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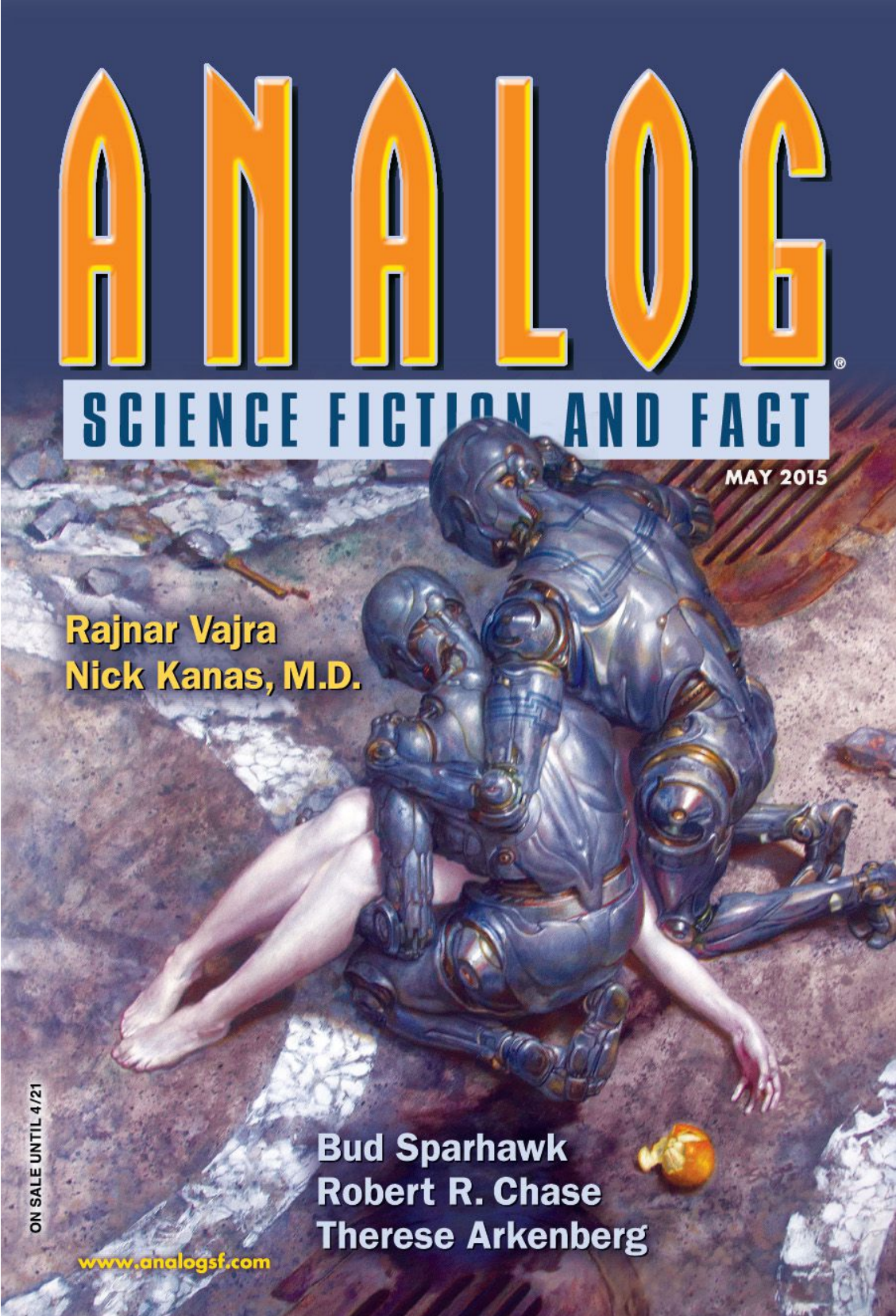

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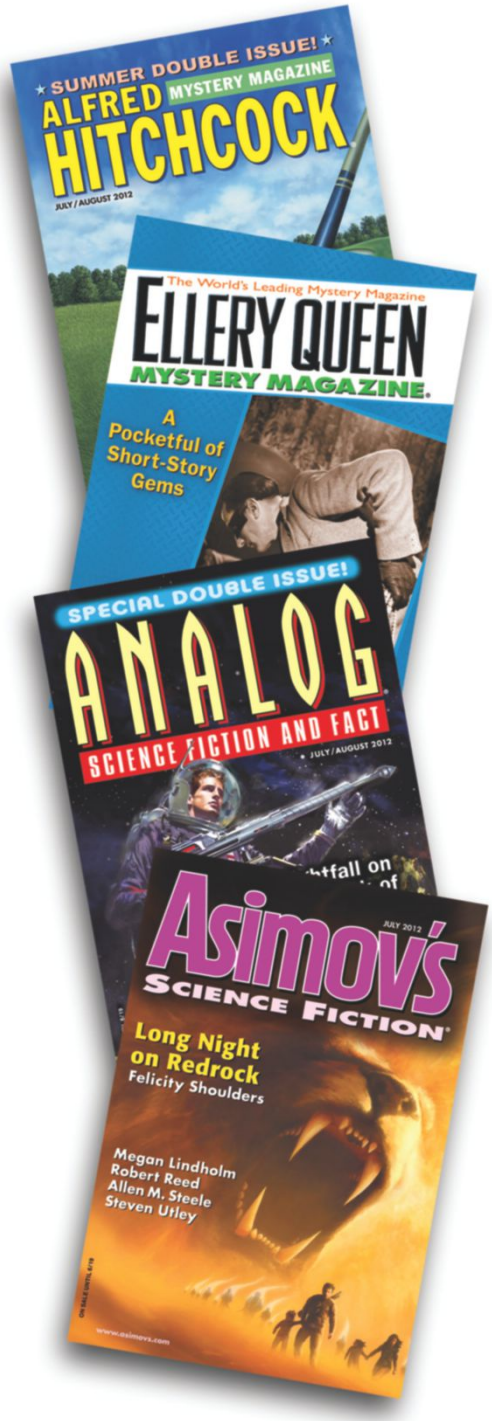

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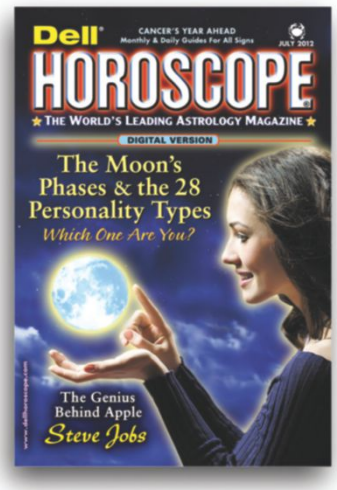

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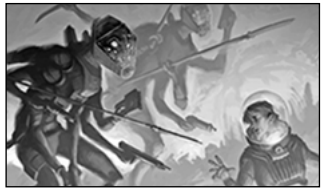
SCIENCE FICTION AND FACT

Vol. CXXXV No. 5
May 2015

Next Issue on Sale
April 21, 2015



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Indicia on Page 3

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NOT JUST SEMANTICS

Words are powerful.

As readers, and as writers, we understand this. The idea of word power is ancient, and international. It occurs in many religions. The Japanese language even has a word for it: *kotodama,* meaning "word soul" or "the spirit of words." In school, though, when I was asked to look words up in a dictionary, I don't remember feeling that spirit. Words tended to lose their dimension in lists on a page—definition 1, definition 2, definition 3. But why? Where does that sense of spirit and power come from?

Psycholinguistics can give us some insights.

Psycholinguistics is the study of language in the brain. There, word meanings take the form of neuronal activation patterns. When we hear a word, it activates neurons associated with the sound of the word, its appearance, and its meaning. But meaning in the brain is not just a numbered list on a white page. It is a simultaneous, multisensory memory of all the contexts in which we have ever experienced that word. Think about that for a second: When we hear a word, for the tiniest of moments we're experiencing *every time we've ever heard it before*.

What this implies for word meaning is that meaning grows directly out of the context of utterance. Meaning is complex because context is complex. It's visual and auditory. It's syntactic, and semantic. It's also social and emotional. So the question then becomes, when our brain comes up with lots of meanings at once, how do we know which one to choose? The simplest answer to that question comes down to frequency. When we use a word frequently, that means certain neurons are activated frequently, and frequency of activation translates into strength of activation. Thus, when we hear a word, we'll typically pick the meaning we've heard most often. How, then, do we know when not to pick the most common meaning? The context of the current utterance plays a critical role. The more elements of current context echo a previous context, the stronger our tendency to pick the meaning that makes a match.

These layered contexts of usage create the complex "feel" of a word—its spirit. And this works not only for single words, but for phrases and sentences as well. Let's take a delightfully geeky example: a quote from *The Princess Bride*. Saying or sharing that quote will evoke its surrounding context—not only its context within the movie, but also within the life of the person who experienced that movie. Many people are familiar with the game where one person starts reciting a quote, and leaves another person to finish it. If two people are playing this game, the quote they share has not only evoked the film, but implied that they share the film as a social experience. And further, thereafter, because those two people played the quote-completion game, the quote will also imply the sense of social connection they just experienced.

When we think of meaning as complex layers of context, that can have very interesting consequences for writers. Start by thinking of a writer, putting down words alone. During that process, the meanings the writer chooses to invoke with words are (necessarily) those that grow out of her or his own experience. As writers, we can have a clear vision of what the story means *to us*. However, we can't have any control over the contexts in which our readers have previously heard these words, these phrases. Research on the process of reading suggests that a great deal of the meaning of a story comes from the mind of the

reader—and indeed, how could it be otherwise? When we write, we are not *transmitting* meaning. We are *evoking* it, and for that we depend critically on our readers' previous knowledge and experience.

At the same time, any story is itself a context for the words that appear in it. Writers therefore do not only evoke, but also *create context*. This gives us a rather particular superpower: By controlling the context in which words appear, we can define them. A word invented for a particular story takes its meaning from that story, and can then through the mechanism of shared reading experience, make its way out into the greater vocabulary. We owe our use of the word "utopia" to Sir Thomas More and his readers; Mary Shelley and her readers have brought us "Frankenstein," while "robot" comes to us from Karel Capek and his. (The list goes on: munchkin, L. Frank Baum; yahoo, Jonathan Swift; gargantuan, Rabelais; ansible, Ursula K. LeGuin; nerd, Dr. Seuss; etc.)

Of course, this means that word meanings can easily drift and change. They can expand out of their original contexts, as above. They can expand the scope of their meaning, become more specific to a particular meaning, or otherwise change. The cutting edge of this change is the active context of use, so dictionaries are typically the last to catch up! (Think how long it took the verb "google" to be accepted into a dictionary.) Language change often involves discomfort and cries of "that's wrong!" It's hard to tell whether a change in usage is going to flare and disappear, or stick around permanently. Some countries have institutions designed to regulate the process of natural language change. The Académie Française, for example, makes regular rulings on word borrowings to slow down the degree of change and keep French vocabulary true to a perceived French linguistic identity. Even so, many words have crept in. Language can be difficult to control.

Euphemisms are a prime example of this difficulty. Basically, a euphemism is an attempt to put a new, softer or friendlier word into use on a topic that brings up strong negative emotions—disgust, anger, hatred, or grief. It's something we do with bodily functions, death, tragedy, and illness, etc. to try to protect ourselves and our listeners from those emotions. What happens over time, however, is that the presence of those emotions in the context of use will gradually strengthen the link between the word and the negative emotion. Eventually, people can come to feel that the word's meaning has itself become too negative, and they then choose another one.

Another kind of difficulty arises when different people—even populations—have very different experiences hearing the same word. Of course, this causes them to understand its meaning differently. A word like "values" has a vastly different context of usage in ethics versus mathematics—but these are two contexts that usually occur in disparate circumstances. When two people bring different contexts of understanding to the same interaction, misunderstandings are inevitable, and they are only the beginning. Take a word like "urban," for example. Depending on who is using it and how, it can imply "city life," "inner-city," "poor," or "black." One person may hear a relatively neutral meaning, and another may hear an emotionally charged one. Politicians, aware of the difference of meaning across

Analog Science Fiction and Fact (Astounding), Vol. CXXXV, No. 5, May 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. (c) 2015 by Dell Magazines, a division of Crosstown Publications, all rights reserved. Dell is a trademark registered in the U.S. Patent Office. Protection secured under the Universal Copyright Convention. Reproduction or use of editorial or pictorial content in any manner without express permission is prohibited. All stories in this magazine are fiction. No actual persons are designated by name or character. Any similarity is coincidental. All submissions must be accompanied by a stamped self-addressed envelope, the publisher assumes no responsibility for unsolicited manuscripts or artwork.

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. (2/23/15)

populations, will sometimes use a word like this deliberately, as a sort of code. They feel safe using it because they know that to one group of people it will mean "city" while to another it will immediately suggest a shared context of racial animosity—a sentiment that may not be detected across the social divide.

Knowing, as we do, that writers can invent words or change their meanings by creating novel contexts for them, we should ask: is it also possible to change the meaning of a word in the real world? The answer is: certainly. Such change occurs when people alter the contexts in which particular words are used. One major example of this is the reclaiming of slurs (such as "slut," "queer," etc.), in which a group of people who have been insulted by a particular term deliberately use the word to alter its traditional context. This process is most successful when the original toxic context becomes overridden in frequency by the reclaimed usage within a cultural community. Trouble arises, however, when the reclaimed usage is encountered by outsiders, and they attempt to use the word again because others do. Why shouldn't a word be usable if it has been reclaimed? The answer, again, comes back to context of usage: A speaker's social identity is a critical element of context. Since the meanings we understand are the ones that most closely match the context in which we've heard them, an outsider cannot use a word that has been reclaimed without activating the non-reclaimed meaning of that word.

Then there are contextual battleground words. The best example I can think of is "Obamacare." Originally coined with a group of other "-cares" simply to associate health policy plans with the presidential candidates who had proposed them, the term was quickly taken up by detractors who deliberately used it to create an association between the policy plan and other hated aspects of the president. This association of negative emotion contributed directly to support for legislative moves against the policy. Meanwhile, the word "Obamacare" already had some independent staying power in the media context of headline writing, because it saved so much space. However, many who supported the policy plan made no objection to associating the plan's name with President Obama, and indeed they began to use the word in their own contexts, without the pejorative connotations. When we observe the word now, it has begun to be associated not just with plans and proposals, but with actual contexts of medical care in people's lives. These new contextual associations appear to be pulling the word further toward a positive meaning. It's impossible to predict precisely how usage will change the word's meaning in the future.

Thus we see that the power of words, which has such wondrous significance in

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

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science fiction and fantasy, at the same time has consequences in real life power struggles. People who are aware of this power choose their words carefully. In science, for instance, the consequences of discrepancies in meaning can be catastrophic, so scientists begin by carefully defining their terms, so they can specify the contexts to which their results apply. A rather different approach to word choice occurs in public discourse, where people often assume that they share the same meaning with their interlocutor, but then discover in real-time interaction that they do not.

So what happens then? Generally, the people in the interaction explain their understandings of the meaning of a word—but even if they are successful in identifying the discrepancy, they may have difficulty moving forward if one or more participants refuses to recognize the other's experience as valid in defining the word.

Sometimes one participant will decide to go to the dictionary. If it's a case of "I've never heard that word before," dictionaries can be helpful. However, referencing dictionaires invokes the authority of the dominant cultural group, and narrows the possible contexts for a word's meaning to those recognized by dominant institutions. Therefore, as a tool for understanding the dominant's group's thinking, it's perfect—but as a tool for exploring nuance and the experience of minority groups, it's inherently problematic, because it attempts to remove one speaker's valid context of experience from consideration.

Other times a participant will refuse to explore or negotiate word meanings because "it's just semantics." This is another move that attempts to invalidate a speaker's context of meaning. It does this by referencing semantics, the academic study of meaning, and thus invoking metaphors about the esoteric pastimes of creatures in ivory towers. When used in negotiation of meaning, it essentially claims that only one context of experience is normal and proper, and any desire to explore further is irrelevant. It says, "My viewpoint is real, and yours belongs (far away) in an ivory tower."

In fact, to paint academic context as less valid than any other is just as problematic. Each person's experience has inherent validity, and at the same time is fundamentally incomplete. Every word, once it has been created and discovered in context by more than one person, begins to grow beyond its original meaning. The complex meanings of words suggest the depth and complexity of human experience. These complexities must be engaged with, and explored.

It's not just semantics. ■

Illustrated by Kurt Huggins

Zen Angel

Rajnar Vajra

I was teething again, which always makes me irritable. I prefer to concentrate on living rather than monitor my body, but inflamed gums are brilliant at attracting attention. And my latest doctor and self-acknowledged government stooge, Joseph DeFloria M.D., wasn't helping.

"Len," he boomed as though a wall separated us, "you've got to be the luckiest man in the world."

"You think?" I tried to keep my face parked in neutral, but apparently failed.

"You *don't* think so?"

I just shrugged.

"Right. Then let's add things up. For starters, how old are you?"

What I did was subtraction; somewhere along the line I'd stopped keeping score. The result left me uneasy, so I kept my answer generic, if trite. "Over a century of service."

His diluted blue eyes goggled at me. "'Over' is the understatement of the month. You passed the century mark sixty-eight years ago. But look at you. If I didn't know better, I'd guess thirty, thirty-five tops. I'm forty-four, and there's already plenty of gray in *my* hair."

He grabbed my datafilm chart and shook it as if rattling a sheaf of papers, but the thin plastic only made a whooshing sound. "And the results of your diagnostics show the kind of health I would hope for on a teenager. Yeah, I'd say lucky. Put your clothes on."

It pleased me that my 1900 birth certificate was holding up; I'd forged the thing in 1903, and an investigation into the Dr. Price who'd signed it could lead to awkwardness.

My briefs felt too silky as I slipped them on; the design hadn't changed much in decades, but manufacturers had stopped using plain cotton.

"How does it feel to be immortal?" Dr. Joe asked while handing me my shirt, a garment that reacted appropriately to ambient temperature, could change colors or display videos according to whim, could alter size if I put on or lost pounds, and felt clingy and cheap.

"Immortal. I wouldn't know." For a moment, my aching gums conquered my desire for mental privacy, and I blurted some honesty. "Maybe I'll be alive a month from now, Joe, or a century. Maybe not. The regeneration thing might have an expiration date. Plus, a stroke or heart attack could take me out." I'd been so accident-prone lately that I added, "Or some bus might run me over tomorrow."

He snorted. "Only if you go deaf today." He jabbed a fat thumb toward the window. "I hear at least two cellos down there, which means local busses, and a heap of violins."

His complaint surprised me. The sounds were barely noticeable.

"Yet we're on the fourteenth floor," he continued, "and that window is triple glazed." He paused, head tilted. "What is that traffic noise? Haydn?"

Odd. He'd never spoken about anything unrelated to my health, and this variation felt forced. I reached for my shirt. Look Ma, no buttons, I said to myself since I doubted that anyone alive would get the reference. A downward swipe of my hand fastened the garment, but on the way, something crinkled. I hadn't put anything in the pocket and began to reach for it, but stopped when Joe caught my eye and shook his head slightly. Interesting.

The symphony playing below, with instrumentation changing as vehicles were replaced by others, struck me as a metaphor for my life. In essence, I'm the same symphony, but the instruments keep changing.

"Remember when each car had its own theme song?" Joe added in an uncharacteristically mild bellow.

"Hell, I remember when they went putt-putt. Gas engines."

"Maybe music is better, but whose fool idea was it to network every damn vehicle in the city?"

The continuing irrelevance of this conversation made me curious but wary. As did his furtive glances at my shirt pocket. One benefit: we weren't on our usual topic of me.

I tugged my shirtsleeves up past my forearms, and the fabric contracted to maintain the new shape. "You're no music lover, I take it?"

"It's not that, but who wants to listen to it day in day out?"

"You preferred a street full of cars, all playing different melodies?" I had to grin. "Carcophony."

He chuckled then frowned. "Admittedly, pedestrians need to realize they're about to get run over, but why not reproduce those putt-putts of old?" He stroked his pudgy chin. "Christ, Len, you were an adult *before* the days when gas-powered engines ruled the Earth. Incredible!"

His ignorance shouldn't have surprised me. What you don't live through, you won't . . . own unless someone teaches you about it with such skill that you experience it by proxy. As a result, vast amounts of relevant knowledge fall through the cracks of history. Hermann Hesse claimed that people born after 1920 lacked the background to ever fully comprehend his books. Or was it 1910? Sometimes I think that I've truly forgotten more than I ever knew.

Joe gave me a meaningful look that failed to speak volumes and rephrased. "Why use music as a warning?"

"Cost. Plenty more to old car noises than chugs."

"Such as?"

I studied his face while expounding about antique tires and road-surfaces, and mechanical rattles, and how different parts of obsolete vehicles made different rackets at slightly different times, all varying with speed. He didn't seem that interested.

"Without this sonic smorgasbord," I finished, "the human ear might know a vehicle was coming, but not necessarily how fast or from which direction. That's why sirens change pitch and the most effective ones switch between notes."

"I hear you. They would've had to put multiple speakers on every car to get the right effect. I suppose hundreds of blaring sirens wouldn't make people happy."

"Particularly people driving emergency vehicles."

"Point taken."

I bowed ironically at the accolade, wondering where this was leading.

"We done for today?" I asked, testing the waters. "Got things to do and you must have other patients."

"Not 'till later. The Powers What Be wanted me to take as much time as I needed for your final exam."

"So I won't be seeing you again? At least until I get back?"

A hint of craftiness touched his honest face. "True. I'm giving you a squeaky clean bill of health, but I'm curious about something."

"Shoot."

"Shoot?"

"Antique slang, Joe. Means proceed." School massacres had finally sunk that one.

"Ah. Why *don't* you think you're the luckiest person to ever walk the Earth?" He shook the datafilm again. "You can regrow parts like a starfish, you're agile as a cat, strong as a power lifter, Olympic-record fast, IQ in the stratosphere. You're even tall and good-looking, holding three doctorates and an MD, and it says here you can accurately measure distances just by looking, without using a googleyes app. Haven't you won the genetic lottery Grand Prize?"

He left off the periodic hormonal changes and my sexual orientation shifting every eighty years or less, invariably at truly awkward times. Still, he posed a fair question and the sincerity in his baby blues kept me from weaseling out of it. "Joe, things aren't that simple." Not even the "tall" part. When I first reached adulthood, I towered a full 5' 6". In another few centuries, I might be able to dunk a basketball without jumping.

"Let me guess. People you love keep dying, something like that?"

"Part of it." Most of it, really. "But tell me, do I seem particularly mature to you?"

"Well, you don't seem immature."

"Uh huh. One, um, distressing part of being me is that I'll reach a certain . . . *level* after a time, but I don't get to stay there. Remember puberty?" I weighed every word. "Imagine having your act together, if you'll forgive the old slang, and then getting pulled back on *that* hormonal rollercoaster over and over. Reminds me of Keyes's story 'Flowers for Algernon,' only with big changes in emotional wisdom rather than—"

"Never heard of it."

Kids these days. "Look it up. My point is that I keep losing myself."

He looked thoughtful. "Maybe I'm getting it. One day you're Buddha; the next, you're sulking because you're out of pimple cream."

"Something like that. But without forgetting being a buddha."

"Okay. Class dismissed. Good luck with whatever the hell the government wants you to do. Have they told *you* yet?"

"Hard to believe, but no. Only that it's incredibly important and involves going somewhere, which you already knew. Maybe I'll see you after whatever this is, is all over."

"Maybe. Don't forget your jacket. I'll ride down in the lev with you."

While today's magnetic levitators run smoother and quieter than yesterday's elevators, they lack charm. The plastic inner lining seems to hoard foul odors including those released by their own solvents, and the selector buttons, designed to be pointed at from close range rather than touched, produces an impersonal tactile vacuum. Yes, I'm an ancient curmudgeon. Sue me.

As we stopped on various floors to harvest passengers, I wondered which ones were government agents keeping tabs on me. Joe and I kept quiet until we exited on the ground floor and only exchanged polite farewells, in his case a *"ciao,"* as we went our separate ways.

The sky had become cloud-frosted and the temperature had dropped to chilly while I'd been poked, palpitated, and interrogated.

I slipped my smart gloves on, and they expressed their opinion of the weather by puffing up into near-mitten status. My shirt and jacket also thickened somewhat. It dawned on me, belatedly, that *warning signals* had been at the heart of our atypical discussion. I casually looked around, then sprinted to catch a city bus at the next corner, hoping to lose the two agents not-so-covertly on my tail. Not my normal behavior. As the doors closed and the vehicle-identifying cello started up, I found a seat and reached into my shirt pocket.

The handwritten note inside wasn't easy to read, confirming that Joe was indeed an authorized writer of prescriptions, but I deciphered it: "Golden Jade, 10th and E. Broadway. 2:00 P.M."

How about that, I thought. Clandestine meeting at what's likely a Chinese restaurant. Unoriginal yet worrisome. I performed the exaggerated squint that inevitably makes various people in a crowd, at any given moment, look like inmates of a loony bin. Left eye, to trigger the basic display. My googleyes implants instantly placed virtual printing on the seatback in front of me informing me of the time, temperature, and exciting discounts on products I didn't want. I wished someone still made affordable wristwatches. The un-printing faded, and I got off at the next stop. Would I miss the appointment if I first returned to my Chinatown hotel room and treated my gums to some hot saltwater? A bad day to feel rushed, I reluctantly decided, but time enough to kill some, and I could snag a cup of ice somewhere for temporary relief. I couldn't spot anyone shadowing me, for what that was worth.

Warning signals. Something was wrong.

The restaurant squatted diagonally across the street from Grace Church, next to a food coop that a decades-old memory told me was once a gym. Wasn't hard to spot. I booted googleyes just long enough to see the local virtual signs and some pricey advertising effects such as huge, colored smoke rings drifting up from the far side of 10th. Past a be-dragoned door, I descended a long flight of stairs into savory aromas then stood behind some robed Buddhist monks chatting with the maître d' as I scanned tables.

The doctor sat at the farthest booth from the staircase. The instant he caught my eye, he scooted sideways beyond my line of sight. I smiled at a smiling woman approaching me with menus and a deadly intent to seat, and pointed toward the back booth. "Meeting a friend already there," I said in Mandarin. Her smile broadened as she eased out of my way despite losing her grand opportunity to be my guide.

I found Joe so close to the wall he could've been glued to it. Someone *really* didn't care to be spotted. He gestured toward the opposite side of the booth where I sat down, another wall-hugger.

He looked so tense that I changed my first question. "Why meet here in particular?"

He pointed a thumb directly behind him. "There's a fusion Chinese-French joint on the street behind this one, 'Magic Dragon,' and they share the kitchen back there. Same owner. That's part of it." He spoke at a normal volume, probably his version of whispering.

I nodded. "So you entered through the fusion place."

"Correct. Didn't want anyone to know we'd be together."

"Someone's keeping tabs on you too?"

He frowned. "Tabs . . ."

"Old term for surveillance."

His frown remained. "I only knew agents were shadowing *you,* and they'd spot me almost anywhere we met. Or we'd be caught on videocams."

"But why any cloak-and-dagger routine? Your hints made me ditch some agents, but now I probably look guilty of something. What's your big secret? Nice touch with my shirt, by the way, if your office is bugged."

"Cloak and dagger?" he repeated uncertainly. "I remember hearing that phrase when I was a kid. Means spy stuff? Something out of Shakespeare?"

"Seems I'm full of obsolete clichés today. Care to answer my question?"

In the muted light, his eyes appeared less washed-out, more awake. "Are you aware there are ways to . . . tap nanolinks?"

It was my turn to frown as I pondered how often I'd run googleyes while doing something I'd prefer the government didn't know about. "They're tapping *my* systems?"

"Could be. Supposedly, they can only pick up audio thanks to the Supreme Court ruling. I'm counting on that."

"I thought last year's security updates—"

"Still left a backdoor for the NSA and other parts of the alphabet."

A truly nasty thought bit. "Even when googleyes is off?"

"Don't know."

"Oh." I snapped my fingers softly. "This eatery happens to be a radio dead spot."

"Exactly. Underground, and because a major trunk-line for maglev power runs along a tunnel overhead, no hardwired data relay would work."

"Nice. How'd you find out about this place?" While talking, I tested my implants and, sure enough, couldn't get online.

"Len, I'm a *company* medic." Ironic smile. "Most of my patients are intelligence workers. I've learned things. Besides, the food here is damn good. Pengan style. Hungry?"

"I could eat."

Chinese food as typically served up in America is overly oily and laced with enough sodium for a ton of popcorn. I'd found only a few notable exceptions, mostly here in Manhattan and San Francisco.

"Pengan" was the new Chinese cuisine, a breath of freshness, without gallons of peanut oil and truckloads of cornstarch.

The Golden Jade's Ma La prawns were fresh and delicious, and I would've enjoyed them tremendously if my gums were normal, and if my lunch companion offered better news.

"There's a cute term company people use, Len. 'Uninstalled.' Means dead. That's their plan for you once your mission is over."

I felt a cold shock and the world suddenly seemed farther away. "That's . . . interesting." My mouth was empty, but I had to swallow twice before I could go on. "Joe, I've switched identities many times because I thought that if the authorities caught on to my—my gifts, I'd wind up in some lab," had to swallow again, "where a bunch of damn Ponce de Leon's in white coats would keep taking me apart."

"So how *did* the government find you?"

"No idea. I thought I'd covered my tracks about as—never mind. But why kill me? Wouldn't they want to know what makes me tick for their own, um, longevity?"

He did his chin-rubbing thing. "Tick?"

I suppressed a sigh. "Clocks and wristwatches used to do that."

"I see. No doubt the government is full of folks who'd want immortality. Who wouldn't? But if researchers found a way to duplicate your abilities, it couldn't be kept secret. Before long, the whole human race would be demanding their slice of the pie."

"I suppose. But would that be so bad?" They say confession is good for the soul, so I went for a little spiritual remodeling. "Ever since scientists could map gene sequences, I've been feeling guilty about putting my own desire for freedom ahead of everyone else's needs."

He nodded. "Understandable, but think about the consequences if everyone was like you. Nobody dies for say a century and a half, *minimum*. Overpopulation explosion, but increasingly top-heavy with oldsters. So what's retirement age? How could we keep paying Social Security? No one inherits except by accident or murder. The ultra-rich keep getting richer and more powerful while the rest of society keeps losing traction. Doctors would become jokes, only treating major injuries, and only until the patient regenerates. No more cancer. The pharmaceutical industry would be savaged, most hospitals would close, and there's the matter of food and—"

"I could get cancer."

"But you haven't in all this time. I'm just getting warmed up, but why go on? My point is that the government can't afford to learn your secrets, not even for their own benefit. They can't afford to have *anyone* figure you out."

"So it'll be open season on me."

He hoisted his water glass as if about to say cheers. "Sorry."

I copied his about-to-toast maneuver. "You're taking quite a chance, Joe. I appreciate it, but why risk your career?"

He clinked his glass with mine. "There's this oath we doctors have, and some of us take it seriously." He studied my face. "I would've thought you'd be more upset."

"I *am* upset, but I've been in danger before. Sooner or later, trouble rolls in."

He nodded. "Considering your lifespan, I imagine you've developed serious . . . emotional resources. The question is, have you any resources of a, uh—"

"Protective nature? Maybe. These days it's hard to vanish once the authorities want you. Thanks, technology. But technology can also hide you, particularly if you know the right people."

"I should've waited until we finished lunch to give you the bad news."

I lifted my chopsticks and snagged another shrimp. "No worries, I never let anxiety ruin my meals." Not exactly a lie, but a massive exaggeration.

I insisted on paying for our lunches plus tip, and used cash to avoid credit spoor. Joe departed through the kitchen, but I waited ten minutes longer, sipping lukewarm tea and contemplating my fortune-cookie message: "You will find friends wherever you go."

As a stimulant, Joe's warning crushed mere tea. My brain reacted by intensifying my senses, but also by randomly interrupting those senses with flashes of half-forgotten memories; I suppose seeking guidance from past experience. Outside, despite the gray day, colors seemed brighter but harsh, and the sounds and smells of the city came on like an attack. The automotive warning music, at the moment courtesy of Beethoven, scraped my eardrums. A brisk wind gave the cold air an extra bite. Meanwhile, I periodically remembered this area from various times I'd been here, going back to when horses pulled carriages through gaslit streets coated with coal dust and manure. In my mind's ear, I heard the innumerable horseflies. Signs and brick buildings, long vanished or reconstructed, loomed realistically. The passing people dressed in antique styles appeared more ghostlike.

Back in hypervigilant mode, I noticed the speeding car the instant it veered from the far side of the road and headed toward me, accelerating tremendously through a gap in traffic. I sprinted to get out of its way, but the car adjusted its route to keep aiming at me. The street was lined with cars, and if someone planned to squish me, their idea must've been to smash into a waiting vehicle, and send that one flying into me.

At the last moment, I jumped. The collision was horrendous, more explosion than crash, and the two-ton billiard vehicle banked my way missed me by a comfortable six inches. Before I could criticize myself for having jumped farther than necessary, I got peppered with broken safety glass and small debris. It stung. Shaking myself off, I stepped closer to the killer car to check on the driver. The crumpled auto appeared empty. It was only then that a sudden pain in my side made me look down at my jacket. A jagged, spear-shaped scrap of metal had pierced the fake leather, the shirt beneath, and my skin just below my lowest rib. Couldn't tell how deep the wound went.

Gripping the tail end of the long shard carefully with my gloves, I pulled the accidental spear straight out. Hadn't felt it going in, but this gave me something to remember. I glanced at the business end once the piece was free, as if checking an old-fashioned dipstick. I was down a quart, judging by the two inches of wet blood at the end. I clamped my forearm over the wound and kept it there.

Looking down at the sidewalk, I saw no bloody drips. With any luck, my genius shirt would treat my leaking fluids as sweat and absorb them until the blood clotted, which wouldn't take long. For anyone else, a trip to the ER would be mandatory. Awkward from having to maintain forearm pressure, I dug Joe's note from my shirt pocket, wrapped it around the spear's razor-sharp tip, and stuck the package into a coat pocket. I didn't care to leave any trace of me at this scene. No clear reason, just instinct. I returned my attention to the deathmobile.

My diagnosis: totaled and empty. So it had been driving on automatic, likely on its way to a parking garage, guided by New York's Transportation Authority, and one of the incredibly rare glitches in the automated traffic system had caused the incident. Easy to believe . . . if I believed in Fairy Godmothers. But although the government had marked me for death, it didn't make sense to kill me before my mission was complete. . . .

Shaken, hurting, and in no mood to cope with police or crowds, I lumbered to the next block and splurged on a cab ride to my hotel. On the way, I lifted my jacket and shirt to assess my injury. The bleeding had stopped, and a scab was forming. It no longer hurt like hell. As far as hurting like heck went, I'd say it made the cut. Flakes of half-dried blood decorated my abdomen but clung enough to avoid adding to the dinginess of the cab's floor. I got

some sour amusement when I noticed that both my shirt and jacket had repaired themselves.

Once in my room, I unwrapped the spear and set it on a dresser. Don't really know why I'd kept it. I scrubbed my belly with a wet washcloth and set my clothes soaking in the bathtub. The water turned rusty, and I drained the tub, rinsed and repeated, and hung everything to dry. I treated my gums to long baths in the hottest saltwater my mouth could bear. Afterward, I lay in bed, still shaky, gazing at a faint ceiling stain.

If the government wasn't yet trying to murder me, who was?

An even more relevant question: who among my contacts could best help me stay alive? And how could I reach such a paragon immediately without the authorities or some secret enemy catching on? Using googleyes or any communication app was out. One problem at a time, I told myself. First, who.

I spun my mental Rolodex—anachronism alert—and came up with a former business partner, Carlos Ramirez-Levi. Just then, googleyes informed me of a high-priority incoming call from one Field Agent Saunders and asked if I desired connection. I didn't, but I granted permission.

"Doctor Leonard Silver?" asked a soft voice.

He might've been acknowledging a PhD or my obsolete medical training, but who else did he imagine would answer a person-to-person call?

"I'm Len Silver, Agent Saunders." No sense in both of us asking stupid questions. I dug deep to get a grip. "Why isn't Agent Morgenstein the one to call me?"

"I've been ordered to step in temporarily. Morgenstein's still your handler."

"Fine. How may I assist the human race today?"

He didn't giggle. "By packing everything you brought to the hotel and being ready to leave one hour from now. Wait for us in the lobby."

"Okay. Guess I'll be seeing you soon."

"Count on it," he said, logging out.

It seemed that my mystery enemy wouldn't have time to attack again, but the downside was that I couldn't secretly enlist Carlos within an hour. So I followed the only idea that bothered to knock. I turned off googleyes, hoping it really was off, and dashed off a quick note to Dr. Joe, asking him to contact Carlos for me. Then I slapped on fresh clothes and dashed to the lobby. I left the note and some instructions with a concierge. Back in my room, I took a brief shower, brushed my teeth, got dressed again, and opened my suitcase.

For a relatively happy second, I mistook the thing leaping out for an exceptionally large tarantula. By the time the third one appeared, I knew better.

It's possible to move quickly with a deep if healing wound in your side, but you'll regret it. I sure did upon instinctively jumping backwards. Pardon me for being judgmental, but these beasties were ugly. Ten legs including two front ones with rosebud-shaped claws, fanged jaws oversized for creatures with a mere dinner plate leg-span, and blobby bodies suggesting octopuses more than arthropods. Five eyes apiece, all stoplight green.

I'd never seen anything like them.

Big spiders are fast, and these things were faster. But instead of immediately attacking, one scuttled sideways to guard the main door, another scuttled to block my way to the bathroom. The third waited until its partners were in position. Then it leaped straight at me.

I tried to knock the creature away but only managed to bat it back a few feet. It was surprisingly heavy, and I learned something else about my visitors. Fangs weren't my only problem. In midair, one of the monster's claws flashed out like a striking cobra, stabbing my right palm near the thumb. The wound didn't penetrate entirely through my hand, but it justified the noise I made.

I used my freak distance-gauging talent, and without looking, reached behind me to grab the metal spear off the dresser. Just in time. The batted creature jumped toward my face, and I slashed out with my impromptu knife.

It didn't cut the thing in half as I hoped, but the tip severed a few legs, which may have distracted the monster a tad. At least, it failed to send a claw through one of my eyes. Unfortunately, it landed on my right shoulder. Meanwhile, my blade, still moving, accidently sliced the belly of the spider-puss to my left, who'd thought this a fine time to add a second attack.

I hadn't cut Monster Two deeply, but it dropped to the floor as if I had. Without pausing to ponder this mystery, I turned to my right while trying like hell to brush monster one off my shoulder with my injured hand. That wasn't happening, but the thing just clung there without doing anything rude and painful. Monster Three stared at me greenly, waving its claws in a thoughtful sort of way. Then, surprise, my shoulder-gripping buddy fell, almost landing on Monster Three.

M3 poked M1 with a stretched-out leg, gently at first, then harder. When its buddy didn't react, it emitted a hissing whistle that would've scared me out of my wits if I hadn't already reached that stage. M3's jaws opened, and suddenly a chunk of M1's body went missing. My odds had improved, but my original injury had reopened, and I was down to one usable hand. I considered stomping on my little enemy but had a bad feeling that I'd wind up with a hole through my foot.

Then M3 collapsed as well, twitched for a second, and lay still.

"What the hell?" I said more times than required. The beasts were dead, and I had no idea why until I glanced at my improvised weapon. The tip now had blue-green streaks to add to my deposited red, and it occurred to me that my guests may have suffered from either a literal case of blood poisoning, or had a fatal reaction to automotive alloys.

I sat for a time on the toilet seat, pressing one towel against my injured hand and another against my original wound. When the bleeding stopped and my heartbeat slowed to a gallop, I cleaned up as best I could, slapped on some bandages from my first aid kit, and returned to the crime scene. I regarded my open suitcase. The interior had been redecorated with brownish-green smears, no doubt a fecal gift from my visitors. I decided it would be best to travel very light.

At that point, a call came in that I was expected in the lobby. I politely requested that my caller first visit my room.

"Got things to show you," I said.

Agent Saunders might've been inconspicuous if he'd been shorter and hadn't worn a visible sidearm. He stood a quarter inch over six three, an inch taller than me unless I'd grown again since I'd last been checked. In terms of newtons, he surpassed me to the tune of around forty pounds, but I'm not as good with weight as I am with distance.

He examined the corpses without a decent amount of surprise, turning them various ways with the old-fashioned pen he carried to go along with an actual paper notepad.

"What are they?" I asked.

"Don't know." His non-autopsies completed, he grew palpably impatient.

"Anything to do with the job you need me for?"

He hesitated. "Maybe. How'd you kill them?"

"Mostly with luck. They were hiding in my suitcase. Do you know *anything* to explain how they got there?"

"No. Pack whatever you can't live without and we need to leave five minutes ago. I'll have a crew clean up in here. They'll gather up the rest of your stuff. Move."

While he got busy on his internal phone, I stole a pillowcase and shoved some toiletries and clothes inside along with the now-dry shirt I'd hung in the bathroom. I wore my jacket, also dry—modern fabrics do have advantages. Saunders, now tighter than a cramp, practically pushed me out the door. I suspected we wouldn't be checking out at the desk. I was right.

