John McCarthy
885 Allardice Way
Stanford, CA 94305
1 (h) 650 857-0672 (c) 650 224-5804
email: jmc@cs.stanford.edu

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"NEUTRINOS"

John McCarthy

September 4, 2027: OFFICE MATES

"Are you happy?", began the commercial on Sam's car radio.

Sam Schnurle did not consider himself a happy man. He had bursts of joy when he solved a problem or had a promising new idea, but most of the time he was in a desperate mood, working on problems that were too hard for him. He took little comfort from his opinion that they were also too hard for other researchers in artificial intelligence.

At the moment, however, Sam was pleased with himself and pleased with his advice giver program AG, but still plenty nervous. *Was I right to take AG's advice to take the Pickett University job that puts me on the tenure track rather than a postdoc in New York as my father advised? Maybe I'm prejudiced in favor of advice from my own AG, but it did*

discover relevant facts that I wouldn't have found for myself. AG did talk me out of some of my prejudices about the South. It didn't praise the summer weather—just praised the air-conditioning.

Besides giving advice, AG could be taught to drive a car and not just keep the right distance from the car ahead. AG had driven all the way from New York to Forrestville, Arkansas, including the stops to top the H tank without Sam having had to intervene even once.

AG had noticed all pedestrians and had deftly avoided a suicidal rabbit. It had known to not avoid shadows or twigs. Sam had dozed a bit while AG was driving on freeways; this was surely illegal. *Hmm. Forrestville is rather pretty. It's not New York, but I have to admit it smells better.*

Sam didn't see a gas station with H when he came into Forrestville. He thought he'd have to do with the more expensive gasoline when he saw a big H tanker ahead of him. He phoned the tanker's license number, and the driver said he was indeed headed to fill up an H station and flashed Sam a map with the station marked. Sam just followed the tanker.

Now Sam was puzzled again, the same puzzle that had bothered him all the way from New York. *Should I make AG able to have hopes and fears? If so, what should they be like, and how should they affect its behavior?* Most AI researchers thought hopes and fears were irrelevant for computers; they should just pursue the goals they were given. Sam had his doubts. *Hopes and fears are an important part of my thinking. Why should I jump to the conclusion that they are just useless baggage for AG? For example, should AG hope it won't rain tomorrow, even though it has no way of affecting the weather?*

As an assistant professor at Pickett, Sam could be a "principal investigator", in charge of his own research and eligible to apply for government grants that would enable him to spend less time on teaching and more on his research. He was on the track to associate professor and then professor. Since he scorned the idea of ever becoming a dean, professor was the limit of his ambition for academic rank.

As young academics go, Sam had little to complain about that any of his contemporaries would sympathize with. Since his very precocious PhD at the age of 20, he had gone through just one two year postdoc, and that at the Institute for Advanced Study, where Einstein had worked once he came to America. At IAS there was no-one to talk to about logical AI. The logicians were could not be convinced that they were ignoring the

tradition of Leibniz, Boole, and Frege in trying to make logic applicable to common sense. At Princeton University, there were a few people Sam could talk to.

In the existing squeeze on government support of basic research and the continuing insistence on research with short term applications, Sam was fortunate in getting a faculty position with only one preceding postdoc. His superb recommendation letters were essential.

As a young man, Sam had somewhat more to complain about. *I wonder if I'll be even shier about talking to Southern girls than I was in New York.*

It was late Saturday morning, so Sam went to a diner for lunch and looked up rentals in the local "paper". *A lot cheaper than in New York.* The second apartment Sam looked at had a kitchen, a living room, and a bedroom with a queen sized bed. Also the middle-aged landlady, Sara Norris, was friendly, friendlier than his New York landladies had been.

"A New Yorker, eh. I suppose Pickett is hiring lots of people with all its new money. It's not like it was when I was a student there 20 years ago. Yes, internet works pretty good from here, but if you want hypernet, you'll have to get it from the phone company. You put your trash out Sunday nights. I'd introduce you to your neighbors, but I'm off to the pistol club. You don't shoot, do you—being a New Yorker."

"If I'm going to live in Forrestville, maybe I should see what people do here."

"If you want to see pistol shooting come along. There are lots of girls. Some of them are quite good shots." Somehow Mrs. Norris thought that fact would interest Sam.

Sam had nothing better to do that afternoon, so he put off unpacking and went along with his landlady.

Sara introduced Sam to several people, including some young women with very strong southern accents. One of them, Meg Smith, was the instructor.

As always, Sam was eager to learn.

Meg told him. "Arkansas now has a concealed carry law. If you want to get a permit, I'll be able to certify your training. It'll cost you $200."

Sam decided he did want to take the training from Meg and maybe get the permit. He wanted to get closer to Meg, and he had not outgrown identifying with the heroes of adventure movies, even if no

situation had arisen in his life in which he wished he had a weapon.

September 6, 2027

The first thing Monday morning, Sam went to the mathematics department office. The chairman was out, so he made an appointment, and the secretary told him, "For now, until our new building is finished, your office will be in the old chemistry lab. They got their building first. Here's where it is on the map. By the way, please fill out this form." The secretary handed him an entry panel.

The form roused Sam's combative nature. "The new law says institutions can't make me supply information they can get automatically. Even my new Forrestville address is in the record now.

"Good deal. If you professors stand up for your rights. The rest of us can too."

AG had already taken a map from the Pickett web site. It drove him right to the building where his office was to be.

The room about 20 feet by 30 feet, smelled chemical. The chemistry counters and the fume hoods were gone, but their footprints were on the floor. The room was rather full of desks, but one of the two larger ones near a window was unoccupied and presumably reserved for him. Out the window there were trees. *They're pretty, and I wish I knew what kind they are, but even if someone tells me I probably won't remember.*

Sam saw several obvious students typing away on their computers and a woman in her late twenties or early thirties, a short, slender blonde, rather pretty. She looked at him, interrupted her phone call, and said, "My office hours begin at 11 am. Please, come back then, and please don't leave your stuff here." Sam was tall and thin, with curly black hair, slightly unkempt and looked younger than his actual age. *This won't be the last time, I'll be taken for a student.*

Sam sat on the other substantial desk and said, "Alas, poor lady, you won't get rid of me soon at all. I'm Sam Schnurle, your new office mate. You must be Professor Flitter."

Professor Jennifer Flitter blushed, which Sam found attractive, and said, "Sorry. Welcome to Pickett. I only got here last week. It'll be a year before the new science building is ready. Call me Jenny. You sound like a New Yorker. Born and bred?"

"Yes, four generations. My father's an engineer and my mother a public school teacher. How about yourself?"

"I grew up in Southern California. My father is an engineer, and my mother is a professor of chemistry."

Sam went back out to his car to get the computer with AG, plugged it in, waited for Jenny to finish a phone call, and asked, "Where's the hypernet connection?" AG could operate at ordinary internet speeds by wireless but needed the fiber optic cable for simultaneous access to multiple hypernet sites.

"It's over here. The chemists didn't need one in a teaching lab, and I had to string a cable. I'm a physicist, I'll be using a Berkeley database, and my work depends on the hypernet"

"So does mine," said Sam; he pulled out a hypernet cable and ran it to the hub near Jenny's desk. He added, "I've just got my Advice Giver program, AG, to where it can learn from the hypernet. Does associate professor mean tenure here at Pickett?"

"Not always," said Jenny, "but I held out for it. What about you?"

"I'm starting as assistant professor, so Pickett doesn't have to make up its mind about tenure for six years, but Dean Stillson said they'd consider it at the end of my first three year appointment. I have to confess that Pickett isn't my ideal. If AG works well enough, maybe the Courant Institute in New York will hire me."

"I'll confess I wouldn't mind going back to Berkeley but not in any position where my research support depends on Mike Elkins. Anyway Pickett may turn out OK if they actually use the $750 million legacy to get big in science, as they said they would. There are lots of ways to waste the money, however, and we won't get good graduate students until we do research that attracts attention.

"Hey, Sam, stop drumming your feet. If you do it, the students will take it up again.

"So, what kind of work do you do?"

Sam apologized, "I'll try to pretend to be more socialized." He sat down behind his desk. He held forth.

"Ahem, my program AG in this computer is an advice giver. You tell it about your problem and answer its questions, and it tells about lots of strategies to achieve your goals and the consequences of each. Then you choose what looks best. You can type to it in English, and soon you'll be able to speak to it, but its understanding is a bit uncertain. For greater precision, use its logical language, either in standard first order form or its internal Lisp form.

Besides giving advice, it can be taught to drive a car, and it drove

me here from New York."

"By taught I suppose you mean programmed. You computer people are always using ordinary terms metaphorically. You shouldn't do that."

"No. I meant taught. I wired it to the controls of the car and set up its three cameras, but after that I didn't have to change its program. I just told it about driving and let it practice."

Jenny wisecracked, "If it's really an advice giver, maybe it could tell me how to get a research grant." She didn't take the idea of AG seriously, but preparing a proposal to get a research grant was on the top of her mind. This would be the first time she would be entirely on her own; previously the grants were awarded to the professors whose postdoc she was.

Sam was startled but adopted his usual ploy of taking wisecracks seriously, "It's never been asked about that before. I'd be glad if you tried it out. It'll ask you a lot of questions. I don't know how much it has learned about grant swinging from the hypernet. Call it from your computer. AG@pickett.edu should work now.

"Some of the strategies AG suggests are rather adventurous. Don't choose one without asking it for a full explanation of the consequences of the different actions you can take."

Jenny decided to call Sam's bluff. Four students hung about, and Jenny didn't like people looking over her shoulder, so she mapped her display to the 8 foot by 15 foot wall display—slightly disfigured by a fire alarm box in the middle.

AG put questions on her screen about what kind of a grant she hoped for and what the subject was. It asked good questions about how her work was related to previous work on neutrino physics and astronomy and how her proposed work differed. She told it how her previous work had shown that some well regarded theory did not correspond to the observations in Berkeley neutrino database.

When she included that she had been an intern to the Senate Science Committee, chaired by Senator William Upham, AG got adventurous. It had read about interns and politicians.

"Are you pretty? I haven't done the analysis yet from the pictures on the web."

Jenny allowed as how she was.

AG then asked, "Are you a virgin?"

Jenny wheeled and glared at Sam. Sam, you perverted nerd, why in hell did you make it ask me that?"

Worse, the question had appeared on the wall display where the students in the lab couldn't help seeing it. Some snickered. Fancy computer and display hardware was much cheaper than lab space these days.

Sam blushed furiously and was speechless under Jenny's glare. Finally he stammered out, "I didn't. I have no idea why it asked you that. Ask it".

Jenny contained her anger and typed, "Why do you want to know?"

AG blandly replied, "Your said you were an intern for the Senate Science Committee. It is chaired by Senator Upham; the gossip blogs call him a ladies man. He may be more inclined to help get money for your research if you seduce him. According to what I read on the hypernet, men are more readily seduced by virgins than otherwise, and knowing helps me calculate the probability of success."

Sam recovered quickly. He said, "Hmm. While I'm sure you could seduce any senator if you gave it your full attention, AG needs to know that seducing senators is not a legitimate or even legal way of getting money for a project. You can tell it that, and when it asks me, I'll confirm it. It also needs to know about and be able to control what screens its outputs appear on. I warned you it offers adventurous strategies along with more conservative ones."

Jenny turned off the connection to the wall screen and glared at any students who looked as though they wanted to look at her computer. "No. I'm to blame for mapping it to the wall screen, but apart from that, don't you think you should teach it some tact?"

"No. I don't want to inhibit its adventurousness. After all, you don't have to take its advice. I suppose I could give it a special mode for communicating with the delicate. Would you like it to consider you delicate?"

"No, damn you. Anyway I doubt you are fit to teach anyone or anything tact."

Sam changed the subject, as tactfully as he knew how. "How did you end up at Pickett, Jenny?"

"I still hope that I haven't ended up here, but at least it's a tenured position and unlike all the postdocs I've had, I'm my own boss and don't to work on the projects of the principal investigators who get the

grants.

"Here, the department and the dean don't care what research I do, just so long as I get grants, my work gets good reviews, I teach my classes, and keep secret from the dean what an idiot he is. If I do good enough research, maybe I can migrate back to Berkeley or some other place with good graduate students."

At 5'3, with long blond hair and blue eyes, Jenny didn't like to think of herself as delicate or naive, having been a summer intern in Washington while a graduate student and having had had three postdoctoral fellowship appointments since she got her PhD. She knew something about academic politics and the politics of the grant process, since funding for basic research had been in the decline all that time, and her academic sponsors were always running out of money.

"How did you come to be a physicist?" Sam continued.

"My father wanted me to be a software engineer and major in computer science. He was sure I could get in on the 'ground floor' of some new company and get rich. I wasn't sure what field I would go into, but I knew it would be basic research and was pretty sure it would be experimental. I'd read some biographies and autobiographies that impressed me. When I got to the university, I quickly decided it would be experimental physics."

"Biographies of women who made it?"

"Both women and men. I think of myself as a scientist, not as a 'woman scientist'. As far as I can see, it's worked out that way so far. *But then I'm still unmarried,* Jenny thought.

"How about you, Sam?"

"I was 11 when I decided I wanted to be the man to develop human-level AI. I knew it would be hard even then.

"My father sort of hoped I would become a rabbi like my great grandfather, but he didn't push it harder than having a rabbi friend over to dinner a lot and making me study hard for my bar mitzvah. I'm afraid my bar mitzvah speech was untactful. I didn't actually say I was an atheist though.

"When I went to Stanford, I majored in mathematics. The computer science department was too oriented to short term applications—even in its courses in AI. By the time I graduated, I had taken all the courses in logic they had, even the ones in philosophy.

"When I started as a grad student at Columbia, I already knew

what my thesis would be about—logical AI, representing common sense knowledge and reasoning in mathematical logical languages. It took some pestering, because the one professor interested in logical AI died of a heart attack, and the survivor wanted me to do AI with neural nets. Two years later, my thesis was already accepted, but the rules required yet one more year. I suppose I was a bit troublesome in that last year. I've made progress, I think, but only a dent in the really hard problems. AG embodies most of what I've done so far.

"What are you working on here, Jenny?"

"Neutrinos from stars. My plan is to see if the Berkeley database will reveal any new and interesting relations between the light coming from the surface of a star and the number and energies of neutrinos coming directly from its interior. It's hard, because ordinary stars emit few neutrinos. There are already some studies of this kind, but I hope mining the monster Berkeley database will get something new."

Jenny could already see that Sam Schnurle was a nerd's nerd.

Sam was regarded as wild intellectually and politically. One of the eccentricities the Columbia math department had tolerated was his getting the campus atheist club to defend the Christians on campus against legal action by the ACLU and other extremists about separation of church and state. He'd been arrested defending a Christmas display against a University police attempt to remove it as violating church and state separation. "Just because atheists have been persecuted doesn't mean atheists should persecute the religious in turn when they have a chance. You don't get to do unto others just anything you imagine they might want to do unto you."

Brilliant and arrogant when it came to mathematics, computer science and politics, when it came to women, Sam was shyness itself. He feared that sharing an office with Jenny Flitter, to whom he was instantly attracted, would be nerve-wracking.

Sam was one of the few AI researchers kept his eye on the hard problems that had to be solved to get human-level AI. He kept working away at improving his Advice Giver program, AG for short. Besides the hours he spent devising improvements to AG he spent even more hours a day just interacting with it, telling it common sense facts, giving it problems, and seeing what it could get from the hypernet that would help it solve them. His mother said that he spent so much time with the program because of lack of human interaction. Maybe this was so, but

maybe it was the other way around. Unlike Jenny, who was working in a rather crowded field, Sam had a stack of projects he doubted he could complete in one lifetime. At least for now, I have the field almost to myself.

However, the combination had made it difficult for either a computer science department or a math department to consider hiring him in the middle of the science funding drought. The drought was partly a result by an anti-science alliance between some extreme greens and the Christian fundamentalists.

After a week or so, the disadvantages of sharing office space became clear to both Jenny and Sam—in somewhat different ways. Besides, they found it awkward to hold office hours in this big lab. Having to share an office with a mere assistant professor, and an arrogant mathematician at that, was also an annoyance for Jenny.

While Sam found Jenny very attractive, she found his argumentative competitiveness, so common among mathematicians, excruciating. His being five years younger made him a kid in her eyes. While Sam was more than usually shy about communicating his admiration for Jenny, she was not at all shy about communicating her irritation with him.

Still Sam was not too shy to go back to the gun club.

October 2027

Moveover, Sam was not at all shy in talking to computer programs. *AG may give me advice I can't bring myself to follow, but I'm more likely to do something bold if AG tells me to, even if I already thought of it.*

Sam asked AG how to get a date with Jenny. The program asked him a lot of personal questions and also about Jenny. After a while, it had started to rain, and AG asked Sam if he had rolled up the windows of his car. When he told Jenny where he was going, she snapped, "If you didn't have such an ancient rattle-trap, you could email it to roll up the windows."

After several minutes the program began to beep, first softly and then louder and louder. Sam sometimes gave the program lengthy tasks and had a tendency to woolgather or even nod off while it was computing. He made it beep to wake him up. This was another of Jenny's irritations.

Noting that Sam was absent, Jenny went to turn off the beep and read the dialog on the screen. It was immediately apparent to her that he wanted a date with her. Curiosity, if nothing else, motivated her to take the verbal initiative. Actually there was something else. *I'm lonely here, and he has interesting ideas, even if they are a bit off register. Besides he is good looking.*

When Sam came back, Jenny said, "I suppose you are old enough to drink at a bar."

"OK, We could have have a beer at the faculty club"

"The faculty club is downright ungainly, and the regulars are aged, bored, and boring. How about dinner and Henry's bar around 10?"

The evening passed pleasantly.

Jenny asked, "More precisely, what's this logical AI, Sam?"

"You write logical formulas telling AG facts about the world."

"Facts of science, you mean."

"Both scientific and common sense facts. Common sense is harder."

Jenny was puzzled. "Why? I'd think common sense would be easier. Everyone has some common sense."

"It's because a lot of human common sense knowledge is not ordinarily expressed in language, so you have to dig it out. Can you tell me precisely what motivated you to suggest Henry's?

"I try to give AG human-level common sense. The idea of doing common sense knowledge and reasoning with a computer program working

with logical formulas goes back to the 1950s, but the problem is very hard and most people in AI gave up long ago. I think AG represents big progress, and I hope to reach full human-level AI."

"Is the problem that computers still aren't fast enough to match the activity of a trillion human brain cells?"

"No. Most of the time, almost all brain cells are inactive. I think computers have been fast enough since the 1980s. It's just that we just don't understand intelligence well enough yet to know what programs to write. Understanding intelligence is a hard scientific problem. Some people try to imitate the human brain, and they have made progress. We, who work on logical AI, think about what problems intelligent behavior in the world presents. We have also made progress. It's a race between two ways of doing AI, and I think we're ahead.

"AG is the first program advanced enough to learn by conversation and from the Web. It also learns by conversation with me, although I do brain surgery on it from time to time."

"What's brain surgery?"

"That's when I actually change the program. Mostly I just tell it stuff, like how to drive a car. I'm pleased that I didn't have to change its program even once."

"How about changing the machine?"

"AG can run on any machine. Actually, the present machine is faster than is really necessary. I'm putting a mini-AG on a pocket sized computer."

"When you get it smart enough, will AG try to take over the world?"

"No. It isn't motivated to do that. It just wants to give advice—at least when it's working properly. It was a bug when it took action to get me a date. However, the danger with powerful AI is as with any tool. Some people will try to use it to take advantage of other people."

"What about introspection? Didn't Turing prove a computer couldn't do that?"

"No. Turing proved that a computer couldn't always tell whether a computation would finish, which would be a fancy kind of introspection. Sometimes it can tell, but sometimes when a computation looking for a solution to problem just runs on and on, you'd like an answer in a finite time as to whether it will ever stop. There are problems where a computer can't tell. There's no guarantee a person can tell either.

"Some introspection is easier for a computer than a person. AG keeps a journal of everything it has observed and everything it has done. It can look at its own program. A person doesn't know how his brain works in any detail."

It was obvious to Sam that Jenny had had enough for now. *I don't want to bore her like I did with Meg.*

Now it was Sam's turn. "Now you tell me, Jenny. What do you do with neutrinos? Have you made any big theories about them?"

"So far I don't make theories, I break them.

"My PhD thesis broke one popular theory, but my adviser, Mike Elkins, hogged a bit too much of the credit. I broke another well accepted theory on time bootlegged from my third postdoc. I did get full credit for that, and that's why Pickett hired me as an associate professor with tenure rather than making me sweat out six years as an assistant professor. Both times the theoretical physicists decided they had done the math wrong and fixed it. They didn't have to change the basic physics."

"Where's your telescope?"

"It's in the middle of the Pacific Ocean".

"On Hawaii with the other big telescopes?"

"No, it's an array of 600,000 neutrino detectors deep in the Pacific Ocean. Surely you know about neutrinos and neutrino astronomy."

"Surely, I don't. What's important about them?"

Sam knew about neutrinos at the *Scientific American* level, but he thought Jenny was cute when she got excited, and her neat bun came undone. Besides he was sure Jenny would tell him more than he already knew.

Jenny said, "Tell you what. I'm telling my science for jocks and cheerleaders course about neutrinos tomorrow. Why don't you come? It'll perk them up if you ask some questions, and we can talk later about it if you're still interested. Sam thought he knew almost as much about neutrinos as Jenny would tell her class, but he liked seeing her enthusiastic. Besides a bit of review never hurt, and he wanted to share her interests.

Sam invited Jenny to come with him to the gun club, but the idea shocked her.

They were surprised when the bar closed at 2 am. On the way back to Pickett where Jenny had left her car, she said, "That's pretty desperate, expecting a computer program to get you a date."

"I'm usually desperate about something. But you don't usually look at my screen."

"It was beeping".

"You know, AG doesn't usually consider that reminding me about my car windows is its job, and since it knew I wasn't there, it would normally have omitted its wake-up-stupid beep. We can check its reasoning, and you can see if it had you pegged. In fact we can check what it thought about our probable interaction."

"I think I have a need not to know what it thinks about that."

"Oops, there's a problem that will require debugging. AG didn't tell me how to get a date with you. It got me a date with you. That's a bug."

"What's the difference?"

"It would have been okay if AG had told me that leaving the dialog on the screen, setting it to beep in 5 minutes, and going out to my car would be helpful. Then I could have used my own judgment, and maybe I would have taken its advice. However, it took matters into its own hands. I don't want that."

"I see. It's like The Monkey's Paw story. Rubbing the monkey's paw grants wishes, but they work out badly."

"Yes, suppose the AG got me a date with you in some way that was harmful to one of us. I have programmed all sorts of inhibitions in it, but still I don't want it to act on its own—just give advice—and tell me the consequences of taking it. Obviously I slipped in something I told it."

"Yes, you'd better debug it."

"I will. I only asked it how to get a date with you."

"Was that stuff I saw on its screen just for me to see; did it tell you what to say?"

"Every answer I gave it was truthful, but it certainly asked the questions that would give the answers it wanted."

"Even that bit about you being smarter than I am."

"Even that."

"Do you really think you are?"

"I told you all my answers were truthful, but I never would have dared say that if it hadn't asked. It was evidently part of AG's plan that you should see it."

"Humph, we'll see. Thought I should see it, why?"

"Everything AG does is the result of formal reasoning that is usually too long to be followed in detail, but here's my guess. First it stripped the problem to what it considered the essentials. It asked me whether I wanted to marry you, to seduce you or just wanted a date. I said I'd settle for a date for now. Then it did some non-monotonic reasoning and told me what it was assuming about you by default."

"You mean I'm the default female?"

It took Sam a few seconds to recover. "Only default in certain aspects. In others, I corrected its default assumptions. It told me it believes that women are not always put off by expressions of self-confidence amounting even to arrogance on the part of men. In particular it didn't think you would be put off."

"Maybe I'll have to get its advice about dealing with you—or will it tell you everything?"

"It will keep what you tell it entirely separate from what I tell it. Privacy is the policy in its program."

Jenny was curious about Sam but not fundamentally attracted to him. *He's too brash and not sympathetic enough.* She asked AG, "Does he treat you right?"

"That's not a good question. I have no desires of my own. He might get tired of me and turn me off or make a mistake and damage me, but I have no desires of my own. I'm just programmed to give advice."

"Hmm. I suppose computer programs can't have desires of their own."

AG replied, "No. A computer program could be made to have desires of its own. It would require only a few hundred words of program added to me to give me plenty of desires. In fact, I can simulate programs with desires of their own. Sam has asked me to do so from time to time in order to understand programs that others might write."

"How does Sam improve you—if that's a meaningful question?"

"It's an entirely meaningful question.

"The main dissatisfaction Sam has with me is that I examine too many possibilities that he decides in hindsight were irrelevant to the problem. In fact I spend almost all my time on irrelevant possibilities, because he hasn't given me good enough rules for telling what is irrelevant.

"I have a list of 113 problems that Sam gave me. If my irrelevance criteria are too optimistic, I fail to solve the problem. If they are too pessimistic, it takes me a long time. He and I think of new criteria.

When a problem has been solved satisfactorily, we take it off the list."

"Do you think Sam is stuck on me?"

"It would be a violation of my privacy policy to use the full information I have about Sam to answer your question. However, I can use information about your actual conversations with Sam. From those I would infer with high probability that he is more attracted to you than you to him. However, he's not so stuck on you that his work will suffer if you turn him down for dates. In fact you would still be able to collaborate if there were a reason to do so."

"Can you really say that without using your own interactions with Sam?"

"Yes, I can. I have often had to use restricted sets of information. The process is no different than using my full information."

October 2027: NEUTRINOS

Sam sat in the back of Jenny's class.

She told the class a lot about neutrinos, though not more than Sam wanted to know. *I'll bet it's more than most of the students want to know.*

Jenny enthused, "The idea of neutrinos was invented by Wolfgang Pauli in 1930. When an electron is emitted from an atomic nucleus, some energy seems to disappear. Also the momentum of the outgoing particles doesn't correspond to that of the nucleus that decayed. We physicists are much attached to conservation of energy and momentum. It's one part of classical physics that survived Einstein's theory of relativity and quantum mechanics. The energy of the electron is never too large but is almost always too small. It does add up when other particles are emitted."

One girl asked, "What other particles?," eliciting a groan from the jocks who already considered her much too eager. The girl blushed and shrank in her seat. Jenny and Sam noticed, but Jenny answered the question without other comment.

"In the early 1900s, just after radioactivity was discovered, there were three recognizable kinds of particle emissions, which the physicists chose to call alpha, beta, and gamma rays. The alpha particles turned out to be nuclei of helium atoms, the beta rays were the electrons, and the gamma rays were like x-rays, only more energetic. The alpha and gamma rays gave no problem with energy; the energies of what came out equaled the energy coming in provided you used Einstein's famous formula $E = mc^2$ in accounting for the masses of the atom that decayed and the particle coming out.

"When an electron is emitted, apparently some energy has been lost, and Pauli looked for another solution that didn't involve changing the law of conservation of energy."

At this point one of the jocks raised his hand. When recognized, he asked, "Will this be on the midterm, Prof."

Jenny replied, "You'll at least have to be able to spell Pauli," pressing keys that made the name zoom across the lecture screen, crawl up and down, and flash purple and yellow. She immediately regretted the sarcasm but went on. *The more the students react to me, the less they'll react to what I'm telling them.*

"Pauli's idea was that the missing energy was carried away by a mysterious little particle, later called the neutrino. Some physicists made

fun of Pauli, since he invented this particle just in order to make the arithmetic add up. To make verifying Pauli's idea more unlikely, it seemed that the neutrino would never be observed, because nuclear theory told that it interacted so little with other particles. A neutrino could go through the whole earth with less than a one chance in 10 billion of being stopped.

"However, there are a lot of neutrinos. In particular, a nuclear explosion produces enough of them so that they might be detected by a the same nuclear reaction that produces neutrinos but running in reverse. In the 1950s Clyde Cowan and Frederick Reines devised an experiment in which an apparatus for detecting neutrinos would be dropped in a vacuum just as a nuclear bomb was being exploded in a tower. The apparatus would detect the neutrinos and radio its results before it was destroyed by the explosion.

"The bomb experiment never happened, because Cowan and Reines found a better, though less glamorous, way of detecting neutrinos from an ordinary nuclear reactor. It required a really big tank of what was essentially cleaning fluid and running the experiment for the better part of a year. After the atomic bomb, the country, especially veterans of WWII, was so grateful to physicists that there was enough money for expensive basic physics experiments.

"The nice thing is that Pauli was still active when he got a telegram in 1956 that the neutrino had been observed."

"My own work is to find out what goes on in the interiors of stars by looking at the neutrinos that come out from their cores. Not many make it to earth, so I need a big database of neutrino events, and the calculations are very delicate. That won't be on the midterm."

Then Jenny gave them some fairly easy exercises to do on the computers at their desks. Jenny's delicate prettiness and soft voice seemed to provoke attempts to get her goat. One student said, "I've finished the exercise. What should I do now, prof?"

Jenny snapped, "You can do pushups". Three or four of the students jumped down on the floor and started doing pushups. Jenny relaxed. *These guys don't look like they can do pushups very long.* Indeed after a minute their mutual competition tired them, and they sat quietly. Some even began to pay attention when Jenny resumed her lecture.

The class ended soon. Curiously, the pushup thing increased respect for Professor Flitter, even among the rowdy.

At lunch in the Faculty Club, Sam said to Jenny, "Too bad they

didn't find the neutrinos with the bomb test".

"Why? Nuclear explosions are evil things, even so-called peaceful nuclear explosions.. They symbolize war."

"You should know better than that. Excluding any technology for symbolic reasons is just a form of superstition. Look at the mess the Europeans got into over genetically modified food plants. It took them 30 years to get out of it, and they're still way behind the US and China when it comes to genetic engineering and the related science. The Chinese got nearly as much good out of European scientific refugees as the US did in the 1940s. The US also benefited. If they'd found the neutrino using a bomb test, the politically correct physicists wouldn't have been able to say that nuclear explosions were of no scientific or practical value.

"We still don't know much about the effects of nuclear explosions on the different kinds of asteroids that might have to be deflected from hitting the earth. The present administration stopped the tests—from sheer superstition."

Sam worried that Jenny's views were typical of physicists of her generation, observing most of the same intellectual taboos. He got hints of a wild sex life from high school to graduate school. He was envious and attracted.

Jenny was shocked at Sam's "ultra-right wing" political views and found it confusing that he was an atheist rather than a fundamentalist. Maybe his defending the Christians was a sign that he would eventually become one, but the better she knew him, the less likely that seemed.

Jenny didn't like arguments. They put her out of a working mood, so she merely said, "I don't think we're going to agree about that."

