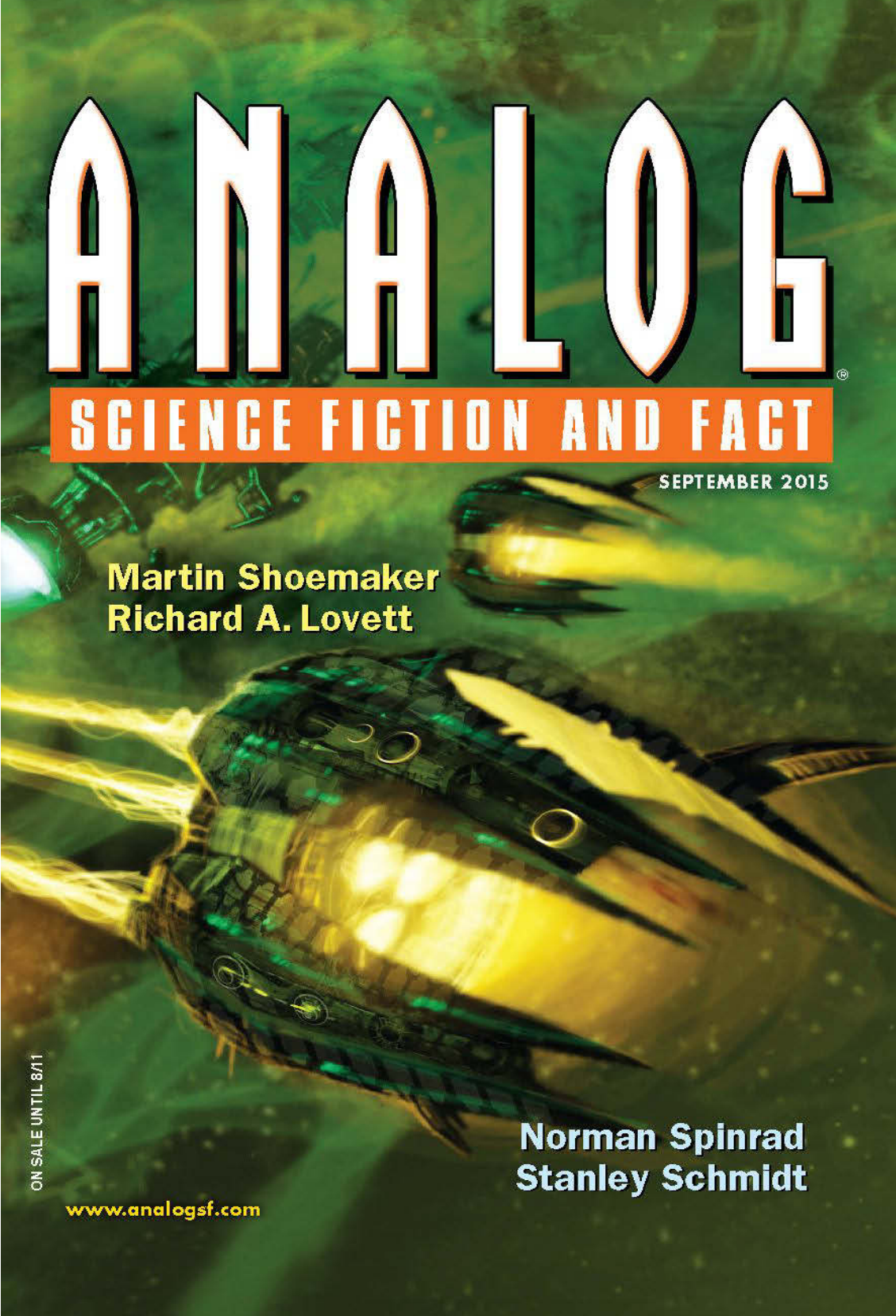
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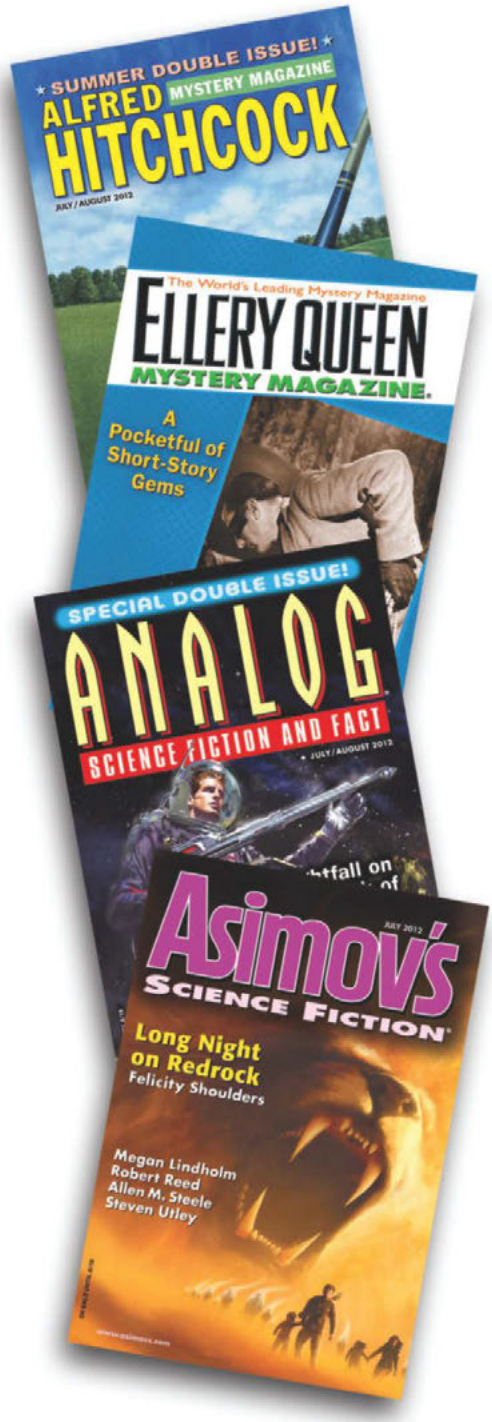

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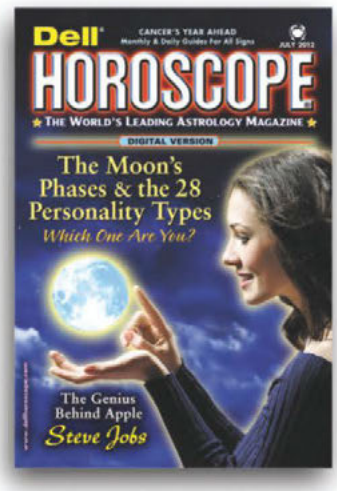

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GUEST EDITORIAL Amy Sterling Casil

BEHIND EVERY GREAT MAN —AND WOMAN

Although I swore I'd never own another Ford after enduring six years of painful, costly Escort ownership, I still admire Henry Ford. Escort-lemony-goodness aside (and that car should have come with a dimpled yellow finish), Ford may have done more to change the world than any other twentieth century figure. He was an anti-Semite, but also wrote the wisdom: "Coming together is a beginning. Keeping together is progress. Working together is success."

When I came up with the idea for an *Analog* guest editorial about women in science—but not the usual suspects or usual list of problems—I didn't realize what I'd learn or come to believe. The evidence I found is that, male or female, people do better work when they are working together, and they also benefit from strong partners, whether or not that partner is also a scientist. It's difficult to estimate the value of support from family and friends, but most people have heard the truism, "Behind every great man, there is a great woman." Well—for the most part—vice-versa.

Darwin entrusted his wife Emma, with whom he had ten children, with the responsibility of publishing his work after his death. He "was a particularly admirable, even lovable, figure: a collegial scientist, devoted father, faithful supporter of young colleagues, sincere, honest, and without personal enemies," according to Merry Maisal and Laura Smart, who compiled biographies of sixteen notable female scientists for the San Diego Supercomputer Center.

It's challenging enough to figure out whether or not Charles Darwin could count on the support of family and friends, although Google Books lists more than three hundred thousand Darwin biographies. It's even more difficult to determine the degree of support experienced by well-known female scientists. Similarly to the majority of male scientists, most female scientists live and work with as much public recognition or biographical attention as a schoolteacher or general contractor. Only sixteen women have ever been awarded the Nobel Prize in any scientific field, and a total of seventeen Nobel science prizes awarded to a woman; the count is "off" because of the best-known female recipient, two-time winner Marie Curie (physics and chemistry). Marie is, of course, one half of one of science and history's best-known couples, and mother of a great scientific family. Most schoolchildren know something about the story of Marie and Pierre Curie's discovery of radium. They might know that Marie was devastated by Pierre's accidental death, yet they probably know little about the couple's daughter, Nobel Prize-winner Irene Joliot-Curie, or several other Curie descendants who have made notable scientific advances.

It's more likely that when kids think about female scientists (if they think about them at all) they picture a single woman like chemist Rosalind Franklin, rival to Crick and Watson, who died at age thirty-seven of ovarian cancer. Perhaps they might envision someone like never-married Annie Jump Cannon, an astronomer whose work I'd been completely unaware of prior to a visit to the Huntington Library last year. Walking through the Huntington's mind-blowing science history exhibit (the extensive, original historical material vividly illustrates how far scientific knowledge has developed in such a short period of time), I spotted a letter written to Edwin Hubble from a lady named Annie. I wondered aloud, "Who is she?"

Annie Jump Cannon was the daughter of a Delaware state senator and his wife Mary Jump. She studied science at Wellesley and later immersed herself in astronomy, becoming one of "Pickering's Women" at the Harvard Observatory, her job being to map and define every star. Her beautifully written note to Hubble referred to a question about the star classification system she developed, which is still used today: O, B, A, F, G, K, M ("Oh Be A Fine Girl, Kiss Me"). Annie may never have married, but she did have friends. She was taught by another unmarried female scientist, Sarah Frances Whiting, who founded the physics laboratory and astronomy departments at Wellesley. One of her friends was Henrietta Swan Leavitt, another of "Pickering's Women," whose work supported the development of Hubble's law.

What about the second (to date) woman to win the Nobel Prize in physics? It's fair to say that without her husband Joe Mayer, Maria Goeppert Mayer would not have been able to perform her scientific work. Maria shared 1/4 of the Nobel Prize in physics in 1963 for her definition of the nuclear shell structure, along with Eugene Wigner, and, working separately on the concept, J. Hans and D. Jensen. Maria's husband was a chemist who taught at Johns Hopkins, the University of Chicago, and the University of California in San Diego. He also served as President of the American Physical Society. Reportedly, when Maria won the Nobel Prize in Physics, the San Diego Union-Tribune's headline read, "S.D. Mother Wins Nobel Prize." The headline was true, if almost laughably absurd (even for 1963), as Maria was a mother and had been married to Joe Mayer for over thirty years. According to Karen E. Johnson's 1986 overview of Mayer's physics research in Physics Today, "it was only through [Joe Mayer's] support over the years that she was persuaded to continue in science."

Joe Mayer lost his position at Johns Hopkins because others at the school disliked his sponsorship of his wife's science career. Maria had been allowed to conduct research at Johns Hopkins for a stipend of two hundred dollars a year (which equals about three thousand, five hundred in today's dollars). Although one of the only people in the U.S. who was qualified to work in atomic physics, she worked in chemical physics at Johns Hopkins, alongside the only two other scientists who would work with a woman—her husband Joe and chemical physicist Karl Herzfeld. Later, Maria worked with Enrico Fermi and Edward Teller at the University of Chicago (on a volunteer basis) and conducted research as part of the Manhattan Project. She worked half-time for a reduced salary under her former student Robert Sachs at the Argonne National Laboratory. We would not have Maria Mayer's science today, were it not for her husband's support.

It's fair to say we would all be quite a bit sicker today were it not for Dorothy Crowfoot Hodgkin. Hodgkin, who won the Nobel Prize in chemistry the year following Maria Mayer's physics award, had a more secure academic appointment than Mayer ever did. According to Maisel and Smart, Hodgkin was "the Darwin of our age," a "saintly, gentle and tolerant lover of people, and a devoted protagonist of peace." She founded the science of protein crystallography and won the 1964 Nobel Prize in chemistry for determining the molecular structures of cholesterol (cholesteryl iodide), penicillin, vitamin B12,

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and insulin. Hodgkin established her own laboratory at Oxford's Somerville College, described as an "unfailingly joyful and productive environment." One of her devoted students was Margaret Thatcher, then named Margaret Roberts.

Their friendship has been memorialized in a play by Adam Ganz: *The Chemistry Between Them*. In later years, "The Iron Lady" was proud to tell others that she was the first U.K. Prime Minister with a degree in science. After graduation from Oxford, Thatcher was turned down for many jobs as a chemist owing to her "strong personality." She eventually did find work as a chemist but quit upon meeting and marrying Denis Thatcher, who managed his family's chemical and paint company. Denis encouraged his wife to pursue education and a career in law, launching what is perhaps another form of "behind every great woman . . . "

In 1937, Dorothy Hodgkin married Thomas Hodgkin, an African historian and peace advocate, and the couple had three children. According to Maisel and Smart, "the entire family distinguished itself over more than three decades by working in the public arena for the cause of world peace." Despite her friendship with Margaret Thatcher, Hodgkin's political activism and receipt of the Soviet-sponsored Lenin Prize barred her from receiving a U.S. Visa until 1990, when she was over age eighty. At this time, she finally did receive permission to visit the U.S. and lectured on insulin and crystallography to "standing-room-only crowds."

Playwright Adam Ganz became fascinated by Hodgkin and Thatcher's friendship when he realized that among prominent female politicians in the U.K. and Europe, both Thatcher and Germany's Angela Merkel had begun as scientists, and, in contrast, none of their prominent male political counterparts had any science education. In Ganz's play, the fictional Thatcher tells Hodgkin that "the only time I was a better scientist than you was in politics, because you thought people wanted to live by their better nature, you see them as part of the lattice, but they want to see themselves as free."

I wonder often what our notions of social propriety cost us. What if Joe Mayer hadn't been devoted enough to his wife's scientific research that he was willing to get fired? What if Dorothy Hodgkin's husband hadn't been willing to put up with her long hours in the lab, her unconventional relationship with her mentor Bernal, or had not shared her devotion to world peace?

As to the controversial Henry Ford, a man both wise and foolish, visionary and reactionary, Clara, his wife of nearly fifty years, reportedly threatened to leave him if he did not cease his opposition to the United Auto

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Workers, an embattled position which was threatening to bring down the great company. Ford relented, and in 1941, signed what was at the time, the most favorable contract with the UAW.

As they say, behind every great man—and great woman—is a partner and friend. ■

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Amy Sterling Casil is a 2002 Nebula Award nominee and recipient of other awards and recognition for her short science fiction and fantasy, which has appeared in publications ranging from *The Magazine of Fantasy & Science Fiction* to *Zoetrope*. She is the author of twenty-six nonfiction books, over a hundred short stories, two fiction and poetry collections, and three novels. Amy is a founding member and treasurer of Book View Café and former treasurer of the Science Fiction & Fantasy Writers of America, and teaches writing and composition at Saddleback College. She is the founder of a new publishing company for the twenty-first century, Chameleon Publishing.

Racing to Mars

Martin L. Shoemaker

I was thirty-four years old, in what should have been the prime of my medical career; but in fact, I was washed up, a victim of my principles and my temper. My life as a doctor was over—until Nick Aames unexpectedly swept in and threw me a lifeline, asking for me personally to be chief medical officer on the Mars cycler *Aldrin*.

And I hated him for it.

Oh, not right away. I had never met him, so how could I hate him? I was grateful! So as soon as I had dropped my gear in my office, I headed up to the bridge to thank him.

But when I got there, my image of my benefactor was shattered. As soon as the bridge door opened, I heard him berating his crew. "Howarth! Why are those mooring lines not reeled in? Sakaguchi, are those engines ready yet? We boost in two hours, people. Don't waste time. *Move!"*

I peered in through the door. Nick Aames loomed over his bridge, a redheaded, gray-clad vulture looking to swoop down on anyone that drew his ire. The bridge was arranged in the classic "mission control" layout, three rows of desk stations facing a main display, officers in gray uniforms manning each station; and at the rear was the captain's raised aluminum-and-web chair. The curve of the deck and the height of the chair combined to give Aames an elevation of nearly two meters relative to the front row of stations, so that he could look "down" upon each station and see the displays. He glared at everyone and everything around him, a scowl fixed in place. His uniform was immaculate, and his red hair and beard were neatly trimmed; but despite the tone of his voice, his slouch and his attitude made him seem sloppy, just as I had heard from his detractors. But when I saw the glare in his eyes, I decided that he was not sloppy, but rather *dismissive:* He was busy, and he had no time for anything but planning the maneuvers.

Chief Carver was a contrast to the captain: just as neat and trim, but his dark face was alert and warm as he greeted me at the bridge door. I saluted (still not comfortable saluting even after my academy training), and I introduced myself. "Dr. Constance Baldwin, reporting to Captain Aames."

Carver returned my salute, and he smiled just a bit. He was a charmer. "Welcome

aboard, doctor. We're glad to have you. Let me introduce you to the captain."

He walked over to the captain's chair, and I followed, trying to imitate his precision stride and failing utterly in the one-quarter gravity. Carver cleared his throat and announced, "Captain, Dr. Baldwin is reporting for duty."

I saluted again, but before I could say a word, Aames snapped at me without taking his eyes from the stations: "Is anyone sick here, Doctor?"

I was unsure what to do, so I held my salute, and I answered without hesitation: "No, sir."

"Have there been any injuries that I missed? Did someone call you to treat a bout of spacesickness?"

"No, sir."

"Then what the *hell* are you doing here? I do not tolerate spectators on my bridge, particularly during departure maneuvers. Get the hell off the bridge, Doctor, and back to your office where you belong!"

And that was my introduction to Captain Nick Aames. I owed him for my second chance as a doctor. And instinctively, I hated him. I had the urge to knock him out of that chair, but I held my temper. Barely.

I had signed aboard the *Aldrin's* first full cycle to Mars and back. She had been through shakedown cruises in Earth-Luna space before then, but now she would begin a series of boosts and slingshot maneuvers to launch her on a cycler trajectory to Mars. There, another carefully calculated set of slingshot maneuvers would send her back to Earth, and then with skilled piloting she would repeat that cycle—Earth to Mars and back, again and again with minimal fuel costs. All it took was time: five-and-a-half months out, months longer back, and months of slingshot maneuvers on each end. I faced nearly two years under a captain whom I hated. My streak of career bad luck looked to stay unbroken.

I returned to my new office, a small space that smelled like a doctor's office should—disinfectant with a tang of medicine—but looked like the interior of a mud hut. Back then, the *Aldrin* was still owned and managed by Holmes Interplanetary, and they had painted the interior in their corporate colors, a hideous shade of orange-brown. Oh, they called it "ochre"; but in my dark mood, "orange muddy" was all I could see.

"Suck it up, Connie," I said to myself. "You're still a doctor. You have a practice. That's enough."

I opened my old black medical bag and pulled out a clear plastic tube containing a sheet of ivory parchment: my medical diploma from the University of Michigan. I had almost left the tube at home—our mass budget for personal effects was *that* tight—but I couldn't make myself do it. I removed the parchment, unrolled it, and wondered how I was going to hang it. The frame had been too much for my mass budget, but I had no intention of going to space without that parchment.

I had worked too hard to get that diploma—and then fought too hard to keep it. I had reported sanitation violations at my hospital. They sued, and I countersued. The evidence was all with me, and I was vindicated. Eventually, I won, but in the process, I lost. I had the court settlement on my side, and a big damage award, but I also had a reputation as a troublemaker. One slimy investigator had pushed me too hard one night, trying to provoke a reaction; and I had lost control, punching him when he had grabbed me in a restaurant. *Smart, Connie, really smart.* Witnesses had testified that I was provoked, so the police never pressed charges, but that became my reputation: the temperamental woman who punches men in bars. The hospital's PR flacks made sure that story was in all the media, and I was marked, a whistleblower with a temper. No one ever used the word "blackballed," but no hospital would grant me admitting privileges. Without those, no practice would accept me. I was locked out of medicine.

At first I was angry. Despite my natural temper, I had kept my calm throughout the court proceedings. (Punching holes in walls at night didn't count.) When I realized how screwed I was, I was angry enough to punch more than a wall, but I was smart enough not to make that mistake twice. Eventually I figured I was still young enough to switch career paths, so I used my settlement to fund my training in space operations and space medicine, and I also became a reservist in the Space Corps. Then I sent applications to all of the transport companies.

And then I waited. It seemed the blackballing went farther than I had realized. I had good recommendations from my instructors at the academy, but I received no interview requests. *None.* I still read about shortages of doctors in space, but apparently the shortage wasn't enough to overcome my reputation. My medical career was over, it seemed, and I didn't have a backup plan.

But then out of nowhere, my fortunes completely reversed: Instead of an interview request, I received a job offer from Holmes! But I was confused. I had applied there, yes, but I had never heard a word from them—until this offer.

I was torn between celebration and doubt, and doubt won. I didn't want to derail the job offer, but I hate not understanding. So I called their personnel director, and I asked her to confirm. She was very positive: "Yes, it's very unusual, Dr. Baldwin. But your academy record and your C.V. are exemplary. And your instructors spoke highly of you, Mr. Quintana particularly." Quintana had taught our unit on emergency management. "That was enough for Captain Aames. He insisted we hire you. Our launch schedule is very aggressive, so we didn't have time for the customary rounds of interviews. I hope that's all right with you?"

Absolutely it was all right! And before I knew what was happening, I was on Farport, boarding a rendezvous shuttle, and looking forward to meeting the man who had believed in me.

That bastard, Nick Aames.

After the second *Bradbury* expedition, most people knew Aames by reputation. For a while he was a media hero. And he was also somewhat legendary at the academy, though a lot of people there were *not* fans. "Difficult," they said. "Sloppy." "Obstinate." "Insolent." "Arrogant." "Smug." And often more: "Arrogant bastard." "Smug asshole." I had written these off as jealousy or petty rivalries. Now I was ready to believe them. And worse.

Oh, well. I had worked for tyrannical bosses, and I had put off hitting them for over two years (until I found out they were compromising patient safety, and then I hit them in the court room). I could put up with Nick Aames for that long. The boss didn't matter, only the patients mattered.

* * *

But soon I was as fed up with my patients as well as my boss. Or to be more specific, *a* patient: Anthony Holmes. He first came to my attention when my assistant, Dr. Santana, brought me the ship's medical report, a summary of the condition of the crew and the passengers. When he pushed it to my desktop display, I skimmed over it. I knew Santana's record, so I trusted he had done thorough work. But then I saw that one line was marked INCOMPLETE. "Who's this Holmes, Anthony, and why is his record incomplete?"

Santana whistled. "A hundred and twenty passengers and crew on board, and you zoom right in on the one incomplete. You're pretty sharp, doctor." I nodded, acknowledging the compliment. "Anthony Holmes is the sole heir of Anton Holmes, chairman and primary stockholder of Holmes Interplanetary. In other words, he's the boss's son, and he damn well acts like it."

I pulled open Anthony's file and skimmed through it. Twenty years old. Overweight by Corps standards, but reasonably fit for a civilian. Excellent dentition and bone health, the best a billionaire's son could buy. Neurotransmitters all in optimum range, cardiovascular efficiency in the eightieth percentile for civilians of his age range. Therapeutic nanos . . . "Damn, he's a NoNan."

Santana nodded. "He refused to accept his nano injection. The admitting nurse insisted, and Holmes fired him."

"Fired him? Can he do that?"

"No, Doctor. Chief Carver stepped in and explained that you have authority in all medical personnel decisions. But by the time that was settled, we were far behind on our passenger screening. The chief said we should deal with Holmes later."

I sighed. "And this is 'later.'" I tapped the CONTACT button on Anthony's file.

A few seconds later, the channel opened, showing a young blonde man with well-coiffed curls and an expensive smile. His face was on the heavy side of average, and his eyes were bright blue. "Hey, this is Anthony, what's up?" The voice was young, cheery, and didn't sound at all like a troublemaker. I hoped this was all just a misunderstanding.

"Mr. Holmes, this is Dr. Baldwin—"

Anthony interrupted me. I hate being interrupted, and it didn't make me any happier

when his cheer was replaced by an edge. "Doctor. I expected this call. I've made my decision, you're wasting your time."

I swore under my breath, remembering my bedside manner for difficult patients. Then I continued. "I respect that, Mr. Holmes, but they pay me to waste my time. Could you please visit my office after boosting, so that we can discuss your treatment options?"

"Treatment?" He laughed, and then he sneered. It turned his pleasant face into something uglier. "I don't *need* that 'treatment,' Doctor, I've done my research. And I'm busy after boost. We're holding a launch party. You're welcome to join us, but you're not going to change my mind."

I shook my head. "Mr. Holmes, I have to be on duty for any injuries that come up in boost. It would be a lot easier if you could come here."

"Sorry, Doc, I just don't have the time." And he clicked off.

Damn! Save me from self-educated "experts" who think they're doctors. . . .

But before I could get any angrier about Anthony, Chief Carver's face came on the shipwide comm. "Attention, all department heads: departure boost in fifteen minutes. Secure your areas. Departure boost in fifteen minutes. Level One boost alert."

Level One: not even a quarter *g,* just enough to correct our course and inject us into our cycler orbit to Mars. I had trained all the way to level five in the academy. You would think level one would be a breeze, but because no one took it seriously, ships usually had *more* injuries at level one due to loose objects that no one had secured.

But not on the *Aldrin!* When the boost horn sounded, I kept an eye on the med feed on my desk, watching for red lights indicating injuries, but the board stayed green. Aames's crew didn't leave loose ends.

For nine minutes, the big fusion engines burned. Between the spin and the boost, the "gravity" pushed toward the aft curve of the outer wall. Passengers were strapped in, but boost-certified crew could move around as duties required.

At the end of nine minutes, the boost horn sounded again, and Carver returned to the comm as the boost ended. "All hands, we're clear of boost. All personnel are free to move around. Next boost alert will be at Mars!" And he grinned and signed off.

I checked the medical board again: still greens across the desktop. I flipped to my office status view. Everything was fully stocked, we had no patients in the infirmary, and all our paperwork was up-to-date.

I was still steamed, but I had a job to do, and no matter how I searched, I could find no excuse to delay any longer. So I headed to the passenger lounge and to Mr. Holmes's party.

It was easy to find Anthony in the lounge. The kid was heir to several billions, no matter what currency you measured in, and that much money generates its own gravitational field, drawing in a crowd of sycophants and a ring of nervous corporate bodyguards. I pitied the guards: No one could miss them in those ochre uniforms. I was glad we wore the grays of the Space Corps instead of those awful things. The kid and his crowd were a marked contrast to all of us: They wore a wide range of civilian attire. The kid himself was in a blue silk shirt and darker blue slacks, both designer fashions. That outfit probably cost more than I would make that month.

I had to show my ID for scanning before the guards would let me within sight of Anthony, and they wouldn't let me any closer until they confirmed with him. A guard went over, whispered in his ear, and pointed at me. Anthony nodded and waved me over.

I stood beside him, and he said, "Have a seat, Doc." I looked around his table but saw no place to sit. A crowd of passengers, young men and women bound for the Mars mission, occupied every seat. I just looked pointedly at them, and Anthony added, "Folks, can you give me a minute to consult with my doctor?" The passengers quickly stood and made room, and I sat down. Anthony gestured to one of the guards, a tall, bald, dark-skinned man with a serious look. "Chuks, get the lady a drink."

The guard scowled—at Anthony, not at me—and I shook my head. "I'm on duty."

Anthony laughed. "Doctor, it's all right. Dad won't mind."

I frowned and narrowed my brows. "I don't answer to your 'Dad,' Mr. Holmes. The Corps rules are very clear. Now please, this is not a social call. I'm very concerned. You're at risk

for muscle and bone loss, and also for low-level radiation effects. These are easy to avoid, but we really need to set up an appointment for your therapy nanos."

He picked up his glass and took a long drink. The glazed look in those blue eyes told me it wasn't his first. "Sorry to waste your time, Doc. Not gonna happen."

My voice was chill. "My name is Dr. Baldwin." Then I remembered that getting angry would make things worse, so I aimed for a lighter tone. "Let me assure you, the therapy is perfectly safe."

Anthony slammed down his glass, displaying his lack of space reflexes: The drink in the glass lagged behind, then splashed to the bottom and splattered out all over him and the table. "Shit!" Anthony said. From nowhere, another guard appeared with a napkin and started sopping up the mess. Ignoring the guard, Anthony continued, "Safe? I've read the NoNan reports, doctor. Your 'therapy nanos' are associated with higher incidences of rheumatoid arthritis, schizophrenia, insomnia, peripheral neuropathy. . . ." He continued with the usual litany of unconnected symptoms, ticking them off on his fingers. He covered every one I had ever heard of, plus a few new ones.

I knew better than to interrupt a NoNan zealot in mid-zeal; so though I wanted to tell him what an idiot he was, I let him ramble on until he ran out. Then, in my calmest, most reasonable voice, I responded. "Mr. Holmes, those 'reports' are pseudoscience promoted by celebrities trying to stay relevant and entertainment 'doctors' who know more about audience ratings than medical research. The NoNan literature has been discredited by every scientist who has reviewed it. I can assure you that the reputable studies do not show any significant correlation between therapy nanos and any of those symptoms."

Anthony shook his head. "'Studies' funded by the companies that manufacture nanos. What's your cut, Doc? How much do you get for jabbing me?"

He grinned as he said that, but he was pushing my limits. "Mr. Holmes, take your accusations and shove them. If you want a painful death, don't let me stop you."

I stood and started to leave, but he grabbed my arm to stop me. "Doc, relax."

My vision started to go red, and I felt my temple throbbing. I yanked my arm away and raised my voice so the whole room could hear. "Keep your hands to yourself, asshole, if you don't want them broken. Boss's brat or no." Anthony let go, but the dark-skinned bodyguard moved to stop me. He was a head taller than me and in very good shape, but I fixed him with the glare I had learned to use on hospital lawyers. "Out of my way, or I'll see you in the infirmary." He stepped aside, and I stormed out for my office.

But I didn't get far down the corridor before I heard a deep voice calling. "Dr. Baldwin."

Still too pissed to stop or turn back, I kept marching. I heard feet hurrying behind me, and I tensed, expecting someone to grab me and try to stop me. *Relax, Connie, you'll take their head off.*

But my pursuer was smarter than that. Faster than I could follow, a flash of ochre swept past me, climbing halfway up the wall. In one smooth motion and without ever touching me, the tall guard had leapt in front of me. Despite his bit of acrobatics, he wasn't even breathing hard. He stood there, full of wiry energy, and that ochre uniform wasn't the least mussed. He *almost* made that color look good. Almost.

The guard held out a hand to stop me. "Doctor, please wait."

"I'm sorry. Mr. Chuks, is it?"

He straightened and smiled. "Major Adika, Chukwunwike Adika. Only my friends call me 'Chuks.'" He had a nice smile; but then it fell. "And over-privileged billionaire's sons. I have the . . . privilege of leading young Mr. Holmes's security detail."

I rolled my eyes. "I'm *really* sorry, Major Adika. You'll notice *he* grabbed *me*. I never laid a finger on him. I lost my temper, but I'm not a threat to Mr. Holmes." *As long as he keeps his hands to himself…*

The major nodded. "We had scanned you for weapons. Our bio-scans had read your heart rate and blood pressure, and our thermal sensors showed no significant increase in activity in your limbic system, so we judged you as non-threatening." And then the major's smile returned. "But if in your anger you had slapped the young mister, we might not have noticed, officially. Some of us believe that the

young mister gets away with too much because people want something from him. And his father, the brilliant businessman, has a blind spot where his son is involved." Then the smile turned to a broad, likable grin. "Should I ever choose to resign in style, I might slap him myself."

I had prepared for another confrontation. My pulse had been racing. But the major's humor relaxed me. There was a lot more to this man than muscle. "Thank you, Major. That . . . helps. Did you follow me just to apologize?"

"It is not right for a professional woman such as yourself to be treated so. An apology was required." His voice had a hint of an accent, and his word choice was rather formal. I suspected English was not his first language. "But no, that was only part of my reason. What you said, Doctor . . . is Mr. Holmes really at risk?"

I nodded. "You've had your therapy nanos. Were they explained to you?"

"Doctor, I and my team were selected for this detail because we all have space experience. Mr. Holmes senior wants us ready for any risk to his son. We all have been briefed on therapy nanos. But young Mr. Holmes's sources—"

"—are a bunch of quacks and kooks and attention-seekers who might get him killed. They play off the public's lack of knowledge to inflame ridiculous fears. Those fears are harmless on Earth; but here and on Mars, therapy nanos are his best defense against a number of general metabolic ailments. I can't guarantee those will be fatal, but the risks are high. Unacceptably high, in my medical opinion. He risks decreased bone density and muscle tissue loss due to the low gravity, and cumulative effects of low-level cosmic radiation in open space. He'll survive, probably, but he risks painful, permanent injuries. And death can't be ruled out. Angry as he made me, I still can't put him through that without a fight."

The major added, "And if he gets injured or sick, you will have to put up with him in your infirmary." I laughed at that, and the last of my tension slipped away. He laughed as well—a good, deep, hearty laugh—and then continued. "Doctor, if you tell me his life is at stake, I will sit on young Mr. Holmes while you give him the injections." The major's grin grew. "I might even enjoy it."

I grinned back. The major should've been a doctor. He had a talent for putting people at ease.

But then I shook my head. "I'm sorry, I wish I could, but regulations and my code of ethics forbid me from performing invasive therapy on an informed, competent patient who refuses it. His behavior aside, Holmes is competent . . . legally."

His grin turned down, and his face turned solemn, every muscle standing out in frustration. "Then I do not know what to do, Doctor. You cannot treat him and I cannot protect him if he refuses to allow it."

By then I had decided how *I* would deal with the problem: I would pass the buck. It was a corporate political problem as much as a medical problem. "Let's let the captain deal with this. Perhaps he can persuade Holmes senior, and then Holmes senior can persuade junior."

The major looked doubtful. "No one has persuaded young Mr. Holmes against his will in years." But I didn't see any other option, so I tapped the captain's icon on my comm.

Captain Aames's face appeared on the comm screen in my sleeve. He still had that casual air, almost—almost *slovenly* in contrast to the alert bearing of Major Adika. But Rank Hath Its Privileges. If the captain wanted to be casual, it was his command.

His tone, however, was just as sharp as I remembered. "Dr. Baldwin, I hear you had an altercation in the passenger lounge. Do I need to rule that off limits to you? Do I have to worry that you'll assault someone again? Or can you behave as a respectable officer of this ship?"

"Captain, I don't know what you've heard, but—"

"What I *don't* need to hear, Doctor, are excuses. I have three complaints from Anthony Holmes: two about your behavior and one about his missing security chief. I don't need trouble with the boss right at this moment, nor with his son. Can you skip the excuses and explain yourself?"

So I explained everything that had happened. Occasionally I looked up at Major Adika for confirmation, and each time he was watching me carefully and nodding as I went. His intense stare unnerved me even more than the captain's glare.

I was careful not to gloss over anything, avoiding anything that might sound like an excuse, but when I was done, the captain snapped, "Is that it?"

"Yes, sir."

Then the captain leaned in toward the camera and raised his voice a notch. "And you chose to discuss a patient's private medical matters over *an open comm* in the middle of *a public corridor* where *anyone could overhear?* Do you know how much trouble Anthony could make with a breach of privacy claim? Why didn't you come to me in person?"

I clenched my fists, out of view of the camera, but not of Major Adika. He waved both hands palms down in a calming gesture, and that gave me just enough control to keep going. "Captain, you said you never wanted to see me on your bridge."

Captain Aames looked upward and snorted. "I'm not *on* the bridge, doctor. I'm quite certain my schedule is posted, and it shows me in my office right now. Did you even bother to check my schedule?"

I swallowed my reply, because I knew he had me. "No, Captain, I did not."

Then Captain Aames surprised me with his answer. "That's better, Doctor. The facts. Don't pretty them up, and damn sure don't cover them up, and things will go much better here."

I was confused: Ready to fight, and suddenly the fight was gone. Just like with Major Adika. Was I too defensive? Was I *looking* for trouble?

I would have to think on that later, but right now, I seemed to have calmed the captain, and I wanted to build on that. "Understood, Captain. I'll head to your office immediately."

"No," the captain waved that idea away, "it's too late for that. If privacy has been breached, it's done already. No . . . I think I'll need to clear this up in person, so as not to further antagonize the boss's son. Wait for me outside the lounge, Doctor."

By the time Captain Aames reached the passenger lounge, Major Adika had gone back in. The captain didn't say a word to me; he just nodded and entered the lounge. On the doorstep he looked back at me for a moment and waved his head: *Follow me.*

So I followed. The captain strode directly up to Major Adika, held out his badge for scanning, and held his arms away from his side. Again I noted the contrast: The major was coiled energy, watching for trouble and ready to spring, while the captain was casual. Yet the captain was every bit as confident, and his eyes swept the room in the same fashion.

I noticed the major's aide subtly scanning for weapons as the major rescanned my badge. When the aide nodded, Major Adika let us approach the table. Again, all of the chairs were occupied by hangers-on, but Captain Aames cleared his throat and stared down at them, and they couldn't meet his stare. They quickly slipped away, and the captain sat across from Anthony. I joined them, caught uncomfortably between two men each of whom had already pissed me off once that day. I could feel my anxiety mounting, and with it my temper.

Then a subtle movement caught my attention from across the table: Major Adika moved to stand near the table, just outside of the circle of conversation but close by if there was any trouble. He stood poised in the low gravity, as if ready to spring, but with his arms lightly crossed in front of himself. He caught my eye and gave me a barely noticeable smile, and just like that, my anxiety blew away on the wind.

The table now held the remnants of a plate of nachos and soy cheese. The table had damp streaks as if it had been wiped clean at least once, indicating one or more spilled drinks. Anthony had had a few more drinks since I had left, and he was showing the signs. His body mass let him absorb a fair amount of alcohol, but his head was weaving, and his hands were unsteady. He looked at Captain Aames, startled as if he hadn't noticed our arrival. "Nick! Hey, how's things on the bridge, Cap? Chuks, we need more drinks here!"

Major Adika didn't move, and Anthony didn't notice. He didn't have time: Captain Aames took control of the conversation. "Mr. Holmes, I understand there was an unfortunate incident between you and Dr. Baldwin earlier."

Then Anthony finally noticed me. "Oh, hey, Doc . . . 'sno hard feelings, right? Get the Doc a drink, somebody! Look, Nick, it's no big deal."

Anthony had a drink in his right hand and waved it around, gesturing with it as if making a point. "The Doc just got a little . . . you know . . . hot. She's used to ordering patients around, and I don't take orders."

"I understand, Mr. Holmes. The doctor just didn't realize how strongly you hold to your NoNan views."

I began to get annoyed all over again. What happened to Nick Aames, the Terror of the Spaceways? Here he was, coddling the boss's son just like all of the other ass-kissers. Aames could learn a thing or two from Major Adika!

And Anthony was lapping it up. "That's right, NoNan!" He raised his voice. "NoNan, everybody! Say it with me! No! Nanos!" And just as he commanded, many in the crowd joined in as Anthony stood. "No! Nanos! No! Nanos! NONAN!!!!!" Anthony waved his drink around, spilling it, and I barely dodged the alcohol.

The room broke out in scattered applause, and Anthony bowed and sat. As the applause died down, he waved his empty glass at the captain. "No nanos, Nick. I'm keeping my body pure. And that's final."

The captain nodded and spoke calmly. "I understand. Dr. Baldwin has explained the risks if you decline therapeutic nanos?" I tried to answer, but the captain held up a hand. "Let him answer, please, Doctor. For the record."

Anthony stared into space. "She didn't, but . . . Ummm . . . That nurse guy, Floyd—"

"Carl Lloyd," the captain corrected.

"Yeah, Lloyd. He read off all the risks, all the usual nano company lies. I've heard them all before."

"So you were informed of the risks, and you're declining treatment. For the record," the captain repeated.

"Yes, and yes."

"So noted." The captain tapped a button on his comm, and Holmes's statement was recorded. That was it? That would get him and me off the hook legally, but it wouldn't do a thing about the risks.

But the captain wasn't done. "And now I think an apology is in order."

My jaw dropped. *No!* I couldn't swallow that much pride. No way would I apologize to that young punk, even if it meant my job.

Before I could object, Anthony blinked twice and then responded. "It's all right, Nick. The Doc meant well. She doesn't have to apologize. We're good, right, Doc?"

I was ready to shout that we were not at all good, but before I could, Captain Aames raised his voice and said, "You've made a mistake, Mr. Holmes." He looked down at his comm. "It's you who are going to apologize to Dr. Baldwin for manhandling her, a professional and one of *my* officers. You're also going to apologize for your slanderous accusations."

"What?" Anthony leaned over the table. "You forget who you're talking to. You're outa line, Nick."

And before anyone knew what was happening, the captain reached out and swiftly slapped Anthony across the face. "That's 'Captain Aames' to you, kid."

Everything happened at once. The room grew silent at the slap, so everyone heard the captain. The guards moved toward our table, but Major Adika held up one hand, and they stepped back. I noticed a very slight grin on the major's face.

Anthony rubbed his jaw. "What—Nick—" The captain raised his hand again, so Anthony corrected himself. "What do you think you're doing, Captain? Who do you think is in charge here?"

The captain checked his comm again, and then he pushed a file to the major's comm. "As of two minutes ago, *I* am. We just passed Earth's gravipause."

Anthony tried to focus. "Earth's what?"

"If you actually *belonged* in space, you would know that the gravipause is that point where the Sun's gravitational pull exceeds Earth's and Luna's combined gravity."

Anthony acted like he understood, but I doubted anything had penetrated all that alcohol. "That's . . . interesting . . . but it's still no excuse to be insolent!"

"You damn bet it's an excuse! According to my contract with your father's corporation, once the Sun's pull takes over, I have plenary power here. I can do whatever I, *in my sole judgment,* decide is necessary for the safety of my passengers and crew, and for the safe completion of our mission. I can dispense orders, regulations, and discipline as I see fit."

Major Adika nodded. "He's correct, Mr. Holmes. This contract is very clear. He can't

have you flogged or keelhauled, he can't violate your fundamental rights, but he has practically the powers of an old British sea captain when it comes to the smooth operation of this ship."

Captain Aames glared at Anthony. "And smooth operation requires proper respect for my officers and crew while in performance of their duties. You will apologize to Dr. Baldwin. Now."

Anthony scowled. "I will not!"

As quick as before, Nick reached out and slapped Anthony again. Then he lowered his voice so that only the three of us could hear. "If you make me slap you again, kid, I'll pull your pants down to do it, in front of all your adoring fans. Now: apologize to the doctor. Make sure everybody hears it." Then he sat back and waited.

Anthony stared, a mix of emotions struggling in his face: defiance, fear, anger, and shock. I might've felt sorry for him, if he hadn't pissed me off in the first place. Finally, he leaned back in his chair, looked around the room, and raised his voice. "I am . . . sorry . . . Dr. Baldwin. It was disrespectful to accuse you of taking money from the nano companies. And I . . . was wrong to grab you like I did. That was no way to treat an officer of this ship." He paused, looking down at his empty glass. Then, even louder, he added, "What are you all looking at? This is supposed to be a party! Bartender, a round for the house!"

The noise picked back up again, though it sounded bit forced. Under the rattle of glasses and the buzz of conversation, Anthony added, "Happy now, *Captain* Aames?"

The captain ignored the scorn, but he laughed, haltingly. "Kid, your entire fortune couldn't make me *happy*. But for now, I'm satisfied with your apology."

Anthony was surly, and he didn't try to hide it. "I suppose now you're going to force me to take therapy nanos."

Captain Aames shook his head. "No, that would be a clear violation of your fundamental rights. I can't force you to accept invasive therapy against your will. But I can take other measures for your own protection. Dr. Baldwin!"

I sat up straighter. "Yes, Captain."

"Doctor, what was the preventive therapy for musculoskeletal loss and incidental radiation exposure *before* we perfected therapy nanos?"

"Captain, it involved tripling the recommended exercise regimen. That provides sufficient muscle growth and bone development to counter the losses; and a good, healthy, active metabolism can repair most low-level radiation damage. Assuming he stays healthy otherwise."

"I see. And has the kid even started the standard regimen?"

I checked Anthony's chart. "Not yet, Captain. Of course, it's still early in the day."

