 3's broken manipulator arm again; I'm assisting him when I'm not talking to Mission Control, monitoring systems, and making sure lunch and supper are ready. Roger and Sergei are going outside today; they'll check Cryo Units 1, 2, and 3, move 2 so that it doesn't get shadowed by 3, clear a trail to Armstrong RJ, and assess the crater's ice resources."

"It's a small crater—100 meters across—and relatively warm, so the deposit should be pure water ice, though it'll be mixed with a fair amount of dust and reg," explained Roger. "The robotic excavator probably will work a lot longer in RJ's less frigid conditions than in Armstrong BC, so we suspect it'll produce more water."

"And we'll have less maintenance," added Pete. "That'd be great, but I wish I'd get a chance to go outside! I'm getting cabin fever!"

"Sunday," said Kimball.

“But I thought we were making another geology excursion on Sunday,” said Roger.

“Sure; take Pete along,” replied Kimball. “You want to go down to the floor of Peary Crater, right? Impact melt. Pete has training in volcanology.”

“Alright,” said Roger. Generally, he and Pete did not work together; their personalities did not mesh well.

“I’ll come along,” said Kimball. “If anyone else wants to go out, we can schedule a second foray. Roger won’t go out on Sabbath morning anyway, when he’s conducting his webinar Bible study class.”

“We can’t restrict geology to one day a week,” complained Roger. “We’re getting the upper hand on the repair work. Northstar 1 has a lot of geology responsibilities.”

“We’re not gaining on the repair work as much as we want,” added Sergei. “The TROVs and other equipment are being used more intensively than ever before, because we’re here to pull them out of a ditch or fix them if they break. Our very presence is creating work for us.”

“Meanwhile, the geologists in Houston are driving all over Hermite Crater in TROVs 2 and 4 and making all sorts of discoveries,” said Roger. “In some ways, it’s better to be a geologist in Houston than on the moon! They’re collecting samples and we’ll have to haul them back!”

“You’ll get your chance,” said Kimball. “If nothing else, after we return, you can be driving the TROVs around and the team here will be supporting your research! If we continue at this rate, we’ll be cleared for a fourth month, and then we’ll be able to plan some longer expeditions; at least a week.”

“Good, because the ranger needs a proper shakedown,” said Pete.

“Of course, we only have one ranger, so we really can’t go very far,” said Sergei. ‘There’s no proper rescue capacity.”

“But it’s rock solid reliable,” replied Pete. “Hydrogen and oxygen storage in four separate locations, six independently powered wheels, 10 kilowatts of mobile solar power and deployable arrays to make 30 more . . . you’d have to crash it to destroy it.”

“And no one will be driving it down any steep slopes,” added Kimball. “I think we can get clearance for a 7-day trip up to 100 kilometers from the station. A second ranger should arrive in December for Northstar 2, so they won’t have the restriction.” She sighed. “But they’ll be too busy repairing things to send out both rangers.”

They all laughed at that. “Live audio’s off, right?” asked Roger.

Kimball looked around. “Hal, live audio’s off, right?” she asked the shelter’s computer, which they had named for the computer in *2001: A Space Odyssey* after it had misunderstood a command and turned off all the lights in the shelter.

“Yes, it’s off until an order to turn it on or an emergency,” replied Hal, whose voice they had even changed to resemble its famous predecessor. Mission Control had not liked their request for privacy in the Common Room, but had agreed to it.

“Because Mission Control really is worrying too much,” said Roger. “I suppose they call it caution, and I can appreciate that. But the ranger is a very reliable vehicle; they drove it around here under remote control for over a year without any trouble. It’s a work of engineering genius, in my opinion. And we don’t need to be repairing six day a week and exploring on our so called day of rest. Frankly, from what I’ve seen, if they slow down some of the water prospecting and fuel production, they won’t really lose much.”

“There’s an imbalance,” agreed Pete. “We need to do more science and less engineering and repair. Swift’s agenda is making money on lunar propellant and ultimately, reaching Mars. Those are fine goals, but it’s short sighted to send us here and not let us do geology.”

“I know what you mean,” said Kimball. “And I can see your point of view. I’m not sure I can convince Mission Control, though. We can modify our day to day schedule and can assign ourselves extra tasks, but they set the overall priorities, not us.”

“Will you take our request to Mission Control?” asked Roger.

Kimball nodded. “Sure.” She looked around. “Anything else?”

No one had anything to add. Then Sergei said, “I see they’ll announce the Northstar 2 crew at noon today.”

“Yes,” said Kimball. “Anyone hear any rumors?”

No one spoke up. “I wonder whether the Moonman will be selected,” said Pete. “He’s on the short list.”

“No one should be sent here who hasn’t served in low earth orbit first,” said Sergei.

“But the geology skills needed here are useless in LEO,” replied Roger. “I’ve had two assignments on ISS-2, and each time I had to spend months getting electrical engineering training or fluid mechanics training so I could be effective. There’s a category of tasks up here that doesn’t apply in LEO.”

“Still, the Moonman’s been in the Corps only a year,” said Kimball. “That’s not long enough for an assignment like Northstar 2.”

“They’ll send Jerry and Sebastian for sure,” said Kimball. “They’ve both earned it. “And since the next Commander has to be a European, it’ll probably be Sebastian. That’s my guess.” She looked around. “Okay, let’s get to work.”

They all rose and headed for their stations. “Are you coming to sick bay for the blood samples?” Kenji asked Kimball. He had nurse training and handled basic medical care.

“Oh, sure,” she said. Tuesday morning was her turn. She followed him to the far end of the shelter, where the geology lab was on the right side and the spiral stair and sick bay were on the left side. She sat while he took her blood pressure; her ear piece continually monitored pulse and oxygenation. He pulled out a needle and drew the blood sample.

“And all is well with you?” asked Kenji. He usually asked standard wellness questions also.

“Yeah, sure. A lot of stress, as you know.”

“I think you’re leading us well, Kimball.”

“Thanks, Kenji, I appreciate that. I really can’t get good feedback from anyone up here or from anyone in Mission Control.”

“I know what you mean; it’s hard to be sure why someone is saying what they say to you. But I’m trying to speak as a physician, here, even if I’m really not. You’ve been decisive, you’ve handled difficult issues smoothly, you’ve resolved social tensions well, and you’ve offered us vision when we needed a sense of the big picture.”

“Thanks. I’m not sure what to do about a certain couple, who possibly have come to you for birth control pills.”

“I . . . I’m not sure I should say anything, but I don’t see any disturbance to the social fabric up here.”

“No, not yet.”

“If there’s anything that worries me, Kimball, it’s your loneliness.”

"Loneliness?" She didn't dare sound defensive or reveal any feelings in response to his comment. She kept her voice neutrally inquisitive.

"Loneliness. When the five of us gather in the commons to talk or watch tv together or play cards, you stay in your room. I know you talk to Mission Control, and maybe occasionally with your brother, but that's it. Come out and laugh with us! I think the atmosphere of the station would be much better if you did. It'd be better for you, too."

That startled her and at first she was put off by his comment. "I'll think about it, Kenji," she finally said.

"Congratulations, Will, for the assignment," David Alaoui said, when the two men saw each other at the briefing on Tuesday morning. "It's quite an achievement. You'll be the youngest man ever to go to the moon, and the first one in this era to have never flown in space before."

"Thanks, David." Will accepted David's handshake. "I'm sorry you didn't get included. It would have been fun to go to the moon together! They don't include many geologists, ironically enough!"

"No, they don't. But I'll tell you, I doubted I would have been included. Paulette's from France, and ESA has only two slots on this flight. They wouldn't have given it to a Frenchman. The odds are made even slimmer because both ESA and NASA are trying to assign one of the slots to a woman. If no women are included, an all-male crew looks sexist, and if only one is included, it is difficult for that woman. Japan, Canada, Brazil, Russia, India, and the other partners have relatively few women they could nominate." David shrugged. "Looks like I'll fly on Northstar 3, though, and that's pretty exciting!"

"Yes, it is, and they'll overlap, so we will see each other on the moon. How did your family take the news?"

"They were disappointed, but it also means that after a month here, I get to go home. The boys really miss me. What did your family think?"

"My parents, sister, and brother in law happen to be visiting us right now; in fact, I'm missing their flight home to be here this morning. They were thrilled. My wife's reaction was interesting; she clearly is trying to be supportive and not look too concerned about my being away or being in danger or being harmed by radiation. But those are uppermost in her mind."

"I can't blame her, there. It's dangerous. And you don't have any children yet, right? I'd worry about the impact of radiation, too."

"She wants me to use a sperm bank!"

"That's probably a wise precaution."

"Hey Will, congratulations!" exclaimed Jerry McCord, approaching the two of them. He held out his hand.

"Thanks, Jerry." They shook hands. "I'm looking forward to flying with you."

"Thanks, I'm looking forward to the mission with you, also. And you're what; 27? What incredible luck, going to the moon at age 27! I didn't go into space until I was 35, and it looks like I'll be celebrating my 40th birthday at Peary Station!"

"I'll bake you a big birthday cake then, Jerry! Because one thing I'm hoping we'll manage to bring along is cooking supplies. I'm a pretty good gourmet cook, and it looks like Northstar 1 is getting bored with NASA TV dinners."

"I don't think you can do much cooking at Peary. The low air pressure, the odors . . . it'd be a real problem."

"Well, there's only one way to find out."

"Alright, so we'll have a cook with us! That's great! Come on, come up front and sit with the rest of the crew, they'll be starting in a minute."

"I will. I don't see Sebastian; where's he?"

"He won't be here today," said David. "He had to fly back to Germany on Thursday. You know that U.N. peace keeper hostage situation in Equatoria? The U.N. negotiator was taken hostage, too, on Wednesday; Christian Langlais, Sebastian's older brother."

"Oh, no! I heard he was taken hostage, but I had no idea he was related! I was wondering, though; how many Germans could there be with a good French last name like Langlais?"

David laughed at that. "More than you think; there are plenty of Germans with French, Italian, Dutch, Polish, even Turkish last names! Just like me, a Frenchman with a Moroccan last name, or Sergei Landsberg up at Peary, a Russian with a German last name!"

"You're right; the world is mixing. How terrible for Sebastian. I hope the hostage situation is resolved soon."

"French paratroopers were on their way last night," said David. "So I suspect it will end soon."

"Let's get up front," said Jerry.

Will nodded and accompanied McCord to the front, where the other three members of Northstar 2 were already standing. They all shook hand and hugged, excited to think about their mission. "I can't imagine the surface of the moon!" exclaimed Silvia.

"No?" said Jerry. "God, I think I can walk around Peary Station in my dreams!"

"I'm an expert in fixing TROVs, not driving them," replied Silvia.

"After this over, come down to the TROV control area and we'll teach you how to control one," offered Will. "In a few hours of 3-D driving, you'll be able to picture the whole area."

"That would be great," said Silvia. "I'll have to learn how to drive a TROV, and I'll have to teach you all how to fix them!"

Just then the Director of the Northstar Project, Dr. Redding Desmarais, called the meeting to order. They hurried to sit. "This is a day of great excitement for all of us," he began. "In a minute I will introduce five members of the Northstar crew, so we can greet them and wish them our prayers and blessings. But first I must acknowledge the absence of the Commander, Sebastian Langlais, and reveal the terribly sad news that we have just received; news that required confirmation, hence the delay in starting this meeting. Sebastian's brother, Christian Langlais, the brave United Nations negotiator who sought valiantly to free twenty-five UN peacekeepers from the captivity of the Lashkarul-Equatoria terrorists, who himself was taken captive by that same group, was killed when the French stormed the compound an hour ago. Ten of the peace keeping troops and twenty-six terrorists have also been killed." He paused while everyone digested the news. "Let us pause for a minute of silence in honor of Christian, the honored dead, his brother Sebastian, and the family."

The auditorium fell silent as everyone bowed their heads.

"Thank you," said the Director. "We do not yet know whether this will prevent Sebastian's participation in Northstar 2. We anticipate he will not be available for at least a week or two. Our thoughts and prayers go out to him and his family."

Will turned to Jerry and Silvia. "We live in a crazy world," he said.

"I'm glad we're going to the moon," replied Jerry.

"I'm sorry Will couldn't come to say goodbye to you," Lurleen said to Katherine, Stephen, Molly, and Taraz, as they prepared to pass through airport security.

"Don't apologize for it, dear," said Katherine. "He had the best reason in the world for it; he has the privilege of doing something he loves and something that is very, very difficult to accomplish. While he is in training and away, you will have opportunities to excel at your career. He will return and both of you will have accomplished marvelous and wondrous things."

Lurleen smiled at that. "Thank you, Katherine. I don't think my own parents could be more encouraging and loving than you have been to me in the last three days."

"You're my daughter in law and love you very much." Katherine gave Lurleen one last hug and kiss. That gave Lurleen a tear in one eye.

"Lurleen dear, I don't know why you want to apologize for Will when we are happy he is where he is," added Stephen. "I just wish you were happier about it as well."

"I'll try." She kissed her father in law.

"We'll try to get back even when there is no cardiology conference," said Taraz, giving her a hug.

"We'll see you again," added Molly. Then the four of them walked into security and waved goodbye.

"Well, we tried," said Stephen to Katherine later, when they were approaching the gate.

"We did," she agreed. "They'll have to work it out themselves. It won't be easy, I'm afraid."

It was an exciting bridge game. Pete and Roger fancied themselves bridge experts and were very competitive. Paulette and Sergei were fairly good, but let their partners take the lead whenever they could. Kenji tended to watch with one eye and occasionally commented, while reading *Asahi Shimbun,* a leading Japanese newspaper.

Kimball wandered into the evening bridge game in the commons about half way through. She stood behind Paulette, listening and looking at her colleague's hand. At one point she pointed to a card in Paulette's hand. Nodding, Paulette played the card, causing sounds of shock from Pete and elation from Roger. Pete tossed in his hand.

"I didn't know you knew bridge!" said Pete, a bit irritated.

"I used to play a lot in my Air Force days," replied Kimball. She pulled up a chair and sat behind Paulette. Kenji glanced at her and smiled. "I'll be glad to be someone's partner, in a game or two."

"You can replace me!" replied Paulette. "This is not my game."

"Alright." The women switched places.

"I thought you usually talked to Mission Control at this time," said Roger.

"We talked early tonight; they're all partying about Northstar 2."

"You guessed right about Jerry and Sebastian," said Pete appreciatively.

"I know something about the politics. Mission Control is also becoming tired of staying in late to talk with me after our work day is over, so from now on we plan to talk at 1 p.m., half way through each work day. That should work fine in terms of planning and will be more convenient for them. It'll also give me freer evenings."

"Did you ask them about the heavy focus on engineering and water production?" asked Roger.

"I did; in fact, right after supper I talked to the two big bosses, Stetson and Swift. They agreed that we had made enough progress on the mission's goals so that we could look at a four-month stay and aim to accomplish the nominal mission plus more. The 'more' primarily is geology. From now on, we can work six days a week, including one day for geology. That's six person-days for geology every week; that could be one person doing it full time, for example, or two day-long excursions involving three people each. Sundays are now a real day of rest, unless we want to do more out of the goodness of our hearts."

"That's fantastic!" exclaimed Roger. "Thank you so much for talking to them!"

"We're well on our way to getting the system up to its main production goals of 270 tonnes of water and 120 tonnes of LOX/LH_2 propellant per year, which will support two crewed flights and one 14-tonne cargo flight. Furthermore, as you know, Peary Resources has committed to two more Thunderbird Heavy launches to increase capacity by a third, so that guarantees sufficient propellant for the transportation system. They still think that once we get past the set-up phase and catch up on deferred maintenance, the fuel production system will require no more than two full-time engineers and the station will require one full time maintenance specialist, leaving three positions for lunar exploration. Consequently, they're willing to start increasing the geological component of Northstar 1."

"Fantastic!" said Pete. "I'd hate to see all the good objectives left to Northstar 2!"

"Me, too!" agreed Roger.

"No, we'll get to do some good science," replied Kimball. "Now, let's play a round of bridge. I haven't played in ages."

“I’m sorry we never got to show you the TROV control area yesterday,” Will said to Silvia Ferreira the next morning. “I thought for sure we’d have the whole afternoon free after the briefing.”

“No problem,” she replied.

“When did the press finally leave you guys alone?” asked David, when he saw that Silvia was immediately appraising the equipment.

Will laughed. “Well, they still haven’t! I’ve been getting emails via my old Brown University mail address—how they got that, I don’t know—messages via all my social media sites, texts on my phone, and even a few calls in the middle of the night on the home phone, which is in Lurleen’s name. The media relations folks were right; we have to refuse to answer all of those queries and let everything get filtered through NASA headquarters, or we’ll never get any privacy.”

“Yes, that’s good advice. Do you want to go out jogging tomorrow morning?”

“Yes, I think everything will have settled down toward normal by then.”

“Oh, you guys jog? Where?” asked Silvia.

“We have a standard route,” replied Will. “We go from the hotel on a five mile route, starting at 6 a.m., and get back about 6:45. Then we shower in the fitness club and come to work.”

“Could I go along some time? I need exercise.”

“Of course, that’d be fine,” replied Will.

Silvia walked up to a TROV station and sat down. “This is standard just like the video games.”

"Same technology; they've really perfected it," agreed Will. "You have to log in and enter passwords to access a TROV, though. I'll show you." He leaned in and pointed to a drop down menu that showed all six of the Prospector-350 TROVs and their status; one was being driven by someone at Moscow State University at the moment, another from Singapore Institute of Technology, and a third from Massachusetts Institute of Technology's Dubai campus. She selected a fourth one and he showed her how to log in. Silvia put on the virtual reality helmet and smiled broadly. "The 3-D is really perfect!"

"Isn't it incredible? I just wish there was no 3 second time delay. But when you start to move forward, you'll see lines that represent where the TROV will be if you make a decision, so you can watch the lines and steer appropriately. The software will even project where the TROV will move accordingly."

"Very nice." She started the TROV forward and practiced movement a minute. "I have twenty-five kilowatt hours of power; that's what, twelve hours?"

"Roughly, depending on speed and other usages, like the cameras and the laser. You'll probably zap a lot of rocks until you adjust and get a sense of what you're looking at. The infrared and ultraviolet cameras help immensely; you can see a lot of stuff you never would if you were actually there."

"So which is better?"

"Being there, I'd guess!" replied Will.

"Actually, I'd say both forms of presence have their advantages," added David.

"The TROVs can go into the permanently shadowed areas more easily, in some ways," agreed Will. "They can see with less light, which is important, because enough light to see colors with the naked eye is enough energy to vaporize the ices in the deeply cold traps. The TROVs

don't last so long in the cold traps, though, because the Americium heaters are inadequate and the battery-powered heaters kick in."

"How long will the batteries last in a cold trap?"

"As little as six hours."

Silvia nodded and began to move the TROV forward across the pock-marked Armstrong Plateau near the shelter. She drove into a small crater, picked up a rock, and brought it close to a camera, where she examined it in ultraviolet, infrared, and ordinary light.

"Fascinating," she said. "But I have no idea what to look for."

"You need to learn geology," replied David. "That takes longer! But if we go out together, I can pick up rocks, pass them to your TROV, and tell you what you're seeing. Since I'm not on Northstar 2, I have the time."

"That'd be great."

Just then, the smart phones in the pockets of all three of them vibrated at once. Will looked around, astonished. Then they all pulled out their phones and read the text from Mission Control.

We must sadly report that Sebastian Langlais has withdrawn from the Northstar 2 Mission. He has returned to the short list for Northstar 3 and may be considered for that mission next summer. He needs to devote the next two months to his family and participation in the investigation of his brother's murder by the Equatorian Lashkar terrorists. Our hearts go out to him and his family in this time of grief.

Jerry McCord is promoted to Commander of Northstar 2. Replacing Sebastian on the team will be Dr. David Alaoui of France.

Will looked at David, astonished. David took a few additional seconds to finish the message and looked at Will and Silvia. “I’m going to the moon with you!”

“You are!” exclaimed Will, very pleased.

“Félicitations, mon ami,” said Silvia.

“Congratulations, my friend,” added Will, translating into English.

9.

Thanksgiving

Late November, 2028

"So, Will, how are you celebrating Thanksgiving?" asked Jerry McCord.

Will looked up from his book manuscript on the depositional history of volatiles at the lunar North Pole. "Lurleen and I are going to my parents' house in Stamford, Connecticut. Lurleen's family is in Providence, so we'll go visit them as well."

"With this impending government shut down, you could easily leave a few days early."

"I suppose, but the fact is that I have to finish editing this book, shut down or not."

"But you aren't supposed to come in."

"I can do most of my work from home anyway. If the shut down lasts long enough, we'll stay in New England. I can always drive TROVs from the Lincoln Field Building at Brown University!"

Jerry chuckled. "As their most famous planetary science alum, I suppose they'd let you."

"This whole 'shut down' situation is really crazy," exclaimed David. "And very inconvenient for the four of us who aren't Americans, since our pay will continue, but we won't be able to come to Johnson Spaceflight Center, unless we're declared 'essential'!"

Jerry shrugged. "I know. Our politics has gotten more and more poisonous. Two members of the House of Representatives beating each other up so badly they both had to go to the hospital: that's absolutely ridiculous."

"It's reminiscent of the fight in the Senate on the eve of the Civil War," said Will. "It's a dysfunctional system."

“And I know, you Bahá'ís don’t do nomination and campaigning, so you don’t have these problems,” said Jerry. “That’s not practical for the whole United States, though.”

“Oh, is your Bahá'í cousin bothering you again?” asked Will. “Because I wasn’t planning to say anything about that. I agree, you could never switch an entire country over to our system, not quickly, anyway. You’d have to start small. No one here is ready for that.”

“We could all use a more peaceful way to govern ourselves, though,” said David. ‘That’s for sure. You don’t really have secret campaigning in the Bahá'í community?”

“No; anyone caught would be declared ineligible to be elected,” replied Will. “But getting back to the shut down, I suggest we get together at the hotel where the four non US crew are staying. There’s plenty of room there to plan things together, teach other, etc.”

“I think that’s a great idea,” said David. “I’ll tell the others.”

Jerry shook his head. “No, if I’m told I’m furloughed, I’m not going to rock the boat.”

“Well, what about this,” suggested Will. “We need more informal time together, just to get to know each other and become a team. Bowling would do that. I’m not suggesting we go bowling, but there are many other similar things we could do together. Would you come to the hotel and do something fun with us?”

Jerry considered. “Maybe that would work. That’s not a bad idea, Will.”

“Thanks.”

“Even if the six of us sat together and just talked about our lives, that would be good,” said David. “Some of us have spouses and children here. We could eat together with the families, too.”

“Alright,” said Jerry, though he sounded reluctant.

“Before the day ends, can you email and ask about my requests?” said Will.

"Oh, I heard this morning," replied Jerry. "I think your request to make one fresh meal per week has insulted every food specialist in NASA, who fancy themselves our gourmet lunar chefs at a distance. They are skeptical you can figure out how to cook on the moon at all, which is ridiculous; I agree with you, there. But Mission Control has approved your request, or maybe I should say my request, since I added my 'weight' to it. We'll be getting ten kilos each of rice, pasta, flour, various frozen vegetables, frozen meats, dried potatoes, couscous, cheeses, powdered milk, etc."

"Fantastic! What about spices?"

Jerry nodded. "Some, but they cut back on your request. They said if it isn't enough, you can always add a few kilos in your personal weight allocation."

"What? I have to include spices in my luggage, instead of clothes?"

"That's what they said. I have an email listing the approved items."

"It's against regulations to ship spices and plant products in my luggage, though."

"I asked them about that and they said not to worry about the regs. They were being very careful with Northstar 1; we didn't know how well the complex life support systems would work in lunar gravity. But everything is nominal, so they are relaxing a lot of restrictions. No smoking, obviously!"

"The moon is a no-smoking world," quipped Will.

"Of course, Sergei seems to have slipped a lot of vodka into his luggage, that was against regs, and no one is complaining," noted David.

"Yeah, I think they're drinking bottle number four up there! I may bring a bottle or two of champagne. Of course, with a Muslim and a Bahá'í on board, the booze will last longer!"

Will and David laughed at that. “I’ll see whether I can add a few things to my personal weight allocation,” Will said. “I’m hoping to go to the moon several times, so I may leave some things there, which will make my luggage lighter in the future.”

“You’re about the same size as Pete,” said David. “Maybe if he leaves a few things there—a sweater or sweatshirt, for example—you could use them and take fewer things up with you.”

“Good idea. I’ll email him,” said Will.

It was a long drive from Hermite Crater back to Peary Station; some 100 kilometers, which took three hours. The track was well worn into the sandy lunar regolith and they followed it closely, since they knew it had no hidden rocks or holes. When the station hove into view, Roger and Sergei almost cheered.

“It’ll be good to be home, after four days,” noted Roger.

“Home for just another week,” added Sergei. “Hard to believe we’ve been up here for four months.”

“It is. Time has flown by. We’ve been busy.”

“Are you feeling better about geology?”

“Definitely. I wish we had been able to go out for a week; we would have been able to get much farther. We never got beyond 86.5 north. But the polar area still has a million mysteries and it was well worth exploring in detail.”

“Certainly. And by taking two TROVs out with us, they got much farther from the landing site than they ever could have by themselves.”

"Swift has to be pleased. We visited and sampled more cold traps in three days than the TROVs managed in three years. When I get back to Houston, I'll need months to write it all up."

"We'll certainly have a solid report about cryogenic resources. They could be worth billions."

Roger chuckled at that. "Assuming the water can be sent to low Earth orbit more cheaply than it can be hauled up from the Earth using reusable stages. That's the flaw in the whole system. I'm skeptical."

"Of course, the same reusable stages can haul water to LEO from the moon, and for much less energy."

"True, but unless the volume is there, it won't be cheaper, because the technology of mining and refining it here, and keeping a maintenance crew here, is pretty expensive."

"But NASA and the other space agencies have absorbed a lot of the set-up cost."

"Enough of it?"

Sergei shrugged. "I don't know. I'm not an economist."

"I hope Swift has some sharp economists on his team." Roger looked at the shelter closely. "Boy, look at all the dust on the shelter! It's gray instead of white!"

"We should blow it off with a spray of gas, or brush it off. Our operations kick up a lot of dust." Sergei pointed to an area that looked puffed out. "Looks like they added a lot more water. They had twenty tonnes ready, before we left."

"With staff to monitor actively, the water production system has been able to produce almost twice as much. Northstar 2 will be able to finish filling the radiation shield and be done with it."

Roger drove past the shelter to the TROV station and backed up against the little building. Magnetic latches grabbed the trailer to hold it in place and connect it to the building's electric connections, so that the two TROVs on the trailer could recharge. Roger released the trailer and drove around to the east side of the shelter. He slowly backed the ranger against its main airlock. It also used magnetic latches to pull the ranger into alignment. Once they achieved a soft dock, a series of hard docking latches slipped in place to lock the vehicle in place and the space between the two pressure doors was pressurized. In two minutes the light over the door in the rear of the cab turned green and Sergei began the process of opening it. The other four crew members waited on the other side.

"Welcome home!" said Kimball, as Roger and Sergei stepped through.

"Thank you!" replied Roger. "It was quite an expedition!"

"Yeah, you got to a 30 degree Kelvin cold trap," said Pete. "Quite an achievement!"

"Colder than the surface of Pluto, and my boots even stayed together!" said Sergei.

"We only stayed in that cold trap ten minutes," added Roger. "Pretty dangerous; just long enough to collect an ice sample."

"But worth it; it had more nitrogen and carbon monoxide than any other sample we've obtained," said Kimball.

"Still; not much nitrogen or ammonia," said Roger.

Kimball shrugged. "Between nitrogen and ammonia, almost one part per thousand, so that cold trap has dozens of tonnes of nitrogen. The big confirmation is the availability of carbon; enough to make methane for the Mars transportation system. That was a key research question Swift wanted us to answer. Come up to the common room, we've got a big lasagna dinner ready to eat."

“Great,” said Roger. They followed Kimball up the spiral stairs into the science area and walked down the corridor to the commons. Paulette and Kenji were setting the table.

“Welcome back!” they both said. Paulette walked over to Sergei and gave him a quick kiss on the cheek, trying to look just friendly but not completely succeeding. He smiled back. Kenji was right behind, shaking hands with both men.

“Very successful!” he said. “From here to Hermite Crater, around its floor, and back; a long trip!”

“And the ranger was great,” added Roger. “No problems. They built it really well.”

“I was impressed when Kenji and I took it out for three days,” agreed Pete. “We’ve laid a good foundation for Northstar 2.”

“Let’s sit,” said Kimball. She sat and pointed to the chairs around her. “Before we eat, let’s remember what we have accomplished. It’s a lot, and we’ve done it together, so I want to thank all of you for your contributions. We’ve set up Peary Station and got everything functioning, including a year of accumulated broken parts and equipment. That took a lot of our time and especially our ingenuity; we fixed a lot of profoundly broken items! Our three cryo units and their supporting equipment are now working at 120 percent of nominal capacity; the water production system is running at 150 percent. We’ve explored and sampled 104 cold traps, big and small, the coldest ones being colder than the surface of Pluto. As a result, we have confirmed that the polar areas have enough carbon and nitrogen for a substantial settlement. In the future, we’ll be able to use the cold traps to test materials and equipment under extreme conditions, preparing for visits to the poles of Mercury and Mars, to asteroids, and to icy moons of the giant planets. We have also explored over a thousand square kilometers of lunar surface, mostly in the last month. We have a lot to be proud of.”

"We do," agreed Sergei.

"More geology would have been good," commented Roger.

"We've laid the foundation for that," said Kimball. "Our mission is historic. We set up the toehold, and the toehold can be done the first time only once. We did it the first time. Northstar 2 may cover more ground, but they'll have fewer firsts."

