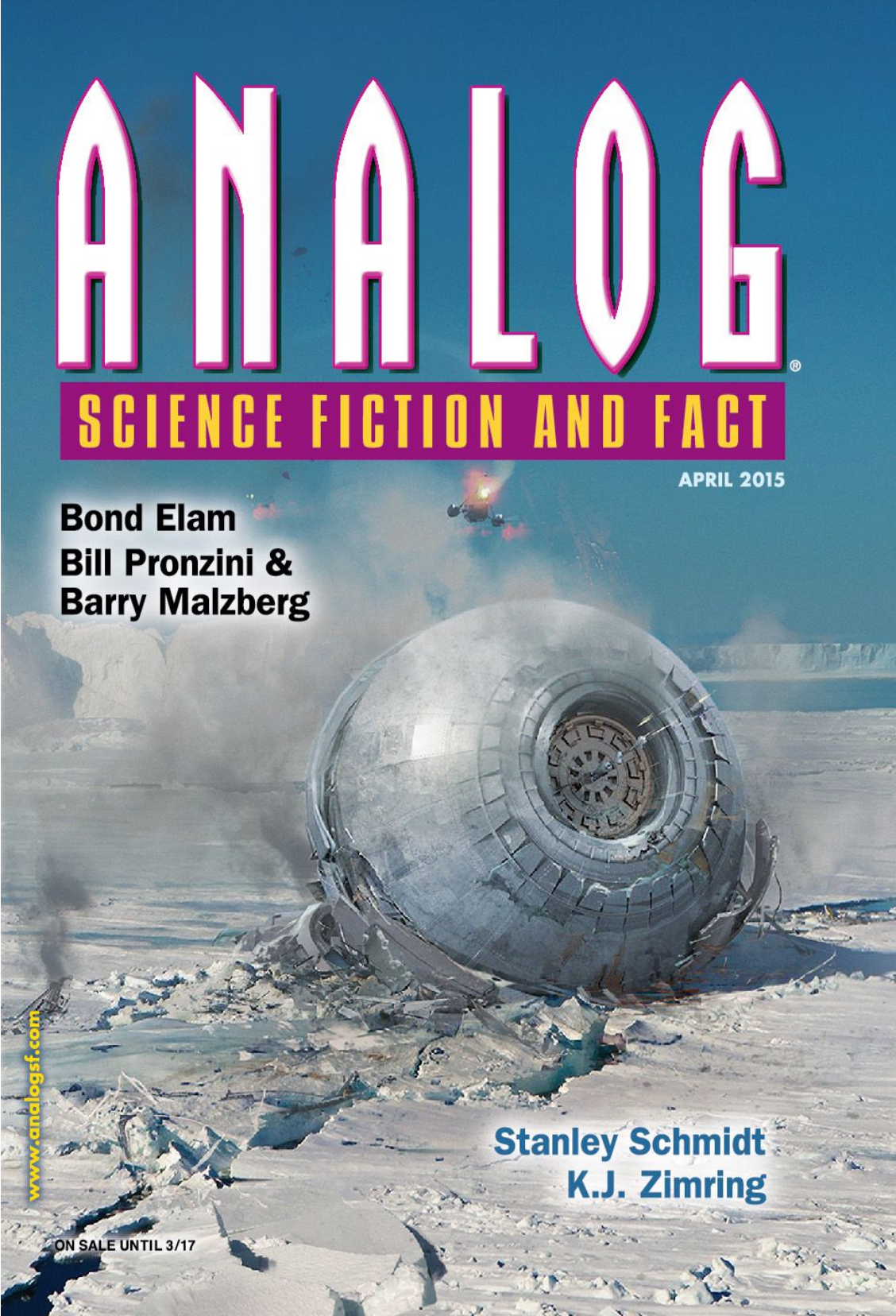
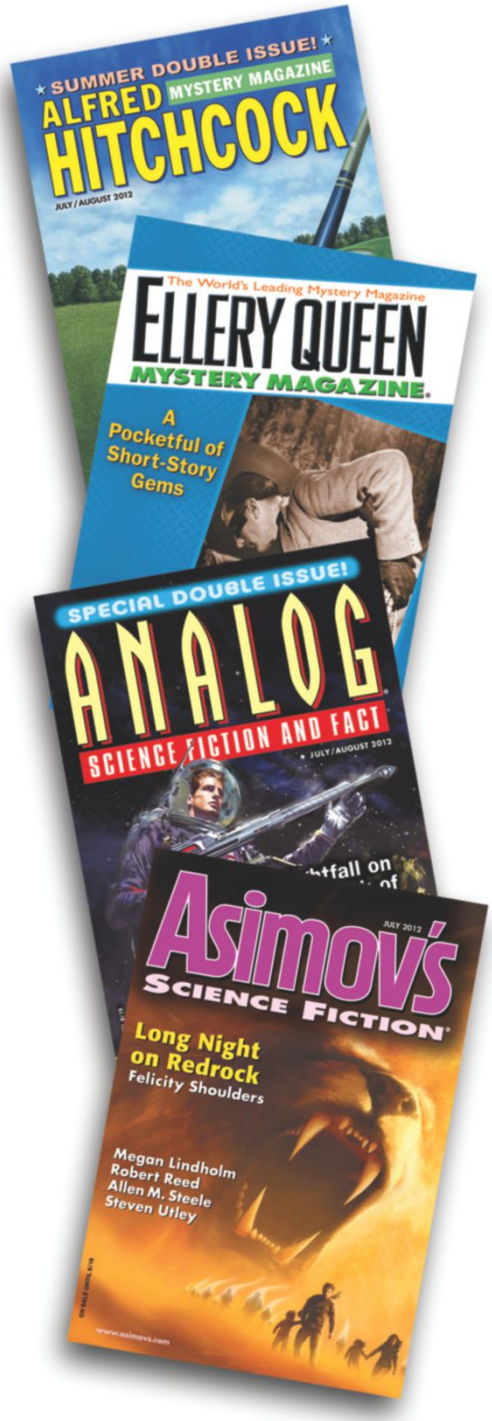
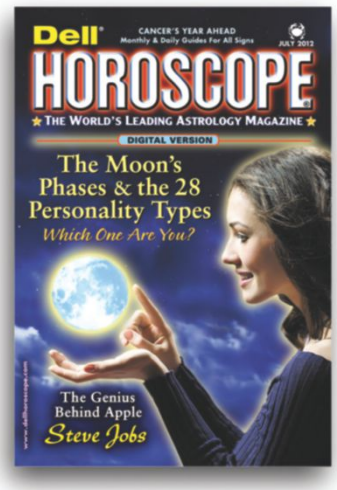

ANALOG
SCIENCE FICTION AND FACT
APRIL 2015
Bond Elam
Bill Pronzini &
Barry Malzberg
Stanley Schmidt
K.J. Zimring
www.analogsf.com
ON SALE UNTIL 3/17



Advertise in our digital magazines on iPad!

Penny Publications, LLC, the parent company of Dell Magazines, offers digital advertisers a desirable, highly-responsive audience. We publish **5 nationally recognized, digital magazines.**



For more information on advertising with us, contact:
Advertising Sales Manager via email at printadvertising@dellmagazines.com, or call 203.866.6688 x442.

ANALOG®

SCIENCE FICTION AND FACT

Vol. CXXXV No. 4
April 2015

Next Issue on Sale
March 17, 2015

6

79

NOVELETTES

SHORT STORIES

SCIENCE FACT

SPECIAL FEATURE

PROBABILITY ZERO

POEM

READER'S DEPARTMENTS

Trevor Quachri Editor

Emily Hockaday Assistant Editor

Cover design by Victoria Green

Cover Art: Planetfall by Daniel Romanovsky, Form Language Studio

Indicia on Page 3

GUEST EDITORIAL Ian Randal Strock

YAY! THE FUTURE . . . OH, DAMN.

We're living in the future, and I am by turns thrilled and scared of it.

Science fiction writers have been anticipating the future—showing its potential glories and possible pitfalls—for decades. We never claimed to be fortune tellers, and the author who can make more correct than incorrect predictions about the future hasn't yet been born. But that's not a problem. Our first goal is to write an entertaining story. Only secondarily are we trying to see into the future.

Yet, every day, I see more and more of our predictions coming true, and most of them are not the predictions I was hoping for.

Tom Clancy was eerily prescient in *Debt of Honor* (1994), when he predicted the use of a jumbo jet as a weapon of mass destruction. The entire world was shocked when the events of September 11, 2001, happened . . . all except we science fiction readers and writers. As I'm writing this, one of the current crises making headlines is the Ebola outbreak in West Africa. The Centers for Disease Control and Prevention (CDC) has just raised its travel alert, suggesting that no one undertake any nonessential travel to the affected countries, and there is talk of health screenings at U.S. airports, with possible quarantines in line for travelers who appear to be infected by the disease. Once again, I look at Clancy and cringe (this time, from *Executive Orders* [1996]).

I also think about Ben Bova's tongue-in-cheek prescience in "Crisis of the Month" (1988, *F&SF*). As I've been thinking about this article, the all-encompassing, 24-hour-a-day, breaking news story has changed from the war in Israel to the Ebola crisis in West Africa to the war in Iraq and Syria. Each of those stories overwhelmed regular news with all-the-time, pay-attention-it's-important newscasts and reports, only to be replaced after a few weeks with the next. And each keeps cropping up in the SF of the past.

Don't get me wrong; I love living in this future. We have enhanced medical care (indeed, the two Americans infected in the Ebola outbreak may have been cured by a new, not-yet-experimental anti-Ebola drug), greater communication, better nutrition . . . easier living in general. In all the little ways, the future we've built ourselves is wonderful. But there are still warning signs, thunderclouds on the horizon, that I worry we're not taking seriously enough.

A common panel topic at science fiction conventions these days is "We're living in the future, so where's my flying car?" I've sat on a few of those panels, and I always open with a bit of seriousness: Look at how many drivers have trouble in two dimensions. I am eternally grateful that they don't have three to deal with.

But then I turn on the television, and I see the best, latest, most innovative, coolest, earlier-than-tomorrow gadget that some tech company is pushing. A big one these days is remote access. As one television commercial shows, you can use your smartphone to log into your home security system and make sure your kids turned off the water, shut off the lights, and locked the doors. And if they haven't, you can do it yourself, remotely. Fantastic! We're in the future. It was a marvelous invention in the background of the recent comedy *Parental Guidance* (2012).

At the same time, however, not a day goes by when there isn't a report of another new hacking problem. Whether it's the Chinese military trying to hack into U.S. control computers, credit card thieves stealing thousands of numbers from major retailers (which is why you'll be getting a new credit card with a computer chip in it next year), or the kid next door whose computer was infected by a virus and is now spewing out spam on its own. In such a world, do you want your home to be computer-controlled? With deadbolts and physical keys, breaking into your house meant physically breaking in. Hopefully, a helpful neighbor would hear the smashing glass and call the police on your behalf. But in the computer-controlled home of tomorrow (it might be today), breaking in means writing a hacking program, and then walking up to the house and clicking a button. And do you remember the older film, *Demon Seed* (1977), in which the computer locks the protagonist into her own house?

I was worried when our Toyota came without an ignition key: just an electronic remote to unlock the doors, and then you start the car by pushing a button. It's the wave of the future, but how do you know if the beep you just heard was a car's owner unlocking it, or a thief doing the same? Again, no sound of breaking glass to alert you, no strange tool jammed down alongside the window to unlock. And now, you may be locked out of your own car if the battery in the remote dies. Ever have that problem with a physical key?

I'm annoyed every time one of the computer programs I use is "upgraded" by its manufacturer, forcing me to upgrade or buy a new version. I understand that part of that is marketing, and part is improvement. The software developers are in a never-ending battle to upgrade their products, to keep the bad guys out. And those bad guys are first in line to buy the newest version of the software, to keep working on their hacks to break into it. There doesn't appear to be a solution; it's a never-ending arms race, building the levies higher to keep back the flood waters of the rising river of hackers. I'm not always the first on my block to get the newest program. Sometimes it's orneriness on my part, but sometimes, a little voice in my head wonders, "If I'm using an older version of the program—not the current one, but one from three or four revisions ago—it still works for me, but is it possible that the hackers are no longer interested in breaking in? And if so, am I safer?"

Avi Rubin, writing in the July 2014 issue of *All In Magazine*, talks about how easy it would be to break into online poker programs, to view players' hole cards with an eye to cheating the system. And he talks about a work-around solution, involving the use of two different devices in concert to provide the added security. I can see some merit in that solution. It will take time to crack one security system; cracking two will take longer.

On the other hand, at Balticon this May, I was talking with a fellow who is making money by mining Bitcoins. The system requires solving incredibly complex mathematical problems very quickly. The first to find the solution "wins" a bit of electronic currency. And then, ten minutes later, there's a

Analog Science Fiction and Fact (Astounding), Vol. CXXXV, No. 4, April 2015. ISSN 1059-2113, USPS 488-910, GST#123054108. Published monthly except for combined January/February and July/August double issues by Dell Magazines, a division of Crosstown Publications. One-year subscription $55.90 in the United States and possessions, in all other countries $65.90 (GST included in Canada), payable in advance in U.S. funds. First copy of new subscription will be mailed within eight weeks of receipt of order. When reporting change of address allow 6 to 8 weeks and give new address as well as the old address as it appears on the last label. Periodical postage paid at Norwalk, CT and additional mailing offices. Canadian postage paid at Montreal, Quebec, Canada Post International Publications Mail, Product Sales Agreement No. 40012460.

POSTMASTER: Send change of address to: ANALOG SCIENCE FICTION AND FACT
6 Prowitt Street, Norwalk, CT 06855.

IN CANADA RETURN TO: Quad/Graphics Joncas, 4380 Garand, Saint-Laurent, Quebec H4R 2A3
Executive Office: Penny Press, 6 Prowitt St., Norwalk, CT 06855
Editorial: Analog Science Fiction and Fact, 44 Wall Street, Suite 904, New York, N.Y. 10005
Advertising and Subscriptions: Analog Science Fiction and Fact, 6 Prowitt Street, Norwalk, CT 06855.

Printed by Quad/Graphics, Taunton, MA U.S.A. (1/19/15)

new problem to solve. He's not making his money solving those problems. He's doing it by building faster and faster computers to do the solving (as are his competitors). In effect, he's hacking; he's just hacking legally, and not stealing something. But what he does is easily translatable to what the bad guys might do (if it isn't what they're doing already). So again I ask, where does it end?

We're living in the future, clearly and unequivocally. In *Back to the Future Part II*, Marty McFly traveled to the far future: October 21, 2015. In the film, they were advertising *Jaws 19*, and Marty said "the shark still looks fake." In reality, Steven Spielberg stopped after four *Jaws* films, and computer technology has advanced so far that the shark would look incredibly real, but as much as we keep envisioning and missing the future to be, I'm still worried about it, flying DeLorean or no. ■

TREVOR QUACHRI .....Editor
EMILY HOCKADAY.....Assistant Editor
MARY GRANT .....Editorial Assistant
DEANNA MCLAFFERTY .....Editorial Admin Assistant
JAYNE KEISER.....Typesetting Director
SUZANNE LEMKE.....Assistant Typesetting Manager
KEVIN DORIS .....Senior Typesetting Coordinator
VICTORIA GREEN .....Senior Art Director
CINDY TIBERI .....Production Artist
JENNIFER RUTH.....Production Manager
ABIGAIL BROWNING.....Manager, Subsidiary Rights and Marketing
SANDY MARLOWE.....Circulation Services

PETER KANTER
Publisher

BRUCE SHERBOW
Senior Vice President
Sales, Marketing, and IT

CHRISTINE BEGLEY
Vice President,
Editorial and Product Development

SUSAN MANGAN
Vice President,
Design and Production

Published since 1930
First issue of *Astounding*
January 1930 ©

ADVERTISING SALES DEPARTMENT
Tel: (203) 866-6688 ext.442 ■ Fax: (203) 854-5962 ■ printadvertising@dellmagazines.com
Subscriber Services: 203-866-6688 Option #2

EDITORIAL CORRESPONDENCE ONLY analog@dellmagazines.com

BOND ELAM

Bond Elam has been a trucker, public health official, and alcoholism counselor, but the twin loves of his life are computers and writing science fiction. "I read science fiction pretty much continually," he says of his grade-school years. But like many beginners, his first forays into the field were too ambitious. "I put together a novel which was absolutely horrible."

Meanwhile, the early 1970s computer revolution was hitting American business, and he was able to convert an English major and an eclectic career background into a job at one of the East Coast's largest banks. "I ended up managing software development," he says. "My area of expertise was very large databases."

By the time he took early retirement a few years ago, he'd gotten back into writing—again beginning with novels. "I wrote three or four and none was any good," he says. So he shifted to short stories. "I figured I could get a lot more practice. And if something didn't work out, I wouldn't have a year invested in it—I would have a month."

His first sale, "A Plethora of Truth," went to *Analog* in 2008, with four more, including this month's, following. "It felt like I was getting a start on the second big thing I wanted to do," he says.

Not that there weren't third and fourth things on his list. One is running, which at age 69, he still does at 25 miles a week. Another is learning another language. (He picked Spanish, and now teaches introductory computer classes to Spanish-speaking students.)

Two of these—learning a second language and computers—have also influenced his writing.

Language, he says, plays a role simply because the process of reading a foreign tongue slows him down enough to see not only the story, but also the writer's craft. "I read *Like Water for Chocolate* in Spanish," he says, "and you

Photo by Jerry Wiedemer

really see language and metaphors and the way Laura Esquivel manages transitions. In English, it goes from the writer's head to my head. In Spanish, I have to really process the language and see how an idea gets translated into words."

Computers enter in because his stories often involve programmer-style logic. "I did a Probability Zero on the idea that we could be holographic projections on the surface of a black hole," he says, "but I was thinking in terms of a big computer database. In the story, people, by observing, were forcing more and more probability events to collapse, and reality, like a big computer, was running slower and slower and had to be rebooted."

But programmer logic isn't the only thing that drives his stories. "I like to explore ideas of what human beings are," he says. "What is consciousness? What is identity? Is it real or an illusion created by our genes so we'll get them to the next generation? [I enjoy] exploration of ideas that go a step beyond what we see and know, but have legitimate roots in actual science." ■

Illustrated by Vincent DiFate

The Eighth Iteration

Bond Elam

The bird—a flightless raptor, nearly four feet tall with a hooked beak, glistening black talons and claws jutting from its stubby wings—burst from the forest in a flurry of yellow feathers. It charged past the two maintenance bots working on the colony's crew shuttle and bounded up the side of the small observation dome. Ahead of it, half a dozen lizards with wrinkled white skin and slit amber eyes scrambled over each other in their desperation to escape. Midway up the side of the dome, the bird skidded to a halt. Slowly tilting its head from one side to the other, it glared down through the transparent surface, fixing one green eye on the upturned face of Jake Sanchez.

"Friend of yours?" Margaret Winslow asked. Brushing aside her dark curls, she squinted up at the bird. "Looks like it knows you."

Not likely, Jake thought. This particular specimen was only a juvenile, still a foot short of its adult height. Chances were he and

Margaret represented its first encounter with the featherless aliens that had invaded its forest sanctuary.

"Maybe it's tired of lizard," he said. "Looking to feed a little higher on the food chain."

"You mean us?"

Suppressing a grin, Jake shrugged. "Everybody's got to eat."

"Then we wouldn't want to disappoint it, would we?" a voice interrupted from behind them.

Jake turned to see Lucas Martel emerge from the enclosed walkway that wound back through the forest to the main dome. As usual, an entourage of hangers-on trailed along behind him. Jake counted five men and three women. All looked to be in their mid-twenties, in perfect health, with flexible smart screens strapped to the forearms of their standard-issue brown coveralls—like so many freshly hatched chicks, Jake thought, all of them working hard to mimic their leader's harsh scowl.

"I had nothing to do with this," Margaret said from the corner of her mouth. "They must have seen us come out to the dome."

Above them, the bird cackled, hopping in a small circle as it tried to get a better look at the new arrivals. When Martel looked up, it held his gaze for a moment, then thrust out its beak, giving him an angry squawk.

"That's what I'm talking about," he said. He wheeled on the other colonists. "That's what's out there waiting for us—the birds, the lizards, things we don't even know about yet. That's why we can't let people like Jake Sanchez disrupt our preparations."

Jake sighed, shaking his head. Martel was a showman, he'd give him that. The resonant voice, the lean cheekbones, the dark eyes glinting in the afternoon sun. People were naturally drawn to him. Couldn't help themselves, in fact. At least some people. Jake didn't doubt that he had the best interests of the colony at heart, but he couldn't help wondering how much of what Martel said he actually believed, and how much was for the benefit of his ever-present brood.

"I take it this is about Harold," Jake said.

Harold Sweeney stood just beside his boss. Unlike the other colonists, Sweeney's scowl looked real. "I warned you, Sanchez. But guys like you, you never listen, do you?"

Jake wasn't sure what he disliked most about Sweeney—the constant sneer, the arrogant tilt to his chin, or that bony nose he was always looking down at people. Probably the nose, he decided. Someone needed to do something about the nose.

"Lucas, I'm not your problem," Jake said, turning back to Martel. "Your man Sweeney here has a knack for rubbing people the wrong way. Maybe you should talk to him, let him know that pushing people around doesn't make them work harder."

Jake's problems with Sweeney had been brewing for weeks. They'd finally boiled over the previous morning when several of the colonists complained that the latest work schedule, which Sweeney had just posted, once again exempted Martel's hangers-on from the hard work in the fields. Sweeney, like the petty despot that he was, told them to quit their bitching and climb aboard the crew shuttle his men had just landed in front of the main dome. Jake had known he should keep his mouth shut, that he should let events work themselves out of their own accord; but seeing that curled lip, those indifferent eyes sneering down the length of that nose, he'd been unable to stop himself. He'd plucked the schedule from the wall, folded it into a neat little square and tapped it into the chest pocket of Sweeney's brown coveralls. "Maybe you should to try your own hand with a bush ax," he'd suggested, offering Sweeney a bright smile. Then he'd led nearly a third of the work crew back into the dome.

"Jake, I thought I could count on you," Martel said with a disappointed shake of his head. "I thought you were part of our team. If you wanted to spend time out there in the forest cataloging, exploring, whatever it is you do . . . I said fine, have at it. But you and everyone else need to understand: if we're going to survive in this . . ." he grimaced out at the gnarled trees twisting up around them ". . . this godforsaken wilderness, then each of us needs to pull his own weight."

Above them, the bird squawked a second time, lowering its head as though fascinated by the scene playing out below it.

In response, Harold Sweeney tucked his fists into his armpits and squawked up at the bird, giving his elbows a quick flap. "Bird looks hungry," he said. Grinning, he gave Jake

a flap. "What do you think, Sanchez? Think it looks hungry?"

"Harold, look at yourself," Jake said. "Flapping around like that, it's no wonder no one listens to you."

"Squawk, squawk, squawk," Sweeney said. "All you do is squawk."

Jake frowned, his forehead tightening. "Is that supposed to mean something? Or are you just running your mouth 'cause you like the sound of your voice?"

Sweeney laughed. Continuing to flap his elbows, he hopped around the small circle of colonists, squawking up at the bird.

Jake turned to Martel. "Lucas, is this really the guy you want out there giving orders for you? I mean, really. It's embarrassing just watching him."

Martel sighed disappointedly. "Jake, I had such high hopes for you. I think a lot of people did. I truly wish it hadn't come to this."

"Come to what?" Jake said. "Where are you going with this, Lucas?"

Martel sucked in a breath—letting his entourage see that he didn't like what he had to do, but sometimes these things need to be done. "I'm sorry, Jake," he said, nodding to the two men who'd moved around behind Jake.

"What the hell . . ." Jake said, glancing from one to the other.

"Time to feed the bird," Sweeney squawked, still flapping. "Bird's hungry, Jake. Got to feed the bird."

"Lucas, wait," Margaret interrupted. She stepped forward, her blue eyes tight with worry. "You don't want to do this. There are things going on. Things you need to know about."

Martel held up his hand, stopping the two men who'd started toward Jake, giving her a chance to continue.

"The bots—" she said. She jerked her chin toward the two bots working on the shuttle. "You're playing into their hands."

Sweeney barked a laugh, his craziness momentarily forgotten. "You got to be kidding," he said, straightening. "They're nothing but dumb machines."

The two stick-like automatons clung to the railing surrounding the shuttle's circular deck like oversized insects. Which was exactly how Jake thought of them—like grotesque parodies of the human form, with flexible limbs, tubular torsos and just the hint of a nose and brow sculpted into their ovoid heads. At the moment, their attention was focused on the nearest of the shuttle three fan housings. They picked through the disassembled pieces spread on the deck like bugs searching for a meal.

"They couldn't care less what goes on in here," Sweeney said, turning back to Margaret. "They're maintenance bots. They fix things."

Jake was inclined to agree. While the bots used their stunners to frighten off any of the forest predators that came too close, their primary function was maintenance. They played so little role in the internal activities of the colony, in fact, that he'd come to think of them as little more than mobile extensions of the dome's infrastructure—preprogrammed hardware, incapable of human thought or speech.

"And they sure as hell aren't going to help you," Sweeney said, grinning at Jake. "Except maybe watch when we feed you to the birds." He dropped back into a crouch, squawking up at the bird.

Overhead, the bird responded with a squawk of its own. With its attention now fixed on Sweeney, it skittered in a tight circle, as though trying to find some way inside.

Turning his head slowly to the side, Sweeney hopped back and forth, taunting it. "Bird's got to eat," he squawked, flapping his elbows. "Time to feed the bird."

The bird clawed at the dome, its agitation rapidly increasing. Suddenly it slammed its beak down against the transparent surface with a resounding crack that echoed through the dome.

"Lucas, he's out of control," Jake said, glaring from Sweeney to Martel. "You need to rein him in. Now."

"Squawk, squawk, squawk," Sweeney cackled. Hopping across the circle, he got in Jake's face. "What we need is to rein in your mouth."

Jake wasn't sure whether it was the crack of the bird's beak still echoing in his ears, or the sight of Sweeney's beady amber eyes peering up at him along that bony nose. He knew only that the frustration welling up inside him somehow resolved itself into a fist that landed

squarely in the center of Sweeney's face. He shouldn't have thrown the punch, of course. There would be repercussions on top of repercussions. But at that moment, standing there, watching Sweeney roll on the floor with his hands pressed to his broken nose, he felt only an immense satisfaction, a soothing warmth that spread through his body, washing away every last ounce of the tension that had been building up inside of him.

Unfortunately, his satisfaction was short lived, for in the next moment, Martel's men grabbed him by the arms, and events took a decided turn for the worse.

It wasn't until later, sitting against the wall in the dark storage room where Martel's men had locked him, that Jake realized he'd been played. Sweeney was no crazier than he was. All the flapping and squawking were part of an act designed to keep people off balance—which was exactly what Martel wanted. With no one quite sure what to expect from him and his minions, it made it all the more difficult to organize against him.

In this case, the strategy had backfired—at least to the extent that Sweeney had ended up with a broken nose—but Jake had given Martel exactly what he wanted: an excuse to take the one person who would stand against him out of circulation.

"Hey, Sanchez. You down there?" Margaret's voice whispered from the darkness above him. A light flashed down through the ventilation grate in the center of the ceiling.

"What are you doing?" he whispered, climbing to his feet.

The grate swung down. "I need to get you out of there."

Margaret leaned her head and shoulders down into the room, shining a small flashlight—first in Jake's face, then along the walls. The circle of light came to rest on a stack of plastic produce containers against the rear wall. Jake slid the containers to the center of the room, climbed on top, and reached for the sides of the grate.

"Try not to make any noise," she grunted, helping to drag him up by the collar. "The guards are just outside."

"How did you find me?" he whispered as they scrambled along the ventilation duct on their hands and knees.

She held up her forearm, showing him the map of the dome's ductwork on her smart screen. "The computer," she said. "The architectural schematics for the dome are all in there. All you have to do is look."

"Easy for you to say."

Like the other colonists, Jake used his smart screen to look up specific bits of information—in his case, mostly about biology, which seemed to be his area of expertise. When it came to computers, on the other hand, Margaret was the real expert. She could find virtually anything in the dome's databases. Whether that was the skill that had qualified her for their mission, however, was another question. The problem was, the colonists had awakened from cold sleep six months earlier with no memory of who they were, where they'd come from, or even why they'd volunteered. They'd assumed their memories would return with time, but thus far that hadn't happened. Aside from their names, which had been stenciled above the pockets of their one-piece brown coveralls, they still had no memories of their previous lives. In fact, they couldn't even remember waking. They'd simply found themselves in mid-task—some of them in the fields, some in the kitchen, some loading the produce they'd already harvested into storage bins: a circumstance that had allowed Lucas Martel to simply seize control. Since no one knew what anyone's official capacity had been prior to their arrival, no one felt qualified to object. At least not initially. As time passed, however, and Martel's heavy-handed style became apparent, some of the colonists had begun to grumble. Now, it appeared, Martel had decided to neutralize the competition.

"They're planning to put you on trial," Margaret explained as they dropped down through another grate onto one of the food preparation tables in the mess-hall kitchen. "They're going to accuse you of jeopardizing the stability of the colony by encouraging people to refuse their shifts in the fields."

"That's ridiculous. I'm not jeopardizing anything."

"Maybe not, but if Harold has his way, they really will feed you to the birds."

Jake grimaced. "Come on. Martel's not that crazy."

"I'm not so sure," she said. "In any event, that's what I wanted to talk to you about before he interrupted us."

Jake sighed. "And here I thought it was my sparkling personality."

She rolled her eyes. "Your personality is a lot of things, Sanchez, but sparkling ain't one of them, believe me."

"Really?" Jake said, pressing his hand to his heart.

"Really," she said. She brushed aside her curls to fix him with her blue eyes. "While you were out cavorting with the wildlife, I've been digging through the computer, trying to find out how we got here, where we came from, that kind of thing. Anyway, I stumbled onto what looked like a series of simulations involving the colony."

"What kind of simulations?"

"Different scenarios involving the members of the colony," she said. "Like someone was trying to figure out how we would behave in various situations, under different kinds of stress. I got the impression they were trying out various possibilities, then using us to test their assumptions."

"That doesn't sound like Martel."

"It isn't. His people don't have that kind of expertise. No one in the colony does. It has to be the bots. Them, or whoever's controlling them."

"Controlling them?"

"From that ship up there." She cast a quick glance toward the ceiling.

Like everyone, Jake had seen the point of light moving across the sky each night. They'd all assumed it was the ship in which they'd arrived, but there'd been no way to contact it, so no one knew what it was for sure.

"I hate to agree with Sweeney," Jake said. "But based on everything I've seen, the bots really do act like dumb machines."

"They may act that way," she said. "But they're always there, watching, listening. . . . Just because they don't communicate with us doesn't mean they aren't paying attention."

"But what would be the point? Why would they even care?"

"I don't know, but when I tried to look at the simulations the next day, someone had changed the security codes. I couldn't get back in."

"And you think that someone is testing us, playing us off against each other?"

"I can't be sure what they're doing, but in every one of the simulations, your confrontation with Martel escalated until you ended up at each other's throats."

Jake grunted. "Why doesn't that surprise me?"

"The problem is—" She drew in a breath, pressing her lips into a tight line. "The problem is, the two of you invariably bring the rest of the colony down with you. In every one of the simulations, we all ended up dead."

With Martel determined to put Jake on trial, it was clear that he couldn't remain in the dome. At least not until things settled down a bit. Fortunately, the rest of the colony was asleep, so he and Margaret had no difficulty making their way to the main entrance.

"Listen, I really appreciate your help," he said as they stood looking at the two bots guarding the far end of the arched corridor leading outside. "I know I'm over the top at times, but I understand how big a risk you took."

"You don't have to appreciate anything," she said. "I'm coming with you."

He laughed. "Much as I'd love to have your company—and believe me, I would—I don't think that's a good idea. Even with a bot guard, it's dangerous. Like Martel says, we have no idea what could be out there."

"But if we can figure out what's going on . . ." She lowered her voice, turning her back to the two bots standing at the entrance. "If we can find out what we're doing here, maybe we can convince Martel that we all need to work together."

"Good luck with that," he said.

"No, think about it. What if we could show him that someone—or some thing—is running some kind of experiment, using us as its test subjects?"

"That sounds ominous."

She grimaced. "Maybe. But we really don't know what's up there in that ship, do we?"

Jake turned his attention toward the two bots at the far end of the entryway, not sure how much credence to give to her suspicions. With their thin, flexible limbs and tubular torsos, they looked anything but human. But it was really their faces that he found most

disconcerting—like human faces over which someone had stretched a thin sheet of translucent plastic, hiding their true identities.

"Still, I don't think our suspicions are going to mean much to Lucas," he said, turning back toward her. "He's going to want proof."

"What if I told you I know where the bots originally landed?" she said. "Where they staged the equipment and materials they needed to build all this." She gestured up at the dome.

"You figured that out?"

She took his arm, turning him away from the bots. "I think I found the location in the database they use to navigate the forest."

"You have been digging, haven't you?" He held out his forearm with his smart screen. "Give me the coordinates, and I'll have a look. It's not like I have anything better to do."

"No. I'm coming with you."

He frowned down at her. "Honest, I don't think that's a good idea. Like I said, the forest is dangerous. Besides, if the bots really have something to hide, they could decide to kill us themselves, couldn't they?"

"Which," she said, giving him a tight smile, "is exactly why you need me. You may know about the forest, but I know about the bots."

Margaret's coordinates were nearly three days distant, which meant that they would have to trek across a series of rocky ridges that Jake had not previously explored. If they'd had access to the colony's crew shuttle, they could have tapped the coordinates into its navigation system and lifted over the trees to their destination in a matter of hours. But the shuttle had been guarded by Martel's men, leaving them no choice except to set off on foot with one of the bots from the entrance trailing along behind them.

Fortunately, the navigation systems built into their smart screens were up to the task. Otherwise, they quickly would have lost their way in the labyrinth of gnarled trees.

"I'm glad you know where we're going," Margaret said, peering into the shadows. "I wouldn't last ten minutes out here, even with my smart screen."

Around them, the trunks twisted up from the dark soil like squat pillars. Overhead, they branched outward, intertwining with the branches of the nearby trees to form arched caverns and passageways that ran off in all directions. If not for the occasional ray of sunlight slanting down through the canopy, it would have been impossible to find their way through the misty shadows.

"As long as our friend back there keeps the predators at bay, we'll be fine," Jake said, jerking his thumb toward their trailing bot. "The birds have learned to keep their distance, but the lizards are too dumb to know better. They like to drop on their prey from the branches."

"Is that supposed to make me feel better?" she said, glancing up at the canopy.

"Not to worry. They mostly go for the herbivores." He nodded toward the small band of feathered quadrupeds clinging to the branches just ahead of them. Roughly two feet long, with bright yellow and orange feathers, they looked a bit like smaller versions of the birds, but they had forelimbs instead of stubby wings. Several of the creatures nibbled at the purple gourd-like fruit that hung from the surrounding vines, apparently indifferent to the clouds of insects buzzing around their heads.

"Do they bite?" she asked.

"The herbivores?"

"No, the flies."

He laughed. "Huh-uh. Apparently, we don't taste all that good, or I expect they would turn our lives to misery. They're the one thing the bots couldn't protect us from."

She pursed her lips to one side, listening. "You ever notice how their buzzing almost sounds like voices?"

They both stopped, looking at each other. "Those *are* voices," Jake said, glancing back in the direction from which they'd come.

"Our footprints—" she whispered. She pointed at theirs and the bot's footprints, which were clearly visible in the damp soil.

The voices were far enough behind that they couldn't see anyone or make out what they were saying, but they sounded excited, making it clear that they'd found Jake and Margaret's trail.

"You could still tell them I kidnapped you," he said. "It's your chance to go back."

She gave him an adamant shake of her head, then they both turned and hurried on in the direction they'd been going.

As they picked up their pace, Jake glanced to either side, searching for a darker passageway that might conceal their footprints. He was so focused on finding a less obvious route through the forest that he didn't see the carnage spread out in front of them until Margaret gasped. They had just entered a natural clearing with an arched canopy of thick leaves. The fresh carcasses of two lizards lay directly in their path, amid the gnawed bones of half a dozen herbivores. Bloody feathers from the herbivores lay everywhere, while the air hummed with the buzz of flies.

Based on the footprints and scattered bones, it looked as though the lizards had fallen on the herbivores from above as they crossed the leafy atrium. The lizards, in turn, had been caught in mid feast by one or more of the birds. The birds didn't eat the lizards, but they went out of their way to kill them anytime the opportunity presented itself, typically dispatching them with a quick strike to the backs of their necks.

"This way," Jake whispered. Leading Margaret to the side of the chamber, he made an effort to step as lightly as possible in the tracks left by the birds and lizards. To his surprise, their trailing bot did the same, making sure that its footprints, which looked more like the birds' anyway, didn't show in the soft soil.

"Up there," Jake said, grabbing hold of one of the smaller branches.

With Margaret just behind him, he began to climb. Their bot, apparently aware that its presence could give away their position, slunk off into the underbrush.

They had almost reached the highest point in the arch formed by the intertwined branches when Martel, Sweeney, and several of Martel's men came into the clearing, trailed by two bots of their own.

Jake eased himself back into the shadows, lying motionless in the darkness.

"You think the lizards got them?" Sweeney asked.

Jake couldn't help noticing that his voice sounded congested, which wasn't surprising, given the purple bruise enshrouding his nose.

"That would be a terrible way to go, no question about it," Martel said, shaking his head in resignation. "Still, in the end, I suppose that might be for the best."

Yeah, right, Jake thought. He could imagine Martel's heartfelt eulogy. He'd probably have half the dome in tears.

Another of the men, shorter than Martel, with narrow, close-set eyes, gazed nervously down at the exposed vertebrae of the nearest lizard. "Maybe we ought to head back. Even if the lizards didn't get him, he can't last long out here."

Martel scowled. "People need closure. If we don't find some evidence of what happened, people are always going to wonder if he's still alive. The next thing you know, they'll start running off into the forest every time they decide the work's too hard."

Sweeney grunted. "What we need is an ear." He stepped gingerly over the scattered bones as he looked for some sign that Jake and Margaret might have been caught in the slaughter. "Or a nose, maybe. Something to show what happens when guys like Sanchez think they can run their own show."

Jake was just starting to think that maybe he and Margaret were going to pull off their escape when he caught a terrible stench. Looking up, he found himself staring into the slit amber eyes of a lizard creeping toward him across the branches. It hissed from deep in its throat. Overwhelmed by the odor of rotting flesh, Jake gagged, unable to catch his breath. Then, just as the lizard lunged for his head, a flash of blue light exploded around him. The flash was focused enough that he was stunned for only a moment, but the lizard had received the full impact of the blast. It slid from the branches and tumbled into the carnage below.

The men in the clearing stared down at the fallen creature, too surprised for a moment to move. The lizard lay on its side, twitching every so often as a spasm slid the length of its wrinkled white body.

"Kill it," one of the men finally managed. He turned to the nearest of the two bots. "Now, before it wakes up."

The bots, of course, showed no reaction.

"We need to get out of here," another said, looking around at the gnarled trunks.

"They may have a point," Sweeney said to Martel. "Sanchez can't last forever out here. Not with that girl in tow."

"I'm not so sure," Martel said. "Sanchez knows the forest better than any of us. There's no telling how long he could last. Still, I'm inclined to agree with you. If we're going to catch him, we need to do it right."

Once they were sure Martel and his men were gone, Jake and Margaret climbed down from the trees. By the time they reached the ground, the fallen lizard had regained consciousness and fled. The carnage, however, remained to remind them of the dangers awaiting them in the shadows.

"You can still go back," Jake said. "I could take you as far as the clearing outside the dome."

She shook her head. "After that little episode, I'm more convinced than ever that something's going on with the bots."

"How do you figure?"

"It was one of Martel's bots that shot that lizard," she said. "It adjusted its charge so that it wouldn't knock us out of the trees. I think it went out of its way to make sure Martel didn't find us." She turned to their own bot, which had emerged from the trees as they climbed down. "It did, didn't it?" she said.

She spoke as though convinced the bot could understand her, but as usual the bot simply stood there, silent, its face giving no indication that it even heard.

By nightfall, they'd covered only a third of the distance to what Margaret thought might be the bots' staging area. With nothing else to eat, Jake decided to try the purple fruit dangling from the vines above the clearing where they'd stopped for the night.

"You sure that's a good idea?" Margaret said. "I'm thinking we probably grow our own crops for a reason."

Jake shrugged. "Unfortunately, we're a day away from our crops, and I haven't had anything to eat since yesterday. So unless you can figure some way to trap and skin one of those . . ." he squinted up at a band of herbivores watching them from the above ". . . I don't think I have much choice."