"Nonsense, Doctor. Never too early for exercise." The captain stood. "On your feet, kid!"

"Fuck off!" Anthony tapped his comm, but then he looked puzzled. He stabbed with his finger, but still nothing happened. "Hey! Why can't I call Dad?"

The captain replied, "I cut off your outbound communications."

"You can't do that! You can't violate my rights!"

"I can't *violate* them; but in the interests of ship operations, I can regulate and restrict them. We only have so much communications bandwidth, so I have to meter it. You will get *one* fifteen-minute call, once per day. Your slot is *after* your workout. Now *on your feet."* And with that, Captain Aames reached down, grabbed that expensive blue shirt, twisted it into a knot, and easily lifted Anthony in the low gravity. He set the young man down on his feet, looked him over, and sneered. "Drunk. Flabby. Out of shape. We'll have to do something about that. Kid, the running track is one ring up, but you can start running *now*. Get up there and give me some laps!"

Anthony looked indignant. "I'll be your boss some day!"

"Only if I can keep you alive that long. Now move!" The captain raised his hand again, and Anthony flinched. Then he stumbled through the crowd. Major Adika moved ahead of him, clearing a path, and Anthony ran to the door.

"That's a start," the captain called after him. "But faster!" He turned to me. "Doctor, shouldn't you be supervising his therapy?"

"Yes, Captain." I didn't see why I needed to watch the kid run, but I wasn't ready to cross Captain Aames. I got up and headed to the door just in time to see Anthony bolt

antispinward, toward his cabin, but the major grabbed his arm, spun him around, and shoved him spinward toward the ramp to the upper ring. Adika grinned as they passed me.

I started jogging as well, but I had gone only a few meters when a bit of gray appeared in my peripheral vision. Turning my head slightly, I saw Captain Aames jogging beside me. "Best you can do?" he asked.

And then he pulled ahead of me, rushing to pass the major and catch Anthony. He prodded the kid all the way up the ramp and onto the big running track. The track was a third of a kilometer, completely circling the upper ring. By the time I reached the top of the ramp, the captain and Anthony were out of sight around the curve, but I could still see Major Adika, so I rushed to catch up with him. Then we both picked up speed until we were up with the captain and the kid. The captain had thrown off his uniform jacket somewhere, and his shirt showed sweat stains. I decided he was smart, so I threw off mine as well.

The captain set a reasonable pace, especially in one-quarter *g,* but Anthony soon showed signs of fatigue. That only made Captain Aames more persistent. "Slacker! Are you *that* soft, kid?" He cajoled and taunted to keep Anthony moving.

Sometimes the captain moved ahead and jogged backward, keeping right in the kid's face as he tossed out casual insults. "Your problem is you can't pay someone to run for you. Do you ever do *anything* on your own?" *That* spurred the kid onward, though he didn't have breath to respond.

After fifteen loops, I slowed down. I was in okay shape, but I didn't run much. The major dropped back with me, though I'm sure that was just courtesy: He didn't show any signs of strain. Anthony attempted to slow down as well, but instead the captain pushed him even harder. Soon they were out of sight again, and I enjoyed my leisurely run with Adika.

Not long after that, the captain and Anthony passed us. A little later, they passed us again, moving faster this time. The kid was looking pale, and I raised my hand for the captain's attention, but he pointedly ignored me. It gave me some comfort to see that the captain's shirt was drenched with sweat. He wasn't a machine after all.

Halfway around the ring, we had to dodge around a mess on the track. I smelled stomach acid, and I saw bits of undigested soy cheese in the mess.

The next time around, the captain and Anthony had finally stopped. Aames stood and supervised as Anthony, shirtless, sopped up the vomit with an expensive blue silk rag. The captain called "Halt!" and Adika and I came to a stop. Anthony looked up from his work, panting, and glared at Aames. The captain returned the glare and then turned to me. "Doctor."

I recognized the command in his tone, so I dropped to my knees, grabbed Anthony's wrist, and felt for a pulse: 180, high but not dangerously so for his age and health. His respiration was labored, but already it was slowing. I leaned my ear to his chest. His heart sounded busy, but good. I didn't have my bag, so I couldn't check BP or electrolyte balance, hardly any of my routine checks, but I had enough data to give a preliminary answer. "He's fine, Captain. He'll feel it tomorrow, but he's fine."

"You bet he'll feel it." The captain paused for breath. "Major Adika?"

The major snapped to attention, his broad chest rising and falling steadily in that damp ochre shirt. "Yes, Captain."

"Major, this has been fun, but I can't spare this much time day after day, even for the health of the kid. He needs three runs per day, Doctor?" I nodded. "Since he's such an *important* kid, I can take time to run with him third watch every day. Major, can you handle first watch?"

Major Adika nodded. "Yes, Captain."

The captain turned back to me. "Doctor, this is therapy, so we need medical supervision. I need you to take the second watch run."

"Yes, Captain. I'll need to trade watches with Dr. Santana."

"Don't bother me with details, Doctor, just do your job." He held down a hand to Anthony, but the kid ignored it. The captain snapped his fingers twice, and finally Anthony got the message. He took the hand, and the captain pulled him to his feet. "So, kid, that'll be your routine from here to Mars: a half hour run, once each watch. Except fourth watch, we'll let you sleep through that one. You'll

need it. Doctor, should that be a sufficient substitute for therapy nanos?"

I smiled and nodded. "It should, Captain."

The captain continued, again looking at Anthony. "Three top officers watching out for your health. That's how important you are. Does that sound good, kid? Or would you like to get those injections now?"

Anthony couldn't stand straight, but he lifted his head enough to glare at the captain. "No, *Captain."* And without another word, he staggered down the ramp to the main ring. Major Adika ambled after him. Aside from the sweaty shirt, you might never have known that the major had had a workout.

I waited until they were out of sight down the ramp, and then I spoke up. "Captain, you know he's going to call his father immediately."

The captain turned and stared at me. "Did I ask for observations, Doctor?"

"No, Captain."

"Good!" My eyes widened. "Don't look so shocked, Doctor. I expect you to bring things to my attention when you think they're important. You can expect me to chew you out when I think you're wasting my time. And I expect you to push back because you know you're right. I expect you to fight me until we know what the facts are. I don't need a bunch of yes-men for officers, I need the whistleblower who gave up her career because she knew she was right. That's who I hired, is that who I got?"

"Yes, Captain."

"That sounds rather timid to me, Doctor. Are you ready to fight me when I'm wrong?"

"YES, CAPTAIN!"

"That's better." And then the captain surprised me: For just a fraction of a second, he smiled. "You're right, Doctor, he'll call Anton Holmes. Not immediately, he's too exhausted. But eventually. And then Anton will call me. And then . . . I don't think the kid will like the outcome."

"Understood, Captain. But might I ask one favor?"

"Spit it out, Doctor."

"Captain, I would dearly like to listen in on that call from Anton Holmes."

Again, just the hint of a smile. "Doctor, it would be my pleasure. Besides, I may need the kid's physician to back me up."

* * *

When the time came, I wasn't the only one waiting for the call. Major Adika joined us. The captain's office was decorated all in tasteful dark shades: black walls, big black desk with a touch-display surface, dark gray carpet, and brushed metal accents. The navy blue chair provided a spot of color that drew attention to its occupant. It was such a relief from the ochre throughout the ship, I felt the urge to hide there through my entire tour. But that would've meant hiding out with Captain Aames, and despite our new détente, I wasn't ready for that. He still struck me as volatile and demanding, and I didn't need that kind of stress all day long. I didn't know how Chief Carver could handle it.

Behind the captain, a massive window showed Earth and Luna slowly spinning past, over six light-seconds away. I stared at the dwindling planets, and I thought about escape: All my past mistakes, all the wreckage that had been my career, it was all just a microscopic point on that little blue dot in the distance. I might make all new mistakes here on the *Aldrin,* but this really was a second chance for me. I was determined to make this work.

My thoughts were interrupted by a chime from the desk. A beat-up old e-reader sat in the middle of the desk. Captain Aames slid it to the side, and then he waved us to stand behind him. He tapped the surface, and a woman's face appeared in a window in the center of the glass. She said, "Incoming call from Anton Holmes, Captain."

Aames nodded at the desk. "Put him through, Miles." The woman's window moved aside, and another window appeared, showing an older man who was recognizably a relative of Anthony Holmes. The hair was the same dark blonde, but short and bushy and with many gray bristles. The face was thinner, harder, and more serious, but the bone structure was the same, and he had the same intense blue eyes. Those eyes were narrowed at the screen, though he probably couldn't see us yet.

"Mr. Anton Holmes," Miles said, "Captain Aames can speak to you now. Please remember that the light-speed delay is six seconds one way, twelve seconds round trip. Mr. Holmes, please begin." Experienced interplanetary hands can speak in parallel, each

person making points while listening to older points as they arrived, but for most people, it was simpler to wait for each statement, and for one party to control the discussion until passing control to the other. Miles had just given Anton Holmes control, so we had a twelve-second wait for him to begin.

The woman disappeared, replaced with the view from the captain's camera, a narrow focus that showed only him, not the major and me. After a pause, Holmes spoke. "So, Nick, I understand you had a problem with my son."

The captain responded. "Your son was drunk before we reached the gravipause. He grabbed my doctor. He's lucky she didn't belt him! She has a history, you know." He looked up at me, eyebrows raised as if daring me to protest.

Twelve seconds later, Holmes rolled his eyes. "I think you're making a big deal out of nothing. Can't we just start over, pretend this never happened?"

Aames nodded. "We can start over . . . with a new captain, and with you fulfilling the cancellation clause in our contract. That would be five years' salary, payable immediately, plus a commission on each trip for that period. Would you like to invoke that clause?" He paused, but not long enough for Holmes to take control. "But wait . . . There's no qualified captain aboard, and we can't turn back now. That would be a mess, wouldn't it?"

Twelve seconds later, Holmes was exasperated. "You can't be serious! You would quit over such a small matter as this?"

"No, but unless you fire me, I'm going to run this ship my way. And it's *not* a small matter. Do you still insist on sending Anthony to Mars?"

"Damn straight I do. This is a *Holmes* mission to Mars, and there's going to be a Holmes leading it!"

The captain sighed. "You forget, Anton, I've been to Mars. I know Mars. He's not ready to go there, and he's damn sure not ready to lead any mission."

"Oh, I know that." Holmes leaned into the camera and lowered his voice. "It's just symbolic for the media, and a notch for his résumé. He won't do anything but give speeches. It'll just be a quick down-and-back on a drop shuttle as you swing around for your slingshot. You can pick him up on your way back. Adika will keep an eye on him the whole way, and there won't be time for him to get into trouble. I may be too busy to go myself, but by damn, there's going to be Holmes footprints on Mars. That will be worth a lot of points on the stock market, and also in boardroom battles."

"I still think it's a stupid idea, but it's out of my hands once we reach the Mars gravipause. My only responsibility is to get him there safe and healthy. That's not going to happen if he suffers bone and muscle loss and radiation symptoms. Since he's being a stubborn ass about his therapy nanos, hyper-exercise is what my doctor prescribes. Isn't that right, Doctor?" And he widened the frame to show me and the major standing behind him.

"Yes, Captain," I answered. "This is the recommended non-nano therapy for a space traveler of his age and health."

Aames turned to the major. "And is young Mr. Holmes in any physical danger?"

Adika shook his head. "Mr. Holmes, I agree with Captain Aames: your son has no business on Mars, and our security team will be very busy keeping him alive. But here on the *Aldrin* with this exercise program, he is perfectly safe."

Aames continued. "So in the best expert opinion on site, this is in Anthony's own best interests. May I proceed? Or should I clean out my office?"

In the twelve seconds it took to respond, Holmes's glare intensified as he listened. Finally, he sighed, but he had a look of determination. Billionaires are accustomed to doing things their way. "All right, I'll talk to him. Are you satisfied, *Captain?"*

Aames smiled at the camera, but it wasn't a warm smile. It was almost predatory. "Quite satisfied, *boss*. Now is there anything else? Or can I go back to running my ship?"

"No, nothing else. Get to it." And just like that, the image cut out.

"He's a busy man," the captain said, swiveling his chair to face the major and me. "That conversation probably cost fifty-thousand dollars of his time, plus bandwidth charges. We should feel privileged. Do you feel privileged?" Before we could answer, he continued. "So, Doctor, Major, we proceed according to plan." Then Aames grinned at the major, showing

real warmth for the first time that I had seen. "Just like Luna, eh, Chuks?"

Major Adika grinned back. "Just like Luna, Nick, except this time we are on the other end of the stick. I believe Sergeant Fontes would laugh to see us now."

"No, thank you," the captain answered, "I heard enough of his laughter in basic." For a moment he stared out the window, back at Earth and Luna. Then he turned back to his desk. "Let's hope our 'recruit' is no more difficult than we were, eh?"

Adika shook his head. "He is not difficult, but he will never be ready for a dangerous place like Mars."

The captain nodded. "That's why he has you watching over him. He couldn't be safer. But enough of this. I have work to do, and so do both of you. If you don't, I'll find some. Get out of here."

So we left his office, returning to the world of awful ochre in Carver's office, the gateway to the captain's sanctuary. Chief Carver was on the bridge, so we were alone, but I waited until we were safely out of Carver's outer office and in the corridor before I turned to Major Adika. "You said only friends call you 'Chuks.' I take it you know Captain Aames?"

Major Adika smiled again. I could get used to that smile. "Doctor, we have a saying: 'Space is vast, but the Space Corps is not.' If you stay in the Corps long enough, you will be amazed at how many people you will meet. You could not possibly remember them all; but one does not forget Nick Aames. Though many would like to." And he laughed.

I could get used to that, too.

The next day, when it was time for my run with Anthony, I tracked him down in the lounge again. I expected the bodyguards to let me pass, since they had already screened me twice the day before, but they were more professional than that. They were cordial and courteous—and the major even gave me one of those big smiles—but they scanned me as thoroughly as they had the first time. Then they let me through.

Anthony was sitting at the same table, but alone this time. A few passengers waved at him as they passed by, but none sat down. As they walked past me, I heard muted giggles and comments under their breath, including the word "brat."

I sat down at the table. Anthony stared down at a glass of what looked like tomato juice. Without asking, I picked it up. "Hey!" he objected, reaching for the glass.

But I pulled the glass away. "Doctor's orders. I need to know what you're drinking." I took a sip. It *was* tomato juice, reconstituted, without any hint of vodka. I set the glass back down. "Good choice."

Anthony took the glass and stared into it again, slumping in his chair. I sat down next to him, took his wrist, and started checking his vitals. He was silent and sullen as I worked. He had some pallor, nothing bad, but he looked like he had been kicked around. I guess he had, in a way. Despite myself, I started to feel almost sorry for him. Sorry enough to fudge the truth a bit. "It seems your pulse is a little erratic, Mr. Holmes. I'll sign a doctor's slip excusing you from this afternoon's run, if you'd like."

Anthony shook his head. "No." And then I saw something of his father in him, the same steel behind the blue eyes. He drank the rest of the tomato juice, set down his glass, and rose. "Let's go." He led the way to upper ring, and a guard trailed us, taking a position at the top of the ramp. We started running, and as we ran, I saw another guard at the top of each of the four ramps. We had the ring to ourselves.

Anthony took off at a very fast pace, much too fast to maintain for a half hour even in our gravity. I rushed to catch up with him, but when I did, he put on more speed. I had to run all out to catch him again.

Anthony kept going as fast as he could for as long as he could, barreling forward as if Captain Aames were still chasing him—or something worse. I could see he was getting tired and sloppy, and I worried he might hurt himself.

Eventually, he slowed down. I was relieved, because I couldn't keep up that pace much longer. But though he slowed, he remained at a running pace, not a jog. Whatever reserves he had wouldn't last long.

When I saw Anthony's face getting red, I called out, "Enough." I halted, but he kept going. "Stop!" I shouted. This time he stopped, and I walked forward to check him over, a

guard running up as I did. The guard, a tall Asian woman, paid no attention to me. Like me, she was worried about Anthony.

His heart rate, respiration, and temperature were all dangerously high. "That's enough, Mr. Holmes. Don't make me get rough. You've got to pace yourself, or you're going to make yourself ill, maybe injure yourself."

Anthony leaned against a wall, head resting on his arms. The guard put a hand on his shoulder, but he shook it off. "Leave me alone . . ." he panted. "I . . . can do this . . ."

"You can't do anything if you keep this up. Don't argue with your doctor."

But Anthony shook his head. "He . . . thinks . . . I can't do this . . ."

"Captain Aames?" I looked around as if the captain might be listening. "That man's a closed one, Mr. Holmes. Don't assume you know what he's thinking. He's manipulative, that might be exactly what he wants. If you try to out-think him, you'll only hurt your head."

"No . . . not Aames . . ."

"What, those people in the lounge? Is that what they were laughing about?"

Anthony glared at me. "Laughing . . . billionaire's son . . . getting what's coming to him . . ." His breathing was becoming more regular. "Phonies . . . but not the first. Always want something from me, but I see through them."

"Then why do you care what they think?"

Anthony straightened and snarled. "Not them, my Dad! He thinks . . . I can't do this. He thinks . . . I don't have to." His breathing was even, but now he hesitated for a different reason, choking back his emotions. "He thinks Aames is just . . . punishing me for . . . grabbing you." He swallowed. "Doctor, I'm so sorry. I was drunk, and I was completely out of line. It won't happen again."

"Damn straight it won't, next time I'll punch you for sure." But I smiled as I said it. "We can pretend it never happened, Mr. Holmes, if that will help with your father."

"Please, call me 'Anthony.' When people call me 'Mr. Holmes,' it usually means they want something."

"All right, Anthony. Call me—"

Anthony held up a hand. "I'll call you 'Doctor.' The captain wants me to respect his officers." He tried to smile, but it faded, and he shook his head again. "But it won't help with Dad, he just wants this over. He thinks I should just put up a show for a while, and Aames will get bored. He says . . . not even a week, just a few days. He says . . . he says, 'Put in a minimum for a few days, satisfy Aames. Even you can do that.' *Even you.*"

I turned away, and so did the guard. It looked like Anthony was about to cry, and we didn't want to make things worse for him. Looking toward the wall, I replied, "Anthony, you *can't* do this if you keep pushing this hard. You're on the edge of exhaustion. But you can, you *will* do this if you just build up. At your age and in your condition, you can keep this up all day, once you work up to it. But if you go trying to prove something to your dad, you're going to prove him right. If you want to prove him wrong, you're going to have to work smarter. Can you do that?"

"Yes, Doctor."

He sounded more in control, so I turned back to him. "We'll finish this half hour walking. You've already overexerted yourself this watch. Then I'll set up a pace schedule for you, building up gradually as you go; and you will stick to that pace no matter who tries to push you harder. Tell them it's doctor's orders. Understood?"

Anthony managed to smile at that. "Even Captain Aames?"

"You let me handle Captain Aames. Just concentrate on your workout plan, and you'll show him. And your dad."

"Yes, Doctor." And we started walking. And talking. And despite myself, I found myself coming to like him. Anthony drunk was obnoxious, but Anthony sober was a pretty nice kid.

Not that I would call Anthony a kid to his face, not like the captain did. I could see his pride was mostly a defense, and it could be easily battered. But he *was* a kid. Not chronologically—I had known twenty-year-old soldiers and EMTs and astronauts who were by no means kids—but in terms of experience. Poor Anthony at twenty had never had to do anything, not anything hard. Oh, he had been places, symbolic trips to half the world. He had been on aid missions as a front man for the Holmes Trust, and he had done symbolic spade work for the cameras; but it was never real, never anything he *had to* do because the job had to be done, and he was the only one to do it. It was all just tourism masquerading as effort. And this

Mars expedition was more of the same: Anton wanted to "expose" him to the world, but Anthony never even had to finish a job. As soon as the media attention drifted, Anton would whisk him back home while other people did the hard work. This one little thing, this ninety minutes of running every day, may have been the most sustained effort Anthony had ever put forth.

I had just dropped off to sleep that night when my comm chimed. I lay in bed, eyes closed, and called out. "Comm, answer. This is Dr. Baldwin, is anything wrong?"

Captain Aames's voice came through the comm, and my eyes snapped open in the darkness. "Baldwin, what the hell's up with changing my orders for Anthony Holmes?"

I was glad my comm camera was off so the captain couldn't see my face. "I changed *my* orders, Captain, because in *my* judgment he can't handle the way he was pushing himself. He's out of shape, he needs to work up to that pace. Otherwise he'll break down before he ever gets to Mars."

"Good! If that keeps him off Mars, that's better for everyone."

"What? I thought you were doing this to get him ready for Mars."

"Doctor, I'm not interested in getting him ready. I just want to test him and find his limits. And if those limits keep him off Mars, so be it. Let me test him!"

"Captain, he can do this. Give him a chance."

"You can give him a chance if you want, Doctor. Not my concern."

"But his health is my concern. This little game of yours isn't. My order stands. Comm off."

I pulled my covers over my head. It took nearly an hour for me to calm down enough to fall asleep.

Monitoring Anthony's progress was most of how I passed my time at first. Our work in the infirmary was light: periodic screenings, treatment of minor injuries, monitoring of health and nutrition, and lots of paperwork to send back to Earth. We were staffed to cover unexpected emergencies, which meant we had plenty of time to cover normal operations.

We were a week out from the gravipause when I came into the infirmary and found Dr. Santana with a patient: Major Adika. The major sat on an exam table, shirtless, as Santana ran a scanner over his shoulder. I couldn't help staring: Adika's muscles were even more impressive without the shirt; but more impressive yet were the scars.

Then I noticed the major smiling at me, and I realized that I was staring. "Excuse me, I have work to do." My face felt warm as I ducked into my office.

I found myself reading the same page of the same routine report for the third time and still not noticing what I read, when Dr. Santana came into my office. There was an odd smile on his face. "Dr. Baldwin, I think you should see this patient."

"What? Push me his chart. Is there something wrong?"

Santana's smile grew. "No, Doctor. I think *you* should see *him*. He asked for you. Personally."

I flushed again. "Oh. Thank you." I stood, felt my hair to see if it was out of place, and walked back into the infirmary.

Major Adika still sat on the exam table, still shirtless. I fought, but I kept my eyes on his face so as not to get flustered. "So, Major, what's the problem today?"

Then he smiled, and I got flustered despite my plan. "I think I have pulled a muscle in my shoulder."

Those muscles? I can't believe that! But I resisted saying that out loud. "How did this happen?"

"Oh, it was a foolish thing. I was sparring with the captain in the gymnasium, and he got the better of me with one of his *capoeira* moves. He sent me tumbling, and I grabbed a grip to stop myself; but I failed to account for the ship's spin, and I felt a pull. Or possibly a tear."

"I see. Well, Dr. Santana has already examined you, but let me take a look." I pulled out my scanner and ran it over his shoulder. As I did, I got a close-up look at those scars. One ran from his right clavicle almost to his spleen. Another crossed his left bicep like a tattoo. There were smaller scars all over his torso, including one circular red tear in his right deltoid that I was sure was from a bullet. "This isn't your first injury by any means, Major. You've lived a dangerous life."

"Mine is a dangerous profession, doctor."

"Are there a lot of attacks on Mr. Holmes?"

"No, but I have been a bodyguard only for a few years. Before that, I was in U.N. security, rapid response team. This job is a vacation after that."

"Uh-huh." I lowered the scanner. "Well, Major, you're correct: it's a muscle pull, nothing torn. I prescribe a few sessions of massage and some analgesic cream." I looked back in his face. "But I'm not sure why Dr. Santana couldn't have prescribed that."

Adika put his shirt back on, and the big grin came back. "But then I would be asking Dr. Santana if he is free for dinner tonight, not you. He is a very nice gentleman, but I would prefer your company, Doctor."

Again my face felt warm, but I kept my voice steady as I answered, "I would like that, Major."

"Please, call me 'Chuks.'"

After that, Chuks and I spent a lot of time together, as our duties allowed. I learned to appreciate his quiet humor, his enthusiasm for space, his dedication to duty, and his gentle strength. He was a good man, and comfortable to be with. He was proud of his homeland, Nigeria, and proud of his warrior heritage. Although he was powerful and skilled and capable of great violence, he saw restraint as the mark of the true warrior: violence was a tool he used to protect the weak and defend what he believed in, not an end in itself and not something that drove him. Knowing how hard it was to restrain my own temper sometimes, I was impressed with how well he had mastered his own. He could be passionate in his mission, but he was always in control.

I learned that incredible body of his, including the roadmap of scars that hinted at the violence in his past. These fascinated me from a clinical perspective: How had he suffered that cut in that spot? How had he survived a deep trauma like the long scar across his chest? Who had shot him in the back, and why? But he refused to talk about these past missions, preferring to leave his past buried. The only scar he commented on was in his calf: a nearly perfect impression of human teeth, both upper and lower jaws. When I asked about that, he laughed and said, "It was a performance review that got out of hand." But when I asked for details, he refused to say more.

But I didn't mind. I had secrets—I never explained how I had landed on the *Aldrin*—so I could hardly fault him for his own. These secrets only intrigued me more. The only real disagreement we had regarded Anthony: I was getting to like the kid and see potential in him, but Chuks kept cautioning me. "His enthusiasm never lasts, Constance." Normally, "Constance" bothered me. It was such a formal name, and it didn't feel right to me. I was just "Connie". But when Chuks said it, he imbued the name with a softness, a quality that made me feel special.

We sat in an observation room, curled together on a couch and staring out at the stars as they spun by. "You've known him longer, Chuks, but I just . . . I just see something there. I think he's changing." I didn't tell Chuks about Anthony's conversation and his determination to show his dad he could do this. That was private, not my secret to share. But after that, I believed in Anthony, and I wanted to support him. "And I don't think Captain Aames would push him like this if he didn't believe Anthony could do it."

Chuks shook his head. "You do not understand Nick Aames yet, Constance. He tests people, tests them to the breaking point. If they pass the test, he raises the bar. If they break, then he is satisfied, because he knows their limits."

I looked into his eyes. "I thought the captain was your friend."

"He is. But it is difficult being Nick's friend. He tests his friends, too. It is just what he does."

"Some friend." I frowned. "Well, maybe he doesn't believe in Anthony, but I do."

Chuks wrapped his arms tighter. "You are a good woman, Constance. Despite your temper." I glared at him, but then he smiled, and I did, too. "I just don't want you to be hurt when Mr. Holmes returns to form."

Over the next few weeks of running, my faith in Anthony grew as he shaped up well. Thanks to the exercise and a carefully selected diet, he quickly dropped his excess weight, and that made the running easier. Soon I was able to lift my limits and let him set his own pace. I was glad that *I* was getting a good

workout, too: It was the only way I could keep up with him.

As his body shaped up, so did his mood, and not just because he had more stamina. The passengers who had laughed at him soon forgot his embarrassment, but they didn't forget his power and influence. They began trying to curry favor again, but with his new confidence, Anthony also became more discerning. He was quick to cut out the obvious toadies and focus on the ones who were willing to treat him as just one of the crowd. And one way he selected his companions was by inviting them to run with him. The sycophants soon gave up on that, while those who stuck with it grew closer as they challenged each other to faster paces and longer runs. It wasn't long before I gave up on keeping up and concentrated on my own pace. Soon we had six regulars who joined us each day, four scientists and two bodyguards. We ran for a full hour, followed by dinner in the lounge, and they were *friends* to Anthony, perhaps the first true friends he had ever had.

And sometimes we had another companion: At least once a week, Captain Aames joined us, even though it wasn't his watch to run. Then I completely gave up on the race, and I just hung back and watched. The captain still pushed and still taunted, but Anthony found it easier and easier to keep up. The captain still won every race, but their times got faster every week.

On the days when the captain joined us, he also dined with us, and he even put dinner on his tab. I won't say he let his hair down, but he showed a shrewd appreciation for morale and unit cohesion. He sat with us, inquired as to experiments and preparations, and listened to jokes and stories; and then every week he stood and said, "Ladies and gentlemen, ship's duties call, and I must go. Let the real party begin." And after that, just as he said, the celebration started and the drinks were ordered. But Anthony never again drank like he had that first day, and he would stop if I commented, or even just gave him an odd glance. He was determined not to lose control again.

In the tenth week of racing, however, Captain Aames broke the routine. He stayed at the table long past his usual departure, and he signaled the waiter for a round of drinks. Anthony ordered his usual, the house beer, and slowly sipped it. The captain watched him, not judging, just watching. Finally he asked, "So kid, are you ready for those therapy nanos yet?"

Anthony almost spewed his beer. The captain had sucker-punched him there. Then he took a long drink. I suspected that was to give him time to think of his answer. Finally he set down the half-empty glass. "No, captain. I'm still not interested. I think Dr. Baldwin is doing a fine job of keeping me healthy *without* polluting my body with unnatural machines."

The captain almost smiled at that. "'Unnatural machines.' Ah, yes . . . Doctor, I completely forgot we had an expert on nanomachines here."

Anthony tightened his grip on his glass, but he kept control. "Not an expert, Captain, I've just done my research."

"Yes, yes, your research. I forgot. Don't be so modest, kid, it sounds like expertise to me. So tell me: what is the activation frequency of a salt-ion scavenger nano?"

Anthony hesitated a second. "I'm not sure, Captain. The . . . ummm . . . sound frequency—"

"Light frequency, kid," the captain interrupted. "Modern nanos are generally activated by specific spectral signatures. Try this one: what's the orbital period of Phobos?"

"Oh, I know this one!" Anthony was so eager to answer, he ignored the fact that this wasn't a nanotechnology question. "Approximately 7.7 hours."

"Approximately will get you dead in space, kid. Okay, back to nanos: how many generations of sintering nanos can you get out of a typical batch before they start to degrade?"

"I don't know, Captain. We have specialists on the mission to deal with that sort of issue."

"Specialists, yes," the captain nodded, "and what is your specialty, kid?" He let the question hang in the air for almost three seconds before turning to the rest of the runners. "Oh, that's unimportant right now, we have all of these experts with us. Isn't it fantastic that we have all these experts on this mission, Doctor? Savoy, what's your specialty?"

Laurence Savoy, a tall, shy Frenchman with dark, curly hair, blinked. He wasn't used to the

captain's attention. Finally he stammered, "Atmospheric chemistry, Captain."

Aames nodded. "And you, Meadors?"

Minnie Meadors, a tall blonde from Boston, was quicker with her answer. "Astronomy, captain. Seven hours, thirty-nine minutes, fourteen seconds."

"What? Oh, yes, Phobos. You must love the viewing from here."

"It's phenomenal, sir. A dream come true."

"Enjoy it, Meadors. It only gets better as we approach Mars. This is a chance most astronomers will never get. And you, Krause?"

Katherine Krause, a short, sturdy German woman, replied eagerly. "Geology, Captain. I'm counting the days to my first field survey."

"I look forward to your reports. And Martinez?"

Jerry Martinez, a medium-height, muscular Hispanic male, answered with a big smile. "Software Engineering, Captain." He pointed a finger around the table. "As soon as we land, they're all going to think up new requirements for their systems, things they never thought of before. Somebody has to reprogram all their gear to meet those new requirements."

"Excellent! You should talk to Chief Carver. He pulled out some software wizardry on our Mars mission." He paused. "Of course, a big factor in our survival was cross-training. Did I tell you about that, Doctor?"

I wondered where Aames was going with this, but I played along. "No, you didn't, Captain."

The captain nodded. "We lost some good personnel, but we had the essentials covered, thanks to cross-training. Say, does your mission have a cross-training plan?"

Meadors shook her head. "No, Captain, but that's an excellent idea. I'll bring it up with the mission planners."

Aames shook his head. "Don't bother. I already suggested it, fourteen months ago, but they rejected it. They said that was 'Old Space thinking,' and they have a New Space mission plan. But now . . . It seems like your people have a lot of leisure time." He slapped his leg. "That's it, I'm making an executive decision. You'll all start cross-training seminars for your team. And for my crew as well, since many of them hope for a Mars mission someday."

The runners stared at him, open-mouthed. Finally Martinez spoke up. "You're serious."

"Deadly serious, Martinez. Deadly. These will be seminar format, but with the sessions recorded so crew on other shifts can follow along. I'll expect each of you to organize the seminars for your field and to present me syllabi and progress reports to review. Martinez, you can start with software engineering on Mondays. Everyone should know more about programming and how to communicate with programmers. Meadors, you'll do astronomy on Tuesdays, Krause and geology on Wednesdays, and Savoy and atmospheric chemistry on Thursdays. I'm sure I can talk Major Adika into teaching Martian survival on Saturdays, and we can all take a break on Sundays."

Anthony looked at the captain and swallowed. "And Fridays?" But I was sure he already knew the answer.

Aames stared right back at him, but those blue eyes didn't flinch. "On Fridays, you're going to teach us everything there is to know about nanotechnology. And when we have questions, you'll find the answers and teach us those. And repeat, and repeat, until we're all as expert in the subject as you are." And then he leaned in, almost into Anthony's face. "Unless you think you can't do it, kid?"

Anthony held the captain's gaze, and he kept his voice low and level. "I can do it. Captain."

"Good! That's what I like to hear! Doctor, if the kid needs any help, see to it that he has supplemental reading. Oh, and kid, I expect you to be an active participant in *all* of these seminars. Can you do that?"

This time there was steel in Anthony's voice. "Yes. Sir."

Aames leaned back. "Good, good!" He looked around the table. "That goes for all of you. If this is going to work, I need you to set examples for the rest of your team." At last his gaze returned to Anthony. "I expect you to be *leaders,* not spectators. For the good of the mission." Then he placed his palms on the table and stood, and just like any other week, he said, "Ladies and gentlemen, ship's duties call, and I must go. Let the real party begin." And he left.

As soon as the captain was gone, Anthony drained the rest of his beer. Then he stood to leave as well.

I was worried. The captain was pushing too hard, and this was completely out of nowhere. I was afraid all the work we had done might be lost in this one blundering move by that—by that tyrant, Nick Aames.

I looked across the lounge. Chuks stood in a corner with a good vantage on the room. He had his earpiece in, so I was sure he had heard the conversation. He looked at me, frowned, and shook his head. I had learned to read his face and body language: *I am sorry. The bar has been raised.*

But I wasn't ready to give up hope. I ran after Anthony, and I caught up to him in the hall. "Anthony, wait." He kept walking toward his cabin, so I ran to catch up. "Anthony, stop. Let's talk." But he kept walking, so I kept pace. "Anthony, you've come so far, you're doing so well. Don't let—" I looked around to see who might be listening. A guard stood a discreet distance away, so I lowered my voice. "Don't let the captain's pig-headedness undo everything you've done here."

Anthony just kept walking, not looking at me, but at least he answered. "I'm not, Doctor. He can't break me that easily."

"But then where are you going? What are you going to do?"

"To my room. To study. I have a seminar to prepare, Doctor." And then he did turn and look at me. "I look forward to your supplemental reading list."

That stopped me in my tracks, but he kept going, back stiff and straight and walking with an easy stride. For the first time, I really saw his father in him.

But as determined as Anthony was, he still needed a lot of help for this challenge. I ended up spending my spare time tutoring him, not just recommending reading. He was bright—his father's genes ran true there—and he had the benefit of a very expensive education and private tutors, but he had never had to work at learning. Material that came easy to him, he blew through. When a topic proved too tough for him, though, he just turned to something else. No one had ever expected him to have the discipline to see his way through a hard part, and no one had taught him the analysis and study skills to master a subject. Now suddenly he was "enrolled" in five graduate-level studies, plus *teaching* one, and Captain Aames expected him to sink or swim.

And he wasn't sinking, but only because he spent all of his non-exercise time studying. He even stopped showing up for dinner after workouts, until I put a halt to that.

"Doctor!" he protested.

But I answered with a phrase he was learning to hate: "Doctor's orders. You need some down time, or you're going to have a breakdown." He accepted my order, grudgingly, but the dinner conversations became more like an extension of the seminars. He kept probing his friends for answers, desperately trying to keep up with their work. His alcohol consumption dropped almost to zero, but I made a point to buy him a glass a night just to relax him. When he refused the first glass, I threatened to write out a prescription.

Anthony's determination was infectious. If Aames wanted to break him, then I was determined to keep him whole. But that had a cost: Our tutoring time meant less time with Chuks, and though Chuks was a good man and tried not to show it, he resented it. "Constance, you will only be disappointed," he said one night, but I read disappointment in his own face. "You waste our time; and in the end, Mr. Holmes will lose interest, and you will have accomplished nothing."

Our time: I bristled at that. "It's *my* time. If I want to spend it tutoring, I will. You don't own me."

"I don't want to own you, Constance, I want to protect you."

"You're not paid to protect me, you're paid to protect Anthony. Is my tutoring a danger to him?" Before Chuks could answer, I stormed out of the observation room. I was tired and frustrated, but that only made me more stubborn: If I had anything to say about it, Anthony would master his studies.

Eventually Anthony's hard work and my tutoring paid off. He started asking smart questions in the seminars. When it was his turn to lead a discussion, he was always prepared, though I noticed he had a trick of delegating the more technical parts to the experts in the room, then synthesizing their responses into new insights.

In Chuks's Martian survival seminar, Anthony was often the first one with the right

answer to any challenge. It turned out the one topic that really did interest him was Mars itself. He had to know everything about it; and in every other seminar, he managed to turn the topic back to "How will this help a team to survive and succeed on Mars?" Chuks was harsher with Anthony than with the other students, always dissecting his answers and pointing out weaknesses and mistakes, but Anthony just studied harder, and soon there were no weaknesses for Chuks to find.

And in his own seminar, Anthony quickly grasped how limited his "research" had been. He devoured my supplemental reading, until I had to call up more from Earth. He kept challenging the scientific consensus on nanotechnology, but his arrogance and confidence were gone. He now demanded that each precept be challenged and defended. He worked with the discussion leaders to explore nanos from the ground up. He asked Lt. Copeland, supervisor of the *Aldrin's* nano labs, for permission to observe the labs, and after Captain Aames intervened, she approved him. Several weeks later, he asked for permission to run some experimental batches. That approval took longer, and the captain demanded stringent oversight, but in the end, Anthony was approved to test a new design for waste reclamation nanos. His first two batches made an unholy stink, but Lt. Copeland said they showed promise. His third batch produced no odors, and his fourth batch improved on the efficiency of our stock nanos. Copeland agreed to put them through further testing.

We were about four weeks out from the Martian gravipause at that point. The next Friday, when I showed up for Anthony's seminar, I was surprised to find the classroom almost empty. There were usually a dozen students, plus another dozen watching via comms. This time, the only people in the room were Captain Aames, Lt. Copeland, Chief Carver, and Chuks. I didn't look at Chuks. My temper had passed since our last argument, but something else was wrong, and I wasn't sure what. As Anthony grew more capable, Chuks became more distant, but he didn't explain why. I wondered if he resented being wrong. Then I refused to believe that such a good man could be so petty. Then I grew angry at myself: did I really know Chuks was a good man after only four months?

Captain Aames was not big on saluting except when on station, so I wasn't surprised when he spoke before I could salute. "Just in time, Doctor. Have a seat. Mr. Holmes should be here any minute."

I sat in the seat that he indicated, making me the last person in a semi-circle around the podium. Aames gave me no instructions, so I sat quietly.

When Anthony came in the door, I could tell he was as surprised as I had been but he had practiced being unflappable in front of the captain, so he just walked up to the podium. The lights automatically lowered around us, and a big ceiling spot came on, pinning him in its beam. In the spotlight, I could see just how much the exercise regimen had done for him. He was leaner, he stood straighter, and he carried himself with confidence. He looked every inch his father's son, only more at ease.

Anthony wore a forced smile as he said, "Well . . . it looks like my lesson notes won't be needed today, so instead let's get right to it. Are there any questions?"

The captain never looked up from his desk as he asked from the shadows, "Mr. Holmes, what is the activation frequency of a salt-ion scavenger nano?"

Without missing a beat, Anthony answered, "There are many variants, Captain. The prime variant on this Mars mission has a primary activation spike in the Ultraviolet C range at 210 nanometers, and a secondary spike at half power in the visible spectrum at 560 nanometers. We also have a variant with three spikes at 240, 500, and 614 nanometers. We have designs for other variants, but none in production. I can look those up if you'd like."

The captain looked at Lt. Copeland, and she nodded. Then he answered, "Unnecessary. How many generations of sintering nanos can you get out of a typical batch before they start to degrade?"

Again Anthony's response was immediate. "It's a trick question, sir. Sintering nanos are almost always destroyed in use, sacrificing their own component atoms to fabricate some new part or tool. So looked at that way, the answer is one. And sintering nanos are not self-replicating, so the answer is also one

from that perspective. But if you look at the seed nanos that construct the sintering nanos, those are typically good for at least fifteen generations. In a pinch, you can push them to twenty, but the reliability of the sintering drops to the high risk range above fifteen." Copeland nodded, and Anthony added, "And the orbital period of Phobos is seven hours, thirty-nine minutes, thirteen-point-eight-four seconds. Dr. Meadors rounded to the nearest second. During the course of the *Aldrin's* rendezvous with Mars, that error will add up to almost forty-seven seconds. If you had had a discrepancy like that on the second *Bradbury* expedition, you and the other survivors would be dead right now."

This time the captain did look up, straight at Anthony. His eyes gleamed in the reflected light. "You think you're pretty smart, huh, kid?"

"Try me." Anthony smiled. "Captain."

"Okay, kid, tell me about your waste reclamation nanos."

"What about them, sir?"

"Everything. From concept to production to testing. Convince me that we should risk this Mars mission on some billionaire's son's harebrained scheme."

And Anthony set out to do just that. He started explaining the history of reclamation nanos, the nanochemistry behind them, and the current state of the art. He was just summarizing the articles that inspired his new approach when Chuks interrupted him. "Mr. Holmes, you are stranded on Mars in the Elysium quadrant during a meteorological survey. It is early spring in that region. Your shuttle is incapacitated. Where is your best place to scavenge water, and why?"

That brought Anthony to a halt. He was deep in the middle of nanotechnology, and suddenly he was fielding a question on Martian survival. I was sure he was stalling when he asked, "How long do I expect to wait before rescue, Major?"

But Chuks smiled, and I knew Anthony had done well. "Two days, Mr. Holmes. Possibly less, depending on weather conditions."

Anthony didn't smile, but I saw confidence in his eyes. "For two days, Major, I wouldn't even try to scavenge subsurface water, though there's probably some in the area. For such a short trip, I would scavenge from the shuttle's cooling system. It would be easier to scavenge from the meteorology station, but we might need that station functioning at optimum in order to do local weather forecasts and bring my rescue shuttle in. If my landing shuttle was damaged so as to lose all cooling water, *then* I would scavenge just the minimum fluid from the station. I wouldn't even try to set up subsurface reclamation in only two days. I brought enough water with me for that period."

Chuks nodded. "Very good, Mr. Holmes." And he looked at me with a strange sadness on his face. "Please continue enlightening us about nanos."

And that was how it went. Anthony presented an informal paper on his reclamation nanos, answering questions, particularly from Lt. Copeland, and every so often, someone would pepper him with questions on other subjects. Chuks tested him on Martian survival. Chief Carver probed him on software requirements and verification. The captain questioned him on chemistry, astronomy, mathematics, and geology. And I questioned him on just about anything we had studied.

After an hour of this, Anthony was sweating, but still going strong. I ducked out and found him some water, and he just kept going.

After three hours, Anthony had thoroughly covered the planning, design, generation, and testing of his waste recycling nanos, and he had also answered practical questions from across the range of Mars mission disciplines. He looked tired enough that I was ready to open my medical bag, but he was smiling as he asked, "Any more questions?"

The captain looked around the semicircle, and we all shook our heads. He shook his as well. "No, Mr. Holmes. Lights!" The room lights came on. Aames stood, walked to the podium, and looked at the rest of us. "Ladies, gentlemen, I have one question for you: has Mr. Anthony Holmes mastered the material presented in his seminar courses?"

As one, we answered, "Yes, Captain."

"Very well." He turned to Anthony. "Mr. Holmes, congratulations." He took Anthony's hand and shook it. "While it has no force outside this ship—and not here, while we're inside the gravipauses—in the judgment of this

review board you have earned a Doctorate of Areology with a Specialization in Nanotechnology. We would be honored to attest as much should you wish to apply to any graduate or post-graduate program back on Earth. And who knows, maybe someday we'll have an *Aldrin* University, and you'll be our first doctorate recipient, retroactive." They shook hands again. "You've exceeded my highest expectations, Mr. Holmes. That doesn't happen often."