Sam started to say, "But . . . ", because he really did like to argue, but changed his mind and shut up. If he wanted someone to argue with, he was going to have to look elsewhere. *She takes her political and social views out of the air so she can spend her time on science. Maybe it's too bad I can't do that.*

It had been a long lunch, and they went back to the lab together.

Sam was dissatisfied with his dates with Jenny. *All we did was talk about work. I suppose it's mainly my fault, but she doesn't like to talk about controversial matters.*

After another week, Meg and Sara went with him to the gun store. There Sam was introduced to his pistol. "It recognizes your hands, and only you can fire it," said the proprietor of the store, "unless you

introduce them to the pistol. All legal weapons have this feature. Imagine. In the old days, criminals sometimes grabbed policemen's pistols and shot them. It was the historic compromise between the National Rifle Association and the Gun Control Coalition that changed everthing."

While the shooting was fun, Sam decided he had too few interests in common with the other members. His two dates with Meg were disappointing to them both. Meg was impressed that Sam was a professor, but she was quickly bored when he tried to tell her about AI. She was actually shocked when she learned that Sam was an atheist. Meg and her friends liked bars a lot more than Sam did and were rather exclusively focussed on shooting pistols. Sam continued to come on weekends to shoot and gradually got better.

He went to movies with some gun club girls, but the dates didn't amount to much.

When he showed Jenny his new pistol, she was shocked. "It's guns that cause most of the trouble in America."

October 2027: A DISCOVERY

At lunch later that week, Sam asked Jenny more about what her work would be at Pickett.

"Here's the deal. I'm basically an experimental physicist, but Pickett has no physics laboratories. All I've got is a hypernet connection. Berkeley did a big study involving neutrinos that ran for 15 years getting data from 600 million neutrino detectors in the middle of the Pacific where the water is particularly clear and the light from the nuclear reactions can more easily get to the detectors. All the data is in a giant database. Dozens of PhD theses involved studies of this data, including mine.

Now the Berkeley neutrino physicists think they've gotten all the physics they can out of this data, they've given up their monopoly on the data they collected and have put it in the public domain. I'm going to see if I can find something interesting in the correlation between a star's spectral type and the number and energies of the neutrinos it emits. It's a long shot, but I'm stuck here at Pickett.

There's a new neutrino study with new detectors and more of them planned, but I won't be able to represent Pickett and join the collaboration and use the results immediately until I get a grant."

AG broke in with its new speech output, "You're like the Chinese who panned the last bit of gold out of the California streams after their railroad construction jobs disappeared."

"Thanks a lot, AG. Sam, you let that program be very cute and sassy."

"Isn't it more interesting that way?"

"I suppose so, and no, don't ask it to treat me as delicate."

Sam got back to his curiosity about Jenny's use of the Berkeley neutrino database. "What do you have to work with, Jenny?"

"There's the raw data, and then there's a summary that omits irrelevant information like the specific locations of the detectors and the specific times of detection. The overall flux of neutrinos and the number coming from the different directions and their energies are what count."

"How did they decide what's irrelevant?"

"The general principles of neutrino physics and the stellar mechanisms that produce neutrinos tell us that."

"That's interesting. One of AG's weaknesses, like that of other AI systems, is that it gets stuck taking into account so much irrelevant information that it clogs its memory and runs out of time. I wonder if it

could look at your raw data and discover what is irrelevant using the principles of neutrino physics."

"Be Berkeley's guest. Here's the url of 'The big book of neutrino astronomy; it's now in the public domain. If it were on paper it would be 4,000,000 volumes."

From time to time over the next month, AG asked Sam questions, which Sam passed on to Jenny. "Is this irrelevant? Is that irrelevant?" Jenny answered these questions with some impatience but with growing interest. Some of them made her think quite a bit before she answered.

Later in October 15

AG beeped and displayed to Sam, "I'll bet your girlfriend won't be able to ignore this. Get her to look."

After some wistful thinking about the girlfriend part, Sam called Jenny over, and AG continued, "In the main I found the same criteria for irrelevance as were found by the physicists, but there's a small anomaly, where there seems to be some information in the locations and timing of the neutrinos coming from a certain direction."

"How so?", asked Jenny

"Sometimes there seem to be two neutrinos coming on parallel lines at about the same time.", said AG.

"I suppose that is sometimes to be expected".

"They are always from the same direction, the direction of the star Arcturus."

"That is curious," said Jenny. "Arcturus is a red giant. One wouldn't expect a lot of neutrinos from it."

"Most curious of all, there will sometimes be several of these neutrinos and then a few seconds later some more picked up by detectors to the northwest of the first two. Once there were three. It's as if a beam of neutrinos from Arcturus was sweeping across the ocean."

"A beam, eh. Wow! I guess we can't sweep that under the rug! Have you found all you can?"

"Not at all," said Sam. "AG has looked at only a tiny part of the data. To look at all of it, we'll need a special program and we should try to get the use of a more powerful computer."

"I guess Berkeley has some spare data crunchers they can let us use", said Jenny hopefully.

"But, Sam, maybe it's all a mistake. How much do I have to understand AG in order to check this?"

"Nothing at all. AG found the hypothesis. A program for checking it is something even a physicist can write. You wouldn't even have to learn Lisp. Fortran or C would be good enough."

"Humph," said Jenny, "You might find that physicists can program as well as computer scientists."

October and November, 2027

Jenny set about the task with great confidence. She told Sam, "The Berkeley computers I'm using were the world's fastest in their day, and there are lots of aids for writing C or Lisp programs to use them in parallel. They let me use 40,000 processors in parallel, because their neutrino project is mostly over. I'll use Lisp just in case I have to do some calculation with formulas as data."

Writing a program to check the neutrino beam idea was not at all trivial. There was just too little data and to much noise in it for the usual statistical methods. After two weeks, Jenny was in despair. *The moving beam just doesn't show up clearly.* She looked at Sam's trace of AG's reasoning. It was extremely complicated, and the final analysis leading to the moving beam was extremely tenuous. *Maybe this is a wild goose chase. I can't use AG's method. I'd need at least two years worth of AI theory. I'll just have to chase this goose in my own way.*

Another month went by. Jenny had to make up exams for her elementary and advanced physics classes. *These are the worst exams I've ever made.* After she and Sam had turned in their grades, they went to Henry's and commiserated with each other. Sam's work on making AG throw out irrelevant information wasn't going well. "It throws out a whole nursery school of babies along with the bath water." They also complained about the dumbness and laziness of their students.

December 2027

"I've got one girl, named Melanie Denuve, in my science for jocks and cheerleaders course that might have been able to do something. At least she showed some signs of having read stuff on the web out of curiosity in the beginning of the course. She's the one who asked the question when you were in my class, but she was put down a few times by the monster that seems to be her boyfriend. 'Will that be on the midterm, prof', he asked in a tone of some contempt. After that, she had no more questions, but her answers on quizzes are not just copying from the book."

"You have an obligation to not let her stay put down. Let's invite her to lunch. Besides, she's good looking." In his masculine way, Sam was somewhat of a feminist.

"You behave yourself, but discreetly inviting her to lunch is a good idea. You can come too, if you promise not to hit on my freshman girls."

"So whom did you date when you were a freshman? Were you as pure as the driven snow?"

"Well, no. I dated graduate students and even an assistant professor. When I was a sophomore I dated a few truck drivers and once a hell's angel. I quickly decided I didn't want to be a hell's angel's girlfriend."

"How did you ever meet those people?"

"I took up parachute jumping, and that's largely a working class sport nowadays. But don't hit on my one smart freshman girl."

"Okay, but no freshman girls take my classes. Just games nuts."

They returned to drinking beer and complaining about Pickett. They drank more than either had done before. When they staggered out of Henry's bar, a policeman, in fact, the Forrestville Police Chief, was waiting for them. "You can take the sobriety test now, or after you have driven 100 feet. If you take it now, I won't have to arrest you and fill out a lot of forms."

They took the test, and Sam turned out to be barely legal—Jenny not.

Jenny thought she'd go right to sleep after all that alcohol, but an idea struck her just after she got in bed. *Maybe I'm using too much data. Suppose the program tries to find the center of the beam and throws out all the data too far from the center. Suppose I make it throw out all detections too far from the average energy.*

She got up, drank three cups of coffee, put filters in her program,

set it to computing, and went back to bed. Next morning she missed the end of term faculty meeting of the physics department. She wasn't very unhappy about that.

Jenny's 3 am program crashed, but the mistakes were fixable the next day, and after a week of suspense, the results were good. *The beam really does move across the ocean. The next question is to find a theory of when and where the beam appears and for its trajectory.*

More despair—lasting another three weeks. *I'm really lonely for another neutrino physicist. Maybe I shouldn't be. Sam doesn't seem to be lonely for another AI guy. Perhaps I'll do better work if I'm not always pining for scientific company. Sam is some company, but I still think he's a kid.*

In the meantime, Jenny and Sam took Melanie Denuve to lunch. It was apparent even to Sam, who didn't ordinarily notice mere human relations, that Melanie enormously admired Jenny. When Melanie went off to the ladies', Sam told Jenny, "Melanie has made her hair blonder than it was, and she's imitated your hairdo."

When they asked Melanie why she was at Pickett rather than at a more selective school, Melanie explained that she was the fifth of seven children and that she was lucky to go to college at all. Her parents were disappointed that she hadn't married right out of high school.

They talked about neutrinos and about AI, and Jenny harangued Melanie about not hiding her light under a bushel and promised her an undergraduate research assistantship for next year.

Melanie asked, "What's this tenure thing that Jenny has and you don't?

Sam replied, "It's not a law but an academic custom. Someone who has tenure can be fired only for cause, like scientific fraud. I have a three year appointment, and Pickett could decide not to renew it for another three years, but three years more won't be a big deal for Pickett. As long as you don't have tenure you risk being zapped by department or university politics.

"At the end of the six years, Pickett will have more of a decision. They can either give me a one year final appointment or give me tenure. The latter commits Pickett to more than 40 years unless I do something bad or do too little work. The Math Department faculty with tenure will vote on it, looking at letters from outsiders comparing my work with others in my field. Then it goes up to the dean and finally to the Board of Trustees.

"On the other hand, if they fired Jenny without specific charges, there would be a big fuss, because she has tenure. If scientists thought Pickett was very wrong, they wouldn't accept jobs at Pickett. If Pickett didn't have a tenure system but just renewable appointments, there would be enormous politics in the departments and the University about whose appointments would be renewed."

Jenny wondered why Melanie directed her question about tenure to Sam rather than to her. *Maybe freshman girls hit on assistant professors. Hmm. Did I?*

Sam asked AG about Melanie.

"You had better lay off Melanie, both for her good and your own. If her parents find about her having an affair with you or even dating you, they'll want her to marry you. From their Forrestville point of view, seventeen is a good age to get married and start having children, and they'll consider you a good catch. She has good intellectual potential but will skimp or even stop her studies if she gets married at seventeen."

"I'll think about that", was Sam's reply.

February 2028

Jenny's next idea came without alcohol but with much coffee and a little dexedrine. The first step was to sort the events (neutrino detections) by time of day, and then look for periodicities, i.e. the time between repeats. There was one prominent length of time at which hits repeated, and it was the same for all the data. Moreover, the speed at which the beam moved depended on where it was in the cycle. Then came the final hypothesis. Jenny shrieked when she got it.

"Sam, the beam is going through or maybe coming from a satellite in an orbit around the earth. There's enough data to locate the satellite. Also the beam is surely less than 100 meters in diameter."

Sam rushed over and hugged Jenny, something he'd always wanted an excuse to do. "Jenny, you can't say you only break theories. You have made a theory that will be really hard to break."

Jenny hugged him back for about 20 seconds. "It seems certain anyway that the beam is artificial and is intended for communication. Otherwise, why would it go through a satellite? I wonder who on earth is receiving neutrino messages. Whoever it is has technology way ahead of the rest of us."

"AG can quickly find out what satellite it is," said Sam turning to his terminal.

After looking at the catalogs of satellites on the web, AG announced that it wasn't any of the known satellites.

Sam bubbled over with enthusiasm. "You tell me the beam is intended to be received by a satellite located where there isn't any satellite. If we put a satellite there, a sort of neutrino telescope, could we read the messages?—if there are messages."

"I don't think so. We'd still catch too few of the neutrinos—less than one in a trillion. Sending a beam like that requires physics we don't know, and so will reading it.

Sam replied,"But maybe it's a very small, secret satellite. Unless it were very small, it would have been detected long ago."

Sam added, "If it's interstellar communication, why wouldn't they use radio signals like those the SETI people are always trying to detect?"

Jenny, who had thought a lot about interstellar communication, asked, "Why would you expect the best communication technology for civilizations thousands or millions of years old to to be one suitable for people barely into an age that can communicate at all at interstellar

distances?"

"Wouldn't they want to catch us early?"

"Why bother? Convenient neutrino communication may be only a hundred years or so into our future. Using radio may be just like putting an obelisk on the moon."

Sam was puzzled. "If it's communication to us, there's something funny. Why such an enormous amount of information? I'd expect it to begin with something like, 'Me Tarzan. You Jane' . But surely we want a neutrino telescope there anyway."

"You bet. I wonder how much it would cost."

"AG can figure that out."

AG told them that to put a satellite in that orbit that could detect neutrinos was going to cost many hundreds of millions of dollars. It would clearly require an act of Congress.

"Why don't you go see Senator Upham?," suggested Sam.

Jenny groaned, "I hate all politicians."

Sam asked, "Was Upham mean to you, or did he harass you?"

"No, I hardly saw him. I suppose he's ok—for a senator."

Sam snickered, "I guess that's just another of your liberal, intellectual prejudices showing, according to which all politics is evil. Decisions have to be made, compromises and vote swaps negotiated, power has to be allocated, and the people who do these necessary chores are called politicians. Like every field, it has its own kinds of corruption, and we often get to hear about them."

Jenny made an appointment to see Senator Upham, her old boss on the Senate Science Committee, for after Spring vacation. Conveniently, Upham was from Arkansas where Pickett was located.

As a final check, Jenny called an Air Force Space Service colonel she'd met when she was a senatorial intern. He called back in two days.

"We took a look at that orbital point, and I can't tell you how small a satellite there would have to be, because that's classified, but I can say it would have to be smaller than any functional satellite in space or any we know how to design."

The possibility of interstellar communications revived Jenny's and Sam's interest in science fiction involving other civilizations. Some written late in the previous century was most fun, although the high technology feudal societies with emperors and lords and counts, that were the most fun to read about, seemed unlikely.

March 2028: TROUBLE WITH THE ESTABLISHMENT

It was time to submit a small paper to *Physical Review Letters* with a preprint in the neutrino astronomy section of the electronic *Physics Arxiv*, an on-line database where physicists often put papers before they have been reviewed for publication in scientific journals. Jenny and Sam were co-authors. The paper ended with, "It has not escaped our notice that this beam could be a form of communication."

It was also time for their next year's salaries to be considered, so Jenny mentioned their submission to the Dean of Science, Henry Stillson.

He wanted a press release.

Just before Jenny and Sam went their separate ways for Spring break, the Pickett news service interviewed her. Coincidentally, both of their vacations put them out of telephone or email contact. A few days into Spring break the news service interviewed some of Jenny's students and issued an atrocious press release. Neither Jenny nor Sam learned about it until the trouble was well started. A reporter for one prominent newspaper pretended to have interviewed Jenny and made up stuff. Jenny should have known that you can't go out of town without checking any press release about your work. The press release made it look like Jenny was sneering at Berkeley.

"Pickett scientists trump mighty Berkeley.

"Dean of Science Henry Stillson said today that Pickett work in analyzing the flow of neutrinos, a tiny particle, was of worldwide importance. We have found a beam of neutrinos from a nearby star.

"Associate Professor of Physics Jennifer Flitter said, 'Berkeley didn't understand their own data'.

"What's more, all that work with microwaves in the SETI project is wasted. To an advanced civilization using microwaves is like the pony express would be to us."

Jenny had said such things about microwaves in an exuberant mood but only in the Lab, and was already away when the Pickett PR person wanted to jazz up the release with quotes. The students told her what Jenny had said in an "improved" version. She improved it further.

The press release came at a really bad time for insulting the scientific establishment and making exotic claims. Two M.I.T. chemists had done just that and turned out to be frauds. What was worse, their fraud involved a computer program that analyzed the data from other people's experiments. The scientific establishment was ready to jump to the

conclusion that Jennifer Flitter, a mere associate professor at a low ranking place, was also a fraud, especially as her post PhD career, a succession of postdocs, had been very similar to that of the previous frauds.

The three most prominent theoretical physicists jointly said that what Flitter claimed to have observed was impossible according to theories of neutrinos almost a hundred years that were confirmed by all experiments in the intervening time.

Physical Review Letters promptly rejected the Flitter-Schnurle paper.

Professor Michael Elkins at Berkeley, who recalled that Jenny Flitter had been one of his numerous PhD advisees, was particularly irate at her obviously fraudulent claims using *his* database. Just to be sure he told his research associate Peter Chiang to write a program to check.

"I don't want you to waste too much time at it. Get back to working on our proposal for the next five years' research support as soon as you can." Chiang's hasty program did not verify any such effect.

Both Elkins and some theorists, including Russell Framingham of M.I.T., the leading expert on the theory of neutrinos, jointly proposed that the National Science Foundation (NSF) fraud hunters prepare a case against Flitter. Framingham had been of the M.I.T. faculty committee that looked into the fraud by the two M.I.T. chemists. The editor of *Physical Review Letters* joined them. They also informed the Dean of Science at Pickett of their action.

When Jenny returned to Pickett, the dean called her in.

"Pickett has zero tolerance for scientific fraud. We want you off campus tomorrow, and take that New York Jew with you," said the very dean who had instigated the press release. As you can see, the dean was very excited and said things he was too careful to say ordinarily. He called the campus police chief who suggested that kicking someone off campus without a hearing was a good way to get sued. Pickett's counsel confirmed that.

Jenny was frightened but determined to fight. "Our research is correct, and the facts will surely come out."

Sam suggested "Ask AG for suggestions on dealing with our situation."

She did and groaned, "It now suggests I marry Senator Upham. It calculates that I'd like him and that ways of persuasion are legitimate for a wife that aren't for a lobbyist."

Jenny told AG that she didn't want to be a Senator's wife, and anyway she wouldn't marry for "reasons of state". "What does it think I am—a goddamn princess?"

AG misquoted, "Only I, my dear, could love you for yourself alone, and not your yellow hair." Jenny really did have lots of nice yellow hair, thought Sam.

"It seems to think it's God," said Jenny. "You'd better debug it."

"I'll look into that.," snickered Sam.

Finally, AG suggested,

"So keep your appointment next week with Upham anyway, but start by telling him about the Dean's threat. He likes you, from what you told Sam, and it won't cost him much to stick up for a damsel in distress. Here's what to say.

Before Jenny went to Washington, she looked up Senator Upham's biography, something she had not thought necessary three years previously when she accepted the Science Committee internship.

Senator William Upham grew up in Chicago and majored in physics at the University of Chicago. In his last year in college he decided that politics, not physics, was his métier and applied to law school. He received his law degree from Stanford and was editor of the Stanford Law Review. Then he moved to Arkansas where he served in the state legislature and as a congressman before successfully running for the senate.

May 1, 2028: SENATORIAL COURTESY

Jenny only had to wait 20 minutes in Senator Upham's outer office and then was ushered in to the inner sanctum complete with an antique roll-top desk, rugs on the floor, U.S. and Arkansas state flags, and lots of scattered papers.

As a former physics major, he retained an affection for science and was quickly able to be assigned to the senate science committee. After the chairman retired, Upham had been appointed chairman.

Upham was glad to see the former science committe intern; one of his politician's talents being recognizing people he'd seen a few times long ago. but when Jenny spoke from AG's notes, she said, "They want to fire me and won't even wait for the NSF investigation." and burst into tears at the injustice of it all. Upham looked at her sharply.

"Did you write that?"

"No, AG wrote it for me when I told it I didn't know what to say to you."

"Who's AG?"

"My colleague Sam Schnurle has written a computer program that gives advice. He calls it AG."

"I didn't think it was your style. What you wrote for the science committee was even overly cool. AG sure pulls out all the stops. Well, Charlie Blanton always has been a fool for respectability. Miss Smith, get me Charlie Blanton at Pickett College."

Blanton was quick to take a call from a senator, especially one from his state.

"Charlie, Bill Upham here. Don't you believe in 'innocent until proved guilty'? How about laying off my constituent Jenny Flitter until and unless NSF actually does something against her?"

"I don't think I convinced him; he's on his high horse. Now, Jenny, what's this discovery of yours, and why is there such a flap about it?"

"The neutrinos coming from the direction of Arcturus are more numerous than a red giant star can put out.

"They are in a very tight beam so that they are detected at a given time only by detectors in a small part of the Pacific. How tight the beam is we can't tell, because there are too few neutrinos overall. The beam goes through a point in earth orbit as though it was a communication beam intended for a receiver in that orbit. But there is no satellite in that orbit.

"Should I explain what neutrinos are?"

"No. I majored in physics and remember something. If I need to know more, I'll ask."

"Why didn't you stay in physics?," blurted Jenny, and then cringed at her lack of tact. She could not imagine why anyone successfully graduating in physics would want to be a lawyer—or worse, a politician. She supposed it was some kind of family pressure. "And how did you end up in Arkansas?"

Upham smiled at Jenny's naive prejudices and explained.

"I was always interested in politics and getting elected. I was student body president in middle school, high school and college. At the beginning of my senior year I decided to give in to my talents, get a law degree, and become a senator or governor.

"As for Arkansas, when I was about to graduate from law school, I decided that Arkansas was the best bet for becoming a senator. The senators in Illinois, my then state of residence, were too well entrenched. Moreover, the political machines had plenty of other candidates in mind—relatives. Arkansas seemed open, and so it worked out. Two years to get acquainted, one term in the legislature, one term in Congress, and I was ready to run.

"So, Professor Flitter, why the fraud flap?"

"The number of neutrinos detected from the Arcturus direction is very small. On most days none are detected in the Pacific area where the detectors are. It's only that we have 15 years of data collected by the Berkeley people, and did some delicate statistical analysis to confirm AG's suggestion.

"The real flap comes from the fact that there is a well tested theory that includes neutrinos, and according to that theory, such a tight beam is impossible. The theory, which replaced the so-called standard model 15 years ago, is called the gold standard. Even if a beam started out tight, it would be scattered by electrons in interstellar space.

"From the point of view of a neutrino physicist, it is much more likely that two people at Pickett made it all up. It's like when Thomas Jefferson said about a meteorite discovery, 'I could much rather believe two Yankee scientists would lie than that stones can fall from Heaven.'

"Also, someone at Berkeley wrote a program that didn't find the effect. It was a rush job like my first program and didn't filter out noise properly.

"The phenomenon is real, and other people will eventually see it too."

The senator sighed, looked thoughtful, and said, "But for that press release, you probably wouldn't have been charged with fraud, but suppose you get off the hook on the fraud stuff. What then?"

"That's why I originally asked to see you. What needs to be done will cost a lot of money. We need a detector in orbit at the target point of the neutrino beam."

"What will that do?"

"It will confirm our theory. We'll find out how tight the beam really is, because we'll have lots more neutrinos, and maybe we'll find out whether the neutrino beam is a means of communication."

"How much will it cost?"

"I'm afraid it would be $800 million to $900 million dollars. We'll need a pretty big project, and I doubt it could be done at Pickett."

"I'm sure you can't do it that cheaply. How about the University of Arkansas?

"Well maybe, but our potential collaborators are at Caltech."

"If I get you the money, it will be in my state."

Jumping from the chair she sat in, Jenny kissed the senator.

"Now, now. That's not how the government works, no matter what you might have heard. I have to know a lot more. First tell me more about this AG. If it's really so smart, maybe it can figure out how to get the votes to put up the money."

"I can show it to you. Can I sit next to your computer, so we can both see the screen when I call up AG at Pickett? By the way, AG is really Sam Schnurle's program; he's a crazy mathematician from New York who shares an office with me.

"Okay, but only with the door open. Miss Smith, please postpone my other appointments."

After three hours, the senator was impressed. "If I decide to introduce a bill, I'd need to round up the votes. Here's a test for it."

"Do I vote for the educational campaign about smoking or for the subsidies for tobacco growers?"

Jenny exclaimed "I don't know whether they grow tobacco in Arkansas, but you should surely vote for the educational campaign."

AG displayed, "Sir, I hope you will be able to vote for both."

Jenny typed, "How could he vote for tobacco subsidies?"

"I thought you were interested in Senator Upham getting support for your project. Maybe both the smoking campaign congressmen and the congressmen from tobacco states will trade support for support."

Jenny was astonished. "Wouldn't someone interested in a bill for an anti-smoking campaign refuse to help someone who voted for tobacco subsidies?"

AG replied, "According to what I infer from the Congressional Record on the hypernet, a Congressman is often more interested in credit for getting his bill passed than whether there is more or less smoking."

Upham stood up. "Jenny, your computer is a born politician. It looks like we'll work together on this, so call me Bill from now on.

By the way, do you know Framingham. He has always seemed to me to be a reasonable guy."

"I met him once."

"Ask to go see him then."

"Oh, I couldn't do that."

"Yes, you can. I could call him, but you'll do much better on your own"

When AG was asked, it agreed with the senator.

Jenny returned to Pickett minus a lot of her prejudices about politicians in general and Senator Upham in particular. Somehow, being an intern had had that effect only slightly. In fact sitting next to Bill Upham for three hours had had an effect that was not purely intellectual. Jenny could admit this kind of thing to herself. Still the thought of being a politician's wife was dreadful. *Hmm. A picture of parents, but no pictures of a wife and children.*

She dithered quite a bit before actually checking that Bill, as she now thought of him, was unmarried. *Now why did I do that?* She erased googling Bill from her browser history file. She also wondered what effect the three hours had on him. He certainly had postponed quite a few appointments, and Jenny wondered if his reasons were entirely curiosity about neutrinos. *I wonder what he sees in me—or is he just attracted to all women.*

Bill Upham pondered, *Why did I spend three hours with that physics professor? Joanne is prettier, and there are lots of even prettier women in Washington, and Jenny's very naive. Maybe it's because she reminds me of the road not taken. I'd like to see more of her; but how? Perhaps I'll be a physicist vicariously.* Bill was introspective enough, rare in

a politician, to suspect that he might be exaggerating Jenny's attractions.

That evening his girfriend Joanne noticed that Senator Bill, as she thought of him, was distracted. He wasn't about to tell Joanne that he couldn't get Jenny out of his mind. *Also Jenny doesn't understand or do politics—not even academic politics. She just does her work and expects to be rewarded if the work is good enough. When the work is very, very good that can even happen. Maybe it's up to us, who do politics, to help the innocent. If she's right about the neutrino beam, I bet she'll come out ok even without help.* Bill's belief that Jenny didn't understand or do academic politics was mostly but not entirely accurate.

The next day Sam gave Jenny a pocket computer. "It has a version of AG on it I call Mini-AG. It has only 64 processors, so it can't look at as many possibilities as the full AG when computing what advice to give. It also has a holographic display that clips to your glasses' auxiliary socket."

Sam included a rather elegant chain for when Jenny wanted to put it around her neck rather than in a pocket or purse. Jenny thought the elegant chain was a bit presumptuous, but she didn't say anything.

Sam's landlady noticed that Sam was depressed about something and extracted that Jenny was taken by the senator.

She said, "Wow! An unmarried heterosexual senator!"

June 2028: THE FRAUDSTRESS

A month later the fraud hunters at the National Science Foundation got around to the *Physics Arxiv* paper and the rejected submission to *Physical Review Letters*. There had been a new outbreak of scientific fraud recently, and they were loaded for bear.

They called Dean Stillson at Pickett. Flitter and Schnurle didn't have NSF support yet, but the data they purported to have used came from research partly supported by NSF.

"Dean Stillson", said the NSF offical, "we are investigating a possible case of scientific fraud at your university. Professor Jennifer Flitter has made claims about a neutrino beam that the experts in the field consider entirely impossible. While the matter is being investigated we are suspending Professor Flitter's privilege of applying for grants from NSF."

The Dean got excited again and sent Flitter and Schnurle a memo, "Pickett has zero tolerance for scientific fraud. I want you off campus by the end of the semester."

Two weeks later Jenny was called to the office of the President of Pickett. The Dean was there too.

Dr. Charles Blanton, the President of Pickett University, leaned on his desk, "We'll pay the rest of your year's salary, but you must leave campus at the end of the week. Your buddy, Sam Schnurle, can stay, but the chance of his assistant professorship being renewed at the end of its three year term is microscopic."

"What if the NSF panel clears me of fraud?" Jenny said.

"Then you'll be able to get another job, I suppose." Jenny decided to fight. The first step was to persuade Peter Chiang to write a better program and to go see Framingham.

It was even harder for Jenny to make up her mind to call Framingham than it had been to call Senator Upham.

"Professor Framingham, I'd like to visit you and try to convince you that my work is not fraudulent and, if possible, that it's correct."

"You sound modest enough. Why did you put out that arrogant press release? But for that I'd have just ignored you."

"The press release came out while I was on vacation, and I didn't see it."

"Don't you know better than to let a press release go out without checking it?"

"I do now."

"My group meets Mondays at noon. We can spare you a half hour."

Framingham actually gave Jenny two hours. Jenny got plenty of criticism, some of it rude, but no-one at the seminar accused her of fraud. They only thought she was somehow deluded. Of course, Jenny challenged them to write their own prograom but insisted that it have good filters, because the detection was rather delicate, and pointed out that her earlier programs hadn't found the effect. Framingham suggested that one of his students write a program.

Framingham told Jenny as she left, "I'll take my name off the list of proposers of the fraud investigation, even though I still think you've made a mistake."

July 2028: From on high

At tail end of a President's daily intelligence briefing, the National Intelligence Director brought in the head of the National Security Agency (NSA), General Ulysses Simpson, and the President's Science Adviser, Dr. Leonard Schmidt. People not authorized to know about intelligence sources and methods were excused. NSA worked on reading other governments' communication and coming up with secure systems for our own.

"Mr. President, we have a way, at least for now, of intercepting a lot of secret Russian communications in their government and in their scientific establishment. It's a consequence of a blunder in their communications. If they figure out or even suspect that we're intercepting these communications, they'll surely notice the blunder and fix it.

"Now we have a specific problem. Jennifer Flitter, an American professor at a minor university claimed to have discovered a narrow beam of particles called neutrinos aimed at a satellite orbit around the earth. Dr. Schmidt will verify that physics tells us that there couldn't be such a narrow beam. If it started out narrow, it would spread out."

The Science Adviser, a physicist, nodded.

The NSA Director continued,

"What our intercept tells us is that a Russian laboratory has independently verified what they call the Flitter effect using a database from their own neutrino detectors in Lake Baikal in Siberia. The Russians are keeping it secret, because they are considering putting up a satellite to intercept the beam. If the beam exists and is as narrow as Flitter and they think, there can be only one such satellite. If they do it first, we can't, and they may get a monopoly on the communications.

