A crystal is a solid material whose constituents are positioned in an ordered periodic fashion along all its dimensions. Examples include most metals at room temperature, table salt and diamonds. Crystals vary in their patterns as well as in the nature of the forces holding them together (although they are all of electromagnetic nature). Crystals are often sorted according to their symmetries, both translational and rotational. In two dimensions there are seventeen different types of symmetries called the wallpaper symmetries. These symmetries classes differ by the types of translational symmetry, reflection symmetry and rotation symmetry exhibited by the crystalline structure. As the small number suggests, not all possible symmetries are allowed. In particular the existence of translational symmetry restricts the rotational symmetry to be 2-fold, 3-fold, 4-fold or 6-fold only. No other rotational symmetries can be supported by a periodic structure.

The classes of admissible crystals in 2D are closely related to the classes of tiles that tessellate the plane, the “atoms” being positioned at the vertices of the tiles. Not all possible tiles allow tessellating the plane periodically. Some of the tiles that allow tessellating the plane periodically can also do so aperiodically by introducing localized defects. During the 60’s and 70’s mathematician asked if there exists a set of tiles that can only tessellate space aperiodically. A first affirmative answer was given at 1966 using Wang tiles, square tiles with edge-color-matching tiling rules. At 1974, Sir Roger Penrose used two types of decorated rhombi to generate an aperiodic tessellation of the plane, known as the Penrose tiling.

In 1982, while on sabbatical at the U.S. National Bureau of Standards in Washington, D.C., material scientist Dan Shechtman discovered a hint of (the theoretically forbidden) ten-fold symmetric structure in an alloy of Aluminum-Manganese. Not knowing how to interpret these results, and fearing the community’s reaction it took Shechtman two years to publish his results. When finally published, in 1984, two theoretical physicists, Paul Steinhardt and Dov Levin, identified in the results of Shechtman the evidence of a new type of order they have been studying, which they termed quasi-periodic crystals, or in short quasi-crystals.
In their study Steinhardt and Levin showed that the Penrose tiling had an underlying long-range order in it that resembles that of a crystal when examined through x-ray diffraction images. They also gave recipes for the construction of quasi-crystals of arbitrary rotation symmetry and showed that unlike commonly believed, quasi crystals do not require long rage interactions nor do they require very complicated building blocks. Soon after their studies were published other materials allowing quasi-periodic crystalline order were found.

The birth of the field of quasi-crystals was painful. The two-time Nobel laureate Linus Pauling completely dismissed the quasi crystal explanation of Shechtman’s results and was quoted saying “there is no such thing as quasi-crystals, only quasi-scientists”. Others have claimed that quasi-crystals are materials created by theoreticians, and while they can be synthesized in a lab, they are very unnatural and unlikely to be found in nature. In 2009 an expedition led by Steinhardt concluded a ten-year search by finding in the Koryak Mountains in Russia the first naturally occurring quasi-crystal. In 2011 Dan Shechman joined Linus Pauling in the distinguished list of Chemistry Nobel Prize laureates.