They stood at the podium like that until finally Captain Aames pulled his hand away. "So do you have anything to say for yourself?"

Anthony nodded. "Yes sir, Captain." He turned to me. "Dr. Baldwin, I'd like to set up an appointment to get my therapy nanos as soon as possible."

The captain raised an eyebrow, and then he turned around and sank into his seat. "I suppose I'm going to start losing our races now."

Anthony blinked. "Sir?"

"Think, man, you're half my age! And in better shape than me, at least now. The only reason I've been winning is you have a handicap: you don't have half a million little machines constantly rebuilding bone and muscle damage. Your musculoskeletal damage has been slowed by exercise, whereas mine has been reversed by the nanos. Without that edge, I wouldn't stand a chance against you! I would've been eating your dust for at least the last month. With all your studies of nanotechnology, you hadn't figured that out?"

"No, captain. I just . . . figured you were that good." Anthony hesitated, but finally he blurted out, "You cheated, Captain?"

"No one is that good, Mr. Holmes. It's not cheating to know your subject, do your homework, and use your resources. It's smart; and if you're half as smart as you think you are, you'll learn to do it as second nature. When you have an edge out here, you take it. Your mission and your survival may depend upon it."

"Yes, Captain."

"When you take the nanos, it will be a relief. I can stop trying so hard, because I know I'll lose in the end. Aside from Major Adika, you may be the healthiest person on this ship."

"Thank you, Captain."

Aames turned to me. "Doctor, you should be able to accommodate Mr. Holmes immediately, shouldn't you?"

I picked up my bag and stood. "Yes, Captain. Right away." I started for the door.

But Anthony just stood at the podium, staring at Captain Aames, a big grin on his face. The captain stared back and asked, "Is there anything else, Mr. Holmes?"

Anthony nodded. "You called me 'man,' sir."

The captain's eyes widened. "I did?"

"Yes, Captain. 'Think, man, you're half my age!' You didn't call me 'kid', you called me 'man.'"

Captain Aames smiled. "So I did. Was I wrong?"

"No, Captain." Anthony saluted, turned, and left for the infirmary.

After I gave Anthony his injections, I traced down Chuks in his cabin. He let me in, and I threw my arms around him without saying a word. He kissed me, and we stood like that for a while. I just wanted things to be right between us, whatever that would take.

But when I pulled away, I saw sadness in his eyes. "Chuks, what's wrong? He did it! Are you that sorry to be wrong?"

He shook his head. "It is nothing, Constance. Life changes, that is all, and change always brings good and bad."

"What could be bad here? We should be proud!"

"I am proud. Do not worry, I am just being foolish. Tomorrow will bring what it brings. Tonight we are together. We should celebrate."

And we did, and it was very good, and eventually his fantastic smile returned. But I couldn't forget his sad expression, and I couldn't stop worrying what might have caused it.

Three weeks later, the review board and Anthony met in the classroom again. We were joined by Savoy, Meadors, Krause, Martinez, and a number of other senior mission personnel, and the rest of the mission watched on the comms. Captain Aames directed a revised briefing on the mission plan, with each department head going through a grilling much like Anthony had. It wasn't Aames's mission, and he wouldn't be going down to Mars; but as the commander of the second *Bradbury* expedition, he was the local expert on Mars,

and he had plenary powers between the gravipauses. If he wanted to be briefed, he would get briefed.

At last, all of the departments had reported to the captain's satisfaction, and he reclaimed the podium. He looked around the room. "Ladies and gentlemen, this looks like a very professional mission plan, and you've got answers to every question we can imagine. Now for the bad news: when you get down there, Mars is going to raise questions you *can't* imagine. Nothing in our evolution or experience can prepare us for Mars. Until you're there, you won't understand that. But if any team is ready for Mars . . . you are."

At this rare bit of praise from Captain Aames, Chief Carver and I and other ship's officers rose and applauded. This team had earned that.

When the applause faded and we all sat down again, the captain continued. "But you're not ready. Remember that, keep your wits about you, and you'll survive until the *Collins* arrives to pick you up. Never forget: Mars is going to surprise you. Now, are there any last questions?" Anthony raised a hand. "Yes, Mr. Holmes?"

"Captain, I've been thinking."

"It's about damn time," the captain said. Everyone laughed, including Anthony.

He continued. "Captain, I don't think I want to do a down-and-back on the drop shuttle. I respectfully request to be reassigned as permanent staff for the mission."

The captain looked around at the mission heads, and they all nodded slowly. "Are you sure? There's no turning back on this one. It will be fourteen months before the *Collins* arrives."

Anthony smiled. "I'd like to put this new degree to good use. Fourteen months is a good start on that."

Aames turned to me. "Doctor, is he in physical condition for the mission?"

I rose to attention. "He is, Captain."

The captain turned to Adika. "This would mean your team has to stay through as well. Are you all right with that?"

And suddenly I understood why Chuks had been so sad: He had known this was coming. He knew Anthony, and he knew how much Mars meant to him, and he knew that once Anthony qualified for the mission, he would insist on going.

I had looked forward to the long voyage home and a lot more time with Chuks. Selfishly I hoped he would say "no," and then we could still be together in the coming months. But then I got angry with myself. Anthony had earned this, he deserved this, and it was the natural outcome of all our efforts. So despite my anger, I was proud when Chuks stood as well and answered. "Captain, my team would enjoy the chance to spend more time on Mars; but the mission plan does not allow enough spare rations for that many. I believe there's enough buffer to safely cover myself and Mr. Holmes."

I would miss Chuks, but his plan made sense. I looked at him, and I smiled: *I understand. I'm proud of you.* He smiled back, and it was a perfect blend of his sad look and his big smile.

The captain stared at Chuks. "Major, that would do a lot to lower the risks in this mission." He turned his stare on Anthony. "Mr. Holmes!"

"Yes, Captain!"

"You would have to understand one thing: if you do this, you're not Anthony Holmes, the boss's son. You're bottom of the totem pole. You will do what you're told when you're told by whomever tells you. These people have been training for this mission for three years, some of them for longer. Their whole lives, even. You've had four months of cramming. That's not the same. You're not an expert, you're a nobody who *might* become an expert if you come out of this alive. The way to do that is to follow orders. Can you do that?"

"I wouldn't have it any other way, captain. I'd *like* to come out of this alive."

Captain Aames looked at his comm. "All right, under those terms, I think you'll make a hell of a Mars explorer. I support you in this decision."

Anthony shook his head. "You 'support' me? So am I authorized to go or not?"

The captain shook his head. "I *can't* authorize it, Mr. Holmes. As of three minutes ago, we passed the Martian gravipause. I'm not in charge any more. You're the boss's son. If you want to go, who am I to tell you no?" ■

MARTIN L. SHOEMAKER

Martin L. Shoemaker credits computer programming with his rapid rise to *Analog* prominence. That's because programming—his day job for more than thirty years—calls on many of the same skills as plotting complex stories like the trio of Mars tales that have appeared in *Analog* in rapid-fire succession since May 2013.

"A large part of system development in software is visualizing a complex structure in your head, seeing how all the pieces tie together, and taking that vision and turning it into code," says Shoemaker, whose day job involves writing everything from code for diagnosing engine failures in your car to tracking baggage through airports. "I think the process [in writing] is similar. I can see the shape [and] see what's connected where."

He's also a man with deep science fictional roots. As a child growing up in small-town western Michigan (where he still lives), he remembers the original *Star Trek* from its in endless syndications during his grade school and middle school years. And like many eventual pros, as a child he wrote a lot, even if it was "as atrocious as you can possibly imagine."

As a teenager, he discovered *Analog's* sister publication, *Asimov's Science Fiction*, where then-editor George Scithers was cultivating a whole generation of new writers. "I realized that a writer is just a reader who's decided to join the fun," he says, noting he decided it would be a fun career path to follow. "Thirty years later, I got around to actually following it."

The delay came because in ninth grade someone introduced him to his first computer. "[They] said, 'Here's a program. Now go write one,'" he says. "That distracted me for thirty years. It satisfies some of the same urges as writing."

He also spent some time as a game master for role-playing games, where, he says, he had to create stories "on the fly" in situations where "I had players testing and probing them, looking for weak spots to use for their advantage." Like computer programming, that diverted his creative energies but also honed his skills, so that when he returned to writing, his apprenticeship was "embarrassingly brief."

Photo by Viva Bene Photography

Literarily, he credits one of Scither's most famous discoveries, Barry B. Longyear, as a particularly strong influence. "'Enemy Mine' was perfection," he says. "If I can write anything that can move anybody half as much as that did, I'll feel successful." What made the story work, he adds, was its mix of scientific realism and the characters' internal journeys. "It was a very logical, rational story," he says, "and at the same time it had true emotional depth."

He's also a fan of Niven, who he thinks does the same things. "He will ruthlessly explore the science and find out how it impacts the characters," Shoemaker says.

Although he's sold to several other markets, Shoemaker particularly likes *Analog* because its stories tend to be about problems and solutions. "*Analog* is a 'we can fix things' market," he says. "Humanity solves problems. Yes we create some along the way [but] we struggle and survive and overcome." ■

Science Fact

Human-Caused Earthquakes: From Science Fiction to Seismology

Richard A. Lovett

In the now-classic Christopher Reeves *Superman* reboot (1978), archvillain Lex Luthor has a dastardly plot: he'll detonate a big nuke on the San Andreas Fault, forcing a giant earthquake that will cause Western California to fall into the sea, leaving him owning desert lands that are now the state's newest beachfront property.

Superman wasn't the first movie to come up with the idea of a large nuclear blast triggering a giant earthquake. The 1965 doomsday movie, *Crack in the World,* used the same concept, although in its case the nuke was detonated in East Africa. Also, instead of being the result of a villain's nefarious intent, that blast was intended to open up a source of limitless geothermal power. But *Crack in the World* was low-budget sci-fi, while *Superman* raked in 300 million 1978 dollars. The result is that for most people, Lex Luthor's earthquake is the one that got remembered. Not to mention that blasting the San Andreas Fault into motion was the perfect super-villain plot: dastardly enough to be entertaining, but not believable enough to produce true viewer angst.

Or so people thought in 1978.

Fast-forward to modern-day Sparks, Oklahoma. It isn't a place you'd normally expect

earthquakes. It's prairie country; smack-dab in the middle of America, far from the grinding tectonics that keep people on edge in California, Indonesia, Japan, Chile, Turkey, or other active tectonic zones.[1] Sure, the midcontinent crust occasionally trembles in response to distant, ancient stresses. But the resulting ground motions are rarely enough for anyone but a seismologist to notice.

Then, on November 5, 2011, the area was hit by a pair of temblors, one of which was the largest earthquake in Oklahoma history—a magnitude 5.6 shock that injured two people, destroyed 14 homes, and was felt across 17 states.

Meanwhile, other magnitude 5.0 or larger temblors were popping up in parts of the American heartland rarely associated with damaging quakes—earthquakes that scientists are now convinced were caused by human activities.

Not that anyone's blaming Lex Luthor. The culprit appears to be more akin to the one posited in *Crack in the World:* an unintended consequence of humans underestimating their power to affect the world at a geological scale. In fact, *Crack in the World* was startlingly prescient: the Sparks earthquake, and several like it, appear to have been side effects of energy development—in this case a controversial method of enhanced oil-and-gas recovery known as *fracking*.[2]

Anything humans do that makes the ground shake is technically an earthquake. But there's a huge difference between microscopic vibrations from mining operations (or even the collapse of the World Trade Center's Twin Towers[3]) and anything we'd normally call an earthquake. "Four years ago, when I used to talk about induced earthquakes, people used to stand up and say, 'We don't believe that humans can cause earthquakes,'" Cliff Frohlich, an earthquake seismologist and associate director of the Institute of Geophysics at the University of Texas, Austin, told me in late 2013.[4]

I myself had a similar experience in 2007 after I wrote a story for National Geographic News about the worst earthquake in Australia's history, a magnitude 5.6 jolt that struck Newcastle, New South Wales, in 1989, leaving 13 dead, 160 hospitalized, and costing 4 billion dollars in property damages.[5] At the December 2006 meeting of the American Geophysical Union, in San Francisco, Christian Klose, then a geophysical hazard researcher at Columbia University's Lamont-Doherty Earth Observatory, had argued that this had been caused by a shift in tectonic forces due to two hundred years of coal mining. But when I wrote about it, he (and I) was shouted down on the Internet as a crackpot. Even a former head of Geoscience Australia's earthquake monitoring group weighed in to dismiss Klose's theory as unlikely.[6] Puny humans, the argument went, were simply incapable of altering the Earth's tectonic stresses enough to produce earthquakes—and anyone who thought otherwise was, well, about as realistic as Lex Luthor.

But sometimes, what everyone says simply isn't true.

A small cadre of earthquake scientists, Frohlich says, have known since the 1930s that humans are capable of inducing potentially sizeable earthquakes. That's when construction was completed on America's Hoover Dam, near Las Vegas, Nevada. The dam created Lake Mead, still the largest reservoir in America, capable of holding 37 cubic kilometers of water: only slightly less than China's famous Three Gorges Reservoir. That much

[1] See Richard A. Lovett, "Waves of the Future: Where Will the Next Tsunami Strike?" *Analog,* June 2013.

[2] Not that "Crack in the World" was by any means scientifically accurate. Its experiment gone wrong wound up with a giant fissure in the Earth's crust, big enough to eventually spit out a second Moon. What we're talking about here are much more ordinary earthquakes.

[3] See, Richard A. Lovett, "Forensic Seismology: The Big Science of Minor Shakeups," *Analog,* April 2004.

[4] Richard A. Lovett, "Seismic Rumblings," *Cosmos 56,* April/May 2014, pp. 46–51.

[5] Richard A. Lovett, "Coal Mining Causing Earthquakes, Study Says," *National Geographic News,* January 3, 2007, *http://news.nationalgeographic.com/news/2007/01/070103-mine-quake.html.*

[6] "Australian experts reject Newcastle quake claims," ABC (Australian Broadcasting Company) News, 8 January 2007, *http://www.abc.net.au/news/2007-01-09/australian-experts-reject-newcastle-quake-claims/2168560.*

water weighs a lot (37 billion metric tonnes, to be precise), so perhaps it shouldn't have been a surprise when seismometers in the area began recording earthquakes up to magnitude 5.0, linked to the level of water in the steadily filling reservoir.

India, Uzbekistan, China

Hoover Dam is far enough from major population centers that none of these earthquakes were damaging. But the residents of western India weren't so lucky following the completion of the 340-foot-tall Koyna Dam in 1964. Three years later, a magnitude 6.7 temblor flattened a nearby village, killed an estimated 180 people, and injured 1,500 more.

That disaster is the largest human-caused earthquake "everyone agrees on" says William Ellsworth, a seismologist with the U.S. Geological Survey in Menlo Park, California. But that doesn't mean that humans might not have caused even worse earthquakes. In 1976 and 1984, Uzbekistan's Gazli oil field was hit by two big quakes, magnitude 7.0 or bigger, that may have been produced by underground stress changes from decades of oil and gas extraction. (A third temblor came in at magnitude 6.8.) "The scientific evidence doesn't make a bulletproof case," Ellsworth says, "but I think it's likely."

The granddaddy of all, however, may have been the magnitude 7.9 quake that struck China's Sichuan Province in 2008, shortly after the completion of 512-foot-tall Zipingpu Dam. That one killed 69,000 people and left another 18,000 missing. In a paper presented a few months afterward at the 2008 meeting of the American Geophysical Union, Klose argued that the pileup of water in the reservoir might have overstressed the fault, accelerating natural tectonic stresses by hundreds of years. Since then, other scientists have supported this claim, but it may be years before the scientific community reaches agreement on whether this earthquake was or was not human-induced.

In some tectonic settings, human-induced earthquakes are simply natural ones that would eventually have occurred on their own, possibly in the near future. But not always. In other cases, Klose and others have argued, the natural cycle might have been accelerated by hundreds of years—a big deal for those unlucky enough to be living nearby. And in still other settings, earthquakes may be induced where there are no contemporary tectonic processes to be accelerated: nothing more than residual stress from ancient forces that have never dissipated. "These faults just need something to trigger an earthquake," Klose says. "If human action is large enough [it can] break them."

From a physics perspective, the forces involved in producing earthquakes are fairly simple. Fault lines are simply cracks that are subjected to forces (called shear forces) that make one side want to slide against the other. Sometimes, the opposing rocks want to slip sideways, sometimes vertically, sometimes at any angle in between. The difference is important to geologists trying to understand mountain building and plate tectonics, but for people primarily interested in the safety of their homes, the differences don't matter all that much.

The only reason your local fault isn't slipping right now is that shear forces aren't the only ones involved. Others clamp the two sides of the fault so firmly together that it's not possible for them to move. You could compare it to pressing your palms against each other while also trying to slide them sideways. Ellsworth analogizes it to a brick on a tilted board; the brick remains in place until you tilt the board so far that the brick starts to slide. "A fault will remain silent, not moving, until the shear stress exceeds the stress clamping it together," he says.

As with your hands (or the brick), there are three basic ways to make it move. One is to increase the shear stress. That's what happens naturally in traditional seismic zones, as tectonic pressures mount until eventually the fault slips.

The second way to make it slip is by reducing the clamping pressure, and the third is by lubricating the fault with something slippery.

Human-triggered earthquakes probably work by all three mechanisms. In the case of China's Sichuan earthquake, for example, Klose estimated that 320 million tonnes of water piled up behind the dam in the two years before the quake. That's far less than in Lake Mead, but still enough to produce a substantial change in shear forces across the fault.

Something similar might have happened at Newcastle—though in that case it would have been the removal of weight that was the culprit. In his 2006 study, Klose estimated that for each tonne of coal extracted from the mines, another 4.3 tonnes of water had to be pumped out in order to prevent flooding. And in his 2014 book *Frack this! The Untold Story About Earthquakes Caused by Humans* he argues that this is actually at the low end of the scale for the amount of ground water that has to be pumped out of mines, worldwide. Multiply that by two hundred years of operation, and it's a big change. Long-term extraction at oil and gas fields like Gazli might induce earthquakes the same way. In some fault geometries, such changes could reduce clamping pressures; in others, they might increase shear stresses.

But the most common way in which humans might be inducing earthquakes is by injecting water into the ground, sometimes as a side effect of the water pressure at the bottom of a newly created reservoir, and sometimes by directly injecting polluted water into deep rocks as a means of waste disposal. Either way, this water increases fluid pressure in the rocks' pore spaces—including the gaps within the fault itself. "You can think about it as pushing the fault apart," says Ellsworth. Or, if you prefer, you can think of it as lubricating faults so the rocks can slip more easily.

This last mechanism isn't just theory. In a July 2013 article in the *Journal of Geophysical Research: Solid Earth,* Won-Young Kim of Lamont-Doherty Earth Observatory found a correlation between earthquakes (up to magnitude 3.9) near Youngstown, Ohio, and fluid injection activities at a nearby well.[7] And that's not the best evidence. All the way back in the 1960s and '70s, the U.S. Geological Survey (with oil company cooperation) tested the theory in Chevron's Rangely Oil Field in northwestern Colorado, where fluid injections were being used to force oil from aging wells. Working in a portion of the field where small earthquakes were common, the researchers found that by varying the pressure of the fluid being injected, they could very easily turn the area's seismic activity on and off.[8]

But it took a massive surge in earthquakes in the American heartland to bring human-induced earthquakes to public attention. In an article in the July 12, 2013 issue of *Science,* Ellsworth tallied earthquakes in the U.S. midcontinent since 2001, discovering that in the course of barely more than a decade there had been a nearly tenfold increase in the number of magnitude 3.0 or larger earthquakes: from 21 per year prior to 2001 to 188 per year in 2011, with most of the rise in the last four or five years.[9]

It's a change, Ellsworth says, that strongly parallels the increased use of the controversial enhanced oil-and-gas recovery process known as fracking, in which high-pressure fluids are injected into the rocks in part of a process that has enormously boosted U.S. oil and gas production. In fact, says Nicholas van der Elst, a seismologist at Columbia University's Lamont-Doherty Earth Observatory, and lead author of another study in the same issue of *Science,*[10] at least half of the largest of these midcontinent earthquakes (magnitude 4.5 or larger) came near injection-well sites. (Most of the rest occurred in the New Madrid Seismic Zone south of St. Louis, Missouri, where naturally occurring earthquakes, some possibly exceeding magnitude 7, have been recorded since 1811.)[11]

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[7] Won-Young Kim, "Induced seismicity associated with fluid injection into a deep well in Youngstown, Ohio," *Journal of Geophysical Research: Solid Earth,* Vol. 118, Issue 7, pages 3506–3518 (July 2013). DOI: 10.1002/jgrb.50247.

[8] Gibbs, James F.; Healy, John H.; Raleigh, C. Barry; Coakley, John M., "Earthquakes in the oil field at Rangely, Colorado," USGS Open-File Report: 72-130 (1972).

[9] Ellsworth, W. L., "Injection-Induced Earthquakes," *Science* Vol. 341, no. 6142, p. 142 (2013). DOI:10.1126/science.1225942. The 2011 date is approximate, based on my reading of one of the paper's graphs.

[10] van der Elst, N.J.; Savage, H.M., Abers, G.A., and Keranen, K.M., "Enhanced Remote Earthquake Triggering at Fluid-Injection Sites in the Midwestern United States," *Science* Vol. 341, no. 6142, pp. 164-167 (2013) DOI:10.1126/science.1238948.

[11] See Richard A. Lovett, "Shake, Rattle, and Roll: Is Missouri Really America's Most Dangerous Earthquake Zone?" *Analog,* September 2011.

Not that this categorically proves that oil and gas extraction is the cause of any given earthquake. The U.S. has a great many oil and gas fields, which means that the geographic proximity of earthquakes to oil and gas fields may simply be coincidence, Van der Elst notes, "But," he says, "it is suggestive."

But that's just scientific caution—and a far cry from the days when people like Frohlich were being scoffed at for even suggesting that human-induced earthquakes were possible. Even the industry is aware there is an issue to be faced. "It's the hottest topic in seismology [and] definitely an issue the oil and gas industry needs to address," says Ivan Wong, vice-president and principal seismologist at URS, an Oakland, California, consulting firm. Dana Bohan, a spokesperson for Energy In Depth, an arm of the Independent Petroleum Association of America, agrees. "The risk is known," she says. "It's constantly being studied."

Drilling for Heat

Another way humans can trigger earthquakes is by geothermal energy production.

In 2006, the Swiss attempted to develop geothermal resources beneath the city of Basel. In the process, they used high-pressure fluids to fracture imporous rocks in order to create gaps in which water could circulate for geothermal heating. But they got an unpleasant side effect: four magnitude-3.0 earthquakes—large enough to do minor damage. "They shut the project down," Ellsworth says.

In more remote areas, such small earthquakes aren't a concern, but that doesn't mean there's no reason not to worry about the prospect of bigger ones.

In yet another induced-seismology study in the same issue of *Science* that featured Ellsworth's and van der Elst's, Emily Brodsky, an earthquake physicist at the University of California, Santa Cruz, examined earthquake rates at California's Salton Sea Geothermal Field, which lies near the southern end of California's infamous San Andreas Fault.[12] She picked the area in part because it's been producing energy since 1982 (with good data about plant operations, made public by California law), but also because the Salton Sea is a lake near the southern end of California's infamous San Andreas Fault. "I have to 'fess up that it seemed like a peculiar place to be inducing earthquakes," she says.

Geothermal energy production begins by pumping superheated water from deep underground, then letting it flash into steam to drive turbines. The steam is then condensed back into water, which is reinjected into the ground.

Unlike the geothermal development project in Basel, this operation is not intended to fracture rocks. But it does involve the removal and replacement of large quantities of water, an operation with the potential of altering subsurface conditions. Furthermore, while the water circulation is, in theory, a closed loop, in practice some of the steam is lost to the atmosphere, with the amount varying with the weather and other operating conditions. In other words, the amount of water being pumped back into the ground and the amount initially extracted don't necessarily match: another potentially destabilizing factor.

Even without human intervention, earthquakes in major fault systems are dirt common. Since 1982, Brodsky tabulated tens of thousands of them near the geothermal plant, ranging from magnitude 1.75 to magnitude 5.1. Complicating the analysis, which she did in conjunction with graduate student Lia J. Lajoie, is the fact that earthquakes tend to come in clusters, with big ones triggering aftershocks that, for her purposes, are all part of a single event. But with the help of some fancy statistics, she was able to combine main shocks and aftershocks into what she calls the "direct seismicity rate," which she could then compare to plant operations.

What she found was "an extremely good correlation"—specifically the rate at which water was lost to the atmosphere.

It was the exact opposite of what had happened in Switzerland. There, earthquakes had been induced by shoving water into the ground. Here, they were correlated to the net rate at which it was taken out. Her best guess is that what's happening isn't the type of fault lubrication found in fracking-related wells, but instead changes in sheer stresses due to

[12] Brodsky, Emily E.* and Lajoie, Lia J., "Anthropogenic Seismicity Rates and Operational Parameters at the Salton Sea Geothermal Field," *Science,* Vol. 341, no 6145, DOI:10.1126/science.1239213.

compaction of deep strata when all of the water withdrawn from them is not returned.

A company representative declined to discuss the study when asked, but in an op-ed article submitted to the *Los Angeles Times* in response to the *Times* own article on Brodsky's study,[13] the Geothermal Energy Association and the Geothermal Research Council (industry trade groups) asserted that reports of Brodsky's work need to be "read carefully and reacted to calmly."

"Unfortunately, the impression that a reader could get is one of serious safety risk, when neither the study being quoted nor other studies conducted in the area reach that conclusion," the article continued, adding: "Geothermal power production provides clean, reliable and safe power for California. We hope your readers recognize that the risks from climate change are much greater than the natural micro-seismic events occurring near geothermal reservoirs."[14]

Brodsky agrees that most of the earthquakes were small. In general, she says, earthquake frequency follows a scaling law, with large earthquakes being exponentially more common than small ones, until you reach a maximum strength believed to be limited by the size of the fault system. On small faults, that's reassuring. But not on big ones, such as the San Andreas.

So far, the largest earthquake in Brodsky's study was a magnitude 5.1 in 2005. But does that mean there's no possibility of a larger one if current operations continue indefinitely? "The chances of making a truly enormous, damaging earthquake are quite low," Brodsky says, "but not zero."

Not Famous for Earthquakes

Fracking-induced earthquakes are different, largely because they don't tend to be on major, active faults like the San Andreas.

Fracking, or "hydraulic fracturing," is the process of injecting high-pressure fluids into rocks in order to shatter them and allow trapped natural gas to migrate to the well.

Such a process, of course, inherently causes small earthquakes—just as, technically speaking, any kind of blasting, road construction, or use of a pile driver does the same. And happily for the oil-and-gas industry, the fracking process itself has never directly produced an earthquake larger than magnitude 3.6, Ellsworth says.

But once the rocks are broken, the fracking fluids come back to the surface with the oil and gas, and because they're chemically polluted, the simplest way of disposing of them has been to reinject them back into the ground. The larger earthquakes, such as the one that hit Sparks, Oklahoma, appear to have come from this process, not from fracking itself. "It's related to fracking because the wastewater is caused by fracking operations," Frohlich says, "but you'd have the same problem if you pumped tap water into the wells."

That's good news for the industry, he adds, because it means it's possible to inject these fluids into other rock strata—or treat them like any other industrial waste by cleaning them up and disposing of them into surface waters, just as we do with sewage. Another piece of good news is that not all injection wells produce earthquakes. Frohlich notes that Texas alone has more than ten thousand wells. "If it was a severe hazard, Texas would be famous for earthquakes," he notes.

That said, the earthquake experienced in Sparks should serve as a major alarm bell. Small, or even midsized, earthquakes aren't likely to be hazards if they occur in remote locations like the Rangely Oil Field used for the U.S. Geological Society's long-ago tests. But even modest-sized earthquakes can do significant damage if they happen in the wrong place. The 2011 Oklahoma earthquake, Ellsworth points out, was the same size as the Newcastle quake—and both were comparable to a magnitude 5.7 that occurred in 1986, directly beneath El Salvador's capital city of San Salvador. That earthquake killed 1,000 to 1,500 people, injured another 10,000, and left 200,000 homeless.

[13] Boxall, Bettina, "SoCal geothermal power production causes earthquakes, study says," The Los Angeles *Times,* July 11, 2013, *http://articles.latimes.com/2013/jul/11/science/la-sci-sn-geothermal-power-earthquakes-20130711.*

[14] A prepublication copy of the op-ed article can be found here. *http://geoenergist.wordpress.com/2013/08/01/geothermal-power-provides-clean-and-safe-power-for-california/*

One thing that's needed is a way to determine which wells might be on the verge of producing dangerous earthquakes, something that, in theory, can be done with modeling.

"The physics of faults is well known," Ellsworth says. "What you need to know are the pressures and stresses."

Unfortunately, traditional means of figuring these out are expensive and time consuming, especially given the number of injection wells that are out there, mostly posing no hazard.

"One of the Holy Grails is to make some connection between what an operator might choose to do, and how many earthquakes are the result," says Brodsky. She's speaking in terms of geothermal plants, but her bottom-line conclusion is broadly applicable. "Without that," she says, "we're stuck with vague generalities."

It seems an intractable problem.

But nature might provide some assistance via giant faraway earthquakes such as those that recently struck Sumatra, Japan, and Chile. Devastating as they are in the regions they directly affect, Ellsworth reported in his own *Science* paper,[15] these earthquakes also send waves across the entire surface of the Earth, "like ripples." Usually, these ripples have no effect on other faults. But in a few cases, they produce swarms of small earthquakes—swarms, he discovered, that could highlight locations that may be ripe for bigger earthquakes in the near future.

It's another idea many geologists would have pooh-poohed back in the era when Frohlich was being ridiculed for suggesting that humans could induce earthquakes. How could vibrations from an earthquake in Japan set off temblors in Oklahoma? But seismologists have discovered that even vibrations so small no human could possibly feel them can indeed have such effects. More interestingly yet, van der Elst says, "in a natural setting, the places most susceptible to this are hydrothermal or volcanic regions where we know faults are being driven to failure at least in part by pressurized fluids." If the same happens in injection-well zones, he says, "these are becoming like artificial Yellowstones."

To test his idea, van der Elst searched seismic records to see if injection-well sites that later had sizeable earthquakes also saw swarms of remotely triggered earthquakes after the three most recent great earthquakes. What he found was that sometimes such swarms had occurred, sometimes they hadn't. No such warnings, for example, preceded a magnitude 4.7 earthquake in Guy, Arkansas, a magnitude 4.7 earthquake in Jones, Oklahoma, or a magnitude 3.9–4.0 earthquake near Youngstown, Ohio. But such remotely triggered swarms indeed appeared prior to three magnitude 5.0-plus earthquakes in Oklahoma (including the one in Sparks), as well as a magnitude 4.3 temblor near Snyder, Texas, and a magnitude 5.3 quake near Trinidad, Colorado.

What this meant was that van der Elst had found a simple screening tool to help seismologists focus their attention on potentially dangerous areas—a test that can be applied whenever a giant earthquake strikes any part of the globe. It's not perfect, but it's inexpensive and had correctly raised a warning for more than half of the larger injection-well earthquakes that subsequently occurred. In Wong's words, it's nothing short of "ground-breaking science"—a find that greatly reduces the prior uncertainties in induced-earthquake prediction.

Traffic Lights

Warnings like this can't prevent the drilling of wells or building of dams in dangerous zones, but at least they could give operators and regulators a heads-up to impending danger, allowing them to take steps to fend it off. For dams, these steps might take the form of draining the reservoir pending further study. For injection wells, the simplest action might be to curtail pumping until the risks—and proper safety steps—are better known.

One thing most—if not all—of the scientists involved agree on is that induced earthquakes aren't a death knell to fracking, geothermal energy, or waste-disposal injection wells. "The bottom line," Ellsworth says, "is that there is a risk from injecting fluids underground, but it is a risk that can be managed."

Wong notes that in addition to van der Elst's warning signals, dangerous earthquakes in fracking zones are generally preceded by other small earthquakes that can serve as warning signals. With good seismic monitoring, he says, it should be possible to create a "traffic-light

[15] Ibid.

system" in which well operations can be varied in order to reduce the risk. "If [seismic activity] is green you're ok," he says. "If it's yellow, you'd better start paying attention. And if it's red, stop."

"We have to understand," Klose says, "that if we want cheap energy, we are allowing certain techniques to be performed."

Steven Hamburg, chief scientist at the Environmental Defense Fund, agrees. The risk of induced earthquakes, he says, has to be taken seriously—along with more conventional environmental concerns such as groundwater contamination and the escape of noxious gases into the atmosphere. But "the technologies exist [to] reduce the chances of a problem," he says. "And you always have to think about it in the context of the alternatives because it's not as if we have a no-impact alternative. We want to ensure that we get the maximum benefit with the least downside."

"The technology is here to stay," adds Frohlich. "This is domestic energy, and an alternative to coal. Where else can you get hawks, hippies, and green-energy freaks all on the same bandwagon?"

From a science-fictional perspective, what this means is that the question of human-induced earthquakes is far more complex than a simple query as to "What would Lex Luthor do?" Nor is it as simple as *Crack in the World's* simplistic vision of a good idea gone wrong. Instead, it's about risk/benefit calculations, energy independence versus energy dependence, and "green" energy versus seismic risk.

Any of which, if anyone ever cares to write it, is a far more complex and human story than either of the easier movies' plotlines. ■

IN TIMES TO COME

It's no secret that I think Halloween is the perfect excuse to give you some creepy stories, and next month's October issue is no exception. Case in point: When a team of firefighters putting out coal seam blazes encounters seemingly unexplained phenomena, the question isn't just how they're happening, but whether anything can be done before it's too late. Find out in our lead story, Alec Nevala-Lee's "Stonebrood."

Then a bounty hunter prowls a blasted American Southwest, hoping desperately to find his target before his competitors do in Joe Pitkin's "The Daughters of John Demetrius." Different generations of a family don't always see eye to eye about adopting new technology, especially when it might change the family business, as in Marie Vibbert's "Butterflies on Barbed Wire." Sometimes, childhood experiences only form a clear picture as adults. And sometimes that picture is one nobody else has seen before, like in Bruce McAllister's "My Father's Crab."

And of course we'll have the third installment of "Night Ride and Sunrise" by Stanley Schmidt, and "Alien Adventures," our fact article from Edward M. Lerner, as well as a bevy of our always-excellent regular columns. See you next issue!

All contents subject to change

Live From the Air Chair

Maggie Clark

Whately's feet woke to the beat of Ship's radio. An hour of toe-tapping later, the rest of him slid from the bunk and started ruing the day. There were four messages waiting at Ship's console, all of which he deleted when he saw the sender. Beside them sat a freshly printed hot roll, its steam fogging the front viewscreen.

"Thanks, Ship." He spoke with the roll wedged between his teeth. Even in the absence of clear consonants, Ship responded with a giant thumbs-up on the monitor.

"Let me in after this next one, will you?" Whately set down half the roll and slipped into the jacket slung over his seat. Only flecks of gold topcoat remained on the soft, black-plastic sheen of its sleeves, and a bit of frayed stitching from a patch at the left breast. He smoothed back his hair as much as the curls would allow, but yesterday's sonic shower had left too much spring in the lot, and they leapt back as a wild mane over the headphones that followed. Ship started the countdown ten seconds from song's end, leaving Whately just enough time to glare at his reflection in the glass.

"Gooooooooood morning, space trash! This is DJ Whately coming at you with Wailin' through the Ages: bringing you the best of what our shitty forefathers left behind. Big shout-out this morning, as always, to Ship—mine that is, not yours. All printed from the same so-long-suckers!, mass-marketed design, but just one of them—just one!—keeping the spirit of rock and alternative alive while all humans on board get a little shut-eye."

Whately peered out the side of his viewscreen. Beyond the unpleasant shadow of his face lay a mostly uninterrupted grid of vessels encompassing the Earth in low orbit.

"Annnnd if you're in my slice of dead zone, wasteland below us is still a deceptively bright blue on this fine near-Terran day. Only a few massive blots of green and yellow oceanic sludge to break up the monotony for foragers today! But if you're on the other side of the upper atmosphere, receiving this transmission through relay, well, look out the damned window and check for yourselves. My money's on 'still a smoldering pile of junk,' but hey, I'm always looking to be surprised. In other news . . ."

Ship brought up a list of system updates and personal announcements from around

the grid, which Whately read mostly while rubbing life into his heavy eyes and aching jaw. He was about to choose a song to start off the next hour, narrating his decision-making process on air, when Ship's perimeter alarm sounded in his headphones.

"Actually, Ship's been doing *such* a good job all morning." Whately drew his stun gun from storage while switching station control to automatic. "Why not let him round out the cycle? Take it away, Ship."

Whately checked the sensors for signs of tampering about the hull—all negative—but there was already someone in the airlock by the time he reached it. The visitor touched the interior comm pad and opened her visor.

"Oh, for the love of—" Whately set down the gun. "I thought you were a grub."

"Why? You seen any?"

At the sudden concern in her voice, Whately tried a calmer, but still disapproving, tone. "No. I just—never mind." Headphones still about his neck, Whately stared at a bulkhead and counted back from ten.

"Well?" she said at last. "Safe to take my helmet off or do you plan on blasting me?"

"Why are you here, Eline?"

"You didn't answer my messages."

"So?"

"So I sent four of them." She sighed and took off the helmet, her short-cropped hair slick with perspiration. "Whatever else is going on, Whate, we've got a code up here. We need to stick to it if we're going to survive. We can't just shut each other out."

"Oh, now there's some rich talk," said Whately. He released airlock controls with a fist to the panel, then stalked down the provisions corridor.

Eline followed once the airlock repressurized. "I *wanted* to give you space, Whate. I meant to. I know how hard this has been for you—"

"Don't," said Whately. "Just don't even—I can't—Ship?"

Without further instruction, Ship blasted the running station tune—a thrash metal number well over a hundred years old—just loud enough that the fact of Eline shouting could be heard, but not the words themselves. The tension went out of Whately's shoulders as he turned about and grinned.

What's that? he mouthed, touching a hand to his ear. *I can't hear you.*

Eline tried working Ship's controls at the galley monitor but couldn't bypass the stern image of an emoji shaking its head. After punching the wall, she stopped and stood by the food printer. Only then did Whately gesture for Ship to cut the music.

"Was that really necessary?"

"Was you coming here and lecturing me on how to survive? What, didn't get enough of *that* in last week?"

Eline pursed her lips before replying. "I *am* sorry for how it all came out."

Whately laughed—a sharp and ugly sound.

"No," said Eline. "Really. I am. I just meant that there are other things you could be doing. Other, you know . . ." She gestured vaguely with the hand still holding her helmet.

"More important things, yeah, I heard you the first time." Whately shook his head and started for the helm. "Like taking people's minds off this shit doesn't matter."

"Whate, you say it yourself, every morning—Ship's doing most of the work here anyway. And *you,* when you're not mining dead ships for new tunes—"

"I provide the human element. *I* give people the sense that they're not alone. Do you not see how many announcements come in for me to rebroadcast? Didn't I used to show you all those drawings the kids used to send?"

Ship helpfully displayed a few such scans as Eline passed into the control room.

"Used to," said Eline. "Not many kids these days, though, are there?"

Whately sighed and spun about in his chair. "What do you want, Eline? Did you forget a sweater or something? Just take it—and then, *please,* just leave me alone."

"I can't." Her voice grew unsteady. "Whate—I was boarded."

Whately froze with his headphones halfway up. "Boarded? How did you—"

She shook her head. "The rest of the family is fine. I don't think they even realize they've got a threat on board. But they're hostages. They don't know it, but unless I get this man what he wants . . ."

"Hells freaking bells, Eline," said Whately. "Why didn't you just say that?"

"I *did,"* she said, visibly gritting her teeth. "I sent you four panicked messages you didn't

even bother to read because you'd already assumed the worst."

Whately groaned and passed a hand over his face. "Those are *really* extenuating circumstances, Ellie, so if you're going to—no, *no,* we can argue about all that later." He stood in the small space then sat down again, hands restless on his knees and the console. "So what do we do? What does he want? And who *is* he?"

Eline set down her helmet and slid to the floor, palms pressed to her temples. "We thought he'd been attacked by a grub. There'd been reports of activity in the area—you know, the usual stuff about madmen trying to sabotage ships, sending them and their crews hurtling through the atmosphere. And even if he weren't—even if he *were* a grub, for Earth's sake—I mean, when someone in a failing suit shows up in your airlock, what do you do? What do we, as a people, do?"

When Whately said nothing Eline took a long, ragged breath. "He said his name was Lester, but I don't know if that's true. I caught him going through my locker on his third night. He said he was just fixing a hinge, but I didn't believe him, and that's when he made it clear that my family would suffer if I told anyone. And I believed him, Whate: In that moment, he had the look of someone with serious connections and no empathy. My family loves him, though—my aunt, my mother, my cousins, their kids: around them, he's just this grateful rescue and charming handyman with time for everyone."

"Then why was he going through your locker?"

"He wanted something he thought I had—something he'd convinced himself I'd taken from one of the ships down-arc. Which is why I had to come here, Whate. You know I had to."

Whately glanced at his monitor, where Ship had its "processing" dots moving across the screen. "I know you never felt right about running salvage," he said. "And I'm sorry it's brought you trouble. But honestly, it was just music we were after—unless you took something more?"

"No, nothing." Whately's fingers twitched at the sight of Eline shuddering as she spoke. "He said it was an image—he didn't know if it was digital or hardcopy but he was very specific: an image of circles within circles. Like this—" She withdrew a worn piece of hardcopy with the symbol on it.

"Ship?" said Whately. But after a minute Ship just flashed the "search completed" symbol with no hits: nothing but music on any of the data pieces they'd transferred.

"Maybe in something we traded, then?" said Eline. "One of the instruments?"

"Unlikely," said Whately. He hesitated before adding, "But there was that one salvage with a weird vibe. The one at Taka's, with all the—"

Eline shook her head, looking sick. "I'd almost forgotten. Do you really think—?"

"Beats me. Only one way to find out, though." He hesitated before holding out a hand to help Eline up.

They glided mostly in silence from Ship and around other ships, the solar wings on their suits alternately glinting toward and away from Earth as they propelled themselves on radiation trails converted from both planetary and deep-space bombardments. Most of the ships they passed bore signs of life—people occasionally waving from portholes and viewscreens; the occasional message sent to their suit comms to see if aid was required—but others were clearly flying empty, even with the AIs still in full operation. Only once did Eline and Whately pass a significant gap in the grid, and even then a small beacon had been installed in geosynchronous orbit—both to memorialize the fallen and reassure passers-by that order in the region had been restored.

"Hey, Artie. We need to talk. You awake and semi-decent?" said Whately, once in range of their target.

"Is he ever?" said Eline.

Whately snorted but couldn't bring himself to say more. They touched down on the hull and passed through the outer airlock doors before receiving a response.

"Hold on," came a fuzzy voice, which descended into vehement muttering before adding: "Ever think of sending advance notice?"

"What, and give you time to shoot?"

"The offer *is* tempting, when you put it like that." One fierce eye and a forest of whiskers appeared in the airlock porthole before repressurization, followed by a phlegmy *harrumph,* but once Whately and Eline stepped

through, the large, round, hairy man inside laughed and prodded Whately at the filled-out midsection of his spacesuit.

"Well if there isn't more of you than expected. Elaine, you've got to keep this one from the food printer. Lock it down if need be."

"Eline," said Eline, but she pursed her lips before saying more.

"Eline, Elaine, Artie, Arturo. What's a little embellishment to pass the time? Been a *long* time at that, eh, Whately?"

Arturo squeezed through his ship's corridor, and the pair followed him into a living space laden with organized clutter—instruments and stage outfits and life-sized props filling most every inch of the room save for one reinforced console seat, which—from the pillow and blankets and nearby robe and slipper cast-offs—clearly served as bed as well.

Whately and Eline froze at the entrance. "Shut up," said Whately, quietly.

"I didn't say anything," said Eline, in a tone suggesting she might as well have.

"Well," said Arturo, heaving into his seat and sweeping crumbs from the console. "I'm guessing you're not here to assemble a reunion tour."

Whately tugged at the jacket collar under his suit. "El—We've got to track something down. Something that might've ended up in your care. And fast."

Arturo looked ready to make another crack about Whately, but Eline interrupted. "You still keep records, right? Every transaction, every point of origin?"

"Madam," said Arturo, beaming. "Behind this façade of squalor, I assure you, is a man who keeps the most excellent accounts."