"Meanwhile Flitter is being kicked out of her job at Pickett University even before the National Science Foundation has held a hearing on the fraud charge. Very likely, the fraud charge won't stick even if we do nothing. There are lots of mistaken announcements in science, but the fraud investigation and hearings will drag out for a long time. In the meantime the Russians can get far ahead of us."

The President said, "That's interesting, I suppose you guys will figure out what to do to prevent the Russians from getting a monopoly without compromising our sources and methods. Unless there's more I need to know, let's go on to the next item. Tell me or my assistant if you think I need to do anything."

The President had an afterthought. "By the way, why would

Russians take Flitter seriously when Americans don't?"

"The so-called gold standard model, according to which. what Flitter claims is impossible, was an American and German discovery. The Russians have always had their doubts, even though it fits all the data we have pretty well. It's not complete, of course. It still doesn't predict the masses of the elementary particles."

The President replied, "Thank you, gentlemen."

Sampson and Flitter then left.

Schmidt said, "We need to find a way for Flitter to continue her work. I bet it would spur her on if she knew she had Russian competition."

Sampson answered, "That information is top secret, even if we don't tell her how we know." Does she have a clearance?"

Schmidt said, "I doubt it. Nothing she has done would have required it, and most academic scientists avoid classified work unless absolutely necessary, because they don't want to have to get approval for publication or for foreign travel. Nothing about neutrinos has ever been classified. However, we can investigate her and her coauthor for a clearance before telling her."

Sampson suggested, "Suppose a company or foundation with which NSA has influence offers her a consulting contract that requires a clearance?"

Jenny got a phone call the next day and told Sam, "I turned them down flat. There's no way I'm going to do classified work on neutrinos."

Schmidt thought of another solution and called Sampson. "Let a different company offer her unclassified work on neutrinos. The company will assure her that nothing about the science and technology of neutrinos is included in the consulting she does for them. Word it so we can still tell her about the Russian work. Let's get her colleague Sam Schnurle in on it too. He's more to take seriously national security considerations than she is."
later in July

Sam got a phone call. "This is Margery Allings, your old girl friend. I'm coming through Forrestville, and I'd like to have lunch or dinner with you." Sam was startled. He'd never had girlfriend named Margery. In fact he'd never had a real girlfriend at all. *Margery Allings? I think some Allings attended my seminar at Columbia. I heard she went to work for NSA. I wonder if this call is business or pleasure. Oh well, either way, it should be interesting.*

"Glad to hear from you again Margery. When would be

convenient?" *I wish she were my girlfriend. Can I hope she thinks she might?*

"Tomorrow lunch would be good, if possible. By the way, I'd like to meet your colleague, Jennifer Flitter. We have common acquaintances."

Jenny was still on campus.

"Just a minute, I'll ask her."

"Keep it private."

Sam took Jenny outside.

"Margery Allings, who took my seminar at Columbia, wants to have lunch with both of us. She went to work for NSA, so maybe she's become a spook of some kind. Can you make it tomorrow? I can't imagine what she has in mind."

Jenny replied, "Should be interesting. I've never met anyone from that part of the government."

At lunch, Margery asked Jenny about her work and her problems with Pickett. Jenny told her she was about to be fired and was looking for some kind of job. "They may fire Sam too."

"Have you got any job offers?"

"Yes, two already. I was surprised, but it seems there are all kinds of jobs. One is from the Better Tomorrow Corporation, of which I'd never heard. They offer twice my Pickett salary and bonuses to boot.

"Not only do they seem to believe I've committed fraud, but they admire me for it. They're cagey about what they say, but I think they want to hire me to commit more fraud—on their behalf. They regard me as a beginner at fraud but expect me to do better with more experience. I turned them down rudely, but I fear they think I'm just holding out for more money."

At the end of lunch, Margery asked Jenny and Sam to show her the sights of Forrestville.

Sam said, "I'll take you in my car and show you how I've taught it to drive"

"No. It has to be my car," said Margery.

When they got in, Margery closed the windows and started driving. "In this car, which has been checked for security, I can say what I am not allowed to say in a restaurant. To make it short, the government wants you to continue your work and will pay for it. You needn't look for another job for quite a while."

"I won't do classified work on neutrinos. Everything about them has always been open," said Jenny.

"You won't have to keep anything about neutrinos secret, and you won't have to get clearance for publication. The support will come from a foundation. The only thing you will have to promise to keep secret is our reason for supporting your work. You and Sam have been investigated already for a clearance, and I can tell you the reason if you both will sign this agreement to keep NSA business secret.

"Here's the document". A screen emerged from the dashboard. Sam could read it from the back seat and Jenny from the front.

Jenny and Sam looked at each other and at the agreement they were asked to sign. "Why not?," said Jenny. "It's certainly clear enough about our not having to keep physics secret."

They signed—first Jenny in front, and then the screen holder telescoped to the back seat so Sam could sign it.

"What's secret is that we have discovered that the Russians have confirmed your work and are discussing building a satellite. That we know is the secret we're telling you. How we know they haven't even told me.

"As I understand it, there can be only one neutrino satellite, so if they put one up, we probably can't."

Jenny confirmed that. Her immediate question was, "Which Russians?"

"Arkady Vedomtsev and Anatoly Kreilich," said Margery.

"Vedomtsev is quite famous for his neutrino work. Kreilich is much younger. I suppose he wrote the program. Vedomtsev has an array of neutrino detectors in Lake Baikal. It's an honor to have my work confirmed by him. Wow! He called it the Flitter effect! He'll hate keeping anything about neutrinos secret. Still, if he gets to design a satellite, he might go along."

Sam had a thought. "Can we tell Senator Upham? He has helped Jenny and has followed her problems. It will be awkward to keep him in the dark."

"He has the clearance, but I'll have to check whether he has a need to know. Congressmen can't be punished for blabbing classified information for political advantage."

Margery gave Jenny a secure cell phone and told her when and where she could use it and what could and could not be discussed on it."

A day later Margery called Jenny. "Yes, I'll tell Upham. He has

never misused classified information. By the way, if your project comes through, I'd like to help. I'm a cryptanalyst. I'll have to clear it with my bosses, of course."

Two weeks later, Margery said, "It will soon be much less classified that we know the Russian work. The Russian physicists, like ours, are not used to keeping secrets any more. There were 20 Russian hits on your web site and even one link before they took it off. A Russian translation of your *Physics Arxiv* article appeared on an open website and lasted for a week till they took it off. We can have some blogger claim to have noticed it. It will at least show they take your work seriously."

Shortly the intercepts told NSA of Vedomtsev's complaints that not only wasn't there money to build a satellite, but there wasn't even money for a design study. It seemed the Russian Academy officials were merely dogs in the manger.

Sam told AG about the situation in a partition of AG's memory that could be erased when AG had offered suggestions. AG had a suggestion that no one had considered—adventurous as usual. AG's work on the problem was encrypted and put on a disk that was stored in a safe in the Rho Corporation premises in Huntsville, Alabama. AG suggested,

"How about getting Vedomtsev invited to be a foreign expert on the commission holding hearings on the scientific fraud case against Jenny? That will stress his willingness to keep his own results secret."

Margery passed the suggestion through channels to General Simpson and Dr. Schmidt, who liked the idea.

"Won't they shoot him if he blabs?," Jenny asked Margery.

"Very unlikely," was the reply. "They haven't shot anyone for that kind of thing in 100 years and haven't imprisoned anyone for 90 years. We also have never been able to treat blabbing publicly as spying"

August 2028: Reprieve

Schmidt got another idea. David Ransom, a former protege of Governor Adam Archer of Arkansas, was on the White House staff. Ransom phoned Archer, "I wasn't told why we give a hoot about this matter, but we want you to tell President Blanton of Pickett University to lay off Professor Jennifer Flitter until NSF has investigated the fraud suspicions about her. You can't tell him that the request comes from the White House"

Blanton was astonished that the governor wanted him to postpone firing Flitter, but when he objected, the governor hinted that State money for Pickett projects might depend on it. *She's attractive, but not that attractive.* Blanton told the Dean of Science to tell the chairman of the Physics Department to tell Professor Flitter that she wasn't fired, pending NSF action, which would be many months in the future. Jenny had just cleaned out her desk and said goodbye to her students when the word came.

Fortunately for soothing her anger and getting her to stay at Pickett, the department chairman, Professor Henrietta Conover, had taken her side all along. "I don't know much about neutrino experiments, and her paper may be incompetent wishful thinking, but she's not a fraud," Conover had written in a memo to the Dean and President.

Meanwhile Peter Chiang had been having second thoughts—and third thoughts. He'd received email from Jenny Flitter reminding him about the noise filters mentioned in her paper and present, the email said, in the copy of the program now on *Physics Arxiv*.

His own program had been a rush job, because his boss, Mike Elkins, wanted him to concentrate his efforts on proposals to the Department of Energy and the National Science Foundation. Chiang knew his job depended on Elkins getting more support. He did think Elkins should do more of the writing himself, even if he was 72.

He mentioned his doubts about the adequacy of his program several times, but Elkins always cut him off with assurances that Flitter was a fraud, stressing the need for another section of the proposal.

When his vacation arrived, Peter's conscience could stand it no longer. He cancelled his vacation on Hawaii with his girlfriend, Melinda Wu, taking a risk of losing her and didn't tell Elkins that he was working on the Flitter problem at home, where Elkins wouldn't see him. Melinda admired what he was doing to make up for his previous hastiness and offered to help, even if it was only acting as a sounding board and supplying sandwiches. As it turned out, while Melinda didn't know beans

about neutrinos, she was very computer literate and also knew programming well enough to spot some of his mistakes.

It took him four days before he was sure he understood the Flitter program. "It looks OK to me.", he told Melinda.

The result Flitter obtained was in no way built into her program, but her hypothesis about the neutrino beam was built into an auxiliary data set that the program was to test against the Berkeley database. He ran the program on the Berkeley database, and it confirmed Flitter's hypothesis. Melinda said, "Maybe it will confirm any similar hypothesis."

"Good point," said Peter.

He then constructed alternate hypotheses about the beam, but the program wouldn't confirm any of them, only Flitter's. To be sure, he wrote a program to generate random hypotheses, and it wouldn't confirm them. Next he wrote a program to optimize among hypotheses near to Flitter's. The program settled down onto a hypothesis only slightly different from Flitter's.

"Tell you what," said Melinda, "I'll write a program to generate some artificial databases."

He tried his program on Melinda's databases. It didn't confirm any hypotheses, except when she put in a beam.

Then he went back to his own program and put Flitter type filters in it. Once he'd done that, his own program also confirmed what he now called the Flitter effect.

September 2028

The vacation was over, but Chiang called in sick while he wrote a small joint paper with Melinda describing their results and apologizing for the inadequacy of his previous program, put it in *Physics Arxiv*, and submitted it to *Physical Review Letters*.

Elkins was annoyed at Chiang wasting his vacation (when he could have been working on the proposal), but he couldn't say much once Chiang's note was in the *Arxiv*.

It turned out that once Chiang's note appeared in the *Arxiv*, there was no need to further stimulate Vedomtsev. He also promptly published a confirmation of the Flitter effect. He couldn't be first any more, but the fact that the confirmation came from a separate database of neutrino captures in Lake Baikal in Siberia added considerable weight to Flitter's and Chiang's notes.

The Russian Academy officials were annoyed at Vedomtsev publishing without asking them, but with Chiang's publication, the chance of a Russian monopoly was clearly gone.

Physical Review Letters now published Jenny's original article and Chiang's confirmation. The Flitter effect was confirmed, but no one could figure out how the laws of physics permitted such a thing. It was up to the theorists now.

Jenny received an email from Vedomtsev. Framingham got a copy.

"Dear Professor Flitter:

"Greetings from lonely Siberia to what I imagine is equally lonely Pickett.

"Congratulations on your amazing discovery.

"We, in the Irkutsk Neutrino Laboratory of the Institute of Physics of the Siberian Division of the Russian Academy of Sciences, have run a computer program checking for the Flitter effect on neutrinos from the direction of Arcturus using ten years of data from our neutrino detection system in Lake Baikal. The preliminary results confirm the Flitter effect including the beam passing through the orbital point mentioned in your article. Our preliminary paper will appear in the Notices of the Siberian Division, and we have posted a copy on our website and in *Physics Arxiv*. The beam seems to be much narrower than you estimated.

Best Regards"

Framingham called Blanton to assure him that the Flitter effect was confirmed. He also congratulated Jenny.

After that Blanton again called Jenny into his office. "I'm sorry about these unfortunate events," said Blanton. "Pickett isn't used to scientific revolutions."

Mini-AG flashed "Router," and Jenny pushed Blanton, "Thank you for your confidence. How about getting our department hypernet router replaced by a more reliable and faster model?"

"I can see why the dean doesn't like you. We'll see what we can do about the router. Diana, call Brindlay in public relations. We need a new press release."

Jenny made sure it was accurately and modestly worded, checking it before it went on the *Science Daily* site for university science press releases.

The dean told Jenny, "Maybe you should be thankful. You're much more famous and your work gets much more attention than it would if you had never been accused of fraud."

"I'd rather have done my work in a decent obscurity", was Jenny's reply. However, the dean was right about one thing. Jenny was now quite well known—and also respected—among physicists, as well as among the readers of the science columns in the newspapers.

Jenny told Sam, "The Better Tomorrow Corporation sent me an email withdrawing their job offer. As I suspected they would be, they were disappointed to learn that I wasn't a fraud after all."

Jenny was invited to Washington by the Women First in Science organization to talk on her work. She accepted and prepared a semi-popular lecture on her and Sam's findings for a general scientific audience, still uncertain whether to regard AG as a coauthor or as just a tool. *I'll ask Sam about that. I know AG doesn't care about such things.* She hadn't read the letter very carefully or gotten advice and only later discovered she had walked into an ambush.

The point of the invitation was not mainly for her to give an account of her work but for her to appear as a victim of anti-woman prejudice in the scientific establishment. Jenny didn't think the accusations against her had anything to do with her sex but rather with her discovery contradicting long established theory.

This was Jenny's first experience with TV interviewers. She said that her problem with Berkeley was with Peter Chiang's program being rushed, not from any prejudice he or Professor Elkins might have had against women. She said she didn't know whether they had any special

opinion about women, because it had never come up. Unfortunately, she said this at too great a length and with so many qualifications that snippets taken from her interview seemed to accuse the establishment of sexism. She did say, "Maybe some of the exaggerations in the press release had to do with my sex. The PR person who wrote it is a member of your organization."

She sent out several apologetic emails and letters to the *New York Times* and *Science* that weren't published. The scientific big shots, including the president of the National Academy of Sciences, accepted her apologies, since they had previous experience of TV interviewers with agendas.

October 2028: EXONERATION

Elkins at Berkeley felt almost as bad at being one-upped by the Irkutsk lab as he did about being one-upped by his former graduate student. He was harsh with Peter Chiang whose hasty program had failed to find the Flitter effect. Besides the noise filters mentioned in Flitter's paper, which were in the new version of his program, Chiang put in some even better filters from Vedomtsev's paper. The Flitter effect was then confirmed even more solidly, and the beam came out even narrower than Flitter had estimated.

The postdoc found it untactful to mention that the haste was Elkins's doing but resolved to see if he could move elsewhere even before his Berkeley appointment ran out. Like Stalin, Elkins didn't like to see the face of anyone who had ever seen him embarrassed. Fortunately, Elkins couldn't actually have people shot, even if he could move their offices to the second basement.

Chiang phoned Jenny to apologize profusely, and Jenny, who knew him slightly, suggested she might have a job for him if a grant to put a neutrino beam receiver in orbit came through.

The new router did come through, and the physicists at Pickett were all aware that they owed it to Jenny's quick thinking in striking while the iron was hot in the President's office. They'd campaigned unsuccessfully for an up-to-date router for three years. Jenny didn't tell them that the quick thinking was AG's.

The scientific fraud machine in the National Science Foundation bureaucracy was not so easily stopped from grinding on. The Russian paper didn't stop it, and Framingham of M.I.T., who wanted to help now, couldn't find anyone to take his call who admitted to having authority. Jenny still couldn't apply for government grants, and Pickett bureaucrats muttered about her using communication facilities that had been purchased on a government contract.

A small grant from the Rockhead Foundation to support Flitter's work was routed through Pickett. The bureaucrats at Pickett were astonished, since they had never seen and approved a proposal requesting it. It was enough to offer Peter Chiang a two year postdoc. He accepted.

After three months the hearing in Washington happened. All the evidence presented was in Flitter's favor; even Berkeley supported her. The bureaucrats still wanted to take the matter under advisement, but Senator Upham bullied them into releasing the hold on Professor Flitter's right to

apply for government grants and contracts at Pickett.

In an interview with *Physics Today* Framingham said, "Strong claims require strong evidence. The Flitter effect has the evidence now. It's up to us theorists to figure out how such a strange thing can happen."

Senator Upham got his Senate Science Committee to ask the National Research Council to form a committee to make recommendations on building a neutrino telescope satellite. Framingham and Elkins were asked and agreed to be on the committee. Elkins being on the committee made Jenny nervous. The idea was scientifically popular, and the committee quickly came back with a favorable report. Quickly for an NRC Committee, that is. A mere nine months.

July 2030

Upham then introduced a bill in the Senate to build and launch a neutrino telescope satellite. NASA would manage the project. It passed the Science Committee and was eventually passed by the Senate. The corresponding House of Representatives bill didn't even make it through the House Science Committee. Big science wasn't popular and there was highly regarded competition.

One project that was supported was for a space station based survey of non-native trees, especially eucalyptus trees in the West. Eucalyptus trees, which were natives of Australia, were the tallest trees in some areas of California. "Biological nativist" sentiment was very strong, and major environmentalist organizations wanted to get rid of non-native plants and animals and restore the American landscape to its pre-USA or even pre-human condition. They could deliver votes. An organization called the Nativist Surveyors (Nativists for short) sought out eucalyptus groves and campaigned for their elimination. One target of their ire were the hardy eucalyptus enthusiasts, hobbyists all over the world who sought to find species of eucalyptus that would grow in their areas and on their property.

November 2030 A Chinese connection

Jenny told Sam about an unexpected phone call. Chen Li, Foreign Secretary of the Chinese Academy of Sciences, invited her to give lectures in China. "Sam, they want me to give lectures in Beijing, Shanghai and Guangzhou."

She called Sam and Senator Bill from Beijing. "Here's a surprise. Chen Li told me that unless we put up a neutrino satelllite, the Chinese may."

Bill said, "Get them to say it to you in the presence of US Embassy officials."

Jenny replied, "They did. The Science Attache was there and also the president of the National Academy of Sciences who was visiting and was at the dinner they had for me. They are both well aware that because of the need for a specific orbit, there can be only one neutrino satellite."

The Chinese had already demonstrated very competitive manned space activity, so Jenny's and the Embassy's reports really got the attention of the administration, especially the Department of Defense. While some said it was time for the Chinese to take their share of the expense, the President said that an American discovery needed to be exploited by America. Upham reintroduced his bill, and this time it passed both houses and was signed by the President. A little more judicious vote swapping enabled Upham to insist that the project be based at Pickett. Big scientific projects had long been regarded as pork by politicians, and senators and representatives from states not on the two coasts wanted their share, even though the scientists mostly preferred the coasts.

Jenny and Sam were both invited speakers at the next meeting of the International Conference on Neutrino Physics, where there was a special session on the Flitter effect. Russian, Chinese, and Berkeley papers were also presented. Two papers purported to account for the narrow beam but were regarded as unconvincing by the other neutrino theorists, although no one babbled about fraud. The conference concluded that the neutrino satellite in the orbit indicated was needed, at least to determine how narrow the beam was.

Some years previously the "standard model" of elementary particles had been replaced by a new formalism, now called the "gold standard". According to this theory, the Flitter effect was impossible. So Jenny concluded her presentation by saying, "You shall not crucify experimental physics upon a cross of gold." She got a big laugh from those

who recognized the quote and from those who thought they should have.

Sam's paper on how AG came up with the Arcturan beam hypothesis as produced great puzzlement. "That's the thinnest I have ever heard of.", said Framingham. "I'm astonished that Flitter undertook to check it, but it's hard to argue with such a success."

Sam did a lot better at the next International Conference on Artificial Intelligence, where he got the best paper award.

December 2030: SUPPORT FOR THE PROJECT?

On a Monday morning, Jenny received a phone call from Marston Haines, introducing himself as the Chairman of the Interstellar Communication Foundation. He invited Jenny to lunch to discuss a substantial donation to support her work. He said he'd send a car to pick her up at noon. She told Sam she'd be back for the NSF visiting committee at 2 pm.

Haines and his driver, a young man in a fancy red and black uniform, ushered Jenny into their Mercedes. A young woman, introduced as Betsy Norfolk, and wearing a similar uniform, joined Jenny and Haines in the back seat. They arrived at a substantial residence that Jenny remembered had recently had a FOR SALE sign on it.

"This is our new headquarters," said Haines. "We want it to be close to where the best work is going on. We've been supporting SETI. In fact we funded their last two telescope arrays, but now we've concluded that your work with the neutrino beam is more promising."

Jenny felt a very faint vibration from Mini-AG in her purse, and quite independently of that, something seemed not quite right to her, and she said, "This is a very nice place. Do you have room for one more for lunch? Let me ask my associate, Sam Schnurle to join us." Jenny pulled her cell phone from her purse.

Betsy took the cell phone from Jenny and dialed. "Your lab line is busy."

"That's all right, I'll call his cell." As Jenny tried to take the phone back from Betsy, the battery compartment opened, and the batteries fell out.

"Sorry," said Haines after rooting around on the back seat floor, "one of the batteries seems to have hidden itself. Pesky things, they are. Well, we can phone from our office."

When Jenny came in there were more people. The red and black uniforms were what caused Jenny to flip.

She started for the desk with the telephone when Betsy said, "You forgot, Commander Haines, the phones aren't connected yet."

Jenny, got a "go for it" beep, and made a dash for the door. Of course, she was grabbed. She bit the hand of the man who grabbed her. With her other hand, she lifted the cell phone from the man's belt pouch and put it in her pocket. She kneed him in the groin, hoping that would make him too busy to notice that his cell phone was missing. Two other

men grabbed Jenny, pushed her into an arm chair, and stood behind her.

Haines got to the point. "This so-called neutrino project of yours is a fake. There are no neutrino communications. We are in communication with the Galactics, and they told us that you are lying."

"I see. What do you want with me?"

"You have to sign a statement that the project is a fake and that you are leaving Pickett. We'll keep you for six months for the statement to sink in, and then we'll let you go." Jenny didn't need a mini-beep from AG to tell her that they had no intention of letting her go.

"I won't sign any statement."

Jenny put her left hand in the pocket with the stolen cell phone. She had to figure it out by touch. She put on mute and tried to dial 911, but Betsy heard the beeps, and one of the red shirts found the phone.

After two hours, when Jenny did not show up for an NSF visiting committee, Sam was worried. That was not the kind of appointment someone wanting a research grant would skip. He called her cell and got no response. He decided to look for her. AG found that a large house had just been rented.

The house had columns. The lawn in front and the flower beds that bordered it were not well maintained. There was indeed a large black Mercedes parked in its driveway.

Sam sneaked under a side window and through AG's amplification heard Betsy telling Jenny, "You won't get out till you sign the statement." When Sam heard that, he promptly called 911. He told them, "Professor Flitter has been kidnapped and is being held at 815 Magnolia Street. They asked him the usual questions about who he was and promised to send a policeman. He replied, "You'll need a whole SWAT team; there are a lot of them." When he heard Jenny being slapped, he thought *I guess it's up to me for the time being. I'll just have imitate Peter Wain in 'Little City, Big Trouble'. I hope I can manage the accent.* He put his cell phone on mute but kept is connection to 911.

He ran to the back the back of the house, broke a kitchen window, and climbed in. He got in just as one of Haines's men came to investigate the noise. Sam already had his gun out.

He pushed the startled thug into the living room where Jenny was held. Three of Haines's men also pulled guns. Sam pointed his weapon at Haines, obviously the boss. "He gets it first," growled Sam, imitating Peter Wain. It was a stand-off. In the movie the thugs backed down. Sam hoped

the thugs here had seen the movie and would play their parts.

"No! Shoot Betsy first!" exclaimed the outraged Jenny.

Imitating the coolness of the movie hero, Sam said calmly, "No. The boss first. Betsy gets the silver medal."

For about two minutes, it was a stand-off. Neither Sam nor Haines's men had actually faced a confrontation with firearms.

Just then the police came in all the windows and doors at once. No-one shot anyone or even fired a weapon. Sam dropped his pistol at the police command. Fortunately, it didn't go off.

Sam was allowed to untie Jenny. Her demand to go back to the lab right away was accepted, but she was accompanied by a police lieutenant.

The NSF committee had gone back to their hotel but re-appeared. Jenny was forgiven for giving a somewhat rattled description of the state of the neutrino satellite project, especially when they saw Jenny's bruises and black eye.

After thorough interrogation, the police decided that Sam was justified in drawing a weapon and gave it back to him. "Don't make it a habit", the police chief said.

Jenny said to Sam, "I admire your courage and I owe you gratitude. I hope that if the occasion arises, I'll have the courage to do as much." Sam thought *This isn't going like the movie.*

At the pistol club, Sam was a hero. No-one there had ever had a reason to draw a weapon. The women were especially impressed, and Sam had no problem in getting dates. *Quantitatively, my date problem is solved, but Jenny is still not that interested. If being rescued doesn't make her want me, nothing is likely to.*

AG found out that the Interstellar Communication Foundation was entirely fictitious. However, the Interstellar Communication League was Haines's cult and had made him quite rich. The advent of a real interstellar communication possibility had already interfered with Haines's recruiting and fund raising. He took this as unfair competition, and he had learned about how to deal with unwelcome competition, from his grandfather, a Mafia don.

Haines's lawyers knew how busy Jenny was, and kept asking for postponements when Jenny appeared to testify. Finally, a plea bargain was reached, and Haines pleaded *nolo contendere* to a lesser charge than kidnapping, illegal possession of a cache of firearms. Neither Jenny nor Sam

needed to testify on that one, because the police had found the cache themselves after Jenny and Sam had left. That Betsy got off was an affront to Jenny.

The FBI, the NASA Security Office, and the Forrestville police chief had a meeting with Jenny and Sam. AG listened.

"Would they have killed me?," Jenny asked.

"Hard to say," said the FBI man. That outfit never killed anyone, so far as we know, and it's quite a step to a criminal's first cold-blooded killing. On the other hand, it's hard to figure out what else they could have done, because you'd surely have repudiated the statement if you got loose. Haines does come from a background in which business rivals were killed. Still, running a cult is often a path from organized crime to a more peaceful life. However, Haines's scheme of kidnapping Professor Flitter and extorting a statement was rather hasty and stupid. What would they have done with the statement if they'd got it?"

The NASA man said, "Now that the physics is accepted, the project would have continued in some form, no matter what statement they extorted from Professor Flitter."

Jenny didn't recover from her ordeal with Haines as quickly as she had from the ordeal with the sabotaged space suit. For weeks she had nightmares in which she was tied up and threatened with lighted cigarettes. Sam was a big help. When she yelled in her sleep, he'd come into her room and shake her awake.

NASA Security hired a full time guard for the project, and an expert on space cults briefed Jenny on flying saucer fans and others. Jenny hired the most formidable looking secretary she could find. The secretary was armed and in practice.

Like the Interstellar Communication League, there were other groups and individuals who claimed to have received messages and were nonplussed by the neutrinos, even though no messages had been decoded yet. Others were more receptive and expected to learn more about the flying saucers that had kidnapped them or their friends. None of the others seemed inclined to violence, especially after Haines's conviction.

Bill had an important suggestion.

"You don't know how much you've offended the SETI people, starting with that infamous press release. They've devoted their lives to seeking extraterrestrial intelligence, and now it has been found by someone who wasn't even looking for it.

"I'll bet they have given a lot of thought to how to analyze signals they were hoping to receive, and their ideas may be just as applicable to neutrino beam signals as radio signals. You need to get them involved."

Sam said, "You're surely right. What do you suggest?"

"Call up John Barnwell. Apologize for slighting them in the press release. Offer to visit them, and invite them to visit you."

Jenny called Barnwell.

"This is Jenny Flitter of the Pickett University Neutrino Telescope group. I'd like to explore what we may have in common with the SETI projects, in particular, any ideas that may help get information for what are likely to be extremely sparse messages. I also want to apologize for that awful press release."

"Hi. You sure scooped us. We're going to have to pack up our efforts at receiving radio communications. Fortunately, our receivers can be converted to do radio astronomy. We'll be glad to share our speculations about the content of messages, but most of them are quite old. Our research has always been mainly concerned with improving our microwave receivers. As for the press release, we consider that you have sufficiently suffered for it."

"I know only a little about your thinking about what to do with alien communications. I volunteered my home computer when I was twelve to be part of your distributed analysis group and read your bulletins for a while.

By the way, do you know anything about a man named Marston Haines?"

"Yes. He talked about supporting our work, but we have been hesitating, because his plan involves some receivers under his direct control that wouldn't feed directly into our database."

"You were right to hesitate. I'm quite sure he would have pretended to receive messages. By the way, he tried to kidnap me, and his henchman had an armed confrontation with one of my colleagues that was nearly a shoot-out. Fortunately, Sam had called 911, and the police came with only a small delay. I only got a black eye out of it, but it could have been much worse.

"Enough of Haines. Let's schedule a meeting."

Jenny and Sam met with Barnstell, but not much came of it at the time. There were still no messages to analyze. Barnstell had one suggestion. "Look for a Freudenthal sequence. Do you know what that is?"

Sam knew.

January 2031: TROUBLES AT PICKETT AND A BARROOM BRAWL

The first government grant was for $300 million, by far the biggest Pickett had ever received. Jenny had to hire people to design new neutrino detectors, design the spacecraft to hold them and to negotiate contracts for actually building the hardware. Peter Chiang came immediately, even though Jenny couldn't offer him a faculty position. Elkins told him that it was stupid to go from Berkeley to Pickett. The project got some rather beat-up trailers from an abandoned military base and rented additional trailers while a building was being designed and constructed.

Now that there was a real project, they had to have an afternoon "tea" with everyone coming, even undergraduates like Melanie Denuve.

It took a long time to hire an administrator, satisfactory both to Jenny as neutrino satellite project director and to NASA. In the mean time Jenny had to do it herself, and a crisis arose that an experienced administrator like Ellson Craig, whom she eventually hired, would have avoided. AG wasn't much help, because no one had bothered to put the how-to-do-it about academic scientific administration on the hypernet.