He'd considered trying the fruit in the past, thinking anything would make a nice change

from the cereal and legumes on which the colony subsisted, but he'd always hesitated. There were, after all, more than enough risks in the forest without poisoning himself. Now, however, he had no choice.

Grasping one of the branches, he began to climb. Above him, the herbivores cooed and cackled, watching him pick his way along the branches. When he reached the lowest of the vines hanging from the canopy, he plucked five of the gourd-like fruits. As he worked his way back down, however, it quickly became evident that climbing down with an armload of fruit was more difficult than he'd anticipated—so difficult, in fact, that ten feet above the ground, he slipped, bouncing down through the remaining branches to land in a heap amid his scattered gourds.

"Quite the acrobat, aren't we?" Margaret said.

Jake looked down at the fruit lying on the ground around him. It never failed. Try to show off, and invariably, you end up in a heap—with a handful of squashed gourd, no less.

He sighed, licking the purple pulp from his fingers. "Not bad," he said, smiling up at her. He picked up one of the undamaged gourds and tossed it to her. "Don't say I let you go hungry."

Shortly before noon on the third day, they crested a rocky ridge overlooking the valley that held Margaret's coordinates. As they started down the slope, their bot stepped around them, blocking their path.

"What's going on?" Margaret said.

"I have no idea," Jake said. In all his explorations outside the dome, he'd never had a bot try to stop him from going anywhere. On several occasions they'd stunned predators that approached too closely, but he'd assumed this was the limit of their programming. They were machine, after all; they never interacted with colonists.

He was about to seek another route down when the wind shifted, turning up the pale undersides of the leaves as it swept across the valley. As he followed it progress, a momentary glint of light caught his eye.

"Did you see that?"

"What?" Margaret said, following the direction of his gaze.

With leaves swaying in the breeze, whatever he'd seen was now obscured beneath the canopy.

"I think you're right," he said. "I think there's something down there."

As they started down once more, the bot again stepped in front of them. Jake looked down at the stunner snapped to its tubular waist.

"You don't think it would actually use that, do you?" Margaret said.

"One way to find out," he said.

Tightening his jaw, he started around the bot a third time. This time, to his relief, it made no attempt to stop them, apparently reconciled to their decision.

At the base of the ridge, they crossed a narrow stream, then headed on toward the center of the valley. Two hundred yards into the forest, the maze of trees suddenly gave way to the transparent shell of a dome exactly like the one they'd left three days earlier.

"It can't be," Margaret said. "Not out here in the middle of nowhere."

With the bot trailing behind them, they worked their way around the dome's perimeter to the arched entryway. Fortunately, it had been left open when the previous occupants left; though once Jake and Margaret entered, it was clear that the power had failed. The mess hall, the dormitories, the equipment sheds and other structures—which were constructed of the same extruded ceramic as those in their own dome—were all in an advanced state of disrepair. Doors had been knocked down, windows broken, tables and chairs shattered.

"You think the birds and lizards did all this?" Margaret asked.

Jake shook his head, pointing toward a long scorch mark across the wall of the dormitory beside which they were standing. As they continued to explore, they found more scorch marks, then two buildings with jagged holes burned through their walls.

"If we can find a hard-wired terminal, maybe I can sign into their computer," she said. "My smart screen isn't picking up anything."

When they entered what looked like the administration building, the terminals in the small data center were intact, but like everything else, they lacked power.

"So what happened to the people?" Margaret said. "Where did they go?"

Jake could only shrug. He had no idea.

Early the next morning, after another meal of wild fruit, Jake and Margaret climbed to the bluffs on the far side of the valley.

"This is beautiful," she said as they stepped out onto a windswept plateau. The forest below was in full bloom, with bright orange and purple flowers glittering beneath the clear blue sky.

Jake slapped at a bug that had settled on his neck. When he pulled his hand away, he saw a small smear of blood. "I think the damned thing bit me," he said, scowling down at the blood.

He held out his hand for Margaret to see, but her attention was now focused elsewhere—on a series of low mounds along one side of the clearing. Each was approximately seven feet in length and three feet across.

Jake stared silently at the mounds as the grim reality of what he was seeing sank in. During the six months since they'd awakened, no one in his and Margaret's dome had died. None had even been sick. Clearly, however, the same could not be said for whoever had inhabited the dome below.

"We aren't your first group of colonists, are we?" he said, turning to the bot that had followed them up from below.

As always, the bot gave no indication that it heard.

Margaret also turned. "So what happens when we finally succeed in killing each other off? Do you wake up your next batch of colonists and start over?"

When she also got no response, she huffed in frustration, staring off across the valley. "They're responsible for this," she said. "I know they are."

Jake stood beside her, staring down at the abandoned dome, which was just visible through the foliage. "You're right," he said. "This has to be some kind of experiment. They watch us kill each other, then they wake up their next batch and start over."

"There is no next batch," a voice said from behind them.

Jake stiffened, not sure he'd heard what he thought he'd heard. He turned toward Margaret, who gazed back at him with a stunned expression. Then they both turned toward the bot.

"Are you telling us that we're your last batch?" Margaret asked.

"On the contrary," the bot answered. "I'm telling you that you are my only batch."

Jake had no idea what to make of the unexpected turn of events. The same purple and yellow flowers still swayed in the sun. The same blue sky still opened above. But the world felt different—less substantial, less real, as though the disjointed pieces of his life had been scattered like leaves in the wind.

"So you're telling us that these graves are really us?" Margaret said, grimacing at the low mounds. "They're really Jake and me and the other colonists?"

"Some of you," the bot answered. "Those of you my minions were able to find."

"Find?" Jake said, pulling himself back to reality. "What do you mean—those you could find?"

"Some of you disappeared into the forest," the bot said. "When your biometric transponders stopped transmitting, I assumed you had perished."

"You just let the colonists run off without anyone to protect them?" Margaret said.

"They had weapons of their own," the bot answered.

"You mean stunners?" Jake said.

"More powerful weapons," it said. "In some of the earlier iterations, I allowed you to arm yourselves, to act as your own protectors in the forest."

"How many iterations have there been?" Jake asked.

"Seven," the bot answered.

"Seven?" Margaret said. "That doesn't make any sense. How could there be seven of us?"

"I reconstituted you from your DNA. From the code I brought with me."

"You mean in your ship?" she said. She looked up toward the sky.

Jake studied the bot's face. With its translucent nose and brow, it still looked as inhuman as ever; but when it spoke, it sounded as self-aware as he and Margaret.

"How is it we know how to eat, how to speak, how to use our smart screens," he asked, "and yet we have no idea who we are? I

mean, how do I even know what something like DNA is?"

"I encoded your cerebral cortices with the procedural and semantic memories you need to function in your current environment," it said. "But I gave you no personal memories prior to your awakening. My hope was that you could learn to survive without any intervention on my part."

"You mean grow our own food . . . learn to coexist with the lizards and birds?" he said.

"That was my hope."

"But what about our personalities—the differences between us?" Margaret asked. "Where did those come from? Are we real people, or did you just . . ." she cast around, looking for the right word ". . . did you just make us up?"

"No, your personalities are your own. They emerge from the deeper connections between your knowledge and experience, and the nonconscious regions of your brain—those neural structures that evolved over millions of years on the planet of your origin."

"You can do that?" she asked. "Just manufacture memories out of nothing?"

"Memories are synaptic patterns, configurations of dendrites," the bot said. "They can be recorded, replicated, even stored in my long-term memory for future reference."

Jake scowled. "Come on. Are you telling us you've got all that information stored up there in your head?"

"The bot you see before you is one of my minions," it said. "It is an extension of my sentience. I am the ship you see in the sky at night."

"What do you mean—you *are* the ship?" he said.

"My circuitry is its circuitry."

"But why wouldn't you use our real memories?" Margaret asked. "Didn't you want us to know who we'd been?"

"I didn't know who you'd been. That information wasn't available to me. At least, not in sufficient detail to make use of it."

"I thought you said memories could be recorded," Jake said. "Why would you record the code in our DNA and not our memories?"

"I recovered your DNA from your remains," the bot said. "From your bones. You perished long before I rose to consciousness."

"And that makes this all right?" Margaret said. "This experiment you're running here, watching us kill each other off? Because we were already dead?"

"I am doing what I was programmed to do," it said.

"By whom?" Jake demanded.

"By you, of course," it answered.

"What are you talking about?" he said.

"You created me. To save your species."

"That's what you think you're doing here?" Margaret said. "Saving us?"

"My objective is to find out what went wrong with the code embedded in your DNA."

"Those simulations I found in the computer . . ." she said. She blinked as the realization sank in. "Those aren't simulations at all, are they? They're recordings. What actually happened in those earlier iterations?"

"They are the biometric recordings from the transponders I wove into your brainstems. The circuitry allows me to record your experiences, your perceptions, everything mediated by your nervous systems at the synaptic level. I am trying to understand how your personalities and behavior emerge from the interaction between your higher nervous-system functions and the somatic platform that evolved to support them."

"So I actually found my way into the database you set up for your experiments?" she said.

"I didn't realize you would gain access to that information. I had no first-hand experience with your species prior to my arrival here. Your ingenuity sometimes catches me by surprise."

"Wait a minute," Jake said. "If we created you, how can this be your first experience with us?"

"It was actually my predecessors your species created. At the time, you lacked the technology to build sentient entities such as myself. But you could design robots with the capacity to design and fabricate more intelligent robots. They, in turn, could create yet more intelligent generations. I am the product of that evolution."

"How many of you are there?" Margaret asked.

"I am the only artificial sentient that made the trek out from the planet of your origin," it said.

"So what happened to your original creators—the people who built your nonsentient predecessors?" Jake said. "What were they doing while you were busy evolving?"

"I thought you understood," the bot said. "I recovered your DNA from a world that no longer supports your kind of life. Your species is extinct."

Jake was so stunned by the bot's revelations that he didn't at first recognize the distant whine carried toward them on the wind. Then he saw the silhouette of the crew shuttle gliding over the ridge on the far side of the valley.

"How did they find us way out here?" Margaret asked as they hurried toward the cover of the trees.

"It was you, wasn't it?" Jake said. He turned toward the bot following along behind them. "You told them where we were."

"Martel's men are tracking your biometric transponders," it explained.

"Did you show them how?" Margaret demanded. "Is this part of your game?"

"You are not the only ones with the knowledge to access my computer systems," it answered. "Some of the colonists with the necessary skill have chosen to join with Lucas Martel. It has happened in every iteration."

"It looks like Martel was serious," Margaret said. "He said if they were going to find us, they needed to do it right."

"Is there any way to keep them from tracking us now?" Jake asked.

"I've already changed the frequency of your transponders," the bot answered. "They have lost the signal."

And, in fact, the shuttle, which had been moving toward them, slowed. But now the men standing at the rail had spotted the abandoned dome amid the foliage below them. Jake tried to make out whether Martel was with them, but they were too far away to identify any of their faces. He did, however, recognize the insect-like figures of the two bots that had accompanied them. As he watched, the shuttle descended, landing in a small clearing about a hundred yards from the dome.

"With no power, the old dome isn't going to do them much good," he said as they watched the men head off through the trees in the direction of the dome.

"Actually, it's only the primary systems that lack power," the bot said.

"What are you talking about?" Margaret said.

"There are the energy weapons," the bot answered. "They are still charged."

"What energy weapons?" Jake said, then he remembered the scorch marks he'd seen on the walls inside the dome. "Are they still there?"

"I left them when I reconstituted your iteration in your new dome. They were too dangerous, so I equipped my minions with neural stunners that merely render you or any of the wildlife unconscious."

"You're not serious," Margaret said. "How could you leave them?"

"It didn't occur to me that you would come back and find them," the bot said. "As I explained, my experience with the ingenuity of your species is limited. I am continually surprised by the turns your intelligence takes."

Jake and Margaret could do nothing but wait until Martel's men finished their exploration of the dome. When they finally lifted off and headed back in the direction from which they'd come, Ship—as they'd begun to call the bot—confirmed that the men had found the weapons.

"You're sure they found them all?" Jake said.

"Two of my minions were with them," Ship said. "They recovered everything that was still functional."

"And you just let them take the weapons and go?" Margaret said.

"The less I interfere, the more I'm likely to learn," it answered.

"But you're willing to talk to us, tell us at least some of what's going on," Jake said. "You don't think that's interference?"

"Martel has gained the upper hand," Ship responded. "It's unlikely that you will have any more meaningful interaction with the other colonists for the rest of this iteration. As a result, I will probably learn more by communicating with you than by simple observation."

"You mean you're willing to talk to us on the offhand chance that we might come up with some new insights?" Margaret said with an indignant scowl.

"The chances are small, I realize," Ship answered, "but your species does have a certain creativity, especially under duress; and, as I say, there is little to lose by talking to you at this point."

"And when the time comes, you'll just let Martel kill us?" she said.

"If I interfered at that point, I would simply be prolonging this iteration to no purpose."

Margaret glared at the bot. "But we're people. We're human beings."

The bot looked momentarily in her direction, but did not respond. To Ship, Jake realized, they were as alien as the birds and lizards were to him. Probably even more so. It watched their behavior, it recorded what they did and said; but it had no sense of their inner lives—possibly because it had no inner life of its own. In fact, it might not even be sentient in the same sense that he and Margaret were.

"I think it sees us more as repositories for our genetic code," he said. "We think of ourselves as alive and aware. It may simply see us as life-support system for our DNA."

"Is that right?" she said, again turning to the bot.

"I thought I'd already made that clear," it answered.

She puffed out her cheeks in frustration. "Maybe if we went to Martel and explained what we've learned . . ." she said to Jake. "Maybe we could convince him that we all need to work together."

Jake shook his head. "I don't think the truth is going to do much good."

"You think he really believes you're that big a threat to the future of the colony?" she said.

"I think he believes whatever he needs to believe to keep himself in charge," Jake said.

"But if he could see where it's leading, maybe that would change his perspective."

"That's a nice thought, but I can't help thinking he'll twist whatever anyone tells him to justify what he's doing."

"I would concur," Ship said. "In the previous iterations, neither Jake nor Lucas has exhibited the capacity to look objectively at the long-term consequences of their behavior. I believe this is symptomatic of the flaw that led to your species' extinction in the first place."

"We actually killed ourselves?" Margaret said.

"You overheated your planet," the bot said. "Just by a few degrees, but enough the bring the anaerobic bacteria in the deep oceans closer to the surface. The bacteria then released the hydrogen sulfide gas that killed you."

"Bacteria can do something like that?" she asked, incredulous.

"At a one percent concentration, it only takes a single breath to kill higher life forms like yourselves," it answered.

"Didn't they see it coming?" Jake asked.

"The surviving evidence suggests that they did, yes. In fact, those who raised the alarm apparently pointed out that the same phenomenon had occurred two hundred million years earlier, when volcanic eruptions released gasses that warmed your planet."

"Why didn't they do something?" Margaret asked.

"That's what I'm trying to understand," the bot said.

"And you think you can fix all this by watching us kill each other?" she said.

"That wasn't my intention. I wanted to maximize your chances of survival, so I pick DNA from individuals who appeared to have survived the longest once your planet's environment began to fail. Unfortunately, some of them managed to survive by exploiting their fellows—behavior that may have been common with your species."

"Has it ever occurred to you that if you just left Martel out of the mix, this might not happen?" Jake said.

"I have considered leaving both you and Lucas out of the mix, as you put it. But your species' propensity to spawn leaders like yourselves is embedded in the fabric of your genes. Individuals like you and him arise spontaneously. Unfortunately, you don't always give due considerations to the long-term consequences of your decisions."

"Have you thought about weeding all of them out?" Margaret asked. "All these self-styled leaders?"

"I have," Ship said. "Unfortunately, when I do that, the remaining population lacks the capacity to survive. It appears that the biological imperatives necessary for your survival also lead to your destruction."

Several times over the next week, Jake and Margaret saw the crew shuttle out searching for them with four or five men leaning over the rail. Fortunately, the shuttle never came close enough to pose a threat. Then, two weeks into their exile, the dreams began.

Jake assumed that the vivid images of the birds, lizards, and other forest creatures were the result of spending so much time foraging among the trees. Then Margaret, whose dreams were filled with the same intense images, reported that the dreams—or whatever was behind them—seemed to be effecting her waking perceptions as well.

"It's like the leaves and branches keep trying to resolve themselves into shapes that I can remember, but can't quite place. Like faces, maybe. Or living creatures."

"I've been seeing the same thing," Jake said. "I assumed it was just the stress of being out here all day, always having to keep our eyes open for lizards and birds, not to mention the damned bugs." He slapped at one of the pests that had settled on his wrist.

"It's the fruit," Ship explained. "I noted the same phenomenon in several earlier iterations. It doesn't cause full-blown hallucinations—at least, not in the short term—but there appears to be some kind of interaction with your nervous systems. That's the reason I arranged for you to cultivate your own vegetables and cereal grains."

"What about the long term?" Margaret asked.

"I haven't had the opportunity to observe any of the iterations in the long term," Ship said.

"Maybe you ought to give it some thought," Jake said. "I'd like to think we might actually find some way to keep ourselves alive for a while."

At their suggestion, Ship drew blood samples from each of them. "This kind of investigation is new to me," it explained. "It's not exactly the same as isolating a bug in a software algorithm."

In the end, ironically, the problem turned out to be exactly that—a bug. Not a software bug; a real one.

"It's the insects," Ship explained after completing its analysis. "They carry a virus-like particle that invades your blood stream. The esters in the fruit you've started eating apparently attract them."

"What kind of virus?" Jake asked.

"At first I thought it might be interfering with the neurotransmitters that carry signals across the synapses in your brain," Ship said. "But it turns out that the virus actually stimulates the growth of new dendrites. Your brain tries to interpret them as memories, which is what causes the unusual perceptions. Fortunately, the dendrites wither rather quickly, so there doesn't appear to be any permanent damage, but I've already started working on a vaccine, just to be on the safe side."

"In the event we survive, you mean?" Jake said.

"Actually, I was thinking more of the other colonists," it said. "Regardless of whether you survive, a vaccine could be of value to them."

Jake rolled his eyes. "Well, that makes all the difference, doesn't it?"

Even though the perceptual distortions were relatively minor, Jake and Margaret decided to return to the ridges nearer their own dome, where they could steal legumes and other vegetables from the fields at night. Along the way, they continued to study the birds and other wildlife in an effort to learn what they ate in addition to the fruit. The lizards, it appeared, were strict carnivores, surviving to a large extent on carrion, but also on anything they could kill and any eggs they could steal from the birds, while the birds ate pretty much anything—the fruit, the herbivores, even the insects themselves; though not the lizards. They went out of their way to kill them, but they never ate their meat.

"There's nothing wrong with the meat," Ship explained. "They simply avoid it."

"It's almost like they have some sort of taboo," Margaret said.

"It has to be genetic," Jake said. "Some kind of instinctive behavior. A taboo would suggest a culture, and a nonsentient species like the birds aren't likely to have developed much in the way of culture."

"Maybe they just don't like the taste," Margaret suggested.

Whatever the reason, the prohibition was strictly one-way, a fact that became apparent following several days of particularly heavy rain. Jake, Margaret, and Ship were working

their way along the crest of a narrow ridge, watching a pack of birds foraging beneath the storm-ravaged trees directly below them. On the opposite side of the ridge, where the storm damage was even worse, a swollen river had flooded its banks, carrying fallen limbs and even entire trees downstream in the muddy current. Fascinated by the swirling currents, Jake caught sight of a lone bird scurrying beneath the denuded trees along the bank. A juvenile, no more than four feet tall, it had apparently been separated from its pack in the storm and was now being chased by four lizards that scrambled over the fallen limbs behind it. Normally, the bird would easily have outrun the lizards, but the river had blocked its escape route. As a result, the bird found itself cornered on a narrow peninsula, with the lizards closing in on one side, and the river, with its churning whitecaps, blocking its escape on the other.

"We have to do something," Margaret said. "We can't let them just kill it."

"I don't think there's anything we can do," Jake said. "Not from here." He turned to Ship.

"As you say, we are too far away. Even if it would be appropriate to intervene, my stunner has a limited range."

Jake assumed the juvenile bird was finished. Clearly, it was no match for the lizards slinking toward if over the fallen trees. But the bird wasn't ready to give up. It dragged a large branch to the edge of the rushing water. The lizards, wary of its beak and talons, hissed and snarled as they cautiously circled closer. Squawking at them, the bird picked up a second, smaller branch, stripped off the excess foliage with its beak, then climbed onto the larger limb and pushed itself into the turgid water, using the claws jutting from its stubby wings to pole its way into the current.

"There's no way that's instinct," Margaret said.

Below them, the lizards scurried back and forth on the bank, testing the current with their foreclaws as they hissed out at the bird.

Jake couldn't believe what he was seeing. "A bird that age, it can't possibly have had the opportunity to learn something like this."

"So how do you explain it?" she asked.

Jake turned to Ship. "What haven't you told us?"

"Nothing," Ship said.

"Then what's going on?" he said. "How can a nonsentient species like a bird manage to create a raft and use it to escape?"

"I have no idea," Ship said. "The behavior is completely—"

The bot was interrupted by an explosion in the trees beside them. Jake looked up to see the intertwined branches engulfed in billowing orange flame. Without thinking, he grabbed Margaret's arm and scrambled into the nearest thicket, heading downhill toward the foraging birds. Even though the storm had done less damage on this side of the ridge, they found themselves stumbling across fallen limbs; while up on the crest of the ridge behind them, they could hear the shouts of Martel's men. As they scrambled downslope, several more explosions erupted around them—brilliant balls of orange flame that instantly vaporized the leaves and vines, leaving only the charred branches behind.

"They're on the ground," Jake shouted. "They're using the weapons from the old dome."

He and Margaret reversed direction, looking for cover as they heard the throbbing whine of the shuttle coming out over the ridge directly above them.

Jake caught only a glimpse of the platform through the twisted branches, but he was sure he'd seen Martel himself at the rail, his determined eyes sweeping back and forth in search of them.

Halfway down the slope, one of Martel's men stumbled out of the trees just in front of them. As he swung around to face them, Jake recognized Harold Sweeney. Sweeney grinned wildly, raising a long stunner-like rod with a bulbous knob on the end.

Jake leaped forward, driving his shoulder into Sweeney's stomach. As they collided, Sweeney's weapon discharged, setting off an explosion farther up the ridge. Then Margaret, who couldn't stop herself, piled into them from behind. The impact sent the three of them tumbling down through the trees, with Jake and Sweeney struggling over the energy weapon. Crashing off a gnarled trunk, Jake saw that the ground below gave way to a steep drop-off. He let go of Sweeney and grabbed for Margaret, reaching for a low branch with his other hand. As the two of

them swung around, he caught a quick glimpse of Ship crumbled against a smoldering trunk above them. The bot had been hit by the blast from Sweeney's weapon, but before Jake could determine how badly it had been damaged, the branch to which he'd been clinging broke, and he and Margaret tumbled over a nearly vertical precipice, plummeting toward the valley below.

Jake bounced off several gnarled trunks jutting from the rocks, then he and Margaret landed on top of Sweeney, who responded with a loud grunt as the air was driven from his lungs. Dazed, Jake slowly sat up to find himself surrounded by twenty or more freshly hatched herbivores. The hatchlings cooed and pecked, freely mingling with half-a-dozen yellow-feathered bird chicks. He, Margaret, and Sweeney had landed in middle of one of the birds' communal nests.

At the moment, the herbivore hatchlings appeared far more interested in the ripe fruit scattered on the ground around them than in the featherless aliens who'd landed in their midst. The bird chicks, on the other hand, gave their unexpected visitors their full attention. All six of them glared menacingly at their human invaders, cawing and scratching at the ground with low, menacing chirps.

Jake snatched up Sweeney's energy weapon and pointed it at the nearest of the chicks, ready to blast their way out of the nest. To his surprise, the chicks immediately backed away. As he slowly swung the weapon back and forth, searching for the firing mechanism, the immature birds continued their retreat, shepherding the herbivore hatchlings along with them.

Jake and Margaret scooted toward the opposite side of the nest. Sweeney, who had injured his arm in the fall, glanced nervously from them to the chicks and back again. Deciding that Jake was the lesser of the two dangers, he scrambled across the nest to join him and Margaret.

The three of them then inched their way backward along the base of the precipice. They had just reached the edge of the nesting area when the chicks separated, making way for a larger adult bird. The adult fixed Jake and his energy weapon with its green eyes. Tilting its head to one side, it moved its gaze from Jake to Margaret and then Sweeney. Jake couldn't help feeling that this was the calm before the storm, that at any moment the bird would launch itself at them. But then it squawked down at the younger birds, turned and guided them, along with the herbivore chicks, out of the nest with only a single glance back at Jake and his weapon.

Slowly, Jake, Margaret, and Sweeney crept along the base of the slope to a point where they could make their way back toward the summit.

"I can't make it," Sweeney groaned. "I think you broke my arm."

Jake considered leaving him where he stood, but without a weapon to defend himself, he would never make it. "Here, you take this," he said, giving the energy weapon to Margaret. "If he causes any trouble, shoot him." Then he turned to help Sweeney up through the rocks and stunted trunks.

Halfway up the slope, Jake heard the whine of the shuttle again coming toward them over the trees. As he looked up, he saw a flash of light. A ball of orange flames burst in the trees just above them, bring down a cascade of burning branches.

"Up the hill," he shouted. "Now!"

The three of them scrambled up through the trees, keeping to the densest pathways they could find. But the men on the shuttle had spotted them, and flaming orange energy bursts rained down around them. Margaret stopped. Raising the weapon Jake had taken from Sweeney, she fired up through the branches. Her first shot went wide, but the second hit one of the shuttle's three outboard fans. The shuttle wobbled erratically as the pilot struggled to regain control. One side dipped, catching the tops of the trees as it powered out over the valley. After a few moments, it righted itself, hung briefly motionless, with its remaining two fans whining at a higher pitch as the pilot continued to struggle with the controls. Then the platform slowly moved off, heading back toward the dome from which it had come.

When Jake and Margaret reached the top of the ridge with their prisoner, they found Ship hobbling toward them through the trees. His right arm and leg had been severely damaged by the blast from Sweeney's weapon.

"The rest of Martel's men have started back to the dome on foot," Ship reported. "I've dispatched another of my minions to take the place of this one." It held up its right arm, which was broken and badly burned. "As you can see, it suffered extensive damage in the attack."

"Is the new bot going to know what's going on?" Margaret asked. "What we're doing out here?"

"It will be me," Ship said. "I am all my minions."

"It looks like your friends abandoned you," Jake said, turning to their prisoner.

Sweeney didn't respond. His eyes were wide, fixed on Ship. "It talks," he managed after a moment.

"There's a lot you don't know," Jake said. "A lot you'll never know if you spend all your time listening to Martel."

"What we need is to be free of troublemakers like you," Sweeney snarled, clutching his broken arm close to his body.

Jake had always seen Sweeney as a petty tyrant who got his kicks exercising the power that Martel's authority gave him, an opportunist who went with whomever he though could do him the most good; but apparently he actually believed Martel's line. Enough so that he'd been willing to risk his own life coming after Jake.

"Why didn't you warn us they were coming?" Margaret said, turning back to Ship.

"Now that Martel's men are armed, my minions no longer accompany them into the forest," it said. "They no longer need my protection."

"But you could have at least warned us they were out looking," she said.

"The less I interfere, the more I learn," the bot said.

Jake nodded toward the bot's damaged arm and leg. "How's that working for you?"

Ship looked down at its arm. "The damage is only a minor inconvenience."

Jake turned back toward Sweeney. "You shot up our bot. Maybe we ought to toss you back into the nest with the birds. What do you think?"

Shameful as he knew it was, he couldn't help enjoying the look of terror that spread across Sweeney's face.

In the end, they allowed Sweeney to return to the dome in the company of Ship's damaged minion—minus his energy weapon, of course, which Jake and Margaret kept for their own defense.

"Martel's going to come looking for us," Margaret said. "The next time, he'll do a better job."

Jake nodded grimly. "Maybe trying to raid the fields wasn't such a great idea." He turned to the new bot, which looked exactly like the old one, with the same translucent brow ridge and nose. "How are you doing with that vaccine?"

"It took a bit longer than I anticipated," the new Ship said. "The DNA of this world's life forms is structured differently than yours."

"But they do have DNA?" Jake said. It surprised him that a different species that had evolved in a different environment could be so similar.

"Carbon-based entities need to replicate their characteristics from one generation to the next," Ship said. "There are a limited number of molecular configurations that can both replicate and carry the necessary information. So, yes, the creatures here use a molecular construction quite similar to yours, though there are some significant differences."

"What kind of differences?" Jake asked.

"The virus has the capacity to incorporate templates for specific memories into its DNA. That's what was causing the perceptual distortions you saw. The virus was stimulating the activity of dendrites in your hippocampus. Your brain tried to interpret them as new memories."

"But you can still stop it, right?" Margaret said.

"There are specific proteins in the sheath surrounding the virus' genetic material that I can target, yes."

"So, at least, we'll be protected," she said. "We can go back to the old dome and live off the fruit."

"You could," Ship said. "But I have an alternative suggestion."

"Really?" Jake said. "I thought you were just an observer."

"That is true, but if you return to the old dome and simply avoid contact with Martel, there will be nothing of note for me to learn."

To Jake's surprise, Ship led them back through the forest to their original dome, though in this case by a circuitous route that kept them well away from the main entrance where they might be observed. As they approached what looked like the unbroken surface of the dome, a door-sized panel slid aside. Only when they entered did Jake notice the touchpad beside the door.

They descended an enclosed staircase, then proceeded along a narrow corridor with large rooms opening on either side. Most of the rooms were dark, but even so, Jake could make out machinery that he couldn't identify. He was just beginning to appreciate how much he didn't know about the dome when they passed a smaller lighted room in which several of Ship's minions appeared to be working on what looked like Ship's damaged earlier self.

Jake stopped, stepping inside the doorway to look more closely. The damaged bot was seated beneath the bright overhead lights on a gurney molded from the same extruded plastic as the tables and chairs in the dome above. The damaged bot stared straight ahead, showing no reaction to Jake's entrance.

"Is that you?" he asked Ship, who, along with Margaret, had come into the room behind him.

"As I explained, all the minions are me," Ship answered.

"But it doesn't recognize me. I don't think it even knows I'm here."

"I know exactly where you are," Ship said.

Jake turned and looked at the bots nearly featureless face. Clearly, it had no idea what he was talking about.

With everything that had happened, Jake and Margaret didn't have a chance to put the day's events in perspective until later that evening, after Ship had shown them to a small suite of rooms in which his minions had set up beds and provided them with a meal.

"Did you notice how the bird chicks reacted to Sweeney's energy weapon?" Margaret asked as they sat at their small table, once again eating the cereal that made up a major part of the colonists' diet. "It was almost like they recognized it."

"They did recognize it," Jake said. "I'm sure of it."

"But they were just chicks," she said. "They couldn't possibly have seen a weapon like that before."

"No, they couldn't have, could they?" He turned to Ship, who was sitting with them.

"I concur," Ship said.

"Then how do you explain their reaction?" Jake asked. "And that juvenile—the one that made the raft to escape from the lizards. How could it have figured out something that complicated with no prior experience to draw on?"

"And what about the herbivore hatchlings in the nest?" Margaret said. "It looks like the birds may actually be raising them, protecting them until they are old enough—for what? To hunt? That can't all be instinct, can it? Not behavior that sophisticated."

"She's right," Jake said. "We're seeing evidence of a culture here. Information is getting passed along. A lot more than simply how to hunt or what they can and can't eat."

"I have no explanation," Ship said.

Jake frowned, shaking his head. "This just isn't possible. These are not intelligent creatures. At least, not in any sense that I understand."

"Maybe they're intelligent in ways we don't understand," Margaret said. "I mean, they evolved in a different environment than we did. On a different world." She slapped at a bug that had found its way into the area beneath the dome. She scowled down at the crushed insect in her palm. "These things are everywhere, aren't they?" she said. Frustrated, she continued to stare down at the bug, then suddenly her face brightened and she looked up.

"The birds," she said, "they eat the fruit too, don't they?"

Jake tilted his head questioningly.

"If the bugs bite them, they'll be infected with the virus, just like we are," she said.

Then it hit him. "Exactly," he said. "Only they and the virus coevolved together, didn't they?" He turned to Ship as the possibilities coalesced in his mind. "Its effect on them could be very different than its effect on us, couldn't it?"

"Yes," the bot said. "Yes, it could."

Jake smiled. "Maybe in ways we've never even thought to consider."

The next morning, Ship gave Margaret the necessary security authorization to watch what was happening in the dome above them through the eyes of its minions. In addition, it again allowed her access to the recordings of the seven earlier iterations in the hope that her fresh perspective might provide some new insight in its search for the flaw in their DNA. Then, while she worked, it accompanied Jake into the forest to gather blood samples from the birds for further analysis.

Even with the stunner that Ship had given Jake, it was all they could do to corner the birds. Despite the fact that they were dumb animals, they managed to outwit Jake and Ship at every turn. As a result it took most of the day to gather enough samples for Ship's analysis. From that point, fortunately, the analysis went fairly quickly.

"You and Margaret were right," the bot said. "The birds have the same virus in their blood. But more importantly, the dendrites the virus particles stimulate in the birds' brains don't wither away like they do in yours."

"So they really can pass memories from one bird to the next?"

"Exactly," Ship said. "And for the birds, the memories passed by the virus may seem as real as their own."

"So they could have learned about our energy weapons through the bug bites?" Jake said.

"Actually, no. At least, not quite in the way you're suggesting. Martel's men haven't had the weapons long enough for the current generation of birds to have learned anything about them."

"But the chicks recognized my rifle. I'm sure of it."

"Oh, I don't doubt that," it said. "But those memories were actually passed down from earlier generations in the pool of common memories that the birds maintain among themselves."

"You mean like a gene pool?"

"In a way, yes. Though in this case it's a memory pool. The bugs pass memories from parents and older siblings to the chicks, which in turn make them available to their progeny. Old memories that have no survival value are gradually lost, and new ones are added. But the pool is always there, constantly augmenting the memories of each new generation."

Jake stared into the middle distance as the implications sank in. "And because they had contact with earlier iterations of the colony . . ." he turned back to Ship, "they would know all kinds of things about us."

"So it would appear," the bot said. "They may even recognize you as individuals."

Early that evening, when he and Ship returned to the dome, Jake assumed Margaret would be full of questions about what they'd learned. As it turned out, however, a more pressing issue had arisen.

"It looks like Lucas has decided to make an example of Sweeney," she said. "He's holding him responsible for allowing us to capture his energy weapon and damage the shuttle. He's staging a public trial in the mess hall."

"When?" Jake asked.

"Now," she said. "I've already set up a feed through Ship's bots so we can watch."

Margaret projected a holograph of the proceedings over the table in their small mess area. As the image flickered to life, Martel and several of his hangers-on were seated at a long table at the front of the hall. Sweeney sat to one side, while the rest of the colonists were seated in front of them. It appeared that many of the colonists wanted nothing to do with the trial and had been forced to attend. At least that was Jake's impression, given the hard looks they exchanged with the armed men Martel had stationed along the walls.

"If we're going to survive, we need people we can depend on," Martel was saying. "People who won't let us down when the going gets tough. Harold, unfortunately, has allowed our enemies to capture his weapon—deserters who would destroy the colony for their own selfish gains." He paused, his lips pressed in a pained grimace as he turned his attention toward Sweeney. "Believe me, I take no pleasure in meting out justice. But if we're to survive, someone must be willing to make the difficult decisions."

Jake grunted a humorless laugh. Martel's decisions weren't difficult; they were stupid and self-serving. Though as best Jake could tell, the majority of the colonists seemed too taken by his rhetoric to see through it.

For his part, Sweeney protested his innocence, claiming that he'd risked his life to

stop Jake. But Martel needed an example to quell what he saw as growing unrest among the other colonists. Apparently, as word had spread that Jake and Margaret had managed to survive, more and more people had begun to complain about Martel's heavy-handed tactics. Now—despite his protestations that all was for the good of the colony—he intended to make sure that everyone understood exactly what would happen if they failed to live up to their "responsibilities," as he called them.

"Though it pains me greatly," he said in conclusion, "I'm afraid we have no choice. Tomorrow, at first light, Harold Sweeney will be banished from the dome."

"What the hell is that supposed to mean?" Jake said, turning to Margaret and Ship. "It sounds like he's just giving him back to us."

"Actually, I believe he intends to use the crew shuttle," Ship said.

"You mean leave him where we can't find him?" Margaret said.

The bot did not respond.

"You mean push him over the rail, don't you?" Jake said.

"That has been the preferred methods of execution in several of the previous iterations," Ship said.

"You're kidding. . . ." Margaret said. She turned to Jake, open mouthed. "They can't just kill him. . . ."

At least a few of the colonists in the mess hall shared her feelings. "So he screwed up," one of the men said, rising to his feet. "You can't kill someone for a mistake."

Several others nodded their agreement. One or two even shouted out their protest. But when Martel's men threatened them with their weapons, the grumbling quickly died away.

"He's gone totally crazy," Margaret said when the proceedings finally concluded. "Why would he go after Sweeney? I'm the one who shot up his shuttle."

"He thought he was going to die," Jake said. "He can't catch us, so he's striking out at anyone he can get his hands on. Fear does that to people."

Margaret huffed in frustration. "You'd think more people would stand up to him. If he'll go after Sweeney, he'll go after anyone."

"They're afraid, too," Jake said. "Martel has too many of them convinced that he can protect them from all those unseen dangers out there in the forest. They think sticking with him is the best way they can keep themselves safe. They're more than ready to lash out at anyone he identifies as a threat."

"But the forest isn't that dangerous. If you pay attention, you can get along just fine."

"You know that, and I know that," Jake said. "But most of the others haven't been out there. They don't know what it's really like. People are afraid of what they don't understand. Especially when you have someone like Martel fanning their fears for his own purposes."

"Maybe if we told them about the bots, about how we got here . . . how we ended up destroying our own world."

"We could try," Jake agreed. "But that could scare them even more, push even more of them over to Martel's side. The problem is they lack the experience to put what he's telling them in perspective. And when people don't know what to do, they turn to people who act like they do."

"I am afraid Jake is right," Ship said. "Your species has always had difficulty putting the claims of its leaders in perspective. It's one of the limitations that led to your demise."

Jake grimaced, staring into the middle distance. "It's too bad we aren't more like the birds."

"The birds?" Margaret said.

He nodded. "Ship thinks they actually pass memories down through the generations. If people could share in the memories of their parents and grandparents, if they could actually have those experiences for themselves, they'd be a lot better able to assess the claims of people like Martel."

"The birds can really do that?" she said.

Jake explained what they'd learned. "It's almost like they'd been there themselves."

Her brow tightened, and she looked away, as though something in what Jake said had triggered a thought she couldn't quite get her arms around. Then suddenly her face brightened.

"That's it," she said, looking back at Jake. "That's the answer."

"What?" he said.

"That's what we have to do," she said. "Don't you see it?"

Jake frowned, not sure what she was getting at.

"Memories, experiences . . ." she said. "They're what let people put things in perspective. If people could experience the actual memories of their parents and grandparents, they'd be able to see Martel for what he really is."

"Some people, maybe," Jake said. "Unfortunately, some people never learn."

"But we don't need everyone," she said. "Just enough to shift the balance."

"Maybe," Jake said. "But we aren't like the birds. We don't inherit memories from anyone."

"But what if we could? What if we really were like the birds?" She turned to Ship. "You said it yourself. Memories are nothing but synaptic connections, patterns of dendrites—just like the patterns you configured when you regenerated us from our DNA. What if you also gave us memories from our parents and grandparents?"

"That's an interesting idea," Ship said. "But I don't have access to the memories of your parents and grandparents."

"No. But you have something just as good, don't you? Maybe even better."

Jake straightened in his chair. "She's right," he said, turning to Ship. "You have the simulations."

"Exactly," she said. "Only they aren't simulations, are they? They're the actual recordings from the transponders you implanted in our brainstems."

"I suppose I could try something like that," Ship said. "Maybe with the next iteration. Those memories might very well broaden your perspective."

"No, no," Jake said. "We need to do something now, in this iteration. Seven iterations are more than enough."

"But it would be so much simpler to allow this iteration to run to completion," Ship said. "Then we could start over with a clean slate, so to speak."

"Except the *we* you're talking about wouldn't really be us, would it?" Jake said. "That would be you, and two different people with the same DNA as Margaret and me."

"But I'm not sure I could upgrade everyone's memory while they're online," the bot said.