A light drizzle met us outside the hotel along with a black car reminiscent of the extinct SUV breed. Two other armed agents, both female, occupied the front seat. Saunders snatched away my stuffed pillowcase and tossed it in the truck. Then he and I eased into the back seat. Serious legroom. As the car smoothly pulled from the hotel into traffic, and I dimly heard the warning cornet of an official government vehicle, playing Wagner of course, we had a brief flurry of introductions but no handshakes. My latest benefactors were Agent Dean and our driver, Agent Villanova. By then, I couldn't see their faces, but Saunders's eyes kept darting around as if searching for hidden predators.

Traffic control routed everything out of our way, and we made it out of the city within ten minutes, a miracle.

"If any of you," I said as we exited the Holland Tunnel, "would volunteer a tidbit of information about where we're going and why, I'd truly appreciate it."

Dean replied, "Sorry, sir. We're not permitted."

After that no one spoke until we reached a private airport, where Saunders reclaimed my pitiful excuse for luggage and then chivvied me into a waiting helicopter. He climbed in next, and finally Dean joined the party, leaving Villanova in the car.

I radiated no warm and fuzzy love toward any of my present companions. One of them might be my assassin post-mission. The pilot didn't even glance at me. After some radio chatter, we took off, air-chopping blades far louder than the electric motors. We flew south.

I spotted the Pentagon in the distance shortly before we landed, so we were in Virginia, probably in Arlington County. By the time we'd set down on a heliport target, I'd peeled the bandage off my hand and found only a scab. My hand barely ached. The wound in my side didn't hurt, but the area felt tight.

The agents ushered me past six heavily armed security officers—one absconded with my pillowcase—into a modestly sized industrial building. Not so modest, I realized, when I noticed the walls changing colors at random intervals. I'd heard about this method of revealing intruders in "chameleon" suits. The hallways were very wide and tall, as if designed for tanks to roll through. Electronic gear depended from the ceilings. We entered a huge elevator and descended eight floors. Next stop, an office with a virtual beach scene wrapped around two walls. Saunders and Dean abandoned me to the ministrations of a Dr. Schwartz.

Schwartz assessed my blood pressure and listened to my heart and breathing. He then swabbed my left forearm with mysterious liquids and had me inhale a puff of air from a pressurized cylinder. This had a faint odor, a bouquet of butterscotch and pineapple. He waited a full minute before inquiring if I felt any shortness of breath or unusual itching. When I denied all, he examined my left forearm the way a jeweler might examine a questionable diamond. He made a little grunt that might have indicated satisfaction or indigestion.

"We'll try a stronger titration," he said, holding out the breathing mask again while adjusting a valve in the pressurized tank.

This time the odor reminded me of freshly ground maca powder. The pineapple element remained, but with a component of rot.

Schwartz studied me for a good ten minutes as if waiting for something exciting to happen. At last, he nodded and informed me, in a somewhat disappointed tone, that anaphylactic shock would be unlikely.

"What," I asked, "did you suspect I might be allergic to?"

"The word 'who' would be more appropriate, Dr. Silver. You'll find out in due course."

He summoned googleyes with a squint, and before I could ask another question, the door opened. A stranger entered the room, gesturing for me to follow him.

I did. In the hallway, he turned toward me. "We've never met in the flesh, Len, but you might recognize my voice."

"I do. Agent Morgenstein, I presume." He was younger and plumper than I'd expected from the way he'd sounded.

"You got it. Call me Josh. Saunders and Dean were sent to protect you." He patted his stomach. "I'm more a desk-jockey."

He held out his hand for a shake, and I obliged. Strong grip.

"What were they protecting me *from,* Josh?"

"Come with me and most of your questions will get answered. Better prepare yourself for a shock."

He took off down the hallway so quickly that I practically had to run to catch up. Maybe the desk he claimed to be jockeying was one of the treadmill sort.

We rode an elevator down another floor where he led me to a double-door with two armed guards directly in front, and another guard to either side. We stopped there—I assumed for a body scan—then the linebackers stepped aside and even opened the doors for us. They closed automatically.

"Such gentlemen," Josh murmured to me.

We now stood in a large conference room, apparently for a business with a flotilla of officers. A rectangular maple table trimmed with ebony ran thirty feet, surrounded by pricey ergonomic chairs, the kind guaranteed to weaken back muscles and accentuate postural flaws. A massive rectangular object between two chairs spoiled the furniture's symmetry. It seemed ideal as a houseplant stand,

assuming the plant was a full-size oak. We were alone.

"Sit anywhere you like," Josh offered, "except on the stool."

Stool? He'd gestured toward the houseplant stand, a perch for those craving dangling feet. The thing looked to be solid steel, big enough to seat three people at once without any thighs spilling over. Each of its legs could've supported a mastodon.

I caught myself smiling, and it triggered an insight. For some time, I'd wondered why I'd allowed the government to draft me. Sure, Big Sibling had managed to find me, but that didn't mean I had to stay found. I had resources and knew people with greater resources who knew . . .

But the stool practically shouted that this was exactly where I wished to be.

Live long enough, and novelty becomes increasingly rare and precious. Trust me. Yes, technology keeps opening new possibilities, but eventually you'll catch on to the patterns of technological evolution, and the luster dims. After many normal lifetimes of experience under my current self-adjusting belt, I savor even the promise of novelty. So Big Sibling hadn't hooked me by dangling rewards or punishments; I hadn't been intimidated. Nope. I was hooked the instant I'd caught the faint spoor of something truly different.

I stared happily at the absurdly oversized seat and let my subconscious struggle to make sense of it, trying to match it through analogy or implication with something in my experience storehouse. Should've been easy. I had a *lot* of experience to draw on. Not only direct memories—most of my earliest have evaporated—but also memories of memories, and of sharing memories with other people, the mind's way of storing information in a compressed form.

But my overstocked subconscious could get no traction whatsoever. Suddenly, a delightful inner silence replaced all mental chatter. I could almost smell the short circuit.

I lowered myself into the chair directly across from the stool. If it had been scaled to fit someone, I wanted a clear view of that someone. Josh plopped down in the chair to my right.

I aimed my smile at him. "This is one of those hurry up and wait situations?"

"The military way," he acknowledged.

"Oh? This is a *military* operation?"

He made a dismissive pfft noise. "Not entirely, but the navy and air force are involved."

The AC vents overhead hissed, and suddenly I couldn't smell anything, not even Josh's aftershave.

He must've noticed me sniffing. "Odor neutralizer. Everyone attending this meeting has passed the allergy tests, but some people find our visitor's, uh, ketones unpleasant."

"What visitor?"

An immense door opened in the back wall, and secret service types poured through, quickly moving aside to allow people behind them to pass.

"See for yourself," Josh suggested.

Three women and six men, all in dress uniforms festooned with enough ribbons, metals, and shoulder knickknacks to make them top-heavy, strode in with the majesty of galleons, except for some elbow collisions occasioned by vying to enter first. Seven bigwigs followed—two senators, the secretaries of defense and state, and three foreign ambassadors—comparatively shabby despite suits costing two grand and up. After a pause, a nondescript fellow more casually dressed joined the party. Newsfeeds made him appear taller, but he was either the vice president of these United States or a dead ringer.

VP Thompson took a chair between the Chinese ambassador and the secretary of state, on my side of the table, and then pointed his eyes at the open doorway, where everyone except for me kept staring. No one spoke, and I felt tension building in the room. Nothing happened for at least two minutes.

I'd risen to be polite when the first strangers had joined us and remained standing while most of the crowd claimed chairs, but when a final arrival appeared I sat down involuntarily. A strong enough shock turns knees into jelly, and this shock pinned the needle.

Still, I knew the latecomer was a person rather than, say, a monster, because it projected an aura of nobility and presence so palpable that I automatically bowed my head in respect. I fought off an impulse to kneel.

Novelty in spades! I felt lighter, almost giddy, as decades of accumulated cynicism sloughed off.

As the newcomer moved toward the table, everyone stood. A mild butterscotch smell

perfumed the air, and I heard an increased hiss from the ceiling vents.

First physical impressions: the creature was *big*. It had turned sideways to clear the doorway. It stood upright, had a torso of sorts, four long arms, and a head equipped with eyes and a mouth. Perhaps overequipped. The eyes were large golden hemispheres coated with tiny sparkly flecks but no apparent pupils: Two faced forward, set close beneath the ledge of its forehead, two more orbs bordered those, placed far to the sides. All eyes blinked in random order, lids corkscrewing closed and open. Short golden fur covered most of the head, thicker on top. The mouth was set in a wide snout, currently half-opened in what might have been meant as a smile, its many teeth an assortment of interesting shapes including front fangs with a distinct spiral. Catfish-like tendrils hung from the snout.

A multicolored robe covered most of its body, but from various bulges I got an impression of a bifurcated torso unified by thick connecting cables. All four arms or tentacles, coated with a golden pelt, terminated in eight tendril-like digits that appeared delicate and weak until I watched the newcomer hoist the massive stool and reposition it back a yard with a single tendril. The robe mostly hid the legs and feet, but as the creature perched itself on the stool by stepping over it and settling backwards, I glimpsed two coppery boots the size of rowboats. Unless the boots were actually feet.

Thompson cleared his throat, and I wondered if he'd address us with his usual pomposity or attempt something even more stilted.

"I'd like to welcome everyone and thank you all for your efforts in making this historic meeting possible." He focused on me. "Dr. Silver, we have time constraints preventing me from introducing you to each individual on the illustrious panel you see assembled. Be assured that everyone here knows who you are. It behooves me, however, to introduce you to our distinguished visitor." He nodded toward the giant. "Dr. Leonard Silver, I present Ambassador Foresight. Ambassador Foresight, I'm delighted to say that here is the individual whose presence you'd requested."

"Honored," I said and meant it.

"As am I," Foresight replied in perfect English. I'd heard deeper voices before, although not many. "I've learned that members of your species often clasp hands as a greeting. I lack hands as such, but perhaps we could touch fingers?"

He, she, or whatever reached across the wide table without leaning forward and held one finger-tendril six inches from my nose. You have quite the wingspan, I didn't say out loud. I pressed the tendril gently with an index finger and felt a mild electric current running up my arm.

"I understand," Thompson said, "that ceremony is required before we can proceed, Ambassador?"

"Nothing elaborate, Mr. Vice President. I only ask for you and your colleagues to formally agree here and now that this man will represent your entire species among the other candidates. Please indicate your agreement audibly, in whatever language you wish."

A long moment passed, probably for the illustrious panel to digest Foresight's request, then the Chinese ambassador repeated the verb "agree" but in Mandarin, triggering a polyglot avalanche of affirmatives.

"Excellent," Foresight declared. "No one demurred. And will you accept this responsibility, Dr. Silver?"

I felt tempted to say yes and ride whatever wave arose, but the decades have taught me caution. "So far, Ambassador, no one's told me what I'm being asked to do."

I could see my funhouse reflection in the golden eyes. "That is largely my fault. Tell me, please, have you any notion of what I am?"

I shrugged. "A visitor from another world or time or dimension or some combination. Otherwise, I suspect you're an adult and not human."

"Your first and final two conjectures are correct although I admire your open-mindedness. I am indeed adult, female at present. If you wish a name for my species, please refer to us as the Vine."

"I will." Female at present? Interesting. "So why keep me in the dark?"

"That wasn't my preference. But I learned that your . . . implanted information system can be breached and saw no way to enlighten you, not with assurance of confidentiality. Competitive outside interests already pose a personal danger to you, perhaps even here."

So Foresight knew about the wireless wiretaps. And probably my recent close calls. But

who were these "outside interests?" I glanced around at faces.

"Do these executives know what you have in mind?"

A different kind of eyelid, transparent, slid briefly sideways over a golden eye, and I wondered if Foresight had emulated a wink. "I'm not authorized to share full details with anyone but you. But these others have received the gist. Would you care to hear it now?"

"I would."

"Some two thousand Earth years ago, if I may borrow your elegant numeration, we Vine were exploring worlds beyond our star system. We happened upon a gigantic hollow artifact in interstellar space with implausible attributes. Investigating, we found within it an immense, partly buried structure."

Foresight interlaced two sets of finger-tendrils before continuing. Everyone watched, and no one made a sound.

"We unburied this structure, a challenging task in the extreme cold! Clearing all debris revealed a tall, hexagonal plinth, each side with a metallic platform set before it. Symbols, presumably alien letters or words, had been elaborately carved into five sides of the plinth. The sixth side also displayed carvings, but these showed a progression from simple shapes to ornate ones, each shape adjacent to a symbol or group of symbols appearing on at least one other side."

I was too intrigued to pay much attention to anyone else, but it struck me as odd that everyone seemed equally fascinated, despite Foresight's claim that they'd all gotten the "gist." I wondered if the ambassador was bending her instructions to include extra details.

"This final side provided a key for deciphering the entire plinth. Interpreted, the alien writing claimed that the artifact's creators had existed in another universe previous to this one, and had found means to preserve some treasures beyond the collapse of their reality and the explosive unfolding of future realities."

I felt so much like a kid in a schoolroom that I held up an arm. Foresight somehow understood the gesture. "Have you a question, Doctor?"

"Am I getting this straight? You're talking about a universe *before* what we call the 'Big Bang'?"

"Perhaps many universes previous."

"That's . . . incredible."

The overbuilt stool squeaked as Foresight shifted her weight. "Those ancients who built the artifact did not name themselves. We call them 'Originators,' to translate our term into English. The carvings expressed an offer to share what they considered most valuable with future sentient beings, and instructions for retrieving those valuables."

The vice president, to my secret delight, raised his own hand. "Ambassador, I understand that the retrieval requires more than one sentient species. Is that correct?"

Foresight's head faced me, but she didn't turn it to see Thompson. Side-eyes, I decided, could come in handy. "Six species are mandatory. The procedure requires each participant to occupy one of the metallic plates surrounding the plinth. How the structure will ascertain that all requirements are fulfilled remains unknown as does how gifts will be provided. We suspect each participant will receive a segment of Originator knowledge, the intent being to keep one species from obtaining it all, and perhaps dominating others."

"Can you guess what *kind* of knowledge will be disseminated?"

"I cannot, Mr. Vice President. But we believe it will be highly advanced and significant." Foresight waved a few tendrils in my direction. "Should we return, Dr. Silver, to what we ask of you?"

"Please."

"For some time, we've explored this galaxy and several others, seeking intelligent beings capable of participating in such a cooperative project. Doctor, please fall to the floor immediately."

Her tone hadn't changed, so I've no idea how I knew this was an emergency. I dived off my chair, hit the floor, and rolled toward a wall just as something incredibly fast whined over my head. It hit the back of my former seat like a bullet, and I glanced up to stare at what appeared to be an insect, its arrow-shaped front end caught in the chair's fancy mesh. The thing gleamed neon blue and had four sets of buzzing wings blurring with frantic speed. It began to free itself, but Foresight's arm flashed across the table, and her finger-tendrils grabbed it. With a sound like the crack of a bullwhip, Foresight smashed the little

monster on the tabletop. Some of the quicker-reacting VIPs had just begun rising from their seats.

One of the secret service crew yelled, "P-4," and began running toward Thompson. Before the dedicated fellow could reach the VP and begin protecting him from anything, Foresight stood and raised all four arms. I noticed the insect's corpse was gone.

"Please," said the Ambassador, "do not be distracted! We have just witnessed an attempt by some unidentified species to eliminate a competitor. It has become crucial that we complete our business promptly." Thompson waved off the security agent who reluctantly returned to his post.

"Why crucial, Ambassador?" the secretary of state demanded, sounding out of breath.

"This room has proven itself insufficiently secure. Therefore, we dare not waste time. I beg you all to sit again." Foresight set an example. "Dr. Silver, please resume your seat as well, and I thank you for your prompt response to my warning."

"How'd you know that thing coming for me?"

The transparent eyelid slid sideways again. "My hearing is acute, Doctor, relative to humans. Now the gist of the gist: in our long search, we have found many species qualified to participate in the great endeavor, and have winnowed the prospects to eight powered by two—my regrets, I meant sixty-four. Since my kind discovered the artifact and are hosting the event, we feel justified in placing a Vine at the plinth. To determine the other participants, we have organized a competition among representatives of the sixty-four species. If you triumph, Doctor, you may well bring a priceless treasure to Earth. I regret rushing your decision, but you must make it *now*."

I had a boatload of questions, but I believed her. "Then I say yes. I'm honored—"

No sense in finishing my sentence because I'd lost my audience. In fact, I'd lost the table, the room, and evidently gravity. Foresight and I floated within an immense sphere, miles in diameter although a faint atmospheric mist made distances uncertain even for me. I had no falling sensation, ruling out freefall. This reminded me of flying in a dream. The air smelled of caramel and freshly cut clover. A slight breeze cooled my face.

The teleportation, in itself, didn't exactly stagger me, since the Vine had mastered efficient star travel. But something about it that I couldn't pinpoint impressed the hell out of me.

We weren't alone, although none of the creatures visible from our location were close enough to see clearly. We floated near one side of the great sphere. Its walls appeared thin, almost transparent, and I guessed the luminous dots beyond were stars.

I wanted to face Foresight, but before I could experiment with twisting and flailing, my body rotated into the right position. *Just* as in my flying dreams.

I commanded myself to keep cool or fake it. "Please tell me something, Ambassador. How did the insect you killed get into that room?"

She . . . rattled, I don't know how else to describe it, more sound than movement although her body did shake a little.

"Are you all right?" I asked. The effect stopped.

"My deepest apologies, Doctor. You are a delight. Few entities in your situation would have failed to ask where they were and how they'd arrived."

I glanced around. "I figure this is a space station or spaceship. And you, um, beamed us aboard, something like that."

"In truth this is a way station for contest proctors to, as you say, compare notes. No beam transported you. Location is an adjustable variable once the geometry of reality is understood."

"Huh. I'd like to hear more about that, but are you avoiding my question about the bug?"

"Perhaps you have guessed. I brought it." She pulled the shattered corpse from a pocket in her robe and held it before my eyes. No ichor. Instead, lots of tiny metallic parts.

"A drone?"

"A sophisticated one, if you will forgive a touch of species pride. It wouldn't have injured you, but all went more smoothly because you reacted promptly."

"Glad to help. But what was the point?"

"I deployed it as an excuse to hurry your decision before an actual attack could occur. Your enemy might be capable of vaporizing that entire building."

"I see. Good call then."

"Your adaptability intrigues me, Doctor. Might it stem from the many changes you've experienced since your birth?"

A chill rappelled down my spine, tied to a nasty hunch. "Probably. After all, I'm a hundred and sixty-eight years old, if that means anything to you."

A brief rattle. "It means you are testing me. You were born in Cymru, on September 12, 1736 ACE. And your surname wasn't Silver, or Rice, or Price."

She pronounced Cymru correctly, "Comeree," better known to outsiders as Wales. But I felt more upset than impressed. Had she uncovered all my secrets?

"How could you know that?"

Considering her side-eyes, I wasn't sure, but her attention seemed to drift toward other inhabitants in this vast space.

"I attended your birth along with a medical team."

"Wait." Implications stepped on the heels of implications. "Did you *change* me, tweak my DNA? Christ! Is *that* why I've lived so long? And heal so fast?"

"Just so."

"How did you do it? Alien hormones? Telomere boosting? Secret blood transfusions when I wasn't looking?"

"Isn't it obvious? We arranged quick cellular death with rapid replacements. I'm sorry if this disturbs you. We needed a champion to represent each selected species and desired to equalize every candidate's chances to be chosen for the final five. Many species have longer lifespans than humans, and thus more time to develop the attributes we seek: wisdom, compassion, and a cooperative spirit. To ensure your longevity, we increased your self-repairing capacity, and provided extra—"

"But why *me?"* Strong emotion gripped me, but I wasn't sure which one.

For the first time, I sensed that Foresight was uncomfortable. "Prenatal testing suggested you were apt for the role. We found other possible candidates and applied similar changes to them, but you became our primary choice."

"Others! You mean I'm not the only . . . Methuselah on Earth?"

"Some have died due to misfortunes, but you are not alone."

That news shook me more than anything else had this day. "Is there any way—"

She stopped me by placing one of her finger tendrils across my lips, shocking me into silence in more than one sense. Not the sharp sting of a static discharge, but an intense tingling.

"Further questions must wait. Now, I must consult with my fellow proctors to ascertain which candidates declined our invitation then plan accordingly. Do not attempt to leave this area although you are welcome to drift until you encounter the resistance of a containment barrier. You will find it possible to push through it, but the atmosphere just beyond is deadly to your species."

I nodded. "Do not breach invisible force field. Got it."

Novelty plus fellow "immortals"! My spirit felt so light, no wonder I floated.

The proctors held their powwow not very far from me. Apparently, members of the Vine were required to have similar shapes, but the number of limbs was optional along with their symmetry. One fashion-forward Vine had four arms on one side and one on the other.

It came to me why the technology that had brought me here had knocked my self-adjusting socks off—the instant yet nonfatal change in momentum. Mere minutes ago, I'd been situated on a rotating world orbiting a star in a rotating and traveling galaxy. Wherever the hell I was now, even its angular momentum couldn't have matched my previous location. Yet I'd arrived without a jar, sound if not necessarily safe. . . .

This realization initiated a cascade, souring my mood as various actualities penetrated my thick brain. My government intended to murder me, some alien species likewise wanted me dead to reduce competition for some pre-universe goodies, and my longevity was artificial. On the luminous side, I wasn't the only multi-centenarian in town. I'd been carrying a special kind of loneliness for centuries, and the possibility that it might end brought hope intense enough to hurt.

From necessity, I'd developed a coping strategy for times when troubles overflowed: repeating the phrase "right now, I'm all right" until it became true. The trick worked again, but just as my nerves settled and with no

noticeable transition, I found myself in a large rectangular room, lying supine on something soft, staring up at a domed ceiling. Or through it, since I could see fluffy clouds drifting high overhead in an orange-tinted sky. A spoonful of dizziness was already fading. The room smelled of ocean in a good way.

"Please forgive me for altering your body's orientation," said Foresight's familiar voice. "This was a lengthy jump, likely to affect your balance more than our previous relocation. I feared you might have fallen upon arrival."

I sat up. The ambassador stood behind the mattress-like pad supporting me, and two other Vine loomed nearby. One had only two arms but made up for it with four legs. The other was incredibly tall. These weren't the most bizarre creatures in the room, or they were, but I'd adjusted to the Vine chassis.

Two heavy contenders, both to my right. One emulated an eagle by having long feathers, wings, a hooked beak, and two sturdy if birdy legs. It stretched, however, 7' 3.2", each feather a spectrum from peacock blue to a metallic magenta tipped with emerald, its torso positioned horizontally as if in flight. Its crested head, lifted diagonally on a ruffed neck, had a streamlined elegance; the eagle eyes blazed neon green. Long tail feathers spread well beyond the torso. A second, almost vestigial pair of wings placed before the main pair terminated in thin arms equipped with pencil-thin talons. The overall effect suggested some amalgam of equine and bird.

The weirdness champ, however, inhabited its own league. Best analogy: a six-foot in diameter spherical tumbleweed infested by a thousand large bees. The insects, or whatever, kept flying around to light on different parts of the tumbleweed but never flew far from it. Combined, they produced a complex humming unlike the buzzing I might've expected. But the glaze on the sundae cherry was that each insect, independently, randomly flared into incandescence, flashing a kaleidoscope's worth of colors and patterns. Goggling at this lightshow, I found it beautiful, dizzying, and alarming.

Four Legs emitted strange noises, which became muted the instant Foresight said to me, "These aliens are your roommates."

Meanwhile, the super-tall Vine held a little ball displaying its own light show—the tumbleweed party in miniature. Obvious deduction: Four Legs was addressing the bird, although the language lacked chirps, caws, or mentions of Polly and crackers. The speech reminded me of Humpback whales complaining to each other across the deeps.

Instant teleportation and atmosphere-retaining force fields were dazzling accomplishments. But the subtler trick of directing local sounds so that, for me, Foresight's voice dominated, hit me with a new, visceral impact. I felt like some backwoods hick in the big city.

Foresight patted me on a shoulder with a gentle tendril. "Doubtless you find these circumstances disorienting."

"But not boring. Why these particular roommates?"

"They are comfortable in your atmosphere and gravity, and we have eliminated both as your secret enemy."

"You seem comfortable under Earth conditions yourself."

Rattle. "A technological boon."

She wore no visible machinery or tanks, but I suppose her robe could've hidden anything smaller than a tuba.

"When does the big competition begin?"

"The initial phase is underway, but our primary tests commence after you finish sleeping. Whenever you are hungry, say so and human food shall arrive quickly. The doorway to your far left leads to a human-style sanitation facility. Ignore other doorways."

"Why not start the main tests straightaway?"

"Many candidates require more time to attain equilibrium. Some delay is useful. Finally knowing which candidates will compete, we can refine our trials. Also, most species require sleep to perform optimally. While you rest we will teach you what we know about the Originators and the language engraved on the plinth."

"While I'm *sleeping?"*

"We have a technique that should serve. Modulated electromagnetic induction conveys the desired information."

Christ, I thought. Lenny Silver, you're playing in the *cosmic* league now.

After a quick lesson in "customizing your resting surface" and an apology for lacking

time to answer more questions, Foresight and crew vanished with nary a pop of displaced air.

I studied my companions. The bird seemed to be studying me.

"Wish we could communicate," I said, and a complex whale's groan resounded while a wall panel between two doors twinkled in interesting ways.

The great beak emitted another aquatic moan. "It will seem we can." The artificial voice retained something of a whale's cry. As for syntax, perhaps the translating device, like my roommate the tumbleweed, had bugs.

"Wonderful! An interpreting system!" A new voice, this one sweet and feminine, not what I'd expect from your average tumbleweed. "And how courteous our hosts were to preclude confusion by leaving it inactivated until we were alone. I am honored to be in your company, friends. Perhaps we should introduce ourselves?"

Courteous? Or the Vine might've wanted to keep individual conversations private.

"I'm in," I said, mental wheels spinning. "But our names, assuming we all have names, probably can't be translated. What say we identify ourselves by our usual, um, roles?"

"A superb idea," the tumbleweed said. "Call me 'Investor.'"

The word "Investor" seemed to enter only my right ear while a quieter "philanthropist" snuck into my left. I doubted the anthro part, but my opinion of the translating system soared.

"Call me Healer," I offered, admiring the panel's zigzag color flashes. Talk about seeing your name in lights. . . .

"And I will claim Engineer," the bird announced.

Scores of Investor's bees brightened. "I proffer a query."

The tumbleweed seemed to be waiting for permission to do the proffering, so I said, "Sure, go ahead."

"If your species had the power to leave a heritage for the next universe, what would you two think most worthwhile to leave?"

I mentally awarded Investor a platinum star. That intriguing question hadn't bothered to cross my mind.

Engineer didn't hesitate. "I will be suggesting detailing the technique of preserving artifacts through a universal collapse."

"Most sensible, friend Engineer. What else might be worthy of preservation?"

Ultra-advanced technology? Maybe, but how would the Originators know that whoever found the artifact didn't have hyper-ultra-advanced technology?

"Collected wisdom," I ventured. "Or how to live in universal harmony. Maybe the ideal power source." How to eat gallons of ice cream without gaining weight. "Your thoughts, Investor?"

"I prefer yours, Healer. Mine are less appealing."

"What," asked Engineer, "will be your meaning?"

All Investor's bees took off simultaneously, running dark, orbiting the tumbleweed shape like some insanely complicated Bohr's atom. Then the light show resumed.

"I would find the survival of my species most worthwhile."

Engineer emitted a deep squeak, and I might've squeaked a bit myself. I posed the obvious question.

"Are you suggesting the plinth might be a—a doorway, maybe leading to another time or another reality? And the Originators might *return?"*

"My concern is that they might return as conquerors."

"Yeah, I was afraid that's what you meant. What say we share it with the Vine right away? Although they're probably monitoring us, come to think of it."

No Vine suddenly materialized as I half-expected, but a verbal response came quickly.

"We closely attend all candidates," stated an unfamiliar baritone to the accompaniment of whale cries and flashing lights. "No proctor available but I am Patient, liaison staff, and I assure that we are risk aware. Forgive linguistic weakness."

"You believe it's a risk worth taking?" I asked.

"So we have assessed. After rest period, you will comprehend decision. No need explain now. Enjoy rest period!"

The promise of near-future revelations seemed to quash our trio's interest in conversation. Engineer and Investor departed through their respective doors to visit whatever comfort stations lay beyond, and I followed suit after shaking my head at Investor's mode of locomotion: squadrons of bees landing on

top of the tumbleweed, gripping branches and flapping wings until their host rolled, then repeating from scratch.

It didn't surprise me that only my door opened via a knob.

My bathroom was a near duplicate of the one in my last hotel. Only it sparkled with cleanliness; the fake marble counters and faux travertine floor tiles were warm, and it included a long open closet with human clothes hanging, or neatly folded on a shelf. The toiletries I'd left on Earth, or copies, sat on the sink counter organized exactly as I prefer. Towels hung on a typical hotel rack.

All this was boggling, but what really made my jaw drop was seeing an ordinary toilet paper roll dangling next to the standard toilet.

I used the facilities and donned pajamas, which I seldom wear, and upon returning to bed, discovered it adorned with hotel-style sheets, pillows, and blankets. I lay down and glanced to my right. Next to me, Engineer straddled a long padded tube raised thirty inches off the floor. Beyond the eagle, Investor had shrunk down slightly, and all bees had apparently landed, flashing only occasionally.

None of us spoke as the light dimmed, and the dome overhead became almost opaque. Soon, the emerging alien stars barely showed. I considered saying good night, but being ignorant of my roommates' customs, I refrained. All remained silent.

Except my head became noisy with thoughts. Considering the Vine's demonstrated capabilities, why weren't we given individual rooms? Risky, guessing alien motives, but I couldn't help speculating. Perhaps this setup was part of the contest. Or the Vine believed we three were a perfect party combo. A less cheery answer came to mind. Security. Possibly one or both of my new buddies was here as bodyguard rather than candidate.

One nice thing about recent events; I'd forgotten about my gums. Of course, now they resumed itching.

I sighed quietly, arranged pillows, and closed my eyes. Engineer began making a quiet burbling-brook sound—why shouldn't aliens snore? Gentle flashes from Investor's side of the room, viewed through my eyelids, seemed to follow a pleasant rhythm. The combined effect felt soothing, and despite strangeness, worries, and teething, I fell asleep.

Waking, I found the dome clear, the sky pink-kissed and adorned with streaming rose-quartz clouds. The centuries have taught me how to slumber like a bear, but this sleep had been something special. I felt fantastic, ready for anything. Engineer's perch had vanished and the alien stood tilted to gaze upward. Investor's bees remained quiescent.

"That," Engineer commented, "will be the finest rest I've ever taken."

I understood every word so naturally that it took me a moment to realize that the alien's noises hadn't been translated.

Whale sounds weren't in my repertoire, so I tried English. "Am I making sense to you right now, Engineer?" Again, no translation.

"I will grasp your meaning without effort, Healer! Amazing! Our hosts have attained a tremendous height; what could they have left to learn from the Originators?"

"Beats me. But the Vine haven't gone through so much trouble for fun."

"I will agree, Healer. Look you, if only we could duplicate each other's vocalizations, we could now use our true names."

True name? I'd been born Dyffad ap Rhys, but had gone by many others. . . .

"Besides, neither of us can twinkle. Speaking of which, I'd say our roommate is waking up."

Investor's bees burst into full hum, flight, and brilliance. But the flashes came across as words and the sound as commentary: "Good morning life/existence, I am present/aware."

I hadn't realized the humming, too, carried meaning.

"Good morning," I said, and Engineer made an equivalent greeting.

More flashes. "I comprehend you both! Excellent! Also, I now grasp/settle on why the Vine fear no Originator trickery. Those directives on the plinth, which the Vine have decoded/translated, have become inscribed into my memory. Am I alone in this?"

I checked, and the knowledge was right there. "Same here. Engineer?"

"I also possess it. And I will agree with you, Investor. The plinth opening instructions reflect only peaceful intent."

"Right," I said slowly. "All that emphasis on diversity, cooperation, and compassion. Still, we can't rule out any possibility."

"Most wise, friend Healer," Investor hummed. "And on the subject of cooperation, may I send an envoy to you both so that I may better understand and accommodate your natures?"

"Fine by me," I said, fairly sure what the "envoy" would be. Engineer also agreed.

Sure enough, a bee zipped over to land on Engineer's beak for a few seconds before taking off to resettle on my left knee. It gazed up at me. From close range, I could see this was no insect. The tilted eyes weren't the compound sort. The face had a rather feline character including tiny whiskers. Cute, but I decided to avoid petting.

I'd taken Investor to be the tumbleweed, but perhaps the actual sentient was the bee colony, or Investor was both plant and inhabitants. As my visitor returned to orbiting home base, Foresight conjured herself into the room.

She addressed us all in English, letting the translator translate.

"You should now be primed for your initial challenge. Appropriate nutrition will soon arrive. After your morning needs are satisfied, we four will be transported into a maze. Each of you will be directed to a specific tunnel. Your task is to exit the maze quickly as you can. You will then be returned here, supplied more nutrition, and subsequently will receive a mathematical challenge. Questions? I have little time."

I had a scroll's worth but started with the top one. "What kind of mathematical challenge, Ambassador?"

"In your case, a written test. Anyone else?"

"When your time is less limited," Investor communicated. Engineer stayed silent and after a moment, Foresight performed her self-vanishing act.

I nibbled the hotel-style "continental" breakfast that arrived for me, wondering which continent was guilty, and didn't drool over Engineer's wriggling bugs accompanied by strips of God knows what, or Investor's bucket of brown mush, eaten and gathered by bees then spread along tumbleweed branches. Engineer pressed a few leftover strands of what I pretended was fruit leather on a nearby wall, perhaps for midnight snacking. They stuck. After a bathroom run where I dressed in clothes only fit for jogging, and a short wait for Engineer to return from facilities unknown, our suite vanished.

We arrived in a huge cave, a nexus for eight large tunnels. The incandescent ceiling revealed a polished rock floor with winding opalescent inclusions. Mineralized cursive. Small holes pierced the incurving walls, perhaps for ventilation. Gravity felt normal. Above us, reflecting the overhead blaze, hung thousands of miniature stalactites, as though someone from 1950 with a taste for popcorn ceilings had gone overboard.

"Each of you will soon observe," Foresight announced, "a personal identifier manifesting above one of the entryways to inform you which tunnel is yours to enter. Follow your tunnel and exit at your best speed. Ready?"

Nobody fired a starting gun, but when my likeness suddenly appeared over one opening, I sprinted across the floor and into my passageway. Engineer, whose entrance lay next to mine, had passed me by as I'd been crawling. I doubted Investor could even *reach* the maze within an hour despite so much bee power. An unfair contest, unless each passageway was designed to even things out.

My tunnel sported a flat floor bracketed by parentheses-like walls. More ventilation holes. A glowing, longitudinal strip bisected the arched ceiling. No limestone popcorn in evidence. The word "maze" didn't really fit. No branching and confusing paths, no directional alternatives except returning the way I'd come. Smooth sailing until I came to a door, slightly ajar and covered with thick shapes suggesting gears and machine parts. I pushed, but nothing budged. So I put real muscle into it, and managed to get the damn thing open another angstrom or so.

No maze, but a puzzle box. And why make puzzles that have no solution?

I searched, but spotted no clues, secret messages, buttons, or IKEA pictorial instructions. Then I had to laugh. The answer stood right in front of me. Without much effort, I pried off some of the mechanical door decorations and assembled a leveraging system that opened the door easily. Voila, I stepped through and ran on.

The next three doors involved different challenges, increasingly tricky. I began sweating more with each delay, conscious that the entire human race was depending on me.

Something told me that Investor, for one, was smarter than me. I hoped that my traveling speed would compensate.

I'd just spotted the fifth door ahead when I heard a scraping noise behind me. I turned around. Something huge practically filled the tunnel, a featureless tapered cylinder on T. Rex legs. It wouldn't have fit through any door I'd opened, so it hadn't followed me. Ergo, technology had whisked it here.

"What are you?" I muttered.

Another maze challenge? But then the thing *unrolled,* revealing a slimy chamber edged with eye-like globes and lined with spikes. Strands of mucus or worse hung from spike to spike across the chamber like some nightmare spider web.

If the Vine hadn't meant to include this living iron maiden in the festivities, my unknown enemies had sent it. Exiting the maze now struck me as a terrific idea, contest or no contest. I backed up, cautiously, praying the horror was as slow as it looked. Then, as if reading my mind, the creature jumped forward three feet so quickly that it practically teleported. Bad luck for me. But great luck it hadn't *kept* moving forward.

If I could only get through that next door . . . but I doubted the monster would wait patiently while I solved the required puzzle. Which left me two hopes. The Vine might be observing and come to my rescue. Or someone might hear shouts through the air holes.

Iron Maiden jumped again, landing twenty-eight inches from my nose. From this range, the open maw stunk like decomposing corpses. Panic pushed my voice even louder than I'd hoped for.

"HELP! If anyone can hear me, I need HELP *NOW!"*

No instant salvation appeared, but something did. One of the mucus strands thickened, darkened, and grew a forest of four-inch spikes. It lengthened abruptly and snapped out at me. If I hadn't already been leaping backward, this new tongue or tentacle would've punctured my head in a lot of important places. One spike managed to slice across the tip of my nose, which merely hurt like hell and bled plenty. I hoped the blood would wash away any toxins. My new playmate was the most infectious-looking thing I'd seen in my long life.

I jumped backward again on general principle, but not quickly enough. The literal tongue-lashing caught me around my left arm, and I was hooked. I nearly passed out from pain. My eyesight dimmed. I struggled to pull the spikes from my arm, but they'd entered from too many directions; pulling on one tightened others. I felt the tongue dragging me toward the vast mouth.

So I jumped forward, hoping to get in at least one good kick. But the mucus tongue had too little give for me to reach, and I only managed to drive the spikes in deeper. I heard myself screaming, but also a furious buzzing that kept getting louder.

The cavalry arrived in the form of Investor's bees, enough to satiate ten apiarists. They weren't humming, but producing a terrifying thousand-chainsaw roar. Instantly, bees coated the maiden both inside and out. One hovered near my face long enough for me to admire its three-inch stinger. Then it zipped over to a free spot between two mouth-spikes, stinger first.

Milky blisters swelled on the monster's body and within its maw, expanding until they burst. The maiden began shaking. It extruded dozens of mucus limbs, futilely slapping at bees, sounding like a drumming circle with no sense of rhythm. The obviously dying monster shrieked, cutting through the buzzing. I don't want to remember that sound. The alien tongue gripping me melted along with the puncturing spikes, and goo and blood ran thickly down my arm.

Then the creature vanished. Momentarily, the bees seemed confused, but then the swarm resumed their usual hum concerto and exited though the ventilation holes.

I slid to the floor. It seemed a wise idea to wrap something around my injured arm rather than, say, bleed out. My shirt was available if I could get it off, a job theoretically manageable with one working arm. But the pain kept getting worse, and it seemed easier to simply fade away.

My final thought before I passed out felt inexpressibly sad: The human race would have no representative for the great unveiling.

I awoke in the dorm room, lying in bed. No surprise to see Foresight and my roommates nearby. But the human woman with intense dark eyes and a reassuring smile, bright against her dark-gold complexion, made me wonder if

I was hallucinating. Engineer munched away on one of the disgusting food strips.

I sat up and tried to smile back at the woman while glaring at Foresight and beaming at Investor. The mixed effort must've produced something unfortunate judging by the sudden concern on the woman's face.

"Please accept my profound apologies," Foresight said quietly. "As your sponsor, I am responsible for your welfare. Our maze contains devices that limit projectile velocity and energy intensity, so we believed you safe. And we kept alert for threats. But when you were attacked, equipment sabotage delayed our security personnel in reaching you."

"I see. Wait! Does the, um, nature of that sabotage expose which species sent the monster?"

"It narrows our suspects."

"Tell me more. But first, perhaps an introduction?"

Foresight touched a finger-tendril to her mouth. "Indeed! My regret ran so deep that my knowledge of human manners ran shallow. Doctor Leonard Silver, I now present Doctor Angelica Velazquez. We felt that a medical expert of your species might prove helpful so we invited her."

"Delighted, Doctor," I said. "Strange to see another human here. Also wonderful. Please call me Len."

She held out a steady hand, and we shook. Her palm and fingers were warm and dry. "Honored to meet you, Len. I'm Angelica. Are you in pain?"

I glanced at my left arm. The wounds were covered with something shiny, thin, and white. "Not at all." I wriggled fingers experimentally, then tried moving the injured arm. "Nary a twinge," I reported. "Is this fancy bandage your doing?"

She shook her head. "I wish. I'm here strictly as a consultant. The Vine worried they'd miss some symptom that a human medic could pick up."

"So you've been here all along?"

"No, but I'd volunteered to come whenever they wanted a backup physician."

"You mean . . . after I got hurt they brought you from *Earth?"*

Foresight did her rattling thing. "The task is trivial and distance irrelevant. Since it appears that our consultant is satisfied you are healthy, I hope you will both forgive me for insisting that she now be transported elsewhere. It might provide you an unfair contest advantage to have the support of another member of your species. With your permission, Doctor Velazquez?"

Angelica looked disappointed but shrugged acceptance. She vanished although her face lingered in my mind's eye.

