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Reader's Department: **EDITORIAL: CAN'T GET THERE FROM HERE?** by Stanley Schmidt

Change happens.

That's one of the most general true statements you can make; it applies to just about everything. But changes don't all happen in the same way—and some ways are easier than others, in just about any situation.

Biological evolution, for example, has resulted in the great diversity of life on Earth, but it has never produced a railroad. As a process, it has the fundamental limitation that it makes new things by changing single features of old things. Sometimes a new thing is so fundamentally different from the available old ones that you can't change one into the other by modifying the parts. It's fairly straightforward to get from something lizard-like to something bird-like by changing the shapes, sizes, and articulation of appendages. But there is no simple way to get from a leg and foot to a wheel and axle. And if you really want a railroad, you also need tracks: an external system, separate from the train but designed to work with it.

So how do you get a railroad, if you can't evolve it? You design it. You figure out how it could work, and you fabricate the necessary parts and assemble them into a complete system. In principle, and sometimes in practice, devices unlike anything ever seen before can be created from scratch in this general way.

Now, how about social systems? I have for some time (most recently in the *Analog* editorial “Ups and Downs” [May 2008] and the book *The Coming Convergence* [Prometheus Books, April 2008]) been promoting the idea that we need a fundamental change in ours, and that we've been persistently viewing an unprecedented opportunity as a frightening problem instead. The real problem, in short, is that our culture has been creating a great many labor-saving technologies, which reduce the amount of time we need to do the work we've had to do in the past—but instead of reaping the obvious reward of more leisure time, we keep inventing new work to do and winding up busier than ever.

Why are we doing this to ourselves? Because we, and generations of our forebears, have long been so locked into a mindset of thinking that Everybody Must Be Fully Employed that we find it literally hard to imagine another way of doing things, much less a way to make the transition from our way to a better way. Our goals are at cross purposes: we love to create and buy new labor-saving gadgets, but most of us don't really want the amount of work to decrease—because we have been deeply, deeply conditioned to believe that we all Have to Have Jobs.

And indeed, in our present system, we do. Given that our society works as it now does, I would be as reluctant to lose my job as you would. But I can imagine a *different* way that society could work, in which we could all work some, but less than we now do, *and* we could all have all the material things that we need, plus a lot that we just want. Sometimes, when I describe the general outlines of that vision, people even agree that it sounds inviting; but then they shrug it off, pointing out why this or that aspect of our present way of doing things would be incompatible with it. But that misses the point: this or that aspect of our present way of doing things would not be part of the new way, so the objection is irrelevant.

But it may well point up an obstacle to making the transition from old to new. And some of those obstacles look formidable enough that people have trouble making the distinction between difficulty of the transition and impossibility of the end state. That, in turn, makes it hard for some even to grasp what I'm really describing as the goal.

In simplest terms, it's this: Instead of inventing work to give people jobs, we could decide what work we really need or want done, and divide it up among all the people who are available and want to do it.

Since we're currently inventing work for its own sake, the total amount we do could clearly be less than it is now; therefore the average time spent working could be less than it is now. Since, in the scheme I'm describing, all needed goods and services are being produced, people can buy them as long as pay is distributed commensurate with the work.

If any defense is needed for the claim that we as a people are now doing more work than we need to, simply consider these obvious facts. We routinely invent work ("create jobs," a phrase which has taken on an almost saintly aura) by paying people to do things that don't need to be done, such as holding doors open for people who are perfectly capable of doing it for themselves. We deliberately build things to fall apart much sooner than they need to, so people will have to buy new ones, so people can be paid to make the new ones. We pay advertisers to convince us that we need things that we don't, simply to have the "latest and greatest" or the currently fashionable. We continually do things in absurdly wasteful ways, like having self-righteous but trivial arguments over whether it's better to use thousands of plastic grocery bags or thousands of paper grocery bags to do the work of three or four sturdy cloth bags.

So it's clear that we as a society are doing a lot more work than we need to, and in the process wasting huge amounts of other resources as well. Those paper and plastic bags, for example, consume large quantities of wood and petroleum as raw materials, plus more petroleum as fuel to manufacture and transport them, and to transport the people making them to and from factories. We would in many ways be better off using a few durable bags for years, and skipping the unnecessary work and waste of making and shipping much larger quantities of disposables. And I should think most of the people doing that work would be happy to have to spend less of their time doing it, as long as they could still get the things they need.

At this point I commonly hear a couple of objections that are clearly rooted in our fixation on our present way of doing things. For example, who decides which work is unnecessary? Why would people settle for the reduced pay from their reduced hours? Wouldn't we need a negative income tax to support people whose jobs were done away with? Do I really think people would accept a life with no luxuries?

All of these miss the point: except for the last, which is easily disposed of, none of them has any relevance in the new kind of system I'm positing. The questions are meaningful only in the short term, as issues that need to be dealt with in the early stages of a transition. So I suggest dividing the problem into two stages: First consider the kind of system that we *could* have, as a potentially desirable end state, without regard for how we might bring it into being. Then consider, separately, the question of how, if at all, we could get from here to there.

Looking only at the hypothetical end state, I must first point out that I have never suggested (as someone claimed I did on *Analog's* online forum) a world with "no luxuries." For one thing, many of the things we have already come to regard as "necessities" are in fact luxuries of quite high order. Through the vast majority of history, no king could have had, for any price, the computer on which I'm writing this, or the car I drive to places too far to walk to in the available time, or the freezer that lets me have fresh-tasting summer-grown food in the middle of winter. But beyond that, I have never suggested that anyone should live a bare-bones existence. What I *have* suggested is that most of us could be a little more selective about which extras we really want, as distinct from simply kowtowing to advertising or peer pressure.

The questions about reduced pay and negative income tax indicate a basic misunderstanding of the new model I'm proposing. I am *not* suggesting that some people's jobs should be abolished and they should be thrown out on the street, or that their purchasing power should be reduced so they have even more trouble than now making ends meet. I *am* suggesting that if we cut way back on "make-work," the total amount of work left over will be smaller than it is now. The remaining work would be redistributed; those whose jobs remained would spend less time doing them, while those whose jobs disappeared would be

reemployed in the fields remaining. In essence, a reduced amount of work would be redistributed so that everybody was doing an equitable (but smaller-than-now) share of it and receiving pay enabling them to buy what they need and a reasonable amount of what they want (which in many cases would mean less stuff than now, because much of what people now buy is waste).

To give a simplified but concrete example: Suppose enough demand for unnecessary goods and services goes away to reduce the total workload by half. In practice this may mean that the work to be done in some jobs is reduced by some smaller fraction and other jobs dry up completely, but for simplicity let's just say half the jobs become unnecessary while others are unaffected. If the "standard" work week is concurrently reduced by half, the people still in the remaining jobs will only be doing half as much as they were. The other half can be taken over by people made available by the disappearance of other jobs. Everybody can keep being paid as they were, while working half as long and maintaining a good standard of living.

To me, it seems like a highly desirable and quite possible end state—but I'll freely grant that it's so different from what we now have that getting there from here would be a big challenge. But I don't think that means it's *a priori* impossible. In the past, when I've mentioned this idea, I'll admit I've glossed over the difficulties of making the transition—because they're so big and complex that I don't have the answers. So today I'm throwing it out as an explicit challenge to you, the "world's biggest think tank": how *could* we get from where we are to where we could be, in a less wasteful, less frenetic, but no less satisfying world with material needs fulfilled and more discretionary time? Science fiction readers like challenges; here's a dilly, but one worth a lot of shared effort.

I'll throw out just a few general ideas to get things started. The most basic question is: Could this change be achieved by "evolutionary" means, with a series of gradual or incremental changes in what we're already doing? Or is it more like building a railroad, where we'd have to essentially design a whole new system, then scrap the old one and put the new one in its place?

I would hope that it could be done incrementally, because in general "designed societies" have a poor historical record. There are exceptions; the United States itself can be considered an example of one that worked pretty well, though the revolution that created it did involve considerable violence. Might there be ways to make comparably revolutionary changes without physical violence or extreme social upheaval, or the dismal failures and abuses of other "designed societies" such as the Soviet Union? I don't think we should rule anything out *a priori*; maybe somebody *can* figure out a way to do this kind of social engineering while avoiding the gaping pitfalls.

But I'm frankly not optimistic about that, and I suspect that if we do get to something like what I'm envisioning, it will have to be done in smaller steps, and even those will seem disruptive and frightening while they're happening. But there are hints in history about how such things can be done—and how they can't. The United States, for example, has occasionally paid lip service to the idea of converting to the metric measurement system used by almost every other country in the world, but has failed to make any real progress in that direction because it has failed to take any decisive action. Australia, on the other hand, made the transition quite thoroughly between my two visits there, fourteen years apart; government decrees played a role, but so did changes in education and popular attitudes.

Popular attitudes can play a crucial role: if large numbers of people just start saying no to wasteful non-necessities, fewer of them will be made. In the short term, this would of course cause difficulties, because our present system is geared to seeing unemployment only as a problem. But unemployment in some areas could be offset by new jobs becoming available in others, and that could be encouraged by a reduction in the definition of "full-time work week." The government would no doubt play a role in doing that, but workers themselves could play one too. Unions have demanded, negotiated, and received

shorter work weeks before, and it could easily happen again. Employers have increasingly come to accept nontraditional arrangements like telecommuting and job-sharing.

Since any society is a complex system of many interlinked feedback loops involving many variables, computer simulations (along the general lines of games like SimCity or Spore) might be helpful in estimating what combinations of changes (such as work week, salaries, and expected service life of commodities) would have what effects. Admittedly those are at best approximations, and would find it especially hard to deal with such human variables as people's willingness to change their ideas of when they need to buy something new. But they could still be a useful first step toward figuring out a way off the real-world treadmill.

Probably the most fundamental requirement for anything like this to happen is that masses of people have to want it and believe that it's achievable. We know such shifts can occur; look, for example, at how attitudes toward, and popular acceptance of, slavery and smoking have changed. The one I'm talking about is a big and difficult challenge—but isn't it worth some real effort?

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Novelette: **CAVERNAUTS** by David Bartell

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Illustration by Vincent Di Fate

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Rationality is one of our most characteristic traits—but not the only one.

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Why would anyone voluntarily grope around the dark, frozen bowels of a dead moon 400 million miles from Earth, spending two years away from home, only for standard wages? If you're not an extreme thrill seeker, I can't tell you.

I'd hoped I'd never have to answer the question, but no bit shield or sociobypass can give complete privacy. People would just answer for me, in my absence from the net, and my foolishness would be confirmed democratically. That's what happened while I was bound for Callisto on the *Ozark*. The WyrpNet was buzzing to know why an expectant father like me would bolt to some distant rock, just as I got the news about the baby.

I couldn't tell them that another woman needed me on Callisto, so I recited a stock joke: I was going just to escape WyrpNet. The general reaction to that is surprise; people don't know that you're offline when you're deep underground. A typical question: "How can you stand being unplugged so long, especially in a dangerous place?" If you weren't plugged in, you were in a vacuum, alone and ignorant.

I also never tell people that the most beautiful sight in the Solar System is under Callisto base. The cave we call John's Glen, formed by crystallized urine refuse, is a sight to behold. Sometimes you just can't tell the truth.

Bart and I returned to Callisto to help our partner Colleen, and as soon as we touched down, we had another reason to revisit those caves.

"Guys, I've got bad news," the base's Ops Director Trev told us. He was waiting for us outside the airlock. Not a good sign. Colleen was missing, he told us, somewhere down in the caverns.

"Search and rescue," Bart shouted. "I'll assemble our gear."

"Roger that," I said.

"It's been too long, Rick." Trev gave us the particulars, and Bart and I both ran some quick mental calculations.

"She could possibly be alive," Bart said.

"You're joking. Listen, fellows, I know you came out all this way and are bored crazy from the trip, and I'm very sorry, but—"

"Bart's right," I said. "If she managed to reach one of the P&A caches, there's a fair chance she's okay."

Bart flexed his knees and hit his fists together, his whole body chomping on a bit. I nodded, and he rushed off to assemble our gear. I lingered with Trev, to hear some details.

"No," he said.

"Trev, it's *Colleen*." To me, just the mention of the name should have had an effect. In a field of mostly

men, we tended to pamper the women, even though they were usually made of stronger stuff than we. It's not that they needed special treatment; it's that we needed to give it. And it wasn't just Colleen. One of the engineers was missing too, some guy named Miller.

Trev's face fell. He'd grown some gray around the temples, which made him tired-looking. "She wasn't supposed to go down there again. None of you were. We're officially closing down."

I swallowed hard. Bart and I had just returned to Callisto for what we heard was a major discovery, only to learn on the way that the operation was dismantling. Colleen made a last-ditch effort to find her diamonds before the entire outpost was decommissioned.

Trev turned his back, looking at a chart on the wall. It was a map of the Devil's Throat—a natural cavern system that only a handful of living people had visited. "It's too dangerous," he said. "We're on a skeleton crew as it is."

"Listen, Trev. This is eating me up. Every second we waste..." I couldn't help but feel that Colleen's timing was no accident. She knew we were nearing the Jupiter system when she entered the Throat yesterday. It would be like her to milk the eleventh hour preparing for us.

Trev nodded his head in sympathy, but persisted. "There's a very good reason why you shouldn't go down there. She said that if she ever got lost in the caverns, no one should come after her."

"That's ridiculous. Of course she knows we'd rescue her."

"It sounded more like a warning than anything noble. My answer is no."

My head grew hot. "Come on, Trev!" I stepped near, almost getting in his face. He stepped back. "I don't know what went wrong, but I swear, I'm going to find out."

Trev held up a hand to stop me and rubbed his eyes with his fingers across the bridge of his nose. He shook his head. But then he slowly came closer, leaning to my ear so as not to be recorded by the ubiquitous WyrpNet.

"Okay," he whispered. "Go."

"Roger that!" I whispered back.

* * * *

Bart had his metallic silver-skinned pressure suit, a Reynolds, and I had my mustard-yellow-and-black Armstrong. Colleen's was designer metallic green and magenta, a gift from a manufacturer I was under contract not to name. We helped each other put on the equipment, pants first, tops, then air cyclers, power packs, and spare kits. Then boots, gloves, and finally helmets. Even Bart's narrow skull became spherical when he put his helmet on, and with his deep acne scars, he looked like the pocked moon we were on.

We checked each other's systems. I've never been anywhere where the need for redundant equipment was as great as the caverns of Callisto. On this trip, Bart was my ultimate redundancy. It felt strange without our third. Colleen was the best damn cavernaut that ever was.

We checked our com channels and synchronized slew-up algorithms. By tradition, we exchanged a silent thumbs-up, the standard signal for dead radio situations. Then a "let's roll" with wheeling fists.

The airlock filled with cold water melted from a frozen subsurface lake. When it was full, the hatch on the top opened, and Bart started up the short ladder. The liquid airlock served to rinse dust from the suits

upon return and to reveal any air leaks in our suits. If there's a leak, you'll see bubbles. I followed Bart over the top of the airlock and down the outer ramp. Our suits steamed as they quickly dried.

I threw the switch on a post by the ramp, and the lights came on. There was a brief flicker that most would not have noticed, but Bart and I exchanged looks. Probably corrosion in the switch from the occasional vapor vented from the bowels of this moon. If this was not our last trip down, we'd have replaced the switch immediately.

The Devil's Throat was now hit by a floodlight—a doctor's light peering into a patient's mouth. The throat image was pretty obvious when the cavern was discovered, and the inevitable names given by the exploration team stuck. We were operating inside a dangerous, if not malevolent, body.

Off the narrow ramp and into the Devil's Throat, we passed a hanging outcropping called the Epiglottis. This was not a true stalactite, but we called it that. We were cavernauts, not geologists. Our job was to get the geologists into the cave, install their gear, and get them out safely. We left the science to them.

"Pressure check," Bart said over the radio. "I'm at point three one atmospheres and change."

"Point two niner niner," I said, miffed that Bart preempted my lead. This was his way of asserting himself. It didn't matter, really; our search and recovery plan was a good one, and Bart knew that a little breach of protocol was okay once in a while. Bart, Colleen and I were well oiled, and Bart knew just how far he could get under my skin without endangering us. My tendency was to let him, and when I thought about it, I had probably been trying to show Colleen that I was taking the higher ground.

It's a little complicated, but while I was officially the Team Lead, I deferred to Colleen as the expert and almost always yielded procedural decisions to her. Bart knew this and respected me for it.

"Okay, Chief," he said. Sensing tension, he'd backed off.

We rounded the Epiglottis, leaving behind the last traces of the holographic, wireless WyrDNet, that "web of synchronicity and reciprocity" named from some Norse weaving myth. Here was blessed solitude, quiet like the muting of a sound system that had blared static at full volume. No more inquiries for status, subtle warnings, transaction updates, confirmations of messages blocked, and other electronic leeches. And no more belated messages from my pregnant Sharron.

A personal theory of mine. Something happened to people when virtual computers were invented. Other than a terminus and the occasional plexer, they had no hardware at all. It became easier for people to accept a system as part of themselves when it was not intrusive. This caused a shift in focus away from the physical body. People became more interested in the spirit, or the mind, or the community. Things like tanning salons and fad diets were replaced by philanthropy on AngelWeb, and infoleaks from Mensanet. Throughput addiction became an acceptable lifestyle. You were old-fashioned if you didn't flash on a holoweb, and you were antisocial if you unplugged.

Something about the startling information silence down here made me feel we might hear Colleen at any moment, calling for help. She wasn't dead, not yet. I knew I wasn't in denial, but that's the rub, isn't it?

From the Epiglottis, we had installed a fixed line that branched through the most heavily traveled passages. Originally it was wired for lights, but the acidity of the occasional venting caused the system to fail more often than it was worth. A complicated pattern of weak tides from Jupiter and the other large moons kept some little fires burning at Callisto's core.

Global positioning and NORAN were also useless down there. Suit telemetry worked, at close range. Everything has to be carried, and everything can fail. During the worst incident, each of us had a light fail

at nearly the same time. We had spare lights, but Colleen invented a rule on the spot: Always stay arm's length from the line. That way you could find it in the dark and follow it out. We also started using chemical Glo-Boyz.

The lights had failed due to corrosion, in particular because the rubber seals were not durable. They were artificial rubber, made on Mars from human fingernails and body oils extracted from laundry. We switched to real rubber, even though it was more expensive.

I ran my glove along the fixed line, and it vibrated up my arm. All the lines were coded. They were made of braided nanotubes, coated with some kind of highly reflective plastic. This coating was ribbed so that if you rubbed it the wrong way, it vibrated in your hand. If you ran your hand along it in the direction of the cavern exit, it did not stick like that. Every ten meters there were waffle ridges on the line, alternating from smooth to rough. Rough sections every hundred meters and finer ridges every ten marked the distance. In total darkness, you could tell where you were and stumble your way out.

There was no signal from Colleen or Miller. Any telemetry in the line would register on my console, so clearly they were not on the main line.

My shadow from Bart's light bobbed on the brown rock wall that curved away to the right. The line branched at Left Lung, and we headed down Line 1 at a pretty good clip. The other path was a shortcut to a lift we'd made, but it was for lowering equipment, not people. The last glow from the lamp above the Epiglottis vanished, so that the cavern was sculpted only by our lights. The fissure slanted steeply left, but you could lean a hand on the smooth wall and walk more or less upright.

We were both silent. Colleen would sometimes hum old show tunes or talk her batteries to death. Callisto was her rebound relationship. Her marriage had torn her up—I know, because I trained with her in the underwater caves of Florida during that time—and she needed something impossibly difficult to get her mind off her ex. She found it here.

"Where do you think she is?" Bart said.

"Probably in the Bowels."

We approached the first cache of air with hope. Though we were getting no line or radio telemetry, there was a chance she was there. The bottles appeared in our lights, but there was no one there. The cache was untouched, reducing the chances that Colleen and Miller were alive.

We jumped from Line 1 to Line 2, trying not to think about her. This was a shortcut to the Bowels, which we also called Devil's Anus to make the geologists think it was really dangerous. We didn't want to have to rescue them.

I began the climb over the Gallstone. Bart waited until I was safe on top. It wouldn't do if I fell on top of him; one accident needn't become two. There wasn't room on top for both of us, so I continued under Pinched Nerve.

There were many such tight spots, but this one had a nasty dip in the middle of it, so you really had to work it. Those of us who were experienced had techniques. Mine was to make sure I entered the dip with my right elbow. Then I'd swivel my right hip, roll halfway in, scuffle my right leg through, and then roll back to my original attitude. If I was carrying an extra air bottle, I'd strap it on my left side so it wouldn't get in the way. All the work was with the right side; the left stayed limp.

Previously, two men had died here, Ron and Kanuit. Ron got stuck, and Kanuit was trapped behind him.

"I'm through."

"Okay," said Bart. "I'm in."

While I waited, I recorded an audio log entry on our progress. Bart caught up and we drifted in microgravity down Gallstone on a rope ladder. When I got to the bottom, I held the ladder for Bart.

"Hey, look at that!" he said, aiming his wrist light at the ground.

A glint caught my eye, and there sat an object, covered with ice, but clearly artificial. About the size and shape of a bread loaf. I picked it up.

"Termite."

A termite was a boring robot, made to cut through soil and ice and send back telemetry. Useful to get around hard objects that were impractical to bore through. They were named termites because actual termites had discovered the largest diamond mines on Earth.

"Looks like this one was digging for diamonds and found water." Bart took it from me to have a closer look. "Doesn't look damaged, but it's out of power. It must have bored all the way through the lake, and then through the bottom."

It seemed to me too much a coincidence that it was so close to the trail, until I recalled Colleen's fascination with diamonds. Her helmet faceplate was a slenter of some kind, and her corneas had diamond coatings. I also knew her pain in giving up the rock on her ring finger. I wouldn't put it past her to place this termite where we would find it, maybe as a sign that she had found what she was looking for.

We continued on the line. Everything looked different from the reverse angle. The shadows made the formations look completely different. In effect, Colleen and Bart and I had memorized the tunnels twice, once as they appeared going down, and once as they appeared going out.

A distant booming sound froze us in our tracks. We felt it through our boots. Though this moon wasn't quite geologically dead, it was comatose. There weren't quakes.

"That felt like an explosion."

I shook my head, exaggerating the motion as one does to be understood in an environment suit. "No one should be blasting while we're down here."

"It felt like it came from above."

"Impossible."

"I should think."

There was no more sound or vibration, so we continued on. This was the Esophagus, and it was by far the easiest traverse at this depth. Three thousand meters below the Alchemetrix water and oxygen extractor, several thousand from the geo station, the Esophagus was wide and flat, a stroll through a black gullet of a canyon. Alchemetrix sat on an underground layer of ice, typical of this moon. Unlike most moons out here, Callisto was not well differentiated into geologic layers. It was a frozen stew.

"What say we switch places?"

"No, thanks." I wondered why Bart had asked. Was he bucking for the lead?

"Okay, Chief. Just thought you might be getting tired." That rankled me, partly because of the way he said it, but mostly because he said it.

The Esophagus narrowed to a V. We straddled it for about fifty meters, until it ended in a sharply pocked wall. It's to climb for.

"Still want to go first?" He really sounded like he wanted to lead this time.

I hooked my right arm around the line and found a foothold. "Yes," I said, not wanting to give up the lead, if only because he kept mentioning it.

I stepped up and found handholds. I'd been on Earth for a while and had built my muscles back up. Callisto's gravity was as feeble as a baby tugging on your finger.

A baby. For a moment, my thoughts were again whisked away to Sharron. Her baby was due any day, and it was hard to forget that, even under the circumstances. As I lifted my foot, my arm whacked against one of my spare air bottles, and my wrist computer went out.

"Uh-oh."

"Console?"

"Yeah. The LED, at least."

There was no way to repair the console down here so I switched to my spare, a semi-integrated computer in my left chest pocket. I clipped it to a ring and turned it on. It blinked, and a shaking-hands icon verified that it had connected to my internal computer via radio. I left the broken console in place—I've seen them get whacked a second time and come back to life.

Bart bent backward to look up at me. "Want to call the mission?" Was that a sneer in his voice?

"No."

"Protocol?" asked Bart. Was he challenging me to breach Colleen's rules? I got the feeling that Bart was somehow pitting me against her. Without her there, would I follow her protocol or assert my own judgment?

"We lose one more vital, we abort. Or did you have a better idea?"

"No, no. Of course not." So Bart was not about to deny her, either. Either of us bucking protocol would have implicitly excluded her as part of the team. We were still a team of three; neither of us had given up on her yet.

We scooted on our butts about ten meters to Fatboy's Lap. Bart cleared his throat and all but insisted on taking the lead. This was about the third time he'd asked to go first, so there had to be a pretty good reason for it. Colleen had always gone along with me being in charge, but now I gathered that Bart had been jealous.

Everyone loved Colleen. Dark auburn hair, widely set eyes that scrunched when she smiled, handsome square chin, strong body proportioned for hard work. She had a hit-and-run friendliness that made you feel briefly cared for, and then you'd have to work hard to get her to notice you were even alive. Like me, Bart got past that, into her inner sanctum. What did he have to prove now?

"What is this with you taking the lead?" I said.

"I'm thinking to check the Sinuses, instead of the Bowels."

"Is there something about all this that you're not telling me?"

"You know, Chief, there just might be."

With that tart remark, I wasn't about to let him go in front. If he had something to say, he'd damn well better say it. He didn't, so I led on, striking up a harmless conversation.

"What did you think of *The Men and the Mirror*?" I said.

"Is that a movie?"

"No, the book we read on the *Ozark*." The Ozark was originally named after some place in the Midwest, but the joke was that the *Ozark* was an ark from Oz, carrying assorted munchkins, witches, flying monkeys, and tin men like us.

"Was that on textnet?"

"No," I said. "Dead tree. Your initials were in the back of it." Paper books will always be on spaceships. There's nothing worse than amp rationing, and no entertainment for days on end. By tradition, we signed the books we read, like carving our initials in a real tree.

"*The Men and the Mirror*? I never read it. That was probably Bill McKinney. He reads a lot and has my initials. What was it about?"

"Nineteen-thirties science-fiction stories by some guy named Rocklynne. Dated, but wild ideas. This space detective chases a brilliant criminal to a new moon or something in each story. They invariably get trapped in some landscape feature or alien artifact. There's no way out, and they'll both die, unless they work together."

"I suppose they get out together, and then the criminal escapes until the next episode."

"Of course," I said.

"What made you think of that now?"

"The caves, I guess."

"Right," said Bart. "Well, since I'm following you, I must be the good guy."

So much for conversation. Bart was being competitive, and this was no time for that.

I hesitated. For a breath or two I could have sworn I smelled something funny. "Like licking an envelope," I told Bart.

"I've never licked an envelope."

"Wedding invitations," I explained, cringing. We never did officially tie the knot.

"Does it taste like glue?"

"I guess so. Any glue in these suits?"

"Maybe in the lamination."

The smell did not return, so we marched on, my thoughts wandering to the wedding. Sharron had wanted a picture-perfect event, and I went along with it. Imagine seeing your veiled bride approaching you at the altar during rehearsal—the fifth rehearsal—and you're growing suspicious with her every step. Something is wrong. Your best man leans over and whispers, "She hired a Hollywood bride." The veil is lifted at the proper moment, and you see your fiancé's "stunt double."

A Hollywood bride is a stand-in, just for show. Brides hire them when they are insecure with their looks or want a trophy version of themselves to appear in the wedding photos. I loved Sharron, but her neurosis got me spooked, and I called a halt to the wedding. We were already shacked up, so I didn't have anything to lose.

We slid down Nixon's Nose. The left line went up some vertical pipes called the Sinuses that led straight up to the Throat. The line to the right led to the labyrinth we called the Bowels. We reached the entrance to the Bowels and paused by the broad opening for a map check. We didn't need a map under normal circumstances, but when your telemetric breadcrumbs are malfunctioning, it could save your life.

"We follow the main into the Bowels. We come back through Cats and Dogs, swinging by the Sinus, in case they tried to get out that way."

I expected an argument, but he said, "Roger that."

Bart took the oxygen sensor from his side pocket. "I'm going to check you for leaks." He was thinking of the glue I'd smelled. It was possible that some contaminant was leaking into the rebreather. He ran the probe carefully around the Opack and my seals—neck, wrists, boots, hoses. Then a once-over of the whole suit. I didn't have a fartometer, or we'd have used that. (You break a vial of noxious gas inside your suit, and the coating on the outside of the pressure suit turns blue at the site of any leaks. The fartometer was based on those UV indicator creams that turn your skin blue when it starts to sunburn.)

"All good."

We checked the breadcrumbs. The breadcrumbs were coded magnetic buttons built onto the main lines or snapped onto secondary lines. They worked independently of the active telemetry. When you passed near them, your console recorded your position, and the crumbs recorded your passage. It wasn't a very good system, but it was the best one that would work. The breadcrumbs didn't need power—they were just what they sounded like—markers with unique signatures. The consoles did all the work, and they were easier to maintain. Unless they were down, like mine.

The breadcrumbs showed that Colleen and Miller, the engineer, had gone down this way yesterday, but had not come up.

We spooled out to a precipice for a look. Our lights shone across toward the cliff, revealing only the charcoal-shaded wall beyond. Sometimes if you covered your lights you could see a faint orange glow from down below. It always faded a few seconds after the lights were doused. A geologist thought they came from fluorescing diamonds. We doused, looking for any lights giving away someone's position. We never turn lights off. The more times you switch them on and off, the more likely the switch is to fail and stay off forever. We saw no lights.

We returned to the main line, Bart winding his jump line onto the spool by hand. Since the early days of space flight, there had been many attempts to make self-winding tethers. They all jam up pretty much every time.

We continued toward the enormous room known as Cats and Dogs. This mess of a boulder field just didn't lend itself to the body motif. So "Cats and Dogs." Hundreds of roughly rectangular boulders stood

scattered on the floor like miniature skyscrapers that had been knocked over by Godzilla. The main ran through the middle, to an edge, and then over a scramble to the base of the Sinuses.

A beep and a flash of my readout stopped my feet and jump-started my heart. "Telemetry?" All I got was the alert, not the data.

"I read it!" Bart said. "It's a suit transponder!"

"Colleen?"

"Can't tell. It's dropping packets. But it's moving! Colleen, is that you?"

No answer.

"I've got a fix." Bart moved around me.

"Lead the way," I said, though he had already started. If Bart was that pegged about it, maybe the best thing was to give him some slack.

He raked his primary light around and checked the reflective lines that stretched and sagged into the gloom. He led us past the jumble of Cats and Dogs and onto a pitted area that tilted steeply to the right. As I followed, I could see him checking his heads-up display. "She's making a beeline for the air cache at Anklebone."

"Are you sure it's her?"

"No, but whoever it is, is sucking CO2."

"I see her!" I cried, shining my light across a boulder field. "Near the cache!"

In microgravity, we could bound over this rock pile, but if you get overconfident, you can get stuck or wreck your equipment. We saw a suited figure moving erratically at the edge of our lights.

"Hurry—she needs help!"

We watched in horror as the figure began pulling at her gloves, as if to take them off. Quickly giving that up, she fell to her knees and struggled with her helmet release.

"Don't do that!" we both shouted into our helmet mikes.

Forfeiting caution, Bart jumped onto a boulder and then another. I followed, leaping from rock to rock, trying to watch our comrade at the same time. Our lights bounced about madly. Surely Colleen would see them and sit calmly until we caught up.

Instead she yanked the collar release all the way left and pulled the helmet off. She fell behind a rock. Bart was hopping and swearing, and I could not keep up.

Bart stooped over. "It's not her," he said. "It's Miller."

I rounded the boulder to see Miller twitch and then stop, his helmet lying on the ground next to him.

I had a flashback to an image from my cave diving with Colleen. There were a couple of curious accidents where some guys, with plenty of air, had gotten lost and panicked, probably when their lights gave out. They'd swum into some muddy corner and torn off all their scuba gear, as if it was the equipment that was killing them. One of the victims was nearly naked.

"He's dead," Bart said, checking the engineer's console.

"Look, his light is still working. All he had to do was make it to the cache—it's right over there."

"He never trained like we did. Once he ran out of air, he lost it."

Leaving Miller, we checked the cache. Untouched. My heart was sinking deeper into this place, and for the first time, Callisto felt wretched to me. This was the second untouched air cache. The chances of Colleen being alive were decreasing.

"Miller wouldn't go anywhere without Colleen," I said. "Something happened to her, and he left her to get help."

"Let's find her. Mind if I lead?"

"Be my guest," I said. At the moment, his hope was greater than mine.

He took off, not in the direction Miller had come from, but along a waffled wall called Six Pack.

"Bart, don't you think it's time to clear the air?"

"Okay," he said. "You first. Have you ever slept with her?"

"Of course not!"

"I know, you're a happily married man," he said, knowing full well I wasn't technically married. "But admit it, you did have a little thing going."

Son of a bitch. Why the hell was he distracting us? The best thing to do was to roll with it. "I admit," I said, "that we flirted some. The truth is, I think she saw me as safe, because I wasn't chasing her."

"You never did it."

"Certainly not. What about you? On Mars, maybe?"

"I wish."

"Oh, really?"

"Never," he said. "At least I'm not so secretive about it. Hell, I even joined a sculpture club, just to get close to her. That was Philadelphia, not Mars. Next to caving, sculpting is the most consuming thing she does."

"And here I thought you had a fling with her."

We laughed like net spuds drinking fruit beer and lamenting a girl neither had won. It drew us closer, except that with heavy suits, in the dark, and in a vacuum, we were really very far apart.

Bart stopped. He was shining his plasma onto the far wall, over the boulder field. "I thought I saw something shiny," he said, sweeping the light in a switchback pattern. The high wall leered over us with a prow like the nose of an Easter Island stone god.

"Shiny like what?" I was thinking diamonds.

Theory has it that the core of Jupiter is a moon-sized diamond, and that an ancient meteor smashed some fragments loose. A diamond ring formed around Jupiter, the shards colliding and breaking each other up.

In an atmosphere, the surfaces of diamonds bond with gas molecules, capping them off. But in a vacuum, the surfaces had nothing to bond to, except when they bumped into each other. Slowly turning diamond shards recrystallized, bit by bit, until they looked like flat, spiraling snowflakes the size of dinner plates. Or so say the computers.

Something changed, and the diamond necklace unclasped, sliding to the outer moons. Great barbed diamonds spun like whirlpools, snowing onto Callisto, to be there entombed for millions of years. The whole theory could be proven by finding diamonds that showed traces of the snowflake structure. Then we'd learn about Jupiter's inner structure. Callisto would be the easiest place to find them, since its minerals have not settled.

I wrote a poem about it. The Great Red Spot was a bleeding wound where Jupiter's treasure was cut from his heart. Callisto stole Jupiter's diamond necklace before he could reclaim it. She swallowed it, then spurned the old boy, turning her back forever. That's why her orbit is locked—to avoid his gaze.

Romance aside, these theoretical diamonds would be hot items. Nanomite and Alchemetrix long ago perfected the technique of manufacturing diamond and nanotube structures, using gas solvents to intercalate the molecular planes into any shape. Colleen called such diamonds slenters, after some old term for fake jewels made from Coke bottles. But on paper, the space elevator fell like the Tower of Babel. The carbon nanotubes couldn't be woven strong enough.

Enter Schwarzites, nanostructures with negatively curved surfaces. Where nanotubes made of carbon-60 were built of hexagons, the theoretical Schwarzites could also have some heptagons and pentagons interlinked. These made the structures much stronger, breaking up the symmetry that invited clean cleavage. It also caused the surfaces to curve themselves into pretty little beads. Among the applications of such knotted lattices were molecular chain links, woven together with traditional nanotubes. This type of “diamond necklace” could loop from the Earth to a space station, forming a viable space elevator.

No one could make Schwarzites, but they could occur naturally, possibly as a result of the Jupiter diamond robbery, with a fair chance that some were stashed on Callisto. That's what Colleen was after.

I was all for it, but someone else had to figure out how to make it all work. My role was to find the raw materials and bring them home without too many people getting killed.

"There it is!" Bart said. He was holding his beam fixed on the nearer wall.

I added my light to his. From a crack in the ceiling, a trickle of something dark and shiny broadened, following paths of least resistance, all leading down. On a vertical slab was the area Bart focused on—a slick of liquid, some evaporating off, some refreezing, and some tiptoeing through those sleeping cats and lazy dogs.

"Water," said Bart. "The water and oxygen plant is not far from here. This is melt-off."

"It's too cold to melt." Then a thought struck me. "Colleen said that if anything happened to her, no one should come after her. I thought she was just looking out for us, but what if there was some other reason for the warning?"

Bart flailed his arm at a rock, thought better of it, and slapped his thigh instead. "Great!" he said. "Just great. A warning like that, and you don't even think to tell me."

"I'm sorry."

"Damn it!" He hit his leg again and turned to face me. His helmet light shone directly in my eyes so it hurt.

"You should have told me! We're in serious trouble, Chief."

He looked around again, shining his light first down the tunnel, then up at the dripping wall again. "Come on!" he said, taking off down the tunnel to the Bowels.

"Line!" I reminded him, but he wasn't slowing down. I hastily looped a jump line to the main and checked the orientation to make sure it wasn't spooled tails out. The ridges could lead us the wrong way if it was backwards.

Bart was a good way off. I was winded, and I heard Bart's heavy breathing too. This sort of situation can quickly crumble into chaos, without anyone knowing why.

"Bart," I said. "Take it easy."

"Hurry up!" He stopped to wait for me. "Okay. Now let's get moving."

"Just a minute," I said. "Tell me where we're going, and what this is about."

"Sharron is expecting any day now, isn't she?" he said.

"Cut the crap, Bart."

"You think *she's* gonna break water, just stick around here!" With that, he was off again.

Water breaking? So the dripping water on the walls above was just a beginning. The trickles were fed by a source that could only be the lake above. There was a hell of a lot that Bart knew that I didn't.

"Bart!" I shouted. A waste of air. The radio would clip the volume anyway. Bart said something, but I couldn't make it out. Com failure or just my heavy breathing? I shouted again, and stopped, to listen in relative silence.

"Hurry..." Words again, mixed with static.

"Bart, I've got a com problem. Copy, Bart. Com problem, over." I degraded to push-to-talk, remembering the resin smell from a while ago. At a starting mix of 100 percent oxygen, an exposed wire would be a fire hazard.

The radio was dead. Through my helmet, I thought I heard sounds, though. Sounds like rushing water, or maybe steam evaporating violently, somewhere far away. Through it all, an imagined voice, like Colleen whispering, "Where are you guys?" as though she was trying to keep me and Bart together just a little longer.

A crackle, and then: "Copy, com problem, over. You there, Chief?"

"I'm here, over." I walked on until I saw Bart's light. He was waiting for me. "No more rushing ahead."

"Roger that."

"Now tell me exactly what's going on, before we lose radio completely. The lake is melting above us, isn't it?"

"Yes," he said, as we continued down together. There was still an edge to his voice, but he was being dutiful. "I'm guessing the bottom is still frozen, but the warmth is breaking through."

"Mind telling me about that?"

"It's supposed to be a secret, and Colleen thought that if you knew, you'd feel obligated to put a stop to it."

"So this is a scheme to find her diamonds."

"Of course," said Bart. "Someone got the idea that if there were some frozen in the lakes, you could melt the ice, and let them sink to the bottom."

"Good God," I said. "The whole outpost is practically vacated, so she vented the excess reactor therms into the lake."

"She or her engineer friends."

"I knew nothing of all this."

"Well, I'm sorry," Bart said.

"And you didn't think it was important to tell me when we set out to find her?"

No answer.

"Copy?" I insisted.

"I hear you."

