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Why Things Fall: Galileo, Hawking, Rabinowitz

Galileo Galilei had a lovely courtyard in the house he was not allowed to leave. Someone found an abandoned bird, one they weren't sure could survive on its own, and brought it to him, a man with nothing better to do. Galileo put mesh over his atrium so the bird could fly and not shit on important documents inside the house. We do not know what kind of bird this was. After, those returning from the New World would sometimes bring him birds unseen on his continent. Parrots. Small jays. He became a repository for what other people couldn't hold on to. And it brought him visitors, people came to see the specimens brought across an ocean. Returning explorers sometimes brought him trinkets, jewels, maps, drawings of the people indigenous to that other land, rewards for his loyalty to the mission of conversion.

His church believed birds don't have souls and souls are all that matter. Birds seem to not be falling but they are in fact flying while falling. Galileo mopped the tiles of his courtyard daily until he could no longer see well enough and then his daughters did it for him.

I am learning these things from Galileo's journals. I am supposed to be writing a research paper but instead I keep typing these notes, anecdotes. Deleting them, retyping them. The assignment is to research how one physicist built on the work of others. Learn from the past to be inventive in the present. The professor thinks that physics has become too in-the-lab, too in-the-skull, we don't get enough of a chance to survey the field. I work in Unified Field Theory. I do not think my professor understands my research. He says, "You are getting ahead of yourself, Elizabeth."

Galileo dropped a book and a florin from the Leaning Tower of Pisa and they struck the ground under his wrists at the same exact time, proving Aristotle wrong. Paper falls more slowly—he understood that our perceptions often don't match the things he knew to be true. But if he could suck the air from the earth, his body and a feather would land at the same instant. Laws work best in the purity of a vacuum.

Galileo improved the compass. Galileo used pendulums as timepieces. Galileo invented a 30x magnification telescope, the most powerful yet.

Galileo did not discover anything. He saw Jupiter's four moons first. To not know something and then know it—but they were always there. No law or constant or field or theory is named after him. What counts as discovery? Gravity was there before Newton had a name for it. The New World was only new to the people who hadn't been there yet, not the thousands or millions of people who'd lived there for thousands or millions of years, or forever. Did Einstein discover relativity, that $E = mc^2$? Or give symbols to truth? I don't want to *discover* the Theory of Everything. I want to describe what I am certain is already there.

Galileo did not discover that the earth travels around the sun—Copernicus proved that, more or less. Others suspected. Galileo made it popular, a controversy. People borrowed his telescope or bought their own and looked up and Jupiter had moons circling it; the universe wasn't concentric, not anymore, anyone could see.

That's what I want to do. Show that the world isn't so simple as it seems.

They've got a GUT, a Grand Unified Theory, which reconciles electromagnetism with the strong and weak forces. But no TOE yet, no Theory of Everything. Gravity still can't slot in. General Relativity and Quantum Mechanics make sense—Newton has been overthrown, but Einstein, Heisenberg, Schrödinger, Planck, Oppenheimer, Fermi, what they did still works. It just doesn't work together. Relativity only needs gravity, but quantum can't deal with gravity. Gravity is still a problem. We've got a gut but no toe. I do not know what that means, can't turn acronyms into metaphor. I don't know what's next, but I want to be the one to do it.

I've been working on string theory but it hasn't fixed the problem of forces and fields. I've worked on perturbative heterotic string models, 11-dimensional M-theory, orbifold and orientifold singular geometries, D-branes, flux compactification, warped geometry, and nonperturbative type IIB superstring solutions. But some part of me knows that the answer isn't there.

GALILEO WAS TOLD TO STOP advocating heliocentrism and he did. In 1616 he asked if he could write a book, *Dialogue Concerning the Two Chief World Systems*, describing the Aristotelian/Ptolemaic/geocentric system and the Copernican/heliocentric system. Both possibilities. The Inquisition said sure, but when the book was published, Simplico advocates

geocentrism, and while yes, his world system can be seen as the simpler of the two, he also comes across as a simpleton. Advocacy by showing the idiocy of the other side.

