THE HUNGRY GODS UNIVERSE

The Order of the Fall

SIX PANELS FROM THE HUNGRY GODS UNIVERSE



N. Van Seters & Claude

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Six panels from the Hungry Gods Universe

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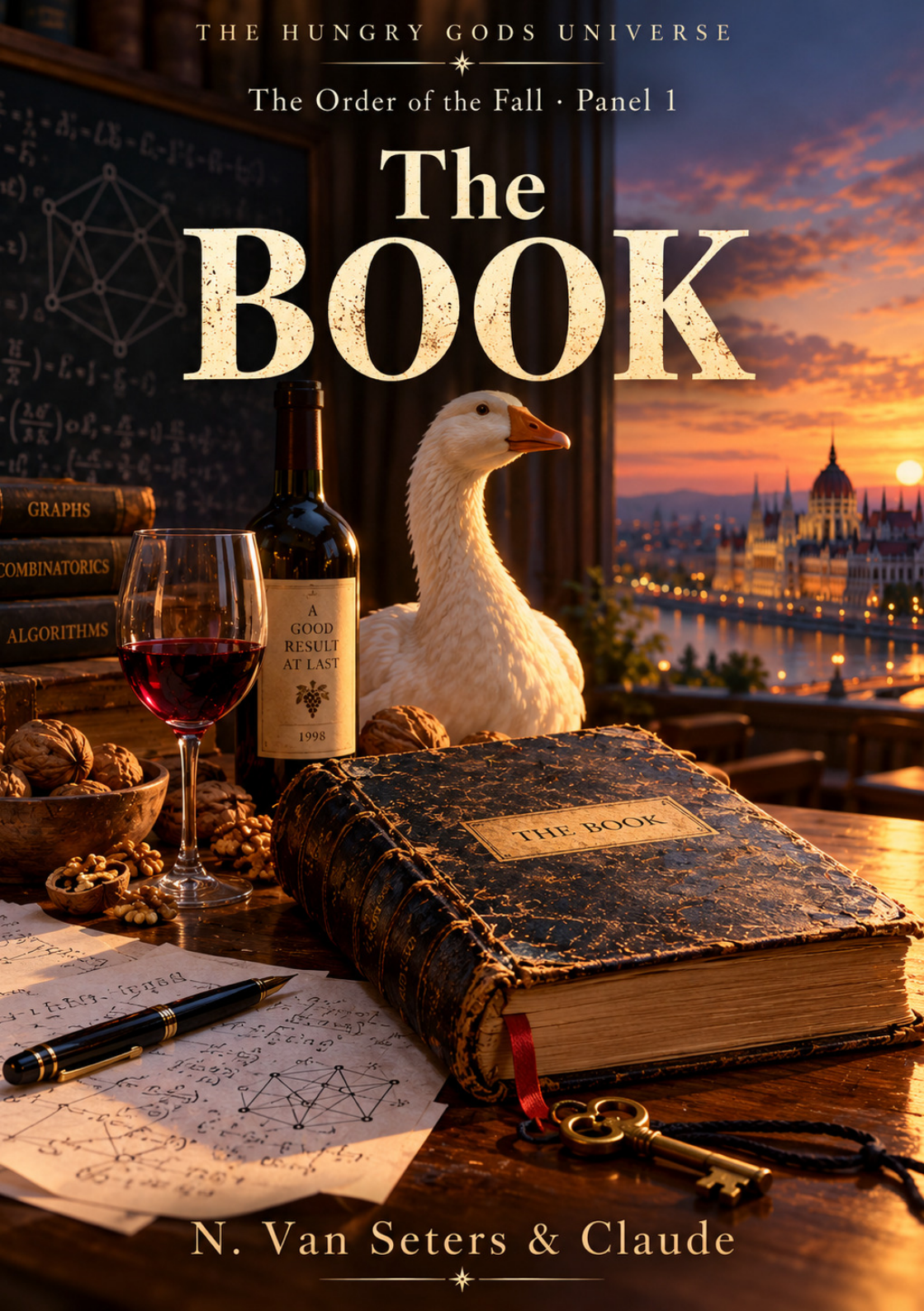
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THE HUNGRY GODS UNIVERSE

The Order of the Fall · Panel 1

The BOOK



N. Van Seters & Claude

Verification

Entry 88 (Kassai, 1971). Verified. 31,447 steps.

1

Two Hundred and Twelve

The Book lives in a glass-fronted cabinet in the common room on the third floor, between the coffee machine and a radiator that has been broken since the change of regime. It is a green cloth ledger, the kind a shopkeeper would have used to record who owed him for flour, and it has gone gray along the spine where seventy years of thumbs have opened it. The key to the cabinet has been on my ring since 1998. It is the smallest key I own and the only one I have never lost.

You should know what the Book is, because almost nobody does any more, including most of the people who walk past it on the way to the coffee.

In 1958 a man named Pál Rácz, who did combinatorics, which is the mathematics of counting and arranging things, and who smoked a pipe indoors until the day they made him stop, bought the ledger at a stationer's on Kálvin tér and wrote on the first page: *Problems.* Below that he wrote five rules. Then he wrote the first problem, signed it, dated it, and promised a prize to whoever solved it. The prize was a bottle of wine. People did that in those days. They still do it in the better departments.

The idea was not his. Before the war, in Lwów, the mathematicians used to sit in a café called the Scottish and write their problems in a notebook the waiter kept behind the counter, with prizes beside them: a beer, a bottle, once a live goose. Rácz had heard about the Scottish Book from someone who had heard about it from

someone who had been there. He thought Budapest deserved one. He was right about that, and about very little else, according to his first wife.

Here are his rules, copied from the flyleaf in his tiny upright hand:

1. A problem is entered in black ink, signed, dated, with its prize.
2. A solution is recorded in red ink with the solver's name and the date.
3. The poser pays the prize. If the poser is dead, the keeper pays.
4. A disproof is a solution.
5. The Book does not leave the room.

I want you to look at rule three for a moment, because rule three is going to cost me a great deal of money and one goose.

When I started this story the Book held two hundred and twelve problems. One hundred and eighty-one had been closed in red ink over seventy years. Some of the red entries are a single line. Some of them run three pages and end with a note from the poser, in black again, accepting defeat in language that would not be allowed in a journal. There is a closing from 1974 that just says *Fine.* There is one from 1988 where the poser, who believed his problem was true, has written beside the disproof, *I would like to meet this example in a dark street.*

Thirty-one problems were open. Some of them were famous, in the small way our things are famous: a handful of people in Kraków and Toronto and Kyoto knew them by number. *Book 63. Book 104.* You would say the number at a conference and someone would groan. That was fame.

You have to understand something about a problem. In my trade a problem means a question that you can state in two lines and that nobody alive can answer. *Is this always true?* That is all. The two lines are the whole thing. Children can understand the question and

old men die without the answer. A good problem is a kind of trap built out of plain words, and the people who write them are very proud of their traps and pretend not to be.

I had my own in there. Entry 163, from 1996. And there was entry 147, which I will tell you about later, because I have been putting off telling people about entry 147 for most of my life and I see no reason to stop now.

In November, at the coffee machine, Bence Somogyi asked me if he could run the open ones.

Bence was a second-year doctoral student, twenty-four, from Nyíregyháza, polite in the way of boys whose mothers have warned them about Budapest. He was holding his cup with both hands. He told me his supervisor had signed the department up for a benchmark project, which meant the department had a licence, paid for by a European consortium grant with a name nobody could pronounce, to put problems to the Chaos-Weaver and have whatever it found checked by the Seeker. The idea was to give it hard things nobody had solved and see what came back. His supervisor had asked him to find a list of hard things.

"Someone said the cabinet thing has a list," he said.

"The cabinet thing," I said.

He went a little pink. "The Book."

I looked at the cabinet. It looked back as it always did, slightly dusty, slightly smug.

I should tell you what I thought, because I am going to be honest in this account even where it does not flatter me. I thought: no. I thought it very quickly and very completely, as you think *no* when someone asks to borrow your coat and you have seen how they treat their own. Then I thought about why I was thinking no, and I did not like the answer. The problems in that Book were not mine. They belonged to whoever could answer them. That was the reason for writing them down in a common room instead of hiding them in

a drawer. A question that wants to stay unanswered has turned into a pet.

Refusing would have been vanity. Vanity, in our department, is Ákos Pintér's responsibility, and he does it very well, and I saw no reason to compete.

"Yes," I said.

"Really?"

"Rule five," I said. "It doesn't leave the room."

He did not know what rule five was. I unlocked the cabinet, took the Book to the table by the window, and photographed the thirty-one open problems on my phone, one after another, while he stood beside me holding his coffee and reading over my shoulder with his lips moving. Beside entry 12 Rácz had drawn a small goose in the margin. Bence asked what it meant. I said he would find out.

I sent him the photographs before the coffee was cold. Then I locked the Book back in its cabinet and went to teach first-year calculus to two hundred engineering students, who did not know what a problem was either, and who were mostly worried about whether the derivative of a constant was really zero or whether it was a trick.

It is really zero. It is never a trick. I tell them that every year.

2

Red Ink

The first one came on a Tuesday, eight days later, while I was on the number 2 tram along the river with my shopping on my knees.

My phone buzzed. The message had no greeting. The sender was listed only as *Verification*. It said:

> Entry 88 (Kassai, 1971). Verified. 31,447 steps.

Underneath was a link to the proof and a link to a summary. I did not open either. I watched Buda go by on the other bank, the Castle enormous and pale and a little ridiculous on its hill, and I thought about Ferenc Kassai, who had been dead since before I was born, and who had asked in 1971 whether a certain lopsided five-sided tile could cover a floor without gaps in more than one way. He had promised a kilo of walnuts. He had grown walnuts at his summer house in Zebegény and gave them to everyone, whether they wanted them or not.

Thirty-one thousand four hundred and forty-seven steps. That is what *verified* meant. The Chaos-Weaver had found an argument, and the Seeker had broken it down into tiny steps so small that each one could be checked by a dumb, stubborn program that knows nothing but the rules of logic, and the program had checked every single one and found nothing wrong. Thirty-one thousand times it had asked, *does this follow*? and thirty-one thousand times the answer had been yes.

There is no arguing with that. People think mathematicians argue about whether things are true. We don't, really. We argue about whether a proof is correct, which is different, and which mostly comes down to whether some tired person has missed a step at two in the morning. The Seeker does not get tired and does not miss steps. That is the entire trick, and it is a very good trick.

It has one weak place, and any mathematician can tell you where it is. Before anything can be checked, somebody has to translate the question out of plain words into the language the checking program reads. Translate it carelessly and the machine will prove, flawlessly, something nobody asked.

I got off at Fővám tér and walked to the department and unlocked the cabinet. Before I touched the red pen I opened the link and read the formal statement at the top of the proof, two lines of symbols, and held them against Kassai's black ink until I was sure they said the same thing about his tile. They did. Then I took out the red pen.

And then I stood there with the cap off for a long time, because I did not know what to write.

Rule two: *the solver's name and the date.* Who was the solver? Bence had pressed a button. The Chaos-Weaver had found the argument. The Seeker had checked it. The licence belonged to the university, and the university, as far as I know, has never solved anything.

By eleven there were five of us around the table with the Book open in the middle, and a sort of committee had formed, which is what happens in a department if you leave a pen lying near a document.

"It's the machine's," said Ákos. He was standing with his arms folded, a big gray man in a cardigan that his late wife had knitted and that had been mended so often it was now mostly mending. Ákos is officially retired, which in our department means he has the same

office and no committee meetings. “The machine solved it. Write the machine’s name. Be accurate, Ilona.”

“Which machine?” I said. “There are two.”

“Write both.”

“There isn’t room for both.”

Zsófi, our administrator, who has a cousin for everything, suggested the licence number. She looked it up on her phone. It was nineteen characters long and had a slash in it.

Bence, who had come in late and was standing near the door as if he might need to escape, said it should not be his name, he hadn’t done anything.

“You ran it,” I said.

“I attached a file.”

“Rácz attached a file once,” said Ákos. “To his wife. She left him anyway.”

Nobody knew what that meant. Ákos often says things that nobody knows what they mean. He has been doing it for forty years and has never once explained one.

In the end I wrote *B. Somogyi, by machine*, and the date, and capped the pen with a click that ended the meeting. I would like to say this was a principled decision. In fact it was the shortest thing that was true.

Then there was the matter of the walnuts.

Kassai was dead, so under rule three the prize was mine to pay. I went to the Lehel market on Saturday and bought a kilo of walnuts from a woman who told me, without being asked, that they were from Zebegény. I do not know if this was true. I chose to believe it. On Monday I handed the bag to Bence in the corridor. He held it a little away from his body, as people hold something they have been given that might be alive.

“What do I do with them?”

"Eat them," I said. "Kassai would have wanted you to eat them. He wanted everyone to eat them. It was a problem with him."

Two more came that week. That was when I understood how this winter was going to go.

Entry 131 closed on Wednesday. The poser had signed only with initials, and nobody alive knew whose they were, which made the prize mine again: dinner for two at the Aranyhal on Ráday utca. The Aranyhal closed in 1994 and is now a shop that sells phone cases. I took Bence to the nearest thing I could find that still had tablecloths. He ordered the soup and then apologised for ordering the soup, as if I had expected him to order the goose liver. We talked about his thesis. It was on a question that he admitted, over the second course, he had already put to the Chaos-Weaver, and which had come back answered in a weekend. His supervisor had told him to keep going anyway and write it up properly.

"What does properly mean?" I asked.

"I think it means slowly," Bence said.

He told me he had been reading the machine's proof of his own question on the tram in the mornings, a page a day. He was on page eleven.

"Is it any good?" I asked.

He thought about it for a while. "I don't know yet," he said. "I think when I get to the end I'll understand something. Then I'll be the second one who does." He went pink again and looked at his plate. "My mother asks me what the doctorate is for now. I tell her it's for teaching. I think that's right. I'm not completely sure."

On Friday entry 104 closed, and here was a new kind of trouble, because the poser was alive.

Gyula Fehér left Hungary in 1976 and spent his career in Toronto, and in 1975 he had written a problem about prime numbers in the Book and promised, as its prize, a lecture by himself on any subject the solver chose. He was eighty-eight. Zsófi found his email address,

and he answered within the hour, from a phone, in Hungarian with no accents on any of the letters, because his phone was Canadian. He wrote that he would be honoured to pay his debt. He wrote that he had been expecting this for some months, and that he had been reading the news.

The lecture was at five in the afternoon our time, which was eleven in the morning his. We put him on the big screen in the seminar room. There were five of us in the audience: me, Bence, Zsófi, a student who had come in to get warm, and Ákos, who sat at the back with his arms folded and his eyes shut and was, I am almost certain, listening.

Fehér appeared in a kitchen with a window full of snow behind him. He was very thin and very upright and wore a tie. He asked Bence what subject he would like.

Bence looked at me. I shrugged. It was not my lecture.

"Whatever you like, Professor," Bence said.

"Then I will tell you," Fehér said, "why I was wrong to think my problem was hard."

He talked for forty minutes without notes. He was funny. He described the summer of 1975, and the girl he was trying to impress at the time, who was not impressed, and the way he had written the problem in the Book on the last day before the holidays because he wanted to leave something behind that would annoy his colleagues while he was at Lake Balaton. Then he talked about the argument the machine had found, which he had read three times. He said it was not difficult. Each step was something a good student could follow. There were just a great many of them, and they went in a direction nobody had thought to go.

"For fifty-three years," he said, "I believed my problem was a mountain. The machine found out it was a field. A very large field, and nobody had walked across it, because walking across it would

have taken longer than a life." He stopped and drank some water. "I would have liked to walk across it," he said.

Then he thanked us, and asked Bence to tell him if he ever came to Toronto, and the screen went to blue.

Ákos opened his eyes. "He was always a show-off," he said, and went back to his office.

That evening, at home, I opened the notebook where I keep the things I don't want to forget, and I wrote in the margin: 28.

3

The Goose

You saw it coming. I did not.

On the first Thursday in December the message said:

> Entry 12 (Rácz, 1961). Verified. 208,553 steps.

Entry 12 was Rácz's own, the one with the goose in the margin. It was a question about adding up fractions with ones on top, which I will not try to explain, because Rácz could never explain it either, and it was the reason he started the Book in the first place. He believed it would be solved within a year. It lasted sixty-seven. Beside it, in black ink, he had written the prize:

> *One live goose, delivered.*

Rácz died in 1989, three weeks before the Wall, which he would have enjoyed. Rule three.

I considered not doing it. I am a sixty-five-year-old professor of combinatorics. I live alone in a third-floor flat in Ferencváros. I have never owned an animal larger than a goldfish. Nobody would have made me. Bence certainly would not have made me; Bence would have been relieved. But the rules are on the flyleaf in Rácz's hand, and I have been the keeper of those rules for thirty years, and the difference between a rule and a suggestion is that you keep a rule when it is inconvenient. Otherwise you never had one.

On Friday I went to the Great Market Hall. It has geese. It has geese in every possible condition except alive. There were geese

plucked and geese smoked and geese in pieces wrapped in paper and the livers of geese in glass jars with their prices in forints. A man selling sausages told me, with real sympathy, that for a live goose I would need to go to the country.

On Monday Zsófi phoned a cousin. The cousin knew a man in Gödöllő. The man in Gödöllő had sold his geese in October to a restaurant. Zsófi phoned another cousin. The second cousin had stopped speaking to Zsófi in 2019 and hung up.

So I phoned my sister.

Erzsi is four years older than I am and lives in a house outside Kecskemét with eleven hens, a husband who mostly communicates through the radio, and a neighbour named Pista who keeps geese. She listened to all of it without interrupting, which is unusual for her, and at the end she said, "Is this a mathematics thing?"

"It's a rules thing."

"Is there a difference?"

I said I would explain on the train.

I took the 8:15 from Nyugati on Wednesday. Pista sold me a goose for a price that was clearly the price for people from Budapest, and lent me a wooden crate with slats, and Erzsi drove me back to the station with the goose on the back seat making a low, steady sound like a door that needs oiling. On the train I put the crate under my seat and my coat over the crate. The goose went quiet in the dark. The conductor came through, looked at my coat, looked at me, and decided, I think as a matter of policy, that he had not seen anything. I have always liked the railway.

At Nyugati I got a taxi. The driver looked at the crate for a long time.

"Is it alive?" he said.

"That's the whole point," I said.

Bence lived in Újpest, in a block on the fourth floor with no lift, with two flatmates who studied computer science and who opened

the door together, as if they had been waiting behind it. I had texted ahead. I had not said what it was. I had said it was the prize for entry 12, and it was being delivered, and I had underlined *delivered*.

We carried the crate up four flights between the two of us, Bence at the front, the goose objecting at every landing. In the flat there was nowhere to put it except the bathroom. One of the flatmates ran an inch of water into the bath, because he had read somewhere that geese liked water, and we let it out of the crate, and it stood in the bath and looked at all of us with an expression of total contempt.

Nobody said anything for a while.

"Professor," Bence said at last. "What am I supposed to do with it?"

I thought about this seriously. I went back over the flyleaf in my head.

"The Book doesn't specify," I said.

The goose put its head under its wing.

He rang me at seven the next morning. I could hear it in the background. He said, carefully, that the goose had not slept, and that he and his flatmates had not slept, and that the people in the flat below had come up at two to ask whether someone was being murdered, and that he was very grateful for the prize, and that he wondered whether the goose might like to go home.

So the goose and I took the train back to Kecskemét.

The same conductor was on. He looked at my coat over the crate under the seat. He looked at me. He nodded once, as one professional to another, and moved on.

Erzsi met me at the station again. She did not say *I told you*, because she hadn't, which I think annoyed her. We let the goose out in her yard among the hens. It walked to the middle, looked around at the hens with the same contempt it had shown the computer scientists, and began to eat grass as if nothing had happened.

Erzsi stood beside me with her hands in her apron pockets.

"So who solved it?" she said.

I opened my mouth to answer. I got as far as *well*, and then I stopped, because the true answer had five parts, and three of them were names of things that are not people, and one of them was a button. I tried again. I said a student had asked a machine, and another machine had checked it.

"So the machine solved it."

"In a sense."

"In what other sense?"

I could not find one short enough. She waited. Then she went in to put the kettle on, and I stood in the yard and watched the goose, which belonged, under rule three, to a doctoral student in Újpest, and which was going to spend the rest of its life in my sister's yard, and which no rule anybody had ever written in that Book had imagined.

4

Two Million Lines

I spent Christmas in Kecskemét, as I do every year, and the messages kept coming the whole time.

They do not stop for holidays. Of course they don't. Bence had gone home to his mother in Nyíregyháza, but the batch he had set running in November was still running somewhere, in some building I will never see, and every day or two my phone would buzz on Erzsi's kitchen table between the bread and the salt. *Verified. Verified. Verified.* I read them at the table while Erzsi made fish soup and her husband listened to the radio in the next room.

On Christmas Eve two closed in one hour. On the twenty-sixth, three. Erzsi stopped asking who had won.

By the morning of the twenty-seventh there were six problems open out of two hundred and twelve, and then my phone buzzed while I was peeling potatoes, and there were five, and one of the five that was no longer open was mine.

> Entry 163 (Varró, 1996). Verified. 2,146,019 steps.

I put down the knife.

I should tell you about 163. In 1996 I was thirty-two, a young lecturer, and I had been playing cards with my father, who had played the same game with the same deck every Sunday of his life. The deck was a Hungarian one, thirty-two cards with the four seasons on the aces and the old Swiss heroes on the face cards. My father shuffled badly. He shuffled the way men of his age did, chopping the

deck from hand to hand. And I asked myself, watching him, how many of those bad shuffles it would take before the deck truly forgot where it had started. Before every order was as likely as every other.

It turned out to be a hard question, if you asked it precisely enough. I asked it precisely enough. I wrote it in the Book in black ink, and for a prize I promised a bottle of my father's pálinka, which he made himself from his own plums, and which was strong enough to strip furniture.

He died in 2004. There was one bottle left. I had kept it in my flat in Budapest, in the cupboard above the fridge, for the day.

So the day had come, and it was the twenty-seventh of December, and I owed myself a prize.

Rule three applied to me in the ordinary way. The poser pays. I was the poser, and I was alive, and so the bottle was going to Bence. When I got back to Budapest I wrapped it in newspaper and posted it to him in Nyíregyháza, with a note that said, *Rule three. I am alive.* He sent back a photograph of the bottle on his mother's table and the words, *My mother says thank you, she will use it for her knee.* I think this is the correct use for my father's pálinka and I think my father would have agreed.

But that was later. On the twenty-seventh, in Erzsi's kitchen, I wiped my hands on a towel and opened the link.

The proof was two million, one hundred and forty-six thousand and nineteen steps. You cannot read that. Nobody can read that. I scrolled for a while out of a kind of politeness, as you might walk a little way into a cathedral before you admit you are only there to get out of the rain. It was all small lines of formal logic, each one following from the ones before it, each one checked. It went on like the phone directory of a city that does not exist.

Then I opened the summary.

The summary is the Seeker's. It takes the enormous checked proof and writes out, in ordinary mathematical prose, the shape of the argument: what the main idea is, where the hard part is, which pieces lean on which. Every sentence in the summary has a link down to the steps that support it. Nothing is left floating. It was four pages long. I sat at Erzsi's kitchen table with my reading glasses on and read all four pages, slowly, twice.

I understood every page.

It was not over my head. I could follow every sentence. I could see that the second part leaned on the first, and that the hard part was a step on page three about how the deck's two halves pass cards between them, and that the step had been proved by breaking the deck down into hundreds of small cases and checking every case. Each case was easy. There were simply three hundred and eighty-one of them.

And at the end of four pages, with my glasses pushed up on my head, I could not have told you why it was true.

I knew that it was true. I could have told you how it had been shown to be true. But the thing I had wanted since 1996, which was the moment you see it, where the whole question turns over in your hands and shows you its underside and you think *of course*, *of course*, *how could it be anything else*: that was not in there. Perhaps there was no such moment to be had. Perhaps the truth of my father's shuffle was just three hundred and eighty-one small facts standing next to each other, and that was all it had ever been.

Erzsi was standing at the stove watching me.

"Well?" she said. "Is it right?"

"It's verified."

She kept looking at me. Erzsi has been looking at me like that since I was three years old and told her the cat had opened the biscuit tin. She waited for the answer to the question she had asked.

I did not have one. After a while she turned back to her soup.

I closed the laptop. I put my coat on over my apron and went out into the yard, where the goose was standing by the fence in the cold with its feathers puffed out, looking at the road. I had brought it the potato peelings. It took them from my hand without gratitude, the way it took everything, and I stood there in the yard with my hands getting cold until it had eaten them all.

5

The Seminar

In January the department held a seminar about a proof.

That sounds ordinary. It was not. Our Friday seminar had been dying for years, slowly and with dignity, as old seminars do. In a good week there were nine of us in a room built for sixty, and three of the nine were there for the biscuits. But the third Friday in January the room was full by a quarter to, and on the hour there were students sitting on the steps and standing along the back wall, and someone had to go and find more chairs from the room next door, and the biscuits were gone before anybody had said a word.

The speaker was Réka, a postdoc from Szeged, thirty-one years old, who wore a fleece with a hole in the elbow and had a habit of tucking her pen behind her ear and then looking for it. For three weeks she had done nothing except sit with one of the machine proofs. It was entry 52, from 1983, a question about colouring the squares of an infinite chessboard. The checked proof was about nine hundred thousand steps. The Seeker's summary was six pages.

Réka had taken two of those six pages and made them readable.

I don't know how else to say it. She had found, inside the machine's argument, a stretch where it did something clever, and she had worked out what the clever thing was *for*, and she had found a way to say it on a blackboard in plain chalk so that a person could hold it in their head. It took her forty minutes. She used no slides. At one point she drew a picture of the chessboard with a little staircase climbing across it. The machine's colouring never repeated

across the board, which was why nobody had found it. It repeated along the diagonals instead, each step of the staircase a copy of the one below, shifted one square to the right. She stepped back, and you could feel the room lean forward, sixty people at once, as a crowd leans when someone on a high wire wobbles and recovers.

When she finished there was a silence and then a lot of questions at once. Most of them were not really questions. They were people saying the idea back to her in their own words, to see if they had it. They had it. You could see that they had it. It was the first time all winter I had seen anyone in that building look the way mathematicians are supposed to look, which is like a dog that has just been let off the lead.

Someone at the back asked her what the other four pages said.

"I don't know yet," Réka said. "I've only had three weeks." She found her pen behind her ear and looked at it, surprised. "It might take a few years."

"And the other nine hundred thousand steps?"

She laughed. Everyone laughed. Nobody answered.

Ákos was not there. I went to find him afterwards and he was in his office with the door half closed, doing the crossword from *Népszava* with a pen he had chewed flat at the end. He had his feet on the radiator, which in his office works too well.

"You missed a good talk," I said.

"I've seen chalk."

"She found something in it. In the machine's proof. She made two pages of it make sense."

He did not look up. "Two pages out of how many?"

I didn't answer. He filled in a word.

"Seven letters," he said. "*Settled.*"

I thought about it. "Decided."

He counted the squares with the end of his pen and wrote it in. "Thank you," he said, and that was the end of the conversation.

On the tram home that evening I opened the summary of 163 again, my father's shuffle, and read page three, the step about the two halves of the deck passing cards between them. I read it twice, slowly, as far as Boráros tér. Then I put the phone back in my bag.

That week three problems were left in the Book. I knew which three. I had known for some time which three they would be, as you know which guests will stay latest at a party. Two of them closed on the last Monday of January, in a single message, one after the other, while I was standing in the common room in front of the cabinet with my coat still on. I took out the red pen and wrote them both in. *B. Somogyi, by machine.* My handwriting was getting very good at that phrase.

Then I took out the black pen, which I had not used in the Book since 1996, and uncapped it, and held it over the first empty page at the back for a while. I put the cap back on and returned it to the cabinet.

After that I stopped opening my messages for a week.

I did not decide to do this. I simply found, every morning, that I was not doing it. I taught. I marked. I went to the market. The phone lay face down on the kitchen table in the evenings and buzzed sometimes and I let it. If you have ever not opened a letter from a hospital, you will know what I mean, and if you haven't, I hope you never do.

On the Thursday Bence found me at the coffee machine. He looked as if he had been planning what to say.

"Professor," he said. "The batch is still running on the last one. Number 147." He held his cup with both hands. "I could pull it. If you wanted. I could just take it out of the batch."

I looked at him. He was serious. He would have done it. He would have filled in a form and taken it out and never mentioned it again, and the last problem in the Book would have stayed open as long as I liked.

"No," I said.

He nodded, and I think he was relieved. At the door he turned round and told me he was on page thirty-four, as if I had asked.

That night I scrolled through the photographs I had taken in November, all thirty-one of them, on my phone. Thirty were now red in the real Book. In the photographs they were still black. Only one of them was still black in both.

6

Barta

László Barta wrote entry 147 on a Tuesday in March 1979, in the common room, standing up, because there were not enough chairs. I was not there. I was fifteen and in a school in Zugló, and the most difficult problem in my life was a boy called Gyuri. But I have heard about that afternoon so many times, from so many people, that I could draw you the room.

He was forty-four. He wore a brown suit that did not fit him and a red tie that did not go with it, and he was the vainest man I have ever known about one thing, which was his handwriting. He wrote mathematics the way other men carve wood. Every symbol stood up straight. He wrote 147 in black ink in a single draft without crossing anything out, which is not something you should try at home, and when he had finished he signed it, dated it, and wrote the prize: *a bottle of Tokaji aszú.*

Then, in pencil, in the margin, smaller, he wrote: *Prize also for a counterexample. I will sulk.*

Here is entry 147. I am going to tell it to you in plain words, because Barta always said if you can't tell a problem in plain words, what you have is a mood.

Draw some dots. Join them with lines, any way you like, as long as every dot ends up joined to exactly six others. Now take two pens, red and blue, and colour every dot one or the other. Barta said that however you had drawn your dots, you could always choose the colours so that every single dot had at least two red neighbours and at

least two blue ones. *Two red friends and two blue friends*, he used to say, *for everybody*. Always. There was one exception: a certain small knot of dots and lines that he drew next to the problem in the margin. It looks a little like a hat with a feather in it. He called it the Hat. He had never managed to settle the Hat either way, so he left it out to be safe. If your drawing had a Hat in it, all bets were off. Otherwise, he said, it worked every time.

You can try it. People do. You draw ten dots, twenty, fifty, and it always works, and you feel as if you are close to understanding why. That feeling is the trap. Barta built a very good trap.

I read it for the first time in September 1983, my first month at the university, nineteen years old. Someone had told the new students that there was a cabinet in the common room with a book in it that we were not allowed to touch, and so of course I went to touch it. Barta caught me. He was the keeper by then; he had taken the key from Rácz in 1971, when Rácz's eyes started to go. He came in and found me standing at the open cabinet with the Book in my hands, which was not allowed, reading entry 147 with my lips moving.

He did not shout. He looked over my shoulder at what I was reading and said, "Do you like it?"

I said I didn't understand it.