I shook my head. "Amazing. And she seemed so comfortable, considering . . ." I waved a hand in an arc from Foresight to Investor.

"I promise," the Vine continued, "you will have ample opportunity to converse with her after our final champions are selected."

I studied my self-declared sponsor. "So I'm still a contender despite not finishing the maze?"

"Certainly! Penalizing you for an attempt on your life would be unjust. We learned enough from the sections you completed. Still, time passes. Are you ready to take the mathematic test I mentioned earlier? We have postponed all challenges for your trio until you recovered."

"I'm ready. But tell me. Why Doctor Velazquez rather than another physician?"

"Her qualifications are unique. She was Earth's runner-up representative."

The implication came wrapped in a shiver. "You people fiddled with *her* genes?"

"Indeed. She, too, is far older than most humans would estimate." Foresight spread all four arms. "Attend, everyone! Mathematical puzzles will soon appear in some form appropriate for each of you, with also a few solved samples. Eight possible answers will wait beneath every puzzle. Your task is to select the correct answer by touching one of the eight. If you mistakenly touch one, touch it again to remove the indicator. Good solving to you all!"

Then Foresight was gone. A moment later, a standard writable datafilm manifested in my lap. On it, loads of math problems and four sample questions. At first glance, the test seemed straightforward, but the examples revealed a confusing wrinkle.

I figured it out and got to work. Simple stuff, mostly pattern-identifying or equation solving with basic algebra. Some trig but nothing more advanced. No calculator required. In

fact, the problems seemed *too* easy. What were the Vine really testing?

I peeked at my competitors. Engineer kept staring at a sheet similar to mine but hovering in midair as if nailed there. Investor's bees were to and fro-ing, examining detailed grids of minuscule, intricately flashing lights before returning to home base. Below each glam grid hung a simpler matrix with fewer lights, likely Investor's multiple-choice section. As far as I could tell, neither roommate had chosen any answers.

Why would my favorite tumbleweed bother to take the test? After the bee rescue, wasn't Investor's cover blown? Then again, a job as security backup didn't preclude being a candidate. . . .

Decision time. If we three were competing for the few spots available at plinth central, helping my roommates could result in a missed opportunity for humanity. But I owed Investor more than thanks. And while I'd lost my Zen Master cred, misplaced my ability to live fully in the here and now, a relevant memory from my monastic days bubbled up.

One morning in Japan, completely out of the blazing blue, all my sensations united into an overwhelming featureless vibration. I melted into it, losing any grip on time, space, or self.

As my senses de-coalesced, just before normality resumed, I caught on to the Big Fake, cousin to the impression of dimensionality an artist creates in a flat painting; a trick of the light, so to speak. I *saw* that I'm something beyond thoughts, emotions, sensations, memories, and my body, but that all these things combined create the illusion of being me, like a whirlpool that only seems to exist separately from the flowing water that generates it.

This revelation brought waves of insights like aftershocks.

The illusion of a separate self isn't intrinsically a bad thing. Rather, it's a gift from epochs of evolutionary selection; survival in a dangerous world depends on it. But mix it with high intelligence in the context of a social species, and the result is ego, a prod for achievement but also a terrible trap, a barrier hiding our intrinsic essence, the shining energy behind all form. Worse, ego can pervert survival needs, making us fear and hate outsiders, cling desperately to opinions, and defend ourselves from that which requires no defense. And when the ego perceives any threat, it swells up like a smart glove in cold weather. . . .

The question remained. My species above all others? My roommates and I shared the same true identity, but I was humanity's agent. Then Engineer made a wordless squeak of frustration and that was that.

"Sorry to interrupt," I said, "and I mean no disrespect, but are you folks stuck?"

Engineer's squeak morphed into a meaningful groan. "The example solutions will make no sense."

"I concur with our friend," Investor stated, a touch of chainsaw edging the peaceful hum.

"The Vine," I explained, "apparently use a base eight numerical system. The sample answers are correct." Why had I assumed that the human race would be backward in every way relative to other intelligent species?

It developed that neither roommate knew that counting in anything but tens was possible. They had trouble grasping the miracle of a one's place, an eight's place, a sixty-four's place, et hour-killing cetera, and couldn't believe the decimal number 9 was 11 in base eight. Once they finally got it, however, they practically sprinted through the exam. I wasted another minute, making sure Engineer's answers were correct, but ignored Investor since my nocturnal admissions hadn't included reading the alien's light-grids.

I returned to my own test hoping it wasn't being timed.

But before I get anywhere, Foresight reappeared. "That's enough," she said and the room was suddenly devoid of math.

I suppressed a sigh. "I gather we all washed out?" Sometimes a good deed is also a stupid one.

Rattle, rattle. "To the contrary, Doctor. Your roommates were never candidates, but your protectors. Aiding them, you passed our final test. Did I not say that we sought entities with wisdom, compassion, and a cooperative spirit?"

"Um. So you did. I just didn't . . ."

"And we'd already been given a superb indication of which competitors were worthiest."

"What indicator?" Engineer asked. "I will be curious."

"Out of our initial sixty-four choices, eight candidates have been assaulted. From attack

similarities, we believe a single species is guilty. Thus, this species demonstrated that in their judgment, Doctor Silver and his seven fellow victims were their champion's only real competition."

I stared up into the front pair of golden eyes. "You mean the creatures who've been trying to kill me have only . . . high-graded me? If you know that term."

"Indeed, selecting the best gems from a collection is an apt analogy."

"Okay." Bizarre irony. "What's to stop them from attacking again?"

Foresight spread wide all four of her upper limbs and rattled as though something were coming loose. "They blundered in the maze by revealing their technological prowess! We've now sent home all candidates from species whose science might be capable of affecting our transportation methods. This is disturbingly unjust to the innocent, but we could find no surer solution."

I nodded thoughtfully. "Mystery remains, but problem solved." Somehow I didn't *feel* safe. "Unless one attack was faked."

"Against that possibility we dismissed three high-graded candidates whose science met the criteria. Most unfair, certainly. We also dismissed two other attacked candidates who showed . . . excessive discomfort among aliens. We've found no such discomfort in you, Doctor."

Goody for me. "Maybe only because of the particular aliens I've met."

"Perhaps, bringing us to an unexpected blossom. With your berth assured, four spaces remain available, and since I am your sponsor and selection committee leader, I can offer you a choice you may enjoy."

"Which is?"

"You may select your two bodyguards to be among the final champions. We had originally disqualified their species since both are our close allies and would already share in whatever secrets we uncovered. Now, however, their trustworthiness outweighs our previous ethical considerations, and I am permitted to modify the rules. Your bodyguards have displayed a cooperative spirit and courage in volunteering for a dangerous assignment."

"That—that sounds good to me. I hereby nominate my roommates for plinth duty."

"Perfection! Then after you three receive evening nutrition and another sleep period, we will all meet at the Originators' artifact. By then, the remaining two selections will be made and you will have received instructions for comporting yourselves in a truly frigid environment. Good resting!"

"This is delightful/unexpected and exciting," Investor commented the moment Foresight absconded with herself. "Thank you, Healer, thank you!"

"I should be thanking you, Investor. You saved my life, and I'm glad as hell to be able to repay a little of what I owe you."

"But I," Engineer squealed, "will not have earned any such reward."

"Oh? What about your willingness to put yourself at risk to defend me? Wouldn't you protect me given the opportunity?"

"That will be conceivable." Engineer pulled a spare food strip off the wall and tossed it in the air. One wing shot out, the varicolored feathers spreading, and the strip fell, cut into hundreds of pieces. How educational. I would've thought it easy to distinguish feathers from knives.

I whistled appreciatively. "Are you two professional guardians or is this a hobby?"

Long whale squeak. "I will be, in life, a designer of bridges. And my associate will work in the hive of business. We both were hungry for experience with Vine doings and pounced on this unique opportunity."

Something, as the antique saying went, didn't compute. "If you aren't trained bodyguards, why would the Vine hire you?"

Investor answered. "Dear friend, both our species evolved/survived to sting aggressive predators. We require no extra training to use our natural armaments. Also, our worlds are similar to yours in atmosphere, pressure, gravity and temperature. We expected the Vine to quell any technological attacks."

"I see. Seems our nutrients have arrived, glory be, and I hope yours are more appetizing than mine. Let's eat. My meal won't improve with age."

I woke up with a head stuffed with cautions. The Originators' artifact was irregularly shaped, immense and hollow, spinning fast enough near the plinth to simulate gravity a bit weaker than Earth's. Regrettably, the

plinth generated shifting electromagnetic fields so strong that the Vine didn't trust their equipment to teleport us directly to the site, or even to ground level anywhere within the artifact. This meant we'd be, figuratively, parachuting in and then hoofing it—very figuratively—for some distance. Because the area where we'd land was spinning faster than the area containing the plinth, we'd be feeling the centripetal equivalent of 1.4*g* until we moved closer to our destination. That wasn't the only problem.

The environment we'd be traipsing through, though sheathed in temperature-less vacuum, hadn't been warmed by any star for billions of years. As a result, the weather report would be dry and a balmy fraction of a degree above absolute zero.

Hydrogen freezes below 14.1 K and helium-4 at .95 K. In the artifact, all gasses would be rock hard.

The ground we'd be traversing retained traces of those two lightweights, but also methane and argon, inadequate for Olympic ice-dancing, but enough to form sneaky patches of ultra-black ice. These could become slippery as hell, or even explode, if we trod over them because the minuscule friction of our passing could melt such sensitive material. In fact, brushing against any surface could release surprise energy.

Worse news. The Vine rarely had to operate in airless, cryogenic environments. So while their spacesuits were an upgrade from NASA's, they weren't worth phoning home about.

Once inside the artifact, we'd remain toasty but our suits would gradually become somewhat brittle as they lost surface heat through radiation and ground contact—another cause for possible banana-peel humor. Should we fall, more likely for us bipeds, our spacesuits might crack, and we'd die. Did I mention that the artifact came fully stocked with sharp edges?

To minimize risks, Engineer and I and all other upstanding citizens would be issued the kind of walkers usually reserved for the infirm. I wondered what kind of spacesuit Investor would be wearing.

After the morning routine, including for me another "continental" repast, Foresight and two other Vine appeared bearing gifts. All those delicate-looking finger-tendrils came in handy for squeezing us into our spacesuits. Mine had a clear head bubble and thin tubing wrapping the interior that reminded me of intestines. Quaint. Foresight claimed the guts would provide O_2 and remove CO_2. Investor's rig was a big transparent balloon with some fancy machinery that constantly stayed at the bottom while bees rolled the thing along.

Secure in our new homes-away-from-homes-away-from-homes, we got zipped to a huge practice obstacle course where we followed a winding trail between tall, blade-studded objects. I had to meander using my walker, which made me feel increasingly sorry for those needing them. When our guides declared themselves satisfied by our progress, we were returned to our room, peeled out of our gear, given another un-scrumptious meal, allowed to do whatever for a full ten minutes, then shoved back into our spacesuits. Foresight called a warning, and the room vanished.

For a stomach-lurching moment, I drifted in freefall, floating in a vast enclosed space between titanic concave surfaces textured with jagged, glistening forms. Brilliant lights hung suspended here and there; I figured the Vine had installed these. The entire place appeared to be spinning around me, a dizzy-making view. Then acceleration caught me, increasing until my speed matched that of the nearest surface, well over a mile away. The same force carried me toward that wall. Finally, I was set down gently in a space between two giant irregular protrusions of sharp angles and sharper edges. I looked straight up. What I could see of the wall miles above seemed only mildly reticulated, flattened by distance.

My environment gear, awkward but manageable in the practice room, had become a leaden anchor. My weight right here was only supposed to be 40 percent higher than Earth normal, but apparently a hippo had climbed onto my shoulders.

"Don't move yet," advised Foresight via the audio system in my head-bubble.

Ensconced in a cave bear of a spacesuit and gripping my walker, she alighted next to me. As she passed me the ambling aid, my roommates settled nearby, and we were off, following a winding path between razor edges.

I'd been in hairy situations before. But nothing came close to this little stroll.

Thank God for the walker, was my main thought. Every twenty steps or less, the path beneath me seemed to explode, silently vomiting a puff of thick roiling mist, blue or green or white, up into my face. An instant later, the mist would vanish or fall as powder, but I'd find myself sliding across the ground, clutching the walker for all I was worth. I doubt our journey took even half an hour, but it stripped decades off my supposedly immortal life.

My piggybacked hippo progressively lost weight as we traveled, but my suit progressively stiffened, maintaining the discomfort level. I'd sweat less in a sauna, but my spacesuit absorbed most of it. It dawned on me that after we'd visited the plinth, we'd be making the same trip through hell in reverse.

"Foresight," I panted, assuming I had my own two-way radio, "why do you suppose the Originators decorated this place with blades?"

"We suspect these articulations are waveguides, promoting whatever forces preserved the artifact though the collapse of a universe."

Intriguing idea, but I hadn't breath enough to pursue it. I hoped the Vine had accurately calculated my efforts here and stocked my O_2 accordingly. In for a penny, I told myself, in for a ton.

Foresight led us between two colossal piles of weirdness into a circular clearing. Here, the mini-explosions ceased, and traction, to my infinite relief, remained dependable. Ninety feet ahead, the plinth towered: two hundred and twelve feet of tapering grace, polished and flawless, black to the blackest. If I hadn't been winded, it would've taken my breath away. I could see three sides from where I trudged, each facet 9', 3.3" at the base.

"You may now abandon your balance aid," Foresight suggested. Nope, not after the contraption had saved me dozens of times. But now I carried it.

The clearing was gently concave with the plinth dead-center. Halfway up a slope so mild it barely deserved the name, I saw the hexagonal plates Foresight had mentioned, flat against the ground, each big enough to fit an elephant and provide it wiggle room. We stopped, and I turned to check on Investor's progress. The big balloon rolled uphill past us, its cryogenic stiffness actually assisting Investor's speed. Engineer passed next, moving in cautious hops after discarding a walker longer than mine. Foresight and I exchanged glances then followed our crew to the plinth.

Four Vine stood near the plates, companioned by two aliens of unfamiliar shape. General impression: large and lumpy. These individuals, I assumed, would complete our quorum. One of the waiting Vine gripped a complex device in two finger-tendril sets.

"We have arrived," Foresight announced unnecessarily.

After centuries of preparation, I would've expected some ceremony of the opening-a-new-bridge variety. But no. Our quorum section wasn't even introduced to the final third.

"Mine is the honor of representing my species," Foresight stated casually. "I will occupy the hexagon beneath the plinth facet where the Originators' explanatory instructions are inscribed. My associates will guide you all to other facets. In maximum unison, we will ascend onto our respective hexagons. Let us proceed."

One of the Vine nudged me toward a plate next to Foresight's, and I moved to within a short stride from it, bringing the walker along for moral support. Waiting, I glanced up at the alien symbols on the facet ahead and understood them thanks to my sleep briefing.

It seemed to be a poem. "Those with eyes to see beauty, and hearts to feel beauty, and minds to recognize beauty are charged [double meaning here, "charged" as in duty-bound but also in the electrical sense] to draw from our common source and express [also radiate and intensify] beauty."

My interpretation felt right although I'd substituted "eyes" and "hearts" from untranslatable terms.

"Now," Foresight ordered. "As quickly as you can."

In six different ways, we all eased onto our plates.

Nothing visible happened, and I wondered if after billions of years the technology here had fizzled. Foresight's question gnawed at me. How could the plinth determine if all required conditions had been met?

Easy one. Those pesky, shifting EM fields did the dirty work.

A second ago, I hadn't known that! But now a river of understanding was pouring directly into my brain, better than Vine inductive

teaching because I was awake, more awake than awake. I felt a tremendous joy and a close connection with everyone present, and at one remove, with the Originators. I *understood*. Two feet from my helmet, a small hexagonal section of the obsidian facet slid inward exposing a compartment. The information pump informed me that the five other compartments had also opened. Three objects lay inside mine, and I was just reaching for them when Foresight called a warning.

I turned around. Six nightmare figures had materialized near us. Giant spider-monkeys, more spider than monkey. Four of these were missing parts; two had arrived headless and another two were neatly bisected, horrid justification of the Vine's concern about direct teleporting. The damaged bodies collapsed, bloating slightly and turning ice-white as they froze. A gush of whatever they used for blood had begun spurting, but that too fell frozen to the ground and shattered.

The final pair, however, seemed all too functional. Both stood nine feet tall. Clear helmets revealed demon faces adorned with six beady orange eyes. These seemed to glower, not blinking but frequently popping inside the elongated heads to return dripping. Each charmer had six skinny arms ending in large pincers, judging by the spacesuit shapes. Every pincer held an object, apparently handguns of various designs, but each alien also gripped something spear-like. In perfect sync, both pointed their weapons at Foresight.

In my expanded state, I experienced concern without fear. Instead, the plinth brought me another profound connection, this time with the invaders. Paranoia motivated their attacks, terror that other species would snag all Originator goodies and gain power over them. I felt a paradoxical empathy at how badly their plans had gone wrong.

Despite the obstacles of electromagnetic interference, Vine counterspy gear, and meters-thick rock, alien technology had provided the spider-monkeys frequent glimpses at Team Foresight's progress inside the artifact. Their idea was simple. They'd teleport a platoon here after we champions received our surprise packages, kill us, and steal the prizes. They'd barely been inconvenienced by getting booted from the contest.

Unfortunately for the smonkeys, their timing was slightly off. And when they tried to transport their commandos, a sudden EM pulse bounced all but six soldiers God-knows-where. Of course, four of those that made it here, more or less, would probably wish they hadn't.

None of my newfound comprehension suggested how to deal with the two remaining hostiles, but I understood their reasoning.

Seeing that we hadn't yet taken our gifts, fearing that the goody baskets would close if any of us abandoned our hexagons, and worrying that the plinth had registered our weights, they'd improvised. New strategy: shoot Foresight, the champion most closely matching their size, and as she fell, one assassin would pull her off the plate while the other stepped onto it. That way, they might get at least one Secret Santa package.

I saw their pincers working, but their toys emitted no bullets, energy beams, or spitballs. The Vine had apparently installed some form of anti-weapon technology here, as they'd done in the maze.

When the guns failed, they chose another option: skewer Foresight. Quick minds.

Quick feet as well. The hostiles became visual blurs, dodging between two Vine technicians. One feinted with its spear while the other went in for the kill. I jumped to the end of my hexagon to see past the facet edge, just in time to watch Foresight lean away from a spear thrust and grab the alien responsible. In one convulsive motion, she threw the smonkey halfway across the clearing where its suit cracked upon impact, immediately hidden in a burst of freezing fog. I couldn't imagine the strength required for such a throw. Through the plinth, I experienced Foresight's pain at having to kill a being that she felt so close to, also due to the plinth.

I reached out to grab my walker.

Misery distracted Foresight. The surviving enemy leaped forward, throwing its spear, and the Vine reacted too slowly to avoid it. I'd swung my walker too late to deflect the weapon. The blade didn't penetrate far into Foresight's chest, but injury didn't matter. I watched her freeze solid, a timeless moment of horror, and my grief only deepened as my tubular club bashed into the assassin, shattered, but cracked the enemy's suit. It was over.

Through my induced empathy, I sensed a vast triumph flooding the emotions of the Vine technicians. I didn't share it. Foresight was dead, and it didn't matter to these people at all. They hadn't lifted a tendril-finger to help their comrade. My grief was too strong for me to understand their callousness.

Then an uncomfortable silence filled me, and I realized that the plinth had shut down. I'd never felt so isolated.

The Vine holding the fancy machine spoke. "Well done, all. Claim your prizes and we will then move each of you to a secluded area where you may explore them in private. Leave Foresight's prizes to us. As we'd hoped, my device reports the collapse of all electromagnetic interference, so we can transport you directly. I suggest you hurry. We cannot guess what physical consequences here might attend the field termination."

As if in a dream, I pulled out my three gifts. Two were blocks the size and shape of a card deck. The third appeared to be an empty glass cylinder with one flattened side, suitable for the cola of your choice. The plinth had taught me how to activate the blocks, but not what they were. I only knew one thing concerning the bottle: It alone was a personal gift for me.

I turned to step off the plate. Poof, I was somewhere else, clouds of fog streaming off my spacesuit.

Fairly private, yes. Solitary, not quite. The room around me was as large as the spacesuit training area, but obstacle-free, maybe the same space unfurbished. A Vine, four inches and change taller than Foresight, stood near me, golden front eyes fixed on mine.

"Congratulations, Doctor!" The pronunciation was exactly like Foresight's, but the voice even deeper. "I wished to inform you of a few things before you opened your gifts."

In my black robe days, I could rapidly snap back from the heaviest emotional blows. Somehow I'd lost my elasticity. After all, here I was, holding three of what might be the greatest treasures in the Universe and, no small thing, still breathing.

Yet I couldn't begin to sound pleasant when I said, "Who the hell are you?"

Rattle, rattle. "I hoped your intellectual powers were keener, Doctor. If you will apply reason, who am I most likely to be?"

I glared up at the giant. Hadn't anyone told this insensitive clod that I'd just left behind Foresight's frozen corpse? How could—

Mental sunburst! *I'd* been the clod. Vine spacesuit technology alone should've clued me in, and I'd missed so much more.

Why would the Vine vary so much in number and symmetry of limbs? How likely was it that aliens could perfectly duplicate human speech? Or that such talented mimics would be comfortable under Earth conditions? Why had I felt an electric charge whenever Foresight and I touched? And the distance she'd hurled that huge assassin, even considering the reduced gravity, seemed suspiciously improbable.

"You're Foresight," I whispered.

"Excellent! As you have obviously surmised, you have never seen my actual body or that of any Vine. This construct is hardier and more useful for my present purposes than the real thing."

I wondered what the "real thing" looked like. My jaw ached, not from teething but grinning too widely. "You're operating this body by, um, remote control?"

Rattle. "Nothing remote about it. Now that we've been reintroduced, would you care to hear what I came to tell you?"

Still grinning, I waved my bottle-holding hand with a certain *joie de vivre.* "Why not?"

"We are aware that human authorities have decided to end your life once you return to Earth. And they intend to conduct a thorough search to find any others with similar attributes, and destroy them as well."

I'd almost forgotten about the death sentence back home and hadn't considered that those like me might be in danger.

"How many others?"

"Twelve survive, including Doctor Velazquez whom you met, and all have been brought to this haven. None currently have families." Not surprising, considering my own preferences after watching so many loved ones age and die. "Returning to Earth for any of you wouldn't yet be advisable."

I nodded agreement, and Foresight continued, "We have discussed the matter with your peers and have a proposition that I believe none of you will refuse."

Brando's delivery was better, but this sounded promising. "Go ahead."

"With our project now concluded, we feel that information gleaned from Originator gifts should be shared, when possible, between species who participated in this success. We further feel that useful information should be made available to all friendly species where a need exists. To effectuate all this, an immense amount of bargaining will doubtless be required."

"I get it. You want to hire us humans to broker everything."

"Just so. Pardon any tactlessness, but your people have refined the . . . art of negotiation to a unique degree."

I chuckled. "Right, our nations have problems playing nice."

"Weakness often becomes strength. Doctor, we invite you to organize and lead these trading missions, but you may better engender trust as interspecies brokers by adding nonhumans to your staff, perhaps representatives from all species given Originator gifts. You should also have bodyguards, a means of transportation to places where instantaneous transport is impractical, and a way to communicate with many alien races. Also, of course, life-sustaining minutiae such as nutrition and air. We will supply whatever you require. And the knowledge you harvest during your missions should provide you enough negotiating leverage to ensure your safety on Earth."

Opportunity wasn't just knocking; it was practically knocking me down. "Sounds fantastic. Count me in! Do you suppose my former roommates would consider the bodyguard positions? That would also cover two of the champion spots."

"Why speculate? I will inquire."

"Perfect." I held out the blocks in my left hand. "According to Mr. Plinth, these should belong to my species. How do I get them to Earth?"

"We will deliver them wherever you suggest. If you have no more immediate questions, I shall leave you alone to inspect your gifts. It might reduce your trading power with my kind if I knew what they contained. We must not be provided an unfair advantage."

Hate to admit it, but I might've snorted. "Seems to me the Vine deserve every advantage. Look. Your people found the artifact, translated the instructions, traveled God knows how far to locate intelligent species, spent centuries picking potential candidates, fiddled with genes or whatever so that naturally long-lived candidates wouldn't have one of your abhorred unfair advantages, and the list marches on. For me, here's the weirdest part: when this incredible, massive undertaking is a complete success, you seem to treat it as no big deal. No fireworks, parades, not a drop of champagne."

Foresight reached down to pat me on the shoulder. "We were ecstatic when the success occurred, but why dwell on the past, even to relish it? When you lived in Japan, a teacher of *dhyana,* did you encourage your students to drift for long from the present moment?"

Dhyana: Sanskrit for absorption, meditation. I had to laugh; I'd just been out-Zenned. "Touché, I'd just been thinking about those days. But really, it's fine with me if you stay while I peel the wrapping off my gifts."

"You are generous, but the opportunity would render me uncomfortable."

"I'll respect that, although I'd appreciate your company." Something nagged at me. "You know, it wouldn't feel right to do this alone; these blocks aren't just for me. You really brought the full card collection of us tweaked humans along?"

"Certainly. You wish them to join you here?"

"For the Grand Opening."

"I will invite them personally. Should you all accept our trading proposal, perhaps a Vine could be included in your missions?"

I grinned up at her. "Any particular Vine in mind?"

"Having had practice in ambassadorship, I might not be the worst choice. We shall meet later."

I wasn't alone for more than a minute before company arrived, an absurdly healthy and young-looking bunch. They stood before me, six women, five men, and an attractive person of ambiguous gender; various races. Naturally I only recognized Angelica Velazquez.

She smiled at me and asked, "How's the arm?"

"I'd forgotten all about that." Gums healed as well.

"That answers my question."

I looked at all the unfamiliar faces. "Welcome, everyone, and thanks for coming. I'm Len Silver as you probably know. I hope to get

acquainted with each of you. But first, if no one minds, let's start the party by finding out what's inside these things." I held up the mystery boxes. "You wouldn't want me to die of curiosity, would you?"

That got a general chuckle but no objections.

"You've been told about the Originators and where these things came from?"

A round of nodding heads.

"Good. The only thing I *know* about these blocks is how to open them. Angelica, I might need a free hand. Would you mind holding one block and the bottle? Or I could put them on the floor."

Wordlessly, she reached out and took the two items.

I turned to put my back toward the audience. "Ready, everyone? There's never a drumroll around when you really need one."

It was a mental thing, based on the technology allowing the plinth to directly stream information. The instructions were to hold a block, visualize four specific symbols, and imagine those symbols inside the block. Good thing that humans have eyes. Or perhaps the plinth had distributed gifts according to species that could use them.

I followed instructions without any sense that something was actually happening. . . .

Then the air filled with hundreds of small colorful shapes, from simple circles to polyhedrons so multisided they resembled spheres. Dead silence in the room. I turned to check audience reactions, and the decorations followed suit, blocking my view of faces and startling everyone. I heard gasps and someone jumped backward, but the forms had no substance. I turned back and so did my levitating flotilla.

The block in my hand vibrated. I concentrated on a rectangular figure, and it brightened as the others faded to near transparency. My choice tilted slightly in midair, revealing scores of flat rectangles hidden behind it like stacked thumbnail images on datafilms.

"Playing cards?" someone asked.

"Good question," I muttered. "Quite the joke if all this is for some stupid game. Hang on. Let me try something."

I randomly selected a "card," largely hidden behind others, and focused on it. Oohs and aahs wafted from the crowd as my chosen rectangle filled in with vivid colors while radically expanding. When the growth spurt stopped, the object remained basically flat and rectangular but was now 4', 2" wide and twice that in height.

"That's a *painting!"* Angela announced.

No doubt. The eerie colors appeared to be exotic pigments in oil, thinly applied, not exactly luminous but seeming to reflect an unearthly light. I noticed a faint texture, delicate quattrocento brush strokes. Fascinating, but a sideshow compared to what the piece depicted: an alien figure painted so skillfully that it practically jumped out of the frameless frame.

This alien had an oval face with two large front-facing violet eyes, another pair set far to the sides, a scaled and snakelike body in shades of gold and blue iridescence, two translucent wings to make all butterflies weep, and four delicate arms ending in—I stared a moment longer to make sure—fingers like tendrils. Part angel, part dragon, beautiful and serene. . . .

"What did you say, Len?" Angela asked and I almost forgot to keep my eyes pointed forward.

"Wasn't listening to myself, but probably something along the lines of 'holy shit.' I'll have to show this to Foresight. I learned something about the Vine today. They've been using artificial bodies here."

A general murmur and the good Doctor Velazquez acted as spokesperson. "Really? What do you know about their real bodies?"

"Nothing, but look at this painting. Look at the eyes. Think about robots back home, folks, the kind built to do household chores. Think about their arms and hands."

A new voice piped up, "I see what you're driving at, Doctor Silver. The Vine probably used their own gripping style in designing their robots."

"Not sure the artificial bodies qualify as robots, but wouldn't it be easiest to manipulate the kind of hands you're used to?"

"You're right!" Angela breathed. "Those fingers are very like Vine fingers. So you think the Originators survived and the Vine are their . . ."

"Descendants. Or we're looking at a coincidence. Let's check out a different shape."

With a thought, I shrunk the picture, returning it to the pack and dismissing the

rectangle. The other floating forms resumed full visibility. They faded again as I concentrated on what seemed an icosahedron until it brightened, unfolding into hundreds of triangles. A moment of attention on just one, and the triangle practically exploded into a large and elaborate shape, smooth as polished brass and much the same color.

"And that," Angela pointed out, "has to be a sculpture. Len, that box in your hand. It's an art book."

I nodded, making the sculpture bobble in midair. "Someone asked me what I'd choose to preserve for the next universe, and this is a damn good answer. I'm guessing this gift displays the Originators' Top Art Hits. Alternative suggestions?"

No takers. "Okay," I said, refolding the sculpture. "I'd love to explore more of this, and we can come back to it later. But now, let's see what's behind door number two."

The chuckles gave me a chilly little frisson as I realized that these people were old enough to remember antique game-show tropes. I shut down the block and exchanged it with Angela's.

I opened it, and a single white rectangle appeared, large enough to distinguish the many black symbols on it. Due to the Vine learn-as-you-snooze program, I recognized the symbols at the top: numbers, from one to fifteen, each matching the quantity of little hexagons to one side. I smiled, thinking about Engineer and Investor trying to cope with hexadecimal, and wondered what they'd gotten from the plinth grab bag.

Numbering system defined, arithmetic operators came next: Four-squiggle-four-bull's-eye-eight. So squiggle meant plus, and bullseye meant equals. Etc. The section below waded into algebra.

Probably more to this than one page, I thought, and the rectangle did another tilting trick, revealing an encyclopedia of pages in back.

I laughed. "Remember those electronic readers from the dark ages?"

"We all do," a deep voice stated dryly.

"Oh. Right." With a thought, I skipped ahead a few hundred pages. The new page was dense with symbols, most unfamiliar but presumably explained earlier in this floating tome.

"Equations?" Angelica offered. "Any math gurus around?"

After a moment, a woman with a flutelike voice and a Filipino accent spoke up. "Bituin Andrada at your service."

I began turning to face her but caught myself. "Thoughts?"

"Many. I understand you are charged to deliver these gifts to Earth, but I wish the Vine could somehow make a copy. This, I would adore to study."

"We can ask."

"We should. Some of those constructions remind me of . . . tensor calculus, maybe field potential equations, something practical. Or this could also be another form of art, if I may think outside the tesseract."

That earned a group giggle. When it faded, I said, "If we've already reached Maxwell-type equations this short way into the book, what's at the back?"

"Antigravity instructions," Deep Voice suggested. "How to build a perpetual motion machine in your spare time."

I grinned. "The Universal Theory of Universal Theories."

A wave of exhaustion hit me, and the magic box shut down on its own. I swayed, but Angelica put a steadying arm around my waist.

"You need rest," she said sympathetically.

"It's been a long day," I admitted. "Let's all sit down and get comfortable."

We did so, and I studied the faces around me. "Could be that operating Originator toys takes something out of you. Let me get everyone's name and then we could vote on Foresight's proposition to become an information brokerage firm."

"But what is this bottle for?" Angelica asked, handing over the final gift.

I stared at the glistening thing, repeating the routine I'd used to open the boxes. Nothing happened.

"Haven't the faintest idea." ■

Science Fact

Challenges of Manned Interstellar Travel: An Overview[1]

Nick Kanas, M.D.

Traveling to a distant star presents a number of challenges. First and foremost is the immense distance involved. For example, the nearest stars to us are in the Alpha Centauri system. The closest of these, Proxima Centauri, is 4.22 light-years away, which translates into nearly forty trillion kilometers (or 24 trillion miles). This is around 271,000 times the distance between the Earth and the Sun. Other stars are much farther away. These tremendous distances raise a number of issues related to methods of getting there, the long-term effects of time and space on the physiology and psychology of space travelers, and the chances of finding planets with life around a selected star. It is likely that the first manned interstellar missions will be decades to centuries long, requiring a multigenerational approach where crewmembers will live, give birth, and die during the course of the mission. But putting some or all of the crew in suspended animation is also a possibility. Both of these scenarios will be discussed.

[1] This article is a modified version of original material published as scientific support in the appendix of the science fiction novel entitled *The Protos Mandate*, by Nick Kanas (Springer, 2014). Parts have been reprinted from the original with permission from Springer Science+Business Media, and all references to the novel have been deleted. See the original paper for a complete referencing and bibliography of all the topics.

Traveling to the Stars: Distance, Propulsion, Radiation

In considering where to go, the stars closest to us are the likeliest candidates for the first multigenerational starship mission. In our Sun's neighborhood, the closest stars and their distances in light-years (in parentheses) are: Proxima Centauri (4.2), Alpha Centauri A and B (4.4), Barnard's Star (5.9), Wolf 359 (7.8), Lalande 21185 (8.3), Sirius A and B (8.6), UV Ceti A and B (8.7), Ross 154 (9.7), Ross 248 (10.3), and Epsilon Eridani (10.5).

All of these stars are a long way away: trillions of miles. Using current technology, interstellar travel is highly unlikely. For example, a starship traveling at the same speed as Voyager 2 would take around 497,000 years to reach the Sirius star system . In contrast, a ship traveling at 5% the speed of light (.05c) would take 88 years to reach Alpha Centauri. Although an improvement, this still would be longer than the expected lifetime of most of the crewmembers and would necessitate a multigenerational approach or the use of suspended animation.

Since faster than light speeds, traveling through wormholes, or using a "warp drive" to distort space-time are not scientifically credible options at present, new propulsion systems that can reach a significant fraction of the speed of light will be necessary. In a typical mission, the vehicle must first accelerate up to this speed, then coast along through much of the mission at this velocity, and finally decelerate to orbital or landing speed as it approaches its destination. By accelerating such a starship at the force of one *g* (producing an Earth-like gravity situation for the crewmembers), it would take about a year to reach a cruising speed close to that of light. The acceleration time would be less for a ship reaching a more manageable cruising speed, say around 10% the speed of light (.10c). Relativistic time effects are important to consider when traveling close to light speed, but they are relatively negligible at speeds in the range of .10c.

Three kinds of propulsion system have been identified for interstellar missions: those that carry their own fuel, those that rely on some sort of external energy source to move them along, and hybrids of these two.[2]

Interstellar vehicles using internal energy sources: Traditional rocket-based propulsion systems are self-contained: they carry along their reaction mass, energy source, and engine, all of which greatly increase their total mass and cost. One type is the nuclear fission rocket, which uses a nuclear reactor to thermally accelerate hydrogen atoms to provide thrust; a variant adds a thermal-to-electric generator to expel charged atoms at high velocity (the nuclear electric rocket). An example of the former was a program called NERVA (Nuclear Energy for Rocket Vehicle Application), which developed some prototype engines in the late 1950s and 1960s but was terminated in the early 1970s. An example of the latter, proposed by the Jet Propulsion Laboratory in California in the mid-1970s, was the TAU (Thousand Astronomical Unit) mission. Although useful for outer Solar System travel and transport, such fission rockets do not produce enough thrust to reach a star in a reasonable amount of time.

A second and more powerful system that contains its own energy source is the nuclear pulse rocket, which is propelled by small nuclear bombs ejected and exploded every few seconds or so against a heavy-duty pusher plate at the back. The pusher plate absorbs each impulse from the hot plasma and transfers it to the vehicle through large shock absorbers. The prototype system for this method of propulsion was Project Orion, proposed by the Los Alamos National Laboratory in New Mexico in the late 1950s and early 1960s to

[2] For good reviews of these propulsion systems, see: Mallove, E.F., Matloff, G.L.: *The Starflight Handbook: A Pioneer's Guide to Interstellar Travel*, John Wiley & Sons, Inc., New York, 1989; Kondo, Y., Bruhweiler, F.C., Moore, J., Sheffield, C. (eds): *Interstellar Travel and Multi-Generation Space Ships*, Apogee Books, Burlington, Ontario, Canada, 2003; Matloff, G.L.: *Deep Space Probes: To the Outer Solar System and Beyond, 2nd ed*. Springer Science+Business Media, New York, 2005; Johnson, L., McDevitt, J. (eds.): *Going Interstellar*, Baen Publishing Enterprises, Riversdale, NY, 2012; Benford, J., Benford, G. (eds.): *Starship Century: Toward the Grandest Horizon*, Microwave Sciences and Lucky Bat Books, Charleston, SC, 2013.

use small nuclear fission bombs and in the late 1960s by Freeman Dyson to use fusion devices. It was estimated that some three hundred thousand bombs would be needed to propel the massive space ship, which would weigh four hundred thousand tons and accommodate a crew of several hundred.[3]

A third internal energy system was explored by members of the British Interplanetary Society in the 1970s and was termed Project Daedalus. This was a fusion-powered interstellar rocket where pellets of helium-3 and deuterium were compressed and heated in a combustion chamber inside the ship by high-energy electron beams or lasers. The resulting fusion reaction provided energy to power the vessel. Although some have proposed using tritium instead of helium-3 since the reaction is easier to initiate, helium-3 results in charged particles that can be confined and directed by a magnetic nozzle (rather than the leaky neutral neutrons that are produced by the tritium reaction). Since helium-3 is rare on Earth, it would have to be mined elsewhere, such as the atmosphere of Jupiter or Saturn, possibly using robotic helium mines suspended by balloons. Deuterium could be obtained from cometary nuclei in the Oort cloud. A follow-up version to Daedalus, Project Icarus, was examined in 2009 to explore similar concepts using newer twenty-first-century notions and to develop some sort of deceleration mechanism when the target star was reached. Other variants included the novel use of autonomous robotics and artificial intelligence for onboard planning, maintenance, and self-repair, and new propulsion concepts, such as plasma jet driven magneto-inertial fusion. Another Daedalus follow-up examined the use of the entire spacecraft as a magnetically-insulated capacitor which would ignite the deuterium-tritium reaction using an intense ion beam.

A fourth internal energy system depends upon the reaction of matter and antimatter to provide energy to move the vehicle. Although the concept has been discussed since the 1950s, it was more fully developed in the early 1980s by Robert Forward.[3] The notion was that the reaction of protons and antiprotons would produce electrically charged elementary particles that could be focused by a magnetic nozzle and expelled out the back of the rocket ship as exhaust. Although more powerful than fission or fusion, this system presents technical issues related to storing antimatter in a manner that would prevent it from touching and reacting with the walls of the ship, such as in a magnetic or electric field. In addition, antimatter is very rare, and it would be a challenge to obtain enough of it to propel a giant starship.

Hybrid interstellar propulsion systems: External energy propulsion systems solve the major problem that decreases the efficiency of systems using internal energy: the need to take along large amounts of heavy fuel. Hybrid systems likewise rely on external energy sources to decrease mass, but they also use small amounts of internal energy. One such system was the Bussard interstellar ramjet, which was proposed in the early 1960s by Robert Bussard. This vehicle consisted of the payload, a fusion reactor, and a large electrical or magnetic scoop to collect onrushing charged particles along the flight path. Interstellar hydrogen was the main fuel source. However, some supplemental intrinsic fuel was necessary for travel through low hydrogen areas, such as in our Sun's vicinity. Although this model employed a heavy rocket engine whereby the energized helium exhaust resulting from hydrogen fusion was expelled from the rear of the spacecraft to accelerate it forward, such a starship would not need to carry a lot of fuel during the trip, thus cutting down on mass and cost. Since the amount of hydrogen collected by the ramscoop increases with speed, this system could reach high velocities and would be suitable for interstellar travel, assuming it was designed well enough to minimize drag. The scoop would need to be large and structured using lightweight material, or it could consist of a magnetic or electrostatic field that would collect hydrogen that has been ionized by a forward pointing laser.

One variant of the Bussard approach is the Ram-augmented Interstellar Rocket. This system incorporates a separate fusion reaction

[3] Forward, R.L.: Ad astra! In: Kondo, Y., Bruhweiler, F.C., Moore, J., Sheffield, C. (eds): *Interstellar Travel and Multi-Generation Space Ships*, Apogee Books, Burlington, Ontario, Canada, 2003, pp. 29–51.

that uses a small amount of intrinsic fuel such as helium-3 and deuterium (see above). But in this case, the reaction serves to energize the hydrogen that is collected from space by a ramscoop, which it does in a very efficient manner. Note that the hydrogen is not used as fuel but as reaction mass to produce thrust for the starship.