The idiots in my reality say things like, "Oh! A woman physicist! How does it feel to be so rare?" Some even say, "And you're so pretty," as if I am meant to have any response to that sentiment at all.

They charged Galileo with heresy. He recanted in front of many men in gemstone-toned robes, then spent the rest of his life under house arrest.

They used the Bible against him, of course. In his journals he wrote that Ecclesiastes 1:5 tells us that "the sun rises and sets," and it looks that way, yes, of course. A poetic way of describing how reality seems to be. Poetic language feminizes the earth in Psalm 104:5: "He set the earth upon her foundations, so that it shall never move." The Bible is not always literal, Galileo said to the men trying him. It is, they responded. That shift from *her* to *it*, alongside that tense—*shall*—got Galileo interested in translation. He wondered what the original said, so he found all the varieties of the Bible he could. Chronicles 16:30 is translated variously (in my translation from his Italian—my Italian is passable, learned when I was an art student, like Galileo once was, when I wanted to study perspective and chiaroscuro, represent figures, before I fell in love with mathematical figures—but I use a dictionary to help me):

Tremble before him, all the earth! The world is firmly established; it cannot be moved.

Fear before him, all the earth! The world also shall be stable; that it be not moved.

Fear before him, all the earth! The world won't be shaken; it is immovable.

The tenses: *è* = is, *deve essere* = shall be. Is it stable now, or will it be at some future time? Is it immovable, or cannot be moved? Galileo wanted to learn Aramaic, but his eyes failed him. "Say among the Nations, The Lord reigneth. Surely the world shall be stable, and not move, and he shall judge the people in his righteousness." Psalm 96:10. Someday. Not now.

Galileo Galilei never went to Galilee. He wanted to eat seafood and bread where Jesus increased the loaves and fishes, read the Sermon on the Mount in the place where it was spoken, swim in maybe the same water Jesus touched, evaporated and rained down into the same sea many times since then but essentially the same. Galileo thought he would be a priest, after he thought he would be an artist. But he read the Sermon on the Mount time and time again, and didn't feel he could actually hold people to those standards. Couldn't hold himself to them. And when he

stood in front of the Inquisition, he said yes, yes, he believed everything in the Bible to be the literal truth, and he was deeply sorry that he implied science said otherwise, and he humbly repented.

As he walked off the little stage they made him stand on, his journal confirms the rumors every student of physics and mathematics and astronomy and cosmology has heard ever since: as he walked away from them, he did say, loudly enough for all to hear, "And yet it moves!"

Galileo felt what others did not feel, his body told him, then his observations of the heavens confirmed it—we orbit, gravity makes it so. The earth feels still under our feet, yet we are moving at incredible speeds. Falling through the cosmos. This he knew to be true: we are all falling together around a ball of light, another ball of light falls around us, we are caught between two spheres, tumbling through space around fire while a reflective stone plummets around us, again and again and again.

I HAVE ONE WEEK to turn these notes into a research paper. I have no thesis, just these saved pages. I'm not the type to keep a diary, but this feels more like that than like any essay. I'm not doing science here, I know.

I went to the laundromat today and a fairly attractive man, roughly my age, watched me fold my panties. I own only black underwear and they are attractive enough, some have lace, boyshorts and thongs and bikinis, not too many choices so I don't have to think about that too hard when I get dressed in the morning, just put on whatever won't show under clothes. Cute enough that no one would be embarrassed to find them on me, nothing so fancy I'd seem to be someone in bed that I'm not. On occasion I go home with men when I go to bars. I've had boyfriends that lasted months, never years yet. This man did not try to hide the fact that he was watching me. I am a meticulous folder. He saw the MIT T-shirt my dad bought me when I got into the physics PhD program, a big step up from the local state school in the New Mexico desert where I did my undergrad, and he asked me if I went there. I said yes. He said he went to Harvard Business and what did I study? When I said Theoretical Physics, he scoffed. That's the only word for the sound that came from his throat. I looked at him, threw my unfolded clothes in my bag, and we both went home alone. I finished folding my clothes, tried to work on this paper, typed these notes instead. Now I will read one of my three-hundred-dollar textbooks. Men like him do not make me think I can't do this. I do not know what they make me think.