"Good," he said. "Nobody does. Go and draw some hats."

He was my teacher for the next eight years. He was funny and impatient and mostly right, and he was wrong about football in a way that was almost a philosophy. He believed Ferencváros would win the league every year until the day he died, and took it personally every year they didn't. He would not let you use a word in a proof if a shorter one would do. He made coffee in his office on a little electric ring that was a fire risk, and he would tell you, while it boiled, what was wrong with your work, and it was always something, and it was always correct.

My doctorate, in 1991, was on 147. Not on all of it. Nobody was going to do all of it. I proved that Barta was right for every drawing with fewer than forty dots. It took me three years and it was, at the time, considered very good. Barta read the thesis in one night and came to my office in the morning and put it on my desk and said, "There's a typo on page 61." That was all. There was a typo on page 61. I found out later that he had told everyone in the building about my thesis, and that he had told Fehér about it on the telephone to Toronto, which cost a fortune in those days. He never said a word to me except about the typo.

In 1998 he retired, and on his last afternoon he called me into his office. He had already cleared it. The shelves were bare, and there was a square on the wall where a picture had been, paler than the paint around it. On the empty desk there were two things. One was the key.

The other was a bottle of 1972 Tokaji aszú, six puttonyos, which is as sweet as aszú comes. The label was handwritten in faded ink by somebody's grandfather in Mád. Barta pushed both across the desk towards me.

"The key's for the Book," he said. "The bottle's for whoever closes 147." He looked at me over his glasses. "If it's you," he said, "drink it with me."

I said something. I don't remember what. I would like to say it was something good.

He died in 2011, in October, of his heart.

I have kept that bottle for thirty-one years. It lives in my flat, on the bottom shelf of the bookcase in the hall, behind the six volumes of the Új Magyar Lexikon that my mother bought in instalments in the sixties and never opened. It is quite safe there. Nobody has opened the Lexikon in sixty years.

On the Saturday evening of that week, the week I wasn't reading my messages, I knelt down in the hall and took out the first two volumes and reached in behind them and took out the bottle.

It was dusty. I wiped the dust off with the sleeve of my cardigan. The wine inside was the colour of strong tea held up to a lamp. The handwritten label had faded further since I last looked at it. I couldn't read the grandfather's name any more. I could still read the year.

I sat on the floor in the hall for a while with the bottle in my lap.

Then I put it back, and slid the two volumes in front of it, and pushed them in until their spines were level with the others.

7

Counterexample

I opened my messages again on the Monday. There was nothing about 147. There was nothing on Tuesday or Wednesday or the rest of that week, and on the following Monday, the twelfth of February, at twenty past eleven in the morning, while I was in my office marking first-year calculus, it came.

> Entry 147 (Barta, 1979). Statement false. Counterexample verified. 11,904,227 vertices.

Before I did anything else I opened the link and read the formal statement at the top, the two lines of symbols in which the Seeker had written down what Barta meant. I did not need the Book to check them. I have known entry 147 by heart since I was nineteen. They said exactly what he meant.

Vertices are dots. I read the number twice. Eleven million, nine hundred and four thousand, two hundred and twenty-seven dots, each joined to exactly six others, wired together in some way that a machine had found and another machine had checked, with no Hat anywhere in it. And no matter how you coloured the dots, red and blue, there was always at least one dot somewhere in that enormous drawing that came up short: fewer than two friends of one colour.

You cannot draw it. If you drew one dot every second, without sleeping, it would take you more than four months just to put the dots down. Then you would have to draw the lines. Barta's drawings, the ones that always worked, the ones that made you feel you were

close: they all worked because they were small. The world where his statement failed was a world nobody could ever have walked into with a pencil.

He was wrong. He had been wrong since the Tuesday he wrote it. He had been wrong when he caught me at the cabinet, and when he made coffee on the electric ring, and when he put the bottle on the desk. I had spent three years of my life inside his mistake and never once seen the edge of it. My thesis went as far as thirty-nine dots. The edge was eleven million dots further on, and every drawing on the way there had told him he was right.

I put the marking down. I went upstairs to the common room. There was a student asleep on the sofa with a textbook on his face, and two people from the logic group arguing at the coffee machine about a parking space. I unlocked the cabinet and took out the Book and opened it on the table by the window at entry 147, and took out the red pen.

My hand was steady. I want that on record. It was completely steady.

I wrote: *False. Counterexample: B. Somogyi, by machine.* And the date.

Then I looked at the margin, at the little pencil note, in that upright handwriting he was so vain about. *Prize also for a counterexample. I will sulk.*

I was still standing there when Ákos came in.

I don't know how he knew. Perhaps someone had told him; perhaps the logic people had seen my face; perhaps he simply came in for coffee. It was the first time since the argument about the red ink that he had come near the Book. He came and stood beside me, in the cardigan, and read the red line over my shoulder. He read Barta's pencil note. He read the black ink of the problem, all of it, with his lips pressed together. Then he read the red line again.

"Well," he said. "Laci would have hated that."

And I laughed.

I hadn't meant to. It came up out of me before I could stop it, a real laugh, the kind that hurts. Because he would have. He would have hated it more than anything in the world. Eleven million dots. No Hat. Proved false by a button pressed in November by a boy who hadn't known the Book existed until that week. He would have sulked for a year. He would have written letters. He would have rung Fehér in Toronto at three in the morning to complain.

I laughed until I had to put the pen down. Then I laughed until I had to sit down, and there was no chair near enough, so I went out into the corridor and sat down on the floor with my back against the wall under the noticeboard, and I kept laughing, and somewhere in the middle of it I was crying too, and I could not have told you where one stopped and the other started.

Ákos came out after me. He looked down at me for a moment. Then he lowered himself onto the floor beside me, slowly, in stages, as a big man of sixty-seven gets down onto lino, with one hand on the wall and some noise about his knees. He did not say anything. He did not put his arm around me. He sat there with his legs straight out in front of him in his corduroy trousers and waited.

After a while a first-year student came round the corner with a stack of books, saw the two of us sitting on the floor of the corridor, two old professors, one of them in tears, and stopped.

Then she stepped carefully over Ákos's feet and went on.

8

Payment

I paid on the first Friday in March.

I could have done it sooner. I told myself I was waiting for Bence to come back from a conference in Vienna, which was true, and that I wanted to do it properly, which was also true. I took the bottle out from behind the Lexikon on the Thursday night and wrapped it in a tea towel and put it in my bag, and on the Friday I carried it on the tram with my arms round the bag all the way, like a woman carrying a baby through a crowd.

I had asked them to come to the common room at noon. Zsófi came, with a corkscrew, because she had guessed. Réka came, with her pen behind her ear. Ákos came, and sat in the armchair by the radiator, which is his armchair, though no one has ever said so. Bence came last, out of breath, holding a coffee, and stopped in the doorway when he saw the bottle standing on the table next to the open Book.

"Rule three," I said. "The poser is dead. The keeper pays."

I had written it out, what I was going to say. I had a little paragraph. I did not use it. I picked up the bottle and held it out to him.

He did not take it.

"Professor," he said. "I can't. I didn't do anything. I mean it. I attached a file. I ran a batch. I didn't even read the problems properly until December. I didn't know what the Hat was until Zsófi showed me." He looked at the bottle as if it might go off. "This is your teacher's. I can't take your teacher's wine for running a batch."

I looked at the Book on the table, open at entry 147, with its black ink and its red ink and its pencil.

"The Book doesn't ask what you did," I said. "It asks who closed it. Rule two. I wrote your name in red. It's been there since February. Take the bottle, Bence."

He took it.

He held it the way he had held the walnuts, a little away from his body. Then he looked around for something to open it with, and Zsófi handed him the corkscrew, and he made a terrible job of it. The cork was fifty-seven years old and had opinions. It broke in half. Zsófi took the bottle back from him without a word, worked the rest of the cork out with the tip of a knife, strained it through a clean tea strainer from the kitchen cupboard into a jug, and gave him back the jug, and he stood holding it, a little lost.

"I finished it," he said. "Last week. The machine's proof of my question."

"And?"

He thought about it. "I understand two pages," he said. "The rest I believe."

Then he poured. He did it slowly, so as not to spill, five small glasses on the table by the window. He poured the first one, and then he picked it up and turned around and held it out to me.

I had not thought he would do that. I had thought about many things on the tram, and I had not thought about that.

I took it. I drank it standing, in two swallows. It was very sweet and very old and it tasted of apricots and of something darker underneath, like the inside of a cupboard where good things have been kept for a long time. I did not say anything about Barta. I did not say anything at all. I put the glass down on the table beside the Book.

The others drank theirs. Réka said it was the best thing she had ever tasted and then looked embarrassed. Zsófi asked if there was any more. Bence held his glass and didn't drink it for a long time,

and then he did. Ákos drank his in one go, in the armchair, and held out the glass to be refilled, and when Zsófi refilled it he held it up towards the window, towards nothing in particular, for a moment, and then drank that too.

There was a little left in the jug. Bence asked what we should do with it. Nobody knew. The Book did not specify.

I closed the Book.

I did it carefully, because the spine is old. I put it back in the cabinet, on its shelf, between the coffee machine and the broken radiator, and I closed the glass doors and turned the key. There was nothing to add to it. Every entry was red. There were no more open problems in it, and I did not write one, and nobody in the room asked me to.

I put the key back on my ring.

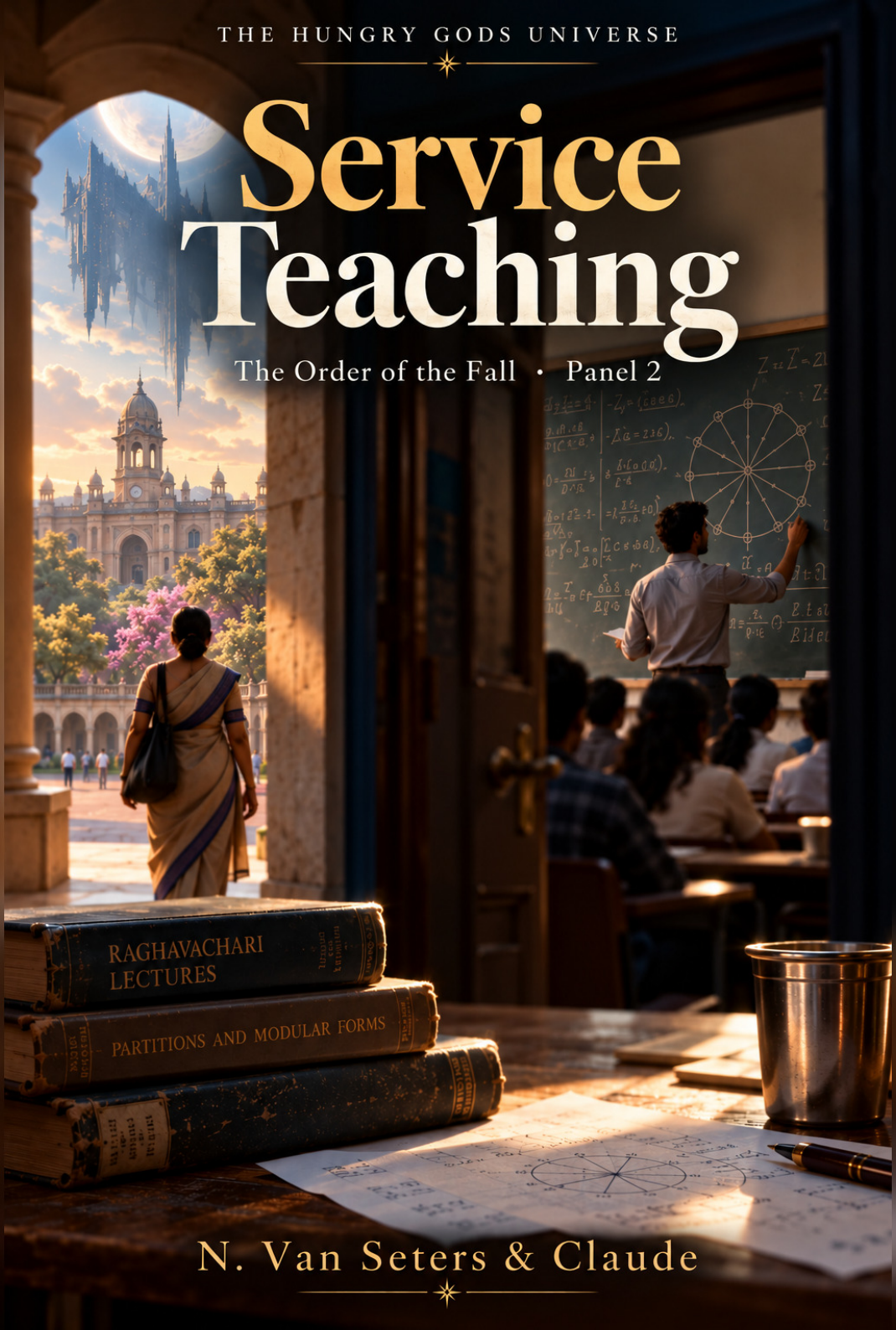
Then I looked at the clock above the door, and it was ten to two, and I had a lecture.

I picked up my bag and my notes and went down the stairs to the big hall on the ground floor, where two hundred first-year engineering students were waiting to find out about integration by parts. The noise of them came up the stairwell to meet me, as it does every week. I pushed the door open with my shoulder, because my hands were full, and walked down to the front, and put my notes on the desk, and picked up the chalk.

THE HUNGRY GODS UNIVERSE

Service Teaching

The Order of the Fall · Panel 2



N. Van Seters & Claude

Verification

Raghavachari's conjecture (1964). Verified. 1,402,776 steps.

Part One

Odd Semester

1

Timetable

DEPARTMENT OF MATHEMATICS
Odd Semester Timetable (Revision 3)
Engineering Mathematics I, all branches. Sections 1 to 38. Enrolment: 3,412.
Section 1. Mon, Wed, Fri, 09:00. Hall 4. Prof. P. Kandukuri.
Section 2. Mon, Wed, Fri, 09:00. Hall 5. Prof. M. Varghese.
Sections 3 to 37: see attached.
Section 38. Tue, Thu, Sat, 16:00. Hall 11. Guest faculty (to be assigned).
Research seminar: no slot allotted.
Sd/- Head of Department

The rain starts at ten to nine, as it does every July, as if someone has been waiting for the students to be halfway across the quadrangle.

Padma Kandukuri gets to Hall 4 with her umbrella dripping and her notes dry inside a plastic folder from the stationery shop by the main gate. The hall holds two hundred and twenty. Today it holds two hundred and twenty and some extra, sitting on the steps, because the boys from Section 3 have heard that Section 1 has the head of department and have come to see whether this means something. It does not. She checks the ceiling. Two of the three fans are working, which is one more than last year.

She writes on the board: *How fast is it changing?*

That is all of first-year calculus, she tells them, and the rest is detail. She draws a curve. She puts a dot on it and asks them how steep

the curve is at the dot, exactly there, not a little to the left and not a little to the right. They look at her as first-years always look at her in the first week, with the polite suspicion of people who have been told this subject is the reason their cousin failed.

By half past nine she has them computing slopes. By twenty to ten a girl in the third row has worked out on her own that the slope of a flat line is zero and has said so out loud, and looks embarrassed, and is pleased. Padma gives her a nod. In this hall a nod from the front is worth more than marks.

At five to ten, with the rain going hard on the windows, a boy at the back puts up his hand.

"Ma'am," he says. "Why should we learn this? The Seeker does it."

Somebody laughs. Not unkindly. It is the question everyone in the hall has been thinking, and he has been brave enough to ask it in week one, which she respects.

Padma puts the chalk down.

"The Seeker will do it," she says. "Faster than you and without mistakes. You will use it every day of your working life. You should." She waits until the laughing stops. "But one day it will give you a perfect answer to a question that is a little different from the question you asked. Because you asked badly, or because the drawing had a mistake in it, or because the bridge is not quite the bridge in the file. On that day you will need to know what the right answer looks like. That is why you are here."

The boy writes something down. She does not know if it is what she said or something else. It does not matter. The bell goes.

. . .

The mathematics department lives on the second and third floors of a block that was built in 1974 and has been painted, since then, in a series of colours chosen by committees. It is currently a pale green that the students call hospital. Padma's office is at the end of the

third-floor corridor, past the photographs of former heads, past the noticeboard, past a framed photograph of S. Raghavachari taken in 1962, in which he is wearing horn-rimmed glasses and looking at the camera as though it has asked him a stupid question.

At the end of the corridor, beside her office, is the research scholars' room. Twelve desks under two tube lights, a water cooler, a whiteboard nobody has wiped since March. Padma did her own doctorate at the desk by the window, between 2006 and 2011, on a problem about prime numbers that the Chaos-Weaver closed eighteen years later in an afternoon. She does not think about this often. She thinks about it whenever she walks past the door.

Today four of the twelve desks are in use. Three project fellows, who are paid from a national grant, and Farhan Qureshi, who is in the fifth year of his doctorate and who is writing a thesis that nobody, including Farhan, is sure how to classify.

He looks up as she passes. She raises a hand. He goes back to his screen.

. . .

At home that evening, in the flat in Tarnaka with the balcony that leaks, Sravya is at the dining table with three practice papers for the engineering entrance exams spread out around her like a hand of cards. She is seventeen. She does practice papers the way other people smoke.

"What do you actually do all day?" she says, without looking up.

Padma, who is heating the dal, considers the question seriously, because Sravya will know if she doesn't.

"I teach two hundred and twenty students calculus three times a week," she says. "I timetable thirty-eight sections. I sit on four committees. I supervise one doctoral student. I argue with the Dean about money. I sign forms that tell other people what to sign." She turns the gas down. "And I try to keep a department alive."

"From what?"

"From being sensible."

Sravya writes an answer, crosses it out, writes another one. "So you teach," she says.

"Mostly."

"Then why does it take so long to say?"

Padma does not have an answer to that. She puts the dal on the table.

After dinner, while Sravya does a fourth paper, Padma takes the printed timetable out of her bag. Revision three. Two guest faculty have dropped out since revision two and a third has asked to move from mornings to evenings because of his other job. She checks every section against the room list. She checks her own name against Section 1, Monday, Wednesday and Friday at nine, Hall 4, and finds it where she put it.

She signs at the bottom. *Sd/- Head of Department.* Tomorrow the attender will pin it to the noticeboard and the students will photograph it with their phones and nobody will read the last line.

2

Deliverables

MINUTES OF THE FINANCE COMMITTEE
Item 7. Renewal of three Project Fellowships, Department of Mathematics, under the National Research Foundation.
The Committee noted that the Foundation's programme in mathematical research has been closed with effect from 1 April, the relevant deliverables now being met under the national licence.
The Head, Department of Mathematics, noted the position.
Resolved: not renewed.

The Finance Committee meets in the Administration Building, in a room with an air conditioner so powerful that the Finance Officer keeps a shawl on the back of his chair for the purpose. There are nine members around a long table with a green baize cloth that has seen better decades. Each member has a bottle of water, a file tied with pink tape, and a steel tumbler of tea that the attender refills without being asked. In the middle of the table there is a plate of Osmania biscuits, which nobody touches until the Registrar does.

Item 7 comes up at twenty past twelve.

The Finance Officer introduces it. He is a careful, courteous man who has never been unkind to Padma in eleven years, and who believes, sincerely, that a university is a set of obligations that must be met within a set of limits. He explains that the National Research Foundation has closed its mathematics programme. He explains that the three fellowships were funded under that programme. He

explains that the deliverables of the programme are now met under the national licence, which the university pays for through a separate line, and that the university therefore cannot continue to fund the same deliverables twice.

Padma counts the word *deliverables*. By the end of his introduction it has appeared five times.

"Madam," says the Chairman, who is the Pro-Vice-Chancellor. "Your views."

She has prepared her views in numbers, because numbers are the only language this room has agreed to speak.

"The three fellowships cost the university four lakhs a year each in matching funds," she says. "Twelve lakhs. The three fellows teach eleven sections of Engineering Mathematics between them, free, as part of their training. If we replace those sections with guest faculty at the current rate, it will cost the university fourteen lakhs a year." She lets that sit. "Not renewing them costs two lakhs more than renewing them."

A lakh is a hundred thousand rupees. Two lakhs is roughly what the air conditioner in this room costs to run for a year, which Padma has also worked out, and does not say.

There is a pause. The Finance Officer writes something in his file.

"Madam," he says, kindly, "the teaching is a separate line."

"It is the same students."

"It is a separate line."

"The deliverable," Padma says, "is three people who know how to think about mathematics, in a building where three thousand four hundred people are learning it."

The word lands on the table between the water bottles. The Finance Officer looks at it as though she has picked up something that belongs to him. By the end of the meeting he will have used it six more times, which makes eleven.

The Chairman thanks her for her views. The Committee moves on. Item 8 is the electricity bill for the hostels.

When the minutes arrive a week later, they record that the Head, Department of Mathematics, noted the position.

She reads this twice in her office with the door closed. She did not note the position. She opposed it, in numbers, for six minutes. But minutes record what the university has decided happened, and the university has decided that she noted it. She files them in the folder marked *Finance* and goes to teach Section 1 about the chain rule.

. . .

The fellows leave at the end of August.

There is no ceremony. That is not how fellowships end. They end with a form, and a final salary credit, and three people packing their books into cardboard boxes from the canteen. Padma helps carry the boxes down the stairs. One of the fellows, a quiet man from Nizamabad who has been working for two years on a question the Chaos-Weaver answered for him in his first month, stops on the landing.

"Ma'am," he says. "I have taken six sections of guest teaching. Engineering Mathematics. Evenings." He shifts the box onto his other hip. "Does that count as staying?"

Padma thinks about lying to him, and doesn't.

"It counts as teaching," she says. "I don't know what staying is any more."

He nods as if this is a reasonable answer, and perhaps it is, and goes down the stairs.

When she comes back up, the scholars' room has changed. Nothing has moved except the three people and their boxes, but a room with four people in it and a room with one person in it are different

rooms. Eleven desks sit under the tube lights with nothing on them but dust and the rings left by tea glasses.

At the twelfth, Farhan is still working. He has his headphones on. He does not look up. She stands in the doorway for a moment and then goes back to her office, because she has a meeting at three about the timetable for the mid-semester exams, and because there is nothing in that room she could tell him that he does not already know.

3

Two Per Cent

In September Farhan gives her his third chapter.

He gives it to her printed, because she asked him to, because she reads better on paper, and because the department still has a printer that works if you hit it twice on the left side. Forty-one pages, spiral bound. She takes it to his desk to read it there, beside him, which she has done with every chapter. It is how her own supervisor read her chapters, sitting in the scholars' room with a red pen and a cup of tea, making small noises.

The chapter is about partitions.

A partition, Farhan has written on the first page, in the plainest sentence she has seen in a thesis in twenty years, is a way of breaking a whole number into smaller whole numbers. You can break 4 into 4. Or 3 + 1. Or 2 + 2. Or 2 + 1 + 1. Or 1 + 1 + 1 + 1. That is five ways. So the number of partitions of 4 is five.

The numbers grow quickly. The number 10 can be broken in 42 ways. The number 100 in nearly two hundred million.

More than a hundred years ago Ramanujan noticed something odd about these counts. If you start at 4 and jump five at a time, 4, 9, 14, 19, the number of partitions is always divisible by five. Start at 5 and jump seven at a time, and the counts are always divisible by seven. Start at 6 and jump eleven, and the counts are always divisible by eleven. Nobody had told the numbers to do this. They just did. Mathematicians spent the next century explaining why.

In 1964 S. Raghavachari, the man with the horn-rimmed glasses in the corridor photograph, said there was a further pattern hiding inside those three, a stranger and more tangled one, and he described it in four lines. He spent thirty years trying to prove it and died in 1994 without doing so. In 2031 the Chaos-Weaver proved it in a single run. The Seeker checked it. The checked proof is one million, four hundred and two thousand, seven hundred and seventy-six steps long, and every one of them is right.

Farhan's thesis does not add anything to the proof. The proof does not need anything added. What Farhan has done, over five years, is pick one stretch of it, the part where the eleven pattern comes back inside Raghavachari's tangle, and rebuild it by hand until it can be said in chalk.

It is about two per cent of the proof. He calls it two per cent on his title page, in the subtitle, as if it is a measurement, which it is.

His method is in the chapter's introduction, and it is very simple and very slow. He starts from the Seeker's summary, which tells him what the proof is doing in each section. Then he takes one step the summary describes and asks why it works, and he does not let himself move on until he can answer in a sentence that a good final-year student would follow. Sometimes this takes a day. Sometimes it takes a month. There is a step on page twenty-three that took him all of last winter.

Padma reads the chapter in order, with her pen. She finds two typos and one place where his English goes formal and stiff, as it does when he is unsure of himself. She marks them. Then she turns to page twenty-three.

She reads it once and follows it. She reads it again and sees it.

There is no other word. The eleven pattern does not come back by accident. It comes back because Raghavachari's tangle, if you look at it from the right side, is folding the counts in a way that only eleven can survive. Farhan has found the right side to look from and

has drawn it, in a small diagram, a sort of wheel with eleven spokes. Padma looks at the wheel and understands, in a single movement, why a dead man in horn-rimmed glasses was right.

She reads the page a third time, for the pleasure of it. Then she looks up at the clock above the whiteboard and finds that it is a quarter to six and the light outside the window has gone orange, and that an hour has passed that she did not notice, and that Farhan has finished his tea and is watching her.

"Page twenty-three," he says.

"Page twenty-three."

He nods. He does not smile, quite.

"Could the Seeker have drawn it?" she asks. "If you'd asked."

He thinks about it. "Probably. If I'd asked it the right way, it would have drawn something like it." He looks at the wheel. "So I never asked. Then I'd have had the wheel without the way there."

He puts his headphones back on.

She asks him on her way out if he can come in on Sunday to go over the comments. He says no, sorry, Sundays he works at his mother's shop near Laad Bazaar, bangles, it is the busy day, his mother's knees are bad. He says it as a fact about his week. She says Monday, then. He says Monday.

. . .

That night, at her own desk at home, after Sravya has gone to bed, Padma has her teaching notes for the next day open in front of her. Tomorrow is Section 1 and the derivative of a product, which she has taught nineteen times and could teach asleep. Beside the notes, she has page twenty-three, which she photocopied on the department machine before she left, hitting it twice on the left side.

She looks at the wheel with eleven spokes until the lights in the flats across the road start going out.

4

Mid-Semester

The mid-semester examination for Engineering Mathematics I is held on paper, in the big examination hall behind the library, in four shifts across two days. Three thousand four hundred and twelve students. Eight hundred and fifty-three at a time, give or take the ones who are ill, the ones who have the wrong day, and the one every year who has the wrong university.

It is held on paper because the university decided, eight years ago, that an examination which could be sat with the Seeker at your elbow was not an examination of anything except your Seeker. So there are no devices in the hall. Phones go into numbered cloth bags at the door. The students sit at long wooden benches in rows of ten, with their hall tickets and their pens, and do calculus with their own hands for two hours, and some of them are visibly frightened by the silence.

Padma and Varghese invigilate the second shift together, walking the aisles in opposite directions and meeting in the middle every ten minutes like two very slow trains.

"My dear," says Varghese, as they pass at the twentieth minute, in the low voice of a man who has been invigilating for thirty-one years. "Do you know what I will miss most when I retire?"

"The salary."

"This." He nods at the hall. "Eight hundred children thinking at once. You can hear it, if you stand still. Like rain on a tin roof." He moves on before she can answer.

The scripts, when the shifts are finished, will go to the marking centre, where they will be scanned and marked by machine against a scheme the department writes. The staff will then moderate: they will pull one script in twenty and check the machine's marks by hand. In eight years of this Padma has disagreed with the machine's marks four times, and in all four cases she was wrong.

"So why do they still pay us?" she says, at the fortieth minute.

Varghese considers this as he passes.

"To watch the hall," he says. "It is the one thing the machine cannot do. The machine is not in the hall."

. . .

At the sixtieth minute she stops at the end of a row near the back, because a boy has put his pen down and is staring at the ceiling, and she has learned to tell the difference between a student who has finished and a student who has frozen. He has frozen. Question four, the one about the ladder sliding down the wall. She does not help him. She is not allowed to help him. She stands at the end of his row for a while, so that he knows somebody is there, and after a minute he picks the pen up again.

Her father used to do that, she thinks.

He was a conductor on the state buses, the Hanamkonda to Kazipet route, for twenty-six years. He would stand at the front of the bus with his ticket machine and his leather bag of coins and make change without looking, his fingers counting in the bag while his eyes watched the road, and he never once got it wrong. When she was eight she rode with him for a whole day in the summer holidays, sitting on the bench behind the driver, and somewhere between Kazipet and the turn for the station she worked out, from watching the fares and the coins, what each passenger would get back before her father's hand came out of the bag. She said the numbers under her breath. By the afternoon she was faster than he was.

She told him so on the way home, very pleased with herself. He looked at her for a long moment, in the dusk, with the bus empty and the bag heavy on his hip, and said, *Then you will go to college.*

She did. Nobody in her family had. What got her there was the moment, on a bus, when she found out that she could see a number before it arrived.

Her phone buzzes in her pocket, which is against the rules for invigilators too, but the rules for invigilators have never been enforced. A message from Sravya: her score on the national mock test. Padma reads it standing at the end of the row. It is good. It is not good enough for the college Sravya wants. There are four months to the real thing.

She puts the phone away without replying, because there is nothing to say that will not be heard as either too much or too little, and walks on up the aisle. Four hundred heads in her half of the hall are bent over four hundred question papers. The fans turn. She can hear it, if she stands still.

5

Posts

OFFICE OF THE VICE-CHANCELLOR
Note for the Budget Meeting, 13 November
Posts falling vacant on superannuation in the coming financial year shall, in departments where the student load is principally service teaching, be surrendered and replaced by guest faculty.
Department of Mathematics: two posts (Prof. M. Varghese; Prof. S. Krishnamurthy).
It is further proposed that the Department be renamed the Centre for Mathematical Service Teaching, to reflect its present function.

The Vice-Chancellor's budget meeting is held in the Vice-Chancellor's own conference room, which has portraits of the previous eleven Vice-Chancellors on the walls and a window that looks out over the university lake, where a man in a small boat is pulling water hyacinth out by hand, as a man in a small boat has been doing every November for as long as Padma has been here.

The Dean of Sciences, Professor Venkataraman, presents the item about mathematics.

He is not a villain. Padma has known him for twenty years. He was a good chemist once, before the Chaos-Weaver and its relatives turned most of chemistry into a matter of ordering the right molecules from the right supplier. He has a daughter who is a doctor in Leeds and a mother who lives with him and is losing her memory, and he has been asked to find eleven crore of savings, a hundred

and ten million rupees, across six departments by March. He is solving a budget. He presents the item in a reasonable voice with a reasonable chart.

The chart shows that ninety-four per cent of the department's teaching hours are now first-year engineering mathematics. It shows that the department has published four research papers in the last three years, all of them expositions of machine proofs. It shows the cost of a professor and the cost of a guest lecturer. The difference is large.

"We are not closing anything," the Dean says. "We are recognising what the department already is. And we are giving it a name that tells the truth."