Pete looked at Roger. "I don't think you should complain about the paucity of geology. We've completed 43 days of excursions and you've been in charge of 17 of them. Of the 24 excursions, you've led 11 of them."

"Well, that's up to the commander and mission control, not me, but I do have a Ph.D. in the subject."

"Pete and Sergei, you've both commanded, and you've done a good job," said Kimball, cutting off the discussion. "Pete, as you gain more geological experience, you'll be a great excursion leader."

"We'll all be back," added Sergei. "This place is permanent. Humanity has come to the moon to stay."

"Assume the U.S. government shut down doesn't crash the terrestrial economy," said Pete.

Roger scowled at him. "We're a vibrant democracy with differences about policy. Don't worry about the U.S."

"At least we're working," said Sergei.

"We're 'essential,'" replied Pete.

"Look, these shut downs happen periodically, and everything has always worked out," said Roger. "They're an inconvenience only."

“It’s more than inconvenience for us; half of Mission Control’s unavailable,” replied Paulette.

“I couldn’t get medical support for blood samples yesterday,” added Kenji.

“At least they won’t complain about my last bottle of vodka,” quipped Sergei.

“At least you haven’t tanked the world economy,” replied Pete. “But you’re giving democracy a bad name! Everyone looks at the chaos in the United States and says, ‘can’t they behave better than that? Can’t they manage their affairs better than that?’ It’s ridiculous. The richest country in the world, still, and you can’t even give medical care to everyone, you have a ridiculous murder rate . . . I’m glad my parents moved from Greece to Canada!”

“I’m glad they did, too,” replied Roger.

“Enough of this!” said Kimball. “Let’s not take out our frustrations about the situation at Mission Control on each other! The food’s getting cold, so let’s eat!”

“Here, here!” agreed Sergei and Paulette almost at once.

“Okay,” said Roger with a smile, and Pete nodded. Kenji pulled the lasagna from the middle of the table and dished some out for Pete, who sat to his right, and Pete did the same for Paulette, for that had become their custom. They went around and soon conversation started up again on more positive topics.

“So: Day 6. How long do these government shutdowns usually last?” David asked Will.

“It varies. We’re averaging one per year, now, and they have lasted as much as a month. It’s a very disruptive, inefficient, immature way to settle political disputes,” replied Will.

“You can say that again. It’s becoming very inconvenient,” said Silvia. “I needed a form completed to enroll my son in school and I couldn’t get it filled out.”

“And I was asked to speak to a class at University of Houston Clear Lake and they had to cancel it because of some sort of budget cutback,” said Kalidas Sharma.

“And it’s disrupting our training hugely,” concluded Larisa Tatarinov. “I wish Jerry would ignore the shut down and come join us.”

“Technically, that would be illegal, but I don’t think anyone will care,” said Will. He held up a scroll. “I bet no one has seen this before.” He put it down on the floor and unrolled an absolutely enormous map of the northern quadrant of the near side of the moon.

“Wow!” said David, immediately moving in to look closely at it. “This is a piece of art!”

“This is an old United States Geological Survey map. You can still buy them, but with electronic versions, no one bothers.”

“Frame it and it would make a good piece of art,” said Larisa.

“They were artists,” agreed Will. He pointed to the very pole. “It’s pretty hard to see the routes of various expeditions that have been proposed because the pole is so foreshortened.”

“Yes, I think only one of them comes below 85 degrees north,” said David. “And it is a shame, considering how much there is to explore.”

“It is.” Will looked at David. “I wonder whether we can change that at all.”

“That would be great, but Mission Control is limiting the expeditions.”

“Do you have an idea?” asked Kalidas.

“Hum. I do.” Will pointed to the map. “Let us say we do a four-day expedition; that’s all Mission Control has allowed so far. We head south along the eastern limb of the moon for two days, loop westward, then head back north to Peary. Then, let us say they allow a five-day expedition, because they have more confidence in the equipment. We drive straight down the return track of the first expedition, but quickly; extend it farther south; then loop to the west and

return. Each time we go south, we follow an old track quickly, go down farther, and create a new return track."

"How far?" asked Kalidas.

"Until we reach Mare Frigoris, I suppose," said Will. "That's the point when we exit from the highlands and enter the maria. We would have traversed the entire highlands unit along the northern edge of the moon."

"There's only one problem," pointed out David. "Mare Frigoris is a thousand kilometers from Peary. The rangers have a total range of about a thousand kilometers."

"That's true," said Will. "But we may be able to extend their range with solar cells and additional hydrogen-oxygen tanks."

"We could also send a lander down with fuel," said Larisa. "There are studies that propose refueling expeditions that way."

"True," said Will.

"But we'd only have two weeks of dayspan; would that be enough time?" asked Kalidas.

"As long as the Earth is at least half full, you can do adequate research in earthlight," replied David.

"We'd have more daylight, too, if we travel west as well as south," replied Will. "The moon rotates at the rate of 4 meters per second at the equator, or about 14 kilometers per hour. At sixty degrees north, it's seven kilometers per hour. Let's say we had a three week expedition, one week to move southward at two hundred kilometers per day and two weeks to move west and north at one hundred kilometers per day. We could travel 1,400 kilometers out and 1,400 kilometers back. That'd get us to the northern edge of Mare Imbrium."

"Let's explore this idea," said David. He pulled a big sheet of electronic paper—over a meter square, the largest size commercially available—across the table to a spot in front of the five of them, while Will rolled up the paper map. David pushed some icons and projected a detailed map of the north polar region onto the paper. They could change the scale with a separation of two fingers, double click on a crater to pop up data about it, and click on icons to add altitude lines, temperature data, and information about mineral composition. Will began to trace a southward line with his finger—leaving a red line on the map—and David amplified with references to cold traps, unusual mineral concentrations, and other geological phenomena. Both men had proposed dozens of short expeditions, sometimes involving a lander flight, and some of the short expeditions could be strung together to make longer ones. Larisa noted potential landing spots for refueling; the idea was to always have enough fuel to make it home. Silvia, knowing the least about the geology, pushed them to justify particular stops and detours. Kalidas asked about spare parts that might be needed and what the composition of the team would be, for presumably they'd involved three crew and two rangers.

They soon lost track of the time as they extended a series of loops to Mare Frigoris, chose a spot for a temporary outpost, and flew expeditions to the outpost to extend the track farther south into Imbrium. They knew that was too ambitious for the four-mission Northstar project, which aimed only for two rangers, two landers, and a crew of six on the moon; but if a third lander, a third ranger, and at least three more crew were available at some point in the future, a temporary outpost would become practical. They considered an alternative strategy of setting up solar powered refueling stations every few hundred kilometers along a main route instead, so that fuel would always be available for an expedition and landers would not be necessary. If the funding for such a system were available, an expedition could drive up or down the route even

during the two-week nightspan. Theoretically, a ranger could drive itself on a preexisting trail, safely and automatically, at least thirty kilometers per hour, which equaled 720 kilometers per day. At that rate, the equator was reachable in three days.

There were many possibilities for the future; which was best depended on funding and technological improvements. Kalidas knew the theoretical capacities of rangers well; Silvia could estimate the costs and capabilities of recharging stations; Larisa had strong general knowledge and was full ideas; so if nothing else, it proved a useful bonding exercise. They were all startled by a voice calling, "are you ready for some lunch?"

"Oh, Madhu, thank you!" exclaimed Kalidas. "I forgot to tell everyone about your offer to provide us lunch! She and I were talking last night!"

"I thought that with all the cafeterias closed because of the government shutdown, the least I could do is cook you something," Madhu Anderson replied. "Oh, Will, good to see you as well. Are you working anyway?"

"Not officially," replied Will. "More like brainstorming. Jerry didn't come."

"Well, there is a shut down." Madhu entered the room and placed a big bag on the end of the table while they turned off and rolled up the e-paper. "I hope you all like Indian food. Kalidas said he missed a good home-cooked Indian meal."

"That'll be marvelous!" said Larisa. "Please stay and eat with us."

"I have some time; I'm going to my church this afternoon at 2:30 to assist with an afterschool tutoring effort. Thank you, I'd love to." Madhu pulled out six plates and cutlery—she had brought enough—and several large plastic containers full of rice, samosas, and a spicy chicken dish. They eagerly helped her distribute the food.

"How's Roger?" asked Will.

"I talked to him early this morning. He's fine. As I'm sure you know, he just got back from a four-day expedition and was very pleased with the result."

"Will and I were driving the TROVs part of the time," said David. "It was a great expedition."

"I keep forgetting you can be on an expedition and still be here. He was thrilled, but I think he wishes he were on Northstar 2 as well! If he had his way, I'm not sure he'd ever come live with me!"

"It gets in your blood," agreed Will.

"Well, some of us are more dedicated than others, Will," replied Larisa.

"He keeps saying I should apply for the astronaut corps; what a ridiculous idea! I have to admit, it would be fun, but there's no need for a nutrition scientist on the moon."

"But there is need for a cook!" replied Will. "Or maybe I should say, 'in my opinion' there is such a need. I gather my request for spices and items to prepare meals with has upset some of the food scientists."

Madhu smiled. "It has indeed! As far as they are concerned, they can make such fantastic frozen and dehydrated meals for you, all you need is a microwave to enjoy gourmet productions. The quality of the food has indeed gotten pretty good, too. Roger has given us a lot of feedback; he has a sensitive nose and palate. We tested him with two dozen dishes before he left, so that we could compare his reports on the moon with his observations here. Cooking would be very tricky, Will. The air pressure in the shelter is 33 kilopascals instead of the earth's standard 101. Aromas don't smell the same at lower air pressure; the low humidity of the shelter also affects them. The smell of the food is half the taste, too. Water boils at 70 Celsius rather than 100, so

cooking times are longer. Bread rises faster, so you need to modify recipes to slow down the rise and bring out the flavor. Cakes rise too fast and collapse."

"Madhu, I knew all that after five minutes of research on the web," replied Will. "What I need is a few hours of professional advice ahead of time and live advice when I'm actually cooking. Think of the challenge! My request to do some cooking is not a negative comment on the products of you and your colleagues. They're great. But you're from India; you know that food and cooking are about more than nutrition. They're part of the culture of a community, part of its socializing, a big part of its glue. Someday, there will be a greenhouse at Peary Station. It'll be there for all sorts of reasons; it'll be cheaper to grow food there than to ship it from Earth; fresh fruits and vegetables taste better than preserved ones; humans crave greenery; etc. We'll need to start cooking up there some time."

"Ah, what you say is so true." She leaned back in her chair, suddenly realizing that the entire food supply plan had been missing a key element.

"What are you going to cook on?" asked Kalidas. "The galley just has a microwave."

"No, it has a hot plate as well, though it is unused. If I could get a pressure cooker added to the cargo manifest, that'd help. It doesn't have an oven, but the science lab has several." He smiled at the thought of baking bread in one. Larisa laughed at the idea of a pressure cooker.

"That would work," agreed Madhu. "Will, I must say, I am intrigued! You are so right; we're looking at food in such a narrow, scientific way. It's sad, really! I'll talk to my colleagues."

"Thank you!"

“And I’ll get you help. I bet we can find experts on high altitude cooking, though their altitude would never be high enough; the air pressure in the shelter is exactly equal to the air pressure on top of Mount Everest! But we can make some educated guesses and help you out.”

“Great. We need to refine some of my menus, too. And I’ll need olive oil; that request was turned down.”

“I bet we can get that fixed.”

10.

The New Antarctica

Late February 2029

She had long, white hair in hippie style braids. Will looked at her, sure he had met her before, but unable to place the face. She had waited patiently for half an hour while a crowd of fans and curiosity seekers had swirled around him to shake hands and ask questions.

"I'm so glad you finally got to the Houston Bahá'í Center to give the long-promised talk about space exploration," she said, when her turn came.

He recognized the voice and that helped with the face. "Linda Newport! I haven't seen you in what; ten years?"

"That's right, I left Providence in 2018 for Brownsville. You should come down and give a talk! The Bahá'ís could sponsor it and we'd get great publicity. But more important, you could come and talk to my kids. I have a big children's class in my house twice a week. I moved into a poor neighborhood, bought the vacant lot next to mine, and converted it into a big organic garden. The kids help me in the garden and they take the vegetables home to their parents. They often don't have access to vegetables otherwise. Their parents buy packaged, *dead* food! My kids would be very inspired to meet an astronaut. I think you could encourage some of them to consider going into the sciences."

"That'd be great, Linda. We don't have enough blacks and Hispanics in the sciences, and I suspect your kids are one or the other."

"Hispanic. You're part Hispanic, right? How's your Spanish?

"My Spanish is terrible. My mother's mother was from Veracruz, but I never learned practically any Spanish as a kid. But I studied some Spanish in school."

"Even a little would impress them. When can you come?"

"Not for a while; I launch to the moon in ten days! But after I come back, it may be possible. One problem is that my wife isn't a Bahá'í. I work very long hours at Johnson Spaceflight Center, so she's very jealous of my spare time. She's not here tonight; she had said she'd come, but backed out an hour before leaving the house. As a result, it's hard for me to travel and give talks to anyone; engineering and science students, Bahá'ís, anyone."

"That's a shame, because you have name recognition; I follow you in the media! I'm so proud of everything you've done, Will! You could interest thousands of people in the Faith."

"I know, and I hope I will have the chance to give more talks. But it's complicated."

"I understand. Say, I saw the piece on CNN yesterday about how you want to cook food on the moon. Thank God for that! As you may remember, I was a vegan back in Rhode Island. Now all I eat is fresh foods, locally grown. All the stuff they're flying to the moon with you: it's *dead.* You probably shouldn't even be eating it; it'll give you cancer in twenty or thirty years—"

"Linda, we're supposed to follow the advice of competent physicians, as Bahá'ís, and we believe in the harmony of science and religion, so we believe in the validity of science. I assure you, the food they're sending with us is highly nutritious, well balanced in terms of vitamins and minerals. The physicians and scientists have all endorsed it, and it has been very successful food used in space for decades—."

"You call Tang food? It's just dead sugar, dead vitamins, and dead flavoring agents, Will; *bad* for you."

"Linda, our food has gone way beyond Tang. That's almost sixty years ago."

"Well, maybe it has, but you need locally grown stuff; a greenhouse."

“Oh, they’re working on that. Even on ISS 2 they’re growing herbs and simple foods like tomatoes now. I think a greenhouse is scheduled for 2031 or 2032.”

“That’s a shame. They’ll kill you with the stuff they’re sending up with you now. Here, I have something for you.” She beckoned him over to a side wall in the auditorium, where she had left a big bag. “This is all for you. Some for now; I’m sure you can’t take fresh fruits and vegetables up with you.”

“Actually, we probably could, but it wouldn’t be fresh when we get to the moon. It takes four days to get to Peary Station.”

“I see.” She reached down and handed him a big plastic bag. “Then eat the vegetables now. I figured you couldn’t take them. But look what else I have for you.” She reached in and pulled out some smaller plastic bags. “Sun dried tomatoes, dried from my organic tomatoes in my own back yard! They’re packed with flavor and nutrients. Put some in the food you’re cooking.”

“Oh, that’d be great! I love sun dried tomatoes!”

“Good. And here are some dried beans, peas, sunflower seeds, even some popcorn. This isn’t hybrid stuff, either! I’d love to hear about popcorn popping in Peary Station!”

Will laughed. “I bet I can try it! Thanks, Linda. Seriously, I can take these along. They don’t weigh too much, so they’ll fit in my luggage just fine.”

“Good, I’m glad to hear it. And can you take this, too?” She reached into her pocket and pulled out an envelope. “These are some quotations from the writings of Bahá'u'lláh that I printed up on pretty paper. I’d like to pass them out to my kids, after they’ve been to the moon and back.”

He took the envelope. “Sure, I can do that, Linda. I’d be glad to.”

"Good, and you'll have to come to Brownsville to bring them to us, too, how's that?"

Will nodded. "Alright, that's a bargain."

"I'm glad both of you can make it for the launch," Will said to his mother and father over the computer. "It'll be . . . comforting to have you there."

"So, we should reserve a room in the Hilton?" asked Stephen. "NASA sent us the information."

"That's right, that's where everyone will be staying."

"Lurleen as well?" asked Katherine.

"That's the current plan." He hesitated to say more and his mother could see it on his face, thanks to the web video connection.

"So, is she coming?"

"I hope so. She hasn't committed."

"Oh, I'm so sorry, dear. Should we . . . try to say anything?"

"No, I don't think so. Maybe Molly could, if she were going, but I know she can't, with her teaching schedule."

"She'd miss a lot of classes."

"We'll say some prayers, Will," said Stephen.

"Thanks. The other day, she backed out of coming to the Houston Bahá'í Center with me, too. Lately, she's been distant. This is very hard on her."

"Be patient and loving; that's the best you can do," said Katherine.

"And we watched the live video of your talk. It was fascinating," said Stephen. "I know several people who watched it, and some who invited friends over to watch it with them."

"That's what I heard. I'm glad it worked out so well. It was the last thing I could do before the launch. We leave for New Mexico day after tomorrow for last minute briefings, etc. It's hard to believe that I'll be walking on the moon in eleven days!"

"The twenty-third human being to set foot there," said Katherine. "That's what I find so amazing! I hope you'll have time to write the blog!"

"Oh, I'll make time. It'll be on my Facepage account, set for 'family only' so that no one else can see it, though later I may change the security setting. If I don't write down my experience, it'll blur together for me! We'll be VERY busy, and the experiences will be coming very fast."

"Have they accepted the modified expedition plans?" asked Stephen.

"Some of them. NASA is still not willing to commit the rangers to expeditions exceeding 1 week in length. Once we get the second ranger set up and operating, and complete some routine maintenance on the first one, I suspect they'll approve a 10-day expedition, and later a 2 week expedition. I hope they'll approve a 3-week expedition before we leave; that's what we'd need to get as far south as Mare Frigoris."

"You probably don't have the time for long expeditions anyway," said Katherine.

"Yes, all the set-up work on the equipment brought by the new cargo lander will take the six of us nine weeks."

"We were biting our nails, watching the cargo landing last week," she added. "Thank God it landed safely!"

"Yeah, they might have postponed our launch if it had failed; it had a lot of crucial equipment for our mission. Not to mention the spices and bulk food for my culinary experiments!"

They all laughed at that. “I’m amazed you got them to agree to that!” said Stephen.

“Well, Swift has an interesting philosophy about these missions, and he has a lot of say, since his ‘Peary Resources’ company is paying for the equivalent of two of the six positions. If NASA had its way, they’d plan every second of our time a year in advance. Swift is more spontaneous. Also, the cargo lander holds 14 tonnes of cargo, which is more than a six-month mission needs, and we already had Northstar 2’s consumables on the ground, so there was flexibility with what is mostly cargo for Northstar 3.”

“Ah, that makes sense,” said Katherine.

“I had better go,” said Will. “I probably won’t call tomorrow night, but I will after I get to New Mexico the night after. Bye for now.”

“Bye, bye,” replied his parents. Will waved and closed the connection. He walked back into the living room, where Lurleen was watching tv. He picked up the box of chocolates he had bought her earlier that day and brought it to her.

“Oh, thanks. How are your mom and dad?”

“They’re well. They have their plane tickets to New Mexico and tomorrow they’re making reservations at the Hilton.”

“Oh, that’s good.”

“So, are you coming? Or not?” Will said it straight out, in a neutral tone, hoping that would generate a response.

“Well . . .” Her voice trailed off, and she didn’t say anything more at first. “I would say that I have too much work at the hospital, but that sounds like a really lame excuse.”

“Yes, it would.”

“I really have no rational excuse.”

"So, what are you thinking, then?"

"I'm . . . Will, I'm scared about losing you, for one thing."

"You mean a launch failure? The Thunderbird series has never had a midflight abort. It's had some launch pad aborts, but they were safe and harmless. It's had a few engine out problems, but that's one reason it has 27 engines in the first stages; if one has to be turned off, the other 26 get you to orbit safely. It's a very safe vehicle."

"I know that. But that's not what I mean. You are going to the moon; *that's* losing you right there. You're going to be gone for six months. That's a long time. And it's six months while you are immersed in your lunar obsession; that won't help things when you come back."

"Look, Lurleen, when I come back, I have no intention of returning to the moon right away. They probably won't let me go back for 2 or 3 years, anyway. If I have a 10 year career with NASA, I'll be lucky if I get to the moon four times. That's 2 years out of 10. There are a lot of traveling salesmen who are away more often than that."

"But they're home every weekend. Six months is a long absence. Do you think things will be the same when you return from the moon?"

"It needn't do it a lot of damage, Lurleen. It won't change me."

"I don't know about that! From what I've seen, it *will* change you. Going into space changes people."

"In a few years they may switch to three month rotations, too. That won't be so bad. And you'll have even more time to pursue your career."

"I will, but my career isn't my entire life. I want a domestic life with someone who is here with me. Someone who will share in child rearing. Someone who will be present to encourage me in my career, every step of the way."

"Haven't I been encouraging you with your career?"

"You have, but from the moon, it just won't be the same. And you can't help raise kids from the moon."

"No, you can't." He didn't know what to reply to that one. "Look, let's not worry about things that far into the future. I *need* you to come to the launch. Do you think that's going to be easy, emotionally? It's not, it's going to be difficult. Very difficult."

She looked at him, genuinely sympathetic. "I know it will be hard on you emotionally, Will. I can imagine it. But . . . it'll be really hard on me, too. Really hard. I don't think either of us can help each other very well under those circumstances. I'm sorry."

"So . . . you won't come."

She shook her head.

"Alright." He sighed and felt tears coming to his eyes. He looked away; he didn't want her to see them. He stood up, walked to the front door, and stepped out into Houston's February nocturnal cold. He walked around the block while he cried.

"I'm going home now," Tad said to Lurleen.

She looked up from her desk. It was good of her office assistant to have stayed as long as he had. "Thanks, Tad, for staying until 6, it's really helpful. I think I've got all the records I need to write the report by tomorrow morning."

"Good luck. If you need anything small, you can email me between 8 and 10. I'll be done with dinner and the gym by then."

"Okay, thanks. The spam filter is working pretty well to block media emails?"

"Yes, they're all going to a special folder now. The software is quite intelligent. You can take a look if you want, or ignore them."

"I'll glance at them later. Good night."

"Night." He waved good bye and she watched him walk out the door. He was handsome; she always enjoyed looking at him. But he was out of sight in two seconds and she turned back to the computer screen. Her automated personal assistant, Mitzi, was still scanning through medical records and assembling a database of insurance company charges; it estimated it had 3 minutes left. So she opened the media folder out of curiosity.

Seventy-two requests for interviews.

She closed the folder in horror. *Astronaut's wife.* That's the last thing she wanted to be. She was a hospital management professional and would prefer to be interviewed about the financial state of the hospitals in greater Houston, or the threats to their financial health, or the crucial importance of insuring more people so that everyone else didn't have the burden of paying for their care. She didn't want to be asked about her fears about the launch or whether she'd be lonely. She really didn't know what she would say about those subjects.

She opened the folder again, highlighted all the emails, and deleted them. But just before she closed it, another email popped in. She deleted it as well and closed the folder.

She turned back to Mitzi. "She" was still assembling the data Lurleen needed from seventeen thousand billing records, but she was nearly finished.

Then Lurleen's smart phone rang. She pulled it out and looked at the screen; it said *Madhu Anderson.* She almost told the phone to send the call to voice mail, but then she pressed the "accept" button. "Good evening Madhu, how are you?"

"I'm pretty well; how about you? The launch is now six days away. Are you in New Mexico?"

"No, I'm on my office at the hospital. I have a big report due tomorrow."

"Oh, I see. How are you holding up? I was receiving a lot of calls from the media during the last week."

"Yes, I just counted 72 emails; no, 73. I'm just deleting them. No one has my cell phone number except friends and my social media sites have the highest security settings, so no stranger can write me there."

"They'll start hanging out at your house or at the hospital in a few days, I suspect. Launch day is the worst, but if you're inside the NASA bubble at the New Mexico Launch Facility, you'll be okay."

"That's a thought. But no, I think I'll stay here."

"Really? Won't Will need your support? Launch is pretty stressful. Stressful for you as well as him!"

"Yes, it is stressful for both of us, but it's better if I stay here, I think. I . . . I really can't talk about it now."

"Okay. Well, if you want to talk, I'm easy to reach. You've got my number. Roger and I are mostly back to a normal schedule. The first week after landing he was in debriefing and Northstar 2 training, then we took off three weeks and went to the Azores for vacation, which was just beautiful. You and Will need to make plans to spend time together after he returns to reenergize your marriage, because the separation does do damage."

"I'm sure it does, but I'm afraid he'll be so busy writing up the scientific results in the form of twenty papers that it'll be very difficult for him to agree to get away."

"The psychologists advising the crew will be recommending it about half way through the mission. Roger was away four months and that was difficult; Will will be gone over six. If you need any help coping, please call me, okay?"

"Thanks, Madhu, I appreciate the offer. I will call, too."

"Great. Really, I want to help, alright? So please don't hesitate. Bye for now."

"Bye." Lurleen closed the call and contemplated the offer. Madhu was a bit of a busy body, but she appreciated the concern. Maybe she would call.

Their sumptuous farewell lunch featured a visit—in a wheelchair—from the last living Apollo astronaut who walked on the moon. On their way out, they had one last chance to see loved ones.

"Slip the surly bonds of earth, dear," said Katherine, giving her son a kiss.

"Without seeing the face of God," added Stephen, quoting the second half of a poem famous to aviators and astronauts.

Will laughed. "No, I plan to see the face of Selene instead." He kissed his father.

All three of them had tears in their eyes. "We'll see you at Kennedy Space Center in six and a half months," promised Katherine. "And I'll see what I can do to get Lurleen there as well," she added in a whisper.

"Thanks. She did call me last night and apologize. But she still couldn't come."

"It's hard," said Katherine, though she still wasn't sure why it was hard.

"Pray for us. Pray for me," said Will.

"We will."

He waved. "I'll pray for you, too, on the moon." He turned and headed down the corridor.

The first stop was the suit up area, where he, David, Kalidas, and Jerry put on flight suits. They picked up their helmets and headed to the van, where they waited for Silvia and Larisa. The six of them joked with the driver and Armando Cruz, who was a fellow astronaut, a physician, and would be the capsule communicator that day. But the six of them were the only ones to get into the elevator in the launch tower.

"Up and up," said Jerry, breaking the silence.

"So much vapor!" added Kalidas, looking at the stream of venting oxygen gas. "And ice is forming fast on the skin, even in this desert."

"They've calculated for all of that," said Larisa, calmly.

They passed the top of the triple-barrel first stages and began to roll past the second stage, which was also 3.6 meters or 12 feet in diameter, and venting. Above it was the long Thunderbird-H stage, a hydrogen-oxygen stage that would push their Polaris capsule to the moon. "Amazing to think that all this metal and fuel will be left behind," said Will.

"One thousand, four hundred tonnes," agreed Jerry.

The elevator slowed, then stopped. They opened the door and crossed the gangway to the Polaris capsule and entered, one by one. The acceleration couches were arranged against the outer wall of the capsule in three pairs, with a porthole between each pair. Kalidas was last and closed the hatch tightly.

"Okay, we're latched in," he reported.

"Excellent," said Jerry. "So, are we sure they put our luggage on board?"

Everyone laughed at that. Will reflexively looked behind his acceleration couch and checked for his flight bag, which was in its place.

"So, is everyone ready?" asked Jerry. "Any regrets?"

“Don’t ask that!” replied Larisa. “We’re all on a high!”

“That’s true,” agreed Silvia. “We just sit back and let the equipment and the computers do the work.”

“Well, you may get to do some piloting,” replied Jerry, with a chuckle. “We’re not exactly an historic mission; nothing can ever equal being first. But being second is pretty good as well. We get to increase fuel production by forty percent, double water production, install a second shelter, complete the radiation shield for both shelters, and launch a series of long distance expeditions.”

“And we may get as far south as Frigoris,” said Will. “Who knows.”

“We’ll see whether Mission Control will allow that,” said Jerry. “It’d be a huge stretch in capacities, Moonman.”

“But it’s possible,” said David.

“We need to give it a try,” agreed Kalidas. “Northstar 1 established Peary as a beachhead, but the beachhead has to lead someplace!”

“Exactly,” agreed Jerry. “Northstar was primarily an engineering mission, but we’re primarily a science mission.”

“The first one,” added Will. “The moon is destined to become the new Antarctica.”

“But not just a continent dedicated to science,” said Jerry. “A world dedicated to science.”

“The first one,” added Will.

11.

Peary Station

Last week of February, 2029

North America is a patchwork of white snow and clouds, green grass, and brownish mountains. South America is enjoying its summer and is mostly bright with verdure. The Pacific is an amazing expanse of azure dotted with islands, even the smallest of which are visible from low orbit. Europe is a galaxy, ablaze with city lights, thinning out to the dark intergalactic expanse of Siberia. The Earth is a feast for the eye. Even now, as we recede from it at 25,000 miles per hour, our home world noticeably shrinking in size before our adoring eyes, its beauty dazzles.

Will paused from his blog to look out the porthole between him and Larisa. He had to twist his neck, but he could still see the Earth, and he could indeed see the Earth shrinking. He stared at it fully a minute before resuming his writing.

Everyone else has finally fallen asleep, but the Earth is too mesmerizing; I keep turning toward it between sentences or even between words. In a few hours it will have shrunk down so much that details will be invisible.

Perhaps that explains why I'm starting the blog with the view, instead of with the launch. It's difficult to describe the physical and emotional experience of launch; the noise, the shaking, the compressive acceleration that makes one feel like lead, and the awareness that in a split second something could go wrong that will abort the mission or blast one into scattered atoms. Six minutes seem like hours. Stage separation involves a bump and a pit-of-the-stomach lapse into weightlessness, then the noise, shaking, and compression resume. If you can lift your head enough to look out the porthole, blue sky turns violet and then black. Gradually the launch angle tips from vertical to horizontal and suddenly a round earth appears in the porthole; it's quite a

surprise! At that point we were over the southeastern US and could see towns and highways quite distinctly.

