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Abstract

When people discover I am a nuclear physicist, they often say, "Oh, like Marie Curie!" And yes, I am like Marie in that I have woman parts, I study nuclei, I have two children and a physicist husband. But had I lived in her time, I would not have been that rare female admitted to the Sorbonne. I could not have quietly made the top scores on the math and physics examinations. I am impulsive and thin-skinned, my occasional cleverness passing for deeper talent. I would probably have been a cleaning girl, pregnant at 15, unable to speak any language but my native one, whatever mine might have been back in 1891. [*excerpt*]

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When people discover I am a nuclear physicist, they often say, “Oh, like Marie Curie!” And yes, I am like Marie in that I have woman parts, I study nuclei, I have two children and a physicist husband. But had I lived in her time, I would not have been that rare female admitted to the Sorbonne. I could not have quietly made the top scores on the math and physics examinations. I am impulsive and thin-skinned, my occasional cleverness passing for deeper talent. I would probably have been a cleaning girl, pregnant at 15, unable to speak any language but my native one, whatever mine might have been back in 1891.

And so I am not that much like Marie Curie, and yet I cannot help myself. I designed a course with her name in the title, one of the perks of being faculty at a small, liberal arts college. I team-teach another course with my historian friend on the history and science behind the bombings of Nagasaki and Hiroshima. I assign readings about Marie. I lecture on Marie. I think a lot, perhaps too much, about this woman.

Things Marie Curie and I agree on: child rearing, talking to oneself, avoiding medical treatment, and nuclear stability.

She had her father-in-law, a careful man, a loving man, watch her two little doves. When he passed away, she narrowed her eyes and interviewed many a girl until the right one presented herself. Marie knew, as I know, that no mother can do nuclear physics when one ear is listening for her child to stir from an afternoon nap.

Marie talks to herself in Polish, always in Polish, deep in the cave of her thoughts, her papers strewn on the Persian rug, sitting crisscross applesauce or crawling around on those leukemia-plagued knees. On a

bad day, I mutter to myself in my office, I swear aloud at the keyboard, the mechanical pencil. On a good day, I whisper to myself as if I am a prodigy.

When I cough my way downstairs on cold mornings, I brush aside pleas from husband and children to seek medical care. I trudge through too many days an illogical martyr, believing willpower exorcises illness. I eventually concede antibiotics. Marie loses the feeling in her thumbs from handling her beloved radium, but she does not stop. She habitually rubs her four fingers against her thumbs at work, at home, in sickness, and in health.

Marie isolated two of the most radioactive elements our planet does keep. My team creates nuclei too unstable for rocky places, volcanoes, sky. My nuclei—oxygen yoked with eight additional neutrons, helium burdened with six neutrons too many—these are naturally the stuff of stars, but with herculean effort we produce them in an oversized Michigan research facility. Our exotic oxygen sheds the excess as fast as the physics allows because the radioactive things of this world, this universe, share one trait, and that is to not be radioactive anymore.

Marie's radium is lovely, a silvery metal, warm to the touch. Her laboratory in the evening becomes a fairy wonderland, with radium in vials glowing blue in the dying light. She has an affinity for this particular element because she had to shovel hundreds of pounds of dark sooty uranium ore to get even traces of it.

Nuclear radiation makes sense. Radioactive materials like radium, nature made unstable. Over time, the nuclei cast out the parts of themselves that disturb. Uranium 238 eventually becomes lead. Uranium becomes stable, immortal.



Radiation is dosed in “curies.” A curie represents a breathtaking amount of radiation. I imagine crawling into a 660-pound igloo of purified uranium-238 mined from the geologic formations near my Pennsylvania home and living there for five and a half days. To get the same radiation dose from her radium, Marie Curie needs only a radium pellet, the weight of a postage stamp, in her lab coat pocket for an hour. I have never been exposed to such an amount. In this respect, Marie Curie and I are not alike.



She moved mountains of dirty uranium ore to get the small nuggets in her pockets, valuable beyond measure. Her silvery-blue radium baubles are so full of nuclear energy that they served her as extremely expensive hand-warmers. But by 1927 some girls in New Jersey have made the news, and Marie Curie is troubled. New Jersey businessmen hired young, pretty art majors to dot radium paint onto watch dials. Amelia, Grace, Katherine, and their co-workers repointed their paintbrushes with their pink lips, their red tongues. Many visited a local dentist, complaining of pain in their jaws and of tender, bloody gums. Of the 70 girls exposed, only five sued. Three years later, the case was settled out of court. The five could use their settlements to live as well as they could in bodies so radioactive their breath set off radiation detectors.