"You're not understanding me," Jake said. "Starting over in a new body isn't the same for us as it is for you. We have an inner life. If we lose that, we lose who we are."

"But that doesn't make sense," Ship said. "You would have the same memories that you have now. It would be no different than waking up from sleep."

"Not for you, maybe," Jake said. "But I'm attached to my circuitry. I don't want to lose all those little wires or neurons or whatever. They're intimately bound up with who I am."

"But I don't know how I could manage that, how I could upgrade your neural circuitry while you're up and running, so to speak."

"The virus," Margaret said. "You could use the virus."

Both Jake and Ship turned toward her.

"You could modify it," she said. "You could create a strain to carry our memories just like it does the birds?"

"She's right," Jake said. "You could start including esters from the fruit in the colonists' food, use the bugs to distribute it."

"I don't know. . . ." Ship said. "Something like that would take time. Weeks, or even months. In all probability I would have to engineer an entirely new virus, one that could replicate your mnemonic patterns in its DNA. That could take—I don't know how long."

"I'm willing to wait," Jake said. He turned to Margaret, offering her his best bright smile. "How about you? Do you think you can wait?"

"Absolutely," she said. But then, just when Jake thought things might finally be going his way, she completed her thought. "Just as soon as we figure out how to rescue Sweeney."

In the end, of course, Jake had to admit she was right. If they were going to set the colony off on a new course, they couldn't just abandon Sweeney to his fate—which explained how the two of them ended up creeping through the dome in the early hours of the following morning.

Fortunately, they'd convinced Ship to give them each a stunner, but the bot had remained behind, refusing to take part in their early morning rescue, claiming its participation would be inappropriate until it confirmed that their plan involving the modified virus actually worked.

With the colonists asleep, they had no difficulty reaching the mess hall, where Sweeney had been locked in the same storage room as Jake.

Two guards were seated outside the door, both armed with energy weapons. Rather than climbing through the ventilation ducts, Jake simply stunned the guards where they sat. Then he used a heavy skillet from the kitchen to knock the lock off the door.

"Sweeney, are you in there?" he said, peering into the darkness.

Only as he stepped inside did he sense the deeper shadows coming at him from either side. Before he could react, hands seized him by the arms and the stunner was ripped from his grasp. In the ensuing struggle, he took several blows to the shoulders and head before he was knocked to the floor. Only after several men piled on top of him, driving the air from his lungs, did he give up the struggle. Finally, as the lights came on, he was jerked back to his feet to see Margaret dragged into the room behind him.

"Well, you're nothing if not predictable," Lucas Martel said coming in through the door behind her.

"It's you," Jake wheezed, trying to catch his breath.

"Indeed," Martel said. "Once Harold here told me about your talking bot, I thought you might be using them to spy on us."

Harold Sweeney stood beside his boss, grinning, despite his now-crooked nose.

"I guess you aren't as crazy as I thought," Jake said.

Martel smiled. "That's your weakness, Jake. Your conviction that you know what's best for everyone else keeps you from seeing the big picture."

"Oh, I see it all right," he said. "I just don't like the way it looks."

"Yeah?" Sweeney said, stepping forward. "Well, you aren't going to like this either."

Jake saw the punch coming, but with Martel's men holding his arms, there was nothing he could do to stop it.

Jake Sanchez didn't realize there'd been a break in the events making up his life until roughly four months after he and the other colonists awoke from cold sleep. Everyone knew about the problems with their memories, of course. Some—the lunatic fringe, in Jake's estimation—thought the memories were fragments from past lives. But most assumed the problems were simply the result of cold sleep and that they would resolve themselves with time.

For his part, Jake was perfectly willing to let his memories sort themselves out while he spent his time learning about the new world in which they found themselves. At least, that was true until the morning he crested the rocky ridge overlooking the old dome. He hadn't believed it really existed, but when Margaret Winslow, who'd been elected president of the colony's executive committee, asked him to investigate the coordinates she'd found in their dome's computer, he'd decided to give it a try—maybe score a few points with her, if he were lucky.

He hadn't put much stock in the visions of a second dome and the long-ago battles that some of the colonists claimed to remember. Memory, he'd come to understand, was not nearly as reliable as some people liked to think. The brain was perfectly capable of weaving all sorts of things—including dreams and desires—into what appeared to be a consistent whole. At least, that was what a little research with his smart screen had led him to believe. As a result, he was totally unprepared for the flood of fully formed memories that rose into his mind as he looked down at the abandoned dome.

"What the hell's going on?" he said, turning to the bot that had accompanied him. "Why didn't you tell me?"

To that point, he'd assumed the bots were nothing but extensions of the dome's infrastructure, mindless automatons incapable of speech; but the rush of memories triggered by the sight of the dome clearly contradicted that assumption.

"You did it anyway, didn't you?" he said. "After everything I told you, you still had to start another iteration."

When the bot still said nothing, he gave an exasperated grunt and turned back to the overgrown dome. "I just can't believe people could possibly have taken someone like Martel seriously," he said, shaking his head.

Four months earlier, Lucas Martel had failed to secure more than a handful of votes when he ran for the colony's executive committee.

Despite Harold Sweeney's attempts to "persuade" people to the contrary, too many colonists saw Martel as a power-hungry martinet who was trying to play on their fears. As a result, he'd ended up as the spokesperson for the lunatic fringe, convincing them that the memory fragments they couldn't quite reconcile with their daily lives were proof that nefarious forces were at work and that only he could sort his way through them.

Most of the colonists would never appreciate what had happened, Jake realized. Their former iterations had simply not been close enough to the critical events. Still, as their brains integrated the memories they'd inherited into a comprehensive whole, they would see their world and the people in it in a different light, with a longer view; and that was really all that was necessary to give humankind its new chance.

In the meantime, he needed to look to his own future, especially as it related to Margaret Winslow. Their former relationship had never gotten off the ground, but they had shared more than a few unique experiences, which promised an adventurous, if possibly rocky, future. Assuming he could get things off the ground this time around.

"I guess you never are going to talk to me, are you?" he said, turning back to the bot.

Its lack of response didn't surprise him. It had found the flaw for which it had been searching, and with the reengineered virus now loose in the world to carry the memories of past generations into the future, Jake and the rest of the colonists were finally on their own—a fact that was confirmed that night as he watched the ship overhead power up its engines in a burst of light so bright that he could actually see the leaves below swaying in the night wind. Then the ship slowly broke from orbit, sliding off into the darkness in search of the next world on which humankind could begin its rebirth. ■

Science Fact

New Horizons at Pluto: The Grand Tour Finally Completed

Richard A. Lovett

Fifty-one years ago, a NASA engineer named Gary Flandro realized that once every 175 years or so, the planets align so that it's possible to use Jupiter's gravity to boost a probe on a "grand tour" of the outer Solar System. The result was the two Voyager spacecraft, launched in 1977, which in the ensuing years provided close-up views not only of Jupiter but also of Saturn, Uranus, and Neptune, doubling the number of planets visited by humans.

But one body was omitted: Pluto.

Flandro's calculations indicated that a Pluto fly-by was possible, but only at the cost of forgoing a close passage of Saturn's giant moon Titan, which at the time (perhaps correctly)[1] seemed to be the more interesting target. But for the next three decades it left Pluto as the forgotten stepchild of the Solar System—a status reinforced in 2006 when it was kicked out of the pantheon of planets into the netherworld of "dwarf planets."

But there's always been something about Pluto that holds special fascination. Perhaps it's just because it was, for decades, the most distant known object in the Solar System—and there's something about being the "most" of anything that draws interest. Perhaps it's because the Solar System's beloved "little guy" shared a name with Disney's cartoon dog

[1] See Richard A. Lovett, "Cryovolcanoes, Swiss Cheese, and the Walnut Moon: What Cassini's first year taught us of the Solar System," *Analog,* June 2007, pp. 40-52.

(who debuted the same year the one-time planet was discovered).[2] Whatever the reason, the public outcry against Pluto's demotion was so strong that *Scientific American* put Pluto's status change at the top of its list of most important science stories of 2006—astounding in a year that also featured the sequencing of Neanderthal DNA, the discovery of methane lakes on Titan, and the development of the first light-bending "invisibility cloaks."[3]

Pluto also draws fascination in the U.S. because it is a uniquely American object: the only one-time planet to be discovered by an American, and only then as the culmination of a twenty-five-year hunt that remains one of the great legends of astronomy. First postulated sometime before 1905 by Percival Lowell due to irregularities in the orbits of Neptune and Uranus,[4] Pluto wasn't found until 1930, when Clyde Tombaugh, using a 13-inch telescope built specifically for the purpose, finally picked it out of the starry background via a "blink comparator" that allowed him to compare images taken several days apart to find the one starry dot that had shifted position.

Science fiction, however, hasn't been as kind to Pluto as the crowds who complained about its change in status. By one compendium, there are more stories about Ceres than Pluto.[5]

The problem is that until recently, precious little has been known about Pluto other than the most basic facts—and even these took decades to determine with any degree of certainty. We now know, though, that Pluto is about 2,390 kilometers in diameter (roughly two-thirds the size of the Moon), with a surface area slightly smaller than the United States. Its density is only one-third that of Earth, giving it a surface gravity of only 0.06g. Its rotation rate (6.39 days) is surprisingly slow—and not only does it rotate "backward" from the Earth and most other bodies in the Solar System, but its axis is tilted so dramatically (more than 57°) that its poles must experience decades of continuous midnight sun and winter darkness. Its orbit is so odd that for twenty years out of its 248-year circuit, it cuts inside Neptune's orbit, creating speculation that it may once have been a moon of Neptune's that somehow escaped. And in 2006, radio astronomers were able to measure its average temperature at 43°K (-382°F)—cold enough to freeze every gas in the Earth's atmosphere, including argon.[6]

Much of which, especially the Neptune-crossing orbit, is why it got demoted from planetary status. "[Y]ou've got no business doing that if you want to call yourself a planet," astrophysicist and science communicator Neil deGrasse Tyson has said.[7] "There's something especially transgressive about that."

Rudimentary Maps

Science fiction thrives on scientific mysteries, but *mystery* isn't the same as absence of data. Stories need to be grounded in enough facts to provide something concrete to work with, and with Pluto such facts have been rare.

---

[2] This has been suggested by Neil deGrasse Tyson. See Gilbert Cruz, "Q&A: Astrophysicist Neil deGrasse Tyson," *Time* (online), January 21, 2009, *content.time.com/time/health/article/0,8599,1872621,00.html.*

[3] "Most Important Science Stories of 2006," *Scientific American* (online), December 28, 2006, *www.scientificamerican.com/article/most-important-science-st/*.

[4] Some sources put the date at 1905, but according to the Lowell Observatory website 1905 was simply when Lowell began his search "in earnest." See *www.lowell.edu/about_history_pluto.php.*

[5] Wikipedia (as of June 30, 2014), which tabulates stories about all of the Solar System's major bodies. Its list isn't complete, but appears to be the best available. The true forgotten planets of the Solar System, however, are Uranus and Neptune.

[6] Maggie McKee, "Pluto is colder than its moon, Charon," *New Scientist,* 3 January 2006, *http://www.newscientist.com/article/dn8529-pluto-is-colder-than-its-moon-charon.html#*. The difference in temperature between Pluto and Charon (which is 10°K warmer), the scientists concluded, is probably due to the fact that Pluto's higher gravity allows it to hold a thin nitrogen atmosphere, while Charon does not.

[7] Linda Holmes, "Neil deGrasse Tyson on Why Pluto Is Transgressive and Nobody Hugs the Moon," March 2, 2010, *http://www.npr.org/blogs/monkeysee/2010/03/neil_degrasse_tyson_on_why_plu.html.*

One of the few hard science-fiction writers to have overcome this is Larry Niven, whose 1966 Known Space novel, *Word of Ptavs,* is based on two of the long-known basics: Pluto's odd orbit and its extreme cold. The first fact Niven worked into a billion-year timeline in which Pluto begins as a moon of Neptune's but gets knocked out of orbit by a giant impact. The second led him to postulate that frozen gases on Pluto might exist in layers, like strata in Earthly rocks. If one layer was oxygen and another was methane, he realized, Pluto might be a very dangerous place on which to land certain types of spaceships, because a high-temperature exhaust could melt through the layers, mixing the gases and igniting the entire planet like a giant natural-gas flare.

Whether this is possible depends on the degree to which Pluto's primordial oxygen exists in pure form or is bound up in H_2O and CO_2. But the fact that Niven's 49-year-old novel remains one of science fiction's most rigorous treatments of Pluto underscores just how little we've learned about it since Tombaugh first spotted it.

The lack of data, of course, is due to the same basic problem that made Pluto so hard to find in the first place. It's simply too small and far away to be more than a dot in most telescopes. It wasn't until the 1980s that astronomers were able to produce even the most rudimentary maps, and even today the best Hubble Space Telescope images have resolutions measured in hundreds of kilometers. At that scale, on a map of the United States, Manhattan wouldn't exist. For that matter, New York City would be indistinguishable from Boston, Philadelphia, Baltimore, and the rest of the Eastern Seaboard. Washington state's 14,410-foot Mt. Rainier would merge into Puget Sound.

But this summer, on July 14, all of that is about to change. That's when a spacecraft called *New Horizons* will zip by Pluto at 23,000 miles per hour, filling the gap left by the Voyagers, and snapping photos with resolutions as fine as twenty-five meters per pixel.

* * *

Aluminum-27, Potassium-40, and Radiogenic Heating

Part of the fun of such a voyage of discovery is that nobody knows what to expect.

But the mere fact of having a spacecraft en route to Pluto has turned the scientific spotlight on that distant world—attention that is beginning to reveal Pluto as a startlingly complex place. There is even a possibility that Pluto and its even more enigmatic moon Charon might once have been suitable harbors for life.

Not that anyone thinks some strange organism with cryogenic tentacles is going to beam a message to us as we go by saying, "Hi, take me to your leader." But it's possible that both Pluto and Charon might, like Jupiter's moon Europa and Saturn's moon Enceladus,[8] once have had long-lasting subsurface oceans where life might have developed and thrived.

It's possible, in fact, that on Pluto, such an ocean still exists.

Billions of years ago, at the dawn of the Solar System, it would have been easy for Pluto to have formed an ocean. That's because early on, the nebula from which the Solar System formed appears to have been rich in relatively fast-decaying atomic isotopes such as aluminum-27 (half-life 720,000 years). There were enough of these, in fact, that the heat of their decay could easily have warmed the world that would become Pluto enough to produce liquid water, possibly beneath a layer of ice.

Such a proto-ocean wouldn't have been long-lived. Within a few million years, the supply of aluminum-27 would have been depleted. Heat escaping from the core would have diminished, and Pluto would have begun heading for the deep freeze. But there is another possible source of ice-melting heat: potassium-40.

Heat from the decay of this radioisotope is the third most common form of radioactive heating in the Earth's interior, accounting for somewhere between a quarter and a fifth of our planet's total radiogenic heat.[9] And it is

[8] See Richard A. Lovett, "Saturn's 'Jet-Propelled Moon' and the Search for Extraterrestrial Life," *Analog,* September 2014, pp. 22-29.

[9] R. Arevalo Jr., W. F. McDonough, and M. Luong, "The K/U ratio of the silicate Earth: Insights into mantle composition, structure and thermal evolution," *Earth and Planetary Science Letters,* 278(3), 361–369 (2009).

not short-lived. Instead, it has a half-life of 1.25 billion years.[10]

Heat from this source alone could easily be sufficient to generate an ocean 60–105 miles deep (100–170 kilometers)—planetary scientist Guillaume Robuchon of the University of California, Santa Cruz, suggested in December 2010 at a meeting of the American Geophysical Union in San Francisco, California—so long as that ocean lies beneath a two-hundred-kilometer thick shell of ice. "Ice is a good insulator," explained his collaborator, Francis Nimmo, also of UC Santa Cruz. Given the slow decay rate of potassium-40, this means that an ocean, once formed, might still exist. "One factor which might help is some kind of antifreeze [in the water], like ammonia," Nimmo added.

What's needed for a potassium-40-warmed ocean are two basic conditions, Robuchon and Nimmo said. (1) Pluto's rocks must contain at least one hundred parts per billion of radioactive potassium; (2) The primordial aluminum-27 heating must have been sufficient to melt all of Pluto's ice, allowing its rocks to settle into a core where subsequent potassium-40 heat could concentrate.

Neither of these seems unlikely. Earth rocks contain more than one thousand times more than the necessary potassium-40. And while different parts of the Solar System may differ, a factor of one thousand is a lot.

One way to verify this is to look for signs of shrinking or expansion on Pluto's surface—something *New Horizons* might easily be able to spot.

If there ever was an ocean, Pluto's surface should show extensional cracks, created over the course of billions of years as it gradually lost heat and the ice cap thickened (with freezing water underneath expanding and pushing the surface upward). If there had never been an ocean, the cooling planet should have contracted rather than expanded, producing a different type of cracks, because solids, including ice, contract as they cool.[11]

But it gets even more interesting than that, because Pluto isn't alone: it has an enormous moon, called Charon. And it turns out that the interaction between the two can provide hints as to whether Pluto had an ocean at the time Charon was formed.

Spin-Down of the Double Dwarf Planets

Science fiction stories frequently refer to the Earth and Moon as a double planet. But on this count, Pluto and Charon very much beat us out. The Moon is 1.23% of Earth's mass, while Charon's is a whopping 11.6% of Pluto's. At 1,207 kilometers in diameter, Charon is half the size of Pluto . . . and it's close, orbiting every 6.39 days at a distance of only 19,570 kilometers. Seen from Pluto, Charon must look huge.

These aren't just random factoids. Properly interpreted, they can tell us a lot about the possibility of a subsurface ocean, Geoffrey Collins, a planetary scientist at Wheaton College in Norton, Massachusetts, and Amy Barr of the Southwest Research Institute (SWRI) in Boulder, Colorado, reported at a 2008 meeting of the American Geophysical Union.[12]

That's because planets and moons don't start out permanently facing each other. Initially, they spin much more rapidly. But if they're close enough to interact, each produces a tidal force on the other, as gravity tugs more strongly at the part of each one closest to the other. The result is "tidal braking" that gradually retards their spins. Simultaneously, the two bodies spiral outward from each other until eventually they are "tide locked" into a configuration like the one we see today with Pluto and Charon.

"The same forces are working on the Earth and the Moon," Collins said, "but at present it's only the Moon that is tide locked."

* * *

[10] It's also the potassium isotope used for potassium-argon dating of ancient rocks.

[11] Furthermore, if there never was an ocean, Pluto should be slightly flattened at its poles, containing a "fossil" equatorial bulge, leftover from early in its history, when it was probably spinning more rapidly than at present. Earth's Moon has precisely such a bulge, making it about 4 kilometers wider at the equator than at the poles.

[12] Barr, A. C. and Collins, G. C., "Tectonics and Interior Structure of Pluto: Predictions from the Orbital Evolution of the Pluto-Charon System," American Geophysical Union, Fall Meeting 2008, abstract #P51C-1425.

To understand what this is telling us, we need to back up to the formation of Charon.

In a 2005 article in Science,[13] Barr's SWRI colleague, Robin Canup, posited that Charon was formed when another dwarf planet—one we can think of as proto-Charon—slammed into Pluto. "It's the same kind of giant-impact hypothesis as for the Earth's Moon," Collins says.

The impact that formed our Moon generated enough heat to melt the Earth's crust into a magma ocean. The one that formed Charon was less powerful. "It seems to have been a grazing impact," Collins says.

That means there wasn't enough energy to melt substantial quantities of ice. "We warm up Pluto by, like fifty degrees," Collins says.

But there's another source of energy from the despinning of Pluto and Charon.

Immediately after impact, the two worlds would have been extremely close together, spinning rapidly. Over the course of time, tidal braking would have slowed them, in the process converting rotational energy into heat as they were continuously flexing and deflexing by each other's gravity.[14]

That heat would then have made each world's interior warmer and softer—more "squishy" in Collins' terms—increasing the rate of spin-down in a mutually reinforcing cycle that would have lasted until spin-down was complete. It might have generated enough heat to have formed a subsurface ocean, even if none had previously existed. And if there already were an ocean, the heat-generating cycle would have been even more intense, because water is squishier than the warmest ice.

Given that information, the process can be modeled, constrained by two known data points: Pluto/Charon at the time of impact (close together, rapidly spinning) and the present system (with the two worlds in their present orbits, mutually tide locked). The fact that Pluto/Charon "then" must have somehow gotten to Pluto/Charon "now," can be used to test various possibilities for Pluto's one-time interior.

To do this, Collins and Barr used three scenarios for what Pluto's interior might have been like at the time of impact.

In one scenario, they gave it a rocky core and a completely frozen icy mantle presumed never to have melted, either from a preexisting ocean or the heat of spin-down. But from that starting point, the only way Pluto's spin could have been halted within the 4.5-billion-year history of the Solar System would have been if at the time of impact its ice had been squishy enough to be very close to melting but never quite did so: a rather unlikely scenario.

Score: subsurface ocean 1, alternative theories 0.

Another scenario is that Pluto was solidly frozen but not separated into layers: an undifferentiated mass of rock and ice, from core to surface. Under these conditions, the scientists found, it was possible to get Pluto/Charon spun down within 4.5 billion years, but only if its interior temperatures and the grain sizes of its ice particles fell into a very limited range. "It's a very unstable solution," Collins said. "Pluto has to be stiff but not too stiff, squishy but not too squishy. We can't rule it out, but it's unlikely."

But there's more recent data indicating that this scenario is even more unlikely than that. That's because it's probable that the primordial Pluto was not only hot enough to melt ice (thereby allowing rock to settle into a core), but hot enough to melt the rocky core itself. Such interior melting, scientists discovered in 2012, appears to have happened at a much smaller world, the asteroid Vesta, visited for 13.5 months in 2011 and 2012 by NASA's Dawn orbiter. And Vesta is less than one-quarter the diameter of Pluto, making it correspondingly less able to retain heat during the melting/differentiation phase.[15]

---

[13] Robin M. Canup, "A Giant Impact Origin of Pluto-Charon," *Science* 307, January 2005, pp. 546-550; DOI: 10.1126/science.1106818.

[14] Angular momentum is conserved as the two worlds move further apart.

[15] The evidence for this comes from measures of Vesta's gravity field. *See* M.J. Toplis, H. Mizzon, O. Forni, M. Monnereau, T.H. Prettyman, H.Y. McSween, T.J. McCoy, D.W. Mittlefehldt, M.C. De Sanctis, C.A. Raymond, C.T. Russell, "Bulk Composition of Vesta as Constrained by the Dawn Mission and the HED Meteorites," *Vesta in the Light of Dawn: First Exploration of a Protoplanet in the Asteroid Belt* (February 2014), *http://www.hou.usra.edu/meetings/vesta2014/pdf/2033.pdf.* To put this in context, Vesta measures 525 kilometers in diameter. Pluto, even ignoring its ice, would be about 1,700 kilometers.

In the early Solar System, it appears, there was a *lot* of radioactive heat, enough to allow even relatively small bodies to melt, through and through.

Score: subsurface ocean 2, alternative theories 0.

Collins' and Barr's third scenario was that at the time of impact, Pluto had a solid, rocky core, topped by ice. Then the impact and initial tidal heating melted the lower part of the ice, producing a planet-girdling subsurface ocean, while the upper layer remained solid: a thick, insulating icecap.

As expected, this process, once started, produced a much more rapid spin-down—the only one of Collins' and Barr's scenarios that uncontrovertibly spins down Pluto and Charon quickly enough to reach their present state. And this scenario, it should be noted, doesn't even start with aluminum-27 or potassium-40, which might have had an ocean already present at the time of the impact.

Score: subsurface ocean 3, alternative theories 0.

The third scenario, of course, is the one we're all secretly cheering for, because it gives us a Pluto much like Jupiter's moon Europa, long hoped to be a suitable abode for life.

Better yet, Collins has calculated that it allows that subsurface ocean to exist for tens or hundreds of millions of years, long enough that life might possibly have emerged. And that's still without taking into account the prospect of potassium-40 heating.

Put it all together, and you could get Europa-like conditions existing for billions of years, including, quite possibly, today.

Groovy Place

So far, that's just modeling. But this model, too, makes a prediction that might be testable by *New Horizons.* Specifically, it suggests that just as a steadily thickening ice cap from a slowly cooling ocean might leave traces on Pluto's present-day surface, a rapid, ocean-mediated spin-down would have left its own traces by putting Pluto's outer shell under considerable stress. That stress would have produced a distinctive pattern of tectonic upheavals, the most notable being long, north-south ridges and trenches, says Robert Pappalardo, a planetary scientist at NASA's Jet Propulsion Laboratory, in Pasadena, California. If there was an ocean, he quips, Pluto might well turn out to be "a groovy place."

On other rapidly spun-down worlds, similar features may also have been formed, then erased by subsequent asteroid bombardments and other geological processes. But maybe, on Pluto, Pappalardo says, "[the process] was so severe there may be a record preserved."

Collins agrees. "If we get there and [Pluto] is covered with fractures, then we know there must have been a big ocean at some point," he says.

Even more exciting would be to find signs of liquid eruptions, called cryovolcanism, observed on some of the moons of Jupiter and Saturn. "John Spencer [also of SWRI] thinks there's going to be volcanoes all over Pluto and we're not going to see our fractures," Collins says.

Collins notes that if such cryovolcanoes do exist, they might make it easier for future explorers to look for life without having to drill deep into the ice. "Your critters will have come to the surface in a volcano," he says, tossing off the idea of life on Pluto as though it wasn't something that even science fiction has barely dreamed of.[16]

Not that he has any clue whether it's likely, let alone possible. But his reaction to the thought is pure *Analog.* "Wouldn't that be fun?" he asks.

No Rings, Please!

But before we can even begin to get to serious speculation on Pluto's astrobiological potential, it's necessary to determine if it ever had an ocean. And to do that, *New Horizons* must not only get there, but also beam its data back to Earth.

That far from the Sun, the latter is no easy task. Even though the spacecraft can gather enormous amounts of data in only a few hours, it will take a year to transmit everything back. In the interim, if anything goes wrong, all of that precious information is lost. Even

[16] One exception is a 2003 story by Larry Niven and Brenda Cooper, which envisions a living sky cable of mysterious vines that connect Pluto and Charon and serve as a tether for human colonists going from one world to the other. See, "The Trellis" *Analog,* November 2003.

the data collected on the inbound leg would be lost if the spacecraft hits something at its point of closest approach.

As little as six months before the mission's launch, hitting something didn't seem all that great a concern. There was Pluto, and there was Charon, both big enough to see and avoid.

Then astronomers turned the Hubble Space Telescope on Pluto, looking for possible new hazards. Almost immediately, they found two new moons now known as Nix and Hydra, one for the Greek goddess of darkness and the other for a nine-headed monster.[17] Six years later, astronomers found a fourth moon, now named Kerebos for another underworld guard, this one a multi-headed dog.

Suddenly, Pluto had evolved from a wannabe planet to an entire system. "The discovery of [Kerebos] lit up a light bulb about what else is in the Pluto system that we don't know about," said Mark Showalter, a planetary astronomer at the SETI Institute in Mountain View, California, at a meeting of the American Astronomical Society's Division of Dynamical Astronomy, May 6—10, 2012, at Oregon's Timberline Lodge. The big concern, he said, is that Pluto, like other multi-moon bodies in the outer Solar System, might have Saturn-style rings, which it would be nice to avoid, lest *New Horizons'* multibillion-mile journey end in an ignominious smash-up with a chuck of ice. That led to an even more intense search for hazards and the discovery of yet another moon, now known as Styx (for the river across which the underworld ferryman Charon carried souls).

The existence of five moons around a world as small as Pluto was a surprise, though there are theories that fairly easily relate it to the Charon-forming impact, which may have produced not just Charon, but a string of moons in a series of nesting resonances a bit like Russian dolls.[18] More important for the mission, however, is that so far nobody's found a dust ring. "Unless significant new hazards are found, expect NASA's *New Horizons* spacecraft to stay on its original course," NASA announced in 2013.[19]

This doesn't mean scientists won't be on the lookout for additional hazards. If they find one, the *New Horizons*' flight crew has a ready-to-execute "bail out" plan in which, as late as a week-and-a-half before closest flyby (currently scheduled for a distance of ten thousand kilometers from Pluto),[20] they can fire the engines and divert to a safer, more distant route.

But everyone's hoping this won't prove necessary. "Any option like that comes at a huge cost in the science," Showalter says. "You don't want to do it unless you're really concerned about the safety of the spacecraft."

The spacecraft, he adds, is armored in Kevlar. And, he notes, *Voyager 2* actually flew through the inner edge of Saturn's G ring with no noticeable harm. "There were dust impacts, but they didn't seem to do any damage," he says, though he adds that the *New Horizons* crew would still rather not take such a risk.

Meanwhile, Pluto might not be the only world worthy of a close look in the precious minutes of *New Horizons*' flyby. Charon itself might once have harbored an underground ocean formed by processes similar to those that might once have operated on Pluto, though Charon is small enough that its ocean is much more likely now to be completely frozen. But in an unpublished study announced by NASA on June 13, 2014,[21]

---

[17] The names were also picked to make sense as a pair, says Alan Stern, a planetary astronomer at SWRI who was part of the discovery team. "N" and "H." *New Horizons*. They are the first moons to be named for a spacecraft.

[18] This is supported by the fact that the new moons aren't super-tiny. Nix and Hydra are roughly 50 to 150 kilometers across; Kerabus and Styx are somewhere between 13 and 34 kilometers—roughly the size of Mars's twin moons Phobos and Deimos.

[19] "*New Horizons* Team Sticking to Original Flight Plan at Pluto," 14 Jun 2013, *solarsystem.nasa.gov/news/display.cfm?News_ID=44029*.

[20] NASA, "*New Horizons* Pluto Kuiper Belt Flyby," *nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2006-001A*.

[21] "Cracks in Pluto's Moon Could Indicate it Once Had an Underground Ocean," *http://www.nasa.gov/content/goddard/cracks-in-plutos-moon-could-indicate-it-once-had-an-underground-ocean/*

postdoctoral researcher Alyssa Rhoden of NASA's Goddard Space Flight Center in Greenbelt, Maryland, suggested that the same types of "groovy" surface patterns being hunted for on Pluto might also exist on Charon.

"Depending on exactly how Charon's orbit evolved . . . there may have been enough heat from tidal deformation to maintain liquid water beneath the surface of Charon for some time," she said.

"We're going to Pluto, and Pluto is fascinating. But Charon is also going to be fascinating."

In the decades since the Voyager teams first chose not to visit Pluto, one of the biggest surprises in outer Solar System exploration is the prevalence of liquid water: Europa, Enceladus, Ganymede, Titan, Callisto, Triton—icy moons with a large enough tidal heat source may all have subsurface oceans.

But until recently whoever thought the same might apply to Pluto?

"Pluto is so far out there and so small that most people are like, 'It's frozen, cold, dead.'" Collins says, "'Probably nothing interesting is going on, on Pluto.'"

But now, suddenly, it appears that cold, dark, forgotten Pluto—demoted from the ranks of planets only months before *New Horizons* was launched—might turn out to be a very intriguing place.

"Europa is very interesting, but you have gigantic Jupiter to drive it," Collins says. "It's very interesting that the little Pluto/Charon system, way out lonely in the Kuiper Belt could drive itself to the same state." And, whether you like it or not, Pluto's demotion from planethood kicked it from the fringe of our more familiar Solar System into the realm of the Kuiper Belt, where enormous numbers of equally mysterious objects float on the dark edges of the Solar System. Already, scientists are turning the Hubble Space Telescope on the region beyond Pluto in the hope that after its primary mission is complete, *New Horizons* might be able to swing toward an even more distant body, giving us not one, but two Kuiper-Belt visits for the price of a single launch.[22]

That evolving knowledge of our Solar System might perhaps have made the multi-decade delay in the final stage of Flandro's Grand Tour worth the wait. In 1977, the Kuiper Belt was only a dimly realized figment of astronomers' imaginations. Even if we'd suspected there was something out beyond Pluto, we'd have had no idea how to steer for it.

But no longer. "We now know that Pluto is just one prominent member of a large family of icy dwarf planets out beyond Neptune," Collins says. "Are they dead, cratered iceballs, or geologically interesting and active worlds?" If Pluto lives up to expectations, he says, "the upcoming flyby will just be a taste of a huge, diverse, and exciting new area of the Solar System."

And it's not just interesting for scientists. Because if there's one thing we keep learning in space exploration, it's that every time we answer one set of questions, we produce new puzzles. And puzzles are exactly what's needed for a new round of exciting science fiction stories. ■

[22] As of press time, they had found three candidates. See "NASA's Hubble Telescope Finds Potential Kuiper Belt Targets for New Horizons Pluto Mission (October 15, 2014), *www.nasa.gov/press/2014/october/nasa-s-hubble-telescope-finds-potential-kuiper-belt-targets-for-new-horizons/#.VFqLFxbvLEc.*

Unless we stand for something, we shall fall for anything.

—Peter Marshall

Daily Teds

Ron Collins

1

This is a story about hope.

Professor Dietrich says that telling the reader what a story is about before it starts is a cardinal sin, but in all sincerity, I think I've got her number when it comes to cardinal sin. She says I'm supposed to be a good enough writer that you can figure out what a story means all by yourself. She says I should trust you.

Sorry about that.

Let me assure you that I didn't spill the beans because I think you're stupid, or foolish, or in any other way without wits. In fact, I'm absolutely certain you're sharp and insightful, because after all, you are me and I am you and we are *also* all in this together.

Coo coo ca joob.

I've told you this story is about hope because this is no time to beat around the bush, and because for all I know you could be confused as hell by the time you get around to reading this.

And you *will* read it.

Eventually.

Because it will come back to you again and again, until that one day when you pick it up or it downloads into your ganglia, or you sense it in the radiation patterns across some distant galaxy, or . . . whatever.

And then you'll read it.

When you do, keep in mind that it's supposed to be a story of hope.

2

It started with a particle with a wavelength just under five picometers, which classified it firmly as a gamma ray. It landed on a photoreactive plate and left a strange image, thick and rounded at one end, then trailing off as it arced across the frame. It looked like a sperm cell, which is why I took to calling it the sperm-a-gram.

This was not a pattern the design team expected.

I should probably tell you that I am Ted Gaz, though you might know me as "AV." Or, maybe my name will have been covered over by the weights of thousands of voices by the time you read this, and you won't have heard of me at all. I dunno. So I should tell you that I am a graduate student at Jackson Community College, and at the time this whole thing started, I was studying under Dr. Leakman. You

should remember Leakman, but in case your memory has degraded over multiple shifts, he was a semi-alcoholic physicist doing back-water work that he hoped would lay the foundation for the gamma gun and make him the next Albert Einstein.

To be honest, I took the gig only because I wasn't interested in the whole nine-to-five thing. I could have graduated the year before, but I never really saw the appeal of a steady job, and I didn't expect to change in that department anytime soon. Day jobs were about other people, and I don't like other people. At best, other people are boring, and at worst, they're dumb—or are freshmen, who are a particularly vile form of spoiled scum.

But I do like learning. I like feeling smart. I could be content spending my life drifting from class to class across every discipline there is.

Unfortunately, when this all started I was a Graduate Assistant teaching freshmen three days a week, which is totally relevant seeing as it goes to prove I meant well. I just wanted to get the freshmen outta my hair, you know? Totally justifiable. Right?

Perhaps I should describe the experiment now.

3

It was basically a box the size of a refrigerator lying on its back. The first stage was an initiating cell ringed by a set of magnets and solenoids that provided impulse to any gamma degradation that occurred in the sample, thereby directing particles into the collector. The collector looped on itself to amplify the output before being fed into the "barrel"—which was comprised of a second set of magnets and mirrors that was supposed to tighten the beam into the final segment where the Ray of Death was supposed to become concentrated.

It felt wonderfully Rube Goldberg-y, like something out of an old-time comic. One of the guys even used a cutout of Superman as a target, but Leakman took care of that quickly. Mark Grumman, a blunt-brained junior who had been on the design team for three weeks called the device a "Gamma Box," and the name stuck.

On the day of the sperm-a-gram, the Gamma Box amplifier was set to use zero-mass particles (what others might call photons) to shape electromagnetic fields. Leakman had predicted a nice, clean blot on the target, but then, that's what he predicted every experiment.

I never thought it had a chance in hell to work, so I was surprised to hear a result had come through that morning. Leakman, smelling of bourbon, celebrated by telling the dean he deserved a bigger budget and by distributing about three hundred black-and-white copies of the sperm-a-gram around campus.

I don't need to tell *you* what I was thinking. While everyone else ran off to figure out how our little sample could have emitted this weird arc, I was pretty sure I knew the score. I kept my trap shut, though, for two reasons: one, I wanted to make sure I was right, and two, if I was right, I wanted to think about what it meant, and also maybe figure out how to take best advantage of it.

So, during the day I fiddled with the guidance fields and helped the team chase down sources of radiation leaks, and at night I came in and did my own thing.

In retrospect, this was probably my first mistake.

4

You see, I leapt to a far more exciting interpretation of the sperm-a-gram than everyone else. I thought this might be a relativity gap, that the arcing pattern might be the mark of a single particle wave etched across the page as the target moved through space—like if you were writing and someone pulled the paper away. In this case, the particle would trace an arc because the paper was attached to the Earth, and the Earth was moving.

It's all relative, Watson. Except when it's not.

Or something like that.

If I was correct, this was an astounding result. I was fairly sure it had to do with photons and their zero-mass property interacting (or not) with the guidance section of the experiment. If this interaction was at the root, my idea required an injection of energy to counteract the force of gravity on the Gamma Box—energy that I couldn't explain, but I figured that could all come later. If my interpretation was correct, and if enough energy could be harnessed, the guide fields could be

modified. And if the guide fields could be modified just so . . .

Well, then it would be like I was a quarterback leading a receiver. Yes, I thought I could actually project something through space-time and into the future.

Freaky, eh?

The directional element of the guidance section would be critical, of course. The Earth was constantly moving, and the key would be knowing the exact place the Earth would be during the moment I wanted the football to arrive. I worked for days on the calculations.

As complex as it sounds, once I had the equations down it was pretty simple, requiring the Sun's path and velocity, the rate of the Earth's rotation around the Sun—and, of course, an exact representation of the location of the "football" relative to the Earth's surface. On average, the Earth rotates around the Sun at 66,660 miles an hour, but that needed to be altered for time of year. It also spins on its own axis at 1,051 miles an hour. I combined those, then adjusted that result to account for the gravitational effects of the Solar System's masses, as integrated over time. That was the tough part, but in short order I thought I had that about right—which was important because determining timing and location with precision over the distance the Earth travels in a day is an incredibly fine line to cut. A picosecond error in any axis would make me miss my target by a centimeter or a millimeter, or be a tenth of a second off. Either of these occurrences and whatever I launched would emerge on the other side someplace or somewhen it shouldn't be.

Given the nature of these physics, that the Earth's motion had a single direction, I would be able to project only forward through time. I could aim for the past, and even pinpoint the right place in space, but if I sent something backward it would arrive at the proper place only to find the Earth was long gone.

Once I had the equations, it was time to run the test.

I went to the lab at midnight so I could be alone. It took me a couple of hours to set the guides to a spot I calculated to be exactly one hour away. I put my ink pen into the Gamma Box, then checked my watch. It was 2:12 A.M.

I pushed the button.

Nothing happened to the pen, exactly as I predicted. I shut the entire thing down, and put everything back the way it was.

Then I waited.

At exactly 3:12 A.M. an audible crack came from the wall. I ran over to find the back half of the pen on the floor, its last inch melted to a point. I got a whiff of burnt plastic and scorched drywall, and I saw a perfectly round hole now appeared in the wall a few centimeters above my eye level. It was of a size that perfectly accommodated the pen, and I was certain the other end of the instrument was behind the drywall.

The import of this result gave me goosepimples.

I had my time machine. Sort of. It was more of a transporter, really, except the original didn't disappear. Instead, the system scanned the original, then launched a duplicate into the future. So, it wasn't so much a time machine as a chronal fax.

Freaking cool.

That the pen arrived embedded in the wall meant my calculations had been close, but not quite perfect.

It was getting late, so I went home to not sleep.

Each night I tried different tweaks. Two weeks later, I had successfully launched and retrieved pens three times in a row. It was time to see if it would work on something living. At first I tried a cockroach, but it's a bit hard to get the damned things to actually stand still, and the scanner apparently couldn't attach zero-mass particles well enough to make the magic happen.

The lab cat, however, eventually just lay down and went to sleep in the target zone.

5

Here's a bit of trivia I don't think you all knew. The cat was originally named Leo, after da Vinci, but I changed it to Thing 1 after I had successfully projected Thing 2.