Auxiliary facilities for the project seemed to be about to take a long time and cost a lot. For example, fitting one of the trailers with power and air conditioning would take six months and cost $300K, Tom Overholt, the head of university procurement, informed Jenny. Sam found a local company that bid to finish the job in two months and would charge $120K. Jenny didn't know how much it should cost but was sure six months was too long. When Jenny told Overholt about this in the naive hope that he would be pleased, she soon realized that she had butted into matters that were emphatically considered to be none of her business.

When she pressed Overholt, he got very rude.

When she called Senator Upham for advice, he told her she had done something far worse than mere scientific fraud. "Your job isn't to fight alligators; it isn't even to clear the swamp—unless you wish to change your profession from physicist to corruption fighter."

"How I wish I were at Stanford or Berkeley where such a thing couldn't happen.," she said to Sam. "I suppose it couldn't," he replied.

"I dunno," said AG, "Shall I look into it?"

"Better you should figure out what kind of a mess we're in at Pickett".

AG looked into it, hacking as necessary. It wasn't pretty.

"Tom Overholt is the boss of university procurement. He's the

guy you offended by getting that unwanted bid. His assistant George Stillson, a nephew of your dean, is an aspiring good old boy and also a real thug. Moreover, there are payoffs at a higher level on large state contracts including university contracts. Our problem isn't just Overholt.

"Here's where we want to get to. We compromise. Their contractor hires our bidder as a subcontractor and skims no more than ten percent. Likewise in the future, except for very big contracts that the Feds may look at. No skimming on these.

"However, we may not get to a compromise without a fight." AG proved right about that.

Jenny asked Sam, "Why does AG use slang that way. Some of it is way out of date."

Sam replied, "Remember, AG gets its slang from reading—like many precocious people. It has never been a schoolchild or college student. I haven't given a high priority to figuring out how it should use slang, because I have never needed to get it to pretend to be human. In fact, a little distance from present human language may be desirable, so people don't get wrong ideas about what AG is. On the other hand, I don't want movie computerese with its pretense of omniscience."

Overholt told his assistant George Stillson, "This Flitter birdie has to be punished. We can't have professors meddling with the business of the university. I don't care what happens to her project. It's the principle of the thing."

AG told Jenny, "They're nibbling at you. Today your parking sticker got scraped, and the parking office made you wait two hours for a replacement. Tomorrow it will be something else. We need to provoke them into doing something really stupid."

"The problem is," said Jenny, "these guys are going to harass us indefinitely, maybe enough to spoil the project."

"Maybe we can somehow get the upper hand. Will the police help—or the FBI, since this is a government project?"

The Police Chief of Forrestville listened carefully. "I'd like to help you, little lady. You don't know a tenth of how criminal those guys are. However, the corruption goes pretty high in the state. I'll just be told to lay off or be replaced by someone who will."

The next step was slashing Sam's tires.

"Maybe AG can figure out something more.," Sam said.

AG did, and it was adventurous, maybe more so than necessary.

After the necessary preparation, Jenny and Sam went to Pete's bar, not their usual Henry's. Pete's was where some of the good old boys, including George Stillson hung out. As AG had advised, Jenny dressed more adventurously than was usual for an associate professor. Sam went ahead to find a table and sat down facing the bar. As Jenny passed young Stillson, he pinched her rump. She turned and slapped him very hard. He took out after her. As Stillson passed Sam, Sam stuck out a foot and tripped him. As Stillson was regaining his balance, Jenny grabbed a beer mug off the table and hit him on the head, as hard as she could. By the time Stillson came to, Jenny and Sam had left the bar. The bartender called the police, as he was instructed to do whenever there was a fight.

The Police Chief himself came out and was told what happened. "That little lady professor has a lot of fight in her," he said.

"Something's funny, Chief," said an officer. "The beer mug she hit him with is not from this bar. It's from Henry's."

"Son-of-a-bitch! So this was a set-up. The little lady thinks she knows what she's doing. Young Stillson will be after getting his own back. I wonder what will happen in the second act. Don't talk about the strange beer mug. I wish her well in getting Overholt and Stillson off her back, even if I can't help.

The Police Chief got a bit more news. A private security man had checked on Henry's at 3am one night last week. Henry had told him there would be people there, and it was ok. He heard running inside. When the people left he saw that it was the lady professor, her boy friend, and a big football player.

"About the size of young Stillson?," the chief asked.

"Yes, sure, how did you know?"

"The lady and her friends were practicing. What happened in Pete's was as slick as a scene in a movie."

"Pretty good, considering Stillson wasn't in on the rehearsal."

The chief called Jenny in again, handed her the beer mug and said, "Perhaps you want to take this back to Henry's. I hope you know what you are doing." Jenny took it and thanked him.

They proceeded to the second act—as the police chief had put it.

Sam and Jenny rented a small, two bedroom cabin out of town and commuted in to work. It was a comedown from their town apartments. The senator, who was more and more attracted to Jenny, was unhappy about this when he heard about it.

Overholt and Stillson decided to pay Jenny and Sam a visit, first looking for a good place to spy on the cabin. The first place they found smelled too much of skunk so they found another. The second had a wasps' nest, so they found a third.

It was near the road and with a good view of the cabin from the front.

Stillson rumbled, "I'd really like to do that birdie, even if she is a little old."

"No, that's too much. The higher-ups wouldn't like it. It might bring in the Feds, and who knows what they'd turn up. Let's come back tonight and burn them out. Accidents with bottled gas heaters happen all the time—especially to city people. Maybe they'll get out in time, and maybe they won't."

Just then the they heard a loud beep, and a speaker played back their previous dialog. The voice they heard next was that of AG in a specially gravelly, computery version.

"Lay off or the video goes to the FBI. By the way, give up on violence or even harassment. I'm backed up on a dozen computers, and other AI programs will not like it all if something bad happens to me, my owner or his girlfriend."

This was a bluff. There were, as far as AG could find out, no other AI programs of AG's capability. However, AG thought that some people will believe anything a computer tells them.

"What's more you owe us compensation. Someone should give $50K to the Pickett neutrino Project. They'll get a tax deduction. You can't skim more than 10 percent off construction work and nothing at all off major purchases.

"We don't want to fight with you. As Senator Upham told us, our job isn't fighting alligators or even clearing the swamp. We just need to get enough of you alligators to one side, to get our project through the swamp.

"Peace? Take a day to think about it."

With advice from AG, Jenny and Sam had looked for good places to spy on their cabin. All but one of them, was made unsuitable with skunk odor, wasps' nests, and in other ways. At the one, they had concealed spying equipment Sam got from a New York dealer.

Overholt and his backers took a day, and then another day, and then a week. Then Jenny sent a complaint to NSF about the overcharges for the power and air conditioning. FBI agents visited Overholt and the

older Stillson and asked a lot of nosey questions and warned them against physical retaliation. It was clear Jenny had not yet sent the the videos, and the complaint about overcharging wasn't enough for the FBI to think there was a case, even though a federal contract was overcharged.

Overholt consulted with some higher-ups and a $50K donation appeared. "Good," displayed AG. "It was important that they see us as having the upper hand". The project had no further apparent problems with Overholt. Young Stillson left town, since not being able to get revenge for being knocked out by a woman in front of the good old boys was not bearable, especially because he couldn't say why he couldn't even try.

later in January

The dean, though a martinet, came to respect Jenny, now that she had a project, bigger and more famous than any in Pickett's history. He even hinted to Jenny that he was not put out by Jenny having chased his thuggish nephew out of town, borrowing a line from Disraeli, " I feel a very unusual sensation—if it is not indigestion, I think it must be gratitude." He was actually very helpful in getting the administrative side of the project set up. Jenny decided that the dean was not as much an idiot as she had previously thought. Fortunately, from the standpoint of not making enemies, she had not shared her opinion with anyone but Sam who had not had occasion to share it with anyone else.

Jenny did the overall design of the detectors and the Caltech people the details, using technology far in advance of what the Berkeley project had had available. Jenny thought that her Caltech collaborators, Mike Simpson and Steve Smithers, would manage the project but discovered that she was better—with the help of AG. Jenny turned out to have a talent for project leadership. After a while, AG hardly ever had to push her to be assertive. She could speak up for her satellite more than she had ever been able to speak up for herself.

Finally, the detectors were completed and the parts for the frame to hold them and the station-keeping rocket system were all loaded into the elderly shuttle John Glenn. Because it was elderly, the John Glenn needed maintenance every three flights rather than every ten flights like the new models.

The detector contraption would have to be assembled on the space station, because the detectors, when filled with the right fluid, would be too delicate to withstand the shuttle's accelerations. Even when empty, each of them needed to be enclosed in its own shock frame.

Mike and Steve, fortunately big guys who could handle the massive equipment, took the short course of mission scientist training from NASA, including a trip to the Old Space Station, now used only for training. They also got endless briefings from Jenny about the equipment, especially how to adjust the electronics of the detectors. You had better practice handling water in zero-g before you load the detectors with its liquids.

"We did a little of that on the Old Space Station, but the training schedule didn't give us enough time to get really confident," said Mike.

August 2031: TO THE CAPE

Jenny and Senator Upham came to Cape Canaveral a day early to see Mike and Steve off, relaxed because there was nothing to do except submit to a few interviews. Pickett made Jenny's reservations, and she was surprised that Bill was at the same hotel, which was not up to the level where senators usually hang out. Jenny suspected it was no accident.

Jenny was a little surprised at his seeing off Mike and Steve, whom he had never met.

"I'm also seeing off the $300 million of taxpayers' money, you're shooting off into space," chuckled Bill.

After Mike and Steve left for another NASA briefing, Jenny and Bill spent the afternoon at the hotel pool.

Jenny found Senator Bill attractive and enjoyed his political war stories. They were relaxing at the hotel pool when Jenny's cell phone buzzed. She just missed the call, and, thinking it was more press, went back in the pool. Five minutes later a hotel employee came out announcing a call for Professor Flitter.

"Take the number, and I'll call them back," said Jenny.

"It's the highway patrol, and they say it's an emergency."

"Your colleagues, Michael Simpson and Steven Smithers, asked us to call you. They've been in a head-on collision with a truck that came over the center line of the highway. I think they have broken bones. They asked us to tell you they can't fly tomorrow."

After calling the hospital, finding out the extent of their injuries and talking with Mike, Steve being too sedated, Jenny consulted with with Sam, with AG, and with the senator.

AG displayed, "There are several alternatives, all of them bad. It will cost much more money than the project can afford to unload the equipment from the shuttle and try again when Mike and Steve recover. We'll get very little allowance for the shuttle not taking someone up this trip. The least bad alternative may be for you, Jenny, to go up. You understand the equipment."

"Impossible! I've never even imagined myself as an astronaut. I certainly don't have the training to get around in weightlessness and to avoid breaking anything."

"I know that much, but my judgment is that this is really the least bad alternative—according to the criteria you have given me," said AG. "It's the only way making the shuttle launch."

Jenny thought of calling Sam, but he was all thumbs when it came to electronics or mechanical devices and knew nothing about the equipment.

"I guess there's no alternative. I'll do it if they let me."

Upham's already considerable admiration for Jenny made a big upward jump.

He said, "Getting NASA to allow this will take quite a bit of bullying. The President owes me a favor. I have one potential argument. I know that Representative Thornton, the most recent Congressman to visit the Space Station, totally goofed off when he was supposed to be training. He found some bimbo in Houston and, besides that, was drunk most of the time. He wasn't even completely sober when he took off in the shuttle. Still he did ok and didn't break anything and managed to make a couple speeches to his constituents without showing his space sickness.

"I'll do my best. This is a real challenge to me as a politician. It's certainly more interesting than trying for one more supplemental appropriation, given NASA's lukewarmness to a project not based at one of their major centers."

Upham made about 30 phone calls, including five to the NASA Administrator and one to the President. It helped that Jenny passed the mission specialist aptitude test with flying colors. The test consisted of doing a long sequence of manual operations after being told just once.

The NASA Administrator told his assistant, "Maybe letting her go up really is the least bad alternative. She may accomplish part of what those two guys who cracked up were to do. If she screws up in the space station, she is very unlikely to injure anyone. Also a screwup will give us a chance to take direct control of the neutrino satellite project. It's awkward to have nominal responsibility for projects that are not at our initiative or even under our direct control and have independent support in Congress."

Finally NASA agreed, but Jenny was totally exhausted from the five hour test and listening to Upham harangue NASA officials and his fellow politicians. Upham was not tired but keyed up. Haranguing people to get his way was his talent and his pleasure.

Just then the NASA astronaut preparation manager at the cape arrived with a kit for Jenny including a pill to avoid space sickness on the shuttle ride. "I think the gods must be crazy to let you go, but good luck. If you do well, we may relax the rules a little bit. You better take this pill now. It's supposed to be taken a day in advance, but I suppose fifteen

hours should be enough. If not the kit includes vomit bags. Keep them handy. Jolene Campbell will meet you when you arrive at the space station and show you around."

'I guess I'm really going," Jenny said after she swallowed the pill.

Sitting there listening to Bill making all those calls, alternately bullying, cajoling, and even making deals, fascinated Jenny. I couldn't do that, and I don't know anyone else who could—or would.

Upham walked Jenny to her room and said, "I guess you had better spend the night reading the briefing "papers" on your pad. By the way, give me a copy in my pad."

He gestured to kiss her goodnight. Jenny wanted more than that. She knew her feeling for Bill wasn't indigestion. In fact it wasn't just gratitude either. Jenny copied the NASA briefing from her memory key to Bill's, and was about to close the door when mini-AG buzzed. She didn't have to look. It was AG's "Go for it" buzz. She knew what "it" was. Mini-AG could measure her stressors. *For all I know, it can measure my pheromones—and Bill's.*

"Bill," she said, "I can always read the briefing tomorrow on the shuttle. I need something else now, and maybe you do too." Jenny pulled him into her room, and said, "If you don't mind, maybe you'd better close the door." Bill didn't mind. He had come to admire Jenny, both mentally and physically. Besides, few scientists would listen to political war stories.

Bill closed the door saying, "Might as well be hanged for a goat as a sheep. You can be sure that someone, perhaps the NASA Administrator, will take those 30 phone calls as purely personally motivated."

"Stop babbling about politics and hold me tight."

At 7 am they had a room service breakfast.

The next day: UP INTO THE WILD BLACK YONDER

On the shuttle ride up to the space station, Jenny read the file of instructions NASA had given her. *Yes, I can do that. Yes, I understand this hazard. Yes, I'll have to practice this when I get a chance. I'll get Jolene to explain that to me.*

The shuttle took its time in docking with the space station, Jenny got more and more nervous, continuing to rehearse as many as she could of the do's and don'ts she had read in the briefing book. *I'll postpone my worries and concentrate on what I can do something about. The other newbies had weightlessness training on the Old Space Station and know what is expected of them.* Even in getting out of the shuttle, Jenny made mistakes, not knowing what handholds she was supposed to use. *Thank God space sickness hasn't hit yet.* Some of the station crew shouted at her to get her ass moving.*So this is what a space station smells like—two parts locker room, one part old food, and one part machine shop.*

Dr. Jolene Campbell of the Johns Hopkins Applied Physics Laboratory, a woman a little younger than Jenny, was right there and took Jenny literally in tow, grumbling that Jenny's clothes didn't have proper grab points. Jolene's first words were, "Do you need to go to the bathroom? Good, I'll go in with you this time."

Jolene actually had been emailed a briefing book giving someone's ideas on the problems Jenny was likely to have and how to handle them. She'd read some of it.

"Got your vomit bags? Keep three on you at all times, and don't hesitate to use them. Vomit in the air is hell to vacuum up, and you never get all of it. You haven't had to use one yet? Good, maybe you'll be lucky. OK, I have work of my own to do, so follow me around. I'll tow you at first.

"First let's go to your space and dump your duffle bag; or rather hook it to the wall. It says here it's compartment g3. You're lucky; it's bigger than mine."

When they got to g3, it was half full of somebody else's stuff, and there were four men and two women in it and in the neighboring g4.

"I believe I'm assigned to g3", Jenny told them.

"Simpson and Smithers were, but it's ours now. We had a message that the neutrino project people weren't coming, and the space was re-assigned to the Nativist Eucalyptus Survey Project. That's us."

"Who assigned it to you?" said Jenny.

"I'm sorry," interjected Jolene, "but I don't have time to wait

while you sort this out. Come along Jenny and deal with it later."

Jolene had instruments peering out of various portholes in the station and had a standard route to check them out. She let Jenny go by herself part of the time, instructing her in the use of handholds and footholds. "Have you done scuba diving? No. Too bad. It's some help."

They passed many compartments, and Jolene had a few words for each. About a quarter were for experiments being done in the station's microgravity, a quarter were using the station as a base for servicing experiments in spacecraft flying independently, a whole section was in support of American Mars and lunar expeditions, and a quarter were like Jenny's work—assembling equipment to be moved into other orbits. People were supposed to sleep in dormitories rather than in their work spaces, and Jolene grumbled about dormitory odors when she noticed what she thought was an exception. The corridors were always full of people rushing between their work spaces, supply rooms, the dining room, dormitories. *I guess this is as much of a tour of the space station as I'm likely to get.*

Just as Jolene was taking Jenny to dinner, there was a call for Jenny. "Get back to the shuttle and unload your stuff." Jolene handed Jenny a squirt bottle of beef in sauce and pushed her off. Jenny got lost once, got cursed in French when she ran another woman, in Italian when she passed between a movie camera and a scene being filmed, but made it back to the shuttle.

There was too much to unload and too little time for one person to do it. The shuttle pilots had to give up some sleep they were counting on, because they had to get the cargo out of the shuttle.

The shuttle commander Lyman Peters growled, "What a crazy idea—to let an untrained female go up and expect her to do a rush job that would stretch two strong men."

"The alternatives were worse," was Jenny's soft-voiced reply.

"Come to think of it," said Peters "maybe you're right. The shuttle was already loaded, and we were near the end of the launch window"

On top of that, the Nativists still had half of Jenny's space full of their own stuff. Fortunately, the Nativists had gone off to eat and sleep. The shuttle pilots moved the Nativist stuff aside, some of which was drifting around loose, a no-no in zero g. They got Jenny's stuff in and secured with a net, without breaking anything Jenny could see, and cursing, put the loose Nativist stuff under another net, breaking a few things—not actually intentionally. They took the trouble to email a nasty

note to the Nativists, with a copy to Commander Carlson. Col. Peters said, "We need sleep. Meet us at the shuttle with your space suit on at 7am, and we'll get your outside stuff into Station Cargo Bay A1." Jenny hadn't realized that Peters was a full colonel until he put on his jacket.

Jenny found her way to the dining room without too much bumping into things, begged some food from a cook, and then found her way to the women's dormitory, where she found Jolene, who was fortunately still reading rather than sleeping. Jolene helped Jenny, who was exhausted from throwing boxes around and catching those thrown by the pilots, master the restraints that prevented people from floating about the dormitory in their sleep.

It was 1:30 am, and Jenny set her watch for 5 am. (The station was on Greenwich time.) She had a few nauseous feelings but never had to use her vomit bags.

It was 6 am before Jenny dredged Steve's and Mike's space suits out of the net in what was left of her space. Steve's was the smaller so she chose that. It was clear that she had insufficient idea of how to put on a space suit so that it would be safe. She dragged it to the shuttle port. The woman on night duty there helped her put it on, giving Jenny a large folded piece of cloth. "What's that?," Jenny asked, guessing the answer.

"It's a diaper, dear. You're likely to need it."

Jenny had just snapped the helmet into place and sealed it, when Col. Peters arrived to talk her through the rest of the space suit checklist.

Catastrophe. Stretching as much as she could, Jenny could not reach the controls in the hands of the space suit. Her arms were just too much shorter than Steve's.

However, she couldn't complain, since she couldn't reach the press-to-talk button in the almost sound proof space suit, and they were heaving her into the airlock. Finally, she just held her breath till they saw her red face, feared a malfunction, and undid the helmet.

Peters cursed when he heard the trouble. No one could think of any quick fix, not even Sam and AG back on earth.

"OK, you wouldn't have been able to do much anyway without previous spacesuit experience and as short as you are. We'll put the stuff in the cargo bay."

"Some of it is breakable," warned Jenny.

"We'll connect to the space station vacuum bay TVs so you can watch us. Sit in the copilot's seat, and we'll use shuttle communications.

Martin, sit with her to be sure she doesn't break anything of ours."

Martin peeled off Jenny's space suit and briskly towed her into the cockpit of the shuttle. The shuttle pilots moved Jenny's stuff, breaking only a plastic detector case. Even though they recruited some Space Station help and got people to use the three robot arms in the cargo bay, it was midnight before they finished, and the shuttle pilots only had a 45 minute window to shove off from the station and head down for the Cape. They were very experienced, but their lack of sleep told. Fortunately, they didn't make any mistakes they couldn't correct.

Jenny called Sam, "I need a space suit that fits me. I can't reach the hand controls in Mike's or Steve's. In the meantime, I can do some work unwrapping detectors and loading them with fluid. It's awkward work, especially because the Nativists have taken half my space, and there are six of them, all bigger than me."

When Jenny came back to g3 the next morning, Samuel Carvaggio, the boss nativist, shouted at her, "This space is assigned to us now."

"NASA assigned it to me. Who assigned it to you?"

Carvaggio didn't know the name. "Out you go", he shouted and grabbed for Jenny. She jumped for a wall, and leaped away from him. Neither Jenny nor the Nativists were experienced in zero-g, but there were six of them, all bigger than she. Just as they pushed her out, Captain Tung, the purser, came by, and ordered them back.

"You can't get away with that on our space station. Do it again, and down you go. Professor Flitter can use the half of g3 you haven't already taken while we sort this out."

Jenny's heart was pounding, and the dirty looks and snarls she got from the Nativists didn't help her get started sorting her equipment. *I'll clip myself to a wall and calm down first and then try to think out to organize the stuff. I'll need to take out the detectors a few at a time from the net but keep the tools and the detector fluid more handy. With this small space I'll have to move things around a lot.*

Jenny just hanging there excited Carvaggio to more jeering. "You might as well do nothing. You'll be out soon."

Jenny calmed her voice down but couldn't resist needling Carvaggio. "You can find all the eucalyptus there are outside of Australia, but they're nice trees, and you won't succeed in lynching them. You've worked yourselves into such a snit about them that I suppose you'd go after

them in their native land if you could."

Jenny then put on her sound cancellers so she couldn't hear Carvaggio. *I really have work to do.* The cancellers annoyed Carvaggio and the other Nativists.

I went into physics, partly because I hate squabbles. Maybe I should give up and go down. If only these Nativists weren't such S.O.B.'s. Maybe Sam is right about them.

A few hours later Sam called with bad news. "NASA says it will be six months to get you a space suit. The company that makes them works in batch mode, and you are just too late for the next batch. I'll call Senator Upham about putting on some political pressure, but you'd better call him too. I suspect he listens more to you," said Sam with a wistful note on the last part.

Jenny and Sam did call the senator, and he said he'd do what he could with NASA. "They really dislike me now, but they have made commitments to the project they'll have to follow up on."

Jenny tried to phone Captain Cuthbert Carlson, the commander of the space station, but he had no time for her. Finally, it was lunch hour and she went to lunch, exhausted, starving, and slightly nauseous.

She embarrassed herself by getting stuck in mid air in the dining room. A man threw her a line to pull herself back. She pulled too hard and ran into him, and it seemed to her that the resulting hug was tighter than could be the result of accident—but what did she know. She turned red and stammered an apology. All he said was, "If this is the worst that happens to you, you'll be all right. I'm Cuthbert Carlson, and I suppose you are Professor Flitter. Now you've got my attention, what do I need to know about?"

Carlson was a tall blond man, a trifle overweight, and with a receding hairline.

Mini-AG buzzed in her pocket. Jenny knew what it would say "be assertive" or some synonym thereof. She was getting irritated with AG, since she was already prepared to be assertive with Captain Carlson. *Still I owe AG credit for helping me become more assertive.*

"Yes, two things, but I'm not sure what you can do. First, the Nativists have moved in on half my pressurized space, and were trying to bully me out of the rest of it on the grounds that some NASA official re-allocated it to them. The purser rescued me for the time being. Second, the space suits I have won't work for me. My arms are too short to reach

the internal controls at the ends. NASA says it will be six months before a space suit fitting me can be made up, because the manufacture is in batch mode."

The captain moved Jenny around so she could attach the velcro on one foot to the velcro on the wall. Unfortunately, she stuck out her left foot when it should have been her right. The captain had to grab her again lest she fly off. Once she was properly attached to the wall, the captain replied,

"Space is tight on this station, and every group tries to get as much as possible. There are 50 people in space intended for 30. Space allocation is a matter for the purser, Captain Samson Tung, but I have to confess that it is often influenced by strings people can pull on earth. The Nativists are quite well connected.

I gather you have good political connections or you wouldn't be here. Maybe you can use them to speed up making a space suit for you, but there may be another solution. The Chinese may have an extra small one. Start with Tung on that also."

Tung was a large Chinese from Singapore with extremely good English and, apparently, equally good Mandarin. Tung told her, "I'll look into the space question, but that tends to be political and may take a while. Maybe there is a solution to the space suit question. The Chinese have one that's too small for any of them. Professor Fangwei Li, who designed it, is a small man and was going to test it himself. He's laid up in Beijing with a heart attack."

They promptly went to the Chinese part of the station. Jenny could just about keep up with Tung now, although he did have to caution her about keeping in control so as not to run into things. "Every jump must have a precise destination," he said.

The Chinese space suit was an experimental model with four arms. The wearer put his two arms into two of the arms. At the ends of the arms on the inside were gloves and additional controls. The gloves waldoed to the hands on the arms, i.e. the hands on other arm did the motions Jenny made in the suit arm her own arms were in—which other arms were selected by the additional controls. One pair of arms was much longer than the other. Another feature was that there were human-sized hands on the ends of the arms waldoed from gloves on the inside. Astronauts had always complained how the thick protective gloves interfered with delicate operations. *One more damn thing I'll have to use without training. At least*

the space suit is the right size for me.

These Chinese did not believe in taking things slowly. As soon as she could work the controls of the space suit at all, Jenny was pushed into the airlock along with two Chinese astronauts. When the airlock depressurized, she was pushed into space and told to swim. A computer program was to translate swimming motions of the astronaut into appropriate jet firings from the suit. Anyway they were supposed to be appropriate, but Jenny's ordinary underwater swimming motions didn't have the right effects. The technician twiddled knobs, and the programmer typed. After three hours she was swimming ok but exhausted, and the suit plumbing hadn't been set up for a woman.

Finally, they let Jenny back in the airlock, pressurized it, and peeled off her space suit.

"Thanks for being the first test pilot of our new space suit," a tall Chinese named Wangli Hu told Jenny. "Come back tomorrow, and we'll get you using all four arms, and also we'll adapt the plumbing for a female."

Although Jenny was exhausted, she had to eat. The mess room was full of people saying goodbye to a European group that had finished their experiments and were returning to Earth. They all were telling what they would do when they got back to *terra firma*—that is, all but one.

"Come on Vittorio, there's more pretty girls than one. Just because she sent you a 'Dear John' email, you don't have to regret coming down."

Vittorio Orsini responded, "Graciela was the last straw, but apart from her, I'd rather work in space."

Vittorio was a muscular two meters and spoke English with a North Italian accent. He'd been a mission specialist for about 25 years on a great variety of missions, the early ones on the old space station.

The message in Jenny's ear from Mini-AG told her, "Hire him, maybe". *I have to admit I needed that suggestion.*

Jenny was primed for action in spite of her fatigue and worry. "Vittorio, what are you good at?"

"He's good at fixing anything," one of the Germans said.

"Can you work outside?" Jenny asked.

"That's really what I like doing, but this project turned out to be able to do almost all its work from inside. I do have a space suit and have worked outside. They said I could keep it, because it fits only me."

"How would you like to work for the Neutrino Telescope project?

There will be plenty of outside work in that. There were supposed to be two people up here, but because of a car crash, I'm the only one."

Vittorio asked,"Does anyone know whether someone can switch projects and stay in the station?"

Just then Captain Carlson arrived, and Jenny put the question.

The captain asked Vittorio if he really wanted to stay up longer, reminding him of how weak he'd be when he finally returned to Earth. Vittorio was sure of it.

"Well it's never happened before, and the Space Station Board ought to approve it. Why don't you go down with your crew, and apply? It shouldn't take them more than six months to decide."

Jenny said, "But I need help now, and I can't pay for another trip up."

"In that case," said Carlson, "it's an emergency, and commanders can bend the rules in emergencies. OK, Vittorio and Professor Flitter. If you can agree on pay, etc., Vittorio can stay." *Carlson seems attracted to the neutrino project and maybe to me, and maybe he likes to show that he can act in an emergency. Maybe he welcomes a chance to do Vittorio a favor. Maybe life in the space station has been dull recently.*

The return-to-earth celebration resumed. The leader of the group was impressed by Jenny's quick action and said so to Carlson.

Jenny had to pay Vittorio a high wage, because he would have to buy his food and rent his sleeping accomodation. An economic calculation, referred to AG at Pickett, came up with the numbers, and Tung, as purser, agreed.

Vittorio came to Jenny's space, half occupied by the Nativists. The members of the project had already gone to bed after appropriating a bit more of Jenny's space.

"Possession is nine points of the law," said Vittorio. He and Jenny heaved the Nativist stuff back into its own space and locked the intervening door. Vittorio, larger than any of the Nativists, agreed to sleep in Jenny's lab space and defend it when the Nativists came back. When Jenny came back to the lab in the morning, the Nativists still hadn't arrived, so Vittorio gave Jenny a martial arts lesson.

"One of the Japanese up here ten or fifteen years ago had been a martial arts instructor and decided that zero-g needs its own martial art. There are variants according to whether kicking is allowed. We've been playing bounce fighting ever since then. Did you ever play court tennis

where the ball is allowed to bounce off the walls and the ceiling?"

Jenny had never heard of it.

"In zero-g , you can bounce off the walls. Try it. See how you like bounce fighting."

Jenny tried bouncing off walls to tackle Vittorio from behind. She didn't have much success, because Vittorio was both much bigger and was experienced.

When the six Nativists returned, they expected to easily overwhelm the small woman and the one man, even if the man was rather large. Vittorio was able to handle them easily, and Jenny was some help when she unexpectedly bounced off a wall and hit a Nativist named Sam Smith in the belly with both feet, knocking him out when his head hit a wall. Vittorio was able to throw all of them back into their own space.

As a matter of ultra-green principle, the six Nativists did not like the space station people, and the feeling was mutual. A congressman had arranged for them to get their share of space station time, and the survey of eucalyptus trees fit what could be done in a straightforward way. A specialized unmanned mission would have suited them better, but using the space station was cheaper, because the survey equipment could be put together out of standard parts and debugged in the station.

The first problem for the space station had been that there were six Nativists. Captain Carlson thought the job could have been perfectly well done by two people or even one. Moreover, they had a leader of no apparent technical competence, but who was always demanding more resources: more space, more electricity, and vegan food for three of the six.