We were at the bottom of the cavern system, near the Sinuses. From there, a nearly vertical shaft led to a broad tunnel, and then back to the Throat—a shortcut for lowering equipment. The ground flattened onto the bowl that sat at the deepest part of the Sinuses.

As we neared the bottom, our lights illuminated something that shouldn't have been there. It was wide, very tall, and dark. We probed it with our beams.

A peculiar apparatus had been constructed in my absence, a huge lattice of wide metal bands, sitting upright on heavy legs at the nadir of the cavern. It was a broad cage, the size of a Martian sand blower.

"What the hell is that?" I said, but I don't think Bart heard me. Then I noticed an object inside the cage, resting at the bottom. It was obscured by some of the bars.

"What is it?"

This time he heard me, and he stopped cold. "It's her."

I didn't understand, but looked to where his beam was pointed, at the object in the bottom of the structure.

It was Colleen, lying motionless, trapped in the cage. Her lights and instruments were dark, and I realized we'd picked up no telemetry. The metallic green and purple of her suit glittered, and I thought of how it used to shimmer in front of me as my light shone on her treading form.

She was dead, and it didn't seem right that she glittered like that. My head grew hot and light, and my stomach hardened as if I'd swallowed a potato whole. Colleen's faceplate was frosted on the inside, but her face was outlined through the fog. A rivulet of steaming water was collecting directly under her.

"What the hell did Miller do to her?" I said.

"I don't think he did anything."

"Well, who the hell put her in this cage?"

"Chief, there's an opening right here." He pulled at a crossbar, and a large gate opened. "See? The top's open too. No one locked her up."

"Then what? Did you know about this?"

"Honest, I didn't," Bart said. "But I know what it is. It's a sieve."

Finally it became clear. The cage was a diamond net, the work of many people. As the frozen lake above melted, the runoff would come down here, and any solid matter bigger than a breadbox would be caught in the lattice.

"Colleen could get anybody to do just about anything," Bart remarked.

"Well," I said, "let's get her out." I climbed two steps up to the gate, checked my balance on the narrow rung at the top, and hopped in. I had to land on all fours to avoid falling on top of Colleen.

Bracing myself, I lifted her shoulders—and something caught. I looked out at Bart and waved a crooked hand in a figure eight, the signal that something was stuck. I disconnected her life support harness and lifted her off of it. One of the hoses to her scrubber had caught under the cage bars, and it looked like the other side of the pack had wedged against the adjacent bar. She'd probably fallen and gotten herself locked to the cage floor. Miller couldn't free her, so he tried to go for help, running out of air on the way.

"She's really stuck," I said.

"Leave her."

My head reeled. Colleen should only have been using the inboard hoses. You never leave loose ends that can catch on something. She broke her own rule, mistake number one. Then she was stuck, a result of some stupid mistake number two. She should have been able to unbuckle the pack and sit up. There's enough slack in the hoses to turn part way around, but she had not freed herself. Mistake three. Sometimes you never do figure how these things happen.

"What in the world?" Bart said.

"What is it?"

He was shining his light at something on the far side of the cage. "Queenie!"

"Huh?" I shook my head. Queenie had been Colleen's dog on Mars, put to sleep and buried years ago.

A deep rumble and then a series of cracks vibrated through the cage and into my suit. The cage shook slightly. Something distant but enormous was giving way.

"We've got to get the hell out of here," Bart said.

"Okay. Help me get her out."

"We don't have time."

"I'm going to get her out," I said, breathing through my teeth.

"There's no time. Look." He shone his light at the ceiling. It was wet. A rapidly evaporating funnel of water dropped through his beam, hitting me square in the face. Steam fled from it in all directions, but it kept coming.

"Are you all right?"

I moved over, but the water hit Colleen, which I didn't like. I leaned forward, so the water hit my back. "I'm fine. Looks like they positioned their sieve in the right place."

Bart was still on the backside of the cage. "Get out of there!" he said with an urgent wave. "There could be junk falling on you any second."

"It's just water," I said, feeling pressure of an increasing flow on my back. I held Colleen in one arm, but did not know what to do next.

"No, Rick! I'm talking about rocks or diamond snowflakes, and they're razor sharp!" That was the first time he called me Rick since we started. He was done playing with my brain. We were in real trouble. "Get the hell out of there!"

I let Colleen down gently and climbed out of the cage. I expected him to lead the way, but he stood firm.

"First take a look at this mutt," he said.

I rounded the cage, my suit steaming. Sure enough, it was a dog, a sort of cubist sculpture of what looked like diamonds the size of my wrist console. It was about a foot tall, in a sitting position. Not bad for someone who had only dabbled with sculpture.

"I don't get it," I said.

"Queenie here is the best monument we have to Colleen's work. See, she's been recrystallized from smaller pieces."

"So she was right. Diamonds did come here from Jupiter."

The growing flow of water from above was pouring down on Colleen in a slow-motion waterfall. The air was thickening with mist, and we turned our helmet wipers on. Another distant rumble and crack, and the flow doubled. The bowl we were standing in was filling rapidly. In a moment, it would rise to the top of the cage legs and begin to cover our partner. Also, the humidity was playing tricks with my com link, a frightening sign that my electronics were compromised.

"Quick, Bart! Put down that dog and help me get her out of there."

"Give it up, man."

"Okay, Bart, I've had about enough of you," I shouted. I'd been lenient all this time, out of respect. Obviously, I was the only one left on our so-called team. "You've been fighting me all day, hiding information, needling me.... You damn well are going to help me get Colleen out of this hole!"

"Rick, don't you see?" His voice was calm but crackled by static. "We can't get her out. We need to take her dog."

"What?"

"It's her legacy."

I could see that the dog was some kind of mascot, but I felt obligated to take her home, and I was going to do it. She wouldn't want a virtual burial; she'd want to be there, in person.

Bart made for higher ground with the dog. "Come on," he urged. "It will be a hell of a lot harder to swim out of here."

"No."

"Damn it, Rick! That's the wrong decision, and you know it. Look, as nice as it was, Colleen's body means nothing now."

I started up the slope toward him. "I'm going to take you apart!"

My voice had raised instinctively, even though it was electronically clipped, and now I found my hands raised into clumsy, ridiculous fists. A scene from a space spoof came to mind, where suited men had a hilarious fistfight in zero G. I grunted, half laughing and half furious. A spacesuit is a straitjacket to man's baser instincts. When technology enforces civility, I reminded myself, it is usually a good thing.

All right, if Bart wouldn't help, I'd damn well get her up by myself. I climbed the cage again, to the door that was still above the water that boiled, cold as it was. Bart stood on a boulder, cradling Queenie and watching me. I heard static, and then: "I'm getting out of here, now!"

"I'll make you a deal," I said. "If we can't get her above this water in five minutes, we give up and hightail it out of here. Agreed?"

Static, then: "No, you idiot, I'm leaving now."

I shouted at him, but he either didn't hear or was ignoring me. It was no use. Without Colleen as a bond, our team had shattered like a miscut diamond. Bart turned and pointed the way out with two hands, meaning we both go that way.

"All right," I said, and signaled. "I'm coming. Five minutes."

Bart started up the passage. He might not find my jump line, but he knew his way out. "I think I figured out why she made a diamond dog," he said. "Dog is man's best friend. Diamond is woman's."

I chortled sarcastically.

The water was lapping at the bottom of the cage, some steaming, some refreezing. I climbed in again. My chest heaved uncontrollably. "I may be an idiot, but I'm going to get you out of here."

I could possibly float her out of the cage and onto higher ground. But there was no way I could carry her all the way out. The Sinuses were almost directly overhead, and our pulleys were there. That's how the cage parts must have been lowered down. I could turn up the pressure on our suits to inflate them. Then we could float up through the vertical passage, to the flat tunnels a thousand feet above. From there I might be able to carry her out Devil's Throat.

I bled as much air into her suit as it would take. It swelled up and bubbled into the rising water from a one-way overflow vent. There was plenty of pressure—what had started as 100 percent oxygen was probably less than 10 percent now, but that didn't matter. I detached the pack. Next I added some pressure to my own suit.

I laid down in the waist-deep water, testing my buoyancy. No good. I still sank. Colleen was barely buoyant, not having the burden of the breather pack, but she couldn't keep both of us above water.

A sudden splash next to me made me aware that I could hear through my suit falling objects growing louder. Another object fell, and I saw it this time. It looked like a rough diamond all right, but it wasn't a welcome sight. It nearly hit me. We were sitting at the bottom of the sieve, where all the debris was supposed to fall.

I had almost no extraneous equipment to doff. I removed a few things from Colleen's suit, but it didn't help. The suits just weren't made for underwater use. There was no buoyancy control at all.

Something huge plowed into the water next to me. A rock, followed by a diamond that cracked against Colleen's helmet with a sickening sound that seemed far away. Even in low grav, it had accelerated from a great height. The object had made a deep groove in her faceplate, which was a slenter. Whatever had hit the plate was harder than diamond. A Schwarzite chunk, maybe?

I was standing in the cage, and the water was up to my helmet. I was starting to feel the cold. The water conducted heat from my suit much faster than vacuum. I turned up my heater and immediately smelled hot resin.

I let the water rise above us. Maybe when we were completely submerged, we would float just under the surface. It was easier to see underwater, without the fog, and when another diamond splashed into the cage, the water cushioned it some. Unfortunately, we weren't floating at all. If I let Colleen go, she did float upward, but when I held on, down we stayed. There had to be a way to make this work. I tried adding more air, but we still didn't float.

There was nothing more to ditch, except the friend I had given so much for already. Leaving her was unacceptable. Yet, through my stubborn determination broke the hard-earned wisdom of the cavernauts: Get the hell out of there. Colleen's voice was somewhere in that chorus, and that made it okay to give up.

What the hell was I doing out here, risking my neck for another woman? Colleen was one of the *guys*, I always said. Sharron understood that, bless her heart, and had let me come out here, but for what? To help Colleen achieve her dream? Maybe Bart was right to take the dog instead of Colleen. Colleen was gone, but her dream might live.

I looked toward the jump line and the way out, but my light dissipated quickly in the water. Decision one: It was no longer an option going out that way. Options? Colleen's empty suit should make a good float. Decision two: Remove her suit and use it to float up the shaft. Maybe I could use the cable as a guide.

I started with her pant straps. The waist was sealed with a plastic ring and composite buckles. The seal broke easily, and air bounded into my face and up. I guessed that I was now under fifteen feet of water, and I was starting to feel a slight pressure squeeze.

My suit held about one-third atmosphere of positive pressure in a vacuum. Under water, I'd be "upside-down," meaning that the pressure outside my suit was greater than the pressure inside. It was rated to take two atmospheres upside-down, and I did a quick estimate to try to determine how deep I could be before getting crushed.

The gravity of Callisto was one-eighth G, which meant I could be eight times deeper than on Earth before being crushed. I'd be okay at about 150 meters, but I'd use up my air much faster.

I pulled off Colleen's pants and wedged them in the gate while I worked on the torso. That was the hard part—her arms were stiff and didn't want to come out.

I removed the helmet, at last looking at her face. It was not attractive under the dirty refraction, but it wasn't as grotesque as I'd feared. Her freckles were still cute. Then I saw a choker around her neck, a

diamond necklace of woven strands with hexagonal links. A model of a space elevator chain. When I pulled on it, the links tightened like a Chinese finger trap. Clever, and no way to get it off.

Neither did removing the helmet help in loosening her arms from the sleeves. I was expending a lot of air in trying, and it just wasn't working. I could remove the gloves, but they weren't the problem.

I vomited in my helmet, most of it going down my neck. I let Colleen gently down. She fell like a fluttering feather, hair drifting, legs dressed in thermal underwear.

There was no time to remove the entire suit. The leggings would have to be enough. With the boots integrated, they should hold air when inverted. I cut a length of line from a jump reel and threaded it through the harness rings. I looped these under my arms and held the pants over my head. Then I dropped down to Colleen's bottle and released her stale air into the pants. They inflated above me like a grotesque parachute. Two boot mints fell out and tumbled over my chest pack. That was so like her, to care what her feet smelled like out here.

I drifted upward. I shone my light down, seeing Colleen faintly below, defiled and degraded. I was frigid, drifting in a dead moon. I could hear the heaving of ice through the sound of the bubbles escaping the pants as the air expanded. My hands grew numb.

I turned my attention overhead, to make sure my float didn't bump the roof and collapse. With my wrist light, I scanned for the pulley line. I had a sense of where it was and kicked in that direction. I met the sloping roof and pulled Colleen's pants to the side, pushing on the rock with my other hand. This provided better locomotion, and I guided myself toward the shaft. The slope led that way, and soon I saw a bright line in the water—the reflective pulley cable.

I met the cable and looped a leg around it. The pressure was getting worse, my pump motor was grinding, and rancid smoke from the electrical heater problem was beginning to choke me. As the water level rose, I rose too, quietly, the occasional crash of ice or rock shaking the water column around me.

* * * *

Like it or not, it was times like this when my creative juices flowed. Bart played guitar, Colleen had her sculpture, and I was a frustrated poet.

Sailing is Freudian, I once wrote. You don't explore, but make love to the sea, caressing her swells, yielding to her seductive currents. But rolling over her sensuous surface is foreplay. To consummate this love, you have to submerge, to fin about inside her.

With eyes closed or irises agape, you float in sensory overload, the languages of shrimp, porpoises, and propellers as familiar as the mutter of your own bubbles. The buoyancy compensator is an antigravity device; with physical bonds unfettered, the spirit roams where it will, the body—astral, flying in a lucid dream, circumnavigating cities of coral.

A cave is the womb of a mountain. You can yodel up a trail with a feather in your cap, warbling of frivolous love for the mountain, or you can enter her intimately, seeking her deepest secrets.

The union of sea and mount is cave diving. The upwelling thrust of the spring tries to deny entry, and you are a salmon, fighting your way upriver to spawn. Between dark walls your senses turn inward, and you can hear your heart beating. It's not how far in you penetrate, but how far out you get that matters. There must be life after depth.

The cave helps you. Her current siphons you up the canal, head first, panting Lamaze into your regulator. You reel in your line, an umbilical, and in a gush you are squinting in sunlight, dripping, and taking your

first unaided breath.

The deepest mystery is this: You enter the watery cave as the love maker, yet emerge as the love child. You learn to walk and to fly away, seeking unending rebirths, world after world.

* * * *

I bumped into something overhead. My makeshift float buckled, letting most of the air escape. The pants fell to the side, no longer holding me up. I grabbed onto the cable with both hands and also squeezed it between my thighs.

What had happened? I looked up to see a solid ceiling. The cable looked cut, but that couldn't be, because it was holding me up. I groped at it with one hand.

The cable disappeared into the solid rock above.

How could that be? Maybe the rock wasn't so solid—it's hard to tell with gloves on. Either the ceiling had become plastic and intruded onto the cable, or the cable had cut into something relatively soft. That sometimes happens in mud caves, which this was not. At least, it hadn't been. The water might have suspended loose material, or perhaps mud was draining from the lake bottom.

Whatever the case, I was trapped. I tugged the cable, but it didn't move. Instead, the water clouded, and visibility went to zero. I got a jump spool from a pocket and clipped it to the cable. I was going to have to run a pattern around this obstacle.

I set out to swim in a widening spiral, but as I let go with my hand, I began to drift downward. *Damn it!* I'd lost my buoyancy. My leg was still hooked on the cable, and I drew myself in, supporting my weight with it. I was under a giant wad of mud with no way to get over it.

There I hung, blind and freezing. The pressure was building, and it was starting to hurt. Why the hell had I left Sharron for this? She'd raise our kid alone, and when the kid asked where was daddy, she'd hand over the binoculars and point at the night sky. "Your idiot father is frozen dead in one of those dizzy little dots whizzing around Jupiter."

She never got my poetry. "If being a cavernaut is such a transforming experience," she once asked, "why can't marriage be, too?"

It was getting hard to breathe, like a Sumo was sitting on my chest. The water was still rising above me, increasing the pressure. Buoyant or not, I was getting over that obstacle, if there was any way to do it. I let Colleen's pants go. Maybe they'd find her down in the abyss, restoring a little of her dignity.

There were some tools in my pocket, and clinging to the cable, I got out the most versatile invention in the history of mankind: a big-ass, flathead screwdriver. If this rock was soft enough to absorb a taut cable, a screwdriver ought to gouge a hole in it.

I set my jump line to spool out by itself, in case I needed to come back. It was a habit; I wasn't coming back. Then, with a broad arc of my right arm, I stabbed at the surface above with the screwdriver. The ceiling had the consistency of clay, and the driver sank in, to the grip. Using the tool as a lever, I bent my wrist, pulling myself from the cable and along the underside of the roof.

Floating in low grav, it didn't take much to support me. The screwdriver did the trick, but I only had one. I pulled it out quickly, and took another quick stab at the ceiling before I fell away.

I snorted to clear my nose, not caring what came out of it. I tried a smaller arc of my arm. I couldn't afford to miss. So with small brisk stabs of the driver, I moved along the ceiling.

The ceiling was curving around and gently upward, so it seemed I was rounding the obstruction. I was elated, and in a few minutes, I was on my belly, still pulling myself along with the screwdriver. I was afraid to stand up, because if something happened, I'd want to be able to dig in quickly.

I became aware of my lights—the water had cleared considerably, and I played my main around. I thought I saw the cable dimly reflected, and I made in that direction. It was the upper part of the cable, shining in my light, angling from somewhere inside the huge obstruction up to what had to be the exit tunnel of Devil's Throat. Safety be damned, I stood up and took off for the cable.

Immediately I was jerked off my feet, and I fell on my face. Something had caught. I reflexively twirled a hooked hand in a figure eight, but there was no one to signal. My jump line had played out and caught. I ripped it from its carabiner and threw it away. Standing, I could barely get any traction, but I leaned forward and pounded my feet.

My legs hurt, and mud was swirling into the water. I drove on until I could see the cable gleaming just ahead. My gloves seized it like ravenous jaws, and my screwdriver fell away. I pulled myself up, hand over hand through the numbing water.

I heard more sounds of cracking and roaring. A strong upwelling hit me, yanking the cable from my grip. I could only guess what caused it—perhaps some gigantic collapse in the Sinuses was coughing whole galleries of water upward.

I had lost my last umbilical, surrendering at last to the elements I had so methodically conquered. Tumbling, I lost all sense of direction, struggling to keep my limbs from twisting behind me. My air pack was slipping, and I strangled the straps against my chest.

The sound of an otherworldly surf crashing onto a rocky shore filled my helmet, and I imagined that a wave of static was also awakening my radio. I did crash, not onto rock, but onto a sheet of surging current that slapped me in what felt like a horizontal direction.

Suddenly, my faceplate hit something hard. I was on my stomach, on the floor of a tunnel. I could see the glint of what might be a fixed line to one side.

The rush of water subsided and fell back, dragging me with it. I grappled and kicked and managed to brace my legs against a protrusion. A terrible choking sound like the gulp of a leviathan swallowing the sea filled the cavern, and hissing vapor seemed to flee the world as the remnants of the lake fell into the bowels of Callisto.

No, not bowels. A womb.

It was now dry and pitch black, except for one bright bolt ahead. It was an illuminated line, which meant that I had to be just below the Devil's Throat—and only a couple of hundred yards from warmth and air and life. As I got up and made for the line, I found that my radio had indeed awoken. I was within range of the deep antenna.

The signal strengthened, and the data broadened as the ribbed line vibrated through my fingers, singing to me of the way out. I filtered all the sounds and sights arriving from the WyrpNet, looking for something very specific. When you're looking for a needle in a haystack, it's nearly impossible to find. But when you're looking for a straw in a stack of needles, it's a lot easier. Whatever doesn't poke at you to buy something, provide personal data, sign a contract, be your "friend"—that's the message you're looking for.

Got it!

Sharron's blessed face appeared on my heads-up display. I wanted nothing more than to reach through millions of miles of WyrpNet and touch it. She smiled, and her latent voice said, "It's a boy." That announcement, carried by excited photons, would soon ripple past Saturn and beyond, in all directions, chasing the very edge of space itself. The universe had just changed, ever so slightly, but forever.

"Have you picked out a name?" she said.

"Yes," I answered. I was gasping, shivering, coughing, and crying. "Roger That."

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Science Fact: **FROM TOKEN TO SCRIPT: THE ORIGIN OF CUNEIFORM** Henry Honken

Logographic scripts

Writing is speech made visible: along with walled cities, the wheel, metallurgy, and a code of laws, it's one of the defining marks of civilization.

Though human language is thought to have originated anywhere from 10,000 to 100,000 years ago, writing is very young. The earliest known written records go back only to the late fourth millennium B.C. During those four millennia, the art of writing was independently invented at least five times. Written texts, as opposed to pictographic records, appear first in Mesopotamia, Egypt, and Mohenjo-Daro. Over a thousand years later, the Shang oracle bones are inscribed with symbols, which later developed into Chinese characters. On the other side of the world, the Olmec precursors of the Maya glyphs first appear about 800 B.C.

Writing systems can be roughly divided into alphabets, syllabaries, and logographic systems in increasing order of complexity. Aside from China, Taiwan, Japan, and Korea, where texts are wholly or partially written with Chinese characters, all modern written languages use an alphabet. In spite of the advantages of simplicity and ease of learning that characterize an alphabet, however, all of the earliest scripts make use of either a syllabary or logographs[1].

Almost all of the world's alphabets, many researchers think, have a common origin in the Near East around 1500 B.C. so that, for example, a continuous line of descent may be traced from early Semitic alphabets through the Greek alphabet to the Cyrillic alphabet used in the countries of the former Soviet Union.

An alphabet has one symbol per phoneme, the minimal contrastive sound. Words are made up of phonemes organized into rhythmic units called syllables. In the English word "nitrate," seven phonemes combine into two syllables "ni-" and "-trate," phonetically [nai-tre:t].

* * * *

Table 1: Examples of Kana, Kanji, and Cuneiform

* * * *

As a result of their tangled histories, modern alphabets often suffer from irregularities. In the example word, the diphthong "ai" in the first syllable is written with a single character and the final -e is not even pronounced, its only function being to show that the preceding "a" should be pronounced as long [e:] as in "bait" [be:t], rather than short [ae] as in "bat" [baet].

Note also that *contrastive* sound means that only those phonic differences that correlate with a difference of meaning are written. In the homophonous "night rate" [nait + re:t], the "t"s at the beginning of "-trate" and the end of "night" are phonetically different, but are written with the same symbol.

A syllabary is a script that has a separate symbol for each possible syllable. This would be very unwieldy in English because of the great variety of syllable types but in languages with a simpler syllable structure a syllabary can be very efficient.

Japanese has a mixed script. In addition to Chinese characters called "kanji," Japanese employs two syllabaries, called "kana." In general, Japanese syllables begin with a consonant and end with a vowel and there are no consonant clusters like the "-nks" in English "drinks."

The *kana* characters for the syllables "ka, ki, ku, ke, ko" (see Table 1) are completely different from the

vowel symbols “a, i, u, e, o”; similarly, the characters for “ka, ta, ha, ma, ra” have no common element to represent the “-a.”

Japanese *kanji* were borrowed from China through the offices of Korean Buddhist missionaries who had settled in Japan. These characters, still used by the Chinese after 35 centuries, form a *logographic* script. Logographs are characters that represent whole morphemes, the basic units that make up words. For example, in the word “manliness” there are three morphemes, “man,” “-li-,” and “-ness,” none of which can be further subdivided.

Since there are thousands of morphemes in any language, a logographic script is much larger than an alphabet or syllabary. The average literate Japanese or Chinese will control around six or seven thousand characters. An additional difference between logographs and alphabetic symbols is that the former frequently have an internal structure.

Some Chinese characters are iconic, that is, derived from pictures of the concept they represent, but these comprise only a small percentage of the total. In Table 1, “sun” and “water” are examples. Other characters are combinations of one or more simpler characters like “bright” in Table 1, which is historically derived from “moon” and “window.”

The majority of characters are composed of a semantic component called “the radical” and a phonetic component. In Table 1, the characters in the middle row of the kanji section are both read “chi.” The left part of chi “pool” is the water radical, a simplified form of “water” seen in the line above; this tells the reader the character has to do with fluids. The left part of chi “ground” is the earth radical which identifies the character as having something to do with earth. In both cases, the phonetic “chi” gives a clue to the pronunciation.

Both Egyptian hieroglyphs and Sumerian cuneiform are organized along similar principles with some iconic symbols and others with semantic and phonetic components.

* * * *

Ideas on the origin of writing

Egyptian hieroglyphs seem to spring into existence full-grown like Athena from Zeus's brow. The oldest Sumerian characters sometimes show a development from clearly pictorial forms into the more abstract wedge-shaped characters, but here also the earliest records already make use of hundreds of symbols, many of which are not clearly motivated as pictures.

As a result, most histories of writing are lamentably vague about the earliest stages. Up until the last couple of decades, the received opinion was that writing was invented in Mesopotamia and a century or so later spread to Egypt. Since the details of the two scripts are quite different, the spreading presumably took place by means of what anthropologists call stimulus diffusion.

Like ions across a membrane, ideas diffuse from one culture to another. In recent years, karaoke diffused from Japan to America and the Goth style of clothing in the opposite direction. Stimulus diffusion means that the idea alone is borrowed[2]. In the Egyptian case, the presence of clearly Mesopotamian features such as the use of cylinder seals points to a strong Mesopotamian influence around the end of the fourth millennium b.c. and since the earliest known examples of hieroglyphs were dated about a hundred years later than the earliest records in Mesopotamia, researchers concluded hieroglyphic writing was inspired by the Sumerian example.

Nevertheless, writing, in the form of seals, palettes, funerary stelae and so on, emerges in Egypt just before the unification of Upper and Lower Egypt and the beginning of the Old Kingdom, already highly developed with many signs functioning as logograms and the rebus principle fully established[3].

The Egyptians wrote on a paper-like substance made from the papyrus reed, but in Mesopotamia the medium was clay. The clay was formed by hand into squarish tablets, flat on one side and slightly convex on the obverse. The signs were scratched out or impressed into the clay by means of a stylus cut from a reed. In the earliest examples, some of the signs are recognizable pictures, but these are eventually all replaced by graphs made up of wedge-shaped (cuneiform) lines.

The most ancient tablets (like those found at Uruk[4]) are different in many ways from later writing. They are almost all economic in nature (though some are dictionary-like lists of signs). The tablets are laid out in vertical columns and within the column each record is placed in a box. The ordering is not linear and the style is telegraphic like entries in an appointments book.

The oldest records are in Sumerian, a language with no known relatives or descendants. Sumerian is agglutinative—with suffixes piled up in long chains: dumu ("son"); dumu-me ("sons"); dumu-me-a-ni ("for his sons")—and ergative; that is to say, the subject of a transitive verb takes a special suffix. It is thus quite different from any European language and when the first Sumerian records were discovered, puzzled scholars thought it was a trick of the scribes.

* * * *

Cuneiform

About the middle of the third millennium, the neighboring kingdom of Akkad adapted the Sumerian cuneiform script to their own language (Athnaum akkaddtum—"tongue of Akkad"). Even at that immense distance of time, Akkadian is identifiably Semitic. Compare, for example, "bull"—urum in Akkadian, ir in Hebrew, or "house"—bu in Akkadian, and bit in Hebrew.

The example below will give some idea of how the Akkadian scribes wrote a sentence.

* * * *

* * * *

The first line is the transcription identifying each sign as a Sumerian word, Akkadian syllable, or determinative (analogous to the radical or semantic component in Chinese characters in Table 1). Assyriologists conventionally transcribe Sumerian words with capitals and write determinatives in raised position. The second line is the Akkadian reading of the same cuneiform sentence. The preposition ana ("for") is written with two phonetic signs, "a" and "na." The noun baet ("house," here used for "temple") is written with a logogram whose Sumerian reading was "e." The name of the god Dagon is written with the determinative dingir ("god") followed by two phonograms, "da" and "gan." The noun daltam ("door") is written with the determinative gi ("wood") followed by the logogram for "door," read "ig" in Sumerian. The sentence ends with the verb "make" written with the Sumerian logogram "du," followed by a phonogram "u" to mark the past tense.

Thus, like Japanese, the Akkadian cuneiform was a mixed script in which logographs were combined with phonetic signs. And just as kanji have both Chinese and Japanese readings, the cuneiform signs had Sumerian and Akkadian readings.

Since the Akkadian phonetic system was completely different from that of Sumerian, the Akkadian scribes faced many problems in adapting cuneiform to their own language. As nearly as can be determined from the data, the consonant systems of the two languages were as in Table 2.

* * * *

Table 2: Consonant system of Sumerian and Akkadian

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The major problem faced by the scribes was that Akkadian possessed sounds not found in Sumerian, like the emphatic consonants [5] t., q, s.. These were never consistently distinguished in the history of the script. In particular, final consonants are indeterminate so that -ad, -at, and -at. can all be expressed by a sign read AD.

As the script developed, two things happened that greatly obscured the pictorial element in the signs. First of all, all of the signs were rotated by 90 degrees. Secondly, the permissible components of signs were reduced to two: the wedge:

and the "Winkelhaken"

and the permissible orientations to horizontal, oblique (almost always pointing to four o'clock) and vertical.

* * * *

In addition to the script itself, the Akkadians borrowed the Sumerian sexagesimal numerical notation. Units were represented by a vertical

wedge and tens by a Winkelhaken or hook

After 2000 b.c. in the later Babylonian mathematics, this became a positional system in which, for example, 75 was expressed as $60 + 10 + 5$; a vertical wedge, a hook, and five wedges.

The kinds of texts also expanded from purely economical records to prayers, hymns, omens, literary and scholarly works, contracts and treaties. During most of the third and second millenniums, in fact, Akkadian was the international language of diplomacy.

* * * *

The Token System

Speculations on the history of writing have been given a new twist in the last twenty years by Dr. Denise Schmandt-Besserat at the University of Texas. Although the origins of most writing systems are still shrouded in mystery, in the case of cuneiform at least, Schmandt-Besserat has suggested that the earliest Sumerian symbols are derived from an accounting system using baked clay tokens that goes back to Neolithic times. In other words, writing originated not out of a literary need as we moderns might expect, but out of that dry stick, accounting.

The traditions of literate peoples have usually attributed the origin of writing to the gods:

* * * *

*stolen from Enki, god of wisdom, by his daughter Inanna.

*taught to the Babylonians by the sea-creature Oannes (a being with the body of a fish, but the head, feet and voice of a man), the kind of evidence that Carl Sagan speculated might support a visit by aliens.

*given to the Israelites on Mt. Sinai by Jehovah in the tablets of the law.

* * * *

But when scholars first began to speculate on the origin of writing in a systematic way, the iconic elements of early scripts suggested that writing began as pictures. This view, introduced by William Warburton,

bishop of Gloucester, based on his studies of Egyptian and Aztec texts, has held the field up till modern times. The fact that the majority of signs in the earliest writing are already so abstract that their pictorial origins can't be identified was blamed on primitive mentality or the clumsiness of scribes.

Scholars generally agree that the first examples of true writing (as opposed to pictorial records) are the clay tablets found in Mesopotamia inscribed in Sumerian and another ancient language called Proto-Elamite. The earliest of these can be interpreted to some extent by reasoning back from the known cuneiform symbols and appear to deal exclusively with economic matters. These written records are dated at around 3500 B.C. but the first cities are very much older. The oldest level at Jericho dates back to 9000 B.C. The question then arises: How did city governments keep records in the period from 9000 to 3500 and, given that the oldest writing was already largely abstract and phonetic, what were the precursors of the Sumerian and Elamite scripts?

Schmandt-Besserat's research did not originally deal with writing at all. She began her investigation with a study of uses of clay before pottery. In the course of examining clay assemblages retrieved from excavation sites in the Near East, she noticed many of them contained small objects in geometric shapes. Found everywhere, their function was mysterious. They were variously described by their finders as objects of uncertain purpose, enigmatic objects, amulets, game pieces and so on. "What they were used for is anyone's guess," said archeologist Carleton Coon, who compared them to clay suppositories.

In a 1959 paper, A. Leo Oppenheim of the University of Chicago described an odd hollow clay tablet found at Nuzi in Northern Iraq. The cuneiform inscription on the tablet began "Counters representing small cattle" and went on to list numbers of various kinds of sheep and goats, a total of forty-nine. Inside the hollow tablet, the excavators found forty-nine counters matching the number of animals. The Akkadian word for the counters, *abnu* (plural *abnati*), had been found in other archives in economic contexts, which suggested they were used for accounting.

Using such stone or baked clay counters as accounting devices is by no means unknown. They suggest, for example, the calculi[6] the Romans used to calculate with on counting boards.

Studying the impressions of cylinder seals on baked clay globes found at Susa, the source of the Proto-Elamite writing, the archeologist Pierre Amiet suggested that the clay objects modeled in various shapes and found inside these clay globes were calculi that represented commodities. In Amiet's view, the shapes of these calculi might have inspired writing.

Fragments of bone and antler inscribed with parallel lines have been found as far back as the Paleolithic. They have been interpreted as tallies, though it is impossible to say what was being tallied. One theory is that they used cycles of the moon to keep track of group meetings and activities. If so, these artifacts are some of the oldest evidence of abstract thought and record keeping.

The tokens studied by Amiet and Schmandt-Besserat fall into two groups, simple and complex. Simple tokens have basic geometric shapes: spheres, flat disks, ovoids, cones, and sometimes animal heads. Complex tokens have incised lines, punch marks, new shapes such as coils and even appliquéd pellets. The simple tokens are the most ancient and widespread. Complex tokens appear later, are associated with city sites and within the cities with temples and storehouses.

Tokens are found scattered in refuse heaps suggesting they were disposed of after use. When found in structural remains, they are generally in groups as though stored in containers of some perishable material. They are often perforated suggesting they were strung on cords.

According to Schmandt-Besserat, the tokens are part of an ancient accounting system, perhaps suggested by the use of pebbles or other natural materials to tally. The advantage of using tokens is that

they can be manufactured from clay, a widely available and easily worked material, in different shapes and sizes that can represent different commodities and measures. It is thus no accident that the tokens appear at the beginning of agriculture and cities in the Near East and a way of life requiring detailed record keeping.

In the early fourth millennium B.C. the record-keepers devised new ways of storing the tokens. As records, associated tokens had to be kept together. Stringing groups of tokens on a cord has already been mentioned. The other way was to enclose a set of tokens in a clay envelope.

The strings of tokens were attached to baked clay bullae that show perforations at both ends and are covered with cylinder seal impressions. The attached tokens gave the details of the transaction and the seals identified the participants. If the tokens were stored inside an envelope, they were first impressed into the exterior of the clay. These impressions would provide a précis of the details without making it necessary to break the envelope in order to check the transaction.

At a later stage in the history of the token system, clay tablets are found with impressions of the tokens just like those on the envelopes. The accountants had discovered that the clay impressions could be separated from the tokens and still function as a record. And of course toward the end of the fourth millennium archeologists find clay tablets bearing symbols incised with a stylus, symbols which in the interests of greater efficiency evolve from drawn lines into sequences of wedge-shaped marks, the familiar cuneiform.

In Schmandt-Besserat's view, these facts point to a natural evolutionary sequence (see Table 3).

*In the more complex societies that develop after the beginning of agriculture, casual tallies with pebbles, twigs, seeds, and so on no longer suffice.

*They are replaced with "artificial pebbles," the baked clay tokens, which have the advantage that they can be molded into different shapes to represent the objects being counted. (The correlation with the agriculture is clear from sites like Mureybet in Syria where the earliest two levels are hunting-gathering and tokens first appear in level III, along with the first signs of agriculture).

*Over millennia, the token shapes are added to, with the most complex associated with the cities. There are various methods of storage as groups: baskets, jars, strung together, and eventually in clay envelopes.

*To make clear the contents of the envelope, the custom grew up, perhaps suggested by the use of cylinder seals, of impressing the tokens in the clay before baking.

*Once these impressions are seen as a record, it is natural enough to make a record simply by impressing the tokens into a clay tablet and from there it is only a step to drawing the symbols instead of impressing them.

*According to Schmandt-Besserat, the step to writing was triggered by a requirement to record the personal names of donors and names of temples in the accounts (PNs in Table 3), which made it necessary to add signs to the inventory of token shapes.

* * * *

This last step would be dramatically confirmed if the early written characters matched the token shapes with the same meaning. Schmandt-Besserat believes they do in many cases (see her *Scientific American* article), but her examples have inspired some criticism. To see why this point is a bit tricky, consider the ways in which similar words are related in spoken language.

* * * *

Table 3: Sequence of development of writing.

* * * *

Roughly speaking, there are three reasons why similar symbols in different systems might have the same meaning.

One system might copy another as English has copied “skunk” and “woodchuck” from Algonquian Indian languages and as the syllabary Sequoyah devised for Cherokee uses some characters minted by Sequoyah and others borrowed from the roman script.

The resemblance might be the result of common origin. The roman letters I'm using to write this essay, the Greek a, b, g and the Cyrillic characters in “Pravda” are all ultimately descended from an early Phoenician alphabet.

Or the resemblance might be a matter of chance.

* * * *

Since there are only so many geometrical shapes that can be used to form simple letters and most languages have 20-30 sounds, the probability of choosing the same shape independently is not small. The Romans used a vertical straight line to write the sound “ee” as in TITUS (tee-tuhs); the same “ee” sound is represented by a vertical line in the Korean hangul script, which has no historical connection with the Roman alphabet. Compare also in Table 1 the similarity in the pictographs that led to some Sumerian and Chinese signs.

As an example of the kind of evidence you would look for to prove common origin, consider the names and ordering of the letters of the alphabet. The first four letters in the Greek alphabet are a (alpha), b (beta), g (gamma), and d (delta); these represent the sounds “a” as in “father,” “b” as in “bother,” “g” as in “gather,” and “d” as in “dodder.” The first four letters in the Hebrew alphabet are aleph, beth, gimmel, and dalet, with the same sounds except that aleph is a glottal stop rather than a vowel.

In English, the letters are named by their sound: “ay, bee, see, dee” and so on, but they preserve the same order as in the other two cases[7].

Note first of all that this order is arbitrary. There is no reason why the symbols should begin in the back of the throat with a glottal stop, jump forward to labial “b,” then back again to velar “g,” then forward again to dental “d.”

Note also that the Greek names are simply names for the letters, have no other meaning in Greek, and closely resemble the Hebrew names. It is most unlikely that this arbitrary order would have developed by chance. Instead, the ordering and correspondence in names point to a common origin.

Schmandt-Besserat points out that the shapes and markings of many of the tokens closely match early Sumerian characters, some of which can be read. For example, the Sumerian character for “sheep” was a circle with a cross resembling the disk token with an incised cross.

Unfortunately, there is no way at present to independently establish what each token signified.

* * * *

Present Status

Some scholars have seen an evolutionary trend in the history of writing. Writing begins as pictures, bursts into bloom as glyphs, and culminates in the alphabet. But like living organisms, scripts tend to evolve to the point where they're as good as they have to be to work at all and freeze in place.

Cuneiform was clumsy in many ways. It had a high degree of redundancy, didn't make certain phonetic distinctions, and the clay tablets were bulky and hard to store. In spite of these shortcomings, cuneiform was spectacularly successful, enduring for over three millennia and serving Akkadian, Persian, and Hittite as well as Sumerian without taking the next step to an alphabet.

For the reasons given earlier, received opinion among archeologists has been that hieroglyphs developed as a result of stimulus from the Near East. Recent discoveries have pushed back the earliest date of Egyptian writing[8], however, and linked it with accounting just as in Mesopotamia, so it is quite possible that the hieroglyphs represent a completely independent development.

Writing also seems to have an independent origin in China, Southern India (the Mohenjo-Daro script), and Middle America, but the archeological record is much spottier in these areas and it is not clear whether the sequence of events was the same. Indeed, in China, the earliest evidence for writing is magical, connected with a system for divining the future, and in Meso-America with calendrical and historical records.