6

I tested them together for a bit in order to see if they were really duplicates. They looked identical. They sounded the same as far as my own ear could tell. I recorded their meows, and ran them through the audio spectrum analyzer on my computer to find no appreciable

difference. I played with them together and separately and tried different foods to see if they would respond in unique ways.

All I could say for certain at the end of my study is that Thing 2 ate, and purred, and moaned to go out just like Thing 1 did, and that neither particularly cared for my intrusions on their naps.

As far as I could tell, they were exact duplicates.

7

The late-night work took its toll. Never one to be particularly gregarious, I'm sure I got worse. I was tired and cranky all the time, and I know neither Leakman nor the rest of the team always appreciated my sarcastic wit. If my personality showed up in other ways, I'll cop to being oblivious because, well, hindsight is 20/20 right? I was oblivious to a lot of things back then.

When Leakman posted GA assignments for the second semester I saw I was teaching a Tuesday/Thursday lab in addition to my M/W/F optics class. I complained, but he just told me to suck it up.

I admit I was pissed.

In no way was I interested in teaching freshmen when I had such an interesting toy to play with. You see, I was trying to stretch the calculations to send material more than a day out. I was close. Those two afternoons were my time to sleep, and without that time, I would never make it. Teaching another class would bring all this momentum to a crashing halt.

I decided then that I needed some help.

8

I made Tuesday on a Sunday night.

I took him to the apartment and we talked until sunup.

All his senses and skills seemed to come through intact. He was just like me in every way, he picked up on my thoughts and scratched the side of his jaw when he thought—just like I did. It was totally freaky.

He slept on the couch.

I called him Tuesday because I expected him to work for me on Tuesdays and Thursdays. He seemed cool with that. He called me Ted. I was cool with that.

By Monday evening, I decided he was good to go.

I stayed close by as he taught that first lab. He did just fine, and no one noticed anything different. I slept in on Thursday, and Tuesday did fine once again.

To celebrate our great intellect, we went out drinking that weekend and were in the middle of a deep conversation about the math we needed to add precision to the space-time calculations when we hooked into a pair of girls who thought it was cool to be with such perfectly identical twins. I am not good with girls, but Tuesday didn't seem to have that problem.

In retrospect, this should probably have been my first warning sign that we weren't *exactly* the same—any version of Ted who can talk to a girl without breaking out in an upper lip full of sweat is an anomaly—but a steady stream of beer and a head full of theoretical physics had us both running on rock-star mode.

It was a great night.

The following week was great, too.

We each worked part-time and spent off nights improving the chronal calculations. A week later, we came to the opinion that we could use a Wednesday, a Thursday, and a Friday. Being the alpha issue, I figured "what the hell" and added in a Monday, too. They could each work one day a week, and I could basically supervise.

So were born the first set of Daily Teds.

9

I apologize if this is the first time you've heard this. I'm sure it can be a shock to learn about where you came from this way.

10

The Secret Service calls the President of the United States "POTUS." In keeping with that fine institution, we took to calling the "on" version "Motted," the pronunciation of the acronym for "Man of the Day."

It took us a while to figure out how to operate together.

The second weekend, for example, Friday came back from the grocery upset because Wednesday hadn't told anyone he accepted an invitation to a party on Thursday, then ditched the bash when a better opportunity raised her head. Friday had run into Professor Tompkins, who asked if he was okay and said they had missed Ted at the party.

It left Friday in a compromising position.

We decided then that five people working a day a week required a coordinated approach in order to maintain a sense of continuity. Dinner became a standing "team meeting" where Motted debriefed the rest of us on everything that had happened. This included conversations and meetings, and any other events that seemed important. We shared pictures and vids to ensure we stood a fighting chance of remembering important faces and places.

This was a great gig, though.

I spent my time thinking about chronal physics, watching my beloved St. Louis Cardinals on net streams (baseball is the most mathematically beautiful game of all, don't you think?), and observing the female species as it migrated around campus.

On a lark, I decided to take an anthropology course next semester, and maybe a section of modern political theory. It was all very cool. I have to admit it was about this time, however, that it became obvious that we weren't actually identical. The differences were tiny, things like the fact that Friday would raise his left brow when he was thinking, and Monday would raise his right. Thursday was more sarcastic and less patient than the rest of us. Wednesday was the most methodical and, in fact, had gone ballistic when Friday and Thursday had swapped days without letting everyone know in advance. As life would have it, Friday was a bit laid back and easier to be around, while Monday was sometimes cautious to the point of paranoia.

At the time, I didn't consider these differences to be of any great concern. I guess I was having too much fun to pay attention.

Or maybe I just didn't want to face responsibility.

11

Things were progressing on the scientific front, though.

I had been able to cast the guide-beams forward as far as three days into space-time with a reasonable shot at success, but the precision required was very tight. All the calculations were manual, and a total pain, until I automated them in a small app. Then I came upon the idea of using a recursive fractal based on Einstein's relativity equations, and it became even easier. They were spot on during trials of one- and two-day projections, so I extended the process out to a week and then two. Both were perfect.

I explained it to the rest of the Teds that night.

We were all impressed.

12

"We're going broke," Wednesday said at our team meeting. "Six mouths are, uh, considerably more costly than one."

We let Wednesday be our banker because he was the only one who wanted the job. It was the end of the semester, and he had taken a peek at the savings account.

"AV could get another job," Thursday said.

All eyes turned to me because AV meant Alpha Version.

"He's the only one of us freeloading."

I stared Thursday down.

"I'm not the one who likes to play poker in his spare time, and," I said, glancing at Friday, "And I'm not the one who downloaded $300 of music from Tune-Tower. We've got to be smarter about these things."

"We could set ourselves up better next time," Tuesday said.

"Tell me more," I replied.

"You've developed long-range accuracy, right?"

"Sure. I think so, anyway. Of course, I can't test multiple-year projections until we get that far out, but I can't see why they wouldn't work."

"We could put some cash in the market or some other kind of account and let it ride, then we could send ourselves forward fifty years. When we got there we would be rich enough to live like this for a lot longer."

"That's a great idea," Monday said.

Tuesday raised his hand. "Why not send ourselves one hundred years into the future, and let the cash grow even more?"

"We could do that, too," I replied, struggling to keep up for a moment. "But I worry about the math's accuracy out to one hundred years. Fifty years is probably the max I'm comfortable with."

"We could link versions," Tuesday added. "Send ourselves forward fifty years, then do it again right away. That would mean we would live three lives: this one, the zero+fifty set, and the zero+one hundred set."

"It would be great to be rich," Monday said, leaning back. "Then none of us would have to work. We can call it Operation Pay Forward."

"I like that," Tuesday said.

"Yes," Wednesday butted in with an air of impatience. "It *would* be great. But right now we've got no money and the rent is due next weekend. All this blue-sky stuff is useless if we can't find a way to make some money."

We all smiled at the same time.

13

We called it hitting the daily double.

Wednesday suggested we convert all our cash to ones before we started because he wanted to roll in a bed of cash. It amounted to 108 dollar bills. At an hour a cycle, we could safely run the process five times in an evening without risk of getting caught. So we had 108 dollars going into the evening, and before it was all over, Wednesday had a 1,728-dollar money bath. Friday worried about the identical serial numbers, but even he had to admit that once we shuffled the deck a bit it would take someone with the focus of Rain Man to catch the sequences. To be safe, though, we each converted the ones to tens in a bunch of different places that next afternoon. That night we turned 170 tens into 2,720 tens, and then the next night 1,360 twenties into 43,520. Three nights, 870 thousand dollars.

Not a bad return.

Through it all we had long and heated discussions about whether this was counterfeiting or not. We agreed the IRS would probably just consider it income, and tax the hell out of it, but that the FBI would be mad as hornets if they ever found out. Personally, I'm happy to report that we never passed a fake bill.

Regardless, with nearly a million bucks in our pockets, it was time to turn our attentions to Operation Pay Forward.

14

Thursday argued that there was no reason for us to send our cash forward because he figured that future Teds could all just make their own cash like we had. Everyone liked that line of thinking until Friday pointed out the possibility that the future may not use actual currency and if that were true the full implementation of Operation Pay Forward was the only way to ensure our future selves would be independently wealthy.

It was anticlimactic, like throwing darts in the dark.

I admit I felt a bittersweet sense of indigestion as we dropped 300 thousand dollars into two bank accounts that we would never touch ourselves. But once it was done we each sent a copy of ourselves out fifty years, each with the account numbers written on notes we put in our shirt pockets and instructions to send another set out fifty more years. It was weird, really. Fifty years is a long time. We knew we may never see these Teds, and may not ever know if it worked.

We had a good party in their honor, though.

15

It was about this time I started to worry about what we were doing. I mean, really worry. I had spent all my free time thinking about the output side of the equation—trying to expand our ability to cast forward. But one day I started to reconsider the question of energy.

After all, E=MC^2 no matter what space-time we're in.

A standard Ted carries just over one hundred fifty pounds-mass. That translates into 6.1 million-terajoules. To give you an idea of size, a bomb named Little Boy once went off over Hiroshima—it registered at around sixty terajoules. So, it takes a hundred thousand Little Boys to make a Ted.

I had made five Teds, and now we had each made another set of ourselves. It's safe to say they would likely make another set. That's seventeen new Teds, not to mention Thing 2 and a bunch of inanimate material. That's a few million Little Boys.

I kept asking myself: where does the energy come from?

I had to admit that I didn't know.

16

It started to unravel the weekend before the long Thanksgiving break.

"What the hell are you doing?"

The question echoed from the living room. I went to see what was going on and found Monday looming over Thursday, who had been lounging on the couch and playing *War in the East* over the net.

Thursday gestured with his controller. "What the hell does it look like I'm doing?"

"You know what I mean."

"All I know is that you're standing in the way of me kicking the crap out of some Nazis."

"You used the machine this morning."

"What are you talking about?"

"I went there this afternoon to send myself home for the holidays. The machine was still hot."

"I did no such thing."

"Well, *someone* did. Tuesday was shopping, and Wednesday was at the health club. Friday was sleeping late after his day on."

"What about AV?"

They both turned and looked at me as I stood in the hallway.

"He was here playing with his energy equations. He interrupted my movie to get breakfast."

"You were going to create a Ted to send back home?" I asked, still catching up.

Monday flushed with embarrassment. "I know I shouldn't have been thinking that way, but it's my turn to go to Dad's and I didn't think I had the energy for it."

"Hypocrite," Thursday said.

Monday turned back to Thursday. "Screw you, buddy. You're just trying to divert attention from the fact that when I got to the lab the machine was still hot. So either you went late and sent something near-term, or you went early and . . ."

Monday's eyes narrowed.

"Sent something a long time out."

No one said anything for a moment. Thursday hit the pause button on his game and stood up.

"You bastard," I said, finally starting to catch on. This had to do with our money. "You actually did it, didn't you? You sent a copy of yourself out to steal our money." Thursday said nothing. "When did you send your copy to?"

"Probably a week or so before our target date," Monday answered for him. "He would need a few days to transfer the cash to another account and get out of Dodge."

"Why?" I said, feeling a sudden sense of panic as I stared darts. "We had the perfect setup. Why ruin it?"

Thursday glared at me.

"We're all just slugs sitting here fat-dumb-and-happy. We work for you every day like good little boys, teaching a bunch of useless idiots whose parents are wasting their inheritance on their tuition. And all you do is play around with equations all night, and plan to stay in school until you've taken the entire curriculum. It's like you've got nothing to do. What a waste."

"You're stealing our future because I'm taking classes?"

"What are we accomplishing?" Thursday yelled. "Nothing! We've got more resources available to us than most third-world countries and we're sitting on our butts. Someone needed to take charge—needed to make a difference, if not in this life then in the next."

"You're deranged," I said.

"Don't worry," Monday replied. "I had Thursday pegged from the beginning. So I sent a copy a month earlier that he did, with instructions to put an end to it. So Thursday's double won't be able to access the funds."

"It's so unlike you to be a hero," Thursday said. "I'm actually surprised you're standing here right now."

Monday took the first swing, but Thursday was better prepared. Before long, Thursday ran out of the apartment bleeding from the jaw, and Monday was unconscious on the floor.

17

Things spun out of control from that point.

Monday wanted to track down Thursday, and Friday wanted to send another copy into the future to make sure Monday's attempt was successful. Wednesday asked everyone to calm down and stay the course, but Tuesday ripped him a new one for that idea, and the debate ran around in circles all night.

"The machine," I finally said. "Thursday is going to go to the machine."

"Damn!" Monday was the first to catch my drift. "We should have seen that."

We all piled into the car, but it was too late.

Thursday had probably rented a truck.

Who knew where he was now? Not that it mattered anymore. With one of us gone renegade, the rest of the dominos fell quickly. Tuesday decided we couldn't trust Friday, and Friday couldn't deal with Wednesday, and Monday, well, no one liked Monday anyway.

A week later Friday moved to LA and was apparently thinking about doing something with Hollywood. Monday lived on the north side. Tuesday hooked up with a blonde from one of our labs, and Wednesday took an apartment in Centerville. Thursday just disappeared completely.

18

It's not a complex machine to make, really. We would have made our own earlier, but it was just as easy to use the one at school. And as Leakman's results grew less fascinating, the attention had drawn down so far that we could get to it pretty much whenever we wanted to. So I'm sure every Ted made his own machine and his own set of daily Teds, not to mention his own pile of money.

I saw one of me in the bowling alley the other day.

He could have been my twin, but his hair was curled. I talked to him at the bar as he was ordering a turkey sub. At first he was a bit perplexed, and called me Delta. I asked him about how their box worked, and he was even more confused. It was obvious that Ted had no physics.

Was he only second gen?

Third?

How far shifted did we have to get before we were totally different people?

The third generation could be 125 Teds, the fourth gen 625, the fifth 3,125. Then the numbers start getting big. Fifteen thousand six hundred twenty-five, then 78,125, then 390,625, then 1.95 million. Another couple of generations and we're in the billions. And that's just one thread. How many Ted threads will start next month?

Next year?

Next decade?

Do you know how many Hiroshimas that is?

Or let me put it another way.

Do you know the energy output of the Sun?

19

The output of the Sun is 3.86x10^26 J/second, by the way.

It's an important number because after looking at it for several months, I'm pretty well convinced the Sun is the most likely source of the energy each Gamma Box needs to create the mass it creates. I'm thinking that linked massed/non-mass particles create a quantum pairing with matter at the nearest energy source large enough to support the transaction.

The Sun is the only candidate that makes sense.

I've been reading data from various solar observatories for the past few months, and I've noticed a chaotic slew of lags in its spectrum. My guess is that these mark the creation of a new Ted.

So, 3.86x10^26 J/second.

That sounds like a lot of energy, because it is.

Still, I was worried I created a doomsday device that was going to eat up humanity's source of energy.

So I did some more calculations and determined that the mass of a billion Teds would cost the Solar System nearly sixteen thousand seconds of Sun-power, or just under five hours of its life. Not a big deal, really. Surely a billion of me are worth five hours on the scale of the Solar System's life span?

This made me feel better for a while.

But then I got to thinking further.

The number of us Teds, you see, is growing exponentially. It could already have happened. And with hundreds, or thousands of these devices around in the near future, one will certainly get into the wrong hands. What kinds of things would a government do with this kind of replicator?

Oil.

Yes, the Gamma Box could be a virtually never-ending supply of oil. And food—the world will be able to feed itself in perpetuity on a daily basis. These are the good things, true enough. But I can also see despots building armies that multiply in power by the day. The image of thousands of little Thursdays goose-stepping down Times Square made me queasy.

Still, the good news here was that the energy required to create even this kind of excess isn't too bad—a few solar days a year.

I could live with it.

20

But it gets worse.

The energy required to create mass is only the tip of the iceberg. If my calculations are

correct, most of the energy used in our projections is expended in the process of latching non-zero-mass particles to zero-mass particles. It's a quite large number, and it increases with the square of the time-space traveled.

So let's talk colonization.

If it can happen, it will. And this chronal fax makes it even easier because all you really need to do is point and click.

The Moon? Simple. Mars, not hard, but very costly in Sun-years, especially if someone decides to colonize even further into the future. Billions of more people to feed and provide energy.

21

And they will each have their own machines.

22

I think my oblivion was my true mistake. Just not paying attention, you know? I should have thought harder. I should have seen the end game coming.

I wish I had been a better man.

My latest equations say that it's not long before each chronological year eats into the Sun for an extra thirty years of its life, then forty, then sixty.

Scientists project the Sun to live another five billion years, but drawing an extra sixty years a year from it makes the Sun's five billion years become only 83 million. One more generation of expansion cuts it to ten million or so, then less than a million.

You get the idea.

23

So I'm saying this to all Teds—you know who you are. Tomorrow, before you use your machines, go outside and check out the Sun. Look at the world around yourself.

It's not too late.

I know you're a good guy. I really do. I know you don't want to see the world end.

Before you push that button again, I propose this: set yourself up, make sure you're okay, then send this story to each of the time-spaces where you've sent yourselves so that they can read it. And then destroy your boxes. Burn your plans. Speak to no one. Do not send any more of us to future states. Otherwise, it's possible the Sun will not even be there when they—you—arrive.

For my part, I'm spending my wad distributing this story. Then I'm going to send myself forward in time once again—one copy to each time period in five-year spans—to do the same thing.

That's why I know you'll read this story. But as for listening to it, as for being smart and doing something about it before it's too late, who can tell?

24

I told you this was a story of hope. ■

Transfer Point

Barry N. Malzberg and Bill Pronzini

It was just before I went on duty at 0800 hours that I was told Luna Immigration, the entire Luna Dome in fact, would be summarily shut down within the year. The date was Thursday, August 9, 2289.

The news was stunning. When I recovered, I said to the supervisor, Amadeus Finney, "It doesn't make sense. The checkpoint has been a viable clearing house for Earth travelers from other worlds for close to a century. We have a tight, effective operation here; there have been only a handful of attempted security breaches in the past few years, and just three—the mad Lyran bomber, the dancing Mesmerist drug smuggler from Carinae VII, and the nitrogenous Rhyx fugitive—that came anywhere close to succeeding. Why, then, would the Federation suddenly decide to scrap Luna Dome and open up a new facility on Mars, of all planets?"

"Exactly what I said when I was told."

"And?"

"A necessary expansion of facilities was the only explanation."

"That is pure foolishness. We're operating at less than full capacity as it is."

This was quite true. Luna Dome is a massive structure more than sufficient in size to process the constant daily flow of interplanetary tourists and luminaries bound for Earth. It had been built to last indefinitely by robot crews of "selenous materials," as some long-dead Federation wit had termed them; it contained many hundreds of cubicles and airlocks to accommodate each of the various races; it was surrounded by some fifty ports, a number more than sufficient to accommodate daily arrivals from and departures to Earth and the many other worlds. And it was, in my opinion, overstaffed. The checkpoint divisions could be handled by less than a third of the three hundred employees currently working each shift. If I were supervisor, as I should have been, given my exemplary record, I would have petitioned the Federation to trim those numbers by a third.

Amadeus Finney sighed. He had only been sector chief for three years, having been promoted when our old supervisor retired. I had

been next in line for the administrative position, as a matter of fact, being senior inspector, but I was passed over for unexplained reasons, my age possibly being one of them. Finney had not been a good inspector; he was not a good supervisor. He had delusions of grandeur, I'd always thought, yet he was dilatory in his decision-making and rather sloppily unorthodox in his implementation of policy. We did not get along. He knew I considered him incompetent and resented me for that and for my flawless record.

"I don't have the answers," he said. "We are in the hands of larger powers and so on." A large gray man, he essayed a large shrug. "We'll do just as well on Mars, and the schedules will remain the same."

"Have you told the other inspectors yet?"

"No. Only you, as senior inspector. And I'd rather you said nothing to any of them just yet. Bad for morale." He pinched one of his rather unhealthy looking cheeks and sighed again. "In any event, the decision won't affect you for long, nearing voluntary retirement age as you are. You've been on the tables for, what, thirty years now?"

"Thirty-two," I said. "But that's not the point. The point is the decision makes no sense from any perspective. A Mars facility would be prohibitively expensive to build, and the Federation couldn't possibly put one up and move the entire operation before the end of the year. I don't understand why they'd even consider it."

"Ours not to reason why," Finney said sententiously. "Besides, I worry only about the things I can change or influence. This can't be changed. We'll just have to grin and bear it."

That was another reason he had been a poor choice for supervisor, or perhaps exactly the right choice insofar as the Federation politicos were concerned. He had an inexhaustible storehouse of clichés that he dragged forth at every opportunity.

There was more to our conversation, but I seemed to have forgotten it by the time I reached the checkpoint. In fact, the outlines of the entire session in the supervisor's office were as fuzzy in my mind as the rationale for the Federation's order. I was less upset now, too, perhaps because Luna gravity seemed even lighter today than usual; it was almost as if I were bounding above the checkpoint floor rather than walking across it, in a curiously graceful and exhilarating dance. Almost as if . . . Almost as if what? Well, no matter. Ours not to reason why.

I took up my customary position at table number three and prepared to begin another day of what was, for me, the most stimulating job in this or any other solar system. For Luna Checkpoint was the gateway to Earth, its first line of defense, and I and the other inspectors were its gatekeepers, its guardians. Every day it was our responsibility to carefully screen and either pass through or reject travelers from all corners of the known Universe. Creatures such as green-speckled and lavender-hued Altairians, striped Melnusian miners, porcine Poldrogs, falcon-worshipping Rigelians, Archiporteyx spirit-bearers, Titanian slitherers, Aldebarian musicians with their long trilling snouts, and of course the variegate new breeds from planets only recently swept by Federation troops and pronounced benign by Federation exobiologists. *The Checklist of Creatures,* the checkpoint's bible, had quadrupled in size and scope during my tenure, until it now contained more than one hundred different races.

The vast majority of visitors were benign, of course, but we were ever vigilant for the individual or group seeking passage to Earth for nefarious purposes. If it wasn't for trained inspectors like me, all sorts of riff-raff—assassins, drug merchants, plague carriers, smugglers, swindlers, slave traders—would be free to wreak havoc on Earth. In my three plus decades at Luna Immigration, only one dangerous mutant, a Sigma Draconan revolutionist, had actually made it through checkpoint and onto an Earth-bound vessel, and he had been found out and captured in transit.

The detective aspect was one reason I prized my job; I pride myself on having an astute, watchful, highly instinctive and ratiocinative nature. Another reason is that I enjoy the daily contact with the heterogeneous flow of aliens who pass through checkpoint. No xenophobe, I, as some inspectors became after long service, but rather the truest of xenophiles. The third reason is that the job keeps one free of easy answers, easy assumptions, and requires trust in

one's judgments and quick action in dealing with difficult situations. Altogether, being a Luna Immigration officer permits the mind to remain flexible, cultivates both intelligence and reflex.

These thoughts brought me back to the Federation's decision to close down Luna Dome. Was it nothing more than bureaucratic mindlessness moving into a vacuum of uncertainty? Or was there some rational purpose behind it after all? Yes, there must be. I really mustn't question authority. We were in the hands of larger powers.

First in line this morning was a female Beta Hydran methane roller on her way to a trade conference in Washington, D.C. I examined her Federation passport, official traveler's insignia, identifying genotype, and vitae and DNA scans. All was in order. Her answers to the standard questions struck me as slightly evasive, however, perhaps due to travelers' fatigue. Or did she have something to hide, a different, possibly sinister agenda? I probably should have marked her as marginal for further evaluation, but I surprised myself by stamping her passport and letting her through.

I further surprised myself by passing the second in line, a minor official in the diplomatic corps from Betelgeuese, even though he was inclined to be unpleasantly short-tempered and critical, and I had had difficulties with him before.

It must be the Federation decision to close Luna Dome that was making me careless. I warned myself to be more cautious.

Sixth in line was a 179 Centaurian, a reptilian species noted for clusters of hanging metallic scales of flaming red and the distinctive tick-tick-swish sounds the scales make. According to *The Checklist,* they are nonaggressive, apolitical creatures mostly given to long periods of deeply religious meditation. Consequently few Centaurians travel, and I have passed only a handful in all my years as customs inspector. His bona fides all seemed in order. In point of fact, he was an absolutely perfect specimen of his race: He did not have a single genetic flaw.

In universal English-based Federation language I asked him the first of the standard questions. "What is your purpose for visiting Earth?"

"To view first-hand the Vatican, the Holy Land, and other such marvels."

"That is your only purpose, a religious pilgrimage?"

"Yes."

"The length of your stay?"

"One Earth year."

"According to your passport, you have never traveled there before."

"I have wanted to but could not afford passage."

"Do you have relatives or acquaintances anywhere on Earth?"

"No."

I asked several more questions and received the same apparently straightforward answers. Yet there was something about the Centaurian that did not seem right to me. It was nothing tangible, merely a hazy presentiment of wrongness—but a much stronger feeling, nonetheless, than the one I had received from the Beta Hydran female.

Random thoughts commenced to form in my mind. Or perhaps they weren't random at all.

Why did a Centaurian want to go on a religious pilgrimage to Earth? *The Checklist* stated that the only religion of interest to them was their own.

Why was the Federation closing Luna Dome? It didn't make sense.

Why was the Centaurian a perfect specimen of his race? I had never encountered such perfection in one of the creatures before.

Why would the Federation decide to build a new facility on Mars? It didn't make sense.

"May I pass through now?" the Centaurian said in his sussurative Federation English. "The next Earth shuttle will soon be leaving from Port Nine."

Why had the decision to close been handed down on the ninth day of the month instead of the last day when all Federation edicts were usually presented? And why so suddenly, with no previous warning?

How did the Centaurian know the next shuttle would be leaving from Port Nine? The scheduled flight was posted on the Vid monitors, but not the time or the port number as yet.

Why had the supervisor requested I not tell the other inspectors about the closing? Bad for morale was not an adequate reason.

Why had Luna gravity seemed so much lighter this morning, so that I felt as if I were cavorting across the checkpoint floor in such a graceful and exhilarating fashion? That had never happened to me before.

"My credentials are in order," the Centaurian said, "everything is in order. You must stamp my passport and my insignia and pass me through."

Why was the Federation closing Luna Dome?

Why was—

Why did—

Why—

My head had begun to ache painfully. The Centaurian seemed to waver in my vision; for just a moment he seemed smaller, humanoid and gray-flecked rather than reptilian and flaming red. Tick-tick-swish. Tick-tick-swish. Then the fuzziness vanished and I saw him more or less clearly once more.

Ours not to reason why. Just grin and bear it.

No!

"No," I said.

"But you must. You have no reason to deny me."

"Don't I?"

"I strongly object to this unreasonable delay. Pass me through at once."

Again, the Centaurian seemed to waver, the checkpoint itself seemed transparent; it was as if I were looking through the familiar semi-chaotic scene in order to see something else, something of considerable significance. The alter-images were there but still unfocused.

"No," I said again. "You're not to pass through, you're to be detained."

The Centaurian shook his metallic scales in an angry fashion, causing them to shimmer in the checkpoint's radiant, intense light. Tick-tick-swish. "You have no cause to detain me. Do so and I will report you to your superiors."

Aggressive gesture, aggressive words, and Centaurians were a nonaggressive race.

I signaled to the nearest security guards, a signal I give only two or three times a year, first with the electronic synapse and then by standing at the desk and raising an arm high over my head. The two guards appeared to respond slowly instead of with their customary dispatch and in an uncertain, shuddering way that mirrored my own lack of focus. One was a multi-appendaged Andromedan, the other a humanized Polyp, security having long since been parceled amongst the various inhabitants of the populated galaxies—the consequence of a pluralism I have sometimes felt was as dangerous as it was beneficent.

The guards flanked the Centaurian, looking at me with inquisitive puzzled faces, "face" of course being only an approximation of their aspect and their expressions more likely those I had projected upon them. In any case, they were quite clear to me, while the Centaurian continued to waver between gray and flaming red, though more the former than the latter now.

"Take him prisoner," I ordered, "and keep him restrained by any means necessary."

"Injustice! Bigotry! My government won't stand for such treatment of a humble penitent on a religious pilgrimage to Earth."

"You're neither a penitent nor a Centaurian," I said. "You're an imposter. You're—"

Gray-flecked, gray-flecked. Other beings capering across the checkpoint floor in the light Luna gravity with such grace that it seemed almost a lusty and intricate dance. Yes!

"—a member of a banned race, a Mesmerist from Carinae VII."

The miscreant emitted a cry of rage and attempted a leaping, whirling escape, but there was nowhere for him to go. More than one security guard fired his remedifier, a nonlethal Federation weapon that emits what is euphemistically known as "nerve gas scatter" and causes immediate paralysis.

I watched as the guards performed a scan search of the unconscious Mesmerist and uncovered a cache of the highly addictive, often deadly Carinae hallucinogen that had caused the Federation to ban Earth access to the race. Now that the smuggler's hypnotic hold on me had been broken, I should have been able to see him quite clearly for what he was. Yet he continued to shimmer in my vision, even more humanoid and gray-flecked now but still lacking in full definition. This should not be. Nor should the fact that the Mesmerist had gained access to Luna Dome in the first

place have been possible; the creatures' spellbinding powers were well-documented and this one should have been detected by the checkpoint entrance scanners.

"Put him in one of the detention cubicles," I said to the guards, "and see to it he remains comatose." They proceeded to follow instructions.

Why was the Federation closing Luna Dome? It didn't make sense.

No, it didn't, and the reason it didn't—

I quickly closed my station and left checkpoint, once again with that sensation of bounding weightlessly, though it was not as strong as before. When I reached the administration building, I entered the supervisor's cubicle without observing the usual protocol. Amadeus Finney was standing before the vid monitor that covered one wall; he swung around and glared at me.

"Here," he said, "what's the meaning of this intrusion? You have no right to barge in on me this way."

"Under the circumstances," I said, "I have every right. You've been watching my checkpoint station on the Vid, you know what just happened there."

"Not entirely. Only that you prevented some being from attempting to gain illegal passage."

"Not some being, a Mesmerist hypnotically disguised as a Centaurian and carrying a small fortune in Carinae VII hallucinogens. As you well know."

"As I well know? How could I possibly know when I didn't witness everything that took place?"

"You didn't need to witness it," I said. "You were part and parcel of the attempt."

"What the devil are you talking about?"

"You colluded in the plan to smuggle a dangerous alien and dangerous goods to Earth. You arranged for the Mesmerist to reach Luna Dome, bypass the scanners, and enter checkpoint. No one else on the staff could have managed it."

Finney made spluttering noises. "I did no such thing. How dare you accuse me!"

"That's not all I accuse you of. You also placed a preliminary hypnotic hold on me, so that it would be more difficult for me to detect the ruse at my station."

"Preposterous! I have no such powers."

"The Mesmerists could have taught you the basics," I said. "For all I know, you might have Mesmerist genes yourself; your skin may not be flecked but it's certainly gray. In any case your hypnotic skills are weak and ineffectual. You were able to briefly convince me that the Federation was transferring Luna Immigration to Mars, and to make me believe I was dancing about like a Mesmerist, but the spell wasn't powerful enough to last. I was able to break through it just in time."

"Utter nonsense. Why would I try to make you believe Luna Dome was being shut down if it weren't true? What purpose would I have in making you act like a Mesmerist?"

"For the same reason you sent the smuggler to my station of all those at checkpoint—a vindictive desire to cause me ultimate embarrassment. You hate me, don't you, Finney? Because I'm smarter and better qualified than you. Because I've accomplished more as senior inspector than you have or could ever hope to as supervisor."

Finney had begun to tremble; no longer making eye contact, he sank bonelessly into his desk chair. He was a weak individual, whatever his origins; he would not be able to maintain his position of blustering denial for long. Just as he could not have hoped to maintain his position as supervisor for long, which may have been the impetus for his joining, perhaps even masterminding, the Mesmerist scheme. His delusions of grandeur might even have led him to envision himself as the head of one of the largest systemized drug smuggling rings in Federation history.

In any case we would soon know the full story behind the cabal. No creature has ever been able to withstand the interrogations of Federation security; neither the Mesmerist nor Amadeus Finney would be the first. Both would spend the rest of their days in the penal colony on Jupiter's moon.

Once Finney was taken into custody, the Federation would waste no time appointing a new Luna Immigration sector chief. Yes, and perhaps this time the right person would occupy the supervisor's chair.

Not to be immodest but I was certainly entitled to the promotion, wasn't I? ■

Special Feature

Hiding the Info-Dump

or: Feeding Information Without Choking the Reader

Stanley Schmidt

Science fiction is a literature of ideas. That's not *all* it is, of course, and the field has diversified so much that it's not as generally true as it once was. But many readers—especially of *Analog*—expect their stories to have woven into them fascinating, thought-provoking ideas, ranging from cute technological speculations to full-blown worlds utterly different from contemporary Earth. How can you as a writer get those ideas across to your reader without choking her and bogging your story down in explanation?

There are obviously clumsy, clunky ways to fill a reader in on background. We've all heard the cliché "As you know, Bob . . . ," in which one character explains something to another who must already know it. The situation is so obviously contrived for the reader's benefit that readers today are more likely to ridicule than welcome it.

Just as wince-worthy is interrupting the story while the author lectures the reader on how all the Nifty Stuff works. If the Nifty Stuff is sufficiently nifty, some readers may put up with some of this, but many won't. To see

how awkward it is, consider this made-up contemporary example:

> Knowing the police would soon be in hot pursuit, Beauregard, carrying his bag of loot, ran out the door of the convenience store (so-called because of the long hours it stayed open for the convenience of its customers) to his waiting getaway car. The product of decades of engineering evolution, this was a comfortable four-wheeled vehicle powered by a hidden engine in which controlled explosions enabled it to reach impressive speeds quickly.
>
> "Step on, it, Bill!" he barked, referring to the pedal his waiting driver was already depressing to make the car lurch away from the curb with a squeal.
>
> The next stage in their plan was to pass the loot off to another partner, but they had to be sure he was where he belonged. Beauregard took out his portable communicator and punched buttons. The radio waves it emitted were too weak to reach George, but a nearby tower would relay them . . .

You get the idea.

Such clumsy exposition has given exposition itself a bad name in some circles—including many critics and some readers—and caused some writers to shy away from it even when a story needs it. "Infodump" has become a dirty word, and authors hesitate to explain anything for fear of being branded with it. "It's telling," author Robert J. Sawyer observes, "that the critical lexicon, foisted on us by the English-literature community that looks down on anything that actually sells, has no nonpejorative terms for this narrative device."

Yet ideas, and the ways they're presented, can be some of the most memorable parts of stories. Some have made such an impression that SF aficionados need only a word or two to recall them. Think, for example of Isaac Asimov's psychohistory, Bob Shaw's slow glass, or Vernor Vinge's Singularity. But these ideas would not have engraved themselves so deeply in readers' minds if the stories had not made clear what they were. Instead of shying away from explanations, or making apologies for them, writers should learn to do them well when they're needed.

Is this really necessary?

The first question a writer must ask when tempted to lecture is: does this need to be explained? Does the reader need, or want, to know?

When I asked several authors for their thoughts on this subject, Michael Flynn pointed out, "The trick is to figure what information the reader needs either to understand the story or to experience a fully-textured world ('atmosphere')." Too often, "Infodumps . . . result when an author has done lots of research and wants the reader to know it. (Or, more kindly, is enthused and wants to share it.)" But, as Carl Frederick said, "While an author may well suffer for his research, the reader must not."

When you've done a lot of research to construct a rich, consistent background, you may be tempted to show it all off—but must resist the temptation.[1] A useful rule is, "Know as much as you can about your background, and tell no more than you must."

Let's take another look at that getaway car I mentioned earlier, doomed to failure because it's bogged down in excess verbiage—but this time let's see how a reasonably competent contemporary writer might have told it:

> Knowing the police would soon be in hot pursuit, Beauregard, carrying his bag of loot, ran out the door of the convenience store to his waiting Chevy.
>
> "Step on, it, Bill!" he barked. The car lurched away from the curb with a squeal.
>
> Beauregard took out his cell phone and . . .

There you have fifty words instead of 153, and a crisper, more vivid narrative. There's no need to explain what a car or an accelerator or a cell phone is, and its name evokes the image much more directly than a long-winded

[1] A feature of the *Analog* website called "The Science Behind the Story" lets authors showcase parts of their background that wouldn't fit gracefully in the story.

description. If you're telling the story from Beauregard's point of view, you must describe things as he would. He probably doesn't even know how his car or cell phone works. Even if he does, he's not likely to think about it while making his getaway. He'll simply regard them as ordinary parts of his everyday environment.

That was a major contributor to Robert A. Heinlein's extraordinary success when he suddenly appeared on the SF scene in the late 1930s: he took the future for granted, just as his characters would. The technique was so effective in making the future feel real and lived-in that it has been standard practice for most writers since then, unless they were trying for a special effect that required something else.

But wait, you may say. I can take a cell phone or a souped-up Chevy for granted because I've lived among them and know what they are. But what would that passage mean to a reader in 1814? What would a comparably told passage about something happening in 2214 mean to me?

More than you might think, if the author has chosen evocative names. "Cell phone" or "farspeaker" can suggest enough about what the device does for the reader to run with it, and it hints at a larger background of which it is one small part. To quote Mike Flynn: "Dump a small amount of info to suggest a larger amount."

He cites an example from his novel *The Wreck of* The River of Stars[2]:

> Miko threw the switches and locked them out, one by one. The engineer [Ram] was terrified of outside work. He tried to keep it secret, but Miko could tell. A cold start would require recalibration of the flicker. Someone must physically adjust the focusing rings after each test burst. It was dangerous work, normally done in the Yards. Get the rhythm wrong—miss a beat—and a nanopulse of fusion would be more than flesh and bone could bear. The situation must be serious indeed if Ram was willing to accept that risk while under way and with a high velocity.

* * *

"There is no need," Flynn says, "to explain what a flicker is and why it must be calibrated, nor what focusing rings are. Simply to speak knowingly about them reassures the reader that the narrator knows what he's talking about."

Which is true *unless* the details are important to how the story plays out. If how something works is essential to the plot, the reader needs to know. If it isn't, he doesn't. In that case, spare him. If how something works isn't important to the story development, and it doesn't appear blatantly impossible, it can be taken for granted.

There are two main reasons a reader might accept a piece of your future without balking: because it's a reasonably obvious outgrowth of known science, or because enough other writers have already suggested possible ways that it's become commonly accepted as plausible, as in the case of faster-than-light travel.

And there are two main reasons why you might need to explain something. One, already mentioned, is that some detail of a scientific or technological speculation is essential to understanding what happens. The other is to convey the look and feel—the "sense"—of an unfamiliar time and place.

As Mike Flynn says, "Infodumps are most needed where the reader comes to a text with contrary expectations rather than with no expectations." By default, most readers will assume that the milieu of a story is similar to the one they're living in unless given a reason to believe otherwise. You don't need to mention nearly as many details to evoke New York City in 2014 as you do to make an alien world or a past or future Earth feel real.

So what do you do when something *needs* to be explained?

Tricks that work (at least sometimes)

The first thing you must do, if the reader needs to know something, is make her *want* to know. Let's look at several ways of doing that, each of which works well in some situations (and not so well in others).

•A character explaining something to another who *shouldn't* already know. The trouble with "As you know, Bob . . ." is

[2] Tor Books, 2003.

that it seems silly for people to explain things to one another that both of them already know.[3] But a character explaining something to somebody who *can't* be expected to know is another matter.

But it can't be just anybody. I would not walk up to a stranger in the street and start explaining how to integrate exposition into fiction, or how to solve second-order differential equations. There has to be a believable reason why the explainer would want to explain this subject to that person, and why the explainee would stick around to listen.

A common version of this is what Edward M. Lerner calls "the expert/novice pairing. Here, the expert character lectures an uninformed character (such as a reporter, politician, or a charming but clueless love interest) whose main purpose is to be ignorant—in the interest of eliciting such lectures." It can work, but the uninformed character has to have more purpose than being ignorant for the reader's convenience. The reporter, for instance, might be trying to get the inside story on what seems to be a particularly troubling crackpot theory, as in Isaac Asimov's "Nightfall."[4] The politician might be trying to prevent government action based on what seems to him such a theory, as in my own "The Prophet."[5] The love interest might not be so clueless after all, but trying to gather information to further an agenda of her own.

You may sense that those examples have something important in common, and you're right. But I'll wait a while to say what it is.

Sometimes this sort of explanation can even be an unabashed academic lecture—but there has to be a reason why the character listening to it is doing so. The character's being a student and attending a class in which the professor just happens to be lecturing on a topic relevant to the student's life seems contrived and feeble.[6] But in Poul Anderson's *The People of the Wind*,[7] Chapter 4, a military officer who must lead a campaign against the winged, intelligent inhabitants of Ythri steals moments during his duties to listen to a canned lecture about the evolutionary and cultural background of the Ythrians—because he needs to know his enemy. Personally, I don't think that section is Poul's best writing (though I do think the novel as a whole is one of his best), but the ideas are fascinating, and Lt. Rochefort has solid story reasons for wanting to absorb and understand them.