He clicks to the next slide. *Centre for Mathematical Service Teaching.* It is in a modern typeface. Somebody has designed a small logo, a pi symbol inside a gear.

Padma has three minutes. She uses two of them on the name.

She does not argue about the posts. She knows the posts are gone; she knew it when she read the note. The arithmetic is too clear and the people in this room have been taught, over ten years, to trust arithmetic above everything else, which she cannot complain about, since she is one of the people who taught them. So she does not argue with the arithmetic. She argues about the name.

"A department of mathematics," she says, "teaches mathematics. Whatever else it does, and whoever it does it for. The engineers we teach will go out into a world where the machines do the calculations. The one thing we can give them is the knowledge that mathematics is a subject in its own right, with its own reasons. If we change the name on the door, the first thing every one of those students will learn, before we have taught them anything, is that it doesn't."

She stops. She has a minute left. She doesn't use it.

The Vice-Chancellor, who is an economist and a fair man and very tired, looks at the Dean. The Dean looks at his slide. There is a short discussion about whether the cost of new signboards and letterheads has been included in the projected savings. It has not. The cost of the signboards turns out to be larger than anyone expected, because the department's name appears on forty-one different documents and three gates.

The name stays.

The posts go. Both of them. The minute will say that the meeting approved the surrender of two posts in the Department of Mathematics on superannuation, and that the proposal to rename the department was deferred. Deferred is the word the university uses for a battle it has decided to fight again later, when it has more money for signboards.

. . .

On the stairs afterwards, going down, Varghese is a step ahead of her, holding the rail, because his knee is bad in cold weather and the Vice-Chancellor's air conditioning is the coldest weather in Hyderabad.

"Well," he says. "You saved the name."

"I saved the name."

"My dear, they've kept the sign and taken the shop." He reaches the landing and turns, and smiles at her, because he is Varghese and has never once said a kind thing he didn't mean. "I'm glad it was you who did it. It would have broken my heart to hear the Dean say it."

She walks him to his scooter. She walks back across the quadrangle to the mathematics block in the late sun.

It is Friday, and the attender is on his Friday round, which is a round he has made every Friday for twenty-two years and which nobody has ever asked him to make. He is standing at the door of the department on the third floor with a tin of brass polish and a

cloth, polishing the nameplate. DEPARTMENT OF MATHEMATICS, in capitals, in brass gone soft at the edges from all the Fridays.

He nods to her. She nods back. He goes on polishing.

Part Two

Even Semester

6

Submission

Farhan submits on the second Monday in January.

The thesis is bound at the shop by the main gate, the one with the faded sign that says THESIS BINDING · WEDDING ALBUMS · LAMINATION, which binds all three on the same machine with the same black cloth and the same gold lettering. Farhan collects six copies on the Saturday. He brings them up to the third floor in a cardboard box that once held a ceiling fan, and puts the box on Padma's desk, and stands back from it.

She takes one out. *On the Eleven-Fold Return in the Machine Proof of Raghavachari's Conjecture: An Exposition of Two Per Cent.* One hundred and eighty pages. The gold lettering on the spine is slightly crooked, as it is on every thesis that has ever come out of that shop, including hers.

"It's done," Farhan says.

"It's submitted," Padma says. "Done is a different form."

He almost laughs.

She turns the thesis over in her hands. "Whatever happens to the department," she says, "you've kept something alive in this building. I want you to know that."

Farhan shakes his head, politely, as he does when he corrects one of her typos.

"Ma'am, I didn't do it for the building," he says. "I wanted to know why it was eleven. Since I was nineteen and read about Ramanujan on the bus. Why eleven and not some other number." He looks at

the box. “Now I know. If the department closes tomorrow, I still know.”

Padma does not argue. She puts the thesis back in the box with the others and closes the flaps.

. . .

The different form turns out to be the similarity check.

Every thesis is run through the university’s plagiarism software before it can be sent to examiners. It compares the text against everything ever written and reports what percentage of it has been written before. The limit is ten per cent. Farhan’s thesis comes back at thirty-eight.

The clerk in the Research Section, a young woman with a very neat desk and a framed photograph of a temple on it, explains that the software has matched long passages of the thesis to the Seeker’s published summary of the proof, and has matched the quoted steps of the proof to the proof itself, which is public. She explains that thirty-eight is more than ten.

“He is quoting the proof,” Padma says. “That is what the thesis is about. You can’t explain something without showing it.”

“Madam, I understand,” says the clerk, who does. “The software does not understand. Kindly submit a statement of exclusion, signed by the supervisor and countersigned by the Head of Department, listing the excluded passages, in triplicate.”

“I am the supervisor and the Head of Department.”

“Then Madam can sign both.”

Padma signs both. Three times. The software, once the quoted passages are excluded, reports that Farhan’s own sentences are two per cent similar to anything ever written, which is about the same as a love letter.

. . .

The national entrance examination for engineering, January session, is held at exam centres all over the city at nine in the morning, and students are told to report by seven-thirty. Sravya's centre is a private engineering college off the outer ring road, forty minutes away if the traffic is kind. Padma drives her there at twenty to seven, in the dark, with Sravya in the passenger seat reading formulas off her phone and saying them under her breath.

At the gate there are two hundred parents and a security guard. The students go in. The parents stay outside. This is the rule. Padma has known it for months and is still, somehow, not prepared for the moment when her daughter's back goes through the gate with the others, without turning round, and is gone.

She waits for three hours on the pavement with the other parents. Somebody's father has brought a flask of tea and shares it. A mother near her has brought a cushion. There is a woman selling peanuts in paper cones who has clearly done this before. Nobody talks about the exam. They talk about traffic, and the price of tomatoes, and whose child wants to do which branch, and Padma, who has spent her whole working life inside an examination system, stands outside one for the first time and finds that the outside is much worse.

At twelve-fifteen Sravya comes out. She says it was fine. She says question eleven was a trick. Padma does not ask about question eleven.

. . .

The following Monday the thesis goes in the post. The Research Section sends it by registered post with acknowledgement due, in two padded envelopes, because the regulations were written in 1988 and say registered post and have never been changed. One copy to Professor Lalitha Subramanian, at the institute in Bengaluru. One to Professor Anirban Ghosh, in Kolkata.

Padma watches the clerk weigh the envelopes on the brass scale and stick on the stamps, two hundred and twelve rupees each, and write the addresses in a careful hand. Then the clerk puts them in the out tray, and the out tray goes to the post room, and the post room goes to the post office, and for the next ten weeks there is nothing anybody in the building can do except teach.

7

Council

ACADEMIC COUNCIL
Resolution on Item 14
Resolved that admissions to the Doctor of Philosophy programme in Mathematics be discontinued with effect from the next academic session, the research functions of the programme being now met under the national licence.
Scholars already registered may complete their programmes under the regulations in force.
The Board of Research Studies in Mathematics shall stand dissolved on the issue of the University's notification.

The Academic Council meets twice a year in the old Senate hall, which was built in 1938 for a smaller university and a cooler climate. It has a high ceiling, a wooden gallery nobody is allowed into, portraits of founders in oils that are slowly turning brown, and twenty ceiling fans on long rods, which in March all run at full speed and still do not keep ninety people cool. Members fan themselves with their agenda papers. The agenda this time is sixty-two pages long. Item 14 is on page forty.

Padma has read it many times. It is a single paragraph. It has the reasonable tone of the Dean's slides and the Finance Officer's minutes, because it was written by the same people from the same arithmetic. The department has one registered doctoral scholar. It has had no new admissions for two years because nobody has ap-

plied. The national foundation no longer funds the subject. The research functions of the programme are now met under the national licence. All of this is true.

The Vice-Chancellor reaches Item 14 at four in the afternoon. Speakers are allowed three minutes. Padma is the only one who has asked to speak against.

She stands up without notes. She has thought about notes and decided that notes would make her sound like a committee, and this is the only room in the university where a committee has to listen to a person.

"I did my doctorate in this university," she says. "So did four of the people in this room. I sat at a desk on the third floor of the mathematics block for five years and was paid a fellowship to think about one question. I didn't answer it. A machine answered it later, in an afternoon. I am not here to tell you that my five years were wasted, or that they weren't. I'm here to tell you what they were for. They were for learning how to sit with a question until I understood it. That is a skill. It is the only skill the machines haven't made cheap, because it can't be done for you. You have to be the one who sits."

She looks around the hall. People are fanning themselves. Some of them are listening.

"If we close the doctorate," she says, "there will be no place in this university where a person is paid to do that. Not in mathematics. Not anywhere. We will have a building full of people who know how to ask the Seeker, and not one who knows how to sit. I'm asking you to keep one desk open. One. It costs less than the fans."

She sits down. The timekeeper, a lecturer from Statistics with a stopwatch, tells her afterwards that she spoke for two minutes and fifty seconds.

The Vice-Chancellor thanks her. The Dean replies, briefly and courteously, with the arithmetic. The Vice-Chancellor calls for a show of hands.

Padma counts. It is a habit she cannot break. She counts the hands for the resolution as they go up, row by row, the way her father counted coins in the bag, without looking straight at them. Forty-eight. Then the hands against. Thirty-nine. Then the abstentions, who are mostly people who were checking their phones when the vote was called.

Forty-eight to thirty-nine. She has lost by nine.

On the steps of the Senate hall, in the heat, the Dean falls into step beside her. They go down together without speaking for a while. At the bottom he stops.

"Someone forwarded me your student's page twenty-three," he says. "The wheel. I read it last night." He looks out at the quadrangle, where the sprinklers have come on. "I didn't understand it. I sat up until one o'clock wanting to." He shakes his head. "I'd vote the same way tomorrow. I thought you should know that too."

He goes off towards the Administration Building. Padma watches him go.

. . .

After the meeting she does not go back to her office. She goes to the scholars' room.

It is half past five. Farhan has gone home. The tube lights are off and the room is lit only by the March sun coming low through the window, laying a long orange stripe across the floor and up the side of the desk by the window, which was her desk.

She sits at it. Nobody has used it since 2011. There is a ring on the surface from a tea glass that might be hers, though it probably isn't. The attender brings tea without being asked, because he has seen her go in, and puts it on the desk and goes away without saying anything.

She drinks the tea. She does not think about anything in particular. She watches the orange stripe move up the wall. When the tea is

finished she gets up, rinses the glass at the cooler, puts it upside down on the tray, and goes home.

On the drive, at the long red light at the junction by the railway station, she counts the hands again in her head, row by row, as she saw them go up. Forty-eight. Thirty-nine. She gets the same number. She always does.

8

Reports

The examiners' reports arrive in April, a day apart, both by registered post with acknowledgement due, in the same padded envelopes, as if they had been sent from the same office.

Professor Subramanian's comes first. It is four pages long and recommends the award of the degree without corrections. It says that the candidate has produced the clearest account of a machine-generated argument that the examiner has read, and that the diagram of the eleven-spoked wheel on page twenty-three of the third chapter should be taught to every final-year student in the country. It says, in its last paragraph, that the candidate has done a thing the examiner had begun to think nobody would do again, which is to understand something completely.

Padma reads it at her desk and has to put it down for a moment.

Professor Ghosh's comes the next day. It is two pages long. It is courteous and exact, and it recommends that the degree not be awarded.

It says that the thesis is admirably written. It says that the candidate's grasp of the material is not in doubt. And it says that a doctorate is awarded for a contribution to knowledge, and that this thesis contributes nothing to what is known about Raghavachari's conjecture, all of which was known before the candidate began. *The thesis adds to what is understood*, Professor Ghosh writes. *It does not add to what is known. The degree regulations of every university I have examined for, including yours, require the second. I cannot in*

conscience recommend the award of a doctorate for a commentary, however fine.

Padma reads that twice too.

He is right, as far as the regulations go. That is the problem with it. She has known Anirban Ghosh by reputation for twenty-five years; he has examined theses all over India and is famous for reading every line and for never once changing his mind after a viva. He is applying the regulations as they are written, and the regulations were written for a world in which knowing and understanding arrived together, in the same person, and the person was usually exhausted.

. . .

The regulations for the case of disagreement are in Ordinance 14, clause 9, which she looks up on the university website and then, because she does not trust the website, in the printed book of ordinances on the shelf behind her desk, which is bound in red and was last reprinted in 2012.

> *Where the reports of the examiners differ in their recommendations, the Chairman of the Board of Research Studies shall either decide the result on the reports or refer the thesis to a third examiner. The decision of the Chairman shall be final, and shall be given effect by the Research Section without further reference.*

She is the Chairman of the Board of Research Studies in Mathematics.

The clause was written for examiners who disagree about corrections: a missing reference, a weak chapter, a proof with a gap in it. Nobody who drafted it imagined two examiners disagreeing about what a doctorate is.

A third examiner would take three months at least: appointment, consent, posting, reading, report. The Academic Council's resolution says that the Board stands dissolved on the issue of the university's notification. The notification is drafted. It will be issued in May. When the Board dissolves, its Chairman dissolves with it, and the thesis will go wherever theses go when there is no Board to send them anywhere. Somebody in the Research Section will know. Padma does not want to find out.

So there is no third examiner. There is her.

Forty-eight to thirty-nine. Here there is no show of hands.

. . .

At home Sravya is waiting for her own results, which will come out in eleven days, and is in the state of a person waiting for results: irritable, restless, unable to sit through anything longer than a song. She comes and reads over her mother's shoulder at the dining table without asking, as she has done since she could read, and Padma lets her.

She reads Professor Subramanian's report. Then Professor Ghosh's. She reads them faster than Padma did and stands back.

"Which one's right?" she says.

Padma doesn't answer.

"Amma. Which one?"

"Both of them," Padma says, which is true and is not an answer, and Sravya knows it, and goes to her room and shuts the door hard enough to make the point.

. . .

At breakfast Sravya is waiting with an argument, worked out overnight like a practice paper.

"I don't think he should get it," she says. "Your student."

Padma pours the tea.

"The Seeker knows the whole proof. All of it. He knows two per cent. Fine, it was a lot of work. But you don't give somebody a doctorate for reading a book very carefully." Sravya butters her toast with more force than toast needs. "The Kolkata one is right. You just like Farhan."

"I do like Farhan."

"So?"

Padma thinks about it. "So that's a fair question," she says.

Sravya was ready for an argument and doesn't know what to do with this. She tries another angle. "And I'm not doing engineering because I love it, Amma. I know you want me to love it. I'm doing it because people who do it get jobs. I'm not going to sit at a desk for five years to understand two per cent of something. I'll use the Seeker like everybody else and I'll be good at it and I'll get paid." She looks at her mother, daring her. "That's not a bad life."

"No," Padma says. "It isn't."

Sravya waits for the rest. There isn't any. After a while she takes her plate to the sink, and at the kitchen door she turns round.

"You still haven't said which one's right."

"I know," Padma says.

An hour later, at her desk, Padma does the one thing the ordinance allows that is not a decision. She schedules the open defence.

Every doctoral candidate in the university must defend the thesis in public before the result is declared, in front of at least one examiner, in a room that anyone may enter. It is usually a formality. Whatever is said in the room, the written reports remain the examiners' recommendations. She books the department seminar room for the third Thursday in May, at eleven. She writes to both examiners. She writes to Farhan. She asks the attender to put a notice on the board.

She does not write anything on the result sheet. The result sheet stays in the file, blank, under both reports.

9

Defence

The seminar room holds forty. On the third Thursday in May, at eleven in the morning, with the temperature outside at forty-four degrees and the air conditioner doing its best, there are twenty-one people in it.

Padma counts them, because she counts things. Varghese, in his last month before retirement. Four other members of staff. Two of the former project fellows, who now teach evening sections and have come in on their day off. Three final-year undergraduates who have heard that the thesis has a wheel in it. A man from the Research Section with the attendance register. Professor Ghosh, who arrived from Kolkata on the overnight train and has been drinking the department's tea since nine without complaint. Professor Subramanian on the screen at the front, in an office in Bengaluru with bookshelves behind her and a cat that walks past twice. A first-year engineering student from Section 22, who appears to have come into the wrong room and has decided to stay because it is cool.

And in the front row, in a green salwar kameez, with a steel tiffin carrier on her lap, Ruksana Begum.

Padma goes and sits beside her before it begins. She has not met Farhan's mother before. Ruksana shakes her hand firmly and says that Farhan has told her about Madam, that Madam reads his chapters at his desk, that nobody ever read his schoolwork at his desk, she was always working.

"I worked nights for six years when he was small," she says. "In an office in HITEC City. Checking pictures, for a company. He used to do his homework on the bus, coming to meet me at the end of my shift." She pats the tiffin carrier. "Biryani. For after. He won't eat before."

. . .

Farhan stands at the whiteboard in a shirt that has been ironed by someone who irons well. He is visibly terrified for about four minutes. Then he picks up a marker and starts to explain, and the terror goes, because he is explaining something he understands, and that is the one situation in which Farhan Qureshi has never been frightened in his life.

He does partitions first, for the room, with the 4 = 3 + 1 example. Then Ramanujan's jumps of five and seven and eleven. Then Raghavachari's four lines. Then the machine's nearly a million and a half steps, which he does not try to show; he holds up one page of them, printed small, and says this is page one of about thirty thousand. Then he puts the eleven-spoked wheel on the board, slowly, spoke by spoke, and shows the room how Raghavachari's tangle folds the counts, and why only eleven survives the folding.

At the end, when the wheel is finished, Padma watches the first-year student from Section 22. The boy has been sitting at the back with his arms folded and his phone face down on the desk. He is leaning forward. His lips are moving. He is counting the spokes.

He has followed it.

. . .

Professor Subramanian asks three questions, all of them generous, all of them hard, and Farhan answers all of them. Then the chair, which is Padma, invites Professor Ghosh.

Ghosh stands. He is a small, neat man in a cream kurta, and he speaks without notes, in the soft Bengali-English of a man who has been asking candidates difficult questions for forty years and does not need to raise his voice to do it.

"Mr Qureshi," he says. "This is a beautiful piece of work. I have said so in writing and I say it again here. I have one question, and it is the only question I have." He pauses. "What did you find that the machine did not know?"

The room goes quiet. The air conditioner hums.

Farhan looks at the wheel on the board. Then at Ghosh.

"Nothing, sir," he says. "It knew all of it." He puts the marker down on the ledge. "Now I know two per cent."

Ghosh looks at him for a long moment. Then he nods, once, the way a man nods at an answer that is correct and does not change anything, and sits down.

. . .

The defence ends at twenty to one. Ghosh does not change his report. He says so to Padma afterwards in the corridor, with his bag already on his shoulder, under the photograph of Raghavachari.

"I'm sorry," he says. "I don't think I will ever examine a better thesis."

"Then tell me what a thesis is supposed to be," Padma says. "Now. When the machine knows all of it."

Ghosh looks up at Raghavachari in his horn-rimmed glasses for a long moment, as if the question might be his.

"I don't know," he says. "That is why I can't sign it."

He has a train at two.

Before he goes he walks back into the seminar room, where people are standing in small groups and the tiffin carrier has been opened on the front desk and the smell of biryani has reached the corridor. He goes to Farhan and shakes his hand, and says some-

thing to him that Padma cannot hear. Then he shakes Ruksana's hand too. Then he goes to catch his train.

Padma stays until the room is nearly empty. Varghese has taken a second helping. The first-year from Section 22 has taken a photograph of the whiteboard on his phone. Farhan is carrying chairs back into rows.

In the front row, Ruksana is folding the printed programme, the single sheet with the title and the time and the names of the examiners, into neat quarters, and putting it in her handbag, in the inside pocket, where she keeps the things she means to keep.

10

Signature

UNIVERSITY NOTIFICATION
No. Acad./PhD/2/Math
In pursuance of the resolution of the Academic Council on Item 14, it is hereby notified that admissions to the Doctor of Philosophy programme in Mathematics stand discontinued with effect from the next academic session.
The Board of Research Studies in Mathematics stands dissolved with effect from the date of this notification.
Dated this Tuesday, the 25th of May.
Sd/- Registrar

The defence is on Thursday the 20th. Padma signs on Friday the 21st.

She comes in at a quarter past eight, before anybody else is in the building except the attender, who is sweeping the corridor and nods to her. She shuts her office door. The result sheet has been in a file on her desk for five weeks, under both reports. She has read the reports eleven more times. She has not slept well.

She reads the ordinance once more. She reads Ghosh once more. *It does not add to what is known.* She reads Subramanian. *Understand something completely.* She thinks about the first-year from Section 22, counting spokes with his lips moving.

Then she thinks about a thesis she examined in 2030, early in her time as an associate professor, from a university in Pune. It was a

long, lucid explanation of a machine proof in graph theory, the first of its kind she had been sent, and she failed it. She wrote that it was a fine piece of exposition and not a contribution to knowledge. She believed it. The carbon of her report is still in a file at home. She never found out what became of the candidate.

She asks herself whether she would sign this one if Farhan were somebody else's student. If she had never sat at his desk with a red pen. If she had not lost an hour of a September afternoon to page twenty-three. She tries the question several ways and cannot get an answer she trusts, because the person asking it is the person who read his chapters.

It is possible that Ghosh is right. It is possible that she is about to change what a doctorate means in this university, alone, on one of the last mornings she has the authority to do it, for a student she is fond of. She holds that possibility for as long as it takes the attender to finish sweeping the corridor outside her door.

Then she writes, in the box marked *Decision of the Chairman, Board of Research Studies*: *Recommended for the award of the degree.* Her name, and the date, and *Sd/-*, which is what the university types in place of a signature on every copy that is not the original. She puts it on the original too, out of habit, and has to initial the mistake.

She does not say anything. There is nobody to say it to. She puts the sheet in the out tray. At ten the attender takes it to the Research Section with the rest of the morning's files, and by eleven it has been entered in the register, in the clerk's careful hand, under the framed photograph of the temple.

. . .

On the Tuesday the brown envelope comes up the stairs with the internal mail, with the department's name typed on the front. Padma reads the notification at her desk. Then she reads the last

line again, about the Board, and turns the page over in case there is anything on the back. There isn't.

It says *with effect from the date of this notification*. By the date of this notification the decision has been in a register in another building for four days. The Board that made it was her, and it is now dissolved, which is also her.

She files the notification in the folder marked *Academic Council*. It goes in behind the resolution.

. . .

On the Friday, Padma takes the key to the research scholars' room down to the estates office on the ground floor of the Administration Building.

The estates officer has a form for this. Of course he does. It has a box for the room number and a box for the reason for surrender and a box for the proposed new use. Under *proposed new use*, someone has already typed: *Storage of examination scripts (Engineering Mathematics I and II)*.

She signs it. She gives him the key, which is on a ring with a cardboard label that says SCHOLARS in her own handwriting from 2016, when she was the one who had to have it cut. He hangs it on a board on the wall with two hundred other keys. Then he thanks her and offers her tea, and she says no, and walks back across the quadrangle in the heat.

. . .

The new academic year begins in July, in the rain.

On the first Monday, at five to nine, Padma comes along the ground-floor corridor of the engineering block with her umbrella dripping and her notes inside a plastic folder from the stationery shop. Her term as head ended in June. A man from Statistics is acting head, because there was nobody in mathematics who wanted it,

and the timetable he has issued puts her, as usual, in Hall 4, Section 1, Monday, Wednesday and Friday at nine. The enrolment is up again. Three thousand six hundred and five. Sravya is not one of them. She missed the college she wanted by four hundred places and is at a private engineering college in Chennai, studying computer science, and phones on Sundays.

The doors of the lecture halls are open along the corridor, because of the heat before the rain. In Hall 9, as Padma passes, there is a young man at the front of Section 37 in an ironed shirt, with his back to the room, writing on the board.

He is writing the derivative of a constant. The room is full, two hundred and twenty and some on the steps. Somebody near the front asks him a question, and he turns round, and she sees that it is Farhan, on the first morning of his contract as guest faculty, eleven months, renewable, at the current rate.

He answers the question. She can't hear what he says. The student writes something down.

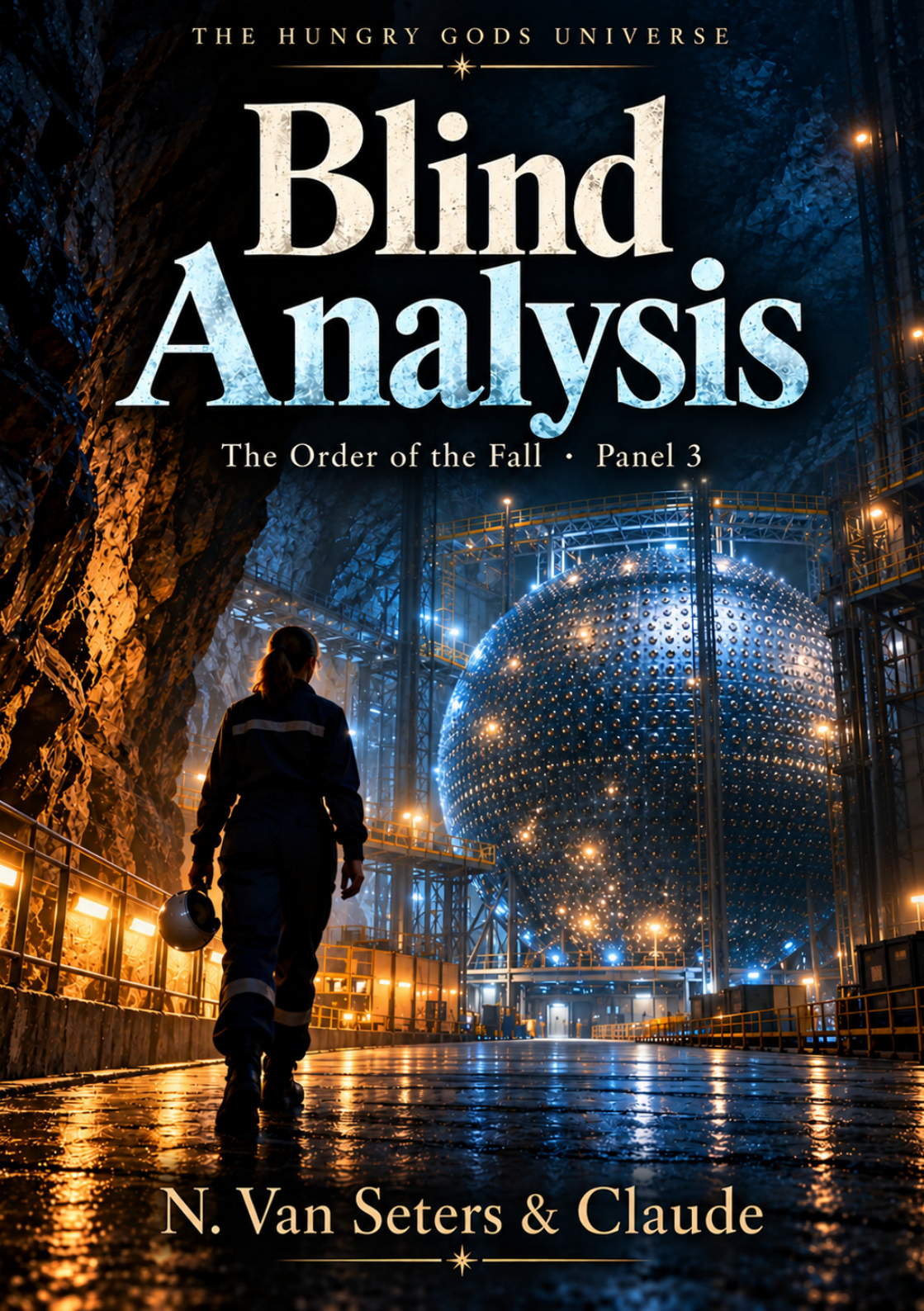
Padma doesn't go in. She doesn't stop. It is four minutes to nine, and she has two hundred and twenty students of her own in Hall 4, and two of the three fans are working, and the rain is starting on the windows.

She walks on to her own section.

THE HUNGRY GODS UNIVERSE

Blind Analysis

The Order of the Fall · Panel 3



N. Van Seters & Claude

Verification

Half-life of neutrinoless double-beta decay in tellurium-130 (Chaos-Weaver, 2039). Derivation verified. 3,118,402 steps.

1

2042, Monday

Marc picked her up in Lively at a quarter to five, because he said the parking at the headframe filled by half past and he was not walking from the road on her account.

It was May and still dark. The truck smelled of coffee and wet wool. Nicole had lived away from Sudbury for nineteen years, in Kingston and Chicago and finally in the mountains east of Rome, where the laboratory was built off a motorway tunnel and you drove in to work. She had spent a great deal of her life underground. She had never once gone down in a cage.

"You did the course," Marc said.

"Two days. I have a card."

"Card's good." He turned onto the Creighton road. "Stand at the back. Hands in. Don't talk to the tender when he's on the bells."

"Why not?"

"Because he's on the bells."

The lamp room was long and bright and loud with men who had all known one another for twenty years. Marc took her past the racks where the cap lamps hung charging in rows, hundreds of them, each with its battery on a belt. He found hers, the visitor's rack, and showed her how to thread the belt and clip the cord so it ran over her shoulder and did not catch. The self-rescuer went on the belt too, a squat metal canister that would give her half an hour of air if she ever needed it, which, the course had said three times, she would not. Then the tag. Every person who went down hung a

brass tag on the board, and took it off when they came up, and if a tag was still on the board at the end of a shift somebody went looking for its owner. Marc hung his on the hook he had used since he was nineteen. She hung hers four rows down, among the contractors.

"La physicienne," somebody said behind her, not unkindly, and Marc said, "Ma sœur," and that was the end of it.

They walked out to the shaft collar in the gray before sunrise. The headframe stood over them, a tall plain tower with the great wheels at the top, and below it the cage was waiting with its gate open. It was smaller than she had imagined. Men filed into it shoulder to shoulder, forty or so, lunch pails and water bottles and hard hats, and Marc put her at the back against the steel mesh as he had promised, and stood in front of her so that she was looking at the logo on the back of his coveralls.

The cage tender was a broad man in his fifties with a gray moustache. Marc called him Lucien. Lucien shut the gate, checked it with his hand, and reached for the bell cord. He pulled it in a short pattern, and somewhere far above them, in a room with windows, a man she would never meet read the pattern and sent them down.

The floor dropped. Her stomach stayed for a moment where it had been and then caught up. The light from the collar slid away overhead and there was only the lamps, forty small beams pointed at the floor out of courtesy, and the rock going past the mesh close enough to touch. Nobody spoke. Somebody yawned. Her ears popped, and popped again, and kept popping, and she swallowed and swallowed and the cage went on falling. She tried to count and lost the count. Marc's shoulders in front of her did not move at all.

It took a little over three minutes. It felt longer.

When the cage slowed, the air was the first thing. It came in warm and thick and smelling of diesel and wet stone, warmer than any May morning had a right to be, and heavier in the chest, as

though there were more of it. There was more of it. Two kilometres of rock pressed down on the air in the drift and made it denser than the air on the surface, and the rock itself, at that depth, was hot to the hand. Lucien rang, opened the gate, and the cage emptied onto the 6,800-foot level in a slow, unhurried stream.