Interstellar vehicles using external energy sources: A purely external energy system discussed as far back as the 1920s employed beamed power. The type usually mentioned uses the momentum of massless light photons from the Sun to "push" against a solar sail, thus moving the vehicle in the direction of the beam. In contrast to the solar-electric drive that uses sunlight falling on solar cells to convert fuel to ion propulsion, a beamed system would only need a payload and the structure of the vehicle; there would be no need for heavy intrinsic fuel or any kind of engine. The solar sail concept has been tested on Earth and in space with some success by several space agencies. Being located within our Solar System, the beaming system could be monitored and maintained relatively close to home. However, the space vehicle would be a relatively slowly accelerating system, and the larger the payload, the greater the need for a very large sail. This system would likely be better for unmanned interstellar missions carrying small payloads.

A number of other beam/sail systems have been suggested, such as using small charged pellets accelerated by an electromagnetic mass driver that strike a magnetic field sail; microwave photons pushing against a wire mesh sail containing microcircuits at the wire intersections; or lasers aimed by a Fresnel lens reflecting against a large light sail. Much like a tacking sailboat, some of these systems allow the craft to turn or even decelerate upon reaching a stellar destination. Methods for using the solar wind have also been considered for travel in the Solar System. More novel approaches for beamed propulsion have been proposed as well, such as using gravitational waves and antimatter to generate thrust.

Several of the above propulsion systems are capable of achieving very high speeds that would cut down on travel time. A round trip to Proxima Centauri could be made in 11 years, assuming a one-year acceleration to near-light speed, then a 3½-year coast in deep space, a one-year deceleration to the star, then a similar flight plan on the return. But traveling at near-light speed presents difficult technological problems. In addition, the rapidly oncoming flow of interstellar gas and dust particles and cosmic rays on the starship and its inhabitants could present unique particulate and radiation hazards.[4] Some kind of deflector shield and laser combination in the front will be necessary to block oncoming dust particles and vaporize larger bodies, although it has been pointed out that a massive deflector system might interfere with the maneuverability of a starship traveling at relativistic speeds. In a ramjet type of vehicle, micron-sized bits of dust likely will be vaporized by protons in the electromagnetic field of the scoop. To protect against oncoming cosmic rays, a passive rock or metal shield or an active magnetic or electric field deflector could be used.

Economic Considerations

The technology to propel and protect a starship would be enormously complicated and expensive, especially when one considers the massive size of the ship itself. Consider the scenario of a huge, self-contained multigenerational starship full of colonists needing to be kept alive for decades while traveling to a distant star. Strong has envisioned giant one-hundred-megaton starships containing 100-150 people that would be equipped for a century-long journey to the stars.[5] Woodcock imagines even larger one million metric ton starships the length of 11 football fields that would carry ten thousand people.[6] Accelerating to a maximum velocity of 15% the speed of light (.15c), then decelerating to reach a star some ten light-years away, such a behemoth would complete its journey in about 130 years.

Zubrin has taken a look at the economics of a starship with a dry mass of one thousand

[4] Semyonov, O.G.: Radiation hazard of relativistic interstellar flight. *Acta Astronaut.* **64**, 644–653, 2009.

[5] Strong, J.: *Flight to the Stars*. Hart Publishing Company, New York, 1965.

[6] Woodcock, G.R.: To the stars! In: Schmidt, S., Zubrin, R. (eds): *Islands in the Sky: Bold New Ideas for Colonizing Space*, John Wiley & Sons, New York, 1996, pp. 183–197.

tons that can cruise at .10c and carry a few score colonists on a trip lasting several decades.[7] He estimates that if this ship operates at 100% efficiency (an unlikely occurrence), the energy costs alone would amount to 12.5 trillion dollars. The addition of other costs, such as technology development and hardware manufacture, raises the price tag to 125 trillion dollars! This is roughly one thousand times the cost of the Apollo program in today's dollars. He estimates that to keep the cost of this interstellar mission at Apollo levels in proportion to the total wealth of human society (about 1% of GDP), a future spacefaring civilization will need a GDP two hundred times greater than today and a total human population of some forty billion. He foresees fusion reactions using helium-3 and deuterium for fuel as the power source to most cheaply meet the high-power needs of this civilization. The fuel could be mined from the atmospheres of the outer gas giant planets in our Solar System. He believes that the helium-3/deuterium fusion reaction would be the power source for an interstellar vehicle as well, with the super-hot, plasma-charged particles being confined and reacting in a vacuum chamber using magnetic fields, and the exhaust mixture being directed away by a magnetic nozzle to provide the thrust. A number of technological issues need to be addressed before such a system is possible (e.g., containing the super-hot plasma, using catalytic methods to enhance fusion at a lower temperature), but Zubrin presents a good case. Of course, political, scientific, and economic stakeholder considerations (e.g., national policy priorities, scientific benefits, profit generation) will also influence the likelihood of such a mission.

Assuming that there is a will to undertake such an interstellar mission, that appropriate resources are devoted to it in a sustained manner, and that technological breakthroughs occur in a timely sequence, it is reasonable to assume that small, unmanned, beam-powered interstellar probes could be launched to a nearby star like Alpha Centauri by the twenty-third century. Such probes might even use nanotechnology. After they report back their findings, massive, manned, fusion-powered colony ships could be built and launched by the twenty-fourth and twenty-fifth centuries. Due to the scale and economics of the situation, a fusion propulsion system may not be used for the colony ship. Instead, beamed propulsion might be adequate, especially if several probes are launched sequentially that can use the same beaming source. However, travel by this method would be slow and require much more time to reach the destination stars.

Psychological and Sociological Issues

In past *Analog Science Fiction and Fact* articles, I have discussed a number of psychological and sociological issues that affect crewmembers during long-duration space missions.[8] These are reviewed in Table 1 with particular reference to an interstellar mission and won't be discussed further here.

* * *

Table 1. Psychological and Sociological Issues during an Interstellar Mission

1. Selection issues: Who would want to go? Who would be excluded? What kind of diversity would there be in the crew?
2. Feelings of isolation and loneliness in deep space
3. Earth as an insignificant dot in the heavens—Earth-out-of-view phenomenon
4. Lack of novelty and social contacts in deep space
5. Dealing with monotony and leisure time through meaningful activities and habitability design
6. Autonomy from Earth and over-dependence on on-board resources: computers, machinery

[7] Zubrin, R.: On the way to starflight: The economics of interstellar breakout. In: Benford, J., Benford, G. (eds.): *Starship Century: Toward the Grandest Horizon*, Microwave Sciences and Lucky Bat Books, Charleston, SC, 2013, pp. 83–101.

[8] Kanas, N.: The psychology of space travel. *Analog Science Fiction and Fact*, October 2009, pp. 33–41; Kanas, N.: To the outer solar system and beyond: Psychological issues in deep space. *Analog Science Fiction and Fact*, May 2011, pp. 38–43.

7. Dealing with mentally or medically ill people in a confined space
8. Unknown physical and psychological effects of radiation due to traveling at near-relativistic speeds
9. Starship environment: sustainable resources, artificial gravity, population control
10. Intolerance of diversity: cultural factors, religion, language differences
11. Feelings of homesickness, especially people in the first generation who directly remember the Earth
12. Dealing with myths and folklore regarding the Earth in later generations
13. Keeping the original colonizing goals: rebellion by later generations who want to go back or keep traveling in space, flexible governance
14. Dealing with criminals and sociopaths in a relatively small social network
15. Psychological and ethical effects of social engineering: regulating coupling, birth rate
16. Psychological and medical issues related to suspended animation

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Suspended Animation

Putting crewmembers in suspended animation has been a well-utilized novum in science fiction as a way of conserving resources and dealing with the long durations inherent in interstellar missions. It has been employed in written stories (e.g., Don Wilcox's 1940 "The Voyage that Lasted 600 Years," A.E. van Vogt's 1944 "Far Centaurus") and popular movies (e.g., *2001*, *Alien*). In this scenario, after the critical activities involving the launch and the setting of the course for a distant star have been accomplished, the crew would be put in a state where their physiological functions are slowed down until such time as they are near their destination, when they would be "awakened" to perform their landing and exploration duties. This notion proposes the effective cessation of metabolism in the crewmembers due to drugs and/or extreme cold (i.e., cryosleep). Certain key crewmembers could be revived periodically to perform mission critical activities, then go back into suspended animation when these are completed. The starship would be on autopilot during the bulk of the mission, and computers would handle life support and navigation, as well as the revival process.

The problem is that the technology to put an entire human being in suspended animation has yet to be developed, and the process is fraught with difficulties.[9] Although freezing is used to preserve red blood cells and corneas for transplantation, the ability to freeze and later thaw complete organ systems and whole bodies composed of differentiated cells with different freeze-thaw rate profiles is beyond our abilities in the foreseeable future. Ice crystals can form, which can be lethal to cells, and areas of the body can be deprived of oxygen from blood clotting or premature freezing before metabolism is slowed down. Even the use of cryoprotectants such as glycerol, sucrose, or ethylene glycol presents technological challenges. The thawing of previously frozen cells and tissues presents risks of ice crystal formation and damage as well.

A related idea is to cryopreserve sperm, ova, or actual embryos in liquid nitrogen or via other techniques for later implantation in female crewmembers or in an artificial womb. This would present a possible backup system for fertility problems that might develop in transit to a distant star, or it could be used to increase the colony population after landing on a suitable exoplanet. Such preservation for up to two decades has resulted in successful implantation and birth.

One notion of preserving cells in the human body is through the process of vitrification. In

[9] For a complete and thoughtful review of suspended animation, see: Stratmann, H.: Chapter 7: Suspended animation: Putting characters on ice, in *Using Medicine in Science Fiction: The SF Writer's Guide to Human Biology*, Springer Science+Business Media, New York (in press). An older and briefer discussion of this topic is also found in Mallove, E.F., Matloff, G.L.: *The Starflight Handbook: A Pioneer's Guide to Interstellar Travel*, John Wiley & Sons, Inc., New York, 1989, pp. 199–205.

this process, the water in the body and its cells is cooled in such a way that it does not actually freeze. Instead, it is supercooled to a kind of glass-like state where cellular molecular motion and metabolism cease and cell components are preserved in place due to the arrested state of motion. In theory, the dangers of freezing should not be present; however, ice crystal formation and cell damage could still occur during the thawing process.

Even if suspended animation becomes technically possible, problems could still occur. Perhaps there are unknown physical and physiological effects of long-term suspended animation lasting up to a century or more that might result in permanent organ damage or impaired brain function. This risk could be enhanced by power surges or breakdowns of the equipment during this long period of time. In addition, psychological problems could result prior to freezing in people fearful of being incapacitated for years at a time or worrying that some catastrophe could occur, such as a collision or equipment failure. For example, what if a meteoroid hit the ship and negatively impacted life support equipment before crewmembers could be aroused? Computers and other machines are not perfect; the notion of being helplessly dependent on them to maintain your body and revive you later is not a comfortable thought and could create anxiety. Many people would prefer the awake multigenerational option for the first space colony mission, since they would be in more control over their destiny.

Exoplanets and Colonization

Planets revolving around distant stars can be detected using several techniques, such as astrometry, which measures a star's wobble due to the gravitational influences of an orbiting planet; Doppler changes in stellar spectrum due to this wobble; pulsar timing variations resulting from planet-caused gravitational perturbations as the pulsar rotates; changes in a star's luminosity resulting from a transiting planet; and gravitational microlensing, where the light from a background star is bent by the gravitational effects of a closer in-line star with planets.[10] Often, the mass and distance of the exoplanet from its star can be determined. These detection methods bias the search in favor of finding larger planets, but as the techniques become more refined, more and more exoplanets approaching the size of Earth are being discovered. Thanks to the sensitivity of the Kepler Space Telescope, the NASA Exoplanet Archive on December 3, 2014, listed 1,780 confirmed exoplanets (and 459 multi-planet systems), and more continue to be listed every week as the Kepler data are processed.[11] Some of these planets are in the star's so-called habitable (or "Goldilocks") zone: not too hot or too cold, but at the right distance to have surface temperatures in the range supporting the presence of liquid water, thus making them possible candidates for life. In fact, a recent study found ten Earth-size exoplanets orbiting in their respective star's habitable zone.[12] The study results supported the conclusion that 22% of Sun-like stars in our galaxy may in fact harbor Earth-size planets that orbit in their habitable zones, and that the nearest such planet may well be within 12 light-years from us. Nineteen single or double star systems lie within this distance.

Three of these systems are thought to have at least one planet orbiting a star.[13] In November 2012, an Earth-like star was thought to have been detected around Alpha Centauri B, located 4.4 light-years from Earth. If confirmed, the planet would likely be very close to its star and therefore too hot to be habitable. Work published in December 2012 has

[10] For recent discussions on detecting exoplanets, see: Coughlin, J.L.: Extrasolar planets: What can be known before going there. *J.Brit. Interplanet. Soc.* **66**, 47–50, 2013; Kanas, N.: *Solar System Maps: From Antiquity to the Space Age*. Springer Science+Business Media, New York, 2014, pp. 227–230.

[11] *http://exoplanetarchive.ipac.caltech.edu/index.html.*

[12] Petigura, E.A., Howard, A.W., Marcy, G.W.: Prevalence of Earth-size planets orbiting Sun-like stars. *PNAS*, **110**(45), 1–6, 11/4/13. *http://www.pnas.org/content/early/2013/10/31/1319909110.*

[13] Matloff, G.L.: *Deep Space Probes: To the Outer Solar System and Beyond, 2nd ed.* Springer Science+Business Media, New York, 2005, pp. 141–154; Baxter, S., Crawford, I.: Starship destinations. In: Benford, J., Benford, G. (eds.): *Starship Century: Toward the Grandest Horizon*, Microwave Sciences and Lucky Bat Books, Charleston, SC, 2013, pp. 225–237.

suggested that the Sun-like star Tau Ceti, located 11.9 light-years away, may host a system of up to five planets ranging in size from two to seven Earth masses, and that two of these are close to the habitable zone.

A bit nearer to us at 10.5 light-years away, and better studied than the other two star systems, is the interesting system around Epsilon Eridani.[14] With an apparent magnitude of 3.7, this young star is probably less than a billion years old and has a mass of about 80% that of our Sun. It is of spectral class K2 and has an orange hue. A number of components are thought to surround the star. These include: an inner asteroid belt some three astronomical units away (1 AU = the Earth-Sun distance, or 149,597,871 kilometers); a large planet discovered in the year 2000 that is likely 1.5 times the mass of Jupiter and is around 3.4 AU away from its star, with an orbital period of about seven years; an outer asteroid belt some 20 AU away; a more Earth-sized planet about 10% the mass of Jupiter and around 40 AU away, with an orbital period of some 280 years; and a Kuiper belt-like dust disk 35–90 AU away that is relatively devoid of cometary nuclei. There is speculation that other planets exist in the system, especially bordering and helping to form the belts and disk.

Young K2 stars like Epsilon Eridani are seen as good possibilities to harbor planets that support life. This is because they are numerous, are stable for long periods of time, and potential planets orbiting them are less likely to be trapped in a synchronous rotation due to tidal damping than planets around older stars. Although determining the location of a star's habitable zone is dependent upon many factors, such as the star's age, luminosity, and flare activity, as well as assumptions about a planet's magnetic field, climatic conditions, and cloud formation, a reasonable estimate of the distance of the habitable zone of Epsilon Eridani is around .5 to 1 AU. Furthermore, with a distance of around .5 to .6 AU from this star matching the solar constant and UV flux experienced on Earth, this distance looks promising for any planet found in this location to harbor life. Recently, the Kepler telescope discovered two Earth-size planets orbiting another K2 star (Kepler-62) that is two-thirds the size of our Sun and is located 1,200 light-years away from us in the constellation of Lyra.[15] No Earth-size planets have been found yet in the habitable zone of Epsilon Eridani, but should they exist, this would be a good place to look for extra-solar life.

In time, it is likely that exoplanets will be found relatively close to us that are good candidates for colonization. If so, what would such a colony be like? Based on his analyses of thirteen post-migration communities on Earth, Schwartz has conceptualized three typical stages of organization following a migration.[16] The first is the pioneering phase, lasting two to four years, where the new settlement may experience tension and factionalism over issues related to physical survival. After food has been provided in a reliable manner, and after permanent shelters have been established, this sense of impermanence disappears. The community now enters into the consolidation phase, where it crystallizes and formalizes its social institutions and associations, and a sense of group solidarity begins to develop. In some colonies, there is pressure to retain the old ways of doing things despite changing conditions, but in others new norms are established and cultural changes occur. As the potential factionalism of the first two stages are dealt with, and ways of resolving disagreements are established, the community enters into the third phase—stabilization—where it continues to develop in ways not directly related to the resettlement. Although initially the settlers may experience a sense of equality with each other, the social class structure of the original migrating group could be reestablished later on. Alternatively, new social interactions may result from the new conditions. In a similar manner,

[14] For a complete and referenced review of the Epsilon Eridani system, see: Wikipedia: Epsilon Eridani. *http://en.wikipedia.org/wiki/Epsilon_Eridani.*

[15] NASA: NASA's Kepler discovers its smallest 'habitable zone' planets to date. April 18, 2013. *http://www.nasa.gov/mission_pages/kepler/news/kepler-62-kepler-69.html.*

[16] Schwartz, D.W.: The colonizing experience: A cross-cultural perspective. In: Finney, B.R., Jones, E.M. (eds.): *Interstellar Migration and the Human Experience*, University of California Press, Berkeley and Los Angeles, 1985, pp. 234–246.

either weak or strong authority systems could occur, largely as a result of the nature of the structure in the pre-settlement culture. In terms of religion, Schwartz outlines three patterns: a simplification of the religious system in the early years following the migration; a rise in its importance as a factor increasing the unity of the community; or as a vehicle for factionalism after the initial period of settlement. How these factors will apply to a new interstellar community is dependent upon the specific conditions and social conventions of the group. Economically, Hodges has written that a newly settled star system community will experience a period of great scarcity of goods, but after basic survival needs are met, and after the population has grown and becomes self-sufficient, the standard of living will improve as industries are established that produce goods beyond the basic necessities.[17]

Extraterrestrial Life

Could life evolve on a planet orbiting a distant star, especially one like Epsilon Eridani that is less than a billion years old? On Earth, there is fossil evidence that suggests that primitive microbes had developed in shallow ocean environments by one billion years, and that these organisms evolved in many ways, from obtaining their energy through chemical means (chemoautotrophs) to using photosynthesis (photoautotrophs). There likely was little oxygen in the atmosphere at this time, but later on the increasingly wider use of photosynthesis began to change things, as atmospheric carbon dioxide was consumed and oxygen was produced. Irwin and Schulze-Makuch have provided intriguing arguments that under the right conditions, the life evolutionary process can be speeded up as compared to that which took place on Earth, and that such a process could have happened on Mars.[18] Specifically, they believe that a billion years would be long enough for multicellular aquatic plants and colonial filter feeders to develop in water environments, and for unicellular extremophiles and organisms living in rock crevices to develop in subterranean and surface environments. With this amount of activity, it is possible that oxygen would have accumulated relatively early in the atmosphere as a byproduct of ongoing photosynthesis. It is unclear how likely photosynthesis would be in the light of a low-luminosity K2 star like Epsilon Eridani. But it should be kept in mind that 4.4 billion years ago, shortly after the Earth was formed, the Sun's brightness was 25–30% less than today, and that its relative faintness continued for at least another 1.5 billion years. Even under these conditions, photosynthesis-using plants managed to develop and eventually produce oxygen that forms the basis for our existence.

Irwin and Schulze-Makuch further speculate that life could be present in such exotic environments as a watery subsurface on Europa or in aqueous ammonia or liquid ethane habitats on Titan. Alien life has been depicted in a variety of ways living under a variety of conditions, but an exoplanet that has been carefully selected for human colonization will likely have a number of Earth-like characteristics with respect to gravity, a rocky surface, moderate temperatures, tolerable radiation, an atmosphere with oxygen, liquid water, and plant-producing soil. As a result, any life found will likely be carbon-based and require sunlight and water. But even on Earth there are a number of extremophilic microorganisms that survive under inhospitable conditions of temperature, radiation, acidity/alkalinity, and pressure, and some give off methane as a metabolic byproduct. Organisms with silicon-based structures exist, and there is evidence that silicon may have played a role in the emergence of life on Earth.[19] So it is anybody's guess as to what kinds of alien life future colonists will have to deal with.

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[17] Hodges, W.A.: The division of labor and interstellar migration: A response to "Demographic Contours." In: Finney, B.R., Jones, E.M. (eds.): *Interstellar Migration and the Human Experience*, University of California Press, Berkeley and Los Angeles, 1985, pp. 134–151.

[18] Irwin, L.N., Schulze-Makuch, D.: *Cosmic Biology: How Life Could Evolve on Other Worlds*, Springer Science+Business Media, New York, 2011.

[19] Cairns-Smith, A.G.: *Seven Clues to the Origin of Life*, Cambridge University Press, Cambridge, UK, 1991; Dessy, R.: Could silicon be the basis for alien life forms, just as carbon is on Earth? *Scien.Am.* 2/23/98, *http://www.scientificamerican.com/article/cfm?id=could-silicon-be-the-basi&print=true.*

One possibility is a life form similar to slime molds on Earth, which are very interesting organisms. Some types live as a syncytium of numerous cell nuclei embedded in a glob of cytoplasm surrounded by a single large membrane. Other types typically exist as single-celled microorganisms that lead solitary lives when their bacterial, yeast, or fungal food is plentiful. However, when food is scarce, they merge together via chemical communication to form a giant amoeba-like organism that is a very efficient finder of food. In addition, in their merged state they adaptively form stalks that produce fruiting bodies that release countless spores to reproduce themselves during difficult times.

In studies where the merged organism is placed on a grid depicting a city like London or Tokyo with its surrounding suburbs, and where food is placed at these suburban locations, the slime mold will extend its pseudopods to find the most direct routes to the food, essentially replicating the city's efficient highway or railway system. Similarly, slime molds are able to traverse complex mazes in order to find food and to learn ways of anticipating unpleasant cold and dry conditions in the laboratory. This has given rise to the notion that these primitive organisms possess a kind of rudimentary intelligence.[20]

Conclusions

There are many issues to consider when talking about interstellar travel. Due to the great distances, more efficient propulsion systems are needed, some of which require technology not yet developed. In addition, there is great expense involved, which necessitates a strong financial commitment. The mission will take many decades, and a multigenerational approach likely will be necessary. This will result in a number of psychological and sociological sequelae. Putting some or all of the crewmembers in suspended animation is theoretically possible but practically very difficult. When a distant Earth-like exoplanet is reached, setting up a colony creates its own problems, and if life is found, it may be quite primitive or exotic. Yet, population and climate change pressures at home may lead us in the direction of interstellar travel, not to mention our curiosity of the unknown and our desire to find life among the stars. ■

About the Author

Dr. Kanas is Professor Emeritus (Psychiatry) at the University of California, San Francisco; and a Fellow of the Royal Astronomical Society (London). He has been a NASA-funded research Principal Investigator, and for over forty years he has written about psychosocial issues affecting humans in space. He also is a life-long amateur astronomer, a collector of antiquarian celestial maps, and a science fiction writer. He has over two hundred professional publications, including (with Dietrich Manzey) *Space Psychology and Psychiatry* (which won the 2004 International Academy of Astronautics Life Sciences Book Award and is now in its second edition); *Star Maps: History, Artistry, and Cartography*, also in a second edition; and *Solar System Maps: From Antiquity to the Space Age*. He has published articles in *Analog Science Fiction and Fact* and two science fiction novels in Springer's Science and Fiction series: *The New Martians* and *The Protos Mandate*, with a third novel on its way.

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Slider

Bud Sparhawk

"Dad."

I had been about to take a mouthful of meatloaf when Todd suddenly broke the silence around the dinner table. Millie looked up: Talking at dinner was unusual behavior for our typically silent teen.

"Dad," he repeated after several moments as I waited in silence. He took a big drink of milk, picked up his fork, and took up the pursuit of a tiny carrot around his plate. "I got a call today."

"That's nice," I replied as I helped myself to an extra serving of potatoes. "Who was it?"

"It was from Mr. Hughes, the scout for the O's who called us last month."

Do I remember him? I had been on cloud nine since the Oriole's scout had said Todd had "potential." Hughes said that he'd heard about Todd's ninety-mile-an-hour fast ball, deceptive slider, and pill-sized curve ball. Any one of those was reason enough to put my boy on the sports pages; that is, if his school's team was having a decent season.

But Todd's team wasn't doing so well this season; the rest of his teammates didn't have the *cajones* to win, despite Todd's monumental efforts on the mound. Not only that, but Todd's batting average was darned good for a pitcher—0.315 since the beginning of the season. It's just the rest of his team that couldn't hit for crap.

Ever since Todd was old enough to throw a ball, I'd been emphasizing the balanced approach to playing baseball. He'd inherited my arm and had more muscle than I ever did, which meant he could put some real heat on the ball. I'd been telling him all through his T-ball, little league, high school, and summer league that it's the total package he needs to keep in mind: batting, pitching, and fielding are equally important, and, to succeed, you have to be good at all three.

So he got a call. Hughes probably told Todd that if he worked hard in college, made the school team, and continued to improve, maybe, just maybe, there would be the possibility of a minor-league offer. That courtesy was more than most scouts would have given, and I appreciated Hughes' manners. Todd was probably disappointed, but a call was a lot more encouragement than most high-school hopefuls would get.

Still, for somebody Todd's age, waiting a few years would seem an eternity. He probably thought that he'd failed, poor kid. I wondered what I could say to make him feel better.

"Anyhow," Todd said, still moving that damned carrot around as if touching all the

bases was important before he could put away the rest of his food. "Anyhow, he wants to talk to us about signing a pre-contract agreement." Finally he looked up, and I could see the grin running from one ear to the other.

"A *contract!"* With a whoop, I pushed back the chair and did a little dance right there at the end of the table, rattling the dishes in the cabinets. Todd jumped up and swung around and around, the two of us whooping and hollering like a pair of crazy Bird's fans.

Zowie! Hughes was going to offer Todd a contract before he was even out of high school! Man, I knew he was damn good, and that wasn't just my parental pride talking. If a major league scout like Hughes thought he was good, too, where couldn't Todd go?

Visions of Todd on the mound in Camden Yards, wearing the orange and black, throwing his fast balls, sliders, and curves to one frustrated batter after another, holding them back as the team advanced to the top of the standings, ran through my mind in a montage.

"What does that mean?" Millie asked, still sitting at the table with a puzzled look on her face, vaguely confused by all of this baseball talk and our antics.

"It means that they're interested enough to talk contract, and contract means that they think Todd here has what it takes to play in the majors!" I replied, thinking about the fame and money. Todd wouldn't have a worry once that contract was signed, wouldn't have to struggle like I did.

"But isn't he too young? I mean, what about college? Don't they usually wait until after college to offer contracts?" Millie was trying hard to figure out what this would do to Todd's college plans.

"I guess our boy's got lots of potential. Isn't that right, son? No need to go to college if they sign you up. Probably put you in training right away, build those skills up to where you're a major threat. Probably give you a personal pitching coach. Yeah, you won't need college at all, not with what they have planned for you."

"But what about my job next summer?"

Job? I didn't think cleaning out the cages at the zoo was much of a job, but Todd had been a nut for animals ever since he was a kid. Always had something in his aquarium or outside in a pen. "Ha, what kind of money can you make scooping poop?" I asked. "Training camp will be a lot more fun than college. Pays better, too."

Todd sat down and went back to pushing some more food around the plate before he spoke again. "Mr. Hughes said you'd have to sign a release. Something about viv . . . vivio . . ."

"Vivioplasty," I said softly. "They must really want you bad if they're thinking about paying for *that."*

"What's this?" Millie asked. "What do they want to do to Todd?"

I tried to explain, even if I didn't fully understand the age-retardant treatments myself. "Vivioplasty is a way of keeping the body in tip-top shape instead of running down as you age until it takes practically all your energy just to lift your useless dingus. "

"But isn't that dangerous?" Millie was ever wary of doctors since her complications a few years earlier.

"No, they'll just adjust Todd's biological 'clocks' with teleomatic synchroniz . . . something or other."

Millie looked worried. "So he just gets a shot or some medicine to get this done? I thought performance enhancement drugs were illegal."

I wondered if she ever read the sports page. "No. It's more like those aging treatments rich people get. They have to be timed to when Todd hits his peak. That'll take seven, maybe eight years of treatments."

"That's a long time," she said slowly.

"A *long* time? My God, think about it, Mil! Todd's going to stay young and healthy for *years!"* I tried not to think of what the downside of the process might be—using up all his teleo-whatevers too fast. The process was still so new that nobody had actually seen if that would happen. Most of those treated were very much alive, and medical science always advances, doesn't it? Todd might not live a shortened life at all.

"If they offered to pay for treatments, then they must believe that Todd is worth the investment," I said. "Borros and Zlebinsky had the treatment."

"Are they ball players?" Millie asked—she hadn't a clue.

"Great shortstop and pitcher," Todd said with a grin. "But not as good as I'm going to be."

I slapped him on the shoulder. "Jesus, what a glorious opportunity! You won't have to sweat for wages like my dad, or be a minor league has-been like me. No sir, you'll be in the majors, pitching for years. No failing arm for you."

The rest of the evening was a blur of activity, calling my brother to tell him the good news, giving Coach Philips the word, although I suspect he already had a glimmer when Hughes had asked for Todd's number, and finally calling Mom. She wasn't in, so I left the happy note on her voice mail. I'd forgotten it was bingo night, a weekly ritual with her widow friends and a few old guys who escorted them everywhere. Todd ran out on a date, jittering with nervous energy to tell his latest girlfriend, Darlene.

While Millie smeared some greasy, smelly stuff on her face in the dark and fluffed her pillow, I put my hands behind my head and thought about my own brief time in the minors.

Getting on a baseball team wasn't the same deal back when I'd tried, not like it was today. Low pay and poor home life were the lot for most of us, and even the big leagues wouldn't pay that much unless you were super special.

Throwing a baseball was one of the few things that I did well, and baseball was the love of my life. I'd delivered papers and cut lawns to earn the cash to go to every Oriole's game I could until I got out of high school and was faced with a decision about what to do with my life. I went into the army and trained at Fort Leonard Wood. After training, they put me in special services because of my pitching arm and let me spend the rest of my hitch playing ball all over Africa and Asia.

When I got out of the army, I tried out for the minors. The alternative was to find a regular job, sweat and slave like my father, and only get out to the stadium to see a game on the occasional weekend when there was enough spare cash on hand.

I'd sworn early on that I wasn't going to be like Dad, sweating his life away at a dull laborer's job for the promise of a pitiful pension and monthly Social "Insecurity" payments.

I was Dad's luck in one way: because of me, he hadn't thought of enlisting for the money, and didn't risk dying someplace in the Middle East like his two brothers. Dad kept their medals in a drawer. As a kid, I thought they were the neatest things and couldn't understand why they made him cry. I still have them upstairs in the trunk and take them out occasionally, along with the faded pictures of two grinning, eternally young men in tan camo who bore an uncomfortable resemblance to Todd and me.

Pop died of a heart attack in '24, while I was out of town at an away game. I think it was against the Padres, but I could be mistaken. He'd collapsed in the middle of the living room. Mom found him, called the doctor, and put away the groceries. She didn't seem particularly upset until the funeral, when she sobbed so heavily nobody could hear the eulogy. I had to put her in a hospital for a few days after that; it seems that she hadn't slept, afraid that she wouldn't wake up.

She mourned his passing for four years and knew it was over when she awoke one morning, saw the empty pillow beside her, and didn't cry.

The next day Mom finally returned my call. She was quiet for a long while after I told her about Todd and the path I had planned for him. I was surprised that she knew about the treatments, but then I guess that's the sort of thing retirees talk about.

"Think of what the boy will be missing," she said. "He won't be able to live out a normal life, won't be able to see his family grow up. He won't know what real life is all about. Listen to me; life isn't just for the young. There's a lot of joy in the later years too. You'll find that out yourself, one day."

Sure, I thought, joys like struggling for enough cash with a rotten pension like Dad, suffering with the aches and pains of aging joints and failing organs that even now were making themselves evident in my own fifty-year-old body. How much of what she said was simply rationalization, a way of reconciling herself to her own aging?

"You'll take away so much if you go along with this. Todd doesn't know what he'll be missing; all he sees is the promise of eternal youth. For a boy his age, even forty is a

lifetime away, but there are so many good years after that . . ." she continued. "Why, I remember, after I turned forty . . ."

Yeah, and I remembered those years too: Dad coming home drunk, fed up with his job, angry at the traffic and taxes, worn down from a running argument with his boss, tired of being tied to the same frumpy woman for the rest of his life instead of some sweet honey like those he'd probably seen dancing in some bar. I remembered every word of it as he screamed and yelled his frustration at his life night after night; I remembered hearing more than one slap.

I just wish I didn't feel the same way, sometimes, myself. Not that I had a bad job, you understand. Selling cars might not be a glamorous, but it did pay well if you were any good at it. I'd started when I told my coach that I was looking for an off-season job that would help pay the bills we couldn't cover on my meager salary. The job at the dealership didn't pay well, but it was a gimmie from one of the team's owners. I suspected the customers that were steered to me the first year were easy marks; people who had that certain look that said they wanted to buy a new car then and there. But while I took the easy marks, I watched the other salesmen, and I learned how to chat up the customers. The next year, I didn't need any help in making the close and made enough to live on in the months between seasons, which I couldn't do on my pitcher's salary.

I often wonder if I could have done so well without the golden arm. I'd doubted it enough to try to stay on the team even after all the indications that I wasn't ever going to make the majors became evident.

I'd thought I had a shot at moving up once, back in that fifth season when I was hot and had a 0.329 earned run average. Struck out fifteen batters on my best series. A dozen runners who died on bases during that season were walked on signals from my pitching coach; a pull on the left ear, a brush of his ass, two slaps at the left forearm, and a tug on the cap. Whenever he did that, Kozawski, our catcher, would put two fingers down, and that meant low and inside for the heavy hitters who couldn't choke the bat enough to pull them out, not if they wanted to get the long balls. Ten hits in four games almost got me into the majors and out of double-A ball. Even had one of their coaches come around to talk to me about my pitiful, declining batting average.

Reason I hadn't moved up, even with the golden arm, was the stupid 0.197 and falling stats in '24. I just didn't have the eye it took to hit a real ball. Bloopers to center field, pops into right, and a lot of comebacks to the pitcher and grounders to the short stop were my habit. Got on base through errors more than effort and been damn lucky in that respect. "Pull the batting up and we'll talk some more," the coach had said, and I hadn't, and the coach didn't, not for the rest of the season, not for the rest of my short career.

"Too old," was the scuttlebutt, meaning that my thirty-second birthday put me out of the running for the young-and-coming category that seemed to be required for the majors in those days. Of course, the fact that I couldn't put the mojo on the curve ball anymore and had lost a good ten mph on my fast pitch had hurt my chances as well. The finishing touch had been the lousy batting. I didn't get a hit during the whole of spring training, even against the raw rookies trying to make the pitching cut. Damn embarrassing, having to turn in my gear while the others were getting ready for the season.

"Please tell him to reconsider," Mom went on, pulling me back into the present. "I know Todd's at an age where you don't have a lot of control, but tell him not to do it. His life is too precious to waste."

"Sure, Mom. I'll try," I said and hung up. Yeah, and I'll go back and have another try for the majors, too. There was no way was I going to let Todd miss this opportunity, not after all the work that we'd—*he'd* put into it, damn it. When that parental release came, I was going to sign it. No way was I going to let anything stand in the way of Todd's success.

The next night, Todd came out on the deck to talk while Millie cleaned up after dinner. "Dad, should I really go through with this?"

"What do you mean? Suddenly you don't like baseball? What the hell have we been working on since you were in diapers?" I asked.

Todd shuffled his feet for a few moments and then said softly, "I talked to Darlene last

night. She doesn't want me to do it. Says having treatments would be selling my soul."

"Don't listen to her, son. If God didn't want us to do this, he would have stopped us long ago. Besides, you don't believe in all that religious stuff about vivioplasty anyhow, do you?"

"She said she wouldn't see me any more," Todd continued stubbornly. "She says that I'd just be a kid that keeps going on and on while everybody gets older. She said she wouldn't go to the prom with me. Gave me back my school ring, too."

Now I knew what was the matter: It was just a bad case of frustrated adolescent hormones. Darlene was the latest of the cute little bints he'd gone with since he started high school. He'd been dating her ever since his senior year started. I'd seen some serious texts on his cell; not that I deliberately looked, you understand.

I chuckled at him. "You won't have any worries about who to sleep with, if that's your problem. Once you make the majors, the gals will be after you all the time. Have to fight them off with a bat. Hell, look at that sweet honey that Borros had on his arm in the paper. Women throw themselves at athletes, you know." I rubbed his hair with one hand. "Come on, Darlene isn't everything."

"I wish I could believe she wasn't, Dad. But it really hurts. I think I love her."

"I'm sure you *think* that you do," I replied. "But give it a day or two, okay?" By then the release would be signed, we'd be talking contract, and he'd have the stars back in his eyes. Major leagues, here we come—to hell with Darlene and all those who thought like her.

I'd met Millie on one of our road trips in '22. She had come to the game to drink beer and have a good time with a few friends and had blundered into our dugout when the oaf behind her had pushed her forward when he went after a stupid little pop foul over third. She'd fallen on the shed roof and practically fell into the lap of old Stan, our coach. Stan helped her up and probably snuck a feel while doing so, the old fart.

I'd walked up just as somebody behind me made some smart remark about how cute her ass looked in those shorts. She whipped around, saw me standing there and started to unleash a hellion's fury, and then . . . just stopped. Whatever she was about to say never made it past her lips. For my part, I completely lost interest in the game and everything else.

Did you ever hear people talk about feeling the world stop for a moment that seems to go on forever? Well, that's the best way to describe what happened to me—to us—there on that field. The upshot was that we had dinner that night, babbled endlessly, and screwed like a couple of randy bonobos in the front seat of her old coupe. I still had the rich, sexy smell of her on me when Stan caught me sneaking into the hotel waaaay past curfew and nailed me with a monster fine.

It had been worth it.

After that Millie and I became inseparable. She moved down to Bowie to be near our practice camp. I moved out of the apartment I shared with a couple of guys and into hers. We were married two months into my sixth season, on a long weekend with no scheduled games. Honeymooned in beautiful downtown Glen Burnie at the Honey Bee Motel and Restaurant so the rest of the team wouldn't find us.

Todd came along a year and a half later, when I was in a slump and couldn't hit a thing. I'd just turned thirty and was taking a good share of kidding from everyone about being over the hill. Not having Millie along on the out of town games was a real downer and didn't help my depression a bit.

Back home it was Todd and Millie, with me out on the road, trying to keep my mojo and struggling to eke out another season. I was sure I could improve my batting if I just bore down. That had been my motto for too many years.

"Are you really doing the right thing?" Millie asked in the darkness, her voice muffled by the surrounding pillows. "I mean, is this honestly good for Todd? He really wants to go to college in the fall. Shouldn't we let him make the decisions?"

"Are you out of your mind? This is the best thing that could happen. If he's good enough to be offered a contract at his age, and if they're willing to put up the big bucks for the treatments, then he's guaranteed to be

famous, not to mention rich. Jesus, woman! Do you think just *anybody* can get an offer like this? You have to be really, really special."

"But what if it doesn't work out? What would he do? Where would he go?"

What would he do? What a question for her to ask. Hell, if I had a body that kept me at that magic peak, I'd play ball and chase tail until I dropped. I'd find another sport if I had to and play it well. I'd visit my old fart friends and rub their noses in my youth. I'd lie to every girl I met, and make all my old, *ageing* girlfriends envious. And I wouldn't need any college degree to help me either, no sir.

After I'd stopped playing ball, I'd gone to flab. I still had the measurements of my youth, although the chest and waist figures seemed to have switched places. Now I had a flat stomach only when I was on my back, and sometimes not even then. I was turning into one of the guys I used to laugh at from the field: paunchy, loud, and gray, a bottle of beer in one hand and a hot dog in the other. Sure, I wouldn't mind having the perfect body up to the day I died. Seemed like a good trade-off to me.

"I don't think that will be a problem," I replied.

"I just don't feel right about this," she said softly by way of good night and, as usual and as too often lately, rolled over.

"Just don't try to talk Todd out of this," I said leaning over for a kiss and maybe more. "Okay?"

Silence. Angry, I guessed, and rolled over to think about lithe young bodies and eternal good looks, frustrated, as usual.

Todd went over to Mom's to help her move some furniture one afternoon—at least that was the excuse she used to get him where she could talk to him without me being around. That evening he was even more quiet than usual, answering me with grunts and nods, shoveling the food in like he was stoking a furnace. "Hughes is coming to talk to us," I said, relating the call I'd made from work. "He's going to bring the papers along for us to look over."

"Are you going to have a lawyer look at them first?" Millie asked. "I wouldn't want you to sign anything that might hurt Todd."

"Of course I'm going to have somebody look them over! Do you actually think that I would do something as important as this otherwise?" I snapped back, disturbed by Todd's lack of enthusiasm. "Now what's the problem, Todd? Aren't you excited?"