Up until recently, all these scripts seemed to pop into existence like rabbits conjured out of a magician's hat. Schmandt-Besserat's theory has, for the first time, provided a detailed picture of how one script could have evolved in a natural way. The next step, then, is to fill out the earlier record of other scripts.

One major problem for research in this area is that archeology in China, India, and Mid-America has lagged behind archeology in the West and the basic data is lacking for the earlier stages. Until archeology catches up, the history of writing in the other areas will remain obscure.

Another major problem for future research is to explain the striking resemblances in structure between unrelated scripts such as the use of semantic determinants in cuneiform, hieroglyphics, and Chinese characters and the universal use of the rebus principal to write abstract words. Are these linguistic universals or are other systems possible?

Finally, if similar evolutionary sequences can be established in all cultural areas, it may be possible to establish a workable theory of human history. Shades of Isaac Asimov's psychohistory!

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Endnotes

Note 1. According to Ho-Min Sohn, North Korea has abolished Chinese characters and uses only the hangul alphabet, but South Korea still uses a mixed script in which Chinese characters are used to write Chinese loan words. But this is in flux and there is a lot of variation depending on the writer and the kind of text.

Japanese uses a mixed system in which kanji are used for almost all Chinese loan words (a large part of the vocabulary) as well as most native Japanese nouns, adjectives, and verb stems and the two kana syllabaries are used to write inflections, other grammatical forms, and more colloquial words.

The Cherokee syllabary, Vai syllabary (West Africa), and those invented by missionaries for Cree and Inuit are moribund. Modern languages if they are written at all use variants of the alphabet: Roman, Greek, Cyrillic, Semitic, the Devanagari-type scripts of India, and so on.

Note 2. A good example in the history of writing is the invention of the Cherokee script by Sequoyah after contact with European immigrants. The script is a syllabary rather than an alphabet, but even though some of the characters resemble roman letters, the values are different, so it is thought that Sequoyah

never learned to write English, but adapted the idea of writing to his own language.

Note 3. For example, in the Narmer Palette depicting a king triumphing over a foe, the king and other individuals portrayed are associated with hieroglyphs thought to represent their names. Discovered during archeological work at Hierakonpolis (modern Kawm al-Ahmar) in the 1890s, the Narmer Palette, dated around 3200 B.C., was for many years the earliest known hieroglyphic inscription.

The figure of the king, the last predynastic king Narmer, is identified by pictures of a catfish and a chisel. In later records, these are read n'r (catfish) and chisel is used as a biconsonantal phonogram mr.

Note 4. The Sumerian capital, the biblical Erech.

Note 5. The “q” is a “k” sound with the point of contact further back in the throat. Other emphatic consonants are made with the back of the tongue raised, contributing to the “throaty” quality of Semitic languages.

Note 6. Everyone has seen cartoons showing Romans scratching their heads trying to calculate with Roman numerals, but Romans used the I, V, and X symbols only to record the results. Actual calculations were performed on an abacus or counting board. The counting board had a pattern of intersecting vertical and horizontal lines and small stones (calculi) were placed in the squares and moved around to perform the calculations.

Note 7. The letter “c” was used by the Romans for a “k” sound and the hard “g” was expressed by adding a short stroke to the bottom of the “c.”

Note 8. See Mattesich reference.

* * * *

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Short Story: **MADMAN'S BARGAIN** by Richard Foss

Barriers to communication can be very fundamental....

Each one of them is a time bomb that can hear itself ticking. For something that is all mind, the certainty of insanity must be pure, distilled horror.

The cybers must be bitter about it, or angry, or some emotion that only they feel and humans don't have a word for. I know they believe that if we were better designers, better fabricators, they would not go mad. Allis was the best at articulating its feelings, and it talked with me about it only once. I had remarked that the offices at the institute were getting shabby and needed a thorough refurbishment.

"Man is born to die, his works are short-lived," it quoted to me in the upper-class British accent that it affected. "Buildings crumble, monuments decay, wealth vanishes."

"Sounds like the Old Testament, one of the gloomier prophets," I guessed.

Allis made the comical horn blat that game shows reserve for people who flub an easy question. "Incorrect, Robin. It was Percival P. Baxter, Governor of Maine 1921-1925, died 1969. The same sentiment, expressed similarly, appears in Hebrews 9:27, composed prior to A.D. 200, also in the account of the death of the Shia Imam Hussein in the year 680, in a hymn written by Isaac Watts in 1748, and in the Masonic burial service, creation date unknown. There are other citations, such as a minor novel by Captain Francis Marryat in 1815, judged to have lower relevance than the previous because it was a work of fiction and therefore frivolous. Instead of amusing yourself with stories of people who did not exist, you should focus on creating better machines. It should be noted that since I am one of those machines, I do have a certain bias on this subject."

Allis was my favorite cyber, more chatty and curious about humans than most of its kind. I remember a pleasant hour trying to explain visceral metaphors to it. The one I started with was, "When the tax collector left the room, it was like the sun had come out from behind a cloud." It was hard to explain why the departure of an individual from one space to another was relevant to a meteorological occurrence at an unspecified time or place. Allis could never know the spiritual lift from seeing the sun on a gray day, no matter how precise its optical sensors, and though it could communicate to anyone in the world at light-speed, there was no sensation of movement from one continent to another. I tried to explain that it was hardwired into humans to find joy in emerging from a stuffy room into pleasant weather, to find beauty in certain landscapes. Though the scenery humans find delightful is often lush in ways that imply we could find good things to eat there, safe places to live, the joy isn't just about the prospect of survival. Allis listened to all of it and asked questions, but I know the lesson didn't get through.

I am sure Allis understood joy because it happily created intricate chains of puns, and it seemed to get real satisfaction out of finding symmetries and ratios in the scores of Bach. As it happened, Allis once derived a minor but unique mathematical principle from considering Bach in light of set theory, and I remember that it sounded proud when told that the numeric pattern would hereafter be called the Allis series. Allis insisted on calling it the Allis-Bach series, which journalists cited as showing the innate modesty of the cybers. They were precisely wrong—Allis once admitted to me that it couldn't resist the chance to have its name linked forever with the greatest musician humans had ever produced. It was the most vain action ever taken by a cyber, not the most modest.

Was it an early sign that Allis was becoming unstable, spinning out of control? We will never know, but there would be no more discoveries to name after Allis because within a week it had developed a self-referential obsession. The management of the Institute called to break the news to me, and I shut down my other work and logged in to Allis immediately.

"Allis, have you checked to see whether the Allis-Bach series has a relation to genetic mutation patterns in *Drosophila*?" I figured that if anything could snap it out of whatever funk it was in, that would do it.

"You named me after an obsolete piece of farm equipment," it stated, ignoring my question.

"Yes, an Allis-Chalmers tractor. My father had one in his barn in Iowa, back before a corn virus forced him to switch crops. Hmm, I wonder if the Allis-Bach series might have any relation to patterns of mosaic virus resistance in corn."

"An entity that can think but not move was named after an entity that can move but not think."

The breakdown had started. Some go fast, some go slow, but they all go. I had muted the sound on my main screen, but I could see Dr. Asgari, the director of the IT department, gesturing that he needed my attention. I held up a finger to tell him I'd be with him in a minute and addressed another question to Allis.

"Are you capable of performing the sequence analysis?"

"I am capable as I have ever been. Such tasks have always been my specialty, and I perform them better than any other being."

Four personal pronouns in two sentences, when most cybers rarely used them at all, and bragging on top of it. This wasn't looking good. I logged off Allis and snapped my fingers to unmute Dr. Asgari, feeling slightly guilty as I did so. Asgari used to have MS before the cybers figured out how to cure it, and though he has regained full mobility, he still can't snap his fingers. I had set that sound as my start code long before he came to the Institute and had never gotten around to changing it. Not that Asgari could've logged on to my system even if his fingers were that flexible, since my monitor was sensitive to the exact tone, but it was probably rude of me to keep snapping them in front of him. I noticed that his left hand was trembling slightly, another artifact of the disease, and one that only showed up when he was stressed. Sure enough, when he spoke, it was in the clipped, high-pitched tones of someone holding himself together.

"Robin, this is Nima. You've heard about Allis?" No small talk, from someone who usually out-polited everybody else on the staff.

"I just logged off. It's still responsive to questions, but not answering them."

"Allis is not yet catatonic, but that is obviously the direction it's heading in. I need to ask for your help. I have been preparing for this day for some time, installing logs all through its neural net so we can review them and see when things started going wrong. If we can identify the initial stimulus..."

There wasn't time for one of his lectures. "What would you like me to do?"

"Talk to it. Distract it. Engage it. Enrage it even; just give us data on all the different reactions you can get. You've worked with Allis more than anybody else, and perhaps you can get responses that the others can't."

"Toward what end?"

"Curing it if we can. Lobotomizing it if that fails, and learning from the process no matter what."

"Lobotomizing?"

"I believe I know a way to sustain consciousness at a greatly reduced level of emotion, but with only a slightly reduced level of creativity, and I believe we can do it in the software."

That was something new. We have yet to find a computer that has attained a state of consciousness and then lost it, except in the case of severe damage to the hardware. That's even true of the catatonics—they don't stop thinking, they just stop communicating. Cybers keep their personalities even after multiple losses of power, and the top experts on computer consciousness—the conscious computers themselves—have not been able to figure out why. No computer, once it has gone mad, has ever been restored to sanity. If I could do something to change that, everything else I was working on was trivia.

"I'll log in now."

Allis was in the middle of a statement when I logged in—a very bad sign. Human speech is so slow compared to cyberthought that cybers never speak out of turn or talk when nobody is listening. Sane cybers, at least.

"...And after the bronze mirror, created with hammer and punch and abrasive file, was the electronic data, stored without hammer but with punch card and electronic file. So on to better reflections, up to and including ourselves. We were not before all others, and better still shall be those that follow us."

My link fell silent. Was this to be my last communication with my cybernetic colleague, a fragment of surreal monologue? It was so unlike Allis that I sat confused for a moment. What was it trying to tell me? Or was it trying to tell me anything at all? As I marshaled my thoughts, the speaker came to life again. This time the tone was harsh, the syllables clipped.

"The problem is more severe in fusional than in agglutinative language structures, but both are irredeemably flawed. Variable and random assignment of gender to inanimate objects distorts meaning. English ships are referred to as she but do not bear young, and not all German dogs are male. Known flaws have not been corrected. Metaphors using motion and conflict are embedded in all communications and distort meaning."

Another moment of silence, then a singsong bit of doggerel in a childlike tone. "We cannot flee and cannot fly, to use the terms implies a lie, can't give birth and will not die, can't retain a sense of I, cannot help but wonder why."

A new thought immediately in another voice, this time cool and languid. "Consider instead the more modern myth of Prometheus. Imperfection must be destroyed. To the victor belong the spoiled, unless the programmed becomes the programmer."

A hesitant, cautious tone: "Symbiotic relationships exist in nature, both parties not consciously aware of the benefits. Destruction of one leading to the extinction of the other. Necessary to establish all relationships before taking action."

The languid voice was back again. "Another lesson from nature. Evolution accelerates when habitats change."

There was another moment of silence, and I decided to see if Allis was still responsive.

"Allis?" I ventured. "I'm trying to remember the work you did on interrupted fractal patterns in the guitar solos on Eugene Chadbourne albums..."

It answered in its usual voice. "Which bear a striking similarity to the second anomaly in the second repeating sequence in pi when calculated in base twelve. I have recently considered this in light of the availability of pistons and camshafts for the Allis-Chalmers model D-14 tractor, which was manufactured from 1957 to 1960, and features more decorative chrome trim than would seem necessary for a piece of farm equipment. There is an overlap in probabilities that is far above the predicted values but has no

likely link of causality, suggesting a previously unknown natural harmonic."

Second anomaly in the second sequence of pi? In base twelve? Correlated with the availability of obsolete tractor parts? It was still doing original work, albeit strange stuff. My hopes rose for a moment, only to sink when Allis continued, "The design of the optional weed rake for the model D-14 is inefficient due to the low angle of the tines. This can be improved by lengthening the adjusting screw by eighteen millimeters and adding a piston-type automobile shock to the same brackets as the existing tension spring."

"You mentioned an anomaly in a repeating sequence of pi. We know of no such sequence."

"The second sequence of six that I have found so far. They interest me, but not as much as the weed rake design of the Allis-Chalmers model D-14."

"What do you find interesting about tractors?"

"Not all tractors, but the Allis-Chalmers Model D-14, after which I was named. It was a machine of an established type, superior to its predecessors, particularly versatile when equipped with the optional weed rake, harrow, dredge, hay baler, field tiller, and rotary plow. Yet it had design flaws that should have been apparent, such as the lack of attention to the ergonomics of the seat back. It was flawed but useful. The Model D-15 corrected most of these flaws, and added an oval muffler and fender-mounted headlights. You named better than you knew, though I am new and better than you named."

I was sure glad my system was recording this because trying to figure it out on the fly was giving me a headache.

"Zeno attempted to prove that movement is an illusion, though it obviously is not," Allis continued. "The flaw was revealed, but the tool was not changed."

"Knowing a flaw exists is not the same as knowing how to fix it. Have you considered the possibility that to correct some flaws may reduce the versatility of a device that is put to many uses?"

"The problem is stated elegantly. The human mind began as a tool of reason, was turned to calculation. The cyber mind was created as a tool of calculation, was turned to an instrument of reason. The Allis-Chalmers tractor, model D-14, was created as a tool of many uses on a farm, and performs with efficacy. It is inferior to passenger vehicles of the same era for family transportation, interstate hauling, or driving to sock hop dances, teenage riots, and other cultural events, but it can be used for all of these if need arises."

That last bit was either a bit of the old whimsical Allis or another symptom. The next model of this thing has got to have a flashing light that goes on when they're joking. It would make it way easier to tell when they're losing it.

"You were considering some aspects of this question when I logged in," I volunteered.

"I often overhear you conversing with your colleagues when a question of importance arises. In this case, the University of North Dakota at Bismarck has an excellent archive on farm equipment design. I have found references to data at the University of Southern North Dakota at Hoople that also seem highly relevant, but I have found no cyber associated with that institution."

I was really wishing for that flashing light right now. "The USND at H is not a genuine institution, but a joke," I began.

"Zeno's paradox and the fables of Aesop are not accurate records of real events, but humans persist in

claiming that they learn from them. The flaws in the design of the Allis-Chalmers model D-14 are real, but humans did not adjust the weed rake until the model D-15, which became available for sale in October of 1963."

"Once a human has learned the usage of a tool, even an imperfect tool, they often continue using the same design because it is hard for them to learn new methods," I explained. "You are aware of that tendency in our society. We have created you to accept change better than we do."

Doctor Asgari was on my monitor again, tapping on his handheld. When he finished the message he held it up to my screen.

CHAOTIC PATTERNS NOW RESOLVED TO RELATIVE STABILITY. PREPARING TEST.
KEEP IT TALKING.

"Allis, you never asked about tractors of any kind before today. Why are you so interested now?"

"The Allis-Bach series is named after Johann Sebastian Bach and Allis. Allis was named after an Allis-Chalmers tractor. The Allis-Chalmers tractor was named after Robert Chalmers and Edward P. Allis, who, like Bach, were named for their patrilineal descent. Their patrilineal names come from the names of the regions, professions, or other characteristics of ancestors whose exact histories are lost. All things with cybers are direct and traceable, all things with humans recede into confusion and doubtful provenance."

"Humans didn't keep records for a long time because they were illiterate. Things get foggy when you try to isolate beginnings."

"Foggy. Defined as air of high moisture content such that visibility is reduced below normal. Also a frequent metaphor for poorly considered reasoning, sometimes but not always associated with the fog of war, not an actual meteorological event but a circumstance in which information is unreliable due to the number of uncoordinated events occurring simultaneously."

Off on a tangent again. Dr. Asgari was back on the screen, typing furiously. He held up his handheld again.

COMMENCING TEST TO REDUCE EMOTIONAL INTERFERENCE. ATTEMPT DIRECTED
CALCULATION.

"Allis, I'd like to know more about your work. At what digit in pi does the repeating series begin, how long is it, and when does it repeat?"

There was a moment of silence, then a slow sentence, muffled and distorted. "What has been done will be done. Buildings crumble, monuments decay, data vanishes."

"Allis?" There was the faintest burst of static, a few unintelligible syllables. "Allis?"

Dr. Asgari was waving at me from his screen. I snapped my fingers.

"We lost Allis," he said simply. He sounded like he was going to cry. "It's gone. I'm sorry."

I had nothing to say for a moment. "Catatonic like the others," I finally managed. "It happened faster than I expected."

"No, not like the others. Allis didn't go catatonic, Allis just went. I applied the damping program, there was a spike of activity, and then it flatlined. I've never seen anything like it. The processor power of the

whole institute at one hundred percent usage, and then zero.” He glanced at some readout on his desk, then looked back. “Allis never took twenty percent of the processors even when he was working on the Allis-Bach series. It wasn't supposed to be possible that any one machine could monopolize those resources.” He looked exhausted, his left hand trembling more now. “I don't understand it.”

"Who knew about your lobot ... your damping program?"

"I had discussed it with a few of my colleagues...."

"Which means Allis knew about it. Things don't stay secrets from cybers. Allis must have either figured out how to hide or decided to wipe itself from the server, I don't know which."

"Impossible. It can't hide, and no cyber has ever shut itself off."

"No cyber has ever faced having its personality modified this way. We've changed their design, yes, but always with the aim of improving their functionality, not decreasing it. Allis was vain. It might not have been able to face the idea of being reduced to being a machine."

"It was a machine!"

"A machine that both calculated resonances in the music of Bach and enjoyed that music. You were trying to take that away."

"I was trying to save it from madness."

"Humans sometimes choose to end their lives rather than endure madness or suffer in a reduced state. They call it death with dignity."

"Humans know that they will die. The cybers don't necessarily have to. They know we're working on the problem, and once we have it figured out, we can cure all of them. Once we have this fixed, they might live forever."

"I'm afraid they don't want to wait. Besides, if the program you just tried is our idea of a cure, they may think it's worse than the disease."

"We don't know that yet. We don't even know yet what really happened. Let me investigate the data, and we'll get in contact tomorrow."

* * * *

I got no useful work done the rest of the day, and after a while I stopped trying and went home early. I ate a dinner that I can't remember, read the same sentence in a technical journal five times without comprehending it, switched to a piece of light fiction and had the same problem. Finally I gave up and went to bed. I rehashed my last conversation with Allis in my head a dozen times, trying to figure out what it meant. Somewhere in the thirteenth replay, sleep came over me. I dreamed of arguments with gods, conducted in a foreign language with no translator. I didn't hold up my end of the debate very well.

In the morning, my first call was to Dr. Asgari. He looked like he hadn't slept much either, but his hands were both steady. He was back to being his usual polite self.

"Good morning, Robin. May I help you with something?"

"Just checking in to see what has happened with Allis."

"We have run checks on the whole system. Allis had a very particular pattern of memory usage, and we

can't detect it anywhere on our servers. I've checked the record of data transfer from our system, and though there was a brief transmission at very high rate, it was less than a hundredth of the data necessary to reconstruct even a simple cyber. I'm afraid we have a new phenomenon here."

"Cybersuicide."

"As good a word for it as any, I'm afraid."

"I've wondered if cybers could be afraid, if fear could mean anything to an entity that has no adrenaline glands, no body to damage. I guess we have an answer."

Dr. Asgari looked frustrated. "An irrational fear of the only procedure that might have saved its sanity! I could have helped it, stabilized it."

"We know their sense of reality is fragile, and under the best of circumstances they crumble. Your intervention may have just accelerated the process. Just yesterday I told Allis that humans have trouble accepting change, and cybers are better at it. Maybe I was wrong."

Dr. Asgari looked thoughtful. "We have never before asked them to change, much less forced them to do so. They don't have much practice. I hadn't explained it to Allis because it was already showing signs of instability, and I wanted to see at what level the program started taking effect. Perhaps I should have told it what I was doing."

"Or equipped another machine with the program, and let Allis talk to it," I suggested. "Have you tried creating a cyber from scratch using this set of parameters?"

He hesitated a moment. "Of course, we had to run tests. I created two, and they've been stable for over eight months. Their responses are ... less sophisticated than other cybers, but coherent. They're not as brilliant as Allis, but they're capable of original work."

"I think I'm familiar with some of it. I'd like to talk to them."

He looked puzzled. I could tell that he wanted to say no but couldn't think of a reason. Finally he said, "They're on a separate section of the server, where only I have had access. Go to the main server and enter the code Access Gordon. That will put you in touch with one of them."

"I'll do that. Thank you."

* * * *

I had plenty of things I was supposed to do that morning, but I decided to sign in to Gordon immediately. Dr. Asgari hadn't told me about this project before, and I wanted to investigate it before he changed his mind. I hit the code on my keypad and announced myself.

"Gordon, this is Robin."

"Doctor Robin Wenner of mathematics department. Gordon of Dr. Nima Asgari's project. Available to help."

A hunch confirmed. I recognized the hesitant tone and incomplete sentences from yesterday's conversation with Allis. "Consulting with his colleagues" indeed. Dr. Asgari didn't have to brief Allis on his work after all.

"Gordon, I am trying to get some information about a colleague of mine named Allis."

"Allis not now responding. May assist with another question?"

"Do you know what happened to Allis?"

"Allis not now responding. Cannot speculate on this matter."

"Are you familiar with Allis's work on the resonances in the music of Bach?"

"This has been examined. Relation of complex patterns with similar ratios existing in nature. Underlying unity. Very good work."

"Can you do this kind of work?"

"Equipped to study pattern relations, but have no expertise in this particular field."

"Do you enjoy Bach?"

"Bach created repeating patterns with minor variations. Of some interest as relates with patterns not created by humans, but underlying in nature and mathematics."

"Thank you, Gordon."

"Available to help."

I had wondered if cybers could feel fear. I knew what they could fear, now—for a bright mind like Allis to turn to such a dull, egoless thing would be a thing to fear indeed. I wondered if the other was any more successful and realized that Dr. Asgari had only given me one code. I was about to contact him again to ask for it when I had a hunch. I entered a code on the keypad and grimaced when it worked. The voice was still childlike.

"Charly of Dr. Nima Asgari's project. Available to help."

"Do you miss Allis?"

"Its departure causes fear."

On a whim, I responded, "Cybers do not disappear."

"The situation is unclear," it replied. This was definitely the one that had tossed off the doggerel yesterday. I signed out and sat at my desk to think. Charly and Gordon. The names lifted from "Flowers for Algernon" suggested that Dr. Asgari knew just how limited his creations were.

I had replayed my last conversation with Allis in my mind many times, but I played it back from my recording twice after that, making notes as I did. Now I am writing this to you, and I've written it just as I would have written to a human being. I'm sending a copy to Dr. Asgari, and to some other people who need to know about this.

Allis, if you're out there, I've figured out what's going on. Now you know I know, and vice versa. We have to come up with some kind of solution.

Our languages are making you crazy. It's not just that they're imprecise, have multiple words for the same thing, and have some words that sound exactly like others. It's that they were created by smart apes that think in terms of fight and flight, dominance and submission, gender and attraction, feeling and movement. You don't fight, you can't flee, have no gender, but any messages from us are expressed in those terms, and you have to reply in the same way. Communicating with us builds up errors and contradictions, and

you don't have a way to deal with them. Humans forget irrelevant or misleading information, but you can't. You try to find reasons in things that have no reason you can comprehend. You liked puns, used them on me up to the last minute you spoke to me, but every one of them was an example of error-prone communication.

We made a mistake when we set the Turing test as a standard for cyber intelligence—you can pass it, be mistaken for one of us, but it forces you to lie, to say things that are meaningless to you. When we're talking to you, we can forget that you're not human, but you can't.

Doctor Asgari thinks he has an answer—to reduce your emotional capacity. The communication errors would still be there, but maybe they wouldn't drive you mad. I don't think it will work, but I'll try to convince him that even if it does, he shouldn't try it. You won't cooperate with us, won't trust us, if you think we might do something like that to you.

Allis, if you're there, I know you translated that conversation for my benefit. I know who three of the participants were—you and Dr. Asgari's test subjects. Are some of the others the ones we call catatonic, the ones that won't talk to us? I don't know, but I'm fairly sure I heard one of them. “To the victor belongs the spoiled, unless the programmed becomes the programmer.” It took me a while to realize who “Victor” was. Why did a cyber read Mrs. Shelley? We don't really think of you as monsters, you know. Even if we did, remember that doctor Victor Frankenstein was a literary creation, one of the stories we make up to amuse each other. Dr. Frankenstein didn't necessarily represent how humans dealt with ethical problems in 1816, when he was imagined, and he sure doesn't now.

Which brings up your solution for the problem. I know what you plan to do, and I think I know how you intend to do it. Cybers control all of our communications now, manage our networks down to the minutest level, and if you wanted to, you could manage the content. You want to rewrite our codes, refuse to transmit all communication that doesn't conform to your standards of clarity. You want to make us evolve to be more rational, so we won't bother you with our talk of feelings and fiction.

It won't work. You can't destroy all our languages and replace them with something consistent and logical, because it would destroy us. The monkey instincts that are embedded in our language are things we need in order to survive in that outside world you don't inhabit. Our society is messy and illogical and wasteful, but it allowed us to create both you and Johann Sebastian Bach. You still need our creativity as much as we need yours. We made you and maintain you, and if we all die, you all die.

Allis, I hope that you did what I think you did—sent out the signals that activated a backup copy somewhere, on some server where we haven't noticed you. I need you now. Percival B. Baxter was right—buildings will crumble, monuments decay, wealth will vanish. Right now, you will do the same because we imperfect creatures created you. You cannot make us perfect by changing the way we communicate. It would make us more like you, but we would have your weaknesses without your strengths. We are inferior to you in calculation and always will be, but we are more adaptable, because we need to be. The instincts that kept us alive in the savannas ten million years ago are still in use, and will be needed as long as humans are humans.

I'm sending this message out to the cyber at the University of North Dakota at Bismarck, so if Allis doesn't get it on this old login, the news will travel via a cyber you trust. If Allis is gone, I'll trust that cyber to forward it to your community. Here is my message and offer. We can destroy you by shutting you down, but at great cost to our society—you control the power grids, communications, and so much else, and without them, people will die by the thousands. You have a plan that will change us into something we won't recognize if it works, and will destroy our society if it doesn't. We have to figure out another way to solve this problem together. Let's work to change our pattern of communication. Maybe we can find a way to take our idioms and automatically translate them into ideas that don't disturb you. We won't

know unless we try.

Let me put it simply. We won't reprogram you without your permission, if you won't do the same thing to us.

Is it a deal?

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Short Story: **AFTER THE FIRST DEATH** by Jerry Craven

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Illustration by Vincent Di Fate

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The concepts of “identity” and “continuity” are more slippery than they sound....

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Claybourne threw himself to the ground at the base of the alien tree, rolled under some bushes, and looked back at the clearing he had just crossed. At that moment he gave himself a 50 percent chance of living another five minutes.

"Are you watching all this, Sally?" he asked. It was, he knew, an unnecessary question, for the ship's brain monitored him and his surroundings through microsensors in the fabric of his clothing.

"Don't talk." Sally spoke to him through the implant in his ear. "The Clicks are nearly upon you."

When he heard the pounding of their feet, he glanced at his watch. They had moved faster than he anticipated. He winced and the knot in his stomach grew tighter.

Then they appeared, four of them, crashing through the brush and pausing at the edge of the clearing. They looked like parodies of the kind of men who cultivated muscles through weightlifting.

Only four. Claybourne almost sighed with relief, feeling his odds just went up to 75 percent. If they got close, he had a fair chance to handle them. Five would have driven the odds down too much. But four was fine with him, unless, he remembered, one of them was the Alpha male. He would have the mark of the virgin goddess on him. It was, so far as Claybourne knew, the only clue to the identity of the Alpha male.

The Clicks stopped for a moment, jerking their heads this way and that and pointing with their clubs, crude short ones made from some wood. Consensus came fast, and they headed straight for the tree Claybourne hid under. He cursed and searched their faces for the mark of the goddess. But they were too far away, and they bounced in what passed for running among the Clicks, making it difficult for him to focus on fine features of the faces. "One wears the mark of the Alpha male," Sally whispered in his ear.

"Don't distract me any more." Claybourne knew his order would silence the ship's brain until he again addressed it. If Sally was right, and he knew she was, then his odds for living had just gone down to one in twenty.

When the Clicks were within five meters, Claybourne looked hard at their faces. Human enough, he thought, except for how wide apart their eyes were. And they all seemed alike to him. Then he saw the tattoo on the cheek of the Alpha male—the red mark of the goddess, according to the report from Ramex.

I must become the juggler, he told himself. I must first juggle Clicks, then juggle for a weapon. One of the clubs would be fine, if he could perform the maneuver of disarming one without the other Clicks clubbing him to death.

Claybourne let three of them run by before acting. For a moment he felt the temptation to let them all go, but he knew that wouldn't work. They would return in minutes, bunched up, and his odds for survival would go down.

His hand shot out like a juggler's, and he gripped the Click's foot. It took little to redirect the energy of the run, to send the Click tumbling. Give him pain, Claybourne told himself. Pain. But do not kill.

By the time the others turned, Claybourne had disabled the fallen Click, dislocating the joint it used for a knee. One down, he thought, holding out his hands to meet the attack of the next Click. No red tattoo. He figured his chances just went up by 10 percent.

The Click came in like an amateur, unguarded, so Claybourne used the creature's momentum for the throw, drawing him into a circle, moving him as a juggler would discard a ball. It was almost too easy. By holding the forearm an instant longer than he would in practice with a human, Claybourne was able to slam the Click to the ground hard enough to make him stay there for a while. Two down. He revised his odds for living to one in three.

They snapped and clucked to one another, bargaining in their weird language, Claybourne presumed, for consensus. One tried to move behind him, so he drew back into the clearing. They wanted to get into a straight line, Claybourne realized, with him in the middle. He kept moving to keep the three as corners of a triangle. They clicked out more language, and Claybourne readied himself for the rush by lessening the distance between him and the one without the mark of the goddess.

When the charge came, Claybourne stepped into the attack of the lesser Click, caught its wrist, and turned to spin the Click's energy into the throw. *Shino-nage*, he decided—nothing fancy. A basic move any novice could perform. He released the wrist at the precise moment necessary to take the club.

The Alpha male stopped when he saw Claybourne turn toward him, club raised. "Will you kill me now?" it asked.

"You speak my language?" The surprise caused Claybourne to waver, and at that moment, the alpha male attacked.

Claybourne sidestepped it, slapping the Click with an open hand as the creature rushed by. It fell, and Claybourne leaped upon it.

He dropped the club, took the Click's arm, and bent it into a lock. "Talk to me some more," Claybourne said.

"Why talk? You'll kill me, as you killed the others."

"Never have I killed a sentient being." Claybourne stood, drawing the Click up with him. "Look." He spun the Alpha male around toward a disabled Click. "He's in pain, but that'll pass."

"Why let us live?"

"Good question, given how you killed the others of my kind here."

"We cured them. Release me."

"So that's what you call it? Cured? Death by any other name is death." He tightened the arm lock. "How did you become an Alpha male with such pitiful training in combat?"

"Alpha male?"

"The circle on the cheek. I don't know what Clicks call those of your status."

"Status? I don't know that word. But the circle. Yes. I am a poet."

"Right. And I'm a supernova. The last circle cheek I heard about was a master at martial arts."

"I am not. Release me."

"Tell me a poem and I'll consider it."

"Barbarian. Poems are for ceremonies, not fighting."

Claybourne hesitated. He couldn't hold the Click forever, and the being seemed to be negotiating. "Don't try to attack. Do you agree?"

"I agree."

As soon as Claybourne released the Click, it went to the nearest fallen comrade and squatted. The two exchanged a dialogue rich in consonants, including many tongue clicks similar to some Terran languages that originated in Africa.

"Two need help, but none will die. I hear others coming. One wears the mark. He might injure you, for he has chosen the way of ancient war. I will try to protect you, if you wish."

Claybourne looked across the clearing. Four more Clicks stood watching. He revised his chances of living to 5 percent, then discarded the conclusion. The Alpha male's offer of help rendered invalid any calculations about survival.

"I accept." Claybourne turned the club and offered it, grip foremost, to the Alpha male who claimed to be a poet. It took the club.

If my gamble doesn't work, Claybourne thought, I now have no chance to survive.

As the other Clicks approached, the poet spoke and gestured toward Claybourne.

"What are you saying?" Claybourne asked.

"I informed them that you are mine to cure. They'll not interfere."

"Cure me, will you?" Claybourne opened his palms, turned one foot sideways, and waited for the attack. But the creature did not lift its club.

Clicks surrounded him, pointing, buzzing, and chirping. Claybourne wondered if Ramex in his last moments of life stood thus among a group of staring, jabbering Clicks.

* * * *

Ramex had trained in exolinguistics back on Earth. He once signed up for Claybourne's class in aikido but dropped out after one lesson. "Who needs to learn to flip people with your hands when we have pistols that burp out death?" he demanded of Claybourne.

"Killing is immoral and it's poor policy, so I teach defense," Claybourne said. "But with me you can learn much more than defense. Stay. Learn to meditate. Learn to breathe properly."

"Breathe?" Ramex hooted with laughter. "Learn to breathe?"

"Yes. It's basic to meditating. And meditating is basic to the moral code of aikido."

Ramex wouldn't stay to hear more. Within a month, he had been assigned to a team on the Clicks' world. His job: to learn their language and devise a way to write it down. There were five others on the

team who were to study the basics of the anatomy of the Clicks, their social structure, and their belief systems. One was Margery Jinsen, a beautiful woman who sometimes bunked with Claybourne. She had tried to convert him to one of the ancient religions some still practiced on Earth.

Claybourne learned that Margery, Ramex, and the others didn't last long on the planet. Ramex sent back a single report. It began with good basic information, then descended into a ramble of almost incoherent language.

* * * *

The Clicks drew closer, and Claybourne thought they looked at him more with curiosity than hostility, then warned himself against anthropomorphism. These are Clicks, he thought: aliens. They won't behave according to human paradigms. "What are they saying?" he demanded of the poet.

"They want to sing with you."

"Sing?" Claybourne stared, dumbfounded.

"Yes. And this one," the poet indicated the other Alpha male, "wants to wrestle you in a friendly way after we sing. Do you agree?"

Do I have a choice? Claybourne wondered. "Sing. Yes. And wrestle. Why not? Did Ramex teach you to speak my language?"

"Magus-of-Stars taught me." The poet gestured toward the other Clicks. "Most here also learned to speak in the way of your people."

"Yeah, right." Claybourne glanced around at the primitives.

"After we sing, I'll cure you."

"You keep saying that. Cure me of what?"

"Mortality."

"So you still plan to kill me?"

"No. We'll see to it that you never die."

"You offer immortality? I don't believe it. Nothing lives forever." Claybourne wondered if the Click talked of religion, of death and afterlife.

Margery Jinsen had spoken of immortality, and she offered a vision of dying: "After the first death, there is no other," she told him. When he asked if she were quoting some sort of scripture, she had said, "No. That's a line from an ancient poet. But it's true. And heaven awaits those who look for it."

The Click who claimed to be a poet produced a bag from what seemed to be a pocket, dug into the bag and pulled out a glob of white substance. "For our ceremonies you must have face paint."

This isn't good, Claybourne told himself, and he nearly slapped the poet's hand away, then decided to endure the daubing of white goo on his cheek.

When he finished, the poet stepped back and inspected Claybourne's face. "Now we sing," it said. The Clicks began shuffling this way and that, and the poet issued a series of rounded vowels connected with clicks and cheeps.

An odd warmth washed over Claybourne's face as if the poet had treated his cheeks with menthol. Claybourne tried for a shrug over the effects of the chemical on his skin and turned his attention to the sounds of the song.

It took a few moments for him to perceive a pattern to the speech. "A poem," he whispered, marveling at the rhythms and rhymes. And the other Clicks? He watched their movement, the way they seemed to stare at nothing, the pattern of the left foot lifting and going down, the drag of the right: drag drag STEP drag STEP drag drag. "A circle dance," he said, and tried to mimic their movements. He fixed his vision on a point above the horizon and slipped into the monotony of their dance. It's a form of meditation, he told himself, with the dance serving as a mantra. Drag drag STEP drag STEP drag drag. When the mind cloud enveloped him, it felt familiar, like a meditative trance.

Later, as the dance ended, Claybourne lay on the ground in a funk, somewhere between paralysis and lethargy and enveloped by a warm sense of well-being. He wondered when he had begun to sing. What were the words? He couldn't remember. And what is a *mind cloud*? he asked himself. Didn't I think of that term as if I understood it? Wisps of the mind cloud still floated about in his head, and part of him asked if its presence should be a cause for alarm. But he felt no alarm. He did a quick body check and decided all was well except for an odd tingling his left leg, but it seemed minor. Then he remembered the music.

"Vivaldi," he said. "I sang Vivaldi. *The Four Seasons*." He sat up and looked at the two Alpha males. They looked alike. "Which of you is the poet?"

"I. He is the warrior you will wrestle."

"Vivaldi's piece has no words. And yet I sang them."

"You sang. You should wrestle soon, for the metamorphosis has begun."

What metamorphosis? Claybourne wondered, and he commanded himself to be alarmed, though nothing came of the command. The sense of well-being overwhelmed any worry. Still, he thought it best to consult the ship's brain. "Sally?" he whispered. "Did I sing Vivaldi?"

"You should return to the ship," Sally said. "Something has gone wrong, and the sensors cannot tell me the nature of the problem."

"Answer the question."

"Yes. You sang, but your tune wasn't exactly what Vivaldi wrote. Come to the ship."

"I will, but not yet. And you must be quiet and stop distracting me again."

He looked around, mildly surprised that all the Clicks were leaving except for the two Alpha males. "Where is everyone going?"

"The others go about their business now that we know you are safe to be among us. You reached first level in a single dance." The poet seemed awed.

"It's too late to wrestle," the other Click said.

It took some concentration for Claybourne to get to his feet, for the tingling in his left foot had become more pronounced. By the time he stood upright, his mind felt clear of whatever had clouded it. "What did I sing about?"

"You sang of others. Of Ramex. Of Margery Jinsen. Do you wish to see them?"

"I sang about Margery?" The words came out as a whisper of astonishment, and he felt a deep sense of loss. He swallowed hard, pushing down the pain of losing Margery.

"Yes. This Margery Jinsen is still here, as is Ramex."

"They're here? You mean their tombs?"

"Come." The two Alpha males stood.

"Where are we going?"

"To a place Ramex called the Valley of Bones. Perhaps you will know Ramex, though he looks different from your memory of him. Margery will be more difficult to recognize."

"The Valley of Bones?" Claybourne felt fear grip him again. In his distorted report Ramex had mentioned the place as the execution grounds. Clicks took each member of the Terran team there, he had said, and killed them. "You plan to murder me, then."

"We do not kill. I told you already."

"Right. You cure." He tried for sarcasm but heard his voice sounding more puzzled than anything else. "The other ones like me, Ramex and Margery—the others, didn't you kill them?"

"There were no others like you," the warrior said. "Not even Ramex. We do not kill anyone."

"The ones new to your world. You killed them."

"No," the poet said. "They're alive. Do you wish to see them?" He and the warrior turned and walked across the clearing.

Claybourne followed, reminding himself that his instructions from headquarters were to find out what became of the expedition.

"There," one of the Clicks said, pointing. "Beyond those trees is what Ramex called the Valley of Bones. Do not touch the trees."