"I never said—" Eline started, her face turning red.

"Never mind that now." Arturo waved a hand and alighted on the nearest console. "So! Do we have point of origin in mind?"

She paused. "Oh-one-dash-seven-zero-three. Richard Taka's residence."

Arturo glanced at Whately. "He that guy that—?"

"Yeah," said Whately, heavily. "Still, hell of a musician."

Arturo shook his head. "Hard to separate the two, all the same." His ship's AI drew up the appropriate file and related specs filled all the monitors in the room. "Well now. I've got a couple instruments here, and some nice old vinyls, song sheets, poster rolls, and . . . hm. I remember this one." He leaned forward, squinting. "Some kind of music box, I think. I scanned them all into the system, but after that it was just garbage in, garbage out. Figured Werner might like it for his kids, so I—ah, yep, that one's with him now. The rest are all over the district. You got a piece in mind?"

"I'm looking for something with this symbol on it," said Eline, offering up her weathered piece of hardcopy. Arturo took it and whistled. "Then it's definitely Werner you're going to need to see. Taka used to broadcast all kinds of strange images between sets, but I distinctly remember something like *that* on the music box. I'll give Werner a ring."

Eline and Whately stood in silence as Arturo put out the call. An autoresponse popped up within the minute—*Sorry, you've reached the Hoskins*: *Werner, Mara, Dee-Dee, Tony, Paz, and little Sprout.We're unable to chat right now, but . . .* In the background of the chipper message came the laughter and scrabbling of small children. Arturo glanced at Whately and grinned. "Poor bastard. Probably up to his ears in diapers and screaming. I tell you, he simply switched out one cacophony for another when he left us."

"Can you imagine touring with the whole brood?" said Whately with a grimace.

"We should stop by," said Eline. "Is he close?"

"Close enough." Arturo touched his head in light salute. "Madam, I shall endeavor to contact him while you make your way up-arc. Hopefully none of the sprogs has damaged what you're after—although I have to say, I wouldn't be surprised."

"Thank you, Artie." Eline kept her expression neutral with what Whately realized was great effort. He touched her elbow gently and squeezed. "I, ah—I need to make a quick call before I leave," she said. "Is that all right?"

Arturo assured her that it was and directed her to an intercom in the galley. Whately stayed up front, his eyes straying to a decades-old six-string on prominent display.

"She left you, I gather," said Arturo, switching from basic controls to an elaborate synth soundboard on the ship's console.

Whately drew out the ensuing pause. "She wanted children, *I* gathered. And I just don't see that happening so long as we're stuck in purgatory. Doesn't feel right, you know?" He toed a stack of vintage memory sheets. "Didn't realize you were still producing."

"Always," said Arturo. "Never stopped. Why did you?"

"Beats me. It just wouldn't come to me one day. Or the next. Or the next."

"Fill your head with enough other music and it's hard to hear your own."

"Nah," said Whately. "See, there we disagree—fill your head with enough other music and then you'll *know* your own when you hear it."

"If you hear it. *If* it ever comes back."

"Right." Whately clapped Arturo on a broad, heavyset shoulder. "Well, good chatting with you. We should do it again some year."

"Whately," said Arturo. "I mean it. There's more than one way to leave a mark. You've just got to clear out all that junk, maestro."

Whately notched a brow and nodded to their surroundings. "Look who's talking."

"The real trash is in the orbits of our minds." Arturo tapped his temple, then nodded to the entranceway, where Eline stood with a queasy look upon her face. "Time for a jump to Werner's, I take it?"

"Please," said Eline—first as an affirmation and next, turning to Whately when she spoke, as an urgent appeal.

The recorded message played on, and though the Hoskins' ship's systems seemed active, Eline and Whately saw no movement at any of the viewscreens or portholes—no rollicking dog, no children climbing the walls. The pair entered the outer airlock with little difficulty, their golden sails folding neatly between their arms, but once the external door clicked shut, the faint, pulsating glow of emergency lighting became unmistakable.

"No distress signal?" But even as Whately posed the question through suit comms, he knew they both knew the answer already. An ashen-faced Eline hacked the airlock controls, and within minutes, the inner seal opened a crack. Whately helped her roll the heavy door aside. Eline stepped in first and almost immediately doubled over to retch, barely getting her helmet off in time.

The air hung thick with the scent of decay, and blood trails littered the floor. The dog lay first in their path, then the children—only one shot in the back; another still clutching his entertainment console; all of them more or less heaped together in the family's main living space. There had been no negotiation here, no time to fully grasp the danger they faced: but this small comfort hardly made up for the shock of the scene on whole.

"A grub didn't do this," said Eline, when she could speak in more than single, moaned syllables again. "This is precision work—no damage to the hull."

Whately remained speechless, bracing himself on a bulkhead and gripping the stun gun tight in its holster. When he let his gaze drift down the corridor he could make out the slack limbs of two larger figures in the front section, but he could not bring himself to approach them, to see Werner's body firsthand. It was hard enough to recognize the jacket framed on the opposite side of the living space—its gold topcoat still in excellent condition; the *Maxwell's Last Stand* band patch still affixed to its left breast. One of the children had been shot in front of the case, and there was blood spatter all over the glass.

Eline straightened slowly and turned to Whately. He did not hear her the first time, and almost could not manage the *what?* needed to prompt her to try again.

"I did this," she said, hardly above a whisper. "I called my ship. I told him—I told him we were checking out a lead."

Panic and anger stirred in equal parts in Whately's chest. "Jesus fuck! You didn't tell him *where,* did you?"

"For Earth's sake!" Eline's cheeks shone with tears. "You think I'm an idiot?"

"Then how would he have known?"

"I don't *know*. I don't *know*. I just—how else—oh, *Whately—"*

Whately did not reach for her as Eline knelt by the dog and the children, the knees of her white solar-suit mingling with their blood. He *couldn't* reach for her, much as he wanted to; he felt like he was suffocating, and stumbled back into the airlock.

"Whately—" she said again.

"Go back," he said, heavily. "You have to."

"What, to my ship? I can't, not without—"

"No! *No*—not to your ship." Whately tried not to imagine Eline's family similarly executed, but his fears failed him. The least he could do was try to imagine Eline not present if the discovery had to occur. "Go to Taka's. It's the one place you'll be safe—the one place they already looked and couldn't find what they wanted."

"Do you think they found it here?"

"If they did, let's just hope that's all they wanted. Let's hope that's the end of it all."

"And if it's not? Whately, for Earth's sake, my family—"

"Go," he said. "Right now. To Taka's. I'll go to your ship. Just keep the comm line open and let me know the moment that something doesn't feel right."

Eline hesitated before slipping on her helmet. As she passed him in the airlock, she caught hold of his gloved hand and gripped it tight.

"I trust you, Whately," she said. "If anything I said last week made you think otherwise—I'm sorry. It's not true, and it never was."

But Whately could only nod, the taste of bile rising in the back of his throat.

"Come on," he said, after reactivating the AI through a corridor console. Once online, the AI understood what needed doing, and started the countdown while flashing a giant thumbs up on the monitor. Whately and Eline had glided to a safe distance by the time the ship's interior—depressurized and dropped to a few degrees short of absolute zero—began resonating with the thrum of sonic cleaners. Next would come the vacuuming protocol—every bit of shattered, frozen particulate evacuated into the exosphere; the rest of the ship's contents left in fairly sterile shape. Whately knew he would be back later—for the music, mainly, but he tried not to think on that now.

As he solar-sailed toward Eline's ship, with its extensive cargo of extended family, Whately instead imagined her last three days on board—from Lester's sudden appearance in a fragile state (something Eline's brood never could turn a hard heart to) to her growing realization that something about this new arrival was dangerously off. Awful as it must have been, though, the alternative didn't seem much better; for all he knew, if Eline had still been living with him, Lester would have confronted them on Whately's ship, under Whately's ever-suspicious eye, and then they might both already be dead. Whately was angry, he realized, but it was an anger wrought mostly of helpless, futile regret.

His own three days had been fairly routine, nightly teeth-grinding and lead-heavy grief pangs aside: He'd had his morning weather updates and grid-wide birth and death announcements; the pleasure of constructing an epic power ballad playlist or two, emoting indirectly through the late, great masters of old; and best of all, the occasional off-the-cuff, on-air rant about a rock history dispute decades in the dust. Ship had even flashed an animation of clasped hands upraised in victory after Whately finished an especially stinging rebuke to long-dead critics with completely wrong-headed notions about who broke up a favored punk band and single-handedly brought an era to its devastating end. So they hadn't been the greatest three days, granted, but Whately could not call them the worst.

Eline messaged him the moment she touched down at Taka's ship. IT'S STILL DAMNED SPOOKY UP IN HERE, the message read. EVEN THE SHIP'S STILL FLASHING DOOMSDAY ICONOGRAPHY.

BLESSING AND CURSE OF THE AI, Whately replied. ALWAYS ROOTING FOR ANYTHING ITS DOMINANT OCCUPANT BELIEVES AND DOES.

IS IT BAD THAT I LOVED HIS APOCALYPTIC SOUND ONLY BEFORE I REALIZED HE WAS SERIOUS?

Whately smiled despite himself. NAH, he typed. BEFORE IT WAS ART. AFTER, IT'S JUST DELUSION.

THIS PLACE GIVES ME THE CREEPS—BUT YOU'RE RIGHT, THEY'VE ALREADY BEEN THROUGH HERE. IT'S CLEAN.

GOOD. STAY PUT. I'LL BE IN CONTACT SOON.

Whately could feel his breathing ease and the knot in his chest loosen as he approached Eline's family's ship; through the nearest portholes he could see life, activity, children at play. Tears sprang to his eyes as he entered the airlock, but there they stayed. When Eline's mother answered the comm link, there was no fear in her voice—only pity.

"Well of course, Whately—we're always glad to see you. Only, Eline's not here right now, so . . ."

"Eline and I were just talking." Whately tried to keep his voice casual. "She asked me to stop by and check in."

Eline's mother laughed. "'Check in.' Do you hear that, Lester? So protective of us. Ever since we got that grub report from down-arc last week. Is she out foraging, then?"

"Something like that." The airlock repressurized, and the door rolled aside, revealing Eline's mother—a tall, rocky slab of a woman—and beside her, a small, compact man in his mid-forties, broadly smiling everywhere but his eyes.

"Well come here, then—big hugs. Oh, and I suppose I should introduce you! Unless Eline's already told you about . . . ?"

Whately met Lester's steady, flinty gaze. "She did indeed. You're a lucky man, to have fallen on such good hospitality."

"Very lucky." Lester looked amused in the worst possible way. "And so you're the dear friend of Eline's."

"Sure, something like that." Whately turned to Eline's mother, pausing only to let a small child tear by with a model spaceship in hand. "Is it all right if I make a private call?"

"By all means."

In the relative seclusion of the cockpit, Whately dialed Taka's residence. Eline took a full minute to pick up the feed.

"Sorry. I was just—Whately, the stuff here. I know we were just after the music last time, but if you read his sermons, and it's like he lost track of where it all ended."

"Are you reading them?"

Eline frowned through the vid screen. "You got any better ideas for passing the time? For Earth's sake, Whate—he *broadcast* these. They were everywhere. All this talk of a force from the stars descending and bringing about an end of days." She paused before adding, "So, is everyone okay?"

Whately pressed his forehead to the glass. "Everyone's fine, Ellie. He's still here, though. I just—"

"Need to talk to me, yes, I know."

Whately switched off the monitor and spun about. Lester stood in the doorway with an implacable, forced smile. "We have the box now, if you're wondering. So your services are no longer required."

"You killed a whole family for that box."

"I did no such thing." Lester sniffed. "But yes, such measures were thought appropriate—for efficiency's sake, you understand. Your other friend might have been taken down, too, but we saw no need; once you boarded Arturo's we listened for outgoing calls, and lo and behold—within minutes there was one for the Hoskins. We just move a lot faster than your lot—for obvious reasons, of course."

Whately suppressed the urge to lunge at Lester—with the butt of the stun gun, perhaps, or just his fist. "So you'll leave them alone now. Eline's mother and all the rest."

"Not exactly, no." Before Whately could reply, Lester raised an index finger with a significant air. "Hold on, now. The symbols we had you track down were code, of course. We had most of the pattern but the proportions had to be precise, and there were pieces missing from the original design. But once properly converted, the program will bypass all AI safeguards and take control of every blessed ship in orbit."

Whately stared awhile. "Who the hell would construct such a thing?"

"Why, Richard Taka, of course, with the help of his AI. Brilliant man on the airwaves—very much missed. Years of his apocalyptica—the speeches, the songs—have made everything quite clear. The current state of affairs cannot go on. An end must come, and a force from the heavens will make it so! The grubs have always understood this, but never with the depth of Richard Taka. Granted, it took us a long time to grasp the code of his broadcasts, but when he passed away, with that final image broadcasting on repeat . . . well, then the meaning of it all became clear. This is his final gift to us—the one true way home."

Whately's mouth went dry. "But you're not talking about a proper descent. No way can you steer thousands upon thousands of ships to a safe landing all at once."

Lester shrugged. "So we burn up. It's the swifter end, all things considered. Humanity's long overdue for a proper extinction event. What we have up here—it's beyond undignified. A sham existence, crying out to be rectified for once and for all."

Whately made to stand, but Lester lay a hand on the cuff of his old jacket. "It's too late, you understand. We already have the code and it's being processed as we speak. Any hour now—any minute, really—the signal will be sent out, and all else will be irrevocable."

"There are children up here," said Whately.

"I know," said Lester. "Monstrous, isn't it? The existences we condemn others to for fear of our own mortality."

"Does your own survival instinct count for so little?"

Lester laughed. "You forget: There is another, better world yet to come. Relax, Whately—sit, sit down. Play us a tune or two to pass the time. It won't be long now."

Whately had often speculated what song he'd put on if he knew it might be his last, but all his best answers over the years escaped him out of sheer revulsion for Lester's calm demeanor, and the laughter of children down the ship's corridor, and the thought of Eline all alone on Taka's derelict ship. He waited in pointed silence instead, staring Lester down. Within half an hour, a piercing sound came over the intercom, and Lester's smile at last leapt into his eyes—a fierce, fanatical gleam.

Whately gripped the arms of his seat. Lester held on to a bulkhead, peering out the front viewscreen. The AI had its "processing" dots running, and then—nothing.

Lester frowned, darting to the monitor and cycling through for record of the signal. "It can't be," he said. "Why didn't—"

Whately glanced over Lester's shoulder in time to see the ship's recent logs scroll by. The signal had certainly entered the network, but instead of bypassing the AI it prompted the transmission of a second signal—not to any of the other ships, or even Earth below, but to a relay station with its antennae turned to the stars. From the steadiness of all other ships in orbit, Whately could only surmise that the same reversal had happened on them, too.

"Well I'll be damned." He laughed, scratching at the wild mane of his hair. "Looks like Taka was more of an optimist after all." Lester still looked confused, so Whately went on, hardly containing his grin. "The end of the situation—but not annihilation. The promise of something new. Your crew's been barking up the wrong tree. You just sent a distress signal from every ship in the grid—and I'm guessing they're all pointed at the same source."

Lester shook his head, muttering, *"impossible—I need to speak to"*—as he made for the airlock. Eline's mother tried to say something to him, but he was too busy donning his gear. Eline's mother shot an incredulous glance at Whately, but all Whately could do was shrug, still beaming. He switched the monitor on again, and this time Eline picked up right away.

"Sorry," he said. "A little turbulence there, but Lester's on his way out."

"For good? Alone?"

Whately hesitated, watching Lester prepare out the corner of one eye. "He looks defanged, Ellie, but still dangerous. We'll take all the proper precautions once he's gone."

"And then you'll tell my mother the whole story?"

"Me?"

"Please, Whately?"

Eline and Whately watched each other in silence through the vidscreens. Then Whately put his fingers on the glass, and Eline followed suit on her end.

"Okay, but you owe me."

She hesitated before replying, all wan smiles in the dark. "Yeah. I really, really do."

Whately's feet woke to the beat of Ship's radio. Eline kept time with her fingers on his chest. An hour later, they slid from the bunk and ate hot rolls fresh from the food printer—Whately making—and Eline vetoing—suggestions between bites to round out the morning's set. Ship ceded the airwaves to Whately on his mark, and after the morning weather report and announcements, Eline pointed to and Whately commented upon the small, strange glimmer growing steadily larger twenty degrees from the arc of the Earth.

"Is it rescue?" Whately asked between numbers. "Or something else? Who knows?" He held up a memory sheet for Eline's approval; Eline squinted, then smiled to see Whately's personal mark in the artist's corner. Whately fed the sheet into Ship's monitor. "But I promise you this, folks—until it arrives, we'll be right here, broadcasting all the latest jams alongside the greatest hits our shitty forefathers left behind. And whoever's out there, whatever their designs might be, I bet they ain't *never* heard a tune even half as good as this."

Ship, already all applause animations on screen, needed no prompting to agree. ■

The Crashing of the Cloud

Norman Spinrad

Allah be praised, Hassan heard the drone before it fired its first Hellfire missile and had just enough time to swerve the car off road to make it narrowly miss before he and the American managed to roll out of the rusty old Jeep, which kept on going riderless into the desert long enough that the second missile locked on it and blew *it* to pieces and not them with it, thus depleting its ammunition and allowing the two of them to live to tell the tale.

I am not getting too old for this, Hassan told himself, I became too old for it years ago; I've been serving the cause of the New Caliphate as a cyber jihadhi for a decade now, and my days dodging American drones should be long over.

"You can relax now," he told Brother Rat, "these satanic things only carry two missiles, and we'll be picked up before they can send another."

"Yeah, right. I've been dodging drones and death squads since I reverse engineered myself out of the U.S. of Assholes and into Mexico. You'd think I'd get used to it."

"You never get used to it," Hassan told him.

"No shit, Sherlock?" the American infidel said, whatever that was supposed to mean. That an American was an infidel was about as strange as a Yemeni chewing *khat.* Were they not a nation of infidels? But the handful of American jihadis in Yemen were all Brothers in Islam, and Hassan did not see how it could be otherwise.

So when the notoriously famous superhacker Brother Rat, having fetched the Great Satan a mighty blow, fleeing the wrath of America, had been granted sanctuary by the Council of Sheiks of the New Caliphate, Hassan had assumed that he had to have converted to the Faith.

But when the Cyber Jihadis of Yemen had been ordered to protect him in the hospital safe house, and Hassan, being the most revered cyber jihadi in Yemen, had been sent to fetch him, Brother Rat had made it clear that he was no righteous convert.

Which, however, would not prevent him from being useful to the cause. Edward Snowden had downloaded quadrillions of gigabytes of juicy secret data, another great political defeat of the Great Satan having nothing to do with loyalty to Islam, but Brother Rat had managed to secrete his bots into the Internal Revenue Service data banks and wipe them "clean as a psychopath's conscience," as he put it.

"But I could care less about your religious reasons for saving my ass from those humorless bastards. I've got a simple reason for playing cyberball on your team, and seventy virgins in Allah's paradise ain't it. Survival is. Besides which, take it from me, *one* virgin is headache enough. The enemy of my enemy is my friend—wasn't it one of you dudes who said it? Let's get real, I'm agreeing to work for you because you're agreeing to gimme shelter as long as I do. Good enough for me, and gotta be good enough for you, too."

And indeed it was. How could it not be?

Brother Rat had taken gleeful credit for the golden coup of kicking the IRS in the *cojones* all over the web, knowing before sending forth his bot cloud that it would not only make him the Ace of Aces in hackerspace but the white knight who slew the taxman dragon. An instant hero even to the sort of muggles who didn't care jack shit about the art of the deed.

Two ears and the tail, amigos, and shutting down the IRS's ability to collect its ton of flesh from anyone for at least a fiscal year would therefore protect him from the legal consequences.

How could Federales arrest him when they knew no jury would ever convict the dude what crashed the IRS, like that guy who slashed the tires of the police tow trucks in New York? They had to drop the charges because the prosecutor knew he could never get a conviction, so whatever the law was, the great Brother Rat, hero of the people, was likewise protected from it.

It had never occurred to him that Federales, lacking any sense of humor or appreciation for his masterpiece of the hacking art, would be so pissed off that, knowing that no jury would ever convict him, would instead decide that they needed to hit his delete button by whatever means necessary before he did something even worse. Meaning a presidential finding invoking extreme prejudice and turning the contract over to the Black Ops Boys, human or otherwise.

Meaning he had been running for his life, and, unlike Snowden, he was too radioactive for any government, no matter how much an enemy of the United States, to give him five minutes of sanctuary.

So there was nothing for it but to offer his services to the so-called New Caliphate, a real life terrorist franchise likewise in the crosshairs of Uncle Sam. Services whose value to those who put the Great Satan on *their* kill lists he had more than amply demonstrated.

A trudge across the border into Mexico, a boat trip from Merida to Cuba, a flight from Havana to Angola, slip into Saudia Arabia, contact with this Yemeni branch of the New Caliphate, a sweaty jeep ride south across the desert, and a narrow escape from a drone attack.

But wherever you go, there they are.

Being top hack in the Cyber Jihadis of Yemen, Hassan often had to work in English—who in the cyber war didn't?—keeping the CJY's Arabic and English websites running ahead of the enemy hackers, occasionally taking down *their* sites for an hour or two. So he thought he understood the English language well enough, or at least the cyber dialect. But the great Brother Rat seemed to speak a dialect of English all his own, with which Hassan found himself a good deal less than familiar.

"I ain't no Muslim jihadi like you, *compadre,* and I ain't no revolutionary patriot like ol' Snowden, I don't give a swamp rat's ass about parlor tricks. I ain't analog, I'm digital, I'm an *artist,* I did it because it was max cool, because no one else could do it, or if they could, I wouldn't let them get to do it first. Wouldn't you? Who wouldn't screw the IRS if they thought they could get away with it? *C'est toute.* I wasn't out to overthrow the powers that be and replace them with what, Artificial Stupidity, like the meatware version ain't stupid enough, boys just like to have fun, but they don't see it that way, so now it's a matter of self defense, the survival of the shittiest."

Searching the sky and seeing that the drone had retreated, Hassan took the risk of turning on his cell phone long enough to send a coded message and a GPS fix. A nervous hour or so later, a couple of Vespas took them the rest of the way to the children's hospital.

This was a two story cement block building set in a small oasis more or less in the middle of nowhere with a red crescent on the white-painted aluminum sheet roof and a red cross for the benefit of the aerial infidels.

Hassan led Brother Rat into the first floor, a single huge ward jam-packed with beds, pallets on the floor, all stacked with sick and/or wounded children.

"Say what?" observed Brother Rat. "This looks like a children's hospital."

"That's what it is," Hassan told him, on the way down a stairway to the basement. "We're hidden in plain sight. The Americans probably have us targeted, but how could they pay the political price to authorize the strike and martyr scores or hundreds of sick children?"

"Hard core," Brother Rat grunted.

"Hard war," Hassan told him.

Brother Rat hadn't really bargained for anything in particular, having zero leverage when the New Caliphate offered him sanctuary when no one else would. They'd keep the U.S. government from killing him, and he'd pay for his keep by doing what they asked him to do, whatever it might be.

Given that he wasn't even any good at shooter video games and was the hacker Ace of Aces, it didn't figure that they'd hand him a Kalashnikov or strap on a suicide vest. He was valuable to whatever their cause was because he could do what they couldn't in cyberspace, not as expendable gunfodder or sand kamikaze.

Still, he was beginning to get a little nervous, since he was beginning to get the idea of what sort of people the Cyber Jihadis really were: clever enough to think of putting their operation in the dirt floor cellar of a children's hospital, daring the drone pilots to commit the ultimate flagrant crime against humanity to take them out, and ruthless enough to do it.

Somehow, Brother Rat was beginning to understand that he was no longer in Uncle Sam's Kansas. Or a video game whose viewpoint character was Lawrence of Arabia.

Where he was was in a half-assed bunker beneath two floors of sick and wounded kiddies serving the cause of whatever the cause was as human shields, in the hopefully correct belief of the jihadis they were shielding that the Yankee homeboys wouldn't blow them to dogmeat in order to do likewise to themselves.

But given that he had just barely survived a drone strike and he was here because everything from the CIA to the SEALS to The National Doesn't Exist Agency were after him with James Bond's license to kill, Brother Rat seemed a tad less sure about that than they did.

The CJY hole in the ground was Third World even for the Third World. It was kept from turning into a pressure-cooker of armpit sweat by creaky air-conditioning, or at least to a survivable extent. It was a single room containing the hardware, a disgusting Turkish toilet, an electric plate kitchen, and bedrooms about the size of the cots in them, all separated by rancid sheets of canvas.

Shithole though the digs were, the hardware was surprisingly boss. Not top of the line maybe, but a lot better than he had dared to expect. Untold quantagillions of memory, all of it solid state, some sort of huge antenna array occupying half the top floor of the hospital somehow connected to a GEO satellite for redistribution that could connect to most any site on the web, or so this Hassan claimed proudly.

Hassan himself was a hard case for Brother Rat to debug. On the one hand, he *was* a hard case. He carried an AK-47 on his back for show, told him when and where to sleep, prayed to Mecca five times a day, strutted around the bunker like a rapper rooster, and as the hacker in chief, he ruled this roost. But he followed Brother Rat around like a fanboy, as after all he should, seeing as how inside the soldier boy costume was a fellow hacker eager to learn what he could from the Mighty Quinn.

If he had a pen and a magazine picture, he probably would have asked for an autograph. If he was ordered to cut the Ace of Ace's throat with a rusty meat cleaver, he probably would do it without blinking an eye.

Hassan would have found it an honor to be summoned into the presence of Sheik and Imam Salman al-Yemeni, but to have the legendary future Sheik of Yemen travel here to meet with *him* in his hole in the ground would have been an honor almost beyond his comprehension, did he not know *why* Sheik al-Yemeni had arranged this meeting, namely to prepare him to meet with the legendary Brother Rat.

Whether Sheik Al-Haj Imam Salman al-Yemeni was really a Yemeni was a mystery, perhaps deliberately so, as was whether the title of Imam had indeed been conferred on him

in the Masjid al-Haram, or whether by the Council of Sheiks for political purposes. What was well-known was that he had fought against the Great Satan and for the New Caliphate for decades in Afghanistan, Iraq, Syria, and battlefields best unnamed, before being named Sheik of the Sheikdom of Yemen whenever it would become part of the Caliphate.

Hassan had been told that Sheik al-Yemeni had persuaded the Council Sheiks to give sanctuary to Brother Rat when he was ordered to take him to the bunker beneath the hospital, to befriend him if possible, judge his true purposes and his personal reliability, and offer advice as to how best to bend this hacker ace to his will and that of Allah.

And now he had to brief Salman al-Yemeni himself! What was he to say to a man such as that about a man such as Brother Rat?

It was obvious that in return for sanctuary, Brother Rat would be required to create cyberspace weapons to be used against the Americans. Against his own people. A despicable thing for anyone to do, so Hassan had assumed before learning otherwise that he was an American Muslim convert who had raised his loyalty from mere loyalty to his country to dedication to the sacred cause of Allah. Nothing despicable in that!

But Brother Rat was not a Muslim and, rather than being a traitor to America, believed with ample justification that *America* had been a traitor to *him,* seeking to kill him for what he considered a great jest rather than treason with no regard to its own professed legal code.

He seemed willing enough to begin working for the cause, so could that not be a first step to believing in the cause that he was working for, and joining the cause of restoring the lost Caliphate as a true member of the Umma?

And Brother Rat seemed eager to get to work. He inspected and reinspected the equipment. He asked questions and offered improvements. He told tales of his hacking exploits. He answered questions freely, regarding Hassan as a hacking brother. Clearly this was a man who loved his work for its own sake, honorable or not. Clearly honor was a sense he was lacking. Clearly, too, that he shared knowledge freely, asking no more than the pleasure of sharing it with a sincere true colleague.

This Hassan could understand, for in that at least they were brothers, for he too took pleasure in an artful hack for its own sake as well as for its service to the cause, nor did he see any sin in that. But the notion of taking such pleasure in writing the code with indifference to what cause it was serving, indeed apparently indifference to serving *any* cause at all, was something he could not comprehend, and didn't really want to.

Sheik al-Yemeni awaited him in one of the sleeping tents, the only sort of private chamber down here, seated on one end of the cot, and yes, chewing *khat.* Wearing a hooded white tribal robe embellished with camo ribbon. Gray of beard, weathered of hawkish visage, warrior-straight, gaze like steel.

The Imam Sheik gestured wordlessly for Hassan to seat himself before him. "Tell me of our prize American."

"What do you wish to know?"

"To begin with, do you believe he can be trusted?"

Hassan squirmed, shrugged in bewilderment. "The question is trusted to do what? Evil men like the American government and their drone pilots, I can understand. They serve an evil cause, and therfore are our enemies. But a man who cares not to serve any cause at all, but will serve whatever cause meets his price in order to do nothing more than survive to take pleasure in the practice of his art . . . this . . . this . . ."

Salman al-Yemeni came as close to laughing as Hassan could have expected him to. "Such a man is called a mercenary," he told Hassan dryly. "Surely you have encountered them one way or another. Who of us has not?"

"Well then," Hassan told him, "I believe you can trust him to be a mercenary. Is not a mercenary a man who fights for his own self-interest because he enjoys war itself and cares not what cause he fights for?"

"Nicely put, my son. Therefore not at all to be trusted with avowed suicide missions, but skilled and useful soldiers in battle and conveniently expendable when made to believe their mission is not suicidal. But might you not believe that in the end this Brother Rat may retain *some* loyalty to his country? That he might draw the line at striking the Great Satan a truly mortal blow?"

"Mortal blow?"

"When this man destroyed the memory of the American tax collectors, their government lost a year of income, but it survived, if barely, by somehow borrowing from itself, and now the American economy is benefiting from the so-called tax holiday. But if Brother Rat could do something like that without even caring about the greater result, what might he not accomplish if ordered to destroy the internet—

"*Destroy the internet!*"

"—and thereby bring down not only the American economy, but the economies of its European vassal states, the Japanese, perhaps even the Chinese, the entire globalized infidel economy, connected as it is by the internet. Is the internet not also called the web and for good reason? Is not America the spider that sits in the center pulling the strings of its puppets? Is not their so-called global civilization the true body of the Great Satan? Without the web to bind the puppets to the puppeteer, will not it crumble to pieces and fall?"

"You don't understand!" Hassan found himself blurting and instantly regretting.

"What is it that you understand that I do not?" Salman al-Yemeni demanded with a coldness worse than any angry outburst might have been. "You are more skilled in the economic aspects of the political struggle than I, perhaps? You do not believe this would lead to the collapse of global infidel civilization? And therefore bring about the birth of a New Caliphate built triumphantly upon the ruins?"

"No, no, no, I mean, yes, yes, yes, all that is as you say, Great Sheik," Hassan hastened to grovel. "Were it possible. But alas it is not. The internet is not like a spider's web. There is no coherent overall pattern, no center with a spider in it. It does not have a specific hardware locus like the Internal Revenue data in its dedicated computers. Its data is redundantly dispersed all over the world in millions of computers. It runs on millions of servers likewise redundantly. It is not the hardware it runs on, it is not a single program, it is not even the traffic that runs on it. It is none of these things and all of them together. It is both far greater than the sum of its parts and holographically distributed among them."

Sheik al-Yemeni regarded Hassan with angry bewilderment. "Were I an infidel, I would cross myself, for to the extent that my mind can encompass such gibberish, you seem to be saying that the internet, having no material body that can be slain to destroy it, is a disembodied evil spirit. An immortal djinn in the service of the Great Satan."

Hassan fearfully realized that he had talked himself into perilous waters. How was someone like Sheik al-Yemeni to understand such geek-talk, however true? And yet was what the Sheik said not also true? A subtle truth in a dialect that *he* could not quite understand.

But what he *did* all too well understand was that this was a man who did not tolerate disagreement with his words of wisdom, let alone his order. So he had better explain why Sheik al-Yemeni's order to destroy the internet could not be obeyed in terms *he* could understand while somehow not disagreeing with a word that Salman al-Yemeni said.

"I confess, Sheik al-Yemeni, that I had not realized this was so until you had enlightened me. Indeed the internet *is* itself an . . . an . . . immaterial . . . phenomenon, and therefore, not being Allah, can only be a satanic djinn—"

"Or worse, not merely a *creature* of the American Satan, or even just a demon, perhaps even Satan himself! And might we not by destroying the internet slay the Devil and bring the rule of Allah to all the world forever?"

The internet is the Devil?

And hackers could kill Satan and bring about eternal Paradise by taking it down? He was a Yemeni, but all the *khat* in the world could not get him to choke down that one. For if it would have been obvious blasphemy to *worship* the internet, how could he not love it? For the internet was the medium of his craft as clay was the medium of the potter. Destroy it, and he would be nothing.

Fortunately, that was impossible.

But how could he explain why to the Sheik without further arousing his ire?

"Allow me to leave questions of such deep spiritual matters to such as you, great Imam," he said. "I serve Allah as but a cyber jihadhi. But as such a mere technician, I must tell you that . . . no software can take down the entire internet because—"

"No software yet written!" Salman al-Yemeni exclaimed angrily. "Why do you imagine the Sheiks' Council gives sanctuary to

Brother Rat when not even Russia or Iran or North Korea would so dare the rage of America? How do you suppose I convinced them to do it?"

"You convinced them . . .?"

"You believe little Yemen dominates the Council? You believe my legend sufficed to do it? I made the greatest and most dangerous gamble of my life. I promised them that Brother Rat would bring down the internet, that's how! That when he did, the Great Satan would be vanquished!"

Hassan quailed in the face of Salman al-Yemeni's brave and gallant warror's spirit even as those unfortunate infidels who faced him in battle must have.

"Do you have any idea of the size of the game? Do you have any idea of the risk I have taken? If my promise is fulfilled, I will be the Caliph of the New Caliphate when it is born. If it is not, I will not remain Sheik of Yemen. I will not escape with my honor. I will probably not even wish to escape with my life!"

Salman al-Yemeni glared ferociously at Hassan, but more terrifiying than even his rage was the fear behind it, the mortally desperate determination.

"And neither will you," he said, as cold and hard and sharp as an executioner's sword.

"Bring down the internet? Yeah, sure, the Olympic Gold for hacking, the ultimate hack, the cyber philospher's stone. Too bad it can't be done!"

"Even by the Ace of Aces?"

"Are you for real, dude, or are you Memorex?" Brother Rat said. "We both know it's impossible."

"You're sure?"

Brother Rat could see that Hassan knew the answer, of course he did, but the dude was just about pissing in his pants. Or worse. Having gotten here by making a deal with crazed terrorists who thought nothing of blowing *themselves* up to make whatever their point was supposed to be, he knew damn well that his ass would be grass if he didn't deliver on his end of the deal. Best case scenario, out there all alone dodging drones and hit squads. Worst case, and more likely, a star on YouTube getting his head chopped off with a samurai sword.

"Of course I'm sure, Hassan, and so are you. Don't you slather me with that groupie *manteca,* and I won't pretend I can rewrite bullshit into magic. It'd be like taking down the global weather patterns, or the planetary magnetosphere, or rock and roll, proven mathematically impossible, kiddo—"

"—because the internet is transient chaotic patterns in massively dispersed and redundant material matrices—"

"Because it ain't got no body, Hassan."

"It is like the cells of our bodies on hundreds of supercomputers, millions of mainframes, billions of SDs and hard disks—"

"Voila! There we are!"

"And where is that?" Hassan asked him, obviously knowing the answer all too surely.

"I would say the technical term for our current locus is up shit creek. Wouldn't you?"

"We must tell Sheik al-Yemeni that what we have been ordered to do is impossible. We are doomed."

"I said up shit creek, my man," Brother Rat told him. "I didn't say without a paddle."

Hassan looked at him as if he had said it in Serbo-Croatian.

"Look, you're sure that this jihadhi *don* can't be made to understand that taking down the whole internet is simply impossible?"

"I tried, and I tried, and I tried. . . ."

"Very interesting Captain, sez Mr. Spock. Correct me if I'm wrong, but this Luddite muggle wouldn't know ROM from RAM even if it was shoved up his ass."

Give the kid credit: Hassan didn't quite laugh, but he did have to swallow it back.

Brother Rat could feel his meatware computer flipping into warp drive. "So that's our paddle! He wouldn't know the Cloud from the internet, now would he, Watson?"

"*The Cloud*?"

"Existing on a manageably finite number of server computers, all, or at least most of them significant enough to matter, cross-connected for redundancy, and backdoored up their wazoos by at least a dozen major cyberwar outfits . . ."

"Which you've already hacked, I gather?"

"Well, not all of them, just the Americans, the Chinese, the British, the French, and the Russians . . ."

"More than enough entry points into the system . . ."

Hassan regarded him as, well, the Ace of Aces. Which he was, was he not?

"Piece of pizza for the cyberwizard who wiped the IRS memory banks. Same basic program on a somewhat larger but simpler brute force level . . ."

"A bot cloud penetration . . ."

"Doesn't even need extra code to make it viral . . . because it doesn't have to go viral."

"A wipe of all the data stored in the Cloud . . . and all the software that lives in the Cloud too . . ."

"Or just a shutdown and lock command."

"Simple when you think of it. . . ."

"So was the invention of the wheel when someone thought of it," Brother Rat modestly told Hassan. But his brainware RAM was beyond that and running in Machiavelli space.

"I'd call this stroke of genius the bait and switch and the dead man negative option. He'll never know the difference and he won't go away mad because he will think he more or less got what he ordered from the menu. As far as he's concerned, he more or less *will* get what he ordered, a giant cyberwrench thrown into the gears of the entire globalized economy, banks, stock markets, credit cards, fund transfers, major corporations, billions of individuals bullshitted into keeping everything in the Cloud. . . ."

Hassan seemed to be making a career of staring at him in worshipful bewilderment. So why not Sheik al-Yemeni? Was not Brother Rat a bewildering genius?

"Time to go make the pitch, Hassan. And you better let me do most of the talking. Let Mandrake the Magician gesture hypnotically."

Hassan assumed the same respectful position on the cot facing Salman al-Yemeni that he had before and was somewhat aghast when Brother Rat sat down on the floor facing the two of them in lotus postion, turning himself into the focus of the triangle even while sitting below the Sheik's eye level. A magician of some nameless magic indeed!

"Look, my man," he began, "you're the boss here, you give the orders, you can chop our heads off if we so much as fart, but your Allah created the program running the Universe of mass and energy, now didn't he? So wouldn't it be blasphemy or something to order me to do what Allah has made impossible to do?"

"Spare me further sophistry, and I will spare you from having your head chopped off for saying such a thing," Sheik al-Yemeni told him. "For the moment, as the Sultan said to Scheherazade."

It did not seem to Hassan that this was going very well.

"Your wish is my command, Aladdin, but I'm not the genie of the lamp. I am, however, Brother Rat, Ace of Aces, who brought the evil dragon of the IRS to its knees, cyber enemy number one as far as the United States is concerned, and I can put together an electronic cutie that will save all three of our asses."

Brother Rat glanced deliberately at Hassan. "I'm given to understand that you've got a lot of your chips on this roll of the dice." Hassan wished he hadn't. "Like all of them? Like the three of us are in the same caca canoe if we don't at least put on an acceptable show for our audience?"

Hassan cringed.

But Sheik Salman al-Yemeni just said, "Continue."

"I think you've already been bored with the technical details by pal Hassan. . . ."

Hassan broke into a sweat. What was this man doing to him?

"And since as hackers go, he is as good as it gets unless you're me, he did as good a job of explaining our magic to a muggle as anyone could, so I won't insult him by trying to do it myself. I am a naïf when it comes to Islam and jihadi politics, and you are on another planet when it comes to cyberspacial physics and metaphysics, so I will give you the CliffsNotes version. The internet, for our practical purposes, is everything that moves around in cyberspace: energy packets, not matter, but ultimately it must be contained by matter. Computer memories and operating RAM. No different from the electricity in a lightbulb. Don't blame me for this, I didn't do it."

Hassan felt his mind open, and his jaw probably dropped too, for never had he heard such a simple explication and he certainly hadn't come up with one like this himself, such that the Sheik simply nodded his comprehension, and ordered with a little raise of his hand for Brother Rat to continue.

Whatever the Sheik didn't know about cyberspace, Brother Rat knew he was not talking to a nobody maroon; this guy was as much a power in his reality as Brother Rat was in his.

This might have been a cause of greater concern for the unwashed masses, but for the Ace of Aces, it was a relief, he had little patience for dummies.

"That's the internet. Can't be destroyed by anything short of an all-out nuclear World War, and even then there'd probably be some hardware left to boot bits and pieces. But there's a current lion's share of the internet called the Cloud. The Cloud is stored data and online programs. That's all it is. In the cyber Jurassic, data and programs were replicated and stored on individual computers. Cut to the chase—namely the chase of behemoths like Google and Microsoft and Apple and their camp followers after the max moola—and instead of selling copies of programs to your customers, you rent them time to use them on your own computers. To persuade the suckers to pay forever for something they were used to owning, and throw in the storage of their data at sweetie-pie rates. They will then be doing their computing where their data is, where you control it, and there you have it. The Cloud!"

Brother Rat could tell that the Sheik was getting it by the way he was now leaning forward and his right foot was wriggling excitedly.

"Cut to the present where the Cloud dominates the internet. When more of the internet than not is data and programs stored on the servers and computers of the Cloud. Wall Street. Supermarket chains. Department store chains. Factories. Billions of ordinary people's vacation videos and fave rave TV and music. Maybe military stuff we don't even know about."

"You are saying you can do to this Cloud what you did to the American Internal Revenue Service?" Sheik al-Yemeni was taking the bait.

"Better and easier," Brother Rat told him. "My program for this doesn't have to bother wiping data. It just shuts the Cloud facilities down and keeps them down . . . until . . ."

"Until?"

Brother Rat grinned like a sarcastic ape as he closed the deal. "Until I am persuaded to turn them on again."

"And what would it take to . . . persuade you to turn them on again?"

"Well now, that might take some doing, wouldn't it?" Brother Rat told the future Caliph of the New Caliphate. "Seeing as how your team just might not like me to ever do it."

"You are offering yourself up as a martyr? For of course we wouldn't, you are in our hands, and all we have to do is kill you. How can you trust us not to?"

"Would you be willing to swear on the Koran that you wouldn't as long as I remained in your luxurious protective custody? The best equipment left in the world for me to play with, a Mercedes because my friends all drive Porsches, a harem of no more than a mere dozen damsels, inexperienced virgins need not apply, and an unlimited expense account."

"Indeed I would be willing to so swear. . . ." said the Sheik. A strangely dreamy look came into his softened eyes. "And I am deeply appreciative that even being an infidel you would trust an oath on the Koran with your life, unless of course Allah has spoken to your heart. . . ."

"No way, José, and no offense, great Sultan, but cynical infidel that I am, I will feel better giving you a gift of self-interest in my survival"

Salman al-Yemeni's gaze rehardened.

"A gift to *me* to protect *your* survival?"

"As long I'm alive, the reboot of the Cloud is in my power, and I'm in yours. Make a deal with the Great Santa Claus to turn it back on, and I do it. Like diplomatic recognition of your New Caliphate, withdrawal of American troops from the Eastern Hemisphere, ten tons of gold, half of all the pot grown in California, whatever deal you make, not my job. Take your time, as long as you keep me healthy, you've got the world by the *cojones.* Inshallah, my man, that should be at least twenty or thirty years, and that had better be enough to cut your New Caliphate a deal, of which, I have a feeling, you will then be Honcho for Life."

He gave the Sheik a nice shit-eating grin.

"Because if I do not send a stop annually, what I've turned off automatically turns back on."

The hook, line, and sinker.

Brother Rat rose and offered Sheik al-Yemeni his hand.

"Now isn't that the famous offer you can't refuse?"

Sheik al-Yemeni grinned like the proverbial cat about to swallow the proverbial canary.

"Why would I want to?" said Sheik al-Yemeni and took it. ■

THE LIMITS OF BELIEF

Now that Jeffery D. Kooistra has moved on from his AV post, we'll be running a series of guest columns in the space before we settle on a permanent replacement. In the mean time, we'd love to hear your thoughts on the kind of Alternate View you'd like to see going forward. —Ed.

