Enough rope

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I've heard it said that only the very young and the feeble-minded are free of fear. While I've lasted many years on earth and mastered walking, dressing myself, and mathematics, and become minimally proficient at cocktail party banter, most of the people who know me well will attest to my success at refusing to grow up. As to my mental competence, there is a vast terrain of opinion.

In any case, I have been mostly free of fear throughout my life. Plenty of bad things have happened to me; some of them so bad, I don't want to discuss them here. These things, however, were not preceded by fear and dread. They just fell on me completely unexpectedly. Fear has to come before the event.

I burned off my eyebrows twice before I was sixteen. I accidentally burned down a large oak tree by using a candle to see inside a hollow in its trunk. I used up two chemistry sets and whatever else the local pharmacist would sell me. I built rockets that almost never flew up, but usually just blew up. I performed a static test of a rocket engine built from a Bernzomatic propane tank in our back yard. I buried it in a hole, nozzle up and stacked concrete blocks around it. I crouched behind a picnic table and punched the igniter button. A beautiful plume of smoke and a most satisfying roar erupted from the hole for about two seconds before it detonated. As soon as the concrete blocks returned to the ground, I got up from behind the table and went to look. You see, I was always alert when doing these things, so I immediately recognized the whishing sound of the steel tank shards coming back down through the leaves of the trees and took cover as I could—I covered my head with my hands. I have been electrically shocked so many times I quit counting when I was twelve or thirteen. One hundred ten or two-twenty volts AC and once, 500 volts DC.

I never feared these things. They were my element. Yes, it hurts to be shocked. Yes, chemical burns on your hands and face hurt and provoke stares and inquiries at school, but they are temporary: no reason to fear.

So, as I approached my twenty-eighth birthday, freshly installed as a Postdoctoral Fellow at Johns Hopkins, I was living the life of a scientist as I had always dreamed I might. With help from some colleagues, I convinced the National Institutes of Health to give me a bit over a half-million dollars to build an atomic-resolution electron microscope. That was pretty good money in 1970, worth several million today. It was intended to enable a scheme contrived by Michael Beer, to accomplish the holy grail of bioscience. It would enable men to read the genetic messages in DNA. Nobel prize stuff for sure.

It took a year of planning and two years of construction before the microscope could be assembled for the first time. In order to image things as small as an atom, the microscope must be absolutely still. The vibration from an automobile two blocks away or the soft whish of the air conditioning would disturb it too much. Thus, the apparatus began with a huge steel and concrete block set into the floor, resting on rubber bags. This isolated the microscope from vibrations of the building. A small surrounding room with a multilayer wall insulated it from sound. The microscope itself was about a ton of iron-cobalt alloys, titanium, Teflon, tantalum, tungsten, copper wires, magnets and electronics. The electron optics were enclosed in a large stainless-steel vacuum chamber. The electrons were propelled by one hundred

thousand volts, a bit of electronics that commanded even my electricity-jaded respect.

The pieces had been assembled over the last few weeks. They had to be installed in a specific order and carefully aligned to ten-thousandths of an inch. Now, everything was in place except the bottom flange of the vacuum chamber. It was a twelve-inch diameter, one-inch thick plate of stainless steel.

Being so close to achieving assembly, I had gone home for dinner, played with the kids for a while, and then had come back to the lab to finish. By the time various odd tasks were done and the flange, its copper gasket, and the thirty-six bolts that held it were ready, it was about two am. To attach it, I had to place the bolts and wrenches where I could reach them, place the flange on my chest, and carefully work my way under the microscope. It was very tight. Once I had slid into place, I had a bit more room: enough to move my arms and work the wrenches. I had to lift the sixty-pound flange to the bottom of the chamber and click two spring clamps into place to hold it until the first couple of bolts were inserted. Then I systematically placed the other bolts. Finally, I began to tighten them. It was necessary to tighten each one in a specific sequence so that the copper gasket would deform properly and seal the chamber.

Finished. It was actually finished. I laid the wrenches down, cupped my hands behind my head, and began to enjoy the accomplishment. The soundproof door was open, so I could hear the rattle of the mechanical vacuum pump, the whir of the computer fans and the soft hum of the other electronics. The steel cap of the antivibration base was cool but the air in the lab was warm enough to compensate nicely. As long as I didn't move, I was rather comfortable. I grinned. It was a very nice milestone.

And then, I looked down at my feet and saw him squatting there. He slowly crawled under the microscope with me. It made no difference that it was so tight there. Fear came in and laid beside me.

He began by just asking questions.

"How much money did the guys at Oak Ridge have to build their machine?"

"Oh, about one and a half million, about three times my budget," I answered.

"How long did they work?"

"Four years, and they're not finished."

"Are you sure you didn't forget some important specification?"

"I don't think so, but I won't know until I try it."

"You don't think so? Did you align it adequately?"

"I did it the best I could."

"Is it clean enough?"

"We don't have clean-room conditions. Those two dust collectors from Sears Roebuck help some."

"Have you ever done this before?"

"Yes, I built a Mossbauer-effect apparatus."

"Was that anywhere nearly as big and complicated as this one?"

"No."

"Will the electrodes withstand one-hundred kilovolts?"

"They'll be okay if Jim polished them smooth enough and they're clean enough."

"If? How will you do the electronic alignment?"

"I don't know. I have to figure it out."

"Tell me again, how much money have you spent?"

"A half million."

Then he leaned into my brain and whispered, "They've given you enough rope to hang yourself."

I just laid there. I didn't really understand his meaning at first.

"It's an old metaphor," he said. "They've given you just enough rope to hang yourself."

And then I understood it. He was right. When you graduate from a research university, you're supposed to get a postdoc position and build a reputation as a researcher. You should turn out at least two papers a year. Several more would be good. Choose a safe project. Choose something where the answer is pretty clear; it just has to be demonstrated. Measure something. Purify a new protein. Get your papers out. Get a real job.

"How many papers have you published in the last three years?" he asked.

"Two. I was coauthor on the paper with Jim White and I did the EMSA talk on the microscope

design."

He just laughed. I knew why. I knew I hadn't published enough.

The chance to design and build a unique research instrument, to use the skills I had learned while building rockets and dropping hot solder between my fingers in my shop behind the garage had been irresistible. I had counted myself so lucky that Mike Beer and the NIH had given me this chance. I had never stopped to think how unlikely to succeed it would be. I had happily taken the rope and even thanked them for it. I had failed to do what is expected of a research postdoc.

So what do I do now? I can't just change to another project. I've had my chance. If the microscope doesn't work, I have no publications; I am a failure. I'll have to beg for some minor industry job. Maybe

over time, I can make a comeback. Maybe not.

"What will Joan and the kids think of you?" he asked. I didn't answer.

"How will you be able to stand yourself?" I couldn't answer.

I laid there for maybe an hour more. Paralyzed. Numb. Desolate. I was in my element. I was surrounded by metal wires, pipes, volatile chemicals, electronics, high voltage. Wedged under the steel chamber and bound in by the heavy aluminum plates that supported it, I was not only in my element, I was almost literally part of it, but he had found me.

Finally, about 3:30 in the morning, I crawled out from under. I switched on the vacuum pumps and started the chamber heaters. I flipped off the lab lights leaving only the glow of the red, amber and green pilot lights and the yellow glow of the vacuum gauge. I always liked to look at it for a while: a high-tech Christmas display; so I just made him wait.

Out behind the lab, next to my Ford Pinto, I asked him, "How long do you plan to stay?"

He opened the passenger side door and looked over the roof at me. "Until we see whether it works or not."