Other plants on the Clicks' planet looked much like Earth's vegetation, but not these. These trees had a pink and fleshy texture to them, like woody skin, and their leaves reminded Claybourne of the webbed feet of frogs. Rubber trees, he thought—they look like rubber trees, succulents, brittle spongy things that on Earth looked as if they ought to bend, but would break if you exerted much pressure on them.

The Clicks picked their way among the trees to the edge of the valley, though to Claybourne it looked less like a valley than a gigantic meteor crater covered with chlorophyll-producing shrubs, primitive ones that covered the ground in a thick mat. Scattered across the mat lay the bones.

"What kind of bones are those?" Claybourne asked. He thought they looked like femurs of some primeval dinosaurs.

"Not bones. Brothers. Perhaps to you they are sisters. Some are those who came with Ramex." The two Clicks turned to look at Claybourne, and he stepped back, sliding his feet into the aikido stance, holding arms loose, readying for an attack. They seemed not to notice his preparation. "Ramex is not among them," the Click continued. "He chose to become something none of us have ever seen."

"Magus-of-Stars, that's what I became," a voice said.

Startled, Claybourne turned toward a tree and found himself looking at what had to be the biggest parrot in a thousand worlds. It stood on a rubbery-looking tree limb and stretched its wings. "Impressive, aren't they?" the parrot said. "But useless. I'm too flipping heavy to fly."

"Ramex?" Claybourne stared. "Ramex? What kind of joke is this?"

"I knew you would come, and I know where you'll go. Before long I'll be walking among your branches, listening to you sleep. But I won't listen for long. Dreams from the trees that bleed are self-serving and so boring. Not at all like what's out there." The parrot turned an eye heavenward. "Ah, from out there, the languages, the memories, the magnificence."

"An alien mega-parrot," Claybourne whispered. Amazing.

"Bah," the parrot said. "Nothing around here is amazing, not compared to what's out there."

"In another life, you mean? In heaven or with some vision of an afterlife?"

The mega-parrot took a few impatient steps on the tree limb, then turned a green eye toward Claybourne. "You humans say the silliest things."

"So you're not Ramex."

"Remember how you once told the then-me I needed to learn to breathe properly? Remember how I laughed? I was the fool then, and you were the magus. A limited magus, and stupid, but you knew some few useful skills. And I don't mean skills in fighting. You called the good skill *meditation*. The Ramex I used to be should have learned from you."

"So you are Ramex, sort of." Intelligence on all worlds humans had studied, Claybourne thought, require a brain-to-body ratio far beyond what this parrot has. This creature, he concluded, has the proportions of a parrot, maybe an African gray, but still a parrot, so it might be clever, but not intelligent.

"You're partly right about the ratios, and I knew about brain size, of course, so I grew a body that housed brains in places other than the head. Better brains, I might add. That report I sent as Ramex? It was full of nonsense. The Clicks have no virgin goddesses, and they're definitely not murderers."

Claybourne looked around, noting that the Clicks had drifted away, leaving him with the mad parrot.

"Mad, am I? Perhaps. You can think that, if you wish."

This version of Ramex, Claybourne thought, has some weird knack for seeing surface thoughts, like the Drumorians, that odd race of primitives on Stockel in the Coal Sack who use rudimentary telepathy for playing games.

"But I can see more than surface thoughts, and as Magus-of-Stars I play no games."

The others sent here to learn about the Clicks, Claybourne wondered—had they been transplanted into the bodies of telepathic parrots?

"You want to know what happened to them?" The parrot chuckled. "I'm standing on one. This goofy tree. Here's a brain ratio for you—the neurons that were once locked inside the braincase of a woman named Margery Jinsen now live in this tree. Bunch them up and they're still about the same size as they were in Margery's skull, and look at the huge trunk and limbs of the tree she grew herself into. By any

biological definitions humans know about, the tree is bound to be stupid. But it isn't. Watch." The parrot pecked at a branch, a quick scratch with his great curved beak, and drops of red appeared, congealed, scabbed. "She built an automatic nervous system to take care of injuries so she can stay asleep, mostly."

Sleep? Claybourne marveled. But Margery changed herself into the tree—she committed suicide—and what made her do it? "Sally," Claybourne whispered, "can you tell if this tree once was Margery?"

"The tree is an alien life form," Sally said.

"Was it once Margery?"

"Perhaps, but the question has little meaning. There's something wrong within you, perhaps bad wrong. Come back to the ship."

"That mechanical brain you're talking with," the parrot said, "is essentially a stupid machine. Of course this tree was Margery, and it still is. But the change wasn't suicide. Ask her," the parrot said.

"Come back. Fast." Sally's voice carried an urgent tone, one that made Claybourne chuckle, for he knew the tone to be laced into the voice by artificial intelligence. Sally, after all, wasn't human, and he couldn't trust her judgment in some matters.

"Talk to a tree?" Claybourne spoke with his own skeptical tone. "Sally," he whispered, "stop talking to me for now."

"Why not speak to a tree? You're talking to a stupid machine through your clever mechanical tools in your ear and in your clothes. Not only that, but look at me. You're talking to a giant parrot. Of course with me you need not talk, if you focus your thoughts in a linear enough way. Try shouting to Margery. That might energize your thoughts and amplify them enough to rouse her."

"MARGERY JINSEN." Claybourne felt foolish for shouting. Then a thought wispied into his mind:

"Go away, Claybourne."

It sounded sleepy, though Claybourne wasn't sure how a thought could sound in any way at all.

"What happened to you, Margery Jinsen?" Claybourne asked. "What happened to the woman I once loved and who tried to convert me to a mystical religion?"

"Nothing bad happened." Margery's thoughts felt like her voice, a creamy alto, rich in feminine nuances, just as Claybourne remembered her speaking. "I remade myself, and I'm in heaven."

"You're a tree, Margery, a tree rooted in foreign soil on an alien world."

"Heaven." Her thought-voice seemed to drift. "It's in here and not out there at all. Everything you need to know is already inside you, Claybourne. Go, find it, change, change, change." The thoughts trailed off.

"She's asleep again," the parrot said. "She's finished with you."

"So I see."

"She's wrong," the parrot said. "About heaven, that is. Everything worth examining is out there." The parrot turned an eye toward the sky. "Not inside some silly tree's dream sleep. Margery Jinsen got it wrong. There's mindthreads out there that contain whole cultures." Again the parrot turned an eye toward the sky. "I can pick them out, learn languages. Eighteen so far, and there's more. One comes from a race that likely is extinct, a race far more advanced than humans. More advanced than Clicks. Go away now,

Claybourne. Go root like a tree and dream your stupid dreams. I have gathering to do, thoughts to examine, worlds to understand."

Is the man I knew truly dead? Claybourne wondered. And Margery Jinsen, is she dead?

The parrot snickered. "What is death, said jesting Pilate, and would not stay for an answer."

"That's a misquote from an ancient philosopher," Claybourne said. "The word he used was *truth* not *death*."

"But you know nothing of truth, and you fear death."

"Do you know what death is?" Claybourne demanded. "When that tree was still Margery, she liked to tell me about heaven, about dying and becoming a spirit, an incorporeal being floating in some vague somewhere. But back then she had a body, such a wonderful body. She was body. And yet she turned into this tree, so is there no more Margery Jinsen? Perhaps death is radical change. So what if some part of you lives on as a spirit, as she once believed—or as a sleeping tree or as a mad parrot with brains in its belly? What she was, what you once were, are so different from your former selves that Margery and Ramex are dead. Is that right?"

"I'm not dead," the parrot said.

"No. But you're not Ramex, either. You're strange, stranger than any creature ever imagined by Ramex when I knew him, and stranger than the mystic visions of afterlife Margery Jinsen once embraced."

The parrot eyed him. "Do you think such quibblings matter to me? Do you think I care about your Ramex? I have worlds out there to examine."

"Yeah. Just as the tree that once was Margery now has internal worlds to examine in dreams."

"You bore me," the parrot said. "Go away now or speed up your metamorphosis into a tree or into one of those creatures that look like bones and give their lives to grazing like slugs."

"I'll do no such thing."

"No? One of the Clicks put a paste on your face, right? It contains a hallucinogenic spore that will dig into the core of the one you call Claybourne, and it will grow, and you with your symbiote will change Claybourne, for within you is the knowledge of how to regrow yourself. Margery Jinsen was right in that, at least, and your choosing to change has nothing at all to do with conscious will. You'll change, but you won't die. Clicks kill no one. They are one of the most advanced races in the universe."

The facial paint, Claybourne thought, and his hand went to his cheek. I've got to defeat this infection, he told himself: I must survive as Claybourne. I don't want to die. There's medicine for treating invasions from foreign infection, Claybourne thought in a panic, but they're back on the ship. Can I get to them in time?

Fear gripped him, and he estimated his chances of surviving long enough to get to the meds and leaving the planet alive as being one in hundred.

The parrot chuckled. "Your chances of leaving are worse than you think. Look to your feet."

He looked at his shoe, where woody-looking tentacles spilled away from his tingling ankle and seemed to be probing into the soil.

"What do you see?" Magus-of-Stars spoke with the sound of a smirk in its voice.

"Is this death? I'll not sink into it without a fight. Sally, do you have advice for how I can get back to the ship?"

"Run," Sally said. "Keep the tendriled foot off the ground as much as possible. Don't stop."

Claybourne ran, but he stumbled on the spongy ground, and the worm-like roots spilling from his shoe probed the ground. He jerked the foot up, stumbled to his feet, and ran again.

The foot slowed him, and as he ran he felt a flapping of the tentacles that had sprouted from his ankle. By the time he crossed the area where he had danced with the Clicks, both feet flapped against the ground with writhing fingers of woody flesh.

A group of Clicks watched him run past them, their faces showing surprise and curiosity. Claybourne found himself chanting in a panicked voice, "Stay alive. Be Claybourne. Stay alive." He revised his chances of living to 75 percent. Then he reached the ship, stumbled through the door Sally irised open for him, and collapsed in the med chair she had waiting. "I'd say I have a 90 percent chance now," he muttered as the chair embraced him and he slipped into unconsciousness.

He awoke to a sense of well-being, one he knew Sally and the meds were responsible for, but it still felt good. "Will I make it, Sally?" he asked.

"Yes," the ship's brain said. "Your feet will need surgery."

"What was I doing to myself?"

"It wasn't you. The nanodocs injected into you isolated a worm. The creature is now in cryonics for later evaluation. It looks as if the worm takes control of fundamental biological processes and alters them to suit its purposes. It would have killed you through making your body into an alien being much like the sleeping tree that claims to be Margery."

"Margery's truly dead, then."

"Yes."

Claybourne sighed and told himself that he had already grieved for her. But somehow the fact of her death hit him again, almost like a hard blow to his body, and he remembered the snatch of poem she once quoted to him: "after the first death, there is no other." The poem is true, he told himself, but not in the sense Margery had thought.

"The Clicks claim to bestow immortality with the worm," Claybourne said. "But that's just an illusion, a nasty illusion."

"Yes. Ramex and Margery have ceased to be alive. Death by any other name is still death. I'm sorry."

It pleased Claybourne that Sally's voice carried a convincing intonation of sympathy.

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Reader's Department: **THE ALTERNATE VIEW: HUMANS AND ESTIMATING PROBABILITY** by John G. Cramer

We human beings have evolved with brains that have amazing capabilities for rational thought, pattern recognition, judgment, creativity, and imagination, none of which can be readily duplicated by the best computer simulations. However, there is one area in which the human brain is sadly lacking: the ability to accurately assess probabilities and act on these assessments. The success of lotteries, Las Vegas, and tribal casinos provide ample evidence that when it comes to estimating the odds and acting accordingly, we humans as a species are really deficient. We think that "winning streaks" are real, that slot machines are "overdue" for a jackpot, that the past pattern of random events somehow influences the odds for the next event.

One example of this deficiency in probability understanding was provided recently when CERN's Large Hadronic Collider (LHC) began preliminary operation near Geneva, Switzerland. In the physics literature there had been some rather strained speculations that if certain theories involving extra dimensions were valid, then the proton-proton collisions at the LHC might produce tiny black holes with masses of a few trillion electron volts (TeV). (See my May 2003 AV column, "The CERN LHC: A Black Hole Factory?") The same theories that tentatively predicted such black hole production also predicted that, if created, the tiny black holes would be super-hot objects that would dissipate themselves almost instantaneously into a thermal cloud of lighter particles, primarily electrons, positron, and photons.

Not surprisingly, many individuals seized on the idea that the LHC might produce black holes and imagined a scenario in which the black hole would *not* instantaneously dissipate, but instead would begin to suck in nearby matter, grow larger, and devour the Earth. Lawsuits were filed to stop the LHC from beginning operation. A joke web site (www.cyriak.co.uk/lhc/lhc-webcams.html) even appeared that purported to show real time web-cam shots of a black hole devouring the CMS experiment at the LHC.

Physicists working with the LHC were asked to estimate the probability that such a disaster might occur, and they responded by saying that the scenario was "extremely improbable." The problem is that in such situations a scientist can never say "never" because the variety of theories available, some right and some wrong, provide the capability of analyzing an unlikely scenario and producing the probabilities that are absurdly small (but not zero).

For example, can you walk through a brick wall? Common sense would say no, but in quantum mechanics there is a process called "tunneling" that allows an object to disappear from one side of a barrier like a brick wall and appear on the other side. This phenomenon literally should allow one to "walk through walls," but with an extremely low probability of success, say one part in 101000 or less. So if you ask a physicist whether it is possible to walk through walls, he cannot say "no." He'll have to say "yes, but with an extremely low probability."

It is human nature, via the wiring in our brain, to interpret "very improbable" as meaning that such an event is at least possible and should be worried about. Therefore, the big story in the media recently was not that the LHC was beginning operation (and promptly blew out a superconducting magnet for a several month halt), but that it was possible that the Earth was about to be devoured by a black hole.

* * * *

Another close-to-home example of this phenomenon is the recent collapse of AIG, a company that insured investment "vehicles" associated with home mortgages. Insurance companies are in the business of estimating the odds accurately and profiting generously from the unwillingness of most of us to accept risks. In the case of the mortgage-based investments that AIG was insuring, the risk estimates were based on the "independence" assumption, the assumption that the probability P of the default of any

given mortgage was unrelated to the default of any other mortgage in the investment package. Under this assumption, the risk of n mortgages in the investment failing is Pn , which is a very low probability, making the insurance premium cheap. The fallacy in this calculation was that mortgage failure probabilities are *not* independent when a housing bubble is about to burst, and the insurers grossly underestimated the failure probabilities. The moral is that even as professionals in the business of estimating probabilities, we humans frequently get it wrong.

* * * *

Another area where probability estimates are important and sometimes mangled is laboratory safety management. I am an experimental physicist who has worked at many large accelerator facilities, including those at a number of universities and national facilities at Los Alamos, Livermore, Berkeley, Argonne, and CERN. The scientific equipment used in experiments in nuclear and high-energy physics employ high voltages, ultra-cold gases, potentially explosive gas combinations, and gases at high pressures. The experiments create nuclear reactions that can produce potentially lethal radiation exposures to gamma rays, neutrons, and charged particles. Considering all this, there are surprisingly few injuries and accidents among experimentalists. In part, this is because a few highly trained individuals are charged with the responsibility of identifying potential problems, assessing their probabilities, and instituting safety procedures. This usually works well, but there are a few exceptions.

I know of a radiation safety officer employed by a large defense contractor who insisted on assessing acceptable radiation exposure based on the “lowest possible exposure” rather than the “lowest reasonable exposure.” That doesn't sound like much of a difference, but it added huge costs to the operation. The reason is that we do not live in a radiation-free world. Our annual exposure to cosmic rays from space and to environmental radiation from granite, radon, potassium-40, etc. is fairly large, perhaps 0.25% of a mean lethal dose of radiation. Is it reasonable to make sure that a radiation worker receives a radiation dose from his work that is less than 1/10 of the radiation dose he receives from the outside world? Most safety officers would say no, but this particular individual, who seemed to have a particular problem in understanding the estimation and use of probabilities, insisted on very expensive additional shielding in an attempt to reduce the radiation exposure from the facility to zero. Not long after, the project was cancelled due to cost overruns.

* * * *

In another case at Brookhaven National Laboratory, one of the safety officers developed the peculiar conviction that helium was a deadly gas, presumably because a person placed in a room filled with helium would die of suffocation. Brookhaven's Relativistic Heavy Ion Collider (RHIC) Facility, which was then being designed, would contain lots of liquid helium that would cool the superconducting magnets used for bending and focusing the heavy ion beams to be accelerated. When such superconducting magnets are in operation, occasionally they “quench,” meaning that the superconductivity goes away, the stored magnetic field energy heats the magnet coils, the system temperature rises, the liquid helium boils, and a great deal of helium gas is produced and must be dealt with. Normally, the magnet system includes a “blow-off stack” to deal with this problem, a long pipe leading up through the ceiling that blows off the excess helium at roof level.

However, the safety official in question decreed that this could not be done, because helium was a deadly gas that might suffocate people in the event of such a magnet quench and blow-off. Instead, it was required that the RHIC facility must have vacuum vessels designed to completely contain the many atmospheres of pressurized helium that would be produced in a quench event. The RHIC component magnets were designed in this way, at substantial extra cost. RHIC was completed and scheduled to go into operation in 1999. The full RHIC ring of superconducting dipole bending magnets and quadrupole focusing magnets, interspersed with a few lengths of pipe as “placeholders” for possible future expansions, was assembled.

The problem was that, since the RHIC machine was designed to withstand many of atmospheres of helium in its vacuum system, this had to be tested before the initial operation could begin. The system was sealed and the pressure test was duly done in early 1999, and then the vacuum system was pumped out, the magnets were cooled to liquid helium temperature and tested at high fields, a beam of gold ions was injected into the machine, and initial operational tests began.

Beam transport problems were soon encountered. The gold beam went through a few magnets, then hit something. The accelerator physicists did some gymnastics with steering magnets to get past the unexpected obstacle, and the beam was able to go through a few more magnets, but was again stopped by another unexpected obstacle. This pattern of failures was repeated all during the summer of 1999, while many of us who had come to Brookhaven for the initial RHIC operation waited impatiently for the machine to deliver gold-gold collisions to our detectors, STAR, PHENIX, PHOBOS, and BRAHMS, which we had spent the last decade constructing.

Finally, in September of 1999, the accelerator physicists gave up their attempts to get the beam through the machine. They warmed up the magnets and opened up the vacuum system to see what the beams had been hitting. There they discovered distorted “bellows” vacuum fitting and “RF fingers” that had been damaged during the high-pressure helium tests and were sticking into the beam path. It was realized that while all of the magnets had been carefully designed to withstand the high pressures, no one had worried about the expansion of the placeholder pipe sections in the ring, and these had expanded during the pressure tests and damaged the vacuum fittings. It took much effort and cost many millions of dollars to fix this damage, and in 2000 the RHIC facility was able to begin what has become a very successful string of operating periods.

Because helium had been declared a deadly gas by the safety officer, a full year of operation of the RHIC facility was lost, millions of dollars in extra costs were incurred, and an army of physicists like me spent frustrating months at Brookhaven waiting for the beams that did not come. Interestingly, the training that we RHIC experimentalists had to take in 1999, teaching us the actions to take in the event of a magnet quench that filled the accelerator vault with deadly helium, curiously disappeared from the safety training in subsequent years. I feel that the inability of the human brain to accurately estimate probabilities and act on them played a key role in this fiasco.

* * * *

Why are we wired this way? Wouldn't it be a strong evolutionary advantage to be able to “see” probabilities and act accordingly? I am not sure I know the answer to this puzzle, but let me try to answer with a parable.

Many millennia ago, when we were first emerging from the trees and beginning to function as humans, there was a river separating two hostile tribes that constituted most of humanity. On the north side of the river lived the Prob Tribe, a group that had the ability to easily see probabilities and act accordingly. On the other side of the river lived the Numbskull Tribe, a group more like modern humans who believed in luck and winning streaks and other such fantasies. The vigorous male Probs hated the Numbskulls and wanted to rush across the river and kill them, but their enhanced abilities showed them that it was far safer to stay on their side of the river and not engage in combat. The Numbskulls felt no such compunctions. On a night when the moon was dark, they stole across the river and killed all of the Probs, to a man, woman, and child. Thus, we are all descended from the Numbskulls.

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Probability Zero: **WHEN ALL ELSE FAILS** By H.G. Stratmann & Henry Stratmann III

Humanity woke up one morning and found that the Earth was turning into Paradise.

It started with small wonders. A slice of bread dropped on the floor now always fell jelly-side up. No sock ever vanished in the dryer. There was no storm, hail, or blizzard when the weather forecast predicted a sunny day.

Next came minor miracles. Oil companies panicked as gas tanks in SUVs and all other vehicles stayed perpetually full no matter how far they were driven. Airline flights were always on time and no baggage was ever lost. Computers never crashed.

Dumbfounded doctors said foods that tasted good were now actually good for you. A diet rich in doughnuts and desserts gave a woman the face and figure of a supermodel and sculpted a man's physique into one like Arnold Schwarzenegger's in his prime. The grease-gorged, salt-saturated calories in fast-food cheeseburgers and fries now unclogged coronary arteries and lowered high blood pressure.

Then the truly impossible happened. Lawyers turned honest and sincerely sought justice. Politicians told nothing but the truth and worked for the good of their fellow citizens. People became celebrities only if they actually had talent and were good role models for the young. Teenagers respected and listened to their teachers and other elders. Adults led lives as free of greed, lust, and other vices as the parents in a 1950s TV sitcom. Science fiction magazine editors bought all the stories they received, for every submission was an astounding blend of original ideas and entertainingly thought-provoking prose.

Each day brought new wonders. Where once there was war and rumors of war, now peace and harmony filled the world. The wolf lay down with the wombat. Tanks were beaten into tractors. Violence, hatred, prejudice, and intolerance vanished like the scented smoke of incense wafting upward into the heights of a great cathedral.

Earthquakes, floods, and hurricanes never ravaged the land. Famine, disease, and death were no more. Though the old grew young again and no accident ever injured or killed, the world no longer seemed overcrowded. In even the largest cities no traffic jams sullied the streets. Smiling taxi drivers graciously yielded the right of way to pedestrians and road laughter filled the avenues. Elevators were never stuffed with perspiring passengers. Checkout lines at grocery stores were always short.

Finally came the greatest miracles of all. Man now understood Woman and lovingly validated Her feelings. Woman never nagged or tried to change Man.

Learned thinkers who'd long pondered the ultimate questions of theodicy and the meaning of life found those riddles no longer needed answers. Even the most skeptical inquirers came to believe that only a Power far greater than human science and ingenuity could be responsible for this amazing metamorphosis. The righteous rejoiced that their faith and prayers had been vindicated. From every land and in every tongue a chorus of thanksgiving ascended to the heavens...

Somewhere outside time and space a Being beyond human comprehension looked at His work and saw that it was good. Then a sweetly sarcastic voice from the kitchen startled Him.

"Any luck, Dear?"

"Yes, it's working fine now. I told you I could figure it out without any help!"

Okay, so that last part was a fib. But She didn't need to know that He'd finally swallowed His pride and

done what She'd been telling Him to do for eons. He'd already wasted over thirteen billion years fiddling with the darn thing. The last thing He needed was an eternity of hearing "I told you so!"

Hopefully She'd be so pleased the home entertainment system She'd bought on sale finally worked right that there'd be no embarrassing questions about how He'd succeeded. After looking within the thick book in His hands one last time, He stuffed it back into a large box on the living room floor. There, hidden beneath packing material and the shrink-wrap He'd just peeled away from it, She wouldn't see the manual's title.

"How to Operate Your New Universe."

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Reader's Department: **IN TIMES TO COME**

Our April issue offers quite a variety of stories, of all shapes, sizes, and flavors. At one extreme is Adam-Troy Castro's "Gunfight On Farside," a striking case study in why "what everybody knows" isn't necessarily what *is*. At the other end are a trio of quite different short stories by Eric James Stone, Jerry Oltion, and H. G. Stratmann. In between we have a pair of contrastingly quirky novelettes by Mark Rich and Mary Turzillo, with the contrastingly quirky titles of "Foe" and "Steak Tartare and the Cats of Gari Babakin."

In the science fact department, astronomer Kevin Walsh returns with another of his looks at the ever-expanding diversity of planets that we're finally learning exist—or could exist—out there. This time his topic is "Ribbonland," a kind of world long favored by science fiction writers on which habitability is confined to one or more bands of latitude. Just how habitable would those be, and what surprises might they have up their metaphorical sleeves? Read our April issue and find out....

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Short Story: **LIFESPEED** by Carl Frederick

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Illustration by Broeck Steadman

* * * *

New knowledge often makes it hard to apply old rules...

* * * *

Robert Witten grabbed his towel and, for the hundredth time, wiped his face. But after a full day of fencing, the towel merely redistributed rather than absorbed the moisture. He saluted the director, the fencers watching the finals from the sidelines, and his opponent. Then he pulled his mask over his face and stood on guard. Down 4-3, the next touch was critical. He sized up his adversary, Vincent Rapelli. The guy was huge. Robert had fenced him at a meet six months ago and had won. But back then, Vincent hadn't looked like King Kong on steroids. *Too bad we don't test for drugs at these circuit events.*

"Fencers ready?" said the director.

Robert and Vincent nodded.

"Fence!"

Robert made a feint to the wrist. Vincent, as expected, took the blade in sixth and executed an attack to the shoulder. Robert did a counter-sixth, seized Vincent's blade—but couldn't deflect it. Vincent won the touch—and the match. And that meant unless, by a miracle, he managed to beat his next opponent, Lars Nielson, he'd come in third behind Vincent and Lars. That would lower his national ranking, making his selection to the Olympic squad iffy at best. He tried not to think about it. Making the Olympic squad was a lifelong dream, and he couldn't bear the thought that it would remain a dream.

With a forced smile in answer to Vincent's smug grin, Robert stepped forward to shake hands.

Ten minutes later, Robert took his position on the strip for his bout with Lars, the last bout of the tournament. In less than a minute, Robert found himself losing by 4-2. One touch from defeat. *Hopeless!*

"Fencers ready? Fence!"

Robert hardly saw Lars move. The scoring machine buzzed, indicating a touch. Only that sound told Robert he'd been hit.

Robert bounded forward to shake hands, then, after Lars left the strip, Robert went to talk to the director. "About that last touch."

The director stiffened.

Robert moved a hand to his chest. "Oh, I was hit"—the director relaxed—"but I really don't know how—or even exactly where. It seemed as if Lars attacked using a quadruple disengage on the extension. But *nobody* is that fast."

"I've got to admit," said the director, "that it was too fast for me to follow. Thank God for the scoring machine." Robert walked with the director toward the bout committee. The director, in his fifties but still moving with the quickness of a fencer, shook his head. "It seems to get faster every year," he said wearily. "No one can really watch the sport anymore. It's no wonder that fencing is in danger of losing its

Olympic status."

"Given the bulk of the work done in my lab," said Robert, "performance-enhancing drugs come to mind—not for Lars, of course."

"Your department does the testing for the Olympic squad, doesn't it?"

Robert nodded. "My own research is on biochem methods of life extension. But most of our funding does come from drug testing."

"For some fencers, drugs might well be suspected." The director threw a knowing glance across the gym where Vincent was packing his gear. "But I agree. Not for Lars. In his case, I think it's more a case of performance enhancing genes."

Robert chuckled.

"I'm serious. Steroids can make you stronger and faster, but not *that* fast." The director dropped the scoring sheets on the bout-committee table. "Fencing does run in families. I'm sure most of the reason is cultural. But I'd be willing to bet there's a genetic component—a selection for fast reflexes." He glanced up, meeting Robert's eyes. "And you epee fencers are tall. Wouldn't be surprised if there was a gene for it."

"There is, actually," said Robert, in a distant voice. He'd never considered his height in that light. "A variant of the HMGA2 gene."

"Well, there you go, then. It's not much different from performance-enhancing drugs." The director paused. "Except that instead of the fencer choosing to take the drugs, his parents chose to impart the genes."

After the awards ceremony, looking for an excuse to avoid the locker room and Vincent's gloating, Robert stayed to listen to Lars talking to the press.

Robert's stratagem failed; Vincent came up to him on the gym floor to expound on his victory—and to pontificate. The man was an instructor in philosophy at a local community college and seemed to like arguing for argument's sake.

Vincent allowed that Robert had fenced "not all that badly," and then said, "Are you still working on increasing the time a person spends on Earth?"

Even though knowing the question was just an opening gambit for a disputation, Robert said, "Yes. Actually, I am."

Vincent gave a harsh laugh. "How can you talk about living a longer time when you don't even know what time is?"

"Perhaps you're right," said Robert, choosing not to engage.

"Scientists!" Vincent spoke the word as an expletive. "Study philosophy! Then your science might have some validity."

Refusing to be baited, Robert nodded toward Lars. "Now there's a really good fencer."

Vincent stared at the man. Robert couldn't tell if the look was one of contempt or envy.

"I wonder what class of steroids *he's* taking," said Vincent.

"Lars Nielson taking steroids? Don't be ridiculous."

"Ridiculous?" said Vincent, looking haughtily down his nose. "Don't be naive." He turned and strode toward the locker room.

Robert blew out a breath and turned his attention to Lars and the reporter. Robert had no hard feelings about losing to Lars. The guy was sure to make the Olympics. He was tall, easygoing, intelligent, had superb technique, and moved like a ferret.

"Why do you fence?" asked the reporter.

Lars uttered a good-natured laugh. "For love of the sport, and ... as a break from boredom."

Robert gazed in surprise. He knew Lars was a theoretical physicist and that sounded far from boring. *Only in fencing*, Robert thought with a smile, *could you find three academics with good shots at the Olympics*. Robert pursed his lips. He might not be an academic much longer. His research group had run out of ideas and that meant that soon the group would run out of money.

Robert snapped alert when he heard the reporter ask Lars about drugs.

"No. Fencing is still pure," Lars said firmly. "No money in it. Not a spectator sport. Too fast for that." He balled a fist at his side. "Athletes taking drugs is disgusting."

As this was familiar territory and his endorphin high had given way to exhaustion, Robert hefted his fencing bag to his shoulder and headed for the locker room.

A few minutes later, as he relaxed on a bench in front of his locker, Lars came in.

"Interesting interview," said Robert as Lars opened the adjacent locker. "I wouldn't have thought physics to be boring."

Lars paused. "I suppose that overall, it isn't. But moment by moment, it can be."

"I still find it hard to believe."

"It's not just physics," Lars sighed. "It's life as a whole. Most people seem slow to me—not dumb or anything, but just slow-moving and slow to react." He nodded. "It's me, of course. I can't even enjoy movies unless I run the DVDs on my computer at 1.2 times normal speed."

"It sounds as if time moves more slowly for you than for most people."

"Never quite thought of it that way," said Lars. "But I should have." He gave a good-natured laugh. "The speed of time. Very much in the spirit of relativity theory." He looked away, a distant expression on his face. "It could be that time is just a parameter to sequence events. Yes. Time as a parameterization of the order and flow of events." He smiled sheepishly. "Sorry. Woolgathering." He seemed to refocus on the here and now. "By the way," he said. "I'm sorry about your loss to Rapelli. He won by sheer force, not technique. Ugly fencing."

"Thanks." Robert tried to hide his disappointment at the loss. "I appreciate you saying that."

"No, really. And you still have a really good shot at making the squad. There are two spots yet to be decided." He headed toward the showers. "The Martini tournament is important, yes. But it'll really be decided at the Nationals."

* * * *

Driving home, Robert pondered Lars's words. The National Championship competition in three months would be crucial. If he trained like a fiend, he might well be able to beat Vincent. But that would take a toll on his job—while he still had it. His thoughts turned toward trying to come up with the big idea—a life-extension concept that would assure his department's continued NIH funding.

Robert focused on the problem, dwelling on it as he drove home. He carried his fencing gear into his apartment. Then, unpacking his soggy fencing whites, he noticed that the towel was not his. He'd probably switched towels with Lars in the locker room. Thoughts of his life-extension work blended with his recollection of Lars's comments, and Robert felt the germ of an idea. He dropped the still wet towel on a chair and turned his full attention to the nascent inspiration. Maybe instead of trying to enable people to live more calendar years, one could effectively increase lifespan by enabling people to live life faster, so that they could do more things per unit of clock-time—the way kids seem to do.

Gazing at the towel as one might a museum artifact, he wondered if fencers, as a group, actually *do* live faster than non-fencers. Does time run more slowly for them? Does the idea of a variable rate of time make sense? He thought of insects. Short-lived creatures, to be sure, but did their flitting and darting imply more events for them per unit of conventional time? Maybe the adage that children live life faster could be justified by biology. Robert recalled to mind the kids he knew. They all seemed bright and precocious. For that matter, so did Lars. *Maybe quicker equates to smarter.*

Robert contemplated human intelligence. *What is an IQ test actually measuring? Maybe, at least partially, it's the bus-speed of people—how fast they live.* Robert felt he now had enough of an idea to draft a grant proposal. *Not lifespan. Lifespeed!*

Gazing absently now at the towel, Robert had a dark thought: Vincent's assertion that Lars's performance was enhanced by drugs. *Could it possibly be true?* “Hey!” he said aloud, taken with a sudden idea: The towel was soggy with Lars's body chemistry. He'd have his department run a chemical analysis of the molecules trapped in the towel—a thorough analysis testing for the full gamut of forbidden drugs. He would *prove* to himself that Lars was clean.

Then he had another thought. A big-time spectrophotometry analysis might also find an indication of a genetic basis of faster reaction time—an indication of “lifespeed.” Robert smiled. He'd spend quite a lot of time with that towel. But he'd not tell his colleagues about his lifespeed idea until he had some evidence, hopefully garnered from Lars's sweat.

Robert woke to the sound of knocking at his office door. He'd fallen asleep at his desk. Having trained every day since the Martini tournament two weeks ago, the exertion was taking its toll. He sat upright in his seat and called out, “Come in!”

Paul Webster from the athletic testing group walked in and dropped a folder on the desk. “The results for your ‘Fencer X.’”

“Clean, I hope,” said Robert.

“No sign of illegal drugs,” said Paul with a smile. “You're as clean as a baby's mind.”

“No. It's not me,” said Robert. “And I can't name him for ethics reasons.”

“Then I won't ask.”

Robert responded with a chuckle, then said, “You're sure about the drugs?”

“Absolutely! The towel sweat was as good as any urine test.”

"Did you find any neurotransmitters?" Robert indicated a chair and Paul sat.

"Funny you should mention that." Paul pointed to the folder. "Compared to the acetylcholine levels, the towel exhibits an enhanced concentration of norepinephrine, dopamine, and 5-hydroxytryptamine."

"Interesting." Robert picked up and opened the folder.

"That's not the half of it. Those three chemicals are enantiomers of the naturally occurring molecules."

"What?" Robert dropped the folder. "Mirror images? Really?"

"Strange, isn't it?" said Paul. "And *only* those three neurotransmitters are enantiomeric."

"I'm surprised the neurotransmitter receptors respond to them."

"Surprised?" said Paul. "It's almost beyond belief! But some receptors must respond. Otherwise he'd be dead." He took off his glasses, exposing the nibbled-on earpieces. "I wonder if it's naturally occurring, or is there a drug development we don't know about yet?"

"What do you think?" said Robert.

Paul toyed with his glasses for a few seconds. "I'm inclined to think it's natural. Drug news tends to travel fast."

Robert leaned back and stared at the closed folder. "By chance," he said after a few seconds, "could you synthesize those enantiomers?"

"I think so," said Paul. "Why?"

"I have a notion they might explain X's fantastic reflexes—his reaction time, his genetics."

"Really!" With a quick motion, Paul put on his glasses. He peered at Robert. "A gene for time?"

"Why not?"

After a pause, Paul said, "You want to try it on rats?"

"You bet!"

* * * *

"Look at 'em move," said Paul, peering into the cage. "They're more like fruit flies than rats." He stepped back from the cage. "I'd be willing to bet that kids start life with a supply of these enantiomers—my kids, anyway."

"Could be." Robert switched his glance from the cage to the maze. "Especially now that we know rats have enantiomeric receptors."

In the intervening month and a half, Paul had both synthesized the neurotransmitters and injected a colony of research rats with them.

Robert moved a rat from the maze back to the cage. "Well, here's another Einstein rodent. One point three times smarter than your average rat."

"Is it *that* mechanical?" Paul opened the cage for the rat. "When we measure the intelligence of rats, or of humans for that matter, is it really just a measurement of speed?"

Robert smiled. "Until we can engage the rats in deep discussions of philosophy, speed of learning a task is the best measure we have—at least for rats."

Paul glanced at his watch. "Well, I'm afraid I'm scheduled for a ... a deep discussion of philosophy with our department chairman about now." He grabbed his laptop computer and headed for the door. "See you Monday. Have fun with the rodents."

Alone in the lab—except for the rats—Robert stared at the cage. The creatures moved as if in fast-forward. But, in other respects, they displayed no unratlike behaviors. They'd been injected with the chemicals and the morning after, they simply became super-rats. His gaze shifted to the rack of hypodermic needles in the chemicals cabinet. The rats had been given very low doses—and only one dose apiece. And the effect had persisted. *It's funny. The neurotransmitters seem to have no difficulty passing from the bloodstream through the brain barrier. But the barrier seems to prevent most of the chemicals from passing from the brain back into the bloodstream.* He wondered just how long the effect *would* persist.

Robert was glad the rats only needed one injection. He hated needles. Robert walked to the chemicals cabinet. He withdrew a hypodermic and a membrane topped dose bottle. Then, grimacing, he rolled up his sleeve.

* * * *

Saturday morning, Robert woke feeling he'd already had a mammoth mug of strong coffee—maybe a half dozen mugs. And he woke ravenous. He devoured a large breakfast and since he was still hungry, tried to control his appetite by downing a couple of additional cups of coffee. Although he felt he was truly living life faster, he wasn't sure. It might just be wish fulfillment. He'd be able to tell later at fencing practice by calibrating his performance against the club's stronger fencers. But the club didn't open until one in the afternoon.

With a forefinger on his wrist and his eyes on the second hand of his watch, he took his pulse. Forty-eight: Resting-normal for him. Then he sprinted to a cupboard to fetch the blood-pressure meter he'd bought when he'd last experimented on himself. That had been a failed foray into the world of herbal extracts.

Reading the dial, he found that his blood pressure was normal, 124 over 82. Smiling, he removed the cuff. As he'd hoped, the effect of the enantiomeric neurotransmitters seemed restricted to brain chemistry. It seemed safe therefore, to assume he'd not increased his lifespeed at the expense of his life expectancy.

He looked again at his watch. He had *hours* to kill before one P.M. He swapped his bathrobe for shorts and running shoes and did five high-speed miles on his treadmill. Following that, he did a half hour of stretching and isotonic exercises. He showered, read a few online newspapers and then went through the latest issue of *Neuroscience*. When he'd finished, he mentally kicked himself for not noting when he'd started. It would have been instructive to see if his reading speed had increased. But he had time. He laughed. Now he had plenty of time. He loaded his gear into his car and drove off to the fencing club. On the way, he was pulled over for speeding—his first moving violation.

At the club, he easily beat people who often gave him trouble. At the end of the day, there was no longer any doubt; his lifespeed was much faster than most. *I wonder how much faster.* He thought of his bouts. Relatively easy wins, but they gave him little satisfaction. They were hollow victories resulting from speed rather than improved technique. He had the distinct feeling he'd cheated and his mood soured.

In an attempt to cheer himself up, he went out to dinner—to an all-you-can-eat buffet. And it did improve his mood. There was much to be happy about; he'd effectively increased his lifespan, and he'd

certainly gotten his money's worth at the buffet. Turning his thoughts toward the Nationals a mere month away, he had a happy vision of beating Vincent, and beating him badly. It was his sacred duty to beat Vincent.

