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From Ridicule to the Nobel Prize: The Discovery of Quasicrystals

When Dan Shechtman took a break from his education at the Technion for a two-year job at the United States National Institute of Standards and Technology, he was not planning on making any big breakthroughs. However, the work he did “instigated a scientific revolution,” according to Pat Thiel, a Chemistry professor at Iowa State.

Shechtman received his initial education from the Technion, eventually earning a Ph.D. in Materials Engineering. He studied the physical and chemical properties of titanium aluminide for three years at the Aerospace Research Laboratories at Wright Patterson Air Force Base in Ohio. Although he went back to Technion for several years, it wasn’t until he went to Johns Hopkins University that his controversial work began. He was studying multiple properties of rapidly solidified aluminum alloys, including “transmission electron microscopy, X-ray diffraction, and neutron diffraction,” according to Newswise. The transmission electron microscope was used to view the molecular structure of the alloys. What Shechtman saw was something thought to be impossible: a crystal built out of a non-periodic shape.

Paul Steinhardt, a professor of physics at Princeton University, says that for about two hundred years before this discovery, a crystal was known to be “a structure in which there is an atom or a group of atoms that repeats with regular spacing between the repeats” (npr.org). Steinhardt makes a comparison between crystals and floor tiles, saying that “there are some obvious rules about which geometry works and doesn’t work.” Shapes such as squares and hexagons, which repeat in patterns, are easy to make a crystal out of. Shapes with five points of symmetry, such as a five-pointed star, don’t work. It’s simply not possible to line five-pointed stars up and have them repeat in a pattern without space in between them. Therefor, it was supposedly impossible for a crystal to be built out of a five-pointed star either.

What Shechtman found on the day of April 8, 1982 said otherwise. He recalls the moment: “... I counted, and there were 10 spots. And I said, ‘No, cannot be!’ And I counted the other way-- 10 spots.” In his notebook, he wrote down “10 fold ???” under the alloy he was studying, but he later found that the pattern actually had five points of symmetry. That day, however, nobody was eager to help him make this connection. His lab chief expelled him from the group, calling him a “disgrace.” While Shechtman says “it was me against the world,” many other scientists were quick to back up his findings, publishing 300 papers over the next year around the world. The only country that wasn’t hot with this topic was the United States, because the two-time Nobel Prize winner Linus Pauling, “the idol of the American Chemical Society and one of the most famous scientists in the world,” lived there, and he greatly disputed Shechtman’s findings (newswise.com). According to NPR, Pauling actively discouraged anyone from looking into the phenomenon. Another story on NPR quotes Pauling saying, “There is no such thing as quasicrystals, only quasi-scientists.”

Shechtman never did figure out how to make a regular pattern out of five-point shapes, but he did discover another way for the crystal to exist. Rather than a normal pattern, the elements in this structure “repeated in a more subtle way.” Steinhardt found Shechtman’s published paper just as he was conducting his own research on the topic, and the patterns Shechtman proposed “agreed beautifully” with the ones Steinhardt computed.

The importance of this discovery is widely disputed. Some sources say the applications of quasicrystals are limited, while others say they have many applications and have even caused textbooks to be rewritten. It is known that man-made quasicrystals have properties such as unusual hardness and slipperiness, making them useful for shaving razors, medial needles, and nonstick cookware. Steinhardt says that they have other strange and potentially useful properties, “such as the ability to turn heat into electricity.” While quasicrystals were discovered in 1982, it wasn’t until just a few years ago, in 2009, that naturally occurring ones were discovered; even now, the field discovered over thirty years ago is still in its infancy.

But Shechtman says that the discovery was important regardless of its applications. He says that they are important for changing a long-held scientific paradigm. “People should be interested in scientific advances because the body of knowledge generated by the scientific community improves our lives,” he says. While the list of applications may be small now, even a seemingly insignificant discovery today could allow something previously impossible to exist a hundred years later.

Shechtman reportedly continues his research on magnesium alloys, along with other materials that are both strong and shapeable. He won the Nobel Prize in Chemistry 2011, officially awarded “for the discovery of quasicrystals.” Not only has Shechtman won the prize, but he has created a story inspirational for scientists going against common opinion in their research.

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