My Mother, the Scientist **by Hirshberg, Charles**	**Vocabulary**
In 1966, Mrs. Weddle's first grade class at Las Lomitas Elementary School got its first homework assignment: We were to find out what our fathers did for a living, then come back and tell the class. The next day, as my well-scrubbed classmates boasted about their fathers, I was nervous. For one thing, I was afraid of Mrs. Weddle: I realize now that she was probably harmless, but to a shy, elf-size, nervous little guy she looked like a monstrous, talking baked potato. On top of that, I had a surprise in store, and I wasn't sure how it would be received."My daddy is a scientist," I said, and Mrs. Weddle turned to write this information on the blackboard. Then I dropped the bomb: "And my mommy is a scientist!" Twenty-five pairs of first-grade eyes drew a bead on me, wondering what the hell I was talking about. It was then that I began to understand how unusual my mother was.	*clean and shiny*
Today, after more than four decades of geophysical research, my mother, Joan Feynman, is getting ready to retire as a senior scientist at NASA's Jet Propulsion Laboratory. She is probably best known for developing a statistical model to calculate the number of high-energy particles likely to hit a spacecraft over its lifetime, and for her method of predicting sun spot cycles. Both are used by scientists worldwide. Beyond this, however, my mother's career illustrates the enormous change in how America regards what was, only a few decades ago, extremely rare: a scientist who's a woman and also a mother.	*ten years; the study of the earth and its relationship to the rest of the universe; a model that uses numbers to show an idea*
To become a scientist is hard enough. But to become one while running a gauntlet of lies, insults, mockeries, and disapproval—this was what my mother had to do. If such treatment is unthinkable (or, at least, unusual) today, it is largely because my mother and other female scientists of her generation proved equal to every obstacle thrown in their way.	
My introduction to chemistry came in 1970, on a day when my mom was baking challah bread for the Jewish New Year. I was about 10, and though I felt cooking was unmanly for a guy who played shortstop for Village Host Pizza in the Menlo Park, California, Little League, she had persuaded me to help. When the bread was in the oven, she gave me a plastic pill bottle and a cork. She told me to sprinkle a little baking soda into the bottle, then a little vinegar, and cork the bottle as fast as I could. There followed a violent and completely unexpected pop as the cork flew off and walloped me in the forehead. Exploding food: I was ecstatic! "That's called a chemical reaction," she said, rubbing my shirt clean. "The vinegar is an acid and the soda is a base, and that's what happens when you mix the two."	*fluffy bread made with eggs*

After that, I never understood what other kids meant when they said that science was boring.

One of my mother's earliest memories is of standing in her crib at the age of about 2, yanking on her 11-year-old brother's hair. This brother, her only sibling, was none other than Richard Feynman, destined to become one of the greatest theoretical physicists of his generation: enfant terrible of the Manhattan Project, pioneer of quantum electrodynamics, father of nanotechnology, winner of the Nobel Prize, and so on. At the time, he was training his sister to solve simple math problems and rewarding each correct answer by letting her tug on his hair while he made faces. When he wasn't doing that, he was often seen wandering around Far Rockaway, New York, with a screwdriver in his pocket, repairing radios—at age 11, mind you.

Scientist who studies concepts of the physical world; someone who says and does whatever he wants even if it is embarrassing or shocking

My mother worshipped her brother, and there was never any doubt about what he would become. By the time she was 5, Richard had hired her for 2 cents a week to assist him in the electronics lab he'd built in his room. "My job was to throw certain switches on command," she recalls. "I had to climb up on a box to reach them. Also, sometimes I'd stick my finger in a spark gap for the edification of his friends." At night, when she called out for a glass of water, Riddy, as he was called, would demonstrate centrifugal force by whirling it around in the air so that the glass was upside down during part of the arc. "Until, one night," my mother recalls, "the glass slipped out of his hand and flew across the room."

education

Richard explained the miraculous fact that the family dog, the waffle iron, and Joan herself were all made out of atoms. He would run her hand over the corner of a picture frame, describe a right triangle and make her repeat that the sum of the square of the sides was equal to the square of the hypotenuse. "I had no idea what it meant," she says, "but he recited it like a poem, so I loved to recite it too." One night, he roused her from her bed and led her outside, down the street, and onto a nearby golf course. He pointed out washes of magnificent light that were streaking across the sky. It was the aurora borealis. My mother had discovered her destiny.