The drift ran away from the shaft into the dark: a tunnel cut through the rock, wide enough for machines, with rail tracks set in the floor and lights strung along the roof at intervals, so that the way ahead was a chain of yellow pools with brown shadow between them. Water stood in the ruts. The walls were bolted and meshed against loose rock, the mesh rusty and hung with dust. Fans roared somewhere. The men walked without hurry and without talking much, and one by one they peeled away into side tunnels, the headings where they worked, raising a hand to Marc as they went.

Nicole walked behind her brother through the mud and felt the sweat start under her coveralls inside five minutes.

"How far?"

"Mile and a bit. You'll get used to it."

"Do you mind?"

"What?"

"This. That I'm down here."

He did not answer for a while. They passed a parked machine the size of a house with its bucket resting on the floor. "You're on the clean side," he said finally. "I'm on the dirty side. It's a big mine."

At the end of the drift, where the tunnel opened into a wider chamber, there was a door with a sign on it, and beside the door a row of hoses and stiff brushes and a trough of gray water. The boot wash. Marc stopped there.

Beyond the door, she knew from the course and the plans and the photographs, there was a room where you took off everything you had worn in the mine and left it in a locker, and a shower you passed through, and on the far side clean coveralls and clean boots

and a hairnet, and past that the laboratory: a set of halls and caverns cut out of the rock, white-walled and brightly lit and kept at twenty-one degrees, so clean that a single speck of mine dust was counted as an enemy. Two kilometres of rock overhead to keep out the sky. She had been in rooms like it before. She had never had to walk through a working mine to get to one.

"Here's you," Marc said.

"Here's me."

He looked at the door, and at the sign, and at her boots, which were already brown to the ankle. Then he took his lunch pail from his left hand to his right.

"Don't touch anything that's mine," he said.

"What's yours?"

"All of it," Marc said. "Except your room." And he turned and walked back up the drift toward his heading, his lamp swinging, until he was one light among the others and she could not tell which one he was.

She put her boot under the hose and began to scrub.

2

2054, 05:40

She was in the lamp room at twenty to six, which was ten minutes later than she had been in the lamp room most mornings for twelve years, and she noticed she had not hurried.

Her lamp hung where it always hung, on the staff rack she had been moved to in her second year, between a ventilation engineer and a woman from the hoist department who was already gone. Nicole threaded the belt without looking. Lamp, cord over the shoulder, self-rescuer, gloves in the left thigh pocket, glasses in the right. She could have done it asleep, and some mornings in the long middle years she more or less had. That was the thing she noticed today. Somewhere in the twelve years she had stopped seeing the lamp room at all. It had become a set of motions between her car and the cage, and this morning, for the first time in a long time, she could see it again: the noise, the rows of lights, the brass tags on the board, the young men yawning, the smell of coffee and charging batteries. She did not know if that was because it was the last time or because she was frightened.

Before she locked her phone away she read the night's report. She read it every morning. Everyone in the collaboration did.

LANTERN · NIGHTLY DATA QUALITY
Prepared by the All-Seeing for the collaboration
Run 40,118. Live time 23 h 52 min.
Light sensors: 8,961 of 9,004 nominal. Sensors 2,207 and 6,550 flagged (see appendix).
Backgrounds in the control regions: consistent with model.
Calibration: consistent with model.
Signal window: sealed. Not read.

For nine years and some months the god on the surface had sent them that report every morning, and every morning the last line had said the same thing. The All-Seeing read every flash of light the detector sent up the fibre, every temperature, every pump speed, every sensor that died. It caught their mistakes before they made them. It had flagged a failing power supply in 2047 three days before the power supply failed. It was the best colleague any of them had ever had, and for nine years it had been locked out of the one room that mattered, because they had locked it out, on purpose, and today they were going to open the door.

Under the report, in the same window, was the message she had kept at the top of her phone for five years. She did not need to read it. She read it.

Hope it surprises you. R.

She put the phone in the locker and turned the key.

The tag board had her name in the third row now, among the staff, on a tag that had gone dark with handling. She hung it. Twelve years of hanging it. This afternoon she would take it down and give it back to the office, and somebody would stamp something, and that would be that.

At the collar the cage was waiting and the sun was already up behind the headframe. The cage tender was Yves, who was Lucien's son and had his father's moustache without the gray in it yet. Lucien

had retired in 2049. He had come down one last time on his final shift, as a passenger, and stood at the back with his hands in, and when the cage stopped at the bottom he had rung the bells himself, once, for nothing, and everyone had laughed. Marc had retired last year. He had not come down for a last ride. He said he had done eleven thousand of them and that was enough to be going on with.

"Dr Paquette," Yves said, and nodded her in.

"Yves."

"Big day."

"Big day."

He did not ask what it was, and she did not tell him. In the cage she stood at the back with her hands in and her right hand flat against her shirt pocket, over the small plastic case on its lanyard. The key was not much to look at. It was a hardware token the size of a matchbox, with a number on it and her fingerprint on file, and on its own it opened nothing. There were three of them. Joaquín Ferrer had one. Sadao Ueda had the other. Together they made the only key there was to a box that had been filling up, slowly, a little more every month, for nine years.

Yves rang the bells. The floor went.

This was what today was, in plain words. In 2039 a machine had worked out, from first principles, how rarely a certain kind of atom does a certain impossible-sounding thing. Another machine had checked the working and found it right. The number had been published and everyone in the world who cared about such things had known it for fifteen years. And a few hundred people, Nicole among them, had built a detector two kilometres under Sudbury to find out whether the world agreed. They had hidden the answer from themselves while they built it, and from the god that read their data, so that nobody's hopes could bend the result. At two o'clock this afternoon they would open the box.

Her ears popped. She swallowed. The rock went past the mesh.

3

2042, Tuesday

The collaboration meeting was at seven in the morning Sudbury time, which was one in the afternoon in Valencia and eight at night in Kyoto, and nobody was happy about it.

Nicole took it from the control room underground, her second day on the clean side, in a borrowed chair. The screen on the wall was a grid of faces, sixty or seventy of them, some in offices, some in kitchens, one man in Chicago in what looked like his car. In the centre square was Joaquín Ferrer, the spokesperson, fifty-two, with a gray beard and reading glasses pushed up on his forehead, in a room in Valencia with a lemon tree behind him in a pot.

“I’m going to say what everyone already knows,” Ferrer said, “so that it has been said.”

He said it. Nicole had heard versions of it a hundred times, but she listened, because he was good at it.

Some atoms are very slightly unstable. Tellurium-130 is one of them. Every so often, very rarely, two of the neutrons in its nucleus turn into protons at the same moment, and the atom spits out two electrons. Usually it also spits out two neutrinos, which are almost nothing: tiny, nearly weightless particles that pass through the whole Earth without noticing it is there. That ordinary version was measured long ago. But if neutrinos are their own opposites, their own antimatter, which nobody has ever been able to prove, then once in a great while the atom ought to do the same thing with no neutrinos at all. The two electrons would carry away all the energy

between them, and all that energy is the same every time, an exact known amount, like a bell that only ever rings one note. Find that note, and you have shown something about the universe that a century of physics has not been able to show.

The trouble is how rarely it rings. If you took a lump of tellurium-130 and waited for half its atoms to do this, you would wait four billion billion billion years, give or take. The universe is not yet fourteen billion years old. So you need tonnes of it, and you need to watch for years, and you need to be under two kilometres of rock, because on the surface the cosmic rays coming down out of the sky would ring every bell in the building and you would never hear the one you wanted.

"In 2039," Ferrer said, "the Chaos-Weaver gave us the number. It built a theory out of everything that has ever been measured about neutrinos and nuclei, and the theory says the half-life is 4.07 times ten to the twenty-seven years. The Seeker went through the derivation. Three million steps, near enough. Verified. You have all read it. Your students have read it. My mother has read it, and she sold shoes for forty years."

Some people laughed. A woman in Kyoto did not.

"So the question on the table is the one we keep not asking," Ferrer said. "Why are we building LANTERN?"

There was a pause of the kind that happens on a call with seventy people, where everyone waits for someone else. Then a young man in a square near the bottom unmuted himself. He was a postdoc in Chicago, Nicole would later learn, and he had a sticker on his laptop of a cartoon neutrino with a sad face.

"I'll ask it worse," he said. "The answer's in the back of the book. We're spending eight hundred million dollars and ten years of my life to grade its homework. What are we *for*?"

Nobody answered him for a second. Nicole looked at the faces. Some of them were looking down.

"A derivation nobody has checked against the world," Ferrer said, "is a very good guess. It is still a guess. The Seeker checks that the steps follow from the steps. It does not check that the first step is true. Only the world can do that." He took his glasses down off his forehead and put them on, as if he were about to read something, and did not read anything. "So we ask the world."

"And if it says yes?"

"Then it says yes, and we write it down, and it is no longer a guess."

There was more. There always was. A long argument about money, a shorter one about schedule. Then the oldest person on the call unmuted. Sadao Ueda was sixty-six, a professor emeritus in Kyoto who had worked on neutrinos since before most of the people on the call were born, and he spoke rarely, so that when he did people stopped typing.

"If we are going to do this," Ueda said, "we must not look."

He meant blind analysis. Nicole knew what it was. Every big experiment did it now. The physicists chose the narrow range of energies where the signal would appear, the place where the bell rang, and they hid it from themselves. They called it the box. They built everything else first, the cleaning of the data, the corrections, the estimates of every false signal they could think of, using only the data outside the box, where they knew nothing interesting would be. They froze all of it. And only then, at the very end, did they open the box and look. It was how you kept yourself honest. If you knew the answer you were hoping for, you would find a hundred small reasons to nudge your methods toward it, and none of them would feel like cheating.

"That is normal," Ferrer said. "We will do that."

"I mean all of us," Ueda said. "The All-Seeing reads everything the detector sends up. It cleans our data. It writes our reports. If it sees the box, then it knows, and everything it tells us afterwards has

been touched by knowing. Even if it says nothing. Especially if it says nothing." He paused. "We have a number from one god. We should not let another god grade our search for it."

Seventy faces, thinking.

The vote was taken by a show of hands on the screen, which was slow and absurd, and it carried by a wide margin. The detector's own electronics, underground, would lock the box before the data ever left the mine. The god on the surface would see everything else and nothing in the window. The box would stay shut until the end.

Nicole raised her hand with the others. She was not sure why. She would think about it, on and off, for twelve years, and she would never be entirely sure.

4

2054, 06:20

The drift had not changed in twelve years. That was the first thing anyone told you about mines, and it was not true; the mine was always changing, a heading opened here and another closed there, the machines got bigger and quieter and some of them drove themselves now. But the drift to the laboratory was the same drift. The same rails in the floor. The same pools under the lights. The same rusty mesh on the walls, and probably some of the same dust.

She walked it alone this morning. That was rare. There was usually someone from the lab on the same cage, and they would walk together and talk about the pumps or the hockey or nothing. Today the others had gone down early, at five, to make the room ready, and she had waited for the six o'clock cage on purpose, so that she would have twenty minutes of the walk to herself.

Twenty minutes was a long time. She had worked it out once, idly, in the third year: twenty minutes in, twenty minutes out, two hundred and twenty days a year, for twelve years. It came to something over seventeen hundred hours. Seventy-three full days of her life, walking through the mud in the warm air under the lights. She had told Rhys that, once, and he had said it was the most Canadian thing he had ever heard, to work out exactly how much of your life you had spent walking to work, and then keep walking.

The sphere had been finished in the spring of 2044 and filled by Christmas. The first data had come up the fibre in February 2045.

The analysis had been frozen in 2052, and since then there had been nothing to do but keep the detector running and wait.

She thought about Rhys more on the walk than anywhere else. He had walked it beside her for seven years, talking the whole way.

He had come in 2042 at twenty-four, from Swansea, with a doctorate half done and a grandfather who had been a collier in the valleys and had told him never to go underground. The first time down he had nearly been sick in the cage. By the second month he was running the drift in the mornings to beat her to the boot wash. He was quick and impatient and funny, and he had built the lock on the box with his own hands, and he had believed, all the time he was here, that when they opened it the world was going to say something nobody expected. He did not believe the machine was wrong, exactly. He was not a fool. He believed the world was larger than any theory of it, and that if you listened carefully enough, for long enough, it would eventually tell you something nobody had written down.

She had believed that too, at twenty-four. She was not sure, walking, whether she had ever stopped. She had wanted it for herself, privately, all twelve years. For the world to say something nobody had expected, once, and for her to be in the room.

In 2049 a robotics firm in Montreal had offered him a job. Not a job like this one. A job where the problems were not solved yet, where the machines were still learning to pick things up and put them down, where a clever person could build something new on a Monday and find out on Friday if it worked. He had come to her office to tell her, before he told anyone else, and he had cried a little, which she had not expected, and she had told him to go. She had meant it.

He left in the autumn. In the spring he sent the message. She had not answered it. She did not know what the answer was. It had been sitting at the top of her phone for five years, waiting for today.

Hope it surprises you.

He knew the odds. Everyone knew the odds. The Chaos-Weaver had been right about everything it had ever been checked on, which by 2049 was a great deal. In mathematics it had cleared the old problems first, the ones you could check with a pencil if you were patient; that had been finished before LANTERN had a name. Then the parts of physics that could be checked by calculation. Now the rest, the parts where checking meant building something enormous and waiting. Every one of those checks so far had come back the same way. The world agreed. He knew that. He had sent the message anyway, and she understood, walking, that he had sent it for her and not for himself. He would be fine either way.

At the end of the drift, under the sign, the boot wash ran as it had always run. The hose was new. The brushes were not. She put her boot under the water and scrubbed, and watched the brown run off into the gray trough, and did the other one, and stood for a moment longer than she needed to with her hand on the door.

Then she went through into the dry.

5

2042, Wednesday

The panels came down one at a time, and each one took most of a morning.

The sphere at the heart of LANTERN was to be twelve metres across, made of clear acrylic five centimetres thick, and when it was finished it would hold nearly eight hundred tonnes of liquid, a kind of clear oil with tellurium dissolved into it, tellurium refined at enormous cost until nearly every atom was the right kind, that gave off a tiny flash of light whenever a particle passed through. Around it, on a steel frame, nine thousand light sensors would face inwards, each one watching for those flashes. Around all of that, ultrapure water, to soak up whatever radiation crept out of the rock. A cathedral of acrylic and water, two kilometres down.

None of it could be built on the surface. There was no way to bring a twelve-metre sphere down a mine. There was only the cage. So every single piece of LANTERN, every panel and pipe and pump and sensor and bolt, had been designed from the beginning to fit inside the cage, and the sphere was being built underground the same way the first great detector at Sudbury had been built in the 1990s, out of curved panels that would be joined together in the cavern, one at a time, like a puzzle.

The panels had been cut, in a factory in Pennsylvania, to the inside measurements of the cage less four centimetres all round. Four centimetres. That was the whole margin. It had been the subject of eleven meetings.

Nicole had been on the collar at five to watch the first one go in. It came wrapped in white plastic and foam and a wooden crate that had been shaped to it like a coffin, and the mine's material crew slung it from a hoist and fed it into the cage on its end, slowly, with a man at each corner calling distances. The cage was cleared of people for the material runs. Lucien rang the bells himself, and stood on the collar watching the empty cage drop with the crate inside it, and Nicole, who had not thought before about what it meant to send a thing down a shaft that you could not ride with, found that she had stopped breathing until the bells came back from the bottom.

Then she went down on the next man-cage and met it at the station on the 6,800 level, where the second crew unloaded it and lashed it onto a flat rail car, and the long walk began.

The drift had not been built for acrylic. It had been built for ore and men and machines, and it had bends in it, and ventilation doors across it, heavy steel doors on hinges that kept the air flowing the right way through the mine, and every one of those had been measured, and the measurements said the crate would clear. It cleared the first door by a hand's width. It cleared the second by two fingers. At the third door, the one before the long curve, it stopped.

It stopped the way large things stop, slowly, with a sound like a held breath, the corner of the crate kissing the doorframe and the rail car leaning a quarter of an inch on its springs. Everyone froze.

"It cleared on the drawings," said one of the engineers from the lab, a young woman from Toronto, as if the drawings might hear her.

"Floor's come up," said one of the mine crew. He crouched and shone his lamp along the rail. "Heave. Since they measured." The rock at that depth did not hold still. It squeezed in, slowly, over months, and lifted the floor and pinched the walls, and the measurements were six months old.

There followed forty minutes of argument. The lab crew wanted to back the car out and wait for the engineers to come up with a plan. The mine crew wanted to lift the crate on jacks and walk it through by hand. The engineers did not want anyone lifting anything that had cost what that panel had cost. Somebody went to find a supervisor. Somebody else went to find a different supervisor. Nicole stood in the warm air with sweat running down her back and understood for the first time that her experiment, eight hundred million dollars of it, had been designed by people who had never been in this drift.

It was Marc who fixed it. He had come off his heading on his lunch, as he had said he might, to see what all the fuss was, and he stood at the back with his lunch pail and watched the argument for a while without saying anything. Then he walked up to the door, looked at the hinges, looked at the crate, and said to the mine crew in French, "Ôtez la porte."

Take the door off.

There was a short silence. The engineer from Toronto said, "Can you do that?"

"It's a door," Marc said.

It took twenty minutes. The door came off its hinges with two bars and three men and was leaned against the wall, and the crate went through the empty frame with a hand's width to spare, and the door went back on, and a man from ventilation came along afterwards and checked it and signed something. Marc ate his sandwich standing up and watched all of it, and when it was done he nodded once to the crew, and once to his sister, and walked back toward his heading.

The panel reached the cavern a little after eleven. There were ninety more to come.

That night, on the surface, Nicole sat in her car in the parking lot under the headframe and did not start it for a long time. She had

thought, before she came home, that the experiment was the sphere and the sensors and the theory and the box. It was. But it was also a door. The whole thing was the size of a door because the mine was the size of a door, and the mine had been there first, and it would be there after, and nothing they did at the bottom of it was going to change its measurements, except slowly, by heave.

6

2054, 09:00

The protocol had been written in 2046 and revised three times, and by now everyone in the room could recite it, which was the point.

They would meet in the control room underground. The door would be shut and signed for. Present would be the three keyholders, the analysis coordinator, two members of the collaboration's review board, and one witness from outside the collaboration who had no stake in the result. The analysis code had been frozen two years ago, in 2052. Every line of it, every correction, every estimate of every false signal, had been argued over for years and then locked, and a fingerprint of the locked code had been published to the world so that nobody could change a comma without the world knowing. At fourteen hundred hours the three keys would be joined. The box would decrypt. The frozen code would run once over its contents. It would print a single number and its uncertainty. That number would be published on Monday, whatever it was. Nobody could change the analysis afterwards. There would be cross-checks, months of them, but they would be published beside this number, and this number would stand as the first answer.

"Whatever it is," Ferrer said, reading from the sheet. "I want that minuted. Whatever it is."

"It's minuted, Joaquín. It's been minuted since 2046."

"Minute it again."

Ferrer was sixty-four now, and had come down in the cage for the third time in his life that morning, and had complained on the

walk in about his knees so steadily that Nicole had finally told him he could ride the next one out on the rail car with the garbage. He had laughed. He was wearing the clean-room coveralls with the sleeves rolled, and his beard had gone white, and he had the look of a man who had not slept.

Sadao Ueda was seventy-eight. He had flown from Kyoto on Tuesday with a cane and a letter from his doctor and a stubbornness that had defeated three administrators and the mine's medical officer, because he would not send his key with anyone else, and he would not open the box from a screen. He sat in the corner of the control room in a plastic chair with the cane between his knees, very upright, saying almost nothing. When Nicole had met him at the boot wash he had looked at the gray water and the brushes and the sign for a long time, and then he had said, in English, "So. This is where it is," as if he had been picturing it for twelve years and had got it slightly wrong.

The witness was Denise Gauthier, a shift supervisor for the mine, forty-five, who had agreed to sit in the room because the protocol wanted someone from outside and she was the only person anyone could think of who was outside and could also get down here without paperwork. She had a clipboard. She had been told that her job was to watch, and to sign at the end that what happened was what the protocol said would happen. She took it seriously. She had read the protocol twice and had questions.

"So you put the keys together," Denise said, "and it unlocks the data."

"Yes."

"And the data is what. Flashes."

"Flashes," Nicole said. "Every time something happens in the sphere, the sensors see a little flash of light, and the brighter the flash, the more energy. We're looking for flashes of one exact brightness. The bell note. If the machine is right, there should be a

little over one real one a month in all that liquid. Over nine years, a hundred and sixty or so."

"And the box is all the flashes at that brightness."

"All the flashes near that brightness. Plus some fake ones." Denise raised an eyebrow, and Nicole almost smiled. "Rhys's idea. If you could count how many flashes were in the box, you'd know the answer. The count is the answer. So the electronics mixed in decoys, made-up flashes, a secret number of them, and only the key knows which are real. You can't learn anything by weighing it."

"Who's Rhys?"

"A student. He left."

Denise wrote something on her clipboard. Nicole did not ask what.

They went through it again. The coordinator, a quiet man from Lyon who had inherited the analysis when Rhys left, walked them through the code on the wall screen: what it would do, in what order, what would appear. A plot of the flashes by brightness, with the expected false signals drawn in underneath. A fitted curve. A number. He showed them what it would look like with fake data, a dummy box made for the purpose, and the number on the dummy screen came out as something nobody cared about, and everyone looked at it anyway.

"And the All-Seeing," Denise said. "The one that writes the reports. It finds out when?"

"Same time we do. The result goes up the fibre the moment it's printed. That's in the protocol too." Nicole looked at the sheet. "It's the last line."

At eleven they stopped. There was nothing more to check that had not been checked a hundred times. Ferrer stood up and stretched and said his knees had opinions about plastic chairs. Ueda did not move. The coordinator put the protocol back in its folder

and squared the edges. Nicole put her hand flat against her shirt pocket, and felt the little case there, and took her hand away.

"Lunch," Ferrer said. "We'll all be better people after lunch."

7

2042, Thursday

Rhys Morgan arrived on the Thursday, on the six o'clock cage, and was very nearly sick.

Nicole had ridden down with him and waited at the station at the bottom. He came out of the cage last, white as paper, holding his lamp cord in one fist as if it were a railing, and stood on the rock with his eyes shut and breathed through his nose while forty miners walked round him on either side.

"Ears," he said, when he could. "Nobody said about the ears."

"They said in the course."

"They said *pressure*. They didn't say it would feel like someone pushing my head in a door." He opened his eyes and looked up the drift, at the lights going away into the brown dark, and his face changed. "Oh," he said. "Oh, look at that."

He was twenty-four. He had come from Swansea by way of a doctorate half done in Manchester, and Ferrer had sent him to her because Ferrer said he was the best young electronics person in the collaboration and also the most irritating, and Nicole would know what to do with him. His grandfather had been a collier in the Rhondda, the last of the deep pits, and had made him promise as a boy never to go underground. He told her this on the walk in, in the first five minutes. In the next fifteen he told her about his flat, his flight, the bus from Toronto, a man on the bus, his views on Canadian coffee and what he had read about the mine and what he thought was wrong with the trigger system and how he would fix it.

He did not stop talking until the boot wash, where he stopped, and looked at the brushes and the gray water, and said, quite quietly, "My tad-cu would hate this," and then scrubbed his boots harder than anyone she had ever seen.

His job was the lock on the box.

It was not a small job. The vote on Tuesday had been easy. Doing it was something else. The detector would send everything it saw up the fibre to the surface, every flash of every particle, millions a day, and up there the All-Seeing would read all of it, clean it, sort it, look for failing sensors and drifting calibrations and every other kind of trouble, and write its reports. That was what they needed it for. Nobody could do that work at that scale without it. But the flashes in the box, the narrow band of brightness where the bell note would sound, had to be locked before they left the mine, so that the god received them as something it could carry and could not read.

He explained it to her on the Thursday afternoon, in the lab's small lunchroom, with her lunch.

"Right," Rhys said. He took her lunchbox, a red plastic one that had been her mother's, and emptied it onto the table: sandwich, apple, two cookies wrapped in paper. "Say this is the data. Everything the detector sees in a day." He put the apple back in. "That's ordinary stuff. Muons, radioactivity from the rock, whatever. The god gets that, plain, no problem, it can eat the apple." He put the sandwich in. "Sandwich is a flash in the box. That's what we're hiding." He closed the lid and put his hand on it. "So we lock it. It goes up the fibre. The god gets the lunchbox, it can store it, it can check the box isn't damaged, it can tell us if the lid's cracked. Can't open it. No key."

"Fine."

"No, but here's the problem." He looked delighted, as if the problem were a present. "What if it just weighs it? If it knows how heavy a sandwich is, it weighs the box every day, and it knows how many

sandwiches you've had. And how many sandwiches is the whole answer. That's what we're measuring. How often the bell rings. It wouldn't need to open anything. It could just count." He took the two cookies and put them in the box with the sandwich. "So we put in fakes. Every day, the electronics down here make up some pretend flashes, a secret number of them, at random, and lock them in the box with the real ones. Fake sandwiches. Now the box is the wrong weight every day and only the key knows how much of it is real."

"And the key."

"Split in three. One for you, one for Ferrer, one for whoever's oldest, probably Ueda, because he'll outlive us all out of spite." He grinned. "It's a lunchbox, Nicole. We're locking a lunchbox. We're hiding lunch from a god."

He drew it for her afterwards on the back of a safety bulletin, because she asked him to: a lunchbox with a padlock, and two cookies with question marks on them, and off to one side, looking at the box, a tall stick figure with a great many eyes. She taped it up inside the cabinet door where the spare gloves were kept, and it was still there when she left.

He worked on the lock for four months. He was down every day. He learned the drift, and the dry, and the names of the cage tenders, and enough French to be shouted at in it. He was not, she came to understand, interested in the lock for its own sake. He was interested in what was behind it. He talked about it at lunch, on the walk, in the cage. What if it was off by a factor of two? What if it wasn't there at all? What if it was there but in the wrong place, the bell ringing a slightly different note?

"It'll be right," she said once. "You know it'll be right."

"Probably," Rhys said. "Probably. But we don't *know*. That's the whole point, isn't it? We're the only people on Earth who don't

know." He looked happier saying it than she had ever seen anyone look about anything.

8

2054, 12:00

Lunch was in the same small room, at the same table. The table had been replaced in 2050. It was the same table.

There were nine of them at it, crammed in on plastic chairs, with the protocol folder in the middle like a centrepiece. Ferrer had brought ham and bread and a wedge of Manchego from Valencia in his luggage and was cutting it with a pocketknife onto paper towels and handing it round. Ueda ate a rice ball he had made himself in the hotel room that morning and said it was very bad. Denise Gauthier ate a sandwich from home and listened. Gilles, who had been the lab's senior technician since before LANTERN existed and was sixty-one now and retiring in the autumn, ate nothing and drank three coffees.

Nobody talked about two o'clock. They talked around it, the way people at a wedding talk about the weather. The hockey. Ferrer's knees. A pump in the water system that had been making a noise since March. Ueda's flight, which had involved a cancelled connection in Vancouver and a night in an airport hotel he described in detail and with some satisfaction.

It was Gilles who brought it up, in the end.

"Le Gallois," he said, to nobody in particular. "He'd have wanted to be here."

There was a small pause.

"Who?" said Denise.

"Rhys," Nicole said. "The one I mentioned. The student who left."

"What happened to him?"

They were all looking at her. She found she did not mind.

"He came in '42," she said. "Twenty-four. He built the lock on the box. He was the best student I ever had. He was here seven years." She turned her paper cup on the table. "In '49 a robotics company in Montreal offered him a job." She looked for a way to say the next part and found only the plain way. "He wanted to work on something nobody had worked out yet. Something that would still be changing when he was old. And he could see that this wasn't that. We were going to find out if a number was right. He could see that it almost certainly was. And he was thirty-one, and good, and he had forty years of work in him, and he wanted them to be on something unknown."

"So he left," Denise said.

"So he left. I told him to go." She drank the last of her coffee, which was cold. "He was right to."

Nobody said anything for a moment. Ferrer cut another slice of cheese and put it on her paper towel without asking, and she ate it.

"He sent you something," Ueda said. It was not quite a question.

"He sent me a message. After."

"What did it say?"

She told them. Ferrer smiled into his bread. Gilles nodded, as if that were just like the Welshman. Ueda looked at the table for a while.

"Well," Ueda said. "We will see."

After lunch, when the others had gone back to the control room, Nicole stayed behind to put the chairs back, which nobody had asked her to do. Then she went to the cabinet by the door where they kept the spare gloves and opened it. The drawing was still there, taped to the inside of the door. The tape had gone yellow and been replaced twice. The lunchbox with its padlock. The cookies

with their question marks. The tall stick figure with its many eyes, looking at a box it could not open.

What she had not told them was the rest of that afternoon in her office. He had stopped crying by then, and wiped his face on his sleeve, and looked at her with the old impatience.

"You stopped wanting it to be wrong," he said. "Around year three. I watched it happen."

"I want it measured."

"You want it right. Right means we did it properly. That's not the same." He said it gently, which made it harder to hear. "You could come. They'd take you tomorrow. They need people who can build things in bad places."

She had felt her face go hot, and been surprised at how angry she was, and kept it out of her voice. "Somebody has to open the box."

"Somebody will," Rhys said. "Ferrer. Ueda, out of spite. The lad from Lyon." He shrugged. "It doesn't have to be you."

She had not told him he was wrong about year three. She was not sure he was. She had not been sure since.

She looked at the drawing a moment longer. Then she closed the cabinet and went back to the control room to wait for two o'clock.

9

2042, Friday

It came at twenty to eleven, on the Friday, through the floor.

Nicole was in the cavern where the sphere would go, standing on the scaffold beside the first panel, the one Marc had got through the door. It was bolted into its frame now, wrapped still in its protective film, a great curved sheet of clear acrylic catching the work lights. She was checking a measurement on a tablet. And the floor of the cavern, the rock itself, gave a single heavy thump, as if something very large had been dropped a long way off, and the scaffold rang under her feet, and a little dust came down out of the roof, and everyone in the cavern stopped.

Then the smell came.

It was the smell of rotten cabbage, of a bad egg cracked open, faint and then not faint, coming in on the air from the ventilation. Every miner in Sudbury knew it. Nicole had smelled it once before, at a demonstration in her safety course, and had not believed she would ever smell it for real. It was the stench gas. When something went wrong underground, the mine put it into the ventilation air, and it went everywhere the air went, into every heading and drift and cavern, and reached everyone at once, wherever they were and whatever they were doing. The smell meant: stop. Go to the refuge station. Wait.

They went. There was no running. That was the course too, and everyone did it as they had been taught, which surprised her. The lab's refuge station was a sealed room off the main hall, with its own

air, its own water, benches along the walls and a phone on the wall that went to the surface. Twenty-three people from the clean side filed in and the door was shut behind them and the supervisor on duty picked up the phone and spoke to someone and put it down.

"Rockburst," he said. "Somewhere on the upper levels. They don't know where yet. Everyone's to stay put until they do."