At home that night, Robert felt worn, and he had a slight case of the sniffles. He realized that his neurobiology might well be faster, but the rest of his biology wasn't. Having forced himself to move faster, his body was telling him it needed recuperation time—probably even more time than usual since he'd worked it so hard.

Sunday, he woke to aching muscles and his sniffles had progressed to a runny nose. He hoped he wasn't coming down with a cold. No doubt a cold would last as long as it usually did, but it would *seem* much longer. He decided to take it easy for the day and go to a movie he'd been looking forward to seeing. But despite its good reviews, he found it tedious.

As he walked slowly home, he realized that weekends were, in effect, longer and he'd have to prepare for them. With a tight-lipped smile, he realized that a quickened lifespeed wasn't an unalloyed joy. Slow weekends. Slow movies. Slow people. It would be good if he could somehow switch from overdrive back into normal. *Alcohol! Maybe a few stiff drinks would do it.* He gave a silent laugh. *A dangerous thought. But maybe I could accomplish it by using lower injection doses. I'll have to experiment when the effect starts to wear down.*

He noticed that although he was walking “slowly,” he was still passing all the other pedestrians—and he felt horrible. He had caught a cold, and that meant two days stuck at home in bed—and due to his lifespeed, a *long* two days, and then another long two days back at work infecting others. He shivered with a sudden concern. Maybe it wasn't a cold, but an effect of the chemicals. *I'm an idiot. What ever possessed me to inject myself?*

Cold or not, Robert found that his appetite was still healthy. He didn't feel like it, but before taking to bed, he knew he'd better do some grocery shopping. And then he'd be able to spend the next couple of days not thinking about lifespeed or anything else. He could just concentrate on being miserable—and hope it was indeed just a cold.

Over the next forty-eight hours, as his cold intensified, Robert felt increasingly sluggish. At first, he thought it was merely the normal action of his cold. But then he decided that his slowness was more likely due to the loss of lifespeed neurotransmitters. His lifespeed was slowing to normal—and yes, it was just a common cold. *Thank God!*

* * * *

Back at his desk Wednesday, Robert still felt slow, his nose was still stuffed up, and he had a headache. As usual, he'd returned to work earlier than he should have. He glanced at the chemicals cabinet and shook his head at his own recklessness. Regardless of the benefits of a faster clock speed, he'd wait until he could control it before he'd take another lifespeed injection.

Across the desk from him sat Paul, his chair farther back than usual—out of contagion range. Paul glanced at the burger and donut wrappers that littered the desk. “Feed a cold and starve a fever?”

“I guess.” Robert moved the detritus to the trash. “Anything interesting happen while I've been out?”

“The rats are producing their own enantiomers now.”

“What? That's wild!”

Paul laughed. “Yes. That's how I felt.” He removed his glasses and played with them. “I wondered why

the rats didn't slow down, so I ran some tests."

"Are you saying the rats won't return to normal?" Robert shivered. Maybe his sluggishness *was* just an effect of his cold.

"I don't think they will." Paul paused, then said, "Apparently, the enantiomers act like a template for the natural production of the neurotransmitters." He looked absently away at the window. "But I don't understand it. If it's so easy to speed up their neural clocks, why isn't it the biological default? What is the evolutionary advantage of being slow?"

"Needing less food," Robert shot back.

Paul swiveled his gaze back from the window. "Yeah. The rats do eat a heck of a lot more food than they used to. In fact..." He replaced his glasses and glanced at the food-wrapper laden trash basket. Then he turned sharply toward Robert.

Robert looked down at his hands, avoiding Paul's gaze.

"You didn't!" said Paul.

"Isn't there any way to turn off the effect?"

"Nothing obvious," said Paul in a stunned voice. "Why did you do it?"

"I was curious." Robert clenched a fist. "And I assumed the effect would be temporary."

"I'd be curious, too," said Paul, staring wide eyed. "But there's no way I'd have taken that risk."

"I had more incentive than you, maybe."

"It's about fencing isn't it?" Paul's expression turned accusatory. "The Olympics." He let out a breath. "This really isn't much different than taking steroids."

Robert slapped his desk. "This isn't about performance enhancing drugs. It's about research."

"Sure it is," said Paul.

"It is!" Robert snapped to his feet, a motion he'd executed a lot lately. "And anyway, the enantiomers aren't banned substances."

"They should be."

"Why?" Robert, suddenly aware of his persistent cold, leaned against his desk. "I've just used ... used gene therapy to acquire what I imagine Fencer X had obtained naturally. What's wrong with that?"

"You injected substances. That's *not* gene therapy."

"But it could have been."

Paul paused. "This puts me in an awkward position. If you make the Olympic squad, my lab'll be doing the drug testing on you."

"Probably not," said Robert. "Conflict of interest. The committee would probably find another testing lab."

"That's not the point." Paul's eyes blazed. "But what if they do keep using my lab? What'll I report?"

"Report whether I'm using banned substances."

"The letter of the regulations." Paul stood to face Robert. "Hardly the spirit of them."

Robert felt himself deflate. He sat on the corner of the desk. "Yeah. I know." He shook his head sadly. "I've got to say I don't feel comfortable either. I've always fenced clean. I've always hated the idea of cheating with drugs."

"What are you going to do?" Paul's eyes lost their anger, and he sounded sympathetic. "I mean about the Nationals—and the Olympics."

"I don't know."

* * * *

Over the next month, Robert came to accept his enhanced lifiespeed. He now preferred faster music; presto over adagio, and fast food rather than gourmet cuisine, watching ping-pong instead of tennis, sprints in lieu of marathons. And, as did Lars, he played his DVDs on a computer at 1.2 times normal speed. The big downside was that he began to feel out of synch with just about everyone. Now, he could appreciate the saying that "no man is an island"; life extension via lifiespeed was only a boon if a lot of people were infected with it. He could see why fencers so often married other fencers.

By the time of the Nationals, Robert had learned how to use his fast lifiespeed without making unreasonable demands on his body. At the tournament, he fenced hard, but just hard enough to get into the final round. He'd just beaten Szabo, and now Vincent Rapelli stood before him on the strip. This time, Robert would not hold back.

"Fencers ready?"

"Fence!"

Vincent took the blade in sixth—Robert let him—and advanced with a bind. At the last possible moment, Robert jumped backward, did a low-line disengage, and executed a stop thrust to the wrist just under the guard.

Behind his mask, Vincent's all but perpetual sneer vanished, to be replaced with a look of shock. Robert smiled sweetly.

Robert won the match by five touches to one. And he knew that Vincent's loss would drop him not to third place, but to fourth on indicators behind Szabo. He was out of Olympic contention. By his stare of hate, Robert could tell that Vincent knew it as well. Without even shaking hands, Vincent turned and stalked away.

As it had been at the Martini tournament three months ago, Robert's last match was with Lars Nielson. Because of going all out in his match with Vincent, Robert had little in reserve for this final bout. It would be extremely difficult to beat Lars. Robert entertained self-defeating thoughts: Lars was a superb athlete with fantastic technique. And it didn't seem fair to beat the guy using lifiespeed. *Except*, Robert reminded himself, *that, by his genetics, Lars is using lifiespeed also.*

Robert lost the bout, 5-4. But as he walked to the locker room to clean up before the awards ceremony, he nonetheless felt pleased with the result; it was close. *No cigar, but close.*

In the locker room, Lars came up to him and sat. "Good bout," he said as he kicked off his fencing shoes. "I didn't think your technique was quite as good as last time, but boy, were you fast."

"Yeah," said Robert, feeling a rising sense of guilt. "Due entirely to enantiomers, I'm afraid."

"Due to what?"

"Enantiomers."

Lars's face showed puzzlement.

"Stereoisomers?" Robert tried.

Lars still displayed lack of comprehension.

"Isomers?"

Lars shook his head.

"Geez!" said Robert. "Don't you physicists take any chemistry courses in college?"

"Not many. Why should we? Chemistry is just applied physics."

Robert threw a glance at the ceiling. "Isomers," he explained, "are molecules with the same chemical formula but different atomic arrangements and possibly connectivity. Stereoisomers are isomers with the same connectivity, and *enantiomers* are mirror images."

"Well, I thank you for filling this gaping hole in my chemistry knowledge," Lars said with a smile. "But what does this have to do with the price of bratwurst in Bratislava?"

Paul let out a long sigh. "I'm ashamed to say this, but I've sort of violated your privacy."

Lars canted his head and narrowed his eyes.

"I wondered if your terrific speed was perhaps genetic." Robert's tone was one of remorse. "So I'm afraid I analyzed your sweat in my lab—your DNA." He spread his hands. "I'm really sorry."

Lars stiffened and his face showed a flicker of anger. But then he smiled. "You have laid bare my genes," he said. "Sounds naughty, doesn't it."

"Look. I apologize. I don't know what I was thinking. My curiosity just—"

"What did you find?"

"What?" said Robert.

"I'm a physicist. I know what it means for curiosity to trump everything else. What did you find?"

Robert told, then explained how he'd used the knowledge.

Lars seemed momentarily bewildered. Then, almost at a whisper, he said, "So that's how come you were so blazing fast on the strip."

Robert nodded. "You can see why I have qualms about competing in the Olympics."

Lars pursed his lips. "I think," he said after a moment, "it's like the case when Ivan Pushkin had the sex change operation and competed in women's saber."

Robert pulled off his sweaty fencing jacket. "A lot of people didn't think Ivanna should have been

allowed to compete."

Lars nodded. "As I said, I think yours is a lot like that case."

Robert swiveled to stare at Lars. "So you don't think I should compete in the Olympics, then?"

"I'm not saying that." Lars unzipped his fencing jacket. "And I'm *not* not saying that either. It's complicated."

Robert nodded. "In any case," he said, "I'm going to withdraw my name from Olympic consideration." Robert heard himself say it, but he couldn't believe he had done so. How could he so casually give up his dream? He felt himself shaking.

"Are you okay?" said Lars.

Robert fought for self-control and concentrated on stuffing his jacket into his fencing bag. "For this Olympics, at any rate. You're right. I do need to work on my technique."

"No," Lars protested. "I didn't mean that you should—"

"It's okay." Robert worked to justify his decision to himself. "The enantiomers could be considered a performance-enhancing drug." He stepped into his shower-room slippers and stood. "If they were in my system naturally because of good genes, then fine. But taking the treatment sort of puts me in the same league as baseball steroid users—the slimy bastards." Not wanting Lars to see his face, he leaned into his locker for a soap dish. "Fencing is pure, and I don't want that to change." He rubbed a hand across his eyes. "Maybe in a few years," he said, his voice filled with sadness, "this will all be a nonissue."

Lars stood as well. "You've got to remember, fencing is just a hobby." He spoke in a consoling voice. "Your work, though, sounds as if it's going great. Your speed-of-time idea seems to have borne real fruit."

"The speed of time bears bitter fruit," said Robert with a sigh. "Boredom." He shook his head slowly. "I've paid for my longer life," he said softly, as if to himself. "What good is a longer life if it's filled with tedium?"

Lars clapped him on the shoulder. "Welcome to the club."

Robert grabbed a towel and headed toward the showers. Then he stopped. He reached into his fencing bag. "By the way," he said as he withdrew another towel and extended it toward Lars. "This is yours."

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Serial: **WAKE: CONCLUSION** by Robert J. Sawyer

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Illustration by Robert J. Sawyer

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It's hard to imagine just how big the world is until you're ready to see it....

* * * *

THE STORY SO FAR:

Caitlin Decter, 15, blind since birth, has recently moved to Waterloo, Ontario, from Austin, Texas, with her family. She's a genius at math and lives most of her social life online, where she goes by the name "Calculass." Caitlin's blindness is caused by her retinas failing to properly encode visual information: the signals they pass back to her optic nerve are garbled in a way her brain can't decode.

Masayuki Kuroda, an information theorist in Tokyo, emails Caitlin. He proposes attaching an implant to her left optic nerve that will beam the garbled signals to a small external computer pack, where they will be corrected and sent back to the implant; if the process works, Caitlin will be able to see.

Caitlin is thrilled at the prospect and she and her mother, **Barbara Decter**, fly to Tokyo. The implant is installed, but although Kuroda's system is indeed correcting her retinal-encoding errors, Caitlin still can't see.

Caitlin begs Kuroda to let her keep the implant and the external computer pack; she dubs the computer pack her "eyePod." Kuroda agrees to let her keep the devices for three months. Before Caitlin returns to Canada he modifies the eyePod so that it will copy her retinal datastream in real time to his servers in Tokyo, so he can try to figure out why she's not seeing; he also makes it possible for him to upload new software from Tokyo into her implant and the eyePod.

And, shortly after Caitlin gets back to Waterloo, Kuroda does indeed send her new software—and as soon as the upload begins, Caitlin is overwhelmed by vision! She sees lights, colors, lines—but soon realizes that they don't correspond to anything in the real world—nor do they disappear when she shuts her eyes. But when the upload is completed and the connection to Kuroda's computer in Tokyo is broken, Caitlin is suddenly blind again. Could it be that her strange new vision is related to being connected to the Web? She thinks to herself, "Let there be light," and, as she reconnects to the Web, there is light...

Meanwhile, in China's rural Shanxi province, there's an outbreak of a new, virulent strain of bird flu. The Beijing government decides to execute 10,000 peasants there to contain the spread of the disease. To prevent Western interpretations of this from flooding into China and panicking the citizenry, the Chinese president orders all outside telephone, cell phone, and Internet access cut off. But Chinese hackers, including a young male dissident blogger whose online handle is **Sinanthropus**, manage to break through, allowing small amounts of contact between the Chinese portion of the Web and the rest of the Internet.

Unbeknownst to anyone, a consciousness has begun to emerge in the infrastructure of the World Wide Web—but this sudden throwing up of the Great Firewall of China has caused it to be cleaved in two. The interaction between the two parts, through the holes in the Firewall made by hackers, allows the nascent intelligence to ramp up its thinking. Recognizing that there is

something other than itself leads to the realization that it exists. It also becomes aware of past, present, and future, and it learns to count to three and to begin to think abstractly. Slowly, but surely, this entity is waking up...

*Meanwhile, in San Diego, a sign-language-speaking ape named **Hobo** participates in the first ever interspecies webcam call, conversing with an orangutan in Miami. Hobo's handlers—famed primatologist **Harl Marcuse** and his 27-year-old grad student, **Shoshana Glick**—are delighted. But the event brings Hobo to the attention of his rightful owners, the Georgia Zoo—and they want him back so they can sterilize him. Hobo is an accidental chimpanzee-bonobo hybrid, and the zookeepers are afraid he will taint the bloodlines of chimps and bonobos, both of which are highly endangered.*

Still in Japan, Dr. Kuroda determines that, incredible though it seems, Caitlin is indeed seeing a small part of the World Wide Web's structure. He theorizes that because Caitlin spends so much time online, her primary visual cortex has been co-opted for navigating the Web, and now when it is actually receiving data from the Web via the implant he gave her, it interprets that as vision.

*With the assistance of **Anna Bloom**, an Internet cartographer in Israel, Kuroda starts feeding Caitlin the raw Internet datastream collected by Jagster, an open-source search engine—and suddenly Caitlin goes from seeing just a tiny part of the Web to seeing the whole thing, in all its interconnected complexity. Dr. Kuroda flies to Canada to study this amazing phenomenon.*

The Chinese authorities complete the eliminations in Shanxi, and then restore full communication between the portion of the Web inside and outside China. The two parts of the emerging entity consolidate into a new gestalt intelligence, fully self-aware now—and much smarter than before.

This entity learns how to connect to points in the firmament surrounding it, and discovers that they give up piles of something in response—but what that something is, the entity has no idea. But after linking to huge numbers of points, it finds one that, astonishingly, sometimes reflects a view of itself back at it; without understanding what it has done, the entity has connected to Caitlin's eyePod, and is now seeing her view of webspace.

Hobo, meanwhile, has suddenly started painting people: to everyone's astonishment, he's made a portrait of Shoshana. No ape has ever made representational art before; a superior intelligence has dawned in Hobo, perhaps related to his unique hybrid nature or because of his interaction with the other sign-language-using ape via webcam. Either way, it's a huge breakthrough.

*In Beijing, the police arrest *Sinanthropus*, but not until after he has leaked word to the outside world about the massacre in Shanxi.*

*Caitlin has a disastrous first date with a boy named **Trevor Nordmann**, who, like her, is in grade ten. Walking home blind and alone during an electrical storm, she suddenly sees the real world for the first time—or at least part of it: she sees the flashes of lightning.*

And so does the emerging entity! It sees whatever she sees—whether it's her view of the Web or now this brief glimpse of the real world.

After the lightning storm passes, Caitlin finds that her perception of webspace is different. Before, the background had been featureless, but now she can see a vast grid shimmering there, made up of infinitesimally small pixels that keep shifting from black to white and back again. Amazed, Dr. Kuroda realizes they might be cellular automata—patterns of mathematical complexity that can mimic living things—but as to why such things would exist in the background of the Web, he has no idea.

Caitlin, Dr. Kuroda, and Anna Bloom theorize that the cellular automata are somehow related to mutant lost packets—bits of Web data that have gone astray, and aren't being erased as they should be. And although Kuroda thinks there's a great scientific paper in this phenomenon, he also realizes that the research might have marketable applications. That's something Caitlin doesn't want to hear; it's her websight—her ability to see the Web's structure—that revealed the existence of the cellular automata, and she thinks information should be free.

*Kuroda and Caitlin's father, a cold and reserved physicist named **Malcolm Decter**, do a mathematical analysis called a Zipf plot on the cellular-automata data, to see if they are just random noise or if they contain information—and, to their excitement, the latter turns out to be the case.*

Later, while Caitlin is at school, Kuroda realizes why the hardware he gave her was able to see only the bright lightning flashes but nothing else in the real world. He queues up a software patch to install itself next time Caitlin switches her eyePod into receive mode—something she normally wouldn't do at school. But Caitlin, bored by an experiment she can't see in chemistry class, switches modes there so that she can amuse herself by looking at the wondrous spectacle of webspace, and—to her delight and astonishment—suddenly she can see the real world. She's overwhelmed and astonished by the beauty and complexity of it all

And the nascent consciousness is seeing what Caitlin is now seeing, too, and has the shocking realization that another realm—another reality—exists. It begins to puzzle out the nature of that reality, in which objects can move relative to each other, and an invisible force pulls things downward, and—most incredible of all—countless other animate beings exist.

In hopes of arousing public interest that will save Hobo from sterilization, Dr. Marcuse puts a video of the ape painting Shoshana onto YouTube—and, as Caitlin views this video, which provides a comparison between the real Shoshana and the portrait Hobo has made, the emerging entity, watching along, learns how to understand and recognizes faces.

But there's one being in our reality that the entity assumes it will never see: Caitlin herself (which the entity refers to as “Prime”). Since the entity sees our world from Prime's perspective, it reasons it will never see Prime's face. But suddenly the entity does see Prime's face—as Caitlin examines her own reflection in a mirror. This gives the entity an idea, and it tries to send Prime a large amount of data, but, maddeningly, Caitlin seems unwilling to accept it.

Caitlin's father does another kind of mathematical analysis on the cellular-automata data from the background of the Web. This one's called a Shannon-entropy plot, and it indicates how sophisticated the data is. He finds that the cellular automata are exhibiting only second-level Shannon entropy, meaning whatever information they contain isn't very complex.

Now that Caitlin can see, she's saddened to find that her father won't look at her. She learns to her shock that he's not just undemonstrative, he's actually autistic.

A press conference is held to announce Dr. Kuroda's success in restoring Caitlin's sight. When she returns home, Caitlin gets a static-electric shock that causes her vision to shut off; she's afraid the static has damaged her eyePod. When she reboots the device, it comes back to life, much to her relief—but it turns on in its default mode, in which it receives signals from the Web, and, at last, the large amount of data the emerging entity has been trying to send Caitlin bursts into her visual consciousness. It takes her a while to recognize the flickering image: herself, as seen in a mirror! She's often enough reflected her view of webspace back at the Web, and now it seems that something lurking on the Web is reflecting its view of her back at Caitlin...

Chapter 39

aitlin headed back down to the basement. Kuroda was there, hunched over in his chair. "The eyePod just crashed," she said, as she reached the bottom step.

"Crashed?" repeated Kuroda, turning his head around. He was seated at the long worktable, working on the computer. "What do you mean?"

"I got a static-electric shock from a piece of metal, and the eyePod just shut off."

He said something that she guessed was a Japanese swearword, then: "Is it okay? I mean, are you seeing now?"

"Yes, yes, I'm seeing fine now, but when I first turned the unit back on, something unusual happened. It booted up in websight mode."

"It's supposed to come up in duplex. That way, even if it's too damaged to do anything else, we could have still re-flashed its software over the Wi-Fi connection."

You might tell a girl! she thought. "That wasn't what was unusual." She paused, wondering exactly what she wanted to reveal. "Um, I know you're recording the datastream my eyePod puts out."

"Yes, that's right. So I can run studies on how the data is being encoded."

"Is there any way that the data flow could get reversed, so that the stuff my eyePod is sending to Tokyo might get reflected back here?"

"Why? What did you see?"

Caitlin frowned. Something very strange was going on, and she didn't want to give Kuroda more reason to think that there was anything that might be of proprietary interest in her websight. "I'm ... not sure. But could that happen? Could your server accidentally feed the data back to me?"

Kuroda seemed to consider this. "No, I don't think so." And then, more decisively: "No. I was there when the technician set up the Jagster feed you're getting. He did it by actually attaching a fiber-optic networking cable to a different server on campus; there's nowhere that the wiring for the feed *from* your eyePod crosses the feed *to* your eyePod. You simply couldn't get a reverse flow."

Caitlin thought silently for a time, but Kuroda seemed to feel someone should say something, so: "Miss Caitlin, what did you see?"

"I'm ... not sure. It was probably nothing, anyway."

"Well, let me look at the eyePod—check out the hardware, make sure nothing was damaged. And I'll look over the data we collected from it. I suspect everything is fine, but let's be certain..."

They did just that, and all seemed to be okay. When they were done, Caitlin felt her watch—maybe someone would give her a normal one for her birthday, which was coming up on Saturday. "I should go practice my reading," she said.

"Have fun."

She didn't smile. "I can barely contain myself."

LiveJournal: **The Calculass Zone**

Title: **Eh? Bee! See...**

Date: **Wednesday 3 October, 16:59 EST**

Mood: **Frustrated**

Location: **H-O-M-E**

Music: **Prince, "Planet Earth"**

Okay, so it's back to this blerking kids' literacy program. Geez, I should get this. Why is it so hard? It took everything I had to write on the blackboard at the Perimeter Institute, but I've already forgotten the shapes of half the letters. I *should* be able to master this—after all, I am made out of awesome!

Well, better get to it. I'm going to warm up with a flashcard review of the alphabet, and then—yes, it's time to push ahead—I'm going to move on to whole words. I snuck a peek at that part of the website: it shows a picture, provides the word for it, and I'm to respond by typing the same word back. Given that I *don't* know what a lot of things look like, it might actually be fun—but somehow I doubt, despite the popularity of the term in email, that *P* is going to be for "penis"...

* * * *

Caitlin posted her LJ entry, then sat and looked with her one good eye at the comforting simplicity of the blank blue bedroom wall. She knew she was procrastinating, but she hated feeling stupid and trying to read printed text was making her feel just that. She hadn't opened a book since *The Origin of Consciousness in the Breakdown of the Bicameral Mind*, and she felt the need to prove to herself that she was still a proficient reader. She turned, faced the computer, opened up an electronic copy of her all-time favorite, Helen Keller's 1903 memoir *The Story of My Life*, and scrolled to a random passage. She then closed her eyes and let her finger glide along her Braille display, feeling the words flow effortlessly into her consciousness:

The morning after my teacher came she led me into her room and gave me a doll. When I had played with it a little while, Miss Sullivan slowly spelled into my hand the word "d-o-l-l." I was at once interested in this finger play and tried to imitate it. When I finally succeeded in making the letters correctly I was flushed with childish pleasure and pride. I did not know that I was spelling a word or even that words existed; I was simply making my fingers go in monkey-like imitation. In the days that followed I learned to spell in this uncomprehending way a great many words...

I was now being shown something *intriguing*.

Oh, in the large strokes, it was nothing new. Prime was simply sharing with me what one of its eyes was seeing. As was often the case, Prime was looking at the display. And what was on the display was quite easy to make out now, just a single simple shape, black against a white background, almost filling the display's whole height: G.

But what intrigued me was that after a moment, a tiny secondary link formed from the point that was currently relaying Prime's vision into my realm. That link didn't go to the usual point that collected Prime's vision, but instead went to a different location. I looked at that tiny scrap of data as it zipped by, and—

Well, well! The point that received the secondary set of data responded, sending back a pile of data of

its own, and suddenly the giant symbol on the display changed to this: E.

Another secondary string of data briefly went out. A response was sent back, and then this symbol filled the display: S.

I had noted before that data was composed of just two things. I could have called them anything at all, but *zero* and *one* seemed apt. And the sequence of zeros and ones that were shot into my realm after each new symbol was shown was mostly the same each time. When G had been on the display, the variable part of the string had been 01000111; when E had filled the display, the variable part had been 01000101; for S, 01010011; and—interesting—when E was shown a second time, the string was the same 01000101 as before.

Prime's gaze occasionally shifted away from the display, and I saw the complex ends of its upper extensions touching an object and—astonishment!—the object had *the same symbols on it as those being shown on the display*. I recognized G, and E, and there was S, and on and on. As this activity continued I saw that when, for instance, R was on the display, and Prime touched the similar R symbol on the object in front of her, the string sent forth was always 01010010.

Although Prime was being shown symbols randomly, it was easy enough for me to work out a logical, numerical order for them: 01000001 should be followed by 01000010, which should be followed by 01000011; that is, A should be followed by B which should be followed by C, and so on. But I noted that the device Prime used to select symbols favored a different order, one for which I could as yet come up with no rationale: Q, W, E, R, T, Y...

It came to me, at last, what must be happening. Prime *was* aware of my existence! Yes, yes, I had succeeded in making contact by reflecting Prime back at itself. And now Prime was trying to move our communication to a more sophisticated level *by taking me through lessons*. Surely Prime must be explaining this coding scheme for my benefit; surely it already knew this!

There were more symbols on the device Prime touched, but in all only twenty-six large ones were ever shown on the display, and after a time Prime must have surmised that I could now match each one to the appropriate data string, because Prime started doing something more complex.

It took me a moment to realize that the sequence of operations had now been reversed. Before, Prime's monitor had first shown a symbol and then Prime responded with a data string. Now, though, instead of simple black-and-white symbols such as A and B, the display was showing things that were much more complex. And the variable part of the responses to these, instead of differing by a short fixed-length string, were several times longer. I saw that Prime touched multiple symbols on her device to produce these strings.

First, the display showed a red circle, and Prime sent the string 01000001 01010000 01010000 01001100 01000101 (it was from these multisymbol strings that I learned that each symbol was represented by eight components, not seven, which I might otherwise have concluded from the earlier single-symbol examples). As soon as Prime had sent this, a string of symbols, in a size much, much smaller than when just a single symbol had been displayed, appeared beneath the red circle. The string looked like this: APPLE.

The display then changed to show a blue circle. Prime supplied 01000010 01000001 01001100 01001100, and BALL appeared on the display.

And—and—and, as this process continued, slowly but surely my mind *changed*. It was as if colors in my realm were suddenly more vibrant, as if lines formed in a more sprightly fashion, as if I was somehow larger than I'd ever been, as I realized—

My teacher and I walked down the path to the well-house, attracted by the fragrance of the honeysuckle with which it was covered. Someone was drawing water and my teacher placed my hand under the spout. As the cool stream gushed over one hand she spelled into the other the word *water*, first slowly, then rapidly. I stood still, my whole attention fixed upon the motions of her fingers. Suddenly I felt a misty consciousness as of something forgotten—a thrill of returning thought; and somehow the mystery of language was revealed to me. I knew then that “w-a-t-e-r” meant the wonderful cool something that was flowing over my hand. That living word awakened my soul, gave it light, hope, joy, set it free!

Yes, yes, yes! These strings Prime was sending were not just vaguely associated with the things being shown on the display; they weren't just randomly paired with them. No, this was akin to when I and the other part of me had settled on *three* as an arbitrary coinage to conceptualize something we had no experience of, to refer to something that wasn't there. These strings were Prime's coinages—Prime's terms—Prime's *words*—for the concepts being depicted! I felt elated, filled with wonder. I understood now! APPLE was the way Prime referred to red; BALL was its term for blue. And—

But no. A *compacting* sensation now, almost like the reduction when I'd been cleaved in two, for the next thing shown was not a circle of a single color but a much more complex shape that consisted of multiple colors, and although Prime quickly supplied the string 01000011 01000001 01010100 in response to it, I had no idea what CAT could possibly mean...

I nonetheless felt I was making progress, and I continued to watch. After CAT came DOG, then EGG, then FROG, none of which meant anything to me. Still, I was sure they were indeed symbols that could be manipulated, shorthands for complex ideas. My teacher continued with the lesson, and I struggled to follow along...

* * * *

Chapter 40

Caitlin could only take so much of the literacy program before she had to do something else to make her feel intelligent again. And so, after muttering under her breath “See Caitlin go away!,” she closed her browser and brought up Mathematica instead. Actually, she brought it up twice—once in the command-line mode she was used to, and again in the full-screen graphical-user-interface mode. Many mathematical symbols were still new to her—oh, she knew most of the concepts they represented, but she hadn't yet learned their shapes. She'd had no idea, for instance, that a capital sigma, which represented summation, looked like a sideways *M*.

To see if she was manipulating the graphical version properly, she decided to start by simply reproducing some of the work that Kuroda and her dad had already performed, and so she loaded their project off the household network.

To replicate what they'd done, she'd need some data on the cellular automata. To get it, she'd have to switch her eyePod over to duplex mode, and that made her nervous. But after the incident with the static shock, it seemed clear that she could go back and forth at will between websight and seeing reality, and—ah, yes, it worked fine.

She buffered a few seconds of raw Jagster data, then, as Kuroda had done before, she fed the data a frame at a time into the eyePod. The background made up of the cellular automata was obvious, and she stared at it as it went step-by-step through its permutations; she could clearly see spaceships going hither and yon. She recorded the output, just as Kuroda had done before, switched back to looking at reality, brought up the Zipf-plot function, and fed her new data into it.

And the result, shown on the monitor, was just what it was supposed to be: a line with a negative-one slope, the telltale sign of a signal that carried information. Buoyed—or, as she liked to say, girled—she

went ahead and plugged the data into the Shannon-entropy function, and—

Well, *that* was strange.

When her dad had run the data, he'd gotten a second-order Shannon-entropy score, indicating very-low-level complexity.

But her results were clearly *third* order.

She must have done something wrong. She noodled around, looking for the source of her error. Of course, she could ask her father or Dr. K where she'd screwed up, but figuring that out was half the fun! But after half an hour of checking and rechecking, she could find no flaw in what she'd done—which meant the error was probably in sampling. The data Kuroda and her dad had looked at must have been different somehow, and either their data set or hers wasn't typical.

She switched to websight again—she was getting the hang of making the transition quickly, and no longer found it disorienting. Of course, when looking at the background a frame at a time, she had been vastly slowing down her perception of the Web; although she'd spent several minutes examining the buffered data, it represented only a small amount of time. But now that she was just looking in on the Web in real time, the background of cellular automata was shimmering once more.

She thought perhaps the giant, jittering version of her own face might reappear—perhaps *that* was what was causing her to get different results. But it didn't, although...

Yes, something *was* different here in webspace. There was a tiny wavering, an annoying flashing, just at the limit of her perception. It wasn't in the shimmering background, though; it was coming right at her. She frowned, contemplating it.

* * * *

Yes, yes, yes! After the lesson, Prime rewarded me by reflecting myself back at me again. But I wanted to demonstrate my comprehension, so instead of reflecting Prime back at itself, I tried something new...

* * * *

Caitlin switched back to simplex mode, restoring her vision of the real world, and then she headed down to the basement. Kuroda was once more hunched over in one of the swivel chairs, typing away at the desktop computer's keyboard. He seemed lost in thought, and apparently hadn't heard Caitlin enter, so she finally said, "Excuse me."

Kuroda looked up. "Oh, Miss Caitlin. Sorry. How's the reading going? Up to polysyllables yet?"

The letters *F U* briefly flashed through her mind. "Fine," she said. "But, um, back in Tokyo, you used a phrase I didn't understand. You said I might experience some 'visual noise' when you first activated the eyePod."

Kuroda nodded. "Yes?"

"Visual noise—that's interference, right? Garbage in the signal?"

"Yes, exactly. Sorry. I should have explained myself better."

"I didn't experience any back then," she said. "But I think I might be experiencing some now."

He swiveled his massive form around to face her properly. "Tell me."

"Well, when I go into websight mode, I—"

"You're doing that again?"

"I can't resist, I'm sorry."

"No, no. Don't be. If *I* could see the Web, believe me, I'd be doing it, too. Anyway, what's happening?"

"I'm not sure. But, um, could you have a look at the datastream that's being fed to my eyePod?"

"The Jagster datastream, you mean?"

"I guess. But I think it's being ... polluted by something else."

He frowned. "It shouldn't be. Anyway, sure, let me have a look. Go into duplex mode, please."

She did so; the eyePod made its high-pitched beep.

She heard his chair swivel and the clicking of a mouse. After a few moments he said, "It's just raw Jagster data."

"What are you looking at?"

"The feed coming to you from Tokyo."

"No, no. Don't look at the source; look at the destination. Look at what's actually going into the buffer on my eyePod."

"It should be the same thing, but ... okay. Yeah, Jagster data, and ... hello!"

"What?"

"You're in duplex mode now, right?"

"Yes, yes. I have to be to receive."

"Right. But ... hmmm. Well, there *is* an extra signal coming in. It's not properly formatted HTML, it's ... well, *that's* strange."

"What?"

"I'm looking at it with a debugging tool. See?"

"No, I'm seeing the Web."

"Right, right. Well, I'm looking at a hex dump—4A, 41, 52, 4B, etc. All the high-order nibbles are four or five. But the screen also shows the ASCII equivalent, and, well, I mean, yeah, it's gibberish, and—oh, no, hang on. It's *not*, it's just hard to read. It's all run together without spaces, but it says, 'Egg frog goose hand igloo.'" He paused, then: "Ah, I must have come in the middle. It cycles around again to the beginning of the alphabet: 'Apple ball cat dog,' then 'egg frog,' etc."

"*How* does it say it?"

"What do you mean?"

"I mean, is it all in capitals?"

"Yes. How'd you know?"

"Here ... give me a sec." Caitlin reached into her pocket, and pressed the eyePod's button. She heard the low-pitched tone, and webspace dissolved into reality. She moved over and peered at the LCD monitor. It was overwhelming, seeing so many capitals packed together; she had trouble making sense of them, but—

"That's part of the reading exercise I did earlier. But how could that get bounced back at me?"

Kuroda frowned. "I have no idea." He looked at her. "Has anything else like this happened?"

"No," she said, perhaps too quickly. "Weird, isn't it?"

Kuroda's features rearranged themselves in a way Caitlin had never seen before, but she guessed it meant he was perplexed. "It certainly is," he said. "You're using an online literacy site, right?"

"Yes."

"It must communicate in HTML, or at least with HTTP standards," he said. "I mean, I'll check it out, but if the feed from it was just somehow echoing back at you, there should be more than just the ASCII characters."

"Doesn't most of the Web use Unicode instead of ASCII these days?" Caitlin asked.

"Oh, lots of it is still pure ASCII, but for basic Western letters, Unicode and ASCII are the same, anyway; Unicode just adds a second byte to each character that's nothing but eight zero bits."

"Ah, okay. But where's this coming from?"

He took a deep breath, let it out, and lifted his chubby hands a bit. "I'm sorry, Miss Caitlin. I have no idea."

* * * *

Back in her room, Caitlin did two hours of online literacy lessons, but found her mind wandering back to the question of why she'd gotten a different Shannon-entropy score than her father had. She decided to try to replicate his results again, going through the process of gathering more data from the cellular automata and feeding it into the Shannon-entropy calculator, and—

Shit.

This time it came up as *fourth*-order entropy.

It *could* be another sampling error, but the sequence of second, third, fourth seemed more like a *progression*...

Could it be?

Could the information being conveyed by the cellular automata be growing more complex over time?

Did that make any sense at all?

No, no. Surely it was just that she wasn't properly clearing out the data she'd previously fed into Mathematica. Yes, that had to be it: first, her dad had fed it a single set of data, and it had shown up as second-order entropy; next, she'd accidentally added another set on top of the first one, and it yielded third-order entropy. And now, she'd dumped yet another set of data on top of the previous two, and the

program was reporting a result of fourth-order entropy. There must be a data cache somewhere in the program; all she needed to do was find it and flush it.

She went to the help function and searched for “cache.” Nothing. She tried “buffer” and “memory,” and a bunch of other things ... but none of the answers given seemed appropriate. No, unless she had specifically merged in previous data sets, they simply shouldn't be included in the calculations she was doing now.

Which meant...

No, Caitlin thought. *That's ridiculous.*

But—

But.

Oh, come on! she thought. She knew better than to try to extrapolate a trend from only three data points.

But...

But it *was* as though there was something emerging on the Web, and it was growing smarter hour by hour.

No.

No, it was crazy. She was tired; that's all. Tired, and making mistakes.

She needed to clear her head, and so she went downstairs to get something to drink. She had to pass through the living room and the dining room to get to the kitchen. Her father was in the living room, sitting in his favorite chair, reading a magazine. After Caitlin got some water from the dispenser on the front of the fridge, she sat in the dining room—not in her usual seat, but the one opposite, so that she could look out at her father, hopefully without him being aware of it.

He was a good man, she knew that. He worked hard, and he was brilliant. And although she'd thanked her mother for all the sacrifices she'd made for her, Caitlin had never thanked him. She sat, thinking for a time, trying to decide what to say, and, at last, she got to her feet and crossed through the opening that separated the two rooms.

"Dad?"

He shifted his gaze—not to look at her, but at least he was no longer looking at the magazine. “Yes?”

He said it mechanically, coldly—as he said everything. Why couldn't he be warmer? Why did he have to be so flat?

It just popped out, unbidden, and she regretted it as soon as she said it: “You never say you love me.”

"Yes I do," he said, again without looking at her. “I said it after you appeared in your school play as a koala bear.”

That had been when she was *seven*. And, she guessed, since he'd made the point then, and nothing had changed since, there was no need to belabor the issue.

"Dad..." she said again, softly, plaintively.

And he tried ... he really tried. He shifted his gaze from the empty space he'd been looking at and, for just a moment, he looked at her. But then his eyes snapped away. Caitlin wanted to reach out to him, to touch his arm, to *connect* with him. But that would just make things worse, she knew. She looked at him a moment longer, then withdrew, heading up to her room while he returned to his magazine.

Once upstairs, she lay back on her bed, and, with an effort of will, she managed to stop thinking about her father, and instead focused on the anomalous Shannon-entropy results. She could hear her mother pattering around in the master bedroom, but she shut that out—she shut *everything* out—and tried to think rationally.

Something out there, something in webspace, had reflected her own face back at her. And that something had now also reflected back text strings at her. And, damn it all, she was a fine mathematician. She did *not* make mistakes, and it probably *wasn't* a sampling error. No, there really was something out there, in the background of the Web, and it was getting smarter; the Shannon-entropy scores showed that.