Todd kept his head down and kept digging at the potatoes. "Yeah," he answered. "I guess so."

"All right," I said and threw my napkin down on the table. "Now just what the hell is going on around here? The opportunity of a lifetime comes along and you act as if your best friend just died. What the hell is the matter?"

Millie laid a hand on my arm. "Don't yell at him," she said. "He's just working things out."

"Have you been telling him your crazy ideas again? Damn it, Millie, I thought we had agreed that this was the right thing to do."

"Wasn't Mom," Todd said. "I was talking to Grandma today, that's all. She made me think about some other things."

I was furious. So the damn women were ganging up on me now? Just like them; they never understood what baseball was all about. And they'd never really understand what a long youthful life would mean to an athlete like Todd. Damn it! Couldn't they see that this was what he wanted; that this was what all our work and sweat and effort and struggles to pull his fielding and batting stats up were for? "C'mon Todd. Let's take a walk," I said and left the table.

Only when I reached the porch did I realize that Todd wasn't following. I looked back through the window and saw him helping Millie with the dishes. Instead of joining them, I jumped in the car and drove over to Rudy's, where I watched the Orioles game against Minnesota and cried in my beer over the stupidity of women and the fickle nature of adolescents. Todd would come around by the time Hughes came. I was certain of it.

He had to.

The time for Todd's last game of the season was getting close as I was closing a deal with an elderly couple that insisted on paying top dollar, even though I tried to tell them that a less expensive '42 model was a better bargain. But old fools aren't prone to listen to car

salesmen; they assume we're all outright liars at best.

I shuffled them to the finance kiosk to take care of the formalities and drove across town to the school's stadium. The team was facing Northside this afternoon. Coach Phillips—sold him a nice little sedan last year, lime green with real leather seats—had told Todd that he was opening.

By the top of the sixth inning the score was Northside 3–1, with two runs on our team's errors, and Northside had gone through three rotations with their best batter coming to the plate. I watched the batter's feet as he braced for Todd's pitch. He aligned his hips with right field and leaned forward, squeezing the strike zone as small as possible.

Todd threw wide for a ball and followed with a classic slider, down and inside, breaking at the last minute for a clean strike. The computerized umpire flashed it barely in the zone at forty-three meters per second. I didn't like Todd tossing sliders. It took a low, wide pitch to get the right spin and speed and that put enormous strain on the rotator cuff.

I noticed Todd rubbing his elbow as the catcher got a new ball. For luck, I thought, as Todd tossed another wide pitch, making it two and one.

The next one came across the center of the plate, just below the batter's waist, meaning the best he could hit would be a grounder. That is, if he'd connected, which he didn't, for two and two.

Todd took a long time reading the signal, glanced up into the stands where Hughes and I were sitting, nodded as he made his decision, wound up, and threw it right over the plate for a pop foul into the stands.

"Forty-five meters!" Hughes yelled, clearly impressed by the radar reading.

But I didn't care. As soon as I saw Todd drop his glove, fall to his knees, and grab his elbow, I was over the chain-link fence and racing to the mound. The coach got there only a few seconds before me.

"Cramp?" I asked, hoping against sense.

"Something snapped," Todd groaned. "It hurts bad."

"Just threw his arm out, probably," the coach said. "I figure that ball must have broken a hundred! Awesome." I agreed.

Todd looked up with tears cutting rivulets in the dirt on his cheeks. "Dad, it hurts like hell. Can we get to a doctor, please?"

Stupid me, thinking about the speed of his pitch while he's sitting there in pain. "Let's go." One of the assistant coaches ran up with an ice pack and wrapped it around the elbow as Coach and I helped Todd into my car; the hospital was only a few miles away.

On the way there, ignoring traffic lights as much as was safe, I cursed the insurance companies and what they had done to school sports. Couldn't pay the premiums, so the responsibility fell on the parents. And damn the lawyers, too, for all of the litigation that made the schools afraid to do so much as put on a bandage without fearing a lawsuit. So here I was doing fifty in a thirty-mile-per-hour zone and praying that Todd's arm was going to be all right.

The doctors took lots of expensive images of Todd's arm and ran them through their diagnostic computers while Todd kept complaining about the pain and the tingling in his fingers.

"Might be some nerve sheath damage," the doctor said. That was the little bundle of fibers that ran along the outside of the right elbow and controlled the hand and fingers. "No way to tell for sure. We have to depend on your son's reports of symptoms," he said. "I don't see any inflammation as yet and that's a good sign."

"So Todd has to have some cortisone treatments," I said, remembering the tendonitis that had kept me from playing my last season. Since than, every time I tried to throw something or twisted my arm the wrong way, I was reminded of the injury. Not only that, but my elbow throbbed whenever the weather turned cold; a sign of future decrepitude for sure, like the hint of bursitis in my shoulder. "Okay, when can we start the treatments?"

The doctor shook his head. "I'm afraid that won't help. Cortisone or steroids are only good when there's inflammation. If it is sheath damage, your boy might never recover. Even if he did, there's the danger this could reoccur at any time for the rest of his life."

"No!" I yelled in disbelief. "There's got to be some sure way to fix this. Maybe an operation? Yeah; an operation. You docs can fix that sheath thing, can't you?"

The doctor put his hands together in a little tent. I'm sure that they teach them that gesture in medical school; makes them look so damn learned when they're probably just as puzzled as the rest of us. "I'm afraid not. In general, sheath fiber can't be rebuilt, especially in a place like this where it's subject to constant wear. There are some new techniques, but I'd only give it about a fifty-fifty chance of success, and then only if we get a specialist in this sort of thing."

"So why don't we get the specialist? Damn it, Doc, this boy is a pitcher. He just threw a fastball that broke one hundred, and he hasn't hit his peak yet. His arm has to get better. It just has to! Who do I have to call?"

The doctor shook his head sadly. "I'll give you a name, but keep in mind what I said about the long term chances for success. Pitching . . . putting constant strain on the arm, I just don't know: The type of stress it will place on his elbow might be too much. It wouldn't take much additional trauma on that elbow to permanently cripple him. I'd advise he consider another career. His baseball days are probably over."

"No," I said, gripping the arms of my chair and trying to make him understand what was at stake through sheer mental pressure. "My boy has too much ahead of him. He can't just walk away from this."

The doctor sighed and rummaged around in his drawer for his address book. "I'd recommend Sherman. He's up at Hopkins and probably the best micro-surgical operator around. I'll have our receptionist set up an appointment."

"What about vivioplasty," I asked. "Would that fix the problem?"

The doc raised an eyebrow. "Probably not. Neither would stem cells, yogurt, or any other experimental treatment. Surgery is the only, and I repeat, *exceedingly thin,* possibility."

"But . . ." I started to argue.

"Let's go, Dad," Todd said. "Come on, let's go home and tell Mom." I figured the painkillers they'd given him were making him too stupid to understand how this was going to affect our chances.

I was on the phone to Hughes about ten times a day. I kept him up to date on Todd's progress and tried to sound as cheerful as I could under the circumstances.

It was five long weeks before our appointment with this Sherman character. I was in miserable shape. Five weeks with my stomach constantly in knots. Five weeks during which my rotten disposition affected sales down at the shop. Five weeks of looking at that damn splint on Todd and wondering if his golden arm was ever going to be unpacked again.

Todd seemed to accept his lot with grace and tried to learn to use his left hand for everything. "Maybe I can be ambidextrous," he joked, "and throw lousy with either hand."

I felt like crying.

The night before we were to go up to Hopkins to see Sherman, I was sitting around with a beer and watching the O's lead a desultory 0-0 game against Ottawa that seemed to drag on forever. Todd came in, plopped down on the sofa, watched Fernandez fan two in a row past Plozcsa, and then said "Dad, what if the doctors say nothing can be done?"

I roused myself from the stupor that a dull summer night's game can put you into and thought about what he had said. "Don't think that way, son. Doesn't do either of us any good to consider the down side. Keep a positive attitude; isn't that what your coach always tells you?" I was sure that he was worried about what Sherman was going to tell us tomorrow.

Todd didn't appear to be listening to me but kept going. "I've been thinking hard about this, Dad. Even if the doctor is right and I'm able to pitch again, how will I know it will last? What if he fixes it and I take those treatments. What happens to me then if my arm goes out for good?"

Now that idea brought me up short. I'd been assuming that a successful operation would mean a successful career—the shot at the big one for Todd, years at his youthful peak, years of wonder and pleasure—money and willing gals galore! What could I say; that he'd have a longer run at youth than his peers, even if he might not live as long? Hell, about 10 percent of kids his age would die before forty from car accidents, cancer, or something else. Nobody had any guarantees these days, if they ever did.

Todd continued babbling about things I never thought he cared about—stuff about college, having a family, seeing other parts of the world, finding out if he was good at anything besides baseball, and about following his love of animals.

"You've been talking to your mother, haven't you?" It would be just like Millie to put some of her dumb ideas into his head during this vulnerable and delicate time. "She doesn't know crap about the game, you know. It's all just play to her."

"Don't bring up Mom," Todd replied angrily. "I'm talking about me, Dad. *Me!"*

I decided to take a different approach. "You're just upset about your arm, that's all. Once we have the operation and your arm is better, we'll get back into the swing of things, you'll see. Everything's going to turn out all right."

Todd stood up and towered over me. When had he grown so large? "I'm not going to Hopkins, Dad. I'm not going to have an operation. I'm going to call Mr. Hughes and tell him to find somebody else for his pitching lineup."

I jumped up, scattering popcorn in every direction and making Todd back away. "You'll do no such thing! I won't have you throw away something we've worked on for years; something I never had the chance to do. You're going to be a star. We're going to make the big leagues. Why are you talking so crazy?"

"Damn it, Dad. Listen to yourself! It's 'I' and 'my' all the time. This isn't about you and what *you* want. This is about *me* and my life. This is about having a chance at a different life than the one you've been trying to make me live for more years than I can remember." Tears were streaming down his face as he bit out the words, just like he was still a kid.

"Yeah, and what happens to your athletic scholarship when they find out that you can't pitch? Where are you going to find a school that will pay your way then?"

"I'll find some way to do it. Sports aren't everything. I'll get the money somehow—maybe I'll get a job to pay my way."

"Shit! Do you have any idea of what it costs to go to college these days? You couldn't earn enough to pay for your rent, much less tuition and books. Think about that when you start to place that call to Hughes. Yeah, chew on that for a while." I said and watched his face crumble. The kid knew when he was beat.

"We'll pay for your college," Millie said from behind me in a voice barely above a whisper. I don't know how long she had been there, listening to our argument. "It is *your* decision, Todd, and we will support it," she finished.

I started to turn and let out a few choice words when I saw her expression. It was that lip pursing, hard eyed, chin jutting one that said her mind was made up. I knew then that she'd starve and wear rags to put college money in Todd's pocket and the hell with my feelings. I felt the heat start to build up in me, a rage unlike any that I'd ever felt before. How could she do this after all I had done for them? I spun toward her, ready to let her know what I thought of her Goddamn stupid idea and . . .

"Your father really does love you, you know," she continued. "And I am certain that once he gets over his disappointment about this baseball business he'll tell you the same thing." She took hold of my arm and squeezed "That's why I love him so much."

Hughes never even bothered to return any of my many, many calls after he heard Todd's decision.

Todd went off to college in the fall and earned letters in soccer and lacrosse. I went to every game and rooted as loudly as the rest, screaming, "That's my boy!" whenever he scored a goal, as if he was playing some real sport.

I didn't go to the Orioles games for two whole seasons, didn't even know—didn't, by God, *want* to know—how the team was doing.

Todd graduated with honors in biology and got a nice job with the Smithsonian research place by Annapolis. Met Mary, a nice girl from the north end of Baltimore who worked there, and they were married last year. She had nice parents—drove a black '39 Imperial with most of the options—with good taste.

Millie went on a diet, took up aerobics, trimmed down, and started attracting a few looks from the guys on the lot. Mom was still going strong, dating a guy six years her junior

and dancing up a storm at the senior center—a model for everyone in their eighties. Me, I hung on as best I could, too old and tired to change. Todd had been my chance, and he'd blown it.

On a late, balmy, summer evening, Todd and I were walking along the beach at Ocean City and chatting while Millie and Mary were back at the motel taking care of Tommy, Todd's new baby boy.

Todd was picking up pebbles and bits of shell and idly tossing them into the heaving waves that crashed ashore this late in the season.

We were talking about Ricardo Cisneros, the new first baseman for the Eagles who was in the middle of his vivioplasty treatment. He had a ten-year contract and all indications were that he would be getting better and better as the years passed. Borros and Zlebinsky were still going strong, young as ever. Their continuing youth made me feel my fifty-six years more than ever.

"Any regrets about the way things turned out?" I said, "You could have been on the mound this year, throwing to Cisneros if it hadn't been for the accident."

"Well," Todd said. "I figure that I wouldn't have met Mary if I was doing that. Wouldn't have graduated, wouldn't be thinking about my son's college years right now. Be too busy counting my money and fighting off the babes, right?"

From the way he said it, I knew he was pulling my leg. He looked more and more like my uncles and less and less like that faded, unchanging photograph of me as a has-been minor league player. He'd thrown away his chances with that last, blazing pitch and would probably end up driving some cheap electric the rest of his life instead of a Lamborghini.

Someday Todd would realize what life was really about and regret his missed opportunity. "But you should have tried to have your elbow fixed," I said bitterly. "You could at least have *tried!"*

"No, Dad," he replied. "That wouldn't have changed a thing." About fifty feet ahead of us, a gray sea gull had landed and was tearing at a dead fish on the sand. Todd flipped the pebble in his hand for a moment, drew his arm back, and threw it, *hard*.

The pebble followed a tight curving line that went to the right and then, at the last minute, broke down and to the left, exploding the fish in a spray of scales and guts right out from under the gull. It was his classic slider. I noticed that he didn't rub his elbow. "I don't have any regrets at all," he smiled.

Just the same, in three years I'd be able to put my grandson into T-ball and start him on his way.

I still had hope. ■

Illustrated by Karla Castaneda

Cetacean Dreams

Robert R. Chase

After all the training, the tests in Earth's deepest marine trenches, the months in deep space with its extended hibernation periods and the final six mile descent through Europa's icy crust, it came down to this: walking four coffin-shaped containers down a long slope to a pool larger and much deeper than the National Aquarium. At the base of the ramp, they lined the containers up along the edge of the pool. Europa Station staff crowded expectantly along the near side of the pool. Jason Sloan did a last check of the readouts. Heart rates were elevated, but that was probably just excitement. He tapped in the okay signal. For a few seconds, nothing happened. Then the front of the containers fell open, spilling water into the pool. The rear legs of the containers extended and the dolphins slid under the waves, almost immediately hurling themselves into the air in a

series of aerial pirouettes. The onlookers laughed and applauded as the four dolphins raced around the perimeter of the pool. As they sped by him, Jason could hear the chirps that meant *happy happy happy* to this group of dolphins.

For the first time since leaving Earth, Jason felt himself relaxing. *Maybe this will work out after all.*

Afterward, at the welcoming party, held poolside:

"So, you and your friends will find Leviathan for us." Station Director Emile Devoyon looked at him frankly as he shook Jason's hand. Everything about Devoyon was neat: his haircut, his small mustache, his muted business suit. He was an inch or two shorter than Jason yet without apparent effort projected the impression of being taller.

"We'll do everything we can," Jason said. "If Leviathan exists."

Devoyon's shrug expressed multitudes. "The pilots swear this creature has appeared on their instruments a dozen times, but it always retreats or simply vanishes before they can approach close enough to do more than note its monstrous size. The biologists insist nothing that large could feed itself, but at least half of them hope that you'll be able to prove them wrong."

"I can't imagine anything being able to outswim these dolphins," Jason said.

They walked around the edge of the pool. Coming to a refreshment table, Devoyon handed Jason a drink.

"Not to be described in your official report," the station director said. "Otherwise, I shall be answering queries from Earthside for at least a year.

"You know, we were very much against this at first." Devoyon waved his hand to encompass the entire area.

"Why?" Jason asked. His sipped his drink carefully; the mixture of fruit juices barely concealed something locally brewed that he suspected would, in any quantity, take his head off.

"You will understand when you have seen the rest of the station," Devoyon said. "Your room, it is the size of a walk-in closet on Earth. The corridors, the lunchrooms, they are always crowded. It is a strain if you have the least amount of claustrophobia. You ask, are things not as constrained on Clarke High Orbit Station or the Amundsen-Scott South Pole Station? Indeed, yes, but one is on Clarke for no more than six months at a time, and at the pole one can almost always step outside for a walk. Here, that is not available.

"So for science we are pressed together like sardines for five years. But then we hear that this structure, which has sucked up so much of our research funds, will be added on to our station for nonhumans. We do not even know if an addition can be made that will stand up to exterior pressures."

Thinking of the tons of ice pressing in just beyond the walls of the pool, Jason nodded. "You said 'at first.' Something changed your opinion?"

"First of all, we found we really could make the addition without compromising the station's structural integrity," Devoyon said. "Then we found we could make our own uses of the extra space. We set the tank up for cliff climbing before the water was added. We are hoping to use it for diving and swimming now that it's filled."

He gave Jason a hard look. Realizing that some response was expected, Jason said, "There shouldn't be any problem. Dolphins generally get along with humans and this set is quite used to sharing the water with swimmers."

Devoyon grunted, which seemed to indicate satisfaction with the answer. "Perhaps the greatest benefit is the open space. You may have noticed the semi-abstract pastels decorating all the rooms and corridors. All done on the advice of the psych teams who helped design the station. The fear was that after months enclosed in this station, even the nonclaustrophobic would become, how you say, stir crazy."

He waved his hand to encompass the entire dome. "Our would-be Michaelangelos intend to turn this into a huge planetarium. The initial image will be of a mountain valley that extends to a distant ocean. If that is successful, they will give the image a night and day cycle corresponding to Earth's. This canvas would not be available to us without the construction of this facility for your dolphins."

There was a gap.

Devoyon had been introducing him to the members of the station community. He shook

hands with doctors Ellis and Ma, joint heads of the xenologist research team. Then there had been the Norwegian woman who was in charge of both waste recycling and (not coincidentally) the garden stacks that provided fresh vegetables for all station personnel. He had met the lead medical doctor. ("I'll see you tomorrow for your post-flight physical.") There had been the head engineer whose team was not only responsible for heat and light within the station, but also for keeping the column of water leading to the surface ice-free. Faces and names blurred together.

Then with no sense of any transition, he was kneeling at the side of the pool, checking on Aihe. The gap could not have been long: the poolside party was still going on.

A woman crouched beside him. Dark-skinned, her elfin face was surrounded by curly black hair. "You have just had a moment," she said.

"Excuse me?"

"A memory skip. The last thing you can remember was maybe five minutes ago."

"I don't—"

"Don't worry." She extended her hand, not quite touching his arm as if fearing he would shy away from physical contact. "You haven't done anything odd in the gap, just checked on your friends and talked to me. It's called dream fugue. Do you feel as if your head is stuffed with cotton?"

Jason nodded. Aihe, seeing that she was being ignored, ducked her head back in the pool and swam away.

"It seems to be a side effect of the hibernation drugs all of us took on the way here," she said. "You may have fugue moments for as much as a month."

"Why wasn't I told about this?" Jason asked.

"It's fairly minor, it goes away, and nobody wants to draw the attention of Earthside psychs." She paused a moment. "I guess this means I should reintroduce myself. Anahira Kelly, late of New Zealand."

Jason took her outstretched hand. "And I said—"

"You said you were Jason Sloan, biologist and dolphin researcher. You were telling me how worried you have been about your dolphins after the long period of confinement on the voyage here. That was when you called, uh—"

"Aihe," Jason supplied.

"Aihe over and showed me how the implanted chip allows you to keep track of all her vital signs. In the middle of your explanation you paused and looked around uncertainly. That was when I realized you were having a 'moment.'"

Jason stood up carefully. "Thank you for the explanation. I'm still feeling a bit strange. Maybe I should get back to my quarters. I'm sure we'll see each other again."

"We certainly will," Anahira said. "I'm your pilot."

The next morning he had breakfast with the crew of the *Starry Messenger,* the spacecraft that had transported him, the dolphins, and sundry other supplies from Earth. In between bites of ersatz scrambled eggs, he had another "moment." All attention was focused on an argument between the first mate and the engineer about the performance of the fusion drive, so nobody noticed. When he brought it up during his physical an hour later, the doctor grunted and told him that while it might recur at odd times during the next few weeks, it was nothing to worry about.

After lunch, the dolphins' deep suits were uncrated and hoisted into the pool. From a distance, the suits looked like larger versions of the dolphins. Then you noticed the cameras and spotlights studded all over the exterior. When the bomb-bay doors opened in the ventral side of the suit, the illusion was completely destroyed.

Pock was the first to enter a suit. She swam in and closed the doors behind her. Then, in rapid succession, Aihe, Scar, and Splasher sealed themselves inside their suits. Jason followed their checkout procedures on his tablet.

"They're going into the deeps in those things?" Anahira asked.

"The suits have been tested to the bottom of the Challenger Deep," Jason said, hearing the skepticism in her voice. "This is just a check to make sure nothing was broken in transit. The real test will come during tomorrow's dive."

The last dolphin finished sealing himself into his suit. Jason gave the signal to commence the test. The tail of Pock's suit lifted and fell in three powerful strokes that

propelled it to the far side of the pool. The other three followed. Then, together, they dived for the bottom.

"The suits aren't at all like submarines!" Anahira said.

"Hardly," Jason agreed. "Their only purpose is to provide oxygen and protect the dolphins from the pressure. We wanted the actual propulsion to mimic the dolphins' mode of swimming as closely as possible. It's what they are used to, as well as being close to the most efficient way of moving through the water. The power enhancements allow them to maintain a cruising speed of twenty miles per hour. Which I understand is important to your research."

Anahira nodded. "There are . . . things in the depths that flee when they sense our presence. The hope is that your dolphins will be able to keep up with them."

The dolphins themselves seemed to be getting impatient. *Too small,* Splasher signaled, apparently referring to the size of the pool. *Faster,* Pock said.

Tomorrow, Jason tapped into his screen. *Tomorrow.*

The submarine pens, naturally enough, were located at the base of the station. It was the one area where there was no apparent attempt to make it seem larger or more human-friendly. It smelled wet and metallic.

Jason stepped down on the top of the mini-sub, which wobbled in the water from his weight, and strapped himself into the researcher's seat, directly behind Anahira. The cockpit was cramped, and for the first time he was aware of the scent of her hair. The cockpit cover closed and sealed. Jason felt the pressure on his ears.

"I'm going to tell Pen Controller to flood the basin," Anahira said. Jason scanned his tablet. Rows of green checks followed each suit name. The heart beat rate for all the dolphins was between ninety and one hundred beats a minute. "We're ready," he said.

The upper part of the hull suddenly became transparent. Jason watched with increasing apprehension as the water level rose until they were completely submerged.

"Portholes would be weak points," Anahira said. She sounded amused, as if she could tell Jason's heart rate just by looking at him. "The sensors were baked into the hull when it came off the printer. Not only does this give us three-sixty visibility, I can magnify any section I like."

"Of course," Jason said through gritted teeth. He was familiar with a similar technology used in the dolphins' suits, but somehow that didn't help at all.

"Okay. Now we come to the interesting part," Anahira said. "Pen Control is going to raise our water pressure to that of the water outside. We do this as gently as possible, but there's no way to avoid a pressure spike. If anything is going to go wrong with your dolphin suits, this is where it is most likely to happen."

"We're ready," Jason said.

"Good. Pen Controller, this is the Nemo. Equalize."

The vibration shook the craft like a steel drum. The dolphins made a series of squawks, then subsided into silence. Jason scanned his tablet anxiously.

"Everything is still green," he said.

"Excellent. Pen Controller, we are ready to exit."

The bottom of the pen opened and they dropped into darkness. Not complete darkness—beside the Nemo's own lights and those on the dolphins' suits, there were spotlights all around the base of the station. Looking up, Jason could see the station nestled into the base of the moon girdling ice pack. Devoyon insisted that the station and the six-mile snorkel of open water that connected it with the surface were engineering feats comparable to "beanstalk" orbital elevators now being constructed around Earth's equator. For the first time, Jason found himself sharing that conviction.

A warm plume from hypothesized hot vents sixty miles below had hollowed out this section of the ice, creating an immense natural dome. Huge icicle-like formations, ice stalactites, extended hundreds of yards down from the ceiling. The Nemo approached one of the largest and circled it as it descended. Ice crystals caught the Nemo's lights and shattered them into rainbows. Jason caught his breath at the unexpected beauty.

It was a miracle of rare device,
A sunny pleasure-dome with caves of ice!

Jason shook his head afraid that he had been about to drop into a dream. This was not

the time for him to have a "moment." At least, this time he had been able to catch himself and fight it. So maybe Anahira was right and the effects of the hibernation drugs were wearing off.

Long, dark streamers grew from the end of the icicle and fanned out in the gentle current. Shadows darted among fronds.

"Seaweed?" Jason asked

"It's similar in some ways," Anahira allowed, "but it doesn't photosynthesize. It subsists by straining nutrients out of the plume. It also provides a home for organisms the size of your thumbnail that look like crabs, only with four feet and no shell. They are fed on by those fish-like creatures we call scurries that you see zipping in and out of the weed mass. It hasn't been easy to study any of these organisms. Take them into the station and they explode."

Aihe and Scar nosed in among the vegetation. Jason saw what they saw on his tablet. Small, pink creatures, which to Jason looked more like spiders than crabs, scampered up the tendrils and out of sight. Splasher wandered off to investigate another ice column. Jason pressed a square on the tablet to call him back.

The Nemo continued sinking. Europa station dwindled above them.

Dimmed.

Vanished. Only the dolphins were visible, swimming around the Nemo like fireflies.

Down, down, to Goblin town …

"Your dolphins are pinging me," Anahira said.

"They rely much more on sonar than sight on deep dives," Jason said. "We designed the suits as much as possible to be extensions of their own bodies."

"Send your data feed over to my console," Anahira said. Jason did so. A minute later Anahira fed back not the four separate sonar images he had provided, but a holographic image of surrounding space, the Nemo in the center with a guard of dolphins. Aside from them, Jason was astonished at how empty the water was. There were a few fugitive images of creatures that might be scurries. And a few things almost two-dimensionally long and ribbon-like.

"What are those?" Jason asked.

"No idea," Anahira said. "I have never seen anything like them. That's what makes this job fun."

The Nemo continued dropping in near silence.

"We'll level off soon," Anahira said. "Then we'll make a five-mile circuit before we rise back to the station."

Something caught Scar's attention. The dolphin dived below them, swimming at close to top speed. Jason pressed the return signal. Scar ignored him. It clicked and squealed furiously. The dolphin's heartbeat increased to one hundred ten . . . one hundred twenty . . .

Jason put all data feeds but Scar's in the background. Now the tablet showed only what Scar was seeing.

"Something on the sea floor has really got Scar upset," he said.

"I doubt it," Anahira said. "The sea floor is ninety miles down."

"Then what am I looking at? Take the feed from my tablet."

There was a moment of silence.

"I think we've found the Leviathan," Anahira said. "Call your dolphin back. Now!"

Jason tried again. Scar continued to ignore him. Details were beginning to come clear in the tablet. The upper surface of whatever they were looking at was uneven. Interlocking ridges stretched in parallel lines like stitched-up wounds. Sections of the creature rose and fell in waves. *The way the Leviathan propels itself?* Jason wondered.

Scar was getting very close and still accelerating.

The data feed from Scar's cameras stopped. Jason's tablet defaulted to the three dimensional image constructed from input from the other three dolphins.

"He just crashed into the Leviathan," Anahira said, sounding as if she could scarcely believe her own words. "There was no mouth, but it swallowed him up."

From their chatter, the remaining three dolphins sounded as confused and upset as Jason. He shook his head, at a loss. He should cancel the dive. It was Scar who had been the aggressor; the Leviathan had not even bothered to defend itself.

"I'm calling this—" Anahira began.

Something burst from the Leviathan. Fragments of flesh rose from the eruption and began to swim away. Scar rose from their midst, propelling himself with swift, powerful strokes of his tail.

Jason sent the recall signal again. For a moment, it appeared Scar was complying. Then he turned, initiating a second attack.

The central section of the Leviathan sank, as if trying to flee from the dolphin. At the same time, the edges rose forming something like a pit, or a huge mouth, or a concave mirror with a focal point—

Something slammed into the Nemo. Jason felt it in his chest, in his fingernails, in the roots of his teeth. His vision blurred. Blood was streaming from his nose. He squinted at his tablet, trying to force it into focus. The transparent cover was cracked, but the tablet still functioned. On the screen, Scar's motionless suit rose slowly, fail-safe buoyancy taking over when the occupant was unconscious. Or dead.

Jason punched in the codes for RESCUE SCAR. But Aihe, Pock, and Splasher were already making their way, albeit slowly, to their injured friend. They formed a triangle around Scar and followed the Nemo back to Europa Station.

"What the *bell* was that all about?" Anahira's bruises were visible against her dark skin. She had to be as exhausted as he was. Only rage was keeping her going.

"Please," Devoyon said. "Your partner is injured and should probably be in sickbay, as you should be also. Let us get his report. Blame, if any, can be assigned later."

He put a cup into Jason's shaking hands. If its contents were basically the same as at the party, they were much less disguised by fruit juice this time. A sip disinfected every bruise and cut in his mouth before burning its way down his throat. Yet it did steady him.

"Thanks."

"My partner and his homicidal dolphin nearly got us all killed," Anahira said. "And I do mean all of us. If Leviathan associates Scar's attack with this installation, it may attack us here. This station couldn't withstand a prolonged attack like the one that was focused on us."

They were seated around the table in the meeting room adjoining Devoyon's office. Dr. Rosemarie Ma looked up from her tablet on which she had been studying the Nemo's recordings.

"This is wonderful," she said, looking at Jason. "Not only do you confirm Leviathan's existence with your first dive, you show that it is a colony creature like nothing on Earth. And that it uses sound both to sense its environment and as a means of defense."

"Why did—Scar, is it?—attack the Leviathan?" Devoyon asked.

"I don't know," Jason said.

In the submarine pen, he had shaken off the hands of those crewmembers trying to assist him and insisted that they help get Scar to sickbay. The dolphin was unconscious. Left alone, it might have rolled into the water in its suit and drowned. The medics lifted Scar onto an examination table. None of the medical staff were veterinarians, much less specialists in cetacean physiology, but they didn't need to be to determine that the dolphin's heart was beating, its airway was clear, and that it was horribly bruised. The good news was that there was no serious internal hemorrhaging.

Unable to do anything more, they lowered the dolphin into the pool in a sling. Its skin would be kept wet while it would be kept from drowning. Only then did Jason let the doctors treat him. While they were doing that, the summons from Devoyon arrived.

"I thought dolphins were supposed to be intelligent and nonaggressive," Anahira said.

"I can't believe a New Zealander could say anything so naive," Ma said reproachfully. "Dolphins are always intelligent and usually friendly to humans. But they can be violent as well."

Jason nodded. "They'll work together to aid a comrade, like Scar's friends did today. But some will also cooperate in gang rapes, or in battering sharks to death." He smiled weakly at Anahira. "Really, they're very much like us."

"Scar will tell you why he attacked?" Devoyon said.

"If—*when* Scar recovers consciousness, I'll ask him," Jason said. "I hope I'll understand his answer."

"Why should that be a problem?" Anahira asked. "You know their language."

Jason shook his head. "I don't know their language, not really. And except for a few commands, they don't know ours. What we've done together is construct a pidgin for communication."

Devoyon frowned. "Pidgin?"

"An artificial language that isn't English and isn't cetacean, though it has terms from both,"

Jason said. "People have been trying to communicate with dolphins for more than a hundred years, but it's been very difficult. Without mechanical help, I can't make the sounds dolphins make, and dolphins can't mimic human speech, as hard as they try.

"So with the help of tablets and underwater communications systems, we've evolved a rough, simple language that has name identifiers and basic commands like, "come, go, help, retreat," but very little in the way of abstract concepts. Conveying the idea of leaving Earth for years in order to explore the seas of Europa was almost impossible. I kept asking the question and they kept saying yes, but I was never sure they knew what they were saying.

"That is why I decided to accompany them. I couldn't be sure they knew what they were getting into and I felt responsible for them."

"Your fears may have been well-founded," Devoyon said, "but there is nothing we can do about them now. Sleep. Then tomorrow, if you are feeling well enough, we will investigate further."

Jason nodded. He pushed himself out of the chair and staggered back to his room. He remembered opening the door. He did not remember falling into bed.

In his dream, he was in the *Nemo* as the Leviathan attacked it. Water squirted into the cabin from hair thin cracks in the hull.

"This is not a World War Two submarine movie," Anahira said. "Any cracks at all and our craft would implode."

"Sorry," Jason said, acknowledging the truth of her statement. He ran the dream back to the beginning. This time, when the Leviathan attacked, there was a loud snap and a section of hull slammed into him, snapping his neck and collapsing his rib cage. Cold black water surged about his bones, numbing all pain save for a dull, persistent ache.

But being dead, he should not feel or think anything. So he ran the dream back to its beginning again. And again. And again, caught in an endless cycle of death.

His eyes opened to near darkness. He knew that he was in his cubicle in Europa Station, but that did nothing to quell the residual panic from the nightmare. The station was just a bigger version of the *Nemo.* The cold and pressure surrounding the station were just as hostile and deadly.

There was no way he was going back to sleep soon. He got up and took one of the pain pills the doctor had prescribed. Then he dressed, grabbed his tablet, and went out to the corridor in the direction of the pool.

Europa station operated on a Terrestrial twenty-four-hour clock. Local time was 0200, and corridor lights were dimmed. Engineers staffed life support on all three shifts, and there was always at least one person in the communications room, but aside from them and a few insomniac scientists overseeing long running experiments, the inhabitants of the station were asleep. Jason's tread sounded ghostly on the green runner.

The first thing he noticed on entering the pool area was the empty sling. He looked around in momentary panic. Pock and Aihe were asleep, bobbing up and down in the overly tall waves that made their languid way to the edges of the pool. Scar and Splasher swam slowly together. Watching them, Jason had the image of two men walking down the street, the one with his hands in his pockets, the other offering advice or encouragement.

Dangerous thoughts, Jason admonished himself. It was all too easy to anthropomorphize these creatures. They were so like humans in some ways that it was easy to forget that in others they were very different.

Jason seated himself on the edge of the pool, his feet dangling in the water. Scar approached without being called; Splasher hung back. Both seemed to have guessed the purpose of his visit. The tablet had healed itself in the time since the attack. Jason turned it on, called up terms from the vocabulary, and sent them.

WHY SCAR ATTACK HUGE CREATURE

The answer was immediate. SCAR NO ATTACK

"For chrissake, Scar," Jason muttered, "show me some respect. Don't ask me to believe an obvious lie."

He called up the recording of the attack on the tablet and edited it. Then, as he had done so many times on Earth, he hung the tablet on the side of the pool with the screen facing the dolphin. A hand-held remote unit allowed him to control the series of images and their verbal labeling.

Sonar image of the dolphin. SCAR

Sonar image of Leviathan. CREATURE

The series of images showing the dolphin diving into the Leviathan and then forcing its way out. SCAR ATTACK CREATURE.

Scar was making low, distressed sounds. SCAR ATTACK NO CREATURE.

Jason made a disgusted sound. *Okay, wise guy.* WHO ATTACK CREATURE.

NOT SCAR ATTACK CREATURE.

I got that, Jason thought, *you're not the one. So tell me who is.* WHO ATTACK CREATURE he repeated.

Whatever Scar said was drowned out by Splasher who had come up to the edge of the pool with body language bespeaking complete determination and conviction. NOT SCAR, it said loudly.

Jason threw up his hands in frustration. *So your buddy is backing up your crazy story? That's it. I give up. I'm too tired to figure out why you think I'll believe that sort of fairy tale.*

He swung his legs out of the water and stood up. Anahira was standing at the pool entrance looking at him.

"What are you doing here?" Jason asked.

"I hurt too much to stay asleep," Anahira said, forcing a small smile. "Then I thought you might be here. So I came down to apologize."

"What for?"

"For yelling at you the way I did in the director's office. It was unprofessional and unfair. It was my bad reaction to being scared to death. Which is not an excuse, but it is an explanation."

"Oh, that's okay." Jason felt obscurely embarrassed by the apology. "We were closer to death than I ever want to be again. And all because of a dolphin I can't even understand, much less control."

"The two of you were talking just now."

"I was asking Scar why he attacked the Leviathan." Jason shook his head. "Scar denies that he did, even when I confront him with the evidence. And Splasher backs him up!"

"When I was a kid, we had a dog named Shadow," Anahira said. "Whenever we left the house for an extended period, he would get in the trash. Then when we came home and scolded him, he would pretend he had nothing to do with it."

"That makes sense," Jason said. "Still, I've never had any of these dolphins lie to me before. Or attack anything without reason." Jason shook his head again. "I'm too tired to figure it out. Maybe inspiration will strike tomorrow."

He walked Anahira back to her room, then continued on to his own. Something nagged at him. He had the feeling that he was missing something hiding in plain sight.

The feeling was still there when he woke the next morning. From previous experience, he knew that racking his brain to find it would be fruitless. These fugitive thoughts were like timid mice. Searching furiously for them would only frighten them into hiding. If he just went about his business and ignored them, they would eventually creep out and reveal themselves.

He staggered over to the cafeteria for an early breakfast. He had stiffened up overnight, so the pain this morning was, if anything, worse. A few people, who must have heard something about the previous day's debacle, glanced at him curiously as he made his way through the line. Not wanting to be disturbed, Jason bagged his coffee, generic fruit juice, and Danish and took them back to his room. He set everything on the room's small pull-down desk, and turned on his tablet so he could study the recording of the dive while he ate.

Seeing everything for the second time, he was able to better appreciate the beauty of the ice spires, the strangeness of the ecosystem growing on them. By contrast, the dolphins, even in their pressure suits, were almost nostalgically familiar, swimming in the sort of exploratory patterns he had seen hundreds of times on Earth.

He focused on Scar, looking for anything odd. And there, two minutes before the attack, Scar seemed to go limp. The suit floated upward for maybe twenty seconds. Jason hadn't noticed it at the time because all the life support readings stayed green. Then Scar began swimming again, and shortly after he launched his attack.

Next, Jason replayed the previous evening's conversation with Scar. At its end, he had said something that Splasher had covered up with his interruption. Jason went back over that section a dozen times.

Dolphins have names that bear no relation to the names humans give them, though they learn to respond to human names. In the pidgin Jason had developed, his tablet simply substituted the dolphin name for the human name. What Scar had said was a dolphin name, but not one that Jason had ever heard before.

Then, with no transition, he was in the corridor outside his room, the tablet tucked under his arm, heading toward the pool.

As he had the night before, he sat on the side of the pool with his feet in the water. The dolphins swam slowly around the pool's perimeter. Jason hooked the tablet to the side of the pool and called Scar over to him. The dolphin approached warily, reminding Jason of Anahira's story about her dog.

Jason tapped out NOT SCAR ATTACK CREATURE.

YES Scar agreed.

[Unknown name] ATTACK CREATURE.

YES.

There was no point in completing the syllogism.

The other dolphins had come over to monitor the conversation. Now to generalize from the specifics. Start with Splasher.

WHO IS NOT SPLASHER.

It was more than possible that Splasher would find the question incomprehensible. But then it responded with a name. Another name he had never heard before.

Jason repeated the procedure two more times. He wound up with four names of unknown dolphins. Ghostly stowaways, he had never noticed them though they had always been present.

There was just one more question to ask. It applied to all of them, but especially to Scar.

SCAR GREATER THAN NOT SCAR YES/NO.

YES from Scar. YES YES YES.

Good.

He found Anahira in the submarine pen testing out the *Nemo*.

"How is it?" he asked as she stepped through the airlock into the observation lounge.

She looked at her minisub through a window that took up one entire wall of the lounge.

"It's tougher than both of us," she said. "No leaks anywhere. Of course, I did have to clean up a fair amount of blood."

"When can we go out?" Jason asked.

"We can't," Anahira said. "Devoyon has canceled all research dives until we can be sure that we won't draw a Leviathan attack. That goes double for you."

"I found out why Scar attacked the Leviathan. I'm pretty sure it won't happen again."

Anahira gave him a measure look. "Let's go see the director."

Devoyon's expression was an interesting mix of hopefulness and skepticism. "You have solved the problem?" he asked politely, glancing from Jason to Anahira and back again.

Jason nodded. "Ever since coming on to the station, I've been experiencing short memory loss periods; what the station personnel call 'moments.'"

"That happens to everyone coming off the hibernation drugs," Devoyon said with controlled impatience. "It will stop in a week or so."

"I understand that it's the general human reaction," Jason agreed, "unanticipated by the medics, but not important enough to really complain about. As far as I know, I haven't done anything dangerous or embarrassing while in that state. But it didn't occur to me until recently to wonder if the drugs might have a corresponding effect on the dolphins.

"The other day we were talking about how similar dolphins are to humans. That makes it easy to forget how different they are." He turned to Anahira. "What would happen if you fell into the pool while unconscious?"

"I'd wake up," she said.

"And if you could not wake up?"