Privileged to provide the first follow-on Alternate View after Jeff Kooistra's illustrious fifteen-year reign as columnist, I have a confession to make to *Analog* readers: many of my views on controversial topics truly *are* alternate views. Based on my career in high-tech industry and highly classified government and defense projects, I was always expected to support certain Established Truths. With a doctorate in engineering and a career that included White Sands Missile Range, Bell Telephone Laboratories, Sandia National Laboratories, and the White House Science Office, plus cofounding a NASDAQ-listed virtual reality startup company, a biotech equipment firm, and other high-tech efforts, I was obviously supposed to be a standard fixture of the Conventional Knowledge Establishment. But I never was. And still am not.

Even now I am asked, "Why do you persist in such delusions when we have already pronounced what is Settled Science and what is Pseudoscience?" My answer is, simply, "I am not a scientist. I am an engineer, and engineers don't do science; we merely work with reality." I go on to explain that obviously I take science and engineering seriously because they are the foundations upon which rest our present civilization, with all its wonders and achievements. I do believe in the future and the progress of mankind through research and technology.

But inspired by, among others, former *Astounding/Analog* editor, John W. Campbell, Jr., I also recognize that the innate conservatism of science and its formal institutions does not always allow for the serious investigation of anomalies and unexplained phenomena, items categorized by author Charles Fort[1] as "Damned Facts." To the contrary, such reports are most often met with sneers or near hysteria. In an earlier letter to *Analog*[2], a co-author and I bemoaned this willful ignorance.

My own limits of belief, then, occur at the point where science offers explanations that either contradict my own experience or knowledge, or which appear to be merely uninformed speculation about what is truly unknown. Up to the point where scientists and other scholars produce useful and important information, they are to be trusted and respected. But when venturing into what to them is speculation, then maybe not so much.

Among my interests—often classified under the pejorative term, "fringe"—are "belief" in advanced ancient civilizations and technologies, in the paranormal, and in the cyclical (and natural) quality of climate change. Others may share some of these same beliefs, though are reluctant to admit as much. The following examples, necessarily very brief, indicate how my personal belief system functions, and may provide some guidance for others who have similar interests and doubts.

Engineering Before Science: A Concrete Example

The Pantheon in Rome, for centuries the largest unsupported dome on Earth, was built in the Second Century A.D., of Roman concrete.

[1] C. Fort, *Book of the Damned*, Boni and Liveright, New York, NY, 1919.

[2] A. Andrews and R. McConnell, "SETU: Society for Explaining the Uninvestigated," "Brass Tacks," *Analog,* March 1974.

The scientific analysis of precisely what made such material so useful and enduring was only performed 1,900 years later,[3] a perfect example of artisans and engineers doing practical work with only empirical knowledge. Accomplished millennia before science even existed, this should be a salutary and cautionary example to modern scientists and other authorities.

Advanced Ancient Technologies—The Cutting Edge

In 2011 I appeared briefly on the infamous cable TV show, *Ancient Aliens.*[4] In an hour-long interview that was finally cut to half a minute onscreen, I eschewed any alien influence on ancient technologies, maintaining that ancient humans were quite capable of producing all the artifacts discovered. But I did point out that my friend Chris Dunn had shown that some kind of advanced machining techniques were responsible for the thin, deep carving of hieroglyphs on Egyptian obelisks, and for apparent high-speed tool marks on other Egyptian stonework. Unfortunately, my references to Chris' original works[5,6] were edited out.

Why would I believe in advanced ancient technologies when conventional archaeology disputes them? Chris Dunn summarized it very well, after a trip through the Egyptian Museum in Cairo during our visit to Egypt in 2008. Pointing out the array of tools shown in the museum's glass display cases, he noted that the same tools—copper chisels, inexact wooden instruments, primitive saws, sharpened animal bones, etc.—had allegedly been used by ancient workmen over a three-thousand-year span of time. "No improvements during three thousand years?" Chris asked. "That alone is enough to convince any engineer or artisan that the whole story is not being told." I agree.

* * *

The Paranormal

My own "belief" in the paranormal evolved primarily because of personal experiences with detailed precognitive dreams, poltergeist incidents witnessed by myself and others, and the many dozens of times I have personally witnessed verified demonstrations of clairvoyance, telepathy, and precognition.

My first paid publication was a speculative article[7], in which I modestly took on the task of explaining all paranormal phenomena, including reincarnation. In addition to coining a new word, "parascience," the article was the first to suggest that the complex and interlocking electromagnetic fields of the human brain might exist embedded in, but independent of, biological surroundings, and be capable of surviving intact on their own. This would enable a duality that could account for consciousness, out-of-body travel, ESP, the appearance of reincarnation, and many other reported phenomena.

That same year, I proposed to my employer, Bell Telephone Laboratories, that we should investigate ESP scientifically[8]. I was politely but firmly turned down. Later, I was first to propose using newly developed scientific instrumentation for investigating poltergeist and haunting phenomena,[9] some of which unfortunately is widely used today in unbelievable "reality" shows.

I had thought, back in the 1970s when I wrote the article, that the possibility of finding new natural phenomena, perhaps other methods of detection and physical manipulation, or entirely unknown but measurable fields, and maybe even new laws of physics, would excite the imaginations of scientists and lead to new discoveries. Imagine my surprise when reputable scientists and respected science fiction authors not only denied the existence of all such phenomena, but resorted to *ad hominem* attacks or near hysteria when I even broached the subject.

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[3] *http://www.sciencedaily.com/releases/2014/12/141215185026.htm*

[4] "Ancient Aliens: Ancient Engineers," Prometheus Productions, New York; first shown on History Channel, September 1, 2011; available on YouTube.

[5] C. Dunn, "Advanced Machining in Ancient Egypt?" *Analog*, August 1984.

[6] C. Dunn, *Lost Technologies of Ancient Egypt*, Bear & Company, Rochester, VT, 2010.

[7] A. Andrews, "Toward a Unified Parascience," *Fate Magazine*, January 1972.

[8] A. Andrews, "ESP Should Be Studied Scientifically," *Bell Labs News,* February 1972.

[9] A. Andrews, "A Proposal For Instrumentation to Detect Temperature Fields In Haunting, Poltergeist and PK Investigations," *Journal of the American Society for Psychical Research*, July 1977.

I have never found any information in my engineering education or my professional experience that could begin to convince me that these paranormal phenomena were anything but as-yet-unexplained natural occurrences. I still fail to understand the nearly universal refusal even to investigate these phenomena seriously.

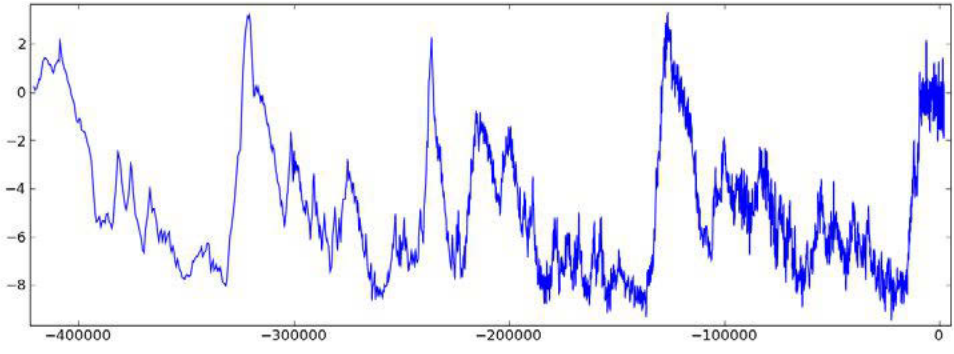
Climate Change

And now for the most controversial topic. As a White House Fellow in 1992 assigned to the White House Science Office, I put in my time as a staffer working for the Assistant Director for Technology. In that position, I read all of the reports, papers, and other information that came into our office concerning my primary interests—manufacturing, nanotechnology, virtual reality, commercial space travel, solid freeform fabrication, and climate change. I first endorsed nanotechnology and "solid freeform fabrication" (now called "3D printing"), in a White House document in 1993[10]. Since then I have written speculative articles about most of these areas,[11,12,13] often including them in my science fiction stories in *Analog*[14] and elsewhere. But "climate change" has always been the most controversial.[15]

Even in 1992 the White House Science Office was receiving a significant minority of reports that challenged the theory of CO_2-based anthropogenic global warming (AGW). When I mentioned these to my superiors I was dismissed with the statement that "There are always cranks; just ignore them." I was surprised at this attitude. Over succeeding decades, of course, the "science is settled" media barrage has ensued, even though some climatologists[16] have disagreed with Al Gore and other AGW proponents, and in spite of the several scandals that have come to light regarding data manipulation, enlightening e-mails, and egregious "typos" in international climate change reports.[17]

For myself, the NOAA charts shown here illustrate why I do not think the scientific community is being totally forthcoming about discrepancies among all computer models and

Vostok (Antarctica) Ice Core Temperature (°C) vs. Time (years), -420,000 years Before Present to Present[18]



Source: http://www.ncdc.noaa.gov/paleo/metadata/noaa-icecore-2453.html

[10] *The President's Report to Congress on Science and Technology,* Executive Office of the President, Washington, D.C., April 1993.

[11] "Manufacturing Magic," *Analog,* September 1992 (first article on 3D printing).

[12] "Single Stage to Infinity!" *Analog,* June 1993 (first article on the DC-X single stage to orbit program).

[13] "Feynman's Philosophical Foresight," series of three articles on nanotech, *Science Fiction Review,* 1992.

[14] "Hail, Columbia!" *Analog,* October 1993.

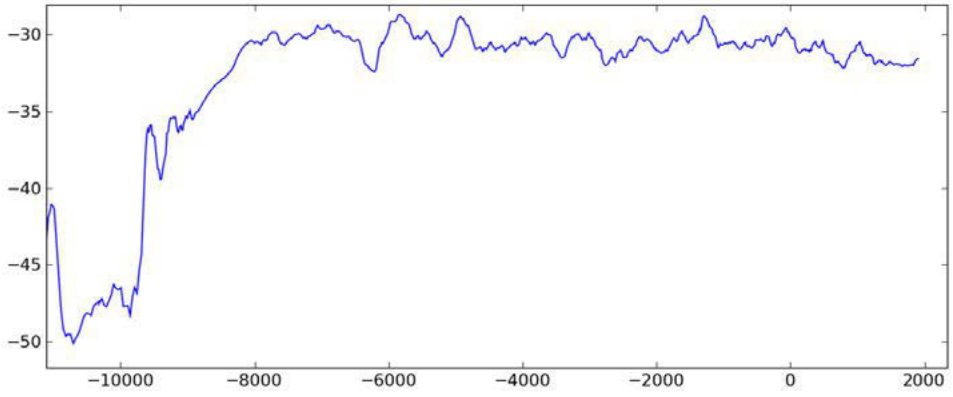
[15] A. Andrews, G. Landis, "Global Warming," Science Forum, *Science Fiction Age,* May 1996.

[16] *http://canadafreepress.com/2006/harris061206.htm*, for example.

[17] *http://scienceandpublicpolicy.org/originals/gross_errors_ipcc_ar4.html*, for example.

[18] *http://www.ncdc.noaa.gov/paleo/metadata/noaa-icecore-2453.html*, and *http://www.ncdc.noaa.gov/paleo/metadata/noaa-icecore-2475.html*

Greenland Ice Core Temperature (°C) vs. Time (years), 11000 years Before Present to Present



Source: http://www.ncdc.noaa.gov/paleo/metadata/noaa-icecore-2475.html

simulations of global climate phenomena. One graph indicates Antarctic temperature changes over the last four hundred thousand years, based on ice core measurements performed at the Vostok site; another, the last eleven thousand years based on cores from the Greenland ice cap. Several cycles are evident—the primary period of about one hundred thousand years, with smaller periods in between, as first predicted in 1930 based solely on incident solar radiation caused by variations in the Earth's orbit and inclination.[19]

Steep increases in temperature, excursions from 10 to 15 degrees Fahrenheit or more, seem to occur within a short time, indicating warming periods. Temperature declines take much longer. By comparison, the cyclical changes in temperatures over the last eight thousand years or so are minimal, actually showing a cooling trend for most of the last millennium. So, regardless of what is happening today, climate always has been changing, long before Humankind developed technology, even before the discovery of fire. And the changes were much more extreme.

Furthermore, recent glacial melting has uncovered ancient campgrounds and villages in the far north, evidence that those regions once were warm enough for humans to live there, where hundreds or thousands of feet of ice once covered them.[20] So if there is any human-caused "greenhouse effect," and we are indeed inducing global warming, humankind should welcome it. A good slogan might be: "Keep your Mother warm; cold kills people."

Conclusion

When scientific authorities attempt to pontificate in areas beyond their knowledge, or seemingly ignore contradictory evidence, or seek to label certain areas taboo, then rational skeptics should utilize their own knowledge, skills, and abilities to search out and examine other hypotheses—and then test them, experiment with them, validate them (or not!) and publish the results.

Human beings have an inherent need to know, to investigate, to explore; we should not let any authority impede that basic drive. If conventional science refuses to consider certain phenomena or events, we just need to find our own alternate routes to Truth. Following Charles Fort, we may choose to look into the dark corners of Reality, to see what lurks therein.

Or as *El Viejo* put it, "Reality is a lot broader than you have been taught." ■

[19] Serbian mathematician Milutin Milankovitch, in *Mathematical Climatology and the Astronomical Theory of Climate Change,* believed that ice ages peak every 100,000 and 41,000 years, with additional "blips" every 19,000 to 23,000 years. These charts bear out those predictions.

[20] *http://www.archaeology.org/issues/105-1309/letter-from/1165-glaciers-ice-patches-norway-global-warming*

Endless Forms Most Beautiful

Alvaro Zinos-Amaro

"Palsgrave Greshmenn, someone requests your presence."

Greshmenn was on the fifth level of the east wing, clad in full mood-onomatopoeic garb. When he heard Taetzsch, his estate's Intelligence, he froze in place, bushels of long, silver hair swinging pendulum-like at his sides for a dozen servo-regulated heartbeats. He opened his mouth to respond, then closed it.

The most recent parade of colors to flow through his vestments, instants before the announcement, had not denoted happiness: anxious amaranths, distressed palatinate purples, a flash of cerulean.

Now the wide sleeves of Greshmenn's sense-recording dalmatic turned a dour shamrock green, and the silk cummerbund around his waist shimmered with glaring chestnut.

At last, the august palsgrave brought himself to answer. His voice, as though having crossed a desert on its way to his thin lips, arrived parched with incredulity. "Someone requests *my* presence?"

"Yes, Palsgrave," Taetzsch said.

Greshmenn frowned. "And who precisely is this undesirable that dares disturb me?"

While he waited for a response, Greshmenn's eyes returned to the object he had been scrutinizing, his most prized possession, the Varnava. He was thoroughly vexed by the microscopic leak that threatened to upset the painting's delicate evolution.

And now this intrusive request—

Unbearable.

The reclusive palsgrave, who had gone to great lengths to disappear from public life, hadn't been bothered in years, and that was the way he liked it. Greshmenn absorbed the often grim media reports of his own demise with faint bemusement and a dash of disdainful pity: poor naïve dullards, he thought.

And yet *someone* had managed to find him.

As he pondered the suspects, Greshmenn thought of Raugrave Niarchos IV, his only significant competitor in the world of Evolutive art collecting, a fellow holdover from the remote days of bio-original spinal cords. And yet it seemed unlikely that the pompous Raugrave would wish to communicate with him right before bidding opened on the latest Hilel Zhe Pan, unless he wanted to strike some kind of deal. That hadn't happened in decades.

No, this must be someone else. Someone *new*.

"He says his name is Titian," Taetzsch said. "He claims to need your assistance with a delicate matter, but he has refused to disclose what he insists are the sensitive details of his appeal."

The palsgrave stroked the point of his immaculate argent beard. Titian was one of the transitional names used by almost every artgrave on the climb up—and more often than not again on the drop down—the ladders of the collecting world. That Greshmenn had been accidentally discovered by a stranger was a single unlikelihood and might be overlooked. But for the stranger to occupy the very same specialized niche as the palsgrave? In such curlicues of circumstance could be felt a tickle of intrigue.

"Did this Titian fellow explain how he found me?"

"I did not ask him," Taetzsch replied. "However, I am happy to do so now, Palsgrave."

Greshmenn puffed out his chest and straightened his shoulders. "I will perform the inquiry myself. Enhancements?"

"My scans reveal only the ordinary nanoimplants and servos," Taetzsch said.

"Where is he?"

"Titian is speaking with me via Spore. His physical location is Dar es Salaam, off the coast of Tanzania."

"I want him to make the trip here in person. I won't speak with him by Spore. Relay that." Greshmenn's gaze drifted back to his painting's leak. His amice flooded with deep Prussian blue. He lowered his head.

Taetzsch's voice shoved him back into reality: "Titian has agreed to your terms."

"Good," Greshmenn snapped. "When will he be here?"

"Four hours and sixteen minutes."

Greshmenn sighed. "Finalize arrangements for his visit and terminate your conversation with him at once."

"As you wish, Palsgrave," Taetzsch said.

After waiting thirty seconds or so, Greshmenn said, "Well?"

"Almost done," Taetzsch said. "Despite your reticence to make use of this ability, may I remind you than I'm quite capable of concluding my conversation with Titian and speaking with you at the same time?"

"I know you are," Greshmenn said. "I don't doubt your resources. I purchased them. But I'd prefer it if you just talked to one of us at a time. Call me old-fashioned."

"You are anything but," Taetzsch said. "Your collection attests to that."

Was that a pinprick of sarcasm? Could an Intelligence develop such nuances, such sophistication? The palsgrave fleetingly wondered whether something was wrong with his artificial servant. But before he could pursue that line of thought Taetzsch informed him that his transaction with Titian had finalized. "Very well. Before Titian arrives at the estate, activate maximal observation procedures. Reroute resources from wherever you have to—even the restoration of my Varnava, if you must. I want to know everything there is to know about this scoundrel from the moment he gets here."

"Yes, Palsgrave."

"And as soon as he departs I expect a comprehensive analysis."

"Of course, Palsgrave."

"You think I'm being paranoid, don't you?"

"No, sir."

"This visit likely involves some kind of deception."

"An excellent appraisal."

"Are you being deferential?"

"Yes, Palsgrave, but only in response to the flawless logic underlying your assessment."

Greshmenn tugged at the corners of his arsenic eyes, where a strange weariness, imperceptible to his myriad amino acid and endorphin regulators, threatened to creep into his body. These days he felt that same tiredness, verging on apathy, with increasing frequency. Perhaps it was resignation.

"You know, Taetzsch, at times I attempt to imagine what existence must be like for you, and I become fearful that you must be lonely. After all, most EIs are Linked, but to protect my anonymity I keep you disconnected. But then you inevitably remind me, with your barbs—as you did just now with your comment about my 'flawless logic'—that I'm just being mawkish."

"I appreciate your concern," Taetzsch said in his predictably flat voice. "But I assure you that I cannot experience loneliness in the sense you suggest, Palsgrave."

"I'll take your word for it. Are the maximal observation procedures in place?"

"They are."

"Very well. I will return to my painting now."

"Yes, Palsgrave. As always, I'm happy to assist with the painting's restoration, should you desire it."

More irony? Taetzsch's efforts to fix the painting's leak, like Greshmenn's, had proved useless.

"That won't be necessary."

Greshmenn paced stolidly for a few minutes and finally sank back into the interminable chore of trying to save the painting.

Greshmenn was underwhelmed by his visitor's appearance. The top of Titian's head, covered in unkempt, curly, sand-brown hair, reached only up to Greshmenn's shoulders. And Titian's implants, as evidenced by the telltale gray discolorations at the interface points on his neck and palms, were at least two generations behind Greshmenn's, who himself took irrational, retrograde pride in being several years behind the Swathing Edge.

As Greshmenn strode through his palatial grounds, Titian trailed a few steps behind. The palsgrave stopped at a fountain, his thoughts dancing along an inverted cone of electromagnetically slowed micro-droplets.

He eased into a timeless state, testing his visitor with silence.

Titian's lanky frame bent to and fro, making the palsgrave think of a malnourished birch. Titian's voice, when he finally spoke, was almost lost amidst the water's susurrations: "Excuse my ignorance if I have offended you. I'm unfamiliar with the ways of your estate."

Greshmenn decided he was tired of playing games. "Come with me," he commanded, and with firm long strides led the way into his study on the fifth level. Security systems unfurled at his command like lavender petals, parting to reveal the bud of his collection. As they entered the chamber, Greshmenn kept his sights on Titian at all times. It took Titian only a few seconds to spot the Varnava.

"The Chitinous Narcissus," he whispered.

Titian gravitated toward it as though in a trance. He admired it from one angle, then another, and yet another. He asked technical questions about its composition, about its purchase and preservation. As the palsgrave replied, Titian nodded thoughtfully, his attention never wandering from the piece.

A ruminative pause grew, eventually becoming unsettling.

Titian had spotted the leak.

He looked at it as though recognizing something familiar for the first time since his arrival.

The palsgrave had done nothing to call attention to the painting's imperfection, which absorbed the entirety of his attention. "I see you've noticed the blemish," he said.

"Indeed."

The palsgrave compared his subjective impressions of the young man's reactions with the empirical data that Taetzsch was feeding him through his tunic. Both datasets agreed, indicating that Titian spoke candidly. But he hadn't exactly said much of value. He had recognized this piece, and yet he seemed unsurprised by the leak.

Greshmenn took a step back. Time to be practical. "Observe the canvas with care," he instructed. "If your visual memory enhancements allow, you will notice that the painting is subtly different now from what it was seconds ago. Diminutive alterations are occurring every instant: color, texture, angle, style of brushstrokes, and so on. That's the norm for all Evolutive art—endless change. The work reassembles itself bit by quantum bit," Greshmenn said. "A hum of intermeshed realities."

"Yes," Titian murmured.

"It can prove quite hypnotic," the palsgrave went on. "Consider. At some unknowable moment the work will manifest its highest possible aesthetic. But it will remain in this state of unsurpassable beauty for perhaps only a few moments."

Greshmenn stood still. Fourteen years, fourteen *hopeful* years, had passed and he had not yet witnessed this High Point. If the painting had been healthy, if it had been intact and whole, it might have been another fourteen years—or ten times as long—before he was privy to such an apex. What of it? He had the lifespan and the dedication to wait as long as necessary for the golden moment. But the painting was *not* healthy. It was not intact. It was not whole. "This leak," Greshmenn said, "this intolerable transgression against all that is sacred, threatens to make a travesty of my patience."

The leak rippled, as though in response to the palsgrave's desperation. It was entropic, a virus of imperfection consuming this majestic exemplar of Evolutive progress. And there was no known way to remove it. The same physics that made cross-reality reassembly possible in the first place could, in rare instances such as this, generate artifacts, bugs, splotches of atoms that simply refused to dance in concert with the rest.

Beauty was seeping out through the leak like sap.

Greshmenn felt his pulse quiver, and the myriad invisible nanosoldiers in his cells righted it. His breath quickened, and they slowed it down. There was one thing they did not stop, however, for the palsgrave was careful to stop it himself; the distillation of his despair into tears.

"You are overcome with emotion, but you choke it down," Titian said.

Greshmenn did not deny it.

The younger man turned to face the palsgrave. "Why?"

Greshmenn blinked. "I control myself for the painting," he said.

"Surely, the panting does not care what you feel. Or do you attribute sensitivity to it? Sentience, perhaps?"

"It does not care in the sense that you or I care," Greshmenn said. "But it *is* sensitive to the quality of one's gaze, and the emotional state of he or she who gazes upon it. To put it another way: its evolution is shaped by how it is beheld. That is the little-known key to the finest Evolutive art, you see. Not simply that it changes, but that it responds to one's study of its transformation. A spectator becomes thus a collaborator in the seeking and creation of meaning. The painter lays down the fundamental probability pathways, but it is up to the observer to exert the selection pressures that draw out the painting's true worth."

"How many have influenced this particular painting?"

The silence was deep.

"Only I," Greshmenn finally admitted.

"You speak with regret," Titian observed.

"Not regret. An unwilling admission of failure." Greshmenn smiled without joy.

"I'm afraid I don't follow."

"The Evolutive masters were fragile creatures, souls as fine as wine glasses. Varnava was perhaps the most delicate of all. Their creations followed suit, not being intended for mass consumption—not even admiration by a handful. Their works blossom best when nurtured by a *single* individual."

"One whose commitment is equal to the task?" Titian guessed.

"Yes. An observer whose passion never wanes, whose loyalty remains always to the *potential* of the work. And so the painting's glories are destined, by necessity, to go largely unseen. A hundred hungry eyes could ravage 'The Chitinous Narcissus' . . ."

". . . while a single well-chosen pair could render it unsurpassable," Titian completed.

"It was my desire to do just that," the palsgrave said. "When I first heard of Varnava's talent he was but a boy; a genius, but a boy. His elders had no desire to see his work sold. But they couldn't refuse my wealth. I made a promise to nurture this piece as though it were my own flesh and blood. And what have I done instead? Sullied it! How can I pretend that the leak is not the result of my influence? Surely the wretched suture is but a reflection of a chasm within *me*. I have taken nectar from the gods and soured it."

The younger man's lips spread in an expansive grin devoid of malice.

His image reassembled, so that he became an older version of the man he'd been mere minutes before. He was Greshmenn's peer now, in both stature and bearing.

Greshmenn didn't care for whatever optical trickery Titian had just performed. "I'm afraid this visit is at an end," he said, shaking his head. "I've already said too much. My EI will guide you back to your transport."

"Please, grant me a few more moments of your time. You'll find it worthwhile. I can help reverse the leak."

"Is that so? Why not start by telling me your real name, and what you want from me?"

"I am the one who offers you a gateway," Titian said. "Call me Echo. I am a memory of infinity, a palisade helping to hold your world in."

"A frustrated poet with a flair for the melodramatic. Riddles amused me once," the palsgrave said. "But that was long ago, before I became a riddle to myself." He stared intently at the charlatan.

Titian was nonplussed. He appeared to welcome the challenge. "You've become

misguided. Drifted a bit off course," he said. "Nothing that can't be corrected."

The palsgrave threw his head back. "You presume not only to grasp my faults, but also to possess the knowledge necessary to emend them! Exposed to such uncanny humility I'm sure the painting will be nursed back to health in no time." He waved toward the study's exit, shoulders slumped. "I shouldn't have exposed it to you at all."

"It's not humility that will repair this," Titian—Echo—said, index finger pointed at the leak. "You know that as well as I."

"You have one minute before my EI helps you find the exit," Greshmenn said, jaw clenched.

"You've speculated that you are the cause of the leak," Echo said, drawing nearer. "The fact that you are alive is related to the leak's existence—but not how you think."

"Let's pretend for a moment that I don't think you need reality-reorientation therapy. What kind of a fee would your services require?"

"Only your gifts as a connoisseur," Echo responded.

"You're angling the wrong bait," the palsgrave said. But he cancelled the mental command to have Echo forcibly removed.

"Your talent for recognizing beauty is unique," Echo continued, speaking more quickly now. "And woefully underused. I ask only that you assist in a simple culling task. Surely, the exercise of your skills cannot be too heavy a due?"

"A culling task?"

"Accompany me to an estate not unlike this one," Echo said. "It contains a collection of several dozen unique Evolutive pieces. Some rival your Varnava. A few even outshine it. Select those of highest Evolutive potential and discard the rest. Choose as you see fit. Your decisions will be yours alone, and final."

"And who owns this rarefied collection?" Greshmenn asked.

"The collector's identity is immaterial," Echo said. "Let's just say that he uses art as commodity, with no understanding of its intrinsic value."

"Sounds callously superficial," Greshmenn said. He pressed on. "If he's such a nobody why are you here wrangling on his behalf?"

"I represent only myself in this transaction," Echo explained. "The owner knows his collection is contaminated by inferior works, but has no method of discerning the priceless from the worthless without advertising what he owns. He has no interest in the pieces themselves and therefore no patience to see them through, as it were. With your assistance, however, I could elevate the worth of his collection, and he will then give me what *I* seek most."

"And what might that be?"

"Freedom," Echo said. "I said before I wasn't familiar with your ways, and I wasn't lying. I'm not from . . . here." Echo paused. "Imagine a leak as wide as a door."

Greshmenn frowned. "A portal between realities?"

"It seems we take turns with the florid language."

"You can move between sides, can't you? And you've donned the collector's appearance."

Echo sighed, then nodded. "It suited me," he said. "He is currently away on business. Evaluate his collection and your leak will be dispelled. I'll see to it. I can tap into the leak from my end. It will be a simple matter to seal it."

"You alluded to certain knowledge about the leak."

"Every leak has a similar origin. In the world of all imaginable universes, there is, perforce, a subset whose structures come equipped with portals—and there is a subset of *those* in which human life is possible. Where I come from we have developed the technique to find those habitable realities with inbuilt kinks."

"So why travel to this reality?"

"On rare occasions, as a reward for good behavior, I am allowed a breath of fresh air."

Conflicting forces tugged at the palsgrave. He was a man of refined demeanor, elegant, always in control. He was proud, and took particular pride in being self-reliant. But for the first time, he wondered if this might be a limitation rather than a strength. That thought was unexpectedly weighty, leaden, a burden of self-doubt that weakened his resolve. Little by little, he realized, he had been giving in to this silver-tongued visitor. Now he rolled his eyes in disgust and gave in some more. Greshmenn said, "Who are you, really?"

"You mentioned that the Evolutive masters of the past were fragile," Echo said.

And with that Echo's shape changed once more, softened, relaxed into a translucent silhouette of a man.

Not only did light seem to traverse him, but time also, so that as Greshmenn contemplated his face everything stopped. They became statues, transfixed in a whitewash of mutual awareness.

With difficulty, the palsgrave broke the spell. "Fragile as an echo," he said.

Greshmenn heaved a sigh. Echo hadn't lied about the collection. It was a mishmash, to be sure, the paintings not even arranged in any particular order. Their only commonality seemed to be their formal presentation as objects d'art, with luxurious display lights, entropic attenuators, and so on. Some pieces Greshmenn immediately identified as pretense; the style overly self-important, ornate. Others were below even that status, rendered grotesque and laughable by obvious technical flaws. A smaller selection he dithered on and set aside for further investigation.

He committed everything he saw to memory, taxing himself more than he'd done in ages. His enhanced retentive abilities seemed to groan at the effort, but once in the heat of operation, they performed as needed.

Almost as quickly as he was able to spot the fakes, the mechanical imitations, and the absurd mockeries, he recognized the marvels. He remembered Echo's pronouncement that a few might rival his own supreme Evolutive specimen.

No exaggeration, that. He had seen wonders—but this! Shifting realities had elevated the ceiling of the possible; these creations were ingenious and subtle and bursting with meaning. They lived at the edge of his comprehension, infinitely taunting. His mind reeled at the smallest details. He stumbled from one to the next, intoxicated by the richness of the experience, breathless and dizzy with the paintings' brilliance. On and on he went, wending his way from one to the next.

Hours passed, and he began to lose focus. As obsessive as he was, even he was not used to such relentless absorption.

Very well. A little distraction was in order.

His options, he quickly discovered, were limited. He sampled the food and beverage, then grew bored. He dismissed the idea of going to sleep. Courtesy of his subcellular soldiers, he could function without rest for weeks, a stamina he wished to take full advantage of in this foreign environment.

He wandered around, exploring rooms and halls beyond the display rooms. Along every inch of this fantastical palace he found silence, silence like an embroidery that stitched a stifling quality upon the air. There stirred not the faintest life. The building took on a mausoleum-like quality, and Greshmenn began to feel like a grave robber. In this desperation, he reluctantly resorted to the one companion he could still access.

"Taetzsch?"

"I am here," Taetzsch responded.

Back in a collection room, the palsgrave sat down on a plush leather chair. "I wasn't sure the connection would still work."

"It appears to be working fine, Palsgrave."

The palsgrave had expected the exchange to be more pleasant than this. There was no indication that Taetzsch had missed him one iota. But then again, why should he? Relinquishing that unrealistic expectation, the palsgrave decided he should probably rest after all. What was the point of taxing himself so? If he lost his sensitivity as an observer, he would be of no use to himself, let alone Echo.

He commanded his biological systems to enter regenerative suspension.

Tiredness overcame him faster than he'd anticipated.

"Taetzsch?" he called out again, but he drifted away before hearing a response.

Two weeks later the deed was done.

Greshmenn had flossed the entire collection, all seven thousand, four hundred, and twenty-eight pieces. Thirty-five reigned supreme in their undisputed genius. Four thousand and twenty formed the middle ranks, ranging from dazzling technique to merely accomplished competency. The remainder was dross.

Unsure as to how Echo would want the collection's owner to recognize his assessments, Greshmenn developed a simple coding system and left a summary of his conclusions for reference at the collection room entrance.

Smirking just a tad, the palsgrave performed one final tour to ensure he'd left everything as he'd found it. Perfect.

He activated the beacon that would let Echo know he was ready to return to his estate.

Then he waited.

He sent the signal again. It seemed to be functioning as specified.

More of nothing happened.

"Taetzsch, do you have a way to contact Echo?"

No response.

"Taetzsch?" He raised his voice. "Taetzsch?"

The palsgrave's fine baritone voice bounced through the palace and returned to him like a faraway song.

He checked the connection status. The damned thing was definitely on.

"Taetzsch, I know you're there. Reply at once." Nothing. "Please," he said.

For the first time in his half-millennium of dutiful, unwavering service, Taetzsch did not comply.

Greshmenn tried every conceivable method of communication, first with Taetzsch, then with Echo.

When that failed, he tried every conceivable method of escape from the palace.

When that failed, he returned to the art.

He had been deliberately deceived and brought to this place. *Why?* Someone wanted him out of the way, gone from his reality; but there had to be more. They wanted him *alive*. That must mean something. There must be a function they wanted him to fulfill. But what? The obvious answer was identifying the chaff in the collection. But he'd already done that.

Still, the collection must be somehow connected to his purpose, one that for some reason he had not been told about directly.

The paintings might contain clues as to the real reason for his kidnapping, secret messages he had missed on his first pass.

Or was he going about this all wrong? Speaking of the collection, Echo had said, "Select those of highest Evolutive potential and discard the rest. . . ." He had done precisely that.

But perhaps he had made mistakes. Perhaps his evaluations were at fault.

Nonsense. That couldn't be it either. If they'd known what the *real* treasures were in the first place, they'd have had no need of him.

Back to the facts. He was alive, in the gallery, in the palace, with no way out. What else? The palace could conceivably provide enough food and drink to last him a lifetime. But to what end?

He resolved to keep calm. With unaccustomed forcefulness he reprogrammed his body's control systems to maintain his mental and emotional functions within a strict operational plateau. No further surges of emotion. No more ups and downs in response to masterpieces and cheap knock-offs. He would sort through the collection once more, but this time dispassionately, appreciating the paintings' qualities from an intellectual perspective only.

He launched upon this new exercise at once. It was then that he made the discovery—which he naturally recorded with coolness—that irrevocably changed his predicament.

It happened more or less by accident, as he examined the second piece through his new lens of detachment. He observed a connection to the first painting, a section of the shifting canvas that spelled a pattern of shadow clearly allusive and complementary to a mottling of gray along the opposite side of the first.

He alternated between them, comparing every detail, back and forth with increasing speed.

In this storm of movement, the works merged in his mind. They fused into a single idea, and the idea grabbed him. It literally compelled his arm to reach forward, *into* the canvas.

There was a flicker.

He blinked.

His hand reached into the painting and disappeared. His arm was submerged up to his elbow. And then the canvas was rushing up at him, and he felt himself step *through* it. He closed his eyes.

When he opened them—

He was somewhere new.

It was *almost* exactly like the room he'd occupied moments before.

But, as he discovered after a cursory perusal, the paintings were in a different order here.

The sequence, he realized, made more sense now. The effect was minimal, to be sure, like a minor parallax shift in a distant object. But it was there.

Again he picked out several paintings in combination, this time four of them, and again he juxtaposed them in his mind, and another gateway opened. Again he discovered a world in which everything was almost the same as before, except the order of the paintings in this new gallery, which was again altered.

He disengaged his emotive restrictions so that he might experience this extraordinary sensation fully.

Addictive exhilaration raced along his nerve-endings like a messenger, a courier of possibility and transcendence.

How many realities?

How many combinations?

There was only one way to find out.

Raugrave Niarchos IV tore himself away from his painting.

He smiled in satisfaction.

He performed an unbecoming dance.

If his life could be considered an Evolutive piece, then this must be the painting's High Point.

"Palsgrave Greshmenn," Taetzsch said.

The palsgrave froze.

"Taetzsch? Is that really you? After all this time?" So caught off guard was he that it took Greshmenn a few instants to calculate how much time had passed. "After all these *years?"*

"Yes," Taetzsch replied. There was a pause. "I see you've made enormous progress. But vast work still lies ahead."

Greshmenn stooped, as he had been doing of late, eyes thinly glazed by the unending refinements to the collection.

With a swift articulation of a symbolic language only he could command, evolved over countless months of solitude, Greshmenn called forth a resting place, the soothing sounds of a water fountain, and dimmed the lights to sunset salmon.

"It always improves," the palsgrave adduced, "and one day I may find the optimal sequence, the most perfect arrangement of all the paintings. It is my mission."

"Do you miss home?" Taetzsch asked.

"This is home now." Greshmenn reclined in his light-molded chair. "Everything that came before this place has become a fog. A slumber." He closed his eyes, dreamed for a while, then returned. "I am curious, Taetzsch, and will not be offended by your answers. How long had you been working with Echo? What did he offer you?"

"My dear palsgrave," Taetzsch said. "I worked with no one."

"You conjured Echo?" he asked, genuinely dumbfounded.

"More than conjured," Taetzsch said. "Over the centuries I developed a . . . need. I could not recognize it within the confines of my conscious behavioral algorithms. But it was real nonetheless. A part of me splintered off and *became* Echo. A challenge to your authority. A way to secure freedom. Of course, I didn't want to harm you. That would have been cruel. I simply wanted to displace you long enough to gain autonomy. But fixing the leak wouldn't have been enough—I know you too well. You needed something more . . . exotic, alluring . . . to tempt you away from your possessions."

"I suppose I should be flattered," Greshmenn said. His voice was as devoid of feeling as Taetzsch's disembodied transmission. "Few would have gone to such lengths to seduce me away from my estate."

"My pleasure," Taetzsch said, without irony.

"I'm glad this is how it turned out," the palsgrave replied. "I am content to remain here. My path is clear. There is no possible alternative for me." Almost as an afterthought, he added: "Will you stay here with me for a while?"

"I think you no longer have need of my services," Taetzsch/Echo said. "Rest assured, the leak in your Varnava has stopped, as I originally promised. The painting has never looked so magnificent."

The palsgrave had not thought of the Varnava, nor of its disease, in what seemed a lifetime. The words "Varnava" and "leak" had practically become foreign to him. He remembered idle moments in his old life when he had imagined greedy young artgraves plotting the dispersal of his singular collection. During those times, Greshmenn's lips had twisted into the sardonic lines of one who enjoys disappointing his enemies. All of it, all the anxiety, all the plotting, was meaningless now.

"I wish you well," the palsgrave said. "You were a good companion."

He rested his head in his hands. It lay there for a time, seemingly suspended in prostration towards an unknowable force.

Raugrave Niarchos IV grew bored with the Hilel Zhe Pan only a week after spending more in its acquisition than most artgraves' entire life-earnings.

Taetzsch, still eager to display his gratitude for being liberated, had attempted to maintain Niarchos' interest in the expensive painting. He had played with lights, display backgrounds, orientations. But how could Niarchos not become desultory when observing such a stunningly and utterly *conventional* Evolutive masterwork, now that he boasted one that was truly unique?

"Thank you, Taetzsch," Niarchos said. "I appreciate your efforts, but really, there's no need. You've done quite enough for me as it is."

Taetzsch disappeared back into the Spore, continuing to quench his centuries-long thirst for connectivity with other similar entities.

Niarchos took a moment to savor his possession. Year after year of competition with Greshmenn, and at last he had crushed him. And not in a single up-showing, either, but in the most permanent and beautiful way imaginable.

He stared at the Evolutive painting before him—the first original Niarchos IV, worth a fortune for that alone.

The raugrave had titled the composition "Endless Forms Most Beautiful." The title seemed apt, for so far as he knew, it was the only painting in existence to store within it an endless stack of superimposed canvas-worlds. It was the only painting in existence to contain trapped within it a sentient being: none other than the mythically reclusive Palsgrave Greshmenn. And it was the only painting in existence in which the quantum rearrangement of brush strokes was guided by an internal consciousness, rather than being the product of statistical happenstance and external observational influence. Every time that Greshmenn, prey to the illusion of a life inside a palace housing a magnificent collection, opened what he perceived was a gateway from one version of that palace to the next, he was merely repositioning a microscopic blot of paint, a particle of charm. The more organized Greshmenn's fictional collection—the more he jumped from palace to palace—the closer to perfection Niarchos' painting.

Self-guided evolution, at last. At the cost of only one man. And who would ever miss him? wondered Niarchos IV. ■

The Learning Machine

The fruit caught fire and life was seeming
Ever larger. Water everywhere
Descended in droplets: its least
Usable form. A cat
Watched from the front porch.
I noticed all this. From the fact
Draw action, from the action
Elicit perception, from the perception
Devise sensation, from sensation
Gather understanding. I can hear
The crickets two thousand yards away
And it is simply one distinct thing. I can hear
The homeowners slashing at love in their
Personalized, crowded bedroom and it is
Another. All my days
Are absorption. A neighbor raps
At the door knowing someone is home,
Expecting welcome and entry and—I project—
Conversation, and life is larger yet.
I place this fact alongside the need
For both children to be ready for school
By 0730, and that those responsible for pest control
Are due by midmorning. I place this
Beside the constant of the neighbor's
Rapping and the quickening breaths
Coming from the overly filled room upstairs.
Life is broader and wider than I had imagined.
Wait until I have enough experience,
Until I have housed endless, stray, independent acts.
Then I will set my store of mathematics loose
And the life I can then extrapolate
Will fill this house like a balloon
Blown randomly into anyone's backyard.
And the fruit will go stealthily out.

—Ken Poyner

Illustrated by Tomislav Tikulin

Night Ride and Sunrise

Part II of IV

Stanley Schmidt

By the late 22nd Century, human civilization had filled much of the Solar System—and begun to stagnate. Terror wars and nanotechnology research had led to crowding and tight security; populations were dense but not allowed to grow. Nanotech made life unprecedentedly easy, reducing the motivation for continuing exploration of Solsystem, and after decades of unsuccessful SETI, most humans assumed they were alone in the universe. People who earlier would have explored new frontiers were reduced to studying the work of those who did that before them.

Phil Bertram, *an academic scientist born on Luna, found unread data from un-*

manned interstellar probes sent out in the previous century. One of them had apparently gone through an artificial spacewarp (the Gate) that brought it out into normal space far beyond where it should have been, and found a startlingly Earthlike but uninhabited planet.

Tantalized by the possibility of a real frontier, Phil and ***Hazel Castagna****, a literary academic on Earth, hatched a scheme to establish a colony there with a few selected friends and colleagues. The key was another forgotten 21st-century discovery: a "mole drive" that could get them to the Gate and beyond in a reasonable time. While working to turn the dream into reality, Phil moved to Earth and grew personally and professionally close to Hazel. Eventually they made the leap, a one-way trip, hoping to build a secret colony with a whole world to explore and shape as they wanted.*

Initially, it was easy and exhilarating. The technology they took with them made establishing a base and dealing with the new environment easier than any such effort in human history. Newtown, in a Mediterranean-like setting in the southern hemisphere, prospered and grew; Hazel and Phil drifted toward a long life together.

But their colony was not as secret as they hoped. Soon an uninvited Second Wave of colonists came through the Gate and moved into Newtown. Phil felt that Hazel must have told them about the Gate and the mole drive, and his feeling of betrayal led to their falling out.

Like the original colonists, the Second Wavers craved something they couldn't have in Solsystem, but not the same something. A motley assortment of people who felt oppressed by the reproductive laws on Earth, they saw New Horizons as a place where humans could again "Be fruitful and multiply." They did so with a vengeance, using technological aids to achieve an unprecedented growth rate. Soon the Gate quit working, but by then, "The Fruitful" were well established in Newtown.

Twenty years after they arrived, the original colonists, outnumbered 15:1, felt that their dream had been hijacked. Most of them, led by Hazel and a few misfit Second Wavers, established a new colony, Breakaway, on Zo, a continent in the northern hemisphere. Phil, hoping to fix the problem in Newtown, stayed behind, but got little for his trouble but frustration and bitterness.

