Materials Scientist Dan Shechtman Wins 2011 Nobel Prize in Chemistry

*On October 5, 2011, the Nobel Prize Committee honored materials scientist Dan Shechtman of Technion in Haifa, Israel, with the 2011 Nobel Prize in Chemistry "for the discovery of quasicrystals." But those five official words describing his discovery in 1982 do not even hint at the years of scientific turmoil from which Shechtman emerged triumphant only after a long battle with prominent dissenters in the scientific community. Shechtman spoke as a plenary lecturer at the XX International Materials Research Congress in Cancun, Mexico, on August 17 this year, and the Materials Research Society filed a version of the following story (with some augmentation here) on his talk.*In a fascinating, funny, and heartfelt exploration of the nature of scientific discovery and the complications that come from being right when most of your colleagues think you are wrong, Dan Shechtman of Technion (Israel) and Iowa State University (United States) told the story surrounding his discovery of quasi-periodic crystals in 1982. Along the way he outlined the history of crystallography and provided a great brush-up tutorial on the subject for those of us who studied it a long time ago.

Shechtman showed the page of his TEM logbook from April 8, 1982, when he performed a selected area diffraction on a pitch black grain of an Al-25%Mg sample and saw a diffraction pattern of 10 spots around a central spot. “Ten spots—that cannot be,” he said to himself, as he carefully counted again. He knew that according to the rules of crystallography, 10-fold symmetry was a forbidden crystallographic symmetry state. He wrote “(10-fold???)” in the logbook and went out into the hall looking for someone to show his discovery, but no one was there. When he started telling colleagues about it, no one believed him, beginning what he called the “the years of rejection,” which lasted from 1982 to 1987. At one point during these years he was called a “disgrace to his research group” and was asked to leave. His attempt to publish his results was reject ed by the Journal of Applied Physics in 1984, and finally found a publisher in Metallurgical Transactions in 1985.

“Immediately after publication,” Shechtman said, “all hell broke loose. A lot of people said it was nonsense.” He noted that “at the frontier of science, there is not much difference between science and religion. They [scientists] have their prophets and their beliefs.” Linus Pauling, a two-time Nobel Laureate, was his biggest opponent. Pauling insisted that Shechtman was observing the effects of twinning, not a diffraction pattern from a single crystal. But he persevered in his investigations of this forbidden symmetry, using smaller and smaller electron spot sizes, until it became evident that if there was twinning, the twinned particles would have to be smaller than the 400-angstrom electron spot size he was using. He was eventually vindicated when x-ray diffraction data—the gold standard in deciding crystallographic arguments at the time—showed 5 -fold rotational symmetry in 1987.

These crystals were not strictly periodic, so they defied the definition of crystallinity that had been accepted for 70 years. Shechtman had discovered quasi-periodic crystalline materials. Instead of a constant distance between each atom in the lattice, the ratio of distances varied in accordance with the Fibonacci series, hence the term “quasi-periodic.” This paradigm shift led to a formal redefinition of the word crystal by the International Society of Crystallographers:

“By crystal we mean any solid having an essentially discrete diffraction diagram, and by aperiodic crystal we mean any crystal in which three-dimensional lattice periodicity can be considered to be absent.” Shechtman noted the “soft” wording of this definition, and said “suddenly the Society of Crystallographers became modest. And a good scientist is a modest scientist.”

In the question and answer session following his plenary lecture, Shechtman was asked what he learned from his scientific struggles. “Tenacity,” he answered. “If you get a result that you believe in, then fight for it.”