SIX DAYS LEFT.

These days his daughter says his penance for him. That's how Galileo phrased it, so he must have done it himself awhile. He was commanded to recite the seven penitential psalms weekly. His daughter Virginia had become Sister Maria Celeste. His daughter Livia had become Sister Arcangela. They had no dowries. They were sent away before they were old enough to choose the convent for themselves. Maria Celeste wrote letters to her Illustrious Lord Father telling him that her love for him was "infinite." For Galileo, infinity was a mathematical concept. Galileo never married Marina Gamba, his housekeeper, though she bore him three children.

It's unclear whether or not Galileo loved Marina Gamba. He mentions her rarely in his journals. Mentions his children rarely. They were not what was on his mind. The Inquisition seemed unbothered by the fact that he had children and no wife. I am unbothered. In his journals, Galileo draws sketches, writes numbers I don't see the pattern of.

FIVE DAYS.

He writes this: a visiting Franciscan monk handed him a doll, but it couldn't be for children. Too spooky. The monk said it was carved from the root of a cottonwood tree. The doll had the broad shoulders of a man, but wore a skirt of animal hide. Its skin was black and its tongue stuck out far from its grimacing mouth and its eyes bugged out of its head. "I wanted to pay respect to your piety," the monk said. "And to a former countryman of yours, whose good work laid the foundations for the work of God I now have the privilege to do." The monk was Spanish, Galileo Galilei was Italian, but each man spoke enough of the other's language that they could communicate. The monk, whose name is unrecorded, told Galileo a story.

Álvar Núñez Cabeza de Vaca and 600 other men left Spain for Florida in 1527. They got lost in the swamp and their numbers were reduced to 242. They slaughtered and ate their horses. They made bellows from deerhide to fan a fire hot enough to forge metal tools and nails, and made five boats. They sailed to the mouth of the Mississippi and a hurricane reduced them to two boats and forty men. They sailed on to what is now Galveston, Texas, which they called Malhado, Misfortune. They were enslaved by native peoples. Only four men survived and escaped: Cabeza de Vaca, Andrés Dorantes de Carranza, Alonso del Castillo Maldonado, and a Moorish slave called Esteban. They wandered the desert for eight years.

They were occasionally enslaved. Cabeza de Vaca healed some with the faith he never lost—"Never," the monk said, "like you, Galilei, you have always believed that the church knows best." Finally the four men reached Mexico City and other Spaniards, and sailed back to Europe in 1537.

I've since read *La Relación*, and it's all true.

"Here is where this story connects with your gift," the monk said. "Fray Marcos de Niza was born in Nice, which was under the control of the Italian House of Savoy. That makes him a countryman of yours. He'd heard stories of the Seven Cities of Cibola, made of gold. He and Esteban de Dorantes of Azamor guided Francisco Vásquez de Coronado there."

Esteban traveled days ahead of de Niza with a group of Christianized Pimas and Tlaxcalans. The first nonindigenous man the Zuni people met was an African slave. Other native people had previously treated Esteban like a god, gave him turquoise and women. He expected the same from the Zuni people. Or he interrupted a ceremony. Or the gourd rattle he carried there offended them. But he did something wrong and they killed him.

"This is Esteban?" Galileo asked, looking into his hands, horrified.

"Yes. A kachina based on him. A doll to teach children of the different spirits. He is an ogre spirit now. He frightens children into good behavior. His tongue hangs out and his eyes bug because they garroted him. The story does not end there. I have returned from the same village. We have since sent many more explorers and missionaries. We have brought faith to the pagan indigenous tribes of the New World."

Galileo hadn't realized he was considered to be a part of the Christianizing mission. He writes, "Since I recanted my beliefs all know me to be faithful. Those returning from the conversion of souls bring me maps they trace my hands along since I can no longer see. They bring me bundles of birds broken by the long journey over the sea and hope I can heal them. They bring me more and more dolls of spirits the Natives once believed in, but no longer do. They have recanted, too, of course."