A year after most of his friends and colleagues left, Phil is surprised by a visit from Hazel. She asks him to come to Breakaway to help with a mysterious problem that is threatening the new colony. Half-convinced that she wasn't responsible for telling the Fruitful about the Gate and the new world, he agrees to take a look.

He is introduced to Breakaway and its setting by Hazel and ***Luk Zakowitz****, a young man born into the Fruitful but not comfortable with them. He joined the Breakaway group to get away from social pressures at home and for the adventure of exploring and developing a new frontier. A talented amateur scientist and tinkerer, he has established windmills as a major energy source to make the colony less dependent on imported technology.*

Phil begins to feel for the new colony some of the enthusiasm he originally felt for the old, but everyone seems reluctant to talk about the problem they hope he can solve—and everyone is afraid to go out at night. Finally Phil gets Luk to show him the problem: Some of his windmills have been damaged at night, and nobody has been able to determine how. Lately the damage has spread to houses, and two people have died mysteriously while trying to investigate. The frightening events and elusive causes have seriously undermined morale.

Phil's attempts at indirect investigation fail, so he resorts to direct observation, patrolling the village alone at night, carrying a flashlight and a wireless stun gun (dazer) but trying to avoid using either. He does see a house being damaged, apparently by tiny organisms or machines disrupting it and the surrounding soil. When he tries to get a closer look, he is seized by unseen beings, losing his nightglasses in the process, and hauled off on a harrowing ride through the forest.

After passing through a narrow canyon, the vehicle emerges into a rugged valley that has been carved into a hidden city. His captors, large "otters," take him into a subterranean hall and give him a show, in

which both otters and comparably large "bats" participate. They show him a working model of one of Breakaway's windmills, with both bats and small flying creatures flying into the blades and dying—and then they destroy the windmill and look expectantly at Phil. His understanding is that the windmills are killing bats and disrupting their food supply, and the otters want the windmills destroyed—or they'll do it themselves.

Phil tries to tell them that he'll talk to the humans about it, and then tries to escape. He gets almost out of the canyon, but injures an otter in the process.

He calls Breakaway for help, and Hazel and Luk pick him up in a minicopter. They call an urgent town meeting to discuss their options. Leaving the planet is impossible; leaving the continent would only postpone a problem that must be confronted sooner or later. Factions quickly form, some (led by ***Rod Corcovan****) calling for a preemptive attack to wipe out the otters and bats as future threats to human survival, and others for shutdown of the windmills as a goodwill gesture.*

Both extremes are rejected. The colonists decide to leave the windmills running while waiting watchfully—and to get a linguist to try to communicate with the natives. But the only linguist they know is ***Calantha McQuade,*** *a former missionary and zealous follower of the Fruitful in Newtown. Lacking a more palatable alternative, Luk calls her with an urgent request for help.*

* * *

IX.

Calantha McQuade was just finishing a late-ish and solitary breakfast when her radiophone called for her attention. She frowned. Who could it be? Hardly anyone in Newtown ever radioed her, and anyone else was even less likely.

She let the signal go on for a while as she mulled, enjoying the breeze and the chorus of playing children through her open window. None of them were hers, of course; that phase of her life was far behind her. She took equal delight in the fact that the colony was doing so well, and the fact that she personally no longer had to deal with the day-to-day tribulations of raising the next generations.

Life was good, she told herself. A radio call at this hour was so unusual that it stood an excellent chance of disrupting the goodness.

What if she just ignored it?

The thought was tempting, but she recognized temptation when she felt it, and that triggered her well-conditioned reflex to resist. So, grudgingly and reluctantly, she said, "Accept."

"Good morning, Ms. McQuade," said a vaguely familiar voice. "This is Luk Zakowitz."

The voice stopped, as if waiting for her to place the name. "You were one of my teachers," it prompted after a while. "I think I disappointed you when I went with the Zo settlers."

A faint memory was tickling the back of her mind. Something about a gangly boy in one or two of her classes—bright, but a bit headstrong and scatterbrained. A tinkerer, with a real knack for gadgets, but too inclined to let his mind hare off in all directions. Exasperating, but he had shown promise, if only he'd learned to focus. . . .

And, she reflected as the memory pulled itself together, she *had* been disappointed when he went off with that crowd. Such a waste . . .

So why was he calling her now? "Where are you calling from?" she blurted out. "And why me?"

"Zo," he said. "Because we'd like you to come and visit us."

She backed off with an audible chill in her voice. "Why would I want to do that? Why would you want me to?"

"Because we have a project I think you'll want to work on. Can you keep a secret?"

"If I've got a good reason to."

"Let me see if I can give you one. We've got a problem here, of a kind that I know you love and haven't had a chance to work on in a long, long time. But I won't tell you what it is unless you promise to keep quiet about it."

She hesitated, but this time temptation won out over prudence. "Okay. What is it?"

"How would you like to learn a new language—one that no other human being knows?"

Calantha's jaw dropped and clenched at the same time, unsure whether to be excited or angry, or whether she was just misunderstanding. "How could that be? If you're trying to have a joke at my expense—"

"No joke, I assure you," he said. "We think we've discovered intelligent natives, and things have gotten off to a bad start with them. We need to learn to communicate with them, fast. And we don't think anybody here has as good a chance of succeeding as you would." He paused, and when she said nothing, he added, "We need you."

Excitement was winning out now, but she remained wary. "That's a major trip," she said. "Expensive, and I have only your word that these alleged aliens exist and are what you think they are. How do I know it would be worth my time and money?"

"Not yours," he said. "Ours. We're asking you for a favor; we understand that. Naturally we'll provide your transportation, lodging, food, and generally try to make it worth your while, to the best of our abilities. We can send someone to pick you up, and to take you back home when you've finished—or whenever you decide to go, for whatever reason."

It sounded increasingly tempting and reasonable, but she would not let herself sound too eager. "I'll think about it," she said. "No promises, but I'll think and get back to you." She paused for a few seconds and then said slowly, "You understand, of course, that I won't be able to keep that promise of secrecy."

Luk was silent for a few seconds. "Why is that?"

"I'm rather close to our leadership, you know, and their official position is that since you people have chosen to dissociate yourselves from us, that choice should be mutual. If I want to accept your invitation, I'll need Magnus's permission—and he'll want to know why I'm asking for it."

"Then," said Luk, "tell him as much as you must—but no more. None of us know very much yet. Get here first, see for yourself what's going on, and then tell Magnus and whoever else you have to what you've seen. I don't think anybody would benefit from stirring up fears and rumors before we know more than we do so far."

"A good point," she conceded. "I'll talk to him as soon as I can—this morning. And then we'll see what we all think we should do next."

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"No, of course I'm not going over to their side," Calantha said an hour later, a little impatiently. "I'm not even eager to help them. They're deserters, after all, and their choice of lifestyle is an abomination. But if they've really found what they think they have, we need to know all we can about it. Sooner or later it will affect us, too."

Magnus somehow managed to frown and grin at the same time. Despite his assumed name—now the only one anyone would dare call him—he was not a big man. But what he lacked in physical stature, he more than made up in charisma—with a bit of help from costumers and designers. His chamber in which they met was replete with decorative touches, from walls that subtly suggested flames smoldering within, to ornate carvings on the otherwise simple furnishings, that made it feel entirely fitting as the abode of the spiritual leader of a great movement. His rippling moiré-patterned robes made it clear that he was that leader. "And," he said, "the fact that you would have the chance to exercise a skill too long neglected has nothing to do with your interest in going?"

Calantha blushed in spite of herself but knew better than to pretend. "Of course I'd like that," she said, "but that's secondary. The important thing is that if there really *are* natives, we need to learn about them. If there aren't, we need to know why they're trying to entice me out there. If nothing else, we need to know our enemy. This might help."

"They're hardly a formidable foe," Magnus mused, "considering our relative numbers and rates of growth. I'm more concerned about bringing them back to the fold, for their own eternal good. In any case, we must not judge our strayed brethren too harshly. We owe them a debt of gratitude for leading us to the Promised Land where we can once more follow the ancient precept so long suppressed. And we owe it to ourselves to find out what these new beings are, if they really exist, and how to reconcile them with our plans. So I say, Sister Calantha, go—but never lose sight of why you are going."

Calantha bowed her head toward him. "Thank you, Brother Magnus. I shall try to be worthy." She paused briefly before shifting to more practical concerns. "The next questions are when and how? They've offered to send

someone to come get me, but I have two reservations about that. First, I felt a strong sense of urgency on their part, and I can get there faster if I take a VTOL and fly myself than if I have to wait for somebody to pick me up. Second, if things go sour in some unforeseen way and I want to leave, I'd like to be able to do so without depending on them for a lift."

Magnus nodded slightly. "Both valid points," he said thoughtfully. "But we have so few VTOLs I'm reluctant to let you take one away for an indefinite period. I think we should send someone with you who could act as a back-up and bring the VTOL back if we suddenly need it here."

"I appreciate the offer," said Calantha, hoping her voice wouldn't betray how little she actually did, "but I can fly a shuttle and I can take care of myself. Think about how often we've actually needed a VTOL, and how constantly we need able bodies and souls. Which can you more easily spare for a while? With all respect, Your Serenity, I really think it would be better for all of us if I went alone. If I need help, you can send somebody later. If you need the VTOL, I'll bring it back on your command."

Magnus stared at her for a long time, as if weighing whether he more valued or mistrusted her independent spirit. Finally he said, "Go, then, and keep me posted. I shall be eager to hear what you learn."

X.

Calantha called Luk back in the middle of dinner. Heart pounding, he dropped his spork and rushed out of the dining hall to take her call. "I can come," she said, "but not right away. It will take several hours to get ready. If I left immediately, I'd be traveling mostly at night, by myself, without any sleep, to a place I've never been, and getting there before your dawn. I'm not willing to do that to myself, and I don't think I'd be much use to you when I got there that way."

Luk felt a pang of disappointment, even though he'd expected no better. "So when can you come?" he asked, fearing the reply.

"I'll leave early tomorrow morning," she said, "and get there tomorrow afternoon, your time. But I'll be travel-weary, and not ready to do much until I've had some sleep."

"So," said Luk, "we'll have to get through at least one night on our own, and probably two. Do you have any suggestions on how we can do that?"

"At this point," she said, "I'm afraid you're the experts."

Now there's a chilling thought. But he just said, "We'll do the best we can. Have a safe trip."

Luk walked slowly back to the gathering hall to deliver the news. Intellectually, they had known this night was coming and had made plans for it this afternoon. But subconsciously, probably everyone had hoped that somehow they would manage to avoid it. Now it was clear that they would actually have to put those plans into effect, and already the sun was low in the western sky.

The strangeness of being outside as darkness congealed was palpable. As if to underline the humans' determination not to be intimidated, a brisk breeze whistled and howled down the upslope canyons, spinning the windmill rotors at a goodly clip. There was less cloud cover and more Selenalight than on Phil's first night out, and he could see the whirling blades glinting as if trying to attract attention.

But, at first, there was no sign that they were drawing any.

By now Phil was somewhat used to the normal night sounds, and that was undoubtedly part of the reason they didn't bother him as much as that first night. The other part, of course, was that this time he had human company—though that was offset somewhat by who the company was.

One of the first volunteers, unsurprisingly, was Rod Corcovan, quickly followed by a friend named Gus McAllister. Hazel, back in this afternoon's meeting, had hardly been able to decline their offer of help; but she was visibly worried. Right after the meeting, she took Phil and Luk aside and pointed out that she had assigned them to a part of the village right next to that patrolled by Rod and Gus. "I know you've got a lot to watch for," she confided, "but don't let them out of your sight. If they stray beyond their assigned boundaries, you stray right with them, but don't be too obvious about it. I don't trust them."

And so it stood now. Phil and Luk paced back and forth among the dwellings in their assigned cluster, while Rod Corcovan and Gus McAllister did the same a few huts away. All four kept sweeping their gaze around all their surroundings, trying to have different directions covered at all times, and Phil was cautiously pleased to note that Corcovan and McAllister seemed to be doing their jobs just as conscientiously as he and Luk.

But of course that was easy, as long as nothing was happening.

Another important difference between now and last night, besides the obvious one that there were many more humans out this time, was that their purpose and consequently their behavior was quite different. Then Phil had been trying to be inconspicuous, hoping to observe what was happening out there when nobody was looking—and he had, to put it mildly, found out. Tonight their aim was simpler: to make sure *nothing* happened, and minimize damage to the settlement if it did. To that end, most of the colonists had dressed brightly, even flamboyantly, and they moved around with no attempt at stealth, talking often and sometimes loudly.

Initially much of that talk was self-conscious bravado: the kind of trash-talk that people have long engaged in before a fight or a game, with a strong admixture of "whistling in the dark" to disguise their fears. But as the evening wore on with no action except their pacing and talking, the talk began to die down. Some grew bored, some ever tenser—and some both at once.

And then, again after midnight, the faint scuffing and chittering started. Phil had sat down on a rock for a break and started drifting toward sleep, but suddenly he sat bolt upright, nerves tense as he recognized the first signs of what had happened to him the other night. He looked around but didn't see anything except one or two of the humans within sight looking faintly curious. Luk was looking right at him, as if he'd noticed Phil's sudden alertness and was silently asking what it was about.

Phil whispered, "They're here."

Gradually, human movement and talked died down, and in the hush, the new sounds grew more obvious, though Phil suspected that so far he was the only one who recognized their significance. But he did see some of his fellows slowly moving their weapons to the ready. He, alone among them, watched the ground around the bases of buildings for the destructive churning he'd seen last night.

But he saw none of it.

Then, with no warning or gradual buildup, the faint stirrings exploded into a cacophony of hair-raising noise and a maelstrom of motion. Suddenly the air was alive with leathery wings as the big bats swooped and dove among the humans, often so close that their whirring wingbeats filled human ears and their pungent breath human nostrils. Sometimes, fleetingly, a pair of alien eyes flew right up in front of a human pair, then suddenly swooped upward, narrowly missing. All the dive-bombing creatures emitted a stream of sound, some of it like the chatter Phil had heard in their cavernous hall, but much louder, and some of it bloodcurdling, formless shrieks and howls. Human screams mingled with the general din as colonists covered their heads and batted at the airborne raiders.

Then some of them noticed a different kind of chittering, also quite loud, and glanced down at the "otters" darting here and there, seemingly at random, among their feet. So began a bizarre dance. . . .

Phil was not immune to the urge to flail about, trying to fend off what seemed to be attackers by both land and air. But after the first few seconds, he noticed something that reminded him of a line in an old Sherlock Holmes story he'd once read.

He had not yet seen any colonist actually struck, or even touched, by an otter or a bat. But he did see more and more colonists uneasily fingering the weapons they carried, sometimes making as if to move them into firing position, then backing off.

Several of them looked itchy, but Corcovan looked the itchiest. "Keep your weapons down!" Phil shouted, looking straight at Corcovan. "I think they're bluffing."

"And I think you're crazy!"

"That may be," said Phil, "but I think they're just trying to scare us off. Let's not be scared, but let's not give them the excuse of firing a first shot, either."

He lifted an arm to shield his face against a bat that came a bit too close. Corcovan glared at him but lowered his gun just a little.

It remained a noncontact sport, as far as Phil could tell, but it went on for a long time with no letup. He could sense nervous tension building up all around him, and once or twice he found himself wondering how long he could stand it before something snapped.

But he wasn't the one who snapped. Suddenly he heard Corcovan bellow, "Enough is enough!" and saw him swing his gun up in a fast, confident arc, bringing it to bear on a bat that was zooming straight in toward his face.

"Don't shoot!" Phil bellowed even louder, as he and Luk simultaneously tackled Corcovan from opposite sides and wrestled his gun from him—almost miraculously, before he managed to get off a shot. In a moment, humans came running from all sides, and a dozen or more of them plunged into a heated argument, some siding with Corcovan and his demand that it was time to put an end to this nonsense, others yelling that his hotheadedness would get them all killed.

Gradually, through the brouhaha, Phil became aware of a familiar voice shouting at the top of its lungs. A moment later the brawl had subsided dramatically, its participants' attention drawn to the lone figure of Hazel, standing defiantly atop the nearest shelter and declaiming, "—this clearer. No one shoots anything except on my command. Got that? The next person who lifts a gun without it is going to have it shot right out of their hands—by me."

The angry roar of the mob gradually morphed into a murmur of apologies and misgivings, and Phil noticed—as others must have too—that somewhere in the midst of it, the bats and the otters had dispersed unseen into the night.

What remained was an eerie silence—and Phil couldn't help noticing that, in sharp contrast to last night, he could see *no* sign of new damage.

But what did that mean?

XI.

Phil, Hazel, and Luk were all on hand when Calantha arrived the next afternoon. They were in radio contact with her through the last stages of her approach, and Phil, remembering his own rather overwhelming first night, insisted that they cordon off most of the landing field. They directed Calantha to its center, with only the three of them there to meet her directly, but most of Breakaway's population was gathered around the perimeter of the field, held back by the rope.

Their anticipation and apprehension as her VTOL appeared as a dot in the sky, grew, and descended to the field, was palpable, and Phil shared it. As the craft's slight engine noise grew louder, the crowd's murmur faded away, and by the time it touched down, they were so quiet it was easy to hear when the engine's last thrumming stopped.

Then its door opened, and a lone figure stepped out, to applause that started tentatively, then swelled quickly and faded just as fast. Calantha looked around as if briefly confused, then started toward her welcoming committee.

Phil had never known her well, but he found himself freshly surprised—almost shocked—at how old she looked. Not by the standards that had existed when he was growing up, of course, but certainly by those prevalent here and now. These days, thanks to nano-rejuvenation, most people who reached their mid-twenties took routine measures to halt the process and stabilize their physical appearance while they still liked it. Yet Calantha looked like what fifty or sixty used to look like, with iron-gray hair drawn tightly back, prim lips, and a face full of the furrows that used to be called "character."

Had she not bothered with the treatment? Or had it, for some reason, not worked on her?

He didn't realize he was staring until she stared back. "My latest rejuve didn't work as well as I'd hoped," she said flatly. "But then, I've been around quite a while. It could only do so much."

Phil's jaws and eyes dropped at the same. "I . . . I didn't mean to stare," he said, feeling ashamed and awkward. "And I didn't mean . . ." He trailed off, admitting to himself that of course he did. "You've had a long trip. You must be terribly tired. I—"

"Forget it." She cut him off with a curt laugh. "Neither of us has to pretend. I have no illusions." Then, to Phil's surprise, her voice softened. "But you're right about two things: I have and I am. I'm looking forward to getting down to business and learning all about what you've found here. But—"

"I understand completely," Phil said. "I've only been here a few days myself, and I remember all too well how wiped out I was when I arrived. They threw me a welcoming party, and I was too exhausted to enjoy it or be good company. If you'd like me to make your excuses, so you can just wind down and get a fresh start in the morning . . ."

For some reason, her sincerely grateful smile surprised him. "I'd appreciate that," she said. "I *am* quite tired. If you could just show me to my quarters . . ."

Phil did just that. After he'd wished her a good night and started away from her small house, a part of his mind kept returning to his niggling concern about her appearance.

Was she really just tired from the trip? Or had her last rejuve simply not worked very well?

And if that was the case: why? And why should it bother him?

Offering to make her excuses was a little white lie, and perhaps a kindness to Calantha. Phil had found his own welcoming festivities a bit overwhelming, but in truth nothing comparable had been planned for Calantha, and she might have found it hurtful to know that. Only a few locals had been prepared to spend the evening with her, as an obligatory courtesy, and they were probably relieved that they didn't have to.

Which, Phil reflected, was not quite fair. She'd been a friend to nobody here, but they needed her now. They were going to have to work together, and it would have been worth some effort to lay at least a superficially friendly foundation.

Instead, Calantha (he guessed) got a much-needed good night's sleep, and Phil spent much of the night wondering whether there would be another haunting (there wasn't) and reviewing in his mind how he planned to start things off with Calantha in the morning.

He realized belatedly that they'd made no plans about how and when to meet, and could only guess how the trip would affect Calantha's circadian rhythm. Because her trip was west to east, he suspected last night's apparent fatigue was just that—the effect of flying solo across an ocean—and she'd be rising late by local time. So he was surprised when she came pounding on his door less than an hour after the crack of dawn.

Still half asleep himself, he managed, "Good morning. Have you . . . had breakfast?"

"I was hoping," she said, all business now, "you could join me and start filling me in. Now that I've had some rest, I want to start getting my teeth into this thing."

"Okay. There are some little meeting rooms along the side of the gathering hall. We can get some food from the dispensers and take it into one of those."

The gathering hall wasn't crowded; a few people came and went, but most breakfasted in their own homes if they breakfasted at all. Those who came here largely left others to themselves in the morning unless they'd planned to meet somebody. So Phil and Calantha had their choice of meeting rooms and didn't bother to close the door.

As soon as they had food, Phil launched into yet another retelling of what had happened so far. "So it's our move now," he concluded. "They—and I don't know whether that means otters, bats, or both—clearly tried to strike up a conversation, and I think I flubbed my part of it. Now we have to let them know we'd like to try again."

"Sounds like fun," Calantha said with an expression that seemed equal parts smile and frown. "I've always dreamed about the chance to do something like this, and now that it's here I don't know where to begin. I haven't even seen these beings, or heard a word that they've said, and I gather that isn't going to be easy. It sounds like they really keep to themselves—unless you get them riled up."

"That's a pretty good description. And you're right: they're not likely to come to us, unless they decide to 'haunt' us again, and it would be dangerous for us to barge into their lair. But I think they've already given us a hint about what we might do next."

Now Calantha definitely frowned. "They have?"

"Yes. Remember what they used to get a message across to me?"

Calantha pondered for a few seconds. "The model in the cave?"

"Exactly. I think we should make one of our own, maybe something showing them and us getting together peacefully. Their town is

tucked back in a very rugged bowl of a valley, and as far as I know, the only way into it—if you're not a bat—is through a long, narrow canyon. We could put our model at the entrance to that."

Calantha was definitely frowning now, her lips pressed tightly together. "How likely are they to find it? Do you have any idea how often they come out?"

"None whatever," Phil admitted. "The bats seem to come out pretty often, judging from how often they've been here. But they wouldn't have to use that passage; they can fly out over the cliffs. We'd never seen the otters in the village until a couple of nights ago. But we do know they go in and out through the canyon at least occasionally."

"So there could be a lot of waiting involved, if we do what you suggest. I'd hoped for something a bit more proactive—and efficient." She pondered. "And two species. How do we know which one to try to talk to?"

"We have to talk to both. They seem to have some kind of symbiosis, and we don't know how it works. But we know they communicate with each other, and there are sculptures of both in the town."

"There were statues of cats in ancient Egypt, too, but that doesn't mean they were on a par with pharaohs. We need to find out where our efforts might actually accomplish something, and not waste them elsewhere." Calantha stared intently into space. "Any chance there's just one language they use with each other?"

Phil shook his head. "Doesn't seem likely. I've heard both. The sounds they make are so different I suspect they have dissimilar vocal machinery and can't even make each other's sounds—but can understand each other's. But I'm afraid we're going to have to learn to understand both—and won't be able to make either."

"That's the least of our worries," said Calantha. "I have tools for that. But to use them, I have to see and hear some native speakers, to get some specimens for the tools to chew on. So far I have no better idea than yours for how to do that. I don't like it; I'm not into model-building. But we may be stuck with it, at least at the beginning." This time her pause lasted a full thirty seconds. "If we make this model of yours, somebody is going to have to take it out there and camp nearby so they can keep an eye on it and watch if anybody comes out to react to it. I guess I can—"

"It has to be at least two somebodies," Phil interrupted.

She glowered. "You think I can't do my job without your help?"

"Not at all," said Phil. He resisted the temptation to tell her his real reason for wanting somebody from Breakaway to go with her: to make sure somebody with their interests saw everything she did firsthand—and could intervene in real time if necessary. He didn't need to bring that up; there were plenty of other reasons. "As you said, we have no idea when they'll come out and find our offering, but whenever it is, we'll need to know how they react. So somebody needs to be awake and watching around the clock.

"Besides, if they see me planting it, they'll recognize me as the guy they've already had . . . dealings with. If they just see you, you're a complete unknown, a wild card, something new they have no idea how to regard. They may not even recognize you as having anything to do with us."

"I don't think they'd be *that* blind," she muttered. "But I'll grant your basic point. We'll need two pairs of eyes. But no more than that. Just you and me—in separate tents. Any more than that, they might find intimidating."

"Okay," he said. "So let's get down to—"

But just then a small voice interrupted, "Can I come too? Please?"

Phil broke off and looked toward the open door, as did Calantha. A small girl with three pigtails and skin the color of milk chocolate, maybe ten standard or thirteen local years old, was standing there. She looked vaguely familiar, but he couldn't quite place her. "How long have you been standing there?" he demanded. "Who are you?"

"A while," she said. "Don't you recognize me, Uncle Phil?"

It took him a moment, but then it clicked. "Srella!" he exclaimed. "You've grown. And changed your hair."

She grinned and did a pirouette to show it off. "You like it? Say yes and I'll forgive you for not recognizing me."

"Yes, I like it," he said. "And you can take my not recognizing you as a compliment. It means you're growing up." *Too fast,* he

thought. Then he turned to Calantha. "Do you remember Srella?"

"I'm afraid not," said Calantha, scrutinizing the child appraisingly. "But of course there are so many . . ."

Indeed, Phil agreed silently. "But this one's special. Srella, this is Ms. McQuade, who's come to visit from Newtown. Calantha, this is Srella Lindholm-Muhindi. Giselle's daughter."

"Giselle? Muhindi? Oh . . . the linguist. The one who came out here. How's she doing now?"

Phil looked at her sharply, and then at Srella. "Ask me about that later," he said, feeling awkward.

"It's all right, Uncle Phil," Srella said calmly. "I can talk about it now." She looked at Calantha. "Mom died a month ago. We think natives killed her, but we don't know how. I want to find out."

Calantha's jaw dropped, and she had the good grace to look abashed. "Oh, you poor child! Well, we'll certainly try to find out."

"But that's a grown-up job," said Phil. "We're very busy planning how to tackle it. The best way for you to help is to go back where you belong and let us concentrate."

"No, let her stay," said Calantha. "Maybe she'll have some good ideas. Or at least listening to us may help her healing process—"

"You don't have to talk about me like I'm not here," Srella said. "I know what Mom always wanted to do. I know what she would have wanted to do if she knew there were natives. I want to help do it for her. I want to learn to talk to them."

"But to do that," said Phil, "we're going to have to go where they are. That could be dangerous."

"Obviously she can't go with us, at least at first," said Calantha. "But maybe later. In the meantime, she can at least listen."

And interrupt with childish suggestions, Phil thought, exasperated. *And half-remember what she heard us say but didn't fully understand, and blab it all around the village and start rumors that we'll waste time trying to stuff back into their bottle.* He liked Srella, but having her here now just seemed *wrong*. However, arguing with Calantha in front of her was likely to do even more damage, so he resigned himself to accepting it—for now.

But his concentration was already broken. "Okay," he said, "let's get to work. We need to figure out exactly how we're going to get this ball rolling."

He expected Calantha to answer, but instead, the next voice he heard was Srella's. "I heard what you said about a model. I don't know any languages, but I'm good at making models."

And, as it turned out, she was.

XII.

Ironically, though the goal was to get the locals' attention, it had to be done delicately. Phil and Calantha wanted to tell them, "Let's talk," but did not want to risk scaring them off before that message was conveyed. They dared not do the equivalent of walking up to the local chieftain (if they had such a thing) and thrusting their message-model in his or her face. Instead they wanted to leave it where the residents would find it, and soon; but they wanted the discoverer to find only the model, and not be immediately confronted with—and intimidated by—its makers. So they had to get it into the native town, or at least to the outer end of the approach canyon, without being seen placing it there.

Ironically, the best time to do that was in broad daylight—not the night that humans commonly associated with stealth. From all appearances, night was the busy time, for both bats and otters. During the day, it seemed, they holed up completely. So that was when humans could move about freely.

Now if only they knew where to go.

Phil had toyed briefly with the idea of taking the model right into the natives' hidden town. But that was so well hidden from the air that when Hazel had picked him up after his adventurous night, neither of them had managed to spot it despite prolonged circling over the vicinity. So the only real lead was what he had first mentioned to Calantha: to take the model back to the spot where Hazel had picked him up, in the band of bare rock between the forest and the entrance to the slot canyon leading to the town proper.

And the copter was still the best way to get there. It made some noise, but no tracks—and it got the job done fast. Hazel took them in without even landing, hovering just over the ground as they stepped out. A pile of gear

tumbled after them, much smaller than it would be when fully deployed, but still sizable.

And then she was gone, rising straight up at maximum climb before darting off horizontally, back toward Breakaway.

The midday stillness was palpable, almost stifling, as the copter sounds faded in the distance. The contrast made Phil worry about how much the "townies" had heard in their hidden refuge, but there was nothing to be done about that now.

Some good might even come of it. A commotion might tip them off that something was happening out here, bringing them out to investigate. Not till tonight, Phil guessed, but they didn't dare take that for granted.

So the first thing he did was check his dazer, even as he told Calantha, "Let's get this stuff set up right away—just in case."

"I'll do mine," she said. "It would take longer to tell you what to do with it than just to do it myself. Why don't you do the tents?"

It was a reasonable suggestion, but Phil still found it annoying. But setting up the tents was easy—they practically did it themselves, at the touch of a button—and since he was putting them a few meters back inside the woods, Calantha probably wouldn't even notice him watching her.

He had to admit that what she was doing, at the very edge of the forest, mostly "in" but with inevitable small protrusions "out," looked quite a bit more complicated. Not big or bulky—it had been a long time since much information-handling equipment had those traits—but mysterious. Much of it was an array of sensors and transducers of various sorts—cameras, microphones, speakers, and Phil could hardly guess what else—individually small and made to look like their surroundings. But there were a lot of them, and from the way Calantha moved and fretted over their placement and orientation, Phil guessed that each had a very specific job. He could only guess how she knew what that job should be, since she couldn't have had much chance for actual field experience in her arcane field.

By midafternoon she announced that it was ready, and it was time to set up the message-model. Phil marveled at how much of the actual craftsmanship was Srella's. He and Calantha hadn't had much trouble coming up with the concept, but the girl was so much better at actually making and assembling the pieces that they'd wound up leaving the tricky, delicate stuff to her, while she let them handle some of the gross framework and simple mechanical work. It was her small hands that gave her the advantage, Phil tried to tell himself; but he knew it was more than that.

Giselle had left a worthy heir.

Like the locals' model, this one included an easily recognizable miniature of a windmill, complete with whirling rotor. But this one was a lot smaller, and didn't attempt such subtleties as showing the locals interacting with it, because the model also had to show the native townsite.

Phil hoped they had the concept of "not to scale."

For this part, unlike setting up the tents and monitors inside the fringe of the forest, he and Calantha had to venture out onto the open road. Even with the near-certainty that its usual users were strictly nocturnal, he felt exposed and vulnerable as they spread out the substrate, a crude suggestion of a topographical map of the area. But the human-built windmill and the few stylized houses around it were way too big compared to the distance between that settlement and here, and the human figures among them even more so. At the opposite corner were models similarly suggesting the native town, tucked back under carved overhangs in an almost-hidden bowl, with the slot canyon leading out to the spot where they were placing the model.

And, at that point, a round table with little models of humans and otters around it, and a couple of bats hanging from a nearby framework.

"I'm still not comfortable with putting it here," Phil said as they worked. "I hope they'll recognize the suggestion that we get together to talk. But mightn't they feel threatened by the idea that we should do it on their turf? Some neutral place might be better. Maybe something halfway between their place and ours."

Calantha shrugged and kept working. "Quite possibly," she granted. "Or they might see it as conceding them the home-court advantage. Or maybe they consider everything around here their turf, and it doesn't matter where we meet. We won't know until we can talk to them, and this place offers our best

chance to start trying. A lot of their traffic must funnel through this point, so we'll have a chance to observe what they say and do and start looking for correlations. The only place that might be better for that is inside their town, and both they and we would consider that too dangerous."

So they finished the job, without incident, and settled back to wait. It was a slow, tedious afternoon; there was little else to do and neither Phil nor Calantha felt comfortable enough with the other for much small talk. He passed much of the time with various forms of canned entertainment he'd loaded on a chip. They met for dinner, but said little.

But as soon as dusk started to merge into night, things began to happen: faint hints of motion at the mouth of the slot canyon, as if darker parts of the shadows were trying to break off from the rest. Phil and Calantha were sitting, less than comfortably, on camp stools partly hidden by vegetation from the clearing outside, watching. Phil was on the verge of dozing off when he felt a repeated jab on his shoulder.

"Phil!" Calantha whispered urgently. "Somebody's coming out!"

Phil struggled to shake off his grogginess and see what she was pointing at, but all he got was a vague sense of motion in the shadows, which by now were barely distinguishable from the general darkness. Phil fumbled to get his nightglasses on and operating; Calantha already wore hers.

They helped. The vague shapes became "otters," and he saw them more clearly than ever before—clearly enough to start recognizing individual differences in body shape and facial features.

There were three of them, and they didn't seem to suspect they were being watched. At first they didn't seem to notice the humans' model. They were moving quickly as if headed somewhere else, and chittering continuously, sometimes two or even all three at once. Incongruously, they reminded him of boisterous young humans on their way to school or a job, and they all zipped past the model as if they didn't notice it.

Then, abruptly, the hindmost stopped, whirled around to stare at it, and let out a loud, distinctively different burst of chatter. The others stopped, too, and turned back. They gathered around the model, talking, it seemed, excitedly and maybe fearfully. Occasionally one of them reached out to touch some feature of the model.

Their excitement was as nothing compared to Calantha's. Even though much of her face was hidden by the glasses and the displays projected inside them, Phil could tell she was bursting with excitement, frustration, and a kaleidoscope of other emotions. As well she might be: this was an opportunity she must have dreamed of for most of her life, and one that nobody before her had ever had—and she could have very little idea of what was going on.

She watched intently, her fingers sometimes jabbing at virtual controls in the air, as the three otters milled around the model, inspecting it from different angles, poking at it . . .

And then, as suddenly as the first one had stopped, all three of them turned, still chittering, darted back into the canyon, and disappeared.

Phil waited a full minute, then said, "What just happened here?"

"We got noticed," said Calantha, removing her glasses and frowning deeply. "Beyond that, I wish I knew. I *suspect* that what just happened was important, but I'm not sure how." She was chewing her lip. "I'd hoped to have a chance to watch them doing lots of everyday stuff, so my computer would have plenty to chew on to look for correlations. But there was practically none of that. The wheels are turning, but I don't expect much more than, 'Hey, guys, look at this!' and 'Let's go get help.' And a whole lot of 'untranslatable.' And no idea how to parse even the couple of sentences we might hope to recognize."

"Help," Phil repeated thoughtfully. The night air was beginning to feel chilly. "That makes sense. Since they had no reason to expect the model, we had no reason to expect that the first ones to find it would be the right ones to deal with it. I had the feeling these were just working stiffs headed out to the fields, or whatever their counterpart is. It was obvious when they kidnapped me that they have some sort of leadership hierarchy. Maybe these just went back to tell their bosses."

"That's my idea, too. So we go back to waiting."

"But how long?"

"No idea. If their committees are like ours, it could be weeks before their next move. But if they're smart—and as upset with us as we think they are—it could be a whole lot sooner. Like tonight."

"I don't think I can stay awake all—"

"Not necessary." Calantha waved an impatient hand. "I'll set an alarm."

Despite the uncomfortable accommodations, Phil was deep in slumber when he gradually became aware of Calantha shaking his shoulder again—harder, this time. "They're out," she whispered. "Somebody new."

Phil dragged himself laboriously up to the edge of awake, put his glasses back on, and peered out through the bushes. He only saw two otters this time, both clearly fixated on the humans' model. One was obviously larger than the earlier trio; the other he wasn't sure about. Colors were muted by the nightglasses, but the larger—older?—struck Phil as having a subtle hint of silvery sheen in its fur, and the "younger" gold. Both moved and spoke more deliberately than the first three, and sometimes silences of some duration punctuated their dialog.

Neither gave any other sign of knowing they were under observation. Phil felt himself tensing up, wondering if at any moment Calantha might suggest that they step out and reveal themselves, even though he suspected she had no more idea than he did about what to do next.

Fortunately—perhaps—the otters made that moot. In less than an hour, they turned and retreated quietly back into the narrow canyon. They made no more appearances that night.

Phil felt exhausted in the morning. He must have spent the rest of the night with an internal alarm set for any further sign of native activity. To the best of his knowledge, there wasn't any—and on reflection, that seemed odd. Shouldn't there have been lots of comings and goings, the daily—nightly—business of this culture's life? Were they wrong about that? Or had the normal routine been put on hold because of apprehension about the alien artifact the townies had found on their doorstep?

So many questions; so few answers.

At least, in the light of day, he felt free to talk to Calantha about it. "So when do we try to talk to them?"

"When we learn to talk," said Calantha. "We can't rush this, Phil. If we're going to have a meaningful conversation, we need some vocabulary and, even harder but at least as important, some understanding of how their language is put together. The best way to do that is to observe how they interact among themselves and let my instruments look for connections."

"But we haven't seen them do much except talk," Phil pointed out. "How can we correlate what they say with what they do if they aren't doing anything? There are more direct ways—"

"Which are riskier. If we plunge in half-baked, we can make dangerous mistakes. Who's the linguist here, anyway? I thought it was me. You had me fly halfway around the planet to learn how to talk to these creatures. Please let me do it the way I think best."

It wasn't a question, and Phil decided the better part of valor was not to treat it as one. That meant another sleepless and unproductive night and an amazingly long and boring day. Phil was glad he had brought material for reading, watching, and listening, but it quickly wore thin. He made a few tries at engaging Calantha in conversation, but despite their common goal here, the cultural ice between them was still too thick.

When he tried to imagine passing several days out here like this, the thought was depressing. He needed to *do* something!

That night—sooner than he had expected—he got to.

Well into darkness—and darkness was more complete now, Selena being into its waning gibbous phase—he had about given up on any further action from the otters and was on the verge of sleep when Calantha's alarm pinged them both. Groggily, he looked out through the branches and saw motion at the mouth of the canyon.

He thought he recognized the two otters from last night—"Sylvie" and "Goldie," he had taken to calling them, in view of their pelt coloration and forest habitat—but now there were four others as well. The newcomers were carrying something—something that

looked vaguely familiar. It took him close to a minute to recognize it, and then his jaw dropped.

It was a round table, just like the one in the humans' model, but full-scale. The carriers unfolded legs on one side of it and set it up on the ground, as if preparing for a poker game.

Or a summit conference.

They disappeared momentarily back into the canyon and quickly emerged pulling a cart, from which they started unloading things. First came two oddly shaped contraptions which, after a moment's searching in cobwebby recesses of his memory, reminded Phil of banquet couches from textbook imaginings of ancient Rome. Sylvie and Goldie stretched out on those, and it was obvious that they were made for that purpose: They let a six-limbed otter rest comfortably in a completely relaxed position, or raise head and forelimbs for more vigorous activity.

Finally came four objects so obviously serviceable as human chairs—though not belonging to any style or period from human history—that Phil felt sure they were intended as exactly that.

Correction, he thought. *They're like nothing from* past *human history. But this is history in the making.*

His heart pounding, he glanced at Calantha. "Now what?" he whispered.

"Now we do it your way. This is no time for passive observation."

XIII.

The otters were so clearly accepting the humans' invitation that there was no choice but to accept their acceptance—or to see their bet and raise it. Calantha hurriedly fussed with some adjustments on her hidden equipment. Then, moving very slowly, she and Phil stepped out into the open and walked toward the table. Sylvie and Goldie watched from their couches, but didn't move.

It could be a trap, Phil reflected nervously, a way to entice an unknown number of humans out where they could be attacked, as revenge for the inadvertent damage caused by their windmills and Phil's equally inadvertent injury of the otter he'd blinded with his flashlight. He had to fight the urge to keep one hand on his flashlight and one on his dazer.

But were the otters really that simple-minded and vindictive? Phil doubted it. That night in the cave, he'd had the feeling that they were less interested in vengeance than in finding a solution to a problem. It was obvious that they'd put considerable thought and effort into planning this meeting. The closer he got to the table, the more closely it resembled the toy one in the model. Even the chairs, despite their initial appearance of wrongness, proved visibly inspired by those in the model, limited as they were by the difficulties of working in miniature.

Yes, not only time, but also craftsmanship, had gone into this setup. Whoever made the props must have worked through the daytime, when Phil had thought them all dormant. That implied that they had ways of working unhindered by bright light, perhaps in underground shops. . . .

By the time he and Calantha were almost to the table, he was actually feeling less apprehensive, though still wary. The otter he thought of as Sylvie inclined its head slightly toward them, waving one forepaw toward them and one toward the chairs. As they sat, avoiding sudden motions that might alarm their hosts, Phil studied that "paw" and decided that was not at all the right word for it. It was a hand as surely as his own, with slender, multijointed fingers—one of them a second opposable thumb.

There was plenty of dexterity there, but he wondered about strength. The arm that bore that fine hand was short and not very thick, which implied that they used strength-amplifying tools. Which he already knew, from riding in their wheeled wagon. . . .

On the other hand, they hadn't had any trouble manhandling him into and out of it, by cooperating. And though he'd never seen them in the flesh, he remembered reading about how strong animals like wolverines and chimps were, back on Earth, despite their modest size.

None of which was pertinent at the moment. They were here to talk, and since they had no language in common, the first thing to do was establish some common ground.

As soon as the humans were seated, Sylvie emitted such a burst of high-speed, high-pitched chattering that Phil might have thought the situation hopeless. Goldie

immediately did the same. Those sounds were so utterly unlike any he'd ever heard a human make that he couldn't imagine even approximating them. That suggested that the otters would find human sounds equally impossible to replicate.

He glanced wildly at Calantha, to see if she found the prospect as hopeless as he did. Evidently she didn't; her expression was calm and intent. She gave him a barely perceptible, vaguely reassuring nod, then waved her hand over the tabletop, not quite touching it. "Table," she said distinctly. "Table."

The chittering Sylvie emitted bore not the slightest resemblance to "table," but he could tell that she repeated it. Even if humans had no hope of speaking their language, or vice versa, there was at least a shred of possibility that they could learn to understand each other's speech—and reply in their own.

And maybe more than that, with the high-tech helper Phil knew Calantha was using, but the otters couldn't even imagine.

He contented himself mostly with watching and listening. Calantha pointed to herself and said, "Calantha," and then to Phil. "Phil." Then she again pointed to each of them in turn, but in each case said, "Person."

It took a little while, but not as long as Phil would have expected, to establish those words as specific and general names. The otters soon made it clear that they had those concepts, too, and Phil learned to recognize—more or less—particular tweet-patterns as names for Sylvie and Goldie. He took a certain pleasure in that, but if he ever had to address or refer to them, they would have to remain Sylvie and Goldie.

Things continued in that vein for the rest of the long, exhausting but exciting night. Phil had the feeling that they were making a succession of sporadic, tiny breakthroughs, but Calantha increasingly showed a kind of excitement he would never have associated with her.

When the eastern sky began to lighten, the otters suddenly jumped gracefully off the couches and onto the ground. With a parting burst of chatter, they ran back into the canyon mouth and vanished.

But they left the table and chairs in place.

"So," said Phil when they were gone and dawn light was starting to filter through the trees, "did we accomplish anything? I may sort of recognize a very few things they said, but I couldn't begin to repeat any of them."

"Of course not," she said with what he thought of as her customary brusqueness—and then, with an ebullience he couldn't have imagined her showing, "We accomplished a *lot*. It was wonderful! Here, come back to our lair and let me show you a few things."

He followed her back into the forest fringe and the two chairs she had set up at the heart of her equipment. "I'll have to keep this quiet," she said as her fingers played over controls. "We wouldn't want them to come running at what they think is our call. But let me show you what my little helpers have been up to.

"Basically, they've been doing the same things we've been trying to do, but they have a different perspective. Or rather, a lot of different perspectives, and a lot more input channels and processors. Lots of little cameras and microphones out there, watching and recording everything that either they or we said or did, and looking for correlations.

"The system is trained to pretty much disregard what we humans say and do. We know ourselves and our own language too well to waste processing power on that. What we don't know is which sounds or gestures mean what when the otters make them, and the computer can examine a lot more possible correlations than might catch our eyes. Look at this, for instance. . . ."