We were told the two side boosters have successfully landed and will be used for another launch next week. The central first stage also landed back at the New Mexico Spaceport but will require some refurbishing. The second stage made one orbit, then reentered the atmosphere. It managed a soft landing and thus can also be reused. It's amazing that the system is now so reusable; every soft landing makes the next launch cheaper.

We completed three orbits, long enough to check out everything and make sure we were go for trans-lunar injection. The Thunderbird-H third stage lit up for just two minutes and we were on our way to the moon. The GPS immediately said we were on a near-perfect trajectory. The Thunderbird-H has enough fuel to put us into lunar orbit. Once we rendezvous with the Lunar Orbit Depot, it'll refuel so that it can push us back to Earth in six months, Northstar 1's effort to refuel the depot having been successful.

I suppose I should say something about weightlessness. It's quite remarkable, a lot of fun, and frustrating at the same time. It will also make you sick; I've been moving very slowly and deliberately, because I don't want to vomit! What I was aware of, but did not experience until our arrival in orbit, was how different the Polaris capsule functions in zero gee. Our personal spaces extend upward along the walls, but in zero gravity the direction is irrelevant. Our acceleration couches can convert into ordinary seats or into vertical beds, around which we can pull a curtain, allowing us to change clothes in privacy. Two other vertical spaces with a curtain around them serve as toilet and wash areas. So even though the capsule is only 5 meters or 17 feet across, it still is fairly open and there is room for a galley against one side and a table in the middle against which our six seats can be moved. There's even room for exercise equipment.

We're heading to the moon in luxury, compared to Apollo, with almost twice as much volume per person!

I had better end this blog entry and get to sleep. It's been a wild and crazy seven hours since launch and I'm exhausted. When we awake, we will be out of the Van Allen radiation belts. The next three days will have plenty of time for blog entries, but there won't be much to say; they'll be fairly boring. But I'll try to write every day, as much for the sake of my memory as for you. Good night.

Will looked over the entire entry once, corrected some misspellings, and hit send. The interplanetary internet was functioning well; it went to his Facepage account in just a few seconds.

"You're such a good writer, Will," whispered Larisa.

Startled, Will turned around. "Oh; thank you."

"So many engineers and scientists write poorly or have a dry style."

"I switched into geology late in my undergraduate years, thanks to a summer internship in Houston. I had been majoring in English and classics earlier, plus I took several courses in religion and philosophy."

"Really? Extraordinary. I majored in languages and philosophy and switched into engineering in the last three semesters."

"How did you manage that?"

"I took six or seven courses a semester instead of four or five!"

"Ah. Some people do that." He smiled at her and Larisa responded by batting her eyelashes at him. He involuntarily smiled back, then caught himself. A six month mission, they

were both married, and he had no intention of being unfaithful to Lurleen. He looked at the light near his head. “I think I’ll turn this out now and get some sleep.”

She nodded. “Good idea, it’s very late.”

“We’re all exhausted.” Will stowed his tablet and turned off the light.

After three days of floating in the Polaris capsule, the crew of Northstar 2 whipped around the back side of the moon. The Thunderbird-H roared alive for one last time, burning off 700 meters per second of velocity and putting them into a 100-kilometer “frozen” orbit around the moon, inclined 86 degrees to the equator; nearly perfectly polar. They began to chase the Depot and reached it six hours later.

“Crowded!” exclaimed Will, as they approached. “Two Thunderbird-Hs are there already!”

“One of them brought our cargo,” replied Jerry, happy to explain something to Will. “Normally, a lander would fly up the lunar fuel needed to send it back to Earth with the water need to manufacture return fuel, but that Thunderbird-H is destined to land at Peary and serve as a fuel storage facility.”

“So we can move the fuel manufacturing units and their solar masts off the cryo landers and repurpose the vehicles,” replied Will, with a nod. Jerry scowled, disappointed that Will already knew, though it was basic information everyone knew.

Jerry pushed a button on his tablet and pulled up a work schedule. “So, 24 hours at the lunar orbit depot. . . Kalidas, are you ready to complete maintenance on the cryo units and install a new one?”

“I was just reviewing the tasks.”

"Larisa, you're ready for the space walk to check the radiator units for leaks?"

"Yes. It'll take at least five hours to find and patch the two leaks."

"The additional cryo unit should be pretty easy to install," added Silvia.

"Pretty soon we'll need a second depot," said David. "Capacity keeps growing."

"Every Thunderbird-H and every Thunderbird second stage that can't be returned to Earth will become a fuel depot," noted Will. "It's a shame all those shuttle main tanks burned up. Think what they could have held!"

"Well, we didn't have the space entrepreneurs then that we have now," replied Jerry. "They've engineered a revolution."

"Unfortunately, every time they make space cheaper, either the budget gets cut, or more gets diverted to a pork barrel project," said Will.

Jerry nodded, irritated. "That's true."

In another hour, Northstar 2 docked to the depot. The six of them crossed through the docking node to the Polaris capsule opposite—it had brought the Northstar 1 crew to the moon and would take them back to Earth—to check it out, then began to transfer cargo and to the lander that would take them down to Peary. Kalidas, Silvia, and Larisa turned to their tasks while Jerry, Will, and David struggled with two tonnes of consumables and equipment, which had to be removed from the storage lockers under the floor of their Polaris capsule and placed in the lander. Everything had to be put in exactly the right place so that balance was maintained; the process took hours and was exhausting. But when everyone went to bed, they had plenty of sleeping space, among the three vehicles.

The next morning Larisa and Kalidas finished up their maintenance and installation tasks and they closed down the depot for six months. They floated into the lander and sat in the six

seats in its cabin, which was 5 meters across, just like the Polaris. At noon, on schedule, they separated from the station and fired the lander's engine to lower their perilune—closest point to the lunar surface—to within fifteen kilometers of Peary Station. If the lander's hydrogen-oxygen engine failed to ignite again, they'd be safe, but once it lit up they'd be committed to the lunar surface, one way or another. But it lit up on schedule.

"Here we go," said Jerry, nervously.

"It's nice to remember what terrestrial gravity feels like," quipped Will, who was excited. The lander's engine generated roughly a terrestrial gee of force on them for three minutes to burn off their orbital velocity and bring them down to Aldrin Pad number 3.

Out the windows of the lander, the lunar surface flew by and came closer and closer. Then the lander began to tilt to vertical and they had to watch the moon on two screens. Dust began to be kicked up as they approached the surface. Then the engine shut down and they settled onto the surface with a slight bump.

"Houston, Northstar 2 has landed," reported Jerry.

"We copy," said Armando, amid cheers and applause.

The six of them unstrapped their safety belts and headed for the windows. David and Will ended up at one, looking out—northward—across the moonscape. "We're almost there, Moonman," said David.

"You're as much a moon man as I! Wow, isn't this amazing!"

"As good as the electronics are, it never looks the same on a screen as it does to the naked eye."

"That's for sure. Wow!"

"Hey, guys, let's suit up!" said Jerry. He was pulling a curtain across the cabin so Silvia and Larisa would have a private area for changing.

"We should let Will go out first, he's so excited!" laughed Larisa.

"No, he's next to last, based on protocol order," said Jerry, who as commander was first.

David pulled on Will's shoulder. He nodded and turned to the task of suiting up. In a way, there was no hurry; Silvia was still busy running through the power down of the propulsion systems. Everyone had to be suited up to depressurize the cabin, and she was to be the second to exit anyway. Once Will had his pressure suit on, he had time to stand at the window and gaze out. He wasn't alone, either.

Three quarters of an hour after landing, they began to depressurize the cabin. It was a slow process; almost fifteen minutes. Finally, Jerry opened the hatch and crawled out, feet first, onto the ladder, then descended to the surface. "Northstar 2 has arrived to a rich and historic mission," he pronounced.

He stood and waited for the others. Silvia was second; Europe paid the second largest amount to support the mission and she was the senior European astronaut on board. Kalidas was third; not only was he the first Indian on the moon, but he was the representative of Peary Resources and the Swift Company. Larisa followed. Then it was Will's turn. He got down on his knees and crawled backward through the short tunnel, felt for the ladder's top rung and stepped onto it, pulled his head out of the tunnel and descended the ladder. He leaped the last meter.

"We have slipped the surly bonds of the Earth and touched the face of the moon," he said.

"Great line," commented Larisa.

Will joined the others awaiting David. He reached down and picked up a handful of regolith, squeezed it in his palms so hard that he could feel the sharp edges of the pebbles, then brought the handful to his helmet so he could look at the bits. Meanwhile, David came out and leaped down the last meter. “Bismullah al rahmani al rahim,” he said, aware that the majority of his French fellow citizens would be outraged, but the Muslim world would cheer. He joined the others in a straight line, they all turned away from the lander to face the TROVs, and the TROVs all raised their right manipulators in salute, a gesture they returned. Will’s idea had become a welcoming ritual.

12.

The First Days

Late Feb/early March 2029

The landing at 2 p.m. was followed by ten hours of exhausting work. They unloaded all two tonnes of supplies and placed them in ranger 1, filling it so much there was barely room for the driver and one passenger. Northstar 1 had arrived with much less because the transportation system had not had the reserve fuel for the extra supplies; but they had had to unload a cargo lander with fourteen tonnes of stuff instead, and spent weeks setting up the station. Ranger 2, which had landed in December with a second shelter, was unavailable for their use because it had arrived full of supplies and the robots were not designed to move boxes, so it had remained at Peary Station.

Once they had unloaded the supplies from the lander, David, Will, Larisa, and Kavidas climbed onto two buggies—four wheeled all-terrain vehicles able to transport two each—and drove to Peary while Jerry and Silvia took ranger 1. Once ranger 1 was securely docked to the far end of the station and the four of them had entered through the airlock at the opposite end, they had hours of unloading to complete. David and Will managed fifteen minutes of exploring outside before going in to help move supplies and personal belongings out of ranger 1. It was midnight before they got to bed.

But who, who could sleep? They were on the moon! Will certainly couldn't. *I can't get enough of looking out the window,* he blogged. *The rolling, gray desolation is so fascinating. Unfortunately, I have one of the two wardrooms without an earth view. One side of the station mostly faces the nearside and the other the farside, and that's where my room is. David has the other one; the rooms were assigned according to the same protocol that determined when we*

would step onto the moon. Each side of the station has four rooms, but on the farside two of them are set up as bathrooms.

But there are plenty of portholes to look out of. The commons room has two on each side, as does the science and medical area. And we have an entire second shelter now, the same size and arrangement as the first, though lacking most of the basic equipment. We have to set up the bathrooms, install the life support equipment, place regolith against the sides of the shelter, and fill the radiation shields with water over the next six months, so when Northstar 3 arrives, there's room for both crews. Meanwhile, we have a huge, empty area to wander around in, a space for solitude if we want it, and a complete backup residence if something goes wrong in this one. I was just wandering through shelter 2, looking out all the nearside portholes, drinking in the view of Earth.

I miss all of you. It is strange to think you are 400,000 kilometers away, a vast, unfathomable distance. It's even stranger to look at Earth, a big, bright, blue-white ball forever hovering above the southern horizon, and think that all of you are there; I can cover my view of you with my thumb! But my homesickness is mixed with and nearly overwhelmed by my excitement for being here. There's an irony in my replacing 'touch the face of God' with 'touch the face of Selene,' as I said to mom and dad right before launch. I said 'touch the face of the moon' when I stepped down, and that was also the first thing that I did. But the former phrase is perhaps a closer expression of my feelings. Selene was a goddess, after all; the moon is just a dead thing. And the excitement I feel is the excitement I feel for a goddess, you might say. There's so much I can do here over the next six months! I want to refine some of the predictions in my dissertation about the rate of accumulation of volatiles in cold traps, which entails collection of a lot of samples of impact melts and potassium-argon dating them with the new

mass spectrometer we brought. We may be able to drill into some of the deposits if we can handle the severe cold. Certainly, we can use ground-penetrating radar to get a sense of how deep the accumulations are. And we hope to start a trail toward the middle of the near side. There's no way of knowing how far we can get or how far the trail eventually can go; it'll be exciting to find out. So pray for me or wish me luck! I may need it.

He sent the posting to his Facepage account. Lurleen still had not responded to his email, sent about midnight; perhaps she'd respond to the posting instead. He went to the New York Times website and waited three seconds for the page to load. The headline startled him: *Touching the Face of the Moon: Northstar 2 lands at Peary.* His phrase had been picked up by the media! He read the article and was surprised to see that he was mentioned several times.

He closed it just as an email arrived from his mother: *Beautiful posting, Will. I wish I were there with you to see the beauty of your goddess. You don't need luck; you're living a charmed existence! But you will have my prayers. Mom.*

That brought a tear to his eyes. It hurt even more to think Lurleen hadn't responded. He laid down on his bed to try to sleep, but from his pillow he could see the moonscape out his porthole, and he kept looking at it. Finally, he rose to use the bathroom instead.

He encountered Larisa, coming out of it. She shook her head. "Use the one on the other side, okay? This is the women's bathroom, that's the men's bathroom."

"Why? But, alright, I'll do that. The two of you probably will use the bathroom as much as us four guys!"

"Probably. And go to sleep! It's hard, but we have a busy day starting in six hours."

"I know. Good night." Will walked across the commons to the other group of rooms and used the bathroom there. Then he walked to the science and medical area, took the spiral

staircase down to the lower area—still set up for donning space suits—crossed through the airlock to shelter 2, walked the length of the lower level and up to the top floor, then back down and through the airlock again to shelter 1. He closed the sunshield on his porthole to shut the moon out. And then he could sleep.

He still rose early; 8 a.m., an hour before he had to. Will went to the "men's room"—the habit of avoiding the bathroom next to his quarters was forming—and then headed to the kitchen. The one-burner stove would be a challenge, but he also had two microwave ovens. He walked to the science area and grabbed one of the electric ovens there, which the food preparation team in Houston had determined would work fine for baking. He brought it to the counter next to the stove. Will put on the coffee brewer and began to pull out various bulk items from the storage lockers to put away in the kitchen cabinets. Soon Larisa and David were up. They joined him in the kitchen; Larisa had some culinary ambitions as well, and David was just curious.

Jerry was surprised to see all of them at work. "How long have you been up? Are you cooking breakfast?"

"Just with the microwave," replied Will. "Today's Wednesday. I'm only cooking on Sundays."

"I may do some on Saturdays," said Larisa. "But I'll need to talk to Will's ground support team first."

"You have a ground support team?" said Jerry, surprised.

"Sort of. Nothing up here cooks the same way as on earth, because of the lower air pressure. They have formulas for roughly adapting recipes."

"How roughly?"

"We'll find out on Sunday!"

Jerry laughed. He poured himself a cup of coffee, grabbed a microwaved Danish, and sat at the common room table to look at newspaper articles about their landing. Kavidas and Silvia wandered in by then as well. "So, Moonman, you trumped me and all of NASA with your 'touched the face of the moon' comment," he said, trying not to sound upset or irritated.

"I saw that the New York Times used it," said Will. "My mom and dad quoted it to me, right before launch."

"You have literary parents. No one quoted me. They seem to have mentioned you a few times in the story, too."

Will shrugged at that. "He's a literary darling," exclaimed Larisa, a touch of admiration in her voice.

"I'll try harder next time to be ordinary," said Will, trying to sound innocent, but realizing there really was nothing he could say. He looked at David, who shrugged.

The six of them sat together at the table with their microwaved Danishes, coffee, fruit cocktail, and microwaved breakfasts of scrambled eggs, sausage, and hash browns. Jerry asked how everyone's families felt about the landing and they went around the table, talking about reactions. Will had gotten an email from Lurleen and thus could mention that. "Alright," said Jerry. "We have assignments for the next week. We have to unpack the rest of the supplies and set up the equipment we brought. Ranger 2 is packed tightly with life support and other equipment for shelter 2 and we need to set it up. We have until August, of course, but the sooner we have the shelter ready, the better, because we'll have a more redundant facility. So set up is scheduled for March. Once ranger 2 is emptied, we can start taking it out on shake-down trips to test its systems. The plan is to take it out every other day for trips up to 18 hours. We won't

venture farther from the station until April, once both rangers are certified for longer trips, and we'll work our way up to whatever NASA permits; possibly fourteen days. Will and David, I'm sure you guys want to go out today."

"Yes," said Will. "The schedule calls for a trip to Borealis GA, a 600-meter fairly fresh crater about 30 kilometers from here."

"Pole side of the plateau," said Jerry, nodding. The Armstrong "Plateau" was a rolling stretch of terrain extending from Peary Station northward and toward the farside; it was also the designation of a geological quadrangle map. Borealis was the next map over and included the North Pole itself. It was pocked by dozens of craters that were identified simply by their map coordinates, which used the letters of the alphabet on both the north-south and east-west sides. "What are the geologic objectives?"

"Characterizing the volatile deposit; thickness, temperature, composition," replied Will. "If we can find an exposure of impact melt, we'll recover a sample to date the crater. There's also evidence that the impactor was a carbonaceous chondrite, so we're curious about that."

"This is all to prove your predicted correlation between age and volatile accumulation?" asked Jerry, suspiciously.

Will looked at him. "It's the main theory being used right now to determine which deposits to excavate. They all have water, but they don't all have nitrogen or carbon, for example."

"I understand," replied Jerry. "Okay. Silvia, you're scheduled to go with the geologists as commander of the expedition."

"That's right," she replied. "I'm anxious to get outside."

“We’ll rotate who goes out. Will and David, are you still planning to be inside tomorrow, then?”

“Yes, to set up the new mass spectrometer,” said Will. “I suggest David and I alternate going out, so that there’s always a geologist going out.”

“Well, I’m going out too, and I have geological training,” said Jerry.

“I apologize; I wasn’t excluding you. You had spoken to both of us, so I was making a recommendation about both of us. I’ll be content going out two or three times a week. If all of us go out twice a week, we can mount two-person expeditions six days per week, which will allow us to complete the study of everything within twenty-five or thirty kilometers of here in a few months.”

“But what about loops?” asked Kavidas.

“I’m not excluding them. We don’t have to complete the study of the immediate vicinity; we can leave some of that work to Northstar 3.”

“We have authorization to devote one third of our time to exploration,” said Jerry. “So if we’re going to make big loops that take three of us away for a week or more, we need to ‘make up’ for the loss of one position that will do something else by devoting less time to geology at a later date. Kavidas, you and Larisa and I are devoting today to unpacking equipment and shelter 2 set up?”

Kavidas nodded. ‘That’s right, and if the geologists and Silvia can help when they get back, we can probably get the water circulation and purification system set up, followed by one bathroom. The basic air purification system is already functioning and it’s adequate for now.”

“It’s a bit cold in there,” observed Will.

"The heating system needs to be set up," agreed Kavidas. "For now, if we leave the connection with shelter one open and a fan going to circulate some air between the two, shelter 2 will be usable."

"How much water do we have for its shielding?" asked Silvia.

"We have sixty-five tonnes of water in the tanks," replied Kavidas. "This shelter needs another fifty to fill its radiation shields fully. We'll have that done in a week. Because we can now go deeper into the cold traps and mine nearly pure ice, rather than the warmer ice-reg mix they were mining before Northstar 1 arrived, we can obtain water three or four times faster than was possible a year ago. We can supply enough water for a faster propellant production rate *and* fill shelter 2's radiation shields."

"But at the cost of more repair work on the automated equipment," noted Silvia. "Next week we have to bring one of the ice miners inside the basement of shelter 2 for an extensive overhaul and upgrading, so it can handle the colder materials."

"Setting up the equipment repair facility in the far end of the basement of shelter 2 is the other priority for this week," said Kavidas. "I'm not planning to go outside for at least a week, unless I get cabin fever!"

"Well, you have a lot to do outside over the next six months," said Jerry. "We have a Thunderbird-H landing next month, a fourth cryo lander coming in May, we need to move the power masts and cryogenic processors off the three landers and to a central location so we can supply them with water and pipe off their hydrogen and oxygen production more efficiently, we need to upgrade at least two of the cryo landers so they can be used to support surface exploration . . . there's a lot to do."

"Through Northstar 5," agreed Kavidas.

“Have you heard anything more about an agreement between NASA and Swift to extend the Northstar project?” asked David.

Jerry shook his head. “Congress is skeptical; that’s the problem. So the more we can do here to make the moon into a routine and essential scientific outpost—like Antarctica—the better.”

“It’d be ridiculous to pull the plug after Northstar 5,” said Will. “After this expedition, lunar fuel production will be sufficient to support the entire transportation system beyond low earth orbit. The Polaris capsules can be launched by a Thunderbird-9 rather than a Thunderbird-Heavy at that point. What would be the cost; less than one hundred million to put a lunar crew in LEO? The rest of the trip would be covered by existing assets!”

“True, but you know Congress; if it’s logical to do something, someone will stop it,” said Jerry.

“Europe is different, though,” said David. “They’ll pay to send two astronauts every six months, I’m sure. I suspect Russia will send one every six months.”

Larissa nodded. “And India,” added Kavidas. “We don’t need NASA because Peary Resources will send at least one. That totals five, which certainly is plenty to run this station.”

“You can go to work for Peary Resources, Moonman,” said Jerry. “But I suspect Congress will feel pretty embarrassed at that point and will fund at least one position per mission.”

“I agree,” said Will. “But I also agree that they don’t always behave rationally.”

“That’s the dilemma of modern governance,” said Jerry. “Well, we’re done here. Let’s get to work.”

Everyone nodded at that, finished their coffees, put their plates in the sink, and headed to work. Will, David, and Silvia headed to the far end of shelter 2, where ranger 1 was docked. It had been emptied of 2 tonnes of supplies the night before, so they suited up, entered, and undocked. They had to make a quick stop to pick up a trailer with two Prospector-350 TROVs on board; three TROV drivers in Houston were standing by to drive them at each field stop. Silvia headed toward Armstrong Pinnacle, the distinctive high point in perpetual sunlight, then turned onto a trail heading roughly toward Borealis GA. At one point, Will pointed. "See that TROV track? Follow that instead, it's more direct."

"Are you sure? This will get us there. It's the route the computer recommends."

"I know, but I drove that TROV and know the track goes to Borealis HH. From there, we can head straight across the terrain. There are no steep slopes or boulder nests."

"Alright." Silvia slowed and turned off the well-worn trail she had been following. Mission Control had been listening and confirmed that Will's route was a good choice.

The three of them gazed out the windshield at the moonscape as it rolled by. The ranger was blazing its own trail across virgin territory. They stopped briefly to dip into Borealis HR, a little 100-meter crater with a half meter of snow and frost on its floor. They didn't get out, but the TROVs deployed to explore; a small, fresh crater on HR's floor punched through the snow and exposed an outcrop of impact melt, which they were able to sample. The ranger's powerful laser cut a tunnel in the volatile deposit almost a meter deep before it hit underlying ground. The escaping hot gasses gave them the deposit's composition, too.

In half an hour they were on their way again. They reached GA 90 minutes later. Six hundred meters in diameter, it was over 100 meters deep and had steep sides that did not allow the ranger or the TROVs to enter safely. But its depth ensured that the bottom was extremely

cold. “A TROV driver needs to take the ranger around the rim to here,” said Will, pointing to a spot on the map. “We’ll go down the slope here, where we are parked, walk across the floor, and go up the slope there; those are the two gentlest slopes, so they will provide the easiest ingress and egress. The ranger’s laser should be able to fire at outcrops from points 1841, 120, 269, and 303; they’re marked on the map of this stop.”

“You’ve planned this stop quite thoroughly,” said Silvia admiringly.

“We spent several days with a computer model,” explained David. “Will and I have dozens of stops of this sort planned out.”

“The geology team has filled in the details,” added Will. “Some of these plans are over a year old; some are from my dissertation; some are from plans Roger proposed for Northstar 1; some are from very bright graduate students at Caltech, Brown, University of Arizona, or Washington University. It’s a mix. While we suit up, we should activate the panorama app that my friends at Brown developed. That’s how I used the government shut down, right after Thanksgiving!”

“Good idea. Ranger 1, please activate the panorama app.”

“At our current position, we can only illuminate and view 100 degrees of the crater rim, but if we move three meters closer, we can view more,” replied the ranger’s computer.

“Alright, move us as close as is safe,” confirmed Silvia.

The ranger moved forward three more meters, much closer to the edge of the rim. From that position it could activate its overhead lamps and scan the entire crater interior, photographing it in high resolution and color, but so quickly that the volatiles didn’t evaporate.

Meanwhile, the TROVs had scattered to pre-planned stops to sample rocks or zap outcrops, while the three of them put on their backpacks and helmets. They donned special

cryogenic overboots to protect their boots and lower legs from the extreme cold of the fluffy ices, and added cryogenic mittens to protect their hands. They headed out through the rear airlock. As soon as they stepped off the ranger, it began to move away toward its first stop.

They had to turn on their helmet lights immediately, because they stepped into darkness. Their heads were out of perpetual darkness as they topped the rim, but the rest of them remained in shadow. GA was very cold on the bottom because it was in the shadow of the rim of another, larger crater on its southern side, away from the pole. As a result, only a small section of rim saw sunlight and the floor of the crater was in permanent darkness, except for a tiny bit of reflected light off a short stretch of rim a few days every month. The floor was at 35 degrees Kelvin; colder than the surface of Pluto.

The extreme cold was actually a problem; they had to turn down their helmet lights because they vaporized volatiles. “How old is the crater?” asked Silvia.

“If my theory of volatile accumulation is correct, a mere 2.2 billion,” said Will. “If we can bulldoze a road down here, it’d be an excellent source of nitrogen and methane.”

“How much?”

Will shook his head. “The methane concentration never gets above 10 parts per thousand, carbon monoxide five parts per thousand, ammonia about one part per thousand, and nitrogen 300 parts per million. Carbon dioxide might reach 11 percent in here. If we can adapt our volatile digging and transporting equipment for the cold and get it in here, we’ll be able to get the CO_2 out for making methane propellant for the Mars missions.”

“Assuming there will be Mars missions,” said David.

"Yes, Congress has turned Swift down," noted Will. "But we need carbon dioxide and nitrogen for Peary Station, also." He pointed. "Let's go this way; there's an outcrop over there that we need to sample."

Silvia nodded. "Okay."

They followed Will down the slope carefully; the regolith was loose and could slide under foot. Silvia watched him and wondered how he could remember every bit of the crater's geography so well. There was indeed an outcrop where Will said and they stopped a few minutes to break off pieces—using new rock hammers with shatter-proof heads—examine the samples closely, and take some. Using a portable analyzer the size of a cigar box, David zapped the outcrop with a laser in several places to take measurements of composition. Then they headed down onto the floor.

The frost deposits crushed under foot and they had to wade across, like they were in old snow up to their knees. They stopped a half dozen times while David used his analyzer's laser to tunnel through the volatile layer to the rock underneath and measure the composition of the escaping gases. Will's estimate of the composition was fairly close. At one point they measured 2.5 meters, or 8 feet, of accumulated volatiles. Will lowered his analyzer to the top of the deposit and sent a ping of ground penetrating radar, so they could check for additional buried layers. A fresh crater punched through to the old bottom on one side of the crater floor and they obtained a sample. Surprisingly, there was very little impact melt.

"Your theory about volatile accumulation looks pretty good, Moonman," said David.

"Thanks. But look at all the carbonaceous chondrite." Will reached down and picked up a blackish chunk. "The impactor was loose and friable and it must have hit at a pretty low velocity,

relatively speaking. It crushed, smashed to bits, blew a big crater from its escaping gasses, but the impact didn't generate much heat."

"Not enough to melt a lot of rock, anyway," said Silvia.

They stopped several time to listen to reports from the TROV drivers. Will asked detailed questions of each driver, directing them to zap or sample. Once they finished crossing the floor, they headed for an outcrop in the inner rim; Will knew where all of them were. After another half dozen quick stops and laser zaps, they reached the spot where the ranger was supposed to meet them. Twenty-nine minutes had elapsed, 1 minute less than the recommended maximum time to spend in such a deeply cryogenic cold trap. They walked down the outer slope of the rim picking up chunks of chondrite, some of boulder size.

"All this carbonaceous chondrite can be mined for volatiles, too, especially carbon," noted Will.

"How much?" asked Silvia.

Will shrugged. "Let's say the impactor was sixty meters in diameter; that's about . . . 100,000 tonnes of carbonaceous chondrite. Let's say a third of it can be found; that's 30,000 tonnes. If it's ten percent carbon, that's 3,000 tonnes. I bet we could get almost as much water from it, too."

Silvia nodded. "That's a lot of methane!"

While they entered the ranger and removed their helmets, the TROVs caught up and rolled onto the trailer for stowage. Will called up the drivers. "Thanks, guys. Looks like we got everything here. Can you complete your reports about the various stops?"

"Sure," said Rick Page, an engineer with a knack for geology who had been selected for Northstar 3. He gave detailed reports about his three stops; he had dictated notes at each one that

he summarized. The other two drivers gave similar reports. Altogether, the TROVs had sampled seven outcrops and the ranger itself, four more. While they debriefed about the stop, Silvia drove them to Borealis PB, a much smaller, shallower crater that was their first stop on the return trip. The TROVs and ranger made a series of investigations, then they headed back to Peary.

"Wow; so much data that my head is spinning," said David.

"It'll take a month to write it all up!" agreed Will. "Maybe Rick can do it for all of us. We spent less than an hour actually outside, too. But we'll have covered sixty kilometers and visited three sites. We could easily add several more."

We'll pass Borealis NR on our way," noted David.

"Let's do it!" agreed Silvia.

"Good, and Borealis PU," added Will. "And there's an area very close to the pole that's almost perfectly flat and covered with scattered snow. I'd love to go outside and walk around there."

"We have the time!" said Silvia.