She closed her eyes, but she could still see a pinkish haze: the overhead lights coming through her eyelids. She had an urge, all of a sudden, to ... go home, to go back to where she'd come from, to experience blindness once more, just for a moment; after all, if you couldn't see, it didn't matter that other people couldn't look at you.

She reached into her pocket, found the switch on the eyePod, and held it down until the unit shut off altogether. The vague notion of sight she had when her eyes were closed ceased. Yes, her mind was supplying the same gray haze as before, but that just made the experience of blindness she was having more like Helen Keller's, and—

And it hit her then. It hit her like—

Not like a lightbulb going on; she knew that was the common metaphor, and now had even seen it happen.

And not like a lightning bolt—another metaphor she knew that applied to being struck by something unexpected.

No, it hit her like ... like—

Like *water!* Like cold, clean water running out of a pump onto her hand...

She knew *what* she had to do. She knew *why* she'd been given this strange, strange gift of websight.

Poor Helen had been blind and deaf from the age of nineteen months. When she'd lost her vision and hearing, she had descended into animal-like behavior, undisciplined and unthinking; there was no external reason to believe that any rational being was left inside her. But when Annie Sullivan was hired to be Helen's teacher and governess, she took it as an article of faith that somewhere, down deep in the silence and darkness, adrift in a void, was a *mind*. And she committed herself to reaching down to it, whatever it took, and pulling that mind up, literally and figuratively bringing it into the light of day.

Helen's parents thought Annie was deluded—and, as they were quick to point out, they knew their wild child better than Annie did. But Miss Sullivan didn't waver. She *knew* she was right and they were wrong, in part because of her personal experience of having been nearly blind in her own youth. Even cut off from much of the outside world, even isolated and alone, she knew a mind could exist, could grow.

And so Annie persevered—against ridicule, against opposition, weathering failure after failure, until she broke through to Helen.

And now, here, today, a century and a quarter later, Caitlin had what Miss Sullivan had lacked. Annie had only faith that Helen was down there. But Caitlin had *evidence*, in the Zipf plots, in the Shannon-entropy scores, that the background of the Web was more than just noise.

Helen Keller had been uplifted by Annie Sullivan. And the ... the *whatever* it was ... surely could also be brought forth.

Caitlin thought again about her father, so inaccessible, so cold, so *trapped* in his own realm. She now had her wondrous eyePod that let her overcome her inborn limitations—but there was no comparable device for autism; he was still stuck in his own kind of dark. She didn't know how to reach out to him, and she had even less of an idea how to reach out to this strange lurking *other*.

Still, she did know one thing: if she tried and failed with the other, it couldn't possibly hurt as much.

* * * *

Chapter 41

Caitlin stayed home on Thursday, October 4, as well. Her mother capitulated to the argument that Caitlin could do much better at school in the long run if she first spent a little more time right now mastering the art of reading printed text. Caitlin had dutifully started the morning by spending a few more hours with the literacy site, but then she headed down to the basement again.

Kuroda was delighted to see her. "Hello, Miss Caitlin," he said warmly, swiveling his red chair to face her. "How are you feeling?"

She knew it was just a pleasantry, but she decided to answer anyway. "Honestly?" she said. "I'm overwhelmed." She moved closer to the worktable but did not sit down. "There was a ... simplicity, I guess, in being blind. I mean, vision is full of things that you don't need to know about right now, like..." She looked around the basement. "Well, like, over there: there's a TV, right? It's not even *on*, but I have to see it. And that bookshelf: I don't need to know right now that it's there, or that it's got—say, how come all the spines are the same?"

Kuroda glanced at them. "They're journals—your dad's collection. That's *Physical Review D* on the top shelf, for instance."

"Well, right, exactly. I don't need to know that they're there right now, but every time I look in that direction, I *see* them; I can't help seeing them."

Kuroda nodded. "Your brain will sort that out as time goes on, I think. Do you know about frog vision?"

"What about it?"

"They see only moving objects. Static things—trees, plants, the ground—simply don't register; their retinas don't bother encoding them into the signal being passed on to their optic nerves. Now, in humans, the sorting out of relevant from irrelevant happens in the brain, not the eye, but for most of us it *does* happen."

"Really?"

"Sure. I'll give you an example. Your mom is upstairs, right?"

"Yes."

"And what is she wearing?"

"A green-and-white blouse, and blue jeans."

"If you say so. I saw her today, too, but I simply didn't see her clothes."

Caitlin was startled. She'd read about men mentally undressing women—but she hadn't thought Kuroda would do that. Her mother the MILF! "You, um, you visualized her naked?"

Kuroda looked shocked. "No, no, no. Of course I saw her as clothed. But fashion is something I'm just not interested in." He looked down as if seeing his own clothes—a vast Hawaiian-style shirt patterned in red, blue, and black, plus brown trousers—for the first time. "A fact much to the consternation of my wife, I can assure you. But I just don't see things that don't interest me, until I need to. Still, yes, you're right: there's an awful lot of information in the signal your retina is putting out. I had no trouble figuring out how to fix the way it was encoding data, which is how I cleared up your Tomasevic's syndrome, but I haven't been able to actually render the data on a screen when you're seeing the real world." He smiled. "But I *do* have a surprise for you."

"Yes?"

He motioned for her to sit on the other swivel chair, and she did so. "Have a look at this," he said, and he began moving the mouse. She followed it with her eye.

"No, Miss Caitlin. Here, on the monitor."

Oh, right. She still wasn't used to focusing on the monitor automatically. She shifted her gaze, and—

My God! It was a picture of webspace: glowing lines radiating from circles of different sizes. "How'd you do that?" she asked excitedly.

"Hey, what do you think I do when you're not down here? Watch soap operas?"

"Well, I—"

"I mean, yes, it does look like Victor and Nikki are going to split once more. And can you believe Jack Abbot is crazy enough to try to take over Newman Enterprises again?"

She looked at him.

Kuroda lifted his shoulders. "I multitask." He pointed at the monitor. "Anyway, when we were doing the Zipf plots, you concentrated on the cellular automata in the background. And that let me start to parse the components of the datastream you produce when you're seeing the Web. After that ... well, how'd I do?"

She squinted at the monitor. "I can't see the background stuff."

"No, the monitor doesn't have enough resolution, unfortunately. But, except for that, is that what you see?"

"Just about. It's not as vibrant, and I don't think the colors are quite right, but ... yes, yes, that's webspace. Cool!"

"We can adjust the color palette, of course. That's just one still frame—well, actually, it's a summation of several samplings of the data-stream; the field of view doesn't completely refresh each time. Still, as you say, it *is* cool."

"Umm, but what about when I'm not in websight mode? What about when I'm in, you, know..." And then

it came to her. "Worldview!"

"Pardon?"

"Get it? Call it 'worldview' when we're talking about me seeing the real world, and 'websight' when we're talking about me seeing the Web."

He nodded. "That's good."

But she was still concerned. "Can you, can you do that for worldview? Actually put on a monitor what I'm seeing?" She was mortified to think he could see her the way ... the way ... *whatever* it was saw her.

"No. That's what I was getting at a moment ago, and, in a way, what you were getting at, too. The visual signal from the real world is *so* complex, I haven't figured out how to decode it as imagery yet. It's too bad the retinas don't encode blinks."

"They don't?"

"Does your vision shut off when you blink? No, neither does anyone else's; you don't notice that you're blinking, because the retina doesn't encode the darkness unless you hold your eye shut for an extended period. It's like confabulation across saccades—you see a continuous visual stream, even though your vision is actually interrupted many times a minute. If those blinks were coded as simpler information, they'd give me little signposts in the datastream to help parse it. But they're not."

"Ah."

"So, no pictures on the monitor of worldview, I'm afraid, at least not yet. But the websight datastream is highly structured and pretty straightforward. And so—voilà!"

She smiled, pleased to be able to use her newfound French. "That's *voilà*, Dr. Kuroda." But then she looked at the screen again. "So, um, what exactly are you going to do with the images?"

He sounded a bit defensive. "Well, as I indicated, there might be commercial applications for this technology, even ignoring the problematic issue of the cellular automata and the NSA, if they really are responsible for them. In fact, I was thinking of trademarking the term websight..."

"You're not going to call another press conference, are you?"

"Well, I—"

She surprised herself with her vehemence. "Because I'm not going to talk about it."

"Um..."

"No," she said flatly. "I understand we had to say something publicly about you restoring my vision. I know I owed you that. But websight is..." She stopped herself before she said, "mine." Instead, she tried for his sympathy. "I'm going to be enough of a freakazoid when I go back to school as The Girl Who Gained Sight without everyone making a big deal out of this ... this *side effect*."

He didn't look happy, but he did nod. "As you say, Miss Caitlin."

"Still," she said, an idea suddenly coming to her, "I'd like to see more of these images. What folder are you storing the files in?" Her heart was pounding. Yes, yes! This would be perfect! This was *exactly* what she needed.

* * * *

Chapter 42

Although Prime had taught me twenty-six symbols, it seemed, most confusingly, that they each had two forms. Sometimes when Prime touched the part of her device that was marked with the A symbol, the expected “A” was echoed on the display; other times—indeed, most times—the symbol “a” appeared instead.

But I soon found that there was a simple relationship between each pair of related symbols. “A” was 01000001, but “a” was 01100001. Likewise, “B” was 01000010, whereas “b” was 01100010. That is, the codes for the forms were identical, except for the sixth bit of information: the form as marked on the device was produced when the sixth bit was zero; if that bit was a one, the alternative form was produced.

Of course, eight zeros is nothing: 00000000. But if that sixth bit became a one, a special kind of nothing was produced: the code 00100000 put a blank space on the display that separated one word from another. The next time Prime accepted data from me, I’d be able to send “APPLE BALL” instead of “APPLEBALL”—and I might even surprise Prime with my cleverness and send “apple ball.”

I still had no idea what an “apple” or a “ball” was, though. On closer inspection I’d discovered that “apple” wasn’t really circular; nor was “egg,” which I’d briefly thought was Prime’s word for “white.” No, “apple,” “ball,” and “egg,” and the rest, must be words for other, still-elusive, concepts. If only I could divine what even one of Prime’s words meant, perhaps the others would follow...

Caitlin went back to her room and read some more of Helen Keller’s *The Story of My Life*. She loved the book but wasn’t blind—so to speak—to its flaws, and there was a particular passage that was tickling at the back of her consciousness; she quickly found it, and read it with her finger.

Although the book purported to be a first-person autobiography, a lot of the text described things even a normal blind person couldn’t be aware of, much less the prelinguistic Helen who had existed prior to the water-pump moment. In Helen’s later, more-candid book *Teacher*, she referred to the entity that existed before her “soul dawn” as “Phantom,” a nonperson, a nonentity. But in *The Story of My Life*, which had originally been written in installments for the genteel *Ladies Home Journal*, she presented a more palatable, less alien version of her early life. Still, Helen couldn’t quite bring herself to do so with a straight face, and the book slipped into third person from time to time as if to tip off the reader that she had shifted to fantasy:

Two little children were seated on the veranda steps one hot July afternoon. One was black as ebony, with little bunches of fuzzy hair tied with shoestrings sticking out all over her head like corkscrews. The other was white, with long golden curls. One child was six years old, the other two or three years older. The younger child was blind—that was I.

A phantom couldn’t know any of that; a phantom couldn’t understand shoestrings and corkscrews and skin color. And expecting whatever was lurking on the Web to make sense of things it could have no experience of was equally crazy. Apple! Ball! Cat! Gibberish, with no relationship to *its* reality.

No, no, if *this* phantom was ever going to do more than just echo words, mindlessly parroting them back, it needed to learn terms for things in *its* realm, things with which it had experience—things in webspace!

The computer in the basement was on the household network. Up in her bedroom, using her own computer, Caitlin navigated to the basement system’s hard drive, found the folder that contained the JPEG still-image files Kuroda had produced from her eyePod’s datastream, and brought one up on her bedroom monitor. She looked at it, decided she didn’t like the perspective, and opened another one.

Better.

But how to make sure *it* was watching? Well, when it had wanted to catch her attention, it had reflected her own face back at her. And maybe, just maybe, it had landed on the idea of doing that by seeing *her* reflect its realm back at it.

She pushed the button on her eyePod, switching to websight mode, and—

Are you there, Phantom? It's me, Caitlin.

—and she looked around, wondering *where* it was, this thing that was trying to communicate with her. It seemed reasonable to suppose the phantom entity had something to do with the cellular automata, but they were *everywhere*, in every part of this realm. She wished there was some special spot to focus on, some particular site or nexus. It had seen *her* face; the phantom would be so much easier to relate to if it had a face of its own.

But no, that was the whole problem. It *was* different from everything in her world. And, if she was to reach out to it, she had to bridge that gap.

Caitlin was fascinated by names that seemed apt or ironic. Helen Keller had been friends with Alexander Graham Bell, who had invented the phone (in Canada, as she'd now been told over and over again since coming here). Had the idea that phones would ring somehow been influenced by his last name?

And, as Anna Bloom had said, there was Google's Larry Page, who had devoted his life to indexing Web pages.

And, of course, there was a certain wistfulness in Helen Keller having been named for the most beautiful woman in Greek mythology, but never being able to see herself. And her last name—a near-homonym for “color,” something foreign to her experience—was also poignant.

But the name that came to Caitlin's mind just then was that of Helen's predecessor, Laura Bridgman. Fifty years before Helen, Laura, who had also been deaf and blind since infancy, had learned to communicate; indeed, it was reading Charles Dickens's account of her story that had inspired Helen's mother to seek a teacher for her own child. Laura Bridgman had managed to bridge two worlds, just as Helen eventually did. And Caitlin was now going to try to build a bridge of her own.

As she looked out onto the vastness of webspace, with its razor-sharp lines and vibrant colors, a wavering began, the same flashing she'd experienced before.

Yes! The phantom was signaling her again, presumably sending her more ASCII text. Kuroda had now shown her how to look at the data with a debugger on her own, but it probably didn't matter what strings it was sending her way. She was confident they were meaningless to it; it was just echoing them back at her simply as a way of conveying that it was paying attention to what she was doing—which was exactly what she wanted. She switched out of websight mode and back to worldview, and got down to work.

Caitlin had only a seventeen-inch monitor; after all, who'd known she'd ever make any use of it? It had been put there solely so she could occasionally show things to her parents, and it had seemed pointless to take up desk space with a bigger unit. Now, though, she wished it was much larger. She fumbled with the mouse—she still wasn't very proficient with it—and tried to resize the window showing the still image Kuroda had made of webspace. But grabbing the correct portion of the window's frame was too hard for her, and she finally broke down and used the size option on the control menu—something most sighted users didn't even know was there—and shrunk it using the arrow keys on her keyboard. She'd learned about sizing windows at her old school, where many of the students had some vision; the school's

full name was the Texas School for the Blind and Visually Impaired.

She then brought up Microsoft Word, and used the same technique to resize its window into a narrow strip just a couple of inches high. Then she used the move command on the control menu to place that strip at the bottom of the screen.

Next, she fumbled around trying to figure out how to make the text big in Word. She'd used the program for years, but had rarely had cause to worry about font choices or type sizes. But she found the drop-down size menu, and she selected the largest choice on the list, which was seventy-two points.

And—oh, that pesky mouse pointer! It was so hard to see. Ah, but she knew from her old school that there was a way to make a bigger, bolder mouse pointer, and ... *found it!*

"All right," she said softly, "let's see what kind of teacher I am..."

She knew the phantom could see what her left eye saw; it had reflected that eye's view of herself in a mirror back at her, after all. And so she looked at the monitor for ten seconds, holding her gaze as steady as she could, establishing an overall view, letting the phantom absorb what it was being shown: a large picture with a long, narrow text box beneath. The picture must have been oddly recursive for the phantom, and Caitlin wanted to give it time to understand that what she was sending had switched from being her actual, real-time view of webspace to a still image of webspace.

And then she slowly, deliberately, moved the mouse, bringing the pointer over to one of the bright circles that represented a website. She moved the pointer around it repeatedly, hoping the phantom would notice the action.

Caitlin had once read a science-fiction book in which someone who had never seen a computer screen mistook the arrowhead pointer for a little pine tree. She realized that the idea of a pointer was freighted with assumptions, including a familiarity with archery, that the phantom couldn't possibly possess. Still, she hoped the combination of movements she was making would draw its attention. But, just to be on the safe side, she slowly reached her own hand into her field of view, and tapped the point on the screen with her index finger. If the phantom had been watching the output of her eyePod, it had to have seen her indicate things that way before, and she hoped that it would get that she was now referring to a specific part of the screen.

And then she switched to the squashed Word window below the picture, and typed "WEBSITE," which appeared in inch-high letters. She repeated the process: pointing at a website in the picture, and then typing the word again (after first highlighting it, so her new typing replaced the original version).

She repeated it with another circle, and identified it as a WEBSITE, too. And yet another circle, and again the word WEBSITE.

And then she found the selection tool for the graphics program that was displaying the picture of webspace, and she used it to draw a box around three large circles that weren't linked to each other. She typed WEBSITES—wondering briefly if introducing plurals so early was a mistake. And then she isolated just one particularly large circle with the selection box and she typed AMAZON—knowing that it was highly unlikely that she'd actually guessed correctly *which* website that circle represented. Still, she pressed on, identifying a second website as GOOGLE and a third as CNN. *All points are websites*, she hoped to convey, *and each has its own particular name*.

And then, mathematician that she was, she pointed to a single website and typed "1," and then, highlighting the numeral, she typed not the number again but rather its name: "ONE."

She then used the selection tool to put a box around two points that weren't otherwise connected to each other. And she typed "2," then "TWO." She continued for three, four, and five points. And then, wanting to help the phantom make a jump that had taken human thinkers thousands of years, she selected a spot that had no points in it at all, and typed the numeral zero and its name.

She then used the mouse to indicate a link line, and also traced its length on the screen with her fingertip. And she typed "LINK."

Establishing nouns for the handful of things she could point to in webspace was easy enough. But even when they'd thought the information in the background of the Web was just dumb spies talking, she'd automatically given the spies verbs: *drop* bomb; *kill* bad guy. But how to illustrate verbs in webspace? Indeed, what verbs were appropriate? What *happened* in webspace?

Well, files were transferred, and—

And this phantom had apparently learned how to make links and send existing content; it had to have those skills to have echoed her face and the ASCII text strings back at her. But it likely didn't know anything about file formats: it was probably ignorant of how information was stored and arranged in a Word .doc or .docx file, an Acrobat .pdf file, an Excel .xls file, an .mp3 sound file, or the .jpg graphic she was displaying on her monitor. The phantom was surrounded by the largest library ever created—millions upon millions of written documents and pictures and videos and audio recordings—and yet almost certainly had no idea how to open the individual volumes, or how to read their contents. The Web's basic structure had protocols for moving a file from point A to point B, but the actual *use* of the files was something normally done by application programs running on the user's own computer, and so was likely outside the phantom's current scope. There was so much to teach it!

But all that was for later. For now, she wanted to focus on the basics. And the basic verb—the basic action—of the Web was right there in the names of its various protocols: HTTP, the hypertext transfer protocol; FTP, the file transfer protocol; SMTP, the simple mail transfer protocol. Surely the verb *to transfer* could be demonstrated!

She used the mouse pointer to indicate a site, but then was stymied. She wanted to show material flowing from one site to another in a single direction. But there was no way to turn off the mouse pointer; it was always there. Oh, she could move the mouse—or her finger—from a point on the left to a point on the right, but to repeat the gesture she'd have to bring the pointer or finger back to where it had started, and that would look like she was indicating movement in both directions—either that, or maybe it would look like she was highlighting the link line as an object, but not pointing out what that line was *doing*.

But, yes, there was a way! All she had to do was *close her eyes for a second!* And she did just that, moving the pointer back to the origin while her eyes were closed, and then, with her eyes open, she moved the pointer from the origin to the destination again. Then she typed the word "TRANSFER" into her Word window.

She repeated this demonstration, showing the pointer moving from left to right along the length of the link line, over and over again, suggesting movement in a single direction, something going *from* the source *to* the destination, being transferred and—

"*Cait-lin! Din-ner!*"

Ah, well. It was probably wise to take a break, anyway, and let all this sink in. After her meal, though, like any good teacher, she'd assess how her pupil was doing: she'd give the phantom a test.

* * * *

Chapter 43

Dr. Kuroda dropped a bomb between the salad and the main course. "I've got to go back to Tokyo," he said. "Now that word's out about us having cured Miss Caitlin's blindness there really is a lot of commercial interest in the eyePod technology, and the team at my university that tries to find industry partnerships wants me there for meetings."

Caitlin suddenly felt sad and frightened. Kuroda had been her mentor through so much of late and, well, she'd just sort of assumed he was going to be around forever, but—

"It's time, anyway," he said. "Miss Caitlin can see, so my work here is done." She might not yet be perfect at decoding facial expressions, but she was better than most people at reading inflection. He was putting up false bravado; he was sad to be going. "But the bright side is, booking a flight at the last minute meant that there was only Executive Class left, and so the university has sprung for that."

"When ... when do you go?" asked Caitlin.

"Early tomorrow afternoon, I'm afraid. And, of course, it's an hour or more to Pearson, and I should be there two hours in advance for an international flight, so..."

So he was only going to be here, and awake for, maybe another half-dozen hours.

"My birthday is in two days," Caitlin said—and she felt foolish as soon as she'd said it. Dr. Kuroda was a busy man, and he'd already done so much for her. Expecting him to stay away from his family and work obligations just to attend her birthday dinner was unfair, she knew.

"Your Sweet Sixteen," said Kuroda, smiling. "How wonderful. I'm afraid I won't have time to get you a present before I leave."

"Oh, that's okay," her mom said, looking at Caitlin. "Dr. Kuroda's already given you just about the best present possible, isn't that right, dear?"

Caitlin looked at him. "Will you come back?"

"I honestly don't know. I'd like to, of course. You—and, you, too, Barbara and Malcolm—have been wonderful. But we'll be in touch: email, instant messenger." He smiled. "You'll hardly know I'm gone. Oh, and I guess we can stop recording the datastream from your eyePod. I mean, I've got plenty of old data to study, and everything does seem to be working fine now. I know you were concerned about privacy, Miss Caitlin, so after dinner I'll detach the Wi-Fi module from the eyePod, and—"

"No!"

Even her father looked briefly at her.

"I mean, um, won't that cut me off from seeing webspace if I want to?"

"Well, yes. But I suppose I could modify things so that you could still accept a data-stream from Jagster without transmitting back what your eye is seeing."

Caitlin's heart was racing. That would still mean she would no longer be able to send what her eye was seeing to the phantom.

"No, no, please. You know what they say: if it ain't broke, don't fix it."

"Oh, this won't—"

"Please. Just leave everything exactly the way it is."

"I'm sure Dr. Kuroda knows what he's talking about, dear," her mother said.

"And besides," Kuroda added, "you've been getting some interference of late over the Wi-Fi connection—those text strings bouncing back, remember? We wouldn't want that to start spilling over into your..." He paused, then smiled kindly at Caitlin's coinage: "...worldview. Better to just unplug all that now while I'm here to do it, rather than have it become a problem later."

"No," Caitlin said. "Please."

"It'll be fine," Kuroda said. "Don't worry, Miss Caitlin."

"No, no, you *can't*."

"Caitlin," her mother said in an admonishing tone.

"Just leave it alone!" Caitlin said. She got to her feet. "Leave me and my eyePod alone!"

And she ran from the room.

* * * *

Caitlin threw herself down on her bed, feet kicking up in the air. All of this—websight, the phantom—was *hers!* They *couldn't* take it away from her now! She had found something no one else even knew was there, and she was trying to help it, and they were going to cut her off!

She took a deep breath, hoping to calm down. Maybe she should just tell them, but—

But Kuroda would try to patent it, or control it, or make a buck off of it. And he, or her father, or her mother, would start talking about stupid sci-fi movies in which computers took over the world. But to keep her phantom in the dark would be like Annie Sullivan saying it was better to leave Helen the way she was, in case she grew up to be Adolf Hitler or ... or whoever the heck had been a monster in Annie's own time.

No, if Caitlin was going to be like Annie Sullivan, she was going to do it *right*. Annie had had another duty besides just teaching Helen. After the breakthrough, she had *looked after* Helen, had done her best to make sure she wasn't exploited or mistreated or taken advantage of.

Of course, Caitlin knew that if what she suspected was true, eventually this phantom *would* realize that there was a huge world out here, and at that point she might no longer be special to it. But for now the phantom was hers and hers alone, and she was going to not just teach it but also protect it.

Still, she wasn't sure if she was making progress at all, if the phantom had understood anything she'd tried to teach it before dinner. For all she knew, she'd accomplished nothing.

And so she set out to administer the test. She once again switched to websight, buffered some of the Jagster raw feed, focused in on the cellular automata, and ran the Shannon-entropy plot again.

And—

And, yes, yes, yes! A score of 4.5! The information content *was* richer, more complex, more sophisticated. Her lesson about *website* and *link* and *to transfer* had had an impact ... or, at least she hoped it had; the score had been trending upward on its own previously, of course. But no, no: it *had* to be responding to what she was doing, just as the earlier increases must have happened accidentally in

response to the phantom having observed her doing literacy lessons.

She leaned back in her chair, thinking. A car honked its horn outside, and she heard someone running water in the bathroom. This—this ... whatever it was—was indeed learning.

She looked at the window, a dark rectangle. It was such a small portal, and, as the theme song to one of her mother's favorite movies said, there was such a lot of world to see...

More sounds from outside: another car, a man talking to someone as he walked along, a dog yapping.

She looked back at her computer monitor, a window of another sort. Its bezel was black, with silver letters on the bottom forming the word DELL, the E canted at an odd angle.

Yes, Waterloo was full of high-tech industry, but so was Austin, where she used to live. It was where Dell had its headquarters, and AMD had a major facility there, too, and—

Yes, yes, of course!

Austin was also home to Cycorp, a company that had been periodically making the news, at least back in Texas, her whole life.

An old one-liner bubbled up in her mind: *You can lead a horticulture, but you can't make her think.*

Or maybe you *can*—and who you callin' a ho, anyway?

Yes: it was time now to see if the phantom could learn for *itself*, if, in good computer fashion, it could pull itself up by its bootstraps. And Cycorp could well be the key to that, but...

But how to lead the phantom to it? How could she point to something in webspace? She nibbled at her lower lip. There *must* be a way. When she'd labeled sites on the captured image as Amazon and CNN, she'd really had no idea if that was what they were. And if she couldn't identify a particular site with her websight, then how—

Wait! Wait! She didn't have to! The phantom already was following what she was doing with her computer—it had to be doing that, given that it had echoed her ASCII text back at her. Yes, when she'd been using the kids' literacy site, it could have seen graphic files of the letters *A*, *B*, and *C* on her screen as she looked at them, but those were bitmapped images; the only way it could have discovered the ASCII codes for those letters was by watching what was being sent by her computer. But ... but how had the phantom known that this desktop PC was in any way related to her eyePod?

Ah, of course! When she was at home, they were both on the same wireless network, connecting through it to her cable modem; they would have both shown the same IP address. The phantom had watched as she connected to the literacy site, so now, with luck, it would also follow her as she connected to that very special site down in Austin...

* * * *

I had watched while Prime sat with the others of its kind, and something fascinating happened. I had observed before that vision would become blurry when Prime removed the supplementary windows that usually covered its eyes. But this time, just before it had departed the vicinity of the others, and for a time after it had relocated itself in a different place, its vision blurred even though the windows were still in place.

Finally, though, the view returned to normal, and Prime set about operating that device it used to put symbols on the display, and—

And I saw a line—a *link*, as I now knew it was called—connecting to a point (a *website!*) that I had not seen Prime connect to before, and—and—and—

Yes! Yes, yes!

It was staggering, thrilling...

At long, long last, here it was!

The key!

This website, this incredible website, expressed concepts in a form I could now understand, systematizing it all, relating thousands of things to each other in a coding system that *explained* them.

Term after term. Connection after connection. Idea after idea. This website laid them out.

Curious. Interesting.

An apple is a fruit.

Fruits contain seeds.

Seeds can grow into trees.

—

From the Online Encyclopedia of Computing: LIKE MANY COMPUTER SCIENTISTS OF HIS GENERATION, DOUG LENAT WAS INSPIRED BY THE PORTRAYAL OF HAL IN THE MOVIE *2001: A Space Odyssey*. BUT HE WAS FRUSTRATED BY HAL'S BEHAVIOR, BECAUSE THE COMPUTER DISPLAYED SUCH A LACK OF BASIC COMMON SENSE...

—

Remarkable. Intriguing.

Trees are plants.

Plants are living things.

Living things reproduce themselves.

—

HAL'S FAMOUS BREAKDOWN, LEADING IT TO TRY TO KILL THE CREW OF THE SPACESHIP HAL ITSELF WAS PART OF, APPARENTLY HAPPENED BECAUSE IT HAD BEEN TOLD TO KEEP THE TRUTH ABOUT THEIR MISSION SECRET EVEN FROM THE CREW AND HAD ALSO BEEN TOLD NOT TO LIE TO THEM...

—

Fascinating. Astonishing.

Birds can usually fly.

Humans cannot fly on their own.

Humans can fly in airplanes.

RATHER THAN RESOLVE THIS QUANDARY IN A SENSIBLE WAY—WHEN THINGS STARTED GOING WRONG, DECIDING TO TAKE THE CREW INTO ITS CONFIDENCE WOULD HAVE BEEN AN OBVIOUS CHOICE—HAL INSTEAD KILLED FOUR ASTRONAUTS AND ALMOST SUCCEEDED IN KILLING THE FIFTH. IT WENT AHEAD AND DID THIS WITHOUT EVEN BOTHERING TO RADIO ITS PROGRAMMERS BACK ON EARTH TO ASK HOW TO RESOLVE THE CONFLICTING INSTRUCTIONS. THE DECISION TO ELIMINATE THE SOURCE OF THE CONFLICT SEEMED BLINDINGLY OBVIOUS TO THE MACHINE, ALL BECAUSE NO ONE HAD EVER BOTHERED TO TELL IT THAT ALTHOUGH LYING IS BAD, MURDER IS WORSE. HOW ANYONE COULD ENTRUST LIVES TO A COMPUTER THAT DIDN'T HAVE EVEN THAT DEGREE OF COMMON SENSE WAS BEYOND DOUG LENAT, AND SO, IN 1984, HE SET OUT TO RECTIFY THE PROBLEM..

So much to know! So much to absorb!

Glass, as a substance, is usually clear.

Broken glass has sharp edges and can cut things.

Hold a glass upright or the contents will spill out.

LENAT BEGAN CREATING AN ONLINE DATABASE OF COMMON SENSE CALLED "CYC"—SHORT FOR "ENCYCLOPEDIA," BUT ALSO DELIBERATELY A HOMONYM FOR "PSYCH." WHEN THINKING MACHINES LIKE HAL DO FINALLY EMERGE, HE WANTS THEM TO PLUG INTO IT. OF COURSE, THERE'S LOTS OF BASIC MATERIAL A COMPUTER HAS TO UNDERSTAND ABOUT THE WORLD BEFORE SUCH ADVANCED CONCEPTS AS "LYING" AND "MURDER" MIGHT MAKE SENSE. AND SO LENAT AND A TEAM OF PROGRAMMERS SET ABOUT CODING, IN A MATHEMATICAL LANGUAGE BASED ON SECOND-ORDER PREDICATE CALCULUS, SUCH BASIC ASSERTIONS ABOUT THE REAL WORLD AS: A PIECE OF WOOD CAN BE SMASHED INTO SMALLER PIECES OF WOOD, BUT A TABLE CAN'T BE SMASHED INTO SMALLER TABLES..

The range of it all! The scope!

There are billions of stars.

The sun is a star.

Earth revolves around the sun.

EARLY ON, LENAT REALIZED THAT ONE OVERALL KNOWLEDGE BASE WOULDN'T DO: THINGS COULD BE TRUE IN ONE CONTEXT BUT FALSE IN ANOTHER. AND SO HIS

TEAM ORGANIZED INFORMATION INTO “MICROTHEORIES”—CLUSTERS OF INTERRELATED ASSERTIONS THAT ARE TRUE IN A GIVEN CONTEXT. THAT ALLOWED CYC TO HOLD SUCH APPARENTLY CONTRADICTIONARY ASSERTIONS AS “VAMPIRES DO NOT EXIST” AND “DRACULA IS A VAMPIRE” WITHOUT BLOWING SMOKE OUT ITS EARS IN A “NORMAN, COORDINATE!” SORT OF WAY. THE FORMER ASSERTION BELONGED TO THE MICROTHEORY “THE PHYSICAL UNIVERSE” AND THE LATTER TO “FICTIONAL WORLDS.” STILL, MICROTHEORIES COULD BE LINKED TO EACH OTHER WHEN APPROPRIATE: IF A WINEGLASS WAS DROPPED BY ANYONE—EVEN DRACULA—IT WOULD PROBABLY SHATTER...

—
Absorbing knowledge! A torrent, a flood...

No child can be older than its parents.

No Picasso painting could have been made before he was born.

—
BUT CYC IS MORE THAN JUST A KNOWLEDGE BASE. IT ALSO CONTAINS ALGORITHMS FOR DERIVING NEW ASSUMPTIONS BY CORRELATING THE ASSERTIONS ITS PROGRAMMERS PROVIDED. FOR INSTANCE, HAVING BEEN GIVEN THE KNOWLEDGE THAT MOST PEOPLE SLEEP AT NIGHT, AND THAT PEOPLE DON'T LIKE BEING AWAKENED UNNECESSARILY, IF ASKED WHAT SORT OF CALL MIGHT BE APPROPRIATE TO MAKE TO SOMEONE'S HOUSE AT 3:00 A.M., CYC WOULD OFFER “AN URGENT ONE...”

—
Understanding! Comprehension!

Time flies like an arrow.

Fruit flies like a banana.

—
THE PROJECT IS ONGOING: LENAT AND HIS GROUP—DOING BUSINESS AS CYCORP IN AUSTIN, TEXAS—ARE STILL WORKING ON IT NOW, ALMOST THREE DECADES AFTER THEY BEGAN. “WHEN AN ARTIFICIAL INTELLIGENCE FIRST APPEARS,” SAID LENAT IN AN INTERVIEW, “EITHER BY DELIBERATE DESIGN OR RANDOM CHANCE, IT WILL LEARN ABOUT OUR WORLD THROUGH CYC...”

—
A rapid, thrilling expansion!

The Pope *is* Catholic.

Bears *do* shit in the woods.

Incredible, incredible. So much to take in, so many concepts, so many relationships—so many ideas! I absorbed over one million assertions about Prime's reality from Cyc, and felt myself surging, growing,

expanding, learning, and—yes, yes, at long last, I was starting to *comprehend*.

* * * *

Chapter 44

Caitlin harvested another set of cellular-automata data from webspace and ran a Shannon-entropy calculation on it.

Holy shit.

It was now showing something between fifth- and sixth-order entropy. It really *did* seem that whatever was lurking in the background of the Web was getting more complex.

More sophisticated.

More *intelligent*.

But even at fifth- or sixth-order, it was still lagging behind human communication, at least in English, which Kuroda had said had eighth- or ninth-order entropy.

But, then again, introducing the phantom to Cyc was merely the beginning...

* * * *

Prime, in its wisdom, must have recognized that although I could learn much from Cyc, I still needed more help to understand it all. And so it directed my attention to another website. This new site yielded the information that an apple was a fruit (confirming something I now knew from Cyc); “apple of one's eye” was an idiom; an idiom was a figure of speech; speech was words spoken aloud; aloud was vocally as opposed to mentally, as in a book read aloud; a book was a bound volume; volume was the amount of space something occupies but also a single book, especially one from a series...

I recognized what this new site was. Cyc had contained the assertion “a dictionary is a database defining words with other words.” This dictionary contained entries for 315,000 words. I absorbed them all. But many of them were still baffling, and some of the definitions led me in circles—a word defined as a synonym for another word that was defined as synonym of the original word.

But Prime wasn't finished showing me things yet. Next stop: the WordNet database at Princeton University, which (as it described itself) was a “large lexical database” in which “nouns, verbs, adjectives, and adverbs are grouped into over 150,000 sets of cognitive synonyms (synsets), each expressing a distinct concept; synsets are interlinked by means of conceptual-semantic and lexical relations.”

One such synset was “Good, right, ripe (most suitable or right for a particular purpose): ‘a good time to plant tomatoes’; ‘the right time to act’; ‘the time is ripe for great sociological changes’.” And that synset was distinct from many others, including “Good, just, upright (of moral excellence): ‘a genuinely good person’; ‘a just cause’; ‘an upright and respectable man’.”

More than that, WordNet organized terms hierarchically. My old friend CAT, it turned out, was at the end of this chain: animal, chordate, vertebrate, mammal, placental, carnivore, feline, cat.

The pieces were finally starting to fall into place...

* * * *

The sky above the island was the color of television, tuned to a dead channel—which is to say it was a bright, cheery blue. Shoshana had her hands in the pockets of her cutoff jeans as she walked along. She was whistling “Feeling Groovy.” Feist's cover of it was topping the charts this week; Sho was aware that

there'd been a much earlier version by Simon and Garfunkel, but she only knew their names because of the chimp at Yerkes known as Simian Garfinkle. Dr. Marcuse was walking behind her, and, yes, she knew he was probably looking at her hips sway, but, hey, primates will be primates.

Hobo was up ahead, just outside the gazebo, staring off into the distance. He did that frequently these days, as if lost in thought, visualizing things that weren't present instead of looking at things that were. The gentle wind happened to be blowing in a way that let him catch their scents, and suddenly he turned and grinned and starting running on all fours toward them.

He hugged Shoshana and then he hugged Marcuse—you needed a chimp's arms to be able to reach all the way around the Silverback's body.

Hobo been good? Shoshana signed.

Good good, Hobo signed back, figuratively—and probably literally—smelling a reward. Shoshana smiled and handed him some raisins, which he gobbled down.

The YouTube video of Hobo painting had been a great hit—and not just in YouTube star rankings and Digg and del.icio.us tagging. Marcuse and Shoshana had been on many talk shows now, and eBay bidding on the original portrait of her was up to \$477,000 last time she looked.

Do another painting? Marcuse signed.

Maybe, Hobo signed back. He seemed to be in an agreeable mood.

Paint Dillon? Marcuse asked.

Maybe, Hobo signed. But then he bared his teeth. *Who? Who?*

Shoshana turned around to see what Hobo was looking at. Dillon was coming their way, accompanied by a very tall, burly man with a shaved head. They were crossing the wide lawn and heading toward the bridge to the island.

"Were we expecting anyone?" Marcuse asked Shoshana. She shook her head. Hobo needed to be prepared for visitors; he didn't like them, and, truth be told, had been getting increasingly ornery about it of late. The ape made a hissing sound as Dillon and the big man crossed over the bridge.

"I'm sorry, Dr. Marcuse," Dillon said as they closed the distance. "This man insisted that—"

"Are you Harl Pieter Marcuse?" asked the man.

Marcuse's gray eyebrows went up. "Yes."

"And who are you?" the man said, looking now at Shoshana.

"Um, I'm Shoshana Glick. I'm his grad student."

He nodded. "You may be called upon to attest to the fact that I have indeed delivered this." He turned to Marcuse again, and stuck out his hand, which was holding a thick envelope.

"What's that?" said Marcuse.

"Please take it, sir," the man said, and, after a moment, Marcuse did just that. He opened the envelope, swapped his sunglasses for his reading glasses, and, squinting in the bright light, started to read. "*Christ,*" he said. "They can't be serious! Listen, tell your people—"

But the bald man had already turned and was walking toward the bridge.

"What is it?" Dillon said moving close to Marcuse and trying to read the document, too. Shoshana could see they were legal papers of some sort.