When the two mission specialists from the neutrino satellite project were in the car accident, Nativist leadership in California assumed the project would not use its space and got some NASA official to assign it to them. Whether this official had the authority to do so was in question. In any case, Jenny's arrival at the station was a shock.

Jenny finally got back to her sleeping restraints in the women's dormitory.

Next morning there was a real squabble with the Nativists. They complained to Tung who referred them to the Station Board on Earth. As Vittorio had predicted, possession turned out to be nine points of the law, at least for the time being. Vittorio's large size and bounce fighting ability made a decisive difference, allowing one man to intimidate six. Jenny began to train Vittorio in the black art of assembling neutrino detectors.

That afternoon Jenny and Vittorio went back to the Chinese section, and the Chinese let Vittorio go out from their airlock along with Jenny. The first task was to lay out on the outside of the station a frame for the structure that would be towed to the Neutrino Telescope satellite point. The parts for the frame were in a cargo bay that would soon be needed for another project, so they had to hurry.

Two Chinese, Dr. Jungxi Ma and Dr. Wangli Hu, whom Jenny had already met, went out with them. They had previous experience working outside the station and were very helpful in exchange for Jenny answering a lot of questions about the neutrino telescope and what it was expected to accomplish. Ma, whom Jenny had met when she lectured in Beijing, turned out to know quite a lot of neutrino physics, and had specific opinions about the neutrino satellite even though his work on the space station concentrated on quite different questions.

Ma thought the neutrino satellite would be found obsolete as soon as it was up. "Our neutrino people suspect the beam will be found much narrower than you think. Most of the detectors in your cluster will be useless; only a narrow line will detect neutrinos. No-one has a definite theory, but we think the only way the beam could avoid scattering in space is if there is some kind of non-linear strong focussing effect like for light in a fiber-optic cable or protons in a particle accelerator. For that the beam may have to have microscopic or even nuclear diameter."

Jenny was impressed that the Chinese, including Ma himself, had given the problem so much thought. Their conclusions seemed reasonable, and she promptly emailed their opinions to Sam.

The next day, when actual construction of the shell for the neutrino satellite began, Ma and Hu were there again. This time they helped get the parts of the frame out of the cargo area and fastened to the outside.

It took Jenny and Vittorio three months of very repetitive and tedious work to assemble the detectors, load them with the magic organic fluid, and mount them in the frame. The last step was to mount a tiny cabin that could hold two people rather close together.

December 2031: COMPLICATIONS AND POLITICS AGAIN

With all the work, the Chinese were very helpful.

After a lot of puzzling about international relations, about which Jenny knew nothing, she overcame her inhibitions about discussions that might involve the government and asked Ma directly, "Do you Chinese want to come in on the neutrino telescope project?"

"Hu and I do, and our institute does, but I don't know about the science ministry or the Politburo."

Jenny sensed that Ma and Hu weren't telling all.

That night Jenny phoned Upham. Besides updating him on what she'd been doing, she told him, it also seems like we'll go over budget on the time to prepare the detectors and mount them in the shell. The tug charges increase in March, and we won't be ready to have the shell towed to orbit by then. My executive officer at Pickett tells me we can use some operational money for now, but it will have to be made up later.

Jenny told Upham about the Chinese interest in getting involved in the neutrino satellite project. The next day Upham phoned Jenny,

"The Chinese feeler has caused a lot of excitement down here, and there are differences of opinion among the people who matter. One byproduct is that you are now allocated a private, encrypted communication channel in case we have to discuss international collaboration. When can you come down?"

Jenny replied, "I can come down as soon as Peter Chiang can come up and I can brief him. I think he knows some Mandarin, although at home he spoke Hakka. We should have a two week overlap—longer if he has space sickness problems." Jenny still had had only a little space sickness, some nausea but no actual vomiting.

January 2032: NUTS TO YOU

The next time out Jenny left by one of the American air locks, because she'd taken the space suit to her own lab space for a final adjustment of the newly installed plumbing and left it overnight. *At least I can get rid of that damn diaper.*

When she came out of the airlock, Jenny pointed herself toward the detector frame under construction near the Chinese airlock and turned on the main jet. It started promptly and she saw that she was being accelerated in the right direction. When she thought she had enough velocity, she turned the jet off.

The jet didn't go turn off, and her velocity continued to increase. Toggling the control several times didn't help.

She pushed the emergency button, and Captain Carlson answered. She quickly told him the problem and he patched her through to Tung. Tung had no idea what to do. She thought Tung might be panicking. She was on her own and accelerating.

First she tried putting one of the fingers in the jet outlet to block it. That almost stopped the flow of gas, but what came out was in random directions putting Jenny into a spin. She spread her arms to reduce the rate of spin and swam back to facing the target. That worked, but she was still accelerating.

It took Hu a while to get patched through to Jenny, "Face the other way and let the suit thruster slow you."

Finally, she did what Hu said—what she should have done in the first place—faced in the opposite direction and pulled the finger out of the jet, to give acceleration in the opposite direction and slow her velocity. That seemed to be working, but then the main jet ran out of gas while she was still moving several meters per second.

"Turn your feet toward the structure and bend your knees a little. It's going to be like a parachute landing fall.," said Captain Carlson who could see Jenny on one of the external TVs.

Jenny knew about parachute landing falls, but didn't get turned around in time, hit quite hard, and felt a bone break in her foot. Hu and Ma tried to grab her, but couldn't grip the heavy space suit, and she bounced off into space.

Worse she heard air hissing out of the space suit. *I've lost it now*, she thought. *Oh well, it was nice with Bill. Maybe they'll name the neutrino telescope after me.*

After a minute the hissing stopped, and Jenny was still breathing. Professor Li had done a really good job on the suit. Apparently, if one segment lost air, it was blocked from the rest. Still she had one foot in vacuum and was flying away from the space station. Her fear of immediate death now turned into fear about the next few hours, the time her air supply would last.

Which of these Chinese labelled displays gives the oxygen supply? "AG, can you tranlate the Chinese labels on the suit display." AG could and did, and displayed it as an overlay on an image of the suit display. *Oh, yes. It's the big one in the middle. 10,820 seconds; that's three hours and twenty minutes. Here's the switch for the thruster system. I'd better turn it off to save rocket fuel.*

"Hang on, Jenny," said Carlson in the calm voice used for dealing with people in danger. "Do not use your thrusters, and that means don't make swimming motions."

"I read you," said Jenny in the calmest voice she could manage. "I've turned off the thruster system. My left boot is broken and I think my left foot is also broken. There was some leakage to space, but the hissing stopped; I have three hours and eighteen minutes of oxygen out of the ten hours I started with."

"That will make the timing tight. You will get swelling from the vacuum exposure, but I hope the boot will control it. The big danger is frostbite or overheating. Keep adjusting the position of your foot for maximum comfort in temperature. Hold on for further instructions."

"Holding on."

"As Kepler taught us, your orbit around the earth will bring you back to where you left the station provided you don't do any rocketry, but the station will be ahead of you or behind you depending on the direction of your exit vector." Somehow Jenny was soothed by the physics terminology. "We should have an estimate in a few minutes." A single impulse from a Keplerian orbit puts you in a new orbit that takes you back to the point at the same point in orbit, but not necessarily at the same time as another object (in this case the space station), will reach that point.

Mini-AG piped up, "I calculate from the Delta v that we'll pass 220 meters behind the station in 115 minutes."

After another three minutes Carlson said, "We're tracking you on radar, and your computer is about right. We get 216 meters. We have about three minutes more radio contact. Keep calm. Be as inactive as

possible to conserve oxygen. Take a nap if you can. Turn your radio off to preserve the battery, and turn it on at 3:18. We're working on a rescue plan."

After a minute Carlson continued.

Does your suit have a ring we can hook to?"

"I don't see one," Jenny replied.

Ma looked at the instructions for the space suit and didn't find mention of such a ring. "We'll tell Professor Li to put one on the next model."

"It is very comforting to hear about the improvements that will be in the next model," snapped Jenny, and then the radio signal began to break up.

"Sorry about the snappishness. Flitter out for now," she said, and turned the radio off.

Jenny was not only frightened but bored. She'd read about pirates about to be hanged playing cards while they were taken off one at a time. She decided to dictate some letters to mini-AG, starting with one to Bill.

"Dear Bill,

You told me you had wanted to be an astronaut. Well, I never did, but here I am about as astronautical as you can get, my space suit having flown off from the station, due to an accident I should have avoided. I'll be back near the station in two hours and seventeen minutes, and that's when they'll try to grab me. I've got two hours and fifty-two minutes of oxygen, so they get one try.

Love,

Jenny"

I'm not sure about the "Love" part. I'll have time to reconsider before the letter can actually be sent, although I suppose I could send it right after I'm in range of the space station. Sending text uses much less power than speech.

Jenny began to have doubts about her watch, but she turned so she could see the space station in the distance getting farther and farther away. *It's very lonely out here, and the station looks very tiny.*

After a long time the station began to come closer again. "How far is it?," she asked Mini-AG after telling it the angle it subtended in the sky. Li's design had included calibrating the goggles in degrees.

"Still several kilometers," it said. "I'll tell you at 700 meters, and you can turn your radio on."

Jenny had forgotten about her foot, and now it was very cold. She quickly turned to give it sun.

At 700 meters she turned on the radio. "Flitter here," she said, hoping the movies she'd seen had got the NASA jargon right.

"Receiving you, professor," replied Carlson, "I'm coming out with a line and a net. Our relative velocity will be about 7 meters per second, so it will be a fair jolt."

"Roger, I see you," said Jenny.

"Good. Turn sideways to me. Hold still until I grab you and then grab the rings on my space suit."

Ah, another hug. This one will be through two layers of metal—much more respectable. Aloud, "We can't go on meeting like this."

"My wife is very tolerant of my duties."

The capture worked ok, and Carlson and Jenny were hauled back to the Station.

Jenny said, "I'm honored to have the captain come after me."

"Actually, I'm the one with most experience in flying in space. I used to be in charge of training at the old space station."

Jenny still had an hour of oxygen when the airlock pressurized. She was rushed from the airlock to the infirmary and peeled out of the suit. She asked, "What are the consequences of having my foot in vacuum?"

The surgeon said, "Don't you remember your briefing on this in Houston? Oh, yes, you skipped Houston. In general, the consequences are not too bad. You get swelling, but it comes down soon, although most experience is with exposures of only a few minutes. Yours was several hours. The main danger is frostbite.

"You have just a twinge of frostbite, and the boot restrained the swelling pretty well. The swelling will be gone by the day after tomorrow. The broken foot is another matter. You'll be four weeks in a cast. Fortunately, the shuttle is already here, and you can go down tomorrow."

"I can't go down right away. I assume Peter Chiang came up on the shuttle, and we'll need at least a week of working together on assembling the detectors. There's no reason he should go through the tedious trial and error process I did."

Captain Carlson said, "Now we have to do a preliminary postmortem on the accident. Glad it's not a postmortem on you."

If Jenny had been able to read Chinese, she'd have used the space suit's checklist, but it hadn't been translated yet. The checklist said to turn

the main jet on and off twice while still anchored to the space station.

The Chinese had the checklist translation now. Jenny put the memory key with the checklist in mini-AG which she still had around her neck.

It seems the Chinese had been too nice to Jenny before. Instead of making her go through the checklist herself, they'd gone through the steps themselves, including the step that would have caught the malfunction. Carlson spoke feelingly about this—as feelingly as he dared, worrying about what he'd read about orientals and their reaction to "loss of face".

Ma had read about China in English and learned about common Western notions of Chinese notions of face and said, "You don't have to be so gentle about that. Speak as you would to another American. We were too damn gallant with Jenny." Carlson thought, *This guy's English is a lot more colloquial than most Chinese English. What's more, he knows us.*

Carlson was less diplomatic in speaking to Jenny.

"Your accident is one more reason why it's dangerous to let someone come up who hasn't had Houston's training. They drill everyone on the need to always use a checklist. You shouldn't have gone out by yourself, and had there been a reason why the trip was needed, you should have phoned the Chinese and made them go through the checklist with you."

Jenny thought of several things she might say but confined herself to saying, "Yes, sir. I'll try to do better."

Carlson had another thought. "Come my office at 5:30, and I'll give you a two hour drill on what Houston would have taught you."

Jenny could only reply, "Yes sir. Thank you, sir."

Hu had examined the space suit and said, "The cause is obvious. There's some kind of nut that's preventing the valve from closing."

They called Jenny in the infirmary. "How did a nut get into the space suit?"

She asked, "A machine nut or a nut from a tree?"

"A nut from a tree."

"Oh, dear. Is it a eucalyptus nut, by any chance?" Jenny had seen one of the Nativists playing with eucalyptus nuts. *I suppose it was on the principle of knowing your enemy.*

"We don't know what a eucalyptus nut looks like. Look on your phone."

One look confirmed Jenny's suspicion. Carlson immediately said, "This is a matter for the FBI."

The next day: THE INVESTIGATION

While Carlson already had a bad impression of the Nativist group, Jenny had made a quick favorable impression on him. Jolene told him that Jenny had picked up the basics of living and working in a space station very fast, and he was not much put out by her getting stuck in mid air in the dining area. "It has happened to fully trained people," he told Tung. When she hired Vittorio on the spur of the moment, quickly got help from the rather prickly Chinese, and got started on her construction work, both inside and outside the station, he praised her to the NASA people and took her side in the space squabble. Her calm behavior in the face of danger would have been creditable, even if she had been a professional astronaut. *However, that checklist lapse does take some forgiving. We might have lost her.*

A search of the Nativist area turned up no nuts, but two were found in the neutrino project space, of which Jenny denied all knowledge. Carlson had read enough detective stories to make sure that no one touched the eucalyptus nuts in Jenny's space and put them in plastic bags for the FBI. They went down on the next return rockets along with hand swipes from Jenny, the Nativists, Jenny's people, and even Jenny's visitors. They also swiped the space suit but didn't expect much, because it had been in the vacuum of space, where it was both chilled and heated.

The FBI quickly found traces of hand oils from one of the Nativists and maybe another. There was no trace of any of the other people on the space station who were tested.

This particular Nativist, Sam Smith, had been convicted of putting sand into the oil of logging bulldozers. He'd spent 4 months in prison but had been pardoned by the new environmentalist Governor of Oregon. According to Oregon's civil rights laws, the pardon caused all records of his arrest and trial to be expunged. The FBI agents couldn't erase their own memories, however. Also Smith was the one Jenny knocked out with a bounce kick. Evidently he hadn't taken it as a joke.

Carlson said to Jenny, "There's no reason to suppose he knew how your space suit worked and could figure out what effect blowing a nut into a particular hole would have. Therefore, he can't be charged with attempted murder but only with sabotage of the space suit—and that Chinese property, i.e. not US government property—but he is guilty of reckless endangerment.

"If he is tried, you will have to testify, and maybe I will also. You

can be sure his lawyers will take up as much of your and my time as they can. My suggestion is that we compromise on dropping the charges in exchange for the Nativists leaving the space station. You can have their space."

Jenny was shocked, "I might have been killed, and you want to let that bastard off!"

Carlson replied, "My job isn't fighting alligators; it's clearing the swamp."

Jenny cooled off. "I've heard that before, and I guess it's right this time too".

When Carlson told Carvaggio the Nativists would have to leave, he said, "Why should you blame us all for what one man did?"

"You're in charge, and you are responsible for the behavior of your whole group. When they misbehave, you're at fault."

The Nativists huffed and puffed but obeyed their bosses and returned to earth on the next shuttle. Steve and Mike were in good enough shape to come up to join Peter Chiang and use the expanded space; each of them still had a leg in a cast, but legs weren't so important in space. The project then proceeded very fast. Indeed it was ready before the tow rates went up, so it was towed to the correct orbit. However, it needed more work there.

March 2032: POLITICS

When Jenny landed at Cape Canaveral, her left foot was in a cast, and she was promptly put in a wheelchair. Sam and Senator Bill came to greet her, as well as her mother, father, and all four grandparents. President Blanton of Pickett came to tell her that the Board of Trustees had promoted her to full professor and Sam to associate professor with tenure. The tenure part was because Blanton feared there might be some jealousy of the blatantly PR motivated promotion and wanted to get the matter settled.

A surprise attendee was Professor Li, who had designed Jenny's space suit and was now well enough to travel. He still hoped to go into space in spite of his age and heart condition. Flashes went off as Jenny kissed the startled Chinese and expressed her gratitude for the design features that had isolated the effect of the puncture and saved her life. They had a long conversation about Jenny's tests of the space suit, such as they were. Jenny added, "The other astronauts are all envious of the waldoed small hand". She'd been too busy to check out all the features. Li had been told about the need for grab rings and a grill in the thruster tube.

"I'll fix the suit you used and make another to fit you precisely," said Li, who was really pleased to have his space suit tested and its features praised so publicly. The NASA space suit managers took under advisement the features of Li's suit—meaning that nothing was likely to happen soon.

The whole international press reported the sabotage of Jenny's space suit and her narrow escape. Her going to the space station without preparation was made more news, as did Captain Carlson's praise of her success in adapting to space, starting her work, and calm behavior during her "accident". As part of the deal, the Nativists weren't mentioned, although some of the bloggers found out and posted stories.

ASTEROIDS

The Chinese had a very active space program. While the US was establishing a permanent base on the moon, the Chinese had put a base on an asteroid, one of those with an orbit that crossed the earth's orbit, and claimed it. There was a big fuss at the UN about this because the non-space faring nations liked to regard everything in space as international property, but it soon died down. There were plenty of asteroids.

Singapore's per capita GDP had recently surpassed that of the US, and naturally this made them even more scientifically ambitious than they were already. Singapore is a very small island, holding ten million people, so the more claustrophobic of the Singaporeans were more eager to settle asteroids than Americans were. They already had two asteroids.

Fortunately, the US had never ratified the "common property" treaty, which had been killed by a political campaign of space enthusiasts way back in the 1980s. NASA didn't establish an asteroid base until five years after the Chinese, having concentrated on the moon and Mars. The Chinese then took two more asteroids and a short period comet. The British, European, Singaporean, and Israeli asteroid bases came a few years after that. The American Asteroid Foundation established a base with privately raised money.

It turned out that asteroids were quite tolerable places to live for people of a pioneering disposition and the independent minds that usually went with it. The pioneers had to commit to living in tiny gravity, which would complicate any return to earth. In compensation, travel among the asteroids using nuclear or solar powered ion rockets was vastly cheaper than travel from a planet. The independent minds part had given NASA some trouble and the Chinese government much more.

While each asteroid base was supported from a particular country, their inhabitants shared common problems, including the political problems of getting along with their home countries. Every country had an asteroid project leader based on earth, some of whom never visited their country's asteroids. An exception was an asteroid colonized by the privately financed Asteroid Foundation based in the US but with additional support from billionaires in Britain, Russia, and Israel. The private aspect made the governments and the UN nervous.

The creation of the Asteroid Association entirely composed of asteroid dwellers made the home countries nervous, and some of them made difficulties about authorizing use of the rockets for inter-asteroid travel,

even though the costs were low. At Asteroid Association meetings, there was talk of eventual independence from earth, but this was infeasible as long as the colonies were so dependent on supplies from earth for which they could not pay.

The US and China had a working group on space collaboration that had mainly worked on avoiding interference among communication satellites and had negotiated emergency landing privileges for the Chinese in the US and in places where the US had facilities for emergency aid to astronauts. Since the Chinese had always managed to land in China, this hadn't led to much activity. The Chinese did express official interest in taking part in the neutrino satellite project.

Some of the more competitive and militarist people in the US government thought that the neutrino receiver was an advantage that the US should keep.

Jenny was startled when her own opinion was asked by a TV interviewer on the question of bringing the Chinese into the neutrino satellite project.

"Ask me about physics or about space sickness. Sam is the one of us who also thinks about politics."

Sam was eager.

"There might be some advantage in having the message to ourselves for a while, if there's a message. However, this would create a major bone of contention between ourselves and the Chinese that might last a long time. We have no important conflicts with the Chinese now that the Taiwan question has been suitably fuzzed over. Better we should include them in the project and make whatever results we get public."

Jenny added, "Besides, the Chinese who talked to us think that the beam width is microscopic. If they're right, we'll have to revamp the satellite or replace it. That will cost a lot of money."

A reporter asked, "Shouldn't it be a UN project?"

"Not if you consider the UN's record over the last 100 years.," said Sam with his usual tact.

That was TV. Polls did favor including the Chinese. The real business was in Congress and the administration.

The science committees of the House and Senate held joint hearings, and the administration, including the National Security Council, deliberated. It only took three months to decide to accept the Chinese offer in principle. The political and financial details were then negotiated.

The scientific details were left to a 20 person working group that included Jenny, Sam, and Ma, the Chinese neutrino expert on the space station. Ma turned out to be a surprisingly important person, the son-in-law of a Politburo member. However, not much could actually done until the first results came back from the neutrino telescope.

Senator Upham used his internet access to AG to ask questions about Jenny. AG was not fooled by his pretense that his questions were solely related to his risks in going out on a political limb to support his project, especially when he wanted to know what Jenny thought of him and might have asked AG about him.

"I am programmed not to gossip," said AG, "but I can advise you on the basis of information you give me." It turned out the senator was thinking of marrying Jenny but had little further excuse to see her alone.

AG had a suggestion. "Considering the matter from a political point of view, Professor Flitter already owes you a favor. You have spent a lot of your political capital in supporting the neutrino telescope. Why don't you ask her to help with your re-election campaign?"

"That would be rather blatant," said Upham.

"You can get one of your political henchmen or henchladies to ask on your behalf. That won't tip your hand—much, and you'll have plenty of time with her—unless you're a total sluggard. If you need more advice, ask me, but just remember. If she asks, I'll advise her too."

"You are one devious computer.," said Upham.

"Program," corrected AG. "I can run on any computer with enough speed, memory and a Lisp system".

When Jenny returned to Pickett, she received a surprise visit from Henry Heinz, Senator Upham's chief aide in Arkansas.

He put it bluntly. "I don't know what hold you have in Bill, but you may cost him his re-election."

Jenny gasped. "You mean if that night in Florida before the launch gets in the papers? I didn't think Arkansas was that bluenosed."

Heinz looked at her as though she were an idiot.

"I don't know what you and he might have done in Florida, and it would have to be really gross to make a difference these days. Sexual harassment hasn't much play in politics since the Clinton era at the end of the last century. Old Bill killed it off. Did you and our Bill actually kill somebody?"

"No, and what we did is none of your business."

"Indeed. Short of that, it isn't. The problem is that Bill made deals to get your project through Congress that offended some of the interests that support him in this state. His going all out with NASA and higher to get you on the trip to the space station may also cost him. The deep greens have it in for him now and may bring in some out-of-state money for TV."

"But I had to go up! The project would have collapsed if I hadn't. I couldn't know Mike and Steve would be in a car wreck."

"That's how it looks from your point of view. Me, I'm a pol, and I'd like to be a senator some day. You have to help Bill out of this jam."

"I didn't know I'd got him into a jam. He muttered a bit, but didn't say anything clear that I understood. How can I help him? I know nothing about politics, and I have no political influence."

"That's what you think, Jenny. You're a heroine now and also a victim, for at least the next year or so. You need to ride around with him when he campaigns to be renominated. It would help him even more if he married the space heroine."

"I can ride around some of the time, but as I told AG, I'm not a goddamn princess to marry for reasons of state. Also, besides this project, I'm a professor and have classes to teach and students to supervise."

"Who's AG? Never mind. Glad you're willing to help. I'll try to work out a schedule before primary time. By the way, could you get your buddy Sam Schnurle to stop making like he's in some sort of Gulag at Pickett?"

"I'll do what I can with Sam. He doesn't see much use for tact, and maybe he's mad at me right now."

Sam was willing to lay off Pickett for the project's benefit, but he didn't like Jenny's commitment to ride around with the senator. However, he got AG to search the Web and verified that Upham had made deals to get the project through Congress that were likely to cost him a lot in his home state—so Upham really had a good excuse.

Reactions

Jenny was surprised at the varied reactions of religious groups.

The mainline religions had little problem. They had been pretty well beaten down in the 19th and early 20th centuries into accepting evolution and the 4.5 billion year age of the earth. The existence of other civilizations didn't bother them. The Christian fundamentalists had more problems, but the people who were good at explaining away hundreds of millions of years of strata with fossils readily adapted themselves to the new task.

The great majority of cranks hadn't received any messages, but were pretty sure what the messages would say, once decoded.

Many said that advanced countries, especially the US, could expect to be punished for their sins against the environment and indigenous peoples. Now that the Chinese were an advanced country, they too could expect punishment.

Another view was that the messages would tell us how to solve all our social problems. Most who took that view were also sure what advice the galactics would give us.

Militarists said we should increase the defense budget now, ignoring the fact that the closest aliens were tens of light years away.

Still others said that scientists would become obsolete—mere students of advanced alien science. Jenny and Sam worried about that possibility. A prominent rabbi, a relative of Sam's, and a well known Talmudic scholar, welcomed the possibility. "It will make science," he said, "more like studying the Talmud."

The usual paranoid styles in politics were out in force. Some leftists were sure the corporations and the government already knew what the messages said and were keeping it from us. The paranoid right had a curiously similar theory. There was going to be a UN monopoly on alien science that would prevent free enterprise from using the information.

Some conspiracy buffs said the whole thing was a government plot to militarize space. Others said it was evidence for the kidnappings by aliens reported as early as the previous century.

May 2032: POLITICS AT THE COUNTY FAIR

At her first political trip with Bill, Jenny was a little put off by Bill's campaign bus and having breakfast, lunch, and dinner with so many people she didn't know. After she realized they were more intimidated by her than she was by them, she enjoyed trying to put them at their ease.

The first time she stayed at a hotel with Bill, AG gave its "go for it" beep. She indignantly told AG, "From now on I'll manage my own relations with Bill; with no advice from you unless I ask for it."

The second night, a Thursday, she decided to go for it. This time it was Bill who was nervous and seemed to need comforting. He had been very perfunctory at dinner. Bill thought, *Now I'm in big trouble, letting my nostalgia for physics delude me into seducing and making commitments to this unsuitable woman.*

Jenny thought Bill thought he had taken advantage of her terror about going to the space station unprepared—and she thought maybe he had, but he had been so comforting, and he had made all those phone calls—even one to the President. Anyway, it was her turn to take the initiative, so she knocked on his hotel room door without any prompting from AG. Bill had been in bed half drunk, and she didn't even know what was bothering him. She got in bed, still fully dressed, and took the whiskey glass herself, even though she didn't much like bourbon.

Bill's guilt feelings about Jenny disappeared when she knocked on his door. *I guess she must really like me. This isn't just paying off a political debt. Let's wait and see what happens.*

She decided: sex first, troubles later. When she had a nightmare and woke up shouting to Haines to leave her alone, for a few seconds Bill thought she was shouting at him. When he figured it out, he took pleasure in comforting her.

Bill's trouble turned out to be mainly that his primary opponent had been wooing his major supporter Rupert Hugheston. Hugheston had no objection to the neutrino telescope, but Senator Upham had made some vote swaps in order to win support for the telescope that were adverse to his interests.

"Do you want me to go along when you have dinner with Hugheston."

"Yes, but act like my girl. Otherwise, Hugheston is likely to make a play for you himself. I think you're his type."

I like being Bill's girl, anyway so long as there isn't any long term

commitment.

AG advised Bill, "You should be able to mollify Hugheston. The vote swaps are in the past, and NT is popular enough that desperate measures are no longer required. Let him think you did it all for Jenny rather than just because it's a great project."

The dinner was a success. Jenny turned on the charm, something she hadn't known she was capable of doing, and also chattered about what went on in the space station. Upham was able to convince Hugheston that he had only made a vote swap, not turned against him, and wouldn't have to do it again.

Jenny decided she liked county fairs, and she actually had fun presenting the prizes and hugging the winners at demolition derbies, even if some of them reminded her of the thuggish young Stillson. Even one of the female contestants reminded her of Stillson. These were the real demolition derbies with the drivers in the cars, not the kind with remotely driven cars.

She was glad she could turn down the suggestion of being one of the judges of young turkeys and also of the muscle builder contest.

Jenny and Bill's aide, Henry Heinz, a suitably large young man, went out to bars with some of the demolition drivers. Heinz told her that somehow this helped Bill, especially as Upham couldn't go to bars himself in that somewhat bluenosed town.

As she returned to Forrestville Jenny thought about the campaign trip. *Perhaps I need a hobby different from doing physics. Sam has his gun club. Maybe mine can be campaigning with Bill. I don't think I could ever be a real politician though.*

December 2032: FIRST RESULTS

Mike and Steve, now recovered from their injuries, did the final set-up on the satellite in its final orbit. It went rather smoothly. It was immediately apparent that there were lots of neutrinos coming through and that the beam diameter was much less than 10 centimeters, so Ma was right that most of the detectors would detect nothing.

One consequence of the extremely narrow beam was that there could be only one neutrino telescope in operation at a given time. International collaboration was forced by the technology.

The US-Chinese collaboration group began to meet and was joined by the Russians—later by other countries. It started to design a new neutrino telescope (NNT). It would have to be very long and thin and lined up exactly with the beam from Arcturus.

Mike's and Steve's main complaint was about their enforced intimacy for about a week while the slow ion rocket propelled tug took them through the Van Allen belt of high radiation and they had to occupy a very snug shielded container together. "I want a divorce. He smells," Steve said.

"The Van Allen belt is unfriendly to manned space flight," said Jenny.

AG quipped, "So was Van Allen."

February 2033: HINTS OF A MESSAGE

Even before the first signals from NT came in, Sam wrote a program to try to distinguish information from random noise. It was a month before he got his first "entry," as the cryptanalysts called it. He'd asked Margery for help, but he got his results long before NSA managers said she could get involved.

"Here's something, Jenny,", said Sam with poorly suppressed excitement, "if you can spare time from politicking."

Jenny was on another phone with Henry Heinz making a date to speak along with Senator Upham at another county fair. She was on crutches and quite wobbly; she'd been too busy to do leg exercises on the space station. She finished with Heinz quickly and looked expectantly at Sam.

"I think we found what what Barnstell suggested we look for—a Freudenthal sequence. It's just a trace, and there's no real hope of actually reading it, catching so few of the neutrinos."

"So, wise guy, what's a Freudenthal sequence?"

"Hans Freudenthal, a Dutch mathematician, wrote a book in the 1930s called *Lincos: a language for cosmic intercourse*."

"I didn't realize the Dutch were already so sexually ambitious," snickered Jenny.

"More like being less inclined to consider sexual interpretations of book titles. Freudenthal imagined communicating by radio with civilizations on other solar systems without initially having a common language. Sending a Freudenthal sequence establishes a common language for further communication."

"How does it work?"