"Okay, let's stop," said Will. "We don't have a plan for NR and PU, but we can put one together as we go."

14.

Sunday Dinner

Sunday, March 4, 2029

"All the geologists in Houston *love* him," Jerry said to Silvia. He was having Sunday morning coffee with the assistant commander in his quarters.

"You can't blame them," replied Silvia. "Who can coordinate and guide geologists better in their exploration of an area than a geologist? When I take him out to a field stop, I have nothing to say about executing the visit. Not because he cuts me off or overrules me, but because he knows what to do. Will is incredibly prepared, and he's a geological genius."

"Geological genius," repeated Jerry. That was not what he wanted to hear. "But what about David? Doesn't he direct the operation?"

"Sure, sometimes. I've seen the two of them debate a particular site, or maybe I should say consult together about it, because they never argue; they build on each other's insights. And he's often right over Will. David has more field experience. While Will was studying English literature and classics in school, David was hiking the Atlas Mountains and the Alps, geologic map in hand. But Will has an overview—a vision—of what to do that David lacks. He defers to Will in planning."

"I see." Jerry looked at the geological field trips for the first full week of March displayed on his tablet. "I guess I'll have to go with these, when I go out."

Silvia nodded. "But remember that Will helped design every one of those trips. NASA first called for geologists to propose field trips four years ago, when the first TROVs landed here and we had detailed low-altitude flyover data. They put it all up on the web and let the geologists go. Will was one of the first. That's one reason he was selected for the astronaut corps; how

many candidates get selected when they're only 26 years old! He has been on every geological planning committee."

"Interesting. He really *is* the Moonman."

"I don't know how he manages a married life, he's so married to the moon."

"Most of us haven't managed that very well. But . . . we can't be a team when one person outshines the rest of us."

Silvia looked at Jerry closely. "I don't think that's the problem. David and I don't have a problem with Will. Larisa seems to really like him; maybe too much. Kavidas is immersed in his engineering and mechanical work. The problem, Jerry, is that you're jealous."

"I am not!"

"I'm speaking as a friend and a disinterested party, Jerry."

Jerry shook his head, but she could see he was embarrassed. "Are we done with the week in review?" she asked. "Because I'm calling my family in Portugal in a few minutes."

"Yes, we're finished. Thanks."

"Sure, any time." Silvia picked up her coffee cup and walked out of Jerry's room, leaving him to think about her comment. She saw Will walking from the science area toward the Commons. "Good morning," she said.

"Morning," he replied. "I just selected another dozen samples for the mass spectrometer."

"You guys are keeping it going day and night! It's quite a drain on the power supply."

"But we're getting good science."

"Good. We have the power. So what are you cooking for dinner today?"

"I'm starting with something simple: pasta. I have a few secret ingredients to add some special flavor. But I won't get started for another hour or so. I have to call Lurleen."

"Good. And you'll play Frisbee this afternoon?"

"Definitely, I'm looking forward to that!"

"It should be fun, assuming we can modify the ISS rules usefully. See you later."

"See you." Silvia stopped in the commons; Will kept walking to his room. Lurleen was expecting the call at 10 a.m. He sat in his chair, set up his tablet so it could show him as well as the moonscape outside his porthole, and called her.

"Good morning," was her reply a few moments later. She looked cheerful and happy to see him.

"Good morning, my dear, how are you?"

"Pretty good. You're missing some lovely weather, for early March; sunny and warm. I suppose it's sunny up there!"

"As always; no clouds to block the sun. So, how was your week?" They had exchanged emails, but nothing in depth since the launch on the previous Saturday, nine days earlier.

"It was pretty good. I took your mother's advice and decided to focus on the job while you are away. The trick will be to stop when you're back, because this is setting all sorts of expectations. I completed a second major review, this time of the Emergency Room's income and expenses, and now I've been asked to work on the hospital's four year growth plan. So I'm getting some pretty interesting responsibilities."

"That's great! You are incredibly smart and talented, and I'm not saying that because you're my wife. You can look at a problem and drill down to the necessary data right away. I wish I had that knack."

"Thank you, I appreciate that. How are you doing? You've been interviewed a lot! I keep hearing from friends: 'I saw Will on BBC,' 'I saw Will on CNN,' I heard Will on NPR.' You're getting a lot of coverage!"

"All of us have. Jerry's interviewed maybe an hour a day. David constantly has interviews in French or Arabic. I think I've been interviewed a half hour a day. Last night the BBC interviewed all six of us at once!"

"I've definitely seen you more than Jerry, even though he's Commander. He's a bit wooden on television and uses too much technical language; you speak plainly and clearly, and your enthusiasm comes across."

"Well, I have quite a bit right now! It really has been great, Lurleen. I go out every two or three days. When I stay in, I'm reviewing notes, compiling data into preliminary conclusions, and completing tests; the new mass spectrometer is incredible but complicated to set up. It's spitting out several Potassium-Argon dates per day for us. When I stay in, also, I'm listening to the field geology going on and sending people emails, usually to David. He does the same when I go out. So even when I'm not out, in a way I am out; sometimes I'll even drive a TROV. In three days, we've covered a lot of territory."

"So I gather; everyone seems to be pleased. But no green light to make loops toward the front side?"

"Not yet, it's premature. The entire month of March is dedicated to station set up and upgrading, and breaking in ranger 2. There's plenty of exploration to do within a hundred kilometers of here; we can travel a hundred kilometers in about four hours if we're following an established track. I think next week we'll get down to Florey. There are a few craters there with ice deposits."

"Good," she said, though she had no idea where Florey was. "How are everyone getting along?"

"Pretty well, so far. Everyone's waiting for me to cook dinner this afternoon! It's my first chance to use a kitchen on the moon, other than microwaving frozen food, that is. Madhu is standing by to advise me, the dear."

"That's very helpful. She and I plan to get together some time."

"Good. I wish you'd consider taking a job in the space medicine department at Johnson Spaceflight Center. It'd be—"

"No, Will, I'm not getting into space medicine." She said it firmly.

"Alright."

"Actually, I got a very complementary email yesterday from the Houston Regional Director of the Texas Department of State Health Services. He was impressed by my report and asked some additional questions about the conclusions I drew."

"Very good!"

"So I think I'll stick to what I'm doing now."

"Yes, that's understandable. Say, I have a suggestion. I know how much you enjoy watching *The Quinn Family*. The next episode is released on the internet tonight at 8, right? Well, why don't we do a conference call where you stream the show live on the whiteboard. We could watch it together and talk about it as it goes."

"That's a clever idea, but I plan to be in the office tonight from 5 to maybe 9, and after that I'll be too tired to watch the show. I was planning to watch it some other time. I'm not sure trying to watch it together would work very well, anyway."

"Well, maybe not. But it'd be good if we could do *something* together. Six months is a long time to be apart."

"It is, but you chose it, Will. You chose it."

"And you don't want to do anything to make it easier for both of us?"

"No, I didn't say that. I just don't like that particular activity. Maybe we can come up with something."

"Well, perhaps. I'll see what else I can come up with."

"Good. Now I had better get going; I have plans, too. Let's exchange emails every day and talk again next Sunday. I think that works pretty well."

"Alright," Will replied, disappointed the call was ending so abruptly. "We'll talk next Sunday at 10, then."

"Good. Bye."

"Good bye." He closed the connection with a sinking feeling that his marriage, which had been rocky, was now in jeopardy. It grieved him. He *loved* her. "Oh, Lurleen," he sighed. It prompted him to say a short prayer. He sat in his room a long time, looking out at the moonscape and feeling the conflict of loves.

But he had to start cooking. He headed to the galley. At the time the Common Room was empty, but David came in before he had put the pot of water on the single hotplate. "So, did you get the specimens set up in the mass spectrometer?" asked David.

Will nodded. "How are Aisha and the boys?"

"Good; we talked almost an hour. How's Lurleen?"

"Good, I guess. She's getting a lot of attention and responsibility at work, which she likes. But she didn't want to watch a television show with me tonight, she wanted emails during the week, and we didn't talk very long."

"I'm sorry, Will. But I think she'll come around; she's a good woman." He looked at the pot of water. "Say, I have another question for you. This is your Bahá'í fast, right?"

Will nodded. "It started March 2; today's the third day of the fast. But I'm not fasting every day; sometimes our schedule is too intense. I asked Jerry to assign me to breakfast duty for this entire Bahá'í month and he agreed, so I'm up at 5:30, eat my breakfast before 6, and then prepare everyone else's breakfast. You see, the sun never rises and sets here and the fast is supposed to be from sunrise to sunset. But at high latitudes on Earth where the length of the day can be very long or short, Bahá'ís are told they can fast by the clock, 6 a.m. to 6 p.m. So that's what I'm doing. Bahá'ís don't have to fast if they are performing hard labor, and going outside definitely counts as hard labor. So when I go outside, I drink water; I have to stay hydrated. I'll also eat lunch. But on days I'm inside I usually fast until 6 p.m., which is about the time we have supper anyway."

"Are you making up fast days later in the year? That's what we Muslims can do."

"No. We can do that, but we also have legitimate exemptions, such as performing heavy labor. Today I'm cooking and I have to taste the food to make sure it's coming out alright, so I'm not fasting today. I've pledged to cook once a week for our entire time here, so I'm doing that. Ramadan was last month, right?"

"Yes, during training, and I postponed my fast instead. You have a salat—an obligatory prayer—too, right?"

Will nodded. “Just like the Muslims, but we can choose any one of three prayers to say every day. One is supposed to say the prayer facing the tomb of Bahá'u'lláh outside Acre in northern Israel, so I face the earth. It’s pretty easy to know which way to face!”

David chuckled. “Yes, I have to face Mecca when I pray. It’s rather convenient that the Earth’s close to the horizon; if I were near the center of the near side and the Earth were overhead, I’m not sure what I’d do! I’d have to ask for a fatwa!”

Will laughed. “I’m not sure what I’d do, either. Isn’t it ironic that you and I are the only two crew members here who have to face the Earth every day, and we’re the only two crew members whose rooms face away from the Earth!”

“Yes, that is surprising!” They both laughed. Will looked at David, relieved he had brought up the Bahá'í Faith positively. David had never asked about it, and Muslims often had a strong prejudice against Bahá'ís, since they claimed that Bahá'u'lláh was a messenger of God after Muhammad, who was understood to be the “seal of the prophets.”

“Well, I’ve got to get to work on the pasta sauce,” said Will. “And I think I’ll experiment with making bread, too. Can you check the mass spectrometer in about an hour?”

“Sure; I’ll make sure the robot reloads it correctly. I’ll also be looking at the geology and deposits in Florey D and Florey M, since they look like excellent field stops for next week.”

“Yes, definitely. There’s a graduate student seminar paper about Florey M on the website. I thought it was pretty good.”

“I saw it. I agree, it was pretty good. I’ll look it over again.” He waved and headed back to his room.

Will checked the water, which was getting pretty hot, and pulled out the pasta. He turned to the refrigerator and pulled out the tomato paste, which had been thawing overnight, and

checked his supply of herbs. Remembering the bags that Linda Newport had given him at the Houston Bahá'í Center, he walked back to his room and brought them to the galley. He spread out the various bags, each neatly labeled. He had never looked at them closely and was surprised to see what they had. Lots of sun-dried tomatoes; he could use some of them in the sauce, for flavor. Coriander seeds. Dried mint, cilantro, and basil leaves; the latter two would be great additions. There were even pumpkin seeds, sunflower seeds, and popcorn, good for snacks. As he pulled out bags, he kept finding more and more; it had totaled nearly 3 kilos and had been a problem for his mass allocation, but they had let him run 1.6 kilos over his limit.

He pulled out some dried tomatoes and put them in a bowl. They had been cut in half before drying and the seeds caught his eye. He picked out a dozen of them; they were probably viable. He was tempted to try planting them, but that would probably make Houston angry, for a variety of reasons. He put them aside in a little bowl, then added water and a little olive oil to the sun-dried tomatoes, and nuked them in the microwave.

"How are you doing?" Will turned and saw Larisa approaching him.

"Pretty well, I've started to cook Sunday dinner. I hope to have it ready by 1 p.m."

"Really? What are you making?"

"Pasta with a nice tomato sauce, complete with herbs, halal chicken chunks, and vegetables, and a loaf of bread."

"Yum!" She picked up a bag of dried beans. "Are you adding these?"

"No. Someone gave me a wide range of vegetables that I brought in my personal mass allocation. I'll probably use the beans in something else."

"Good. It'll be nice to have some *real* food!" Larisa leaned in close to look at all the bags and the items Will was putting out on the small, cramped counter in front of him. He turned to

his tablet and popped up a tomato sauce recipe that the food preparation experts in Houston had sent him. He was aware that Larisa seemed to be spending as much time looking at him as at the food.

"Do you want to help?" he asked.

She put her hand on his shoulder. "I am *so* impressed! Russian men rarely have any interest in cooking!"

"My mother and father often entertain lots of people in our house, and they often cook side by side. My dad does more clean up than cooking, but he does some. My sister and I picked up our interest in cooking from them."

"My babushka—my grandmother—loved to cook for family."

"We did a lot of that, but we invited lots of friends to our house; hospitality was an important value to us."

"Did you do that down in Houston?"

"No, Lurleen isn't the entertaining sort of person, and I've been buried in work. But at least I get to do it up here on Sundays."

"Well, we are all grateful." She put her hand on his shoulder again.

"Thanks." He looked at her and nodded; she smiled back. She kept her hand on his shoulder, so he bent over to pick up the bag of beans and put it away. She removed her hand. "Tell everyone I'll have dinner at 1."

"Alright, I can do that," she agreed. Larisa walked out of the galley.

He watched her go, wondering how to discourage her apparent interest in him, and wondering whether he should just enjoy the attention, now that Lurleen was being so distant. He

had no intention of violating his marital vow, but it was comforting to know someone found him attractive.

Once the pasta was cooked, he pulled it off the one-burner stove and started to simmer the tomato sauce, to which he added various herbs, precooked chicken, and some frozen vegetables such as carrots. Then he turned to the bread, adding water, powdered milk, and powdered eggs to the flour, kneading, and adding yeast powder. He called Madhu—by then she was home from church and waiting for his call—and he confirmed a few details with her. It was going well.

The aromas permeated shelter 1 and pretty soon everyone was coming to the commons to watch, comment, set the table, and wait. It was an enthusiastic team that sat at the table awaiting the pasta and sauce, which arrived at precisely 1 p.m. Will returned to the oven to pull out the loaf of bread and was immediately disappointed. "Oh, darn, it fell."

"What happened?" asked Jerry.

"The loaf rose, as expected, but then it fell. The bread's a failure."

"Well, bring it anyway, we'll try it."

"I'll add the garlic butter; maybe that'll help." Will returned to the galley to split the loaf—which just made it fall more—and added the garlic butter he was able to prepare.

"Will, what is this?" asked Silvia, holding up a small red chunk.

"Sun dried tomato. Isn't it great? A friend of mine gave me some and I added them to the sauce."

"They're so good!" Silvia replied.

They really are," confirmed Will. He glanced at the little dish where he had placed a dozen wet tomato seeds. Feeling encouraged by the compliment, he ran his fingers under the faucet and splashed even more water on them.

Finally, he came to the table with the collapsed bread. "No, this isn't so good. It's rather hard. I was warned that in our air pressure—a third Earth normal—bread would be tricky. The Earth team guessed what would work, but it appears their estimate was wrong."

"Are you sure it was them, and not you?" asked Jerry.

"Well, perhaps we need an investigative team!" replied Will, which provoked laughter from several of the others.

"The spaghetti and sauce, Will, are exquisite," repeated Silvia. "I thought you said that flavors and smells wouldn't be the same in lower air pressure, but I think you did very well!"

"Thank you. Yes, taste doesn't work the same, but the food preparation team advised me how much more herbs to add, and I followed my taste buds as well. The sun dried tomatoes and the basil and cilantro a friend gave me were the keys, I think."

"Now, how much does Mission Control know of your bags of herbs and vegetables?" asked Jerry.

"They should be fully aware. The food prep people and I were emailing back and forth and copying Mission Control."

"Thank God for the sun dried tomatoes!" said Silvia. To that, Kavidas added, "here, here! They have really added favor."

"We definitely need a greenhouse where we can grow vegetables," said Larissa. "Our food would be so much fresher."

"That would be a welcome development," agreed Jerry. "They're talking about adding one to Northstar 4." Changing the subject, he added, "So, how have our first five days gone?"

"Awesomely," said Kavidas emphatically. "We've got our new repair facility set up, complete with three-dimensional printer, plastic recycler, and plastic extruder. We've added the rest of the water to this shelter's radiation shield and have started on the shield of shelter 2. Shelter 2 set-up is proceeding."

"And the geology has been awesome as well," added Will. "Armstrong RR has at least three layers of volatiles buried under the surface, according to the ground penetrating radar. We recovered a tonne of volatiles from RR, quite an experiment considering its extreme temperature, and the volatiles have been partially processed. We have geological data from 17 new craters or depressions that have cold traps."

"And we have ambitious plans for next week," added David.

"Shelter 1 is in great shape and all the equipment checks out, after almost two months in mothballs," said Silvia.

"We're ready for the Thunderbird-H," exclaimed Larisa.

"Good," said Jerry. "I'm proud of all we have done; it's very, very impressive. No doubt about that. We're slightly ahead of schedule. We have a lot scheduled for next week. Kavidas and Silvia will be taking down the solar power mast for cryo station number 1 and moving it to our new cryo station number 4, which landed just fifty meters away, then they'll move the cryo station itself off of lander 1 and move it to a spot next to cryo station 4. The solar power mast will be added to the top of cryo station 4's, so that it sticks twice as far into the sky and is able to power both cryo stations. Cryo lander 1 will then be towed on its wheels over to Aldrin Pad 4 so that it is ready to transport cargo or water to orbit, boosting our launch capacity significantly. All

this will tie up ranger number 1 and its crane attachment, so the geologists will have to take their two-day expedition to Florey with ranger 2 only. Friday and Saturday, when the geologists are back and the work with the crane is finished, I want to take a ranger to Rozhdestvenskiy Crater. David, want to come along? Or Kavidas, would you like to get away?"

"Rozhdestvenskiy?" asked Will, surprised. "You're talking about the back side of the moon and close to 85 degrees north."

"Correct. We haven't gotten to 85 north yet, anywhere, but Rozhdestvenskiy has a big, flat floor, and it has several smaller craters with volatile deposits, and its central peak is extremely off center; there's certainly a story there."

"But we're working on progressively longer loops toward Mare Frigoris," said Will.

"We don't have to make that the focus of all our expeditions. The expedition to Florey really doesn't build a loop toward Frigoris."

"It builds the return loop," replied Will. We can't loop outward toward the eastern limb of the near side because the sun is setting there now."

"Well, the eastern limb will be in darkness next week as well," said Jerry. "Meanwhile, Rozhdestveskiy will be experiencing sunrise. This is the best time to explore the proximal far side. Two weeks from now is the soonest you can start your eastern loop."

"That's true," agreed Will, trying to sound reasonable and accepting. But he couldn't help but think that Jerry was intentionally countering his plans.

"Rozhdestvenskiy has some good geology," said David. "There are a few proposed expeditions on the web. Sure, I'll go with you," said David.

"Great," replied Jerry. "I can't wait to get out. I'm getting tired of a short walk outside every few days."

14.

Greenery

Second week of March 2029

"I'm so glad you could help me," Larisa said to Will, as they exited from ranger 1 near the summit of Armstrong Pinnacle. "I know you were anxious to get started on analysis of the data from Florey, but if Jerry had come out with me, he and David would have to postpone their expedition to Rozhdestvestkiy by a day, which means returning Sunday evening, or postponing the whole thing until Monday."

"I'm a pretty quick study," replied Will. "And I remember the many, many briefings we got about the cryo systems. I should be able to assist."

"Oh, I'm sure." Larisa closed the ranger's outer airlock hatch and led the way to cryo units 1 and 4, just four meters away. "So, I gather Florey was quite significant."

"Indeed it was; I'm glad Mission Control allowed us to stay an extra day. There's a huge area in the shadow of Florey's southern rim, the northern rim is over the horizon and thus provides no illumination, and the southern rim area is so far south that the sun never rises above the northern horizon. We found several spots that were 23 Kelvin; the coldest areas on the moon. One crater, for some reason, had volatiles that were nearly 1 percent ammonia or nitrogen; that's a lot of nitrogen. Presumably a fragment of comet nucleus impacted nearby, at some point in the past."

"Interesting. I had no idea the volatile composition was so variable."

"Neither did we, but we're beginning to discover anomalies that don't fit the standard models." Will turned to look at cryo units 1 and 4. They had been resting on top of landers 1 and 4 respectively, but over the last 4 days, ranger 1's crane attachment had removed their solar

arrays and the mast that supported each one, picked up the cryo units and placed them on metal pads a few meters from lander 1, and then had reinstalled both masts atop cryo unit 4. “That mast just looks too high and too thin to support the arrays,” he said, shaking his head.

“It does, but don’t worry; this is the moon and the gravity is low. Cryo unit 4’s mast was designed to be raised forty meters and hold three times as many square meters of solar arrays. Transferring them was a delicate and difficult job.”

“I know you and Jerry trained for a month to do it.”

“That’s for sure! And yesterday we worked sixteen hours to get it done. But now it’s done and we don’t have to worry about one mast shadowing the other. The Northstar 3 cargo flight will bring another fifty square meters of arrays. If we need more, we can get a taller mast, raise it a hundred meters, and leave the lower forty meters empty of arrays so this mast doesn’t get shadowed by them. In a few decades, Armstrong Pinnacle could have arrays reaching as high as skyscrapers.”

“Or we’ll install arrays on another pinnacle a few kilometers away and string a power line,” said Will.

Larisa nodded. “We’ll probably do that, too.” She pointed to a pad near their feet. “The Sabatier reactor goes here, next to lander 1, which will serve as a permanent volatile storage facility. Questions?”

“No, let’s get started.” They returned to the back of the ranger and picked up the Sabatier. It was about the size of a household air conditioning unit and had a similar mass, but was fairly easy for two to carry in lunar gravity. They brought it over to the pad, put it down, extended a power cord to cryo unit 4 just three meters away, and plugged the unit in. While Mission Control ran through a series of equipment checks, Will and Larisa grabbed a flexible metal hose and

attached it from the "gaseous carbon dioxide out" nozzle on cryo unit 4. They install a Y-shaped junction on the Sabatier's "gaseous carbon dioxide in" nozzle, so two CO_2 hoses could be joined together into a single input line. They attached a hose from the Y to cryo unit 1. Finally, a hose had to be installed from the "liquid methane out" to cryo lander 1's input nozzle just a meter away. They wrapped the hose with thick, silvered insulation to protect the liquid methane from the sun's heat.

It was slow, precise work; 90 minutes elapsed before they had the three lines installed. Larisa checked everything Will did. "So, how much methane will we be able to make per year?" he asked, as they walked back to the ranger to grab the Sabatier's heat radiator.

"Depends on the volatile deposits we mine. So far, we've been mining the units in shallow craters near here that aren't very cold and have almost no carbon dioxide. The two hundred tonnes of ice we've mined had almost two tonnes of CO_2. Northstar 2's inhabitants exhaled over a tonne of carbon dioxide, but it was vented. Once we capture that as well, that will boost CO_2 output. Every tonne of CO_2, combined with almost 1 tonne of water, can make almost 2 tonnes of methane and oxygen propellant, but only a fifth of the output is methane."

"The transporters were sized to dig and transport a tonne of volatiles and regolith at a time from relatively warm deposits," said Will. "But I gather they can't be adapted for the really cold deposits that have CO_2."

"The new transporter that came with cryo 4 is designed to handle 90 Kelvin on an experimental basis. That'll get us into deposits that are up to ten percent CO_2 and with them, theoretically, we could make a tonne of methane/oxygen propellant for every four tonnes of hydrogen/oxygen propellant. But in practice, it's pretty complicated. Every piece of equipment has various production bottlenecks. This Sabatier is an experimental unit for Project Redstar,

since the Mars missions will need methane. It can't process more than a tonne of carbon dioxide per month."

"And we don't have any use for the output, anyway."

"That's right; we'll be storing it until Mars equipment needs testing. I doubt we'll bother to dig the colder deposits very much because we don't need the non-water components."

"Not for a few years, anyway."

"Exactly. These heat radiators will need to be recharged with ammonia in a few years and it'd be great if we can make it by then. The Sabatier can be used for that, if we don't extract enough ammonia from the deposits."

"Even the warmer deposits contain traces of ammonia," agreed Will.

They put down the radiator, which was a meter square, and its support rack two meters from the Sabatier and began to connect two hoses, one to carry compressed, warm gaseous ammonia to the radiator and the other to carry the cold, condensed liquid ammonia back to the Sabatier. They were quicker with that task and in half an hour were able to attach a bottle of liquid ammonia to the Sabatier's input nozzle to charge the system. They checked the pressurization for leaks, then headed back to the ranger to get the shiny, silvered isolation cone. They installed it around the radiator, its large opening facing straight up toward the cold of space, blocking sunlight from the radiator and the routing the expelled infrared heat of the radiator upward, away from the cryo units and the lander. They had to check a few more things and tighten one connection that Will had not tightened enough, but after an hour, the system was ready to go. Mission control sent a small amount of carbon dioxide and hydrogen into the system to test it and reported that they were finished.

“Great,” said Larissa to them. “Good to work with all of you!” She turned to Will. “Let’s head back to the shelter.”

“Okay.” They walked back to the ranger and stepped into the little airlock, one by one. While Will waited for Larissa to clear the airlock, he enjoyed the view from Armstrong Pinnacle. The moon had its own distinct, raw, desolate beauty, and he enjoyed it so much more than he ever had on a TROV control screen.

Finally, the light over the airlock turned from red to green. He opened the hatch, entered, brushed the doorway’s edges with a special brush to remove any dust, and closed the airlock. Will began to brush his space suit as well; for two minutes the air in the filling airlock was run through special filters to remove the dust that he shook free. Once the light over the other door turned from yellow—indicating the lock was filled, but had too much dust in the air—to green, he knew the air was sufficiently dust free and he could enter the ranger, which he did.

“Good to have that task complete,” he said, moving to the seat next to Larisa, as she started the ranger forward.

“Yes. Slow progress. I wish we could see things move faster, but—” She shrugged.

“Space exploration has many bottlenecks, just like our cryo system, but the main one has always been political will. I wish someone like Swift had come along thirty years earlier.”

“I doubt he was possible then. A certain maturity of technology had to occur. So, do you think he’ll take us to Mars?”

“I don’t know. The bill to authorize Project Redstar died in the Senate. I’m pretty sure NASA killed it; they’re mad at Swift.”

“That’s clear from the legislation to authorize the ‘Liberty Shuttle’ that is supposed to be 99.9% reliable and the same cost as the Thunderbirds.”

“Fat chance! It’s a pork barrel project to employ engineers and rocket builders. They’ll either cancel it before it’s built, or use it and spend two or three times as much for every person and kilogram they put into orbit.”

“That’s what I’m afraid of, too. Swift hasn’t lobbied very effectively. The Gulf sultanates and India have backed away from participation in Redstar, too.”

“That’s just as well, since their involvement probably scared Congress.” Will shrugged. “We need some time to get the lunar exploration system set up. We’ll encounter environments here as extreme as any on the poles of Mercury or the asteroids or the moons of the outer planets. It’s a good laboratory.”

“That’s true.” Larisa suddenly moved her hand to her right earpiece for a moment, listening to a message from Mission Control that Will couldn’t hear, then she said, “alright, we’ll head for the nearside entrance.”

“A change of plan?” asked Will.

“Mission Control wants us to get the bulldozer blade onto the ranger before we go inside.”

“Are they going to push more regolith against shelter 2?”

“Maybe, but that job is just about finished. I think they’re going to run the ranger all night, while we sleep, to excavate around the farside plaza.”

“The excavation there is quite intriguing! They’re making it both very wide and very long!”

“But not long enough for a third shelter. I think it’s the site of the ‘Lunotel’ as they’re calling the tourist accommodation. There was a web report I read yesterday that said Northstar 5 would set it up.”

“Really? That’s pretty soon.”

“By then a moon trip will be $30 million per person.” She laughed at the thought and added, “It makes one wonder why NASA won’t agree to send astronauts here, after Northstar 5!”

“I’m sure they’ll come around on that, too.”

She nodded. “So, how’s Lurleen?” she asked, after a moment of silence.

“Pretty well. We exchanged emails this morning. Anything new with Feodor?”

“No. We have an interesting relationship. We’re apart a lot, and we understand the implications of that fact.”

Will nodded at that.

She looked at him and saw he wasn’t going to respond. She pushed an icon to set the ranger on autodrive; between GPS and the known locations of the quad-coded posts marking the buried power cable next the trail, the ranger would have no difficulty continuing to the shelter. She pushed another icon to close the audio circuit to Houston. “You know, I find you very attractive.”

Will considered his words carefully. “Larisa, you are a beautiful woman. All men would say so, and certainly I am attracted to your beauty. But I have a covenantal commitment to Lurleen.”

“A ‘covenantal commitment.’” She repeated it, uncertain whether to ridicule it or be impressed by the phrasing. “Alright. You can’t blame me for trying, though, can you?”

He smiled. “No, I don’t blame you.”

“Good. I may even raise the matter again. You know, a friend of mine told me that she found sex in lunar gravity to be exquisite.”

"Really?" He laughed at the thought, all the while wondering whom she talked to. She laughed as well.

They continued to the shelter in silence, a silence that started out feeling normal and that felt more and more abnormal as it persisted. Larisa took over the controls again and drove to the nearside plaza, where a TROV helped to hitch the bulldozer blade to the front. Then they drove to the farside plaza and slowly backed the airlock up against the shelter's docking mechanism. They were home.