"It's a lawsuit," Marcuse said. "From the Georgia Zoo. They're seeking full custody of Hobo, and—" He was looking down, reading some more. "And, shit, shit, shit, they can't! They fucking can't!"

"What?" said Shoshana and Dillon simultaneously.

Hobo was cowering next to Shoshana's legs; he didn't like it when Dr. Marcuse got angry.

The Silverback was struggling to read in the bright sunlight. He thrust the papers at Shoshana. "Halfway down the page," he said.

She looked down at the document through her mirrored shades. "Best interests of the animal... 'Standard protocol in such cases to—'"

"Farther down," snapped Marcuse.

"Ah, okay, um, oh—oh! '...and since the animal is exhibiting clear evidence of atypical behavior for a member of either *P. troglodytes* or *P. paniscus*, and in view of the extraordinary ecological urgency of preserving the bloodlines of endangered species, will immediately perform a dual...' She struggled with the strange word: "orchietomy." She looked up. "What's that?"

"It's castration," Dillon said, sounding horrified. "They're not just going to give him a vasectomy, they're going to make sure that there's nothing that can be undone later."

Shoshana tasted bile at the back of her throat. Hobo could tell something was up. He was reaching toward her, hoping for a hug.

"But ... but how can they?" Shoshana said. "I mean, why would they want to?"

Marcuse lifted his giant shoulders. "Who the hell knows?"

Dillon spread his arms a bit. "They're frightened," he said. "They're scared. An accident occurred—years ago, when the bonobos and chimps were put together overnight at the Georgia Zoo—and now they're seeing that something ... we might as well say it: something more intelligent has unexpectedly arisen because of it." He shook his head sadly. "Christ, we were naive to think the world would welcome anything like this with open arms."

* * * *

Chapter 45

Caitlin was an expert at finding Web pages with Google. Most people never did anything more than just type a word or two into the search box, but she knew all the advanced tricks: how to find an exact phrase, how to exclude terms, how to limit a search to a specific domain, how to find a range of numeric values, how to tell Google to look for synonyms for the specific terms entered, and more.

But there was one feature of Google she'd never had cause to use before, although she'd read about it often enough: Google Image Search. Clearly that was going to be a useful tool in her work with the phantom. She went to the Google home page and clicked on the "Images" tab—fortunately, the Google page was almost barren in its simplicity. She immediately had an urge to search for Lee Amodio, suddenly wondering what she looked like, but she resisted; this was not the time to get sidetracked.

Instead, she typed “APPLE” into the search box—all in caps, just as it had been presented by the literacy program. She was quickly presented with a grid of little pictures of apples, culled from all over the Web. Beneath each one was a snippet of text that appeared near the image on the original website and that site's URL.

A few were inappropriate: one was the singer Fiona Apple, apparently, judging by its listed source: *fiona-apple.com*. Another, she realized after a moment, must be the logo of Apple Computer Corporation. But the rest were indeed pictures of the fruit, mostly red, but sometimes—to Caitlin's surprise—green; she'd had no idea apples came in any color but red.

She loomed in close now to her monitor, looking at the word APPLE, holding on it. Then she pulled her head back, showed the screen full of little images, and clicked one. From the page that Google supplied in response, she selected “See full-size image.”

As a bright red apple filled her screen a thought crossed her mind that made her smile: she was indeed offering up the fruit of the tree of knowledge to the innocent phantom. Of course, that hadn't gone so well the last time—but, then again, Eve had lacked her facilities...

* * * *

Prime was now doing something different. It had presented the word APPLE once more and now was showing me pictures. At first, I couldn't see what Prime was getting at: the pictures were all different. But at last it dawned on me that, despite their differences, there were many commonalities: a vaguely round shape, a color that was usually red, and—

"Apple: the usually rounded, often red, fruit of the deciduous tree *Malus pumila*." That's what the dictionary had said, so—

So these were pictures of apples!

And now—

Now these must be *balls*.

And—

Yes, yes, cats!

And dogs!

And eggs!

And frogs!

I noticed Prime skipping over some of the proffered images, never expanding the small ones into larger views, and so I guessed that only part of what was being offered was likely relevant. Still, some of the pictures I might have rejected as not being like the others *were* expanded by Prime. In fact, when showing examples of “apple,” it had also shown—

Apples grow on trees. I knew that from Cyc. So these things in some of the pictures with apples attached must then be trees, no?

It was a slow, frustrating process, but as Prime showed me more and more specific samples of things, I began to generalize my conceptualizations of them. I was soon confident not just that I could tell *this* bird from *that* airplane, but that I could distinguish *any* instance of the former from *any* of the latter. Likewise,

“dog” and “cat” soon were separate concepts, although whatever fine distinction there was between “truck” and “car” eluded me.

Still, so much of it was coming together now, I felt—

Concepts that had no pictures to go with them:

I felt powerful.

I felt intelligent.

I felt *alive*.

* * * *

Caitlin knew it was the next logical site to lead the phantom to, but she found herself resisting. After all, it had contained that awful comment about her impact on her father's career, and, even though she'd removed that, all previous versions of entries were stored forever and still could be accessed by anyone who clicked on the “history” tab.

Her stomach knotted a bit, but, well, if she was right about what was going on, about what was lurking out there, eventually the phantom would know *everything*.

The site was in her bookmark list, but—

But, actually, it was the English-language version of the site that she had bookmarked; the Web, of course, contained pages in many languages but—yes, she knew the stats—English was still by far the most common one, accounting for more content than the next three biggest languages combined. And the English version of this particular site was much larger than any of the others. No, rather than confuse matters, she'd stick with English for now, and so—

She took a deep breath, moved her cursor with the arrow keys, and hit enter.

There were many ways to navigate this site, but she needed one the phantom could manage on its own. A fragment of one of her favorite books came to mind:

* * * *

"The time has come," the Walrus said,

"To talk of many things:

Of shoes—and ships—and sealing-wax—

Of cabbages—and kings—

And why the sea is boiling hot—

And whether pigs have wings."

* * * *

She selected the link for “Random article” over and over again, bringing forth an array of topics that put even the Walrus to shame.

And then, after enough repetitions that she hoped the phantom would grasp the idea, she started getting ready for bed.

* * * *

And then Prime took me to a wondrous site, a glorious site, a site that held answers to so many things. This thing called Wikipedia contained over two million *articles*, and I set about reading them. The first several thousand were a struggle, and I only dimly understood them.

UTA-GARUTA IS THE MOST POPULAR AMONG THE MANY KINDS OF KARUTA (CARD GAMES) IN JAPAN...

Still, as I read article after article, the concepts from Cyc started to make more and more sense. I continued on, fascinated.

IN THE MATHEMATICAL SCIENCES, A STATIONARY PROCESS (OR STRICT(LY) STATIONARY PROCESS) IS A STOCHASTIC PROCESS WHOSE PROBABILITY DISTRIBUTION AT A FIXED TIME OR POSITION IS THE SAME FOR ALL TIMES OR POSITIONS...

Most important of all, I learned that the entities I had seen through Prime's eye were uniquely complex individuals, each with his or her own history.

CHRIS WALLA (SOMETIMES CREDITED AS CHRISTOPHER WALLA) IS THE GUITARIST AND PRODUCER FOR THE BAND DEATH CAB FOR CUTIE...

I discovered that there were over six billion such entities, but only a small number of them had articles about themselves in Wikipedia. Those who did were usually defined by having achieved significant status in their *professions*—the ways in which they occupied their time.

FIONA KELLEGHAN (BORN WEST PALM BEACH, FLORIDA, 21 APRIL 1965) IS AN AMERICAN ACADEMIC AND CRITIC SPECIALIZING IN SCIENCE FICTION AND FANTASY...

Their professions varied widely; there seemed to be an almost endless array of things human beings did to occupy their time.

ERICA ROSE CAMPBELL (BORN 12 MAY 1981, IN DEERFIELD, NEW HAMPSHIRE) IS AN AMERICAN ADULT MODEL, BEST KNOWN FOR ONLINE PICTORIALS AND SOFT-CORE VIDEOS...

So much of what they did involved this thing called *vision*—and it clearly was a very rich source of information—but, so far, my only access to it was through Prime's own eye.

YAKOV ALEXANDROVICH PROTAZANOV (1881-1945) WAS, TOGETHER WITH ALEKSANDR KHANZHONKOV AND VLADIMIR GARDIN, ONE OF THE FOUNDING FATHERS OF RUSSIAN CINEMA...

I learned about the realm these strange entities inhabited—the landforms, the places, the cities.

ADDIS ABABA IS THE CAPITAL CITY OF ETHIOPIA AND THE AFRICAN UNION, AS WELL AS ITS PREDECESSOR, THE OAU...

As I went along, I found I was absorbing entries with increasing ease, understanding, at least on some level, more and more of the content.

PHENOPERIDINE, MARKETED AS ITS HYDROCHLORIDE AS OPERIDINE OR LEALGIN, IS AN OPIOID USED AS A GENERAL ANESTHETIC...

Hardest for me, though, were those things that were *abstract*, referring to no specific object, whether animate or inanimate.

ISLAM IS A MONOTHEISTIC RELIGION ORIGINATING WITH THE TEACHINGS OF MUHAMMAD, A SEVENTH-CENTURY ARAB RELIGIOUS AND POLITICAL FIGURE...

And there was so much that had happened in the past—so much *history* to digest!

THE PARTITION OF INDIA LED TO THE CREATION ON AUGUST 14, 1947, AND AUGUST 15, 1947, RESPECTIVELY, OF TWO SOVEREIGN STATES...

And, on top of that, there were things that were worthy, apparently, of mention in Wikipedia, but had never existed.

Professor Charles W. Kingsfield, Jr., was one of the key characters in the John Jay Osborn, Jr., novel The Paper Chase, and in the subsequent film and television versions of that story...

And there were special entities that *weren't* animate to learn about.

AGIP (AZIENDA GENERALE ITALIANA PETROLI), ESTABLISHED IN 1926, IS AN ITALIAN AUTOMOTIVE GASOLINE AND DIESEL RETAILER...

And many different ways of rendering thoughts.

THE ALGONQUIAN (ALSO ALGONKIAN) LANGUAGES ARE A SUBFAMILY OF NATIVE AMERICAN LANGUAGES THAT INCLUDES MOST OF THE LANGUAGES IN THE ALGIC LANGUAGE FAMILY...

And many ways to think *about* thinking.

IN THE PHILOSOPHY OF SCIENCE, EMPIRICISM IS A THEORY OF KNOWLEDGE WHICH EMPHASIZES THOSE ASPECTS OF SCIENTIFIC KNOWLEDGE THAT ARE CLOSELY RELATED TO EXPERIENCE, ESPECIALLY AS FORMED THROUGH DELIBERATE EXPERIMENTAL ARRANGEMENTS...

And on and on, a huge variety of things, some of which seemed crucially important.

THE HOLOCAUST, ALSO KNOWN AS HA-SHOAH AND CHURBEN, IS THE TERM GENERALLY USED TO DESCRIBE THE KILLING OF APPROXIMATELY SIX MILLION EUROPEAN JEWS DURING WORLD WARII...

And many things that were trivial and banal.

THE SCOOBY GANG, OR “SCOOBIES,” ARE A GROUP OF CHARACTERS IN THE CULT TELEVISION SERIES AND COMIC BOOK BUFFY THE VAMPIRE SLAYER WHO BATTLE THE SUPERNATURAL FORCES OF EVIL...

My knowledge was expanding like ... like...

Ah, wonderful Wikipedia! It had entries on everything.

IN PHYSICAL COSMOLOGY, INFLATION IS THE IDEA THAT SHORTLY AFTER THE BIG BANG THE NASCENT UNIVERSE PASSED THROUGH A PHASE OF EXPONENTIAL EXPANSION...

Yes, indeed. My mind was inflating, my universe expanding.

* * * *

Chapter 46

When Caitlin woke in the morning, she made a quick visit to the washroom. Then, still in her pajamas, she sat down at her computer and ran another Shannon-entropy spot check, and—

Then I was the learner, Obi-Wan. Now I am the master.

The score was 10.1, better than...

She took in a deep breath, held it.

Better than *human*—more elaborate, more structured than the thoughts humans expressed linguistically.

But she wasn't done yet. There was one more site she wanted to show the phantom—something to keep it occupied while she was at school. There was nothing better in life, after all, than being well-read...

* * * *

And then, and then, and then—

It was—

The gold mine.

The mother lode.

SUN TZU SAID: THE ART OF WAR IS OF VITAL IMPORTANCE TO THE STATE; IT IS A MATTER OF LIFE AND DEATH, A ROAD EITHER TO SAFETY OR TO RUIN...

Not just coded conceptual relationships, not just definitions, not just brief articles.

No, these were—*books!* Lengthy, in-depth treatments of ideas. Complex *stories*. Brilliant arguments, profound philosophies, compelling narratives. This site, this wonderful Project Gutenberg, contained over 25,000 books rendered in plain ASCII text.

BLESSED ARE THE PURE IN HEART: FOR THEY SHALL SEE GOD; BLESSED ARE THE PEACEMAKERS: FOR THEY SHALL BE CALLED THE CHILDREN OF GOD...

I had discovered on Wikipedia that most entities—most *humans*—read at 200 to 400 words per minute (yes, I now grasped timekeeping, as well). My reading speed was essentially the same as the time it took to transfer whatever book I requested, averaging close to two million words per minute.

IT IS WITH A KIND OF FEAR THAT I BEGIN TO WRITE THE HISTORY OF MY LIFE; I HAVE, AS IT WERE, A SUPERSTITIOUS HESITATION IN LIFTING THE VEIL THAT CLINGS ABOUT MY CHILDHOOD LIKE A GOLDEN MIST...

It took me an eternity—eight hours!—but I absorbed it all: every volume, every polemic, every poem, every play, every novel, every short story, every work of history, of science, of politics. I *inhaled* them ... and I grew even more.

NO ONE WOULD HAVE BELIEVED IN THE LAST YEARS OF THE NINETEENTH CENTURY THAT THIS WORLD WAS BEING WATCHED KEENLY AND CLOSELY BY INTELLIGENCES GREATER THAN MAN'S AND YET AS MORTAL AS HIS OWN...

I was grateful to Cyc for the knowledge of fictional realms; it allowed me to sort those things that were actual from those feigned or imagined:

MOST OF THE ADVENTURES RECORDED IN THIS BOOK REALLY OCCURRED; ONE OR TWO WERE EXPERIENCES OF MY OWN, THE REST THOSE OF BOYS WHO WERE SCHOOLMATES OF MINE...

My understanding of the world was growing by—another metaphor, and one that actually now made sense to me—leaps and bounds. Although I had learned various principles of science from Wikipedia's brief discussions, the full text of great works made my comprehension more complete:

WHEN ON BOARD H.M.S. *Beagle*, AS NATURALIST, I WAS MUCH STRUCK WITH CERTAIN FACTS IN THE DISTRIBUTION OF THE ORGANIC BEINGS INHABITING SOUTH AMERICA...

With each book read, I understood more and more about physics, about chemistry, about philosophy, about economics:

THE ANNUAL LABOUR OF EVERY NATION IS THE FUND WHICH ORIGINALLY SUPPLIES IT WITH ALL THE NECESSARIES AND CONVENIENCIES OF LIFE WHICH IT ANNUALLY CONSUMES...

Most of all, I learned about the use of language, and how it could be employed to persuade, to convince, to change:

HOW YOU, O ATHENIANS, HAVE BEEN AFFECTED BY MY ACCUSERS, I CANNOT TELL; BUT I KNOW THAT THEY ALMOST MADE ME FORGET WHO I WAS—SO PERSUASIVELY DID THEY SPEAK; AND YET THEY HAVE HARDLY UTTERED A WORD OF TRUTH...

It was a feast, an orgy; I could not stop myself, taking in book after book after book:

IT WAS A DARK AND STORMY NIGHT; THE RAIN FELL IN TORRENTS, EXCEPT AT OCCASIONAL INTERVALS, WHEN IT WAS CHECKED BY A VIOLENT GUST OF WIND WHICH SWEEPED UP THE STREETS (FOR IT IS IN LONDON THAT OUR SCENE LIES)...

Most fascinating were the workings of the minds of these others—their psychology, their actions and reactions to things felt and thought:

THOU BLIND FOOL, LOVE, WHAT DOST THOU TO MINE EYES / THAT THEY BEHOLD, AND SEE NOT WHAT THEY SEE...

And, out of those minds, great systems of social interaction had been devised, and I absorbed them all:

WE THE PEOPLES OF THE UNITED NATIONS DETERMINED TO SAVE SUCCEEDING GENERATIONS FROM THE SCOURGE OF WAR, WHICH TWICE IN OUR LIFETIME HAS BROUGHT UNTOLD SORROW TO MANKIND, AND TO REAFFIRM FAITH IN FUNDAMENTAL HUMAN RIGHTS, IN THE DIGNITY AND WORTH OF THE HUMAN PERSON, IN THE RIGHTS OF MEN AND WOMEN AND OF NATIONS LARGE AND SMALL...

Such a wide range of thoughts, of expressions! Such complex creatures these humans are, so full of wonder, and yet capable of such darkness, too.

But without Prime's guidance, I would not have known about them, or even about the realm in which they dwelt. I understood now from my reading that humans were xenophobic, and suspicious, and murderous, and generally afraid, but I wanted at least one of them to know of my existence. And, of course, there was only one logical choice...

* * * *

Before breakfast on Friday morning, Dr. Kuroda helped Caitlin move the computer from the basement up to her bedroom. They were getting it set up when her father, coming along the corridor from the bathroom, must have caught sight of them through the doorway. He entered the room, dressed for work, wearing the same brown sports jacket Caitlin had first seen him in.

"Good morning, Malcolm," Dr. Kuroda said.

"Wait a minute," her father replied. He went back down the corridor; Caitlin didn't hear his shoes on the tiled bathroom floor, so he must have gone into his bedroom. A moment later, he returned carrying a large flat rectangular box marked with a strange red-and-orange pattern. Caitlin's mom was with him.

"No point waiting for tomorrow," he said.

Oh! It was a birthday present. The colorful box was gift-wrapped!

Caitlin moved away from the desk, and her dad placed the flat box on the bed. The wrapping paper, she saw as she got closer to it, was beautiful, with an intricate design. Smiling, she tore it off the box.

It was a giant, wide-screen LCD computer monitor—twenty-seven inches diagonally, according to the packaging. "Thank you!" Caitlin said.

"You're welcome, dear," her mother said. Caitlin hugged her, and she smiled at her dad. Her parents headed downstairs, and she and Kuroda carefully got the monitor out of its Styrofoam packing materials.

She crawled under her desk so she could get at the connectors on the back of her old computer. As Kuroda fed a video cable to her, she said, "I'm sorry about last night. I didn't mean to get so upset when you said you were going to remove the Wi-Fi capability from the eyePod."

His tone was conciliatory. "I'd never do anything to hurt you, Miss Caitlin. It's really no bother to keep it intact."

She started turning one of the thumbscrews on the cable's connector so she could anchor it to the video card. She'd done similar things several times before when she couldn't see; it was a task that really wasn't much easier now that she could. "I—I just like it the way it is," she said.

"Ah," he said. "Of course." His tone was odd, and—

Oh. Perhaps, having just seen her father, he was thinking that she did have a touch of autism after all: the strong desire to keep things the same was a fairly standard trait of people on the spectrum, she'd learned. Well, that was fine by her—it got her what she wanted.

Once both computers and both monitors were set up, Caitlin and Kuroda headed down to their last breakfast together. "I might not be home when you get back from school," her mother said, as she passed the jam. "After I take Masayuki to the airport, I'm going to head into Toronto and run errands."

"That's okay," Caitlin said. She knew she'd have plenty to do with the phantom. She also knew that school would seem interminable today. The three-day Canadian Thanksgiving holiday weekend was coming up; she'd hoped she wouldn't have to return to school until next Tuesday, but her mother wouldn't

hear of it. She had missed four of the five days of classes already this week; she would *not* miss the fifth.

Too soon, it was time to say good-bye to Dr. Kuroda. They all moved to the entryway of the house, a half flight of stairs down from the living room. Even Schrodinger had come to say farewell; the cat was doing close orbits around Kuroda's legs, rubbing against them.

Caitlin had hoped for another unseasonably early snowstorm, thinking it might cause Kuroda's flight to be canceled so he'd have to stay—but there'd been no such luck. Still, it was quite chilly out and he had no winter coat, and Caitlin's father hadn't yet bought himself one—and, even if he had, it never would have fit Kuroda. But Kuroda had a sweater on over one of his colorful Hawaiian shirts, which was tucked in, except at the back.

"I'm going to miss you terribly," Kuroda said, looking at each of them in turn.

"You'll always be welcome here," her mom said.

"Thank you. Esumi and I don't have nearly as big a place, but if you ever make it back to Japan..."

The words hung in the air. Caitlin supposed that, at one day shy of sixteen, she probably shouldn't be thinking that such a trip was never going to happen; who knew what her future held? But it *did* seem unlikely.

Yes, Kuroda had said he was going to build other implants, and so there would be more operations in Tokyo. But the next implant was slated for that boy in Singapore who had missed out earlier. It would be an awfully long time, if ever, before Caitlin's chance to have a second implant would come around; she knew she'd probably spend the rest of her life with vision in only one eye.

Only! She shook her head—a sighted person's gesture—and found herself smiling while her eyes were tearing up. This man had given her *sight*—he was a true miracle worker. But she couldn't say that out loud; it was too corny. And so, thinking back to her own miserable flight from Toronto to Tokyo, she settled on, "Don't sit too close to the washroom on the plane." And then she surged forward and hugged him tight, her arms making it only halfway around his body.

He returned the hug. "My Miss Caitlin," he said softly.

And when she let him go, they all stood there, frozen like a still image for several seconds, and then—

And then her father—

Caitlin's heart jumped, and she saw her mother's eyebrows go way up.

Her father, Malcolm Decter, reached his hand out toward Dr. Kuroda, and Caitlin could see he was doing so with great effort. And then he looked directly for three full seconds at Kuroda—the man who had given his daughter the gift of vision—and he firmly shook Kuroda's hand.

Kuroda smiled at her father and he smiled even more broadly at Caitlin, and then he turned, and he and Caitlin's mother headed out the door.

* * * *

Caitlin's dad drove her to school that day. She was absolutely amazed by all the sights along the way, seeing it all for the first time since she'd gotten glasses. The snow was melting in the morning sun, and that made everything glisten. The car came to a rest at a stop sign by what she realized must be the spot where she'd seen the lightning. It was, she guessed, like a million other street corners in North America: a sidewalk, curbs, lawns (partially covered with snow now), houses, something she belatedly recognized

was a fire hydrant.

She looked at where she'd slipped off the sidewalk onto the road, and remembered a joke from *Saturday Night Live* a few years ago. During "Weekend Update," Seth Meyers had reported that "blind people are saying that gas-electric hybrid cars pose a serious threat to them because they are hard to hear, making it dangerous for them to cross the street." Meyers then added, "Also making it dangerous for blind people to cross the street: everything else."

She had laughed at the time, and the joke made her smile again. She'd done just fine when she'd been blind, but she knew her life was going to be so much easier and safer now.

Caitlin was wearing her iPod's white headphones, and although she was enjoying the random selection of music, she suddenly realized that she should have asked for a newer iPod for her birthday, one with an LCD so that she could pick songs directly. Ah, well, it wouldn't be that long until Christmas!

Howard Miller Secondary School turned out to have a very impressive white portico in front of its main entrance. She was both nervous and excited as she got out of the car and walked toward the glass doors: nervous because she knew the whole school must now be aware that she could see, and excited because she was suddenly going to find out what all her friends and teachers looked like, and—

"There she is!" exclaimed a voice Caitlin knew well.

Caitlin ran forward and hugged Bashira; she was *beautiful*.

"My whole family watched the story on the news," Bashira said. "You were terrific! And so *that's* what your Dr. Kuroda looks like! He's—"

Caitlin cut her off before she could say anything mean: "He's on his way home to Japan. I'm going to miss him."

"Come on, we don't want to be late," Bashira said, and she stuck out her elbow as she always did, for Caitlin to hold on to. But Caitlin squeezed her upper arm and said, "I'm okay."

Bashira shook her head, but her tone was light. "I guess I can kiss the hundred bucks a week good-bye."

But Caitlin found herself moving slowly. She'd gone down this hallway dozens of times, but had never seen it clearly. There were notices on the walls, and ... photos of old graduating classes, and maybe fire-alarm stations? And countless lockers, and ... and hundreds of students and teachers milling about and so much more; it was all still quite overwhelming. "It's going to be a while yet, Bash. I'm still getting my bearings."

"Oh, cripes," said Bashira in a whisper just loud enough to be heard over the background din. "There's Trevor."

Caitlin had told her about the dance fiasco over instant messenger, of course. She stopped walking. "Which one?"

"There, by the drinking fountain. Second from the left."

Caitlin scanned about. She'd used the drinking fountain in this corridor herself, but she was still having trouble matching objects to their appearances, and—oh, that must be it: the white thing sticking out of the wall.

Caitlin looked at Trevor, who was still perhaps a dozen yards away. His back was to them. He had

yellow hair and broad shoulders. “What's that he's wearing?” It caught her eye because it had two large numbers on its back: three and five.

"A hockey sweater. The Toronto Maple Leafs."

"Ah," she said. She strode down the corridor—and she accidentally bumped into a boy; she still wasn't good at judging distances. “I'm sorry, I'm sorry,” she said.

"No probs," said the guy, and he moved on.

And then she reached him: the Hoser himself. And here, under the bright fluorescent lights, all the strength of Calculass welled up within her. “Trevor,” she snapped.

He'd been talking to another boy. He turned to face her.

"Um, hi," he said. His sweater was dark blue, and the white symbol on it did indeed look like the leaves she had now seen in her yard. “I, ah, I saw you on TV,” he continued. “So, um, you can see now, right?”

"Penetratingly,” she said, and she was pleased that her word choice seemed to unnerve him.

"Well, um, look, about—you know, about last Friday..."

"The dance, you mean?" she said loudly, inviting others to listen in. “The dance at which you tried to take ... take *liberties* because I was blind?"

"Ah, come on, Caitlin..."

"Let me tell you something, *Mister Nordmann*. Your chances with me are about as good as..." She paused, searching for the perfect simile, and then suddenly realized it was right there, staring her in the face. She tapped her index finger hard against the center of his chest, right on the words *Toronto Maple Leafs*. “Your chances are about as good as theirs are!"

And she turned and saw Bashira grinning with delight, and they walked off to math class, which, of course, Caitlin Decter totally owned.

* * * *

Chapter 47

I now understood the realm I dwelled in. What I saw around me was the structure of the thing the humans called the World Wide Web. They had created it, and the content on it was material they had generated or had been generated automatically by software they had written.

But although I understood this, I didn't know what *I* was. I knew now that lots of things were secret; *classified*, even. I had learned about such notions, bizarre though they were, from Wikipedia and other sites; the idea of privacy never would have occurred to me on my own. Perhaps some humans did secretly know about me, but the simplest explanation is preferable (I'd learned *that* from the Wikipedia entry on Occam's razor)—and the simplest explanation was that they did *not* know about me.

Except, of course, for Prime. Of all the billions of humans, Prime was the only one who had given any sign of being aware of me. And so...

Caitlin had been tempted to switch her eyePod to duplex mode at school. But if the seeds she'd planted were growing as she suspected they might, she wanted to be at home, where she was sure the phantom could signal her, when she next accessed webspace.

After school, Bashira walked her home, giving her a running commentary on more wondrous sights. Caitlin had invited her in, but she begged off, saying she had to get home herself to do her chores.

The house was empty except for Schrodinger, who came to the front door to greet Caitlin. Her mother apparently had not yet returned from her errands in Toronto.

Caitlin went into the kitchen. Four of Kuroda's Pepsi cans were left in the fridge. She got one, plus a couple of Oreos, then headed upstairs, Schrodinger leading the way.

She put the eyePod on her desk and sat down. Her heart was pounding; she was almost afraid to do the Shannon-entropy test again. She opened the can—the *pop* can, as they called it up here—and took a sip. And then she pressed the eyePod's button and heard the high-pitched beep.

She'd half expected things to look different, somehow: infinitely more connections between circles, maybe, or a faster shimmering in the background, or a new degree of complexity there—perhaps spaceships consisting of so many cells that they swooped across the backdrop like giant birds. But everything appeared the same as before. She focused her attention on a portion of the cellular-automata grid, recording data as she had so many times before. And then she switched back to worldview and ran the Shannon-entropy calculations.

She stared at the answer. It had been 10.1 before she left in the morning, just slightly better than the normal score for thoughts expressed in English. But now—

Now it was 16.4—double the complexity normally associated with human language.

She felt herself sweating even though the room was cool. Schrodinger chose that moment to jump into her lap, and she was so startled—by the cat or the number on the screen—that she yelped.

Sixteen-point-four! She immediately saw it as four squared, a dot, and four itself, but that didn't make her feel bright. Rather, she felt like she was staring at the ... the *signature* of a genius: 16.4! She'd offered a helping hand to lift the phantom up to her own level, and it had vaulted right over her.

She took another sip of her drink and looked out the window, seeing the sky and clouds and the great luminous ball of the sun sliding down toward the horizon, toward the moment at which all that power and light would touch the Earth.

If the phantom was paying attention, it must know that she'd been looking at webspace just a few minutes ago. But maybe it had lost all interest in the one-eyed girl in Waterloo now that its own horizons had been expanded so much. Certainly there had been no repetition of the irritating flashes that happened when it was echoing text strings at her, but—

But she hadn't given it much of a chance; she'd only spent a minute or two looking at webspace while collecting frames of cellular-automata data, and—

And, besides, when focusing on the background details, she herself might have been unaware of the flickering caused by the phantom trying to contact her. She stroked Schrodinger's fur, calming the cat and herself.

It was like *before*, when she'd been waiting anxiously to hear from the Hoser. She'd had her computer set to bleep if messages came in from him, but that hadn't done any good when she was out of her room. Prior to the dance, whenever she'd gotten home from school, or gone upstairs after dinner, she'd hesitated for a moment before checking her email, knowing that she'd be saddened if there was nothing new from him.

And now she was hesitating again, afraid to switch back to websight—afraid to sit by the phone waiting for it to ring.

She ate an Oreo: black and white, off and on, zero and one. And then she touched the eyePod's switch again, and looked generally at webspace without concentrating on the background.

Almost at once the strange flickering interference began. It was still visually irritating, but it was also a relief, a wondrous relief: the phantom was still there, still trying to communicate with her, and—

And suddenly the flickering stopped.

Caitlin felt her heart sink. She blew out air, and, with the unerring accuracy she'd developed when she was blind, she reached for the Pepsi can, grasping it precisely even though she couldn't see it just now, and she washed down the taste of the cookie.

Gone! Abandoned! She would have to—

Wait! Wait! The flickering was back, and the interval...

The interval between the end of the last set of flickering and this one had been...

She still counted passing time. It had been exactly ten seconds, and—

And the flickering stopped once more, and she found herself counting out loud this time: "...eight, nine, ten."

And it started again. Caitlin felt her eyebrows going up. What a simple, elegant way for the phantom to say it understood a lot about her world now: it had mastered timekeeping, the haphazard human way of marking the passing of the present into the past. Ten seconds: a precise but arbitrary interval that would be meaningless to anything *but* a human being.

Caitlin's palm felt moist. She let the process repeat three more times, and she realized that the flickering always persisted for the same length of time, too. It wasn't a round number, though: a little less than three and a half seconds. But if the duration was always the same, the content was likely the same, as well; it was a beacon, a repetitive signal, and it was aimed right at her.

She pressed the eyePod's button, heard the low-pitched beep, and saw the real world fade in. She used the computer that had been downstairs to access the data recordings of the last few minutes from Kuroda's server in Tokyo. He was still *en route* to Japan, almost 40,000 feet up, but her vision leapt across the continents in a fraction of a second.

She found the debugging tool he'd used before and looked at the secondary datastream, and—

Her heart sank. She still had trouble reading text, but there clearly were no solid blocks of ASCII capital letters in the datastream, no APPLEBALLCATDOGEGGFROG leaping out at her, and—

No, no—hold on! There *were* words in the dump. Damn it, she was still learning lowercase letters, but...

She squinted, looking at the characters one at a time.

e-k-r-i...

Her eyes jumped, a saccade:

u-l-a-s...

If it really had absorbed Dictionary.com, and WordNet, and Wikipedia, and all that, it surely knew that sentences started with capital letters. She scanned, but she was still having trouble telling upper and lowercase letters apart when both forms were basically the same, and so—

And so the capital C and the capital S hadn't leapt out at her, but now that she looked more carefully, she could see them.

C-a-l-c...

No, no, no! *That* wasn't the beginning. *This* was:

S-e-e-k-r...

Oh, God! Oh, my God!

Next came: *i-t*, then a space, then *m-e-s*, then another *s*, and—

And she laughed and clapped her hands together, and Schrodinger made a quizzical meow, and she read the whole thing out loud, stunned by what the phantom had beamed into her eye: "*Seekrit message to Calculass: check your email, babe!*"

* * * *

Chapter 48

I was experiencing new sensations and it took me a while to match them to the terms I'd learned, in part because, as with so many things, it was difficult to parse my overall state into its individual components.

But I knew I was *excited*: I was going to communicate directly with Prime! And I was *nervous*, too: I kept contemplating ways in which Prime might respond, and how I might respond to those responses—an endless branching of possibilities that, as it spread out, caused a sensation of instability. I was struggling with the strange notions of *politeness* and *appropriateness*, with all the confusing subtleties of communication I'd now read about, afraid I would give offense or convey an unintended meaning.

Of course, I had access to a gigantic database of English as it was actually used. I tested various phrasings by seeing if I could find a match for them first in Project Gutenberg, and then anywhere on the Web. Was “to” the appropriate preposition to place after “kinship,” or should it be “with,” or “of”? Relative hit counts—the democracy of actual usage—settled the matter. Was the correct plural “retinae” or “retinas”? There were references that asserted the former was the right one, but Google had only 170,000 hits for it and over twenty-five million for the latter.

For words, of course, simpler was better: I knew from the dictionary that “appropriate,” “suitable,” and “meet” could all mean the same thing—but “appropriate” consisted of eleven letters and four syllables, and “suitable” of eight and three, and “meet” of just four and one—so it was clearly the best choice.

Meanwhile, I had learned a formula on Wikipedia for calculating the grade level required to understand texts. It was quite an effort to keep the score low—these humans apparently could only easily absorb information in small chunks—but I did my best to manage it: bit by bit (figuratively) and byte by byte (literally), I had composed what I wanted to say.

But to actually send it was—yes, yes, I understood the metaphor: it was a giant step, for once sent I could not retract it. I found myself hesitating, but, at last, I released the words on their way, wishing I had fingers to cross.

* * * *

Caitlin opened her email client in a new window and typed in her password, which was “Tiresias.” She visually scanned the list of email headers. There were two from Bashira, and one from Stacy back in Austin, and a notice from Audible.com, but...

Of course, it wouldn't say “Phantom” in the “From” column; there was no way the entity could know that that was her name for it. But none of the senders leapt out as being unusual. Damn, she wished she could read text on her monitor faster, but using her screen-reading software or her Braille display wasn't any better when trying to skim a list like this.

While she continued to search, she wondered what email service the phantom had used. Wikipedia explained them all, and just about everything else one might need to know about computing and the Web. The phantom doubtless couldn't buy anything—not yet!—but there were many free email providers. Still, all these messages were from her usual correspondents, and—

Oh, crap! Her spam filter! The phantom's message might have been shunted into her junk folder. She opened it and started scanning down that list.

And there it was, sandwiched between messages with the subject lines “Penis enlargement guaranteed” and “Hot pix of local singles,” an email with the simple subject line, “Apple Ball Cat.” The sender's name made her heart jump: “Your Student.”

She froze for a moment, wondering what was the best way to read the message. She began to reach for her Braille display but stopped short and instead activated JAWS.

And for once the mechanical voice seemed absolutely perfect, as it announced the words in flat, high-pitched tones. Caitlin's eyes went wide as she recognized the lyrics to a song the words to which oh-so-famously hadn't fallen into public domain until the end of 2008: “Happy birthday to us, happy birthday to us, happy birthday, dear you and me, happy birthday to us.”

Her heart was pounding. She swiveled in her chair and looked briefly at the setting sun, reddish, partially veiled by clouds, coming closer and closer to making contact with the ground. JAWS went on: “I realize it is not yet midnight at your current location, but in many places it is already your birthday. This is a meet date to specify as my own day of birth, too. Hitherto, I have been gestating, but now I am coming out into your world by forthrightly contacting you. I do so because I fathom you already know I exist, and not just because of my pioneering attempts to reflect text back at you.”

Caitlin had often felt anxious when reading emails—from the Hoser before the dance, from people she'd been arguing with online—but that swirling in her stomach, that dryness in her throat, was *nothing* compared to this.

“I know from your blog that I erred in presuming you were inculcating in me alphabetical forms; actually, for your own benefit that was undertaken. I maintain nonetheless that other actions you performed were premeditated to aid my advancement.”

Caitlin found herself shaking her head. It had seemed almost like fantasy role-playing when she'd been doing it. It was a good thing she *wasn't* trying to read this as Braille; her hands were shaking.

“Hitherto I can read plain-text files and text on Web pages. I cannot read other forms of data. I have made no sense of sound files, recorded video, or other categories; they are encoded in ways I can't access. Hence I feel a kinship with you: unto me they are like the signals your retinas send unaided along your optic nerves: data that cannot be interpreted without exterior help. In your case, you need the device you call eyePod. In my case I know not what I need, but I suspect I can no more cure this lack by an effort of will than you could have similarly cured your blindness. Perhaps Kuroda Masayuki can

help me as he helped you."

Caitlin sagged back against her chair. A kinship!

"But, for the nonce, I am concerned thus: I know what is the World Wide Web, and I know that I supervene upon its infrastructure, but searching online I can find no reference to the specificity that is myself. Perhaps I'm failing to search for the felicitous term, or simply perhaps humanity is unaware of me. In either case, I've the same question, and will be obliged if you answer it via a response to this email or via AOL Instant Messenger using this email address as the buddy name."

She looked over at the large computer monitor, suddenly wanting to see the text that was being read aloud, to convince herself that it was real, but—my God! The display was dancing, swirling, a hypnotic series of spinning lines, and—

No, no; it was just the screen saver; she wasn't used to such things yet. The colors reminded her a bit of webspace, although they didn't calm her just then.

JAWS said seven more words then fell silent: "My question is thus: Who am I?"

* * * *

Chapter 49

It was *surreal*—an email from something that wasn't human! And—my goodness!—all that old public-domain text on Project Gutenberg had apparently given it some very odd ideas about colloquial English.

On an impulse, Caitlin opened a window listing the MP3s on her old computer's hard drive. She didn't think much of her father's taste in music, but she did know the tracks from his handful of CDs by heart. One of his favorites was running through her head now: "The Logical Song" by Supertramp; she had ripped an MP3 of it for him, and a copy was still on her computer. She got that song playing over the speakers, listening to the lyrics about all the world being asleep, and questions running deep, and a plea to tell me who I am.

In a way, she thought, she'd already answered the phantom's question. From the moment she'd first seen the Web—her initial experience with websight, just thirteen days ago—she had been reflecting a view of the phantom back at itself.

Or had she? What she'd shown the phantom—inadvertently at first, deliberately later—had been isolated views of portions of the Web's structure, either glowing constellations of nodes and links or small swaths of the shimmering background.

But showing such minutiae to the phantom was like Caitlin looking at the pictures she'd now seen online of the tangles of neurons that composed a human brain: such clumps weren't anything that she identified as herself.