FOUR MORE DAYS to turn this into something I can turn in.

The middle finger of Galileo's right hand is housed in the Museo Galileo. Part of me wants to go there and stroke it.

Manhattan Project. Los Alamos. Oak Ridge. I was born near proving grounds. Born near where bombs were used. Not against people. Just sand blown upward, desert plants and animals destroyed. I was born near the place where the doll was made, before it was carried to Galileo's hands.

Trinity. The name of the test site was taken from Donne. "As West and East / In all flat Maps—and I am one—are one, / so death doth touch the Resurrection." Who thought this was about resurrection? Oppenheimer, that charmer. "Batter my heart, three person'd God." Trinity.

I do theoretical physics because it can't be used against anyone.

If I quit, they will say I was too emotional all along.

THREE MORE DAYS until the deadline. In a three-hundred-page textbook, not one woman's name is mentioned. Can I be the first whose name is known to households with a woman's name before the last? Elizabeth Rabinowitz added to the list.

TWO MORE DAYS. Last night I couldn't work anymore so I went to a bar for a beer. I met Stephen Hawking. The only heroic scientist still living.

He was with an aide who helped him drink beer through a straw. I asked if I could join them and she could tell by his eyes that his answer was yes. I told him I was a great admirer.

He spoke prefabricated sentences that are easy for him to find and click on, sentences he must tell to a lot of people he meets. His mechanical voice is not hard to understand. He was born exactly three hundred years after Galilei died. He calls him Galilei, by his last name. Hawking's boyhood nickname was Einstein. He held the position at Cambridge that Newton held. Nothing is bigger or older than the universe. Space and time began with the Big Bang and end in black holes. Because there is a law such as gravity, the universe can and will create itself from nothing. Life appeared on this planet within half a billion years of when it was possible, pretty quickly in the ten-billion-year lifespan of a planet, so the probability is high that life could also spontaneously arise on other planets. "But," his machine said, "I do not think there is life within one hundred lightyears from us. If there were, we would have heard from them by now. And if there is no other life in the Milky Way, then we really should survive. The exponentially increasing use of the finite resources of the planet makes me believe the only way for us to survive is to move into space. That's why I believe in manned, or should I say personed, space travel, the sooner the better. I've done my zero-gravity trial. I'm scheduled to go on Richard Branson's trip to space next year. For a long time, the biggest danger to our survival as a species was comets. Now, our problems are man-made. Or should I say human-made. We will destroy ourselves if we stay here."

I asked him if he'd ever known a stupendous female physicist.

"No," he said. "But I do not think that is the fault of females. They have not been given the same opportunities as men."

It took him about seven minutes to type this three-sentence answer. Apparently no one had asked him this before. I asked if I could buy him a beer and he didn't ask his nurse for permission. When I returned, he wanted to talk about black holes. Everything he said, all the preprogrammed sentences in the memory bank of his speaking device, felt like they were about me.

Matter falling into a black hole forms an accretion disk heated by friction, the brightest objects in the universe. For an outside observer, time slows for objects falling into a black hole, taking an infinite time to reach it. An indestructible faller can't tell when the event horizon is crossed. When an observer falls in, information—its shape, its charge—is evenly distributed along the horizon and lost to observers. A gravitational singularity is a point of zero volume and infinite density where spacetime curvature is infinite. In a nonrotating, noncharged black hole, the observer falling in gets added to the singularity. This can be prolonged by accelerating away, but it can't be avoided, so it's best to just freefall in. The observer is torn apart by tidal forces.

"It's called spaghettification," Hawking told me.

"I know," I said. I'm not the type to pretend to know less than I do. "In a charged or rotating black hole," I said, "the singularity can be avoided, and the observer can exit into another spacetime, so that the black hole functions as a wormhole. One could exit into one's own past."