As a child I squatted on yellow-and-gold shag carpet, head drooping over the 1960 *World Book* volume C, picking mosquito bites on my lower legs while staring at her serious profile. She chose not look at the photographer, this woman of the two Nobel Prizes, but a tight nervousness emanates, even side on. Her frizzy hair was unsettling. Her childish proportions, with that microsized ear, the playground nose, upturned like a caricature of a snobby schoolgirl: her profile made me squeamish. I preferred the G volume. The Girl Scouts had smart dresses and clean hair and eyes free of worry.

When those close to me find out about my family—my grandfather a physics professor at a community college, my father an engineer, my mother a chemistry teacher—they conclude that my decision to study physics, to be a nuclear physicist, was pushed along by an encouraging home life. Here we are, the imagined family lazing around the dinner table with dessert. Our inside family joke perhaps about methylxanthines, those molecules that stimulate the mind: coffee, tea, or chocolate? We are all methylxanthine addicts! Ha! It never gets old, that one.

The reality was of getting by, of divorces, of loss. Still, I like to think their nonchalance about science and mathematics straightened my path.



As a child in Warsaw, Marie Curie may have had dinner conversations about science, but if she did, no one has recorded the details. Marie's father taught physics and mathematics, and that should have been enough to cover the expenses. But it was not. He had to take in boarders. A crowded house, a changing guest list for the evening meal. Later, in Paris, Marie lived with her sister and brother-in-law, both of whom were studying medicine. Marie did, I think, try to talk science with her brother-in-law, but he was put out because she gave him "no respect." He was her legal guardian, but she was her own man.



Marie Curie probably had bad teeth. There is no recorded image of her smiling to support or refute this claim. My smile, on the other hand, is the product of torque and force, brace and retainer. I was five years old when my mother first drove for over an hour to the orthodontist. The lobby was spacious, sunlit. The light-colored wood in the chairs implied an eye to the future, to innovation. For the next ten years as a team remade my mouth I would appreciate the German-made wooden toys in that lobby, the push trains made with precision.

Dentists today remark on my orthodontists' skill. My teeth suggest parents with the means to cover college tuition, perhaps a gap year in Europe. The reality was of a mother who made sure her daughter could one day look the part, a mother who clipped coupons and grew her own food. A mother, once she had the funds at nearly 40 years of age, who finally went to the orthodontist for her own sake.



One could argue that instead of crooked teeth, Marie Curie's stoic look was from her childhood. When Marie was only five years old, the bacteria *Mycobacterium tuberculosis* found Marie's dark-haired mother a welcome host. Trillions of those plush, slender rods had a field day within her aristocratic nose, quickly establishing residence in the comfortable nooks of that young mother's lungs.

And then typhus for Zosia, Marie's oldest sister. *Rickettsia prowazekii*, more velvety rods under the microscope, albeit shorter than *Mycobacterium tuberculosis*. Typhus' posh, stubby rods erode a young girl's health with far-flung meanness. Her blood vessels become second-rate, flimsy. Fluid moves to abnormal places, angry spots crop up under the skin. Too little blood flow makes toes and fingers rot. Fluid on the brain, delirium. High fevers, extreme pain in the smallest movement. Death, take her soon. The smell is awful.

Years later, when Marie was a 42-year-old mother of two working in France, she might have read that a Frenchman, Charles Nicolle, discovered how the beautiful rods of typhus are transmitted, through lice of all things, earning him the Nobel Prize in 1928. By then Marie had earned two Nobel Prizes. No record suggests Marie attended the ceremony. Would she have even wanted to?

Tuberculosis, Marie's mother's disease, was only a breath away from each of her children, her dear husband, her friend come to help with the housework. The disease toys with time, quick to infect but slow to manifest. She lived for five years before her cough became bright with blood, before she started choking, face flushed with fever. Probably her kidneys, that pair of dark workers stationed deep within her graceful torso, forgot their occupation. The tuberculosis death is noisy, dramatic, memorable. A ten-year-old child might not smile at all after seeing such things, but I still argue that she had bad teeth. Marie's daughter describes a mother who never lost her love of life. Marie would, in her final years, still find mirth "to the point of tears, with an unexpected laugh of youth."

If Marie could be alive today, we might talk about how tuberculosis and typhus still rampage the poor, the displaced, the crowded in Africa and Eastern Europe. I would be appalled for her sake, but once she left me I would put those diseases out of my mind and think about laundry or dinner.