That is when the trouble started. Her mother, Lucille Feynman, was a sophisticated and compassionate woman who had marched for women's suffrage in her youth. Nonetheless, when 8-year-old Joanie announced that she intended to be a scientist, Grandma explained that it was impossible. "Women can't do science," she said, "because their brains can't understand enough of it." My mother climbed into a living room chair and sobbed into the cushion. "I know she thought she was telling me the inescapable truth. But it was devastating for a little girl to be told that all of her dreams were impossible. And I've doubted my abilities ever since."

the fight for women's right to vote

The fact that the greatest chemist of the age, Marie Curie, was a woman gave no comfort. "To me, Madame Curie was a mythological character," my mother says, "not a real person whom you could strive to emulate." It wasn't until her 14th birthday—March 31, 1942—that her notion of becoming a scientist was revived. Richard presented her with a book called Astronomy. "It was a college textbook. I'd start reading it, get stuck, and then start over again.

imitate or try to be like

This went on for months, but I kept at it. When I reached page 407, I came across a graph that changed my life." My mother shuts her eyes and recites from memory: "'Relative strengths of the Mg+ absorption line at 4,481 angstroms . . . from Stellar Atmospheres by Cecilia Payne.' Cecilia Payne! It was scientific proof that a woman was capable of writing a book that, in turn, was quoted in a text. The secret was out, you see."

My mother taught me about resonances when I was about 12. We were on a camping trip and needed wood for a fire. My brother and sister and I looked everywhere, without luck. Mom spotted a dead branch up in a tree. She walked up to the trunk and gave it a shake. "Look closely," she told us, pointing up at the branches. "Each branch waves at a different frequency." We could see that she was right. So what? "Watch the dead branch," she went on. "If we shake the tree trunk in just the right rhythm, we can match its frequency and it'll drop off." Soon we were roasting marshmallows.

The catalog of abuse to which my mother was subjected, beginning in 1944 when she entered Oberlin College, is too long and relentless to fully record. At Oberlin, her lab partner was ill-prepared for the advanced-level physics course in which they were enrolled, so my mother did all the experiments herself. The partner took copious notes and received an A. My mother got a D. "He understands what he's doing," the lab instructor explained, "and you don't." In graduate school, a professor of solid state physics advised her to do her Ph.D. dissertation on cobwebs, because she would encounter them while cleaning. She did not take the advice; her thesis was titled "Absorption of infrared radiation in crystals of diamond-type lattice structure." After graduation, she found that the "Situations Wanted" section of The New York Times was divided between Men and Women, and she could not place an ad among the men, the only place anyone needing a research scientist would bother to look.

a book-length essay or report written to achieve a specialized degree

At that time, even the dean of women at Columbia University argued that "sensible motherhood" was "the most useful and satisfying of the jobs that women can do." My mother tried to be a sensible mother and it damn near killed her. For three years, she cooked, cleaned, and looked after my brother and me, two stubborn and voluble babies.

noisy, talkative

One day in 1964 she found herself preparing to hurl the dish drain through the kitchen window and decided to get professional help. "I was incredibly lucky," she remembers, "to find a shrink who was enlightened enough to urge me to try to get a job. I didn't think anyone would hire me, but I did what he told me to do." She applied to Lamont-Doherty Observatory and, to her astonishment, received three offers. She chose to work part-time, studying the relationship between the solar wind and the magnetosphere. Soon she would be among the first to announce that the magnetosphere—the part of space in which Earth's magnetic field dominates and the solar wind doesn't enter—was open-ended, with a tail on one side, rather than having a closed-teardrop shape, as had been widely believed. She was off and running.