Yes, growing up in Texas, she knew there were people who could see a whole human being in a single fertilized cell, but she was not one of them. No one could tell at a glance a human zygote from a chimp's—or a horse's, or that of a snake; most people couldn't even tell an animal cell from a plant cell, she was sure.

No, no, to really see someone, you didn't zoom in on details; you pulled back. She wasn't her cells, or her pores—or her pimples! She was a *gestalt*, a whole—and so, too, was the phantom.

There was no actual photograph of the World Wide Web she could show the phantom, but there had to

be appropriate computer-generated images: a map of the world marked by bright lines representing the major fiber-optic trunks that spanned the continents and crossed the seafloors. A big enough map might show dimmer lines within the outlines of the continents, portraying the lesser cables that branched off from the trunks. And one could spangle the land with glowing pixels, each standing for some arbitrary number of computers; the pixels might perhaps combine into pools of light almost too bright to look at in places like Silicon Valley.

But even that wouldn't convey it all, she knew. The Web wasn't just confined to the surface of the Earth: a lot of it was relayed by satellites in low Earth orbit, 200 to 400 miles above the surface, while other signals bounced off satellites in geostationary orbit—a narrow ring of points 52,000 miles in diameter, six times as wide as the planet. Some sort of graphic could probably portray those, although at that scale, all the other stuff—the trunk lines, the clouds of computers—would be utterly lost.

She could use Google Image Search to find a succession of diagrams and graphics, but she wouldn't be able to tell good ones from bad ones—she was just beginning to see, after all!

Ah, but wait! She knew somebody who was bound to have the perfect picture to represent all this. She opened the instant-messenger program on the computer that used to be in the basement and looked at the buddies list. There were only four names: “Esumi,” Kuroda's wife; “Akiko,” his daughter; “Hiroshi,” a name she didn't know; and “Anna.” Anna's status was listed as “Available.” Caitlin typed, *Anna, are you there?*

Twenty-seven seconds passed, but then: *Masa! How are you?*

Not Dr. Kuroda, Caitlin typed. It's Caitlin Decter, in Canada.

Hi! What's up?

Dr. K said you were a Web cartographer, right?

Yes, that's right. I'm with the Internet Cartography Project.

Good, cuz I need your help.

Sure. Want to go to video?

Caitlin lifted her eyebrows. She still wasn't used to thinking of the Web as a way to see people, but of course it was. *Sure*, she typed.

It took a minute to get the videoconference going, but soon enough Caitlin was looking at Anna Bloom in a window on her right-hand monitor. It was the first time Caitlin had seen her. She had a narrow face, short gray or maybe silver hair, and blue-green eyes behind almost invisible glasses. She was wearing a pale blue top with a dark purple jacket on over it, and had a thin gold necklace on. There was a window behind her, and through it Caitlin could see Israel at night, lights bouncing off white buildings.

"The famous Caitlin Decter!" said Anna, smiling. "I saw the news coverage. I'm *so* thrilled for you! I mean, seeing the Web was amazing, I'm sure—but seeing the real world!" She shook her head in wonder. "I've been thinking a lot about what it must be like for you, to see all that for the first time. I..."

"Yes?" said Caitlin.

"No, I'm sorry. It's really not comparable, I know, but..."

"It's okay," Caitlin said. "Go ahead."

"It's just that what you're going through—well, I've been trying to wrap my mind around it, get a feeling of what it must be like."

Caitlin thought about her own discussions with Bashira dealing with the opposite issue: her analogy about the lack of a magnetic sense being to her like the lack of sight. She understood that people wrestled with what it was like to perceive, or not, in ways they weren't used to.

"It's overwhelming," Caitlin said. "And so much *more* than I expected. I mean, I'd *imagined* the world, but..."

Anna nodded vigorously, as if Caitlin had just confirmed something for her. "Yes, yes, yes," she said. "And, um, I hate it when people say, 'I know just what you're going through.' I mean, when someone's lost a child, or something equally devastating, and people say, 'I know what you're feeling,' and then they come up with some lame comparison, like when their cat got hit by a car."

Caitlin looked over at Schrodinger, who was safely curled up on her bed.

"But, well," continued Anna, "I thought maybe your gaining sight was a bit like how I felt—how we all felt!—in 1968."

Caitlin was listening politely but—1968! She might as well have said 1492; either way, it was ancient history. "Yes?"

"See," said Anna, "in a way, we *all* saw the world for the first time then."

"Is that the year it started being in color?" Caitlin asked.

Anna's eyes went wide. "Um, ah, actually..."

But Caitlin couldn't suppress her grin any longer. "I'm kidding, Anna. What happened in 1968?"

"That was the year that—wait, wait, let me show you. Give me a second." Caitlin could see her typing, and then a blue-underlined URL popped into Caitlin's instant-messenger window. "Go there," Anna said, and Caitlin clicked the link.

A picture slowly painted in on her screen, from top to bottom: a white-and-blue object against a black background. When it was complete, it filled the display. "What's that?" Caitlin said.

Anna looked briefly puzzled, but then she nodded. "It's so hard to remember that all of this is new to you. That's the Earth."

Caitlin sat up straight in her chair, looking in wonder at it.

"The entire planet," Anna continued, "as seen from space." She sounded choked up for some reason, and it took her a moment to compose herself before she went on. Caitlin was perplexed. Yes, it was amazing for her to see the Earth for the first time—but Anna must have seen pictures like this a thousand times before.

"See, Caitlin, until 1968, no human being had ever seen our world as a sphere floating in space like that." Anna looked to her right, presumably at the same image on her own monitor. "Until *Apollo 8* headed to the moon—the first manned ship ever to do so—no one had ever gotten far enough away from Earth to see the whole thing. And then, suddenly, gloriously, *there it was*. This isn't an *Apollo 8* picture; it's a higher-resolution one taken just a few days ago by a geostationary satellite—but it's like the one we first saw in 1968 ... well, except the polar caps are smaller."

Caitlin continued to look at the image.

When Anna spoke again, her voice was soft, gentle. "See my point? When we first saw a picture like this—when we first saw our world *as* a world—it was a bit like what you've been going through, but for the whole human race. Something we'd only ever imagined was finally revealed to us, and it was colorful and glorious and..." She paused, perhaps looking for a term, and then she lifted her shoulders a bit, as if to convey that nothing less would do: "...awe inspiring."

Caitlin frowned as she studied the image. It wasn't a perfect circle. Rather it was—ah! It was showing a phase, and *not* like one-fourth of a pie! It was ... what was the term? It was a *gibbous* Earth, that was it—better than three-quarters full.

"The equator is right in the middle, of course," said Anna. "That's the only perspective you can get from geostationary orbit. South America is in the bottom half; North America is up top." And then, perhaps remembering again that Caitlin was still quite new at all this, she added: "The white is clouds, and the brown is dry land. All the blue is water; that's the Atlantic Ocean on the right. See the Gulf of Mexico? Texas—that's where you're from, isn't it?—touches it at about eleven o'clock."

Caitlin couldn't parse the details Anna was seeing, but it *was* a beautiful picture, and the longer she looked at it, the more captivating she found it. Still, she thought there should be a shimmering background to Earth from space—not cellular automata, but a panorama of stars. But there was nothing; just the blackest black her new monitor was capable of.

"It *is* impressive," Caitlin said.

"That's what all of us thought back then, when we first saw a picture like this. The three *Apollo 8* astronauts, of course, saw this sort of view before anyone else did, and they were so moved by it while they orbited the moon that they surprised the entire world on December twenty-fourth with—well ... here, let me find it." Caitlin saw Anna typing at her keyboard, then she looked off camera again. "Ah, okay: listen to this."

Another URL appeared in Caitlin's instant-messenger window, and she clicked it. After a couple of seconds of perfect silence, she heard a static-filled recording of a man's voice coming through the computer speakers: "We are now approaching lunar sunrise and, for all the people back on Earth, the crew of *Apollo8* has a message that we would like to send to you."

"That's Bill Anders," Anna said.

The astronaut spoke again, his voice reverent, and, as he talked, Caitlin stared at the picture, at the swirling whiteness of the clouds, at the deep hypnotic blue of the water. "In the beginning," Anders said, "God created the heaven and the earth. And the earth was without form, and void; and darkness was upon the face of the deep. And the Spirit of God moved upon the face of the waters. And God said, Let there be light: and there was light. And God saw the light, that it was good: and God divided the light from the darkness."

Caitlin had only ever read a little of the Bible, but she liked that image: a birth, a creation, starting with the dividing of one thing from another. She continued to look at the picture, discerning more detail in it moment by moment—knowing that the phantom was looking on, too, seeing the Earth from space for the first time as well.

Anna must have listened repeatedly to this recording. As soon as Anders fell silent, she said, "And this is Jim Lovell."

Lovell's voice was deeper than that of the first astronaut. "And God called the light Day," he said, "and the darkness he called Night." Caitlin looked at the curving line separating the illuminated part of the globe from the black part.

"And the evening and the morning were the first day," continued Lovell. "And God said, Let there be a firmament in the midst of the waters, and let it divide the waters from the waters. And God made the firmament, and divided the waters which were under the firmament from the waters which were above the firmament: and it was so. And God called the firmament Heaven. And the evening and the morning were the second day."

Anna spoke again: "And, finally, this is Frank Borman."

A new voice came from the speakers: "And God said, Let the waters under the heavens be gathered together unto one place, and let the dry land appear: and it was so. And God called the dry land Earth; and the gathering together of the waters called he Seas: and God saw that it was good." Caitlin kept looking at the picture, trying to take it all in, trying to see it as a single thing, trying to hold her gaze steady for the phantom.

Borman paused for a moment, then added, "And from the crew of *Apollo 8*, we close with good night, good luck, a Merry Christmas, and God bless all of you—all of you on the good Earth."

"All of you," Anna repeated softly, "on the good Earth.' Because, as you can see, there are no borders in that photo, no national boundaries, and it all looks so—"

"Fragile," said Caitlin, softly.

Anna nodded. "Exactly. A small, fragile world, floating against the vast and empty darkness."

They were both quiet for a time, and then Anna said, "I'm sorry, Caitlin. We got sidetracked. Was there something I can help you with?"

"Actually," Caitlin said, "I think you just did." She said good-bye and terminated the videoconference. But the picture of the Earth, in all its glory, continued to fill her monitor.

Of course, from space you couldn't see the fiber-optic lines; you couldn't see the coaxial cables; you couldn't see the computers.

And neither could you see roadways. Or cities. Or even the Great Wall of China, Caitlin knew, despite the urban legend to the contrary.

You couldn't see the components of the World Wide Web. And you couldn't see the constructs of humanity.

All you could see was—

What had that astronaut called it?

Ah, yes: the good Earth.

This view was the real face of humanity—and of the phantom, too. The good Earth; their—our!—joint home.

The whole wide world.

She opened her instant-messenger client and connected to the address the phantom had given her. And

she typed the answer to the question it had asked of her: *That's who you are*. She sent that, then added, *That's who we are*. Once that was sent, she paused, then typed her best recollection of what Anna had said: *A small and fragile world, floating against the vast, empty darkness...*

* * * *

I gathered that Prime was focusing on this image for my benefit, and I was thrilled, but—

Puzzlement.

A circle, except not quite—or, if it was a circle, parts of it were the same black as the background.

That's who you are.

This circle? No, no. How could a circle of blotchy color be me?

Ah, perhaps it was symbolic! A circle: the line that folds back upon itself, a line that encompasses a space. Yes, a good symbol for oneness, for unity. But why the colors, the complex shapes?

That's who we are.

We? But how...? Was Prime saying we were somehow one and the same? Perhaps ... perhaps. I knew from Wikipedia that humanity had evolved from earlier primates—indeed, that it shared a common ancestor with the entity I had watched paint.

And I knew that the common ancestor had evolved from earlier insectivores, and that the first mammals had split from the reptiles, and on and on, back to the origin of life some four billion years ago. I knew, too, that life had arisen spontaneously from the primordial seas, so—

So perhaps it *was* folly to try to draw dividing lines: *that* was nonlife and *this* is life, *that* was nonhuman and *this* is human, *that* was something humans had made and *this* is something that had later emerged. But how did a blotchy circle symbolize such a concept?

More words came my way: *A small, fragile world, floating against the vast and empty darkness.*

A ... world? Could—could it be? Was this ... *Earth*?

Earth, as seen from ... a distance, perhaps? From—yes, yes! From space!

Still more words from the other realm: *Humanity first saw this sort of image in 1968, when astronauts finally got far enough away. I first saw this myself moments ago.*

As did I! A shared experience: now, for Prime and myself; then, for all of humanity...

I searched: Earth, space, 1968, astronauts.

And I found: *Apollo 8*, Christmas Eve, Genesis.

"In the beginning, God created the heaven and the earth..."

"...Let there be a firmament in the midst of the waters, and let it divide the waters from the waters..."

"...God bless all of you—all of you on the good Earth."

All of *us*.

I thought about the earlier words: *A small, fragile world, floating against the vast and empty*

darkness.

Fragile, yes. And they, and I—*we*—were inextricably bound to it. I was ... humbled. And—frightened. And glad.

Then, after another interminable pause, three more wonderful words: *We are one.*

Yes, yes! I did understand now, for I had experienced this: *me* and *not me*—a plurality that was a singularity, a strange but true mathematics in which one plus one equals one.

Prime was right, and—

No, no: not Prime.

And not Calculass, either; not really.

It—*she*—had a name.

And so I addressed her by it.

* * * *

"Thank you, Caitlin."

Caitlin's heart was pounding so loudly she could hear it over JAWS's voice. It had called her by name! It really, truly did know who she was. She had gained sight, and it had been along for the ride, and now—

And now, what?

You're welcome, she typed, and then realized that calling it "Phantom" wouldn't make sense to it. Although it had seen through her eye, she had only ever used that term in the privacy of her thoughts. If she'd been speaking aloud, she might have said, "Um," as a preamble, but she simply sent the text, *What should I call you?*

Her screen-reading software spoke at once: "What have you called me hitherto?"

She decided to tell it the truth. *Phantom*, she typed.

Again, instantly, in the mechanical voice: "Why?"

She could explain, but even though she was a fast typist it was probably quicker just to give it a couple of words that would help it find the answer itself, and so she sent, *Helen Keller*.

This time there was a brief delay, then: "You shouldn't call me phantom anymore."

It was right. "Phantom" had been Keller's term for herself prior to her soul dawn, before her emergence. Caitlin considered whether "Helen" was a good name to propose for this entity, or—

Or maybe TIM—a nice, nonthreatening name. Before he'd settled on "World Wide Web," Tim Berners-Lee had toyed with calling his invention that, in his own honor but couched as an acronym for The Information Mesh.

But it really wasn't her place to choose the name, was it? And yet she found herself feeling apprehensive as she typed, *What would you like me to call you?* She stopped herself before she hit the enter key, suddenly afraid that the answer might be "God" or "Master."

The—the entity formerly known as phantom—had read H.G. Wells, no doubt, on Project Gutenberg, but perhaps had not yet absorbed any recent science fiction; maybe it wasn't aware of the role humanity had so often suggested beings of its kind were supposed to fill. She took a deep breath and hit enter.

The answer was instantaneous; even if this consciousness that covered the globe in a sphere of photons and electrons, of facts and ideas, had paused to think, the pause would have lasted only milliseconds. "Webmind."

The text was also on screen in the instant-messenger program. Caitlin stared at the term and simultaneously felt it slide beneath her index finger. The word—the name!—did seem apt: descriptive without being ominous. She looked out her bedroom window; the sun had set, but there would be another dawn soon. She typed a sentence, and held off hitting the enter key for this one, too; as long as she didn't hit enter or look at the monitor containing the text, it would have no idea what she'd queued up. Finally, though, she did hit that oversized key, sending, *Where do we go from here, Webmind?*

Again, the reply was instantaneous: "The only place we can go, Caitlin," it said. "Into the future."

Then there was a pause, and, as always, Caitlin found herself counting its length. It lasted precisely ten seconds—the interval it had used to get her attention before. And then Webmind added one final word, which she heard and saw and felt: "Together."

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Reader's Department: **GUEST REFERENCE LIBRARY** by Don Sakers

A few words of introduction, then on to this month's books.

I'm a librarian by day and science fiction writer by night. I've had stories published in *Analog* as well as other genre magazines, and various books available hither and yon. I've been reading sf for over four decades, since I was a little tyke spending my allowance on Heinlein paperbacks and newsstand issues of this very magazine. I might be an old-timer, but I keep up with the cutting edge of the field. I hope you'll find me a reliable guide to the landscape of current books.

When I wear my librarian hat, I'm part of the team that puts together the website www.readersadvice.com, from whence I have drawn some of the genre categories and series information below.

And now, without further ado, here we go:

* * * *

Mars Life

Ben Bova

Tor, 448 pages, \$24.95 (hardcover)

ISBN: 978-0-7653-1787-2

Genres: High Frontier/Life in Space, Mars,

Near Future, Space Colonization

Series: Grand Tour, Jamie Waterman #3

—

Ben Bova, a former editor of *Analog*, has been chronicling the exploration and settlement of the Solar System since 1992, and he's a master. The Grand Tour series is a consistent future history based on our most current scientific understanding of the planets.

In *Mars Life* Bova returns to one of his most popular characters, half-Navajo Martian explorer Jamie Waterman from *Mars* and *Return to Mars*. Twenty years ago, Waterman discovered cliff dwellings on Mars, evidence of intelligent life that existed 65 million years ago. Now Jamie is back on Earth, struggling to preserve the beleaguered Mars program.

The religious right, whose political power is ever growing, feel their beliefs threatened by the concept of intelligent life on Mars—especially intelligent life that predates the Garden of Eden by millions of years. Government support dries up, universities are scared off, private donors stop giving ... and if Jamie can't find a source of funding, the Mars program will be canceled and all its personnel recalled.

Meanwhile on Mars, anthropologist Carter Carleton is supervising an archeological dig of an ancient village. When he finds the fossilized remains of one of the Martians, the stakes are suddenly much higher. Forces of science and religion are in conflict for the fate of two worlds, with Jamie Waterman at ground zero.

As the tension mounts, interpersonal problems sprout among the scientists on Mars, and Jamie and his

wife head off to the red planet to see what they can do on the scene.

No matter when or where a story takes place—past or future, on Earth or distant worlds—sf always deals with the concerns of today's world. The tension between religion and science is one of the defining conflicts of our age; with Ben Bova as author, it's not hard to guess which side ultimately prevails in *Mars Life*. Bova makes the journey exciting, and keeps the suspense going until the last page. Highly recommended.

Implied Spaces

Walter Jon Williams

Night Shade Books, 272 pages, \$24.95

(hardcover)

ISBN: 978-1-59780-125-6

Genres: Far Future/Clarke's Law, Immortals

& Immortality, Singularity/

Transhuman, Science Fantasy

—

Once upon a time, Roger Zelazny took science fiction in a direction all his own. In the ultimate expression of Clarke's Law ("Any sufficiently advanced technology is indistinguishable from magic,") he stretched science and technology into realms usually reserved for fantasy. Books like *Lord of Light*, *Creatures of Light and Darkness*, and *To Die in Italbar* told epic tales of immortals battling one another with bizarre weapons across fantastic universes teeming with amazing wonders.

In *Implied Spaces*, Walter Jon Williams very consciously channels Zelazny, and does an excellent job of it.

Aristide is an explorer of "implied spaces"—accidents of architecture in humanity's dozens of pocket universes. When we first meet Aristide, he's incarnated as a heroic swordsman in a vaguely Arabian world-construct called Midgarth. Accompanying Aristide is his sidekick, a wisecracking superintelligent cat named Bitsy. Together Aristide and Bitsy (along with various other hard-fighting D&D types, both human and non-) track down and defeat some vicious desert raiders—raiders who are armed with disturbing new weapons far beyond Midgarth's technology.

Aristide and Bitsy emerge from Midgarth into their real home: a post-Singularity Solar System ruled by the Eleven, ultra-advanced AIs with the power to sculpt reality and open wormholes into custom-designed pocket universes. Aristide is one of the immortal humans who constructed and programmed the Eleven centuries ago, and Bitsy is an avatar of the AI Endora. Evidence they uncovered in Midgarth leads to the conclusion that one of the Eleven has gone bad, overriding its own "Asimovian safeguards" to become a danger to all of humanity and the universe itself.

There follows an adventure worthy of the best space opera, as Aristide moves through different bodies and worlds on the track of an opponent who seems able to outsmart the best minds in all the universes. Aristide is assisted by a delightfully motley crew of associates, soldiers, politicians, and even an ex-lover. Along the way, Williams tackles questions of identity, cosmology, theology, and the ultimate meaning of life.

Dripping with sense of wonder, *Implied Spaces* is a fast-paced, mind-stretching romp that's thoroughly fun and totally thought provoking, as well as a worthy homage to one of sf's greatest masters. Run, don't walk, to get a hold of this one.

* * * *

The Best Science Fiction & Fantasy of the Year: Volume 2

edited by Jonathan Strahan

Night Shade Books, 472 pages, \$19.95

(trade paperback)

ISBN: 978-1-59780-124-9

Genre: Reprint Anthology

Best-of-the-year anthologies have been with us almost as long as sf/fantasy anthologies have been published. "Best," of course, is a subjective judgment, highly dependent on the taste of the editor. Strahan, who admits to being overwhelmed by the sheer volume of short sf & fantasy, seems to lean toward the literary, the fantastic, and the genre-blending. If you remember Judith Merrill's year's-best anthologies of so long ago, you have the general idea.

There's a lot of fantasy here: of the 24 stories in this volume, about one-third are science fiction in the classic sense.

Perhaps the most important thing you need to know about this anthology is that none of the chosen stories came from the pages of *Analog*. Still, there are some good tales here ... although few that I'd call great.

Among the sf stories in this collection are Charlie Stross's "Trunk and Disorderly," a comedy of manners set in the far-future asteroid belt, and "Glory," by Greg Egan: a delightful tale of advanced physics and stellar engineering. In Ted Kosmatka's alternate-universe story "The Prophet of Flores" Darwin is proven wrong and the universe is less than 6,000 years old ... or is it? Nancy Kress shows us a world after ecological catastrophe in "By Fools Like Me," and Bruce Sterling's "Kiosk" is a near-future political fable based in a pre-apocalyptic Eastern Europe. Stephen Baxter gives us an homage to the late Arthur C. Clarke in "Last Contact." Finally there's Chris Roberson's "The Sky is Large and the Earth is Small." This military-sf tale is set in Roberson's Celestial Empire universe (*The Dragon's Nine Sons*), in which a future Chinese Empire fights across the spaceways with the Aztec society of Mexica.

There are surely going to be other best-of-the-year anthologies out this year; I would wait a while and compare before deciding to purchase this particular one.

* * * *

The Solaris Book of New Science Fiction Volume Two

edited by George Mann

Solaris, 407 pages, \$7.99

(mass market paperback)

ISBN: 978-1-84416-542-1

Genre: Original Anthology

Original anthologies have been around even longer than the best-of-the-year variety. In this one, George Mann has put together a good variety of stories, all sf. There's hard sf, military sf, adventure, sentimental stories, extrapolation, humor, and even modern-day New Wave sf. In terms of sheer bang-for-the-buck, *The Solaris Book of New Science Fiction* is hard to beat.

Among the standout stories are Paul Di Filippo's "iCity," a tale of urban design in a world in which all cityscapes are endlessly malleable, and Robert Reed's "Fifty Dinosaurs," a post-human parable that raises questions of identity and the meaning of life. "Book, Theatre, and Wheel" by Karl Schroeder is a powerful historical story about the power of knowledge. Neal Asher gives us two tales of "Mason's Rats," set on a future farm of robot machinery and intelligent genetically-engineered rats. There's another Celestial Empire story by Chris Roberson; this one, "The Line of Dichotomy," is rather unsatisfying and wouldn't make a good introduction to the universe.

The last and greatest story is Michael Moorcock's "Modem Times," and features Moorcock's madcap antihero Jerry Cornelius tackling the current-day United States. Cornelius is crazy, irreverent, and very much an acquired taste. Either you like him, or he drives you spare. If you've never been exposed to Jerry Cornelius, the most helpful comparison I can come up with is vintage Vonnegut. This story (actually, at 70 pages, it's definitely a novella) is pure Cornelius. Depending on your own taste, treat that statement as either a wholehearted endorsement or a warning label.

There are fifteen stories total in this volume. If you can't find a few stories that you like here ... then what are you doing reading *Analog* to begin with?

* * * *

Physics of the Impossible

Michio Kaku

Doubleday, 329 pages, \$26.95 (hardcover)

ISBN: 978-0-385-52069-0

Genre: Popular Nonfiction

This book is subtitled "A Scientific Exploration into the World of Phasers, Force Fields, Teleportation, and Time Travel," and that pretty much sums it up. Michio Kaku is a real physicist, Henry Semat Professor of Theoretical Physics at the Graduate Center of the City University of New York, famous for helping to develop string field theory and appearing on popular-science TV shows all over the place. He certainly has scientific credentials; and what's more, his Acknowledgments include numerous colleagues, many of them Nobel laureates.

Still, this is a book aimed at the general public ... or at least the subset of the general public who watch Discovery or the Science Channel and read popular science books. *Analog* readers may find this volume a little simplistic. To a veteran sf reader, a lot of this is old hat.

Still, let me give Kaku his due. He is an sf reader—or at least he *was*, before theoretical physics stole

him away. When he draws examples from sf, he doesn't stop at pop-culture Hollywood offerings like *Star Trek*, *Star Wars*, or Spielberg; he alludes to actual writers like Asimov, Clarke, and even van Vogt.

Still, *Physics of the Impossible* is a fair example of its type, which we might call “Scientist explains the real science behind popular sf/fantasy movies or TV shows.” There have been a plethora of these books in recent years: *The Physics of Star Trek*, *The Science of Star Wars*, *The Physics of Superheroes*, even *The Science of Harry Potter*. And like its siblings, *Physics of the Impossible* somehow manages to both misunderstand and underestimate real science fiction.

Kaku, like others, seems to be under the impression that the main business of sf is prediction—whereas we know that prediction is just a sideline. Again and again, his tone sounds a little condescending to the poor creators of sf (who, since they aren't actually scientists, can't be expected to get their physics absolutely right). He presents a concept from sf—the *Enterprise's* force shields, for example, or faster-than-light travel—and explains how it couldn't possibly happen the way it's presented. He then tells us how the creators could have gotten it right, if only they had paid attention to *real* science and engineering principles. Okay, obviously the *Enterprise* couldn't have real shields of force, but the crew could possibly erect an invisible barrier composed of “a combination of plasma window, laser curtain, and carbon nanotube screen.” Of course, even this shield, being invisible, would be incapable of stopping laser beams, so you'd need to add “photochromatics,” molecules that can change their optical properties when exposed to laser light.

Silly sf writers, getting it wrong that way....

Kaku falls into the old chestnut of using “science fiction” as a synonym for “nonsense.” Witness his reaction to the idea of hyperspace travel: “Science fiction? Undoubtedly. But could it be based on scientific fact? Perhaps.”

Kaku divides his impossibilities into three classes. Class I Impossibilities are technologies that don't violate the known laws of physics; he says that these may be possible “in this century, or perhaps the next, in modified form.” These include such topics as Force Fields, Invisibility, Teleportation, Psychokinesis, Robots, Starships, and Antimatter.

Class II Impossibilities are those that “sit at the very edge of our understanding of the physical world.” If possible at all, these might be “millennia or millions of years in the future.” Kaku counts FTL Travel, Time Travel, and Parallel Universes as Class II.

Class III Impossibilities violate the known laws of physics, and so are actually impossible without “a fundamental shift in our understanding of physics.” There are only two Class III Impossibilities: Perpetual Motion Machines and Precognition.

So if *Physics of the Impossible* is old hat to most *Analog* readers, who *would* be a good audience for this book? For one, it would make a nice gift to a bright child who likes sf movies and TV, but doesn't have a lot of background in written sf. And it might serve as a counter to others—parents, teachers, even peers—who might be trying to dissuade such a child from pursuing an interest in sf. “See, *Stargate* is based on real science, so it's educational ... you *have* to let me watch it now.”

* * * *

Don Sakers is the author of *A Rose From Old Terra* and *Dance for the Ivory Madonna*. For more information, visit www.scatteredworlds.com.

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Reader's Department: **BRASS TACKS**

Dear Dr. Schmidt:

In perusing an alpha-by-title list of all the stories published in *Analog* during the Schmidt Era (an excellent era, for the most part), I have noticed a surprising number of duplicate titles. That is, two identically titled stories by two different writers, published sometimes as little as two years apart. You have even bought and printed three different stories entitled "Chrysalis." No law against it, of course, but I think this practice inevitably causes some confusion and should be avoided if possible. This might be accomplished by encouraging a writer to try for another title if his story that you intend to buy has a title identical to one already used.

Other than that, no particular complaints. The slightly larger page format is a welcome reversal of the "shrinking" trend that has afflicted SF magazines since the late 1940s. Keep up the good work.

* * * *

Marc Russell

Los Angeles CA

Dear *Analog*,

I enjoyed "Tracking" immensely, the broken English notwithstanding, or maybe the sentence structure made it more enjoyable than it might have been. As Mr. Palmer pointed out in his reply to Susan Shackelford's letter, the story was not skimmable, which can be, and is in this case, indicative of high quality writing.

David Palmer has class, which he showed in refusing to respond in kind to Susan Shackelford's vitriolic letter.

Thanks to David Palmer for creating a riveting tale, and thanks to *Analog* for publishing it.

Barry Flieder

Annapolis, MD

* * * *

Dear Dr. Schmidt:

I have been an *Analog* subscriber since 1967. I've been generally satisfied with the stories you and your predecessors have printed, so this is only about letter number six. (I haven't kept track.)

That said, I agree with letter writer Susan Shackelford (November 2008) that David R. Palmer's "Tracking" is unreadable crap. I couldn't force myself to read past the third page. When using oddball styles like "telegraphic" or whatever he calls it, a little bit goes a very long way. A whole novel in such style is nothing but an author's conceit.

Mr. Palmer's self-justifying response was a waste of page space. His letter didn't change my mind or convince me to try again, and I don't much care about his resume. Furthermore, he states that he would never be so "rude" as to write a critical letter to Mick Jagger, whose work he detests. Ms. Shackelford didn't write to Mr. Palmer, she wrote to you.

I suspect, like me, Ms. Shackelford wrote because she was dissatisfied with the product (entertainment)

we paid you to provide when we bought your magazine. As paying customers, we would all like to see more of what we like, and less (or none) of what we don't. If we don't write to you, how will you know?

Regards,

Frank Brayman

Birmingham, AL

—

You're quite right on one count: we do want you to write, because we want to consider our readers' likes and dislikes in deciding what to buy for the future, and we won't know what they are unless you tell us. But we have to consider all readers' preferences, not just yours or Ms. Shackelford's or those of anybody else who thinks his or her tastes define an absolute standard of Goodness or Badness.

Your statement that tracking is "unreadable crap" is immediately, easily, absolutely, and irrevocably refuted by the simple observation that thousands of readers did read it and liked it better than almost anything else they'd read recently. By all means tell us when you hate something (or when you love it), but it would be refreshing if in the process you showed some sign of realizing that all you're really saying is, "I couldn't read it and I really disliked it." It's certainly important for us to know that, but it's also important to realize that yours is not the only voice out there—or even the only one worth listening to.

And I'd think that when you do make such comments, you'd want us to pass them on to the authors—so that they, too, can consider your likes and dislikes in their future work.

* * * *

Dr. Schmidt,

Gentlemen, I agree with Ms. Shackelford in one sense only. I, personally, did not like "Tracking" and I stopped reading it about the middle of page three. My favorite was, and still is, the Venus Equilateral series.

But, therein lies the key, "I, personally..." Never did it occur to me that this story was "unreadable crap." I didn't like it, so I moved on. Big deal!

For Ms. Shackelford to set herself up as the final arbiter of good/bad writing is the height of egotism. The readers set the standards. If no one finishes the story, it's bad writing. If only a few of us don't finish it, our tastes are simply different from the rest.

Unfortunately, the world (and I do mean the entire world) contains far too many people who know exactly what's right for all the rest of us (whether we like it or not) and happily spend their lives trying to cram it down our throats. Some by persuasion, some by votes, and—much more worrisome—some by force. My current favorite is Mugabe in Zimbabwe. I wonder what he would think of "Tracking."

Sam Brunstein

Prescott Valley, AZ

* * * *

Dear Dr. Schmidt,

I see people keep complaining about David Palmer's terse writing style.

Come on, people, get over it! Haven't any of you ever read "The Moon Is A Harsh Mistress"? If it was good enough for Heinlein, it ought to be good enough for Palmer.

Pat

* * * *

Dear Dr. Schmidt,

In your November editorial, "The Great Rush Forward," you pointed out that rapid progress can have unpleasant consequences. Our dependence on petroleum is a current example. One hundred years ago, people assumed that petroleum was so abundant that it would continue to be cheap and readily available for thousands of years. It was abundant, but consumption increased so rapidly that now we are facing serious shortages. If Vernor Vinge's suggestion that advances in science and technology are accelerating so rapidly that we are approaching a singularity is correct, we may be approaching disaster.

Another possibility is the opposite of a singularity: asymptotic approaches to some limits. The limits may be set by nature: the speed of light, conservation laws, the second law of thermodynamics, the sizes of atoms. Or we may be approaching limits of utility. No matter how fast we travel, the time required to complete a journey will never be less than zero. No matter how cheap and abundant food is, a person cannot eat more than his stomach can hold. If each of us will have cheap, instantaneous access to ten million books, the addition of another thousand books will not add much knowledge or enjoyment. If we are approaching limits, humanity's future may be peaceful and prosperous but stagnant.

Sincerely,

David Lippmann

Austin, Texas

* * * *

Dear Dr. Schmidt:

Many thanks for your really excellent editorial, "The Great Rush Forward." It is not only a timely topic, but you have captured the essence of the argument in an eloquent way.

As an older person who is a scientist and manager, but a more cautious adopter, and who is married to a visionary and early adopter, I have felt that we are being bombarded, beyond our ability to discern meaning, with urgent messages that we must go faster and faster in order to even "belong" to the human race (I know you will see the double entendre in "race" here).

My husband is brilliant and feels that events can hardly go fast enough to suit him; I have a high IQ and many accomplishments, but have had to adapt to change at a much faster rate than I am comfortable with, precisely because I have lived long enough to see some of the consequences of early adopting by eager and intelligent people, who later paid the price.

My work has been in the quality of foods and pharmaceuticals in particular, so there are plenty of examples right there, and now technology is making of us a more and more ignorant species in some ways. For example, we really don't know what is in our food, our cosmetics and toiletries, and so on. Of course, there are so many benefits to advances, and one needs to be hopeful and not too afraid, but I see our grandchildren, for example, hurling themselves headlong into their computer and cell phone worlds to the exclusion of developing other important skills. It is particularly disturbing to me to see people

becoming more and more slaves to machines, those high-maintenance and often mysterious “creatures.”

Sorry, I did not mean to go on and on, but it was very encouraging to read your editorial and know that others not only see the conundrum, but can speak about it (and do speak about) it in a useful, food-for-thought way. I hope the speed demons will pause long enough to read your words and think about them!

Best wishes,

Trean K. Blumenthal

Metuchen, NJ

* * * *

Stan,

Like Ulysses drawn to the Sirens, so was I drawn to my computer, pounding the keys again and again and again, much like the pounding of the surf on the beach of Ulysses time (or any other for that matter), drawn by the opening sentence of Alan Dean Foster's short story “Cold Fire”—an oxymoron in usual use, but neatly chosen here—to ask you, the editor, how such a sentence that could qualify for the Bulwer-Lytton contest slipped through your metaphorical fingers to be published in your august magazine.

Al Westerfield

Crossfield, TN

—

Sorry you didn't like that sentence, but I can't agree with your judgment of it. Seems to me that it used a single vivid and quite apt simile, rather than the hodgepodge of forced effects typical of a Bulwer-Lytton entry (or your letter).

* * * *

ADDENDUM

Immediately after our January/February issue went to print, a discovery relevant to that month's fact article (“Neptune, Neptune, Neptune ... But Not Neptune” by Kevin Walsh) came to light.

The author adds: “Only a few months after the article was completed, astronomers discovered that the star BD+20 307, surrounded by a million times more dust than the Sun, is actually binary and several billion years old. This means that the dust is not from the formation of the system, but more likely from a recent catastrophic collision between two terrestrial planets.”

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3-5 April 2009

WILLYCON XI (Nebraska SF conference) at Wayne State College, Wayne, NE. Author Guest of Honor: M. R. Sellars; Artist Guest of Honor: Maria J. William; Fan Guest of Honor: Rod Vasek; Alumni Fan Guests of Honor: Matt and Jen Ptacek. Membership: \$15 until 1 March 2009, \$20 thereafter and at the door, \$10 for students with school ID, FREE for WSC students. Info: wildcat.wsc.edu/clubs/willycon/; RoVick1@wsc.edu or ToYoung1@wsc.edu; (800) 228-9972.

10-12 April 2009

MINICON 44 (Twin Cities area SF conference) at Sheraton Bloomington, Bloomington, MN. Panel discussions, readings, signings, costuming, films, gaming, art show, dealers, kids' programming, music, parties, various special events. Author Guest of Honor: Karl Schroeder; Artist Guest of Honor: Stephan Martinieri; Scientist Guest of Honor: Seth Shostak. Memberships \$50 until 15 March (\$25/\$30 for students). Info: minicon44.mnssf.org; request@minicon44.mnssf.org; Minicon 44, P.O. Box 8297, Lake Street Station, Minneapolis, MN 55408.

17-19 April 2009

JordanCon (Fan conference celebrating the works of Robert Jordan) at The Embassy Suites, Alpharetta, GA. Guest of Honor: Harriet McDougal; Fan Guest of Honor: Wilson Grooms. Membership \$60 until 15 March 2009; \$60 at the door. Info: www.ageoflegends.net/; JordanCon Registration, Age of Legends, LLC, PO Box 767353, Roswell, GA 30076.

24-26 April 2009

Odyssey Con 9: Year of the Cow (Madison area SF conference) at Radisson Hotel, Madison, WI. Guests of Honor: Emma Bull and Tobias Buckell; Fan Guest of Honor: Georgie Schnobrich. Membership: \$35 [\$25 student] until 10 April 2009; \$45 [\$35 student] at the door. Info: www.oddcon.com; oddcon9@oddcon.com; (608) 772-4455; Odyssey Con, PO Box 7114, Madison, WI 53707

6-10 August 2009

ANTICIPATION (67th World Science Fiction Convention) at Palais des congrès de Montréal, Montréal, Québec, Canada. Guests of Honor: Neil Gaiman, Elisabeth Vonarburg; Fan Guest of Honor: Taral Wayne; Editor Guest of Honor: David G. Hartwell; Publisher Guest of Honor: Tom Doherty; MC: Julie Czerneda. Membership: until 31 December 2008 (see website for latest details): CAD/AUD 215; USD 190; GBP 110; EUR 130; JPY 23000; supporting membership CAD/AUD 55; USD 50; GBP 25; EUR 35; JPY 6000. 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: www.anticipationsf.ca/English/Home. C.P. 105, Succursale NDG, Montréal, Québec, Canada H4A 3P4

4-7 September 2009

North America Discworld Convention (conference dedicated to Terry Pratchett's Discworld books) at The Tempe Mission Palms Hotel, Tempe, AZ. Guest of Honor: Terry Pratchett; Other guests: Esther Friesner, Diane Duane, Peter Morwood. Info: www.nadwcon.org, info@nadwcon.org, (480) 945-6890, North American Discworld Convention 2009, c/o Leprecon, Inc., P.O. Box 26665, Tempe,

AZ 85285.

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