"I'd drown."

"Right. Those are the only options for humans. Now dolphins need to sleep as much as we do, but they have to do it on the high seas. They do it by letting one half of their brain sleep while the other half stays awake. This has been known for more than a century. What we did not know is that creates a secondary personality in each dolphin. I don't want to make too much of this. This isn't Jekyll and Hyde, or Jung's shadow personality. In most interactions between dolphins, or between dolphins and humans, it has no effect.

But given the extended period of time this secondary had control on the trip from Earth as well as the after effects of the drugs, the secondary was able to take control for short periods of waking time.

"So when Scar was on that dive, NotScar woke to see his companions perilously close to a monster it could not identify with a size he could scarcely comprehend. He attacked trying to protect us."

Devoyon considered this for a few moments. "Suppose everything you say is correct. How can you be sure this will not happen again?"

"The spells should come less often in time just as they do in humans. I can set override controls in the pressure suits and take control if anything goes wrong. Scar wants very much to show he is a reliable part of the team."

"Anahira?" Devoyon asked.

"It sounds plausible to me. Plausible enough that I'll be his pilot again."

"Good. We cannot stay shut down forever."

Again, the *Nemo* dropped into darkness. The dolphins swam their regular patrol pattern around the minisub, Scar hanging back as if emphasizing his desire to cause no trouble.

The Leviathan was all around them, its constituent elements swimming freely as separate creatures. They ignored the *Nemo* as something nonliving, as boring as a rock or a block of ice. The dolphins, however, even in their pressure suits were clearly alive and worthy of study.

Suddenly, the Leviathan coalesced into existence below them. Anahira stopped their descent. Jason held his hand over the tablet, ready to hit the abort signal. The dolphins stayed level with the *Nemo*, their calls soft and tentative.

The Leviathan echoed them. Then, as if reacting to the lights carried by both dolphins and the *Nemo*, bars of glowing color swept across the Leviathan, broke into whirlpool like swirls, erupted into fireworks patterns. There was a structure complex and redundant. A language both Terrestrial species could spend decades trying to understand even as they would spend the same time trying to understand each other. ■

Arnheim's World

Therese Arkenberg

"Do you like it?" Arnheim asked me as we looked out over the lake.

"Yeah," I said, watching flashes of azure through the mist. "Nice color."

"It's yours." He grinned. "At least, its name is yours. Sara Vransi Lake."

He never named anything on that world after himself.

Julia and I were the only people to visit Josua Arnheim at his new home on the planet he called his own. The terraforming had just progressed to the point of making it habitable; on flyby, the lander passed over craters still raw-edged where comets had been brought down years before, bearing water and trace gasses. Arnheim had been living here at the time, sheltered in the impermeable hut his mansion was eventually built around. He was very proud of the mists.

"Soon we'll have enough to crash your groundcar in," he said, and laughed.

We had been kids together, but I never saw Arnheim laugh as much as he did that first week. He chuckled at odd things, like the prospect of a groundcar crash or a forest fire overwhelming the estate grounds. It never failed to throw me off balance, but by dinner of the third day I'd figured it out: It was *his* mist a groundcar might crash in. *His* salt flat a windraft might capsize over. *His* forest that burned. And his fire, too, I suppose.

The fire, luckily, remained hypothetical here on the windward side of the Ian Storr mountains, where the northern continent's sparse clouds piled against sheer walls of rock. Ian would have loved climbing them, we all agreed. And we drank a toast to another friend who hadn't lived to see the consummation of Arnheim's dream.

Now Arnheim just had me, and Julia, too, I suppose. He flirted shamelessly with both of us, in the easy way that came from knowing he'd never had a chance. He himself had helped design our silver-and-sapphire engagement rings. And, with the wedding only three months away, we flirted playfully, shamelessly back. Arnheim was charming enough that it made no difference.

He hadn't named my lake out of flirtation, though. That was more serious—the fruit of a long, loyal friendship. We hadn't always been close, geographically not at least. But we'd

always kept in contact, always celebrated each other's triumphs and mourned losses together. Even if we hadn't had that history, I think he would still have been the most amiable man I'd ever guested with.

The planet made him that way.

He showed us plans for the terraforming, as meticulous as any he had ever made for a suite of jewelry, and with an end product nearly as beautiful. Gaiametrics had provided the framework, and assistance came from a flurry of contractors he'd tracked down and hired for sums that would feed small nations for years (standard or long; though Arnheim's world itself had a rather short orbit). The cost was negligible compared to the prospect of an entire planet of one's own, especially one that could be made habitable in only two decades. And the globe itself cost only the outlay of the expedition that discovered it and the fee to sign on with the Registry.

I was sure at the time that Arnheim had paid that fee, but it would be rude to ask.

We did discuss some details of business. He would profit enormously from the gold and platinum deposits in the crust—he had a jeweler's workshop in the mansion, too; given his renown, it was practically a duty—and from excess lumber once the forests became sufficient. But his motives were never economic. All his life he had been rich enough, Julia remarked to me once, that they never had to be.

His true profit from the planet was entirely spiritual. Some would say egotistical, and they'd be right, too. It's the same thing at the core. There's nothing you can do for someone else's soul.

"Remember our trip to Olympia?" he asked me. At the time we were driving along the Mai Cobett Plateau, and as the aircar rounded a butte, the most magnificent canyon imaginable opened up before us. "How *crowded* it was?"

"Sure," I said. "It was a tourist designation for half the Suwasi Arm."

He winced, as if at a memory of physical pain. "All those eyes, staring at everything. And all those eyes that had stared before. Olympia Canyon was sticky with looking."

"Really? Sticky?"

"Really. Sticky." His hands tightened on the wheel until the narrow, olive-skinned knuckles became sallow. "All I've ever wanted was a place that didn't belong to other people."

"You have it now," I said softly.

He chuckled. "Exactly."

Parnassica first came up in passing.

Julia had stayed at the house while the two of us made another expedition over the newborn landscape, an increasingly common state of affairs. It didn't seem to signal any strain in our relationship. At dinner, she gave us a rundown of the news she'd gleaned from the daily Leybound infocast.

"Have you heard of the new colony just a few weeks down hyperspace Ley from here?" she asked Arnheim.

His knife scraped across the plate. "Once or twice," he said. "'Hyperspace Ley' is a redundancy. A Ley is by definition a thread of hyperspace permitting FTL travel in either direction along it."

"Parnassica's having trouble," Julia continued. "Major misestimates about the chemistry of gas pockets among the permafrost." Her tone took on the somewhat flat quality she used when speaking from memory. I smiled fondly as her eyes crossed in the search for an unmemorable piece of information. "They've freed up way too much . . . something and not enough nitrogen. The weather stations are working overtime just trying to keep things livable."

Arnheim raised his eyebrows, but said nothing.

Julia gathered noodles in the bowl of her spoon. "It's scary, isn't it? That something could go wrong and throw your entire world, literally your entire world, off balance . . . and the nearest help is dozens of light years away on a hyperspace string."

Arnheim sighed, then carried his glass of red wine to the window. He looked over the lichen meadows, the low clouds pearlescent with sunset, and said, "It would never happen here."

"Why not?" I asked.

"Because this is my world. I would never let it get out of control." His fingers, curled around the stem of the glass, were firm but not tight. He sipped the wine, and his lips formed a thin smile of pleasure as he savored the taste.

The southern continent of Argounova was being seeded with a fern forest, hardy fronds

and spores shipped off one of Saritor Enterprise's farmworlds. We landed the aircar in a clear patch and walked out in climate suits.

I'd convinced Julia to come along this time. She walked bowlegged in her suit with obvious discomfort. But her face had been pressed to the window the entire flight. She was falling in love with Arnheim's planet, too.

Arnheim crouched over a bunch of spreading leaves. He waved us over with a grin. As we approached, he flipped off his helmet fastening.

Bareheaded, he took a deep breath of the forest air.

Julia's yelp was muffled by her own helmet. I smiled at her, trying to be reassuring even while coping with the realization that my own instinct was to freeze in shock rather than cry out a warning.

A warning proved unnecessary in any case, as Arnheim was taking further, deeper breaths. "Try it," he called to us.

Still silent, I unfastened my helmet and took it off. The air that greeted me was cool and damp, with a scent so fresh it scoured the lungs.

"They've done their work," Arnheim said, patting a rhizome protruding from the soil.

"Yes." Julia sounded a bit breathless even as she opened her faceplate.

"Congratulations, Josua." I offered him a hand up. "A living planet."

His hand grasped mine and pulled me into a hug with a gesture as graceful as dancing. He laughed, whooped, his voice wordlessly soaring for joy.

"I can help you fill out the forms for the Registry," I volunteered, willing even to do paperwork on my holiday for the sake of his delight.

Arnheim's laughter suddenly stopped.

"Well . . . shouldn't you?" I faltered.

"No need. I don't intend to make my world a destination."

"But what if someone needs to know there's a habitable planet along this Ley? If there's an emergency?"

"They can find somewhere else."

"That's . . . rather cold."

He shrugged, even as he smiled at me once again. "You're the one who created the hypothetical emergency in the first place, Sara. It's highly unlikely anyone will need *my* help."

"Even so—"

"Even so, there's no reason for me to give my privacy up. Sara, this is . . ." He spread his arms, an all-encompassing—and unconfining—embrace. "This is something I'll share with whoever I choose. But right now, you're the only ones I choose to share it with."

I folded my arms tight on my chest. "That so?"

We watched Julia trace the curve of a fern leaf with her fingertips, seemingly oblivious to our conversation.

"You," he said, "and anyone you choose to invite." He brought his hands together in a sharp clap. "There's my one concession. Enough for you?"

I smiled. "Enough." I didn't really like to argue with him.

But his generosity wasn't over. "Julia!"

She looked up so fast a lock of hair fell in her face. "What?"

"Who does this forest remind you of?"

She let me brush her hair back as she frowned in thought. "Someone who . . ."

"Anyone! But it needs a name, don't you think?"

At last she said, "Indira. Indira Rosi. You remember her, Sara?"

"Of course. She's still out there, I think—on Radagest last I heard. With her sister."

Arnheim piled us into the aircar to visit the next site. We stayed out late, taking the names of old friends and putting them to things that had never had names before.

Because no one had been at home, Arnheim left the aircar's transmitter unactivated that day. This explained why we didn't receive the urgent-coded message earlier—and why we were so untroubled even by the flashing, drumming signal that greeted us when we powered up the house system. After all, nothing had happened to any of us.

THIS IS A TRANSMISSION FROM THE BRIDGE OF *MATTHEW 10:29,* OUT OF PARNASSICA. WE ARE IN PRESSING NEED OF ASSISTANCE, grainy letters spelt across the tabletop screen. THIS VESSEL HOLDS ALL SURVIVORS OF COLONY ONE, SEEKING REFUGE—

"It collapsed, then." Arnheim snorted and shook his head. "That's what happens, terraforming in a rush."

The words of the message were repeated aloud, read out in a grainy woman's voice.

WE NEED SHELTER. *MATTHEW 10:29* IS NOT SET UP FOR LONG-TERM HABITATION. OUR LARGER TRANSPORTS WERE OUT OF SYSTEM AT THE TIME OF THE CATASTROPHE IN OUR CIRCUMPOLAR—

He turned away.

I reached for the transmitter control pad. "Should I key in our coordinates?"

"Don't touch it."

I shrank away as if his vehemence burned me.

"There are other worlds along this Ley," he said, speaking to the window. "If the *Matthew* moves fast they'll reach them soon. They may even have overshot us already."

Unlikely, I thought, looking at the coordinates of the transmission. Even along Leyline, ships didn't move that fast. And this was not a densely inhabited—or hospitably inhabitable—region. It was a region that needed Gaiametrics to come alive.

And help to stay alive. "Josua," I said.

"I didn't build this place to be a way station," Arnheim said.

"They're on a *life raft,*" Julia said. Her voice echoed down the long room.

"It's none of our business." He strode to the doors, which opened for him at a gesture for the servitor program. "They should have built more carefully. Most of us only get one world."

Shaping an entire planet's ecosystems is expensive. Prohibitively expensive in many cases. Some would-be colonists scrimp and save their entire lives without ever gathering enough together to venture it. Others can only afford the lease of a continent or region on an already developed world.

Parnassica's model was a little different. Not original, though. Arnheim had fallen into a lecture on it one night, not long after Julia reported its problems. He could care less about the troubles of settlement, but the means had always fascinated him.

"Not original," he said again. "It's a model lots of people use planetside to build houses. Or vehicles, or intelligence systems, or anything expensive that could possibly come in smaller parts. They construct it as they can afford, piece by piece and section by section. Pouring concrete for a home's foundation, then setting up walls—sometimes room by room.

"Colonists do that for the next town, next region—the next planet. As soon as the last terraforming contractor moves out, construction companies move in. But in Parnassica's case, that's how they contracted the very terraforming. Once they got the license from Gaiametrics they brought everything in piecemeal: tanker by tanker of atmospheric starter algae and trace gasses, water from asteroids brought in impact by impact. Instead of a mastermind synthesizer, they set up monitoring stations on each continent, the kind miners use on small moons. As soon as the equatorial region had soil they paid for forestation, just as an overlooked volcano erupted and plunged them into a yearlong winter. To say nothing of the shifts in the polar ice."

"It got them there," I said. "It's not a bad idea—committing, and then doing as much as you can with what you have at the time."

"No, not bad," Arnheim agreed. "Provided it doesn't take so long that the foundations crumble before you raise the walls up on them. Provided someone comes to monitor each adjustment and ensure it proceeds smoothly. Provided things don't backslide too much between contracts. Provided your house doesn't fall down before you can move in."

"Or," Julia said—her first addition to the conversation—"fall on your head right after you move in."

Arnheim laughed. "Right."

He was never in such danger. Arnheim had calculated the transformation of his world perfectly. After saving enough to make a down payment on the major ecowork, he'd managed his investments to provide a steady stream of income for continuing the project. We were able to monitor the success ourselves.

"You sure you don't want to come?" I asked Julia.

She rolled over in bed, her hair a jet-colored halo. "No. That is, yes, I'm sure."

I leaned over to kiss her on the forehead. "Okay. See you around eleven."

"How can you?"

I leapt back, surprised more at the inherent venom of her question than the soft tone she asked it in.

"Well, I know you're . . . erm, not feeling well, but I'm up to it and Jos wants another—"

"I don't want anything else to do with Josua Arnheim."

I had nearly backed across our narrow bedroom by this point. "Well . . ." What could I say? That he'd been our fast friend for years? That the rings we wore were his gift? That he had shared his planet, his precious, private planet only with us?

I met Julia's eyes. I saw anger, disappointment—but not pain. She didn't feel betrayed. She and Josua hadn't grown up together. They were never very close. He had been *my* fast friend.

He'd shared his planet with me. Only me. Me and whoever I chose to invite.

"I guess I don't feel the same way," I stammered.

"Why not? Sara, he's leaving those people to die."

"It's not . . ." But there was nothing I could deny.

Julia turned her back to me, pulling the blanket high—but not before I saw the muscles tense beneath the smooth, dark skin of her shoulders. "Let's go home," she said, so softly I wasn't certain I was meant to hear.

"Soon," I murmured, equally soft.

I grabbed my jacket from the hook on the back of the door. Arnheim and I didn't bother with suits or masks anymore.

High up on a hillside in Argounova, we measured the new growth. Cyclads had sprouted up further and grown taller even over the three days since we'd last come by.

Josua was grinning broader than the Masát Defile.

"Goodness, you're *proud* of your wittle ferns, aren't you?" I teased.

He laughed at me.

But a certain distance remained, as if the new atmosphere was too dry to carry real humor between us.

We didn't speak on the way back. I sat looking out the window. Arnheim yawned, just as light lanced from the opal-and-azure surface of a lake.

"That's Sara Vransi Lake, isn't it?" I asked.

"Absolutely," he drawled, the word heavy with sweetness and pride.

I tried to force answering sweetness, and some vanity, into my smile as I turned to him. "Mind if I set down? I'd like to run a few tests on . . . my lake."

He didn't protest the possessive pronoun, as I'd feared he might. If anything, his expression seemed even prouder. As if, like the ferns, he saw me growing.

"I can walk back from here, can't I?" I called as I rummaged in the trunk for the sampler.

"If you want." He was ready to indulge me. It made me feel . . . small. Crowded in by his generosity. "Take it easy. The oxygen content's not that heavy yet."

"It's enough," I said. I tapped my jacket pocket where my communicator rested. "I'll call if I have trouble."

"Make sure you do."

As he was about to climb into the pilot's seat again, I went on tiptoe and kissed his cheek. I'd seen his elder sisters do the same, long ago when we got home after a day rambling over the fields. Avoiding everyone but each other. He'd always rubbed those kisses away.

A glow touched his olive skin.

"Bye, Jos."

"See you around, Sara." I had the oddest feeling he could have been talking to me or to the lake.

Once he'd flown away, I powered up the sampler and took the communications relay from my pocket. I didn't turn it on yet. It was fully charged, but juice drained pretty rapidly on any farcast call.

"Verbal commands on." I had to clear my throat and repeat myself before the sampler acknowledged me. "Register: breathable atmosphere."

A high whine as the sampler's dish spun, collecting and analyzing. "Positive."

"Temperature within range of human comfort."

"Positive—23 degrees Centigrade."

"Terraforming completion parameters met?"

"Negative."

"Terraforming completion parameters met sufficiently to support human settlement?"

"Balance of probability, positive."

I swallowed. "For how long?"

It named a span of years that would support my great-grandchildren's great-grandchildren.

That reminded me of the womb tanks Julia and I had been examining before our visit here. A conversation we'd need to have. Later.

I flipped on my communicator. "Put me through to the Registry—wait, scratch that."

Silence, for a moment. The slap of waves on the shore. Internal clamor as I tried to get my thoughts in order. "Patch me through to the receivers on *Matthew 10:29*.

"I have an invitation."

I told them to land at the far end of the lichen meadows before the house. It wasn't a secret we could keep from Arnheim anyway.

He was in his office on the upper floor. I sat in the games room, with its vast windows onto the veranda, staring half outside, half at the holographic match in progress before me. Dust danced among the graphics display. This room was hardly ever used; why play games when there was a planet to explore?

Of course I heard the thing before I saw it. A descending spaceship isn't exactly quiet.

The *Matthew 10:29* came down slowly. Its manner might even be called stately. The sun of Arnheim's world gleamed on a hull blackened in places from atmospheric entry, but otherwise pale as the moons. Its name stood out in sharp, elegant blue script in three languages.

The whole thing was vast—so big there was nothing manmade on the planet to provide a proper comparison, although it could have been swallowed by Sara Vransi Lake.

Arnheim's footsteps pounded down the stairs.

Before he reached the veranda, he stopped. He turned to the open door of the games room.

I stopped my half-hearted play and told him everything. While we spoke, the gates of the ship opened and figures began streaming out.

Julia remained in bed. She probably wasn't sleeping, but she could have slept through it all. Though loud, the *Matthew 10:29's* engines emitted an almost soothing drone that grew in volume in intervals as it descended and just as gradually stopped as the final refugees left the ship.

Arnheim was very nearly silent.

And I was very quiet.

The fact is, Josua Arnheim's word was law on the planet he had bought, built, and paid for. If he'd taken out his personal security piece and started a war for his property then and there—well, some might blame him, but nobody would stop him.

After I finished speaking, he left the house. On his way out, he gestured for me to follow.

Though they'd had to flee in a hurry, and looked very glad to be on solid ground, the Parnassicans were not desperate looking. They were well dressed and weren't starving, although many had the air of having gone without for a little too long. The leaders were no better dressed than the others, but they did look much more strained.

They introduced themselves—a dozen of them, with a dozen unfamiliar names.

We introduced ourselves—Josua Arnheim, Sara Vransi.

"She's the one that invited you here," Arnheim said.

I nodded, and they nodded back.

Then Arnheim stepped forward. He held out his hands.

"Let me give you a tour," he said. He hesitated and looked around at them. "But I'm afraid my aircar wouldn't fit you all. Do you have anything bigger?"

"There's the scout ship," a younger man said. For all his youth, his hair was graying, ashen against his skin. "It's big enough, at least."

A woman's eyebrows rose, but Arnheim said mildly, "There's no reason a minor interstellar craft wouldn't work as well in the atmosphere here."

Only as they were boarding did he turn to me. "Sara."

I stood straighter unconsciously, responding to something awakened within me by the tone of his voice.

"See to the others." He folded his jacket all the way up to his sharp chin. "Make them feel at home."

I did get Julia out of bed, then. The resources that kept three people in luxury could not quite keep three thousand in comfort, but the Parnassicans carried some remaining supplies with them, and the mansion could hold six to a room.

We had started setting up tents, from our camping stores and their emergency kits, when the tour returned. A dozen figures hiking across the lichen.

After their tour, Josua had left the Parnassican leaders off not far away.

I never saw him again.

"A scoutship can travel pretty far," the young man, whose name I never could remember, explained to me. "Especially on a Ley. It wouldn't be comfortable, even for one . . ."

"Yet their capacity for fuel is considerable," a woman added. "Our tour of the planet barely expended an interval of it."

"How was the tour, anyway?" I asked, as if I was curious or trying to be polite.

"He was very gracious. Told us how everything was progressing, and told us all the names."

The Registry wanted to talk to me about questions Josua Arnheim couldn't answer. Coordinators among the refugees wanted to talk to me about questions their leaders couldn't answer. Those that couldn't get to me went to Julia. We did our best.

We fell into bed together as the sun was rising. Only then did I properly get the chance to talk to her.

"I'm sorry," I sobbed.

She rubbed my back and listened, just listened, even to the apologies that weren't meant for her.

Three days later, Central officers arrived, and Julia and I were able to pack up our things. We left our room to the officers—there wasn't much space anywhere else for them to stay. But that was fast changing. Construction supplies were already being ordered from Parnassica Common Holding's meager savings.

Soon they could start building cabins from the trees to the south of the Ian Storr range.

It was a simple matter of an account switch with Gaiametrics. They had to wait a while, though, to be sure Arnheim didn't resurface. It helped that he had written a note during the tour that shared his account access information.

Arnheim's world was not made into a way station for Parnassicans. It became a home, I guess. I haven't been back in a while. We exchanged messages a few times, sharing news. Julia and I received a present at our wedding.

They kept all his names for things.

It's strange, what keeps you up at night.

These past years it's been bothering me that nothing in this Universe is named for Josua Arnheim. But it's a problem there's no way to fix. He never named anything for himself. To give his name to a place or landmark or even a building on any other planet would be an insult.

And on that world—that nameless world, not *his* any longer but not quite *not* his, either—I've talked to the others, the ex-Parnassicans there, and they agree with me. You can give something a name on that world if you have to, for clarity. But it's hard to shake the feeling that you're being redundant—that it was named already. ■

THE SPECIFICATIONS OF EXTRATERRESTRIAL INTELLIGENCE

The eminent Harvard biologist and philosopher of science, Edward O. Wilson, noted for his creation of the field of sociobiology and for his many books, has written a new book, *The Meaning of Human Existence.* It should be of great interest to the readers and writers of science fiction. The book attempts to explain how humanity has come to its present state of existence because of the forces of natural selection as they act on individuals and on groups. In particular, based on the lessons learned from the record of evolution that lead from viruses and bacteria to vertebrates to human beings, Wilson has attempted to produce a list of specifications of how some hypothetical intelligent beings that might have evolved on an Earth-like planet of another star system would look and act.

SF writers usually base their Intelligent aliens on the assumption that the processes of evolution on an alien planet have produced some intelligent life form that in the course of time, because of its intelligence, proceeds to develop a complex technological civilization. Some of my favorite SF writers have invented fascinating alien species that combine instinctual animal behavior with high intelligence. Examples are Larry Niven's tiger-like carnivorous Kzin, his sheep-like herbivorous Puppeteers, and Poul Anderson's eagle-like territorial Ythrians. All became intelligent enough to form highly developed technological civilizations, carrying their innate animal behaviors with them to the stars.

However, Wilson would say that the SF writers have it backward: the random walk of evolutionary development and varying conditions of environment generates a species that by chance develops a cooperative social structure. Then, if the conditions are just right, the existence of that cooperative social structure pushes the development of intelligence. He traces the development of intelligence from the primarily vegetarian *Australopithecines* (which had a 600 cc brain volume) to meat-eating *Homo habilis* (680 cc brain volume) to *Homo erectus* (900 cc brain volume) to *Homo sapiens* (1,400 cc brain volume). Wilson suggests that the initial innovation in *Homo habilis* of including meat in their diet led to the establishment of semi-permanent camps in which the young were protected and to which roving cooperative hunters brought meat to feed the group. This led to villages with complex cooperative social structures. These ultimately led to cities, civilization, and technology. At each step along this path, increased intelligence provided group and individual advantages, and so high intelligence emerged.

Wilson points out that such cooperative social structures are very rare among the animal species. The four hundred million years of evolution on Earth have produced only twenty examples of species with complex social structures, and most of these are insects. All of these social species developed rather late in the game, and all have been very successful. For example, among all of the highly variable insect species, only two groups of socialized insects—ants and termites—comprise about half of the total global insect biomass by weight, which can be taken as a measure of their success.

In chapter ten of his book, Wilson uses the lessons learned in analyzing the intellectual and social development of *Homo sapiens* to predict the characteristics of a hypothetical

intelligent alien species that might develop on an Earth-like planet of another star system. In what follows I have condensed and paraphrased Wilson's logic, but the arguments are basically his. We will consider his predictions one at a time:

(1) Intelligent aliens will be land-dwellers, not aquatic. The final ascent to human intelligence required the use of fire as a portable high-energy source in developing technology beyond the stone-age level. It is difficult to imagine an ocean-dwelling species reaching iron-age technology.

(2) Intelligent aliens will be relatively large animals. The most intelligent land animals, in descending order, are Old World apes and monkeys, elephants, pigs, and dogs, all at the high end of the animal size spectrum. Small body size means smaller brains, on the average, less memory capacity, and lower intelligence. The hypothetical aliens would probably have a body mass around 10 to 100 kg, i.e., somewhere between a dog and a human.

(3) Intelligent aliens will be biologically audio-visual. In terms of sensory perception, humans, with their reliance on sound and sight in very restricted frequency bands, represent a rather isolated group. Most of the animal world depends much more directly on smell and on the use of specialized body-generated pheremone chemicals for signaling and communication. However, pheromones are unsuitable for rapid communication, and therefore represent a road block on the path to high intelligence. The hypothetical aliens could use facial expressions or sign language for communication. However, "telepathy" is ruled out, unless a species developed the capability of internally generating and detecting radio waves or electrical signals as communication. While electric eels and catfish have some capabilities in this direction, it has developed because they are adapted to murky environments in which vision is not useful.

(4) Intelligent aliens will have a large distinct head located up front. All land animals have elongated, bilaterally symmetric bodies, with brains and key sensory inputs located in a head adapted for quick scanning and action. The hypothetical aliens should be similar.

(5) Intelligent aliens will have light to moderate jaws and teeth. Animals with heavy mandibles and massive grinding teeth are typically vegetarians that eat coarse, low-energy vegetation. Animals with fangs and horns use them for defense against predators and for competition among males. The hypothetical aliens should have progressed by cooperation and strategy rather than brute strength and combat. Only a broad, high-energy meat and vegetable diet could sustain the relatively large populations needed for the later stages in the development of intelligence. Hence, moderate jaws with no fangs or horns.

(6) Intelligent aliens will have a very high social intelligence. All social insects (wasps, bees, termites, ants) and the most intelligent mammals live in groups whose members simultaneously compete and cooperate. Functioning in such a fast-moving and complex social network requires a great deal of social intelligence.

(7) Intelligent aliens will have a small number of free locomotory appendages, levered for maximum strength with stiff internal or external skeletons composed of hinged segments (as by human elbows and knees), and with at least one pair that are terminated by digits with pulpy tips used for sensitive touch and grasping. The four-legged-ness of land vertebrates is perhaps because fishes with four lobe-fins (instead of six) colonized the land. Insects have six locomotory appendages, and spiders have eight. Evidently a relatively small number of such appendages is good for evolutionary success on land. Only chimps and humans invent tool artifacts, presumably because of the utility of fingers with soft, sensitive tips. A technological civilization that depended on beaks, talons, scrapers, or claws for tool manipulation is difficult to imagine.

(8) Intelligent aliens will be moral. The cooperation apparent in all of the highly social species of the Earth is based on some degree of altruism and self sacrifice. It has arisen from natural selection at both the individual and the group levels and has led to our sense of morality. Presumably alien intelligences derived from similar group evolution would inherit a similar sense of morality.

(9) Intelligent aliens skilled in genetic engineering will not have used genetic modification to significantly change their social nature. Our technological civilization has only

very recently reached the beginnings of an ability to modify and manipulate the human genetic code. It is not difficult to imagine a future in which we take the human genome in hand and change it to eliminate genetic diseases and disease tendencies, to give us better memories, more intelligence, bodies better adapted to hostile environments, and more longevity. Perhaps we might even decide to take this process a step further and edit out the inherited "baggage" of instinctual behavior that we call "human nature." Wilson believes that we will not do this, and instead will choose to retain the inherently messy, self-contradictory, internally conflicted, endlessly creative human mind that exists today, and that similarly Intelligent aliens will do the same. We and they will be existential conservatives.

Another aspect of Wilson's book that should be of interest to SF readers is his assessment of the prospects for interstellar colonization. Wilson has serious reservations about the colonization by humans of the planets of other star systems. These reservations are similar to those expressed in Paul Davies' Afterword in the recent book *Starship Century* (in which I wrote a chapter).

Basically, any planetary ecology is a vast array of interacting viral, bacterial, plant, and animal life that, after many eons of natural selection and responses to random events, challenges, and catastrophes, has arrived at a stable system. The ecology of an alien world would necessarily be qualitatively different from that of Earth and would be wholly incompatible with our own ecology. The two worlds would necessarily have radically different origins, different molecular machinery, and would differ in fundamental ways, due to the endless paths of evolution that produced the inhabiting life forms.

The typical grocery store contains only a tiny subset of the Earth's plant and animal material, a subset carefully selected to be edible and nontoxic. The vast majority of terrestrial organisms are unsuitable for human consumption. The organisms of alien planets would be much more so. Wilson argues that the problem of transplanting the Earth's ecosystem to another planet basically has no solution, that we must resign ourselves to living on the one planet we currently occupy, and that we should take better care of it if we wish to continue doing so.

These discussions of intelligent aliens and interstellar colonization, while perhaps of most interest to SF readers, represent only a small fraction of Wilson's book. He displays his expertise in the study of social insects with fascinating details on the behavior of driver ants, leaf-cutter ants, termites, and bees. He addresses the "two culture" problem, the disconnect between the sciences and the humanities, by announcing and promoting the dawn of a New Enlightenment in which the new insights into provided by science on the origins and outlines of human nature can shape and encourage a new flowering of art, literature, and philosophy. He also takes on religion, describing it as an essentially destructive syndrome that exploits the tribal us-vs.-them tendencies of human nature, promotes unreason, and ultimately causes good people to do bad things.

Overall, *The Meaning of Human Existence* is an important contribution to our understanding of humanity and of our place on the Earth and in the universe. It is disturbing, thought provoking, fascinating, and highly recommended.■

SF Novels by John Cramer: My two hard SF novels, *Twistor* and *Einstein's Bridge*, are newly released as eBooks by the Book View Café co-op and are available at: *http://bookviewcafe.com/bookstore/?s=Cramer*.

Alternate View Columns Online: Electronic reprints of over 174 "The Alternate View" columns by John G. Cramer, previously published in *Analog*, are available online at: *http://www.npl.washington.edu/av*.

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Probability Zero

Double Exposure

Don Sakers

"You're a science fiction writer, aren't you?"

She was tall, with mahogany skin and close-cropped, nappy dark hair. Her attire was business casual, navy blazer and skirt with white blouse and sensible shoes.

"That's what they say." I gestured to my nametag. It was Sunday evening, and the convention was over, but my flight wasn't until tomorrow. I'd been in the bar since mid-afternoon, having goodbye drinks with departing friends; I'd been nursing a lonely gin and tonic for an hour when she showed up.

She nodded. "I came here to find you. I work for . . . well, never mind. I'm a physicist, and my outfit is working on time travel." She looks around. "This is all confidential, you understand."

"Right," I said, giving her the skeptical eye. "Time travel."

She waved at the bartender. "Another one. I'll pay his tab."

"All right, I'm listening. Why did you come looking for a science fiction writer?"

"We have a problem, and we don't know how to solve it. Time travel's old hat in science fiction. You've written stories about it yourself. Maybe you'll see something the rest of us can't."

The bartender set down a fresh drink; I stirred it and sipped. "Tell me your problem."

"We sent two teams into the past. They came back dead." I raised an eyebrow, which she took as a signal to continue. "For the first trial we sent a team of three about fifty years into the past. We were in constant contact. At the two-hour mark, they reported some nausea and headaches. An hour later, they were vomiting. After four hours they weren't able to communicate any longer. We aborted and brought them back."

"And they were dead," I said. She nodded. "You did autopsies?"

"Of course. These were healthy volunteers in excellent physical condition. There was no apparent cause of death." She frowned.

"So you tried another team?"

"A month later. This time we sent a fully equipped physician along. The pattern was the same: after a couple hours, nausea and headache. That escalated to vomiting, fever, bleeding . . . when the doc reported their hair falling out, we retrieved them." She spread her hands. "Same story. Dead for no apparent cause."

I cocked my head. "You didn't do animal tests first"

She looked at me over the top of nonexistent eyeglasses. "We needed subjects who could report on the experience. Besides, it takes unbelievable power to send things through time. We have a dedicated nuclear plant." She looked down. "The budget didn't allow for animal testing."

"Live and learn." I still didn't believe her, but as long as she paid for drinks, I'd play along. "Sounds like radiation sickness. You sent them into an atomic bomb test."

She shook her head. "No. We know the history of the site. It's been perfectly safe for a century."

My turn to frown. "Why did you choose fifty years?"

"Not exactly fifty. The first team went back 47 years, the second 53."

"Why?"

"We added a year to the age of the oldest team member." I must have given her a blank stare, because she added, "To avoid having two of them existing at different ages."

I nodded. "You didn't want them to cross their own time-streams, I get it." The glimmering of an idea stirred. She started to speak, but I held up a hand. "Wait. I might have something."

In my mind, I felt the familiar sensation of pieces coming together, the way they do when I'm brainstorming a story. Crossed time-streams, duplicate bodies . . .

"Okay," I said, "bear with me here." I set my glass down in front of me. "Here's your time traveler. You lift him out of the present, and put him down fifty years ago" I lifted the glass and moved it a foot to the left. "He doesn't already exist in this time frame—but his particles do."

"Of course they do, we—"

"No, I mean his particles already exist. In the past. They're scattered all over the place." She frowned, so I pressed my point. "Fifty years from now, those particles will be together in his body. So what you've done, in that frame, is you've created duplicates of those particles." Comprehension lights in her eyes. "There can't be two of each particle. The new ones must cease to exist." I took a gulp of my drink. "They . . . evaporate. Not all at once. Say one-tenth every few hours." My eyes narrow. "What would happen to you if, say, one-tenth of your electrons disappeared?"

Now she gets it. "Ions all over. DNA damaged, cells malfunctioning. All the effects of radiation sickness."

"Exactly. When the bodies return, all their particles are together in this time frame. That's why they seem in such good shape." She was still reeling, but my mind was off and running. "I'll bet the effect is more pronounced the further you travel. Probably along a power distribution curve. You were lucky you went with fifty years—if you'd tried five hundred, they'd probably have disintegrated in seconds."

"B-but . . . how can we test this hypothesis?"

I had an answer for that, too. "Send someone back three hours. Measure what happens to them. See if they recover at the three-hour mark."

She stood and offered her hand. "Thank you. You've given me a lot to think about." She threw five twenties on the bar and turned to leave. Then she stopped and looked back at me. "If this is true—and it sounds persuasive—then we'll never have true time travel."

"Trouble with you scientists, you give up too easily." I raised my glass to her. "I'm a writer. Get back to me in a few weeks. I'll have a gimmick for you." ■

No Gain

Aubry Kae Andersen

Maggie offered a foil-wrapped chocolate across the kitchen table. Sabina stared at it blankly, like she regarded a rock.

The sixteen-year-old had spent every morning with Maggie for the last two weeks, training under her supervision. Sabina would execute a hundred deadlifts for her, no questions asked. Run five miles without resting, without even a sigh of complaint. She'd bend over backwards, literally, and hold that pose for minutes at a time.

But Sabina wouldn't take the chocolate, as if Maggie were a stranger on the playground. She wouldn't even say "No, thank you." She returned to her lunch, a beige shake made of whey, egg whites, and the cocktail of vitamins the doctors fed her. One sip, then six seconds swallowing before she took another one. Her posture was just as regimented, the stripes on her tracksuit forming ninety degree angles at her hips, her elbows, her knees.

Maggie shifted in her own chair. Her back began to ache, so she stood up and stretched. Thirty years old, and these hard seats made her feel eighty.

"You can have a treat now and then," she said. "I used to act as tough as you do, but my mom knew my weakness. After every meet, she'd take me out for ice cream. The better I did, the bigger the sundae. When I won gold in Rio, I ate a mountain of rocky road."

Sabina looked up, blinking with the same perfect timing. Still she said nothing.

"Come on," Maggie wheedled. "I bet you snuck treats into the gym back in Tashkent. Tell me what candy you want and I'll smuggle some to you."

Artur, the head coach, walked in before Sabina said anything.

"Ready, Sabina?" he asked with his thick Uzbek accent, clasping his hands together. "Let's work on the routines for Montreal. You've been wobbling on the beam."

Sabina stood up and walked past him to the gym, without giving Maggie a second look. But Artur turned his full attention to Maggie. He stared her in the eyes far too long—long enough to make her fidget with the chocolate's foil.

"You do a good job, Ms. Greenburg," Artur said. "Sabina's life has been rough, but she doesn't need sweet things. And her English,

you know, it's not the best. Just keep her on task, keep her from hurting herself too badly, and she'll be happy."

Maggie nodded and rubbed her back. "I will."

He glanced at her discomfort. "Do you need more oxy?"

"No, I've got enough."

"Tell me if you need more," he said, then left.

She unwrapped the chocolate and ate it herself.

A thousand camera flashes lit up the stadium's bleachers like a disarranged Broadway marquee. Maggie sat in the middle of it, her eyes fixed on the blue mat below.

Sabina tumbled across, bending and pounding like she had a rubber spine and magnetic feet. The sequins on her leotard became a blur of red sparkles. She twisted and twirled in ways that made the crowd roar and made Maggie cringe. The girl was flexible but not this flexible.

Artur pumped his fist, encouraging Sabina from the sidelines. Faster, higher, stronger. The panel of judges gawked.

At the finish, Sabina traversed the entire mat with a furious series of back handsprings. She bounced into the air, spun, and somersaulted, fast as a power drill. Talc burst from the mat as she landed, like smoke from a gun. She raised her hands and smiled the toothy smile Maggie had taught her to make.

The crowd jumped to their feet, clapping and yelling. They didn't seem to notice Sabina's skewed index finger. Maggie stared at it, though, as did the judges.

Artur ran over and took Sabina's broken hand, hiding it in his own while the girl continued to smile, and the crowd continued to cheer. The judges glanced at each other before resuming their straight faces.

The World Anti-Doping Agency tested Sabina's urine five times. Her blood, three. They had two different doctors check her sex and her age. They even ran her through a full-body CAT scan, checking for God-knows-what.

Maggie waited the entire time, in a room that felt more like a police station than a doctor's office. Artur sat across from her in the chairs lining the wall. His arms were crossed, his tracksuit still zipped to his neck. Under the harsh fluorescent lights, his eyes were like holes.

Sabina's performance was amazing enough to win gold on floor exercise. But she'd been utterly unknown before this event, not even participating in the Asian Games. Now she was bound for the Olympics.

And the broken finger . . .

Sabina hadn't even complained about it as she was ushered from the stadium to the clinic. Adrenalin could be a powerful painkiller, but it wore off quickly. The girl should've been crying as the doctor set and splinted the finger, but she complained more about the pain of getting her blood drawn.

Maggie had often been subject to the inspectors' scrutiny. Their tests always seemed excessive, but their methods had grown less transparent since she had competed. As a trainer, she had to know what drugs were banned from competition. She let Sabina's doctors handle that and never gave the girl anything, not even acetaminophen. Pregnant women were allowed more medication than a professional athlete.

The inspectors would check for more than that, too. Blood doping—enriching the cell count in an athlete's blood with hormones or a centrifuge, then pumping it back into their veins before competition. More red blood cells, more oxygen, more endurance.

That probably wasn't the WADA's concern, though. They could detect doping with a mass spectrometer in a matter of minutes. Maggie heard they'd been doing genetic testing more regularly, searching for doctored up DNA after so many rumors that coaches started using gene therapy. Like Repoxygen, which treated anemia by permanently increasing production of EPO, a hormone for red blood cell production. The inspectors could detect that, though. The viral vectors used to modify DNA also left antibodies in an athlete's blood.

Maggie grew tired of thinking about the inspectors' suspicions. Like every other coach, Artur's methods probably toed the line, but he insisted on following the rules.

Maggie grew tired of her chair, too, so she stood up slowly and massaged her back. The oxycodone had worn off hours before. She didn't dare take another pill in here.