educated, open-minded

My mother introduced me to physics when I was about 14. I was crazy about bluegrass music and learned that Ralph Stanley was coming to town with his Clinch Mountain Boys. Although Mom did not share my taste for hillbilly music, she agreed to take me. The highlight turned out to be fiddler Curly Ray Cline's version of "Orange Blossom Special," a barn burner in which the fiddle imitates the sound of an approaching and departing train. My mother stood and danced a buck-and-wing and when, to my great relief, she sat down, she said, "Great tune, huh? It's based on the Doppler effect." This is not the sort of thing one expects to hear in reference to Curly Ray Cline's repertoire. Later, over onion rings at the Rockybilt Cafe, she explained: "When the train is coming, its sound is shifting to higher frequencies. And when the train is leaving, its sound is shifting to lower frequencies. That's called the Doppler shift. You can see the same thing when you look at a star: if the light source is moving toward you, it shifts toward blue; if it's moving away, it shifts toward red. Most stars shift toward red because the universe is expanding."

I cannot pretend that, as a boy, I liked everything about having a scientist for a mother. When I saw the likes of Mrs. Brady on TV, I sometimes wished I had what I thought of as a mom with an apron. And then, abruptly, I got one.

It was 1971 and my mother was working for NASA at Ames Research Center in California. She had just made an important discovery concerning the solar wind, which has two states, steady and transient. The latter consists of puffs of material, also known as coronal mass ejections, which, though long known about, were notoriously hard to find. My mother showed they could be recognized by the large amount of helium in the solar wind. Her career was flourishing. But the economy was in recession and NASA's budget was slashed. My mother was a housewife again. For months, as she looked for work, the severe depression that had haunted her years before began to return.

changing, moving frequently;
having a bad reputation for something

Mom had been taught to turn to the synagogue in times of trouble, and it seemed to make especially good sense in this case, because our synagogue had more scientists in it than most Ivy League universities. Our rabbi, a celebrated civil rights activist, was arranging networking parties for unemployed eggheads. But when my mother asked for an invitation to one of these affairs, he accused her of being selfish. "After all, there are men out of work just now."

Jewish house of worship

slang for highly educated people

"But Rabbi," she said, "it's my life."

I remember her coming home that night, stuffing food into the refrigerator, then pulling out the vacuum cleaner. She switched it on, pushed it back and forth across the floor a few times, then switched it off and burst into tears. In a moment, I was crying too and my mother was comforting me. We sat there a long time.

"I know you want me here," she told me. "But I can either be a part-time mama, or a full-time madwoman."

A few months later, Mom was hired as a research scientist at the National Center for Atmospheric Research, and we moved to Boulder, Colorado. From then on, she decided to "follow research funding around the country, like

Laplanders follow the reindeer herds." She followed it to Washington, D.C., to work for the National Science Foundation, then to the Boston College Department of Physics, and finally, in 1985, to JPL, where she's been ever since. Along the way, she unlocked some of the mysteries of the aurora. Using data from Explorer 33, she showed that auroras occur when the magnetic field of the solar wind interacts with the magnetic field of the Earth.

each affects (acts upon) the other

In 1974, she became an officer of her professional association, the American Geophysical Union and spearheaded a committee to ensure that women in her field would be treated fairly. She was named one of JPL's elite senior scientists in 1999 and the following year was awarded NASA's Exceptional Scientific Achievement Medal.

Soon she'll retire, except that retirement as my mother the scientist envisions it means embarking on a new project: comparing recent changes in Earth's climate with historic ones. "It's a pretty important subject when you consider that even a small change in the solar output could conceivably turn Long Island into a skating rink—just like it was some 10,000 years ago."

The first thing I did when I came home from Mrs. Weddle's class that day in 1966 was to ask my mother what my father did. She told me that he was a scientist, and that she was a scientist too. I asked what a scientist was, and she handed me a spoon. "Drop it on the table," she said. I let it fall to the floor. "Why did it fall?" she asked. "Why didn't it float up to the ceiling?" It had never occurred to me that there was a "why" involved. "Because of gravity," she said. "A spoon will always fall, a hot-air balloon will always rise." I dropped the spoon again and again until she made me stop. I had no idea what gravity was, but the idea of "Why?" kept rattling around in my head. That's when I made the decision: the next day, in school, I wouldn't just tell them what my father did. I'd tell them about my mother too.