There was no one to greet them as they entered. David and Jerry were busy loading the other ranger; Silvia was cleaning filters and doing environmental control systems management; Kavidas was repairing and upgrading a TROV. Larisa headed for the galley to nuke some dinners for everyone; Will hadn't been in the galley since Monday and had rather enjoyed the break from cooking. He went to his room and drafted a blog for his private Facepage account:

I was just working on the cryogenic propellant system, helping upgrade it so that it can manufacture methane propellant from water and carbon dioxide. This not my usual job, but I really enjoyed it because the work has great potential. Our landers hold up to 27 tonnes of liquid hydrogen and oxygen. This number was carefully chosen so that a fully fueled lander can fly to low lunar orbit, pick up fourteen tonnes of cargo, and bring it to the surface. Our Thunderbird-H third stages similarly are carefully designed to use 36 tonnes of liquid hydrogen and oxygen to fly fourteen tonnes of cargo from low earth orbit to low lunar orbit. A lander also has enough fuel to fly a passenger module to low lunar orbit, to begin our return to Earth, and then return to the surface with the next crew plus several tonnes of consumables. Another lander flight to the depot is needed to transfer fuel to the Thunderbird-H, so that it can return itself and our Polaris capsule to low Earth orbit for a future mission.

The next step we just took is to free up two of the four landers that brought the cryo units so that we have four functioning landers. That gives us immense redundancy; there will be no reason to worry about equipment to launch us back to lunar orbit. But more importantly, a fully loaded lander can fly itself to any spot on the lunar surface with five tonnes of cargo and return here. That means we can support surface exploration anywhere, because a fully loaded ranger masses 4.5 tonnes. We could fly one with a crew of two inside to any spot, they could explore for two weeks, then fly back here.

And later this week, we will take yet another step: we will land a Thunderbird-H here. It will become our new hydrogen and oxygen storage facility, freeing up two landers to provide backup storage for them and primary storage for methane, carbon dioxide, and ammonia. A full Thunderbird-H can return to the lunar orbit with twenty tonnes of fuel for the depot and return to the surface for more, or can push thirty-eight tonnes of water toward earth, where several months of gentle aerobraking maneuvers can bring it to low Earth orbit. Once we can do that, an ordinary Thunderbird can launch a Polaris into low Earth orbit, cutting the launch costs in half; the Polaris can dock to a Thunderbird-H filled with hydrogen and oxygen propellant made at the low Earth orbit depot from lunar water; and lunar propellant can bring the crew to the surface and return them to Earth. No one is sure how much this new version of our transportation system will cost, but the estimate is that it will cut the cost in half. Tickets to the moon could fall to $10 million per person in a decade! As you can imagine, this is immensely exciting for me. It opens the possibility of frequent visits, and three to four month stays rather than six month sojourns, as is standard now. Indeed, tourist flights will last a week or two and could provide convenient access to scientists investigating specific research questions. I'm delighted to be involved in that!

He reread his posting and sent it. It was getting close to suppertime, so he headed to the common room. David was sitting in a comfortable chair next to a porthole reading an Arabic newspaper on his tablet, so Will slid into the other comfortable chair. “So, ready to go?”

David looked up. “Yes, we have all the consumables and equipment moved into ranger 1, we’ve reviewed the itinerary, and checked out all the ranger’s systems.” He lowered his voice. “I see you’re not scheduled to provide us any backup!”

“Yes, Jerry revised my schedule this morning because of ‘pressing priorities’ according to his email. That’s why I was outside for five hours setting up the Sabatier.”

“Which could have been postponed until he got back!”

“Yes, I don’t know why he shifted me to that task; I guess because Larisa and he were supposed to do it yesterday and he didn’t want it to delay your departure. But he has eliminated my expedition support time; I’ll be catching up on our ‘huge backlog’ of samples to date and analyze.”

“That could wait, too.” David leaned in close. “He’s jealous of you.”

“I think that’s true.” Will shrugged. “Some of the stops in Rozhdestveskiy are my proposals anyway.”

“I know; he knows. But he plans to make a lot of unscheduled stops and do original exploration. That’s good and very useful, and will probably produce some good, original results as well.”

“And get to 85 north?”

“We were speculating about trip extensions that would be possible if we rode back on autopilot all night, and he was talking about a crater at 83.9 North.”

Will smiled. “Even better. Well, I’m not going to play that game. I can’t help it if I’m a better geologist than he. First of all, I have a Ph.D. in lunar geology and he doesn’t. Second of all, he’s a Navy pilot, and consequently is a much, much better pilot than I! But that means he has had less time to learn geology, naturally.”

“Yes, of course. I agree, don’t play that game. Be gracious.”

“Exactly. That’s good Muslim advice, as well as good Bahá'í advice!”

David chuckled at that. Just then Jerry entered the common area, walked to the galley to see how supper was coming, and walked back to the dining table with utensils and napkins. “Gentlemen,” he said to them.

“So, you’re ready to go?” asked Will.

“Yes, after we finish supper,” replied Jerry. “We can go five hours before we sleep. We’ll make two stops on Rozhdestvenskiy’s outer rim and collect samples with the ranger’s manipulator arms. Tomorrow morning we’ll be on the floor of the crater and start working our way southward to the central peak complex, which we’ll explore, and Rozh S next to it. The next day we’ll loop to the west and return.”

“The off-central peak complex is an important investigation,” agreed Will.

“We’ll be stopping at a lot of the field sites you and David proposed,” said Jerry. “But we’ll certainly find plenty of other important stops as well.”

“Oh, I’m sure,” agreed Will. “I’m looking forward to seeing the results. Good luck and God speed, Jerry. It’s an important expedition.”

Jerry smiled and nodded. “Thank you.”

The shelter was always very quiet when there were only four people at the station. Will was usually awakened by the sounds of someone preparing food—the microwave's beep was loud—and this time he overslept because no one was up early. It meant fasting without breakfast, but he was staying inside all day anyway, so it would not be that difficult. He rose, took a shower, shaved, and got dressed. As he was walking to the commons, he heard Kavidas say, "light as a feather, a friend of mine said. Very soft, comfortable, and intimate: that's sex on the moon, he said."

"Really? Never heard about it," replied Larisa, sounding uninterested. It was enough for Will to ponder the situation; she wanted to sleep with him, but not with Kavidas. He wondered whether the Tamil's very dark skin was a factor.

He entered the common room. "Morning."

"Morning, Will," replied Larissa, very friendly.

"Good morning, Larisa," he replied. "No one made the coffee?"

"Silvia's on galley duty and she's not up yet."

"I see." That was the sort of attitude that irritated Will, but he didn't say anything; he walked to the galley and got started on coffee and toast. A few slices of the bread he had made proved edible, though most were not, so he put a few in the toaster and added two slices of frozen bread. He pulled thawed fruit salad from the refrigerator—its smell told him it would need cleaning soon—and put it in bowls, then turned to the cereal and frozen ham and eggs. Might as well eat the ham while David was away. By the time he had everything on a tray, complete with jam and butter, Silvia entered.

"Good morning; oh, thank you, Will. I apologize I missed my duty this morning, we'll swap later."

"Whatever. No problem. How are you this morning?"

"Pretty well." She took the tray and brought it to Larisa and Kavidas, then sat with them. Will came along and sat as well.

"Skipping breakfast entirely?" she asked.

Will nodded. "When I was in university, sometimes I ate breakfast at midnight and slept as late as I want. Fasting isn't so hard; your body adjusts."

Silvia nodded; the three of them were now used to his fast and didn't ask about it. "So, we're ready for our tasks today? Jerry left us a pretty thorough list."

"Now that cryo units 1 and 4 have been moved and are functioning together, I need to do some routine maintenance on unit 2," said Kavidas. "Mostly changing filters; unit 2 was fed a lot of regolith and dirty ice right before Northstar 1 landed and the filters are now clogged."

"Ranger 1's airlock filter, too," said Silvia. "I put it on the maintenance list yesterday."

Kavidas nodded. "Okay. Now that we can go deeper into cold traps and get pure ice, the filters will last longer."

"Not to mention, output is higher. Larisa, you're working on TROV 3's manipulator?"

She nodded. "Left manipulator. The second joint is sticking. It may just need cleaning. If that's the case, I'll spend several hours supporting Jerry and David. If not, someone in Houston will drive a TROV when they go EVA."

"I can help, if they need someone local with faster response time," said Silvia. "I'm working on the waste management system in shelter 2; it needs contributions to be fully tested out, so use its bathrooms this morning if you can. Think of crapping as an assigned duty for our mission. Will, you're inside working on samples."

"That's for sure. We have a backlog of nearly 200 samples that require something; dating or detailed compositional analysis in the mass spectrometer, general compositional analysis with the alpha back scattering instruments, slicing and thin sectioning, etc. I set up a dozen batches before I went to bed last night and the robot should have processed them all. If the instruments are run 24 hours a day for two days, we'll take care of maybe half the backlog."

"You've got to stay inside more, and collect fewer samples!" replied Silvia, with a chuckle. "When Jerry and David come back, they'll have a hundred more, too!"

"Absolutely," agreed Will. "We're keeping nearly a hundred researchers busy on Earth. "We're running high on the sample return quota, though. Jerry will have to ask Mission Control whether we can haul 600 kilos back to Earth, rather than 500."

"Try to get more processing done here," replied Silvia. "The mass allocations are pretty tight for the return flight. By the way, when are you planning to plant your tomato seedlings?"

"What?"

"The tomato seedlings next to the sink. The seeds had dried out by Tuesday morning, while you and David were out at Florey, so I gave them more water, and I did it again last night."

"Oh?" Will stood up and walked to the sink. The dish into which he had placed a dozen seeds from the dried tomatoes was still there, and most of them had started to sprout. He picked up the dish and brought it to the table. "How do you like that."

"Those are tomatoes?" asked Kavidas.

Will nodded. "A friend of mine gave me some herbs and dried vegetables from her organic garden down in Brownsville. I put some of the sun-dried tomatoes in last Sunday's pasta sauce."

“Which was absolutely delicious,” added Silvia. “Well, they’re growing; we shouldn’t kill them, we should plant them!”

“Mission Control will be unhappy, though,” said Will.

“Why?” asked Silvia. “Because we haven’t spent ten million dollars on support staff and preparation to make the experiment successful? Rubbish.”

“I helped grandma in her garden every year,” added Larisa. “It’s really not hard, and if we have problems, we can ask for help. The public will help, if NASA’s budget is too tight to hire a consultant!”

“There’s a small greenhouse on ISS2 and at the Mir Industrial facility,” said Silvia. “It’s not like our experiment will prevent pure research.”

“Nor will it contaminate the moon’s biosphere!” added Kavidas, with a laugh.

“Alright,” said Will. He pointed to the empty plastic container that Kavidas’s ham and eggs had arrived on the moon in. “We can use these; we have a thousand of them.”

“I have a better idea,” said Kavidas. “All these plastic containers for our frozen meals are scheduled to be washed, melted down, and converted back into plastic for the three-dimensional printer. I’m scheduled to set it up next week. I can print anything you need!”

“We’ll need a space, and light,” noted Silvia. “Shelter 2 is empty and has lots of portholes.”

“We have spare LED panels,” added Larisa. “We can give them a couple kilowatts of light. Shelter 2’s cooling system can handle the extra heat, since no one’s living in it.”

“Especially if we ran the lights at night when we have a lot of the equipment shut down,” said Silvia. “Will, we need soil.”

He nodded. “I’ve been thinking about that. There’s a moon full of regolith. Crushed basalt or crushed anorthosite are both pretty good mediums; fresh ash falls in Hawaii get populated with plants pretty quickly, and they’re basically the same composition as lunar basalt. We can also find carbonaceous chondrite chunks in the regolith; those meteorites are rich in organics. If we can find chucks of KREEP ejecta up here, they’ll enhance the supply of potassium and phosphorous.”

“Regolith’s pretty coarse, though,” said Kavidas. “I can keep the stuff we clean off the filters. There’s a lot of it.”

Will nodded. “The finer stuff is better because it’ll break down and release its mineral components faster. We have sieves in the geo lab, so we can obtain any size fraction we want. Kavidas, if you can bring me a couple kilos of reg when you come back in from your EVA, I can sieve it.”

“Sure, and we can probably get 100 grams of the really fine stuff from all the filters. We have all of Northstar 1’s discarded filters. We can run them through the water-based cleaning system that we brought.”

“And I can contribute sewage sludge,” added Silvia. “It may provide the plants with the nitrogen they need.”

“Or I can synthesize a bit of ammonium nitrate from our ammonia supply,” suggested Larisa.

Will laughed. “Sounds like quite a plan. What will Jerry think, though?”

“We can find out after he gets back,” replied Silvia. “Because he left me in charge until then! And I’d really like to have some plants up here! We’re going to be here for six months, and that’s a long time to go without greenery!”

"I agree," said Larisa. Kavidas and Will nodded.

"Alright, the plot is complete, then," said Silvia. "Shall we set up our greenhouse tonight?"

"Definitely!" said Kavidas.

"But let's not call it a greenhouse; that's formal and will get us in trouble," said Larisa. "More trouble," she corrected herself.

"It's a 'greenery,'" suggested Will.

Silvia nodded. "Greenery it is!"

The four of them worked together as a team that night for two hours, bringing together dust from the filters, sieved regolith, a bit of sewage sludge, and stale bread—a better use for it than eating—to fill a dozen trays and pots with artificial soil. They put them on a table in an empty bedroom in shelter 2, at the same level as the room's porthole, raised a shiny silver backdrop behind them to reflect the sunlight on the greenery, and installed several light emitting diode panels overhead to supplement the sunlight. Because they had made way too much "potting soil," each of the six seedlings got their own pot and there were six pots left over. Into the other six they placed other seeds from Will's collection; cilantro, mint, basil, beans, pumpkin, and peas. If they all germinated, they'd need a lot more pots and a substantial space, but shelter 2's lower level had a large area dedicated to storage that could be rearranged.

Mission Control watched much of their activity by video, no doubt; the camera in the bedroom was turned off and the microphones throughout the shelter remained turned off because there was no emergency, but Houston saw enough to get a pretty good idea what was going on.

The next morning, Will got a text from David: *What's going on? Jerry's busy emailing Mission Control and is furious.*

Will could picture the scene; no doubt Jerry and David had pulled the curtain across the ranger's cabin and laid the seats flat to sleep. If Jerry wanted to talk to Mission Control in privacy, he'd have to retreat to the airlock, into which they also moved the portable toilet at suitable times. The cab was almost as cramped as a capsule. He texted back, *we planted the tomato seedlings that sprouted. We even planted some mint seeds I found among the mint leaves, so in a few months you'll be able to make Moroccan mint tea.* A minute later, David texted back *Good!*

Silvia looked nervous all day; no doubt she had heard from Mission Control, Jerry, or both. Will went to check the "greenery" and found Kavidas in there, sitting cross-legged, meditating. He retreated quickly, fascinated that Kavidas had moved his private devotional practice from his room to the greenery.

It was close to midnight before Jerry and David returned from their triumphant excursion to 82.9 north, 213 kilometers as the crow flies—if there had been any crows that could fly—from Peary Station. It was the longest trip yet and both men looked jubilant. Everyone had stayed up to greet them and over cups of hot cider—it was amazing what choices for beverages they had—Jerry and David recounted many details. "We'll talk more tomorrow," said Jerry. "We need to review the work schedule and various other aspects of our efforts here. We'll have a half hour meeting after breakfast."

"Are we planning loops?" asked Silvia.

Jerry nodded. "Houston doesn't want us to go any more than 210 kilometers with a single ranger; if there's a breakdown, that's a seven-hour drive to make a rescue. But both rangers are

working well, so we can now plan longer excursions that use three people and both vehicles. We'll talk tomorrow; let's get to bed." He stood from the table, so everyone else did the same. But Jerry fixed his eyes on Will. "We need to talk in my room."

"Okay." Will followed Jerry to the commander's room while everyone else watched worriedly.

Jerry closed the door behind them and pointed to two chairs. They sat facing each other, nearly knee to knee. "I am disappointed and furious," Jerry began. "A 'greenery'? Is this a scientific expedition or a hippie's organic garden?"

Will struggled to keep himself calm. "We are most certainly a scientific expedition, and what we have is no 'hippie garden.' I didn't mean to start a garden, but Silvia water the tomato seeds, and all four of us created the soil. Did you hear Silvia's account?"

"I did, and I blame you anyway. Why did you pull out the seeds? Why put them in a dish? We can't be distracting ourselves growing tomatoes when we have 60 hours a week of work! Besides, a proper greenhouse needs proper planning, scientific development of the soil, detailed measurement of the growing conditions and of plant growth, experiments with different combinations of growth media . . . you know how the biologists do it! How would you like it if biologists were gallivanting outside picking up rocks and commenting about how pretty they were? Stick to rocks and leave the tomatoes to the professionals!"

"Jerry, if we had biologists outside, they'd be talking about the 'pretty rocks' to professional geologists in Houston, who would steer them. There's nothing we're doing that prevents NASA from spending $50 million on a 'proper' biological experiment on a later mission. Meanwhile, if they want to study growth, we can install cameras in the greenery and place centimeter sticks around so that interns and grad students can measure the growth from

Houston. We'll be glad to provide lighting measurements and record the amount of water we give the plants, and we can give them the composition of the artificial soil; we recorded the number of grams of everything we used."

"So, you want to be an amateur biologist? Is there anything you can't do, Moonman!"

"Jerry, I went into the greenery today and Kavidas was there doing his daily meditation. Plants are not like rocks; they aren't just a scientific object of interest. They calm us, make us feel more at home, more human. The moon is magnificent desolation, but it isn't *nature.* And we need nature."

Jerry shrugged. "Suit yourself. Mission Control is angry, but they aren't asking anyone to throw away the 'greenery.' That's got to be your word; Silvia, Larisa, and Kavidas wouldn't have dreamed it up. It's a *liberal arts education* sort of word. But watch out, Will. People aren't going to give you assignments just because you're supposedly brilliant. You can be an astronaut and be confined to the TROV control area in Houston. And I have some say about that."

15.

The First Loop

Mid-late March, 2029

Will glanced at the chronometer on the ranger's dashboard. How much longer before the landing burn? Three and a half minutes?"

"I think that's right," replied Kavidas. He popped up the live data stream from the Thunderbird-H as it approached Aldrin Pad 1 on North Ridge. Everything was nominal.

"By the way, when we finish with landing set-up, I want to spend 10 or 12 minutes scanning the regolith for KREEP samples and maybe for carbonaceous chondrite."

"'Creep'?"

"It's an igneous rock that formed late in the cooling of the moon's magma ocean, after the anorthosite floated to the top to make the crust and the pyroxene and olive sank to the bottom to form the mantle. It erupted to the surface volcanically, primarily in Oceanus Procellarum and Mare Imbrium, but impacts tossed chunks of it widely, even up here. It's rich in potassium and phosphorous, two elements the plants need."

"I see, so this is for the greenery. Good." Kavidas looked at Will. "So, did Jerry chew you out about it, the other night?"

"I suppose you could say that."

Kavidas's face turned red. "He can't blame that just on you, all four of us decided to set it up! He's just jealous of you, Will. I wouldn't take this; otherwise he'll push you around again and again. You need to stand up to him."

“Kavidas, don’t worry about it. I have a different approach to people than that; in my experience, returning negativity with kindness often softens the other person and resolves the matter.”

“Well, suit yourself. If he were to single me out for participating in something that all of us did, I’d be furious, and I’d make sure he understood that! Furthermore, I’d look for a way to get right back. Perhaps that’s not the kind approach, but it usually works!”

“Well, I plan to try my way first.”

Kavidas pointed to a moving spot in the southern sky. “There it is.”

Will leaned close to the ranger’s windshield and spotted the Thunderbird-H. Just then, the “star” expanded to become a long, pale blue flame. “The engine’s firing!”

“Right on time.”

“And if the engine failed to ignite?”

“The Thunderbird would pass overhead with perilune about thirty kilometers farside of us and several kilometers above the surface. If the engine started its burn and turned off, the Thunderbird would crash some distance farside of us, depending on how long the engine burned.”

Will nodded and looked up. “She’s a beautiful sight to see.”

The Thunderbird’s engine burned a bit over two minutes, removing some 1,500 meters per second of orbital velocity. As she approached Aldrin Pad number 1, the flame grew longer and fuller. A great cloud of dust and vaporized volatiles were blasted skyward as the hydrogen and oxygen powered interplanetary stage settled onto its five landing legs. “Touch down!” exclaimed Kavidas as the engines went out and the cloud began to dissipate. “Permission to approach.”

They had to wait several seconds. Then Mission Control replied, “permission to approach to 100 meters.”

“Copy.” Kavidas activated the wheels and moved out of the crater 250 meters distant, where they were partially protected in the event of a crash or explosion, to the observation pad at the 100 meter point of the road. “Permission to approach within 25 meters.”

“Wait another minute,” replied Mission Control. Then a minute later, “permission to approach within 25 meters and circle vehicle granted.”

“Copy.”

While Kavidas drove closer, Will activated additional cameras so that the condition of the Thunderbird-H could be evaluated in detail. They slowly drove all the way around, photographing the various plumes of escaping gas. They were miniscule; the hydrogen and oxygen tanks were nearly empty. Will looked at the telemetry that Houston was getting from the Thunderbird’s main computer. Everything looked nominal.

They finished their circling. It was now ten minutes after landing and the shutdown of the propulsion system was complete. Kavidas glanced at the screen, then said to Mission Control, “permission for EVA and completion of the landing check list.”

“Permission for EVA granted.”

Kavidas smiled. “We’re going in!” He pushed his seat all the way back, stood up, and headed for the airlock while he snapped on his helmet and gloves; both men had been wearing their life support backpacks. Will had to wait for Kavidas to clear the small airlock; by the time he was outside, Kavidas had pulled the mylar sunshade off the ranger’s trailer.

Once Will was out, they picked up the sunshade and walked to within five meters of the Thunderbird-H. “It really is a big version of the lander,” commented Will.

"Of course," said Kavidas. "Both are 5.5 meters in diameter; the lander has two tanks for 27 tonnes of liquid hydrogen and oxygen and stands 3.5 meters high, whereas the Thunderbird has three tanks for up to 40 tonnes of liquid oxygen and hydrogen and 40 tonnes of water and stands 7 meters high. Both have five landing legs, but only the Thunderbird has a light heat shield. The lander has five Wizard-H engines that are more advanced, the Thunderbird-H has eight Wizard-G engines. I gather they plan to replace it with Wizard-H1s soon."

"I wouldn't want to descend a seven-meter ladder to the ground."

"That's for sure, and unload cargo from up there! Come on, let's get the sunshade up."

Will nodded and added, "agreed" because nods were not easy to see in moon suits. They headed to the spot where the road approached the pad. The silvered mylar sunshade was six meters high—tall and awkward to handle—and had metal stakes with sharp bottoms built into it every six meters. While Will held onto the bundle, Kavidas pushed the first stake into the ground. They followed a white spiral that had been spray painted onto the compressed regolith, a spiral that was often hard to see. When they returned back to the starting point, they were three meters farther from the Thunderbird, which provided a vehicle accessway. The cryogenic tanker that would bring the Thunderbird liquid oxygen and hydrogen had to get to it.

They pulled out a portable cryogenic refrigerator, brought it to the vehicle, hitched it to the Thunderbird's hydrogen and oxygen input and output lines, and hauled a power cord over from the nearest electric cable—buried fifty meters away—and plugged the refrigerator and Thunderbird into the station's power system. The cryogenic tanker would dock to the refrigerator and pour its propellant into the vehicle via the refrigerator's input nozzles. They installed a metal bumper around the refrigerator and Thunderbird to keep vehicles at the proper distance.

“Done,” said Kavidas, when they completed the set-up two hours later. They walked back to the ranger and stopped to look quickly. The top of the Thunderbird stuck out of the sunshade, but just part of the empty water tank. He nodded, satisfied, and turned to Will. Will was already slowly walking across the ground, scanning the regolith for chunks of KREEP and chondrite. He leaned down and picked up a small fragment the size of a pack of gum. “This is carbonaceous chondrite; it’s nearly black because of the high carbon content. It also tends to be friable—it crumbles easily—which makes it easy to add to potting soil.” He handed it to Kavidas.

“Okay, I’ll look as well.” Kavidas took the piece, rolled it around in his hand while he examined it, then he set out to look. But he quickly grew frustrated, because the lunar surface consisted of rock material ground up and mixed as a result of impact gardening, some of it as fine as dust, some of it irregular, large chunks. None of it had been rounded by wind and water. All of it was shades of gray.

“Ah, here’s some KREEP.” Will picked up a piece the size of a larger marble and showed it to Kavidas.

“How did you find that? It looks like everything else!”

“A lot of experience; hours of looking at stuff. Don’t worry about it.” Will handed that piece to Kavidas as well, as a model, and continued to walk across the surface slowly, scrutinizing every fragment large enough to scrutinize. Then he spotted something utterly different.

He reached down to pick it up, rolled it over in his hand, looked at it more closely, then rolled it over again. “Huh.”

“What is it?” asked Kavidas. When Will didn’t answer immediately, he walked over to look more closely. “It looks like a piece of mudstone; of shale.”

"Exactly," replied Will. "This is a piece of earth."

"It is?!"

"Yes, I'm fairly certain of it."

"What's it doing here?"

"The same thing as pieces of the moon on the Earth; lying on the ground. More pieces of the moon have been blasted into space and fallen on the Earth, but they usually erode away. Someone has estimated that every square kilometer of the moon's surface has hundreds or thousands of fragments of the Earth, blasted into space by impacts. And when are most of them from?"

Kavidas considered. "Probably the earliest period. Maybe even from terminal bombardment."

"And what era of Earth history do we have the fewest outcrops and pieces from?"

Kavidas's eyes grew large. "The very same period."

"Exactly. We have virtually nothing from before 3.8 billion, and even rocks from before 3.5 are very rare. The first fifth of the history of the Earth—" he held up the fragment, "will have to be reconstructed from fragments up here."

"Wow!"

"Exactly!"

They returned to the shelter and shared the discovery with the others, then Will and David retreated to the geology lab to examine the rock using various magnifiers and analyzers. Before they finished that evening, they even had a tentative date: 3.9 billion years.

"Tomorrow we'll write it up and email the article to *Nature*," Will told Lurleen that evening, when they were able to connect by video.

"Wow, that's amazing," she said. "A chance glance at the ground, and look what results! And you can rearrange the next day that easily?"

"We weren't scheduled to go out, anyway, so the TROV drivers in Houston had other assignments. It does postpone some sample analysis, but I can always move some of that to Sunday. I always squeeze some work in then."

"And now there's the 'greenery' to keep all of you busy, too. I caught a story on CNN this evening about it. I guess they asked Larisa to take some video footage of it. They're really playing it up as 'a little oasis of Earth on the moon.'"

Will chuckled. "That's making lemonade out of lemons! They were not happy when we set it up. I suppose they decided news of it would leak out soon enough, so they should publicize it, rather than looking critical."

"It's a good human interest story. This rock will be interesting, too, but not as interesting to the public as tomato seedlings!"

"I suppose you're right."

"Now, let me tell you my news." Lurleen paused to take a breath. "Yesterday I received a call from someone in the Department of State Health Services up in Austin. My second report was read up there and they were immensely impressed and suggested that I apply for an opening. It turns out, they need a researcher and writer to supervise the department's studies of the health situation in Texas. It's a position that reports straight to the Commissioner. I think I'll apply. It's a chance to influence health policy in a very meaningful way."

"Really? That's very exciting! But if they give you the job, where would we live?"

"Well, that's the issue we need to consider. I'd have to spend a fair amount of time in Austin, which means an apartment there. But a lot of the research data is available via the web, so I could work out of the house or the department's Houston operation some of the time. The salary's very good, so we could afford it."

"Well, that would work," replied Will, hesitating. "It's too bad we can't be together to make a decision like this; a video link with a three-second time delay is not the ideal situation."

"I agree, but this position can't wait six months. If I'm going to apply, I need to do so now. I . . . really want to apply for it, Will."

He saw the yearning in her eyes. It was an exciting opportunity. "You'd be good at it, too, Lurleen. You're brilliant at putting data together and writing it up clearly. But what does this do to our plans to have children?"

"What plans? We've postponed that indefinitely, for now! This is the problem, Will. With your job taking you off the planet entirely for months at a time, how can we plan anything together?"

"It's not easy, I concede. I'm sorry about that, too."

"Thank you for saying that, Will. I appreciate that. Anyway, let's sleep about this possibility, alright? Let me know what you really think. We can talk about it in day or two."

"Alright, fair enough. We probably should get off the line, anyway, it's almost midnight up here."

"And here. Talk to you the night after tomorrow. Bye."

"Bye." He pushed a button to close the connection and leaned back in his chair.

He was losing her.

He could feel it. And in a way, he could only blame himself. Someone had to sacrifice to make the marriage work; both of them could not pursue demanding, high pressure jobs that took them to different places. Someone had to be the anchor, at least for the two of them. He couldn't be, traveling to the moon periodically. Now he doubted she could be the anchor instead. He looked out the window at the moonscape and the sun fiercely pouring in at him from just above the horizon. The same sun that would be shining on Houston in a few hours. But Houston was a quarter of a million miles away, and he had every intention of coming back to this fascinating place whenever he could.

He stared out the window for a long time, feeling that there was nothing he could do. At some point, he'd have to call dad and mom about this one. But they couldn't be his anchor, either; he was an adult now. He'd start by talking to David.

Dr. Dorinda Stetson hated to negotiate with Zeke Swift. She never knew what trick he had up his sleeve, what last minute supporter—either a billionaire or a small country—he would cite. But for once, she was fairly confident she had the upper hand, for she had the President and Congress on her side. At exactly 2:00 Eastern time she picked up the telephone on her desk at NASA headquarters and called him.

Swift didn't like receiving phone calls; he preferred web video for everything. The phone was actually in his office and so seldom used, his assistant didn't answer it. It rang five times before the man himself picked it up.