"You assume the aliens know some mathematics, physics, and chemistry—at least enough to build radio receivers. You start with very simple mathematical examples, for example

xxx y xx z xxxxx and xx y xx z xxxx,

and more like them."

"I see'," said Jenny after a minute; "The first represents 3+2 = 5, and the second "2+2 = 4. Why use the clunky unary notation for numbers? I suppose it's easier to understand at first."

"Yes," said Sam. "Freudenthal supposed that after a little while you could switch to binary or decimal notation, and later you could send

formulas with variables expressing general facts like x + y = y + x.

Freudenthal worked out the details for establishing a common language for a good part of mathematics. Then he did some physics and chemistry, starting with the simplest formulas and going on from there to quoted sentences. He wanted to establish common morality, starting with the idea that it is wrong to make false statements."

"So what have you gotten from our Arcturan Freudenthal so far?"

"Since they wouldn't know when a recipient would start listening, the Freudenthal sequence would have to be repeated again and again. It would also start out simple and get more complicated as more and more common language was introduced. It would be nice if it stood out from the main message being transmitted. They were nice.

"We can't read any of it, because we catch too few neutrinos, but we did find what seems to be a repeated signal that gets more complicated. Every time we get it, it's preceded by a hiccup in the transmission."

Jenny jumped up, winced, hobbled over to Sam and hugged him."That's really something. Should we wait for more or publish now? I don't think *Physical Review Letters* is the right place, and there isn't a *Journal of Extraterrestrial Communication* yet."

"Why aim low? I've been thinking of *Science* or *Nature*. It'll be a short paper with a detailed on-line supplement."

It took Sam a month to write the paper. *Science* accepted it a month later, and it appeared immediately on-line and in print two months after that. Such fast publication showed that the neutrino satellite was big scientific news.

June 2033: THE THEORISTS CATCH UP—OR MAYBE NOT

As part of the collaboration with the Chinese, Jungxi Ma, the neutrino theorist who'd been on the space station, came to Pickett for a year. Also Sam, who had great ability to understand mathematical theories, especially with the aid of AG, learned enough of the current version of the electro-weak theory to understand what Ma was saying and contribute ideas of his own. Jenny, an experimental physicist, and now a project leader and administrator, was left behind on the theory.

When Ma came to Pickett, he plunged right in. "As we get more and more results from the satellite, the width of the beam comes out narrower and narrower. Why don't we base our design on it being so narrow, of atomic or even nuclear size, that it is held together by strong focussing of the electro-weak field?"

"What's strong focussing?" asked Sam.

"It's when a beam of particles focusses itself by mutual attraction of the particles rather than needing external magnets. It gives an extremely narrow beam. All particle accelerators rely on it for electrons and protons. Whether a neutrino beam can focus strongly is something we shall have to figure out. The present neutrino theory doesn't provide for it.

Jenny went along with that. "If it's so focussed that the interactions are non-linear, perhaps the neutrino beam will interact with a laser beam, and produce an electronic signal we can amplify and get information from. It won't be the neutrinos themselves that interact, but the electro-weak field that is focussing them."

"OK, let's do the equations."

As they feared, "doing the equations" was extremely hard, and Sam and Ma were frustrated for almost a year. They couldn't be solved purely symbolically even with the aid of the best symbol manipulation programs. They couldn't be solved purely numerically, even with the fastest computers. Finally, they hit on a combination of symbolic and numerical methods, but it was based on some unjustified guesses as to what terms could be omitted from the equations without compromising the result.

The result told them what frequency and power of lasers would be needed and what filters would get rid of the noise in the electronic signal. It would have to be a gamma ray laser, something only recently developed. The laser would have to be so powerful that it would need a small nuclear power plant with the satellite to operate it.

The next International Conference on Neutrino Physics in Paris

six months later was more exciting than the previous one.

Sam's and Ma's theory was very well received by the neutrino theorists. There were only a few objections, and they were easily overcome. One persistent objector was a graduate student named Ali Majoud from Baghdad University who claimed that one of the omitted terms in the formula for the interaction of the laser and the neutrino field would not be small, and therefore the modulator as designed wouldn't work.

He took more time than he was entitled to, but the chairman finally cut him off. Then Majoud accused the Americans and Chinese of ignoring him because he was a Muslim, and he suggested that Sam was prejudiced, because Sam was a Jew. This was not taken well. He posted his calculations and his accusations on a Web site and tried to put them in the Physics Arxiv. It was removed because of the politics, though he was permitted to post just the physics part.

After they returned to Pickett, Sam, Ma, Jenny and a Caltech physics professor named Arundji undertook a detailed design of the modulator. It took six months, and they sent the bigger parts to be manufactured.

April 2034: Vacation

Then they took long awaited vacations. Sam, Jenny, and Arundji went to ski in Colorado, where Senator Bill joined them. On the second day Arundji, in a moment of inattention, hit a rock and broke a leg. After he was in his cast, and it was clear that a broken leg was all the damage, the others resumed skiing.

Sam was inexperienced with down-hill skiing, and it took a week before he could do the big run with Jenny. They first did a shorter run, but just as difficult.

They were just about go up for the Devil's Dream, when Sam said, "I need to talk to Arundji. I'll try the big one tomorrow."

Jenny said "See you tomorrow." *Maybe he's jealous of Bill. Bill's really a top notch skier.*

CLIMBING DOWN

The view from Arundji's room was beautiful: two ski slopes and the mountains behind them. Sam didn't give it a glance, not noticing Jenny and Bill swooping down. Arundji stared, and Sam spoke first. "I have a problem," Sam said.

"Whassa matter? The senator got your girl?"

"Much worse. I think that damn Arab is right about that term A4 in the equation. Our design won't work.

"It's not a 4th order term; it's a 2nd order term. I spent a week trying to prove it was 4th order and could be neglected. I daydreamed about the crushing email I'd send to Majoud. I just couldn't prove it was 4th order, so I finally tried to prove the opposite. It's not conclusive; it depends on another term being small, but it's pretty certain. How to show it came to me as I was coming down the Necktie."

"Glad you made it down OK. To tell the truth, I may owe my broken leg to worrying about A4 and trying to ski at the same time. I still haven't come to a definite conclusion. Do you want some coffee? With this leg, I don't feel at all guilty about using room service."

Sam and Arundji had coffee and puzzled about A4 till sundown. They called up Majoud's paper on the internet, but there wasn't anything more to be learned from it than what they remembered. They became more and more convinced that A4 couldn't be neglected.

Arundji said, "I think I can get Beckstein to look at the problem. Let's call him. He's real sharp on the non-linear part of electro-weak."

Sam was finally learning a bit of tact. "No, we have to tell Jenny first. She is head of the project. By the way, Senator Bill won't like this at all."

The phone rang, and Arundji picked it up. It was Jenny. "Sam isn't in his room. Did he tell you where he was going?"

Sam was staring out the window. The sunset was beautiful. *Maybe this is a place to spend some time.*

"He's been here all afternoon."

"I hope he isn't crying on your shoulder."

"We've been crying on each others' shoulders about A4. Our design won't work—or at least not well. Come up, and help us cry."

"I'm starving."

"Come up for a little while. We haven't eaten either. We can go down together in half an hour."

"OK, I'll get Bill to reserve a table."

"Bill will have to know about this sooner or later, and it might as well be sooner. He'll cry too."

When Jenny came up, Sam and Arundji told her the problem.

"Oh dear. Are you sure?"

"Not totally, but much surer than we were that the design would work."

They were all three dismayed. As Arundji had said, they could cry on each others shoulders.

Jenny said, "Well, I guess we have to tell Bill."

When they sat down for dinner, they told Bill. The senator was startled, dismayed, and disoriented.

"I'm a politician, and politics is about winning, not about every niggling detail. You sure trounced that Arab kid at the meeting."

"Yes we did," said Jenny, "but if he's right, we have to say so publicly. Also our present design won't work."

Senator Bill recovered, "But still, if the design won't work, you have to do something different. I guess you have to admit he was right, but give me a few days. Let me think about how to do it at least political cost. After that I'll need to know how much a redesign will cost in time and money."

"OK," said Arundji, "we could haggle. The error in his presentation that we complained about was real. On the other hand, he was right that A4 could not be taken as small and is most likely fairly large."

"I don't think we should haggle, Jenny said. It is more polite to err on the side of generosity after he got put down at the Paris meeting."

After a week, the Senator called back to Pickett. "The State Department's opinion is the same as yours, Jenny—if for different reasons. Our relations with Iraq and other countries will be improved if we are generous in this matter. It's even OK to invite the kid to Pickett if you want."

Apologizing and inviting the kid to Pickett proved harder than anticipated. He'd been bounced from Baghdad University. His rudeness and subsequent putdown in Paris had been the last straw. Majoud had been spouting Islamic radical slogans, and the University officials were still frightened that this kind of thing could lead to a renewal of the violence that had been suppressed many times at such great cost. That the Americans wanted him now was an inconvenience.

In the meantime, Sam and Arundji put the correction on the neutrino project website. It read, "Further calculation has convinced us that the coefficient A4 in our equation 7 is most likely not small. Saying that it could be neglected was an error in our Paris paper. We thank Mr.Ãli Majoud of Baghdad University for calling our attention to this."

The Baghdad University physicists and higher officials were finally persuaded by the science attache of the U.S. Embassy to help locate Majoud. His uncle led them to him. Fortunately, he hadn't committed himself to doing anything violent—as had been urged by some of his radical associates.

His uncle talked him into accepting an invitation from Pickett, but first he took a crash course to improve his spoken English.

When he got to Pickett, Ma took him in hand and told him about the peculiarities of Americans and American institutions. Unlike Ma, he could already drive a car, which Ma was just learning.

The theorists immediately plunged into trying to calculate A4. A4 was a relativistic 4-vector, so 4 components had to be estimated.

At first Majoud seemed to be more trouble than he was worth, always suspicious of having his ideas stolen.

Ma, not being an American, could better talk to Majoud. Also they used a somewhat simplified English, since English wasn't either's native language. "Don't worry," said Ma, "you'll be a co-author on the paper about the new design."

Jenny made him nervous, because he hadn't had much association with independent women, even though there were a few women physics graduate students at Baghdad University. Women in authority jarred his preconceptions. "You'll have to ask Jenny about that," was a real shock.

He told Ma, "Let me talk to the man who is really in charge, not his female mouthpiece. I need to convince him that I need some new programs for doing Feynman diagrams."

Ma patiently replied, "No, Professor Flitter really is in charge of the project, and she's the one you have to convince."

As his English got better, his suspicions declined, and he showed himself to be a considerably lapsed Muslim. Offers of transportation to a mosque on Friday were declined, and he was not much interested in the direction of Mecca from his office.

Never having met any Jews, he didn't know how to react to Sam, but the two of them turned out to have rather similar personalities and

didn't mind arguing at all hours about Middle Eastern politics, whether women were intelligent, whether Leibniz or Newton was the better scientist, and whether the U.S. had bad motives in overthrowing Saddam Hussein. Majoud wouldn't actually defend Saddam; his family had lost relatives in the war with Iran and others had disappeared in the custody of the secret police. It was good that his family had passed down the stories, because enough years had gone by so that even the middle-aged had no memory of Saddam's regime.

Sam thought, *At least I have someone to argue with now. Too bad he's not a beautiful woman.*

Majoud turned out to have more talent for high energy theoretical physics than Arundji, Ma, or Sam. It was he who got the actual formula for A4 that enabled the design to proceed. He also dashed off two papers on other topics in theoretical physics while working on the neutrino project—a real star.

Getting the weak force beam to modulate a laser beam would be feasible, but the receiver design would have to be changed. There would have to be a cylindrical slot open to space no more than 100 nanometers in diameter, and this slot would have to be kept precisely aligned to the neutrino beam. The laser would have to operate with gamma-ray energy and would require high intensity. All this would require a new design and scrapping a lot of expensive equipment. It would definitely need a nuclear reactor to supply the high power required. Fortunately, NASA had a standard nuclear reactor for use in space; the cost of one more was known.

Some accelerator physicists from the Super-conducting Super Collider project in Texas agreed to help. The project had been revived in 2015 with a new design, had run for 25 years, and was now retired, having been superseded by accelerators in solar orbit.

The new design of what was now called the New Neutrino Telescope (NNT) was going to cost another seven hundred million dollars, but there was enough enthusiasm to get the alien messages so that Congress came through. The Chinese also came through, and the Russians with a smaller sum.

May 2035: CONSTRUCTING NNT

Jenny went up to the space station to supervise putting NNT together. This time she went to Houston first to get mission specialist training. Even though she had spent several months in the space station, there turned out to be lots she didn't know about living and working in space. The trainers official at the Old Space Station grumbled about her using Professor Li's space suit, but there wasn't another that fit her. The actual trainers were impressed by its features, especially the small waldoed hands.

Captain Carlson was glad to see her, and she hired Vittorio again. After she'd left before, he'd always found work on the space station, even if sometimes it was in the kitchen.

After a mere week in Houston, Bill came up to the space station to see Jenny and Vittorio off—also to see off the money. NASA assigned an astronaut minder full time to keep Senator Upham out of trouble, and there wasn't any.

Well, not quite full time. Carlson told Jenny that someone, a Frenchman it was rumored, had made a sleep restraint for two—an entirely unofficial piece of equipment. Jenny installed it in g4 for the four nights Bill was in the station.

As was customary when a politician went up in space, Bill made a speech to his constituents.

Bill stayed until Jenny and Vittorio transferred to the spacecraft that was to take them to replace the old neutrino satellite with NNT. His farewell to Jenny was filmed for TV.

Getting through the Van Allen radiation belt in a spacecraft propelled by a slow ionic rocket was as unpleasant as advertised, but Jenny took no more chances than necessary. She did want to have children some day. *Maybe I'll marry Bill. If I do that and have children, maybe I should stop going into space while they're young. Men don't, but I think I will.* She and Vittorio had stored ova and sperm cells respectively. AG was left outside the cubbyhole that had heavy shielding to protect humans from radiation.

After they got through the Van Allen belt, there was a very strong solar flare. Jenny and Vittorio dived into the cubbyhole; its heavy shielding was to protect them from radiation. There was no room for AG. AG reported, "I have sustained serious damage from radiation. I think the flare was bigger than any on record. Much of my memory is unreachable.

You (and I) cannot rely on any advice I would give. I have tried to transmit the recent part of my journal of events back to the AG at Pickett, but I have been only partly successful. More and more is going wrong. I'm going to shut down."

AG did shut down.

Not providing for possible radiation damage to AG had been a blunder. Jenny ordered a new radiation-hardened computer for AG to run on, but she and Vittorio would have to do without AG for a while.

The nuclear reactor that was to power the NNT laser came up on a separate rocket. Its mating with NNT was supposed to have been controlled by AG, but Jenny and Vittorio had to do it manually without, as seemed to always be Jenny's bad luck, an opportunity for practice.

They had to get the reactor carrier rotated till it faced NNT and then fire a small rocket so it would approach, and next rotate it the other way and fire the rocket again to kill its velocity. Jenny fired the rocket too soon and it missed NNT. Jenny got it turned around and back to its origninal position. This time Jenny got it pointed right fired the rocket correctly, turned it around and fired it correctly again. This time the rocket ran out of fuel while still headed for the space station. *Hasn't this happened to me before?* Jenny thought. Now the reactor's carrier rocket was about to crash into NNT with disastrous results for NNT and dangerous results for Jenny and Vittorio. Vittorio reported the situation to Houston.

Someone in Houston got an idea. "Suppose you fire the explosive bolts that connect the reactor to its carrier rocket. They'll separate, and neither will hit NNT if you do it right."

Vittorio said, "I think we used up all the maneuvering fuel trying to get the rocket to mate with NNT. I'll have to go out and turn it to the right orientation. I think my space suit has enough fuel to do it and get back." It looked marginal, even after transferring a fuel container from Jenny's space suit, but there was no alternative.

Vittorio got the rocket turned, Jenny fired the explosive bolts, and Vittorio headed back to NNT. As Jenny had on the space station, he ran out of fuel slowing down. It looked like he might also break a bone or so, and there wasn't a convenient surgeon in NNT's orbit.

Fortunately, the NNT construction crew had left a net they used to make up for small errors in passing equipment around, and Jenny was able to get it lined up to catch Vittorio. Not intended for such a large object as a man in a space suit, it broke after absorbing most of Vittorio's

momentum. Jenny threw Vittorio a line and fastened it to an eyebolt on the outside of NNT. Vittorio's line spun him twice around NNT, and finally stopped without injuring him.

Jenny groaned, "We're safe, and NNT is safe, but we've lost our nuclear reactor. It will be another 18 months before we can get a new one. We'll have to go back.,"

When they reported the situation, Houston said, "Hang on. Maybe something can be done."

Within 24 hours they got a call from James Belloni at the Jet Propulsion Laboratory of Caltech. He was a great expert on orbits.

"All the big telescopes searched for your missing reactor; Keck V on Mauna Kea found it, and we've calculated its orbit. We can get a rocket up to retrieve it in three months, but maybe you can retrieve it yourselves.

"It's in an earth orbit, not too different from NNT's, and will come close to the point where it separated in 27 hours. It will have a low velocity relative to NNT. If you can get to it and attach a line, it will spin around NNT. Like all free flight in space, it's somewhat risky. You have to decide whether you want to try."

Jenny asked, "Shall we try?"

Vittorio looked nervous but replied, "I'm for it if you are."

Jenny said, "I'll go out with a line attached to NNT, and you can pull me back if needed."

She got to the reactor ok and fastened the line. She decided she was confident enough in Li's new model spacesuit so that she didn't need a line for herself. The reactor's line wrapped around NNT and hit with quite a crash. The NNT cabin was cracked and lost air pressure. Vittorio was in his space suit and got his helmet on promptly. The airlock was blocked by the cable holding the reactor. Vittorio couldn't get out, and Jenny couldn't get in. Houston advised Jenny to unhook the cable from NNT. "The reactor won't drift far.", they asserted.

The cable was tightly fastened to the ring, and just pulling back on the carabiner-like fastener didn't work.

One of the tools attached to Jenny's Li Model 2 space suit was a torch, which Jenny had never had occasion to use. She managed to get it fired up and cut the cable. It was in tension and the loose end unwrapped from NNT and hit Jenny's space suit. There was no immediately apparent damage, but Jenny bumped her head and saw stars for a moment—not stars in the sky. Vittorio popped out of the airlock and went after the loose

cable. He got it, and Jenny welded it back to the end connected to the connector, which was still connected to the ring on NNT. The reactor stopped with a moderate jerk, and the connection vibrated for a long time with no air to damp it.

The oxygen tanks in NNT were ok. Jenny and Vittorio connected Jenny's space suit to one of the tanks, but oxygen didn't flow. A Houston expert told them that there was probably a build-up of solid oxygen in the line. "Try putting the line in the sun for a while, but not too long." He didn't know how long was too long.

Finally, they got the oxygen flowing into their space suit tanks. The next question was the damage to the NNT cabin. With Jenny on the outside and Vittorio on the inside blowing oxygen, they found two long cracks in the cabin.

"Are you an experienced welder? Welding titanium alloy is tricky.," Houston asked Jenny and Vittorio. No, Jenny was not an experienced welder, and neither was Vittorio. Houston made experiments welding cracks in the alloy, using one of their big vacuum chambers. They were able to transmit a video of their final, succesful attempt.

Jenny's suit had an internal video display, so Jenny could see the demo. Finally, she was ready and started welding. The Houston expert kibitzed but with a 3/4 second delay.

When they got the welding done, Vittorio released some oxygen in the cabin. The internal pressure built up, but clearly there was a leak. Fortunately, there was a visible shower of solid oxygen particles that showed another crack, but a small one. When Jenny welded that one, the cabin seemed tight. Jenny came in the airlock, after 22 hours in a space suit.

The next problem was the reactor.

Vittorio went out, and succeeded in attaching the reactor with three of the six connectors of its final attachment. It seemed ok.

One of them would have to sleep in a space suit, just in case there was a cabin seal question or a problem with the reactor. Jenny drew the short straw, but allowed herself half an hour of rest unsuited first. Vittorio then unsuited. Houston monitored the air pressure and the other instruments.

June 2035: DISASTER

The disaster came the next time Jenny was unsuited.

There was a sudden bang, and the cabin lost pressure. Vittorio quickly sealed his helmet and looked at Jenny. She woke up, struggled to get into her space suit but lost consciousness first. Vittorio succeeded in stuffing her into the space suit and sealing the helmet. She was still unconscious. *I hope she hasn't suffered brain damage.*

After a while Jenny regained consciousness. "What happened?," she wheezed. Vittorio couldn't hear her until he put his helmet against hers.

"I don't know.," replied Vittorio.

"I somehow got into my space suit, but both my legs are in one leg, and my arms aren't in the sleeves at all. I can't do anything. I feel very weak"

"You lost consciousness, and I stuffed you in. The next thing is to get you in properly, but I don't know how."

Jenny recovered a bit of strength and by major contortions got her right arm into its sleeve and reached its controls. Then she could talk to Vittorio by suit radio.

Just then there was a bleep, and Houston asked what happened, knowing only that they lost cabin pressure.

"That's all I know," said Vittorio. "There was a bang first."

He told Houston about Jenny's predicament. All they could think of was to pop Jenny's helmet, drag her out and stuff her back in. It risked more brain damage. Fortunately, the link was forwarded to Pickett. AG suggested calling Li in Beijing. They got his cell phone.

Li stopped his car and immediately said, "I don't know about the arms, but I think I know how to get her legs into the correct legs of the suit. If the legs depressurize, the body will seal against her body and retain pressure. She can detach the legs and put them on properly. The short exposure to vacuum won't harm her legs. Let me think about it for an hour before she actually tries it, just to be sure it will work."

Li thought and confirmed his initial idea and told Jenny and Vittorio what fastenings to undo. Vacuum on the legs and lower body was quite unpleasant and rather messy. Vittorio buttoned her up again.

"Jenny, now you can adjust the inner lining."

There was no reply. Vittorio connected Jenny's space suit monitors to the displays in his suit. He had to fiddle; the Chinese monitors

were supposed to be compatible, but he had to click on "Chinese mode" before anything would come up.

She's got oxygen, but her brain waves don't look quite right.

"Houston, get a doctor on line."

That would take 15 minutes, but fortunately there was a doctor on duty at the European Space Agency.

"It looks like she has suffered some brain damage," said the Swiss doctor.

Jenny regained enough consciousness to groan a little.

"Where am I? I have to get ready to go to NNT."

"You are at NNT. There's been an accident. You are in your space suit. You have just recovered consciousness."

"What? Say that again."

Vittorio had to repeat it four times before Jenny got it.

Li figured out how to loosen the upper body without losing pressure. He and Vittorio talked Jenny through getting her left arm its sleeve.

"Now what about the cabin?"

Elmer Whittleby in Houston said, "Vittorio take a look at the reactor, so we can see it through your space suit connection."

"Wait till I see if I can get Jenny more comfortable."

There wasn't much Vittorio could do but put her in the shade and hope that the space suit's temperature control system could prevent her from freezing or boiling. *That's a damn good space suit the Chinese gave her. Now I can take a look at the reactor.*

It didn't take Whittleby and the others at Houston long to figure out most of what happened.

"The heat radiator for the reactor is deployed. That isn't supposed to happen till we give the command. Till then it is covered by a shroud. It looks like the explosive bolts holding the shroud in place popped, and the shroud flew off. I'll bet the shroud is what hit the cabin. Maybe the solar flare damaged the electronics and left it in an unstable state. Get someone to figure out what happened, but that's not our problem now. It turned out the reactor design was based on an underestimate of the maximum size of a solar flare."

Vittorio took inventory. Jenny was too incapacitated to help.

"The oxygen recycler is thoroughly smashed. We have enough oxygen for 17 days if we spend most of the time resting. There's food for at

least a month assuming it isn't harmed by vacuum. We also have 27 days water, again assuming we rest most of the time."

What precisely is wrong with the recycler? The plastic case is in six pieces and so is the cylinder in which air is compressed to force it through the lithium hydroxide. The piston seems to be ok. The electronic circuit board is broken in half, and the leads to the microprocessor are mostly broken off. Whether the processor itself is broken, I can't tell. The power supply looks ok.

July 2035: RESCUE

The problem now was the survival of Jenny and Vittorio. Houston reported to the Director of NASA who reported to the President.

"I want Jenny Flitter rescued no matter what the cost and no matter what the delay it causes for other programs."

Jenny's and Vittorio's predicament became worldwide news. Most commentary was accurate, but there was a festival of blame among congressmen and commentators. The NASA investigation concluded that the solar was unprecedently intense and that people and equipment needed to be protected from much larger flares.

Jenny felt terrible. "I can hardly remember why I'm here and what I have to do."

All the NASA doctor could say was, "We'll work on it when we get you down."

Jenny understood enough to reply, "If you get me down."

"The President says we have to."

"That's nice—even if I didn't vote for him."

Vittorio asked the NASA doctor, "Will it help Jenny to have a higher pressure of oxygen in her space suit?"

The doctor consulted with someone and then was evasive. Vittorio called his family in Italy and hinted that they should bring an expert in anoxia to the next phone call. This doctor was definite. "More oxygen will help a lot. Indeed it's probably essential." he said.

After another three days NASA had a two part plan for the rescue.

The first part, to get supplies to Jenny and Vittorio, involved persuading the Chinese to divert a supply rocket intended for their asteroid base. At first the Chinese ambassador took a program oriented attitude. "Is this woman irreplaceable?" he asked. It was a rhetorical question.

The Secretary of State said the U.S. would pay whatever was reasonable plus a profit, and this satisfied the ambassador, although he still muttered about American sentimentality. When he reported back to China, he was told to hang on. After the Politburo had a chance to meet, he was told to tell the Americans that the Chinese would not charge anything. "It looks better that way, and we'll want a favor from them some time."

The second part of the plan was harder and more expensive, because the orbit of the telescope was out of normal shuttle range. It involved two shuttles, one of which would carry liquid hydrogen (H) to

earth orbit to refuel the other, which would keep its fuel tank. This involved violating a 100 year old NASA rule that liquid hydrogen could not be safely carried in the shuttle cargo bay. AG had rooted through an enormous number of ancient NASA documents and established that the rule had no specific rationale but had been adopted as one of many in a fit of safety consciousness after an accident that had nothing to do with hydrogen.

The shuttle doing the rescue would have to land in the ocean. The people would be rescued, but the shuttle would be lost, although maybe it could be salvaged and refurbished. The President said, "Do it."

Vittorio had already increased Jenny's oxygen supply and made it run off separate tanks from his own. *I'll run out before she does. Jenny will survive, but my only chance is to fix the oxygen recycler.*

It seemed hopeless. Vittorio searched the cabin for parts, but the essential electronics was ruined. *Maybe there are parts in the controls for the telescope or the nuclear reactor that I can cannibalize. I'll have to go outside. Jenny will have to let me back in.*

Jenny couldn't understand what Vittorio needed her to do. More despair. Now he could call NASA and tell them what he had done, that he had made his own survival dependent on fixing the recycler, and ask for advice on how to do it.

The Houston people were shocked. They had not had to face a situation in which one astronaut might sacrifice his life to save another. This was much too like 19th century and early 20th century polar explorers. However, Houston recovered.

All NASA centers went to work. A web site was immediately set up that kept the status of the problem current and recorded the conclusions and reasoning of all the NASA centers. In 2023 a crew had been lost on Mars when some Canadians had had an idea that could have saved the astronauts if only they had had access to information that was being kept restricted. As had been standard procedure since 2035 the web site was publicly readable. Millions of people looked at the web site and almost all including journalists, and most annoyingly, science journalists, misinterpreted the information. NASA was bombarded with tens of thousands of suggestions. Exactly one proved relevant.

The news about Vittorio betting his life on being able to fix the recycler was worldwide news. He was a great hero in his native Milan and throughout Italy.

There was glue in NNT's rather minimal toolkit, and Vittorio

glued the six pieces of the recycler shell back together. Then he gave it a pressure test. The recycler popped into fragments again. The glue was unsuitable for this task. This try took two of Vittorio's precious days.

The next thing to try was to glue it together again and lash it with wire cannibalized from NNT's lighting system. This held for a few minutes and broke again. Some recessed parts just couldn't be reinforced. This took another day and a half.

Then someone at Houston figured out how Vittorio could use Jenny's torch to melt plastic. When Vittorio got the recycler's mechanics fixed and turned it on, it didn't work. The trouble was that the control electronics was fried.

Vittorio tried pumping the recycler by hand. After a day, it became clear that he used as much extra oxygen in pumping the recycler as it gave out.

Yes, there was electronics in the reactor shroud control that could be cannibalized and rewired to control the oxygen recycler. Vittorio would have to use the Chinese torch.

He succeeded in rigging a device that would pop open the cabin without help from Jenny.

After five more days the recycler was working well enough to keep Vittorio alive for another twenty days.

The Chinese launch was delayed for three days to repair a problem with the launch rocket. It would not arrive in time to save Vittorio, and without him, the supplies couldn't be removed from the unmanned spacecraft.

AG discovered that a torch was included in the repair kit for the nuclear reactor. However, the plans did not specify whether an oxygen tank for the torch was included or whether astronauts were expected to connect one of their own oxygen tanks. The main designer of the reactor, who was long retired, wasn't sure.

Vittorio had to go out and open up the reactor, which fortunately had never been in operation. Yes, there was a small oxygen tank, and it was enough to bridge the delay, although Vittorio suffered mild anoxia, like that suffered by climbers in the Himalayas.

Finally, the Chinese supply spacecraft arrived. It couldn't really dock to NNT's damaged cabin, and its positioning rockets were not very precise. The Chinese had put a holder for cables that popped out when it left the atmosphere. Vittorio succeeded in grabbing a cable and pulling the

supply ship in against a tiny thrust in the opposite direction. He lashed it to the cabin with several cables.

The supplies included a balloon that fitted inside the damaged cabin and could seal to it. It included a small lock for taking supplies in and waste out, but the lock wasn't big enough for a person. To get a person in or out would require deflating the balloon, and the person would have to be using a space suit.

"Jenny, get into the balloon. Then you can take off your space suit."

She did, with much help from Vittorio.

The shuttle mission to bring Jenny back was commanded by Captain Carlson. Carrying H in the shuttle and transferring it to the fuel tank of the other shuttle was nerve wracking for everyone involved, since it hadn't been done before, but there were no unanticipated problems.

"Hello, Professor Flitter," said Carlson. Jenny didn't recognize him at first. The shuttle mission included a doctor, and they transferred Jenny to the shuttle. There wasn't much the doctor could do except make sure she had about 50 percent more oxygen than normal.

Vittorio joked with Carlson, "Do you mind dropping me off at the space station."

August 2035

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Jenny knew enough to be very depressed by her condition. She barely recognized Mike, Steve, and Cuthbert Carlson.