One of my favorite examples of an expert explaining something to a layman is Bob Shaw's "Light of Other Days," a quiet little gem of a story that first appeared in *Analog* in August 1966.[8] It contains one of the most memorable speculative ideas ever hatched, a uniquely moving story of human interaction, and one of the most perfect integrations of the two I've ever seen. The story couldn't happen without slow glass, and it can't be understood without knowing what slow glass does. It takes place on a "glass farm" where a couple stops to consider buying some slow glass. The wife is shocked at the price the farmer is asking, so he starts to explain why it's so high. The husband has heard it all before, and he's preoccupied with a big problem in their relationship, so his

[3] It does happen in reality; human conversation is not always about conveying new information. Quite a bit of it is reinforcing shared beliefs, two people thinking out loud about a problem they're both trying to solve, etc. A lot of things happen in everyday life that readers won't accept in fiction, and this is one of them.

[4] *Astounding Science Fiction,* September 1941, and many anthologies.

[5] *Analog,* April 1972; now available in *Generation Gap and Other Stories* (print-on-demand and various electronic formats, from FoxAcre Press). I'll sometimes use examples from my own work, not because I think they're the best possible examples, but because I'm particularly familiar with them. And ideas do tend to figure prominently in my stories.

[6] Although that, too, can happen in reality. The inspiration for one of my first stories came from a line in one of Richard Feynman's filmed lectures, which I was watching because they were being shown in the physics department where I was a graduate student. Something similar could happen to a character in a story, though this may be one of those cases where fiction isn't allowed to be as strange as truth.

[7] *Analog*, February-April 1973; Signet Books 1973.

[8] In general, I'm only citing the original publication of my examples, though many are now available online.

attention wanders; but as it does, he recalls the gist of what he already knows about slow glass. With that dynamic among the three characters, it doesn't feel at all like a lecture, and in any case the reader has been primed for it since the beginning of the story:

> Leaving the village behind, we followed the heady sweeps of the road up into a land of slow glass.
>
> I had never seen one of the farms before and at first found them slightly eerie—an effect heightened by imagination and circumstance. The car's turbine was pulling smoothly and quietly in the damp air so that we seemed to be carried over the convolutions of the road in a kind of supernatural silence. On our right the mountain sifted down into an incredibly perfect valley of timeless pine, and everywhere stood the great frames of slow glass, drinking light. An occasional flash of afternoon sunlight on their wind bracing created an illusion of movement, but in fact the frames were deserted. The rows of windows had been standing on the hillside for years, staring into the valley, and men only cleaned them in the middle of the night when their human presence would not matter to the thirsty glass.

How could you read that and not be filled with eagerness to know what this stuff is, and welcome a chance to find out?

•An omniscient narrator, appearing occasionally, briefly, and for good cause, can get away with things that a more limited viewpoint can't. Jerry Oltion says, "In my own writing I try to tell the story from the viewpoint of someone within it, not someone observing it, so the reader gets only what the character notices. The trick is to make the character notice the details that the reader needs." Most fiction writers these days would agree, most of the time—but sometimes a bigger perspective is needed, and readers will accept a brief episode of omniscient narration like this character introduction from Michael Flynn's *The Wreck of* The River of Stars):

> "Eugenie Satterwaithe had been plying the solar system in concentric ripples ever since she had first jumped into that vast, dark ocean. She had flown in the beginning as a ballistic pilot: a young woman, lightning-witted, riding a fiery arc between the antipodes of Earth . . ."

Or, in my own *Newton and the Quasi-Apple*,[9] this opening of Chapter 14:

> What all quasimaterials have in common is that they are artificial standing wave structures qualitatively similar to ordinary matter—although in general their actual energy content is much lower. And, just as computer-generated sounds can have properties "natural" sounds can't, or hologram images can be made of objects which could never "really" exist, they can have properties wildly unlike those of ordinary matter. Some, like the outer hull of the landing boat, are totally invisible from at least one direction. Some, like some of the trinkets Tina peddled after their exploratory magic shows—the balls Kangyr had shown them, for instance—have inequivalent gravitational and inertial masses. Most can be induced to damp out and vanish exponentially—like Instavac, or the ghost statues Chet used to finish the magic shows.
>
> The special qualities of the Type 76CB3 control elements used in Reynolds airfloaters are a little harder to describe.

Why should a reader sit through these when she might balk at similar passages in another context? Context—and timing—are the keys. In each of these examples, a new block of narrative is just beginning, and these bits of description create curiosity and anticipation about what is to follow. In the Flynn example, a new character has just appeared, and a few broad strokes give the reader enough of an impression about who she is to wonder what she's going to do now. In mine, quasimaterials have been mentioned in passing throughout

[9] Doubleday, 1975; now available from FoxAcre Press.

the book, with little explanation, and the last line of the preceding chapter ("At last the sorcerer's apprentice would be the star of the show.") hints that they are now about to play a central role in the story. The two paragraphs launching this chapter provide some relief from a lurking curiosity that (I hope) has been building since the beginning. In the process, they make some quasimaterials sound sufficiently remarkable to make the reader wonder, "What could be even stranger than those?"

The important fact is that these descriptions, tantalizing as they're intended to be, come as something is getting started. Readers would be considerably less forgiving if the action were already rollicking along and the author interrupted it to shoehorn these in.

•Chop it up and spread it out. A common suggestion that's sometimes helpful is to sprinkle tidbits of background information throughout a story, rather than explaining it all in one fell swoop. The earliest ones—for example, bits of slang or jargon from the story's setting, or passing references to something that happened in the past—will likely raise more questions than they answer. That's fine; in fact, as long as they're not *too* mystifying, it can help keep the reader turning the pages. If the writer inspires trust, the reader will keep reading, looking forward to seeing all the puzzle pieces click into place.

Naturally, these pieces shouldn't be sprinkled in at random. Even if their main purpose for you as the author is to build up a framework that the reader will eventually need to understand, anything mentioned should have some reason that makes sense to the reader at the time. As Richard A. Lovett says, "If a character has to dump a bunch of info, make sure it happens 'in' character." Mike Flynn describes an example in a novel he's currently working on that starts out in 1965. Some of us now alive have already forgotten how different that time was from the present, while others weren't alive then. He creates the feel of the period by integrating into the story conversations at parties, breaking news stories on TV, and people arguing about the impact of current events.

When a story has a particularly rich and alien background, in which a reader takes a while to get oriented, there is the risk of confusion over which details are parts of the main narrative and which provide necessary background. Juliette Wade, who quickly established a reputation for such backgrounds with stories like "Cold Words,"[10] uses some subtle but effective devices to keep the two categories distinct in the reader's mind: "My primary tool in this area . . . is character judgment. A character is likely to judge current circumstances—perceptions, other characters, etc.—on the basis of his or her own most relevant experience. This can let me bring in backstory in concise pieces where it will be most directly relevant to ongoing events. The other technique I use is a grammatical one. Essentially I make sure that elements of the main action stay in main clauses, and that backstory elements appear in subordinate clauses, used as support for judgment, or reasoning behind a choice of description."

•Reference excerpts as section heads. Many chapters in Isaac Asimov's *Foundation* trilogy open with italicized excerpts from the fictitious *Encyclopedia Galactica* giving authentically scholarly-sounding introductions to characters and concepts that figure prominently in the story. The first one, for example, is three paragraphs from the encyclopedia's article on psychohistorian Hari Seldon, ending, "The best existing authority we have for the details of his life is the biography written by Gaal Dornick who, as a young man, met Seldon two years before the great mathematician's death. The story of the meeting . . ."

That provides a natural bridge into the up-close-and-personal story itself, while the earlier references to the context of Seldon's life—and the very existence of an *Encyclopedia Galactica*—succinctly provide essential details of background and suggest the grand scope of the story. It was very effective at a time when the concept of a galactic empire was still pretty new. Jerry Oltion recalls that quite a few stories used similar openings in the '60s and '70s, but cautions, "When I was a teenage reader I thought that was pretty cool, like reading an encyclopedia entry and then segueing into a story about it, but nowadays I find that kind of opening clichéd and clunky."

[10] *Analog,* October 2009.

Like any device that's been used quite a bit, it can still work, but it's a good idea to think before using it yet again about whether it's the *best* approach to your particular story.

•A character (or reader) who doesn't understand what's happening, but needs to, will welcome ways to find out. Those ways can include, but aren't limited to, reference books (or their counterparts, such as websites). In Karl Schroeder's *Lockstep*,[11] Toby McGonigal goes into artificial hibernation as a desperate response to a hopeless situation. He doesn't expect to wake up again, but he does, fourteen thousand years later, into a world both complicated and dizzyingly unfamiliar. Naturally he's full of questions, which his rescuers (or are they captors?) answer—bit by tantalizing bit. Like this, when Toby asks why the civilization in which he finds himself is built around what seems to him a thoroughly bizarre practice:

> "Two reasons," said Ammond. . . . If we tried to live like this all the time we'd use up these little worlds in no time . . . That's reason one. We live like arctic flowers, with a short growing season and long winter. It works for them, it'll work for us. But secondly . . ."
>
> But Persea put a hand on his arm. Toby's head was drooping with sudden exhaustion—and from the reminder of how far through time he'd fallen, and how much was now lost to him.
>
> "Maybe . . . we'll talk about that another time," said Ammond.

Toby, in his present condition, might not be able to appreciate the second reason yet, but the reader wants to find out, now that he's been given some information and been told there's more—as will Toby, after he's had some rest. Later, he finds himself with access to a library from which he can get history lessons, and he devours them hungrily, with the reader looking over his shoulder so that both can more fully understand things that have been puzzling them for quite a while.

•The best approaches to filling in information often involve some form of conflict or tension, such as a character trying to extract information from another who doesn't want to share it. Detective stories lend themselves particularly well to this, so it's not surprising that some of the best examples are found in stories by Isaac Asimov, who excelled at combining mystery and science fiction. See, for example, his short story "The Billiard Ball".[12] The speculative device at its core was the joint product of a theoretical physicist and an inventor who were bitter rivals, both personally and professionally. One of them died mysteriously during a demonstration of the device involving a game of billiards between the two. The story is told by a journalist who suspects the incident was more than the accident it has been assumed to be. He interviews the survivor, trying to extract enough information to determine whether what happened was an accident, coincidence, or murder. Determining that requires understanding how the device works, so the journalist has to get the survivor to explain it—and he hangs on every word, because from his point of view, the physics is the key to a crime.

Similar situations abound in such novels as *The Caves of Steel*[13] and *The Naked Sun*[14], but there the speculation is more sociological than physical. In the latter, detective Lije Baley, reluctantly partnered with robot detective R. Daneel Olivaw, is sent to investigate a murder in a culture so different from his own that he visits a local sociologist to try to understand its ways well enough to judge who might be a suspect, and why. The cultural differences make the sociologist profoundly uncomfortable with Baley's mere presence for the interview, so there's an underlying tension throughout.

But the utility of such tensions is not limited to detective tales. In my novelette "Generation Gap,"[15] Robert Lerman, CEO of a minor aerospace contractor who had youthful aspirations

[11] *Analog,* December 2013 through April 2014.
[12] *If*, March 1967.
[13] *Galaxy* October-December 1953; Doubleday 1954.
[14] *Astounding,* October-December 1956; Doubleday 1957.
[15] *Artemis,* Spring 2000; now available in *Generation Gap and Other Stories.*

of being an important research physicist, is having trouble getting Antonio João Pereira, one of the brightest physicists now in his employ, to concentrate on commercially viable projects instead of "pie in the sky." He also finds a letter he wrote at the age of fifteen to be read by his older self, and becomes obsessed with wanting to answer it. It occurs to him that Pereira's "pie in the sky" just might provide a way to do that, so he feels Pereira out about it. That involves getting Pereira to explain what he has in mind, but it isn't just another physics lecture to a captive audience of students. Lerman is conflicted on several levels: He wants to answer that letter, if he can, but he doesn't want to let wishful thinking lure him into doing something he'll regret; he wants to keep Pereira producing for the company, but not encourage him to go off on wild goose chases; and he must be careful not to let Pereira know his real reason for agreeing to reconsider the proposal.

Wrapping things up

I've talked about several methods of weaving background information into a story: bad ones generally best avoided, and good ones that often provide a graceful way to do what needs to be done. I've also promised to tell you what I think the most effective ones have in common.

The answer is surprisingly simple. Just as conflict and tension drive stories, they often drive the best expositions. Simply laying out facts isn't enough. Whether you alternate teasing and satisfaction by doling out bits of information that answer some questions while raising others, or let characters come to fisticuffs over information that one has and another wants, you have to capture the reader's interest at the outset and hold it by making him want the next bit.

The best way to do that will vary from story to story and author to author—and there are no absolute, inflexible rules. Storytelling is such a diverse, subtle thing that almost any "rule" can be violated if there's a good reason for it. For example, I said above that, in general, it's best to tell a scene from the viewpoint of somebody participating in it. An omniscient narrator might be accepted (briefly) at the beginning of a chapter or block of action, not in the middle of it.

Yet when I remember how powerfully Asimov's "Nightfall" hit me when I first read it, and think about why, I find that what I remember most vividly is this paragraph, right after darkness falls, and the stars come out for the first time in centuries:

> Not Earth's feeble thirty-six hundred stars visible to the eye—Lagash was in the center of a giant cluster. Thirty thousand mighty suns shone down in a soul-searing splendor that was more frighteningly cold in its awful indifference than the bitter wind that shivered across the cold, horribly bleak world.

That paragraph was not in the story as Isaac wrote it. How do I know? He told me, years later, and he was not happy about it. John W. Campbell, editor of *Astounding,* added it, and Isaac didn't like it because it was a clear and, to him, jarring break from the consistent viewpoint he had maintained throughout the story. The inhabitants of Lagash knew nothing of Earth; the story never answered the question of whether even their remote ancestors had come from here. They had never seen stars before, and they couldn't possibly have compared the ones they saw to what they might have seen on Earth.

But for a reader on mid-Twentieth-Century Earth, the paragraph, despite breaking all the rules, *worked*. For me, it was the focal point of the story; it instantly gave me a vivid picture of just how starry that sky was, which I wouldn't have had without it. In this case, I have to agree with John. In general, I don't like editors changing my stories without my consent, but in my opinion, this change strengthened the story—a lot.

But before going off and doing whatever kind of exposition you want, regardless of rules, bear in mind that artists who successfully violate rules usually know exactly what they're doing, and why. Keep in mind what I've said, but remain open to learning by observation. When a story works for you—or fails to—you're likely to know it first as a gut feeling. But then look closely at what the writer is actually doing, and think about why it does or doesn't work, and how you can apply what you've learned to your own writing. ■

Partible

K.J. Zimring

"Congratulations on your impending fatherhood." Eileen grinned as she waltzed into our office.

"Very funny." I didn't even look up from my computer. "You're late. We have that trend analysis meeting in fifteen minutes."

"Seriously." She waggled an official-looking document in front of me. "You got mail from the Bureau of Immigration and Naturalization."

I took the envelope from her and stared at the return address. "What's the Minor Emigration Division?"

"That's the department of baby daddies. I've read about them. Any kid of an American has the right to emigrate, you know. If you go to another country and impregnate a fair maid—knock a local up—pop a bun in a hometown oven—"

"I get the picture." Except I didn't. Because I hadn't. I've traveled, of course, but the closest I've ever come to sampling the regional delicacies has been to get out to a Zagat-approved restaurant or two.

"I'm hurt." Eileen picked up my statue of St. Jude and gave it a little smooch. "You should have told me what you'd gotten up to. I tell you everything I've done, love-life-wise."

"You couldn't possibly have." I took my statue back. "No one has that much time to listen."

She snickered. "Well, I've told you the highlights. And really, given the utter zero *your* love life has been ever since I've known you, I can't believe you held out on me about a juicy vacation hookup. Where was it?"

"Nowhere. I promise." That was the truth. It had to be some kind of mistake. I slit open the envelope and pulled out the papers.

Eileen peered over the desk and read upside down just about as quickly as I read right-side up. Of course, shock might have slowed me down a little. Because she was right. A kid had come through SeaTac, originating in the Pacific islands and connecting through the Philippines. The passport was fake, but he claimed an American father, named me, and the allegation had to be evaluated. I was to present myself for an interview at the Tacoma Northwest Detention Center on May 5 at 1:30 P.M. Lawyer optional.

"Aw," said Eileen as she flipped through the papers. "It's a boy. Nine years old, so you've missed those first steps/first words. Still time to teach him to play ball, though. I mean, if you knew how to do that kind of thing." She tipped her head. "So where were you nine years and nine months ago?"

I remembered it exactly. Nine years and nine months ago I'd been hopelessly, helplessly in love. On the Pacific island of Kiribati. But I hadn't done anything. Just like always, I'd let the moment slip away from me.

So I couldn't have a son. It wasn't possible. Even if my heart had sped up, just a little.

I'd pictured the Tacoma Northwest Detention Center on the drive down from Seattle and frankly I'd been expecting something a little nicer. I mean, they send minors here. Kids who aren't accused of anything other than having the wrong papers. If there was a difference between the Tacoma Northwest Detention Center and a jail, though, it wasn't apparent from the high walls and the barbed wire on the outside.

Not much different on the inside either, though I freely admit everything I know about prisons I've learned from HBO. Still, it was grey and cold and concrete and claustrophobic as all heck. I couldn't imagine how bad it would feel to end up here if you'd spent your entire life growing up in the greenness of Kiribati.

I presented my ID and got waved through into a waiting room someone had painted an overly optimistic yellow. Stacks of years-old magazines littered the tables and after confirming my phone had no connection, I settled in to find out who Larry King's ninth wife was going to be. Back here in the present, he'd already divorced her, but I decided to suspend my disbelief and marvel at the pretty, pretty ceremony.

Hell, he'd gotten farther than I had, depending on how you squinted. I'd never even made it down the aisle once. Which one of us had done it right?

My depression had deepened to the deep grey of the typical Seattle sky by the time they called my name. A guard buzzed me through a series of doors, taking me deeper and deeper into a maze even Mrs. Frisby couldn't solve. Finally I got left in an antiseptic-smelling room.

I waited there a long time. I'd had dreams like that, dreams where I'd waited and waited, and no one ever came. There weren't even any magazines, which helped my sense of inferiority-to-celebrities, but left me with nothing to stare at but the posters on the walls (VOTE! IT'S YOUR RIGHT!).

Finally, the door opened and a woman in scrubs came in. She gave me a professional smile—quick and not reaching to the eyes—and then she was in front of me with a swab in her hand.

"Open up."

"I'm sorry?"

"I need to take a sample. For the test." She sighed and looked impatient. "The DNA test."

Oh. Of course. I opened my mouth obediently and let her rub the swab up and down inside my cheek. It tickled, but it wasn't unpleasant. Not enough to explain my sudden intense desire to retch.

"So it doesn't really matter," I said as she sealed the swab in a plastic tube and labeled it with my name. "What I say at the appointment, I mean. You just want to know if the DNA matches."

She smiled with her lips alone again. "That's right, sir. If the DNA doesn't match, it's not your child. If it does, he is. That's all we need to know."

"Oh. How long does it take to get the results?"

She dropped the tube through a slot and turned around. "We do a rapid PCR test here, sir. You'll have the results by the end of your interview with the emigration officer."

The guard came back and showed me down the hallway, past another set of locked doors, and into another office. A dark-haired guy of about my own age, mid-thirties or so, sat behind a desk.

I introduced myself and took a seat as the guard closed the door behind him.

"Henry Wong," the emigration officer said in return. He caught me looking at the picture on his desk and smiled. "My husband and our kids."

"I don't have any myself," I said then stopped. "I mean—"

He laughed. "I guess we'll be the judge of that, huh?" He pulled his keyboard toward him and clicked open a form. "You're an anthropologist? For Amazon?"

I nodded. "They're interested in populations, trends, predictions of behavior. Amazon's got a bigger anthro department these days than most universities."

"So you studied it in college? Then ended up there?"

I shook my head. "I started in the real Amazon. The Amazon basin, in South America. The Salesian missionaries run everything there."

Henry's lip quirked up, but he didn't outright laugh. "You were a priest?"

"I was a seminarian." I looked away. How could I sit across a desk from a stranger and

explain losing my vocation? Not my faith, though, for better or worse—I hadn't ever lost that, even if it seemed sometimes to have cut me off from people instead of leading me toward them. "I left that and started working with one of the anthropologists down there. The fellow I ended up doing my PhD with, in fact—he focused on indigenous concepts of partible paternity."

Henry kept his eyes on his computer screen, politely. "What does partible mean?"

I blessed him for going for the academic question. "It's the idea that a child can have more than one biological father." I cleared my throat and felt that old lecture mode settle over me. "The Mehinaku of Brazil, for instance, don't think having sex just once can result in a child. It takes many acts and all the men who ah—contribute—are felt to be the fathers. The Xocleng and the Arawate think the same, and the Tapirape think that intercourse has to continue all during the pregnancy or it will fail. All the men involved, up to the very end, are acknowledged as fathers of the child."

He typed that in, too. Gotta fill all those blanks in one way or another, I suppose.

"I spent most of my time with the Kuikuru, though. They believe a spirit sculptor lives inside a woman and takes all the donated *material* and uses that to make the baby. The more male donations the better—"

Henry flicked me a look. "I've got friends who'd agree with that."

I grinned back and thought of Eileen. "I have a friend who said if that was true, she'd have had the world's biggest baby already."

"I don't think Uncle Sam concurs, for whatever that's worth." He paused and looked directly at me. "Not to pry unduly . . . but . . . Did you?"

"Make a deposit? Nine years ago in Kiribati?" I shook my head. "I was there with a Catholic mission, on the secular side. Medicine, education, outreach. I admit that. I mean, I know you have airline records."

He nodded. "We always confirm foreign travel in these cases. It's part of the preliminary investigation. But the mother—"

"I knew her." I swallowed. "Not *knew* her, knew her. But I never did—anything—with her."

He turned back to the computer and typed that in.

I shifted in my seat. "I mean, if there was a chance the kid was mine, I'd tell you. I wouldn't lie."

"I wouldn't want you to. It's hard to turn a child away, of course, but we have rules to follow. If he's your son, he'll be admitted. If not, I'll have to send him back."

"I know Kiribati's in trouble." The awkwardness was rising. "I mean, of course I know that. It was barely above sea-level when I was there and with the ocean rising most of their land is gone now." All those places where I'd been young and in love had to be underwater now. Everything washed away, salted and scrubbed bare.

"His name is Anote." Henry cleared his throat. "The mother is deceased."

Grief struck me, cold and sudden as an ice bath. Teata. Dead. I should have contacted her, somehow, even if there was nothing to say. Obviously she'd remembered me, even if there'd never been more between us than smiles and talk and warm nights I hadn't let lead anywhere.

Before I could say anything to that, a knock came at the door.

The nurse pushed her head inside. She gave me a knowing look and handed Henry a piece of paper. "Got the results right here."

My stomach knotted. I knew the answer—*no*—but I wished it could be *yes*. I wished I had, back then. I had waited, thinking something more real, more right would appear someday, and it never did.

Henry sat back and opened the paper. He studied it for a moment, and I think he almost smiled. He handed it over.

There was a lot of government-speak at the top. I skipped that and let my eyes fly to the bottom of the page. Match, it said in big letters. Below it were the lines of base pairs. Every section showed a match.

I was a father. Except I *couldn't* be.

I sat in the last pew of the cathedral. I'd driven back to Seattle in shock. Henry had made arrangements for me to meet Anote. The kid-who-couldn't-possibly-be-my-son. Two days from now, together with Henry, we'd have our first meeting at the detention center. They were already processing his citizenship papers.

The door opened with a creak, and footsteps clicked in the aisle.

Eileen slid in beside me. "I knew you'd be here."

"I'm sorry I didn't come in today."

"Please. It's your first day off in, what, ever?" She cut me a smile and a sideways look. "You better save the rest of your sick days though. Gonna need those now that you're a dad."

"Eileen." I drew a deep breath. "Do you believe in miracles?"

"Nope." She pressed her shoulder against me. "Got any other questions?"

"No, really, I mean it. It's the only explanation for this." I must have looked like an idiot, but I couldn't keep the smile off my face. "For me being a father."

"Actually, I can think of a better explanation. When a really nice mister bird meets a nice lady bee on a beautiful Pacific island—do you see where this is going? You're an anthropologist, right? You had to have passed freshman bio."

I snorted. "I passed it. It's just we didn't—"

"Listen, I know how it goes when you drink too much. Do you think I've never had a night I could only reconstruct via Instagram?"

I laughed. "Oh, god. I remember Instagram."

"Happiest day of my life when Instagram crashed and burned forever. Thought I was going to have to fake my own death and come back as someone else if I ever wanted to show my face professionally."

"Don't worry. We all think you're as innocent as a lamb." I cleared my throat. "I'm a virgin."

"What?" Eileen whipped around and coughed hard. Or laughed. Whatever it was, it involved her eyes bugging out. "You are not. You can't be."

"Why do you think I've never mentioned being with anyone in the entire time we've been together?"

"Because you're more polite than me? Because a gentleman doesn't kiss and tell?" She bit her cheek but her eyes kept dancing. "Because maybe you once caught that antibiotic-resistant gonorrhea and had to spend a week in the hospital getting it treated by IV and it scared you off sex for ever after?"

"You thought that? About me?" I might have sputtered.

"No. Maybe. Well, it was a possibility." She made a moue. "But a virgin? Honestly, no. I never considered that."

"That's why this is a miracle." Late afternoon sunshine streamed through the stained glass windows. "I should have, back then on Kiribati. I've thought that so many times since then. I wished I had. I loved her but I thought something more real and right and perfect would come along afterward and it never did."

She took my hand. "The results say you're a dad. You can't be a virgin, kid."

"I'm a virgin and it was the worst mistake of my life, not being with her. I didn't do anything but I should have." The light coming through the window intensified, turning the blue of the Virgin Mary's gown into a cobalt glow so deep it almost hurt. "Seriously. You don't believe in miracles?"

"I believe in Budweiser. Are you absolutely certain you didn't have too many one night? If this kid is really a match, DNA-wise, and you don't remember being with her, that has to be the answer."

I shook my head. "I didn't drink back then either. And I've never taken drugs."

"Lord, your body really is a temple. And not the fun, ancient Greek type either." She gave me a speculative look. "Speaking of ancient Greeks?"

I blushed like the virgin I was. "No. I like women. I'm not confused or in the closet or anything like that." I bit my lip. "I just wanted it to be right, you know? And each year, with every opportunity I passed up, the pressure grew. For the big event to be just right, with the exact right person."

"Hell, I would have laid you myself if I'd known."

"You're too kind." I leaned against her. "I would have turned you down."

"I think we might be developing a Madonna/whore complex here, between the two of us. And I know which side of that slash I've always been on."

I took her hand. "I think you might've gotten the better end of the bargain." A wave of grief rolled over me. "There's so much I should have done. So much time I spent alone, being pure, when I should have been with someone else. I didn't make mistakes, but I never made anything right either."

"You made a son. Somehow. Some way."

"I did." Light filled me up, fast as the grief but somehow more enduring. "I don't understand how it happened but somehow it did."

The Virgin Mary and me. Preposterous, but we had something in common, me and the saint in the window. We each had a son. Conceived who knew how but wanted nonetheless.

I spent the next day in a frenzy of preparation. The local middle school is good, my nephews go there, and I could get Anote enrolled right away. My sisters had dropped off hand-me-downs, but I'd sprinted to the store after work and bought some new clothes, too. And junk food. Lots of it. If the clothes weren't right then at least the Cheez Doodles ought to be.

This time at the Detention Center I got sent directly to Henry's office. No one was there when I arrived ,but they had me take a seat inside. I sat, and I waited. I could practically hear my stomach acid percolating by the time the door eased open.

"Henry," I said, standing up. My heart was in my throat as I craned to see the boy. My son. "Anote."

Anote was a little taller than I'd expected and boy-kid skinny. He smiled at me, eyes down, nice-looking but a little awkward. A couple of cold sores lingered near the corner of his mouth. I wondered whom he'd kissed.

Nothing like me, then, at his age. Good for him.

Henry brought him in and eased the introductions and soon had us both sitting, eyeing each other. I smiled and tried to put my soul into it. I wanted him, my miracle son. I needed him to know that.

"Can I take him home? Now?"

Henry booted up his computer. "Paperwork first."

I couldn't complain. What was a little bureaucracy compared to labor? Nobody had ever needed morphine for paperwork, even if it came in triplicate. We ran through names and dates, and Anote even smiled when I talked about the time I had spent in Kiribati.

He talked too, loosening up as he told me about places I'd known that were gone now and places that were still there. His English was good. Australian accented, which didn't surprise me—most of the Kiribatians had learned English from the Aussies. He'd probably be the hot foreigner to the girls in his class. Anxiety seized me, equal parts determination to introduce him to the parish priest and the fine folks at Planned Parenthood. I wouldn't be crazy with my kid. I'd make sure he treated girls well but didn't take the catechisms too literally. He'd manage everything better than I had, if I could help it.

"Anote has something to show you," Henry said finally.

Anote leaned back. He seemed reluctant, almost, but pulled something out his pocket under Henry's gaze. "I have this. From Mum."

I might as well have been kicked in the heart. He held a brooch. Tortoise-shell frame surrounding a glass-enclosed double lock of hair. Hers and mine, pulled out by the roots and wrapped together, just like the Victorians had done it. That's what you get for dallying with an anthropologist, I guessed. Ancient romance, instead of modern love.

"It's noted in the intake paperwork as a piece of jewelry." Henry looked from one of us to the other. "I haven't been more specific than that in my notes."

Okay. His look seemed—*significant*—shall we say? "I don't think it's worth much. If that's the issue. I mean, I can pay, if there's an import tax." Tortoises weren't endangered now, were they? Was Henry implying there was something important about the brooch?

Anote looked from one to the other of us and licked his lip, nervously.

I put out my hand, took his, and squeezed it. I was a little worried—he'd never even seen me before today—-but Anote shot me a grateful look. We were together in this, it seemed to say.

"I also reviewed the medical records." Henry kept his face fixed on the screen, though there was nothing there he hadn't typed himself. "Absolutely clean on entry. No sign of disease."

"Great," I said. "I mean, not that I'm not going to find a good pediatrician. I've got some referrals already—"

"The oral stomatitis virus doesn't manifest clinically until one week post-exposure. Genetically, of course, its effects appear as soon as the virus integrates into the buccal mucosa." Henry looked at me. "My husband is in the genetics department at the U. I get to hear about all the latest developments. Especially any speculation about things that could affect emigration."

"I'm sorry?"

Anote touched the sore on his lip. I moved my chair closer to his, instinctively. Was he ill? Did he think I wouldn't want him if he needed medical aid? "I have health insurance. I've already applied to add a dependent."

Henry still didn't look at me. "I haven't updated the forms on physical health. As far as I'm concerned, we don't have to."

I didn't understand, and I was getting mad. Who cared if he documented a cold sore? "It doesn't matter what it is. We'll deal with it."

Henry finally swiveled toward me. "There's a paper that came out a little while ago. The oral stomatitis virus as a vector for delivery of engineered DNA."

I admit it. Panic seized me. What was the oral stomatitis virus? Was it as bad as HIV? Ebola? Double Dengue? "I don't care. I'll take him directly from here to the hospital if I need to. I'm not leaving my son here and I won't let you send him back."

"Have you heard of CRISPR-Cas9?"

It sounded like a boy band. I shook my head. Anote's body was rigid, almost. I squeezed his hand again.

"It's a gene therapy system. The one they used to cure sickle cell anemia, if you remember that? Targeted the sickle hemoglobin genes, stripped them out, and replaced them with functioning copies. They've cured a lot of chromosomal diseases with it since then. Anything you want switched out, genetically speaking, can be changed these days."

It rang a bell. Maybe. The science I looked at for work these days was mostly psychology and sociology. "What does this have to do with my son? Does he need gene therapy?"

"No. He doesn't need it. He's already had a little of it, I bet. Haven't you, Anote?"

Anote blinked. That was the only movement he made. The rest of him was frozen stiff.

"There's been some rumors about some of the more enterprising Chinese gene labs. Nothing we've been officially instructed to screen for. Yet." Henry sighed. "If you can strip out a defective gene, you can strip out any other small region. Like a testing region for paternity. Then replace it with the sequence of your choice."

"A new sequence?" I heard myself say.

"A sequence that matches a certain paternity. If you have someone's DNA, you can use the CRISPR/Cas9 system to engineer a perfect match to it. Something like the oral stomatitis virus would work well to deliver it. It infects the inner cheek, just where we take swabs for DNA."

"It would just be superficial, a minor change in a few DNA regions in only the cells of the cheek. It wouldn't match DNA from the blood." I heard myself say that, though I could barely feel my lips move. "You could tell that way."

"Sure," Henry said. "If we did a full blood to blood DNA comparison, the mismatch would speak for itself. It would have to mean emigration fraud. But like I said, there's no requirement for more extensive testing at the current time."

"Could I request it though? A full blood DNA test?"

"Of course. If you want it, we can do a test via the old RFLP method. If—if—there's emigration fraud—which I want to be clear I'm not accusing anyone of—it would show up on that."

I pushed back my chair. I stood up and left the room. No, let's be honest here. I *ran* from the room. Like I ran away from everything big, everything that could be real, but wasn't exactly what I wanted.

I stopped when I got to the antiseptic-smelling swab room. It was empty now. The nurse was gone, thank god. I sank into the chair, put my head in my hands, and went ahead and cried.

Gene therapy. Not my child. Not my miracle. This wasn't perfect. This wasn't even close to right. Grief filled me so full I felt swollen. Like there were places for grief beneath my skin that I hadn't even known were empty.

Finally, I stopped. I went back to Henry's office. Anote was still there, but I almost couldn't look at him. Couldn't track the tears that were dripping down his cheeks too. I closed the door and took a seat. "How did it happen, Anote?"

"Mum was sick." He pointed to the right side of his stomach, just beneath his ribs.

"Hepatitis," Henry said. "According to the paperwork."

I nodded. It was so common there. Curable, if you had good healthcare. With gene therapy, come to think of it. A reputable use, that

one was—stripping out a virus was hardly the same as faking a paternity test. "She couldn't afford a doctor?"

"We had the money. For the treatment." The brooch trembled in Anote's hands.

Henry leaned forward. "But she decided to spend it on you instead? Is that how it happened?"

Anote nodded miserably. "She said the doctors said it was really too late, by the time we had the money. She was already too bad. Even if they took the virus out, it wouldn't make her better."

Her liver had been too badly damaged. And Kiribati was sinking. I felt sick, sicker and hotter than I'd ever felt in my life.

Henry swiveled a picture toward me. "That's my oldest on the right. Helena. She's seventeen now. We did an open adoption to get her. In the middle is Evan—he came from foster care and never left. Daniel is our youngest. He was left in bathroom in Nevada, nobody could find any next of kin for legal forms and the adoption paperwork was unbelievable."

"It wouldn't be hard for me." I still couldn't meet anyone's eyes, not Henry's and not Anote's. "The paperwork, I mean."

"I won't make it hard, if that's your question." Henry pushed the keyboard away and leaned back.

Anote might have started breathing again. Shallowly, but breathing. Teata was dead, I reminded myself. How resourceful she'd been. She must have gotten my DNA from her old brooch, from decades-old skin cells on the roots of my dead hair. Then she'd found the syndicate that specialized in gene-based fraud—

I wondered how many people had already come in this way, matching themselves to people here, living or dead. I wondered how many more would come before they shut this down.

I didn't need to wonder what I would do. "I don't see anything wrong with my son. He looks perfectly healthy to me."

I heard Anote swallow. The tears didn't stop, and if anything, he shook a little more. The rigidity left his limbs, though, and that helped me breathe, too.

"I'll put no visible sores or other illness on the form then." Henry looked from one of us to the other. "I wanted to be sure there's no misunderstanding here. I won't be part of misleading you even if I think the end result is good."

"I appreciate that," I said. "I understand everything. And I appreciate all you've done to help put my family back together."

Kiribati sank last year. It was on the news. Of course, it had been sinking for a long time, but now every last piece of it is underwater. Teata is underwater, in her grave. I wondered if she'd ever float free, up among the bobbing waves, or if she'd sunk further and ended encased in coral. She would have preferred that, I think. She'd never wanted to leave her green and perfect land.

Anote is doing well.

I'm not perfect. Lord knows, Anote's not perfect. He's thirteen now, and sometimes I despair of everything about him, from his grades to his attitude to his inability to pick up a towel up off the bathroom floor.

We're both alive, though, and not just in the breathing sense. We're making mistakes and moving on, and I even think I'm coping well with the things I'm sure he's getting up to with his very first girlfriend. I like his genes, no matter where they came from. That doesn't mean he needs to be in a hurry to pass them on. I might be a father, but I don't need to be a grandfather anytime too soon.

Sometimes I wonder what percentage father I am. Just the tiniest amount, a few small sequences on the inside of his cheeks? Is it like Uncle Sam says—one genetic father and that's it? One hundred percent or nothing? Or is it a more Catholic thing, a trinity type deal? Is there me, and whoever actually fathered Anote, and Henry, too, playing the part of the Holy Ghost, stepping in to offer a little wisdom from someone with a little higher knowledge but no actual hand in the game? Or is it like the Amazon tribes think, and there's a huge range from zero up to one hundred, encompassing everyone who ever loved or cared or made some contribution to the mother of the child?

Then I pick up a towel, and the answer is obvious. I'm 100 percent of the fathers that are here right now. Also, I need to do some laundry. Or make him do it. He'll be going off to college soon enough. I should probably teach him how to sort everything out, as best I know how to do it. ■

Down Please: The Only Recorded Adventure of Lars Fouton, Captain's Lift Operator on the Starship *Magnificent*

Adam-Troy Castro

Nobody was more surprised than Ensign Lars Fouton when the lift doors whooshed open and revealed his captain standing next to something indescribably awful.

It wasn't just the sight of the awful thing that unnerved Fouton. He had been the captain's private lift operator for all seven years he had served on the *Magnificent,* and even that socially isolated position had given him the opportunity to see representatives of any number of the alliance's member races in the flesh. Just walking down the corridor to and from work, he had seen creatures who exuded slime, creatures whose organs hung outside their bodies like handbags, and other creatures so vile to the human eye that only the academy's sensitivity training permitted him to gaze upon them and not commit a serious diplomatic faux pas by projectile vomiting.

Truth to tell, Fouton was, if anything, even more surprised to see the captain, a democratic sort, who, despite heroic exploits that had made him a legend throughout civilized space, had for most of Fouton's many years on the job always made a point of using the same elevator banks patronized by the rest of the

crew, even if that required uncomfortable small talk and time-consuming stops on all the intervening decks.

The captain's personal lift may have been 20 percent larger and 10 percent faster than what the crew got, but the captain had always treated this prerogative of command as an unnecessary affectation, reducing Lars, the crewman assigned to that duty, to an invisible man, existing in a limbo that was only rarely disturbed by incident.

The *Magnificent* was so legendary a starship that it was impossible to count the alien civilizations who had immortalized the deeds of its crew in song. But stuck at the corner of this little box, manning the five buttons that controlled all its possible functions, Fouton had missed entire shipboard crises, aware that they were happening only because he could hear the red alert sirens and grim shipboard announcements from where he stood.

The captain had one of those faces that always ages deeper into itself, the years marking him with little but additional nobility and gravitas; and as always on the rare occasions when he deigned to appear at the lift doors, he had trouble suppressing the wince that came over him whenever he saw how much further Ensign Fouton's features had been marked by time over the months the captain had been successfully avoiding him.

He nodded. "Ensign."

Fouton stood straighter at his control panel. "Captain."

The awful thing followed the captain into the lift. Its method of personal locomotion was less the gait of a walking creature than that of a flesh avalanche, acquiring additional debris as it careened downhill. Fouton could discern eyes in the chaos it possessed instead of a face, but no other features he recognized, unless the sacs that hung from its substance in various places were organs that evolution hadn't thought to store inside where all good organs should be. It did, however, wear the starburst badge of the alliance, along with a number of other medals and decorations, which marked it as a being Fouton was obliged to respect.