"Hello?"

"Good morning, Dr. Swift," began Stetson, to a man who was in California. "How are you today?"

A long pause before he replied. “The weather is nicer here than there, Madame Administrator. I hear you’ve had an unseasonable snowfall.”

“Indeed we have, damaging the cherry trees. Global warming is quite unpredictable.”

“It certainly is. What’s your assessment of Northstar 2?”

“We had a review yesterday afternoon. This crew appears to be working together fairly well; the last crew had some tensions, as you know. But they are also more unpredictable, more innovative than we would prefer.”

“I much appreciate their innovations. The ‘greenery’ is very important, in my opinion. The series of exploratory loops will take us farther south than we had expected even for Northstar 3 or 4. We can’t send a crew to Mars and expect them to follow a schedule rigidly. They’ll be so much more on their own. We have to adjust our management philosophy.”

“I take it, then, you plan to be much more flexible with Northstar 6?”

“I think so. Launch is still a year and a half away, and its objectives are dependent on the accomplishments of Northstars 3 through 5. We’ll see. But you didn’t call me about the moon, I take it.”

“That is correct. As you know, Congress has approved our plans for a Liberty reusable launcher able to put thirty tonnes into low Earth orbit starting in 2038. This may be the last rocket that NASA builds; the capabilities of industry have expanded exponentially in the last two decades. With some of the innovations we have pioneered in our two previous experimental rocket programs, we think our system will eventually attain a launch cost of only $500 per kilogram. Consequently, this sets us on a path to utilize the Liberty for our launch needs starting in 2039 or 2040. We will probably continue subcontracting lunar flights from you because the Thunderbird-Polaris combination is tried and true, and won’t need replacement with an updated

system for a decade or more. But we anticipate using the Liberty for our missions to asteroids and to Mars. Next week we will announce a decision to inaugurate 'Project Columbus' to send a crew to Mars in 2039-40."

"I see." Swift was a fairly patient man, at least on the surface—he was not one to shout at people—but his frustration and anger was beginning a slow boil inside him. "If I may say so, Madame Administrator, the Thunderbird system and the Liberty system are not your only choices. The new Lyra launcher by LEO Systems will be quite competitive; probably $1,800 per kilogram initially, and it should drop in cost over time. I won't even mention the new Russian, Chinese, Indian, and French launchers, because I know you wouldn't consider them, but they will be no more than $2,500 per kilo, which is also a revolution compared to the $20,000 per kilo of twenty years ago. As for the Liberty, I have examined the public data about it quite closely and was very disappointed. The quality standards are unnecessarily complicated; the procurement conditions are excessively politicized; the rocket design itself is unnecessarily complex. If you want my prediction, the Liberty won't fly until 2040 and will cost at least $2,000 per kilo, maybe even $3,000, which will postpone your Mars mission until at least 2042."

"I have been assured by our top engineers that the development timetable and launch costs are very achievable. Nine years should be ample time to develop this rocket because we will be reusing many elements from other systems. What we would like to arrange with you is that you postpone your own plans for Project Redstar and use the Liberty for the majority of its launches. In return, we will use the Gryphon capsule and the Martian landing system you have begun to develop and will cover your development costs 100% plus 10% profit; the 'cost plus' standard we have used with contractors for decades."

"And why, Madame Administrator, should I accept your offer? You know that the Gryphon's design is well under way; it's essentially an enlarged Polaris and utilizes upgraded Polaris systems, just as the Polaris is a doubling of our earlier low Earth orbit capsule. The Gryphon will cost us perhaps a billion dollars to design and we have already spent most of that. It'll fly for the first time in two years and will be used to transport tourists to low Earth orbit, thereby gaining flight experience. The Mars landing system is also not too expensive for us to design because it will be a modification of the system used by Thunderbirds and Polarises. If we can bring stages to a soft landing from 8 kilometers per second through the Earth's thick atmosphere to a safe, soft landing, it isn't that hard to design a system that can slow from 4 kilometers per second and land on Mars! The shelters on the moon are a prototype of a Mars shelter, and the hotel going up next year will be an improvement on that system; the inflatable modules in low Earth orbit are prototypes of the interplanetary hab; the lunar rangers are prototypes of Martian surface vehicles. We can test in situ resource utilization here and on the moon, where we have access to plenty of water and CO_2. If NASA wishes to duplicate our system, no double with much improved technology, you are free to take the matter to Congress; but they will no doubt be aware that your system will cost the American people at least ten times as much ours. Do I understand the facts correctly?"

"Well, let me put it this way, Dr. Swift. Your goal is colonization. Redstar won't get you there; it'll get footprints on the ground, but no more than six at a time, and not continuously. If you are willing to wait and go with us, we will pay for the entire system you have developed and more, and that will free up your resources to expand and improve on the system yet again. Your work on the Gryphon was made possible by our generous contracts for launch services, which enabled you to generate quite a profit. We offer you the opportunity to do the same again."

"I see." Swift said nothing for a split second. "No deal, Madame Administrator. You'll need to do much better than that."

"That's our only offer."

"Well then, I wish you the best with your Mars plans. I'll be sure that our crew has a bottle of champagne to welcome your crew to Mars, when they arrive."

"Don't do this, Zeke. You need us."

"We'll see who needs whom, Dorinda."

It was another week before Will, David, and Larisa could set out on the first "loop" expedition southward. They left on March 22 when the moon was only a quarter full but the Earth was three quarters, which guaranteed a powerful source of light in the shadows.

Will took the lead in ranger 1; David and Larisa followed in ranger 2. Several expeditions had already traveled to the east of ancient and battered Peary Crater, over rough highland saturated by craters of all sizes, many with icy pools of cold on their bottoms, to Byrd Crater. They followed the existing trail and reached the southern end of Byrd, 200 kilometers from the station, in six hours. They stopped, docked the rangers together to eat lunch and talk, then pushed farther south across terrain never explored before. They headed due south and a bit west over the battered rim of Byrd and through a gap into Gioija Crater, 41 kilometers in diameter, old, battered, and crater-filled. They got out of the rangers and explored a crater chain on the northern side for several hours, supported by three TROVs, the rangers following behind them robotically. Then they headed for the southern side, where they parked at the edge of the permanent shadow of the southern rim. They docked the two rangers together, nose to nose, and Will came across to ranger 2 for supper with David and Larissa.

“It’s amazing that we can actually see a snow patch against the rim wall,” said David, looking out the windshield as they ate. Gioja’s southern rim was eroded, but was still nearly 2 kilometers high and quite steep in places.

“It’s a big patch, too,” observed Larissa. “It must be a half kilometer long and high!”

“But fairly shallow; it’s not a very cold spot,” said Will. “Looking at the temperature map, there appear to be very small cold traps with bits of snow down to 65 degrees north. With any luck, in a day or two we’ll get to Euctemon at 76 north; there appear to be snow patches in Euctemon H and K. I hope we can develop a trail to the south that is close to several of these patches.”

“So we can set up refueling depots?” asked Larisa.

Will nodded. “The rangers have a range of 1,500 kilometers at most and Mare Frigoris is a 2,000 kilometer round trip. We’ll have to set up a refueling cache somewhere. Ideally, it should have its own source of water.”

“We may be able to get permission to relocate the prototype cryo system,” said Larisa. “It was sized to make up to 4 tonnes of liquid hydrogen and oxygen per year. It masses 1 tonne. We have spare parts we could use to repair it.”

“That’s an intriguing idea!” said Will. “We’d want a spot at about 70 north, 600 kilometers from the pole. How much would a refueling station cost, if it were based on the prototype cryo unit?”

Larisa shrugged. “A couple million.”

“The equator is 2,700 kilometers from the pole; perhaps 3,000 kilometers if the route weren’t straight,” noted David. “That’s five refueling stations.”

"But no one would drive the whole way," replied Larisa. "At 30 kilometers per hour it'd take 90 hours; 4 days. It'd be faster and easier to use a lander to fly a ranger to a spot, explore for two weeks, then the lander would fly the ranger back to Peary."

"I agree; I suspect Peary Station is a practical base of operations for exploration as far south as about 60 north, but no farther," agreed Will. "We'll fly anywhere else, once that transportation system is set up."

"So, what do you think the future of the moon will be?" asked David. "Will there be settlement here?"

"I suppose," replied Will. "The big question is what lunar gravity does to the human body. So far, 6 months of exposure to it appears to be much less damaging than weightlessness."

"Exercise is easier," agreed Larisa.

"Everything's easier," added David.

"The next question, then, is whether children can be born and raised here. I'm more skeptical of that," said Will. "The lower gravity may do permanent damage to the bones and heart."

"At least radiation is manageable, under one meter of water shielding," said Larisa. "We may want to add regolith shielding to the shelters, also."

"A year in the shelter is equal to a month in low earth orbit," said Will. "As long as we limit our outside time, we'll be able to spend years here safely. I suppose the next question is when to move from six personnel to twelve. Everyone is saying that with Northstar 5, the price of transportation drops to $30 million per seat, and Swift is proposing flights every four months with six-month stays. That means the station will have 12 personnel for two months out of every

six-month stay. Shift to four flights per year and Peary could always have twelve, and people could stay three months, six, nine, twelve . . . depending on their research. It's quite exciting."

"So, how much time do you want to spend up here, Moonman?" asked Larisa.

Will thought a moment. "I wouldn't mind alternating, 6 to 12 months here, then 6 to 12 on Earth."

Larisa was surprised by that. "I can't imagine spending that much time here. Three-month stints would be manageable, though."

"Aisha would kill me if I stayed away that much," said David. "Six months every twenty-four might work, though. She's pretty patient." He scraped the last bit of potato from his dinner and downed the last swallow of hot tea. "It's 8 p.m. and that may sound early, but I'm in favor of going to bed early. We've had a long day."

Will nodded. "I'd like quiet time, too, and then a chance to sleep."

Larisa looked at him. "Well, you have your own ranger."

David shook his head. "No, Larisa, one of these rangers will be the men's dorm, and the other the women's dorm."

"Why, I don't bite!"

"That's the way it's going to be," replied David, quite definitively.

"You are free to go to the other ranger, I suppose," she replied.

"Alright; fair enough," agreed David. "That's quite easy." He turned around and dropped the plastic dinner tray into the garbage bag and put the metal fork and knife into the tiny sink built into the passenger side of the cabin. Will did the same and pushed his seat back, so he and David could access the docking tunnel to the other ranger. David picked up his duffle bag. "Good night, Larisa."

"Good night." She sounded a little hurt. Will opened the hatches under the windshield and crawled through to the other ranger. David followed and closed both hatches tightly.

"Tunnel closed successfully," confirmed Will, checking the sensors.

"Good." David put down his duffle bag on the passenger side seat. "I'll take this one and make us tea in the morning; you take the driver's seat."

"Alright, we can switch tomorrow night if you want," agreed Will. He grabbed a sun screen and put it over the windshield so they couldn't see into Larisa's vehicle, just a meter away.

"She is such a *pain*!" exclaimed David, frustrated. "She kept hinting about sex all day. I ignored her."

"She came right out and asked me. She explained that she and Feodor had an 'arrangement.'"

"I see. Well, so do Aisha and me, and it sounds like our arrangement is not the same as hers!" David tipped his head back and laughed loudly.

"Lurleen and me as well. I called it a covenantal commitment and she didn't seem to appreciate or accept the term. But Kavidas; he sort of propositioned her the other day, and she ignored it."

"Really?"

"Yup."

"Hum." He didn't speculate why. "Other than that, I think the six of us are working together reasonably well."

"I agree, and we're ahead of schedule as well. Let's hope this expedition works out, because it can lead to a lot more."

"I agree. Here, let's pull the curtain across the cabin, so my light won't bother you."

"Alright." David helped him pull the curtain across and Will hooked it in place. While David brushed his teeth, Will pulled out pillows and blankets from overhead storage for both of them; then Will brushed his teeth in the sink while David pushed the potty into the airlock to use it. When Will came out of the airlock, David was in his pajamas. He lowered his seat into a bed and laid down. "This is pretty comfortable in lunar gravity."

"It is." Will pulled off his clothes and put on his pajamas. He lowered his seat into a bed. "Say, I need your advice."

"Sure, about what?"

"Well, I was talking to Lurleen about ten days ago and she told me that she was contacted by an official in the Texas Department of State Health Services. He was very impressed by two lengthy reports she wrote for her hospital and invited her to apply for a research job for the department; a very responsible job, it turns out. It's in Austin, but she'd be able to go back and forth and work from home a lot of time. Then, three days later, she called and said she was going to Austin for an interview. Then, on Tuesday, she said they offered her the job and it was bigger than she had thought: she'd be heading a new subdepartment with a staff of six research assistants and writers. That means spending most of her time in Austin."

"Do you think she'll take it?"

"She didn't say and sounded like she doubted it. But that's to soften the blow. Yes, I'm sure she'll take it. She very smart, an excellent writer and researcher, a natural leader, and it's her field. It's the sort of job she has dreamed of." He sighed. "I'm pursuing my dream and she's pursuing hers."

"What are you going to do?"

"I don't know." His voice broke when he said that. "She has always said she wants an ordinary life. But what she means by that is that she will have a high-powered job and she'll come home every evening to a husband who shoulders at least half the domestic work, more likely closer to three quarters. She wants to have children, but she needs a husband around the house to help raise them, because she wants an ambitious job. I don't blame her; she's incredibly capable. Before I was selected for the astronaut corps, we had a really great relationship because I was a graduate student and had a flexible schedule. We had great conversations and we traveled."

"But she knew you wanted to be an astronaut!"

"Yes, but the chances of being selected are miniscule; she didn't think I'd be chosen. She figured I'd end up a college professor teaching planetary science somewhere, home by 3 or 4 p.m. every afternoon, able to pick the kids up from school and make sure they had supper. And I was willing to do that, too; why not? My dad did a lot of house work while I was growing up."

"That's the difference between us, I guess. Because we don't have that many feminists in Islam. We have some, of course, but most wives understand that they have to be the primary caregiver for the children. Aisha certainly understands that. Look, Will, when there are children, someone has to be home to take care of them, even when there's day care, because sometimes they get sick. That's the way it is. If you can't because you're on a different world and she's unwilling because of a high-pressure job, then you don't have the conditions for a family. Are you willing to give up being an astronaut?"

"No. I don't expect to go to the moon that much; probably no more than six months every two years, because there are a lot of people who are in line to go. I'd like to go more often. But I suppose after ten years or so, I'd cut back. In ten years she and I will be 38 and we could still

have children. Maybe by then, she'd be willing to cut back. Maybe by then we'd have the income to hire a live-in nanny, too. We could do that now. But I'm not sure she's even willing to take off half a year to have a baby, and that's something I can't substitute for her!"

"No, you can't, though you could stay home six months after the birth."

"I could; I could do a lot of work with a baby around, too. I wouldn't be on the moon or in training to go, but I could help intensely with a baby for a year, and then we could hire a nanny. We've considered that option, too. Neither of us really like the idea of a nanny. She wants an anchor, meaning a husband who's around."

"Well, I think you're in an impossible situation, then, Will. If you won't give her what she wants and she won't change what she wants, it's not going to work out."

"Do you think I should resign from the Corps?"

"Resign? No! I think both of you have to figure out how to make space for each other's dreams. Neither one of you will be happy if you surrender your career for the other. Have you considered counseling?"

"Yes, but we haven't pursued it. I suspect a counselor will say the same thing."

"And I can give you the advice for free!"

"Yes, that's true."

"A lot of astronaut marriages break up over this issue of separation. It's very hard. The best advice I can give is, if this marriage fails because of it, find another wife who can be *your* anchor; who wants to be your anchor. I can introduce you to some very nice, pretty Moroccan women who'd love to be an astronaut's wife!"

Will chuckled. "I'll remember that. I hope it won't come to a divorce, but I'm afraid it will. More and more, I'm afraid it will."

“I’m very sorry about that and I’ll pray that won’t happen, my friend.”

“Thanks.”

16.

Magnificent Desolation or Barren Wasteland

April 2029

Their "first loop" was the most ambitious expedition ever mounted on the lunar surface: seven days of rolling across thirteen hundred kilometers of ancient cratered terrain. From Gioja, they headed southeast to Main N, which they were able to drive into to explore its ice deposits, and Main L, which required a long hike to enter because the rim was too steep for the rangers. From there, they continued southeast across old, battered and ruined crater rims to De Sitter, where they spent two days exploring rilles—some of which were collapsed lava tubes—on the northern side of its floor. From the rilles they crossed De Sitter and De Sitter L—an older crater on which De Sitter had been blasted—southwestward to Euctemon. Euctemon K, at 76 North, had ice deposits. From there they drove southwest to Meton, a large crater that was old and so lava flooded that it consisted of a flat plain. They ended at Meton B, a small, fairly fresh crater at 71.4 north that had traces of water ice in a few permanently shaded areas. Because their fuel cells had used up half their hydrogen and oxygen, to lighten their vehicles they dumped nearly a tonne of waste water in one of the shaded patches. It shot out of the tanks, a small fraction of it vaporized, and the rest either became snowflakes or fell onto the cryogenic regolith and frozen into ice in seconds. It was quite a thing to watch.

I love to rove the lunar surface, Will wrote in his private blog after they returned to the shelter. *It's really thrilling; it's not boring at all! The geology is right there, not covered by plants, waiting for you to investigate it. No amount of remote sensing, whether photographic, by radar, or via spectrometers, can give you the complete story; you still need the ground truth, and that's what we provide. We brought back nearly a thousand samples massing a hundred kilos,*

and in the next three weeks, before we go out again, we are hoping to run two hundred of them through the mass spectrometer so we can get compositions and dates. The lava plains up here were emplaced during several discrete events and the dating can tell us the sequence and history of the volcanic events. Mare Frigoris is not much farther south; we managed to get more than half way. As we go farther south, the lava flooding will get deeper and deeper until craters completely disappear underneath them. In a way, that's a definition of Mare Frigoris; an area flooded to such a depth that the preexisting craters are buried. But before we can get there, we need a way to refuel; either a solar powered refueling station or a special lander flight. Getting permission for the former appears easier, but we'll see.

I spent an average of two hours a day outside. Lunar gravity is now very familiar and comfortable. It's much easier to bounce or lope than to walk because each bounce can carry you pretty far. David and I have spent a lot of time looking down at the regolith and we trained Larisa what to look for as well. As a result, the three of us managed to find eleven terraclasts, as we are calling the broken pieces of Earth we are discovering on the moon. Dating them will be a high priority and we are already receiving dozens of emails from geologists studying the Hadean and Archaean eras who want samples or who want to coauthor papers with us. I'll have a least a year of writing to complete after this!

Will's mother loved the entry. *We're so proud of you, Will! It's thrilling to see you engaged in such important work for the future of humanity, and engaged in such a dedicated fashion. Your father and I pray for you every day.*

Will reread his mother's posting twice more before saving it because it had a hidden reminder in it as well: our purpose is to serve humanity. It was a kind critique, in a way, a

reminder that lunar geology was important, but might not be ultimate. He pondered it several times that evening.

The next day, however, while he was loading the mass spectrometer with another set of samples, the email he got from Lurleen was potentially sarcastic: *I'm glad you are so engaged in your life's work. I think I have found a similar opportunity in the offer from the Texas Department of State Health Services. I just accepted the job, starting May 1. I'll end my work at the hospital in two weeks and will have two weeks to look for an apartment in Austin.*

He spent a lot of time pondering that.

It would be a month—late April—before they went out on loop number two; they were waiting for the best lighting conditions. Meanwhile, Jerry, Silvia, and Kavidas made their own loop toward the far side, crossing all of Rozhdestvenskiy, exploring the deep and fresh crater Rozhdestvenskiy K, crossing into the large and mature crater Plaskett, sampling its southern snow fields, then crossing its southeastern rim and returning to Peary via Hevesy and Rozhdestvenskiy W. They planned to repeat the four-day trip a month later as well to reach the craters Bosch and Haskin. One advantage of a polar base was that optimal lighting conditions for an expedition always existed; one just chose which route was illuminated that time of the month. David and Will had so many samples to run through the mass spectrometer, they had to request additional spare parts. They applied for a newer, more sensitive instrument for a future cargo flight.

Larisa had little time to recondition the first cryo unit that had been landed at Peary five years earlier, because the expeditions tied up the team's engineers and pushed more maintenance onto the shoulders of those left behind. But on April 18, with Jerry and his team back and working on deferred maintenance, Houston suddenly emailed them and gave the green light for

them to take the old prototype to Meton B. The six of them rearranged their schedules so that the prototype could be brought inside the shelter and thoroughly cleaned and repaired.

It was a lot of work. The prototype was a one-tonne, $1/8^{th}$ scale model of their eventual eight-tonne cryo systems. The solar panels only made 5 kilowatts of peak power; the ice harvester/transporter massed only 150 kilograms and could move only 50 kilograms of dirty snow at a time; the electrolysis unit and cryogenic refrigerator could only produce and liquefy 20 kilograms of hydrogen/oxygen per day; the storage tanks had a maximum storage of 110 kilograms of hydrogen and 880 kilograms of oxygen. But Larisa had some tricks up her sleeve. Additional panels could be installed on top of the steerable mast, raising the power output to 8 kilowatts. A second heating unit added to the ice transporter tank could vaporize all the water in the tank in 12 hours, allowing the vehicle to make two hauls of icy regolith per day. Upgraded software allowed the ice transporter to move autonomously more quickly. Special plastic guards over the metal mesh wheels and on the shovel allowed them to operate at 100 Kelvin longer, with less damage. A plastic tank with a small heater could be installed and filled with waste water from the rangers, reducing the need to mine and transport lunar ice. Upgrades to the electrolysis and refrigeration units allowed them to process 30 kilos a day instead. At that rate, two lunar dayspans of 14 days each would be sufficient to nearly fill the storage tanks. They'd have enough fuel to get to Mare Frigoris and back in late June.

Will, Larisa, and Kavidas set out in late April in the two rangers for Meton B. They cut new, straight stretches of trail where they had previously meandered to stop at craters or rock outcrops. The rangers drove themselves robotically much of the time, but the lead ranger had to have a driver to watch. Twelve hours into their twenty-hour drive, they stopped for dinner and

docked the two vehicles together. “How much waste water will the fuel cells produce to get us to Meton B; 700 kilos?” asked Will, as they finished eating.

“I checked when we stopped; the projection is 745,” replied Larissa. “One option we have is to add two hundred kilos of water from our radiation shielding. We can replace it with the water generated by the fuel cells over the next few days.”

“Then what’s the point of bringing the ice mining and transporting unit?” asked Kavidas.

“It’ll still be useful,” replied Larisa. “The cryo unit can electrolyze and refrigerate 33 kilos of water a day if it doesn’t have to devote electricity to mining and transport.”

“I see what you’re saying.” Kavidas nodded. “This is an interesting experiment, but we need to be using the landers instead.”

“But Mission Control hasn’t authorized that yet,” replied Will.

“Peary’s fuel production isn’t really high enough to spare some for an extra lander flight, either,” added Larisa.

“No, it is; sales to low Earth orbit are still not very strong. The landers are very capable; one wouldn’t have any problem at all with a flight to Mare Frigoris to refuel the rangers. Maybe they don’t want to pay Peary Resources for the propellant; about 7 million bucks.”

“We refurbished the prototype for a lot less,” said Larisa. “But I doubt that’s the reason. The cryo unit is also less risky.”

“True,” agreed Kavidas. “Will, I gather there are no potential resources down here, like ilmenite, for example?”

“No, none,” replied Will. “The trip to Anaxagoras, if we can get into it, is primarily geological. It’s one of the freshest craters on the moon; it has rays extending 900 kilometers.”

“I suppose that’s useful in its own way.”

"We'll only know what the resources are, Kavidas, if we look," said Will. "I know your approach to the moon is intensely practical: go for the resources, do geology to find resources, build the size of the station based on sales."

Exactly right," said Kavidas. They had had the discussion before. "I know you see magnificent beauty here, Will, but I just see wasteland. We can't spend money based on beauty. We need to spend it to build toward making more money."

"I don't altogether disagree," replied Will. "But I think sometimes we do need to spend some on beauty. Certainly, we spend some on indirect benefits or efforts that may yield long-term benefits. Isn't that what Swift is doing, in his drive to colonize Mars?"

"I agree that his goal of Mars colonization is long term at best, crazy at worst. But he never intended to come to the moon. He did that because he had business partners willing to invest in lunar equipment that would be useful for Mars and because NASA was willing to put money into it, once they saw the price he could offer, and once the President decided to make it a priority. The Thunderbird is becoming so cheap, it'll be hard for lunar water to compete. And Helium-3 is a boondoggle that'll never yield a profit."

"So, what do you think we should do with the moon?" asked Larisa.

"I think we should have skipped it entirely, from a commercial point of view; no offense, Will. Low Earth orbit is just beginning to become profitable, after sixty years. Industrialization and tourism should expand quite a bit in the next decade. There's nothing on the moon that helps LEO development all that much. When the transportation system gets a lot cheaper the moon can provide resources to LEO at a reasonable price, but that's decades away."

"So meanwhile, the Antarctic model is the one to follow," said Will. "It has no residents and its natural resources aren't being exploited, mainly because its ecosystem is so complex and

fragile. The continent is dedicated to science. It attracts several thousand researchers and support staff over the summer, plus tourists, and two hundred personnel over the winter. The same amount of money, spent here, would mean a station of perhaps twenty residents."

"That's about right," said Larisa, calculating.

"I could see that," agreed Kavidas. "The transportation system is established and if it is used, it'll get cheaper. Science is the 'business' that will make commercial development possible. Of course, governments waste a lot of money, and this could be one of them."

"It was, in a way, because NASA has degenerated partly into a dispenser of pork barrel projects," said Will. "We need the hard business sense you're talking about to prevent that."

"And lunar development on the Antarctic model needs engineers and mechanics like us," Larisa added to Kavidas. "Including expeditions."

"I can't go out in a ranger for hundreds of kilometers by myself, because of breakdowns," said Will. "You're essential!"

"Well, I appreciate that," said Kavidas. "And I assure you I enjoy my work. But this barren, desolate wasteland; I'll never fall in love with it!"

"That's okay; leave the appreciation to the geologists!" replied Will. "Now, it's 9 p.m. and we have eight hours more driving to get to Meton B. I suggest we continue forward the way we've been going, with one of us driving the lead vehicle and the other two resting. I can take the lead until midnight."

"I'll take over until 3 a.m.," volunteered Kavidas. "I'm often up that late anyway, and I'm well rested."

"Alright, I'll take the last shift," agreed Larisa. "Are we continuing the current arrangement?" She looked at Kavidas, and Will suspected the two of them had had some sort of conversation already.

"Sure," Kavidas replied. "We'll continue in this ranger and Will in the other one."

"Alright," agreed Will. "Let's go, then." He put his plastic tray and utensils in the garbage and opened the hatch to his ranger.

In a few minutes he undocked and they started forward again, with him in the lead. He followed a dotted green line on a large map on the screen in front of his steering wheel and cut a straight path across the moonscape, heading for another section of trail they had blazed the month before. At midnight he pulled over and Kavidas passed him, waving. Will set up a hammock across the cabin—it was the easiest way to sleep in a vibrating, moving vehicle—and soon fell asleep. He was awakened by a beeping at 5 a.m. when they arrived in the middle of Meton B. He climbed out of the hammock and called to the other ranger. "Shall I dock?"

"Sure," replied Larisa. "But Kavidas is sound asleep in the hammock, so there's no reason to wake him. I suggest you dock, then go back to sleep."

"Okay," said Will. He drove around to the front of the other ranger and slowly moved in until the docking collars in the vehicle's noses touched, magnetically pulled them together, and locked into a hard dock. Then he covered the windshield with a screen to keep the sun out and went back to sleep.

They didn't eat breakfast together until 8 and didn't go outside until almost 10 a.m. They had a long day of hard work ahead of them to set up the cryo unit in the middle of the crater, where it had an entire 14.7-day dayspan of sunlight. It was surprising to see the sun and the Earth so much higher in the sky than it had been at Peary the morning before. Erecting the solar power

mast took the most amount of time, since the electrolysis and refrigeration systems were ready to go. While Larisa and Kavidas tackled that task, Will emptied the waste water from both vehicles—746 kilos—into a tank and used the ranger to pull it over to the cryo unit. Once the latter had power, it would convert the water into liquid hydrogen and oxygen.

They deployed the water harvester/transporter and led it into the permanent shadow. The tonne of water they had dumped a month earlier was still on the ground; using rock hammers and cryogenic-rated shovels, they smashed it into little pieces and tossed the pieces into the harvester, then made a pile of loose pieces that it could easily obtain later. In an hour, alternating who used the two shovels, they scraped up a big pile of "snow" as well so that in the future, the harvester could easily obtain even more water. They added an additional cryogenic storage tank so the unit could manufacture up to two tonnes of liquid oxygen and hydrogen. Finally, they cleared away the warmed surface regolith and shoveled the colder ground underneath against and around the storage tanks, so they had better insulation against the sun's fierce heat.

Will still had enough energy to make a half hour hike across Meton-B to a crater on the north side that had punched into the impact melt that had once filled its floor. When he returned to the rangers with samples, supper was ready. They went to bed early that night, and Will again was alone in his ranger.

The next morning they turned west and headed toward Anaxagoras, a 50 kilometer crater 200 kilometers west of them. They took their time and got there in two days, detouring around steep slopes to climb up over the rim of Goldschmidt, making frequent stops on Goldschmidt's floor, then focusing on Anaxagoras's ejecta blanket. The route to the top of the rim was manageable, but the way to the crater floor was too steep for the rangers, consequently the three of them made a six hour hike half way down, proving that one could do a pretty extensive trip in

a spacesuit. Even Kavidas was impressed by the immense, deep hole with its terraced inner slopes, hummocky floor, steep central peaks, and a far wall sharp and clear on the lunar horizon.