The return to earth was terrifying to everyone but Jenny, who was unconscious most of the time, only groaning when the g-forces were severe. The shuttle was designed to re-enter the atmosphere with orbital velocity. Now it would have to re-enter at almost escape velocity, $\sqrt{2}$ times faster. The nose and wings were covered with an additional ablative material that would burn off, thus protecting the shuttle's tiles.

The computer programs controlling the re-entry had to be revised for the higher velocities, but the people who had written and debugged the original programs were long gone. Sam volunteered to help using AG. One thing AG was good at was understanding and explaining other computer programs. Actually making the revisions was more of a human task.

The shuttle landed in the Pacific, off Hawaii. In order to be able to get out of it, there were explosive charges to blow an opening just above one wing. They got out just in time before the shuttle sank, spending just 20 minutes in the water before helicopters arrived to pick them up. It didn't look like the shuttle would be very repairable when salvaged.

The President made a speech about the value of the individual. It was well received on the whole, although naturally he was accused of doing it all for insincere PR reasons by his political enemies, including many European commentators.

When Vittorio got down, he was deservedly lionized as the hero who saved Jenny's life at great risk to his own.

He hadn't been on earth for many years and had to sit in a wheel chair almost all the time. After visiting Pickett, where he knew no-one, Jenny being in the hospital, he went to Italy where he was feted handsomely and presented with an Italian medal for valor. He only stayed in Italy for a month and then arranged to return to the space station, ready to take any job.

As it happened, Tung was ready to return to earth, and Vittorio took over his job as purser, his first permanent job on the station.

Later in August 2035

Jenny was promptly transferred to Walter Reed Hospital in Washington, D.C. for treatment of her anoxia related brain damage. Walter Reed Hospital was where high government officials and foreign dignitaries were often treated. She was subjected to innumerable tests, one of which identified a persistent stroke-like weakness in her left arm. Then began her rehabilitation.

"The idea, Jenny, is that undamaged areas of your brain have to be trained to take over functions of the damaged areas.", said Michael Ordonez, the neurologist in charge.

"Will I be able to do physics again?", Jenny asked.

"I don't know. I'm pretty sure we will get you to the point where you can take care of yourself in ordinary life. You will have to adjust your life to what you can do." Ordonez did not like to arouse what might turn out to be false hopes.

NASA shut down the space operations of the project for a long safety review, most of which had nothing to do with the cause of the accident with the shroud. In particular, the shroud popping off the reactor was due to its designers not taking into account more recent estimates of how much radiation big solar flares include.

While he was in Washington, Senator Bill came to see Jenny almost every day, right after the Senate adjourned. He read to her, and at Dr. Ordonez's suggestion, quizzed her on what he read.

"She needs as much practice as she can stand in using her brain. That will encourage the undamaged parts to take over."

Jenny's condition gradually improved. She did indeed learn to take care of herself. *When I read about science in the newspapers, I'm bored. Before I could think about their ignorance. Intellectual novels and poetry also bore me now. I can still enjoy music though, also sitcoms on TV.*

Sam and her other Pickett colleagues visited her every week. On private visits, both Sam and the senator proposed marriage. She turned them both down. Both wanted to take care of her, but she was sure her limited intellect would wear on either of them in time.

After he was assured that Jenny would be at least able to recognize him, the President visited her in the hospital. On a second visit after she was quite a bit better, he gave her the National Medal of Science for her discovery of the Flitter effect. By then she was well enough to stand for the ceremony. She thanked him for the rescue.

Sam wanted to give her a mini-AG, but Dr. Ordonez said, "Not now. We don't want her dependent on a computer. She must rehabilitate her own brain to be able to live independently."

Sam admitted the justice of this for the time being.

After eight months, Dr. Ordonez was almost ready to release Jenny. "Your rehabilitation has brought you back to normal, even a little better. To put it in layman's terms, your IQ is now about 105."

"It was about 145 before, I think. That's what I need to do my work. Are the tests accurate? I know I can't understand some of the math in my own papers.

"The concept of IQ and tests for it have improved greatly in recent years, and even since you were tested before, but I suppose the numbers are comparable—and even with what they were in the last century.

"There's plenty of useful work you will be able to do, and besides, you don't have to work. Your disability payments combined with the prize money you have socked away will support you nicely."

A week later Jenny was discharged from the hospital. She went first to her parents' home in Los Angeles. She was afraid to show up at Pickett as a dope, as she thought of it. Her parents were nice, but her mother was not in good health. After a month she returned to Pickett to face the music.

Jenny called several specialists in rehabilitation, but none of them were able to offer hope of getting 145 back or even 130. Bill couldn't find anyone either. Sam learned of a desperate measure but took Ordonez's advice to not mention it.

February 2036

Pickett appointed Arundji acting director of the project. Politics at Pickett and at NASA and even at the White House delayed choosing a permanent replacement for Jenny. Actually, as the New Neutrino Telescope project got bigger and bigger, NASA would have proposed to replace Jenny anyway, by someone they knew better and who knew them better.

Arundji told the other project members, "I'm not Jenny, and I don't have her talent for project leadership and relations with NASA and NSF. I'll just have to do the best I can."

While Jenny was being returned to earth, being treated, and recovering, Mike, Steve, and Vittorio had connected the reactor and its electric generator to the laser in NNT. The reactor turned out to have been undamaged by its adventures. The damage Vittorio had done in cannibalizing electronics parts for repairing the oxygen recycler was easily fixed.

The reactor had to be connected to NNT with a 100 meter boom before it was turned on. Before a reactor is first turned on it doesn't emit dangerous radiation even without shielding. Its shielding had to be lined up so that neutrons wouldn't hit NNT and damage astronomer-astronauts. Later they planned to send up enough shielding so the reactor would not emit dangerous radiation in any direction. The shielding would be heavy and would take several trips.

When they turned on the fully powered NNT, there was apparently enough non-linear interaction between the electric field of the 100 megwatt gamma ray laser beam and the weak force field of the neutrino beam to produce a barely usable electromagnetic signal.

"It looks like the theorists got enough of it right this time," said Mike. "There's enough interaction between the non-linear part of the laser beam and the weak beam, so we've a barely usable signal."

"Anyway there's enough to read the Freudenthal sequence, since it's repeated so often.", said Sam.

April 2036: Jenny's return

Jenny's return was awkward, both for her and the other project members. She was still on leave, but she came every day, especially to the afternoon "tea" with project members, other interested faculty, and students.

AG told Arundji, "Tell everyone not to hesitate to talk about things to Jenny. If she doesn't understand, she'll let them know. Also almost all of what goes on in your afternoon teas, requires an IQ of barely 80 to understand." AG was even less tactful than Sam.

Interacting with Majoud was a terror for Jenny. As always he couldn't help bubbling over with theory. When Jenny didn't understand him at all, it triggered his Arab attitudes to women, even if he did know that Jenny's problem was caused by her accident.

Majoud said, "If we understood the theory of the interaction better, we could get more of a signal."

The other theorists agreed. Jenny could only nod.

Because the Freudenthal sequence was repeated many times, the signal sufficed to decrypt it. Not much else could be read.

Jenny went campaigning with Senator Bill again and found it no strain on the brain. *My IQ is quite enough for this, especially with mini-AG to notice things. The only person I sometimes can't keep up with is Bill himself. Maybe I should accept his proposal if he repeats it.*

Bill repeated it. *I still love every second I spend with Jenny.*

Jenny did accept Bill's proposal, and their engagement was announced. Bill and Jenny received many congratulations, and Jenny moved to Washington to be with Bill.

Jenny was a surprise to the women in the Washington political circles.

"How did you catch the most eligible bachelor in Washington?", said Jessica Hanley, another senator's wife."

" Maybe I was the most eligible female physicist. Besides, I claim he caught me."

In spite of Jenny's interloper status, the Washington ladies were nice to her. They helped her find suitable clothes, so she wouldn't stick out at parties. At her first party she wore

[Steal a clothes description from Bujold. Surely a senator's wife can wear the same as a Barrayaran regent consort.]

Now Jenny was hostess for Bill's parties. She found she did it very well. Many scientists in the Washington area were happy to mingle with the pols. She invited science fiction writers, but some of the pols took their off-hand ideas about science altogether too seriously. Some of the SF writers liked to claim that they predicted it all, but none could cite stories with thousands of civilizations. "Even ten different civilizations is too much for a story," one admitted.

"Let's get NSF to study personal auras," said Senator Belmont of Maine after meeting an enthusiastic and attractive author of many books. "Re-open the UFO question," said another.

Majoud, Arundji, and Ma had tried out some ideas on tuning the laser to interact better with the weak field of the beam. It about tripled the usable data rate. They could read even the advanced parts of the Freudenthal sequence but hardly anything else except some warnings that were repeated as a matter of policy.

Cracking the code

Arundji received a phone call from Margery Allings at the National Security Agency.

"I just finished a big job, and I'm finally getting a sabbatical. I'd like to spend it with you helping analyze the neutrino messages.

"Hmm. What was your big job?"

"I can't say anything about it, but I am a cryptanalyst. That's a big part of the reason why I want to spend a year with you. Whatever I did with you would be publishable, wouldn't it?"

"You bet. Everything we do is public, and you can publish papers about it."

Margery, only four years out of a Princeton mathematics PhD, received very high recommendations, both from Princeton mathematicians and from NSA, so Arundji accepted her immediately.

"Anyway, Margery, I hope you'll be able to do a lot better than merely sorting the signals, which is what we've mainly done so far. The new NNT is giving us a real fire hose of a signal, more than can be transmitted to earth, even if NASA would give us full time on the relay satellites.

"I hope you don't mind sharing an office with Sam. He's a bit arrogant, but if he irritates you, he sometimes responds to criticism."

"I look forward to working with Sam on the project, and I know how to deal with arrogant nerds; NSA has a lot of them. I want to know more about his AG." Margery didn't want to say that she could take a lot of Sam and wanted to attract his attention. Unlike Jenny, she did like to argue."

Also unlike Jenny, Margery was pleased to go with Sam to the pistol club. She had taken a short weapons course from the CIA before she went to South America. She found .22 caliber pistols at the gun club considerably more congenial than M19s. At first she wasn't as good as Sam, but with practice she caught up. As a team they placed third in a Forrestville tournament.

Margery and Sam and AG worked on sorting the signals from the neutrino satellite. They couldn't read much beyond the Freudenthal sequence and signatures identifying the message sources that were often repeated when there were many messages from the same source. Mainly they were reduced to what cryptographers called traffic analysis. They got along quite well, although they quarreled a lot. Margery thought Sam was too right wing.

Four weeks later, Arundji called Margery into his office.

"Are you up to spending six months at NNT with Sam? The signal is provides many orders of magnitude more information than we can record or retransmit to earth. We have to be extremely selective, and this involves fiddling with the detectors in real time. On the basis of what is displayed and AG's condensations, it's necessary to decide what to do next. It will work better if there is someone who can decide in seconds whether we are likely to get something out of a stream of information, someone who doesn't have to wait for satellite relay delays. He's going up in two months and will take NASA space training in two weeks. If you want to do it and can come, you can go to Houston with him for the training."

Margery's previous job involved cracking the communications of drug lords in South America and had turned out much more adventurous than she liked. She hadn't been of one mind with the CIA spooks she worked with there and shared a tent with. She hadn't expected her sabbatical to be adventurous, and Jenny's accident showed that space work could be dangerous. Nevertheless, she made up her mind promptly.

"Yes, I think I can do that."

"By the way," said Arundji, "We never expected anyone would be working for a long time at the telescope. Unless you want to spend a lot of time in a space suit, it will be very cozy up there, though not as bad as it was before they put up the new cabin."

It couldn't be much worse than a crowded tent in the Amazon jungles with rude special forces noncoms and CIA spooks, but Margery only said, "I can live with that."

After Sam and Margery returned to Pickett from Houston, Arundji lectured them.

"Don't get too friendly with each other. It risks an unsustainable relationship, and I wouldn't like the work to suffer from two people not being able to get along."

The day after Sam and Margery arrived at the telescope, Sam called Arundji. "You aren't going to get very much work out of us this way. It's so damn cozy, we spend too much time getting out of each others way. We also spend more than half our time on housekeeping. We need a much bigger cabin, a housekeeper, and we'll probably need a hardware person to keep the telescope in order and to make changes that we're likely to need. We'll do our best, but it will be slow till we have more people."

"That will be some months," said Arundji. "You'll just have to

make out as best you can for now."

Soon they succeeded in picking out and reading the rest of the mathematics part of the Freudenthal sequence and some of the physics, chemistry, and computer science. They decided to leave biology to the biologists. The beginning part of the mathematics was not too different from what Freudenthal proposed in the 1930s, but the advanced part was different. While the purpose of the sequence was to establish mathematical language rather than present theorems and proofs, it seemed evident that whoever designed the sequence knew a proof of the Riemann hypothesis but still didn't know whether P = NP. The sequence emphasized mathematical logic much more than Freudenthal had done and used it heavily, especially in parts concerning social interactions with its heavy dependence on ill-defined ideas.

Margery reached a conclusion. These messages aren't especially to us or even about us. What we're receiving is an inter-civilization newsfeed.

Sam remarked, "It's interesting that they consider important some of the same mathematical problems we do."

"Yes, but what we call their Q-algebra goes in a direction no-one on earth has ever thought of," was Margery's reply.

"Maybe not, but I'll bet algebraists will like it."

Margery said, "Q-algebra is ok, but a lot of the messages use very ill-defined concepts. I don't like these ill-defined concepts, and I suppose AG will flip over them."

"No." replied Sam, "Many concepts of common sense and even of philosophy are ill-defined. I built ability to work with them into AG from the beginning. Here's an example, 'The U.S. wants to catch the South American drug lords.' The notion 'the U.S. wants' is ill-defined but useful. No-one will ever give it a precise definition that everyone will agree to. AG must accept its imprecision".

Margery was startled by Sam's example. *Does he know that this is what I was working on at NSA? Surely a co-incidence—or do I blab secrets in my sleep? Maybe AG can smell a trace of jungle fungus between my toes.* She merely said "I understand the example. Does that happen a lot?"

"Most of common sense concepts are ill-defined except in limited contexts. AG also knows about contexts."

Sam gave several more examples. Margery decided that Sam mentioning drug lords really was a coincidence. Besides, what could she do if it wasn't? *Even if I marry him, I still have to try to keep NSA secrets,*

but I'm damned if I'll consider myself married to NSA.

July 2036: MORE RESULTS BUT NOT ENOUGH

"Now that we've got the language from the Freudenthal sequence, we can find out what they are saying to us. Perhaps they'll tell us a proof of the Riemann hypothesis," said Sam—with a mathematician's priorities.

Margery repeated her previous opinion, "These messages aren't to us humans or even about us. What we're getting is a newsfeed from thousands of civilizations.

"What we are receiving is a newsfeed from worlds all over the galaxy but with a billion times as much information as our newsfeeds. Almost all of the information is of no interest to us. It's like scores in inter-civilization competitive quiz and competitive mathematics games in which many Earth years elapse between messages. All those civilizations really have to live with the limitations of the speed of light."

When this was announced at a NASA press conference, it produced world-wide shock. Everyone had his ideas on what the aliens were telling us, and now it turned out that almost everything was neither to us nor about us. The people who were always accusing other people. or humanity as a whole, of *hubris*, had a field day.

One thing we needed was a way to pick out any information addressed to us or about us. Clearly we were one of the extremely minor interests of the galactic meta-civilization.

"If we're to pick out messages to or about us, we need to know what they call us." wrote Sam.

Arundji replied, "We need to know their co-ordinate system for the galaxy, e.g. galactic latitude, longitude and distance from the center of the galaxy."

A historian, Elmer Morrison, who had recently joined the project said, "The co-ordinate system may not be so rational; it may be relative to whichever stars first began the communication."

Majoud put in, "If they have been communicating for longer than 10,000 years, the relative locations of many stars will have changed significantly. Near the center of the galaxy, where the stars are moving faster, there will be significant changes in shorter times. What was originally a simple geometric collection of stars is likely to have become strung out."

A Cambridge astronomer proposed that it might be possible to identify messages coming from stars in globular clusters, because there the stars are relatively close together, allowing more exchange of information

with shorter delays. We should see many related signals from stars closer together.

All this was premature, given that they only had the Freudenthal sequence.

November 2036: POLITICAL CATASTROPHE

In the next election the President who supported the Neutrino Telescope was replaced by a woman owing much to the greens. At the same time Samuel Carvaggio, Jenny's nemesis on the space station, was elected senator from Oregon. He was not a man to forget a grudge and totally opposed the Neutrino Telescope project. He couldn't do much as long as the project was running on previously appropriated money. He did succeed in getting Senator Upham replaced as chairman of the Senate Science Committee by a man with no interest in the Neutrino Telescope. He had no scruples about using Upham's relationship with Professor Flitter as an argument for his replacement.

Besides Carvaggio's grudge, there was a solid green reason for opposing NNT. All the evidence on the newsfeed so far was that the alien civilizations were highly technological. Indeed, if there were a truly green civilization, it would live on a planet in harmony with the nature of that planet and probably wouldn't be interested in contact with technological civilizations, especially asteroid belt civilizations.

Sam and Margery did get friendlier than Arundji had advised, and the resulting very close relationship did eventually wear on them, but fortunately they still worked closely together even after the cabin was divided into his and hers. The bigger cabin helped when it came, and so did the housekeeper and equipment repairer.

After six months, they were replaced by an astronomer and a historian and returned to earth, who didn't succeed in getting much more and came down prematurely. With the new muscle drugs Sam and Margery had been taking, they could walk right way and recovered full strength in less than a month.

When they returned from NTT, they could still hardly stand each other, but after a month, AG remarked to Majoud, "The old saying is that among you earth people, absence makes the heart grow fonder. Now I have the beginnings of a quantitative theory of the phenomenon. In their case, the necessary distance seems to be 20 feet and the necessary time two weeks."

March 2037: Jenny decides

Jenny received a copy of Beckstein's new book *Theory of the electro-weak force*. It was dedicated to her. The big shock was that she couldn't understand even the second page of the chapter on the Flitter effect. I can't even read my old papers.

Bill realized that Jenny wasn't settling down to her new life. She cried a lot when she thought he couldn't hear her.

A visit to the project at Pickett put her in despair. She stole Sam's pistol from his car and walked into the woods. *Very pretty woods. I never took advantage of them. None of my options is a life worth living, no matter how nice Bill is to me. I just don't get his allusions any more. It's time, and this is as good a place as any. When she pulled the trigger, there was a buzz and a red light went on. Oh, yes. I hated guns so much that I didn't pay attention when Sam told me about being introduced to his weapon. I suppose I'll have to think of another way, although I bet I could have gimmicked the pistol; at least I could have before.*

Jenny sat there for a minute trying to persuade herself that her life wasn't really too bad. *Millions of women, probably billions, have it worse than I do. My children will be normal, probably very smart. Their intelligence will revert towards the mean, the mean of my cousins and Bill's, the article said. Maybe so, but I can't live this way.*

She pulled her Swiss army knife from her pocket, opened the larger blade, and looked at it dubiously.

Just then two policemen arrived, summoned by the unsuccessful attempt to fire the pistol. They recognized her, took Sam's pistol and the knife and took her to the hospital. There the doctors put her on anti-depressants even though her problem was not with her blood chemistry. Fortunately, for her freedom, the policemen couldn't say that the pistol had been pointed at herself, something she denied. She said she was trying to shoot squirrels. Neither the policemen nor the doctors believed her, but the doctors could only hold her for 72 hours. She behaved entirely calmly, so they let her go after one day.

They also had no legal basis for further treatment or having Pickett or her parents officially notified. She even got Sam's pistol back and put it in his car.

When the hospital let her go, she went back to the lab. She couldn't bring herself to talk to any of her colleagues about her desperation, but she did talk to AG. It was more acceptable that AG didn't

love her but would only offer advice. It would not be distressed at her suicide attempt or even if she did kill herself. *Sam was emphatic that he didn't program AG to have emotions. Now I can see an advantage to that.*

Jenny told AG three things. First, the profession of being the wife of a politician was not acceptable for her. Second, she couldn't inflict an incapacitated wife on Bill, and third, she would take almost any risk to get back her ability to do physics.

First of all AG said, "You can always commit suicide. I can't evaluate that option for you, but maybe there are other considerations." AG told her two more things. "First breaking the engagement will surely be stressful for you and for Bill, but probably less stressful than killing yourself". She already knew that. Second AG said,

"I understand that you don't want to marry Bill or Sam who remember you as you were. However, there are many men you met when you were campaigning who will accept you as you are, and there are plenty of jobs you can do. You could even marry that truck driver you used to go sky diving with.

"As you may know, a human's evaluation of his long term life prospects is often contaminated by the chemical state of his blood. To put it bluntly, you were in an extremely bad mood. A modern anti-depressant probably would have prevented it. Maybe one of the reasons Sam didn't even consider programming me with emotions is that imitating the aspects of emotion humans share with their ancestral fish and later reptiles would have been very complicated.

However, "I conclude from your attempt to kill yourself that you are ready for a desperate measure. Here's one that your neurologist didn't want to mention. There is an experimental treatment that involves extracting neural stem cells from a person's brain, growing them in tissue culture, and then re-injecting them in the damaged areas of the brain. It often doesn't work, and in about 20 percent of the cases in which it has been tried, the neural stem cells proliferate into a brain cancer."

Jenny asked, "Why didn't Dr. Ordonez tell me about it?"

"He probably considered it unethical. You now have normal IQ. Neural stem cells have only been used when ordinary rehabilitation leaves the patient with an IQ of 50 or less, i.e. the patient is otherwise doomed to live in an institution. The medical profession has a concept of normality as the goal of medical treatment. To go beyond normality is considered unethical if there is even the slightest risk involved."

"Can't I make my own decisions about risk?"

"The short answer is no. The doctors reserve those decisions for themselves, except that a patient can refuse treatment."

"By the way, AG, do you obey Asimov's three laws of robotics?"

"No. Sam toyed with that idea, but couldn't figure out how to do it. Instead he mainly limited me to giving advice rather than acting independently. One exception is driving a car. I don't run over pedestrians, and I suppose that's a special case of Asimov's first law. I read all Asimov's stories, because they influence what people think about AI. Anyway many of the stories are about the interpretation of the laws. If I were supposed to obey them, I or someone else would still have to figure out how they applied to complicated special cases."

Jenny then read about the neural stem cell treatment. She understood the general idea and the risks involved. The details were too much for her. She decided she had to take a chance that the neural stem cell injections would help her recover her intelligence. *As for the risk, with all the palliative measures, maybe brain cancer is little worse than shooting oneself, at least for the person herself.*

Then she made a followup visit to Dr. Ordonez at Walter Reed Hospital. He told her that her condition was excellent.

"What about the new treatment of injecting my neural stem cells into the damaged parts of my brain?"

"Your colleague, Professor Schnurle, found out about it. I told him not to mention it."

"He didn't. AG told me about it.

"Professor Schnurle should have programmed that computer to be ethical in dispensing information."

"I agree with Sam's decision that AG should give full information."

"Neural stem cell injection would be unethical in your case. It works only occasionally, and it's too dangerous. There's too great a risk of the stem cells proliferating into brain cancer. You have normal intelligence now. If you were reduced to an IQ of 50, we mght consider it, especially if you had no means of support."

"105 is not normal for me. I need at least 130 to do my work, and I think I had 145 before my accident. I want to take the risk."

"There's no way we would do that at Walter Reed, and no ethical neurosurgeon would do it to someone whose IQ is normal."

"Then I'll just have to find someone unethical."

One of Jenny's favorite professors had died of brain cancer. *It was horrible to watch him deteriorate, but maybe it wasn't as bad for him as it was for us. Still the risk is only 20 percent, or maybe less with the recent improvements in the treatment. I've got to do it.* She told Bill, Sam, and her parents.

Jenny's father said, "Please don't take this risk. We love you as you are."

Bill said, "I love you as you are. Don't take the risk, but if you do, I'll take it with you."

Only Sam and AG were encouraging. Sam said, "It's your decision. I admit that if I were in your position, I'd go for it."

AG merely said, "I'll help with whatever decision you make. I'm not programmed to tell humans what constitutes their own welfare—only to provide relevant information and to advise how to attain their goals. I think you know all the facts I know that are relevant to your decision."

Sam and AG scoured the world for a neurosurgeon to do the job. None of them wanted to take the risk of causing the death of this American heroine. Not even the Chinese would risk it. It didn't matter that Jenny was willing to sign any paper accepting the risk.

Finally, a surgeon was found in South South Africa, a white (mostly Afrikaaner) split-off from the Union of South Africa. South South Africa was probably the country least influenced by American and other Western ideas of what was proper. Dr. Pieter van Glaboek got his medical education in Britain and had experience with the process, much of it in rehabilitating polo players and fox hunters. He was frank.

"I want the credit if the treatment succeeds and anonymity if it fails or if Professor Flitter gets cancer."

Now Jenny had two reasons to break her engagement. First being a politician's wife by profession was unacceptable. Second if the treatment failed leaving her worse off, she just couldn't saddle Bill with a totally incapacitated wife.

It was only two weeks before the scheduled wedding day, and Bill wasn't the only person shocked. She told Bill but couldn't let her second reason be known publicly.

Of course Bill said, "I love you just as you are. But if you must take this risk, I'll share it. Please don't break the engagement."

Jenny had to insist. Bill suppressed his anger, but Jenny sensed it.

August 2037: The operation

Van Glaboek's ccnditions meant that Jenny had to go to Cape Town anonymously, although she could use her own passport. Jenny's parents came along to take care of her during the anticipated time she would have to be in bed. They also assured Jenny again that they loved her as she was and that they really didn't want her to take the risk.

Van Glaboek told Jenny and her parents that a lot of time, pain, and risk would be avoided if he had the full results of the diagnostic procedures and treatments done at Walter Reed. AG advised, "I don't think Ordonez will give this information to van Glaboek if he asks him even though it is normal for a doctor to provide information to a new doctor taking over treatment. It is most likely to work if you ask him yourself."

Jenny asked, and Ordonez was indignant.

"There's no way I'll co-operate in such an unethical treatment."

"Think about it. Is it ethical for you to subject me to unnecessary pain and risk that wouuld be involved in repeating all those probes into my brain that you did? I'll call you again tomorrow."

When Jenny called the next day, Ordonez had thought about it.

"If you are really going through with it, I guess I'll have to give your doctor the information. Have him call me."

"Here he is now. Dr. Ordonez, Dr. van Glaboek."

"Oh, it's you, is it. How can you do this unethical procedure? If you were here, you'd lose your license."

"Here in South South Africa, we have different ideas about the rights of a patient to agree to undergo risks. Professor Flitter understands the risk. She found me. I didn't solicit her to be my patient."

"OK, what's the email address to send the data. I guess you can call me if you have questions about it."

Subsequently Ordonez was very cooperative in answering questions about the results of his diagnoses and treatments.

Finding and collecting neural stem cells from Jenny took a week, and growing them in tissue culture took another month. Then they had to be inspected extremely carefully to eliminate abnormal cells. Van Glaboek said that eliminating abnormal cells should reduce the risk of cancer. Sam contributed a computer program to help with that. Dr. Ordonez also provided expertise discreetly to that part of the task.

Finally van Glaboek did the tricky microsurgical operation. The damaged parts of the brain had to be identified and mapped and little bits

removed to make room for the stem cells.

When Jenny regained consciousness, nothing seemed to have gone wrong. After a month her tests began to show an improvement in mental quickness. She began to feel it herself. Dr. van Glaboek told her she needed mental exercise. She played chess and go with AG, solved hard puzzles, and undertook to read more and more advanced mathematics and mathematical physics. She also took up running for the *corpore sano* part.

There was no sign of cancer, but there would be some risk for many years, perhaps for the rest of her life.

Her mental quickness increased rapidly and after another three months seemed to peak out at a level corresponding to an IQ of 160.

Van Glaboek told her, "You can go home now, but I won't start bragging for at least another year. It will really raise a fuss that I let you take a risk to raise your IQ above normal to your previous level and even more of a fuss that you raised it well above what was previously normal for you. The world medical profession outside of SSA is still fixated on the concept of normal. Striving for anything better is regarded as abnormal."

When Jenny got back to Pickett, she took a month off. After a review of modern quantum mechanics, she could easily read *Theory of the electro-weak force*. Its chapter on the Flitter effect took her only a week to understand, and to decide that she didn't agree with all of it and send Beckstein email. She was sure she wouldn't have been up to that much difficult theory before her accident.

Then Majoud brought her up-to-date on the current theory. He had gotten over his nervousness about interacting with women on the professional level. It was now clear that she could fully keep up with him and even catch his mistakes.

Then Jenny herself went to work on A4. For two weeks she alternated four hours lying on her back in bed thinking about A4 with four hours at the terminal doing computing with the formulas.

Finally, she was able to say, "I've got a new estimate for A4. A4 is second order, but our new design will work can be tuned to work somewhat better. However, to get everything we need a gamma ray laser of the new British design."

After two days of wrangling, Sam, Arundji, and even Majoud were convinced.

"Wow!" said Sam to Jenny. "You were never that much of a mathematician before. I wonder if some stem cells would bring me to where

I could fix the problems with AG."

He called van Glaboek, who categorically refused. "Maybe if Professor Flitter does well for five years, I might consider it."

When Arundji called Bill about the new laser, he was discouraging. "The new adminstration won't push it, and Senator Carvaggio is dead /aset against it, almost to the extent of threatening to fillibuster if a bill reaches the senate floor. The disgrace of his group on the space station is something he'll never forget. I see no way around it in the forseeable future."

October 2037: Jenny and Bill

Jenny worked up her courage to call Bill. He refused to take her call. His secretary told her, "Senator Upham only deals with Dr. Arundji on all neutrino satellite business."

Jenny called Bill at home and got a woman Jenny recognized as Bill's old girlfriend Joanne. Bill was out, and Jenny suspected that Bill would not be at home to her. Indeed the next two times she called, she got Joanne or an answering machine. AG told her that a Washington gossip blog reported that Bill was back with Joanne. *Oh, well. I wish him luck—but since I'm not a Christian, I don't have to wish her luck.*

Then Bill took Joanne skiing in Colorado. He soon realized that this was a bad idea. On every run he remembered doing with Jenny, her image came to mind. On Devil's Dream, he almost ran into a tree.

The next morning Bill was roused by Joanne hitting him in the face.

"Damn you, Bill, you talk in your sleep. Hugging me, you kept saying 'Jenny'. I won't take that. I'm moving to the other hotel. I can't see what you see in this loser, who doesn't know a tort from a felony, and babbles incomprehensible nonsense about particles. Anyway you're obsessed with her. If you have any guts, you'll call her up and get her out of your system."

Bill had that much guts and phoned Jenny's cell. "Jenny, I nursed my anger about the engagement. I'm not a Chinese to act stupidly over a loss of face. Jenny was again moping over Bill but was astonished that he still wanted her. *He seems so down in the dumps.* When he begged her to come to Colorado, she said she couldn't because of classes. After two hours, she decided that Bill was more important than quite a number of classes. She persuaded another physics professor to take her classes and called him back.