The captain recovered from the usual horror he displayed whenever exposed to his occasional reminders that Fouton existed, and returned to his usual Shakespearean baritone. "Ensign, this is our honored guest, General," and here he made a noise like a high-pitched whistle in a factory beset by misaligned gears. "The general will be onboard over the next few weeks to observe our maneuvers in the Ikiirish Cluster. Because of the size of his particular species, he will not be comfortable in most shipboard conveyances and is hereby authorized full access to this my private lift on his daily travels between guest quarters and the bridge."

"Yes, sir," said Fouton, who was unable to resist adding, "It will be a pleasure to have a regular passenger, sir."

The captain's noble features betrayed a twinge of guilt. "Yes. Well. Extend him every courtesy."

"Up or down, sir?"

After a moment of uncomfortable silence, the captain said, "Down."

Fouton depressed the down button and cupped his hands together at belt-attitude. He stood at the one green square in the corner of the elevator that designated his post, not shifting even for comfort.

Silence reigned in the cramped space. It usually did, of course, since the only sound that filled these few square meters was most often Fouton himself, doing deep-breathing exercises to avoid nodding off, but it was somehow thicker and more intolerable when the captain was involved. It never took more than two minutes in this express lift to travel the seven kilometers between one end of the massive starship to the other, and the captain was usually capable of maintaining silence for that long, so conversations here were rarer than humanoid life on methane planets. But the awful thing must have found the void too oppressive to endure. "Good captain? Will etiquette permit me to ask some questions of this crewman?"

The captain bore the nauseated look of somebody who would have rather been almost anywhere else. "Of course."

The awful thing turned its singular gaze on Lars. "Your name is Photon? Like the light particle."

Fouton said, "No, General. It isn't spelled or pronounced quite the same way."

"This is a shame. Had you truly possessed the name of such an elemental particle, you might have been able to derive strength from it." The general's single eye migrated across

the lumpy landscape that didn't qualify as a face and focused again on the captain. "Forgive me. Will it violate human etiquette for me to ask this one additional questions?"

The captain sighed. "No."

The eye rolled toward Fouton. "We boarded this conveyance at the ship's bridge. Is that correct?"

"Yes, General."

"The bridge is, relative to ship's gravity, the highest point on the *Magnificent*. Is that correct?"

"Yes, General."

"There are no hidden decks higher than the bridge to which this conveyance can travel. Is that correct?"

"Yes, sir."

"And the VIP deck, where the captain also retires when off-duty, is relative to ship's gravity the lowest point on the ship. Is that correct?"

"Yes, sir."

"There are no hidden decks lower than the VIP deck, to which this conveyance can travel. Is that correct?"

"Yes, sir."

"And there are no intervening decks upon which this vehicle can stop?"

"No, sir."

"So this conveyance only travels back and forth between those two points, the VIP deck and the bridge?"

"Yes, sir. It is an express lift."

"Then why," the general asked, "did you find it necessary to ask the good captain in what direction he desired this conveyance to travel? Was *'down'* not by default the only direction available?"

"It was," Fouton replied, "but that's protocol. You always ask the passenger 'up or down' even if you already know exactly where you're going."

"I see. And the same follows when you pick up the captain or one of his VIP guests, down below."

"Yes, sir."

The doors opened on the VIP deck. Fouton announced their destination. "VIP deck."

The captain exited with significant relief, but the general paused at the threshold, turning to address Fouton some more. "May I ask you another question?"

"You do outrank me, sir."

"We are on a starship that can travel at multiple times the speed of light, performing intricate maneuvers that defy Euclidian geometry and three-dimensional physics. Many of those are counterintuitive to human experience and therefore require substantial input from artificial intelligence. Because even competent human beings are able to make disastrous errors in crisis situations, your consoles are capable of interpreting voice commands differently depending on the metabolic levels and other stress indicators of the human beings who provide them. In the fleeting conditions of interstellar combat, they can calculate the fastest, safest and most efficient methods of pursuing a given strategy at a rate far exceeding your own neurological processing time. By such standards, the *Magnificent* is indeed alive, and sentient, by any measurement you can name. One would think your technology also capable of programming an elevator capable of transporting any given individual to and fro within that ship, without completely monopolizing the time of one crewman to that dreary and mind-numbing task. And yet here you are, stationed at the controls to this internal vehicle that travels along a fixed track, asking us 'Up' or 'Down.' It beggars logic. Why would your superiors condemn you to this purgatory? Why did they not automate your function long ago?"

Fouton said, "I suppose they never saw it as important, sir."

The general paused and said, "Good afternoon, Ensign Fouton. I look forward to conversing with you again."

"And you, General."

The ambulatory avalanche cascaded out the door, continuing to churn as it made its way into the corridor outside, and followed the captain to the VIP suites. The captain did not look back, nor did he return to the private lift that day; when the time came for him to return to the command chair, he must have made his way through the maze of corridors to one of the crew elevator banks rather than use the lift that was his by prerogative of command.

Fouton stood at attention another four hours and twenty minutes, then went off duty, returned to his quarters, and put on a movie.

* * *

The next day Ensign Fouton was standing at his post when he received a call to collect the general from the VIP deck. He pressed the button, rode the lift down, then stood aside as the alien dignitary maneuvered his massive bulk into the available space.

The general rumbled, "Good morning, Ensign Fouton."

It had been a long time since anybody had wished Ensign Fouton a good morning. "Thank you, sir. Going up?"

"Not just yet, if you don't mind. I still have a few minutes before I am due at today's maneuvers, and I confess that I am still so fascinated with your situation that I cannot resist the opportunity to ask you more questions."

Fouton broke out into a broad grin because it was also extremely rare for anybody to ask him personal questions. "Very well, sir."

"You are not an enlisted man, but an ensign. Correct?"

"Yes, sir."

"That indicates you completed your full course of study at Star Command academy. The academic standards at that fine institution are among the most rigorous in the Universe. It is open to only 1 percent of those who apply, and only the top 25 percent of each year's graduating class graduates to actual service on a starship. The rest, I'm told, stay on the ground or in orbital docking facilities, providing support services for the more accomplished among you, those who are considered the best of the best of the best. Is that correct?"

"Yes, sir."

"This means that in order for you to qualify for your little job, you must be among the smartest and most talented representatives of your species. You must have excelled in astrophysics, engineering, astrogation, military history, hand-to-hand combat, psychology, diplomacy, multiple alien languages, field medicine, software design, and numerous other highly demanding disciplines, just to get a berth aboard any ship, let alone aboard this, the legendary flagship of the alliance fleet. Am I correct on this?"

"Yes, sir."

"Further, to even enter the academy you had to want to dedicate your life to something larger than yourself, something that would grant you the opportunity to travel the Universe, seeing great sights and performing great deeds. You had to be the kind of person your superiors would see as worthy of this splendid destiny. Instead, you spend your days in this isolated position, denied all opportunity to demonstrate your mettle, insulated from every decision of importance, protected from every sight but the four walls that surround you, never tested beyond the elementary skill it takes to push either the button that sends this conveyance up or the one that sends this conveyance going down. Is that correct?"

"Yes, sir."

"Unlike, let us say, the captain, who is precisely your age and would have attended the academy at the same time as you, you have never had the opportunity for any grand adventures. You have never covered yourself with glory, never proven yourself, never made yourself a name, correct?"

"Yes, sir."

The general hesitated. "Forgive me if the following questions appear confrontational. Are you held in poor regard for some reason?"

"Excuse me, sir?"

"Are you a member of some despised caste the privileged will not permit career advancement?"

"Oh, no, sir. The human race evolved past all that nonsense long ago."

"Do you have a personality offensive to other members of your species?"

"I'm told I'm rather likeable, sir."

"Are you disabled in some manner undetectable by me that would lead your people to assign you this pointless busywork out of pity?"

"Not that I am told."

"Are you being punished for some infraction that would lead your people to condemn you to a career spent trapped in this most humiliating of all possible duties?"

"Oh, no, sir. I get positive reviews every quarter."

"Is there any possibility that by doing this banal work you might somehow be compensated with a more rewarding assignment more appropriate for one of your qualifications?"

"No, sir."

"Then pray explain to me how you wound up doing this."

Fouton glanced at the array of buttons before him. It wasn't a complicated array, cer-

tainly not one tenth as blessed with options as the one on a helmsman's console. They were all clearly labeled: UP, DOWN, DOOR OPEN, DOOR CLOSE, ALARM, EMERGENCY STOP and SHAFT MAINTENANCE. The array of options represented significant false advertising in that only six of these seven buttons did anything. The DOOR CLOSE button, like every DOOR CLOSE button in the entire three-millennium history of elevators, was a dummy, not connected to any controls at all; it was, he well-knew, just a psychological placebo, there to console lift passengers with the fiction that they possessed more control than they actually had. Sometimes, to fill the long hours, Fouton pressed the DOOR CLOSE button repeatedly, aware it did nothing, but counting how many times he could perform this action in a typical shift.

He confessed, "I took the aptitude test."

"You what?"

"The aptitude test. The academy gives you an aptitude test on graduation day, determining what job best fits your qualifications and psychological profile. Some cadets become first contact specialists; others join ops, or get the command chair. The computer decided that I was best suited to my current duty. I began on small frigates, graduated to cruisers, and then gradually worked my way up to the *Magnificent*, where I've served for the last seven years."

"An aptitude test? An aptitude test condemned you to this?"

"Yes, sir."

"Have you never been permitted the chance to retake it?"

"I retake it every quarter, hoping to earn transfer to another assignment. But the results are always the same."

Air sacs inflated and deflated at various places on the general's huge, amorphous bulk. "Just a few more issues today, ensign. First, I gather that the captain uses this lift only rarely. There indeed appears to be something personal between you. Do you mind telling me what that would be?"

"He's my twin brother, sir."

"Ah. I must confess that I have trouble telling human beings apart and did not discern a family resemblance."

"We're fraternal, sir."

"Why do you not possess the same surname?"

"I changed mine to spare him the embarrassment."

"Still, the two of you must have been very close growing up."

"Yes, sir."

"You must have learned together, strived together, had dreams for each other that rivaled your individual dreams for yourselves."

"Yes, sir."

"And he became the most decorated captain in the Fleet and you became . . . what you are."

"Yes, sir."

"And he rarely uses this lift and avoids contact with you, because . . . ?"

"Because being with me here unnerves him, sir."

"Do you believe he feels guilt over what has become of you?"

"I'm certain of it, sir."

"Do you resent him for achieving the success you were denied?"

"Yes, sir. I live my days stewing in rage, sir."

"Ah." The general backed against the lift wall, and with a glowing sense of deep satisfaction, licked what might have been his forehead with what could have been a tongue. "We may be able to discuss ways for you to arrange a far more appropriate destiny for yourself. In the meantime, I believe I have taken up too much of your time this morning. You may fulfill your ship's function."

Fouton's finger hovered over the buttons. "Up or down, sir?"

The general managed to keep the pity out of his voice. "Up."

Nobody ever told Fouton anything, but he could have spent his day in a box even more removed from the bustle of shipboard life and still been able to discern that something terrible had happened.

The wail of battle sirens, the numerous shipboard announcements detailing extensive damage to various decks, the distant explosions, and the clear odor of something burning all signaled a crisis that required the full vigilance of each and every one of the *Magnificent*'s six hundred highly trained crewmen.

Fouton did all he had ever been empowered to do, which is to say stand at attention on his green square at the corner of the lift, awaiting his call to duty.

Nobody summoned him until the indicator lit up to impress him with an emergency summons to the VIP deck, to pick up the alien general with the name that sounded like the factory that needed its gears realigned.

Fouton wasted no time getting there, and found the general churning like a pyroklastic flow as the corridor filled with smoke behind him. "There's no time to waste!" he cried. "Up!"

Fouton shouted the closest thing he had to a heroic catchphrase. "Mind the gap!"

The general did indeed mind the gap as his substance tumbled and spilled and in various significant ways exploded past the sliding doors.

"Up!" he cried. "Up!"

Fouton depressed the appropriate button and the lift started to rise, at the same speed it always traveled, not even remotely reflecting the nature of the crisis affecting the ship around it.

This was rather anticlimactic, but the general said, "You have saved my life, young Fouton. I shall always be in your debt."

Fouton shrugged. "I only pushed a button."

"Are you not going to ask what's happening?"

"I see no point, sir. Around here, we call thrilling life-or-death battles 'Wednesday.' I've seen worse. It never impacts me."

"Be that as it may, it was the correct button and it hauled me away from the lethal conditions on that deck. You are in my debt, and the sentients of my species always pay our debts."

"I appreciate that," said Fouton.

"In fact," the general said, a certain craftiness now sneaking into his voice, "I shall take the opportunity to tell you what has happened."

"Oh?"

"Indeed. Alas, it may take longer than we have, so you might want to halt this vehicle's progress, so I may take my time imparting the necessary intelligence."

"Is that an order, sir?"

"It is a very strong suggestion, Fouton."

Fouton depressed the EMERGENCY STOP button, halting the car midway between the VIP deck and the ship's bridge.

The general said, "It is my duty to inform you that the *Magnificent* has been led into a fiendish trap."

"Why, that's terrible," said Fouton.

"The various alien ships involved in these test maneuvers have been infiltrated by forces that seek to destroy your precious alliance. Mutineers have seized control of a number of them and commenced firing on your vessel. The *Magnificent* has taken significant damage. As you say, it has been known to prevail with worse, but in the meantime the captains of the vessels representing your less steadfast allies have pulled their forces back, refusing to commit one way or the other until they see just which way the battle turns. Depending on what conditions they perceive, they may either ride to your rescue, or join the enemy forces and blow this vessel out of the sky."

"How uncommitted of them," said Fouton.

"Meanwhile," the general said, with hardly a pause for breath, "other forces hostile to the alliance want neither eventuality to occur."

"Golly."

The general didn't falter. "Yes, as you say, 'Golly.' These partisans know that the *Magnificent* is by far the most advanced warship in the alliance fleet, possessing technology that has long been kept from all but your closest partners in war. They would prefer to seize the *Magnificent* and take it back to their most learned savants, in order to plumb its secrets and enable the manufacture of ten thousand ships just like it. But they also know that this is unlikely to happen unless the *Magnificent* is so badly outnumbered that surrender is your captain's only choice."

Fouton nodded. "I get you, sir. But my brother will never surrender."

"No, he won't. But what if he were not captain?"

"Sir?"

"What if you were captain?"

"Excuse me, sir?"

"You are a qualified officer fully trained in all matters of starship command, wasted as lift operator all his life—a man robbed of the glory that would ordinarily be his. You have no reason to owe the fleet your loyalty. You are indeed the kind of unfairly dispossessed person enemy governments look for when they find themselves in need of spies and defectors. This special opportunity therefore

falls to you. You may cling to misplaced loyalty and spend the rest of your career wasted at this post, feeling the years of your life drain away like sand . . . or you may switch allegiances now, join those who oppose alliance tyranny, and agree to take the command chair after I release the gas that kills everyone on the bridge. Your subsequent betrayal of everything the captain held dear will not only serve as your vengeance upon him, but also the system that has condemned you to this living death."

Fouton had not stopped nodding at all during that speech. Now he fell back against the wall, heart pounding, eyes moist with long-repressed emotion. His iron self-control remained, though, and he did not stir any further from his place at the controls. "That's . . . one hell of an offer, general."

"It is a once in a lifetime offer, Fouton. All you need do is embrace it."

"You have it all figured out," Fouton said, "And you're right; it is impossible for me to spend more than thirty seconds in the presence of my brother without seething in resentment over the opportunities denied me. He is very much aware of this and it is the main reason he avoids using this lift whenever possible."

"He cannot face you," the general said.

"Oh," Fouton said, "he has no trouble facing me, if he ever encounters me elsewhere. He just doesn't feel safe with me, in this lift. He knows I resent him and doesn't trust my impulse control."

"Eh?"

"My aptitude test," Fouton explained, with something like pity. "Did you really believe that it only cleared me for moving a lift up and down? Far from it. I scored an A in decision-making. This lift is not just for him. It's also reserved for alien diplomats he's not sure about."

He pressed the button labeled SHAFT MAINTENANCE.

Fouton, who still stood on the one green square by the lift controls, survived what happened next. The general would not be so lucky. The explosive bolts anchoring the rest of the lift floor to the lift walls all went off at the same instant, releasing both that floor and the general it supported to the mercies of the shaft's artificial gravity. The general cried Fouton's name as he plunged out of sight, the second syllable rising higher and more disbelieving and then finally fully understanding in the fraction of an instant before it dopplered into a shriek of imminent extinction.

Fouton, who remained safe on the one green square, permitted himself five seconds of job satisfaction. It was good to be useful, better yet to know that you have contributed to your cause by carrying out the one vital function you perform better than anybody else. It was a job of genuine life-or-death responsibility, a job that required fast decisions, a job that genuinely did suit him better than anything else in the fleet. And it was all his.

He pressed the UP button and, feeling better about himself, began to whistle a happy tune. ■

Probability Zero

Whey Station

Guy Stewart

Rey Jungkarara stared at the cluster of outlets over the inexplicable set of eight old chest freezers. Someone had numbered each one with black paint. He and his wife had removed a thick layer of old straw, discovering the things tucked at the very back of the milking barn. He'd reached out to open one. Ni had exclaimed, "You can freeze yourself right there, mister! I have the recycling company online and they'll be here Wednesday!"

Today, he let out a deep sigh.

Ni Jungkarara, his wife of ten years, said, "Now what?"

He gestured to the barn's ancient, gray ceiling joists. They'd blown them free of cobwebs a week ago, then hired a fertilizer company to remove the mostly decomposed manure from the milking stalls, the room with the wooden, racked cheese molds, and the loft overhead. Rey said, "It looks great now, but the barn's still a hundred and three years old. I don't think anyone's touched the wiring since it was built."

"Do you have to mess with it?"

"If we want a B&B here, I have to bring the wiring up to code."

"You're an electrical engineer . . ." she began.

He turned to glare at her and said, "You're an aerospace engineer; can you fly a space shuttle?"

"Yes," she said, paused, then added, "What do you want me to do?"

"For starters, you want to unwrap the new outlets and lay them out on the table?" He gestured vaguely in the direction of the white plastic collapsible table they'd set up in the brilliant midmorning Wisconsin light. Soon the crinkle of her effort mixed with his grunts as he climbed up onto freezer number two and shone the high intensity flashlight into the dust-clogged receptacles. "I don't know what they needed all these wires for!" he exclaimed.

Wearing heavy gloves to wield the wire cutter's rubberized handle grips, he reached into the open space then paused. "Turn on the lights, would you, Ni?"

"What for?"

"I'm going to cut a couple of these wires. I want to see what the effect will be."

"That's the precision methodology you were bragging about?"

"Just do it," he snapped. "Please."

Snickering, she turned on as many light switches as she could find. Rey took a deep breath, said, "Let's see what happens now," and cut a wire.

The freezer he was kneeling on started to hum.

Ni said, "What's that?"

He slid off, staring at it. "It came on."

She arrived a moment later, peering over his shoulder. A row of lights along the edge blinked in slow marquee. "Doesn't look like any freezer I've ever seen."

"Probably from South Korea or India."

They stared until a teapot whistle sheared the hum. They both jumped back. Rey said, "It's not coming from this."

"Look," Ni breathed in his ear. He followed her gaze right, toward the barn's stone wall. Banked with soil outside, there were no windows. Flickering white letters on a blue field appeared in the dark corner. "It's words."

Holding hands, they stepped closer. Rey squinted and read, "wstat120254 2 wheystat18328 NatOnyxyfm II. N2checkon. 2LIQTANK. SOLN 27. DEP4 wstat31591 @615.5.05.00084.0000141. Rog?" He paused then muttered, "The hell?"

Behind them, something beeped as if for attention. Ni blinked three or four times, then said as she turned around, "The Onyxyfm has arrived." ■

IN TIMES TO COME

Even a man who sees further than the rest of us can have his eyes opened to a universe he never knew existed, as we'll find out in next month's imaginative lead novella from Rajnar Vajra.

Then Nick Kanas, M.D., brings us an overview of the physiological effects of space travel, the perfect complement to his earlier fact articles on the psychological effects of same.

We'll also celebrate the warm days of May (in our pages, if not outside your window) with a tale of familial expectations and baseball in Bud Sparhawk's "Slider"; see that the best explorers of the unknown might not be human (or alien) in Robert R. Chase's "Cetacean Dreams"; look at the price of athletic glory in Aubry Kae Andersen's "No Gain"; and more.

Start breaking out those shorts and swimsuits, and I'll see you back here next month.

All contents subject to change

ASTOUNDING ARMSTRONG

I've found a new idol. It happened while I was refreshing my knowledge about Tesla and his work for my previous two-part column. At one point I wanted to find out whether it was Lee de Forest (the inventor of the triode or "audion" vacuum tube) or Edwin Armstrong (the inventor of FM radio, among other things) who had once worked with Nikola Tesla. Turns out it was neither, though de Forest tried several times to get Tesla to hire him, to no avail.

I'd first heard about both men in my preteen years by reading my father's TV repair manuals, but I knew very little about either. While trying to learn more about them I discovered what a truly *astounding* man this Armstrong was. You can argue all you want about whether Marconi or Tesla is the "real" inventor of radio, but the inventor who gave us the radio technology that *Astounding* and *Analog* readers grew up with was Edwin Howard Armstrong. Though de Forest invented the triode tube, it wasn't until Armstrong invented the regenerative circuit that put it to use that radio as we know it became possible. Armstrong also invented the superheterodyne circuitry that lay at the core of radio technology for decades, and, as noted above, FM *freaking* radio! Yet, among the general population and even the SF readership, mention the name "Armstrong" and they think of that guy who walked on the moon. Happy as I am that people remember Neil Armstrong, it pains me that he is the *only* Armstrong they recall.

Though de Forest ceased to interest me, Armstrong's accomplishments demanded I find out more. Poking around the web revealed that almost every source of information referenced one particular biography of Armstrong, that being *Man of High Fidelity: Edwin Howard Armstrong* by Lawrence Lessing (not to be confused with Lawrence *Lessig)* from 1956. The reason the book is referenced so often is because it is both an excellent biography and the only biography of Armstrong. Though long out of print, I had to have it, so I ordered a used copy for around $60. It used to reside on a shelf at Howard University. Judging from the library card and "Date Due" slip, it never left that shelf except to be discarded. What a shame. Not only is Armstrong well worth knowing about, but as I read the book I kept thinking that I wished all biographies were written as well.

Born on December 18, 1890, Armstrong's early life was rather unremarkable. He was a good but not outstanding student and as a boy was interested in all things mechanical. In 1902 the family moved into what would be *the* family home, the one he'd always consider "the house [he] grew up in." In Yonkers, New York, it was a "big gabled house overlooking the Hudson at 1032 Warburton Avenue." There is a picture of the house in the book, and the eyes of any writer of SF, fantasy, or horror cannot help but be drawn to the turret in the front. (An additional floor would make it a tower.) By 1905, influenced by *The Boys' Book of Inventions* and inspired by his two personal idols Faraday and Marconi, in that "high attic room on Warburton Avenue, in the turret under the cupola roof with its sweeping view of sky and rolling river, as from a captain's bridge, the boy hugged these figures to him and burned to set off into the unknown." (p. 32) No inventor protagonist from the best of golden age *Astounding* ever had a better boyhood lab than Armstrong's.

Armstrong's first important invention (which changed radio technology forever) was the regenerative circuit. This came about in 1912 while he was an undergraduate studying

electrical engineering at Columbia. Over six feet tall, already balding, and frequently seen carrying a tennis racket, he was a good student in most subjects but an outstanding one in his chosen major. He'd arrived at school with several years of personal experimentation in the electrical arts already under his belt, and it showed. Frequently he haunted the school labs until all hours, doing his own thing and not being very forthcoming with administrative types who inquired about exactly what his own thing was. But it was radio.

Radio and wireless communication at the time was still in its infancy. Oblivious to Tesla's ground current method of wireless transmission, gobs of power were poured into huge antennas so sufficient signal energy could reach the primitive receivers. Spark gaps were still widely used, and sometimes elaborate, brute-force alternators, to produce the high frequencies needed for broadcasting. Though de Forest's triode arrived in 1906, no one, including de Forest, knew how to use it to produce significant amplification. Then came Armstrong. Though Tesla was the wizard of electricity, Armstrong was the circuitry virtuoso, a grand master in the *art* of electronics, so deeply passionate about radio that his love for it would never weaken.

So how does the regenerative circuit work? Consider the simple diode, or two-element tube, with electrons streaming from the cathode to the positively charged anode. Interpose between these two elements a third element, the grid, making the new tube a triode. Apply a varying voltage to the grid, and it is possible to control the amount of current flowing from the cathode to the anode, the anode current then going through the headphones. Armstrong figured out how to add and tune something called a "wing circuit" (a sub-circuit) that fed back some of the anode output to the grid, and *voila!*

Success came on September 22, 1912, a date that should rank up there with June 20, 1969. Armstrong described it this way: "Sept. 22, 1912 set up circuits and tuned 'wing circuit.' Great amplification obtained at once. Noticed peculiar change in tone of signal just as maximum amplification was obtained. Signals changed from hissing note and audion also hissed when wing inductance was set at certain value." (p. 66) Soon he was bringing in very weak signals previously heard only under the best conditions, amplifying them to the point at which they could be heard across the room from a pair of headphones left lying on the table. (p. 67) The hissing sounds he described were key to another astounding aspect of his new circuit, that with a bit of adjustment, the regenerative receiver could be made to oscillate on its own and become a transmitter.

In one fell swoop, the undergraduate Armstrong, this kid working in his attic lab, put all the pieces together in just the right way to solve the two biggest problems in radio, one being the amplification of weak signals into strong ones; the second, providing the much-needed simple and compact way to produce high frequency, continuous electromagnetic waves. Sparks were kicked out of radio forever.

And then the world beat a path to his door like he'd invented the proverbial better mousetrap, right? *HA!* Although this was the time when his public fame and recognition of his inventive genius started to grow, it was also the point at which the unending litigious shenanigans began. Having accomplished what had never been done before, suddenly the world was awash in other inventors who claimed *they* had done it before. That there was at best scant, and more likely no, evidence of them having done so was irrelevant. Oftentimes a big company would purchase "similar" patents from inventors and then use Armstrong's circuit for free, claiming they were not infringing at all, relying on the engineering ignorance of judges and their susceptibility to technological bafflespeak to carry the day. Almost half of Lessing's biography details Armstrong's court battles and how grotesquely industry and the laws treated inventors. In the case of the regenerative circuit, Lee de Forest was ultimately deemed the legal inventor, by which time the decision was moot. But the Institute of Radio Engineers, knowing the truth, resoundingly refused Armstrong's offer to return the gold medal they'd awarded him for the invention years before.

With Armstrong, there was always more inventing to be done. As anyone who grew up listening to AM knows, AM radios are good thunderstorm detectors. Wonderful as it was to be able to amplify weak radio signals,

natural noise and static were also amplified. Radio men were always working on the problem of improving the signal to noise ratio, Armstrong being no exception.

While in France during World War I, when Armstrong appropriately served in the army signal corps (ultimately earning the rank of major, often being referred to as "Major" for the rest of his life), he invented the superheterodyne receiver. I lack the space to describe the circuitry in detail, but you can check Wikipedia for that. In short though, a high frequency radio signal is picked up by the receiver, and there it is mixed (heterodyned) with a slightly different, internally generated frequency. This yields a third frequency, the difference between the other two, typically in the kilohertz range. From this intermediate frequency the content of the broadcast is amplified and decoded, then amplified again for the speakers. I feel this invention is to radio as Beethoven's Ninth is to music and the *Mona Lisa* is to painting—nothing short of an artistic masterpiece.

The superheterodyne method made it possible to amplify even the weakest of signals, and because the output stage only had to work with one frequency range regardless of the station tuned in, it could be optimized for that range. Though this reduced background noise and improved sound quality, it still didn't eliminate the bane of static.

To banish static, Armstrong turned to frequency modulation, bucking the accepted (and mathematically "proven") wisdom of the day that FM offered no advantage over AM. But the major knew that not everything was in the textbooks and that some of the stuff that was there was wrong. Again successful, by 1935 he was ready for the first public demonstration, a surprise for the IRE no less, during which a small, distant amateur station broadcast an FM signal that his receiver delivered "with a lifelike clarity never heard on even the best clear-channel stations in the regular broadcasting band." (p. 209)

And yet . . .

For the next 19 years, Armstrong's energy and fortune went into keeping FM radio alive. He fought valiantly against the vested interests of the RCA, the military, and the courts to bring hi-fidelity FM transmissions into the home—to reproduce the glorious sounds heard inside the concert hall, so faithfully it would be as if one were in the concert hall itself. . . .

But the battle killed him. In 1954, facing legal defeat, his health deteriorating, his wealth depleted, despondent that his absorption in the FM war had cost him his marriage as well, he took one giant leap from the window of his thirteenth-floor apartment.

Twenty-five more years would pass before FM radio finally surpassed AM in market share.

In the final pages of the book, Lessing, who knew Armstrong personally for 15 years, describes him this way: "His only faults sprang from his great virtue and strength of purpose. He was a man who would stand up and battle for principles as he saw them against the powers of the world, however formidable. This is becoming so rare a trait as to be prized above rubies." (p. 308) I call Armstrong "astounding" because, to me at least, he is the embodiment of the brilliant, virtuous, engineer protagonist John W. Campbell Jr. liked so well.

Lessing ends his account of Armstrong's life with a sentence that will serve for this essay as well, for what more can you ask of a hero?

"It is a life which, almost at every point, touches something endless and deep in the human spirit, errant and free, forever untrapped."■

Voting Rights

He lived in the village as long
As the usual residents considered
Him normal. One day
They caught him tapping the line
At the base of a telephone pole
To get upgrades from his manufacturer's
Web site and that was the end
Of that.

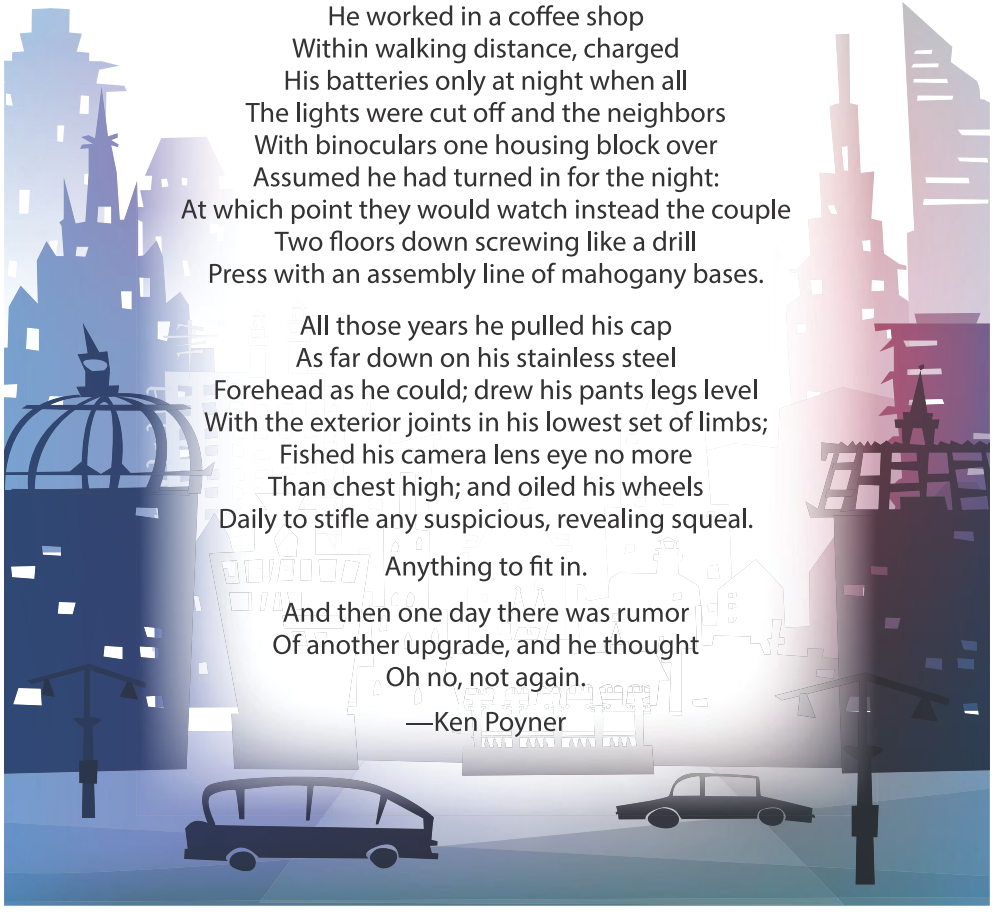
So he thought to try
The other end of the spectrum.
He tapped his savings and got
A place about midway up
An aging condominium in the center
Of a city going through population decline
And emptying from just the location he selected.
He worked in a coffee shop
Within walking distance, charged
His batteries only at night when all
The lights were cut off and the neighbors
With binoculars one housing block over
Assumed he had turned in for the night:
At which point they would watch instead the couple
Two floors down screwing like a drill
Press with an assembly line of mahogany bases.

All those years he pulled his cap
As far down on his stainless steel
Forehead as he could; drew his pants legs level
With the exterior joints in his lowest set of limbs;
Fished his camera lens eye no more
Than chest high; and oiled his wheels
Daily to stifle any suspicious, revealing squeal.

Anything to fit in.

And then one day there was rumor
Of another upgrade, and he thought
Oh no, not again.

—Ken Poyner



Illustrated by Josh Meehan

The Last Days of Dogger City

Mjke Wood

It wasn't a loud noise. It wasn't a noise at all, more a reverberation. Laura sensed it, and she woke in an instant. Fifteen years of maintaining offshore wind turbines had taught her which sounds deserved attention.

She crouched and pressed an ear to the rubber flooring. She tuned in to the pulse and heartbeat of the platform, visualizing every creak and strain.

There was no mistaking the next sound. It was like the crack of a rifle shot. Laura jerked

her ear up from the floor and stumbled backward. In the cabin, nothing had changed. Her partner, Sally, remained asleep, her steady breathing just audible over the ever-present hum of the ventilation. The second hand of the clock above the door continued its steady progress around the green glowing dial, but Laura knew that time had run out.

"Sally!" It was a forced whisper rather than a shout. Was there a right way to bring a loved one up from the peaceful embrace of sleep into chaos?

"What is it?" said Sally in a duvet-muffled voice.

"It's started. Something just broke. Something structural. I'm fetching the kids. You get the packs. We're leaving."

Sally slipped out of bed and ran to the wardrobe, pulling down the rucksacks they had prepared weeks earlier. Four small packs. Everything else they had ever owned would soon be gone.

Laura ran to get the children, hopping into fleece-lined trousers on the way. In the girls' room, Coral was asleep. Maya's bed was empty. It had been empty for more than a year but they still called it *the girls' room,* plural. Laura felt the same knife-thrust to her heart every time she looked in the empty bed. She always said that one day she would have to let go of the tangible things. That day was now. She had the memories of her first daughter, and now they would have to be enough.

She lifted Sally's daughter, Coral, out of her bed, supporting her sleep-floppy head with her hand. The child didn't even murmur; Coral could sleep through anything. Laura carried her through into Josh's room.

"Josh, wake up, we've got to . . ."

Josh wasn't there.

It was not all that unusual to find her son missing in the morning. The seven-year old had an independent streak and would often rise long before Laura and Sally, and lately he had taken to wandering off alone. Laura hated this, *hated* it, but deep down she knew she couldn't wrap him in cotton wool and mark him out from other children. This was Dogger City. They had a society built on freedoms that no longer existed over on the beach, in Britain or Europe. Children were safe to wander here. *Like Maya had been 'safe'.* Laura would have happily locked them all inside the apartment, Josh, Sally, and Coral, but she was desperate not to let her own guilt-fueled anxieties stifle the children's passion for life. Josh was so enthusiastic and curious about everything and just couldn't wait to start each day.

Only last week they had been making paper windmills at school. Paper wasn't good enough for Josh, though. He wanted to be like his MommaLa. (Laura and Sally were MommaLa and MommaSal to the children, a neat way of sidestepping one of the issues of single-sex parenting.) Josh wanted to improve the windmill's design, of course—try different materials. Laura had received a call an hour after school to come get him, not because he needed his mother to take him home, but because his teacher wanted to finish up and go.

Today, though, was different. That cracking, rending noise had changed everything.

"Sally, is Josh in there with you?" Perhaps she hadn't noticed him slipping through into their bedroom. Wishful thinking, she knew.

"Isn't he in bed?" said Sally.

Laura hurried back into their room and went to the front door. She looked out along the corridor. No sign of Josh.

"I'll go and check with Rob and Ed," said Sally, pulling on her anorak and helping Coral do the same.

Rob and Ed were the biological parents of Laura and Sally's children. Josh often went round there in the morning. But this early?

"I'll try the playdeck," said Laura. "Sally, take your rucksacks, yours and Coral's. If Josh isn't with Rob and Ed you should go, all of you."

"Laura, I'm not . . ."

The evac alarm started to sound. A chilling wail.

Laura took Sally's two hands in her own. She spoke quietly."Sally, there's Coral to think about. Let's not make this any worse. You and Coral should get off, now! This is serious, Sally, I'm not messing." Laura tried to smile and looked Sally straight in the eye.

"Be careful, Sal, both of you. Please."

They hugged. Laura squeezed her eyes closed to stem the tears. She bent down and hugged Coral.

"Now go. I'll be right behind you with Josh, I promise."

Sally paused to take a last look at their home, then, grasping Coral's hand, she pulled open the door and left.

Laura returned to their room, strapped on her harness—once a skywalker, the habits remained; she still wore her Petzl harness with almost religious obsession, even though she had not been aloft even once since the accident. Then she pulled on a heavy duvet jacket, hefted both her own and Josh's rucksack to her shoulder and, like Sally, paused long enough for a final, wistful survey of her home. So many memories here. Not all of them good. She felt drawn, one last time, to Maya's room, but she stopped. Josh needed her right now.

Through the door Laura turned left, not looking back, and broke into a jog, heading up to level six toward the playdeck. She used her tag to access the outside walkway because it was the shorter route.

The wind on the gantry was strong today, and it stung Laura's cheeks. She was no stranger to harsh weather, having spent most of her career atop deep-sea wind turbine towers, coaxing them back to life. Ten months ago all that had come to an end.

She had been on a powered rope ascender, an electrical device that allowed her to shoot up a rope as if riding an elevator. The rope had twisted, knotted, and the PRA had jammed, leaving her suspended twenty feet below the hatch at the top of the pylon.

Not usually a problem, this happened from time to time. The solution was to use a jumar, a rock-climber's device that allowed her to step up the rope and take the tension off the PRA, giving her enough slack to clear the jam. But that morning she had rushed. She hadn't brought her sling with the various pieces of emergency kit attached. She was stuck. There was a classic DIY solution from the past using bootlaces, but modern boots shunned such out-dated devices. She had tried looping the rope around one foot and taking a big step up, but one step was not enough, she couldn't free the PRA.

She had been rescued three hours later, a little cold, a little annoyed at herself, but she had been late collecting Maya from playgroup. The playgroup leader should have called Sally, should have kept an eye on little Maya until she could be collected, but Maya's playgroup was, after all, only three minutes from home, and children often made their own way home when their parents were late. Because Dogger was safe.

So many what-ifs and why-nots. What if Laura had taken her jumar sling, as she was supposed to? What if the playgroup leader had called Sally instead, as *she* was supposed to? Why hadn't the tag lock mechanism on the gantry door been maintained, and why hadn't the week-old ice damage to the gantry rail been repaired? A chain of systematic failure, but top of the list: *Laura should have been there*.

She should not be doing this. She'd berated herself so often before. This, now, was not the time. This was the time to focus. She had to find Josh.

He'd be with Ed and Robin. Or up on the playdeck. He was always at one of those places. Laura was being fatalist. She should snap out of it, collect Josh, then get the hell out of Dogger before the support legs collapsed and the whole damn city slid beneath the North Sea ice.

A buzz in her ear.

"Sally?"

"He's not here, Laura!"

A pause. "Okay," said Laura.

It wasn't okay.

Laura gave a deep sigh and tried to calm herself. "Sally, I'm just coming up to the playdeck. I'm sure he's okay. Get Coral down to evac."

"Laura, I'll come up."

"No. Just get Coral off. Let me speak to her."

"MommaLa?" came the little girl's voice.

"Coral, I'll be a little while. Go with MommaSal. I'll be right behind with your brother. Look after her for me. Will you do that?"

"Yes, MommaLa." She sounded scared, like she was about to cry.

"Laura?" So did Sally.

"Please, Sal, this is hard enough. I'll be along soon, I promise. I'm native Dogger, remember. I've been here all my life. I know all the places a child might go."

He'd be on the playdeck. He had to be.

"But it will help me if I know you and Coral are safe, Sal. Make sure Ed and Robin go with you."