From Anaxagoras they made a slow return trip northward to Florey across the rolling highland plains, its craters so smashed and filled with debris that they were nearly erased. Except for escaping Goldschmidt's pummeled floor, there were few significant obstacles; it was a simpler, straighter route to the north than the southward one they took to Meton B. They returned to Peary seven days after leaving. The second loop was a success.

"Welcome home!" exclaimed Silvia, as they entered Peary Station. "Will, we can't wait to have more of your home cooking!"

"Tomorrow," he promised.

"It was a historic trip," said David. "NASA is saying that this loop—not the previous ones—has proved the capabilities of the rangers."

"They really did well," agreed Larisa. "They need only a little routine maintenance."

"And the loop was very popular," said Jerry. "The spectacular views of Anaxagoras were widely viewed on the web. Your six-hour hike down the rim was watched live by millions."

"It made good television," agreed David. "And Will, your interview summarizing the achievements is being aired repeatedly on both BBC and CNN."

"You were both brilliant and articulate," said Jerry, a note of jealousy in his voice.

"So, the next loop gets to Frigoris," said David.

Will nodded. "We should be able to make it to 60 North; there are wrinkle ridges there near the zero meridian."

"We'll probably be there for the eclipse, then, on June 26th," said David. 'The sun and Earth will be 'overhead' on that day."

"Oh, that's right," said Will. He held up a big bag of rocks. "Lots of samples to analyze. We found twenty-two more terraclasts."

"Fantastic!" said David. "I'll walk to the lab with you."

"I'll come back to get my duffle bag later. Let's stop at the greenery."

"Sure. It's down here now." David pointed to shelter 2's lower level, where they had entered. They walked back through the TROV repair facility, past the storage area, to a cleared space at the far end of the lower level. There, LED panels shone down on a series of large plastic trays that Kavidas had made with the three-d printer. NASA had finally hired some consultants, who had advised them how to synthesize a larger quantity of artificial soil. The five tomato plants—one had died—were all a foot high and growing upward fast. The mint plants were beginning to leaf out nicely. The peas and beans were shooting up. Even the pumpkin plant was beginning to climb a plastic trellis they had made for it.

"Wow, they grew a lot in eight days!"

"Yes, they're doing well. We're all watching the garden closely; it's very peaceful." He pointed to the mint plants. "I should be able to make a little mint tea next week."

"I'll make couscous for the occasion. This *is* nice. I didn't feel like I missed the greenery while I was away, but now that I'm looking at it, I feel the loss."

"I know what you mean. So, how did the relationships work out on the trip?"

"We clicked as a team pretty well. Kavidas amused us with his complaints about how impractical moon exploration is, but he clearly enjoyed the trip."

"He likes to beat that horse. Did Larisa bother you anymore?"

"No, that wasn't a problem. But, let us say, she wasn't alone and lonely, either."

"Oh, really? Well, maybe that means she won't bother me anymore, either!"

“I think we’re now safe. Us, and our marriages, that is.” He sighed. “So, two of the six of us don’t have to be celibate. Larisa’s divorced. Gee, I miss Lurleen.”

“I miss Aisha, too. That’s a big reason to return to Earth! We’ve been here a bit over two months; more than a third of the mission.”

“Four months to go.” Will pointed to the airlock and they crossed to shelter 1, then up the spiral stair to the geology lab, where they set up some of the samples for the spectrometer.

Will went back to the ranger to get his duffle bag. He loaded the washing machine with his dirty clothes—he was surprised Larisa hadn’t gotten there first because she was a stickler for washing clothes—and headed to his room. There, he found a video message from his mother that had just arrived.

“I’m glad you’re back to the station safely, Will. I followed the entire expedition; the EVAs are all stored on the NASA website for replay any time. I’m beginning to adjust to the moonscape; it really does have a wild beauty of its own. Your interview is on CNN every hour, right now. Bahá'ís are constantly emailing and saying ‘I saw Will on TV again!’ Your father’s been reading up on lunar geology so he can discuss it with you when you return, because we’re planning to come to Houston after you get back. How’s Lurleen? How’s her new job? I hope that’s going well for her. Looking forward to hearing from you. Bye.”

Behind his mother’s nonchalant tone was a note of worry about the marriage. He recorded a quick message back to her because he wasn’t yet in the mood to open a line with her. But he was curious about Lurleen; today was the day she planned to move into the apartment she was leasing. He pulled up her email address and made a video connection to it.

He heard several ring tones. He was about to close the connection when she picked up. The video came on, showing her in a nearly bare apartment with a man standing behind her putting books on book shelves. “Hello, Will,” she said. “So, are you back to the station now?”

“Yes, we just got back fifteen minutes ago. It was an incredible trip; our lunar surface transportation system is now set up and ready to go. Have you seen my interview on CNN?”

“No. I haven’t; I’ll look for it. What’s it about?”

“Exploring the moon! So, who’s that behind you?”

Lurleen turned around; she hadn’t realized Will could see her helper. “That’s Tad! I needed an assistant in the new job, so I asked him to apply. He starts work on Monday.”

Tad heard the conversation and waved. He looked nervous. “Yes, I remember Tad. I’m glad you have someone assisting you. How’s the apartment?”

“Well, you can see it; it has a living room, a small dining area and kitchenette, and a single bedroom. Small and basic, and it’s a five minute walk from the office, if it isn’t too warm to walk, anyway.”

“That’s convenient. So, how’s the job?”

“Hard to say; I’ve been in the office only one day! But it looks really good, so far.”

“Good. Excellent. Say, shall we talk later tonight? I thought I’d touch base and tell you I was back from the trip.”

“Sure, around 11? That should work out. How’s your radiation exposure?”

“It’s still fine. The ranger has twenty centimeters of water built into the ceiling and the shelter has a meter. I could spend a decade up here before I hit my lifetime limit.”

“That’s good to know, but I worry. Talk to you at 11.”

"Alright. Bye." Will reached up and touched the screen to close the link. *Tad.* Young, very handsome, very smart, an excellent assistant, and available. That worried him very, very much.

17.

Eclipse

June 2029

"I thought you'd be looking down for terraclasts, Moonman, not up! What are you looking for? Boogeymen—I mean Chinese?"

Will turned to Larisa and she could see his harsh scowl through his helmet. "Larisa, the Chinese are very intelligent and hospitable people. Have you been to Beijing? I was there in the summer of 2026, less than a year before I was added to the astronaut corps; in fact, I met one of the guys in the capsule up there in lunar orbit. Very friendly people. Bright scientists."

"I'm sure they are, Will, but we Russians share a very long border with them. They have strong armed us into billions—hundreds of billions!—of dollars of contracts for Siberian minerals, gas, and petroleum. If they could, they'd take the entire eastern half of our country from us! They may be friendly, but they're also nasty, pushy diplomats."

"Well, the taikonauts up there are not diplomats," replied Will. He looked at the cargo lander, which had landed that morning. "Are we done here for the day?"

"Definitely; the trailer and the cab are full. Let's go."

They entered the cab via the rear airlock, one at a time. Getting to the airlock was tricky because the trailer was packed with equipment. The cab was stuffed with boxes of consumables as well; the entire rear space behind the seat and the far right passenger side was filled to the ceiling. There was barely room for both of them to sit. Normally, landers could bring only eight tonnes of cargo to the surface at a time, but lander 1 had flown to the Depot with a full load of fuel, so when lander 2 arrived, it refueled before docking with the fifteen tonne cargo module. Peary Station now had an entire year of food for a crew of six, including a lot of fresh and frozen

vegetables, meat, poultry, and fish; spare parts for the same time period; another "buggy"; and additional scientific and medical equipment. Houston had even agreed to several hundred kilograms of supplies to develop the "greenery" further, including additional seeds.

They lowered the manipulator arms on the ranger's roof—perfect tools for lowering heavy boxes 7 meters from the cargo module to the trailer—and headed for Peary Station. Once there, they dropped the trailer off outside shelter 2 and docked the ranger's rear doorway airlock to the station's. For the next hour, four of them formed a human chain to move the big boxes out of the cab and place them in the storage area. Will had to ignore an email, a text, and a videocall during the work, but when he returned to his room, half an hour before supper, he called them up on his tablet.

Hope you're having a good day. Texas has so many health problems! I'm wading through twenty years of reports about tuberculosis. Lurleen had taken to emailing him short, friendly, informational emails every day, usually during the day, and often ignored the videocalls he made at night. He didn't like the development. He replied, *busy day; we began to unload the new cargo lander. It'll take three or four days to get it all out and a week or more to set things up. The station's going to get crowded with all the equipment! And the arrival of the Chinese is intriguing. Hope you are well. Love.*

He sent it, hoping she'd respond similarly.

The text was a surprise; it was from a telephone number beginning with the country code 86: China. *Dr. Elliott, I hope you remember me, this is Yang Jiayi, we met in Beijing two years ago. The moon is so beautiful!*

That shocked him; Yang Jiayi was one of the three taikonauts in orbit! He did indeed remember him. The videocall was also from him; it was intriguing that the man had brought his

cellular phone with him, and that it worked via the capsule's communications system and the interplanetary internet. Will texted back from his tablet, *Yes, I remember you well, Dr. Yang. It's so nice to be in touch with you again. Yes, the moon is beautiful, both from up there and from down here! Very beautiful. I hope you can join us some time.* He hit send and, five seconds later, a beep indicated that it had been received.

How bizarre, to be texting a Chinese cell phone in lunar orbit via a tablet computer set to a US cell phone on the lunar surface! It briefly occurred to him that he would be charged some sort of long distance fee.

He rose to walk to the commons and tell people about the exchange. As he left his room, he heard the tablet beep: an incoming video call. He stopped in his tracks, wondering what to do with it. Could anyone really get mad about a spontaneous call? Yes; but wasn't that stupid? Yes, it was.

Will walked back into his room and pushed the activate icon. There was a long delay—about 6 seconds—as the connection signal went to Earth and back to Yang's phone, and his video signal went to the earth and back to Will's tablet. "Greetings from Peary Station, Dr. Yang! What a huge surprise to receive this call from you!" Will said in the interim. He picked up the tablet and began to walk to the common room.

"Dr. Elliott, greetings from lunar orbit!" The live image appeared on Will's screen of a smiling taikonaut, with companions seated on either side. It was indeed Dr. Yang. "You may recall that after I met you in Beijing, we exchanged telephone numbers so I could call you again. I did call you and we met for coffee at the Starbucks in the Hilton to talk about lunar geology. And look, I still have your number in my phone!"

"What an immense surprise and pleasure, Dr. Yang. Yes, we had a marvelous conversation that evening almost three years ago." Will came around the corner of the corridor and headed for the table in the common room, where David and Jerry were seated, waiting for supper, while Silvia bustled about in the galley. Fortunately, Larisa wasn't present. They looked up when they heard the voices from Will's tablet. "Have you been enjoying your flight? We paused in our duties down here yesterday when you fired your engine and went into polar orbit. We were very happy to have guests, as it were."

"The taikonauts?" asked Jerry, startled. Will nodded and sat at the table; Silvia hurried over.

"We were anxious about the firing, of course, but it was a perfect burn," replied Yang. "We have greatly enjoyed our views of the moon below and can't wait to see fellow taikonauts on the lunar surface in the next few years."

"You will be welcome," replied Will. "It's a shame you can't dock to the station and transfer to the passenger lander there! You'd be here in a few hours!"

Yang and his companions laughed at that; Jerry was startled by Will's joke. "Well, as you know, we're working on our own lander, and we're looking at various landing sites at both poles. Both have great geology and lots of volatiles."

"They do indeed," agreed Will. "There is immense potential up here. And infinite possibilities for international cooperation."

"Absolutely. Very true. We passed over Peary a few minutes ago and could see everything; the shelters, landers, cryo units, vehicles, even the tracks. A few hours ago we traveled northward above 'loop 2' and could see the trail as a faint line in the terrain. You'll be heading out on 'loop 3' in two weeks. Best wishes with that trip."

"Thank you. Officially, I believe it will be 'loop 6' because we've made two loops on the far side and a loop to Nansen on the eastern limb. Our rangers can travel 750 kilometers out and back; that means there are almost 2 million square kilometers of moonscape within reach of a one-week expedition, which is five percent of the moon. With one refueling stop and a two-week trip, we can reach about ten percent of the surface. We hope to use the landers to reach even more."

"Of course. The sky's the limit, as they say, and China will be a full participant in the exploration. It's very good to talk to you, Dr. Elliott. Have a safe sojourn on the moon and a safe trip back to Earth."

"Thank you, Dr. Yang, may your flight be safe and successful. Good bye."

"Good bye."

Will closed the connection and Jerry looked at him in shock. "How did *that* happen?"

"Dr. Yang and I met in Beijing, less than a year before NASA selected me for the astronaut corps. We exchanged cell phone numbers and got together for coffee. He has his cell phone with him right now and called my number, which was stored in its memory."

"Really?" Jerry tipped his head back and laughed.

"That explains the extreme time delay," said David. "When there's no official diplomacy, pull out the cell phones and make a call!"

"That's about right," said Will. "I was shocked when I got a text from him, then a videocall!"

"This is a diplomatic incident of sorts, though," said Jerry. "You should have ignored the call, Will. NASA will be anxious, the State Department will be furious, and then NASA will be furious."

"Look: we can't exchange any state secrets, nor can we make any commitments or promises. So what harm can the call do? It's good person-to-person relations."

"Will, person to person relations aren't our business! The United States government talks sweetly about international cooperation in space and has absolutely no intention to cooperate with the Chinese. On the contrary, they'll try to keep the Chinese out, for strategic reasons. Swift has no restrictions on his equipment, officially, but do you think the Chinese will be able to send any 'tourists' here? Fat chance!"

"Jerry, he called me."

"Will, do I need to repeat myself? Don't be a dumb ass! I'd better call Mission Control right now and let them know this happened, so they can issue a sweet press release about friendly scientific relations on the moon before the Chinese do!" Jerry rose and headed to his room, leaving Will, David, and Silvia dumbfounded.

It was the perfect job.

Will hadn't been able to sleep very well that night, thinking about the newly created position of Director of Lunar Surface Exploration. He had been up until 2 in the morning completing the application form and updating his c.v., to which he had to add twenty-six new publications. He couldn't wait to tell Lurleen; the position would keep him in Houston at least two years, which meant stability.

He glanced at the chronometer on his desk; it was 7:30. She would be up and getting ready to go to work, so it would be a good time to call. He pulled out his tablet and entered her phone number.

Ring. Ring. Ring. Ring. Ring. Ring. He was surprised the phone didn't go to videomail. He almost closed the circuit, but then the screen lit up with her face. She was dressed and sitting at her breakfast table.

"Good morning, Will," she said. She looked surprised by his call, but that was to be expected; he had almost never called at breakfast.

"Good morning, dear. How are you today?" He took his eyes off her face—her beautiful face, which he loved to look at—to wander around the screen. He was surprised to see, on the far right edge, a second cup of coffee and a plate with toast on it.

"Quite well, thanks; you?"

"Ah . . . quite excited. Last night I got an email from a friend in Mission Control that NASA had negotiated with Swift about providing proper ground support for our expeditions, and he had agreed to turn the Prospector TROVs over to them. NASA has created a new position: Director of Lunar Surface Exploration. The person would be based in Houston and would not go to the moon. It's a two-year contract, renewable. They particularly want members of the Astronaut Corps to apply. So I've applied."

"Oh? So you'd be staying in Houston?"

"Yes, at least two years. After that, I think lunar missions will be shorter; possibly three months. So this may be an excellent solution to our problem."

"Yes, it might indeed." She sounded like she was trying to be enthusiastic. "And you could go back and forth to Austin?"

"I'm sure I could on weekends and probably some other days, just like you could come to Houston some weekends and some other days."

"Yes, you're right. This could change everything. That's great news, Will. But this isn't the best time for us to talk; I have a meeting at the office at 8:15. And aren't you headed to Frigoris in a few hours?"

"Yes, about noon. Do you want to check your schedule and email me? I can be interrupted just about any time." He glanced again at the second coffee cup and the other plate with toast on it.

"Alright, we can talk tonight, but I suggest we not try to have a big, life-planning talk by video. You'll be home in a little over two months. We'll need to sit down and have a long talk then."

"I see. That's a long time from now!"

"Well, by then you'll know whether you have the job, right? It's easier to make plans when we have concrete information, don't you think?"

"Yes, I guess you're right."

"Now I have to get ready for work and get to my meeting. I'll email you tonight, alright?"

"Alright. Bye," said Will.

"Bye," replied Lurleen. Will pushed the "end" icon, then leaned back in his chair, feeling numb. Lurleen hadn't been alone in her apartment at 7:30 in the morning, and she hadn't been enthusiastic about his news. She was cheating on him.

"It's a real pain to have to move the cryo unit," Will said to David and Larisa, as they walked from the ranger across the floor of Meton B.

"I'm sure Jerry insisted that we stop and take it along to Mare Frigoris because you had mildly objected," replied Larisa.

"Meton B is two thirds of the way to Frigoris. That's why we chose the spot; it's just about as far south as you can go and still harvest ice. But I agree with his argument—or maybe I should say Mission Control's, since they approved the move—that every time an expedition heads to Frigoris, it can bring spare water or ice with it and keep the depot supplied. The cryo unit doesn't need to be near an ice supply."

"Just the harvester/transporter and a trailer with a water tank," agreed David. "I don't know what we can do to get Jerry to ease up on you, Will. If I had gotten that call from the Chinese, he would have backed me up, not complained to NASA about my answering it."

"I was pretty surprised," agreed Larisa.

"Well, I don't know what to do," said Will. "Maybe there will be a chance for me to talk to him."

"No, that won't work," said Larisa. "But I'm not sure what will."

"The mission will end and the problem will end as well, I'm afraid," said David. He stopped to look at the permanently shadowed southern rim and the scattered frost deposits streaked along it. "Really pretty."

"A relief from shades of gray," agreed Will.

They got started, disconnecting the empty water tank and the filled hydrogen and oxygen tanks, moving them to the trailers attached to the backs of the rangers, lowering the solar power mast and folding up the solar arrays, removing the mast and arrays and stowing them on the trailers, then winching the cryo unit itself onto ranger 1's trailer. All they left behind were three square meters of solar panels—able to produce one kilowatt of power—and a large open metal

container in the permanent shadows into which up to a tonne of ice or frosted regolith could be poured. The harvester/transporter could go out into the sun to recharge its batteries from the panels and slowly fill the container.

It took much less time to take the cryo station down and stow it than to set it up in the first place. They spent an additional hour exploring a part of the crater, then headed back into the rangers.

While Larisa was in ranger 1's airlock, David switched to a private line with Will. "So, no email from Lurleen yet?"

"No, not yet. It's been . . . 31 hours now."

"I'm sorry, Will."

"But I have gotten an acknowledgement from Mission Control that they received my application. I still want to pursue the Director's job."

"You should, it's a great opportunity."

Will entered ranger 2's airlock. In fifteen minutes they were ready to move forward again. But Will was depressed and wondered whether he should email Lurleen, even though she said she'd email him.

The two rangers headed southwest over untraveled ground, across the floor of Meton C—a huge ruin of a crater—over the bumpy remains of its southwest rim, and due west for a stretch until they entered the crater Barrow through the break in its southeastern rim. The day saw 100 kilometers and four stops. The next day they crossed Barrow and the rough ground south of it and entered W. Bond, an old, walled plain 156 kilometers across with its walls mostly missing. The third day took them across Bond and to the outer ejecta blanket of Timaeus, a young crater on the very northern edge of Mare Frigoris. They prolonged the day to explore the eastern side of

Timaeus and get right up to the top of the rim, where they stopped for the night. There, the magnificent, desolate hole of Timaeus provided a vista to the west while the basalt lavas of Mare Frigoris formed a beckoning dark blotch to the north.

"There it is," said Will to David and Larisa, pointing out the windshield at the mare. "We'll be at Webb Dorsum tomorrow."

"A whole new terrain," said David. "We're authorized for a 14-day mission altogether and we'll need 5 days and 900 kilometers to get back to Peary, so that leaves about 5 days and 500 kilometers. We could actually reach the rim of Plato."

"We'll get as close as we can," agreed Will. He looked at Larisa, whose familiarity with lunar geology was spotty. "If we can get to Plato, on the northern edge of Mare Imbrium, we'll have crossed the entire inner rim of the Imbrium impact. The trip from Meton has been across the outer ejecta deposits; that's why the craters are so shallow and degraded."

"Yes, I know. Plato would be quite an achievement. It's at what; 53 north? A little farther and we'd be half way to the equator!"

The three of them laughed at that. "Well, we'll set up the cryo unit at Webb Dorsum and leave every drop of water we can," said Will. "The next trip down can bring another tank and another tonne of water. If we had three tonnes of hydrogen-oxygen fuel, we'd have enough for a complete refill for both rangers and an 800-kilometer expedition out and back, plus enough to get both rangers back to Peary in Earthlight."

"A three-week expedition?" asked David.

Will nodded. "It'd be possible. Earthlight is plenty for driving and for geology."

"That'll be for Northstar 3 or 4," said Larisa. "And by then, they may have figured out how to add a ramp to a lander so that a ranger can be driven on top and anchored there."

"The Russians have the contract, right?" asked Will.

Larisa nodded. "It seems really difficult—six meters is a long way off the ground—but in lunar gravity it isn't so bad."

Will glanced at the chronometer. "We should get to bed soon; it's just about midnight. It's been a long day."

"I know, I'll take the hint," said Larisa. She drank the last swallow of lemonade in her cup and began to put her plastic tray and utensils in the garbage, so she could crawl through the docking tunnel to her ranger for the night.

Just then the video line to the ranger rang. It was a call from Jerry. Will reached over and activated the connection. "Good evening, Jerry."

"Good evening, Will. I gather you all haven't gone to bed yet? What a day! Very satisfying, but exhausting!"

"It was indeed. No lunar mantle fragments, unfortunately, but the Imbrian event wasn't expected to dig that deep, anyway. A lot of the fill in Bond is middle to lower crust, I think. We'll have to analyze the samples back at Peary to verify their chemical composition."

"And you'll be on Frigoris by noon."

"We sure will be, barring problems."

"Say, we got a call from Zeke Swift himself today, followed up by a call from the NASA Office of Media Relations. For once, the two of them coordinated their request. As you know, tomorrow evening is the total lunar eclipse; or for us, a total solar eclipse; starting about 9:30 Central time. They want us to plan an eclipse event; sometime people on Earth can watch on their televisions. But there are two problems: none of the three of us here at Peary have a clue

what to offer, and the Earth will be partially below the horizon here at the station. You guys have a much better view, so I'm giving the task to you."

"To us!" exclaimed Larisa. "What are we supposed to do?"

"I don't know; sing and dance for 102 minutes, which is the duration of totality."

"We've got a really good, IMAX-quality camera, so we can use that to broadcast the eclipse," said David.

"We'll come up with a program," promised Will.

"We will? *You* will," replied Larisa.

"Alright, I will," said Will.

"I'm counting on it; don't make it a dry science lecture!" exclaimed Jerry. "Something more like Apollo 8's reading of Genesis from lunar orbit in December, 1968."

"I'll come up with something," promised Will.

Jerry ended the call with some encouraging words, then Larisa went to her ranger to sleep. Will and David set up their ranger for the night. Will laid awake a long time, then finally emailed his mom and dad: *We need a program of interfaith scripture readings for the lunar eclipse tomorrow night, on peace and unity and the goodness of nature and the earth. Can you get some help and pull something together?*

He didn't sleep well that night because he wasn't sure what program he could create or how many hours he'd have to take from his usual chores to do it. But after breakfast the next morning, as they were about to head northward, an email arrived from his mother with *How's this?* and an attachment.

"It's perfect," he said, as he showed David and Larisa.

"Rather theistic," said Larisa. "But I think I can add some poetry."

“Okay, great,” replied Will. “It needs to be uplifting and inspiring, not explicitly religious.”

“How did you get this?” asked David. “I like the quranic quotation.”

“My parents put it together. It’s basically a Bahá'í devotional program, where we bring our friends together and everyone provides something inspirational from their own tradition. We do this all the time.”

“Good, it should be quite nice, accompanying the grandeur of the eclipse. But we need some background music,” said David. “I suffered through a decade of classical piano training! So I can find some music.”

“Excellent, we have a program, then,” said Will.

They lingered an extra hour on the top of Timaeus’s rim while Larisa found some poetry and David selected some music, then they headed down Timaeus’s rim toward the mare below. Will called Peary and spoke to Silvia and Kalidas, who both agreed that they would read some of the extracts. Kalidas even proposed a few additional Hindu texts, which they added.

Mare Frigoris was a mere twenty kilometers away. They descended Timeaus’s ejecta blanket and soon transitioned to a flat, darker plain, the ancient, pummeled top of the basaltic lava flows that flooded the Imbrium basin’s outer ring to form the Sea of Cold. They stopped at the edge and explored the transition. Several kilometers farther west a few small craters punched through the thin sheet of basalt and they were able to explore the contact between it and the underlying ejecta. Water and gasses escaping downward from the molten lava over three billion years earlier had created distinctive minerals with copper, calcium, and fluorine, some of which were familiar from the Earth. Because of the immense implications for utilization of lunar

resources, they spent two extra hours taking samples. Kalidas in particular was pleased to listen in and ask questions about the possibilities.

They were now behind schedule, so they turned southwestward and headed for Webb Dorsum 90 kilometers away. Named by Northstar Mission Control for a former NASA administrator, it was one of a series of parallel wrinkle ridges, crumpled and folded heaps of lava, formed when the underlying lunar crust cooled and shrank, forcing the outer shell of lava to buckle into a pile. Frigoris was quick and easy to cross because it was flat and had very few large craters, so there were few scattered rocks and boulders to avoid.

It was late afternoon when they reached Webb Dorsum. They exited the rangers to set up the cryo unit; the more sunlight it had, the better their fuel supply to return to Peary. The mast went back on top of the unit, the solar panels went back on the mast, and the mast went back up; the water, hydrogen, and oxygen tanks came out and were attached; while Mission Control ran a testing program, Will and David headed to a 300-meter crater nearby that blasted through the dorsum and exposed its crumpled and folded lava flows. Larisa had to call them back. "Come on, you need to rest and eat supper before the eclipse!"

"Is the cryo unit functioning?" asked Will.

"Yes, everything's nominal," she replied.

"We're on our way," said David.

He and Will climbed out of the crater, which they had called James Webb A—there was a Webb crater elsewhere on the moon, named for a British astronomer, so the first name was necessary—and headed back to the rangers. They entered ranger 1, which Larisa had turned to face the sun and earth high in the southern sky. There was barely enough time to eat and rest;

indeed, they never took the time to rest, because the eclipse began with the slightest blocking of the sun at 8:30.

At first, there was nothing to see; the sun was far too bright to look at and the brilliant light it poured out declined so slowly, they didn't notice. The power output of the cryo unit's solar mast, however, showed a steady decline, and NASA's web broadcast included that data on the bottom right of the screen. Fifteen minutes before totality began, the moonscape began to grow dimmer, grayer, and tinged with a reddish glow; looking out the windshield, the terrain began to take on an eerie appearance. At 9:31 the last, brilliant flame of solar limb disappeared behind the earth.

"Wow!" exclaimed Will. "Look at the solar corona!"

"Pearly and beautiful!" agreed Larisa, awestruck.

"The earth is a flaming hoop with a whitish-yellow gem on one side!" exclaimed David. "We can see every sunset and sunrise in the world!"

"And look what their light does to Mare Frigoris!" added Will. They turned from the Earth-hidden sun to the copper-red land around them. Will's first impression was that the landscape was downright Martian, a rolling vista of craters and mounds lacking any vegetation at all.

Then it occurred to him that it was time to start the program. He turned to his tablet and popped up the script; the others looked on as he punched an icon to start the music. As the first piece neared its end, he nodded to Silvia, who was watching at Peary, and she began to recite Psalm 8:

O LORD, our Sovereign,
how majestic is your name in all the earth!

You have set your glory above the heavens.
Out of the mouths of babes and infants
you have founded a bulwark because of your foes,
to silence the enemy and the avenger.

When I look at your heavens, the work of your fingers,
the moon and the stars that you have established;
what are human beings that you are mindful of them,
mortals that you care for them?

Yet you have made them a little lower than God,
and crowned them with glory and honor.
You have given them dominion over the works of your hands;
you have put all things under their feet,
all sheep and oxen,
and also the beasts of the field,
the birds of the air, and the fish of the sea,
whatever passes along the paths of the seas.

O LORD, our Sovereign,
how majestic is your name in all the earth!

Kalidas followed with a text from the Bhagavad-Gita:

By me, Unmanifest in form,
This whole universe was spun;
In Me subsist all beings,
I do not subsist in them

And yet contingent beings do not subsist in Me--
Behold my sovereign power!
My self sustains all beings, it does not subsist in them;
It causes them to be.

As in space subsists the might wind,
Blowing at will every and everywhere,
So too do all contingent beings
Subsist in Me; so must thou understand

David was next, reading a passage from the Qur'án, chapter 14, in Arabic and English:

It is God who hath given you the earth as a sure foundation, and over it built up the Heaven, and formed you, and made your forms beautiful, and feedeth you with good things. This is God your Lord. Blessed then be God the Lord of the Worlds! He is the Living One. No God is there but He. Call them upon Him and offer Him a pure worship. Praise be to God the Lord of the Worlds!

Will was next, with a Bahá'í text:

All praise to the unity of God, and all honor to Him, the sovereign Lord, the incomparable and all-glorious Ruler of the universe, Who, out of utter nothingness, hath created the reality of all things, Who, from naught, hath brought into being the most refined and subtle elements of His creation, and Who, rescuing His creatures from the abasement of remoteness and the perils of ultimate extinction, hath received them into His kingdom of incorruptible glory. Nothing short of His all-encompassing grace, His all-pervading mercy, could have possibly achieved it. How could it, otherwise, have been possible for sheer nothingness to have acquired by itself the worthiness and capacity to emerge from its state of non-existence into the realm of being?