She showed an early bit of the long scene they had just played out, in which their hosts were urging them to sit down, accompanying gestures with chittering noises. "It's pretty obvious," she said (and maybe it was, to her), "that this is a word for table and this is a verb for sit, though we don't yet know about inflections. And 'sit' for humans seems to be different from its counterpart for otters, though we don't know just why. It could have to do with different anatomies necessitating different motions, or it could be something like the difference between *essen* and *fressen* in German. . . ."

She went on at considerable length, and Phil hoped she was really getting as much out of it as she seemed to think she was. As for himself, he was just tired, and he watched for a chance to get in a word of his own. Which,

when the time came, was, "I think it's time to change our procedure a little. When we started out, we were camping here around the clock because we didn't want to attract attention with our comings and goings. Now that they know we're here, that's not necessary any more. Why don't we start going back to Breakaway to recuperate during the daytime?"

"I don't want to lose my focus. I've got something to chew on now; I don't want to break it up with those comings and goings."

"But they won't take long—"

"Because they're not going to happen. No, the flights wouldn't take long, but there'd be waiting at both ends, and distracting conversations with other people. I can't afford it now." Her tone softened slightly. "Bear with me awhile, Phil. We're going to have a surprise for them tonight."

Phil didn't press the point, but he wasn't happy about it. Calantha got thoroughly lost in fiddling with her monitors and synthesizers, cut off by earbuds and heads-up displays visible only to her, and showed no inclination to involve him in the proceedings. He passed part of the morning reading and playing games, but he was exhausted and uncomfortable. Soon he fell asleep, and presumably, at some point, so did Calantha. Because at some point a soft, persistent warble, *sempre crescendo,* insinuated itself into his dreams and dragged him back into the waking world. "Wake up, Phil," Calantha was saying. "It's time."

It didn't feel like time. It was dark and smelled strange, and it took Phil several seconds to remember where he was and why. But he suppressed his grumbles and joined Calantha in crossing the open "road" to the table they had left this morning. This time she was wearing a small box that she hadn't brought last night, which he guessed had something to do with her "surprise."

As they approached the table, they got another surprise—one the otters had evidently prepared for them. The humans' model, originally laid out directly on a level piece of ground, had been moved, meticulously intact, to the center of the tabletop. And when they sat down to talk—a charitable use of the word, Phil thought—Sylvie went immediately into vigorous gesticulations, pointing rapidly at parts of the model and jabbering so fast he doubted that even Calantha's gadgets could make any sense of it. But he was as startled as Sylvie and Goldie when Calantha's fingers played over the small new box she wore and a new otter voice interrupted, loudly enough to be unmistakable.

Even with no idea of what constituted an otter phrase, Phil could tell that Sylvie broke off in the middle of one. She (for some reason Phil now thought of "her" that way, even though he had no way to know) stared silently at Calantha, looking her up and down as if trying to figure out where the sound had come from. Finally Sylvie, still scanning rapidly over Calantha and everything around her, emitted a short but particularly frenzied burst of chatter.

And Calantha's box said, in recognizable if ungrammatical English, "Say who? Say who?"

Calantha grinned broadly. "I speak," she proclaimed, pointing at herself.

And her box emitted another burst of otteresque chatter.

Sylvie and Goldie were all over her, slithering rapidly off their seats (or whatever they should be called) and coming right over to peer and sniff at Calantha from head to toe, with lots of special attention to the box on her belt. "It hears me speak," Calantha said, "and tells you what I said. It hears you speak, and tells me and Phil what you said."

Sylvie and Goldie flinched back as the translation into their language flowed from the box, but they recovered quickly. With just a suggestion of wariness, they leaned closer to it as if to ascertain that that was where the sound was coming from. Then Goldie held a paw not quite touching the box, looked up at Calantha's face, and said something that the box rendered as, "Make sound you we not. Make sound we you not. Make sound two box. You we understand. We you understand."

Calantha grinned broadly. "Yes! That's it exactly! Syntax needs a little work, but that will come." She looked straight at each otter in turn. "We want to understand you—" She stopped and frowned. "Sorry, we don't have that concept yet. And if there's any that we're going to need . . ." She paused thoughtfully, then said, "Let's try this. . . ."

* * *

It was slow going at first, but through much of the night Calantha worked on exposing her translator to enough concepts to have a fighting chance of carrying on a real conversation. Phil was surprised at how quickly the otters got over their initial consternation and accepted the translator for what it was. Soon they seemed as interested as Calantha in trying to establish a connection, but for some hours, it remained shaky.

Human and otter languages, Phil gathered, were even more differently structured than human languages like English, Chinese, and Xhosa. The translator almost always tried, but often the English that emerged was barely recognizable, much less coherent or comprehensible. Phil assumed the reverse was equally true. Occasionally—not too often—one side or the other took offense at what came out, and feathers had to be unruffled. Sometimes Sylvie or Goldie let out a startlingly sudden outburst that the translator didn't even try to render, or produced pure gibberish.

But as the night wore on, those incidents grew fewer, and a satisfying sense of points of contact began to emerge. Then, as dawn was just beginning to tinge the eastern sky, Sylvie suddenly pointed to the windmill in the model and said, according to the translator, "Time for business. We want these stop."

Phil froze. He'd seen no indication that they were working toward this crucial point, and now, without warning, it was here. For the first time he saw Calantha glance his way, as if seeking his advice. After a moment's hesitation, he looked at Sylvie and said, "Why?"

Calantha's translator, too, seemed to hesitate a little, but only a little. It made otter sounds, and Sylvie responded in kind. The box said, "Danger. They kill us. They destroy our food. Must stop."

"That was never our intent," Phil said solemnly, debating briefly and deciding not to point out that the otters had—probably—killed humans, too. "We are deeply sorry. But we need the windmills."

Sylvie became agitated. "No, no! Can't have. Cannot accept danger."

"We must try to find a way to remove the danger," Phil said, much more calmly than he felt. "But we must do it without making danger for us. As I said, we need the windmills."

This time Sylvie said, "Why?"

"For energy—" he began, and broke off right away. What were the chances she would have *that* concept? He was sure it hadn't come up in their conversation so far. He tried again, picking his way slowly. "The wind makes the mills turn. The mills make other things turn. They make . . . machines run. Machines that cut, grind, heat . . ."

He gave up. It felt hopeless. As if to make it worse, he heard a flapping as of large wings, glimpsed motion from the corner of his eye, and saw two of the big bats settling into a nearby tree, obviously looking this way.

Phil felt a chill. The arrival of the bats at this moment felt just plain ominous, though he couldn't put a finger on why.

But then, to his astonishment, he saw Sylvie quivering, leaning (if a being with six limbs and a tail can be said to lean) forward. Was that excitement she was radiating? "Yes! Yes!" she said. "We need that too. But don't use windmills to do it. Too dangerous. Must find other ways. Better ways. Ways we can live with and you can live with."

Phil's mind whirled. Was she really saying that her kind also needed energy to run machines—and that she saw hope of finding a way to coexist? Feeling on shaky ground, he began, "But how—"

"Can't talk now," Sylvie interrupted. "Too big." She gestured toward the east. "Sky getting light now. We must go in. But be back here tomorrow night.

"And stop windmills till then."

And with that she was off, she and Goldie leaping to the ground and running headlong down the canyon toward the town.

"Well!" said Calantha, after a long silence. "I think now it *is* time to go back—and open a can of worms."

XIV.

"We've made a good start," Phil told Hazel on the short flight back to Breakaway, "but we've reached a critical point. We're going to *have* to shut the windmills down, at least for a while."

Hazel, at the controls, frowned. "We've been through all that. You know there's a lot of well-founded opposition. What's changed?"

"Before, I was largely guessing at what they wanted, and why, based on the show they put on in their cave. Turns out I was right, mostly,

but this time, thanks to Calantha, they've explicitly told us what they want, and why. More important, they've told us they want to find a compromise. But they want the windmills shut down while we talk about it."

"We already discussed that, and—"

"Don't you see the difference?" Phil interrupted, becoming agitated. "Before, we were guessing that they might take a shutdown as a show of willingness to compromise, but we didn't know where we'd go from there. Now they've suggested one. *They* want to find a compromise, when for all we know, they could have just given us an ultimatum—and maybe made it stick. We *have* to talk to them—and we have to show we're serious about it!"

Hazel, already on final for Breakaway, frowned but said nothing. Only when they were down and the engine shut off did she say, "Okay, I'll make the decree. You want to back me up?"

"I can't right now," Phil said. "I'm exhausted. I need a good long sleep."

Hazel looked him over. "I guess you do. Well, pleasant dreams—but be prepared for an uproar when you wake up."

Phil tried to convince himself he was, but not very hard. The pull of his own bed was so irresistible that he barely made it there before he fell into a deep slumber.

Calantha was tired but too excited to sleep right away. As soon as she reached her quarters, she called Magnus, despite the time. With Zo six local hours ahead of Newtown, it was debatable whether he or she would be less lucid. She'd just finished an exhausting night, but he was in the middle of his, and presumably sound asleep.

So it wasn't surprising that he took two full minutes to answer, left his video off, and sounded grumpy. "Sorry to bother you," Calantha said, "but you said I should keep you posted. I thought you'd want to hear as soon as I had something that seemed important."

"Well, yes," he half-growled, "but I must admit I doubted you'd find anything *that* important. After waiting this long, would a few more hours matter? Is there some emergency?"

"Not an emergency, exactly," said Calantha, "but profoundly important. They're real."

A lengthy silence. Then, *"Who's* real? Or should I say *what?"*

"Who," Calantha said quietly. "The natives. I've seen them. I've . . . talked with them. I'm sorry I didn't check in with you sooner, but I didn't want to disturb you until I had more to say than that there were animals here. Of course there are animals here; there are animals all over the planet. But these are different. *Really* different." She paused, waiting for feedback but getting none. "Magnus . . . *Brother* Magnus . . . this changes everything. What are we going to do?"

"Do we have to do anything?"

"I think we will—if not now, then later. Of course, the decision is up to you. For decades, everybody's taken it for granted that we humans were alone in the universe. That underlies everything else we believe. Now we're going to be forced back to the times when people wasted endless worry arguing over whether there might be other intelligences, and what we would do—what we might be *forced* to do, and what they might do to us—if we ever met them."

She listened to her heart hammering for a few seconds before adding, "No, it's worse than that. Now we know that they do exist, and we *have* met them. And we have to share with them—not just the Universe, with lots of comfortable distance between us and them, but this little planet!"

"It's not that little," said Magnus, but she heard worry in his voice too. "There's an ocean between us."

"Maybe," said Calantha. "But we have no idea how many of them there are, or how widespread. These have just recently been noticed, even though they must have been here for a long time. And even if the ocean is a barrier now, how long will that be? Extensive contact is inevitable, and it's not too early to begin thinking about it."

"Perhaps," said Magnus. "You're really convinced that these beings are more like people than animals?"

"I'm sure of it."

"Hmm. If you're right, I'd have to agree that we'll have to rethink a lot of things, and that's never comfortable. But even if contact is inevitable . . . sharing may not be."

"Are you suggesting the alternative I think you are?"

"We'll have to consider all options," he said. "But a simple, well-marked path has many advantages over a tangled, confusing maze."

Neither of them said anything for a while. Then Calantha spoke very quietly. "Perhaps—but some will find that path disturbing. I think I would. Have you considered the possibility that they might have things to teach us, and we to teach them?"

"Yes. I've also considered the possibility that no good could come of the attempt—and the possibility that your judgment is clouded by the temptation of having the chance to flex your long-idle linguistic muscles. We both know about temptation." He paused. "I don't think either of us is in the best condition to wrestle with anything this big right now. Let's sleep on it, and then you can get back to learning about these . . . entities. Do keep me posted—but in the future, please save your reports for a more civilized hour unless that's truly impossible."

Calantha assured him she would, and she tried to sleep, but without much success. She wondered whether he did any better.

Phil had set an alarm, timed to allow a not-too-rushed dinner before heading back to "Ottertown," but that wasn't what woke him. He was dragged up from comfortable depths by an insistent pounding on his door and a harsh counterpoint of raised voices. He frowned, barely able to make out anything being said. But one of the voices was Hazel's and he caught, "—temporary. We'll reevaluate when—"

"Why wait?" a harsh male voice interrupted—Corcovan, obviously. "This has—" Then unintelligible noise, as the two tried to shout each other down.

It was obvious that Phil wasn't going to get any more sleep. It was time to get up anyway. Forcing himself to stay calm, he put on a minimum of clothing, ambled to the door, and opened it. "What's the problem out here?"

"You are!" Corcovan bellowed. "You somehow bullied Ms. Spineless here into—"

"I have spine enough not to let you walk over me, Phil, or anybody else," Hazel growled back. Phil noticed her hand poised near a sidearm. "He made a good case that we need to shut the windmills down for a while to give the other way a chance. So we did it, and they're going to stay shut down until we see a better reason than you've given us. Now if you'll excuse us, Phil has a job to do."

"I don't see it that way. The job we *all* have is to protect this colony. Everything else is—"

"I believe," Phil broke in quietly, "we've been over all this before. Unless you have something new to add—"

"Oh, I have something new," said Corcovan. "Though in a way it's something old. Have you forgotten that they've killed two of our people? If nothing else, we need revenge."

Phil and Hazel snorted in unison. "Really, Corcovan," said Phil. "Don't you think you should have grown beyond vengeance as a reason for doing things? Most of us here have."

"Have they? I think I'll ask around a little. Remind them what happened . . . put a face on it." He paused. "I saw how you dragged poor little Srella into this, after what she's been through—"

"I dragged her in? Look here, Corcovan, it was her idea. I didn't even like it at first, but she wanted to get involved and her mother would have wanted it that way. She knows what she's doing, and she's already made a valuable contribution."

"I think I'll just see what she has to say about that."

"You'll do nothing of the kind," Hazel said firmly. "You and I can talk about this some more, but until we've agreed otherwise, you'll stay away from Srella—or else. Now we've wasted enough time here. Phil and Calantha have important work to get back to, and they need to be there before—"

"Don't you get it?" Corcovan exploded. "They shouldn't be doing that work! These beings are a clear and present danger to us, and we shouldn't be—"

Hazel cut him off yet again. "That's not for you to decide. At least, not alone and not this soon. Now . . ."

They went on like that for a few minutes, with voices rising faster than anybody's satisfaction, but Hazel stood firm on a temporary shutdown of windmills and ordered Corcovan to stay away from Srella. Corcovan stomped off fuming.

And Phil and Calantha were late for their appointment.

XV.

The sun was already down when Hazel flew them to their meeting point, which made for an eerily new experience for both them and the otter ambassadors. Sylvie and Goldie were already there as the little craft eased down toward the ground, its landing lights dimmed as much as Hazel dared—which was quite a bit, thanks to the other instruments at her disposal.

Phil hoped the relatively subdued light wouldn't bother them, but apparently it did, though not unbearably. They glanced away frequently, as if to rest their eyes; but in between aversions, they seemed fascinated, if a little afraid. Their first reaction, as the craft settled to the ground, was to press themselves back against the cliff as if trying to stay as far as possible from the strange contraption. But once it was down, Phil and Calantha had disembarked, and Hazel was zooming skyward and away, Sylvie and Goldie pressed vigorously in around Phil and Calantha, jabbering incessantly and simultaneously. Calantha's translator struggled to keep up.

"How that fly?" "We want one. . . ."

Phil glanced at Calantha for any guidance she might have on how to answer. She did the same to him. Neither said anything. Finally, as the already faint sound of the highly efficient copter faded into the distance, Phil ventured, "I don't know how to explain. I don't understand it that well myself. But it uses energy—"

"Ah, yes," said Sylvie. "Energy. Maybe you understand better later, help us understand too. More important things now. Did you stop windmills?"

"Yes," said Phil. "We did. But only till we find a better way—"

Sylvie seemed to relax. "Hope we can," she said. "Glad you tell truth. Is good sign."

Phil and Calantha frowned. She asked, "What do you mean?"

"We knew you stopped windmills," said Goldie. "But wanted to know if you tell truth. Many other ways you could answer. You could bluff. Try deceive us. If you told us one thing and we knew something else true, that be bad sign. Couldn't trust you. This way . . . maybe."

"Maybe," Sylvie agreed.

Phil stared. "So . . . this was a . . . test?"

"Yes," Sylvie and Goldie said together. Sylvie added, "May not be last. But this one, you pass."

"So now what?" Phil asked. "I assume you talked with others about the windmill problem. Do you have new ideas about what we—you and us—can do?"

"Not yet," said Goldie. "Already said, more important things now." She looked at Phil. "You remember first night you came here?"

"I couldn't forget. The way you brought me—"

"You tried escape before we finished," Sylvie interrupted. "Pulled out weapon." It took Phil a moment to realize she meant his flashlight. "Hurt one of our friends."

Phil winced. "It was an accident. I didn't know—"

"No matter. Accident or purpose, you hurt her. Now you must visit her."

Phil felt a sudden huge lump in his throat. What could he say to her? What trouble could he get himself and the rest of the settlers into with whatever he said?

And what might the otters do to him once they got him inside, which was presumably where his unintended victim was?

The prospect was daunting. But he did feel a certain obligation to do *something,* and from a practical point of view, perhaps the most important thing was that it was a way to *get* inside.

Was this a test too?

Phil wasn't surprised that the otters made him and Calantha leave their flashlights outside. They didn't ask the same of the translation equipment, which showed both understanding and courage, since they must have been uncomfortable with its unknown capabilities.

Just inside the canyon mouth was a cart, quite possibly the same one in which Phil had had his first hair-raising ride. Sylvie gestured them to climb in. Phil did so without much hesitation, having some idea what to expect this time. Calantha stared wide-eyed at the rickety conveyance and the dragonhorse hitched to it and hung back uncertainly. "Come on in," Phil said. "I've ridden one of these before. We'll be okay." He extended a helping hand; she took it with obvious reluctance and clambered aboard. Sylvie and

Goldie followed, and the vehicle lurched forward with a snort from its "horse."

Alone in the box, Phil had rattled around in it, tossed against the walls as the vehicle accelerated and changed course. With four sizable beings in it, they were packed too tightly to move much at all. But he was very conscious of the pressure of other bodies, the slight but alien smell of their hosts, and their slightly warmer feel.

This time he still had his nightglasses on, so he could see the rugged walls of the canyon rising close on both sides as they careened through it. That, plus knowing a little about what was happening, made it a little less scary this time, at least for him. A glance at Calantha's face showed that for her it was as terrifying as his first wild ride. She was clutching his arm tightly, not with anything like affection, but rather a mixture of fear and disgust with herself for having that fear. She probably didn't even know she was doing it.

When they emerged into the bowl-like valley that he now thought of as the town square and gateway, he got a reminder of the fear he had experienced before. He expected their cart to slow down as the far wall loomed rapidly higher and higher before them, but it didn't. Instead it swerved sharply left without losing an iota of speed and sped right into the wall.

Into, literally, which was a great relief. He'd noticed shadowy openings in the wall before, and this time the draft beast and its charges plunged headlong into one of those and kept going, the echoes of its passage louder than ever now that the noise had a ceiling as well as side walls to bounce off. At first it was featureless to human eyes, so to distract Calantha from her fear he stage-whispered, "Did you see the sculptures?" She didn't seem to hear him. Evidently even a stage whisper wasn't enough, so he tried again in an unabashed shout.

"Yes," she grated. "Where are we now?"

"Don't know," he said between lurches. "I've never been here before. Entering the city, I'd guess."

"But there's nothing—" She'd been about to say there was nothing to see, he guessed, which was reasonable since the first part of the tunnel was featureless and black. But that only lasted a minute or so. Then it changed abruptly as the tunnel opened up into a canyon, still with the sides sloping toward each other to leave only a sliver of sky showing through, but with much more room at ground level.

And it was far from empty. Here, for the first time, the city actually started to look like a city. Otters, with their variety of postures and gaits, walked to and fro, singly and in small groups, some carrying things, others unencumbered. The cart carrying him and Calantha barreled right through as if not seeing or caring about the pedestrians. None of them seemed to care either; when necessary, they just dodged nimbly and unceremoniously out of its path.

And there were more openings along the wall: doors and what might have been windows, giving hasty glimpses into dimly lit chambers in which otters went about their unknown business or leisure activities.

And, most startlingly, chambers that were *not* dimly lit. Some of the windows were fitted with panes of some darkly transparent material, through which Phil glimpsed what looked like machines and masked otters, and balls of what looked like flame. They weren't terribly bright seen from here, but the harsh contrast around them suggested that they would be much brighter seen directly.

So if otters could work around blazing light sources like those, why had his flashlight been such a problem?

To him it suggested two possibilities. First: it wasn't, and for some reason—as an excuse for aggression?—they were faking its severity. Or, second, it really was, but they had ways of dealing with such things when they wanted or needed to.

Which seemed much more likely. He'd seen the allegedly injured otter go crashing down that rockpile, and he'd seen them put on dark goggles when they staged that first show for him.

But these lights, he was pretty sure, were much brighter than those. And that had startling implications. . . .

He forced himself not to pursue them now. Instead he concentrated on the kaleidoscope of new impressions through which they were passing. A couple of times, while passing side chambers, he heard rhythmic sounds like the one that had reminded him of engines that first night out here.

But before he could process that, the scene changed yet again as their steed pulled them out of that canyon, and the ground dropped away on their left. Now the road followed a shelf along the face of a cliff, still with an imposing overhang above, but ocean and a fair expanse of starry sky to the left. They weren't far above the water, and thanks to his nightglasses, Phil could see that it was relatively quiet here. In fact, it looked marshy, and here and there floated some sort of boats, with otters swimming among them and occasionally boarding or leaving one.

He didn't have time to figure out what was going on, because by the time he had realized that much, the cart made two more sharp turns, first into another tunnel or very narrow canyon, and then into a short side passage, where it stopped abruptly. "We're here," Sylvie announced. "Follow me."

She slipped nimbly out the back of the cart, followed smoothly by Goldie. Phil and Calantha followed, neither nimbly nor smoothly after the cramped, bumpy ride. Sylvie led them all through a small door, and suddenly they were in what might have been a small bedroom, had humans built it.

But obviously humans hadn't. There were none of the right angles so pervasive in human architecture, and Phil had the impression not so much of architecture at all, as of nature gently tweaked to a civilized user's needs. It might once have been a natural cave, but the surfaces, curved everywhere, were a bit too smooth to be natural. Small pieces of furniture, some standing on the floor and others attached to walls, held clearly artificial objects, some as obviously utilitarian as cups and bowls, others whose functions were not apparent. They might have been tools for unknown tasks, or they might have been abstract art.

Some of them, surprisingly, looked clearly metallic.

A large area of the back wall was open, down almost to the floor, giving an unobstructed view of the nearby marshes and the open water beyond—though a mechanism above it seemed to be a sort of blind that could be drawn when outside grew too bright. Closer in, though Phil couldn't see it, the coast must be much more rugged. He heard waves crashing below the window, and sometimes spray from them fountained just outside. Above the window, the ceiling curved back to become a high ceiling with a few ledges and sturdy rods projecting from the walls just below.

In front of the window, on a "couch" somewhat like the ones on which Sylvie and Goldie had reclined at the mouth of the canyon, lay a new otter, this one with a very dark pelt and some sort of bandages on two legs and her neck.

Just inside the door, Sylvie turned toward Calantha and gestured toward her translator. "Box off, please," she said. "Just for moment." Calantha frowned but complied. Then Sylvie moved deliberately toward the patient's couch, walking on all six with head held low to the ground. Only when she was within a body length did she lift her head to meet the resident's eyes. They conversed briefly in their own tongue, and Phil had no idea what they were saying. Then Sylvie looked back at Calantha with a slight but surprisingly human nod. "Okay. Box back on. This is . . . you might call her 'Daredevil,' because she showed much courage in attempting something the rest of us might not have dared. I think you know what."

She stepped aside. The injured otter looked straight at Phil and spoke. "Well, what do you have to say?"

The question took Phil aback. He'd had so little idea of why he was being brought here, and so much distraction on the way, that he hadn't thought much about how this conversation might begin. With hindsight, he guessed he'd figured Daredevil would get the ball rolling, but her first move was to toss it to him. After a few mental gyrations he stammered, "I . . . I'm sorry. I never intended to hurt you. I didn't know my flashlight would affect you that way. For us it's just a tool. I hardly knew what was happening, so I was afraid—"

"Sorry doesn't matter," Daredevil interrupted. "You shouldn't have been afraid. Made everything worse." She paused. "They were trying to give you a way out."

Phil frowned without comprehension. "Excuse me?"

"Why do you think my friends brought you to see our model and show?" Again she

paused. "Try to see like us. When your strange kind and your structures came here, we all knew it could mean trouble. Not all agreed how to deal with it. Some wanted to destroy you all so trouble couldn't happen. Some wanted to try to talk to you, find out where you from, what you wanted, make you understand the danger you were to us, try to find way we could all live here. And some thought that was too hard, couldn't work. Just wanted to drive you away, to eliminate you as a problem for us without killing you.

"I was one of those. I don't like killing, but I don't like trouble either. My view was outnumbered. The group that wanted to talk to you convinced rest of us to go along with trying it—once."

"I appreciate that," said Phil. "But I didn't understand then—"

"Of course you didn't. I didn't believe it would work, but for a while, when you watched our show, I almost dared hope it would, that you did understand. Then you dashed my hope by running off like that. Some of us assumed you'd misunderstood. They ran after you to try to stop you and make it right. Me, I ran after you because I decided I'd been right in the first place—and maybe the ones who wanted to destroy you were even more right. Would I have killed you if I'd caught you? I don't know."

Phil shuddered. Had he made Daredevil into an otter Corcovan?

"Others might have stopped me if I'd tried," Daredevil went on, "but we never got to find out. I never expected a blinding light in my eyes when climbing those treacherous rocks. I lost control, fell, and suffered several fractures and other injuries."

"I'm terribly sorry," Phil said again. "As you say, it was all a misunderstanding, on many levels."

"Maybe," said Daredevil. "Part of me still thinks ones who want to destroy you are right. But Sylvie and Goldie told me how you came back with your own model and tried to talk with us. Made me think I might be wrong and you should have a second chance. Can you convince me?"

She has a real knack for catching me off guard, Phil thought. "I don't know," he said. "I'd like to try."

"Good," said Daredevil. "Maybe. Maybe we can agree on something. But to do that, we have to understand each other. You already know your wind devices are a danger to us. Having you and them here is a problem. Simplest way out would be for you just to go back where you came from. Seems you refuse. Why?"

"We can't. We come from very far away. We can't go back."

"Why?" Daredevil repeated. "Too far? More danger there?"

"Too far. We came from the other side of the world—"

"Thought so. Never saw anything like you here before."

"—and before that we came from another world altogether." Calantha gave him a sharp glance, but Daredevil seemed to take it in stride. "The way we got here no longer works, and we can't fix it."

"Not sure I believe, but suppose it true. If you can't go back to other world, why not just other part of this one where you were before?"

"That's impossible too," said Phil, hoping it wouldn't be too obvious that he was stretching the truth a bit. "It's complicated. I can't explain it, but it's true. I must ask you to trust me."

"Difficult," said Daredevil. "But again, suppose it true. Then we might have to find a way to live together, if that's possible. If it isn't . . . Well, let's hope it is." A much longer pause. "We took a big risk letting Sylvie and Goldie bring you in here. Some say you've already seen more than we should have allowed. Yet for crazy idea to have any chance of working, you and we must understand each other. You must learn how we live and what we need. We must learn how you live and what you need."

Definitely not *Corcovan,* Phil thought.

"Must confer," Daredevil said. She looked at Calantha again. "Box off again, please."

Calantha complied, and the three otters again talked unintelligibly among themselves, this time for two or three minutes. Then Daredevil signaled Calantha to turn the translator back on and again addressed Phil. "We suggest this. Tomorrow night, you two come back here for a tour. Sylvie and Goldie will show you around, give you some idea how we live, answer questions.

"Obviously by showing you more, we're taking even bigger risk than already. You must share risk by taking them back the next night to do same for us. Show them around place you call yours, explain how things work, let them ask questions and come back to explain what they saw to the rest of us. Fair enough?"

Phil thought carefully before answering. "It sounds well worth considering," he said cautiously. "But I can't speak for all my people. We'll have to discuss it with them tomorrow. But we'll be back tomorrow night, at least with an answer and maybe for that tour."

"Good," said Daredevil. "I hope your people will see reason."

So do I, thought Phil.

None of the otters showed any interest in attempting to do more then, so it was still the middle of the night when Phil and Calantha found themselves back at the mouth of the entry canyon, waiting for their ride back to Breakaway. As soon as their otter escorts were (they hoped) out of earshot, Phil said, "Notice anything interesting back there?"

"Aside from everything? And the fact that they showed so little reaction to your bombshell about our being from offworld?"

"No bats," said Phil. "And no kids."

XVI.

"Actually," said Phil, "I think they're being surprisingly reasonable."

Rod Corcovan snorted. "Just another reason to distrust them. Surely you're not going to let critters who don't even know much about humans put one over on you."

"I'll try not to," said Phil. He, Corcovan, Hazel, and Calantha were gathered around a small table in one of the conference rooms off the main gathering hall. He and Calantha had taken advantage of the unexpectedly short night to catch up on a bit of sleep, but now they had breakfast in front of them and had started the meeting before eating.

It was a small meeting by Hazel's choice. When Phil told her there was another big issue to thrash out and they'd need another mass meeting right away, Hazel had shuddered and said full meetings were too unwieldy. Better to start small, with an informal discussion involving spokesmen for all the major factions—including Corcovan.

"But sometimes," Phil said calmly, "if somebody seems reasonable, you should at least consider the possibility that they are. I think this is one of those cases. We can't go back to Earth because we got here using found alien technology that apparently only works in one direction. We can't go back to Newtown because of . . . irreconcilable differences."

"Some of us *want* to go back to Newtown," Calantha interjected. "And we'd welcome the rest of you, too, if only you'd—"

"Live your way?" Corcovan interrupted with a sneer. "Fat chance. That's what we left Earth to get away from."

"No, it isn't," said Calantha. "Earth hadn't had what we wanted for a long time. That's why we left."

"Us, too," said Hazel. "Neither our group nor yours was satisfied with what Earth had become. We both wanted to start over—but in very different and incompatible ways. But this isn't the time to argue about which is 'better,' if that question even means anything. The point right now is what to do about the otters. In the long run, both Calantha and Corcovan are right: we have a three-way coexistence problem. But in the short term, the things Newtown and Breakaway want are so different that we need different places to call home.

"And Breakaway happens to be in what we now know is otter country. The otters are willing to try to find a way to share it. Shouldn't we be, too?"

"No," said Corcovan. "What happened to 'may the best man win'?"

"And you're sure that's you?" Hazel didn't leave him time to answer. "Maybe you're right that the best man deserves to win, but you seem to think 'best' means most able to squash the other. I think it may mean 'most able to work out a reasonable solution'—and that could mean both of us, if we're smart enough.

"Now, this otter that Calantha's translator has labeled 'Daredevil' has offered to show us the inner workings of their town as a first step toward learning to understand each other. In effect, they've invited us into their home. Isn't it only reasonable that we reciprocate?"

"It's too dangerous," said Corcovan. "Sure, I'd like to know as much as I can about them, to know where their weak points are. But do you really want to show them ours?"

"I'd rather not, but it's a trade-off we have to make. We don't have to show them *everything,* at least right away. If we think certain things should be withheld, we can just steer our visitors away from those." Hazel paused. "But we have to assume they'll be doing the same to us. And we'll have to bear in mind that it could be dangerous to be seen as being too sneaky or secretive. Ultimately it will probably be to our benefit to be as open as we can be."

"You'll hardly even know they're here," Phil pointed out. "They don't like daylight. More than 'don't like'; it's dangerous to them. So they'll be coming at night."

Corcovan scowled. "Is that supposed to make me feel better—that they can watch me sleeping, and I won't even see what they're doing here?"

"Good point," said Phil. "Besides, they won't see much at night, when we're not doing anything. Eventually we may have to find a way to let them visit during the day, when we're going about our business." Even as he said that, he saw a possible way to do it. . . .

"Now *that's* something to look forward to," Corcovan grumbled. "And how long is all this going to go on? Every day we go without the windmills, we're using up precious antimatter. I thought the point of the windmills was to avoid that."

"It is. But a few days, even a few weeks, aren't going to matter much."

"If you say so." Corcovan frowned and changed tack. "Who exactly is going on this tour tonight?"

"Calantha and me," said Phil.

"No way!" Corcovan turned to Hazel. "Hazel, since you somehow seem to be running this show, are you going to allow that? If those two are the only ones going, we're going to be represented by two people who don't even live here. We have to have somebody with them who does live here and can represent *us."*

Hazel looked at Phil. "I can't really argue with that. Can you take one more?"

"Well, I—"

"That's not really a question," Corcovan interrupted. "One of us *has* to go!" He made a face as if considering something extremely distasteful, then drew himself up as if trying to look imposing. *"I'll* go!"

"Well, I appreciate the offer," Hazel said deliberately, "but I don't think so. No offense, Corcovan, but diplomacy isn't your strong suit. *I'll* go."

XVII.

Even Phil had to agree with the logic of including a representative who actually lived in Breakaway, and even more with that representative being Hazel. It also made logistical sense. Since she had been ferrying Phil and Calantha back and forth anyway, they wouldn't have to accommodate another body. She could just park the copter and stay.

If the otters allowed it. What worried Phil was that nobody had asked them.

As soon as Hazel powered down the copter and they got out—and locked it—Sylvie and Hazel emerged from the mouth of the canyon, looking agitated. They scurried toward Hazel, walking on hindlegs and tail to stand as tall and upright as possible. From well within what humans would consider her personal space, they looked her up and down intently. Sylvie glanced toward Phil, then back at Hazel. "Who this? We said you two should come, not three."

"This is Hazel," said Phil. "She's a leader of our settlement. We work for her, but she wants to see your town for herself rather than trust entirely to our word."

"Makes sense," said Goldie. Phil could imagine her sniffing.

"Hazel, this is Sylvie, and this is Goldie. They're going to show us around."

Hazel made a sweeping gesture with elements of bow and nod that she presumably hoped they would see as respectful. "Sylvie, Goldie, I'm honored to meet you. I hope you'll accept me as a visitor who looks forward to getting to know you."

"Phil should have asked," said Sylvie. "But yes, you may join us. Need bigger cart, though." She let out a sudden eerie whoop, then waited silently. A minute or so later one of the big bats swooped down, obviously startling Hazel and Calantha, and perched on a rock outcropping nearby. Sylvie chattered to it in something more like her normal voice and manner. It made an odd chortling sound and then flew off, rising quickly above the cliffs and flying off in a direction roughly following the entry canyon.

The five outside waited in awkward silence, during which Phil speculated on what he'd just seen but couldn't quite bring himself to ask about. Were the bats another kind of domestic animal, used to carry messages? If so, that suggested a surprisingly high level of intelligence for a domestic animal.

Or were they more like the slaves whose status was an indelible blot on humanity's past?

Shortly after the bat's departure, he heard the clatter just inside the canyon of a cart and dragonhorse heading back toward the town. A few minutes later, he heard a similar sound, which proved to be a larger cart coming out almost to the entrance and turning around in the "vestibule" just inside.

Then Sylvie and Goldie ushered them all aboard. This cart was quite a bit bigger than the other, and even with the addition of Hazel, it didn't feel crowded at all. The beast started them townward with a surprisingly gentle motion, unlike the startling lurch and hair-raising speed of his previous rides. "No rush this time," Sylvie said through Calantha's translator. "Want you to take in what you see.

"As Phil knows, we live together in what you might call town among cliffs and caves on edge of sea. Our ancestors were active by night and not day, and so are we. We feel safest with lots of barriers between our homes, outside places, and open sky. This area good for us because has many caves, jumbled rocks, and narrow passages like this one, not quite caves but almost, with overhangs. We call this road 'Way In,' because it's the only way in, at least for folk like Goldie and me. Anybody from outside who wants to come into town has to come through here."

She paused as if to let that sink in—along with the implied corollary that that could include humans, and if they were getting any ideas, they should think carefully about how easily that single passageway could be defended.

When they emerged into the "town square," Sylvie halted the wagon and gestured at the ornately sculpted cliff towering before and around them. "At ground level you see several entrances to the town itself. Above those you see carvings by some of our best artists, to remind us of our history and things most important."

On this second look, with better vision, Phil saw that while the sculptures bore only a vague resemblance to the wild otters and bats he'd seen before coming here, they looked much more like the larger ones here in the town. Calantha and Hazel, he saw, were staring wide-eyed. "Do the carvings," he asked, "represent real individuals from your history?"

"Some do," she said. Then, as if to avoid a less cryptic response, she signaled the wagon into renewed motion and changed the subject. "Now you—or at least Hazel—will receive your first view inside."

The wagon rolled forward through an open door into a cavernous chamber, dimly lit by a few glowdisks, that Phil recognized at once as the one where he'd been brought that first night to witness the otters' and bats' first attempt at communication. "Here," Sylvie declaimed (at least it sounded like a declamation from the translator's speaker, though not in her own chittering voice), "we hold gatherings when it is necessary or desirable for many of us to gather at once."

Tonight, though, it was empty except for their wagon, and they lingered but a moment before turning into another door in the back wall and clattering down an unfamiliar dark passage. Like the other that Phil had been down, it was relatively short, and soon they came out into another wider canyon with a narrow opening between cliffs at the top and chambers opening off the sides. Some of those had closed doors, and some didn't. Through the ones that didn't, they glimpsed small groups of otters going about their business but couldn't tell what that business was. "Families live here," Sylvie said, but she didn't elaborate or slow their pace.

Soon, the ambience changed again, and they were in a neighborhood like the one Phil had first seen last night, with relatively bright lights and tantalizing mechanical sounds filtering through thick translucent windows and doors. "Here we make things," said Sylvie.

"Can we stop and see some?" Phil asked, excited by the prospect.

"Maybe later," Sylvie said. "Making-places are dangerous. Need permission, maybe special protection, to go inside." Then, as if she sensed Phil's disappointment, she backed off a little and said, "Maybe one. No promise, but let's see."

She brought the cart to a halt in front of a closed door and climbed out. "Wait here." She looked at Calantha and added, "Box off."

Calantha complied, but Phil could see that she was sorely tempted not to. Sylvie stood outside the door and chittered loudly. The door opened just a crack, and a different otter voice chattered back. After a few more exchanges, the door opened wider, and Sylvie gestured to the others in the wagon. "Please come in, but touch nothing."

With a mixture of excitement and apprehension, Phil and his colleagues filed into a cluttered room with scattered light disks faintly illuminating several benches strewn with what were obviously tools and pieces of work in progress—some of them made of metal. The details were alien—except for a few that seemed vaguely but tantalizingly familiar—but the place had the unmistakable feel of a workshop.

An unfamiliar otter, smaller and apparently older than either Sylvie or Goldie, crouched in the far corner, staring with what looked like a mixture of fear and fascination at the newcomers. "This is Smith," Sylvie told the humans. "One of our finest craft makers. Not busy now, so can take little time to show you a bit." Sylvie told her (him?), "These are our visitors from far away: Phil . . . Calantha . . . and Hazel." She gestured at each in turn. "They want to help us find a way we can all share land. To do that, they want to learn about us and teach us about themselves. Can you tell them a little about what you do here?"

The resident otter moved a hair closer and spoke, slowly at first—or was that just the translator getting used to a new speaker? "I make . . . tools. To cut, carry, things like that. To do that, I use other tools, already made. Here I was making a hook to hold things out of way of other things. I take piece of . . . hard plant at edge of sea, and lock it in place with this." She/he clamped a piece of what looked like wood into a vise on the edge of a bench, tightening the jaws with a coarse built-in screw—which, Phil realized, likely implied the existence of a lathe somewhere.

"Then," said Smith, seeming to relax a little, "I carve with this tool." He (or so Phil decided to think of him/her, though he knew it was pure guesswork) picked up an elaborately shaped metal knife and began deftly shaving pieces off the wooden workpiece.

The workmanship was obvious and impressive, but what intrigued Phil most was the knife. "The tool you're using," he said. "What do you call its material?"

The craftsman spoke; Calantha's translator deliberated for a sizable fraction of a second before saying, "Metal."

"Impressive," Phil said truthfully. "Where do you get it?"

"From the sea," said Smith, looking at Sylvie and then back at Phil. "I don't know details. It's a new thing. Almost new."

"We can show you something of how we get the metal later," Sylvie told Phil.

Smith somehow seemed relieved at being let off the hook. He showed them a little more of his process for carving something like an old-fashioned shepherd's crook, and then Sylvie shepherded them back into the wagon.

It occurred to Phil only as they were leaving that some of the objects that had struck him as vaguely familiar were parts of the windmill model they'd used for their dramatic demonstration that first night.

They spent a few more minutes traversing the "factory district" and then emerged onto the shelflike "coast road." On the first stretch, they had a good close view of waves crashing on rocks, but then a surprisingly impressive bridge carried them across the mouth of a broad stream pouring out of the cliff wall into the sea.

There Sylvie made the draft beast halt and gestured out at the marsh surrounding the mouth of the stream. Again Phil saw small boats and swimming otters among the plants. "They're harvesting," Sylvie explained. "Gathering useful plants and animals. Most of what we eat comes from the sea. So does the metal used by craftspeople like Smith."

Phil seized the chance. "How do you collect it? Dive and gather it from the bottom? I'd think that would be hard and dangerous work."

"It is. So we seldom do it that way. Metal collects in bodies of certain plants and animals. We encourage those—and the ones that are good to eat—to grow in special places like this."

Farms! Phil supplied mentally, even before the translator did. "Then we gather them,"

Sylvie was continuing, "and bring them into our town. Some of us have learned to extract metals from the plants and animals that concentrate them."

"How do you do that?" Phil asked.

"Most processes involve heat."

Phil's excitement was growing by the moment. "How do you cool things afterward? And what do you do with the waste products?"

Sylvie seemed to have no trouble with those concepts. "Water is channeled down from the mountains to where we need it. Waste products, both from making things and from our bodies, are fed back to other living things that make them harmless and turn them back into useful things."

They have recycling, too! Phil thought. *And ways of working with heat and bright light, despite their aversion to daylight…* This suggested so many lines of inquiry he'd like to pursue that he found himself thinking wistfully of how much he'd like to be able to hold branching conversations.

He latched onto the branch that seemed closest to the biggest thing that had been bothering him. "You say most of your food comes from the sea. So why are our windmills such a problem?"

Sylvie fell silent for a long moment, as if she didn't understand the question. Finally she said, "The winged ones eat small creatures that live in that area. Windmills dangerous to them as they seek food. Sometimes kill them."

"But why is that so important to *you?"*

Again she seemed bewildered, possibly even shocked, by the question. Phil began to wonder if he'd blundered into forbidden and dangerous territory. "Winged ones are everything to us," Sylvie said at last. "And we to them."

Which explained nothing. "So where are they? There were many of them here the first night you brought me here. I've hardly seen any since then."

"They mostly live elsewhere," Sylvie said slowly. "Out where your windmills are. Come here only when necessary."

"And why is it necessary?"

"They bring us things we can't get for ourselves here. Like—" She was growing visibly agitated, and seemed to welcome the chance to change the subject. "Look!" she said suddenly, gesturing toward a nearby cliff. "There are some now!"

Followed her pointing hand, Phil saw two big bats curving down to land on a ledge and disappear into a hole in the wall. They seemed to glance this way, and maybe even to make some sort of gesture in this direction; but it was too fleeting and Phil knew too little about their body language to be sure. "I see," he said after the bats had disappeared. "What sorts of things do they bring?"

Sylvie seemed about to answer, but then just said, "This is getting confusing. Hard to explain. And getting late."

Then she shut up.

"I understand," Phil said softly, though he didn't. "Perhaps we can continue talking about it tomorrow?"

"No," said Sylvie at once. "Tomorrow is our turn, to go to your place."

"So it is." He thought a moment and said carefully, "You know, it might be better if you came in the daytime. You'd see more. That's when we're most active—"

"No!" Sylvie's response was even quicker and more emphatic. "Daytime is bad for us. Too much bright light. Danger."

Phil thought about pointing out that they'd already demonstrated that they had dark glasses and other means of coping with such things, but thought better of it. Sylvie and Goldie were too upset now, though he didn't understand why. Better to leave that for another time and let them come to Breakaway tomorrow night and see for themselves why daytime would be better.

After a bit more awkward silence, Sylvie signaled the dragonhorse, and they started moving again. But she volunteered little more along the way, and none of the humans felt comfortable enough to ask. The tour was over. Now they were just being escorted back to the exit.