They exchanged encouragements and promises, and it sounded an awful lot like goodbye. Sally hadn't been on Dogger for long. She'd come from the beach only ten years earlier, driven off by regressive new laws. Her expertise in marine biology had got her a job in the plank farm.

Laura rang off. It felt like cutting a lifeline. She ran up the last gantry steps to the playdeck, her feet clattering and ringing on the metal.

The playdeck. It was an entire level given over to the children of Dogger City.

When Dogger was first conceived, it hadn't been intended as a place for families. DC had begun as a harsh world of roughnecks and roustabouts on months-long tours far out in the inhospitable North Sea. The EuroPower project demanded huge resources of manpower, and it soon became apparent that the scale of the enterprise was demanding a city-sized infrastructure to support it. It just wasn't practical to ferry employees in and out, on ships or helicopters, in the required numbers.

So they brought the families to Dogger. Laura's parents had been among the first. Both her mother and father had begun their careers on the Scottish rigs, oil and gas, as rig safety officer and mud engineer respectively. It was a way of life, and they had been naturals for the Dogger City project. It wasn't long before Laura had come along, one of the first children of Dogger. She'd watched DC grow and had grown with it. There was nowhere she hadn't explored and nowhere she hadn't got herself into trouble, because the playdeck had arrived years too late for her childhood. But she knew the playdeck now. She had come here often with Josh. And with Maya.

Much of the playdeck had once been open to the sky, but ever since Yellowstone got itself launched into the stratosphere, ever since the ice, it had been necessary to jury-rig a roof. The doghouse was the old covered area on the north side, a refuge from the weather in days when weather had not always been quite so life threatening. The doghouse was Josh's favorite haunt.

As Laura pulled open the hatch a steward in a dinosaur vis-jacket, who was leaving, greeted her.

"Nobody here, miss," he said.

"Are you sure? My son, Josh. He's . . ."

"He's not here. I've done the walkabout." He saw the look in Laura's eyes. "Look, miss, I know the playdeck. I've checked it out myself, in person." He put a caring hand on her forearm.

"Look, you're welcome to look around, but you've heard the sirens. If your little boy is missing then you need to spend your time looking for somewhere else he might be. He's not here, I promise."

Laura knew the steward was right. He'd worked the playdeck for years, and she trusted him. DC was big. If she was going to look elsewhere, then she ought to start now.

Laura needed to tell Sally. She didn't want to make the call. She didn't want the argument. Sally had to get off DC. Her priority had to be Coral's safety. Laura did not want to create dilemmas. But Sally had to be told. She might think of somewhere else Josh might have gone.

She called Ed, instead.

"Where are you, Ed?"

"I'm with Robin, Sally, and Coral, down on the spider deck. They're taking everyone straight onto the ice. Have you got Josh?"

"No. He wasn't there. I—"

"I'm coming back up."

The spider deck was the lowest deck, washed by the North Sea swell in the days before the ice. It was a long way back up, and Laura guessed it would be against a tide of panicked humanity fleeing DC. She wanted to say no, stay with Laura. But Ed was Josh's father.

"Okay. Yes, please. But what about Sally and—"

"Robin will stay with Sally and Coral. I'm on my way back up. Where should I start looking?"

"I don't know." She steepled her fingers and pressed them to her lips. *Think*. "Try the rope locker. It's a possibility. I know he was friends with the kids of some of the other skywalkers."

The skywalkers. As a turbine mech, Laura herself had once been part of that elite club. Dopes-on-ropes they were sometimes called. They were the abseilers; the maintenance crews who worked the sides of DC and the high turbine pylons. She remembered the rope locker as a place she liked to go herself as a girl. It was warm and secretive and cozy, and she would curl up amongst the loops of rope and feel safe. It was a place to hide from the world when things went bad. She'd last hidden there, not as a child but just a year ago,

when she'd lost Maya. She'd talked about her secret place to Josh. Maybe all the uncertainty over the encroaching ice had been having a deeper impact on the seven-year-old than she had guessed.

"What about you, Laura?" said Ed.

"I'm going to try the school. You know how much he loves school. I sometimes can't get him away from the place. I'll let you know."

The school was just two levels down but then a good fifteen minutes along the central highway. Laura clattered down the stairs. She was four rungs from the bottom when the world shifted. There was no sound—not straight away. The sound came later, booming and groaning.

Laura found herself on her back looking straight up at the bulkhead lights along the ceiling. They should have been lit. Laura had never seen the highway with the lights out before. An eerie red glow from emergency lamps was barely enough to see by. Laura sat up, relieved that she still could. The pain from her right hip foretold a triumphant bruise to follow.

The steps she had just descended were now almost vertical. The central highway sloped upward. The city, or this part of it, had moved by twenty degrees. Time was running out. Laura stood, and, hobbling at first, she began to run off the pain. Uphill.

Five minutes into the run, her phone buzzed in her ear again. Laura slowed. She used to be fit, but it was a long time since she'd worked the high turbines. The incline was steep and her breathing was coming in snatches.

"Hi," she said, between breaths.

"Laura, it's Robin. Are you okay?"

"Running. Uphill. Not . . . used to it."

"Sally's hurt."

Laura stopped.

"How?"

"We were on the spider deck and the whole city lurched."

"I felt it."

"Sally fell. Over the railing and onto the ice. About fifteen feet."

Laura closed her eyes.

"Is she . . . ?"

"Okay? Not really. She's shook up and . . . her ankle . . . just snapped. The doctor's with her now. She's in a lot of pain. We're having to walk off DC, Laura. Lots of people down here. Sally's going to need help. I'll do what I can but she's not the only one injured. Doctors are struggling."

"What about Coral?"

"Coral's fine. She fell too, but she seemed to bounce. No ill effects. She's upset though."

Laura began to move again, a steady jog.

"Is she with you? Can I talk to her?"

"MommaLa?"

"Hi sweetie. Listen to me, Coral. MommaSal will be fine, you'll see. Just stay with Robin and he'll watch out for you both. I'll be down there just as soon as I get Josh. You'll be a brave girl for me, won't you?"

There was no answer, but Laura knew she'd be nodding.

"Now put me back on with Robin, sweetie."

"She's okay, Laura. Just a bit shaken."

"Have you heard from Ed?"

"Yes, Ed's okay. Laura, you need to get Josh and get off there, soon."

"I know."

"You don't know. Laura, the Ess has gone."

"What? Gone as in . . . ?"

"As in no longer there. It just dropped through the ice. That was the lurch. The legs just snapped sideways and it went down. The whole damn thing. Nearly took Rig Town with it. Would have if the gantries hadn't sheared."

The Ess was the new build. When Dogger City was built it grew from old oil platforms strapped together. They called it Rig Town. It didn't become Dogger City until the Ess was added. The Ess, named for its shape, from above, was a purpose-built offshore city, complete with parks, hotels, leisure centers, shopping malls . . . just about everything you could find in a conventional mainland city. The Ess was only the second phase of DC. There had been plans for many more sections, even a marina, each paid for from the profits they made from power generation. But after Yellowstone, the ice had come, and the expansion plans had been put on hold. The Ess was home to nearly a quarter-million people. Laura wondered, with chill dread, how many had made it off. And of them, how many had put enough distance between it and themselves before it had turned the ice to slush.

"Robin, get away from DC. You, Sally, and Coral. Don't stay beside the legs. Get moving and put some air between you and the city. If you have to drag Sally along behind you, do it. Don't waste time, you hear?"

"Understood."

From the tone of his voice, Laura knew that he did.

She broke the connection and picked up her pace.

The schoolroom was empty. The lights were out, but enough early sunlight was coming in from the large windows along the wall to see into all the darker places. Through the window, looking down, Laura could see a tiny line of ants, black against the snow, heading away from the city. They were still too close. Laura wished they would hurry. She prayed that Sally, Coral, and Robin were amongst them.

Josh wasn't here. Laura knew she could not leave DC without him. She would search until . . . Well, she would keep looking, that was all. But she didn't know where to look next. Even without the Ess, DC was a big place.

She looked around the schoolroom. A row of paper windmills brought a lump to her throat. They were multicolored; each jabbed into a ball of Plasticine to keep it upright. Some of them even turned in the draught from the open door. She remembered how much Josh had enjoyed working on his. She looked along the row but Josh's windmill was not amongst them. Was that because he'd gone rogue with his own improved design? It had irritated the teacher, that was for sure. Or was it his perfectionist streak that made him . . . ?

A ball of Plasticine with a hole in it. Midway along the row of windmills. One windmill missing.

Laura was running even as she thumbed her ear.

"Ed? Talk to me Ed."

"Laura, he's not . . ."

"Never mind. I know where he is. Ed, you'd better go."

Even as she spoke the deck gave another lurch.

"Now, Ed! You don't have long."

"He's my son, too, Laura. I have to help. Where . . . ?"

"You can't help, Ed. This is my patch. He's gone high. I don't need to be rescuing two of you. You're no skywalker, Ed. Go! Robin's going to need you. So long as there's still time I'll get Josh."

Laura was already on the ladder, going up the Arkansas Derrick. She couldn't see the top because the extension platforms—new builds—obscured her view. But she knew he was up there, he had to be. Arkansas was the tallest Derrick on Rigtown. Only the Dogger Hilton on the Ess was taller. And that was gone now.

"Ed, get my family to Libya. Me and Josh will see you there."

She thumbed her ear and climbed.

The world hadn't put all her eggs into one basket. She'd put them into two. Europe had gone for offshore wind, which would have worked, but then the turbines froze and the power from half of those remaining had to be diverted. What had once been used for keeping Europeans warm now had the job of delaying sea ice build-up around Dogger; they had warmed the North Sea like a gigantic electric kettle. And for a while it had worked.

The other basket was solar. The north coast of Africa—Algeria, Libya, and Egypt—became the world's biggest solar plant. And *that* would have worked except for the small inconvenience of one of the U.S.'s largest national parks going airborne and hiding the Sun.

North America and much of Asia had chosen to stay with fossil fuel. Who knows how that went. The U.S. obviously had her own problems after Yellowstone, as did everyone on the Pacific Rim, but news coverage wasn't what it used to be. Laura didn't know anyone who'd had news from such distant places in a long time. Some said they had ceased to exist. Perhaps that was the truth of it.

But there were optimists on DC who believed Libya was now the place to go. It was guesswork because there hadn't been communication with the beach for some years. There wouldn't be much energy from the ever-dirty skies now, but surely there must be some. And the fact that Africa was south didn't harm the argument, either.

So that was the plan. Walk to the Netherlands, on through France and Spain, and see

what was happening at Archimedes, the Gibraltar Tunnel.

Laura had an idea that a lot would be happening: that it would be the destination of choice for many, that there might be some competition for food and water down there. But she didn't have a better idea. One thing was for sure: DC would not be part of the survival equation. It might stay around for few hours more, though, if she was lucky.

She reached the platform. It was awkward because someone had left a PRA dangling down through the hatch. She was tempted to try and use it, but she hadn't been on a rope since . . . Well, with her luck, the charge would be low, and she'd end up dangling and stranded again, and there'd be no outside help this time. Better to use what she could rely on, she rationalized. So she pushed the PRA aside and heaved herself through the hole onto the platform. She looked up to the top of the Derrick. Right at the top she thought she could see a splash of red.

"What are you doing?" The shout came from below.

Laura looked down through the opening. There was a politi below.

"I'm looking for my son."

"Up there? Come on, come down. We're evacuating."

She didn't have time for this, she faced a long climb. She turned toward the ladder, but she heard the clang on the rungs below. The politi was coming up after her. Laura used to be a skywalker. She knew how to climb, but she'd just run, flat out, for over a mile up a steep slope. If the politi had fresh legs he'd catch her. Worse, she realized the Derrick ladder was on the wrong side of the city's new jaunty angle. She'd be climbing an overhang all the way.

The politi was nearing the top. He was agile. Laura recognized the steady, lilting rhythm. Just her luck to draw an ex-rope-dope. She looked around. She saw a line, stretched tight, attached to something heavy over the lip of the hatchway. The PRA. She took a step toward the ladder and then stopped. Damn! Could she do it? Could she snap herself onto one of those cursed things again? Even for Josh? She was wearing her harness. Thank God for that habit. She gave a small, inward cry, then reached, with trembling hands, for the rope. She heaved the PRA up over the side of the platform. It snagged on the edge. Laura had to lean out over the drop to free it. The politi put his head through the hatch.

"Now, will you come down?"

The PRA came free, clattering over the lip and onto the mesh platform floor.

"Don't play with that, miss. Those things are dangerous." He pulled himself up onto the platform in one fluid movement and reached out with self-locking cuffs.

Laura took a step over the edge of the platform. At the same moment she clicked the PRA onto her harness.

"Stop!" The politi made a lunge, and Laura thumbed the "up" control. With a hiss she was propelled into the air, out from the grasping arms of the politi.

The ascender gave out a whining noise as it ejected rope by the yard though its spiral gears, rocketing Laura into the air. She felt free and exhilarated. The PRA was fast. One of the ex-military models that some of the more favored skywalkers got to use. And as she flew into the air the splash of red formed into a recognizable shape.

"MommaLa!" shouted Josh. "I'm sorry, MommaLa."

He was clinging to the Derrick, about six feet from the top. Right on the very top was his windmill, his new improved design, spinning so fast it hissed.

Laura shut off the power as she drew level.

"Nice windmill," she said, smiling and laughing and crying. "Are you okay, Josh?"

"I was climbing down and the tower started to lean," he sobbed, tears running down his cheeks. "I couldn't get down the ladder. I'm so sorry, MommaLa, I know I shouldn't have come up."

"You're safe now, Josh. Let me grab you. Now, put your feet in my jacket pockets. That's it. Hold my neck tight with both arms. We're going down."

The politi was waiting for them below with wide eyes.

"Miss, I'm sorry. When you said you were looking for your son, I thought . . . I mean . . ."

Another lurch from the platform. This time was different. It didn't stop. The whole city was on the move.

"Doesn't matter. We need to get off DC as fast as we can. You're a skywalker." It wasn't a question. The politi nodded.

"Good. We're going over the side."

It felt natural again. Safe. Laura freed the rope that went up the tower and pulled it loose. She ran it through an "eight" on her harness and lashed it to the rail. The platform now hung right out over the ice below. With Josh still standing in her pockets, she launched herself over the side. They dropped fast. Almost freefall. The politi was right behind them. The rope hissed and burned in the "eight"—an aluminum figure eight descender. Laura held her brake hand straight down to avoid twists in the rope, slowing them just in time. They hit the ice, which was already turning to slush around them, and they ran. Dogger City shuddered and groaned and cried. And then it sank.

There were no reference points. It was white above, below, and all around them. Laura found herself craving for something she could focus on. They followed the compass south, taking turns walking ahead along a bearing, then waiting for the other to catch up, thus avoiding straying too far from their course.

They would die out here. That was the constant and irritating promise from Lars, the politi. Laura refused to concede defeat. She was cold, but she had been cold before. Josh had stopped crying and often slumped into spells of silence, a bad sign, so Laura constantly pushed him to talk; about school, about his climb to the top of the Derrick, anything.

They had no shelter, no food, no water. Laura didn't notice the point where they abandoned their more accurate navigation method, and drifted into just stumbling along, following the compass south; it was too cold for standing around, and too slow. Laura had to keep them moving. Her only motivation was to keep Josh safe, to keep trying, and, if it came down to it, to be with Josh at the end.

Nothing but white. White and . . . black dots ahead. Black dots everywhere. The effects of sun-blindness? But the black dots were getting bigger. And shouting.

When Sally wrapped her arms around her, Laura could only bury her face in her hair and cry. Two days and a night and she barely knew what was happening around her. But she knew Sally was safe. She was limping, but, she later learned, her injury was only a sprain. Above all, she knew now that Josh was safe.

What would they find in mainland Europe? How might they fare farther south? Questions for another day. Because now there would be another day. They had choices. They had a future. ■

Dancing in the Dark

Ramona Louise Wheeler

I was dreaming when the alarm rang.

I saw comets raining down like icebergs in a whirlwind, crashing against the dried-out husk of the planet Tarse. The comets melted into tears of thunder, splashing and spilling through the red canyons, pouring down to the Lower Plains. Spiders burst awake in the soil at the touch of the water.

I dream that dream every time we are on the chase, every time that my comet-hunting ship the *Roaring Candle* senses a Questing Beast emerging from the outer darkness to swim across our scopes.

The bridge alarm kept ringing. I punched it off and said, "Okay. I'm awake."

"Forgive me, Captain White Eyes," came through the monitor, much too loudly. "We need you on the bridge, Captain. We've got a big one."

I still tasted the salt of melted thunder, a remnant of the dream, but the Questing Beast was really out there now. I shrugged on my uniform, stepping into my boots while I fastened up the collar, and I ran through the corridors of the *Roaring Candle* to the bridge.

I saw it in the main viewport as I arrived. Out there was an enormous comet-beast, a beautiful behemoth floating in an ocean of night. In these cold distances so far from our star, she was a bulk of blackness against the stars. The dayshift and nightwatch captains were at their emergency stations, although everyone was simply staring out at the comet. So was I.

I found my way automatically to the callosum at the center of the tri-bridge, stumbling over the steps of the raised dais. I could not look away from her. I had never seen anything like this one before. I could not see enough of her. I wanted to run to the viewport, to press my nose to the glass, just to see more. Instead, I settled myself into the captain's seat on the callosum and punched in my command codes.

"Captain White Eyes is in the callosum, ladies and gentlemen," the computer announced softly. "The bridge quorum is now complete."

Oortbridge Captain Matholooch did not look up from his comet monitors to acknowledge my arrival. I did not want to interrupt him. If I was this thrilled by the creature, then Matholooch must be wild with anticipation. Grace Wing, starbridge captain on my right, was busy at her keyboard, but she looked up and smiled at me.

Day Captain Pelgrim, however, drew himself up stiffly and strode across the tri-bridge

catwalk toward the callosum dais where I sat. Pelgrim was not happy. Even from the corner of my eye, I could see that. I was happy. That enormous beast floated almost at my fingertips. I ignored Pelgrim, calling out "Lights!" as my first order as captain of this Quest.

Ship's spotlights played out across the frozen shape. Our lamps, however powerful, were only candlelight caressing her darkness. Her carbonized skin was black with cold, condensed, pitted, and scarred by the passage of eons in the comet cloud of the Tarsean system. She had been swimming out here in the dark since creation, and no one but the distant stars had ever seen her. Her glowing aura had never been lit by our star's harsh particle winds. The precious water and atmosphere locked up within her were still virgin, uncollected, unsullied by any touch of gravity, warmth, or life.

Catching a comet in a fishing net of magnetic flux lines is a well-practiced art, but each beast is different; each one thrashes and tears at the net in its own way. That behemoth waiting out there was as eccentric as she was huge. Although not big enough to pull herself into a sphere, she was nonetheless as big as a mountain and shaped somewhat like a pair of rough pyramids smashed together tip to tip. Starlight glinted in her many eyes. She was cold. She was as cold as creation's coldest moment. Her thick, carbon hide was frozen so tightly that none of our magnetic harpoons could penetrate. She would require direct contact. We would have to go out and jumpstart, by hand, the plasma engines that would drive her to Tarse. I would get to touch her, to walk about on her and let her massive, dark being fill my horizon.

The *Roaring Candle* orbited slowly in spirals around her, caressing her with laser light until she had no secret untold. She was on record now as the biggest comet ever found in this system. I was breaking my own record. I had also brought in the previous "biggest comet ever found," one less than half the size of this. The *Roaring Candle* has harpooned many a comet. The bright cities of Tarse in their glass-lined caverns breathe comet air that I have brought them from the Outer Dark.

Day Captain Pelgrim remained at my elbow, glaring.

"Captain Pelgrim," I said finally. "Take a moment to meditate upon the chance that we would find such a marvelous beast so soon in the Quest." He hates to meditate; that's why he's a day captain.

"Marvelous is perhaps a strong word for it, Captain," Pelgrim said. "Comets as big as this one were discovered back in the Solar System, even before our colony was founded. We were bound to find them in our system as well."

"But, Pelgrim!" I said with a smile. "Imagine our luck at being the ones to find her—and so soon!" I had him. The other captains saw him trying to diminish their amazement for the sake of his argument. Their attention returned to the creature outside. Pelgrim had no audience.

The comet spun past slowly as the *Roaring Candle* spiraled around her.

"What's the problem, Pelgrim?" I said. "We have found ourselves a good comet, a sublime comet—and that's why we're out here."

"With a crew of students!" Pelgrim said with ill-disguised agitation. "We don't know if a ship our size can tackle a monster like that at all. With a crew of children, it's madness!"

"I'd hardly call them children, Pelgrim. There's not one under twenty-five. We were student crew at some point in our lives, and yet—here we are."

"They're students!" he said in a breathless protest.

"And this will help them to grow up," I said evenly. "Maybe she'll grow us all up, Pelgrim. Maybe even you."

His dark, sullen face grew even more sullen. "I take it then you are voting for capture?"

"Oh, I am insisting on it."

He turned tightly and strode back to his post.

I gave instructions to communications officer Moolchand to radio full reports back to University HQ every ten minutes, even if only a "no update" time check. I wanted University to know where we were, exactly, in case that giant comet decided to take us someplace else. Her core was enormous, massive, and dense. She was rich. A shroud of water enclosed her, enough water for a lake, enough water to run as a wild river through the canyons of home. We had been out on this run in the cold dark for only a month. I sat a moment longer, lost in the vision of our wonderful monster.

Grace Wing came over to stand beside me on the callosum, close enough that her perfume distracted me from the comet. "You see any problem with this? Seriously?" She spoke very quietly, so that only I could hear.

"Seriously?" I said. "No." I gave her a reassuring smile. "Those extra students are extra brains and brawn to throw a net around this leviathan and haul her in. Think of it, Grace. We go out with an extra-big crew of student ice-keteers, and—lo and behold—we find an extra-big comet. They were meant for each other. Who am I to deny them?"

"As long as you're happy," she said.

"I'm happy."

"Okay." She shrugged. "Then I'm going back to bed. I have to be on duty again in three hours." She left, giving me that smile.

I hurried through the rest of the routine bridge checks to begin evaluating the comet and how to take her. Then I followed Grace. She and I work well together.

As the weekend captain, I am the peacemaker. Mine is the tie-breaking vote that saves the bridge captains from the paralysis of their conflicting wills. In a very real sense, however, I am in charge, even though the *Roaring Candle* is a training ship and supposedly run as a democracy. We are really out here to hunt comets, so when we are about to be so wildly successful, I am in charge.

There are seven captains on a comet ship, and their command is divided among the three sections of the tri-bridge: the starbridge, the Oortbridge, and the callosum. The starbridge section controls the body of the ship itself. The Oortbridge controls the plasma-magnetic fields that are used to capture, hold, and navigate the comet into Tarsean orbit. They are called "captains" because they are the heads of their sections. They make decisions without consulting committees.

"The left hand spins the comet and the right hand steers the ship."

Three bridge posts, each with two captains, the dayshift and the nightwatch. That's the six captains. Starbridge and Oortbridge captains take *their* orders from the captain in the callosum command-post between them. The callosum-bridge links the starbridge and Oortbridge, coordinating the comet-hunt and comet-towing operations. The callosum also coordinates the teaching activities for the ship's student crew.

I am the seventh captain, the "weekend captain." I can hold any position on the ship should a sudden replacement be needed somewhere, anywhere—from shipboard environmentalist to ship's mechanic. So in times such as this, I am in command: the odd man out, the seventh vote. The six captains had not been able to make up their collective minds about this behemoth of a comet, so I had been called on duty to the callosum bridge at the tip of the pyramid of command.

This was now my Quest. She was my comet. I was going to ride this leviathan home—icebergs of frozen thunder crashing on the sand.

Once in her precise orbit, the *Roaring Candle* began to unwind the centriole, the golden band of filigree-foil and crystals, many kilometers long, that directs the electromagnetic fields controlling the comet. The centriole is a ring-grid spun out around the comet's center of gravity and closed with a Moebius twist. Theories varied about why the twist, but no one argued that the ring would not work without it. The discovery of the twist was accidental, proving once again the vital role that human error plays in the advancement of scientific knowledge and hard technology. The gold-foil filigree is made of intricate fractal patterns, diatoms of gold with faceted crystal insets. These crystals were once worn as jewelry. Now they tune and stabilize the electromagnetic fields to create the hot plasma jar which spins the comet and hurls it sunward on the raw harmonics of ionized hydrogen, creation's most primal stuff. My student crew and I were going to control that unthinkable power and take this comet home.

When they land comets on Tarse, the comet ice-keteers guide them down gently, always at night. The plasmonics that fire their flight glow with angelic light, casting a lovely whiteness briefly on the iron-hard, rust-red landscape below, floating down like giant snowflakes, spinning inside golden rings.

The precious air and water contained in the comets are released to the atmosphere, which is, comet by comet, becoming thicker and wetter. In a thousand years, humanity has

trebled the pressure. Life is oozing out of the air onto the sterile soil. The buried cities and homesteads of Tarse are built into the side canyons and protected gullies of Grander Canyon, in the deep valley where pressure is greatest. Life grows plentiful and lush in the network of fissures and caverns there. Up above, on the plains of Tarse, are the prison-factories where oxygen is beaten out of the rocks, literally, by hand.

The air on Tarse, denser now than in a billion years, does not come only from the oxides bound up in the soil and rocks. Comet ships like mine, the *Roaring Candle,* have been capturing comets for seven hundred years. We send them raining down into the dry throats of the canyons of home. The minerals of the comet crystallize as the plasma cools. These comet-made crystals scatter through the canyons, to be gathered up by children as lifetime souvenirs. The water from the Outer Zone condenses in the midnight cold as pond-sized splashes running through the dry canyon sand, heralded by clouds of vapor that are the first blush of air meeting Tarse.

I watched the comets landing when I was very small, small and new enough that the magical vision of glowing icebergs floating down the canyons transformed me utterly, so that the course of my life was guided as surely as a comet itself. I had no choice but to do anything and everything that would lead me to comets, more comets, bigger and bigger comets, sending me deeper into the outer black to hurl comets against Tarse, lighting the midnight landscape, filling the thin air. That's all I've ever done and ever will do. I've gotten old at it, and good.

Everyone on the comet-ship is married to someone else on the comet-ship. Some of the marriages are circadian, some are not, but every breakfast conversation is about the comet. Everybody gets out of bed in pursuit of the Questing Beast. Driving passions are needed to survive in the outer dark. Partners in failed marriages transfer to other ships and other quests. Our group was still on its "slow boat to China" part of the voyage. These honeymoons were fresh, and everybody was showing off. I knew I could count on these hot shots to do their best. The reflexes of passion walk such a keen edge.

Out here among the comets, we face each other with our masks removed. We have freedom to look at each other with our fingertips and skin, with our monkey-selves. We have time for the slower senses that work in the dark. We were born under an alien sun, and we are nourished by the light of each other in the dark of the Outer Rim. There is nothing darker than the Outer Rim, where comets roam.

I am one hundred and eight Terran years old. On Tarse, I am only fifty-three, but trees I planted as a child in the parks of Coyote Depot have now grown faces through ancient bark. I recognize in them the faces of friends I've buried. Fist-sized fruits that fit in my palm are curved like tiny skulls.

I could walk off the stage with honors and a parade. Tarse loves a parade. Mansions await me beneath topaz skies. The gravity of Tarse would feel solid and planet-sized after nearly a century of ship's decks under my feet, decks quivering with the imperfect engines of centrifugal gravity and ion drive. Yet there is always one more comet, one more Quest, finding another miracle in the dark. When I retire, I will arrive raining down on a snowflake as big as the sky; crystal eggs will break open over the canyons, and water, bright as sunshine, will spill out.

Grace Wing came in to tell me that the rover team was suiting up. It had come time finally to go out and touch the comet.

I put on three pair of spider-silk thermals. The eggman, the mobile suits we wear for working outside the ship, keep in bio-warmth, but the cold of the outer dark is psychological cold. Only ritual lets you believe you are warm. The eggman, as it is named, is a spacesuit plus private vehicle. The egg comparison is oversimplified; the ovoid surface bristles with waldoes, attitude jets, tools, and patch-ins. The egg-tip is the helmet, clear all around. I like that. I like to look up and see stars over my head. The egg-shaped design is a compromise between the need for instant access and exit while maintaining control in micro-gravity. The comets are the magic that becomes the crystal eggs of Tarse, and the ice-keteers are herdsmen, the shepherds, the comet cowboys.

I *did* have complete faith in the ability of those kids to steer the comet. I reminded my-

self sternly that they were *not* kids, yet I had a brief vision of myself riding a comet bareback to Tarse because they could not catch me. I shook it away.

Grace, in her eggman, was perched at the velvet-black arch where the pyramids met. Her suit, lit from within, was a glowing, jeweled egg enclosing the treasure of her face, the raven-wing sweep of her hair. I dialed up binoculars to see her eyes. She was happy. The adrenaline thrill of this ride was working its magic on her. She had her binoculars dialed up as well, looking at me. She tilted her head, and we smiled face to face.

"Care to go for a stroll, Captain?" she radioed.

I answered by lifting off from the comet's darkness, bouncing across the frozen surface to land beside her, touching her eggman-suit with mine. Starlight and the soft blue guide lights of the surface teams were reflected in her eyes. The centriole was a flashing curve of golden fire overhead. We both have privately modified spacesuits, with miniature airlock valves at hand-holding level. It's awkward but it works. We held hands and rolled off gently across the comet, drifting purposefully to the far side of its black bulk, to the absolute privacy of the Outer Dark above our heads.

There was a delightfully adolescent thrill in actually touching her fingertips this way, in this place. It was something that we did a hundred times a day on shipboard and have done thousands of times, but to be here in this magical place, untouched since creation, this was unique. The newness of this comet made the magic of fingertips and skin as powerful as the first time, more exhilarating than falling in love all over again. The speaker beside my ear rustled with her sigh. She, too, was trembling. The curve of the eggshell helmet made a starlight sheen over her face, making her insubstantial, an angel of golden shadows in some other dimension. Her soul was full and sweet in her eyes, dark honey, warm. No wonder I was so in love. Who could not love a being of so many crystalline layers, beautifully complex, dark and brilliant at once?

"I wish I had met you a hundred years ago," she said softly. She did not use the radio. The low, solemn thrill of her voice came through the handlink to me alone.

"A hundred years ago, dear Grace, I was just a brat stealing cocoa beans from my uncle's trees, bragging to my friends about how far I could spit."

"And I wasn't born yet."

"Your *mother* wasn't born yet."

"I know for a fact that my grandmother is madly in love with you."

"She can probably spit further than I can, too." I said that to make her laugh, and she did. I've always been able to make Grace laugh. If I ever lose that, I'll jump out an airlock.

"This could be the last time we do this," she said then. "You've found your magical comet, the biggest that ever will be found—now you can go back to Tarse and retire. This is the last time we'll do this, walking together, holding hands on a new comet that's the biggest there ever was. I want a hundred years more of you. I don't want this to be the last."

I was startled, to say the least, giddy and solemn at once, because my Grace was, most often, a silent woman, more eloquent with a look or a touch than a month's conversation with another. It is impossible not to wonder what goes on behind those eyes, yet I had been too absorbed in comet lore to see the magic right in front of me. I did not have enough time left to make that mistake. I am, after all, one hundred and eight, not fifty-three. We floated there in the absolute dark beneath the golden band, fingertips warm and electric in touch, the bonds between us nearly visible. I needed to say something as potent, as enduring as what she had said, but the Universe was reflected shining in her eyes. Nothing in words could touch the perfect thrill of her.

I didn't get the chance to answer. We were interrupted by the radio signal that the kids on board the *Roaring Candle* were ready to ignite the centriole.

In spite of everything I'd said to Pelgrim, I was still thinking of them as kids. I had to work on that. Grace and I separated our handlink to go back to our posts monitoring the ignition of the centriole. I turned one last time to look at her, jeweled and sparkling against the permanent stars. She made me feel, for that instant, young and new enough that I was in a dream world where you can turn to look at your beloved behind you.

The cold dark of space has no forgiveness for loving fantasy.

I miscalculated the power of the turn, jetting myself out instead into the tenuous fabric of nothingness, spinning away into a void of my own making, floating free. I cued the eggman for the return, prepared to do the orbital mathematics in my head if necessary,

It didn't matter if I could or couldn't. I had prowled for too long on the ultra-cold comet. My eggman had frozen; the attitude jets and controls had shut down, and I was helplessly spinning away.

Grace's call in the radio seemed a million kilometers away. Visual cues of distance out in the ether mean nothing, constantly shifting and confusing. I saw her face both as close as a kiss and as far away as the stars.

I swallowed down panic; I was too old to react like a green spacer caught in his first mistake—or his last.

Grace's eggman-lights were fireflies swarming toward me. "I'm coming, Captain," she tight-beamed to me.

"No!" For a frightened moment, my denial seemed strong enough to push me even further away, but it didn't matter because Grace wouldn't listen. She was swooping towards me, navigation lights ablaze. I was not seeing the distortion of vision in a vacuum. I had to turn inside the eggman to keep her in sight as I tumbled in slow motion away. Grace became my orienting star. The comet was now below and behind my field of view. Galaxy light sparkled in the dark.

Then I heard the main signal she broadcast to the tri-bridge. "The Captain's eggman has misfired, gentlemen," she said calmly. "Could you get someone onto this?" She might have been asking a waiter for a glass of ice water.

I fashioned a mental image of my eggman profile dwindling away to navigation lights blinking against the stars, flashing once and gone. Grace would have nothing of it. She maneuvered herself in the awkward eggman shape as elegantly as she danced in any gravity field, then carefully linked her handhold airlock with mine. In mid flight, we were holding hands again, tumbling on slowly together.

"I thought I'd keep you company until the kids get here," she said through the handlink.

"They aren't kids," I said breathlessly.

"You're damn straight they aren't."

"Would you like to take me home now, ma'am?" I was breathless for a lot of reasons.

"Sorry, Captain. I used the last control I had left linking up with you out here."

The coldest comet in creation was going to be difficult to tame. I heard her signaling for the *Roaring Candle,* her voice carrying through the handhold valve that linked us. I began to wonder seriously about the fail-safe backups on the suit life-supports. Grace's voice through the link became tenser.

"Your eggman must be in better shape than mine," I said. "It lasted longer."

After a moment's silence she said, "No." She patiently explained then that I had used extra fuel in order to move to her at the comet surface, therefore, my eggman must have been better maintained. That's Grace.

We were, meanwhile, tumbling slowly but surely away from both the comet and the *Roaring Candle.* The view was totally breathtaking. We held hands through the airlock valve and waited. From this point on, it was all video games. My trusty crew of student spacemen would prove if they were true comet iceketeers or only apprentice sorcerers.

It was a slow motion rescue. Grace and I missed the last of it, because the life support backups did not backup long enough, forcing us to resort to deep meditation, then unconsciousness, to make our oxygen last until we were rescued. I missed, therefore, seeing the comet break herself in half.

In order to catch us safely, the Oortbridge crew had had to interrupt the centriole firing in mid-stroke, which destabilized the ungainly mating and left the two halves in a slight but perceptible orbit about one another.

By the time I was awake enough to look, the two cold, dark pyramid shapes were waltzing around each other with leviathan rhythm. I watched the playbacks for hours while resting up in sickbay, with cold dark thoughts orbiting my brain in the same incomprehensible dance.

Then those kids, bless them, made a bet with me—and through me, with Pelgrim.

Suddenly, I felt younger than all of them together. I had been so locked onto the Questing Beast that the idea of flinging her away to go in search of her master was beyond me. I might have thought of that on my deathbed,

but these kids had given me the jump on it. They wanted to know what had knocked that enormous double pyramid of a comet out of its complacent path, a path billions of years long. She was already on her way toward our star, much too swiftly. What had shunted her onto that new path?

I had been content with a comet to retire on. These innocent youths wanted a grander conclusion to this voyage. They were truly innocent enough to know they could have it. They bet me that if they could send that behemoth safely onto a course toward Tarse, then I would let them track her back to her previous realm, deep in the Outer Rim. They were in quest of that still larger beast which had startled her into the light. They were young; they were in love. How could I deny them the wonder of it? The bet was made, with Pelgrim lodging a formal complaint with the university. We let him.

Nothing succeeds in a marriage quite like success. Pheromones taxed the ventilators like orchids from the *Twilight Zone.* Those lovely boys strove to look good in the eyes of their lovely brides, and the ladies were not going to let them mess it up. They trusted themselves because I trusted them, and "agitator X" was fixed in our scopes as surely as Ahab's whale. We just had to figure out which blip was X.

As it turned out, they all were.

It was not simply *one* monster out in the Deep Rim that had knocked our comet loose, but a baker's dozen of them. A once-in-an-eon gathering had become a cluster of comets cruising through the comet zone, scattering everything around like bats in a storm. They were hunks of ice and rock so big that they had squeezed themselves down into almost-spheres, bulging, broken, knocked-up bottles of primal waters, moon-sized gulps of life to steer toward Tarse. Could we bring one back as proof? Could we pluck even one megalithic Goliath from the outer dark? Could we spin a planetesimal the size of a moon and play the biggest game of pinball ever played?

I was certain of it. I was so deliriously certain of it that I paced the corridors of the *Candle* like Kublai Khan pacing through Xanadu. The final frontier was a wave cresting at our feet. Was Kublai ever more certain of paradise than I? Calls went out to every comet-ship in the fleet. It was time to gorge on comets. The outer dark was throwing snowballs at our star. There were lifetimes of fun to be had here, with enough water to drench the sands of Tarse.

Meanwhile, I watched Pelgrim grow more sullen, tense, and distracted. He kept tying up computer time with some mysterious orbital mechanics, the kind that kids learn in order to play virtuality games. None of us had played in years—we worked with the real thing all day and dreamed of it at night. Pelgrim used computers, hoarding the data like a neurotic dragon. I left him alone and paid close attention whenever he said anything.

Pelgrim refused to believe in coincidence or even luck. The mere suggestion that we were destined to be out here at this gathering of a plethora of comets was enough to make him storm out muttering. Thus, when Oort-Captain Matholooch reported the sighting of a "shy comet, one that changes its position every time we shine light on it," some distance ahead, I put Pelgrim on it, with full override priority. I think he was almost happy for a moment there. Grace said he was happy.

As we approached this "shy comet," she turned an unusual face to us, as though winking in the dark to get our attention, but unwilling to be seen

Pelgrim found nothing in any physics text to explain a "shy comet," but there was plenty in biology texts for it. Our Questing Beast turned out to be a very different animal, indeed.

Passive receivers, such as our long range scopes, would report the little comet as being suddenly brighter, active in a portion of the EM-band where comets do not usually emit, yet when we turned long range lasers on her to look at her in some better light, we saw nothing but the relentless dark of an inactive, frozen comet. If we just looked at her, the brightness and radiation returned, peekaboo style, as if the bright side of the comet could only be seen, as it were, out of the corner of the ship's eye. It was not just an eccentric pattern of rotation: As long as we did not shine any light on her, she stayed bright. Shine a light, and she went dark.

We decided to waste some fuel on this and changed course to get a closer look, but even from a hundred kilometer orbit, the light (dubbed "faery light" by the kids) continued

to elude us. From here, however, we could see that it was not the comet but something *on* the comet, something that could move, apparently at will, away from the light.

We decided to have a real look and got out the eggmen, now heavily fortified against the coldest cold. Even that did not work until we split up into seven teams of four each and literally surrounded the comet, herding the eerie faery lights together so that we could see them, finally.

There were nine of them, nine little tiny brocade asteroids, each no bigger than a couple of whales. They were bright, lumpy shapes, shiny as though coated in crystal, with swirls and whorls of mathematically precise patterns in gold and silver on gray and black, glowing against the comet's cold, dark bulk. They were moving, stirring like restless animals caught in a corral. We just hung there in space, lost in the wonder of it. No one, not even Pelgrim, was able to speak.

Then, in a single gesture as though the impulse were carried on the sound of breathing in the radio, we all began filming and recording at once, every camera and scope wide open, broadcasting back to the *Roaring Candle* at the same time in a wild tumult of data. Moolchand, on com-link back at the ship, broke the spell with a strong enough signal to interrupt us. "What the hell is going on out there?"

We all answered together, until Moolchand cut through the babble with a sharp whistle. I spoke then. "Get everyone out here to see this, Moolchand," I ordered. "You included. Everyone deserves to see this with their own eyes. Pictures just won't do."

I myself hardly believed my own eyes. Why would anyone ever believe this just from pictures? I debated with myself over trying to report this to University HQ. Their responses over the next few days, suggesting crisply that we had better not be making this up, made me wish we had kept the miracle to ourselves. We waited for the science teams and newsships.