Even when sitting for a portrait at 62, Marie Curie is rubbing her left thumb with the fingers of her right hand. Over the past 30 years her entire person has been irradiated, but one digit squawks the loudest, or perhaps it is silent, a ghost thumb. We do not know if she was trying to rub life in or push pain out.

Eve Curie thought her mother was beautiful. While it is true that over time Marie developed an intensity that comes through in photographs, especially the rare portrait face-on, I would not call it beauty. Two towers of books on Marie Curie live on my desk, along with a terrarium, a plastic deer, and two computers. My astronomer friend noted that Marie Curie, upside down, looks just like Art Garfunkel. That is not a compliment.



Alan Alda is “in love with Marie,” his feelings forcing his hand; he must fly first class to spend a few moments in her lab. While in Paris, he racewalked from her place to her lover’s, just to experience the haste she might have once had. Last year he debuted his play, *Radiance: The Passion of Marie Curie*, a work of creative expression that I refuse to see, because what kind of man professes to love Marie and then casts a 5’10” blond to play her? It is hard to imagine Anna Gunn shoveling uranium ore with her perfect Hollywood arms.

Hawkeye is not alone in his misguided fawning. Lauren Redniss published *Radioactive: Marie and Pierre Curie, a Tale of Love and Fallout*, a coffee-table book that glows in the dark, supposedly, though my copy seems to lack this property. When Lauren Redniss talks about Marie Curie, wide eyed, she will say that radioactivity and love are both invisible. I am not sure this is entirely true. Our eyes cannot resolve the beta and alpha particle, but with the right equipment, they can be measured. On comparing love and radioactivity, Marie and I might agree on two things: there are different types of love, varying by level of stability, and just as the universe seeks stability, so too do we.

I don’t believe in ghosts—I am a physicist, after all—but I do feel a sisterly tug to protect Marie from people like Lauren and Alan. Even when she lived, others took her life and made profit (Einstein called those journalists “vipers”), especially when she dared to act like a widower instead of a widow and find love again, this time with a married man.

Perhaps those who can understand Marie Curie’s world, a world of data, of graphs, of precision and accuracy, are the only ones who should hold her near. A band, the Radioactive Orchestra, uses physics and music engineering so we can hear the march toward stability from radium, uranium, polonium.

Their music is an echo of the radiation being emitted all around us. A Radioactive Orchestra member says nuclear physics requires the language of mathematics, this “dry language the only real gateway” to understanding. And yet everyone tries to sneak in through a side door, to know her mind and her world, without understanding her science.



Math is the same throughout the universe. I changed schools six times before I was 12 years old. The math was consistent, even if the clothes, the rules, the outcomes were not.



Over the past six months, seven books have been published on our double Nobel laureate. Her letters, her biography of husband Pierre with her weird, abbreviated autobiography at the end, the quotes from her famous physics and chemistry colleagues, her daughter’s biography of her—all these taken together point in no particular direction, a compass gone haywire. She was not all that smart, just married well, and was in the right field at the right time. No, her intelligence was beyond compare. Was she naive, surprised at the press’s reaction to her affair after four years a widow, or was she sophisticated, choosing her battles with those gray (blue?) eyes wide open? She was unbalanced, prone to bouts of depression. No, she was an exemplary example of the working mother. Was she a genius from day one or did her intelligence come at once, an explosion of brilliance? She was a friend to younger female scientists, or she wasn’t. She loved her artsy daughter as much as she loved the science-minded one, or perhaps she didn’t.



Radiation, the kind that radium throws out in such quantities that it literally glows, is a mixed blessing to medicine. Radiation has enough energy to pass through a hand or a foot, no needles or scalpels needed. But like a surgeon’s blade, radiation damages the straight path through that same hand or foot, invisible, like love.

Take some innocent water molecule in an unsuspecting toe. Radiation can rip apart one of that water molecule’s hydrogen bonds, leaving the other hydro-

gen hanging on for dear life to its larger oxygen. This is OH, “oh” indeed, a hydroxyl radical, and in 0.000000001 seconds, this radical will react with anything within spitting distance. And here is DNA, found in each and every cell, miles of the stuff wound in ways we still do not understand. Usually our DNA can withstand chemical assault, but not from a hydroxyl radical. DNA is damaged, and since DNA is our cellular blueprint, when the damaged cell divides, any damage is copied too. Wee little pockets of damaged cells divide in some backwater of your hand, your foot, Marie’s thumb. Cells that divide often, even in adulthood, are the most susceptible: skin, blood.