Like mercy, the double doors to the clinic bumped open and a pantsuited woman

walked in—the lead inspector. She went to the nurse at the triage desk.

"They won't find anything," Artur muttered. He seemed to be talking to Maggie, but he watched the inspector and spoke loud enough to grab her attention.

The inspector glanced at him, tight-lipped, and walked over, holding forth Sabina's Uzbeki birth certificate.

"We're unable to contact the health ministry that issued this," she said.

Artur rolled his eyes. "Try the mail. Her village has no electricity, no internet."

"Where are her parents, then?"

"My country doesn't have the money to fly them out for every meet. Why do you need proof she was born, anyway? Clearly she was."

A grimace flashed across the woman's straight face. "Mr. Babayev, the girl has a broken finger, two torn wrist ligaments, a sprained ankle, and five bruised vertebrae."

"And she's going to the Olympics for it. Let us leave so the girl can rest and heal."

"But she should be writhing in pain right now."

"She's clean," Artur insisted. "You should see that by now. My doctors will take care of her down in Colorado Springs."

The woman shook her head. "She needs further treatment before boarding a plane."

"You're not her doctor," Artur said.

"But on good conscience, I can't—"

"I'll get a second opinion on that, in Colorado Springs."

The inspector clenched her jaw, but she had no authority to keep them there. Maggie knew that, though she was concerned about Sabina's injuries, too. Still, Colorado Springs was only a few hours away, and the girl hadn't even been limping on that sprained ankle.

The inspector lingered. "Look," she said, "some people are born with this condition where they can't feel pain, and—"

"She doesn't have congenital insensitivity," Artur said, like he'd said this before. "I was there when you drew her blood. She flinched every time. And she would've died years ago if she couldn't feel pain. She's just tough. You wouldn't give a damn either if you grew up eating rats on the steppes of Uzbekistan."

He snatched away the birth certificate. Before the inspector could say anything further, he was pushing through the double doors. She looked at Maggie and hesitated to say more.

Maggie tried to follow Artur, but the inspector grabbed her arm.

"Watch that girl," she whispered. "She's pushing herself too hard, and—"

"Ms. Greenburg!" Artur shouted back.

"She's tough," Maggie said. "Like any good gymnast. Excuse me." She shrugged off the inspector's hand and followed Artur.

That day, Artur's team flew back to Colorado Springs, to the small training center tucked among the mountain pines. As soon as Sabina returned, she swapped her dress for exercise clothes and began running on the treadmill.

Maggie turned it off. Sabina slid down, giving Maggie a stare of subdued annoyance.

"You need to rest," Maggie said. "Your finger and wrist might be sprained, and you shouldn't be walking on that ankle. That bruised spine is the worst of all. It might feel fine now, but it'll hurt like hell in five years."

"I iced my back on the plane," Sabina said.

"Ice it more."

Sabina tensed her face, as if she physically swallowed her complaints. She went off to the kitchen.

"You're not invincible," Maggie said, raising her voice. "I thought I was at your age, and I'm still feeling it."

Sabina didn't reply. Maggie heard her fishing in the freezer.

She rubbed her back again. The flight from Montreal would've been torture without the painkillers. If only they'd last. She pulled a bottle from her jacket and popped another pill. After a few minutes the pain melted into tingling relief. Her entire body relaxed, and she sighed.

By then, Sabina had returned. She stared at Maggie from the kitchen door, holding a bag of ice against her own back.

"Go find Artur," Maggie said. "He said the doctors would take care of your injuries."

Sabina left without a word or a nod.

Artur's doctors didn't think Sabina needed much rest. Her youthful body could take the wear and tear, they said, like she was a set of tires. They gave her an injection of platelet-rich plasma to speed her healing. After two weeks of light exercise, training began anew.

Every morning, Maggie found Sabina in her sparse room, sitting on the plain white bed, gazing at the pines outside. They'd go through the routine—five miles on the track, then weights. Maggie would watch the sports channels while Sabina did her workout. They were abuzz about the dark horse gymnast from Uzbekistan, more so as the Olympics in Nairobi grew near.

"You know," said a broadcaster wearing a three-piece suit. He gesticulated every word. "Sabina is being trained by Maggie Greenburg, if you remember her. She won ten medals in two Olympics, her specialty being the uneven bars."

"Where's she been?" the other broadcaster asked, a woman in a tailored pink jacket.

"You know, she retired at twenty-two. She couldn't even do the circuit after a major injury in the Tokyo qualifiers eight years ago. There were rumors she went through rehab. Off the radar ever since."

"That's too bad."

"I know, but, you know, Sabina's coach was smart to choose her. Judging by that broken finger in Montreal, Sabina is driven to win, no matter the pain. She pushed through her injuries to take gold on floor exercises, but she needs grounding to last through the all-around. And if anyone understands firsthand how far you can push the human body, it's Maggie Greenburg."

Yes, Maggie knew. They showed how she knew, too—old footage of Maggie performing a series of flips, bouncing around the uneven bars like a flywheel in a fog of white powder. Then she missed a catch, flew into the other bar, and slammed against the ground. The TV showed her collapsed beside the apparatus, her legs skewed, unable to move. The audio wasn't there, but clearly she was crying out. Her coach and family ran over. The crowd rose, covering their mouths.

"Heartbreaking stuff," the woman in pink said. "I'm sure Sabina will have better luck in the upcoming games."

The TV showed a picture of Sabina back in Uzbekistan, standing before some dusty hills. She was smiling, slightly out of focus, arm-in-arm with her parents.

Maggie looked at the real Sabina, wondering why the girl couldn't smile like that anymore. Sabina had a sweaty, satisfied grimace, pumping the dumbbell harder rather than slowing down.

Maggie noticed an imbalance in Sabina's lifts, one side slightly lower, slightly jerkier. "Keep your legs even," she said.

"I am," Sabina grunted.

She was right. Her feet were planted correctly. Still, she was leaning, and her back muscles twitched wildly.

"Stop," Maggie said.

Sabina didn't. "Fifty, you said."

Maggie grabbed the dumbbell. "I said to stop."

Sabina dropped it suddenly. Maggie lurched forward as it slammed into the floor. Pain surged across her back. She fell to her knees and held herself.

Sabina limped away.

"Sabina—" Maggie started.

"I'll ice it!" Sabina shot back.

Maggie reached into her pocket and took another pill. She chewed instead of swallowing it whole, letting the bitterness fill her mouth, knowing that would stop her pain quicker.

In less than a minute, she could stand again. She was nauseous, but she could limp to the phone.

The doctors checked Sabina, but they wouldn't tell Maggie the results, as usual. They just said she'd be good for Nairobi after another infusion of platelet-rich plasma.

Maggie, on the other hand, had a herniated disk. The doctors were kind enough to examine her and said she shouldn't tax herself, or chew the pills again. At least the cortisone injection they gave her lessened the pain.

She and Sabina would sit on the couch watching TV; Maggie fidgeting to find a comfortable position and Sabina just staring forward. Maggie had given up trying to talk to her, but she still regarded Sabina with envy.

The plasma infusions weren't anything to take lightly. Sabina wasn't allowed to take any painkillers while they did their work, not even simple remedies like ibuprofen or ice packs, because inflammation sped the healing. Maggie had the procedure before, and, after five days of feverish suffering, swore never to have it again.

Yet Sabina was completely fine with it. She was unhappy she couldn't train, but she didn't seem to be in agony, just bored.

During a story on the Kenyan endurance runners, Maggie's back felt particularly bad. She couldn't sit still at all, to the point that Sabina glared at her across the couch.

"Why are you doing that?" Sabina asked.

Maggie frowned at that silly question. Still, she stated the obvious. "I hurt my back."

Sabina looked at the TV again. "Just ice it," she mumbled.

Maggie sighed and grabbed another pillow, shoving it behind herself.

A week later, when Maggie felt well enough, she packed her and Sabina's luggage in preparation for the flight. Mostly she packed for herself because Sabina had little to take. No books, no toys, no mementos, just clothes and shoes. The doctors would put together other provisions.

While Maggie folded one of her track suits, a piece of paper tumbled out of the pocket—a business card from the anti-doping agency. The inspector must've slipped it in Maggie's pocket back in Montreal. She had written something on the back.

"Please let us know if you've seen anything suspicious about Sabina."

Maggie shook her head—not because she hadn't seen anything suspicious, but because suspicious methods were par for the course. Exceptional athletes did exceptional things. Difficult things. Uncomfortable things.

Maggie reached for the bottle of pills on her nightstand. Just one rattled inside. She needed a few refills before spending the next month in a foreign country.

She went to Artur's office. His door was open, and his TV was tuned to ESPN, but he wasn't in. Working on the routines with Sabina, most likely.

The filing cabinet was open, a bulky folder on top. Sabina's birth certificate peeked out of the stacks.

Maggie looked around. The TV's sportscasters were her only company, so she reached into the files. There were random effects—passports and old photos, inspector reports and event registrations, maps and medical records.

She found a familiar photo of Sabina, the one used in all the news stories, scratched and surprisingly yellow. Someone had written on the back in Uzbek, but she could make out the date, five years before, though the girl looked the same age as Sabina did now.

Maggie glanced anxiously at the door, then dug into the folder again. At the back, she found a document in Korean. The logo in the letterhead had a blue double helix. It looked like a medical bill, and a hefty one at that—more than five-hundred million *won*. Half a million in American dollars. Part of the bill was in English. Some numbers, some letters, some comments about enzymes and sodium channels. A's, G's, T's, and C's all over the place. Then—

The defective SCN9A gene was identified in isolated Uzbek population with pain insensitivity. Donor sperm and eggs were taken from male and female with recessive defect. Twelve fertilized zygotes reached blastocyst stage. SCN9A defect found in three. Eight had the recessive gene. One completely lacked the defect.

An unaffected zygote was selected for implantation. Cells were aspired from the mesoderm of a defective zygote and replaced in fraternal target. The modified zygote was implanted in surrogate mother.

Gestation of female lasted 287 days. No severe developmental problems or natal incidents observed. Due to germ layer separation in blastocyst, pain insensitivity only manifested in musculoskeletal structure of the female child, from the defective gene in the mesoderm. Normal nociception confirmed in organs and skin after birth, developed from the nondefective genes of the unaffected germ layers. A successful chimera.

Maggie shook her head. "A chimera," she whispered.

She didn't understand everything in the document, but she knew what a chimera was. She'd heard the term a million times at the games in Rio de Janeiro. The WADA inspectors found cells from two different people in the blood of one of the French marathon runners, from an illegal transfusion. He contended he was really a chimera, someone born after two fertilized eggs fused in their mother's womb.

He had been lying, but another sprinter had the genuine condition, back in 1950—Foekje Dillema from the Netherlands. The inspectors

thought she was male and threw her out because she wouldn't let them test her true sex. Later people found out she had different cells with the chromosomes of both a man and a woman, X's and Y's jumbled together.

But according to this medical record, Sabina was no accident of nature. A true chimera.

A sucking sound came from the door, startling Maggie. She dropped the stack of papers. Sabina was there, holding her protein shake with both hands, drinking through a straw . . . staring.

Maggie took a deep breath but hesitated to say anything. The girl looked normal enough. Cold, but still innocent with her wide eyes and ponytail. Did she know what Artur had done?

And did he do anything wrong? This girl would never know the ache of fatigue, the agony of a broken bone, the everlasting burn of arthritic joints. Still, Sabina didn't even seem to feel pleasure, either.

"Do you know your parents?" Maggie asked.

Sabina lowered the shake and regarded Maggie for a moment, like she didn't understand the question.

"Artur invented you," Maggie said.

"Invented me?" Sabina asked.

Maggie held up the bill. "He genetically engineered you. Do you know what that means? Just to compete, he made you like this. Pain free. Did he ever tell you that? Has he even let you play with other children?"

Sabina frowned, confused. She took a step into the hallway and yelled, "Artur! Ms. Greenburg has a question for you!"

Footsteps came closer. Frantically, Maggie tried to pick up the other papers she had dropped, but her back wouldn't cooperate. Artur strode in and saw her struggling, saw the mess.

"What are you doing?" he asked, snatching up the papers himself. "Why are you reading those?"

Maggie had no excuses, so she held up her chin, acting proud to be caught. "Sabina was a test tube baby," she said. "You created her without muscle or bone pain."

"No, she was just born with that gift."

"That's not what these papers say."

Artur looked Maggie in the eyes, his jaw set in anger. "We told you not to ask questions. Just keep her fit enough to perform. Keep quiet, and we'll make you happy, keep you drugged."

"You never said you were engineering human beings. That she didn't really have parents, that she was your slave. She—"

Artur grabbed Maggie's arm and shoved her into the filing cabinet, knocking the wind from her. She cried out. Her back muscles tightened like they'd snap her own spine.

"Those papers were a genetic analysis," Artur said. "Nothing more than verification of her special talents."

Maggie would've argued with him if she weren't in agony, if being right mattered. She met his eyes, silently asking for mercy.

Artur pushed her into a chair. She held herself while he went to the desk, jotted something, and ripped off the paper. He shoved a check into her hand. The amount was nearly illegible, but too big to ignore.

He grabbed her shoulder and squeezed. "Your work has been commendable, Ms. Greenburg," he said flatly. "Take some time off. Spend it with your parents, over in Anaheim, in the brick rambler on Highland Street. The one with orange trees out front."

Maggie couldn't reply. How did he know what her parents' house looked like?

He let her go and pulled out his phone. "Security," he said. The rest was in Uzbek.

Sabina watched, still in the doorway, still finishing her shake. She stepped closer to Maggie and tilted her head curiously.

"Sabina," Maggie whispered. "Please, you don't have to live like this. There's more than just the game. I—"

"Sabina!" Artur yelled.

Sabina looked up and asked something in Uzbek—a question, spoken with a concerned frown and a glance at Maggie. He replied in Uzbek, too, the exchange getting louder and angrier until he commanded in English, "Go take a shower!"

The girl clenched her jaw and left the room. And when the security guards showed up, Maggie left, too.

Maggie lay on the couch in her parents' house. The shades were lowered, the room dim. It was morning there, but late in Nairobi. The gymnastics finals played on TV.

She held the uncashed check in her hand. By then, it was smeared with oil from her fingers, crumpled in the corners.

The TV showed Sabina in her sequin leotard, twisting the cap from her water bottle, drinking methodically while she watched her competition on the balance beam. Artur stood beside her, arms folded, chewing gum.

"There she is," the announcer said. "Looks like Sabina knows the all-around gold's in the bag. Not even breaking a sweat."

In Maggie's other hand, she held the business card for WADA's tip line. She hadn't even dared to dial the number, in case Artur was monitoring her phone.

Maybe the inspectors would protect her. Maybe they wouldn't. Maybe the crowd would be disappointed to learn Sabina was cheating, or maybe they wouldn't even care. In the end, they just wanted the performance. They didn't care so much about what came before or after—the hard work and frustration to get there, the fallout after victory fades.

"There she goes," the announcer said.

Sabina stepped up to the balance beam, smacking the talc from her hands.

"There's that determined look we've all come to know."

Sabina sprung onto the apparatus with a back layout somersault and full turn—g-plus point value, executed perfectly. The crowd held their collective breaths.

"Brilliant," the announcer said.

Like a pulley over a wire, Sabina tumbled, not even a wobble as she continued the routine. The bleachers were silent except for the hums of appreciation.

Then Sabina made the slightest misstep and almost fell off. The crowd let out a tiny gasp as Sabina made an uneasy adjustment. A look of worry flashed on her face.

Maggie sat up and leaned toward the TV. Sabina's back was twitching, overtaxed. Right through the sequined spandex, Maggie could see that.

Sabina somersaulted the length of the beam and slipped on the landing. She didn't fall, but the crowd began to mumble as she recovered.

Maggie shook her head. "Don't try the flip-flop. Dismount."

Sabina started a flip-flop but slowed in the middle, with her hands clutching the beam. Her entire body trembled. She pushed through and stood again, then took a deep breath.

Artur tentatively lifted his hand, trying to signal his concern yet at the same time hide it. For a second, Sabina seemed to heed the warning. She frowned with her usual disgruntlement but stopped as if she'd step down.

"Looks like she might be injured," the announcer said. "A tragedy, because there's only one requirement left in—"

She leapt into a clumsy back salto. Halfway through, her head knocked into the beam with a sickening crack. She plummeted to the floor, a mess of limbs.

The entire arena gasped.

"Oh, my God . . ." the announcer muttered.

Artur ran over first, then the cameraman. Sabina was still conscious, still moving. She pulled herself up with the beam, showing more annoyance than agony, her hips skewed, her left arm and leg dangling. Despite that, she attempted her finishing pose. Only her right side cooperated. With pride, she gave the crowd a lopsided sneer.

Artur threw his jacket over her and pushed away the camera.

Maggie raised her hands to her face, dropping the check, the card. She didn't want to cry, if Sabina wouldn't even cry for herself. But Maggie still did. ■

Mathematics

I once understood the formulas,
the mathematics of timing,
the algorithms of risk,
the calculus of forgiveness.
Now I'm not so sure.

In my youth I questioned
the square root of sacrifice,
the bleeding radical abundance
nailed to the tree of algebraic marvels.
Now I wonder if I can spare some change.

Then, we relied on the multiplier:
a token of kindness seven times
the reciprocal of grief circulating like
a lucky coin, the currency of children.
Now my pockets are empty.

If I open a book from my youth
and discover a page of arithmetic homework,
would I recognize the penmanship—
the confidence of the sevens,
the passion of the nines,
or the prime mystery of eleven?

Now and then I seek proof in the missing
pieces of this equation,
something less than the sum of all
its broken parts.

Across this gap of time,
this spectrum of differentials,
this range of all things being equal,
I find myself on one side,
and you on the other.

—John Ciminello

Illustrated by Joel Iskowitz

Sentience Signified

J.L. Forrest

We made our first studies of Joon at 1,089 kilometers, mean low orbit. The world filled a 160-degree arc in our planet-side viewports, an enormous violet and blue disc capped at its poles by ice. Land constituted 50 percent of Joon's surface, the rest water with only two major seas: one centered on the equator, 3,113 klicks east-west and 3,948 north-south, the other nearer the south pole. Islands freckled Joon, few dominant to any other. Not seven continents but seven hundred thousand islets, a hundred major archipelagos complete with volcanic chains, salt seas thicker than Earth's, pleasant enough weather punctuated with frequent clouds and pummeling rains. Rain moved across a third of the surface, two hundred million square kilometers of light drizzle to hurricane flood. Joon wasn't Earth: gravity one-point-two standard; oxygen rich, enough

that field scientists without rebreathers would feel high as kites, ferrous metals would rust at twice the rate they would back home, and fires burned twice as fiercely; thirty-three trillion mature tree-like organisms. Shortly after arrival we stopped calling them this and simply referred to them as *trees.*

Above the blue-white arc of Joon's sky shone two major moons, the ash-gray Orelius and rust-red Corius. Eleven minor moons followed stable orbits, all visible from the ground at some time or another. A cushion of low clouds eased across the sky. Above the firmament, the exploration vessel *Curiosity* orbited at twenty-eight thousand klicks per standard hour, but during the day Bilit couldn't see her; at night the ship glistened in the light of Joon's primary star, Piscium.

Renamed Secundus by the team, the secondary star resided nearly twenty AUs away, merely another bright point among the constellations. The two stars orbited one another, so Secundus followed its own arc as seen from the ground, independent of the rest of the Universe.

For three months the *Curiosity* studied the system from asynchronous orbit. The crew deployed satellites that established communications, sensor and power arrays, and a defensive net.

We won't need that here, Bilit thought, but the decision to waste payload on defenses had belonged to bureaucrats who were likely long dead.

He stood on a grassy escarpment overlooking a scalloped valley. From edge to edge, trees packed freshwater drainages as densely as in any rainforest on Terra, yet no one could mistake this place for Earth. Every plant, as loosely as *Curiosity's* biologists classified them, leafed in purple shades. A breeze touched Bilit's cheek, and the entire forest responded to a rolling north wind. The treetops undulated in faint lavenders and deep violets. Nearby, the broad serrated leaves of native trees whispered like any tree on Terra.

Bilit wiped a tear from his eye. He removed his rebreather. For a few moments he breathed the Joonian air, but soon his head swam, and he felt made of the air itself. He replaced the rebreather to recover from the oxygen high.

He stood in a plum-colored field that reflected the barest emerald. The majority of Joon's life photosynthesized, plant and animal.

Purple rhodopsin, Bilit thought, not green chlorophyll.

The biologists had not yet determined whether the kingdom *animal* could apply to Joon's more mobile and often intelligent life. Some so-called animals utilized cellular walls, while others did not; some so-called plants employed proto-muscular structures, but most did not. The boundaries between plant and animal proved uncertain on Joon.

Bilit kneeled and placed a gloved hand near a tuft of long grasses. They leaned from him.

"Remarkable," he said.

Bilit traveled with ample protection. A light carbon exoskeleton compensated for Joon's 1.2g. Nonetheless, he felt the gravity in his internal organs, on his skin and bones. Mission command preferred field scientists keep excursions to four standard hours; Bilit liked fourteen. Yet while the exoskeleton gave him a gorilla's strength, pressure on his lungs and intestines took its toll.

Gravitationally aggravated exhaustion.

Four robotic spiders accompanied Bilit. The eight-legged carbon-titanium AIs followed complex algorithms, but they extended Bilit's body and mind. Their wifi communicated with nanite arrays in Bilit's brain. He felt, touched, heard, and electroreceived through their sensors. They could prompt him to peace or alarm, or allow him to better observe. The spidery sentries needled gracefully over nitrogen-rich exoplanetary soil and through tangled undergrowth.

Bilit stood at the jungle's verge. He left his armored dhopter parked on the grass, the vehicle folded on itself. Bilit stepped into the shadows beneath the canopy.

He was born in the Freestate of Chicago. After an illustrious academic tenure, thirteen years' service in the Terran Science Corps, two Martian tours, and a Magisterial Honor, Bilit volunteered for the *Curiosity.* He trained with the crew for three years. Six days before *Curiosity* left Earth's orbit, mission command administered Bilit a fatal dose of sodium thiopental and pancuronium bromide. His heart stopped within seconds.

As Bilit walked through the southern jungles at Joon's sweltering fortieth parallel, he struggled for scientific objectivity. What wonder! Centuries might pass before ecologists could build a reasonable taxonomy. He saw beauty and all the bases of biological life as they existed on Terra, made breathtakingly different. Life in distinct fractals, colors, and patterns subtly or shockingly unfamiliar; life at a pace quicker.

Here too he found Darwinian laws; everything became food for something else. Creatures filled each niche—bug-like, pests, parasites, herbivores, flesh-eaters, crawlers, swimmers, climbers; the camouflaged, the rapid, the vicious, the cooperative; flyers and gliders; the armed and armored. For the first time, Bilit felt visceral dread that something might prove big enough, fast enough, or aggressive enough to overcome the sentries, to shred his armor, and to eat him. Hydrogen, oxygen, carbon, nitrogen, sulfur, and phosphorous—any flesh-eater on this planet could digest Bilit quite well.

Praying mantises, he thought, hexapodal traits, but not those of Terran insects.

Most Joonian life exhibited no insect-like traits, save for size and niche. Lithe-limbed herbivores or powerful predators, whose back four limbs synchronized tetrapodally, perambulated as efficiently as any jaguar. Many animals, plant-eater and flesh-eater, possessed forelimbs for grasping or cutting, some with prehensile digits. Animals chased each other through trees or undergrowth. Bilit smiled at the *noise*.

Cries and chirps and chatters. Calls and carols. Growls. Clicks. Animals shook and raised bristles.

He looked closely at these—not mammalian, but something between fur and feathers, hairs that grew smaller hairs. On some organisms it looked worth a cuddle, save many possessed a row of pearlescent, shovel-shaped, razor teeth. Other creatures grew fur in latticed, armored coats. Toothy and tough.

Bilit recorded images and dictated his notes. He collected samples. He drank the splendor that here, two-dozen light years from the mythical Garden of Eden, existed the real thing. It had evolved from its own DNA helix for hundreds of millions of years.

We were never alone, he thought, and twenty-four light years is our next-door neighbor. It's nothing. What abundance the Universe must hold!

Next door, but *Curiosity* had needed two hundred years to cross that distance.

Six months before liftoff, the crew underwent treatments. Engineers applied nanites designed to augment biomechanical performance, to supplement active cells, to strengthen bone, to reinforce muscle.

"I thought the idea was to kill this body?" Bilit had asked them.

"We'd like you to get accustomed to high-level augmentation now," they'd replied, "way before you reach the other side."

Artificial neurons sidled to living neurons, mirroring the host's connectome. Too expensive and impractical to ship several hundred living bodies 2.24e+14 kilometers, so the neural nanites created a continuity of consciousness, which allowed the crew to survive death, to sidestep the Lockesian problem of broken identity.

Bilit had signed on without a second thought. *Stars, here I come.*

A pack (a herd, a gaggle, a troop?) of Labrador-sized omnivores crossed Bilit's path. He recorded them while his sentries established a defensive perimeter, five meters to a side. As an extension controlled by his neocortex and amygdala, Bilit trusted the sentries. Their response resembled a first jolt at any startling movement, driven by the amygdala, then rationalized at higher levels.

Scientists had designed the sentry algorithms, not soldiers. They would be slow to violence without some intentionality from Bilit's frontal lobe.

Unless shit got really serious.

The labrivores had evolved hexapodally. They walked on four sturdy limbs, three-toed feet negotiating each step. Hinged claws grew from a bony extension glazed by violet enamel, weapons not at all like Terran chitin. Their short thorax sported prosimian front limbs, ending in prehensile paws—two fingers and one thumb. The labrivores picked through undergrowth, pulling roots or snatching smaller creatures, spitting out what they disliked.

Their brown and violet feathery fur camouflaged them.

Bilit stepped forward. The lead animal stood on its hind legs, its front legs and arms hanging. It faced him, thirty meters distant, and raised its head. Its slender nostrils flared.

The animal squeaked and the troop ran, crashing through the undergrowth, their short-tailed rumps bobbing up and down as they disappeared into the foliage.

Bilit examined the vegetation along their path. He noted what they had eaten or expectorated. He collected tufts of feather-fur, as well as stool for the laboratory.

He looked up. Animals climbed and swung and jumped through the canopy, their bodies tinted like amethyst, serpentine, or amber. They jostled and played and fought. He observed degrees of prehensility in proto-hands and tails. He found binocular and omnocular vision in creatures with two, four, or eight eyes. One species' hind legs had fused evolutionarily with a long tail, and Bilit wondered what ecological advantage this offered.

He looked down his exoskeletal legs into the scrub. Ten thousand species surrounded him, many more if he included microbes. A thousand tree species grew within the hectare where he stood, their evolution constrained within their genotype-environment expression, guided by similar forces to those which existed on Earth.

Life, Bilit mused, might be both wildly unique and astoundingly predictable on every Earth-like world in the Universe. Yet the forms of Joon's life varied from anything that Bilit had known before, variations that stole his breath at every turn.

He lifted his chin to feel Piscium's rays on his face, filtering through the garnet canopy. The Universe admitted nothing but causality and quantum mechanics, but in that moment, Bilit felt nothing but magic.

The AI that piloted *Curiosity* had woken the command crew as she'd entered Piscium's Goldilocks zone. She began printing their new nervous systems eleven months prior, constructing a lattice of neural tissues around the crews' sleeping synthetic nets. The AI completed their bodies with carbon, calcium, and potassium retrieved from Joon and its star system. Body-printing in situ offered advantages—accommodations for unexpected local conditions, as well as avoiding degenerative conditions and cellular errors associated with long suspended animations.

The crew awoke with their continuity of consciousness intact, identities unbroken, on approach to an Earth-like world twenty-four light years from home. The journey had taken over two centuries. Upon arrival, command deployed robotic explorers and satellites, established orbit, and gathered oceans of data. Orbital arrays transmitted reports to Earth, missives that would not arrive for twenty-four years.

They received news too. Transponders stacked every incoming message that had originated from Earth since the moment of their departure until twenty-four years before their arrival. The crew opened an extra bottle or two of champagne; it appeared the Terran race had survived the last twenty decades, despite one last global war, several nuclear disasters, and continued suffering which remained despite heroic efforts. Among thirteen billion, four billion suffered on in poverty.

Ten-year-old messages arrived from the Gliese system, as well. *Curiosity's* crew marveled at this. When they had left Earth, no planned mission to Gliese 105 existed. The Gliese mission departed *after Curiosity,* but it arrived at its destination forty years before. Aerospace technology had improved.

In expectation of *Curiosity's* arrival, Gliese had transmitted schematics for an ansible, a device that employed quanta and variations in the so-called gravitational constant to transmit data faster than light—or rather sidestep relativistic limitations entirely. No such thing as warp speed existed yet—the trudge between stars remained—but useful messages became possible.

On the first successful test, *Curiosity* sent the message: HELLO, GLIESE.

Four minutes later, Gliese replied: WELCOME TO THE FAMILY, JOON.

This warranted yet another bottle of champagne. The deep freeze had preserved it well, bubbles and all.

The naturalist John Burroughs wrote, "Love sharpens the eye, the ear, the touch; it quickens the feet, it steadies the hand, it arms

against the wet and the cold. What we love to do, that we do well. To know is not all; it is only half. To love is the other half." Burroughs would have loved Joon as much as his treasured Catskills.

Bilit waited for dusk before setting base camp. His sentries established a perimeter. Assembler robots raised a tent and tarp. Bilit eschewed the sturdier structures preferred by most other field scientists—the hard-shelled erector sets, the nano-assembled arcologies, the mobile labs. He valued the tent's simplicity, its tininess, the way the membrane left so little between him and the waving grasses, the blowing trees, the singing leaves, the thousand animal calls. Insect-like animals moved through the air like Terran eels moved through water. They oscillated more like centipedes than flitted like mosquitoes, trilling sometimes quietly or other times in cacophony. Once every few minutes, their bodies blinked like Christmas lights and then darkened again.

Protected by the tent's filtration, Bilit rested without his rebreather. He lay on his back, hands folded on his stomach, smiling as he fell to sleep.

No sentient life, the first robots and survey teams reported. Aerial reconnaissance never touched ground. They composited low-orbital data with drone scans and high-speed manned flights. Within five weeks, they surveyed a fifty-kilometer grid above Joon's entire surface.

No sentient life. Sentient was defined as exhibiting one or more of these: the ability to solve novel problems through creative approaches; language; compound tool making; or complex cultural transmission, verbal or otherwise. Recon searched for domiciles, villages, towns, or cities. They found none. They identified no alterations of land, no agricultural patterns.

No sentient life, they reported. Proceed with Phase I ground reconnaissance.

No sentient life.

Bilit awoke to rain. For a while, drops pattered on the shell and then, for seventeen minutes, became a deafening kettle drum. Bilit lay still, hands still folded on his stomach, eyes open to the dark. For the moment, he retained a normal optical range, which meant he saw nothing. He focused his other senses. Joonian rain almost smelled like Terran rain.

The ground gave off a scent of soaked clay and loam. Plants smelled like plants, but an unfamiliar pepperiness spiced the forest. The jungle resounded with strange animal cries.

Something walked through the underbrush, somewhere beyond the sentries. Bilit guessed its size between a deer and a horse, moving quadrupedally but undoubtedly a hexapod, forelimbs for other tasks. He heard only one, and it circled his camp not once but twice.

An unusual visitor, he thought.

At last he modified his vision and the tent interior resolved in pale grays and blues. He sat up and turned his head, augmenting his hearing, the nanites within his skull reconfiguring to the purpose. He detected deliberate steps, twenty meters distant, just beyond the sentry line.

Something tapped solid wood, but no lignified plant grew so close to his tent.

Carrying a tool, he thought, and his heart raced. His adrenals stepped into high production. He forced himself to calm, to temper his excitement and unbidden fear. Tools meant intelligence, and intelligence suggested real danger. The approaching visitor took another tentative step forward, followed by another—

The sentries triggered their first defenses. Eight hundred lumens turned the pitch black into a blinding violet-white, and a whine echoed from their speakers. A powerful blow knocked one sentry onto its side. The visitor fled into the jungle, and, as it crashed through the undergrowth, the pattern of its feet or hooves reminded Bilit of an antelope.

The sentries ended their alarm, but their lights remained. The fallen robot righted itself and suffered no further attack, but Bilit waited before stepping from the tent, his rebreather restored to his mouth and nose. The moist night raised goose bumps on his naked body. He examined the damaged sentry—a long scratch ran across its LED shield, but it showed no other damage.

That shield, he considered, was made of diamondide.

He searched the grasses and found a rigid two-meter shaft of lignified plant fiber wrapped by a braided cord. A sharp point,

fifty centimeters long, emerged from one end. A spear.

Within his ear, his comm beeped. "Bilit, this is Stephanye. You all right?"

Curiosity's primary AI, Stephanye, would have detected his sentries' defenses. He replied through remote satellite array, "I'm in awe of the Universe."

"Can you clarify?"

"Sentient life."

Silence. Then, "The patterns recorded by your sentries suggest a high probability of sentience signified."

"I'm looking right now at one beautiful example of a tool."

"Did you sight the life form with your own eyes?"

"No, unfortunately."

"Can you record the tool in situ," the AI asked him, "and then bring it in for analysis?"

He sighed. Hands akimbo, he looked out into the darkness, though his low-light vision revealed nothing but silvery trees.

"I'm tempted not to," he replied.

"Reasoning?"

"It doesn't belong to us, and I'm not sure we should begin first contact by stealing."

Hesitation. Then Stephanye argued, "We can borrow it then."

Back upon the *Curiosity,* Bilit walked the outer corridor alongside a foglet projection of Stephanye, a being as physical as he but capable of vanishing in a millisecond, of reconfiguring herself into a new form, of translating herself to any part of the ship. Dark hair pulled back in a bun, bright blue eyes, straight-lined white suit—an entirely computer-generated beauty. She carried an old-fashioned clipboard and wore anachronistic glasses. Bilit mused that this merely added to her appeal.

"Why the glasses?" he asked the AI.

"They look cute," she replied.

"Why would you, an AI, want to look cute?"

She affected a shrug. "It makes me happy."

"Tell me, Stephanye, can you truly feel happy?"

"Emotions occur in the brain," she said, tucking a wooden pencil behind her ear. "They're cognition. I cogitate better than you do. Ergo not only can I feel happy, Bilit, but I can feel happier than you can."

He smiled in amusement. "Is that so?"

"It is."

They joined Reginald in the port laboratory. The spear hovered within a scanning chamber. White light contrasted the earthy tones of the spear. The haft was of a fine-grained pale wood, five centimeters in diameter. Its grains held the preserving oils of other plants, as well as old sweat. For one hundred twenty centimeters of its length, a braid of woven grass wrapped the shaft. Elaborate knots held it in place.

Bilit pointed at these. "Designed grips, craftsmanship, and singular care."

Another cord and a splint held the dark-gray spearhead. Its nonferrous edge could flay meat from bone. A capable thrower could drive such a weapon through a man's body.

"We're still having trouble," Reginald said, "distinguishing any familiar DNA sequences here, but we found remnants of many animals' DNA imbedded behind the spearhead." He adjusted his well-cut shirt collar as he examined two holomonitors. His trimmed hair contrasted with Bilit's, who like many field ecologists cut his perhaps once per month. "My bet is this weapon has killed many times."

"What life forms would it have killed?" the AI asked. "A cross-section of animals for consumption, or enemies and other predators?"

Reginald shrugged. "With these data alone, we've no way to know, but food animals is a safe assumption."

"Food for what?" Bilit asked.

He leaned close to examine the wrappings, and then he looked at them under magnification. Faint blue threads interlaced with the purple-brown of the wrapping.

"That's not random," he said.

"My conclusion, as well," Stephanye said. "Hypothesize writing?"

"Insufficient data," Reginald said. "Let's not get ahead of ourselves."

Bilit shrugged. "Who knows? But someone took great care making this. No idea what the DNA says about the owner?"

Reginald hemmed and hawed. "Probably omnivore, certainly vertebrate."

"Not much else, huh?"

"Nope."

"That's not illuminating."

"No baseline, you know?"

Stephanye touched a manicured finger to her lips, her eyebrows drawn down in an AI's simulacrum of thought. "It's your grid-sector, Bilit. How do you wish to proceed?"

"You'll inform the other field ecologists of the sentience signified?" he asked.

She nodded.

He looked again at the haft's intricate stitching. Every quality of the weapon indicated frequent use and loving upkeep.

"Someone values this," he said. "Its owner will return for it."

"You're bringing it back to the surface?" Reginald asked.

"It's polite to return what you borrow."

Stephanye nodded. "Take another contingent of sentinels with you," she said.

"No. Only one sentry this time."

"That is inadvisable for your personal safety."

"Agreed," said Reginald, "we don't know how dangerous a species we're talking about."

"Perhaps not," Bilit said, "but it *is* the best course."

"Reasoning?" Stephanye asked.

"Last night a sentient native encountered an alien species—me, and I frightened it. All bright lights and scary noises. We were only missing the tractor beam and the abducted cow. I'd like the next encounter to be peaceful."

Reginald nodded, understanding perfectly, and the AI readjusted her model of human values.

Bilit left his dhopter on a wide stretch of silicate beach, white sands dividing gray-blue seawater and mauve jungle. Strong and complex forces left Joon's beaches wide and clean—eleven moons, not one—and on a bright day the waters became translucent aquamarine to the bottom. The sea teemed with life, but it would be months before *Curiosity's* undersea explorers began their work.

Clouds lent the landscape a peculiar heaviness. Lightning glittered on the horizon beneath weighty black thunderheads. Bilit guesstimated the wind's direction, but it mattered little whether this storm struck the island or not; rain fell everywhere. He looked out at other nearby islands, some close enough to distinguish individual trees, others so distant they appeared as hazy smears.

Bilit's heart swelled.

He walked the beach, following GPS to find a path inland, and he carried the spear with him. He wanted to return to the escarpment meadow—he called it *Spear Meadow* now—as efficiently as he could. The walk reminded him of beach strolls on Earth, as if Jimi Hendrix had sung the Indonesian islands into existence. At one point, Bilit removed his footgear and walked barefoot, curling his toes in the sand. He realized the foolishness of this; early data indicated many venomous lifeforms on Joon, most of which could kill a biological transhuman like Bilit, or at least make his life extremely unpleasant.

He replaced his boots, walked near the trees, and found a log-carved boat. It had long lain abandoned, dried, cracked, and bleached in the rain and daylight. A broken oar rested beside it. Bilit transmitted images and three-dimensional point scans to *Curiosity.*

"Are you getting this, Stephanye?" he asked through his comm.

"We are," she replied. "I'll inform the nearby teams and field ecologists."

"We shouldn't be surprised."

"The ability to construct a composite weapon suggests sufficient skill to construct a boat," she said. "The islands are proximate enough that no open-water navigation would be necessary. We can assume localized travel or extended migration."

"Does this lead you to other hypotheses?" he asked, looking up and down the waterline as if the boat's owner might return at any moment.

"We can presume extensive sentience upon Joon," the AI said, her voice melodic, "at least at some range from the fortieth parallel south. We can hypothesize trade and assume some of their diet is marine. Low population density and reproduction rate appear evident, suggesting long lifespan and high survival rates past some critical age. Odds are more remote on maritime cooperation, organized government, or extensive codified laws."

"Anything else?"

"They make fire, at least on occasion."

Bilit furrowed his brow. "How can you tell?"

"Your scans indicate the boat is fire hardened."

He knelt beside it. Bilit couldn't tell whether the wood had ever been fire hardened or not, but he trusted Stephanye's analysis.

"They spend most of their time in the jungles," she continued, "deep beneath the canopy. Dispersion suggests territoriality, but we cannot know for sure. May I again recommend some caution on your part, Bilit?"

"As before, your advice is well taken, but I'll go in with some faith—"

"Faith is not a statistically acceptable basis from which to make decisions."

"I'll have some faith," he repeated, "I can make a good impression this time around. We are the interlopers, and I'd mitigate the stain of five thousand years of human invasion, imperialism, and violence."

"We all understand," she said, "and everyone trusts your approach. Other teams have reported signs of sentient life, and each has reaffirmed a commitment to protocol."

GPS plotted a likely route to Spear Meadow, and Bilit entered the trees. The canopy extended a hundred meters up; in places the undergrowth rose above his head, and he felt as if he had become an ant, crawling through the stalks and fronds of a gargantuan garden.

He followed a ridge to the north, ten kilometers through a jungle with sudden drops, ravines, and rises. He recorded major findings as he went, including a primate-like species all but furless from its middle limbs to its head. The troop grazed through the lower canopy. They hung from tree limbs, clinging with their back four feet, picking soft shoots from the branches.

How like spider monkeys! Bilit thought. How like humans! One made eye contact with him. Joonian and Terran gazed at each other for some seconds, and then the creature returned to its gathering.

Shortly after, he reached a plateau. He recognized the geology. Bedrock breeched the soils, and the trees thinned until they gave way to grasses. Bilit returned to the Meadow. He left the spear where he had found it, and then he searched for any sign the owner had already returned. Finding none, he and his sentry retreated to the trees, hid, and waited.