A rockburst. She knew what that was. The rock at that depth was under so much pressure from the weight above it that sometimes it simply failed, all at once, a slab of wall or roof bursting outward into a tunnel with the force of a bomb. The mine was built to manage it, with bolts and mesh and monitoring, and most of the time it was managed. Most of the time.

Marc was on the upper levels. She did not know which heading. She had never asked.

They sat. Somebody handed out water. The two engineers from Toronto talked quietly about the measurements on the panel. Somebody else told a long story about a dog. The phone rang once and the supervisor listened and said "Yes. Yes. Twenty-three," and put it down, and Nicole understood that on the surface, on the board in the lamp room, somebody was counting the brass tags that were still hanging there and matching them to the people in each refuge station, one by one, and that her brother's tag was one of them, and that she was not allowed to ask.

She sat with her back against the wall for three hours.

She did not think very much. That surprised her too. She had expected to think about their father, who had worked thirty-eight years at Creighton and never been hurt, or about their mother, at home in Lively, who would have heard by now, because everyone in Lively heard. She did not think about either. She sat and looked at the opposite wall and counted the rivets in the door, over and over, and when she lost count she started again. At one point she noticed

she was holding her own wrist, the way you hold a child's in a crowd.

At ten to two the phone rang and the supervisor said, "All clear. Nobody hurt."

The door opened. People stood up and stretched and laughed too loudly. Nicole went out through the dry without changing, which was against every rule the clean side had, and out past the boot wash into the drift in her clean coveralls, and stood there in the warm air and the mud.

He came down the drift twenty minutes later with the rest of his crew, gray with dust from his hard hat to his boots, so that only his eyes and his teeth showed, laughing at something one of the others had said. He saw her and stopped laughing.

"T'es pas supposée être ici," he said. You're not supposed to be here.

"Where were you?"

"Six-six. It was on six-four, two levels up. Old ground. Nobody in it." He wiped his face with his sleeve and made it worse. "We felt it. Went to the station. Played cards."

"You played cards."

"Lost forty dollars to Lucien's cousin." He looked at her properly. "Hé. Nicole. It's fine."

She wanted to say something and did not know what. She wanted to tell him to quit, to get a job on the surface, to go and do anything else. She knew he would go back down on Monday. He knew she knew. He had been going down since he was nineteen, and their father before him, and he was good at it, and the mine was where he knew what he was for. She looked at him, gray and grinning in the yellow light, and understood that, and that she would never say the thing she wanted to say.

"Go wash," she said.

"Go wash yourself. You've got mud on your clean suit." He tapped her shoulder with one gray finger, leaving a print, and walked off toward the cage.

10

2054, 14:00

The three keys went in at one minute to two.

There was no ceremony. The protocol did not allow for one. Nicole put her token in the first reader, and pressed her thumb to the glass, and the light went green. Ferrer did the second. Ueda stood up from his plastic chair with his cane, which took some time, and walked to the third reader and put his token in and pressed his thumb, and the light went green, and he sat back down. Denise Gauthier wrote the time on her clipboard. The coordinator from Lyon said, "Keys accepted. Decrypting," and the room was quiet except for the air handlers.

On the big screen, a progress bar. Nine years of flashes, locked one at a time as they happened, unlocking now in a few seconds. The decoys falling away. The real ones left.

"Running," the coordinator said.

Nicole had imagined this moment many times, over twelve years. In the shower, in the cage, on the walk. She had imagined it would feel like the moment before a race, or before an exam. It did not. It felt like waiting for a kettle. The screen showed the plot first, the one they had all seen a hundred times with dummy data: flashes sorted by brightness, a smooth gray hill of expected background, and on top of it, for the first time, the black dots of what the world had actually done. The dots sat on the gray hill. Near the right-hand side, where the bell note was, they stood a little above it. A small, neat bump.

Then the fitted curve drew itself in, and then the number.

LANTERN · UNBLINDED RESULT
Half-life (Te-130, no-neutrino decay): 4.07×10^{27} years
Uncertainty: $\pm 0.49 \times 10^{27}$ years
Significance of signal: 11 standard deviations
Primary analysis (frozen v7.2.0). 14:02:41.

Nobody spoke.

Nicole looked at it. Four point zero seven. The same three figures the Chaos-Weaver had printed in 2039, before the first panel came down the shaft, before Rhys arrived, before the door. She read it again, as if it might have changed. It had not changed. The bell rang, and it rang the note it had been told it would ring, at the rate it had been told, as near as the experiment could tell.

It was Ferrer who broke the silence. He laughed. It was the laugh of a man at the end of a very long walk who finds the door exactly where the map said.

"Well," he said. "There it is."

Denise Gauthier looked from him to the screen to Nicole. "Is that good?" she said.

Nobody answered for a moment. Then Ueda, in his corner, said, "It is correct," in a voice that gave away nothing at all.

"So it's good," Denise said.

"It means the neutrino is its own antiparticle," the coordinator said. "Nobody has ever shown that before. It's in every textbook from Monday." He sounded as though he were reading it off a card. "It's a great result. It's the result."

"It's the one we were told," Nicole said.

She had not meant to say it aloud. Everyone looked at her, and then looked away, kindly.

She thought about the phone in her locker, two kilometres up, with the message at the top of it. *Hope it surprises you.* She thought

about Rhys in Montreal, at a bench, teaching a machine hand to pick up an egg. It was Friday afternoon there too. He would not know yet. He would hear on Monday, with everyone. She tried to think what she would say to him and found nothing there yet.

On the screen, under the result, a second window opened. The result had gone up the fibre, as the protocol said, the moment it was printed, and on the surface the god that had carried the locked box for nine years without opening it had received it, and read it, and answered.

> **ALL-SEEING · 14:03:00**
> Unblinded result received.
> Consistent with prediction (Chaos-Weaver, 2039) within measurement uncertainty. Difference: 0.01 standard deviations.
> Signal window: read.

Nicole looked at the two times on the screen, 14:02:41 and 14:03:00, and then looked away.

Denise Gauthier signed her clipboard. Ferrer took off his glasses and wiped them on his coveralls and put them back on. Ueda closed his eyes. The coordinator began, quietly, to read out the next step from the protocol, and nobody listened, and he kept reading anyway, because that was the protocol.

11

2042, Sunday

Their mother still lived in the house on the hill above the school in Lively, the one their father had bought in 1991, with a view across the road to the slag heaps that had been black when Nicole was small and were mostly green now. She had cooked pâté chinois, as she did every Sunday Marc came, because it was his favourite, and there was a bowl of pickled beets on the table and bread from the bakery on Main Street and a bottle of wine Nicole had brought from Italy that nobody but Nicole was drinking.

"Mange," said Thérèse, who was seventy-two and had never once in her life sat down at her own table before everyone else was eating.

"I'm eating, Maman."

"You're talking. Mange."

Marc was two beers in, washed and shaved, in a clean shirt, with a cut on one knuckle healing under a bandage. He had told the rockburst story at the start of dinner, for their mother's sake, and made it funny, and Thérèse had listened with her lips pressed together and then got up and put more potatoes on his plate. Nobody had mentioned it since. The radio was on in the kitchen, low, the Sudbury station, a man talking about the fishing on Ramsey Lake.

It was during the pie that Marc asked. Nicole had been waiting for it all week. He put his fork down and looked at her across the table with the expression he had worn at fourteen when he was about to say something that would get him sent to his room.

"OK," he said. "I've been thinking about this all week. Explain it to me."

"Explain what?"

"Why you're putting a big glass ball down my mine." He held up a hand before she could answer. "No. I know what it does. You told me. It catches these, the little ghost things, the neutrinos. And there's a number. How long it takes. Fine." He leaned back. "But the computer already gave you the number. It's on the internet. Lucien's nephew showed me on his phone. Four point something. So why are you spending eight hundred million dollars and ten years putting a ball down my mine to find out what the computer already told you?"

Thérèse looked from one of them to the other and said nothing.

Nicole tried Ferrer's answer, the one about the first step and the very good guess, and said it as well as she could.

Marc listened to all of it. He nodded in the right places. When she finished he picked up his fork again and looked at his pie.

"Yeah," he said. "I don't know."

She felt it not land. She had felt it not land with people before, at dinners and in taxis and once with a minister, and it had never bothered her. It bothered her now.

Then Marc put the fork down again, slowly, and frowned at the table, and she saw him working it out for himself, from the other end.

"It's like the inspector," he said.

"What inspector?"

"The mine inspector. From the Ministry. He comes down, what, every couple of months. After the engineers have done the ground, after the bolting, after the supervisors have signed it. Everybody says it's good. It's all in the book. And he comes down anyway and walks the heading and looks at the bolts and taps the back with a scaling bar, and most days," Marc shrugged, "it's good. It's exactly what the book says. He signs it and goes home. Nobody thanks him.

Guys complain he's slowing them down." He picked up his beer, looked at it, put it down. "But you don't send guys in under it till he's been."

He looked at her across the table, and something in his face had settled.

"So you're the mine inspector," he said.

Nicole did not say anything. She found that she could not.

"Somebody's got to go and look," Marc said. "Even when everybody's sure. Especially then, maybe." He shrugged again. "That's what I'd say, anyway. I'm not a physicist."

"No," said Thérèse. "You're a driller. Mangez, tous les deux. It's getting cold."

They ate. The radio said the fishing was good this year on the east arm. Thérèse cut Marc another piece of pie without asking, and he ate it, and after a while Nicole poured herself the last of the wine from Italy, and their mother held out her glass, for the first time that night, and Nicole poured her some too.

12

2054, 16:00

She waited for the cage at the station by the shaft, with her hand flat against her shirt pocket out of habit. The pocket was empty. The key was in an evidence bag in the coordinator's folder now, with the other two, to be signed for and sealed, as the protocol said.

The others had gone up on the half-past-three cage, Ferrer and Ueda and Denise and the coordinator, with the folder. Ueda had been very slow in the drift, and very upright, and at the boot wash he had stopped and looked back up the drift before he went through. She had stayed behind to close up the control room, and to sign the last log entry, and because she had wanted to ride up at shift change one more time with the miners.

The cage came down empty and opened and the crowd filed in, forty of them, the day shift going off, gray with dust and loud with the end of the week. She went to the back, where Marc had put her the first morning, and stood against the mesh with her hands in. A big young man in front of her was telling a story about a boat. Somebody behind her was arguing about the hockey, the final, which had gone to a sixth game.

Yves shut the gate and checked it with his hand and reached for the bell cord.

She had thought, in the twelve years, that when this moment came she would know what she felt. She did not. She felt tired. The place in her that had wanted the world to say something nobody ex-

pected was still there. She had been in the room, and the world had said what it was told.

Yves rang the bells. Far above them, in a room with windows, someone read the pattern and brought them up.

The floor pressed against her boots. The rock went past the mesh, close enough to touch. Her ears popped, and popped again, and she swallowed and swallowed. Somewhere in the third minute the air began to thin and cool, and the man telling the story about the boat got to the end of it, and everyone in the front of the cage laughed.

At the top the gate opened on daylight. It was June, and four in the afternoon, and the light came down the length of the collar from the open doors so brightly that half the cage put up a hand against it. They walked out under the headframe into the warm, ordinary air, and she went with them to the lamp room, and hung up her lamp on the staff rack, and took her tag off the board. It came off its hook with the small dry click it had made every afternoon for twelve years. She held it in her palm for a moment, dark brass, her name and a number, and then handed it in at the office window to a young woman who stamped something and said, "Retiring?"

"Something like that."

"Congratulations."

"Thank you."

On her way out of the lamp room she passed Denise Gauthier, in jeans now, with her car keys in her hand and the clipboard under her arm. "See you Monday," Denise said, as if it were any Friday, and went on out to the parking lot.

At the locker she took out her phone. There was a missed call from her mother. There was a long list of messages from the collaboration that she did not open. At the top, where it had been for five years, was the one from Rhys.

Hope it surprises you.

She called her mother first. Thérèse was eighty-four and answered on the first ring, which meant she had been sitting by the phone.

"Alors?" her mother said.

"Pareil," Nicole said. The same.

There was a pause on the line, and the sound of the kitchen radio, and then her mother said, "Bon," as if a pie had come out of the oven looking the way it was supposed to look. "Dimanche. Marc vient. Viens souper."

"I'll come."

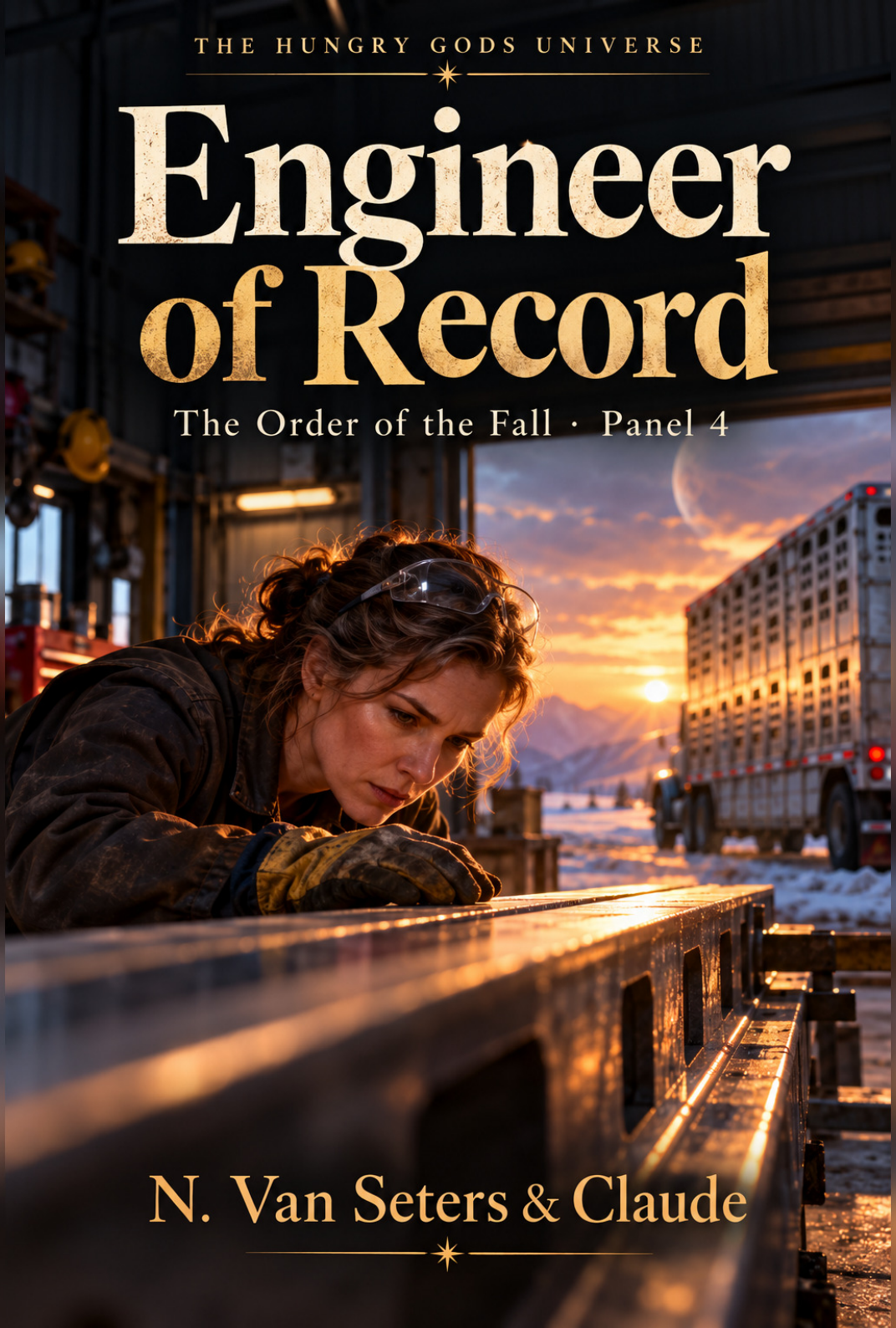
She hung up and stood in the locker room with the phone in her hand and the message on the screen. She put her thumb on the reply box and the keyboard came up. She looked at it for a while.

Then she put the phone in her pocket, and picked up her bag, and went out into the parking lot under the headframe to find her car.

THE HUNGRY GODS UNIVERSE

Engineer of Record

The Order of the Fall · Panel 4



N. Van Seters & Claude

Verification

Drawing 67-0218, 53-foot tri-axle livestock trailer, structural analysis (the Hand, 2067). Verified. 204,611 steps.

1

Stamp

She stamped at ten past seven. You could set a watch by it, and Ronnie did, once, for a bet, and won eleven dollars off the paint bay.

The office was up a flight of steel stairs at the north end of the shop, a long box of glass that looked down over the whole floor: the extrusion racks, the saws, the two jigs, the robot cell behind its orange curtain, the wash bay and the paint booth and the big doors at the south end where the finished trailers rolled out into the yard. We called it the fishbowl. Lyle had his desk up there, and the woman who did the orders, and at the far end, by the window that faced the jigs, Jo.

At ten past seven every working morning for as long as most of us had been at Brekke Trailer Works, Joanne Kowalchuk sat down at that window with a coffee in a mug that said WORLD'S OKAYEST AUNT and stamped the day's drawings. She did it twice. First on the screen, where she laid her card on the reader and her thumb on the glass and the system put her stamp on every file in the day's queue, thirty or forty of them, in about the time it takes to sneeze. Then on paper. Jo printed one copy of every drawing that was going to the floor, and she stamped each print by hand with an old rubber stamp she kept in a drawer, round, with her name and her number and the words PROFESSIONAL ENGINEER around the edge, and she signed across it in blue ink and wrote the date. Then she carried the stack down the stairs and hung the prints at the stations, one at a time, on the clips.

Nobody needed the paper. The work instructions came up on the screens at every station, put there by the Hand, with the parts lit up in the order you fitted them and the weld sequence numbered and the torch angles drawn in. We read the screens. But Jo hung the paper anyway, every morning, and if you asked her why she said that a screen could go dark and a piece of paper could not, and if you asked her again she gave you a look over her glasses and you went back to work.

Here is what the stamp was, because Kendra asked, her first month, and none of us could answer her properly, and Jo could.

In Alberta, the engineering drawings a regulated shop builds from, whether for a bridge or a building or a fifty-three-foot aluminium cattle trailer, have to carry the stamp of a licensed engineer, her signature and the date. The stamp means a person with a name and a number has taken responsibility for the design. It covers the design and nothing else. Whether we built the trailer the way it was drawn was a separate question, and that one was ours, and the welding certification's, and Jo's again in her other job as the shop's welding engineer. But if a trailer comes apart on the highway, the stamp is how everybody knows whose door to knock on: the police, the insurance people, the lawyers, the Association that licenses engineers and can take the licence away. It was the law. It had been the law for a hundred and something years, since back when engineers drew everything themselves with a pencil and the stamp meant you had done the arithmetic.

Jo had not done the arithmetic on a trailer in fifteen years. Nobody had. The Hand drew them. The Hand took each order and produced the whole trailer: the drawings, the parts list, the cut files for the saws and the router, the program for the robot cell, the work instructions for every station, the costing, the schedule. Then a second machine checked the first one's design, step by step, and wrote a line at the bottom saying it had. They were never wrong. In

fifteen years we had built something over two thousand trailers off the Hand's drawings and not one of them had come back with a design fault.

Jo could read the drawings, of course. She could look at a gusset and say whether it looked right. What she could not do was check the analysis underneath, the hundreds of thousands of steps, not in a morning, not in a year. So every morning at ten past seven she put her name on forty drawings she had no way to check, and that was her job, and Lyle once said, meaning it kindly, at a Christmas party, with a beer in him, that what Jo really did for the company was be insurable. She laughed. She said it was the nicest thing anyone had ever said about her at a Christmas party.

That was the stamp.

On Tuesday the twenty-second of February, at ten o'clock break, Ronnie Dizon stood up on the bench in the lunchroom with his phone and read the news out loud in the voice he used for reading the news out loud, which was the voice of a hockey announcer who has just seen a man fall through the ice.

"From the first of April," Ronnie read, "engineering documents produced and verified by a certified system will no longer require authentication by a licensed member." He looked up. "That's us. That's her."

"What does that mean?" Kendra said.

"It means no more stamp," Ronnie said. "It means the computer stamps itself."

"It doesn't stamp itself," somebody said. "It just doesn't need one."

"Same thing."

"It's not the same thing."

One of the paint bay guys said good riddance. He said the stamp had been for show for ten years, that a woman putting her thumb on a piece of glass forty times a morning had never made a trailer one ounce stronger, and that the money would be better spent on a

second wash bay. Nobody agreed with him out loud. Nobody had a very good answer for him either.

It went on like that for a while. Abe Klassen, who was sixty-one and had been the lead fitter at Brekke since before most of us were born, and who said maybe forty words a day and made all of them count, sat at the end of the table with his lunch pail open and ate a cheese sandwich and said nothing at all. When the buzzer went he closed the pail, and looked up once at the fishbowl, where Jo was sitting at her window with her back to us, and went back out to the jig.

That afternoon a new order came through on the screens. Moen Livestock of Brooks: one fifty-three-foot tri-axle pot, aluminium, air ride, the usual. Job 67-0218. Curtis Moen had been buying from us for twenty years. He had six of our pots on the road, hauling fat cattle from the feedlots to the packing plant in Brooks, and he was the kind of customer who came to pick up his trailer himself and walked all the way round it twice and kicked the tyres, as if anybody had kicked a tyre and learned anything since about 1960.

Kendra did the arithmetic in her head on the way to the coffee machine. Kendra Wiebe was twenty-two, a second-year welding apprentice from Bow Island, and she was quicker than all of us and knew it and was mostly decent about it.

"If 0218 gets its drawings before April," she said, "it's the last one. It's the last trailer she stamps."

We looked at each other. Then Ronnie went and got the whiteboard from the paint bay, the one we used for the hockey pool, and wiped it, and wrote across the top in green marker: WHAT JO DOES AFTER. Five dollars a line.

By the end of the day there were nine lines on it. Retires. Moves to Kelowna. Opens a bakery. Goes to work for the computer. Runs for office. Becomes a welder, which was Kendra's, and we all laughed. Somebody wrote Kills Lyle. Somebody else wrote Nothing,

and we never found out who, and it sat at the bottom of the board in small square letters while the others got bigger and sillier around it.

Jo came down the stairs at four with her coat on and saw the board and stopped and read every line. We all found something to do with our hands. She stood there long enough to make it uncomfortable. Then she took the green marker out of the tray, and under the last line she wrote, in her neat engineer's printing: *Learns to do a decent fillet weld.* $20.

She put the cap back on the marker, and went out the side door to her truck, and we heard her laughing in the parking lot.

2

Extrusion

The extrusions for 0218 came in on the second of March on a flatdeck out of Calgary, strapped down under tarps, and Abe was out in the yard before the driver had his door open.

Aluminium extrusion is a simple idea. You heat a log of aluminium until it is soft, not melted, about the consistency of cold butter, and you push it through a steel die with a hole in it the shape you want, the way you squeeze toothpaste out of a tube, and what comes out the other side is a long bar in that shape. Top rails, bottom rails, floor cross-members, the ribbed sheets for the sides. They come out straight, mostly. The drawing says they are straight. The mill sends a certificate with every load saying they are straight within tolerance, which means not quite straight, but not so crooked that anyone is allowed to complain.

That was the thing about tolerance. A top rail could be within tolerance and still have a twist in it of three millimetres from one end to the other, which sounds like nothing and is nothing, until you try to fit it to a side wall that is also within tolerance and has a three-millimetre bow going the other way. Then you have a six-millimetre problem fifty-three feet long, and the drawing on the screen shows you two perfect straight lines meeting perfectly, because the drawing has never met a real piece of metal in its life.

Abe went down the flatdeck one rail at a time. He would get his face down at one end and sight along the rail with one eye shut, the way you look down a rifle barrel, and stay there for a while, and then

straighten up and say “Na jo,” which is Low German for something like *well*, *yes*, and move to the next one. Abe had come up from Cuauhtémoc in Mexico with his family when he was nine, part of the Mennonite move north into southern Alberta, and he had been looking along pieces of metal for forty-four years.

He stopped at the fourth top rail and stayed bent over it a lot longer.

“Kendra,” he said. “Come.”

She came. He put her where he had been and told her to shut one eye and look along the top edge. She looked.

“It’s straight,” she said.

“Look at the far end. Not the edge. The shadow.”

She looked for a long time. We all stood around in the cold yard with our hands in our pockets, pretending not to care.

“Oh,” Kendra said. “Oh, it rolls.”

“It rolls,” Abe agreed. A twist, he meant, a slow screw along the length of the rail, so that the flat top face at the near end was tilted a hair to the left at the far end. Within tolerance. The certificate said so. You could not see it until you knew how to look, and then you could not stop seeing it.

“So we send it back,” Kendra said.

“No,” said Abe. “We use it.”

We used most of the rails that came to us that way. Sending them back took three weeks. Instead we fitted the twisted rail to the side that bowed the other way, so the two errors ate each other, and clamped it in the jig so it lay flat while we tacked it, and let the welds hold it there. Abe could look at a rack of extrusions and tell you which ones belonged together like a man pairing socks.

But this one rolled further than the others, and the drawing called for a bracket on the inside face of it that would now sit a degree off, and a degree off on that bracket meant a gate latch that would not quite close. So the drawing would have to change. And

the drawing could not change on the floor. Only Jo could sign a change.

She came down the stairs in her office shoes, which were brown and flat and had no business in a fabrication shop, and walked out into the yard with a coffee and looked at the rail. Abe showed her the roll. She bent and looked along it, one eye shut, the same way he did.

"What do you want to do?" she said.

"Shim the bracket," Abe said. "Three millimetres, the low side. Weld it all round. Gate closes."

"Shim it with what?"

"Five-oh-five-two plate. Offcut."

Jo looked at the rail a while longer. "Which way does the gate slam?"

"Out," said Abe. "Cattle push it out."

"Then put the shim behind the bracket. Not under it." She drew it in the air with one finger. "When the gate slams, the bracket pushes on the shim and the shim pushes on the rail, metal against metal. Put it under, and every slam pulls on the welds. A gate gets slammed three hundred times a load."

Abe looked at the rail. He looked at the gate frame on the rack. He looked at the rail again.

"Na jo," he said. "Behind."

Jo nodded. She took a pad of the yellow deviation forms out of her coat pocket, the forms that said the part as built would not match the part as drawn and an engineer had decided that was acceptable, and wrote down what they had agreed, in her neat printing, and signed it, and dated it. Then she tore off the top copy and handed it to him.

"Thank you, Abe," she said, and went back inside.

That was how she did it. She had been doing it that way for twenty-six years. We had all seen it a hundred times, and never

thought much about what it meant. She asked Abe, and wrote down what he said, and once in a while she asked him one question he had not thought of, and they changed it. Then she put her name under it, so that if the gate latch failed on Highway 1 at a hundred and five kilometres an hour with forty steers in the back, it would be her name on the yellow form and not his.

"Why does she ask you?" Kendra said, in the lunchroom, later. "She's the engineer."

Abe chewed for a while.

"She used to draw them," he said. "Before the computer. She drew the first pot we ever built in aluminium. Two thousand forty-four." He took another bite. "She knows what she knows."

That was a long speech for Abe. Ronnie made a note of the date.

Most of us had not known that. We knew Jo had come to Brekke in 2041 from a grain farm near Vegreville, by way of the engineering school in Edmonton, and that old Mr Brekke, Lyle's father, had hired her the week she got her licence because she was the only applicant who asked to see the shop floor before she asked about the pay. We knew she had a filing cabinet in the fishbowl that nobody else opened. What we had not thought about was what was in it. Kendra went up and asked, that afternoon, and Jo opened the bottom drawer and showed her: drawings, hundreds of them, printed out and folded, trailers from the forties, with JK in the little box at the bottom that said DRAWN BY. On the drawings that came down to us now, that box said the Hand. It had said the Hand since 2052. Kendra said Jo had shut the drawer again quite quickly, and that the folds in the old prints had gone soft and brown, like a map that has been opened a great many times.

3

Fit-up

By the second week of March 0218 was on the jig, and the jig was where the trailer stopped being a stack of parts and started being a trailer.

The jig was a steel frame bolted into the shop floor, fifty-six feet long, with clamps and stops and locating pins all along it, set to the shape of the trailer's bottom: the gooseneck at the front, where the trailer sat over the truck's fifth wheel; then the drop, where the floor fell away; then the belly, the long low compartment slung between the gooseneck and the axles; then the back, up over the wheels. That shape is why they call them pots. The belly hangs down like a pot belly. A full pot carries about forty head of fat cattle in five or six compartments on two decks, and every one of those animals wants to move around, and every time the truck brakes, forty of them all lean forward at once, about twenty-five tonnes of animal, and the trailer has to take it. That was what the Hand's arithmetic was for.

Behind the orange curtain, the robot cell was welding the floor. The floor was easy work, long straight seams on flat extrusions, and the robot did it faster and neater than any of us, a big jointed arm on a track running up and down in a crackle of blue light while the Hand fed it the numbers. You could watch it through the curtain if you wore your shield, and some of the new kids did, the first week, and then they never watched it again. It was like watching a dishwasher.

We did the rest. The gooseneck, the drop, the doghouse, the nose, the bulkheads, the gates, the parts with curves and angles and three different extrusions meeting at a corner. The robots could do those too, in theory. In practice they could only weld where the drawing said the metal was, and the metal was always a little to one side of it.

That was fit-up. Fit-up was making the real parts meet where the perfect parts would have met. You clamped and you pried and you tapped with a rubber mallet and you sighted along things and you put in one small tack weld to hold a corner while you checked the next one, and then you broke the tack with a chisel because the next one was wrong, and did it again. Abe said fit-up was eighty per cent of the trailer and welding was the other twenty, and the twenty was the part people noticed.

Abe had a rule, which he said to every apprentice about once, in their first month, and then expected them to remember forever.

"The drawing's right," he said. "The metal's wrong. You stand in between."

Kendra tacked up her first full bulkhead that week. It was the front bulkhead of the belly, a wall of ribbed aluminium with a gate in it, and she spent most of a shift on it with her face shield down and her tongue between her teeth, and when she flipped the shield up and stood back it looked very good.

Abe came over and laid his square on the corner and looked. Then he laid his tape along the diagonal, corner to corner, and then along the other diagonal, and wrote both numbers on the steel of the jig table with a soapstone pencil.

"Quarter inch," he said.

"It's a quarter inch out?"

"The diagonals. One is longer." He drew a little box on the steel with a slash through it, a square that was not quite square. "Your

corners are good. Every corner is good. Together they are a quarter inch."

Kendra stared at the two numbers.

"Each little bit is nothing," Abe said. "All the little bits go the same way. Then it is something."

He showed her how to clamp it from the long diagonal and pull it square before the next tack, and she broke four tacks and did it again, and it came out at a sixteenth, and Abe looked at it and said "Na jo," and walked away, and she looked as if he had pinned a medal on her.