Radiation can also forgo the middleman and blast DNA right off the bat. Damage done, different method, same result: a cell with a glitch in the blueprint, a glitch that may tell the cell how often to replicate itself. The gimpy cell slows down replication in some cases, never divides at all in others, or divides like crazy, making tumors.

Radiation is an equal opportunity Shiva: it damages all DNA, mutated or not. Cancer cells divide quickly, which means the chances of damaging the DNA increase as well. Oncology uses radiation to damage the very tumors some earlier radiation may have created. Marie Curie’s radium is a bone seeker. Her body interprets radium as a friendly stand-in for calcium, and therefore sends the glowing element to her white bones. Nestled in her skeleton, her radium. In sickness and in health.



At nine in the evening, on a Tuesday, the 28th of February, Dudley the round-eyed Yorkipoo struts before his leash, Mercury the planet glows like a star—not that the dog notices, but I do—and the night air touches sidewalk and elm tree, slides against my neighbors’ golden windows, pushes squirrel clicks and tuts toward canine and human ears alike, an atmosphere of winter-still-here, keep kindling by the fireplace and blankets on the beds. We walk, dog and human, and he sniffs and he marks, he stops and he breathes, and I only think, as I so often do these days, of Marie Curie.

Tonight, her voice. Was her English as heavily accented as Einstein’s? I assume, due to my own silly way of making correlations regardless of causation, that her voice is higher than my own because she is shorter than me. And her voice is surely softer; everyone leans in toward her in pictures. Much softer than mine.



Marie Curie will contract leukemia, but considering the radioactive dose she accumulated during her lifetime, one must marvel at either her immune system or her refusal to seek medical care. As an old woman, she has cataracts, low blood pressure, and a big gallstone that she refuses to have surgically removed. And yet, in the winter of 1933, on vacation with her daughter, her son-in-law, and her sweet little granddaughter, Marie straps on snowshoes and goes off for hours on a solitary hike to see the sun set over Mont Blanc.



Growing up, I rarely walked anywhere. My mother, when she was married to my father and later to one stepfather and then another, always chose to live on family land, be it hers or her husband's. Long commutes to school, church, grocery, to anyone outside the family. Far from normalcy and accountability.

Now I am a pedestrian—a seven-minute stroll to the campus office, 15 minutes with the daughter to the Saturday farmer's market. After a night at the bar, the girlfriends and I giggle home on foot. Over lunch, the dog and I will stretch our legs, breathe fresh air. My husband and I are sometimes the only ones walking in the dark of our Gettysburg, not the inky black of the backwoods but past neon in bars and streetlights on neighborhood streets, our steps sure, the route stable.



By May 1934 Marie was ill with what we now know as aplastic pernicious anemia. Her bone marrow had stopped doing its job, and her blood was subpar. Her symptoms put her in the hospital, albeit in the beautiful Savoy mountains, where she had hiked in the snow months earlier. She tried to finish her textbook on radioactivity. On July 3 her fever broke, and one day later she left us, her book unfinished. Had she lived today, she might have been strong enough for a bone-marrow transplant.



My world, Marie's world, is a place where measurements must be clever else the ion, the nucleus, the light will not cooperate. Wild horses need a soft

hand. In this world, light and ions behave in ways that are beyond telepathy, but since ions and light are not sentient beings, and since physicists try to be precise, we call them entangled.

The 2012 Nobel Prize in Physics went to two specialists in quantum entanglement, the odd situation when one particle is affected by another, even if they are breathtakingly far away from each other. Some say quantum entanglement is the key to better computer security. Some call quantum entanglement spooky.



Why a high-energy photon—one of the particles Marie Curie's beloved radium produces in abundance—would care what another distant photon does, each too far away to exchange information under the limit of the speed of light, is an interesting question.

It is a question, this question of quantum entanglement, that if Marie were here, we could discuss in my comfortable living room. My Russian physicist friends prepare tongue-scorching tea with lemon and sugar, a tradition to ensure a long conversation while the beverage cools. On my substantial coffee table I would lay out a pot of Irish Breakfast tea, the pot decorated with dogs and cats, a gift from my children. In a small round dish I would serve sliced lemon, sugar in a clever dispenser my husband brought back from a trip to Germany. There in my living room, I would serve the tea hot with biscotti made by a talented local baker. I would encourage Marie to open her mind; biscotti is a delicious companion for piping hot lemon-sugar tea.

Would she look me in the face? Would she interrupt? If we talk physics, let the scene be morning, let the air be fresh with oxygen, let the slateboard be clean. Talking physics with Marie will require all I have.