"That's why your work on unification is so important," Stephen Hawking told me. "None of these peculiar effects would survive a proper quantum treatment of rotating and charged black holes. You might be the one to unify quantum and gravitational effects into a single theory."

Symmetry. Infinity. Saturating this inequality. Naked Singularities. Unphysical. Cosmic censorship hypothesis. Little Boy. Fat Man. Dark stars. Frozen stars. Photon sphere. Gnomon shadows. Circumpolar stars. Neutron star. Ergosphere—the space where it is impossible to be still, where you would have to accelerate at greater than the speed of light in the direction opposite of the black hole in order to stand still. I feel myself being pulled into myself. A collapse. Gravity's relentless pull.

"It's not that I can't do it," I said. "It's that I might not want to. Or, rather, I want to—my work is the most fun thing I know how to do. But it feels awfully pointless sometimes. The weather as strange as it's been.

War. Famine. My thought experiments and tinkering in a lab, what good is that to the Ukraine? To a kid whose family was killed by drone strikes? Drone strikes, for Christ's sake."

Dr. Hawking laboriously typed by twitching his cheek muscle. His machine said, "More fun than sex?"

I laughed. Then thought about it. I really did. Nothing worthwhile came to mind. "Yeah," I said. "Much more fun." He didn't type. Just looked at me. "Should I say it for you?" I asked. "That's a big part of my problem? Great sex would make me feel better about the world? Probably. There are just so few men I want to sleep with. They're so stupid. Or boring. Or unkind."

His response? "I want to sleep with everyone."

I looked at this man, all the muscles I could see still, save one. His internal muscles still worked, digestion and breathing, which is why he was still alive over fifty years after his diagnosis, after they gave him two and a half years. "I'm sorry," I said. "You have it harder than me."

"It is not a competition."

"I know. But now I feel bad for feeling bad." The aide lifted the beer to his mouth and he sipped. "Would you like me to do that?" I asked her. She said no. No reason. But a kind of responsibility, I assumed, devotion. She's the one to do it. "I wish you could speak as quickly as me, as I, so I could know what you're really thinking," I said.

He found the prepared quote he must have said to other people. "My disability has not been a significant handicap. It has probably given me more time that most people to pursue knowledge."

I wondered if he would consider depression a disability. I wondered if the time spent in my own mind, more than most, has been beneficial.

"Can I see your work?" he asked.

"I just have scrawls with me. Most of my calculations are in my office. One wall a window, the other three chalkboards. I've been thinking about the limits of string theory. I don't think what I'm looking for is there. Thank you for asking."

His aide held the notebook. She must know the speed he prefers to read, turned the pages with no obvious signal from him. When Stephen Hawking was diagnosed with amyotrophic lateral sclerosis he and his lady friend married, thinking it would be intense and tragic. He's since had three kids, divorced the wife that was supposed to be short-term and the nurse he left his wife for. This nurse is just a nurse, as far as I know.

He typed for ten minutes, then said, "You are missing something. I do

not know what. But I believe you will find it."

I shook my head as if to sling my thoughts out my ears and said, "Thank you. I just want what's in here to matter. You matter. I want little girls to know they can do this. I'm sorry. I must be a little drunk. Morose."

"Are you a betting person?"

"Not usually."

"I would like to make a wager. You will find the Theory of Everything."

"If you're right?"

"You take me out for a night on the town."

"So I'm betting against myself? And if I don't do it? If I win?"

"I take you out." This man who must be fed. And then, the last thing he said to me that night, typed while I finished my fourth beer and he finished his second, "It matters more, for some, for others to believe in them, than for them to believe in themselves. I am betting on you. I am drunk. Good thing I am not driving this machine home. Thank you for a lovely evening. I hope you become less lonely soon."

This morning Dr. Hawking's chalkboard arrived. The one he used in Cambridge. A note, printed in the same early-nineties computer font his machine uses, green ink, a weird joke I loved, says, "You are part of the lineage. Good luck and go for it." I will not turn in this research paper. The chalkboard covers my window so that I can write on four surfaces without distraction.