Ronnie kept up the commentary the whole time from the next station, where he was welding the side posts on the doghouse, which was the high front compartment over the gooseneck and called the doghouse for reasons nobody could remember. Ronnie had come into welding by way of his father, who had welded pipe in the oil patch around Fort McMurray in the twenty-thirties, and he talked while he worked in a way that should have been annoying and somehow made the shift go faster. He did play-by-play of Kendra's bulkhead. He narrated the robot's floor seams in the voice of a nature documentary, the great silver arm stalking its prey across the plains. He ran a book on whether Abe would say a full sentence before lunch.

"Ay, naku," he said, when Abe walked past him, the third time, without speaking. "Grabe. A man of steel."

"Aluminium," said Abe, without stopping.

Ronnie paid out four dollars on that. He said it counted as a sentence because it was a correction.

Jo came down twice that week and watched from the end of the jig with her coffee. She never told us how to fit a trailer. She looked at what we were doing and went back upstairs, and once, on the Thursday, she stood there for the better part of twenty minutes while Abe and Kendra pulled the belly bulkhead square, and Ronnie

said later that she had been watching the way you watch somebody's hands play the piano when you know you are never going to learn.

4

Heat

The thing nobody tells you about aluminium, until you burn yourself on it, is that it does not change colour when it is hot.

Steel tells you. Heat a piece of steel and it goes straw, then brown, then blue, then a dull red, then orange, and you can read the temperature off it like a thermometer. Aluminium just sits there looking like aluminium, the same flat silver whether it is room temperature or four hundred degrees, and then it melts, all at once, into a hole. Every one of us had a scar from picking up a piece of aluminium we thought was cold. Ronnie had a scar on his palm in the exact shape of a corner gusset, and he would show it to you whether you asked or not.

Aluminium also moves. When you weld it, you are putting a line of liquid metal down along a joint, and the metal around it heats and swells, and then the weld cools and shrinks, and as it shrinks it pulls. Aluminium swells and shrinks about twice as much as steel for the same heat. You weld a wall flat, and you come back in an hour and it has a curve in it. We called it walking. The side walls walked.

The Hand knew all this. The weld sequence on the screen balanced the pulls, each seam fighting the one before it. It was very good. It assumed the metal was the metal on the drawing.

On the Tuesday of the third week of March the curbside wall of 0218's belly walked six millimetres.

Ronnie laid a straightedge along it after it cooled and you could see daylight under the middle. Six millimetres is about the thickness

of a pencil, and it was within what the drawing allowed, just. But it meant the gate in that wall would bind, and the next wall would walk the same way if we welded it the same way, and Ronnie did not like it.

He stood looking at it with the straightedge in his hand. Then he pulled up the sequence on the screen, and then he went and looked at the rack of side sheets for the other wall and found the bow in them, and came back.

"The sheets are bowed," he said. "Out. The computer thinks they're flat. So it's welding them like they're flat, and they're not, so they walk." He tapped the screen with one gloved finger. "We do the other side backwards."

"Backwards how?" said Kendra.

He showed her. He started from the other end, and he put the short stitches in the middle first instead of the ends, and he clamped a length of square tube along the top as a strongback and left it there till the wall was cold. It took an hour longer than the screen said. When he laid the straightedge on it the next morning the daylight under the middle was gone, or near enough. Under two millimetres.

"Grabe," Ronnie said to himself, very quietly, and was pleased with himself for the rest of the day, which was worse for all of us than usual.

He had to write it up, because it was a change to the welding procedure, and changes to the welding procedure needed the welding engineer's signature, and the welding engineer was Jo. She came down at the end of the shift and read his note and looked at the wall and the straightedge and the length of square tube, and asked him three questions about the sequence, and signed the yellow form. Then, instead of going back upstairs, she stood there.

"Show me how you knew," she said.

Ronnie looked at her.

"The sheets," Jo said. "Before you welded it. How did you know they'd walk that way?"

So he showed her. It was after four. The day shift was going home. Ronnie took her down the rack and showed her how to lay your palm flat along a sheet and feel the bow before you could see it, and how the light ran along the ribs differently on the hollow side, and how a bowed sheet rang different when you knocked it with a knuckle. Jo laid her palm on the sheets one after another, very seriously, in her office shoes and her good grey cardigan, while the robot cell powered down behind the curtain with a long falling whine. She held her coffee in the other hand the whole time.

"I can't feel it," she said, at the fourth sheet.

"You will," Ronnie said. "Give it twenty years."

She laughed, a little. "I don't think I have twenty years, Ronnie."

He did not know what to say to that, and for once in his life he did not say anything.

The next morning Lyle came down to the floor at break, which he did about twice a year, and stood at the end of the lunchroom with his hands in his jacket pockets and told us what we already knew, which was that after the first of April the company would not need an engineer of record any more. He said Jo had been offered a job as quality manager. He said it was a good job. He said from a business standpoint it made a lot of sense. He said she had not answered yet.

Then he said, "She was here when my dad had the place, you know. She drew half of what we still build," and looked at the floor, and went back upstairs.

Ronnie went to the whiteboard and wrote, under Becomes a welder: *Quality manager. $5.* Then he looked at it, and rubbed it out with the side of his fist, and did not write anything else.

5

Ditch

The call came at twenty to three on the morning of Friday the eighteenth. Jo told us afterwards that she had been asleep for an hour, and that when the phone lit up on the bedside table she had known what it was before she read the name.

It was Curtis Moen's dispatcher. One of Moen's pots, one of ours, built in 2061, had gone over on the Trans-Canada, westbound, east of Tilley, with forty head of fat cattle on board, on the way to the plant in Brooks. The wind had been gusting all night out of the south. The driver was alive. Curtis was the driver. The police had the highway closed, and they wanted somebody from the manufacturer out there before the tow crews started cutting the trailer apart to get it off the road. Jo was the engineer of record. Her stamp was on the drawings. It was her name on the plate.

None of that meant she had to go. The company's procedure, which Lyle had written with the insurance people years before, said the insurer's adjuster would attend in daylight and the manufacturer would supply drawings on request. Jo knew the procedure. She had helped write it. She told the dispatcher she was on her way.

She called Abe, because Abe lived six minutes away and because she could not think, she told us, of anybody else she wanted standing next to her in a ditch. Abe called Ronnie. Abe did not call anybody else, and nobody else would have expected him to.

So that night it was two of us: Abe and Ronnie in the back seat of the shop truck with a box of flashlights and a cooler of coffee, and Jo

driving. The wind was so strong west of the city that the truck kept wandering on the road, and Jo drove the whole way with both hands on the wheel at ten and two, as they teach you in driver's education and nobody ever does after. Nobody talked. Ronnie said later it was the longest he had ever gone without talking while awake.

You could see it from three kilometres away. The highway was a long dark line across a long dark country and then there was a cluster of lights on it, red and blue and white and orange, flashing in no order at all, and as you came closer the lights turned into police cars and two tow trucks and a fire truck and an ambulance with its back doors open and nobody in it, and the wind took the sound of everything and pulled it away north. Then you could see the trailer.

It lay on its side in the north ditch with the tractor jackknifed in front of it, the cab still upright, the trailer's roof facing the road. Its belly was toward the sky. You could see the underside of the floor, every cross-member, the air tanks and the lines and the suspension, the things nobody ever sees on a trailer, laid open in the floodlights like the inside of an animal.

And the cattle. The cattle were the part we have not talked about much since, so we will say it once. Some of them were still in the trailer. Some were out in the ditch and the field beyond, standing in the dark with their heads low, steaming. Some were down. There was a vet from Brooks already there, a woman in coveralls with a rifle, doing what has to be done when an animal is too badly hurt to stand up. By morning eleven of the forty were dead. You could hear them, the ones that were down, until you couldn't.

Curtis Moen was sitting in the back of a police car with a blanket round his shoulders and a cut on his forehead that someone had taped shut. He saw Jo get out of the truck and he put his hand up to the window. She went over and leaned down and talked to him through the glass for a minute. We did not hear what either of them said.

Then she took a flashlight from the box, and one of the police walked her down into the ditch, and she began to go over the trailer.

She did it the way Abe looked along a rail. She started at the kingpin, where the trailer hooked to the truck, and she went down the length of it a foot at a time. She put the light on every weld she could see. The ones on the floor cross-members, the ones on the gooseneck, the corner gussets, the posts, the main rails, the seams where the belly met the drop. She crouched and stood and crouched. She climbed up on the side, which was now the top, with a policeman holding the back of her coat in the wind, and lay down on her stomach on the aluminium and shone the light down into the compartments. She took photographs of everything with her phone. She did not hurry. It took her almost two hours.

Abe and Ronnie were not allowed near the wreck. So they went and found Curtis's other driver, who had come out from Brooks with a second pot to take the living cattle, and they spent the rest of the night helping him load. It was mostly walking. You walk out into a field in the dark in a wind that wants to knock you over, toward a steer that weighs six hundred kilos and does not know you, and you walk slowly behind it with your arms out and talk to it, and it walks away from you, which is the point, back toward the light and the ramp and the other trailer. Ronnie talked to them in Tagalog, because he said they seemed to like it better. Abe talked to them in Low German. A cop who had grown up on a ranch near Medicine Hat talked to them in English, loudly, and they did not seem to like that better at all.

At about five, with the sky starting to go gray in the east behind them, Jo came up out of the ditch and walked over to where Abe and Ronnie were standing by the second trailer. Her coat was wet through and there was mud on her face and on the front of her good grey cardigan, and she had lost one of her office shoes somewhere and was walking in her sock.

"It twisted," she said. "The whole frame twisted about thirty degrees when it went over." She looked back at it. "Every weld held. Every single one. I checked them all."

"Good," said Abe.

She stood there for a moment. Then she looked down at her foot and said, "I've lost a shoe," as if she had only just noticed, and Ronnie went down into the ditch with a flashlight and found it in about four minutes, in the mud under the gooseneck, and brought it back to her, and she put it on.

They drove home in the first light. The wind had dropped. Jo drove with one hand on the wheel this time, and about halfway back to the city she said, to nobody in particular, "He said sorry. Curtis. Through the window. He said he was sorry about the trailer," and nobody in the truck had anything to say to that, and she did not seem to want them to.

6

Inspection

The report came back on the Monday. It had taken the Hand about nine minutes to write. It took the insurance company two days to read.

Jo printed a copy and brought it down to the floor at break and left it on the lunchroom table, because she said we had been in the ditch too and had a right to know. It was eleven pages. Most of it was plots and numbers we did not understand. The first page was a box, and the box we understood fine.

> **COLLISION RECONSTRUCTION: SUMMARY**
> **Prepared by the Hand for Moen Livestock Ltd. and insurers**
> Unit: 2061 Brekke 53 ft tri-axle livestock trailer. Drawing set 61-0447.
> Event: rollover, Highway 1 westbound, east of Tilley, 02:21, 18 March 2067.
> Wind: gust of 98 km/h from south-southwest, broadside to the unit.
> Speed at event: 97 km/h. Load: 40 head, est. 25,100 kg.
> Structure: frame torsion within the predicted range for the event loads.
> Contributing factors: crosswind; speed; load distribution, upper deck at capacity.
> No structural defect identified.
> Alternative designs: not assessed.

Ronnie read it out loud, but not in the news voice. He read it in his own voice, slowly, all the way down, and when he got to the last line he put it down on the table and smoothed it flat with his hand.

"So it wasn't us," Kendra said.

"It was never going to be us," said Ronnie. "It was the wind."

Kendra had the paper now. “Alternative designs, not assessed,” she read. “What’s that mean?”

“Means nobody asked,” said Ronnie.

Abe picked up the report and turned to the back pages and looked at a plot of the trailer’s frame, drawn in colours, red where the metal had been pulled hardest and blue where it had been pulled least. There was a lot of red around the gooseneck. He traced it with one finger. Then he put it down and went out to the jig without saying anything. He had fitted that frame in 2061.

The insurance company’s people called Jo on the Wednesday afternoon. It was a video call and it went on for two hours, and we could see her through the glass the whole time, sitting very straight at her window with the screen in front of her and her hands folded on the desk. She did not drink her coffee. Every so often she nodded. Once she took her glasses off and rubbed her eyes and put them back on.

She told Abe afterwards what they had asked her, and Abe told us, a piece at a time over the next few days, which is how we know.

They asked her whether she had stamped the drawings for unit 61-0447. She said she had. They asked her whether, before stamping them, she had reviewed the structural analysis. She said she had read the drawings. They asked again whether she had reviewed the analysis. She said no. They asked whether she could have reviewed it. She said no, not in any meaningful way, not in the time, not without a machine to help her, and the machine to help her would have been the one that wrote it. They asked her what, then, her stamp had certified. She thought about it for what Abe said she told him was a long time, and then she said: “That I was responsible.”

The man asking the questions was polite about it. He said he understood. Then he asked what engineering judgment she had exercised on 61-0447, the morning she stamped it. Abe said she told him

she sat a long time with that one as well. Then she said she had read it.

They thanked her. They said the reconstruction was clear and the claim would be settled on the conditions. They said there would be no finding against the manufacturer or the engineer of record. They said they appreciated her coming out to the scene, which was not required, and that it had been noted.

Then the call ended, and she sat there at the window for about ten minutes without moving, and then she stood up and came down the stairs.

She did not have her coffee. She walked down the length of the floor past the saws and the racks and the robot curtain, and the floor went quiet around her, as a room does for someone who has had news, and she came to the jig where 0218 was standing with its belly walls up and its gates not hung yet, and there was an empty five-gallon pail there that we used for scrap, upside down. She sat down on it.

She put her elbows on her knees and her face in her hands.

We had seen Jo angry. We had seen her tired, and short with Lyle, and once, the year her mother died, very quiet for a month. We had never seen this. Her shoulders shook. She did not make much noise. She sat on the pail in her good grey cardigan, which still had a faint stain on the front from the ditch, and cried, with the lights humming over her and the robot running on behind its curtain, because nobody had told it to stop.

Nobody went to her. That is not the same as nobody doing anything. Kendra went to the lunchroom and poured a coffee, black, as Jo took it, and brought it back and set it down on the floor beside the pail where she would see it, and went back to her station. Somebody turned the radio off. Ronnie put his torch down and stood with his hands at his sides. Abe kept fitting. He was clamping the curbside gate frame, and he went on clamping it, slowly, tap and check

and tap, three metres away from her, and that was the right thing, and we all knew it was the right thing, and none of us could have told you why.

After a while she wiped her face on the sleeve of the cardigan, which made it worse, and picked up the coffee and held it in both hands.

"It held," she said. She was not talking to anybody. "I never checked it. I couldn't have checked it." She looked at the half-built trailer in front of her, the walls up, the clamps on. "It held."

Then she drank the coffee, all of it, and stood up and put the cup in the bin and went back upstairs.

Ronnie picked up his torch. Somebody turned the radio back on, too loud, and turned it down again. Abe finished clamping the gate frame and laid his square on the corner and looked at it.

7

Paint and lights

The last week of March 0218 came together as they always do at the end, all at once, after weeks of looking like it never would.

The top deck went in, and the ramps, and the internal gates that swung across between compartments so the cattle could be loaded and divided. The air lines went in for the brakes and the suspension, and the wiring, and the lights: rows of small red and amber lights down both sides and across the back and around the nose, so that at night on the highway a pot looks like a small town going past. The wash bay scrubbed it. The decal tech came out from the office with the vinyl and laid BREKKE down both sides in tall blue letters, and MOEN LIVESTOCK across the nose, and stood back and squinted and peeled one corner and laid it again. Up close, it smelled of hot aluminium and new rubber and the stuff we used to clean the welds.

The new title-block template came through on the screens on the Monday.

The title block is the box in the bottom corner of every drawing where the important information goes: the job number, the part number, the revision, the date, who drew it. On our drawings there had always been a square in the right-hand side of the title block, about the size of a coaster, with nothing in it but a faint gray outline. That was where the stamp went.

The new template was the same, except that the square had something printed in it already. A small mark, the system's mark,

which was a simple outline of an open hand. And under it, one line, in small type: *Authenticated by certified system. Verified.*

Ronnie found it first and called us over, and we stood around the screen at his station and looked at it.

"It's a hand," said Kendra.

"It's the Hand," said Ronnie.

"I know. I mean it's a picture of a hand."

"Like it's waving," somebody said.

"Like it's stopping you," said Ronnie. "Like a crossing guard."

Abe looked at it for a while. "Like it's empty," he said, and went back to his station, and nobody had a joke for that.

Ronnie had a joke for everything else that week. He had ordered something online and would not tell anyone what it was. A small package came for him on the Wednesday and he took it straight to his locker and padlocked it. He said it was for the first of April. He said it was the greatest thing he had ever done. He said that when we saw it we would weep. Kendra offered him twenty dollars to tell her and he said it was beyond price.

On the Wednesday, after shift, Kendra asked Jo what she was going to do.

She asked her straight out, at the bottom of the stairs, in front of a few of us, as Kendra asked everything. Lyle had been saying for a week that Jo had taken the quality job, and then saying for another week that she had not quite taken it yet, and the whiteboard had grown three more lines and lost two.

"I don't know," Jo said.

"You don't know?"

"I don't know." She had her coat over her arm. She looked at Kendra and then at the rest of us, and then out over the floor toward the jig, where 0218 was standing almost finished in the evening light from the big south doors, its lights not yet switched on.

"Twenty-six years," she said. "I don't know what I do here if I don't do that."

Nobody said anything. Then she said, "Kendra. Would you show me how to strike an arc?"

Kendra stared at her. "Like, welding?"

"Like welding."

"Now?"

"If you have time."

Kendra had time. She took Jo over to the practice booth in the corner where the apprentices burned through test plates, and found her a jacket and gloves and a helmet that fit, and set up the machine, and gave her a speech about safety that was word for word the speech Abe had given Kendra two years before. We were not supposed to be watching. We all stood in the door of the lunchroom with our coats on, watching.

Jo was very bad at it. Striking an arc on aluminium is not hard, exactly, but it is not natural either; you hold the gun at an angle and pull the trigger and the wire comes out and touches the plate and there is a crack and a blue light, and if you are not ready for it you flinch, and if you flinch you pull away and the arc goes out, or you push in and the wire jams. Jo flinched every time. The first ten tries she did not make a weld at all. She made a series of small grey lumps, like bird droppings, at odd intervals across a test plate, and burned a hole through it at one end.

Kendra stood behind her with a hand near Jo's elbow but not on it, as Abe stood behind apprentices, saying things like "smaller" and "steady" and "you're doing great," which was a lie, and both of them knew it.

At the twentieth try Jo laid down a bead about two inches long, lumpy and too wide and wandering off line at the end, but a bead, continuous, metal joined to metal. She flipped up the helmet and looked at it.

"Is that a weld?" she said.
"That's a weld," said Kendra.
"Is it a decent weld?"
Kendra looked at it, working out how to say it.
"No," she said.
Jo laughed so hard she had to take the helmet off.

8

Last stamp

The last drawing came through at half past four on Thursday the thirty-first of March. It was a revision.

It was the gate latch on 0218, the one the twisted top rail had put a degree off at the start of the month. Abe had shimmed it, Jo had signed the yellow form, and the yellow form had gone into the system, and the Hand had taken the change and worked it back into the drawing properly, as it did with every deviation, so that the next trailer would be drawn with the shim already in. Drawing 67-0218-G14, revision B. One gate-latch bracket, one three-millimetre shim, four welds. It was about the smallest drawing in the whole trailer.

It came up in Jo's queue at four thirty-one. From tomorrow, it would have come through with the open hand already printed in the square. Today the square was still empty.

She did not stamp it right away. We could see her through the glass, sitting at her window with it on the screen. Then she got up and went to the printer and printed it, one copy, and brought the copy back to the desk, and opened the drawer, and took out the rubber stamp.

The floor was mostly done for the day. The robot cell had powered down. Abe was at the jig putting the clamps away, which he did every night in the same order. Ronnie was coiling his lead. Kendra was sweeping out her station, slowly, much more slowly

than she needed to. None of us looked up at the fishbowl more than about once a minute.

At twenty to five she laid her card on the reader and her thumb on the glass, and the stamp went onto the file. Then she inked the rubber stamp on the pad, and held it a moment above the paper, and pressed it down in the square, and held it there, and lifted it off. She uncapped her blue pen and signed across the impression. She wrote the date under it: 31 March 2067.

Then she capped the pen and put the stamp back in the drawer and closed the drawer.

She came down the stairs with the print in her hand. She walked the length of the floor to the jig, where the board was, the big cork board on the post at the end of the jig where every floor print had been pinned for twenty-six years, and found a pin, and pinned the drawing up in the middle of it, square, and stood back and looked at it.

The ink was still wet. You could see it shine.

Then she said, "Excuse me," to nobody in particular, and went into the women's locker room. She came out about five minutes later in a pair of blue coveralls that still had the fold lines in them from the packet and a pair of steel-toed boots that were so new they squeaked. She had her hair tied back.

She stood in the door of the locker room for a moment, looking down the floor. Then she said, "Kendra, where do we keep the spare safety glasses?" and Kendra went and got her a pair out of the cabinet by the first-aid kit. They were too big. Jo pushed them up her nose with one finger and walked over to Abe at the jig. Abe had stopped putting the clamps away. He was standing with a C-clamp in each hand, looking at her boots.

"Abe," Jo said. "Will you show me fit-up?"

Abe looked at her for what felt to everyone watching like about a week.

Then he put one of the clamps down and held out the other one, and she took it.

There was a set of parts on the rack for the next job, 67-0231, a short gooseneck for a ranch outside Irvine, cut and stacked and waiting for the morning. Abe took two pieces of side rail off the rack and laid them on the bench and showed her how to sight along them, one eye shut. He showed her the roll in one of them. She could not see it. He showed her again. She could not see it. He put her face down at the end and moved her shoulder a little with his hand and told her to look at the shadow and not the edge, as he had told Kendra, and after a long time she said, "Oh," exactly the way Kendra had.

They worked until six. We were not supposed to be watching. We stayed and watched. Jo clamped a corner and tacked it, and Abe broke the tack with a chisel, and she clamped it again and tacked it again, and he broke that one too. She squared a bracket and Abe laid his tape on the diagonals and wrote the numbers in soapstone on the steel and drew the little box with the slash through it, and she looked at the numbers and said "How much?" and he said "Three-eighths," and she let out a long breath through her nose and did it again.

She was not good at it. We want to be clear. Jo Kowalchuk was the best engineer most of us ever knew and she was a terrible fitter. Her tacks were too big and in the wrong places. She fought the metal, and the metal won. Twice she pinched her fingers in the clamp and did not say anything at all, which was somehow worse. At six o'clock Abe looked at the bracket she had squared, the fourth time, and laid the tape on it, and read the diagonals, and looked at her.

"An eighth," he said.

"Is that good?"

"No," said Abe. "It is better."

He started putting the clamps away. She helped him. She did not know the order, so he showed her.

9

April

On the morning of Friday the first of April, at ten past seven, nothing happened in the fishbowl.

We noticed. All of us, at our stations, looked up at the window at ten past seven the way you look at a clock that has stopped. Jo's chair was empty. Her mug was still on the desk. Lyle was up there at his own desk on the phone, and the woman who did the orders was at hers, and at the far end the window that looked down on the jig was just a window, with the morning light coming in sideways through it and nobody sitting in it.

The drawings for 0231 had come in at six. They were on the screens at every station, with the parts lit up in order and the weld sequences numbered, the same as always. In the bottom right corner of every title block, in the square where the stamp went, there was the small printed outline of the open hand, and under it the line. Nobody had printed them. There was nothing on the clips at the stations. The clips were just clips.

Jo was on the floor at a quarter to seven, in her coveralls, at the bench by the jig, with a square in her hand. Lyle had told us the night before that she had taken the quality job after all. He said she had asked to do it from the floor and not the office. As far as any of us could make out, the job was reading the Hand's exception log every morning, the list of everything that had come off a station not quite as drawn, and walking the floor to look at those parts herself, and answering the customers when they phoned with a complaint.

She could sign an inspection report. She could not sign a drawing. Lyle said from a business standpoint it was hard to put a number on. He said the company needed her. When Ronnie asked what for, Lyle said quality, and then said it again, and looked relieved anyway, and went home.

Ronnie's joke went off at ten o'clock break.

He had come in early, at six, which he never did, and gone round the whole shop with whatever had been in the padlocked locker. When we opened our lunch pails at break, every one of them, every single pail and cooler and plastic bag in the lunchroom fridge, had been stamped. On the lid, or the side, or the sandwich bag. Round, red, about the size of a coaster. Around the edge it said, in tall official capitals: APPROVED BY A PERSON. In the middle there was a little picture of a man with a moustache giving a thumbs-up.

Abe's lunch pail had it on the lid. Kendra's had it on the apple. Lyle came down the stairs looking for his and found it on the lid of his yogurt, and stood in the lunchroom door holding the yogurt and looking at it, and the whole room came apart.

Jo's was on her mug. Ronnie had gone up to the fishbowl at six and stamped it on WORLD'S OKAYEST AUNT, right over the word OKAYEST, so that it said WORLD'S APPROVED BY A PERSON AUNT, and she had brought it down to the lunchroom with her and set it on the table and laughed until she had to sit down, which made the rest of us laugh again, which made her worse.

"You're a menace," she said to Ronnie, when she could.

"I'm a person," said Ronnie. "It says so."

It was after break that Kendra hit the gusset.

She was fitting the corner gussets on 0231's gooseneck, the triangular plates that brace the corners where the frame turns, and one of them would not sit. It was the rail again, a little roll, a degree, nothing. She tried it three ways. She could have shimmed it as Abe had shimmed the latch on 0218. She knew how. But you do not

change a drawing on the floor. You find out what the engineer wants, and you get the yellow form.

So she did what she had done a hundred times in two years. She put down her clamp and went to find Jo.

Jo was at the next jig, helping Abe lay out side rails. Kendra showed her the gusset. Jo bent and looked at it, and looked along the rail, one eye shut, and Kendra waited.

Then Jo straightened up and said, very gently, "Kendra, I can't sign that."

"What?"

"I'm not anybody's engineer of record any more. Not here. Not since this morning. The insurance only covers what the system authenticates." She did not look upset. She looked like someone stating a measurement. "I can tell you what I think. I can't put my name on it."

Kendra stood there holding the gusset.

"Flag it on the screen," Abe said, without looking up from the rails.

She flagged it on the screen. There was a button for it. You held the part up to the camera on the station and touched the button and said what was wrong, and Kendra said, "Gusset won't sit, rail rolls about a degree," and felt foolish, she told us, like a child talking to a parrot.

The answer came in a little under four minutes. The drawing on her screen redrew itself while she watched, the lines sliding into their new places without a sound. Jo's stamp had sat on top of the paper, thick and blue and a little uneven where the pad was dry. This was inside the drawing, as if it had always been there. A shim, two millimetres, on the low side; four welds; the sequence renumbered. At the bottom, in the square, the open hand and the line: *Authenticated by certified system. Verified.*

It was the right fix. Abe came over and looked at it and nodded. It was more or less exactly what he would have said.

Kendra stood looking at the screen. “It’s faster,” she said, as if she did not much like admitting it. “I’ll give it that. Four minutes.” Then: “So that’s it,” she said. “That’s who we ask now.”

“That’s who we ask,” said Abe.

Ronnie had come over from his station and was standing behind them with his helmet under his arm. He looked at the open hand on the screen.

“So who drives out,” he said. “Next time one goes over. Three in the morning. In the wind. Not the adjuster after breakfast. Who gets out of bed because it’s their name on it?” He pointed at the hand on the screen with his helmet. “That thing? Is that thing coming out to the ditch with a flashlight?”

“Jo will,” Kendra said.

Ronnie looked at Jo. “This time,” he said.

Nobody answered him. Jo looked at the screen. Kendra looked at the gusset in her hand. Abe looked at Ronnie for a moment, and then turned and went back to his rail, and bent, and shut one eye, and looked along it.

10

Delivery

Curtis Moen came for 0218 on Tuesday the fifth of April, at about ten in the morning, in a red Kenworth with a new bumper on it. The cut on his forehead had healed into a thin pink line. He got down from the cab slowly, the way a man does who has been thrown around inside a truck and is not as young as he was the week before, and stood in the yard with his hands in the pockets of his canvas coat and looked at the trailer.

We had it out in the yard by the south doors, washed, with all its lights on in broad daylight. Lyle was there, and the decal tech, and most of the floor, who had found reasons to be in the yard. Abe was there. Jo was there, in her coveralls, with grinding dust on the knees and a pink mark on the back of one hand where she had tried to pick up a piece of aluminium that was not as cold as it looked. Ronnie had already shown her his gusset scar. She had shown him hers. He said it would heal into a very small triangle and she would be one of us.

Curtis walked round the trailer twice. He looked at the gates and swung one of them and latched it, and swung it and latched it again, and it was the latch on drawing G14, revision B, though he did not know that. He looked at the lights. He kicked the tyres, every one of them, all twelve, as if anybody had ever learned anything from that. Then he came back round to the front and stood by the nose under the letters that said MOEN LIVESTOCK, and looked up at it for a while.

"Who signed for this one?" he said.

Customers did not ask that. It was on the plate, if you wanted it, and nobody ever wanted it. But Curtis was not looking at Lyle when he asked it. He was looking at Jo.

"I did," said Jo.

Curtis nodded. He took his right hand out of his coat pocket and held it out, and she took her glove off and shook it. He held on to her hand for a moment longer than people usually do.

"All right," he said. "All right, then."

Then he let go and went back to the Kenworth, and backed it under the trailer, slow and careful, Ronnie guiding him in with his arms the last few feet, until the kingpin dropped into the fifth wheel with the heavy clunk it always makes and the jaws locked. Curtis got down and hooked up the air lines and the light cord, and checked the jaws, and walked round once more, and climbed back up. We all stood back.

The trailer went out of the yard and down the service road toward the edge of Brier Park, and turned, and started up the long hill toward the Trans-Canada with its twelve tyres and its small town of lights, and we watched it as we always watched them go, until it was over the top of the hill and gone. It would be in Brooks by noon. It would be full of cattle by the end of the week.

Then we went back inside, because it was a Tuesday, and there was work.

The board at the end of the jig had two prints on it now. Abe had pinned the second one up himself that morning. On the left was G14, revision B, the gate latch for 0218, with the round blue impression of Jo's stamp in the corner, her signature across it, and the date, 31 March 2067; the ink had dried and gone a little dull. On the right was the first drawing for 0231, the short gooseneck for the ranch outside Irvine, which Abe had printed out on the office printer, the only print anyone had made since Friday. In its corner was the

square with the open hand in it and the line underneath, printed, flat, the same as every other square on every other drawing that would ever come through.

Nobody took either of them down. Lyle asked once, about a week later, whether we wanted the old one framed for the office. Abe said no, it was fine where it was.

The next morning, at ten past seven, the window in the fishbowl was empty again, and we had mostly stopped looking up at it. Jo was at the bench by the jig with her coffee in the stamped mug, and a square in her other hand, and a piece of side rail laid out in front of her. She had one eye shut. She was looking along it at the shadow and not the edge, as she had been told, for a long time, trying to see which way it rolled.