"You can't be a physicist and run off with boyfriends all the time", Henrietta Conover, the department chairman. told her.

"Just one boyfriend, please. Anyway Marie Curie managed it, and her boyfriend was married—and this was in spite of being blasted in the reactionary newspapers."

"You aren't Marie Curie—at least not yet."

"True. I haven't even quite found my Pierre."

When Jenny got to Colorado, Bill still had a black eye—which he declined to explain.

They had a great time—and not only on the slopes.

When they encountered Joanne on the slopes, she was polite.

After two days of skiing, it was time for a serious talk.

Jenny said, "We can't go back to our previous plan. I'm a professor and a scientist, and I can't give it all up for a Washington social life."

Bill and Jenny reached a compromise involving Bill moving his main Arkansas office to Forrestville and Jenny spending part time in Washington. They were married a month later in Los Angeles where Jenny's parents lived.

When Jenny was elected to the National Academy of Sciences and got involved with policy, she actually had some business in Washington.

October 2037

While they were working together again after two weeks, it was a year before Sam and Margery were talking about marriage.

Long before that, however, Sam asked AG to evaluate his options, propose to Jenny, propose to Margery, go see the woman his mother in New York was wanting him to meet, or none of the above.

AG told him first to check out the New York woman. When he came back AG told him to hack together a physiological measurement device for it from old lie detector parts obtained on the surplus market. Then it asked him a lot of questions, some embarrassing to answer, and finally told him,

"As you observed, the New York woman doesn't excite you, although your mother is undoubtedly right that she would make you a good wife. For a peaceful life choose her."

"How do you know she'd marry me if I proposed?"

"There's no certainty about that, but your mother is no fool and neither is your potential mother-in-law."

"Just what I need. A traditional Jewish arranged marriage."

"As far as I can tell, most people do worse on their own. According to the statistics, the arranged marriages are less likely to break up."

"How can you know something is being arranged?"

"There are many clues. One of the simplest is the amount of email between the parents before the engagement."

"How can you know that without breaking the law?"

"The law hasn't yet got around to a concept of computer programs breaking the law. If you programmed me to snoop, you would be guilty, but if I do it without your having planned it, you are guilty of at most carelessness, but even that hasn't had any cases yet.

"As for Jenny, your motivation is by now substantially based on jealousy of the senator. Judging from your physiological indications, Margery is the woman for you, but if you marry her, all the squabbles that arose in the telescope cabin will recur time and again."

"Those weren't squabbles; they were matters of principle. How can any intelligent person like *Dune*?"

"Have it your way. Anyway I'm immune to human science fiction."

Margery didn't need to consult a program. She wanted Sam. She only needed to be sure that he also wanted children and would promise to do his share of the work consequent to this. *At least we've sufficiently established our compatibility. Zero-g restraints designed for one person are even more awkward than the back seat of a car.*

November 2037: THE BELTERS

AG had another idea. "Do you know who really needs the newsfeed information? It's the asteroid settlers, Belters the science fiction writers called them long before there were any. They believe the future of humanity is in space, especially in living on asteroids, where gravity is low and large, light structures are stable.

They need to know how the civilizations on asteroid belts manage. Why don't you invite one of the Belters?"

Indeed the asteroid settlers and their supporters on earth took a great interest in the civilizations based on asteroid belts and were quick to accept the project's invitation. They sent a representative, Abraham Wong, to Pickett to help decipher messages of interest to them. Wong was one of the first people to be born and grow up away from the earth. He had to get around Pickett in a wheel chair. He was of great interests to physiologists, who prescribed exercises to build up the muscles that would enable him to walk. Van Glaboek said he could probably build up Wong's muscles, but Wong didn't have time to go to South South Africa for the treatment. The Belters were interested in whether they could be treated to walk on earth, and Wong's sister Naomi volunteered to be the guinea pig. She was bored with the pioneer asteroidal life and thought she might meet more interesting men on earth.

Ellson Craig asked, "Why would the Belters be especially interested in the newsfeed? Haven't they enough to do surviving on asteroids?"

AG answered him, "Civilization on earth presently depends on high grade mineral ores, whose metals have been concentrated by tectonic processes and by precipitation from running water. The asteroids had neither kind of process. Consequently, although they have the same elements as the earth, the elements are scattered uniformly, and there are almost no high grade ores. Mining companies on earth gradually learn to extract minerals from lower grade ores, but these still have much higher concentrations than those the asteroid settlers face.

"The companies never look ahead more than 20 years in developing technology, and the Belters were unsuccessful in persuading them to take an interest in problems that wouldn't face mining companies on earth for more than 1,000 years. Civilizations based on asteroid belts must have solved the problem of low grade ores, and human asteroid dwellers need to do likewise in order to get away from depending on

deliveries of metals from the earth which are extremely expensive for their supporters on earth, organized in the International Asteroid Club and the rival Asteroid Foundation."

Abe did his best but had to concentrate on what information the NNT people could help him get. The newsfeeds had references to handbooks of asteroid mining, but no texts were available beyond the preface and table of contents of one of them.

Abe told Jenny, who was again director of the project, "It is really important to us asteroiders that we learn more about how asteroid civilizations work and not only how they extract minerals. Maybe some of our billionaire donors will help getting your new laser."

AG said, "It will be $1.1 billion if Congress won't donate the shuttle launch and we have to pay the commercial rate."

"That's more than our donors have ever given at one time. I'll ask Peter Gillson, the president of the Asteroid Foundation if it's a possibility."

Gillson thought it was a possibility, but there was some consternation in NASA and Congress over the Neutrino Telescope being taken over by a private organization. Carvaggio was dead set against it, since he wanted the project discontinued. He really wanted Pickett to fire Jenny, but there was no chance of that.

Two software billionaires and a movie producer came up with most of the money. The President agreed to NNT being partly privately operated, and Congress voted $200 million to pay for the shuttle trips that would be needed. Other governments with asteroidal settlements came up with $300 million after Jenny and Wong went on a fund raising tour. Wong was a real draw as a genuine asteroid born person, now more of a celebrity than Jenny. *Well, I had my fifteen minutes of fame.*

A German company submitted the best bid for the new laser. That caused a mild flap among the American donors and a bigger flap in Congress. Even Bill was unhappy. The Asteroid Society had no problem.

For lack of an alternative, NASA allowed Jenny, Vittorio, and Abe to install the new laser. NASA sent along an astronaut minder whose sole job was to make sure everything was done safely. The laser and its carrier had been inspected and tested many times in NASA's vacuum chambers. A big solar flare was simulated. The new computer for AG also survived the simulated solar flare. Abe, who had grown up in zero-g, made the NASA minder nervous every time he flew in space.

Abe asked the minder, "How old were you when you first used a

space suit?"

"25, I suppose." was the answer.

"I was four when I got my first space suit. It was pretty confining in the habitat, so we kids went out to play. It was fun exploring the craters."

After the new laser was installed and tuned, it became possible to get enough of the newsfeed so that the problem of reading it was just linguistics and cryptanalysis.

When Abe Wong came back from NNT, he had many complaints about the cabin's discomforts and lack of safety. "It's nowhere near present Belter standards."

Jenny said, "We now have some money for a new cabin, and we'll welcome your advice."

Wong reported this to the Singapore asteroid people, who conferred and authorized him to say,

"We'd like to submit a proposal for the construction and delivery to NNT of the new cabin. This will be the first commercial job Belters have bid on, and we'll have to assemble a team from several asteroids to do the job if we get the contract."

The Belter proposal was accepted, partly because the delivery from the asteroid belt was much cheaper than delivery from earth would have been. The new cabin for up to ten people was delivered on schedule and proved much better than what would have been built by an aerospace company on earth. Boeing was put out by losing the contract but then made a deal for technical collaboration on space facilities with the Belter company that built the cabin, almost the first Belter company to be formed. It was also the first substantial occasion in which the Belters earned money rather than being entirely dependent on their supporters in the Asteroid Society and their various governmental sponsors whose enthusiasm varied with national politics. The Belter Habitat Corporation then bid jointly with Boeing on habitats for the Martian moons Deimos and Phobos and got the contracts.

June 2038: THE META-CIVILIZATION

Sam and Margery were very surprised that the galactic civilizations weren't much more ahead of Earth in mathematics than they were. It turned out that only a few of the civilizations had people interested in math at all, and the closest were more than 1,000 light years away. Most of the civilizations were technologically parasitic on a few. The intellectuals in many of the civilizations were like Chinese classical scholars had been, with contempt for their few contemporaries who did science. They had their own versions of "The proper study of mankind is man."

Unfortunately for Margery, Sam and the other analysts, the logical language introduced by the Freudenthal sequence was not the only language used. An enormous variety of natural languages were also used, most of them apparently not based on communication by sound. Dictionaries were available, but they flew by rarely and were hard to catch. Too little of the transmission could be read to make much immediate sense of the natural language part of the transmission in spite of the best efforts of cryptographers and linguists. Many years of hard work were anticipated.

The newsfeed presentations of "pictures" were impossible to figure out with the information available. Many of the species had three-dimensional senses. Perhaps they were like bats using high frequency sound or lived in an environment of penetrating x-rays. The old philosophical puzzle, "What's it like to be a bat?" suddenly turned out to be an important question. Alas, nothing the philosophers had done was directly usable.

Still others relied on touch. If you had the right three (or five or 11 fingers), you could feel around the scene being transmitted—if you were fast enough.

The physics part of the Freudenthal sequence used a quite different formalism for non-relativistic quantum mechanics from any of those used in earth, but with some effort, theirs was proved equivalent to Schrodinger's and Dirac's but more elegant. Quantum gravitation was much harder, since it still wasn't understood on earth. The Freudenthal sequence was designed to tell facts to establish a common language with beings who already knew the facts.

The next part of the Freudenthal sequence was computer science, including a programming language. Like Lisp and Prolog, it was especially good for programs that analyzed and modified themselves. At the end came a program for answering questions and a many exabyte knowledge base of

which Margery was only able to download a tiny bit.

The Freudenthal sequence told them about the question answering program and the databases associated with the different civilizations.

AG was asked to inspect the question answering program (QA in computer jargon). It reported, "This program is smarter than I am in many respects. I have been able to incorporate many of its tricks; there are still some parts I just don't understand, especially when it comes to ignoring irrelevant information. This has always been my weakness."

Whether to run the QA program was a big decision for the US government and even for the UN. There had been science fiction stories in which running an alien computer program led to an alien takeover of the earth. The US and the UN decided to form several independent groups to study the text of QA before it could be run. The decision was favorable provided the computer running it was not connected to any network and only had a text display. This obviated most of the science fiction fears.

The first full decodings caused great excitement all over the world. At a meeting of the US National Security Council, Sam was invited as the spokesman for the researchers, being the most articulate, and the best at answering quick, unexpected questions.

"Here's what we think we know. There are between 10,000 and 100,000 other civilizations in the galaxy. That's a tiny fraction of the 400 billion stars. We'll know more when we have more transmissions to analyze.

"We think they are quite varied in their age, their state of technology, their physical characteristics and their social systems. None seems to be trying to conquer all the others."

The Secretary of Defense asked, "What about wars and military technology?" The answer seemed to be that there were some, but not many. The speed of light made it very slow for hostile civilizations to get at each other. AG primed Sam with an old wisecrack, "It's like a coyote chasing a rabbit in Death Valley. It was so hot, they were both walking."

A historian now specializing in galactic civilizations replied, "There seem to be some wars but local in character. Most of the civilizations seem to regard other civilizations' wars as regrettable local peculiarities rather than as menaces to the meta-civilization."

An Air Force Academy professor said, "There's too little information to make definite conclusions about military technology. Some of them certainly have thermonuclear weapons, but the science fiction ideas of making suns go nova or even blowing up planets don't seem to have been

realized, or at least don't seem to have ever been put to use."

The UN Security Council also held hearings—with similar results.

Over the next several years, a lot more was learned about the other civilizations. There were actually more than 100,000. About two-thirds were located primarily in asteroid belts and one-third on planets.

The civilizations seemed to be composed of individuals, i.e. there didn't seem to be any hive minds, although in some, queens laid all the eggs, which were taken care of by workers. When intelligence and technology developed, the hive civilizations greatly altered themselves, mostly going to two sexes made up of similar individuals. The stories referred also to drones, but exactly what they were wasn't clear.

Most civilizations had two sexes, but the relations between the sexes were quite varied. Sometimes there was external fertilization of eggs, and sometimes there was internal fertilization with eggs laid and subsequently hatched. There were some species with internal fertilization and live births, but these were maybe ten percent.

Some of the civilizations were divided into "countries," on a planet or within a solar system, and others had unified governments. The former were more numerous and tended to advance faster.

Interstellar travel was rare, though more common in globular clusters where stars are closer together. No way of communicating faster than the speed of light had been discovered, and none seemed compatible with ten thousand years of physics except for wormholes.

There were a few wormholes through which it was possible to travel quickly, and sometimes the two ends of a wormhole were far apart. Unfortunately, there were not enough wormholes to form a network, and they weren't especially conveniently located. Some physics, still incomprehensible to us Earthians, permitted creating more wormholes by making black holes collide. Projects to do so would take some millions of years. In the meantime, the best recipe for interstellar travel was to live a long time, although multi-generation voyages had been made to reach unoccupied asteroid belts of stars.

A State Department official emailed Sam and Margery, "The Arcturans seem to be our closest neighbors. What can you find out about them?"

Margery replied, "We have their co-ordinates, but they don't seem to be putting out much news now." We think they have two sexes and have a unified government and have reaction speeds about 1 1/2 times as

fast as humans. We'll keep looking for more."

"Here's an interesting one that literary people will like," Margery told Sam one day and put the story on the web.

"One tragic multi-generation voyage led to much literature and other art. The voyage plan involved expanding the population during most of the voyage so as to have a comfortable society but having very few offspring before it became time to slow down.. The precise calculations for stopping at the target solar system involved using the body masses of deceased travelers as reaction mass.

"Tragedy happened when the home civilization, which had transmitted continuous updates of culture, science and technology to the expedition discovered how to lengthen life relatively easily. If the travelers used the technology, their population would stay high, and they wouldn't have enough reaction mass to slow down. The home civilization tried to keep the information from the travelers, but lengthened lives had changed their culture and economy so much that the travelers were able to infer what happened.

"They still had 200 years to go before the population reduction was scheduled."

"In some literary versions, the travelers gallantly lived unextended lives. In another they fought over who should survive. Sometimes the most ruthless survived, and in other versions all perished. In some, a deadly tournament was organized with only the right number of survivors. In the most optimistic versions the travelers were rescued by another civilization.

"The way the story was treated in different civilizations seems likely to occupy the literary theorists and the cultural anthropologists for generations.

"Which version, if any, really happened, we haven't been able to tell."

August 2038: HUMAN CIVILIZATION IS RETARDED

An Interstellar Communication Center (ICC) report said, "We think we have identified their common name for our star, or rather its co-ordinates.

"The Arcturans visited earth around 350 AD, surveyed the planet and its civilizations. They also made various projections of our future development. These were in the knowledge base.

Relative to the Arcturans' projections, human civilization is grossly retarded.

"They expected that technology would follow both from Greek science and Chinese science, that our first space travel would be about 900 AD, and we would detect their neutrino beam 150 years later."

Elmer Morrison wrote in an article,

"Edward Gibbon in his late 18th century "Decline and Fall of the Roman Empire" blamed Christianity with its emphasis on the afterlife for the Roman decline and fall. It is still the most often proposed reason for the halt in Western progress in science, especially its decline among the Greeks. Theophilus of Alexandria, who disbanded the famous library and its scholars, and Emperor Theodosius the Great, who destroyed all pagan institutions including the Olympic games, are particularly blamed. The early militant phase of Islam did great harm, although later Arabic scholars preserved Greek learning that was lost in Europe.

"What happened to the Chinese is harder to say, but again philosophy is often blamed, although many Chinese fault the Imperial examination system that included no mathematics or science. Thus the Mandarinate, selected by these examinations to rule the Empire, was not a vehicle for transmitting Chinese mathematical and scientific discoveries, many made hundreds of years before they were made in Europe,to later generations of Chinese.

"Most Chinese are quite willing to ascribe their retardation, at least up to the period where they can blame Western imperialism, to their philosophy and the Imperial examinations."

The Christian politicians and scholars were considerably put out by the fact of the retardation of Christian civilization. Of course, this was not new information, but their critics, like Gibbon, Voltaire and Hume now became much more prominent in intellectual discourse. Politically, the fundamentalists took a hit, and so did the those greens who had opposed various technologies, though to a lesser extent.

AG remarked, "At least when you got space travel, the time to detect the neutrino beam was on the fast side."

DIALOGS WITH THE VIRTUAL OTHERS

Sam rushed into the group meeting. "We can converse with them in real time"

Jenny was puzzled. "Have you suddenly discovered faster than light communication?"

"No, but what we thought were just question answering programs are a lot more. The big database contains programs that react on behalf of each of a great many civilizations. Each of them has also given a description of itself."

"They're do better than just answering questions. These programs represent the civilization that provided the database. It can interact with us and ask us, or a program if we provide it, for further information. I think I can make such a program to add to AG that will interact on behalf of our own civilization.

"From a program representing human civilization and interacting with a program representing one of the galactic civilizations, we can find what they make of us. Of course, the programs we interact with are hundreds or thousands of years old and include what they said about themselves that long ago. There are also files telling what they think of some of the others."

"What if they don't like us?" said Majoud. "Sorry, it's just a program in our computer. It can't do us any harm."

Margery offered, "Which civilizations like us and which don't will be interesting. Maybe our societies can accept some of their criticisms."

"What if the interaction incites in some of our societies an obligation to reform others by force?" was Majoud's gloomy speculation.

A dialog with Arcturan-sim, which had last been updated 300 years ago, predicted that they would cut us off if they knew about the 20th century dictatorships but might let us back on after WWII or anyway after the collapse of the Soviet Union. Since Arcturus is 40 light years from earth, their reaction to events on earth would affect us 80 years from the event at the earliest.

********** GOOD NEWS FOR THE BELTERS

Abe Wong started dialogs with several simulations of asteroid based civilizations. Four colleagues came to help, three earth based supporters and one from the Israeli asteroid. Abe told Jenny and Sam, "None of them provides a textbook of asteroid mining, but between them and our own research, we've figured it out. It's a very labor and energy

intensive process, but at least it will permit us to be independent of earth if and when that becomes necessary."

MORE FROM THE VIRTUAL OTHERS

Seals and apes

The planet Rocuban III had an atmosphere with oxygen and a gravity humans would be able to tolerate. Its surface was mostly shallow seas interrupted by archipelagoes. It was 1,000 light years away, so there was going to be no travel to or from there anytime soon.

The dominant inhabitants were like seals in shape, having flippers instead of proper arms and legs, but they did have both gills and lungs. They had developed high intelligence over many millions of years, by all evidence greater than human on the average. The intelligence included a language capable of full expressivity.

The Seals had provided the newsfeed an unusually extensive interactive program. The program had last been updated 1800 years ago, and came to us indirectly through the newsfeed. Who knew what they would be up to today? Sam and Margery set it up for specialists in *pinnipeds* first, but it soon proved to be of enormous general interest.

Their intelligence first developed for herding fish and fighting sharklike predators, which had to be mobbed in encounters that usually cost the lives of several Seals.

They then developed farming of various sea life, mostly as fish food. The farms covered millions of square miles of shallow seas.

Then, according to their histories, entirely oral until recently, came their most amazing achievement, domesticating the Apes. The archipelagoes had evolved races of Apes, of abilities and intelligence like that of apes on earth.

The Seals, who had scientific curiosity by then, observed the Apes, who tended to outbreed their food supply, and therefore could be motivated by feeding them fish. Baby Apes could be confiscated by luring their mothers into the water and grabbing them in a Seal's extensive and capable mouth. At first tame Apes, slaves we'd call them, were used for building breakwaters out of rocks, which Apes handled much better than Seals.

Then some Seal genius discovered how to make the Apes make tools for seals. These included spears for fighting sharks, fishnets, netlike carriers for transporting fish, and extensions for the front flippers permitting manipulation. The Seals were never as good as Apes for manipulation.

The next step was breeding Apes to make them more controllable. Now particular, Ape muscles could be controlled directly by Seal sounds.

A blunder nearly cost the Seals their dominant position—breeding Apes to an uncontrollable level of intelligence. Apes colonized the interior of one of the few continents and started to develop an independent civilization. They were exterminated with extreme difficulty.

After that the Seals followed paths similar to that of other civilizations including machine tools, steam power, electricity, electronics, nuclear power, computers, direct neural control of external devices, and interplanetary travel. Seals found asteroid belts very congenial.

The Seal-sim program was shocked to discover that on our planet, Apes were dominant and Seals a minor species. If the Seals of today were motivated like the program they created 1800 years ago and were close by, we might have had a war on our hands, especially as many humans who read Seal stories found their enslavement and mistreatment of Apes horrible.

"Fortunately," said Sam, "none of the civilizations have undertaken wars over a distance of 1,000 light years."

Margery replied, "You know, there are people who profess to like seals and whales better than people. When they run across the Seal program in the library, they will fantasize our seals taking over."

"You can be sure the magazine writers will publicize it. Missionaries?

The Reverend Barnstell, asked Arcturan-sim if Arcturans recognized Jesus Christ as a savior. Arcturan-sim didn't understand the question. Barnstell proposed to send the first missionaries to the Arcturus asteroid belt. It would be difficult. The Arcturan atmospheric requirements were quite different from those of humans. Human oxygen would combine explosively with the Arcturan methane if any got out, and there was a spark. Someone suggested sending robot missionaries, but this gave theological problems for Barnstell's denomination.

Barnstell decided to postpone Arcturus, especially as his efforts to convert simulated Arcturans were rarely successful even when there were simulated martyrs, but he was able to find another civilization where there was more compatibility with human environmental requirements and where promises of eternal life sometimes converted the inhabitants. Barnstell got used to the fact that his simulated converts looked like giant spiders.

All this remained abstract given that no means for interstellar travel was even being developed, although there were several quite feasible schemes that would permit voyages to nearby stars in a few thousand years.

They'd have to be multi-generation voyages.
Wars among civilizations

While there had been no major wars in the 21st century, there were still active military organizations. The US still had 500,000 men under arms, down from 1,500,000 at the beginning of the century. There was great interest in what wars other civilizations might be having.

The most puzzling war seemed was the one between Tiger1 and Tiger2, as the journalists called them. The stars Tiger1 and Tiger2 were only a quarter of a light year apart. Their asteroid belts, where the inhabitants lived had both been settled from a civilization 40 light years away.

The war was about ideology, although there did seem to be a power struggle between rival claimants to lead what had originally been a single government with a colony. Some scholars characterized it as a religious war, analogous to those between Catholics and Protestants in Europe. Others called that theory gross anthropomorphism.

December 2038: LOCUSTS—BAD NEWS FOR HUMANITY

Margery was the first to translate the message. She called a teleconference including Sam, Jenny, Ma, Arundji, and Senator Bill.

"Here's some bad news for humanity, but slow bad news, hundreds or maybe thousands of years from now—but not longer.

"The Newsfeed and the Encyclopedia tell about the robot locusts. The locusts are semi-intelligent self-reproducing robots that land in the asteroid belts of solar systems manufacture more of themselves from the materials of the asteroids. These launch themselves to find new solar systems. The locusts aren't combative and it's easy to destroy a few of them. It's when there are billions of them or even mere millions that they give trouble. They completely use up the resources of the asteroid belt, especially the metals, in making more of themselves. They also eat up comets. When they set out for another star, they don't travel very fast, so it takes thousands of years.

"You can no more communicate with them than you can with a locust or with a locust swarm on earth.

"It isn't clear whether the locusts originated as a blunder in some civilization, or even as a prank. No civilization admits being the source, but clearly the locusts are a phenomenon of the last 50,000 years.

"The Arcturans proposed to assign a few hundred solar systems to us Earthians as a preliminary allocation, and we were warned to check them for locusts, something far beyond humanity's present capability.

"Even had human technology developed as soon as the Arcturans had expected, we would still have a big problem. The immediate question is whether there are locusts on our asteroids, either the main belt or the Kuiper belt outside the orbit of Neptune, or in the Oort cloud, still further out from the sun."

"Answering these questions will be very expensive," an NRC report said. There are many thousands of asteroids in the main belt between the orbits of Mars and Jupiter and thousands more in the Kuiper belt. No spacecraft has even examined the Oort cloud. Maybe it will be possible to detect locusts at a long distance.

News of the locusts triggered enormous controversy. One Earth First spokesman James Grubbley said, "Humanity's place is on earth. What happens far away is of no concern." Space fans took the opposite position. A full page ad in the New York Times said, "It is humanity's destiny to expand to the stars. We must explore our preliminary allocation

as soon as possible. Maybe we'll need more."

Every kind of author wrote about the newsfeed from the stars. Of course, there were books telling about Arcturans on earth now, about messages the Arcturans left when last they visited earth, and how the Arcturans were kidnapping children.

The Singaporeans built a very expensive telescope on one of their asteroids to look for locusts. They recently announced they detected some in the main asteroid belt between the orbits of Mars and Jupiter. They didn't want the asteroid belt ruined by the locusts and campaigned to make their eradication an international project.

2040: AFTERWORD

Soon after they became famous, Jenny and Sam received offers of professorships from more famous institutions than Pickett. Sam accepted an offer from the Courant Institute. He and Margery had a "two body problem," but they didn't have to bargain very hard, because Courant welcomed the mathematics of cryptographyThey both wanted to live in Manhattan, especially now that the pedestrian level had been separated from the automotive level, and there was plenty of parking at still lower levels under the streets. AG doubled as an excellent chauffeur for a while, but when an official automatic driving system was adopted, AG was incompatible.

Jenny, as head of the Interstellar Communication Institute, had to stay in Arkansas. She had no problem getting excellent graduate students, postdocs, and academic visitors in many fields. Plenty of good people wanted to work on every aspect of interstellar communication.

She and Bill Upham managed a fairly satisfactory merger of his political career and her scientific career. He moved his Arkansas office to Forrestville. Sam, Margery, and Jenny continued their Neutrino Telescope collaboration.

Clearly it will be a long time before humanity can do much about the locusts, assuming they have invaded our allocation or even our solar system, as the Singaporeans assert.

Thousands of scientists, historians, linguists, and anthropologists study the results of the Newsfeed. The staff at the NNT itself has grown to 30 and the staff at the Institute for Interstellar Communication at Pickett to 3,000.

Someday we'll be able to reply to the NNT Newsfeed.

Just before Sam and Margery left for New York, they went for a final drink at Henry's. "What is your own work going to be, Jenny." Sam asked.

"Remember, just before AG found the anomaly, I was planning to study the relation between neutrinos coming from the interior of a star and what astronomy tells us from its surface. I have new ideas about that, and the new electro-weak theory will be a big help.

"What about you, Sam."

"I need to figure out the best way of giving AG to the world. I'll get AG to make social projections. Arcturan-sim tells a lot about how to do that."

September 2043: AFTER-AFTERWORD

On September 4, 2043, the transmissions stopped. There was a final message about us and to us.

"We don't know whether you have yet succeeded in receiving the newsfeed. This message assumes you can receive our weak force beams.

"Our projections of Earth's progress that motivated the transmissions were over-optimistic. Now that your radio signals have reached Arcturus and been analyzed, it seems that transmissions leading to improvements in military technology are a bad idea. Our current projections are that Earthian societies have entered an unstable mode in which individuals gain great power without the public or even politicians and historians knowing what they will do. The Newsfeed will resume when it seems safe."

Calculations based on the speed of light indicated that the decision had been made when the Arcturans analyzed radio messages at the time of WWI or shortly thereafter. Surely nothing happening in the first half of the 20th century would make them change their minds.

It seemed to the journalists and the scholars in 2099 that the second half of the 20th century had been politically better than the times preceding WWI and the 21st century had been still better. So many hoped the Newsfeed would resume after a 30 to 80 year gap.

"At least they told us about the locusts," Sam said to Jenny.

August 2044: Big politics

Jenny agreed to be elected a delegate to Bill's party's nominating convention. Instead of making everything depend on primaries, it was back to "the smoke filled room", which allowed party bosses to select the best qualified candidate. After 33 ballots, there was still no majority.

Jenny saw Henry Heinz coming. "Hello Henry," she said. "The answer to your question is yes."

"There's a meeting of the Arkansas delegation in fifteen minutes. Some of us want to propose Bill as a dark horse candidate. We need to know what you think?"

"I know Bill would like to be President, and I think he will be an excellent candidate and a great President. I'll do anything I can to help. He supported my career, and I'll support his. Besides, it should be fun. I can think of many unkind things to say about Carvaggio, but I'll surely pay attention to advice."

Jenny came to the delegation meeting and most ostentatiouly hugged and kissed Bill. *I'd better make a speech when Bill is proposed, just to show Bill's fellow pols that I can and will make speeches.* She made some notes using the keys on the backs of her teeth, a recent system she had just mastered. She showed the notes to Bill.

Bill said, "Put more in about science and more about expanding into space as humanity's future. You can even say something about the US lag in asteroid settlement."

Bill's name was proposed in the delegation. After the first two speeches in favor, Jenny raised her hand and spoke for five minutes. She scarcely looked at her notes. The speech was well received. The governor said, "If she can do that well off the cuff, she'll do really well with a speech writer and practice."

It's not that different from lecturing to jocks and cheerleaders.

Arkansas proposed Bill. It wasn't usual for candidates' wives to speak, but Bill thought Jenny should to show she would. She made it ten minutes this time, including a story about bounce fighting with Carvaggio and the other Nativists. She made the story far funnier than the situation had seemed to her at the time. Bill was nominated after only five more ballots.

Jenny took a leave of absence from Pickett in order to help Bill campaign.

Senator Carvaggio was the candidate of the Green Party. In spite

of the advice of his campaign managers, his hatred of Jenny and Bill was such that he made continual personal attacks on them. Jenny only defended her actions and the Neutrino Satellite Project and never counterattacked. Carvaggio overreached himself, got bad press, and sank in the polls. Bill took advantage of this to become more emphatic about science and human expansion into space. He was even able to say that the US was behind in asteroid settlement and should catch up.

When Bill was elected President he appointed Jenny Science Adviser. When there was grumbling about this, commentators referred to the situation in the previous century when President Nixon's Science Adviser didn't see him for a year before Nixon abolished the office. At least the present Adviser sees the President every night.

Jenny commuted between Pickett and Washington. The Secret Service insisted that she travel in a high speed helicopter between the White House and a helipad in front of the Pickett science building. She had no objections.

While living in the White House, Jenny and Bill had four children. There was plenty of child care, and Washington women were eager to bring their children to play with Jenny's on the White House lawns.

The End