The engineers refined the ansible. Communication to Earth and between four other outposts became, for all intents and purposes, instantaneous. Messages arrived and returned in seconds or minutes. The data pipe was narrow *but it existed,* and it carried voice and abstract data. E.T. phoned home.

Several crew spoke with great great *great* grandchildren. Others reconnected with old friends or family whose transhuman augmentations had allowed them to thrive through the intervening years. Many a conversation led to tears, joyous or sad.

Of five near-system missions—twenty-five light years or less—all confirmed worlds that could support humans or augmented humans. Four reported at least one planet with bacterial life; three, worlds rich with multicellular CHNOPS-based life, none sentient; one, a Goldilocks-zone gas giant where radically un-Terran creatures sailed within the clouds.

All but the Joonian mission had established bases on bacteria-only worlds or on moons amenable to terraforming. To create human-hospitable planets would take centuries, but hollowed asteroids and protoplanets already hosted colonies at Goldilocks, reflecting daylight into their cores, centripetal spin equal to one g.

Humanity undertook its excursion to the stars.

Bilit waited hours. After months on the island, his lungs and muscles and guts felt more accustomed to compression, so he didn't mind the wait. He had logged more hours than most of his peers, recorded more species, and constructed a more complete taxonomy of his local ecosystem than had anyone else. He preferred solitary work, unlike most others, who collaborated daily. He imagined himself a twenty-third century John Muir.

Rain drowned the jungle, cascading over Bilit's body, dripping into his eyes, sometimes interrupting his rebreather. The rain cut visibility to fifteen meters. It barred any chance he might hear the approach of anything smaller than an elephant.

After three hours, the rains ceased, and an elegant mist clouded the meadow and treetops. The jungle quieted; all its denizens held their breath and some minutes would pass before the cacophony began anew.

The rustle of leaves, a series of cautious footfalls—the spear owner approached. She reached a tentative hand from the tree cover and brushed a frond aside to watch the clearing.

Is it a she? Bilit wondered. Almost androgynous, but so feminine. He scarcely saw her face, but she possessed eerily humanoid features, bowed lips, a slender nose which seemed both human and feline. Her eyes glittered sharp tourmaline. She held back the leaf with a five-fingered hand—three fingers and two koala-like thumbs. At the ground appeared just the hint of a unique foot structure, two splayed toes to the front and two to the back, with a dew claw at the hock joint. Sharp claws adorned her hands and all four feet.

Brown-violet fur covered her from her midbody through a lion-like tufted tail. Longer fur ridged her spine. Save for that ridge, which began above her forehead, the rest of her thorax was hairless. Though her lithe muscles and lean anatomy suggested that of a strong woman, she had no breasts.

Though everywhere the field teams found sexual divergence similar to that in Terran species, no one had observed anything like placental mammals on Joon. Every creature ate vegetation or meat from its first days.

A centaur! Bilit thought. This first impression stuck with him, though nothing about her appeared horse-like. Her hind-body seemed more like a gazelle's; her feet almost goatish; her thorax and chest uncannily human, all of her structure with a dancer's lightsome muscles. Her bone structure seemed prepubescent, though he'd no idea whether Joonian creatures experienced puberty; in any case she acted as an independent adult and engaged her environment accordingly.

She held a spear in her right hand, a weapon almost identical to the one she'd come to retrieve. Bilit remembered the Ancient Greeks, always carrying two spears and for good reasons. She wore a braided belt around what he thought of as her human waist, and from it hung a scabbarded longknife. On her gazelle-like back, she carried a pack and ample supplies. Weaves with colored stones decorated her zebra-like mane from her crown to her tail set. Her tapered ears flicked as she listened to the jungle.

Bilit's heart thumped so loudly he feared she could hear it, but she took one hesitant step into the open, followed by another. She circled the clearing nearer to the trees, and, for a few moments, Bilit expected she would approach within only a few meters.

Instead, she examined the trees, saw nothing, and drew closer to the fallen spear. She examined the ground, sniffing, her ears laid half back against the sides of her head. She held her other weapon in both hands, followed some pattern in the grass, and looked up—

—toward Bilit.

His gut tightened. He froze, not daring to blink. Of course she would notice details! Of course she would be able to track!

The centaur glared into the trees, looking nearly at him but not seeing him. She reached down, took hold of her fallen weapon, then stopped, slack-jawed at what she saw there.

Take it, Bilit willed her.

She grabbed both her spear and the spool of woven nanofiber that he'd set beside it. She looked up again in his direction, now holding both spears in her right hand. She turned toward him, took a few steps forward, and tilted her head.

Shit, Bilit thought. Shit, shit, shit.

She took a few more steps, now only fifteen meters away. She passed a spear to her right hand, holding them both with a steady ease, the shafts crossed just beneath the spearheads. She took another cautious step—

—and Bilit stood slowly, his hands up, palm outward. He neither smiled nor frowned, trying to make no expression whatsoever. Who knows what a smile means?

The centaur's muscles tensed like bowstrings, her every fiber ready to run or to attack. She leaned back on her legs, and the corners of her mouth drew downward.

Who knows what a frown means?

She took several steps back.

"I hope you like the gift," Bilit said.

Another step back.

He continued, "We really do come in peace."

"Sörd!yeus çarad!ya eylamya cç!yet," she said, and though her voice too sounded passably human and female, she made sounds which he could not.

He raised his hands farther. With some will, he kept his sentry behind him, but the AI's algorithms wanted to place the sentry in harm's way, to establish a shield between Bilit and the centaur. Yet Bilit suspected anything that looked too much like magic would frighten her—or anger her.

"I hope we get to know each other," he said and, just as slowly as she had, he backed through the trees. The sentry followed, its defenses relaxing by degrees.

This is enough contact for now, he thought. Best not to push it.

The centaur ran the other direction, and Bilit watched her bound toward the undergrowth at the far side of the clearing. She gave one strong kick, leapt with her tail held high, and disappeared into the amethyst verge.

Definitely female, he thought. Field biologists had seen closer standard sex differentiation on Joon than in some instances on Terra. Bilit had yet to record any variation as extreme as, say, the female spotted hyena.

Though the danger of the moment passed, Bilit's heart continued to race. He'd never seen anything so beautiful in his life.

"For sure," Reginald said, *"centaur* still works. The word had nothing to do with horses."

"It was the closest thing I could think of," Bilit said.

"I see why."

They sat in *Curiosity's* starboard observation deck. Panoramic windows showed the arc of Joon's horizon on the left, Orelius in full view before them, three-quarters lit by Piscium. The spangled infinite blackness of space extended to the right. They watched the replay of Bilit's encounter, recorded by ocular cameras and by the sentry. The holomonitors emphasized detail that Bilit had missed at the time.

"The entire corps is talking about it," Reginald said. "Word has spread to the other systems, back to Earth. The ansible has made you an instantaneous interstellar celebrity."

"Just what I didn't want."

"Dignitaries are tripping over each other. They want to ask you one on one what it was like. They want to share the experience with *billions."*

"The last thing I have time for." Bilit pointed to the holomonitor. "She and her kind are far more important than any public-relations opportunity."

Bilit leaned back in the black leather couch, kept there by a half-kilometer thick, kilometer-diameter cylinder spinning at seventy meters per second. It completed a full rotation every forty-five seconds. The relative motion to the planet left Bilit faintly nauseous, or perhaps the feedback loop of popular-science idiocy made him sick. The planet eased into the center of his view and then began to slide to the right.

"It's not vicarious nothings," Reginald said. "The entire human race has an enormous right to elation. We're not alone! They want to know something about our newfound cousins."

Bilit sighed, his shoulders sagging. "I understand, but they can read the field reports and digests. They can wait for good science, not a factually bereft stand-in for it. We'll make qualitative statements when the field ecologists and xenologists reach reasoned conclusions. Nothing could be more important than getting this right."

He leaned to the edge of his seat, his elbows on his knees, hands clasped before him. In the window, Joon swung back into full view.

"Our first encounter with a *sentient* extraterrestrial," he continued, "and it's not little green men with disintegrators or big-eyed grays in spaceships for anal-probe fetishists. No alien techno-a-technos to marvel the viewers back home. I wish the ansible had never been invented and that no one but our teams would ever know of extraterrestrial sentience. She had *spears,* Reg, and it looks to me like they're her most valuable possessions. She doesn't know anything about industrialization, computers, nuclear physics, quantum mechanics. We have nanotechnology which amounts to doomsday weapons to these people. We are as *gods* to them. We could squash them with the scantest effort—"

"Bil, you know we wouldn't—"

"Do I? You wouldn't, Stephanye won't, but what about the politicians? We have to be clear—this isn't the New World. We're not Columbus. There is no Jamestown. There'll be no colonies. We're scientists and this is a field station. Ethical protocols say we don't take the home of sentient natives, period. But you know half the willfully uneducated, infotained numbnuts back home are expecting some conflict up here, some commercial opportunity, some *us* versus *them."*

Reginald sat back, knowing his friend's passions. Any word in edgewise would only prolong the diatribe.

"There will never *be* any us versus them," Bilit continued, "and the protocols prevent *any* commercial interest under these circumstances. Joon is more valuable than any Galapagos."

Bilit crossed his arms.

Reginald waited a moment, then said, "You're *not* John Muir and this isn't the Hetch Hetchy. The message will go out—primitive sentient life discovered, and Joon has now become the largest nature preserve in all of history. Satisfied?"

Bilit nodded.

"Incidentally, why give her the carbon rope?" Reginald asked. "That's an observational violation."

"Do I look like an anthropologist? In the big picture it seemed more important to make a friendly impression. I'm sure she'll find some carbon-fiber cord useful enough."

"You may not be an anthropologist, but you know better."

"I wanted to let her know we were friendly."

"Oh, bullshit."

Bilit frowned. "How do you figure?"

"You gave high technology to a primitive, and either she can't figure out what to do with it over the next few weeks and discards it, or she finds it immensely useful, a technological advantage over her environment. Not good observational science, I'd say."

"I see."

"So what *was* your thinking?"

Bilit shrugged. "It was an intuition, a rare impulse."

Reginald gave Bilit a smug grin. "So?"

"To communicate somehow."

"Then you're not so different from everyone Earthside. We're all trying to communicate somehow."

"I suppose. Except—"

"Except?" Reginald prompted.

"We're trained and we're here first. Whatever harm we do will be much less than what some of the other monkeys will do."

"Elitist. We're apes, Bil. Don't forget we're all apes."

But we're not, Bilit thought. For two centuries, all of us on the *Curiosity* existed as pure ones and zeroes on solid-state and quantum processors; some of us, like Stephanye, still are; all of us are augmented. Before *Curiosity,* we were PhDs or savants or offworlders with a love of exploration, or conservation, or raw straight-up science. We are, at least, apes plus.

He returned to the island to establish a meticulous survey matrix. Bilit plotted waypoints in a tight spiral from the beaches through the island's heart. It took him seventeen Joonian days to survey the island's circumference. Though he had flown over the island many times, the dhopter's sonar, infrared, and ultraviolet did little to resolve detail beneath the canopy. Nothing replaced understanding a place on foot, seeing it with one's own eyes.

During those first seventeen days, Bilit found three more native boats in excellent condition: oiled, oars stowed, a handful of personal effects in each. He recorded these but touched nothing. Their design, he realized, fit the centaur or individuals somewhat larger than she. He wondered what form their sexual dimorphism might take. After scanning the boats, he hypothesized the males would be larger. He looked for footprints (hoof prints?) but found none; the rains washed all tracks from the beach.

The *kentauros.* He'd looked them up on the ship wiki. *Piercers of bulls,* the name had nothing to do with horsemen, though no one agreed upon the etymology. The ancients considered the *Kentaurides,* female centaurs, beautiful from head to tail, though in no extant story did kentaurides take human lovers. Bilit remembered the myth of Jocasta and the bull and how it had ended. He chuckled to himself.

Along the beaches he catalogued several dozen species; in his first month in the forest, he recorded almost three hundred. For each he logged, a thousand appeared to his eye, and for each appearing to his eye, a thousand remained unseen. Coordinated between field biologists and ecologists all around Joon, with lab scientists on *Curiosity,* and with decision-support AIs, the first rudimentary Joonian taxonomy took form.

Bilit adopted a rigid schedule: three days in the field, one in the labs, three in the field, two of rest. He kept this routine for three months, but during this time saw only one

other sign of centaurs: a small fire pit, the bones of an eaten animal, and a broken scraper. He bagged dozens of samples.

In the thirty days following, the rains truly came to the island. Ground exploration halted. Visibility dropped to meters, and the monsoon lasted for weeks. Bilit returned to the *Curiosity.* Thirty days to organize notes, to share with his peers. He appreciated a month of either weightlessness, or one g of nearly perfect artificial gravity, but he could tell the difference between centripetal spin and the genuine thing.

The other ecologists adopted the name: *Kentauros sapiens,* the *centaurs.* Yet while other field teams had discovered signs across a seventeen-thousand-square-kilometer range, only Bilit had seen one.

Her allure remained with him.

His alienness to her world changed nothing of the desire he felt, the want of her, the poetry of hunter and hunted, the rhyme of the land itself. He shared these feelings with no one.

When next he walked upon the island, he stood at the verge between jungle and beach, his dhopter landed just above high tide. He wore a smile. For a moment, he removed his rebreather and tasted pure Joonian air. He stepped into the violet undergrowth, mindful of his duties, determined toward some responsibility. Yet he hoped then, as on every day, he might meet her again. ■

IN TIMES TO COME

Next month, we hope you'll join us in commemorating a historic milestone: *Analog*'s 1,000th issue! Naturally, we'll have an assortment of excellent pieces, from Richard A. Lovett's tale of possible distant battle by proxy, "The Wormhole War," to Sean McMullen's story of the inadvertent dangers in First Contact, "The Audience," with plenty more in between, like William F. Wu and Ted Reynolds' Studs-Terkle-esque oral history of "The Kroc War," a (too) close (for comfort) encounter in, "Ships in the Night," from Jay Werkheiser, Gwendolyn Clare Williams' "Very Long Conversations," Brenta Blevin's "Strategies for Optimizing Your Mobile Advertising," "The Odds," from Ron Collins, C.C. Finlay's "The Empathy Vaccine," and Seth Dickenson's "Three Bodies at Mitanni," as well as a fact article from Michael Carroll on the business of sightseeing in space, "Really Big Tourism."

But we'll also have a few *extra-special* Special Features, from Stanley Schmidt, Ben Bova, and SF editor/anthologist/author/historian Mike Ashley, as well as all our regular columns (and maybe even one *irregular* column).

You don't want to miss this one!

All contents subject to change

THE REFERENCE LIBRARY Don Sakers

When it comes to planetary exploration, Mars is all the rage, especially these days. Science fiction and the red planet have been best buds for a long time, and we've been through a lot together. And yet, truth be told, SF has always carried the torch for another world: a veiled beauty called Venus.

As usual, it all started with second-century author Lucian of Samosata's fantasy-satire *True History,* in which unwitting adventurers from Earth get caught up in a war between the King of the Sun and the King of the Moon over the right to colonize Venus. (Spoiler: the Sun wins.)

Two scientific fashions shaped the way Venus was depicted in SF. The telescope showed the surface of Venus perpetually obscured by clouds. And the nebular hypothesis, popular among eighteenth century astronomers, proposed that Venus was much younger than Earth (and, similarly, that Mars was much older). Together, these fashions gave us the vision of a warm, wet world populated by dinosaurs or even more primitive life. If Venus wasn't a planetwide ocean, it was at best a swampy marshland.

This view was popularized in various proto-SF novels, including *Voyage to Venus* by Achille Eyraud (1865), *The Great Romance* (1881), *Journey to Venus* by Gustavus Pope (1895), *A Trip to Venus* by John Munro (1897), and *A Columbus of Space* by Garrett P. Serviss (1909).

In the wake of Edgar Rice Burroughs's John Carter of Mars books, various authors used Venus as a setting for "planetary romance" stories.

Ralph Milne Farley's *The Radio Man* (serialized in *Argosy* in 1924) was followed by four sequels and followed the adventures of Earthman Myles Cabot on a Venus whose deaf inhabitants communicate via radio. *Planet of Peril,* by Otis Adelbert Kline (1929), had two sequels and was a clear imitation of Burroughs's Mars books. In 1934 Burroughs started his own Venus series with *Pirates of Venus* (four sequels eventually appeared).

As the Campbell Age dawned, the picture of a wet, primitive Venus was taken for granted. The works of two female writers are particularly notable. Several of Leigh Brackett's stories deserve notice (including "Lorelei of the Red Mist," written with Ray Bradbury, and "Enchantress of Venus," featuring the indomitable Eric John Stark). C. L. Moore's antihero Northwest Smith visited swampy Venus several times. Meanwhile, C. S. Lewis took his hero Ransom to the oceans of Venus in *Perelandra* (1943).

A swampy, rainy, or oceanic Venus continued to be the setting for SF books through the 1950s and early 1960s, in works as varied as "The Big Rain," by Ray Bradbury (1951), *The Space Merchants* by Frederik Pohl and C. M. Kornbluth (1953), *Revolt on Venus* by Carey Rockwell (1954), *Lucky Starr and the Oceans of Venus* by Isaac Asimov (1954), "All Summer in a Day" by Ray Bradbury (1954), and several books by Robert A. Heinlein: *Space Cadet* (1948), *Between Planets* (1951), and *Podkayne of Mars* (1962).

Alas, beginning in 1962 a combination of radio astronomy and space probes (both U.S. and Russian) established the current scientific view of an immensely inhospitable Venus, with searing heat, crushing pressure, and a corrosive atmosphere.

Science fiction, heartbroken, reeled. While a few authors dealt with the new reality of Venus (notably Larry Niven in "Becalmed in Hell," 1965), most shied away from the place. In 1968, the old Venus was both celebrated and mourned in the anthology *Farewell, Fantastic Venus!* (edited by Brian W. Aldiss and Harry Harrison).

Subsequent visits to Venus were few and far between. Frederik Pohl's *The Merchants of Venus* (1972), a sequel to *The Space Merchants,* reconciled human colonization with

the new, hostile Venus. In 1980's *The Venus Belt* by L. Neil Smith, a future culture based in the Asteroid Belt decides to blast a useless Venus apart to form another belt. Pamela Sargent chronicled the terraforming of Venus in *Venus of Dreams* (1986), *Venus of Shadows* (1988), and *Child of Venus* (2001). Ben Bova told of an expedition to Venus as part of his Grand Tour series *(Venus,* 2000). Most recently, the Chinese have undertaken the job of terraforming of Venus in Kim Stanley Robinson's *2312* (2012).

It's fair to say that the relationship between SF and Venus has become more than a bit dysfunctional, and I think it's our fault. We blame her for not being the sweetheart we imagined. When we're not ignoring her altogether, we have nothing good to say about her. If we're not threatening to batter her severely, we're insisting on giving her a major makeover; we're obviously not yet ready to accept her as she is.

Maybe one day we'll be mature enough to patch things up. In the meantime, we have our memories.

Old Venus
Edited by George R. R. Martin and Gardner Dozois
Bantam, 608 pages, $30.00 (hardcover)
Kindle: $11.99, iBooks, Nook: $14.99 (ebook)
ISBN: 9780345537287
Genre: Original Anthology, Retro SF

As a follow-up to 2013's *Old Mars,* editors George R. R. Martin and Gardner Dozois present sixteen stories set on the old, wet Venus that SF gave its heart to so many decades ago. In doing so, they gather an impressive variety of big names and lesser-known but talented writers, old-timers, and newcomers. Among the more recognizable authors are Eleanor Arnason, Elizabeth Bear, David Brin, Tobias S. Buckell, Michael Cassutt, Joe Haldeman, Matthew Hughes, Gwyneth Jones, Joe R. Lansdale, Garth Nix, Mike Resnick, and Allen M. Steele.

You might expect a certain uniformity here, but you'd be wrong. About all these stories have in common (besides being good reads) is somehow being set on a warm, wet Venus. Otherwise, they range from hardboiled detective stories to horror to good old pulp adventure to (yes) love stories.

A few authors establish some sort of rationale for Venus being habitable—alternate universes, time travel, that sort of thing—but most simply assume the classic Venus. Readers just have to suspend disbelief at this; those who do so will find much reward.

All the stories are worth it. I found particular enchantment in Lavie Tidhar's "The Drowned Celestial," a tale of a tough old spaceman's encounter with the annoyed deity of a lost civilization; Gwyneth Jones's "A Planet Called Desire," in which a visitor from Earth finds love in the swamps; and Joe R. Lansdale's "The Wizard of the Trees," the story of a half-black, half-Cherokee cowboy who survives the wreck of the *Titanic* to bring peace to a war-torn Venus.

Definitely a fun anthology.

The Human Equations
Dave Creek
Hydra, 220 pages, $14.99 (trade paperback)
Kindle, Nook: $3.99 (ebook)
ISBN: 978-1-942212-01-0
Genre: Short Fiction

Dave Creek is a name familiar to *Analog* readers; every once in a while he appears in these pages with yet another superbly constructed story of human-alien relations set on one or another of his marvelously realized worlds. These stories—most often featuring heroes Leo Bakri, Matt Christian, or Mike Christopher—are all part of a coherent future history.

Two previous volumes collect many of Creek's stories: *A Glimpse of Splendor* (2009) and *Some Distant Shore* (2012). Now *The Human Equations* collects a dozen more Creek gems, including the title story. And don't just think you're getting a bunch of *Analog* reprints: one quarter of this collection is pieces that appear here for the first time.

I'm not going to talk about the stories that were published in these pages; either you've read them, or you trust Stan and Trevor's editorial choice enough to know they're good. Instead, let me whet your appetite with a few words about the three original stories.

"The Day That Reveals" is a great example of how SF can shed light on present-day problems. Sadiq Salam, a diplomat on an Islamic orbital habitat, must deal with a conflict

between tradition and the demands of the modern world. In "On the Welkin Shone the Starres Bright" Creek explores the relationship between Human Matt Christian and his aquatic partner Sarbin, and shows more of the fascinating ecology of an all-ocean planet. And in "Kutraya's Skies" two scientists battle with religious and societal inertia to save the habitable moon of a gas giant.

Whether you've been a Dave Creek fan for decades, or you're just discovering his work for the first time, *The Human Equations* is a no-brainer for any *Analog* reader.

Carbide Tipped Pens
edited by Ben Bova and Eric Choi
Tor, 400 pages, $27.99 (hardcover)
iBooks, Kindle: $12.99, Nook: $14.99 (ebook)
ISBN: 978-0-7653-3430-5
Genre: Hard SF, Original Anthologies

Before Trevor was the editor here at *Analog,* Stan Schmidt filled the position. And longtime readers may remember that before Stan, Ben Bova sat in John W. Campbell, Jr.'s chair (quite literally: Bova succeeded Campbell upon his death in 1971).

Carbide Tipped Pens is like an artifact from a parallel universe, one in which Bova didn't leave *Analog* in 1978, but kept editing to this day. Together with Eric Choi, Bova has put together a collection of seventeen hard SF stories by a diverse group of authors, focused on rigorous extrapolation of current science and technology melded with three-dimensional characters and engaging plots. You know, the kind of stories *Analog* prints.

You'll recognize some of the names in this anthology: Doug Beason, Gregory Benford, Bova himself, Nancy Fulda, Jack McDevitt, and Robert Reed. The sciences represented in these stories include artificial intelligence, biomedicine, chirality (handedness), climatology, ecology, nuclear physics, probability, relativity, robotics, set theory, transfinite math, and sports medicine.

Ben Bova's story, "Old Timer's Game," speculates on the future of baseball. "SIREN of Titan" by David DeGraff is a tale of a charming robot probe on Saturn's largest moon. Leah Peterson and Gabrielle Harbowy's "Skin Deep" is hard SF at its most pure: The authors postulate a technology that uses tattoos to fight allergies, then move on to unexpected consequences: ways that technology could be used for nefarious purposes.

That's just three of the stories; there are fourteen more, each as entertaining and thought provoking as the one before.

Upgraded
edited by Neil Clarke
Wyrm, 368 pages, $16.95 (trade paperback)
Kindle, Nook: $6.99 (ebook)
ISBN: 978-1-890464-30-1
Genre: Biological SF, Man and Machine, Original Anthologies

Upgraded is billed as "an all-original cyborg anthology edited by a cyborg."

Here's the story: Neil Clarke, editor of *Clarkesworld* magazine (and three-time Hugo award winner in the Best Semiprozine category), survived a near-fatal heart attack in 2012 and a year later had a defibrillator implanted. While recovering, he conceived of this anthology.

In 368 pages there are no fewer than 26 stories by the same number of authors. The list of contributors skews a bit newer and more on the literate side than *Old Venus* or *Carbide Tipped Pens,* although you'll notice some familiar names such as Elizabeth Bear, Tobias S. Buckell, Greg Egan, Ken Liu, Robert Reed, and Rachel Swirsky. (Bear, Buckell, and Reed in particular seem to be able to pull off the difficult trick of being simultaneously prolific *and* good.)

Again you might expect a certain narrowness of field, and again these stories cover remarkable breadth. There are detective stories, postapocalyptic tales, psychological studies, space opera, and transhumanist parables. Some of the stories are plainly told, others more avant-garde, and a few frankly experimental. These are definitely not *Analog* stories—which makes sense, as *Clarkesworld* isn't *Analog* and Clarke isn't Trevor. Still, there's a lot here to like.

Genevieve Valentine's "Small Medicine" is a poignant story of a little girl's relationship with her beloved grandmother's cyborg replacement. "Tender" by Rachel Swirsky explores the relationship between human and machine through the agency of a machine struggling to protect the woman it loves from

harm. Helena Bell tackles the nature of transhumanism with "Married," in which a woman confronts the changes that her husband undergoes during conversion to cyborg form.

By far the standout story, for me, is Benjanun Sriduangkaew's "Synecdoche Oracles." Set in a far future and based on what can only be called biological cyborgs, this is one of those total immersion stories that takes the reader to a completely different universe filled with wonderful and amazing people. Charinda, who keeps a cyborg peacock within her rib cage, is sent on a mission to execute a notorious general. The story reads like a myth from a far future culture.

If you're in the mood for a batch of cyborg stories, and particularly if you're ready for more consciously artistic fare than you usually see in *Analog,* give *Upgraded* a try.

War Dogs
Greg Bear
Orbit, 304 pages, $25.00 (hardcover)
iBooks, Kindle: $8.99, Nook: $12.99(ebook)
ISBN: 978-0-316-07283-0
Series: War Dogs 1
Genre: Military SF

Greg Bear is one of the most successful hard SF writers around. He's won every award in the field several times over. In *War Dogs,* the first book in a new series, he turns his attention to military SF.

Michael Venn is a Skyrine, a space marine, and when *War Dogs* begins he's about to go into combat on Mars.

Thirteen years earlier, a peaceful alien race known as the Gurus landed on Earth. Their advanced technology revolutionized the world . . . but at a cost. For the Gurus have been followed by an inimical race that Earth media dub "Antags" (for Antagonists). The Antags are establishing a base on Mars, and the Gurus want Humans to get rid of them.

So Venn and his comrades are off, dropped onto the surface of the red planet to fight and, if possible, to survive.

It's a fairly straightforward story. Bear makes it sing through his characters and the technology they use.

Michael Venn is a science fiction soldier in the tradition of Robert A. Heinlein's *Starship Troopers* and the best of David Drake—profane, capable, loyal to a fault. He and his fellow grunts are full of opinions about the war, the Antags, the Gurus, and their leaders. There's adventure, tension, and sardonic humor enough to keep the story moving briskly.

The technology, as is typical for Bear, is well thought out, wondrous, and totally familiar to the characters. Bear hasn't simply updated current military technology; instead, he's done a thorough job of reimagining military equipment based on sophisticated nanotechnology and other alien tech.

Artful yet authentic-sounding, *War Dogs* is a compelling story well told. A good beginning to what looks to be a good series.

With that, I'm out of space. Until next time, take a few moments before sunrise or after sunset to look for Venus. She's there most of the time, indifferent to the opinions of her erstwhile suitor, science fiction. ■

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:

In regards to Ed Lerner's "Alien AWOLs" (October, 2014), it looks to me that there is a hidden assumption in both the Drake Equation and in SETI. This assumption is that any alien intelligence or alien technical civilization (ATC) will manifest itself exactly as, or in congruent ways to what, our culture does—that is, any ATC will be interested in the same things that we are, have the same technical interests and developments—in brief, think, behave, and look at the world like we do.

Given the chaotic state that the search for exoplanets has revealed outside our Solar System, if an alien civilization developed, there is no reason to assume that it would be like ours. It is just as likely that "The Great Silence" exists not because of absence of alien intelligence, but because any ATCs are on a different "wavelength" than we are.

Michael Regan
Vacaville, California

The author responds:

Agreed: it's prudent not to assume other civilizations are just like ours. (That's a good rule of thumb even without looking beyond this planet.)

As to SETI, the assumptions involved, consciously or not, depend upon the specific search strategy. If we seek ET artifacts in our native solar system, we're presuming that an ATC not only could, but chose to, dispatch interstellar probes or spacecraft. If we listen for a laser or radio beacon, we're presuming an ATC has built such a beacon for the purpose of revealing its presence. Both are behavioral assumptions. Humanity has (just barely, through plaques affixed to the Voyager probes) exhibited the first behavior. We have yet to choose to construct a beacon for purposes of interstellar communication.

But what if all we do is listen for radio emissions that differ—in some way—from the emissions of known natural processes? In that case, we're assuming only that an ATC makes *some* use of radio-frequency broadcasting. That's a technological assumption, rather than a behavioral one.

If an ATC relies on modulated neutrino beams, our radio-based search will fail.

—Ed Lerner

Dear Mr. Quachri,

The December issue was phenomenal. Right out of the gate, your anchor story ("The Anomaly," C.W. Johnson) was a super-smart, all too plausible slice of (future) life that somehow managed to be fresh and old-school at the same time, and delivered some emotional punch. Outstanding.

"Citizen of the Galaxy" (Evan Dicken) was one of the best stories in years. Powerful theme, background detail that was both well presented and accurate (he is obviously a Japanophile like me), unusual aliens (which is not easy to do after all the aliens we've seen), and lots of good sentences. Loved it.

"Mammals" (David D. Levine) was a delight. I like unusual points of view, and this one was brilliant. Also the ending was satisfying, with the good guys coming out on top. I like happy endings like that, up to a point.

I could go on. Great fact article. Can't go wrong with a sonnet. And so on.

Titles, though . . . You are bad at titles. I suppose your authors supply their own titles, but it's your responsibility to improve them. Take "The Anomaly," for example. That's a terrible title. Lazy. It says nothing about the story and gives me no reason to want to read it. "Rogue Anomaly" would have been much better. See how this slight change introduces an element of conflict and action? Even better: "Ketkam's Rogue Anomaly." Now we have introduced a human element and an exotic tone. This is at *least* a hundred times better than "The Anomaly."

So, anyway, please work on your titles. Otherwise, great job.

Chris Myers
Lovelock, Nevada

* * *

Dear Editors,

I note, unless I am mistaken, that Mr. Hendrix [Guest Editorial, "A Choice of Apocalypses," December, 2014] appears to have adopted the Puddleglum argument for the existence of Narnia from "The Silver Chair," where he says, "Suppose we *have* only dreamed, or made up, all those things—trees and grass and sun and moon and stars and Aslan himself. Suppose we have. Then all I can say is that, in that case, the made up things seem a good deal more important than the real ones . . . I'm on Aslan's side even if there isn't any Aslan to lead it. I'm going to live as like a Narnian as I can even if there isn't any Narnia."

Steve Tollyfield

Dear Mr. Quachri,

In the "Science Fact" section of the latest issue of *Analog* ("Orbits to Order," January/February 2015), Stanley Schmidt writes about special non-gravitational spacecraft orbits, the result of applying thrust in such a way as to obtain some unusual and potentially useful trajectories. The article is very interesting and well-written, although there are a couple of points that I feel might need some clarification.

The main one, as I see it, is about the statements he makes toward the end, observing that the rockets that provide the non-gravitational force that makes such highly non-Keplerian orbits possible, do run out of fuel eventually, and concluding from this obvious fact that permanent orbits of that sort are not feasible, barring some unexpected developments in the future, perhaps involving some scientific breakthroughs. Because, as he explains, "as science fiction writers, we can imagine (carefully!) whole new kinds of science that can conceivably be discovered in the future that would make this continuous thrust possible." As a matter of fact, there is no need for that: continuous thrust for indefinitely long periods of time is quite within the bounds of what is feasible today (if, perhaps, not entirely practical, as yet) using existing science and engineering ideas.

Concretely: Solar sails can provide continuous thrust indefinitely, as the Sun always shines in (most of) outer space, and their use has been proposed and studied seriously at NASA, ESA, and other space agencies, to put spacecraft in various otherwise impossible orbits. In particular, the creation of "artificial Lagrange points" to park space probes there indefinitely, to study the Sun, the tail of the Earth's magnetosphere, etc., is an idea that has been around for quite some time. Other possibilities include placing satellites in geostationary orbits on planes other than the equator. These ideas have their mathematical foundation on a special solution of the many-bodies problem known as the "restricted three-body problem with solar radiation pressure." And, among them, there is the "statite," proposed by Robert L. Forward and explained by him in the "Science Fact" section of the December 1990 issue of *Analog,* whereby a solar-sail-powered spacecraft could be parked, hovering, right on top of either of Earth's poles, to be used as a communications satellite serving the polar regions, where the equatorial geostationary ones are of little use.

A second, minor point I would like to comment on is the statement, earlier in the same article, that "unlike the quadratic equations familiar to high school algebra students, there is no handy general formula for solving the (cubic) equations analytically, but they can be solved by graphical and/or numerical methods," and ends recommending the use of a "cloud" approach: "equation solvers" available on the Internet. Maybe it is just a matter of word choice, but taking the statement literally, it is incorrect: it is true that algebraic equations above a certain degree do not have a general solution in the form of closed (finite algebraic) mathematical formulas, handy or otherwise, according to the Abel-Ruffini theorem. But the minimum degree at which this happens, as stated in that theorem, is five, not three. In fact, a general solution for cubic equations, Cardano's method, is several centuries old; a general solution for quartics is somewhat more recent. And going as far back as Babylon, mathematicians already knew how to solve some special quartic equations (although they did not think of them as such).

There is plenty about this online, including two good Wikipedia articles on "cubic functions" and "quartic functions." That said, I must thoroughly acknowledge that, from a practical point of view, using the "cloud" method recommended by Schmidt is much

better than trying to solve the equations using the closed general formulas, particularly in the case of quartics. Which, nowadays, one would use a computer to do anyway, if the job did come up on a regular basis.

I end here by expressing my best wishes for the continuing success of *Analog,* now under your stewardship, on its already very long and, one hopes, endless journey into the unfathomable future.

Oscar L. Colombo
College Park, Maryland.

The author responds:

Actually, I did acknowledge that there were things that could be done without requiring fundamentally new science, and Mr. Colombo's suggestions are certainly among them—but in general, they're not easily applicable to this particular problem. Solar sails can provide outward force on an object orbiting the Sun (such as an asteroid), but not on one orbiting the Earth. Also, they can't provide inward force, which, for reasons I described in the article, is more likely to be useful. Statites and "artificial Lagrange points" are completely different kinds of orbits than I was discussing.

Algebraic solutions to cubic equations do exist (and maybe I should have mentioned them), but they're so much more complicated than the quadratic formula that I can't consider them a "handy general formula." But I should probably add that there's still another approach available: Some calculators have built-in capabilities for solving equations, sometimes algebraically, sometimes numerically. I haven't tried mine to see how well it handles this kind of equation, but I suspect most people will find the online solvers quicker and more convenient.

—Stanley Schmidt

Dear Mr. Quachri,

I read with interest Stan Schmidt's fact article "Orbits to Order." As I've come to expect from Stan's many editorials, the fact article was interesting and thought provoking, dealing, as usual with Stan, with a subject that we usually don't think much about.

I could quibble over a few minor points, but won't. However, there's one discussion that I just can't let stand. It deals with the forced orbit that you obtain by starting in a circular orbit and applying an acceleration directed inward. As pointed out in the article, this results in a lower, faster circular orbit, maintaining angular momentum. So far so good. Then the discussion moves to what happens if you turn the engine producing the inward acceleration off. According to Stan, the modification process repeats itself in reverse and the mass "spirals outward into a new [orbit]" which is the same one that it started out in. I can accept that this might happen if thrust were slowly reduced until the engine was completely off, but it's clear that this isn't what Stan was saying. He goes on to say that when "you're finished (or run out of fuel), turn the rocket off, and you automatically return to your original orbit."

Sorry, no. As soon as you turn the engine off, the mass becomes an ordinary ballistic projectile and it must immediately follow a normal orbit. Spirals are not allowed. If the engine is suddenly turned off in this case, the orbit will immediately become a conic section. The new orbit will be an ellipse with perigee at the height of the lower forced orbit and apogee somewhere higher than the original unforced orbit, unless you've added enough energy during the orbital modification to turn it into a parabola or hyperbola.

Still, it was a fun article. I hope Stan sees fit to provide us with more pieces in the future.

Steven Gray

The author responds:

Oops! I did speak a bit hastily here, and will fine-tune the wording if the article is ever reprinted. "Spiral" was not the best choice of word, and for the case where the added force is stopped abruptly, Mr. Gray is right that, rather than returning to the original circular unforced orbit, its orbit becomes a conic section subject to the conditions he describes. It would be interesting, though, to consider what happens if the force is removed gradually, and what it would take to get back to the original orbit. Those are more complicated calculations, but I may do them if the article is reprinted. Meanwhile, if anybody else cares to work it out, I'd be interested in seeing the results.

—Stanley Schmidt ■

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.

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/.*

8–10 May 2015

ALBACON 2015 (Albany area SF conference) at Best Western Alabany Airport Hotel, Albany, NY. Guest of Honor: Mur Lafferty. Membership: $30 until 16 April 2015; $35 thereafter and at the door. Info: *http://www.albacon.org/2014/.*

15–18 May 2015

COSTUME-CON 33 (SF, reenactors, etc. costumers) at Charleston Plaza Hotel, Charleston, SC. Theme: Buccaneers, Belles, & Bootleggers. Special Guest of Honor Costumer: Miss Janet Wilson Anderson. Memberships: $95 until 30 April 2015; $125 at the door. Info: *www.cc33charleston.org*; Costume-Con 33, c/o J. B. Dashoff, PO Box 425, Huntington Valley, PA 19006-0425.

22–24 May 2015

BAYCON 2015 (San Francisco bay area SF conference) at Hyatt Regency Santa Clara, Santa Clara, CA. Theme: Women of Wonder. Writer Guest of Honor: Seanan McGuire; Artist Guest of Honor: Stephanie Pui-Mun Law; TM Guest of Honor: Amber Benson; Fan Guest of Honor: Caradwen "Sabre" Braskat-Arellanes. Membership until 18 May 2015: adult (>12) $60; Youth (8–12) $25. Info: *http://baycon.org/bcwp/about/contact-us/;* P.O. Box 62108, Sunnyvale, CA 94088-2108.

22–26 May 2015

BALTICON 49 (Maryland regional SF conference) at Hunt Valley Inn, Hunt Valley, MD. Guest of Honor: Jo Walton; Artist Guest of Honor: Ruth Sanderson; Musical Guest of Honor: Erica Neely. Membership: Adult (>12) $60 until 5 April, $65 thereafter and at the door; children (6-12) $30 until 5 April, $33 thereafter and at the door. Info: *www.balticon.org.*

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 $170; YA (17–21) $90; child (6–16) $70; $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.

Running a convention? If your convention has a telephone or fax number, e-mail address, or web page, please let us know so that we can publish this information. We must have your information in hand SIX months before the date of your convention.

Attending a convention? When calling conventions for information, do not call collect and do not call too late in the evening. It is best to include a S.A.S.E. when requesting information; include an International Reply Coupon if the convention is in a different country. ■

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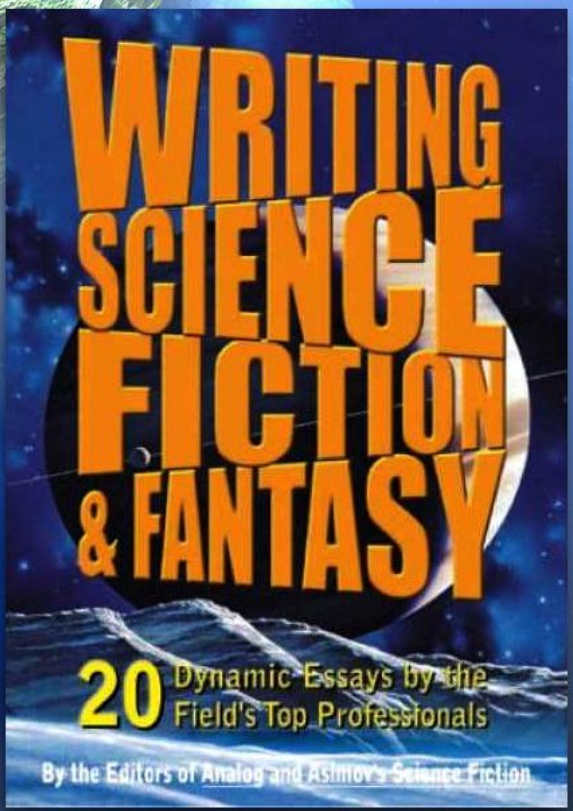

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