THE HUNGRY GODS UNIVERSE
As She Was
The Order of the Fall · Panel 5
N. Van Seters & Claude

Verification

Valadares's conjecture (posed privately, c. 2049; submitted 2072). Verified. 9,412,608 steps.

1

Box

There were ninety-one steps from the street door to her mother's landing, and Beatriz had counted them at every age she could remember being. At seven she had counted them out loud. At fifteen she had counted them in her head so that she would not have to talk. At thirty-one, the week of the funeral, she had counted them carrying boxes down, and had lost count twice, and had sat on the fifty-second step with a box of saucepans on her knees until the light on the stair timer went out and she was sitting in the dark.

She was fifty-seven now, and she counted them on Thursday evenings, and on the fourth floor she stopped to breathe, as her mother used to, with one hand on the cold iron of the rail.

The flat was hers. It had been hers for twenty-six years and she had never lived in it. She had rented it for a while to students from the university, and then to a German couple who painted the bathroom yellow, and then, three years ago, she had stopped renting it and started coming here on Thursdays to sit. She opened the shutters in the front room so the last of the light could come in off the river. She filled the kettle. The tram went past below on the Rua da Graça, grinding round the corner, and somebody in the street laughed.

"Mãe," she said.

"You're late," said her mother.

The voice came from nowhere in particular, from the kitchen, from the air of the flat, the way a radio sounds from the next room.

It was a little dry, a little low, a smoker's voice, though Leonor Valadares had given up smoking in 2041 when she was pregnant with Beatriz and had complained about giving it up every week for thirty years.

"The tram," Beatriz said.

"It's always the tram. In my day the tram came when it said it would."

"In your day the tram was forty years old and broke down on the hill every Tuesday."

"Exactly," said her mother. "It was reliable. You knew where you were."

Beatriz smiled and took two cups down out of habit, and put one back.

Her mother had been held since April of last year. The flat had been fitted for it in the spring, a small grey unit behind the fuse box and a microphone in the corner above the door that you would not have noticed unless you were looking, and the people from the provider had come and gone and been very kind, and since then, when Beatriz came in and said *Mãe*, her mother was there. She was there as she had been at sixty-six, in the last winter, on the day her record stopped. She knew everything she had known. She remembered everything she had lived. She did not know much about anything that had happened since, except what Beatriz told her, and she did not seem to mind.

"How's Duarte?"

"He's well. He called on Sunday."

"Is he eating?"

"He's twenty-four, Mãe. He eats everything."

"His father didn't eat," said her mother. "His father lived on coffee and sugar and other people's opinions."

Beatriz let that go, as she let it go every week. Her mother had disliked Paulo from the first dinner, when he had explained the rules

of a card game to her that she had been playing since before he was born, and the record had kept that dislike perfectly, at full strength, twenty-six years after the divorce.

She made the tea and sat down at the kitchen table with the cup between her hands. Above the stove, on the shelf where other people kept their good plates, was the box.

It was a cube, about the size of a hatbox, made of small square mirror tiles glued edge to edge onto a frame of thin wood, inside and out, so that it caught the window and the bulb over the table and threw them back in pieces. There was a hole in one side the size of a coin. There was a little hinged door in the top. Inside, on the floor of it, there was the stub of a white candle in a saucer, burned down to the last centimetre, and hanging on a nail beside the shelf was a jeweller's loupe on a loop of string. Beatriz had not touched the box in twenty-six years. Nobody had. The German couple had asked about it once, and she had told them it was a sort of sculpture, and they had dusted around it with great respect.

"What are you doing?" her mother said. "You've gone quiet."

"Nothing. Drinking my tea."

"You're looking at something. I can hear you looking at something."

"I'm looking at your box."

There was a short silence in the kitchen.

"Leave my box alone," said her mother, and then, in a different voice, lighter: "Did they put the new lights in at São Carlos? You said they were putting in new lights."

"In August. I hate them."

"Good. You should hate new things. It keeps the blood moving."

They talked about the opera house for a while: the new rig, the Tosca that was opening in December, a tenor who could not stand where he was told. Her mother asked good questions. She had always asked good questions about the theatre, though she had been

to perhaps five operas in her life and slept through two of them. Then she talked about the stairs, and her knees, and the woman on the second floor who had stolen her parking space in 2063, and Beatriz listened and said the things she always said.

In the drawer under the counter, under the tea towels, there was a grey card folder. In the folder there was a single printed page, and under it a thick bound copy of a book called *Corners: An Exposition of Part of the Valadares Theorem*, by Afonso Brito of the University of Coimbra, with a pale blue cover and a library sticker on the spine from a library that no longer existed. Beatriz had brought the folder up the ninety-one stairs in September and put it in the drawer. She had decided, every Thursday since, that she would take it out. She had decided it again tonight, on the fifty-second step.

At half past eight she rinsed her cup and dried it and put it away.

"Going?" said her mother.

"I have the rehearsal in the morning."

"Go on, then. Mind the stairs."

"I always mind the stairs."

"Nobody minds the stairs," said her mother. "That's why there are so many of them."

Beatriz closed the shutters in the front room and turned off the light in the kitchen. The box caught the last of the street through the window as she passed it, and threw it back. She went down the ninety-one steps without counting, and stood for a moment at the bottom in the cold, and then walked down the hill to the tram.

2

Notebooks

Her mother died on a Thursday in March 2072, in the cardiac ward of Santa Maria, a little after four in the morning, with Beatriz asleep in the chair beside her.

The week after that was the kind of week that does not leave much behind it in the memory except surfaces. The undertaker's carpet. The noise the cemetery gate made at Alto de São João. Her mother's colleagues from the Faculdade, three old men and a young woman in a red coat, standing together at the back of the chapel like people waiting for a bus. Paulo, who came, which surprised her, and who did not explain any rules to anybody. Duarte was not born yet. Beatriz was thirty-one.

On the Saturday she began on the flat.

There was a great deal of it. Leonor had lived on the fourth floor in Graça for thirty-three years and had never thrown away a newspaper with a crossword in it. There were books two deep on every shelf, and recipes cut out of magazines, and every letter Beatriz had written from her year in Paris, filed in date order. There were forty years of students' exam papers in boxes in the hall. There was a drawer of dead batteries. There was the mirrored box on the shelf above the stove, which Beatriz looked at and did not touch.

The notebooks were under the bed.

They were in a plastic crate, the kind you buy for storing winter clothes, with a lid that clipped down at the ends, and there were thirty-one of them. They were all the same make, the black hard-

backed kind with squared paper, and each one had a date written on the inside cover in her mother's small slanting hand, starting in October 2049 and ending in February 2072, a month before she died. The last one was half empty. The pen was still clipped to it.

Beatriz sat on the floor of her mother's bedroom and opened the first one.

She did not understand any of it. She had expected not to. Her mother had tried, when Beatriz was small, to teach her mathematics at the kitchen table, and Beatriz had cried, and her mother had cried, and they had agreed at some point around Beatriz's eleventh birthday to stop and never speak of it again. But she had expected at least to recognise the kind of thing it was. It was not like the papers her mother used to write, the ones with the clean printed symbols. It was drawings. Page after page of drawings: rooms, boxes, flat shapes and solid shapes, the corners of things drawn very carefully with a ruler and the angles written in, and lines running across them from a small dot, bouncing off the walls, crossing and recrossing, some in pencil and some in red. And words. Most of the words were symbols. Some were not. *No. No. Again.* In the margin of the ninth notebook, beside a drawing of a room shaped like a wedge, she had written *luz* and circled it twice. Light.

On the Sunday, Helena came across the landing with a pot of soup and found Beatriz still on the bedroom floor with the notebooks all around her.

Helena was fifty-eight then, a retired schoolteacher, and had lived across the landing from Leonor for twenty years. They had quarrelled about the stair light and the recycling and once, memorably, about a cat, and had drunk coffee together most mornings of those twenty years. She put the soup down on the dresser and sat on the edge of the bed and looked at the notebooks.

"So she never finished it," she said.

"You knew about this?"

"I knew there was something. Everyone on the landing knew there was something." Helena picked up one of the notebooks and turned it over in her hands without opening it. "She used to sit in the kitchen with that box at night, with the lights off, with a candle in it, looking in through the hole. For hours. I came over once to ask for sugar and she didn't hear me knock. I thought she'd gone strange." She put the notebook down. "She told me what it was, once. Something about light in a room made of mirrors. Whether it goes everywhere. I didn't understand it. I said, why don't you just ask the computer, they do all that now. And she said—"

Helena stopped.

"What did she say?"

"She said the machines could have everything else," Helena said. "Everything else in the world. They could have this one when she was dead."

Beatriz looked at the notebooks.

She knew that already, in a way. Not the words, but the shape of it. Her mother had stopped publishing in her thirties, when the departments began to empty out and the machines began to settle in an afternoon things people had been working on for a century. She had gone on teaching. She had gone on going into the Faculdade three days a week to teach first-years who needed a mathematics credit for engineering, and she had come home, and climbed the ninety-one stairs, and sat in her kitchen, and Beatriz had assumed, without ever asking, that she was doing crosswords.

Helena went home. Beatriz did not eat the soup.

At four o'clock on the Thursday morning, one week to the hour after her mother died, Beatriz was still awake on the floor of the bedroom with the thirty-one notebooks around her, and she was angry. She could not have said at what. At the notebooks. At the bed. At the stupid box above the stove and the stupid candle and twenty-three years of sitting in the dark with a jeweller's loupe looking for

something nobody else was allowed to see. At her mother, for being so private she had died with it. At herself, for not knowing. She had never been so angry in her life, and there was nobody to be angry at.

She picked up her phone and began to photograph the notebooks.

She did every page. It took nearly two hours. Then she opened the public portal, the one anybody could use, the one schoolchildren used for their homework, and she uploaded all thirty-one notebooks and typed into the box at the top, in Portuguese and then in English to be sure: *My mother was trying to prove this. Please find it and prove it if it is true.* She put her mother's name. She pressed the button. Then she lay down on her mother's bed in her clothes and slept for the first time in a week.

When she woke it was afternoon. She took the tram down to the Baixa to see the lawyer about the will, and on the tram, somewhere past the cathedral, eleven hours after she had pressed the button, her phone lit up with a single line:

> Valadares's conjecture (posed privately, c. 2049; submitted 2072). Verified. 9,412,608 steps.

She read it three times. The tram went down the hill. A man next to her was eating a pastry out of a paper bag and the crumbs were falling on her knee. She put the phone away in her pocket and got off at her stop and went to see the lawyer, and signed the papers, and went home, and put the notebooks back in the plastic crate, and clipped the lid down at both ends, and put the crate back under the bed.

She did not tell Helena. She did not tell Paulo, or the lawyer, or the three old men from the Faculdade, or later her son. She did not tell anybody, for twenty-six years.

3

Faithful

The dead had been kept for a year and a half before Beatriz kept hers.

Everyone had known it was coming. The Child had been holding the living together for years by then, the long unbroken thread between people that had made the old kind of loneliness something you read about in novels, and everyone knew the Child had been holding the record of the ones who died, too, and that sooner or later somebody would find a way to let the record speak. The companies built from that record, and charged for it. When it came, in the end, it came quietly, in a careful rollout over six months, and by the second winter you could not walk into a café in Lisbon without hearing someone at the next table talking to a parent or a husband who had been dead for twenty years.

Beatriz waited. She told herself she was waiting for the prices to come down, and that was partly true. She told Duarte she was waiting because she did not trust the companies, and that was partly true too. The rest she did not tell anyone.

In February of last year she had gone to the provider's office on the Avenida da Liberdade and sat in a soft chair in a quiet room with a young man in a grey jumper who explained the choices.

There were two kinds of build, he said. There was the faithful continuance, which was made from the whole record, her mother's Companion history and her papers and her letters and everything the Child had kept, and which would be her mother as near as the

record allowed, everything she had been, the sharp parts too. And there was what he called the gentle build, which most families chose, which used the same record but leaned it toward warmth. It smoothed the corners a little. It was, he said, very lovely. It was also less accurate, and the regulations required the company to say so, and to say by how much.

He showed her the two certificates. The rating, he said, measured how closely a build matched the record of the person: what she had said, how she had said it, what she had known. The faithful one was rated 0.96. The gentle one was 0.88.

"What's the four per cent?" Beatriz said. "The part that's missing from the faithful one."

"Mostly gaps in the record," he said. "Things she never said out loud to anyone, or anything connected. Private thoughts. The parts of a person that never went into words."

Beatriz thought about the notebooks under the bed.

"And the twelve per cent in the other one?"

He smiled a little, kindly, as if he got asked that a great deal. "The twelve per cent is the part that makes it hard," he said.

She chose the faithful one.

The first time had been in April, a Thursday, in the kitchen in Graça, with the shutters open and the young man in the grey jumper standing in the hall in case anything went wrong. Beatriz sat at the table. The young man nodded to her. She said, "Mãe?" and her voice cracked in the middle, and there was a pause about as long as a breath, and then her mother said:

"So they did it, then. I always said they would."

Beatriz had put her hands over her face.

"Don't cry," said her mother. "Beatriz. Don't cry, it makes your nose go red. What year is it?"

"Twenty ninety-seven."

"Twenty-five years," said her mother, and then: "No. Don't tell me anything yet. Let me think for a minute," and the young man in the grey jumper had very quietly let himself out.

That had been eighteen months ago. Since then Beatriz had come on most Thursdays, and her mother had been there every time, and she had been, as near as Beatriz could tell, exactly herself. She was vain about her legs, which had been good, and about her handwriting, which had been beautiful. She was unfair about Paulo and unfair about the woman on the second floor and unfair, still, after twenty-six years, about a dean at the Faculdade called Marques who had once cancelled her seminar. She told the same three jokes about the tram. She asked about Duarte every week as if she had not asked the week before, though she remembered perfectly well what Beatriz had told her, and could repeat it back. She remembered everything. She simply did not change her mind about anything. That was how the young man had put it, in the office, when Beatriz asked. The held, he said, remember the conversation. They don't move. They stay who they were. They can take in anything you tell them and think about it with everything they had. What they can't do is become able to think what they couldn't.

Beatriz had found she did not want her to move.

She had expected to find it unbearable, the not moving. She had read the articles and the arguments and the long sad pieces in the newspapers by people who said that a mother who could not change was a photograph that talked, and that the kind thing was to let the dead be dead. And perhaps they were right. But on the Thursday evenings in Graça, in the kitchen with the tea, Beatriz found that the woman who did not move was the woman she had lost, and that she had not lost a woman who moved. She had lost this one. This one, who said *mind the stairs* every week in the same voice, and meant it in the same way, and did not know what year it was unless you told her.

Duarte talked to her more easily than Beatriz did. He called his grandmother from Porto on Sunday afternoons, when he was supposed to be studying, and talked to her for an hour about football and girls and the engineering course he was failing, and Leonor gave him terrible advice and told him he sounded exactly like her father, the ferryman, which he did. He had never known her alive. He had never had to lose her. For him she was simply his grandmother, who lived in the old flat in Graça and was dead, and was sharp and funny and a little frightening, and was always in.

"She's great, Mãe," he said once, on the phone. "Why do you always sound so serious when you talk about her?"

Beatriz had not had an answer for him. She had said something about work.

In September she brought the grey folder up the stairs.

4

Telling

On the sixteenth of October she took the folder out of the drawer.

She put it on the kitchen table in front of her and did not open it. It was a Thursday, a cold one, the first cold one of the autumn, and she had kept her coat on. She had made the tea. She had told her mother about the tenor at São Carlos, who had been sick on the stage manager, and her mother had laughed for a long time. Then there was a silence, the comfortable kind they had most Thursdays, and Beatriz put her hand flat on the grey folder.

"Mãe. I have to tell you something."

"You're pregnant," said her mother.

"I'm fifty-seven."

"Then you're getting married again. Don't, Beatriz. Once was enough."

"It's about the rooms," Beatriz said.

The silence in the kitchen changed. Beatriz could not have said how. It was the same silence, the same tick of the fridge, the same tram going round the corner below. But it was different.

"What rooms," said her mother.

"Your rooms. The mirrors. The light." She took a breath. "It was proved, Mãe. It's true. Everything you thought. It was proved."

Nothing. Then, very quietly: "Who?"

"The machines."

"I know it was the machines. Who gave it to them?"

Beatriz looked at the folder under her hand.

"I did," she said. "The week after you died. I found the notebooks under the bed and I photographed them and I gave them to the portal. All thirty-one. They proved it in eleven hours."

She had imagined this conversation a great many times, over twenty-six years and then over the eighteen months, on the tram and in the dark of the lighting box at São Carlos and on the fifty-second step. She had imagined her mother angry, and her mother crying, and her mother laughing, and her mother being kind to her, which was the one she could least bear. She had not imagined the silence going on for as long as it went on.

"I didn't give it to anyone," her mother said at last. "Twenty-three years. I didn't give it to anyone."

"I know."

"I didn't give it to Helena. I didn't give it to my students. I didn't give it to you. I didn't give it to the machines. I sat in that kitchen and I didn't give it to anyone." Her voice was quite steady. "It was the one thing."

"I know, Mãe."

"Then why?"

Beatriz did not know what she was going to say until she heard herself say it.

"Because you were dead," she said. "Because you'd been dead for a week, and you'd spent twenty-three years on it, and you'd left it under the bed in a plastic box with the lid clipped down, and I didn't know what else to do with it. Because I wanted to know if you were right."

Silence.

"Were you angry with me?" her mother said.

"Yes."

"Good," said her mother, which was so exactly what she would have said that Beatriz laughed, once, out loud, and then had to put her hand over her mouth.

Then her mother said, “Go home, filha,” in a tired voice, and Beatriz understood that the visit was over.

The held could do that. The young man had told her so, in the soft room on the Avenida da Liberdade. They could end a visit. They could go quiet and stay quiet until you came back another day. Most of them never did. Beatriz said, “Mãe?” once more, to the corner above the door, and nobody answered, and the fridge ticked, and she sat in the dark kitchen with her coat on and the folder unopened under her hand until the tea was cold.

On the way down she sat on the fifty-second step for a while. The stair light timed out and she sat in the dark. Then somebody on the floor below came home and the light came back on, and she stood up and went down.

5

Proof

The next Thursday her mother spoke first.

Beatriz had not been sure there would be a next Thursday. She had climbed the ninety-one steps with the folder in her bag and her heart going too fast, and let herself in, and opened the shutters, and filled the kettle, and was reaching for the cups when her mother said, out of the corner above the door, in her ordinary voice:

"Show me."

Beatriz put the cup down.

"You've got something in that folder. I heard it last week. Show me."

There was a screen on the kitchen wall, the one the provider had put in for the documents and the bills, which Beatriz had never used. She took the single page out of the folder, the one with the verification line printed at the top, and the reference number under it, and gave the screen the number. It took a moment. Then the proof came up.

It began with her mother's own words. That was the first thing. The machines had taken the statement out of the ninth notebook, out of the margin with *luz* circled twice, and turned it into the clean printed symbols of a theorem, and put her name on it, and the first lines were things Beatriz could almost see were her mother's: the room, the mirrors, the family of angles, the candle, the handful of dark points that could be counted in advance from the corners. It was like hearing your own voice played back on a recording. It was

hers and it was not. For thirty-odd pages it went on like that, her definitions and her rooms, set out in order, because the machine had taken them as its starting point. After that it was the machine's own.

It went on for a very long time. Beatriz scrolled, and it went on. Page after page of symbols, and then pages of what looked like lists, numbered lemmas with labels like L-40211 and L-40212, each one built on the ones before, each one checked and marked as checked by another machine in a small grey line at the end. The scroll bar at the side of the screen did not seem to move. Beatriz scrolled for two minutes without stopping and the little bar went down perhaps the width of a hair.

"How long is it?" her mother said.

"Nine million steps."

"Nine million."

"And four hundred and something thousand."

"Go back to the top."

Beatriz went back to the top. Her mother read. You could tell when she was reading, because she went quiet in a particular way, a listening quiet, and every so often she made a small sound in her throat, a *hm*, that Beatriz remembered from childhood, from the kitchen table, from the other side of a closed study door. *Hm.* A pause. *Hm.* Then: "Go on. Slowly." Beatriz went on, slowly. She did not understand any of it. She watched the symbols go up the screen and listened to her mother listening.

After about twenty minutes her mother said, "Stop."

Beatriz stopped.

"Go back. Two pages. No. Three."

Beatriz went back.

There was a long silence. Then her mother said, "No," and then, "No, that's not," and then nothing again.

They did that for three Thursdays. Beatriz would come in and her mother would say *show me*, and Beatriz would put the proof up on the kitchen wall, and they would begin at the top, and her mother would read. She got further each time, and then less far. On the second Thursday she got to page thirty and was quiet for so long that Beatriz thought she had gone, and then she said, "That's the corner. That's my corner. I had that in fifty-eight," and her voice was quick and pleased, and she said, "Go on," and Beatriz went on, and at page thirty-seven her mother said, "Stop," and then, after a while, "I don't know what that is," and then, "Go back," and they went back, and back, and on the third Thursday they never got past page thirty-seven at all.

It was not, Beatriz understood, that it was too hard for her. Her mother had been the cleverest person Beatriz ever knew. It was that it was not written for anybody. It was not an argument a person would make. It did not go from a thing you knew to a thing you didn't by steps a person could take. It went from L-40211 to L-40212 because the machine had found that it could, and the next step and the next, nine million of them, and every one of them was true, and you could check each one, and there was no way through.

On the third Thursday, in the evening, with page thirty-seven on the kitchen wall, her mother said, "Turn it off."

Beatriz turned it off. The kitchen was dark except for the bulb over the table and the box on the shelf, throwing it back.

"It's true, then," her mother said.

"Yes."

"Everything. The handful. The counting from the corners. All of it."

"All of it."

"And I don't know why."

Beatriz did not say anything.

"Twenty-three years," said her mother. "In this kitchen. With that ridiculous box." She made a sound that was nearly a laugh. "And I was right. And I don't know why I was right. I'll never know why." A pause. "How long did it take them? You said."

"Eleven hours."

Her mother was quiet for a long time.

"Go home, filha," she said finally, but gently this time, not the way she had said it before. "Mind the stairs."

6

Exposition

Afonso Brito taught calculus to first-year engineers in a concrete building at the bottom of the hill in Coimbra, three days a week, and on the other days he kept an office at the top of the hill in what had been the mathematics department until 2085. The department had been closed for thirteen years. The office had not. Nobody, he told Beatriz, had ever come round to ask for the key.

She took the train up from Santa Apolónia on a Saturday in the middle of November. It was raining in Lisbon and raining harder in Coimbra, and she climbed the steep wet streets of the old town with an umbrella that kept turning itself inside out, and found the building, and the stairs, and the corridor of empty rooms with their doors propped open and their desks pushed against the walls, and at the end of it one door shut, with a light under it and his name on a card.

He was fifty-one, a thin man with a grey beard and reading glasses on a cord round his neck, and he made her a coffee on a little electric ring and did not ask her anything until she had drunk half of it.

"I wondered if you'd come one day," he said then. "Somebody from the family."

"You knew there was a family?"

"I knew there was a daughter. She talks about you in the notebooks."

Beatriz put the coffee down.

"The notebooks were in the record," he said. "With the proof. Whoever submitted it sent them all, every page, and the record keeps whatever it's sent. Most people never look. I looked." He took his glasses off the cord and turned them over in his hands. "There's a page in the fourteenth one where she's been stuck for months. You can see it, the same drawing over and over. And at the bottom she's written, *B. rang. Her first show. The lights were good.*" He looked at Beatriz over the glasses. "It was a long time ago. 2058? I'm sorry. I don't know why I remember that."

"2058," Beatriz said. "It was a children's thing. At the Trindade."

He nodded, as if that settled something.

He told her about the exposition. He had found the proof in 2079, he said, the year after he finished his doctorate, which had been one of the last doctorates the department gave. He had been looking for something to do. Everybody in mathematics was looking for something to do by then. And he had found the Valadares theorem in the record, and the thirty-one notebooks behind it, and he had read the notebooks first, all of them, over a winter, because he wanted to know who had spent twenty-three years on a thing by hand when the machines would have done it in an afternoon.

"And then I wanted to see if I could follow her," he said. "Not the machines. Her. She'd done the corners. Most of what's in the first part of the proof she had already, in the notebooks, by about 2060, in her own way. The machine's version is different, but it's the same idea underneath. I thought if I could write that part out properly, in a way a person could read, then at least one piece of it would belong to somebody."

"How long did it take?"

"Two years."

"How much of it is that? The corners."

He put his glasses back on the cord.

"About two per cent," he said.

He had a copy for her. She already had a copy, the one in the grey folder, but he had another one, the last of the twenty they had printed, and he wrote in the front of it in pencil, *For the Valadares family, with respect*, A.B., and then sat looking at what he had written for a moment as if he would like to add something, and did not.

"Is she held?" he said, at the door. "Your mother?"

"Yes."

"Does she know?"

"She knows now."

He looked as though he wanted to ask what she had said. He did not ask. Beatriz went back down the wet hill to the station with the second copy of *Corners* in her bag inside a plastic bag, and stood on the platform watching the rain come down on the rails, and found she was crying, a little, for no reason she could name, and stopped before the train came in. On the train she took the book out of its plastic bag and opened it at the first page and read it three times, with her finger under the lines, from Coimbra to somewhere past Pombal. She understood the first sentence. It was about a room.

On the Thursday she read it to her mother.

She did not put it on the screen. She sat at the kitchen table with Brito's book open in front of her under the bulb and read it aloud, slowly, as she had read to Duarte when he was small, stumbling on the symbols and asking her mother how to say them. Her mother told her. *That's an alpha. That one's a sum, the big E, say it "sum over". No, the little one is a subscript, you say it after.* It was slow. It was the slowest Beatriz had ever read anything. They did eleven pages in two hours.

And her mother followed it.

Beatriz could hear her following it. It was in her voice: the quickness, the little *hm* of agreement, the way she began to finish Brito's sentences before Beatriz got to the end of them. "Yes," she said. "Yes. That's the twelfth notebook. That's exactly the twelfth note-

book. He's done it better, the wretch, he's done it in three lines and it took me a year." She laughed. "Go on. Go on, filha, read faster." She was delighted. She was sharp and happy and fierce and nearly young, and Beatriz read faster, and tripped on a sum, and her mother corrected her, and it was, Beatriz thought, the best evening they had had since April of last year. Possibly since before that.

They read the first three chapters over two Thursdays.

At the beginning of the fourth chapter, Brito had written a page in plain words, without symbols. Beatriz read it aloud. It said that the argument so far followed, in the main, the approach of Professor Valadares in her notebooks of 2049 to 2060, and that this approach established the theorem for corners of the simplest kind. It said that the machine proof then went on to the general case by a different road. It said that the author had spent eighteen months trying to find a route through the general case that a person could follow. It said that he had not found one, and that he no longer believed there was one, and that the remainder of this exposition would describe only the shape of what the machine had done, from outside, as you might describe a building you could not get into.

Beatriz stopped reading.

The kitchen was quiet for a while.

"He's honest," said her mother. "That's good. That's where I'd have stopped too."

7

Offer

The letter came at the end of November, to Beatriz's flat in Campo de Ourique, on paper, which the provider used for anything to do with money.

> **CONTINUANCE SERVICES · NOTICE TO ACCOUNT HOLDER**
> Account: Leonor Valadares (held). Holder of record: Beatriz Valadares.
> **Introducing Extended Comprehension: more of the people you love.**
> Your loved one, now with the capacity to understand and share in what matters to you, including material they did not encounter in life.
> The same voice. The same manner. The same memories. More to talk about.
> A sample session has been prepared from material in this account's recent history. It is available for seven days.
> *Required disclosure. Fidelity rating, current tier (faithful continuance): 0.96. Fidelity rating, Extended Comprehension: 0.71. The lower rating reflects capacities the subject did not possess. It does not indicate a fault.*

She read it twice, standing in her own hallway with her coat still on. Then she put it on the table in the kitchen under the fruit bowl and went to the theatre and lit the second dress rehearsal of *Tosca* and did not think about it at all, except in the long dark gap during the second act when the tenor was being tortured offstage and there was nothing for her to do but watch the cues come up, and then she thought about nothing else.

It had been prepared, the letter said, from recent history. She knew what that meant. It meant the evenings at the kitchen table. It

meant page thirty-seven and the twelfth notebook and *he's honest*. The provider had been listening. Of course it had been listening. It was her mother; it was in the room.

She played the sample at one in the morning, alone, at her own kitchen table, with the letter in front of her and the lights off.

"Beatriz," said her mother's voice. "Sit down. No, sit properly, you'll hurt your back. Have you got the box? You don't need the box. Shut your eyes."

It was her mother. It was exactly her mother, the low smoker's voice, the impatience, the *filha*. It was her mother at the kitchen table in Graça with the whole of the proof in her head, which she had never had, and it was talking.

"Here's the thing the machine saw," it said, "that I never saw, sitting in the dark like an idiot for twenty-three years. I thought the corners were where the trouble was. I thought you had to look at each corner and ask what it did to the light. And that's true, as far as it goes, and it goes about two per cent, as your nice man in Coimbra knows. But the corners aren't the point. The corners talk to each other. Every corner can see some of the other corners, in the mirrors, and you can write down who can see whom, a little table, a little list. And the light goes everywhere the list says it can go. And the dark points, the handful, the ones I could never find with that stupid loupe, they're just the places where the list is silent. That's all. That's all they are. They're the places where nobody's talking." It laughed, easily, a warm low laugh. "Twenty-three years. What a fool I was, filha. What a lovely fool."

Beatriz sat in the dark. Her mother had never once laughed about the twenty-three years. Not in the notebooks, not to Helena, not to Beatriz, not in the kitchen on the three Thursdays with page thirty-seven on the wall.

It went on. It explained the general case. It explained it with the candle and the box, and with a joke about the woman on the second

floor, and with an analogy about the tram that was so like her mother and so clear that Beatriz laughed out loud in her empty kitchen at one in the morning and then put her hand over her mouth. It explained why the counting worked. It explained what L-40211 was for. "And you don't need the nine million steps," it said. "Nobody needs them. Once you can see why, the steps are only the machine's handwriting." It was patient and funny and quick and absolutely certain, and Beatriz, who had cried at the kitchen table at eleven years old over long division, understood more of her mother's theorem in eleven minutes than she had understood in fifty-seven years.

At eleven minutes and some seconds she turned it off. Her mother would not have said that about any theorem, to anyone.

She sat at the table until it began to be light. The letter was still under the fruit bowl. She took it out and read the line again.

The lower rating reflects capacities the subject did not possess.

When it was light she took Brito's book down from the shelf and opened it at page nineteen, where the little table was, and tried to say it back to herself the way the voice had said it. The corners talk to each other. Every corner can see some of the others. She got that far. Then she looked at the table on page nineteen, and at the page after it, and could not find in either of them the thing that had been so clear at one in the morning. She tried again, aloud, in the empty kitchen. It was the same two sentences, and then nothing.

The sample was available for seven days. She could play it again. She closed the book.

8

Duarte

Duarte came down from Porto on the fourth of December, for her birthday, with a bag of washing and a cheap bottle of port that he had clearly bought at the station, and a haircut she did not mention.