Having created the world and all that liveth and moveth therein, He, through the direct operation of His unconstrained and sovereign Will, chose to confer upon man the unique distinction and capacity to know Him and to love Him -- a capacity that must needs be regarded as the generating impulse and the primary purpose underlying the whole of creation.... Upon the inmost reality of each and every created thing He hath shed the light of one of His names, and made it a recipient of the glory of one of His attributes. Upon the reality of man, however, He hath focused the radiance of all of His names and attributes, and made it a mirror of His own Self. Alone of all created things man hath been singled out for so great a favor, so enduring a bounty.

They paused for more music, then Jerry read a passage from the Buddhist Dhamapada:

All fear violence. All fear death. One should not compare oneself to others, and should neither kill nor cause to kill nor cause to be killed. Whoever harms another being, seeking his own happiness, will find no happiness hereafter. But whoever, seeking happiness, harms no other being will find happiness hereafter.

Larisa closed the program with a poem in Russian about the glories of nature, which she translated into English. Will triggered the last musical piece and they sat back to listen, contemplate, and watch at the glorious eclipse.

As the music ended, Will felt his phone vibrate. The cameras on them were now turned off, so he pulled out the phone. It was a simple message from Lurleen: *Beautiful.* He held the phone up so David could see.

“She’s right,” he replied, and then he added. “That’s a start.”

18.

Space Day

Late July 2029

"So, what did you think of your expedition?" Will asked Silvia, as he brought her a cup of morning coffee. "I never heard your comments."

Silvia smiled. "I really don't have much to say because of my limited understanding of lunar geology. I was pretty busy maintaining the rangers; we had to shut down one fuel cell and run ranger 2's life support on emergency while I fixed a pump that never should have seized up. Mare Humboldtianum was . . . fascinating. The hills in the southeastern corner gave a good idea of the underlying material and the history of mare flooding, and the crater chains in the western side were quite interesting. And hauling three tonnes of liquid oxygen and hydrogen two thirds of the way down so that we could refuel on the way back; that was an important experiment."

"Yes, that was an important experiment. We can get to 60 north and back without cryo units. That gives us access to a lot of terrain."

"Jerry's still competing with you." She shrugged. "But it wasn't much of a competition, compared to an eclipse program, followed by a trip to the north rim of the crater Plato."

"That was quite an expedition. We've finally caught up on the dating of the samples, too."

"I don't think we're going anywhere for a while. Two and a half weeks to Plato, a week of rest, two weeks to Humboldtianum . . . the rangers need a lot of maintenance. We may manage a one-week trip in mid August, though."

"That's pretty close to Northstar 3's arrival and our departure," said Will. "Sounds like we'll be wrapping up local projects and providing a lot of sample analyses."

"I think so. Have you heard anything about the job?"

Will's eyes lit up. "I'm in the final cut! I had a two-hour interview last week."

"Director of Lunar Surface Exploration: that would be quite an accomplishment, at age 28."

"My age is my biggest problem. But it should please Lurleen because it's for a two-year term, renewable, and that means no trip to the moon for at least 2 ½ years."

"It'll solve the problem of being away."

"And maybe gives us time to start a family."

Silvia frowned. "They don't want the director to go to the moon?"

"No. Clearly, we need someone running the terrestrial support; our expeditions haven't been planned as well as they could be, or at least not as far in advance as they could be. The director needs to be there, not here. Besides, it'd cost 300 years' salary to fly him here and back!"

"That's true. They need someone who has already been here, though, and has geological experience. That narrows the field."

"It does." Will was tempted to ask Silvia whether Jerry had applied; he suspected he had. "Anyway, we'll find out in a week or two."

Just then Kalidas and Larisa came in, so Will walked back to the galley to get them their breakfasts. Before he got to sit, Jerry entered. "Good morning."

"Morning," everyone replied.

"I suspect the analysis of that sample from Bel'kovich is on the web, now," Will said to Jerry. "David said he planned to get it into the machine late last night. I suppose that's why he isn't up yet."

"Thanks, I checked. The age was Nectarian; 3.86 billion, as predicted."

"That's what I thought."

Jerry nodded. "It was quite an expedition. We need to make a similar expedition to Sinus Roris at the western end of Mare Frigoris, and another one down the middle of the far side toward Mare Moscoviense. That would characterize the northern highlands quite well."

"Tasks for the next two Northstars," replied Larisa.

Jerry nodded. "Now, next week is a big anniversary: can anyone name it?"

There was silence a moment, then Silvia said, "Apollo 11."

Jerry nodded. "July 20, 1969: first landing of humans on the moon, sixty years ago next week."

"Space Day," commented Will. "On July 20, 1976, Viking 1 landed on Mars; the first successful robotic mission."

"Oh, do they call it Space Day?" asked Jerry. "I've never heard of that before."

"Some people celebrate it on that day," said Will.

"Anyway, I thought we'd take the day off and have a big dinner, even though it's Friday and not Sunday. What do you think, Will; can you cook for us on that day?"

"Sure. I did something pretty basic last Sunday, because three of you were away."

"Great. Make it a nice dinner, okay? And don't worry about a program. I'll take care of that myself."

Will contemplated various possibilities for the big dinner all week. He reviewed the contents of the pantry and visited the rapidly expanding greenery daily to see how many tomatoes, herbs,

and vegetables would be available. He would be able to make a full salad for everyone and provide people with some fresh vegetables.

But for dessert, he wanted to make peach cobbler, and Lurleen had a particularly delicious recipe. They were emailing back and forth every few days and talking briefly every week or two—their marriage seemed to be in a peculiar suspension—so on Friday morning, Will emailed her: *Can you send me your recipe for peach cobbler, or a link to a website with it? I've started working on a big Space Day dinner and want to make it for dessert.*

He turned back to dinner. He had pulled out six frozen chicken breasts, with which he planned to make chicken parmesan; nothing fancy, but more daring than anything he had tried previously. He was working on the tomato sauce when he heard a ring. The recipe on the screen of his tablet was replaced by "call from Lurleen." He pushed a button. "Good morning; I'm surprised you called."

Her face, however, was very grave. "The peach cobbler: oh, it was just on the web somewhere, and I'm at work, so I don't know where I got it. Can we talk?"

He looked at the food all over the galley's counter. "Now? I'm in a public place and in the middle of dinner preparation."

"Can you go to your room? You've got plenty of time."

He wasn't so sure of that, but he knew he couldn't refuse. "Okay." He picked up the tablet and walked around the corner to his room. He closed the door and sat. "Okay, I'm in my room."

"Thank you." Lurleen took a deep breath. "Will, we need to talk about the future. I thought I could wait until you returned, but this is just eating at me. This new job you've applied for—"

"I heard yesterday that I'm on the short list now—"

"Great. This new job, though, doesn't solve our problem, which is the long hours you and I both work. There is no way we can have a stable domestic life together without both of us being unhappy about our careers. Look, we love each other, we've had a great time together . . . but Will, I want a divorce."

"Divorce? Lurleen, you don't want to try out this new arrangement? You just said we love each other!"

"I'm sorry, Will. I really don't want to hurt you, I don't. But this is not working for me."

"Is Tad living with you?"

She was startled by the accusation. "Well, no—"

"Because when I called you to tell you I had applied for this job—the day we started south to Frigoris—there was a second breakfast on your table, with coffee and toast."

That startled her as well. "I'd rather talk to you face to face about this, but yes, we want to get married. He's willing to stay home with the kids. We're perfect partners in just about every way, Will; he's smart, a great conversationalist, but he's willing to support my ambitions, because his are simply more modest. There's nothing wrong with that, either."

"And I guess he's okay in bed, too."

"Let's not go there, Will."

Will stared at the screen, uncertain what to say. "Well, you've asked for a divorce. There's really nothing I can say or do about that, is there? No plea, no call for patience; nothing that will change your mind."

"I . . . suppose not."

"Alright. Then I guess we're done talking." He was tempted to say "good bye," but that sounded too final. He pushed the "end" icon and the tablet's screen went blank.

He sat at his desk a long time, staring at the wall, letting the tears come. Then Silvia called from the hallway, "Will, what happened to you? Do you need help with the food?"

"Oh, sorry; no, I'll be right out." He wiped his eyes, stood up, and walked back to the galley. But he put the thawed peaches back in the refrigerator and pulled out frozen apple slices. He'd make apple pie instead.

Cooking was a good release; it gave him time to think, not that he had any useful thoughts to consider. Numbness was replaced by pain; by grief. He forced himself to pay attention to the cuisine because he didn't want to screw up the meal as well. His life was screwed up enough already. He thought about Tad and his "modest ambitions." He was winning Lurleen with them, and there was nothing Will could do, a quarter million miles away.

By noontime he was feeling a bit better. The chicken parmesan was ready to go in the oven; so was the apple pie. He put the chicken parmesan in the refrigerator—not an easy task because the fridge was crowded—and put the apple pie in the oven. That gave him time to go down to the greenery to harvest the vegetables and greens he needed. He took a big salad bowl with him.

It was an interesting task. The greenery had no insects or plant diseases, so there were no leaves with holes in them, no spots on the vegetables. The lights shone on the plants from all directions and went on and off on schedule, giving them twenty hours of light every day. Sensors in the soil and a computer program told them when to water and how much. Will and David had to pick sample leaves every week or two and run then through the mass spectrometer to provide the biologists with information about mineral deficiencies. It was a use never envisioned for a

geological instrument, but it worked. Silvia took a small cotton swab on a stick every morning and went from flower to flower, serving as an artificial bee. As a result, the greenery was thriving and producing amply.

He was picking spinach leaves when his phone vibrated with an incoming text message. *Now what,* he thought. He pulled out the phone and saw a text message on the screen.

Dear Will: Thank you for applying for the position of Director of Lunar Surface Exploration. You are a very strong candidate with very impressive credentials, but ultimately we have decided to go with a different candidate. We are confident that your skills will continue to develop and your devotion to the field will only grow, and look forward to continued association with you.

"Huh," he said.

Two blows in one day.

He put the salad bowl down and walked to the geology lab, where David was busy loading the X-ray fluorescence machine. "Oh, I'm so, so sorry, Will," David said, seeing tears welling up in his friend's eyes. He gave him a hug. "I don't know what else to say. Two disasters in one day!"

"At least there aren't any more disasters in my life waiting to happen!"

"Maybe two at once is better, then! You get to grieve only once."

Will smiled at that. "And I won't mess up the dinner. I'm determined!"

"Let me come help you with that. These samples can wait."

"No, I don't need any help."

"I insist. This is no time to be alone, even if you don't want to talk. I don't think you should feel bad about the Director position. You're only 28! It's a position that requires more

than being the Moonman. It's not just geological expertise that's needed. You need experience running a team, managing people, devising and managing a budget . . . it's a complicated task."

"You're right. That has occurred to me."

"You can apply again, or maybe something else will come along. And as for Lurleen; she cheated on you, and she admitted it! And she even told you why. So you have to heal, my friend. That will take time."

"You're right, David. I had better get back to the greenery to pick the stuff I need for dinner, or the apple pie will burn before I get back to the galley."

"Okay, I'm coming along." David pointed the way to the greenery and they headed there.

David told Will jokes and funny stories and managed to keep Will laughing. David had no idea how to cook anything at all, but he could find ingredients—especially after Will described them, since David often didn't know the English words—and he could move dishes and pans around. They had fun together and the dinner was ready at 2:30 p.m., as scheduled.

When the apple pie and home-made vanilla ice cream were finished and people were drinking their coffee and tea, Jerry tapped on his glass to get everyone's attention. "First of all, we have to thank Will for creating this magnificent feast for us. He was slaving for some six hours to prepare it, and we are all very grateful." Jerry began to applaud, so everyone else followed. Will nodded in thanks. "Let us also remember that we are commemorating Apollo 11's landing on the moon, exactly sixty years ago today; and that we are remembering Viking 1's safe landing in Chryse, Mars, fifty-three years ago today.

"So it is a fitting day to look back at our own accomplishments over the last five months. When we arrived, terrestrial operators had managed to dock shelter 2 to shelter 1 and inflate it;

we set it up, so it is now possible for two Northstars to be here at the same time. We were able to complete the break-in of ranger 2 and start two-ranger expeditions that completed the primary survey of the north polar region. Our exploration culminated in two great expeditions, to Mare Frigoris and Mare Humboldtianum. We raised water production significantly; enough to fill the radiation envelopes of both shelters, which together now have 500 tonnes of water in them. We saw the arrival of our first Thunderbird and we were able to fill its fuel and water tanks, as well as launch two landers to the Depot with fuel for the Thunderbird tankers there. We received a fourth cryo lander and set it up; Peary Resources is now producing all the hydrogen and oxygen it had planned to produce. In two unexpected developments, we created a greenery and spoke to Chinese visitors. And we were the first ones to cook on the moon! We have moved exploration forward significantly, moved the possibility of tourism forward significantly, and moved lunar water and fuel production forward very significantly. All sorts of new possibilities have now opened up. All of you made these accomplishments possible. I want to thank you for your hard work, dedication, and vision for completing our goals and then some. We were quite a team."

"Thank you for your leadership, Jerry," added Larisa, and everyone said "here, here!"

"Thanks," he replied.

"So, who's coming back?" asked Larisa, looking around the table.

"I will, if ESA lets me," said Silvia.

"Probably not," said Kalidas. "I'd like to move into government service and serve my country in Parliament. I'd love to have the chance to help India make changes."

"I'll be back," said Will. "Over the next year I'll spend most of my time writing up the results of our work."

David nodded. “No doubt I’ll be back in a few years. The moon is in my blood, you might say.”

Jerry hesitated a moment, glanced at Will, then back at the others. “I won’t be back for at least two years, because I just heard this morning that I’ve been appointed the Director of Lunar Surface Exploration. But after that I’m sure I’ll be back.”

“Congratulations!” said Silvia, Larisa, and Kalidas almost simultaneously. David echoed them a split second later.

“Marvelous, congratulations, Jerry,” added Will.

“Thanks, everyone. I look forward to playing a support role for all of your exploratory efforts. That includes the write-up of Northstar 2, Will. If I can be of assistance, or if the lunar surface geology department can help, let me know. I really mean that.”

Will smiled. “Thanks, Jerry, I really appreciate that. There is a lot of writing up to do, too.”

“There should be; we did a lot,” concluded Jerry. “I’m confident this mission will go down in history. Let’s finish up the ice cream and open another bottle of wine. We have a lot to celebrate.”

19.

Cairn

Late August 2029

“Welcome to the moon!” exclaimed Jerry to the Northstar 3 crew, who were clustered around Commander Sebastian Langlais in their Polaris capsule.

“Thank you, Jerry,” replied Sebastian. “We were relieved that our orbital insertion burn went well. The Depot is already bigger than a star; we can see the Thunderbird stages!”

“We saw you fly overhead a little while ago,” replied Jerry. “We had the long-distance telescopic camera programmed to track you. We could even see the second docking node attached to your capsule!”

“Yes, we’ll have that installed on the other end of the depot in twelve hours and we’ll be at Peary in twenty-four. We’re looking forward to moving into shelter 2 and raising the population of the moon to 12!”

“We’re sorry to be leaving, especially since you have some exciting objectives. We wish we were aiming for the first expedition involving a 3,000 kilometer round trip! We’re glad you’ll expand the greenery, too. It has proved very useful and important to us.”

“I can imagine; plants are an important psychological addition to the station. We have some new objectives, too, as of yesterday: it has been confirmed that cryo units 5 and 6, which will be arriving in October, will include greatly improved mining capacity to obtain carbon dioxide and nitrogen rich volatiles in the cryogenic cold traps, that is, those below 100 Kelvin.”

“That’s marvelous; we’ve been able to do very little with the traps below 150 Kelvin. What’s the purpose? Liquid methane for Project Redstar?”

“More than Project Redstar, I think, but I’m not sure what,” replied Sebastian. “Our Peary Resources folks, here, are pretty discrete.” He pointed to a man and a woman on the far right of the image. “We’re looking forward to see you guys tomorrow.”

“Same here,” replied Jerry. “Have a safe journey, my friends! Godspeed!”

“Thank you! Bye.”

“Bye.” Jerry closed the connection with a smile and turned to the others. “Well, this place is our place alone for another 24 hours, then we have company for a week while we brief them, then we head home.”

“Six months: it’s hard to believe,” said Larisa, shaking her head.

“Late February to late August,” said Jerry. “The Earth has gone from late winter to late summer.”

“The sun has circled the station six times,” said Kalidas. “It’d be good to do something together for one last time.”

“To give us closure?” said Will. He thought. “Let’s go over to the exact North Pole and build a cairn; a big rock pile. Maybe every expedition that comes here should go add to the pile.”

“That’s a great tradition!” said Jerry, nodding. “Let’s do it after supper!”

“Yeah, it’s not like it’ll get dark then,” quipped Kalidas.

“Let’s get back to work, for now,” said Jerry.

Everyone nodded and headed out of the common room except Will; the lunch dishes were his responsibility that day. He picked them all up from the table, rinsed them, and put them in the dish washer. The last cargo flight had brought a very expensive, high quality, commercial dish washer; since the galley had been designed to microwave frozen dinners, it had to be added.

Will’s tablet vibrated with an incoming email. He pushed on the notification.

Will: As you can guess, I won't be coming to Canaveral for your landing. But I do want to see you in Houston. We have a lot to talk about. I hope we can part amicably; no big divorce fight. I'd like to think that we can still be friends. But we have common property and other matters to resolve. When will you get to town?

He looked at the message and all the pain and grief he had been submerging rushed back. They had managed a few brief, polite, impersonal emails over the last month, since she had said she wanted a divorce. They had not videomailed.

He ignored the message a while and focused on rinsing the dishes, though he rinsed them so well they really didn't need washing. Finally, he turned back to his tablet and typed out a message: *I don't know when I'll be back; I plan to take a little vacation. I'll let you know.*

Better to let her wait, too, and besides, he really had no idea when he'd be back.

He headed down to the geology lab to process another batch of samples. With any luck, they'd get so many finished that they'd need to take only 100 kilos back to Earth. Will and David had managed to run tests on over a thousand. By suppertime, three more had been dated.

After supper, they all headed to rangers 1 and 2, docked to the eastern and western ends of the shelters respectively. They suited up and headed off. "Down Aldrin Trail." Will said, looking at the map. 'There's a TROV track that goes off the trail and within a few hundred meters of the exact pole."

"Do you know every TROV track?" asked Jerry.

"No, but I know a lot of them."

"I guess so," said Jerry, shaking his head in wonder.

They passed Aldrin Pad 1, where the lander that would take them to the depot awaited. They passed pad 2, where Northstar 3 would touch down the next day. They passed pads 3 and 4,

where landers were parked and being slowly refueled from the cryo units, a tonne of hydrogen and oxygen at a time. The pads were 2 kilometers apart; when they passed the last one they were half way to the North Pole. In three more kilometers, Will pointed to a faint track in the lunar regolith. Jerry slowed and turned right.

Aldrin Saddle was a rolling crater-pocked surface that slowly descended toward the North Pole. At the time it was mostly in shadow, for the sun was over the near side of the moon. They watched the ranger's GPS very closely as it showed them closing on the pole. Finally, the GPS showed that they had reached the exact spot. "Let's get outside and move the ranger out of the way," said Jerry.

He, Kalidas, and Will pulled on their helmets and gloves while Silvia, David, and Larisa did the same in ranger 2. As the last ones came out, Jerry asked Mission Control to move the ranger twenty meters forward. Then he picked up a rock, walked over, and dropped it. "Let's make the cairn here, with a wall around it, about six meters back."

"With benches," suggested David.

"Eventually. I doubt we'll want to do that today!"

Will walked to a large rock sticking out of the regolith, kicked it free, and picked it up. It was way too big to pick up on Earth, but in lunar gravity it wasn't bad. He brought it over and placed it next to Jerry's rock. Meanwhile. David pulled a tape measure out of the supply pouch in the back of lander 2. With Silvia's help, they traced a two meter circle for the cairn and an eight meter circle for the wall around it, leaving a six-meter space between them. He marked the larger circle by dragging his foot in the ground, then placed stones along the circle every meter or so.

With six of them hauling rocks, the cairn built up quickly, and soon the wall around it was at least marked out. After an hour they were all getting tired. “Shall we quit?” asked Jerry.

“We need a picture!” said Silvia.

“Good idea,” said Jerry. He walked to the cairn and turned to face ranger one. “Mission Control, we need a picture of the six of us in front of the cairn.”

“We copy,” replied the cap com. “The media people want it, too! This is a nice attraction for the tourists.”

“Oh God, have we built the moon’s first tourist trap?” commented Will.

“At least there are no trinket sellers,” replied Jerry. “Not yet, anyway!”

The six of them stood next to the cairn—three to the right, three to the left—and Mission Control turned the cameras on them. Then it was done. The six of them headed for the rangers for a long, sad trip home. “Can we take the long way around?” asked Will. Past Borealis AL, Armstrong AJ, the top of the Whipple Trail, and Armstrong Pinnacle?”

“A tour of the area?” said Jerry. He nodded. “Sure, you take the wheel.”

“Thanks.”

They entered the two rangers and made their tour of Peary Station’s highlights; past the cryo units and power masts, the new pads on the Armstrong Plateau, and past the vista point where the great, black expanse of Whipple Crater spread out before them. When they returned to the station, they were all a little teary-eyed.

“That was a good idea,” David said to Will in the geo lab, where they were loading samples into the mass spectrometer, alpha backscatterer, and X-ray fluorescence machine for the night.

“I’ll miss this place. I want to come back.”

"In another year or two, it'll be even bigger."

"Heading towards becoming a McMurdo," agreed Will. "As long as there's money, anyway."

Will's phone vibrated with a message. He reached into his pocket and pulled it out.

Will: What are you doing after landing? I'm sorry you didn't get the Director's position for lunar surface exploration. I can't imagine anyone more qualified than you. If you can, come to Brown for the fall semester as a visiting scholar. I have a NASA grant (!) that can cover it and we have a course on lunar geology scheduled. We'd love to have you. Tim Foote.

"Huh."

"What is it?" asked David.

"My old doctoral advisor, Tim Foote, has invited me to be a visiting scholar at Brown University for the fall."

"A great chance to get away, do some teaching and writing, and reflect."

Will nodded. "You're right, it's perfect."

19.

Home

The burn was perfect.

Will and the other members of Northstar 2 watched the Thunderbird-H stage fall away from them as their Polaris capsule fired its eight landing rockets briefly to speed their path toward Earth. The Thunderbird's hydrogen and oxygen fuel was largely spent, but it had carried thirty-six tonnes of water from Peary to the lunar orbit Depot; now that it had also pushed the Polaris to Earth, it would skim the top of the earth's atmosphere just enough to burn off a little of its speed, and after three weeks and eight gentle aerobraking passes it would arrive with its water at the Swift fuel depot in low Earth orbit, where the water would provide the fuel for Northstar 4. Northstar 2's last contribution to lunar exploration was to provide the first complete lunar fuel supply for a future mission.

For three days, the Earth grew larger and larger outside their portholes as they fell toward home. Will realized how much he missed Earth, as it loomed ever larger, but he also felt uneasy about his future there. The moon, at least, was a kind of suspended animation, where life was concerned. But it couldn't last forever.

They hit the atmosphere at 25,000 miles per hour, aimed very precisely for the angle where they skimmed along the top of the atmosphere, rather than falling like a rock toward the ground. The computer guidance was perfect; gee forces built to 3.5, then dropped as they cut deeper and deeper into the layers of air. Finally, at 6,000 meters, the landing rockets built into the sidewalls of the Polaris came on with a roar, slowing them to an extent that the Earth's

gaseous envelope could not. The landing legs extended and the Polaris touched down perfectly in the middle of its landing pad at Kennedy Space Center.

The next fifteen minutes were a surreal experience for Will. His leaden weight, after six months of lunar gravity, came as an unmitigated shock. He was surprised to feel his heart racing, though the physician on the bus that took them to the arrival area was watching all their heart rates on his tablet and was unconcerned. Walking was difficult and wobbly; he felt like he was 90 years old. His flight bag felt like a lead weight and he was relieved when someone took it from him. The hot, humid tropical air came as a shock after six months of ideal conditions. Sounds seemed abnormally loud because they were transmitted through the thicker air more efficiently. The glare of the sun hurt his eyes and made him wonder whether he had developed any cataracts during his six months of radiation exposure. All these different stimuli, coming at once, felt almost overwhelming. He was most displeased by what he had thought would be an exhilarating arrival.

His parents embraced him warmly and he felt tears in his eyes when they did. But the absence of Lurleen stung deeply. The welcoming ceremony, featuring the Vice President of the United States and a rather loud orchestra, was a blur for Will. When it was over, the six members of the Northstar 2 crew said farewell to each other for the day. They'd be back together the next day for a debriefing and a thorough physical, but they were free for the rest of that day.

"Can we not go to the hotel NASA has reserved for us for the night?" asked Will, as he got into his parents' rental car with Catherine and Stephen. "There will be journalists and all sorts of onlookers. I think I need some peace and quiet and a good night's sleep."

"Sure," said Stephen. "We stayed at the Quality Inn in Titusville last night. We can go back there."

"We might get followed by journalists, though," said Catherine.

"I'll drive to the new hotel, then go around back and drive away," said Stephen. Will nodded, so they headed toward the fancy hotel with several dozen other cars, then looped around the back and drove to Titusville.

They stopped at a quiet MacDonalds near the hotel to eat some supper and sat in a corner booth out of the way.

"So . . . no Lurleen," said Stephen.

Will shook his head. "We're emailing back and forth every few days, but it's all routine stuff about the house. She wants a divorce and plans to marry Tad in the spring."

"I'm so, so sorry, Will," said Catherine. "No matter how much you try to get to know someone before marriage, there's no guarantee it'll be enough. The only way to know a marriage will work is to give it a try."

"I know. I blame myself to some extent, for being so totally devoted to my research and my career. I blame her for being so focused on her career, too. But I also blame her for cheating on me. That hurts the most."

"It's the worst," agreed Stephen. "And it'll take some time for that pain to heal. But you can find happiness and a good, happy marriage. I'm confident of that."

"So am I. You have a lot to give to a wife, dear," agreed Catherine.

"So, you're going to Brown?" asked Stephen.

Will nodded. "Once I'm done here, I'm going to Martha's Vineyard for a week just to have some peace and quiet. The course at Brown is an afternoon seminar that meets once a week, and Dr. Foote will get it started. In a few weeks I'll fly to Houston, load up my car with stuff, and drive them to Providence. I plan to come down to Stamford a few times, too."

"You're always welcome."

"Thanks, dad, I know that. I'll plan to give some talks to the Bahá'ís in various places in New England and New York, too, and I have a lot of research to write up."

"Are you selling the house?" asked Catherine.

"Yes, after I get back in January and get an apartment. While I'm away, Lurleen plans to use the place occasionally."

"Then what?" asked Stephen.

"I have a lot of research to write up; that'll take at least a year. I want to rewrite my thesis and update it so that it can be published. I'll keep my eye out for potential wives, but not for six months, and after that, rather carefully! And I want to go back to the moon."

"The moon is a harsh mistress," said Stephen, quoting the title of a famous science fiction novel.

Will nodded. "She is. But she has me in her clutches, and I love it. I'm giving her at least ten years. Any wife I find will have to understand that."

Field Trips, Northstar 1:

3 weeks in September
3 1-day excursions per week; (=9 days) (=27 cold traps)

4 weeks in October
3 1-day first week; 2 2-day for 3 weeks (=15 days)(32 cold traps)

3 weeks in November
2 3-day for 2 ½ weeks, 1 4-day (19 days)(45 cold traps)

Totals: 43 days of travel; 24 excursions; 104 cold traps

Northstar 2:

Cargo lander 4: Arrived in December with 14 tonnes; a ranger, consumables, equipment to expand water and cryo production (unload in Feb/March)

March: test ranger 2, complete local field geology
4 field trips of 1, 1, 2, 4 days each

Late March: Thunderbird-H that brought Cargo Lander 4 lands to serve as propellant storage facility

April: Loop one: 200 km south and back in 1 week.
Loop 2: 400 km south (along Loop 1's return route) and back, 8 days

Cryo lander: Brings a fourth cryo plant, **early May**

Loop 3: 600 km south (along Loop 2's return route) and back, 12 days
Permission received to create a "Frigoris trail"
Loop 4: 800 km south (along Loop 2's return route again) and back, 15 days (**late May/early June**)

June: Chinese astronauts orbits the moon. One telephones Will!

Loop 5: 1,100 km south (along Frigoris Trail) (**20 days, late June to mid July**)

June 26, 2029: total lunar eclipse

Cargo lander 2: Brings small quantity of supplies down in **late July** when Polar Station depot is expanded. Thunderbird-H that brought it from Earth lands as well

Loop 6: 1,250 km to Frigoris and back at higher speed (20 km/hr continuous), set up of depot 1 (km marker 600), fly cargo lander 1 down to endpoint and set up depot 2, 15 days, **first half of August.** Jerry leads it.

Two weeks before departure and 1 day before Northstar 3 arrives: crew goes to exact North Pole point and builds a cairn. Will and Jerry reconcile

Northstar 3:

Sebastian Langlais (was supposed to command NS2 but had to pull out)

Northstar 5:

Introduce portahab. Introduce Conestoga later

Complete work on Lunar Suites Hotel; have first tourists in shelter 2

Started Sept. 21, 2013; completed November 3, 2013; totally and accidentally deleted, November 20, 2013; recovered pages 1-223, November 26, 2013; rewritten/reconstructed the ending after finishing volume 2, December 16-19, 2013; reread and edited, July 1, 2014.