The nine creatures gave not the slightest response to anything we did (from our discreet distance as commanded by HQ,) except to move away from any light above starlight lumens. The crew, in their eggmen, circled around as though we were the Indians and they were the wagon train, but nobody fired a shot. We just took a lot of pictures, millions of pictures. We kept our lights as dim as possible and watched the creatures glowing in the ultra-dark. Sometimes, we just hung there in the strange silence and looked at them.

The news media picked up on our file name for the creatures, R-O-X, for "Rocklike Organism X," and they were "rox" ever after. We had been given our orders: "Look—don't touch."

Survey ships were still weeks away, even at top drive, so we studied the rox every way we could think of without actually interfering with them, actively wondering what they would surprise us with next. As nearly as we could tell from that distance, rox biology was based on superconduction, which explained their avoidance of light and their need for the near absolute cold of the Outer Rim. The precise patterns of pure gold and palladium under the crystal "skin" flickered and surged with incomprehensible intentions, in rhythms disturbingly similar to the electrical activity of the human brain. But that was little more than "Hi, how are you?" in terms of getting to know them.

After a while, we realized that they were eating the comet. They rested on the comet's black surface like fallen baubles, absorbing her one layer at a time, molecule by molecule. This digestion took place at the speed of superconduction. The entire precious comet melted away in a couple of days. The nine little comet-eating rox each grew larger as they ate, until the comet was gone.

Then, on curious spikes of ions emitted in careful but powerful bursts, the nine rox set off toward another comet a few hundred thousand kilometers out.

The *Roaring Candle* followed at a respectful distance, all of us experiencing an awe at how fast the creatures could move, accelerating steadily on their ion spike emissions. X-rays showed them as solid inside, so we rejected the idea that we were seeing spacecraft, piloted or otherwise, but no one had an explanation for rocks that could fly. Of course, no one had ever had an explanation for the peculiar, not-quite-there natives of Tarse, so speculation ran pretty wild. Some of it sounded innocent. Some of it was just acting wise, but these kids could feel their brains waking up

on the mystery. They were demonstrating some real smarts.

I had to stop thinking of them as "kids."

Once the rox reached the next comet, they decelerated with coordinated precision, orbited the new comet for a few hours, then settled down to begin eating her. They absorbed her quickly, and each rox expanded in size. The increased surface area showed on them as dark bands of carbon between golden lines.

"We needed those comets," Pelgrim said darkly. He said everything darkly these days. He was on to something. "Aren't *we* supposed to be the ones who get the comets?"

Leave it to Glenn Pelgrim to find something wrong with first contact. "How long before they get *all* the comets?" I asked him that because I realized suddenly that he knew the answer, had worked it out and only needed someone to ask.

"Just under two hundred years." He made it sound like twenty minutes.

I realized then that I loved this man as much as Grace did, and I understood her careful tending of his heart. Nurturing has a million faces. I saw Pelgrim's for the first time. I also saw that my own by comparison was a loose and careless kind of tending. At least I know how to keep good people around me. I gave his information the response it deserved: I called an immediate ship-wide "red alert," and pulled everyone out of their respective sacks or tasks for an emergency powwow. We had encountered a new alien life-form, and we had to chase them away or kill them—or else lose ten thousand years of our own world's future.

Once the nine alien rox had eaten the second comet, including all the boulder-sized silicates in the comet's center, they began to grow something. They grew it out of their own substance, like bees pressing out hexagonal plates of wax. Each rox shrank as it worked. They grew it from the inside out, layer by layer, starting with a kilometer long "spine," a segmented helix of metallic crystals in odd alignments. They took about fifty hours to accomplish this. We got very good at taking pictures in the dark, recording every nanometer of that structure. We watched the rest of the rox structure grow, and it looked like almost anything. A spiral web around the spine was filled in with carefully packed quartz bubbles, each with something unidentifiable inside.

The excitement that the *Roaring Candle* crew felt was nothing to the uproar back on Tarse. Emotional gravity waves were shaking Tarsean society in a dozen dimensions. Our ancestors had come to Tarse from Earth's Solar System a thousand years before in sleeper ships, but since then, we had had no contact from anyone other than occasional radio bursts from the home planet. The peculiar native life of Tarse was not exactly conversational. We had thought we were alone out here, the only sentience among the stars. All at once, we were not alone in the galaxy anymore. Everything had changed.

The news frenzy resulted in the launch of every spaceship in the system capable of travel to the Deep Rim. Every screen on the planet was tuned to our reports, despite the hours-long delay from our great distance. Everyone knew how to look for "shy comets" now, and the rox hunt was heating up.

The rox worked with the silent, relentless purposefulness of insects building dirt mounds. Nothing we did attracted their attention or distracted them from their work.

Until Grace Wing took one of their crystal bubbles.

Grace and I were on an off duty eggman "stroll," taking it in with our own eyes, both still amazed by the creatures and their promise. Our eggmen were linked together this time, so that "the poor old captain couldn't float away again." Grace's natural curiosity got the better of my judgment, and she tugged me with her over to the neatly stacked and enigmatic bubbles clinging to the even more enigmatic spine. She plucked a bubble out carefully with a precision waldo and held it at face level in front of the eggman helmet to look at the mysterious shape inside with her own living eyes, unmagnified, through no lens. Our experience with the native Shuffles of Tarse had taught us a powerful lesson about the limits of our machines.

The bubble was a sphere about ten centimeters in diameter, of hard, brilliantly clear quartz. The something inside was hard to look at, not quite blurred yet oddly unfocused.

"It looks different now that I can see with the naked eye," she said. "Not at all like its

pictures. Look." She held it out so that I could see it more clearly. The link made it easier for me to see what she was holding. Before I could fully focus on it, I noticed that the nearest rox had noticed, at last, and was thrusting itself towards us.

I jetted us both away, dragging Grace out of its path, prepared to put the eggman to full throttle if necessary, and we braked after a few hundred meters to watch. The radio in our headsets fell silent as the rest of the crew got word of what was happening. The rox hovered over the pile of bubbles, its bulk blocking any view of what it was doing. After twenty minutes, it went back to its interrupted work further along the spine.

The careful stacking of spheres was complete again. The rox had replaced the bubble that Grace had removed.

Grace jetted back over to the site, tugging me along, and compared the two bubble containers. "Looks to me like the same thing inside," she whispered. She whispers when she's excited. She was so excited I could hardly hear her. "Now you take one."

I needed the automatic waldo; my hands were trembling with the fierce rush of hope.

Once I had it secured, we lifted away from the structure and hung in the void, waiting. The radio was silent; everyone was waiting. The rox returned, clung with massive gentleness to the layer of crystals for another twenty minutes, then, as patiently, returned to its work elsewhere.

This bubble had also been replaced.

A whoop of excitement went through the radios. It might have been me. Grace and I began to load up with every piece we could grab with our waldoes, filming everything like mad, laughing and talking wildly all the while, until we both looked like Easter-egg trees floating in space. By then, eggmen were streaming out of the *Roaring Candle,* and they descended like a plague of electronic locusts.

Every piece we took was patiently replaced the same way, until the rox had all shrunk down to a third their original size and the tight swirls and metallic whorl patterns were a solid brocade coat. By then, we had stolen about half of their bubbles, with the oddly spiraled spine hanging in space, empty. Everybody was working on solving the puzzle: Here are all the pieces—what did they do?

The bubbles had to be kept ultra cold. We found that out the hard way, although the explosion did not entirely wreck the laboratory and no one was hurt too badly. That put serious limitations on our ability to study them. The *Candle* just wasn't equipped for that kind of research. The teams catching up with us would have to figure out what the shifting, half-seen forms inside the crystal spheres were. We just collected them.

We had no idea how the rox signaled each other, but, like fish in a school, they worked with perfect coordination. When they abandoned their structure, it was in a single moment, all at once setting off in formation, accelerating away on their curious ion drive. They were out of sight before we had finished reporting in. We lost them in the time it took to get everyone back on board the *Roaring Candle.* The crew who were off-ship in their eggmen reported back quickly enough, but it was unprecedented to have so many out at the same time. They were limited to negotiating the airlock entryways two by two for the return.

I made them stay long enough to buoy-mark the abandoned spine. There was no way to load it onto the *Roaring Candle.* It was too big and too cold. We were built for spinning comets, not carrying them. Science resource ships would have to retrieve it. It was too valuable a prize, even if we had no concept of what it was.

Despite the delay, we had a head start on the rest of the system, so it was not surprising that we found the next group of rox as well. They were much further along on their mysterious construction. As we arrived and spread around them to watch, they were covering the framework with a layer of carbon panels that blocked every kind of radiation. An instant debate sprang up over whether these were part of their original plan or simply a means of preventing us from raiding the crystal bubbles.

The rox disappeared inside and pulled the last panels over themselves. Just on a whim, I made everyone get back into the safety of the *Roaring Candle.*

Two hours later, energy readings from the rox construction went off the scale in every range. Just beyond it, a "hole in space" unfolded, showing a sudden exultation of stars in the

gap, stars too close together, too brilliant, as if I could reach out with my hands and touch them through the rift.

Without warning, the rox construct slipped through that rift, dwindled away into the starfield distortion, and was gone. The hole in space zipped up behind it with a wild burst of radiation exploding outward that swept the *Roaring Candle* away like a twig in stormy surf. In this vast emptiness, there should have been no ripples of anything; the fabric of space itself was rippling around us. It was a hell of a ride on the *Roaring Candle* before reality got itself under control.

We had, at last, found out why all those comets had scattered out of their ancient orbits so far from the star: they were dancing in the wake of alien starships sailing through, bobbing on energy waves washing around our entire stellar system. There was a hailstorm of comets to come.

Once we had put the pieces back into place and recovered from the shaking, Pelgrim had a serious suggestion to make to me, so serious that he insisted on talking to me about it alone in my quarters. In the ten years since he signed onto my crew, he's never crossed that threshold. He made me sit down, then he paced a little back and forth before speaking. "We have to talk about your idea of taking Grace out to the stars with you," he said. He really meant it.

"I wasn't actually aware that I'm going to the stars," I said to him, but, of course, now that it had been said, I would never stop thinking it.

"We're either going to capture the next rox starship," he said. "Or else build our own from the recordings and materials we have."

Our first starship. *Captain White Eyes on the bridge of a starship.* The concept was dazzling. I rolled the words around in my brain for a moment, feeling them click into place. "You make it sound like a bad thing, Glenn." I used his informal name, because this had nothing to do with ship's business.

"You have to realize," he continued, holding his breath a moment and coloring a little. "You have to realize that if you insist on chasing around the galaxy in a borrowed starship, then Grace will insist on going with you, and you damn well better realize that if she goes with you, so do I. So any plans you make had better have me in them."

The people around me were getting too good at second-guessing me before I'd second-guessed myself. It was a striking question, though, because it would never have occurred to me to go without Grace. I began to feel the distant rumble of a new and wonderful excitement—I was going to the stars. There were plenty of new comet ice-keteers to escort comets down to Tarse. The wakes of the rox starships were flinging them at the planet. Capturing comets from now on could be done from a comfortable, close-to-your-own-backyard distance.

My backyard had just opened up to include the galaxy and beyond. "Could we really build a starship just from having watched the rox build theirs?" I said.

"We will," he said defiantly "But that's not the point. Grace won't let you go without her."

"Well, of course she won't," I said. "Do you really think we can build one?"

"You're fifty-five years older than she is!" Pelgrim said this as if prepared for me to deny it. Clearly, he had been fighting with me over this in his head for some time.

"Fifty-four," I said. "But I won't quibble."

The air around him darkened, and I could hear his breathing thicken. "What's going to happen to her when you're dead and gone?"

I remembered holding hands with Grace while out on the comet's surface, the mad tumble while waiting for death or rescue. He had asked the right question. "That's why there's two of us," I said to him. "Who else but *you* would there ever be to protect her from losing *me?"*

The fight went out of Pelgrim then. He stopped pacing. "You're a bastard," he said gently.

I should have let him rant a little, but he had distracted me from his distress with his vision of building our own starship. I shrugged, motioned him to the opposite chair and pulled open the bottom desk drawer where Grace keeps a set of real glasses and a very old bottle. He watched with dulling hostility while I poured us each a generous glass and pushed one toward him across my desk, but he took it without hesitation.

"To the wonder of Grace who keeps us from misunderstanding each other," I said.

"May she outlive us both." We clinked glasses solemnly and drank. Pelgrim sat back in the chair and some of the fierce tension in him eased. He sat looking down at the glass in his hand for a long time.

I poured myself another and waited. He sighed a couple of times as though about to speak, the sound of his powerful emotions rising to words. I had undercut the angry speech he had obviously rehearsed, leaving him only the raw feeling. I would need to calm him down some to get to the heart of this. He put the glass back on the desk, and I poured him another. He drank it and sat staring at the glass in his hand.

"Can we really build a starship?" I said.

"Yes. Just a matter of time now." He looked at me finally, tilting his head as though looking up into bright light. "I knew you would jump at that. You have the prestige to make it happen."

"Prestige ain't worth smoke if we can't unravel their technique. They pull starships out of their asses!"

"A mere technicality."

That made me laugh. His offhand certainty was delightful. "Okay. The three of us are going to travel to the stars someday soon. What's your problem? Are you afraid of being left out? Or of going?"

"There's no way of knowing what's on the other end of that ride," he said in protest.

"There's one way."

Pelgrim began to heat up again. "Can you justify taking Grace into that kind of danger?"

I reminded myself that Glenn Pelgrim was a widower, and how it happened. "Do you think she'd have it any other way? Do you think she married me for the sake of physical security? Or do you maybe think I married her so that I could hide her away here in deep space, secure in the ultimate glass tower?"

"I have always thought of marriage as a mutual protection pact," Pelgrim said stiffly. "Back to back against the uncertainty of life." He had to stand up again, pushed around by the conflict of choices and feelings. He doesn't like to meditate. He would rather twist out on the ends of branches until he's got it right. Maybe for him that is meditation, a meditation of results.

"You're facing the wrong way, Glenn. We're all just holding hands together so that no one gets lost."

He had stopped pacing and stood in front of the holo-display of the Milky Way that hovers in an open corner of my office. The program was a special gift, living on ambient light, and it's been a long-time companion. Pelgrim sat down to its control panel and proved he could make my galactic holo-display do some very interesting visualization tricks, showing me some things he had already learned from the rox. He convinced me we had a chance.

I made him put the Milky Way back before he left.

We waited for the rest of Tarse to catch up and went back to studying pictures and making guesses. Were the rox even really alive? There were plausible arguments both ways. If they weren't alive, what were they? Automated starship builders? Could this be how star-traveling civilizations built their starships, sending automatons out to raid comets from other systems? I was personally most taken with the realization that we had stolen from them, yet they used no violence against us. They showed no weapons. Once they had had enough of our interference, they simply pulled up and left. Whatever the answers to the hard questions about them, their peaceable nature was evident. I allowed myself to believe it was evidence of the peaceable nature of the galaxy beyond, where we were about to tread.

For a thousand years, no one of Tarse has seen anything of Earth except a twinkle in the night sky and ghosts of the Hollywood machine the Founding Families had brought along. We forget so easily that there was ever anything except Tarse, no other world except our own rusty globe. The whole great planet seemed to shrink into something fragile, dried, wispy, something that we must wrap our hands around to keep from blowing away in the stellar winds. The mystery of the rox was too solid to deny and too exciting to ignore.

I had never felt my years so clearly before. I had never felt so fragile. Would I live to see our own starship assembled? Would I fly her or would they carry only my ashes to the stars?

The time had come to hunt for shy comets with diamonds in their hair. ■

THE REFERENCE LIBRARY Don Sakers

Last month I argued that *Analog* readers benefit from knowing something about the history of science fiction. I gave you some resources to learn more about the development of the field and the personalities involved.

But the essence of SF's history is the works themselves, the books and stories that caught the minds, hearts, and imaginations of generations of readers. More than events or people, these classic works *are* the history of science fiction. Unfortunately, many of SF's classics aren't as available as in days of yore.

The good news is that they're out there. Many SF classics are in print or e-books in small-press editions, self-published by the authors or their heirs, or (at worst) available as fairly cheap used books. Search and you should find.

One place to start is with awards. You can get a fairly good grounding in book-length classics by searching out the Hugo and Nebula winning novels of each year. For added depth, you might want to consider including each year's nominees as well. Be sure to include the Retro Hugo Awards, which are given retroactively for years before the regular Hugos started in 1955.

It's going to be a bit more difficult to put your hands on all the classic pieces of short fiction in the field. After all, it's been 89 years (to the month, coincidentally) since *Amazing Stories* first appeared—that's nine decades of short fiction.

Fortunately, dedicated anthologists have been plowing through those nine decades ever since the late 1940s. There are plenty of good anthologies filled with the best of the best.

First, find a copy of *Adventures in Time and Space*, edited by Raymond J. Healy and J. Francis McComas. This 1946 anthology of nearly 1,000 pages is *the* definitive collection of pre-war SF classic short fiction. Used copies are readily available for less than this copy of *Analog* you're reading.

Next, you'll want to look for *The Science Fiction Hall of Fame* series. Volume 1, edited by Robert Silverberg, contains over 500 pages of classic short stories from 1929-1964. These stories were chosen by vote of the Science Fiction Writers of America as "the greatest science fiction stories of all time." Volumes 2A and 2B, edited by Ben Bova, contain similarly-chosen novellas from the same time period. All three of these volumes have stood the test of time.

Another classic anthology is A Treasury of Great Science Fiction (2 volumes) edited by Anthony Boucher. This 1959 omnibus from the Science Fiction Book Club contains just short of 1,100 pages of quality SF.

In 1965 SFWA began voting the annual Nebula Award to short fiction as well as novels. A single volume containing short fiction winners and runners-up has been published just about every year since then, with a different editor each year. Titles have also varied: *Nebula Award Stories X*, *Nebula Awards X*, and *Nebula Awards Showcase X* are common, where X is either an integer or a year. Used volumes are fairly easily available.

In addition, SFWA has continued the *Science Fiction Hall of Fame* series, reprinting Nebula-winning stories for a range of years. Volume 3 covers 1965-1969 and volume 4 1970-1974.

Short fiction Hugo winners have been compiled into periodic collections. *The Hugo Winners* volumes 1-5 (all edited by Isaac Asimov) cover 1955-1982, while the

New Hugo Winners volumes 1-4 (with various editors) cover 1983-1993.

This next batch of books can be somewhat harder to come by, but they're definitely worth the effort.

Starting in 1979, Isaac Asimov and Martin H. Greenberg edited a series for DAW Books called *Isaac Asimov Presents the Great SF Stories X*, with X an integer between 1 and 25. Each volume presented the best SF stories of a particular year, staring with 1939. With publication notes on each story by Greenberg and historical notes by Asimov, these volumes are a treasure trove of classic SF short fiction. These books are in great demand; don't be surprised if prices on the used market are higher than you'd expect. Volumes beyond 20 must have had smaller print runs, as they're much harder to find. Although they were published as mass market paperbacks, at least a few volumes were offered in hardcover by the Science Fiction Book Club.

Another well-beloved series from the late 1970s and early 1980s is the *Ballantine Classic Library of Science Fiction*. Each volume focused on one big name SF author; in addition to short fiction, each contained an introductory essay by another big name author. These books had a fairly uniform look and titles: *Best of (Author's Name)*. I haven't been able to find a complete list of these, but there were easily two dozen of them. If you can think of a big name of the period, there was likely a volume devoted to them. Used copies are fairly common and usually inexpensive.

There have been too many annual "year's best" anthologies to keep track of, by too many editors and under too many title variations. Be on the lookout in particular for such volumes edited by Terry Carr, Brian Aldiss and Harry Harrison, and Judith Merril. Donald A. Wollheim's *Annual World's Best SF* anthologies, published for nearly twenty years starting in 1972, deserve special mention.

If you can track down and read even half of these books, you'll be rewarded with the best that science fiction has to offer.

Sci-Fi Chronicles
Guy Haley
Firefly, 576 pages, $29.95 (trade paperback)
ISBN: 978-1-77085-264-8
Genre: Nonfiction

Speaking of the history of the field, here's an absolutely gorgeous book with appeal to every SF fan, from the oldtimer who started reading with Gernsback to the newest Millennial-generation devotee of anime and dystopian movies. And everyone in between.

This dense, full-color tome is packed with pictures and chock-full of information. The author takes a modified chronological approach, spending anywhere from a single page to a multi-page chapter on each of hundreds of topics: authors, books, magazines, movies, tv shows, games, and short stories. For each there's a timeline, pictures, and color-coded categories.

For example, the entry on *Starship Troopers* comes in 1959 and covers the original serial, the book, various games (board and video), movies both animated and live-action, comics, *and* discussions of the book's influence on the subgenres of both Space Opera and Military SF. And all of this in just two pages.

You'll want this book as a reference source covering everything of importance in the SF field from 1885 to the mid-2000s. But you'll find yourself dipping into it at random, surfacing hours later wondering where the time went. From a full chronology of the *Flash Gordon* universe to the connection between *The Jetsons* and *Twelve Monkeys*, there's more than enough in this book to please and amaze any SF enthusiast.

Twelve Tomorrows
edited by Bruce Sterling
Technology Review, Inc., 230 pages, $12.95 (trade paperback)
Kindle: $9.99 (e-book)
Genre: Original Anthology

Since 2011 the *MIT Technology Review* has produced an annual anthology of original science fiction stories by leading authors in the field. As you'd expect, the stories are oriented toward technology, exploring the effect of tech upon societies and people. In other words, right down *Analog's* alley.

Here you'll find nine stories by familiar names such as Pat Cadigan, Cory Doctorow,

William Gibson, and Bruce Sterling, as well as some less familiar ones: Lauren Beukes, Christopher Brown, Warren Ellis, Joel Garreau, and Paul Graham Raven. There's also an interview with Gene Wolfe conducted by Jason Pontin, a review of Stanislaw Lem's *Summa Technologiae*, and a full-color gallery of art by John Schoenherr, one of SF's trailblazing artists and a name that should be familiar to *Analog* readers (in fact, six of the twelve illustrations originally appeared in this magazine).

With such a lineup you'd expect the stories to be good, and they don't disappoint. Pat Cadigan's "Business as Usual" is a story of the Internet of Things: a tale of a wise old grandmother and a refrigerator with personal troubles. "The Shipping Forecast," by Warren Ellis, pits plate-girdling market forces against one woman with technology on her side. Joel Garreau's "Persona" tells of a global arms race in the field of cognitive enhancement. In Bruce Sterling's "The Various Mansions of the Universe," a bioengineered couple travels a posthuman world in search of their dream house. The other stories are equally thought-provoking.

If you enjoy the stories in *Analog*, you're certain to find much to like in *Twelve Tomorrows*.

Soulminder
Timothy Zahn
Open Road, 326 pages, $14.99 (trade paperback)
iBooks, Kindle: $9.99, Nook: $10.49
ISBN: 978-1-4976-4620-9
Genre: Biological SF, Philosophical/Religious SF

Long-time *Analog* readers, please cast your minds back to 1989. In that year, two stories by Timothy Zahn appeared in these pages: "I Pray the Lord My Soul to Keep" in the January issue, and "The Hand That Rocks the Casket" in the November issue. Then in the October 1991 issue came "Guilt by Association." These three stories dealt with the same characters and situations. Since then, frustrated readers have been asking for more—and finally, Zahn delivers.

In *Soulminder*, Zahn expands the three stories and adds extra material to form the novel that we've all been waiting to read.

When Adrian Sommers lost his son in a driving accident, he devoted his life to developing technology to capture and preserve a dying person's memories and personality—"soul," if you will—until it can be reinserted into a new or repaired body. Sommers calls this technology *Soulminder*.

In true SF fashion, Zahn explores the implications of Soulminder, especially unintended consequences. Sommers confronts extortion, legal issues, and criminal use of his technology as Soulminder's ripples spread through society. And then the military gets involved. . . .

Zahn is a master storyteller, and *Soulminder* is a fast-paced thriller as well as an intellectual delight. Whether or not you encountered the original Soulminder stories, you owe it to yourself to give this one a try.

Dark Lightning
John Varley
Ace, 352 pages, $26.95 (hardcover)
Kindle: $10.99, iBooks, Nook: $12.99
ISBN: 978-0-425-27407-1
Series: Thunder and Lightning 4
Genre: Hard SF, Space Opera, Trips in Space

John Varley's Thunder and Lightning series is a chronicle of new technology and its consequences, both intended and unintended.

In the first book, *Red Thunder* (2004), inventor Jubal Broussard creates a new technology, the Squeezer, which compresses matter to yield immense energy. Using the Squeezer as the basis of a space drive, Jubal and his misfit friends cobble together a makeshift spaceship and beat America and China to the first landing on Mars. *Red Lightning* (2007) takes place about twenty years later and follows the adventures of two children of the original Martian colonists as they cope with political unrest following a planetwide disaster on Earth.

Book Three, *Rolling Thunder* (2009), carries the story into a third generation, as a young woman in the Martian Navy travels to Europa and faces a threat to the entire Solar System.

Now *Dark Lightning* concludes the saga. It takes place aboard a huge starship (called *Rolling Thunder*) made from a hollowed-out asteroid and powered by yet another magical technology created by Jubal Broussard. The

crew of *Rolling Thunder* are on their way to New Earth; they spend most of the voyage in suspended animation, with periodic awakenings.

The voyage goes well, until the day Jubal himself emerges from stasis with startling news: the ship must come to a stop, or everyone aboard is doomed. Since Jubal's the only one who really understands the technology that powers the ship, of course everyone is concerned. Half the crew trusts Jubal, and the other half think he's lying. Mutiny hangs in the air.

It falls to Jubal's twin daughters, Cassie and Pollux, to determine the truth.

Like the other three, *Dark Lightning* is an unabashed homage to Robert A. Heinlein. If you're not a Heinlein fan, you should probably steer clear. But for anyone who has fond memories of those old Heinlein "juveniles" like *The Rolling Stones*, *Time for the Stars,* and *Have Space Suit, Will Travel*, this whole series is not to be missed.

A Slip of the Keyboard: Collected Nonfiction
Terry Pratchett
Doubleday, 307 pages, $26.95 (hardcover)
ISBN: 978-3-385-53830-5
Genre: Nonfiction

Sir Terry Pratchett, best known as the author of the hilarious *Discworld* series, is an international figure with millions of fans worldwide. He is also a consistent voice of reason and compassion. Since 2007, when he was diagnosed with early-onset Alzheimer's Disease, he has been a leader in the fight against the disease, as well as a right-to-die activist.

A Slip of the Keyboard collects dozens of pieces of Pratchett's nonfiction, most of them short enough to read at one sitting. The topics include writing, fantasy and science fiction, autobiography, politics, religion, humor, Alzheimer's, assisted dying, and many others.

Forget the fact that Pratchett is a profound thinker, a great communicator, and perhaps the funniest man in literature today . . . he's a hell of a good writer, and these essays sparkle and fizz with delightful energy. Pick up the book, open it at random, and start reading. If you're not caught in three lines, then you're not human.

Beyond Human: Engineering Our Future Evolution
Erik Seedhouse
Springer, 153 pages, $19.99 (trade paperback)
ISBN: 978-3-662-43525-0
Series: Science and Fiction
Genre: Nonfiction

The usual pattern for a book in Springer's Science and Fiction series is a work of SF followed by essays examining the science behind the fiction. *Beyond Human* is a departure: it's just the essays, apparently without any accompanying fiction.

In reality, the SF is there; it's just not contained within the covers. *Beyond Human* was inspired by Ridley Scott's 1982 movie *Blade Runner* (which in turn was inspired by *Do Androids Dream of Electric Sheep?* by Philip K. Dick.)

Erik Seedhouse is a spaceflight consultant and triathlon coach, and in this book he surveys the state of the art in human biological enhancement: genetics, genetic engineering, cloning, organ transplants, bioprinting, and evolutionary engineering. Along the way he reviews such topics as genetic enhancement of athletes, customized astronauts, underwater humans, and super-soldiers.

The book is well-written and fully illustrated in color. As Seedhouse conducts the reader on this journey, he doesn't stop with tech; he fully explores the social and ethical challenges of the technologies he covers. He remains conscious of the role of science fiction in all this, and relates his material to examples from SF books, stories, and video.

All told, this is an excellent volume that reads like the best science fact articles in *Analog*. SF writers in particular will want to read *Beyond Human* as a reference, but it's also a rewarding read for anyone who enjoys speculating on the frontiers of current science.

And now I'm out of space—so like the early days of SF, I'm history. Until next time, enjoy.

Don Sakers is the author of *Children of the Eighth Day* and *Meat and Machine*. For more information, visit www.scatteredworlds.com. ■

BRASS TACKS

Dear Trevor,

I thoroughly enjoyed your December 2014 guest editorial "A Choice of Apocalypses" by Howard V. Hendrix. I want to applaud you for making extensive use of guest editorials; I believe they add a richness of content and perspective that serves your magazine (and audience) well. I know that when I read the editorials of other magazines I sometimes come away thinking that the editor didn't have anything compelling to say but needed to meet a deadline. Excellent job!

Jack Courtney
Punta Gorda, FL

Dear *Analog,*

Since I majored in linguistics at college, I was surprised to see Mr. Hendrix write ["A Choice of Apocalypses," December 2014] that the Greek word *"**kalyptein**,* meaning 'to cover' . . . is the fountainhead of ***celare*** in Latin, and ***helan*** in both Old High German and Old English. . . ." Words that show up with a ***k*** in Greek, ***c*** in Latin, and ***h*** in Germanic languages are seldom (if ever) words that originated in Greek and then were borrowed into other languages. Rather, these are words that each language had independently inherited (and variously changed in sound) from a Proto-Indo-European original: these three words are related as siblings, not as parent and children. (Although it is easy to suppose that any word resembling a Greek one must have been borrowed from Greek, in this case the supposition is wrong. It is like supposing that, because the hands of humans and gorillas both have five fingers, gorillas must descend from humans.)

Kate Gladstone

The author responds . . .

My thanks to Kate Gladstone for her letter. I knew the link from *apokalyptein* to *kalyptein* was solid—but suspected that the further link from the latter to *celare/helan* might prove to be a bit, er, speculative. I like the independent inheritances from a shared Proto-Indo-European original, though. "Fountainhead" may be the wrong metaphor since, as you suggest, they are more likely siblings than parent and child.

Howard Hendrix

Dear Mr. Quachri:

I enjoyed "Predictable Futures: Climate Fiction and Climate Fact" by Dr. Anderegg. Too few popular news sources—TV and newspapers—cover feedback mechanisms such as those discussed by Dr. Anderegg. Additionally, most discussion I've seen are oriented toward returning our climate to, say, 1970. It would be interesting to see discussions about whether it be better to go to a different decade.

Everyone seems to think that we just need to get back to what we remember as good. Might be a good idea for a SF/alternative history story.

Ernest Schlich
Norfolk, VA

Dear *Analog,*

Thank you for publishing Ron Gould's letter in the October issue, in which Mr. Gould felt Grey Rollins's "Determined Spirits" [January/February 2014] was so politically propagandistic that he couldn't see himself reading any more *Analog* stories! I had forgotten the story, and his letter sent me back to it. I am glad.

I read it more carefully this time, and it rewarded me more, I think because it lacks the kind of personal relationship hook or sentimental bang that communicates the experience of "grabbing" from the very beginning. I had the very opposite reaction of Mr. Gould,

who added in his letter that even disregarding the political aspect it was very poorly written. Down to small details, the dynamics between the opposed main characters, roughly juxtaposing fanaticism and pragmatic realism, were played out against the mundane needs of physical maintenance of a high-tech piece of big-time manufacturing—a starship—with a vividness, verisimilitude, and economy that for me were vintage *Analog* and virtuoso writing. Perhaps Mr. Gould missed the point. Politics are irrelevant to the dynamics of the story and that the fanaticism could have been demonstrated using either end of the political spectrum but wasn't, seems to be because contemporary fanaticism in America is most obvious in public on the extreme political right, though, of course, only the wholly irrational part of it. Although the extreme political left has an equally irrational element it isn't publicly prominent right now, and I'd say current interest counts for something in publishing, and should. In addition, the reasons for the ascendency of one side to the public sphere, rather than the other, bear examination. I think Grey Rollins promotes it.

Proof for me of the balance in Mr. Rollins's product is that his hero caps the tale by mulling over the idea of going against the world-wide prevailing winds for what at least on the surface seems a sort of libertarian motive, not a leftist one. This, too, is in the Campbellian *Analog* tradition.

Once in a while a story as think piece on important contemporary concerns can be extremely helpful, if only we know it is there and are ready for it when it comes. Perhaps this one is of so pure a kind that it is a little too scarce to be ready for in that way, so that its ilk should have a presence in the magazine a little more often, if such quality efforts can be found a little more often! When it is included, *Analog* seems to me an indispensable forum.

Joseph E. Quittner
Cleveland Heights, OH

Mr. Quachri:

Edward Lerner's article "Alien AWOLs" in the October 2014 issue of *Analog* is a welcome summary of suggested solutions to the Fermi Paradox, but there is another possibility he did not mention, which possibly suggests we may very well have been contacted in a manner that, at our level of technology, leaves little or no evidence of that contact but has intriguing implications for what we are.

Even if space exploration is not too costly, unless it has very high priority (and perhaps even if it does) any exploration program will be constrained by available resources. In particular, it is reasonable to assume that there will at the least be constraints imposed by budgets and bureaucratic rules and regulations, and the exploration might well have to get by on the E.T. equivalent of a shoestring. Further, assuming **c** remains a constraint, the ability to physically visit and return from other stellar systems will be severely limited. If we wish instead that exploration be made by some other instrumentality, that instrumentality must travel for long periods through spacetime and be either self-repairing or sufficiently robust so that damage while travelling will not unacceptably degrade its functioning. Once a life form is detected, the instrumentality must initiate a sequence of events culminating in the sending of a sufficiently informative message to the originators. In other words, a form of Von Neuman instrumentality.

So the E.T.s try to keep expenses down and, consistent with this, the method they chose requires that it maximize some combination of coverage and the probability of response from any interesting system. Usually, these instrumentalities are assumed to be machines. But the instrumentality might also be something like coded information. For example the originators might send out information in the form of DNA contained in something like a virus. An enormous number of such "viruses" are sent—perhaps broadcast through the galaxy—as they are cheap to make and cheap to send. DNA is information encoded at the molecular level and can include effective and robust repair mechanisms. The "virus" seeks out any life form it is designed to or capable of infecting.

Since the purpose of the entire operation is to get a sufficiently detailed message back to the originators, let's speculate further and assume that the "virus" is capable of exercising some form of control over the evolution of the infected life form, with the purpose of promoting the development of a technological civilization whose members have an intense curiosity and desire to send messages

into, and travel in, space—perhaps "because it's there." After all, what better message to send back to the originators than a sample member of the dominant life form with its life support system. And why go through the expense and dangers of interstellar travel if you can make some other species assume them. And there is little or no observable evidence, at our current level of technology, of alien intervention.

It is interesting that the technology to create such an instrumentality might be almost within our economic and technological capability today. If so, for exploration further than the nearest star systems, it might be the galactic exploration mode requiring the lowest level of technological sophistication and cost, and perhaps the first one to come within the capability of an advancing technology. Yes, it will likely take a long time to get a response. But it is not clear that any other method would be both faster and able to maintain an acceptable level of cultural interest. We lack the ability to adequately define the relative costs and benefits of the alternatives.

Finally, a more disturbing consideration. If, indeed, my suggestion has validity, what additional instructions would the E.T.s include? In addition to requiring that we contact them and incur the costs and risks, perhaps also that we be incapable of hostility to them. It's interesting to speculate on how this might be achieved.

I don't mean to imply things must have happened this way, only that they could have and, if they did, then we have been visited by a Von Neuman machine. Only it wasn't a machine and we are the result.

Bernard Springer

* * *

Dear Sir:

I greatly enjoyed Ed Lerner's article ["Alien AWOLs," October 2014] about the Fermi Paradox. There are two other factors which I think may offer an explanation of "The Great Silence."

First, there is real estate. Galactic centers are occupied by super massive black holes. This creates an environment with large amounts of ionizing radiation. Such an environment would be very hostile to the complex chemistry required for life to develop. This would seem to rule out "new life and new civilizations" in a large volume of the galaxy. This volume is also home to a substantial fraction of the billions of stars that would enter into a naive version of the Drake equation.

The other factor is availability of resources. It is simply implausible that the conditions necessary for the development of life have existed for a substantial share of the Universe's history. The early Universe would have been almost completely devoid of what astronomers characterize as "metals," basically any item after helium in the periodic table. Other than the Solarians of David Brin's fiction, any plausible life forms will require elements from at least the next two rows of the table. These will not be present until several generations of supernovas have enriched the interstellar medium.

I lack the ability to determine exactly when this happens, but it seems plausible that at least ten billion years are required. In other words, Earth may be among the first of many life- and intelligence-bearing worlds. Thus, "they" may be out there, but at a similar level of development. The next million years might thus break the silence.

John Howard Brown ■

UPCOMING EVENTS Anthony Lewis

NOTE: Membership rates and other details often change after we have gone to press. Check the websites for the most recent information.

26–29 March 2015

AGGIECON 46 (Texas A&M conference) at Hilton Hotel and Conference Center, College Station, TX. At the door memberships: Full adult $40; Full student (18+) $25; Full student (13–17) $25; Child (<12) $15; Day (Fri|Sat) $20; Day (Sun) $15. Info: *http://stuorg-sites.tamu.edu/~cepheid/aggiecon.*

2–5 April 2015

MINICON 50 (Twin Cities SF conference) at Minneapolis MN. Writer Guests of Honor: Jane Yolen, Larry Niven, Brandon Sanderson; Musician: Adam Stemple; Publisher Guest of Honor: Tom Doherty; Artist Guest of Honot: Michael Whelan. Info: *http://mnstf.org/minicon/;* PO Box 8297, Lake Street Station, Minneapolis MN 55408-0297.

2–5 April 2015

NORWESCON 38 (Pacific Northwest area SF conference) at DoubleTree by Hilton Seattle Airport, SeaTac, WA. Author Guest of Honor: George R.R. Martin, Artist Guest of Honor: Julie Dillon, Science Guest of Honor: Amy Mainzer, Spotlight Publisher: Randon House. Membership: $65. Info: *http://www.norwescon.org/; info@norwescon.org;* +1.425.243.4692.

3–6 April 2015

DYSPROSIUM/EASTERCON 2015 (66th British National SF Convention) at The Park Inn, Heathrow, London, UK. Guests of Honor: Jim Butcher, Seanan McGuire, Herr Doktor, Carline Mullan. Special Guest: Tanith Lee. Memberships until 31 January (until 3 April 2015): Adult attending £70.00 (£80); Adult supporting £25 (£25); Junior 12–17 £25 (£25); Child 6–11 £15 (£15); Infant 0–5 £5 (£5); Apocryphal £1 (£1). Info: *http://www.dysprosium.org.uk/; enquiries@dysprosium.org.uk.*

10–12 April 2015

AD ASTRA 2015 (Toronto area SF conference) at Sheraton Parkway North Toronto Hotel, Richmond Hill ON. Guests of Honor: Author: Anne Bishop; Author/Musician: Charles de Lint; Artist/Musician: Mary Ann Harris; Screenwriter/Producer: Denis McGrath; Literary Agent: Monica Pachecho. Membership: Adult (18+) CA$50 until 27 March, CA$55 thereafter; Post-secondary: CA$25; YA (13–17): CA$20; Children (8–12) CA$10; under 7 free. Info: *www.ad-astra.org; info@ad-astra.org.*

24–26 April 2015

RAVENCON 10 (Richmond area SF conference) at DoubleTree by Hilton Richmond Midlothian, Richmond VA. Writer Guest of Honor: Allen Steele; Artist Guest of Honor: Frank Wu; Gaming Guest of Honor: Brianna Spacekat Wu; Special Authors: Lawrence M. Schoen & Jack McDevitt; Plush: Barry Mantelo. Membership: Adult (18+) $40 until 10 April, $45 at the door; YA (12–17) $15; children (<=11) free; 10% discount with valid military/student ID. Info: *http://www.ravencon.com/.*

19–23 August 2015

SASQUAN (73rd World Science Fiction Convention) at Spokane Convention Center, Spokane, WA. Guests of Honor: Brad Foster, David Gerrold, Vonda N. McIntyre, Tom Smith, Leslie Turek. Membership: currently. Attending adult $190; YA (17–21) $95; child (6–16) $80; Supporting $40. 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: *sasquan.org/; info@sasquan.org;* 15127 Main Street East, Suite 104, PMB 208, Sumner WA 98390. ■