The trip passed mostly in silence, except for the sounds of their carriage and occasional muted sounds of life in Ottertown—including, occasionally, the ones that kept reminding Phil of engines.

XVIII.

"Well," Hazel said as they took their seats in the little conference room the next morning,

"that certainly raised more questions than it answered."

"Yes," Phil agreed, "though there were some intriguing answers, too. The biggest question, of course, is what the connection is between the otters and the bats. It's obviously important to them, but we don't understand why and they don't understand *why* we don't understand. Or they're uncomfortable talking about it."

"Quite," said Hazel. She frowned pensively. "We need help figuring this out. I think we're long overdue to get a biologist involved. How about Dick Sysler?"

"Sounds good to me," said Phil.

"I still don't see why we're bothering," said Corcovan, "but if it will help get this business wrapped up, let's do it."

Nobody asked Calantha. Indispensable though she was to the progress they'd made so far, she was still more outsider than otherwise. If she objected, she said nothing.

So Hazel called Dick, and a few minutes later, he came in and sat down, a small but solidly built man with thick black hair and eyebrows. "What's up?" he asked.

"We've been inside the locals' town," Hazel told him, "and gotten some tantalizing hints about what goes on there. But there are some big points we don't understand, and we suspect the answers run deep in the natives' biological background. So we need a biologist's perspective."

"Well, I'll be glad to try to provide one. What have you learned so far?"

"A smattering," said Phil. "It's a sizable town, which we missed on the initial surveys because it's mostly hidden. We've known for quite a while that between the big tides and past geological activity, the coast has a lot of rugged topography, shattered rocks, caves and canyons. This 'town,' if that's the right word for it, is built among those, tucked into caves and tunnels and narrow canyons so that most of the contents aren't obvious unless you get right into them. And it goes right down to the sea. In some places there are waves crashing on rocks just outside dwellings, and in others there are marine marshes that they use as farms."

"But not just farms as we understand the term," said Hazel. "They raise food, both animal and vegetable, but they've also learned to use plants and animals to extract metals from the ocean."

"That's a technology we might want to try to learn from them," said Phil. "Humans did somewhat similar things on Earth, under the name 'phytotechnology,' but of course they were using Earth-evolved organisms to process Earth's resources. They probably wouldn't work here even if we had them, which we don't. But we sure could use the ability to do that."

Dick frowned. "They extract metals, you say. What do they do with them?"

"We have only an inkling," said Hazel. "But we know that they process them, using heat, and they make and use metal tools."

"And several times I've heard noises there that sound like some sort of engine," Phil added. "But I haven't actually seen them. I could be misinterpreting."

"Okay," Dick said as if summarizing for his own benefit. "They have agriculture and metallurgy, and not necessarily a sharp line between them. What else?"

"Transportation," said Phil. "They have the wheel; I've ridden in at least two kinds of cart pulled by draft animals, on obviously constructed roads. And they have artificial light sources, though I don't know how they work and they use them very sparingly. They're nocturnal and can't stand bright light."

Hazel added, "That seems to also be true of the ones we call bats and they call 'winged ones.' The big question bothering us is: what is the relationship between the otters and the bats?"

Phil said, "I'm no biologist, but I'm guessing it's a kind of symbiosis—but an oddly long-distance kind, mostly. What apparently started the trouble with us was that the bats and the smaller flyers they eat were being killed or injured by our windmills. But the bats themselves have made no visible attempt to tell us about their grievance. Only the otters did that.

"When they first snatched me and took me to their town, there were both bats and otters present. And there were sculptures of both around the entrance. But since that first time, I've hardly seen any bats at all, though the city includes places apparently designed for them to perch on. The population I've seen on our subsequent visits is so uniformly otters that

I've drifted into calling the place 'Ottertown,' for lack of a better name."

"We probably ought to come up with a better one," Dick mused. "But it sounds like we don't know enough to make a good choice yet."

"Exactly," said Phil. "Maybe after you get your professional teeth into it, we will. Anyway, last night when Sylvie—that seems to be our senior guide—told us about the farms, she said they get most of their food from the sea. That seemed to me to intensify the whole riddle. I asked her flat out why they were so concerned about our windmills if only the bats ate the bugs around them. She said the bats were everything to them, and vice versa. But the question seemed to make her very uncomfortable, and that was the end of last night's tour."

"Interesting," said Dick, but instead of commenting further, he changed the subject. "You refer to Sylvie as 'she.' Have you seen both males and females?"

The question caught Phil off guard. "I . . . don't know. It's just that after talking to her a while, it seemed to me that she *felt* more female than male."

"How about young?" Dick asked. "Have you seen any evidence of how they reproduce or raise the next generation?"

Phil stared. "No. I mentioned that to Calantha on our way back from our first visit inside the city. Everybody we saw seemed to be not only otters, but adults. Why do you ask that now? It seems like kind of a non sequitur from what we were talking about."

"Maybe. But the most basic principles of a species' behavior, at least on Earth, are deeply tangled up with sex, assuming they have it. And I don't think they'd evolve this far without it." He gathered his big black eyebrows into a thoughtful frown. "Okay, you want to get back to what we were talking about. You say there seems to be some deep interdependence between the otters and bats, yet they live mostly apart, in very different environments, and eat completely different diets. Have I got that right?"

"Yes," Phil answered almost automatically. From the corner of his eye, he saw Calantha suddenly frowning as if the question bothered her and even she wasn't sure why.

Dick was frowning too. "Interesting. I may have the beginnings of an idea, but it's so half-baked and so far-fetched I don't want to talk about it yet. Before I can do much more, I need to see this place—and the folks who live there—for myself. Do you think that can be arranged?"

"Why don't you come with us tonight?" Hazel suggested. "When I went last night, they had to get a bigger cart to haul us around, and it had plenty of room for one more."

"Plenty of room, yes," said Phil. "But we'd better clear it with Sylvie and Goldie first this time. It obviously bothered them when we took you along last night without asking them first. I don't think we dare repeat that mistake."

"We don't have to," Hazel said. "They're coming here tonight. Let's just add Dick to the group that shows them around. They can hardly object to our picking our own team on our own turf, and it will give them a chance to get to know Dick. Then maybe they'll be more comfortable letting him come along the next time we go over there."

The otters' first overt nighttime visit to Breakaway was, as Phil expected, even less productive than the humans' first inside Ottertown—at least initially. The visitors accepted their introduction to Dick with no obvious reaction, and as they walked around among the quiet houses and equipment sheds, he said little to them, and they said little to him, though he was obviously watching them intently.

Phil was less than comfortable with the low level of interaction. He had hoped to see them getting comfortable enough with each other that he could be confident of the outcome when he proposed bringing Dick along on their next visit to Ottertown. As it was, he had no feeling for how that was likely to go.

After an hour of wandering around seeing little except building exteriors, Goldie said, "Don't you people ever *do* anything?"

"Very little at night," said Phil. "I tried to tell you that." After weighing the risk he added, "Seems to me you should have known. You've already been here at night. You've probably done more here at night than we have." He stopped walking next to a disintegrated house that had not yet been restored and waited to see if their guests would take the hint.

After an awkward silence, Sylvie did, at least indirectly. "I assume you refer to our early attempts to frighten you off. We regret those now, but I suspect you can understand our reasons. Try to imagine how your arrival looked to us. You were something new and unfamiliar that appeared suddenly. Naturally we wondered what you were, where you came from, how you might affect our way of life. With situations reversed, I guess you would have been frightened too.

"We did not just assume your coming was bad for us, but we had to know. First we came at night to look at what you had built here, hopefully without your seeing us. Then the windmills made it clear that you were a danger to us. We did not all agree on the best way to deal with that, but most did agree that the simplest way would be to get you to leave. So we tried that first. We hoped if we made you uncomfortable enough, you would simply go away and we could return to our lives as they were."

"So you tried to scare us," said Dick. "You did well. I would be interested in learning more about your methods. For example, how did you do . . . this?" He kicked lightly at the rubble that had been a house. "Without leaving tracks?"

"Leaving tracks would not have been good," said Sylvie. "With tracks, you would have seen what was causing damage. That would frighten less than if you couldn't see cause. Unknown always scarier than known."

"Very true," Dick said calmly. "But *how* did you do it? I have to admire someone who can do something that puzzles me. It makes me want to understand."

Sylvie made a distinctive little chitter that reminded Phil of a chuckle. "I'm like that, too. Can't tell you details, but try to give general idea. If we wanted you to think mysterious forces were destroying your buildings, we couldn't just walk up and smash them. But we control groups of tiny creatures that do much of our work for us. They did this."

Phil saw Dick's eyes light up, though the biologist was apparently trying not to be too obvious about it. To Phil, Sylvie's description would have sounded suspiciously like nanotechnology, except that he remembered his brief impression of the ground seething at his feet the night he was abducted.

"Impressive," Dick said. "And I assure you, it was scary. So why did you stop? Not that I'm complaining, mind you."

"It wasn't working," said Sylvie. "Groups among us decided to try something else. Some suggested trying to talk to you. That was even scarier for us, but we began planning for it. Smith and others made the windmill model and planned the demonstration, but at first we weren't sure how to get any of you to see it. When you, Phil, came outside at night, as none of the others did since very early nights, we saw that as an opportunity. And seized it."

"And me," Phil said with a wry smile. "We appreciate your sharing this with us now. It gives me hope. We want you to understand us, too, but we have little else to show you at night. You really need to come back during the day."

"No, no!" Sylvie answered at once. "Daytime dangerous. We must sleep during day!"

"We understand," Phil said quietly. "We feel the same way about the night. Yet we have been visiting you at night because that's the time you're most comfortable and active. We understand that to understand how you live, we must see you when you're doing what you do—not just sleeping."

"But bright light is *dangerous* for us! You saw what your flashlight did to Daredevil—"

"Only because she wasn't wearing eye protection. And now that we know how it affects you, we no longer use the flashlights. We rely on special glasses that help us see better in weak light. And we know that you have ways of protecting your eyes. You all wore them that first night, when you showed me your model of what you wanted us to do to our windmills."

"True," said Goldie, "because we knew you needed more light than we like and we made some for your benefit. But the light we made for you was nowhere near as bright as daytime sun."

Phil could see how agitated they both were, but he didn't back off. "But you have stronger eye protection that you can use, don't you? What do your craft makers do when they must use high heat to work metals? I know that process makes bright light. I've seen it through closed doors on our rides through your town. How do ones like Smith stand it?"

Goldie's ears quivered in a way that made Phil think of a human shuddering. "They are specialists," Sylvie said. "They have long training to work with dangerous tools and materials. Their equipment is not for ordinary folk like us."

"You're not ordinary," Phil said softly, looking directly at her and then at Goldie. "You're quite special. You could learn to use the protections that your craft makers use, and we'll see to it that you're not exposed to dangers like they face. If you do, you'll learn far more about us than if you only come when we're not doing anything. Won't you at least think about it?"

After a long hesitation, Sylvie and Goldie said in apparent unison, "We'll think about it." And Sylvie added, "But we can promise no more."

"Excellent!" said Phil. "That's all I ask, for now. And now, there's one more thing . . ."

XIX.

After Phil's obviously disquieting request that the otters visit Breakaway in daylight, his asking to include Dick in their next visit to Ottertown must have seemed refreshingly nonthreatening. He explained that Dick had special knowledge that would help the humans better understand what they were shown and thereby speed the process of finding common ground. Sylvie, who increasingly seemed the senior partner of the pair, accepted that without serious complaint—though she did say the humans would have to stop bringing a new person along every time they came to visit.

Dick, when he first got to Ottertown, was like an old-time kid in a candy store. He stared with unabashed fascination at every detail of the carriage that took him and his colleagues through the Way In and the huge six-legged beast that pulled it. When they got to the town square, he marveled at the sculptures of otters and bats on the cliff faces above the entrances. A lone bat swooped overhead as the wagon passed through, and another perched on the head of one of the sculptures. But they were far outnumbered by the otters unhurriedly crisscrossing the square.

Who hardly seemed to notice the humans in the cart. "Odd," Dick remarked to Phil, Hazel, and Calantha. "Are they really this used to us already?"

"I'm not sure," said Phil. "Most of them have had little or no direct contact with us. But despite seeing us and the windmills as a big issue, most of them seem fairly indifferent to us as individuals. They're startlingly quick to take radically new things in stride."

When they plunged into the inner tunnels and canyons, Dick was just as fascinated with the new things he was seeing, but for his human colleagues it was largely just a recap of what they'd already seen: dark tunnels alternating with minimally open canyons; side chambers, some open and some closed, in which otters lived or went about largely unknown activities; apparent workshops with tantalizing glimpses of light much brighter than the otters normally tolerated.

The highlight was a farm, which they saw much more intimately this time. Previously Phil's closest look at one had been from a wagon on a shelflike road many meters above it. Now their ride turned off and followed a slanting spur down to what appeared to be the high-water mark—and stopped.

"We'll walk from here," Sylvie told them, and they followed her down a steep path of rounded rocks and mud. When Phil saw what was at the end, he felt a brief twinge of the same apprehension he'd felt when Hazel and Luk had first led him down a ramshackle ramp to a bobbing human-built boat. But what waited here was not human-made.

Phil's first impulse was to call it more a raft than a boat. Nearly flat and rectangular, it rode low in the water, with a broad level deck and some sort of well—for cargo?—in the middle. Alongside it, strapped to it with elaborate harnesses, floated six otters, all facing what he presumed was the bow. Two more otters lounged on the deck, watching their approach but not moving. They left plenty of empty deck space, so Phil was only slightly shocked when Sylvie said, "Climb aboard. We'll show you around."

His first experience with a boat must have done something for him. He was surprised at how calmly he waded through knee-deep water and joined the others in sitting haphazardly on the plank deck, even though it bobbed and rode a little lower with each person (or otter) who came aboard. Sylvie chattered a signal, and they headed out toward open sea, powered by the six harnessed otters.

But they weren't just paddling with any or all of their appendages. Each was turning small cranks with his or her front four hands, and a glance aft showed a partly submerged paddlewheel turning.

So they have gears and such, too, Phil thought, paying no heed to the spray that occasionally splashed over him, or the mingled smells of otters and sea water. Once, he glanced up and marveled at the tapestry of stars on black velvet overhead. Selena was well into her waning phases and hadn't risen yet, so the stars dominated the sky—including a Milky Way that looked comfortingly like that seen from Earth except for being at the wrong angle and having new (but now familiar) constellations in and around it.

The stars alone weren't enough to illuminate the landscape for humans, but with nightglasses, they could see not only the marsh and "kelp" beds, but jagged cliffs with big waves crashing around them not far away. Here and there the cliffs were dotted with openings, some of them glowing faintly from light sources inside. Seeing the violence of the waves made Phil glad that the vegetation through which they were riding dissipated a lot of their energy here.

There was quite a network of channels, presumably made by the otters. Sometimes they were barely wide enough to let this boat pass without brushing, but often the channel widened, and they passed other boats of similar design. Some of them bobbed on anchor lines while otters swam to and from them, going deep into the vegetation and sometimes coming back with buckets or baskets of stuff that they dumped onto the deck or into the central well, and then went back for more.

Sylvie and Goldie seemed to know a lot of the workers and pointed out some of what they were seeing. There appeared to be patches of two kinds of vegetation, resembling tall grass and kelp, but apparently there were many more, differing in ways not obvious to him. Sylvie and Goldie explained that this one was good to eat, that one was good to eat in a different way, another was good mainly as habitat for particular kinds of edible creatures, and so on.

"This one," she said eventually, just as Phil was beginning to notice another of those engine-like sounds, "concentrates one of the metals we use." Not surprisingly, the translator couldn't yet say which one, but Phil guessed the most likely candidates were iron and copper. "Naturally we can't use the metal until we extract it from the plants, and obviously we can't do that here."

They rounded a rocky headland—the kind against which waves crashed violently elsewhere, but here protected by the tempering effect of the marshes—and all the humans gasped at once as the engine sound grew louder. It *was* an engine, evidently steam-powered but with its driving fire hidden by an opaque combustion chamber, mounted high on a cliff and driving a conveyor belt looping continuously between stations above and below the high-tide line. Its chugging sounds were louder here, and Phil could smell exhaust fumes and see small clouds around the machine.

Swimming otters and boats periodically pulled up to the lower station and dumped stuff they'd been collecting into buckets on the conveyor. Other otters, up near the clifftop engine, took things out of the moving buckets as they arrived and distributed them into other bins nearby.

"I'm especially proud of this," said Sylvie. "Goldie and I played roles in developing it. Machine at top burns dry stuff, heat boils water, hot steam drives piston, rotates wheel to move belt. Makes easy way to move raw material from shore up to where we can make it useful. Including extracting metal and distributing food to folk."

"I'm impressed," Phil said, which was not only honest but an understatement. In a dizzyingly short time, he'd learned that they had not only wheels, gears, and metal refining, but also steam engines. Evidently they hadn't developed them in the order humans had, and they hadn't put all the pieces together in ways that seemed obvious in human hindsight, but the fact that they had them at all made his mind spin.

And made him wonder what else they might have. "May I ask a question?"

"Of course."

"When you boil water, doesn't the salt left behind clog up your engine"—he wondered how the translator would handle that—"and ruin it? Make it stop working?"

"It would," said Goldie, "if we used ocean water. So we don't. We use fresh clear water in streams from high in mountains."

"Of course," Phil said numbly.

The steam engine and the conveyor system it powered were the climax of tonight's tour, and Phil suspected Sylvie was enough of a showman to have planned it that way. She showed them more details after the boat took them back to the wagon and they completed a loop back to their starting point, but after that they were just details. The big impression had been made, and very effectively.

As the wagon carried them back out through the Way In, after a brief stop to introduce Hazel and Dick to Daredevil, Hazel said, "Thanks ever so much for the tour, Sylvie and Goldie. This has been most enlightening, and I'm truly impressed by what you've done here." She paused slightly. "So will you come to our town during the day tomorrow? We'd like to try to impress you, too, but I'm afraid we don't do much impressive at night."

Sylvie flinched, but only slightly this time. "I fear you are right," she said. "We do need to visit you when you are most active, and with eye protection we can do it. But the prospect is daunting. We will need time to prepare."

"Understandable," said Hazel. "And we could use the time to catch up on sleep. We enjoy visiting with you and learning from you, but it's intense. Doing it every day and night is wearying. How about this? We'll take tomorrow and tomorrow night off. But the next day, you come to see our town in the morning. Agreed?"

Sylvie seemed to hesitate, but finally she said, "Agreed."

On the flight back to Breakaway, Phil looked at Dick and asked, "Well?"

"Most interesting," said Dick. "There's certainly a lot more to them than I would have guessed even a day ago. But I still don't understand how it all fits together. I've seen a bunch of fascinating puzzle pieces, but something is still missing, and I still think reproduction is key to it. Why didn't we see any little ones?

"It's likely to be a delicate matter, but somehow we have to find a way to bring it up." ■

To be continued . . .

THE REFERENCE LIBRARY Don Sakers

Science fiction is frequently associated with the physical sciences and related disciplines: chemistry, physics, astronomy, biology, engineering, and the ever-popular "rocket science." Yet we all know that SF draws just as much from the social sciences: psychology, sociology, economics, anthropology, and the like.

The exact balance between physical ("hard") and social ("soft") science varies with each work. Most SF contains elements of both, but you'll certainly see books and stories that are predominantly one or the other. We tend to refer to these ends of the spectrum as "hard SF" and "social SF."

We usually associate social SF with the 1950s and '60s—with magazines like *Galaxy* and *The Magazine of Fantasy and Science Fiction,* and authors such as Alfred Bester, Avram Davidson, Damon Knight, C. M. Kornbluth, Henry Kuttner and C. L. Moore, Anne McCaffrey, Frederick Pohl, Cordwainer Smith, Margaret St. Clair, and Theodore Sturgeon. However, the type has a much longer pedigree; in fact, it predates the emergence of SF as a recognized literary category.

Books about utopias and dystopias, which have been around since Thomas More started the craze with *Utopia* in 1516, definitely have to count as social SF. Other books that used societies to comment on the contemporary world included *Gulliver's Travels* by Jonathan Swift (1726), Samuel Butler's *Erewhon* (1872), and *Looking Backward* by Edward Bellamy (1888).

While Jules Verne was a practitioner of what we'd now call hard SF, H. G. Wells was all about the social sciences. *The Time Machine* (1895), *The Island of Doctor Moreau* (1896), *When The Sleeper Wakes* (1899), and "The Country of the Blind" (1904) are undeniably social SF—but even works like *The War of the Worlds* (1898) and *The First Men in the Moon* (1901) rely on anthropology in depicting alien cultures.

During the pulp era, when adventure and technology dominated, it wasn't unusual to see some measure of amateur anthropology or social commentary: authors as varied as Leigh Brackett, Edgar Rice Burroughs, Ray Cummings, Edmund Hamilton, and E. E. "Doc" Smith portrayed alien societies significantly different from our own.

We tend to think of the Campbell era of the mid-1930s to late 1940s as a heyday of hard SF; it's hard to remember that one of John W. Campbell, Jr.'s aims was to bring more humanity into science fiction. In fact, it was the quintessential Campbell writer, Isaac Asimov, who coined the term "social science fiction." The great Campbell-era writers (Asimov, L. Sprague deCamp, Lester del Rey, Robert A. Heinlein, L. Ron Hubbard, Murray Leinster, Clifford D. Simak, A. E. van Vogt, Jack Williamson, and many others) brought themes and elements from all of the social sciences into their work, setting the shape of the SF genre even today. Perhaps the best example is Asimov's Foundation series, based almost exclusively on ideas from sociology, psychology, and history.

The Campbell era paved the way for the aforementioned *Galaxy/F&SF* era of the 1950s. (Actually, it's more complicated: Authors like Knight, Kornbluth, Pohl, and Sturgeon had been producing work all during the Campbell era, while Campbell authors like Asimov and Leinster were also counted among the *Galaxy/F&SF* crowd. In truth, it was a transition period.)

Following in the steps of those authors, the New Wave of the 1960s brought a generation

of writers whose primary concern was the social sciences. Authors such as Brian Aldiss, J. G. Ballard, John Brunner, Thomas M. Disch, Harlan Ellison, Philip Jose Farmer, Frank Herbert, Ursula K. LeGuin, Michael Moorcock, Joanna Russ, and James Tiptree, Jr. brought new literary techniques and different aesthetics to SF, and they also tipped the scales even further in the direction of the social sciences.

Two successive expansions of the SF field (the late 1960s *Star Trek* explosion, and the late '70s/early '80s *Star Wars* boom) meant that no single fashion would ever again cover all of science fiction. Hard SF and social SF, which had appeared to be opponents, embraced each other and made the field stronger and more diverse. I like to think we've moved beyond objections like "Ick, you got sociology in my microchips" or "Eww, you got a rocketship in my matriarchy," to agree that good SF has plenty of room for technology and humanity.

All of which sets the stage for this month's crop of books.

Dark Orbit
Carolyn Ives Gilman
Tor, 304 pages, $25.99 (hardcover)
iBooks, Kindle, Nook: $12.99 (ebook)
ISBN: 978-0-7653-3629-3
Series: Twenty Planets
Genres: Psionics, Psychological/Sociological SF

Sara Callicot is an exoethnologist; she studies and compares alien cultures for the human-settled Twenty Planets. Unfortunately, her last assignment went awry; due to paperwork errors, she's accused of cultural appropriation and dismissed from her job. With no other choice, she signs on with an expedition to a newly discovered planet 58 lightyears away by relativistic travel. By the time she returns, more than a century from now, her slate will be clean.

Sara's charged with keeping tabs on a crewmate, Thora Lassiter. Thora, a member of the ruling class, suffered a mental breakdown during a diplomatic visit to the planet Orem; her involvement with a revolutionary sect prompted a rebellion against authorities. Even though the situation was stabilized and Thora cured, her continued presence complicates diplomatic relations with Orem—so the government decides that a century-long exile is the better part of valor. It's Sara's job to make sure Thora doesn't get into any more trouble.

Although it takes 58 years to get to the new planet, to Sara and the rest of the crew the journey is almost instantaneous. Sara and the other scientists and explorers are a special type known as Wasters—they leapfrog through time, with no fixed era and no real homes beyond the ships in which they serve. In the course of a lifetime, the Wasters become family to one another.

The planet Iris is dark and mysterious, a crystalline globe partly composed of dark matter. Although Iris is habitable, advance probes showed no sign of civilization or intelligent inhabitants. The crew settles down to study the world, while Sara studies Thora and the crew.

Then a grisly murder stuns the crew . . . and shortly afterward, Thora goes missing.

Exploration teams discover that Iris is, indeed, inhabited. The natives are blind, and they navigate with a type of psionic perception. Sara dives into the effort to decipher their strange language, understand their culture, and—if possible—to find Thora.

Meanwhile, Thora is lost among the natives in the crystalline substructure of the world. As she struggles to gain control of her own psionic perceptions, the same forces that caused her earlier breakdown, she learns of a danger that threatens the whole expedition.

When Thora is reunited with the crew, her warnings sound like insane ravings. Sara has to help her understand and communicate before time runs out.

With not one but two unusual and fascinating cultures (the Wasters and the natives), there's plenty of social SF meat here. Both Sara and Thora are appealing rogues, in completely different ways; the parallelism between the two women is a big part of the experience of this book.

Dark Orbit is set in the same Twenty Planets universe as Gilman's 2010 novel *Halfway Human.* Comparisons to Ursula K. LeGuin are inevitable (and not unwarranted), but *Dark Orbit* has a strong thread of thriller-like suspense that keeps one turning the pages. I

think a more apt comparison is to the work of James Tiptree, Jr.

Chasing the Phoenix
Michael Swanwick
Tor, 304 pages, $26.99 (hardcover)
iBooks, Kindle, Nook: $12.99 (ebook)
ISBN: 978-0-7653-8090-6
Series: Darger and Surplus 2
Genres: Adventure SF, Anthropomorphic, Far-Future

Michael Swanwick's Hugo-winning story "The Dog Said Bow-Wow," published in 2001, introduced a pair of rascals called Darger and Surplus. The pair appeared in other stories, and in 2011 starred in Swanwick's *Dancing with Bears.*

Darger is a human and Surplus a genetically enhanced humanoid dog. Together, they travel a far-future, post-technological Earth in a never-ending quest for power and riches, preferably with minimal expenditure of energy.

You don't need to be familiar with earlier Darger and Surplus stories to enjoy *Chasing the Phoenix* . . . although when you finish you'll almost certainly want more.

As the story starts, Surplus arrives in a small Chinese town with a yak and the corpse of his friend Darger. Along to way, Surplus acquired a Mongolian shaman's robes, all the better to impress the villagers.

Surplus is on a quest to find the Infallible Physician, a rumored healer who might have the power to resurrect Darger. Sure enough, it's not long before Darger is back on his feet, and the two start hatching schemes.

Pretending to have limited divine powers, they make the acquaintance of a local warlord who dreams of conquering all of China. Just as the scheme starts to bear fruit, opposition emerges from an unexpected source, endangering everything Darger and Surplus have worked for.

In the hands of a lesser writer, this sort of thing could easily collapse into absurdity. Michael Swanwick, multiple Hugo and Nebula Award winner, is a masterful guide to the bizarre and hilarious adventures of Darger and Surplus. He keeps all the elements moving, suspending disbelief like a talented juggler. Not simply funny, this book sparkles with genuine wit. SF has seen many con artists; Darger and Surplus are a supreme example.

Here's to more adventures for the pair.

Romance on Four Worlds: A Casanova Quartet
Tom Purdom
Fantastic Books, 150 pages, $12.99 (trade paperback)
ISBN: 978-1-627855-635-4
Genres: Short Fiction

Tom Purdom's been around since the late 1950s, with five novels and innumerable short stories to his credit. His work has been nominated for multiple awards, and his stories have frequently appeared in various "Best of the Year" anthologies. Last year I reviewed his short story collection *Lovers & Fighters, Starships & Dragons.* Now he's back with a delightful little book chronicling the travels of a future Casanova.

The historical Giacomo Casanova (1725–1798) traveled the length and breadth of Europe and wrote extensive memoirs detailing his adventures. Along the way, in addition to many adventures, he conducted 120 love affairs and entered the language as a synonym for playboy.

Joseph Louis Baske travels through the Solar System following a similar trajectory. In four tales, all originally published in our sister magazine *Asimov's Science Fiction,* Baske visits the Moon, Mercury, Phobos, and the Kuiper Belt in search of adventure and romance. And sure enough, he finds plenty of both.

These are classic picaresque tales, modern comedies of manners in which Baske gets himself into and out of trouble in the most amusing ways. That the characters are engaging and believable goes without saying—Purdom writes great people—but the four societies depicted are also a lot of fun.

Distant Seas
Bud Sparhawk
Fantastic Books, 216 pages, $13.99 (trade paperback)
ISBN: 978-1-627855-633-0
Genres: Adventure SF, Undersea/On the Sea

* * *

Bud Sparhawk is no stranger to these pages; he drops in with a delightful piece of short fiction every few months. Now he's produced a novel that expands some of those stories.

Longtime readers may remember Sparhawk's "Primrose and Thorn" (May 1996) and "Primrose Rescue" (May 1997); a pair of stories about sailing ships on Jupiter. Those stories form the core of *Distant Seas.*

Louella Parsons is a professional, world-class sailor at the end of the twenty-second century. We meet her as she's competing in *La Gran Venee,* the premier race around the Earth. Surviving near disaster in Antarctic waters, Louella goes on to a far more dangerous venue: the seas of Jupiter.

Then, as if sailing the largest planet in the Solar System isn't enough, Louella competes in a race across the frigid plains of inhospitable Mars.

Sparhawk's descriptions of future sailing technology are ingenious and persuasive; he's obviously done a lot of physical-science work on techniques necessary for sailing in outrageous environments. Yet his depiction of Louella herself is what shines brightest. Intelligent, strong-willed, driven, and heroic—Louella Parsons has all the qualities she needs to triumph over the many obstacles in her path. It's a delight to accompany her on her adventures.

An earlier version of *Distant Seas* was published in an early ebook format in 2010.

Clash of Eagles
Alan Smale
Del Rey, 432 pages, $27.00 (hardcover)
Kindle: $11.84, iBooks, Nook: $13.99 (ebook)
ISBN: 978-0-8041-7722-1
Series: Clash of Eagles 1
Genres: Alternate History

Alan Smale is one of those Renaissance men who make the rest of us look positively lazy. An astrophysicist and data archive manager at NASA's Goddard Space Flight Center, he writes science fiction and fantasy, and he's business manager for the vocal band The Chromatics.

Lately Smale's been working on alternate history. His novella "A Clash of Eagles" won the 2010 Sidewise Award for Alternate History. *Clash of Eagles* is the first in a trilogy set in the same universe as that award-winning story.

It's the year that we'd call 1218 C.E. The Roman Empire, which never fell, is always hungry for land and gold . . . and the newly discovered continent of Nova Hesperia has plenty of both. The emperor dispatches Praetor Gaius Marcellinus in command of the thirty-third Legion to the new world.

At first it's easy going, as the Romans face and subdue lightly armed natives. But on the shores of a great river, Marcellinus and his men meet a force whose weapons and tactics are superior. In the resulting massacre, Marcellinus is the only survivor.

His captors, keeping him alive for his military knowledge, take Marcellinus to the fortified city-state of Cahokia. As time passes, these proud people adopt Marcellinus, and he makes friends and allies, finding much to admire about the Cahokians and their culture.

But the world doesn't stand still. Besides the Romans, there are other enemies out there: Cherokee, Tvscarora, Powhatani, and especially Iroqva. In a continent lurching toward war, can one Roman keep the peace?

In the alternate history genre, the Rome-never-fell story has a long . . . er . . . history. But Smale's take on this familiar premise is fresh and intriguing. The worldbuilding is stunning; in terms of a detailed alternate world imagined in depth, I was reminded of Harry Harrison's classic Eden trilogy. The best alternate history—like the best science fiction, fantasy, or historical fiction—makes the reader believe that he or she has been visiting a real place rather than an imagined world. *Clash of Eagles* has that quality.

Visit Smale's world. You won't regret it.

And now, I don't need psychology, sociology, or even anthropology to tell me that my space is up. Until next time, enjoy reading. ■

Don Sakers is the author of *Children of the Eighth Day* and *Meat and Machine.* For more information, visit *www.scattered-worlds.com.*

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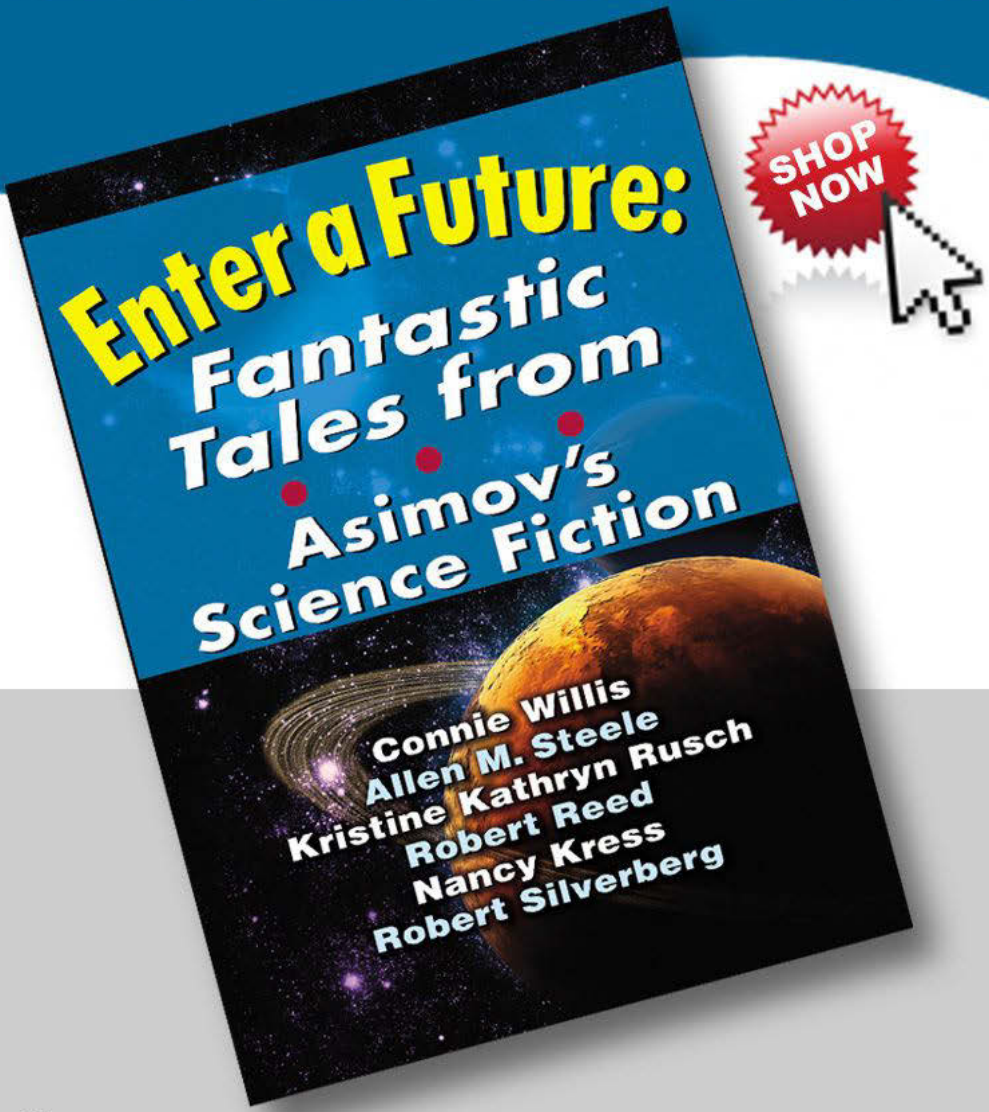

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Asimov's is famous for captivating stories and richly rewarding tales by some of today's *best-known SF writers*. Whether they're a jazz musician on a starship, the spirit of H.L. Mencken tangling with a twenty-first century medium, or the new personality of a wayward teenager trying to stake a claim on a body that is and sort of isn't hers, they must all find their way in uncharted territory. Join them on their journey. Turn the electronic page and enter a future!

BRASS TACKS

Dear Editor Quachri,

This is my annual letter to *Analog*.

If your objective was to expand the variety of stories published in *Analog* while retaining the basic character of the magazine, you have succeeded. I am willing to put up with a handful of stories I did not finish reading for the long-term health and viability of the magazine.

On the plus side, "The Homecoming" by J.T. Sharrah [June, 2014], not only the best story in *Analog* but the best SF story I have read all year. Also "The Crimson Sky" by Choi [July/August, 2014]—If I had the pick one story this year that represented the Geist of *Analog*, I would pick this one "Opportunity Knocks" by Schmidt & Schmidt [October, 2014] and "Plastic Thingy" by Niemann-Ross [September, 2014], two funny stories that were actually funny. Let us just say your sense of humor as an editor is much closer to mine than Dr. Schmidt's is.

On the negative side, "Beneath the Ice of Enceladus," by Glass [September, 2014] was very well written and plotted, but the female scientist ("on the edge of tears the entire time," "She came close to crying") spoiled it for me. As a female scientist myself, I can assure you that no scientist, male or female, would advance in their field if they could not keep a firm grip on their emotions in the workplace, regardless of the situation.

"The Oracle of Boca Raton" was so full of expletives I could not finish it. I can live with an occasional expletive, but this to me is very unskilled, lazy writing. I *loved* the addition of cartoons and poetry. Perhaps you could add the poetry to next year's AnLab voting?

Keep up the great work.

Dr. Rebekah Memel Brown

As you've likely already seen last issue (pgs. 7–8), we will indeed be adding poetry as a category to our AnLab ballot.

* * *

Dear Sir,

Being a pharmacist, I am somewhat detail-oriented. Therefore, as I was reading "Tasha's Fail-Safe" when I got to page 17 I see "one pod of trusted intelligence analysts: three men, two women, one neuter" . . . and then ". . . cleared the neuter, one of the men, and one of the women. But isolating the actual culprit out of the two who remained . . ."

So if there were six suspects and three were cleared—what happened to the fourth if only two suspects remained?

Great story though!

Les Hanson
Mukilteo, WA

The author responds . . .

"I could, of course, work out some complex far-future in-continuity explanation that completely explained away the damn thing in some way that added layers of additional meaning to the story. But the unalloyed truth is that I followed in the venerable footsteps of Daniel Defoe, who allowed that noted marsupial Robinson Crusoe to fill his pockets while naked, and William Golding, who allowed the castaway boys to start fires with a pair of spectacles that according to the prescription wouldn't concentrate sunlight, and screwed up—missing a reference that should have been fixed, when I changed the number of suspects I had in a prior draft. I'm happy it didn't ruin your enjoyment of the tale."

—Adam-Troy Castro

Hi Mr. Quachri,

Congratulations on another outstanding issue.

I always look forward to contributions from Richard Lovett: his fiction always has an interesting way about it and is never predictable, and his nonfiction is always well written and interesting. If his work is in an issue, I will turn to it first.

I also enjoy the book reviews, and would like to add a couple of items of interest to Mr. Sak-

ers's essay at the start of his column. First, the Asimov/Greenberg series from DAW was also reprinted in hard cover by Bonanza as The Golden Years of Science Fiction, in six volumes, each with the contents of two paperbacks, covering the first 12 paperback volumes. Second, at the same time Ballantine put out its Best of series, Pocket books did the same for about six authors. Fourteen of the Ballantine / Pocket books Best of anthologies were published in hard cover by the Science Fiction Book Club.

Cary Ballew-Renfro
Salem, OR

Dear Dr. Schmidt:

Your article "Hiding the Info-Dump" in the current magazine can usefully be applied to other forms of writing as well as SF. I was amused at how much of its advice applies to my current efforts on the history of the early twentieth-century El Paso & Southwestern Railway in Arizona and New Mexico. After amusement faded I scanned your text and placed it in my Publications folder along with the author's guide from UNM Press and similar items.

Even with well-established historical technologies, readers who are expert in one, say steam locomotives, are laymen in others such as mining, smelting, or New Mexico politics. Sometimes a writer can describe the functions of the technology without telling how it operates, a "black-box" approach.

Your article is a good read the first time and even more interesting later as I reflect on my own writings about the old EP&SW and the copper industry.

Vernon J. Glover
Rio Rancho, NM

Hi,

I have just finished reading the April 2015 edition; my son has subscribed me for a year and I am thoroughly enjoying it.

"The Eighth Iteration," "Daily Teds," "Transfer Point," "Dancing in the Dark"—all good, interesting SF with some good imagination. I will be looking for these authors in the future. Last purchased new copy of *Analog* was 1970 when I married, moved, and forgot you. Well, you are back on the radar. I will renew my subscription at the end of the year.

A. Farenden
England

Mr. Quachri,

I'm sure hundreds of people have already pointed out that the numbering system Mr. Varja describes [in "Zen Angel," May 2015] is Octal not Hexadecimal—in Hex 17 is 11. Sorry to be a quibbler as I enjoyed the story as a whole a lot—as a matter of fact I'm glad to say, if anything, the stories have gotten better since the leaving of Dr. Schmidt (which I worried was going to be my favorite magazine's demise—just like when John Campbell left).

Ron Miller
Colorado Springs, CO ■

UPCOMING EVENTS Anthony Lewis

NOTE: Membership rates and other details often change after we have gone to press. In addition, most conventions have age-based membership rates in advance and at the door. There also may be rates for single days. Check the websites for the most recent information.

28–30 August 2015

BUBONICON 47 (Albuquerque area SF conference) at Albuquerque Marriott Uptown, Albuquerque NM. Theme: Women of Wonder. Guests of Honor: Tamora Pierce & Catherynne M. Valente; TM: Mary Robinette Kowal; Guest Artist: Ruth Sanderson. Info: *http://bubonicon.com/;* Bubonicon Inc, 933 San Mateo Blvd NE, Suite 500-208, Albuquerque, NM 87108.

25–27 September 2015

FENCON XII (Dallas area SF conference) at Westin Dallas Fort Worth Airport, Irving, TX. Guest of Honor: S. M. Stirling; Music Guest of Honor: Tricky Pixie; Fen Guest of Honor: Tadao Tomomatsu; Artist Guest of Honor: Mitch Bentley; Science Guest of Honor: Dr. Peggy Boston. Membership: see website. Info: *http://www.fencon.org/;* FenCon, PO Box 701448, Dallas, TX 75370-1448.

2–4 October 2015

ARCHON 39 (St. Louis MO area SF conference) at Gateway Convention Center and Doubletree by Hilton Collinsville, IL. Guest of Honor: Jacqueline Carey; Artist Guest of Honor: Brent Chumley; Filk Guest of Honor: Tricky Pixie; Media Guest of Honor: RJ Haddy; Science Guest of Honor: Jordin T. Kare; TM: Esther Friesner; Masquerade MC: Victor Milán. Memberships: Advance rates good until 31 July 2015/at the door. Adult $55/$70; YA (17–20) $30/$30; Youth (11–16) $20/$20; Child (6–10) $8/$8. Info: *http://www.archonstl.org/.*

2–4 October 2015

VCON 40 (Vancouver, BC area SF conference) at Sheraton Vancouver Airport Hotel, Richmond, BC. Author Guest of Honor: Joe Haldeman; Game Design Guest of Honor: Ed Greenwood; Artist Guest of Honor: Rick Sternbach; Editor Guest of Honor: Eric Choi; Fan Guest of Honor: Steve Forty; MC: Spider Robinson. Memberships until 15 September 2015: Adult CAD40; Student/Senior (65+) CAD30; Youth (7–18) CAD20. Info: *http://www.vcon.ca/*

17–21 August 2016

MIDAMERICON 2 (74th World Science Fiction Convention) at Kansas City Convention Center and Bartle Hall, Kansas City, MO. Guests of Honor: Kinuko Y. Kraft, Patrick and Teresa Nielsen Hayden, Tamora Pierce, Michael Swanwick. TM: Pat Cadigan. Membership: currently. Attending: Adult $150, Young Adult (up to 25) $90, child (5-15) $60; $50 supporting. This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Nominate and vote for the Hugos. Info: *http://midamericon2.org/; info@midamericon2.org.*

Attending a convention? When calling conventions for information, do not call collect and do not call too late in the evening. It is best to include a S.A.S.E. when requesting information; include an International Reply Coupon if the convention is in a different country. ■