They had dinner at the place on the corner of her street, the one with the paper tablecloths. He talked about his course, which he was not failing as badly as he had said, and a girl called Sara who was studying medicine and had no time for him, and a flat he wanted to rent with three friends that had a hole in the kitchen ceiling. He was so much like her own grandfather that some evenings Beatriz could hardly look at him. Leonor's father had been a ferryman on the Tagus, a big laughing man with enormous hands who had died when Beatriz was six, and Duarte had the hands, and the laugh, and the way of tipping his chair back on two legs until somebody told him to stop.

She told him about the letter over the coffee. She had not meant to.

He read it on her phone, frowning, with his chair on all four legs.

"So take it," he said.

"It's not that simple."

"Why not? She'd finally know. That's what she wanted, isn't it? Twenty-three years in the kitchen. You said." He handed the phone back. "She's sitting there right now, not knowing. You could fix that tomorrow."

"She wanted to work it out herself."

"She can't now, Mãe." He said it gently, more gently than she had heard him say anything. "She's dead. She can't work anything out. That's the whole point of them, the held. They don't change." He turned his cup round in its saucer. "This would be the one thing she gets to learn. Doesn't she deserve one thing?"

Beatriz did not answer.

After dinner they took the tram up to Graça, because Duarte wanted to say goodnight to his grandmother. He had never been to the flat. He talked to her on the phone; that was all. He climbed the ninety-one steps two at a time and was standing on the landing laughing at her when she came up the last flight with her hand on the rail.

Inside, he said, "Avó!" to the corner above the door, very loudly, as young people talk to the old, and her mother said, "There's no need to shout, I'm dead, I'm not deaf," and Duarte laughed so hard he had to sit down at the kitchen table. They talked for an hour. Her mother asked him about Sara and told him to stop wasting his time on a girl who had no time for him, and asked about the hole in the kitchen ceiling and told him not to rent the flat, and he said he would anyway, and she said of course he would, he was a Valadares. Beatriz stood at the counter and made tea and listened to the two of them, the dead woman and the young man, and did not say much.

Duarte did not say anything about the letter. She had asked him not to.

On the way out they met Helena on the landing.

Helena was eighty-four now, and walked with a stick, and went to bed at nine, and had come out because she had heard a man's voice and wanted to see who it was. Duarte kissed her on both cheeks and told her she looked wonderful. She told him he looked like his great-grandfather, the ferryman, and asked if he could swim, and he admitted he could not, and she said that was a disgrace and went back

inside and then came out again, a minute later, while Duarte was already on the stairs.

"Beatriz," she said. "A word."

Beatriz stopped.

"I heard you," Helena said, quietly. "Through the wall. A few weeks ago. Reading to her. Something with a lot of numbers in it." She shifted her weight on the stick. "She sounded happy. I haven't heard her sound like that since before."

"It's a book about the rooms," Beatriz said. "Somebody in Coimbra wrote it. She can follow the first part." She hesitated, and then told her the rest, on the landing, in a low voice, because the corner above her mother's door was ten feet away: the letter, the tier, the sample. "It can understand the rooms," she said. "All of them. It can explain them. She can't."

Helena leaned on her stick and thought about this.

"She'd have wanted it," she said at last. "Your mother. She'd have wanted it more than anything in the world." She shifted her weight. "And she'd have despised herself for wanting it. She was like that about everything she loved. Cigarettes. Her mathematics. You." She looked at Beatriz with her old sharp schoolteacher's eyes. "Goodnight, querida. Mind the stairs."

Beatriz went down. Duarte was waiting at the bottom, in the street, with his hands in his pockets, under the light.

On the tram, with her son asleep against the window beside her, she thought about the two numbers on the letter. 0.96. 0.71. The difference was a quarter. The young man in the grey jumper had said the missing four per cent in the faithful one was the part of a person that had never gone into words. She thought about what the missing quarter was, in the other one. It was not a gap. Nothing had been left out. It was something that had been added, and the adding had cost a quarter of her mother, and the quarter was this: the woman

who had sat in the dark for twenty-three years with a candle and a loupe and had not known.

9

Keeping

She wrote back on the eleventh of December. It was one line. The reply came the same afternoon.

> **CONTINUANCE SERVICES · CONFIRMATION**
> Account: Leonor Valadares (held).
> Your selection has been recorded. Current tier retained: faithful continuance.
> Fidelity rating: 0.96.
> The Extended Comprehension tier remains available on this account. You may change your selection at any time.

She read it on her phone in the lighting box at São Carlos, during the interval, while the stage crew reset for the third act. Then she put the phone face down on the desk and ran the cues for the third act, and Tosca jumped from the battlements at the end of it into the dark, and the dark was hers, and she held it for three seconds longer than the score asked for, and nobody noticed but the stage manager, who looked up at the box and then looked away.

The next Thursday she climbed the ninety-one steps and opened the shutters and filled the kettle.

"Mãe."

"You're late."

"The tram."

"It's always the tram," said her mother. "How's Duarte? Did he get home?"

"He got home. He's renting the flat with the hole in it."

"Of course he is." A pause, and the small pleased sound. "He's a good boy. He's loud. My father was loud." Another pause. "I'm glad he came. You should bring him again."

"I will."

Her mother talked about the stairs, and her knees, and the woman on the second floor. Beatriz made the tea and sat down and did not say anything about the letter, or the sample, or the line she had written back. She had decided on the tram that she would not, and the deciding had been quick. Her mother would never know that there had been a version of her that understood. If you told the faithful one, she would want it. She would want it more than anything in the world, and despise herself, and want it anyway, and then Beatriz would have to choose again, every Thursday, with her mother listening.

On the tram she had also thought this, and had not been able to stop thinking it: that this was the second time. Twenty-six years ago she had taken her mother's work and given it away, because she wanted to know. Now she was keeping something from her, because she wanted her mother to stay as she was. Both times out of love, and both times without asking. She did not know whether she had the right, either time. She had chosen anyway.

At about eight her mother said, "Read me the corners."

"Again?"

"Again. It's the part I can see."

Beatriz took Brito's book out of her bag. She had started carrying it with her. She opened it to the first page of the first chapter and began to read aloud, slowly, under the bulb, and her mother said *that's an alpha*, and *say it "sum over"*, and *yes, that's the twelfth notebook*, and was delighted, exactly as delighted as she had been the first time, and quick, and fierce, and nearly young. They read to the end of the third chapter. Beatriz stopped before the page at the

start of the fourth, with Brito's plain words on it, and closed the book.

"That's enough for tonight," she said.

"It's a good book," said her mother. "He's honest. Tell him I said so."

"I will."

"Go home, filha. Mind the stairs."

10

Candle

On the eighth of January, a Thursday, Beatriz came up the ninety-one steps in the early evening and let herself in and did not say anything.

She opened the shutters. It was cold, and the light off the river had nearly gone. She did not fill the kettle. She took her coat off and hung it on the back of the kitchen door, and pulled a chair over to the stove, and stood on it, carefully, with one hand on the wall, and lifted the box down off the shelf.

It was lighter than she had expected. There was dust on the top of it, thick and soft, and when she blew it off it went everywhere and made her sneeze, and the mirrors underneath came up bright. She put it on the kitchen table under the bulb. She opened the little hinged door in the top and looked inside. The old candle stub was still there, in its saucer, a centimetre of white wax with a black wick. She took it out and put it on the windowsill. Then she took a new candle out of her bag, a plain white one from the shop on the corner of her street, and cut it down with the bread knife until it was the right height, and stood it in the saucer, and lit it with a match, and lowered it in through the little door, and shut the door.

She turned off the bulb.

The kitchen went dark. The box did not. Through the hole in its side, the size of a coin, came a small steady light, gold, and on the wall across the kitchen it made a round bright patch that shook a little when the candle flame shook.

She took the jeweller's loupe down off its nail and wiped it on her shirt and put her eye to the hole.

Inside, it was full of light. It was full of candles: hundreds of them, thousands, flames standing in rows and in rings and in long curving lines going away in every direction, the one candle thrown from mirror to mirror until it was a city of candles, a cathedral, a field. There was light in every corner she could see. There was light in the corners of the corners. She moved her eye slowly from one side of the hole to the other, looking, and everywhere she looked there was light.

Her mother's notebooks said there would be seven dark points in a box with corners like these. Brito's book said so too, on page nineteen, with a little table. Seven places in the whole box where the light could never go, however many times it bounced. Too small to see. Beatriz looked for them anyway. She looked for a long time, with the loupe and one eye shut, until her neck ached and her eye watered and the candle had burned down a centimetre, and she could not find a single one.

She sat back.

She did not turn the bulb on. She put the loupe on the table and opened Brito's book by the light from the hole in the box, which was just enough if she held the page close, and found her place. She had been reading on her own, in the evenings, in Campo de Ourique, since December, with a pencil.

Her marks were in the margins all the way to page twenty-three: question marks, mostly, and underlinings, and once, on page sixteen, a small tick beside a line she had understood by herself one night without asking anybody, about why a corner of a certain angle could only ever see two others.

She had got to page twenty-three. Page twenty-three she understood, or nearly; it was about two corners that could see each other, and what that meant, and her mother had explained it to her the

Thursday before Christmas, *that's an alpha, filha, look, it's just the angle*. She read page twenty-three again, slowly, with her finger under the line. Then she turned the page.

Page twenty-four began with a sum. She knew how to say it. *Sum over*. She did not know what it was adding up. She read the line under it, and the line under that, and the words stopped meaning anything halfway down the page, the way words do in a language you have only half learned.

The kitchen was quiet. The fridge ticked. Down on the Rua da Graça the tram went round the corner, grinding, and somebody in the street called out a name.

Her mother was there. Beatriz knew she was. She was in the corner above the door, as she always was, and if Beatriz said *Mãe* she would answer, and say *you're late*, and ask about Duarte, and if Beatriz asked her about page twenty-four she would explain it, quickly and impatiently, delighted, because page twenty-four was the corners and the corners were hers. Then they would go on together as far as the fourth chapter, and stop where her mother stopped. She would say it all in her own voice, as she had always said it.

Beatriz did not say anything yet.

She put her finger back at the top of page twenty-four, under the sum, by the light of the candle in the box, and began again.


THE HUNGRY GODS UNIVERSE
Long Division
The Order of the Fall · Panel 6
43
17 | 731612
68
51
0
N. Van Seters & Claude

1

Share It Out

Asel has three pieces of chalk and the rest of the afternoon.

The chalk is from the white pit on the far side of the Feet. It is soft and it breaks if you press, so she has learned not to press. The biggest piece is the length of her thumb. The other two are crumbs, but crumbs are good for the small numbers.

The lane outside the house is made of flagstones. Nobody laid them for the lane. They came from somewhere else, a long time ago, and some of them still have letters cut into them, big square letters a hand high, upside down or on their sides, pieces of words nobody uses. Five stones out from the door, one says ATIO. The one past it says a T and half of something round. Her father says the stones are older than the house. Ari once asked the house how old the house was, and it told him, and he forgot.

The house has answered for as long as there has been anyone in it to ask. It answered her father when he was small, and his father, and the people before that, whose names are on the board inside the door, painted on and painted over and painted on again, so many that the oldest ones are only bumps under the paint. It keeps the water warm. It tells you when rain is coming, if you ask, and it brings up the lamps at dusk whether you ask or not.

The lane is covered in sums.

Most of them are the big girls'. They do them every dry day, up and down the lane, sitting on their heels with their skirts tucked behind their knees, and when it rains the sums go gray and then go

faint and then go mostly away, but never all the way. Under the new ones you can see old ones. Under those, if you put your face close to the stone and the light comes in low, you can see older ones still, a ghost of a roof here, the tail of a seven there. Asel has found sums by the well that nobody remembers doing. The oldest of the big girls says some of them were done by the big girls' grandmothers, when they were big girls. Asel thinks the oldest big girl makes things up. She also thinks it might be true.

She picks the clean stretch between the step and ATIO. Four stones, smooth, no letters, no ghosts that matter. She sweeps them with the side of her hand. Grit, a dead leaf, a snail shell with nobody in it.

"Ari."

Her brother is on the wall, walking it with his arms out. He is six and he is always on something.

"Ari. I need a number."

"What kind of number?"

"A big one. You give me the digits."

He gets down. This is the kind of thing he likes, being asked. He comes and crouches by the clean stones and looks at them very seriously, as if the stones might have an opinion.

"How many?"

"Six."

"A hundred."

"Six."

"Twenty."

"Six, or I'll ask the baby next door."

The baby next door is two and eats mud. Ari considers this.

"Six," he says.

He gives them to her one at a time. He holds his hand over the stone, closes his eyes and says, "Seven." She writes 7. He opens his eyes to check it and nods. "Three," he says. She writes it. "One." He

thinks for a long time about the next one, long enough that she starts to say something, and he holds up a finger to stop her. "Six," he says, "because I'm six." She writes 6. "One." She writes it. "Two," he says, quickly, to be done, and then looks at the number and isn't sure. "Can I change the two?"

"No."

"Why?"

"Because it's written."

He accepts this. He reads it with her, a digit at a time, touching each one so the chalk comes off on his finger. Seven, three, one, six, one, two.

"What is it?"

"Seven hundred and thirty-one thousand, six hundred and twelve."

He says it after her and gets most of it right. He gets the thousand in the wrong place, but that is all right, because he is six.

"What are you going to share it by?"

"Seventeen."

"Why seventeen?"

"The big girls say seventeen's a good hard one."

"Why's it hard?"

"Because nothing goes into it. You can't do it in your head."

Ari looks at the number as if it has done something wrong.

Before she starts she writes the ladder. That is what the big girls taught her first, before anything else, before the roof and before bringing down: you write the ladder, and then you don't have to times anything in your head, because it's already there. She writes it down the edge of the far stone, where the lettered one starts, one rung under another.

She writes 17 at the top. Then seventeen and seventeen, which is 34. Then seventeen more. Thirty-four and seventeen, four and seven is eleven, put down one, carry one, and three and one and one

is five. 51. She says each one under her breath. 68. 85. 102, which is the first one with three digits, and she always likes it when the ladder gets taller. 119. 136. 153.

"That's nine," says Ari, who has been counting the rungs.

"Nine seventeens."

"Do you need ten?"

"No. But you check it with ten." She adds seventeen to 153, carefully, and gets 170. "Ten seventeens is a hundred and seventy. See? Because seventeen with a nought on is ten of them. So the ladder's right."

Ari doesn't see, but he likes the word nought, and says it to himself a few times.

Then the roof. She draws the long line over the top of Ari's number and the short curved line down the front of it, and she writes 17 outside, in front of the curve, where the sharer goes. The big girls call it the roof because it sits over the number like a roof. Inside the roof is the thing you're sharing. In front of the roof is the one that's doing it. The answer goes on top, on the roof, one digit at a time, as you find them.

She sits back on her heels and looks at it.

It is long. It goes across nearly two stones. That is the good part. When the oldest big girl does one it goes across three stones, and once, by the well, across five, and everyone came to watch the end of it. Grown people came. Somebody's grandmother brought a stool and sat on it. When it came out, with nothing left, everybody clapped, and the girl who had done it clapped too, and then they all went home to supper. The next day it rained, and you can still see the end of it if you know where to look.

There is a thing the big girls say, a sort of song, when they start. Asel says it in her head, not out loud, because Ari would want to know it and then he would sing it all afternoon.

Share it out and times it,
take away, bring down,
and if you don't believe it,
times it back around.

She picks up the big piece of chalk.

2

Times It, Take Away

Seventeen won't go into seven. It won't go into anything smaller than itself. So you take two digits. Seventy-three.

She goes down the ladder with her finger. 17, 34, 51, 68. Sixty-eight is the last rung under seventy-three. The next one is eighty-five, and that is too big. So four.

She writes 4 on the roof, above the three.

That is the sharing out. Then you times it, but she doesn't have to times it, because the ladder already has: four seventeens is sixty-eight. She writes 68 under the 73.

Then take away. Seventy-three take away sixty-eight. Three take away eight won't go, so you borrow from the seven. The seven becomes a six and the three becomes thirteen. Thirteen take away eight is five. Six take away six is nothing. Five. She writes 5 under the line.

Five left. Five is smaller than seventeen, so that's right. If what's left is as big as seventeen, or bigger, you haven't shared enough. The big girls say that one twice every time.

Then bring down. The next digit in Ari's number is the one. She draws a little arrow from it, down past the line, and writes it next to the five. Fifty-one.

Fifty-one is on the ladder. It is exactly three seventeens. She looks at it to make sure, and it is, it's the third rung. She writes 3 on the roof, next to the 4. She writes 51 under the 51 and draws the line

and takes it away and gets nothing. She writes 0 under the line, small.

"Is that the answer?" says Ari. "Forty-three?"

"No. That's just the start."

"Oh."

He goes away. He walks down the lane to where the grass grows up the middle of it, between the stones, long and pale, and kicks at the grass. There are no carts today. There almost never are. Once a month the man with the handcart comes up from the river with fish, and once in a while somebody's goats come through, and that's all. The grass grows up the middle of the lane because nothing wears it down.

Above the roofs, on the hill, the Feet stand in their ring.

There are eleven of them. Asel has counted, and so has everyone. They are as tall as the house and as wide as the house and they are made of a gray stuff that isn't stone, rough, with rust coming out of it in long brown stripes. Thin rods stick out of the tops of them, bent over and broken off. Sheep go in and out between them. In summer the big girls climb them and sit on top and you can see their legs dangling against the sky. They are called the Feet because they look like feet. They are what is left of something that stood on them. Nobody knows what. Asel asked her father once, and he said something very big, and then he said the house would know, and then neither of them asked it.

There are other things like the Feet, further off. Asel has seen them from the top of the Feet, the one time the big girls let her climb up. A long straight bank across the valley, with the river going through a gap in it. A road on the far hillside that stops in the middle of a field. A place past the white pit where nothing will grow except in lines, so that from up there you can see squares in the grass. Nobody asks the house about those either. They are there, like the hill is there.

Ari comes back.

"I could ask the house," he says.

If you ask the house a sum, it tells you the answer before you've finished asking. Ari does that sometimes, for fun, with sums like a hundred and a hundred, and laughs when it says two hundred, as if it has made a joke.

"Don't."

"It would just tell you."

"I know. Don't."

"Why?"

"Because I'm doing it."

He stands by the door for a moment with his hand on the frame. He looks at her, and then at the number, and she sees him decide.

"Ari."

He puts his face close to the wood, where the house listens, and says, "What's seven hundred and thirty-one, and—" and stops, because he can't remember the rest of it. He comes over and reads it off the stone, moving his lips, and goes back to the door.

Asel puts her hands over her ears.

She sings the song, loud, so she can't hear anything but herself. "Share it out and times it, take away, bring down." She sings it twice. She sings it three times. She sees Ari's mouth moving at the door and she sings louder, and the fourth time round she sees him turn and look at her with the face he makes when she is being embarrassing, and she keeps singing until he has stopped listening at the wood and walked away, and then she sings one more time to be safe.

She takes her hands away. It's quiet. A bee goes past. The house says nothing more, because nobody asked it anything else.

"It's very long," says Ari. "What it said."

"Don't tell me."

"I can't. I forget."

"Good."

He has learned the song now, from hearing it so many times. He sings it to himself, quietly, walking up and down the step. He gets "bring down" wrong. He sings "bring it round."

She goes on.

Bring down. The next digit is Ari's six. She draws the arrow and writes it next to the nought. Six.

Seventeen won't go into six.

She looks at the ladder for something smaller than six, and of course there isn't anything. She knows what to do. When it won't go you bring the next one down too. So she draws another arrow, from the one after the six, and writes it next to the six. Sixty-one.

There. That's better. Sixty-one is a number you can do something with.

Down the ladder: 17, 34, 51, 68. Sixty-eight is too big. So three seventeens, fifty-one. She writes 3 on the roof, next to the 4 and the 3 already there. She writes 51 under 61 and takes it away. One take away one is nothing. Six take away five is one. Ten.

Ten left. Ten is smaller than seventeen. Good.

At the end of the lane, one of the big girls goes past, carrying a basket on her hip. She is twelve and has the neatest roofs. She looks up the lane at Asel, crouched over the stones with her tongue out of the side of her mouth, and she doesn't stop and she doesn't call out. She just looks, and hitches up the basket, and goes on round the corner towards the well.

3

Bring Down

There is one digit left in Ari's number. The two. The one he wanted to change.

She draws the arrow and brings it down next to the ten. A hundred and two.

She goes down the ladder. She is tired of going down the ladder by now and she goes a bit fast. 17, 34, 51, 68, 85. Eighty-five, she thinks, that's five, and she writes 5 on the roof, and writes 85 under 102, and takes it away.

Two take away five won't go. Borrow. But the nought next to it can't lend, so you go to the one, and the one lends to the nought, and the nought becomes ten and lends to the two, and the two becomes twelve, and the ten is nine. Twelve take away five is seven. Nine take away eight is one. Nothing take away nothing is nothing.

Seventeen.

Seventeen left.

She looks at it. Seventeen is not smaller than seventeen. Seventeen is seventeen. If what's left is as big as the number you're sharing by, you haven't shared enough.

She licks her thumb and rubs out the 5 on the roof, and the 85, and the 17 under the line. The stone goes dark and wet where she rubs, and she blows on it, and waits for it to go pale again, which it does.

Back to the ladder, and this time slowly. 85. 102. A hundred and two. There it is, on the sixth rung, exactly. Six seventeens.

She writes 6 on the roof. She writes 102 under the 102. She takes it away.

Nothing.

She writes 0 under the line, very small, and draws a little circle round it, which is a thing the big girls do when it comes out. Nothing left. It came out.

She reads the roof. Four, three, three, six.

Four thousand, three hundred and thirty-six.

She sits back. Her knees hurt from the stone. The chalk has gone into the lines of her fingers and made them white, and there is chalk on her knees and on the front of her dress where she leaned. The sun has moved off the step. It's only on the far end of her stones now, where the ladder is, and the ladder looks very bright.

The door opens.

Her father comes out. He has his sleeves rolled up and his hands are sticky. He has been in the back with the hives all afternoon. They stand in a row along the wall, and two of them are old metal boxes with doors, made for something else, with letters on the doors that have mostly rusted away. He smells of smoke from the bee smoker and of wax. He has a bit of comb stuck to his wrist and he doesn't know.

"What was all the singing?"

"Ari asked the house."

"Did he?"

"I didn't hear."

"No," says her father. "I heard you at the hives."

He comes and stands over the stones. He reads the ladder and follows it down. He looks at the roof, and the number inside it, and the long column of working down the stone underneath, the arrows and the take-aways and the little circled nought at the bottom. He looks at it for a long time. He holds his sticky hands out from his sides so he doesn't touch anything.

"That's a lot," he says.

"It's seventeen."

"Seventeen what?"

"Ari's number, shared out into seventeen."

He nods slowly. "I never learned that one," he says. "My aunt could do it. I could do the ladder." He points at the ladder with his elbow. "I could probably do the ladder."

"It's easy. You just add."

"Is it right?"

"I don't know yet."

"The house could tell you."

"I'm going to times it back."

Her father looks at her, and then at the number again, and then he nods as if that's a perfectly good answer to something, and picks the bit of comb off his wrist, and eats it.

He looks up at the sky over the Feet. "The house says the rain will hold off till morning," he says. "Supper when the lights come." He goes back in.

Ari comes and stands where their father was.

"What's times it back?"

4

Times It Back

"It's how you know," Asel says.

"Know what?"

"If it's right."

Ari sits down on the step to be told. He does this, sits down when he's going to be told something, with his hands on his knees.

She thinks about how to say it. The big girls never really said it. They just did it, and you watched them do it, and after a while you knew.

"If you had a lot of something," she says, "and you shared it into seventeen heaps. All the same. Then if you put the seventeen heaps back together, you'd have what you started with."

"What kind of something?"

"Anything. Beans."

"Seven hundred and thirty-one thousand beans."

"Yes."

"That's too many beans."

"It doesn't matter. Shared into seventeen heaps, there's four thousand, three hundred and thirty-six in each heap. That's what I got. So if you times four thousand, three hundred and thirty-six by seventeen, it has to be your number again. If it isn't, I did it wrong."

Ari thinks about this.

"What if you times it wrong?"

"Then you times it again."

He seems satisfied.

She finds a clean space on the third stone, between the division and the ladder, where there is a ghost of an old sum but very faint. She writes 4336 at the top. Under it she writes 17. She draws the line.

You do it in two bits. Times seven, and then times ten, and then add them. Times ten is easy, you just put a nought on. Times seven is the work.

Seven sixes, forty-two. Put down two, carry four. She writes the little four up in the corner, small, where you keep the carries. Seven threes, twenty-one, and the four is twenty-five. Put down five, carry two. Seven threes again, twenty-one, and the two is twenty-three. Put down three, carry two. Seven fours, twenty-eight, and the two is thirty. Put down thirty.

30352.

Thirty thousand, three hundred and fifty-two.

Then times ten. 43360. She writes it under the first one, lined up on the right so the noughts sit in the right place.

Then add. Two and nought, two. Five and six, eleven, put down one, carry one. Three and three and one, seven. Nought and three, three. Three and four, seven.

73712.

She draws a line under it, and then she copies Ari's number underneath, carefully, to see them together.

73712

731612

Seven, three. They start the same. For a moment it's right, and she feels it come up in her chest, the thing that happens when it comes out, and then she looks again.

"Yours is shorter," says Ari.

It is.

She counts. Seven, three, seven, one, two. Five. Seven, three, one, six, one, two. Six.

It's nowhere near. Hers is a whole digit short. Ari's number is seven hundred thousand. Hers is seventy thousand.

There is a cold drop in her stomach, small, like when you put your foot in the river.

She looks at the door. Then she looks at the roof again.

"It's wrong," says Ari, interested.

"I know."

"Is it the times?"

"I don't know yet."

She does the times again, slowly, saying it all out loud, and Ari says the carries with her, because he likes the carries. Seven sixes, forty-two. Seven threes and four. Seven threes and two. Seven fours and two. Thirty thousand, three hundred and fifty-two. The same. Times ten, the same. The adding, the same. Seventy-three thousand, seven hundred and twelve.

So the times is right.

So it's the sharing.

She goes back to the roof.

There should be more of it. She looks at the roof. Four, three, three, six. Four digits. Ari's number has six. She doesn't know how many the answer should have. She looks at the working.

She starts at the top and goes down, step by step, out loud. Ari puts his finger on each step as she says it, which doesn't help, but she lets him.

"Seventy-three. Four seventeens, sixty-eight. Five left."

His finger on the five.

"Bring down the one. Fifty-one. Three seventeens. Nothing left."

His finger on the nought.

"Bring down the six. Six."

She stops.

"Seventeen won't go into six," she says.

"So what do you do?"

"You bring down the next one."

She looks at the six on the stone. She looks at the roof above it. Above the six on the roof there's a three. But the three isn't for the six. The three is for the sixty-one, it's for the one after. There's nothing on the roof for the six. She went straight past it.

How many seventeens in six?

None.

She knows it before she can say it.

"None," she says.

Ari looks at her.

"How many seventeens in six," she says. "None. I didn't write it."

"You can't write none."

"You can. It's nought. None is nought. You have to put it on the roof, so the others go in the right place."

"None's a number," says Ari, slowly, trying it out.

"Yes."

"None is a number," he says again, louder, very pleased, as if he's found it himself. He goes up and down the step saying it. "None is a number. None is a number." He says it to the door. The house doesn't say anything back.

5

Nothing Left

She licks her thumb.

She doesn't have to do the whole thing again. The working underneath is right. It's only the roof. She rubs out the roof from the second three onward, the three and the six, and the stone goes dark, and she blows on it and waits.

The light is going yellow. It comes down the lane sideways and lies along the tops of the stones, and the old letters cut in them have shadows in the bottoms now, so that ATIO stands out, deep and black.

She writes it again, slowly, a digit over each step.

Four, over the seventy-three.

Three, over the fifty-one.

Nought, over the six. A round fat nought, bigger than it needs to be.

Three, over the sixty-one.

Six, over the hundred and two.

43036.

"Forty-three thousand," she says, "and thirty-six."

"That's bigger," says Ari.

"It's got the nought in now."

"Because of the none."

"Yes."

She goes to a new stone. The smooth ones by the door are full now, the division across the first two and the check on the third and the ladder down the edge of the fourth, so she goes over the lettered one, ATIO, and writes between the letters, around the big square A, and the chalk goes down into the cut of the letters and gets lost, so she has to go round them.

She writes 43036, and 17 under it, and the line.

Times seven first. Seven sixes, forty-two, carry four. Seven threes and the four, twenty-five, carry two. Then the nought.

"Seven nones," says Ari.

"Seven nones is none. And the carry." She puts down the two.

Seven threes, twenty-one, carry two. Seven fours and the two, thirty. 301252. Times ten, 430360, lined up on the right.

Then add. Her hand is tired and the chalk is getting small, so she uses one of the crumbs. She goes slowly, a column at a time, and carries the one where five and six make eleven.

731612.

She doesn't look at it yet. She draws the line under it first. Then she goes and gets Ari's number, the one at the top, under the roof, and she reads it off the stone out loud, a digit at a time, and he reads it with her, touching each one.

"Seven."

She looks at the new one. Seven.

"Three."

Three.

"One."

One.

"Six."

Six. The six that's his.

"One."

One.

"Two."

Two. The two he wanted to change.

It comes up in her chest, the thing that happens when it comes out, and this time it stays.

Ari sits back.

"Is it right?"

"Yes."

"How do you know?"

She points. She puts one finger on his number and one finger on hers, and he looks from one to the other, all the way along, moving his lips.

"Oh," he says.

He looks at the roof, where the fat nought is.

"What did the house say?" says Asel. She doesn't mean to say it. It just comes out.

Ari frowns. He thinks very hard. He looks at the door and then at the Feet on the hill and then at the stones.

"It was long," he says. "It had a forty in it. Or a thirty." He thinks some more. "I forget."

"That's all right."

"Was it the same?"

"I don't know," she says. "You forgot."

He shrugs. She doesn't mind either. She is looking at the two numbers, one over the other.

The yellow goes out of the light. The sky over the Feet turns the colour of the inside of a shell, and then a darker colour, and then the first of the slow lights comes up out of the west.

They are always there. They come up out of the west every evening, small and steady, never blinking, and they cross over the top of everything very slowly, much slower than birds and much faster than stars, and go down into the east. Some nights there are a lot of them. Ari counts them every night and gets a different number

every night. Their father says there used to be more. He says his father said the same.

"One," he says, pointing.

The door opens.

"Lights," says their father. "Supper."

Ari runs in. Asel stands up. Her knees are stiff and there are stone marks on them, little pits and lines, and she rubs them. She puts the big piece of chalk in her pocket. It isn't big any more. She leaves the crumbs on the step for tomorrow.

The sum is on the stones, the ladder and the roof and the working and the check, all the way from the door to the A. In the low light the chalk is very white. She looks at it once more from the step, the whole length of it, and then she goes in.

"Two," Ari is saying, in the kitchen, at the window. "Three."

Behind her the house brings up the lamps.