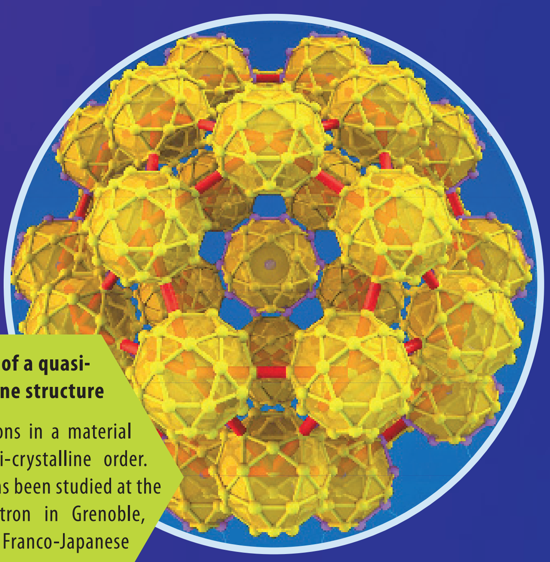
# Play around with symmetry: build yourself a crystal

We can pave a surface with identical patterns or shapes (squares, rectangles, hexagons), and we can fill large volumes with smaller volumes (bricks) which are identical (cubes, parallelepipeds, prisms, ...). The shape of the building blocks determines the symmetry of the lattice.



**Model of a quasi-crystalline structure**

Atom positions in a material showing quasi-crystalline order. This structure has been studied at the ESRF synchrotron in Grenoble, France, by a Franco-Japanese team.

© Nature

## Try with these shapes...

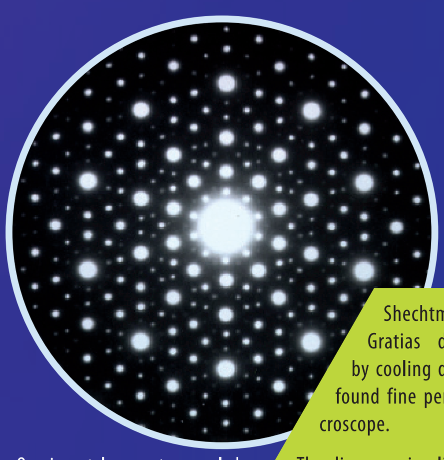
All of these volumes or shapes have axial 2-, 4-, 3- or 6-fold symmetry (angles of 180°, 90°, 120° or 60°). If we use the pentagonal (5-sided, angles of 72°) or decagonal (10-sided, angles of 36°) shapes with surfaces with 5- or 10-fold symmetry, we could not pave the surface completely; there would be gaps. The same is true of volumes with a 5- or 10-fold symmetry, such as the icosahedron or pentadodecahedron,... For crystallographers, therefore, these forms of symmetry could not possibly be found in crystals.

**Build a crystal using the same type of brick.**

## «Quasi-crystals» cloud the picture

The discovery of «quasi-crystals» in aluminium and manganese alloys in 1984 undermined the certainties of crystallographers and physicists: a quasi-periodic order could exist - the regular stacking of two different types of brick.

**Build a ten-pointed star with these two different and distinctive shapes.**

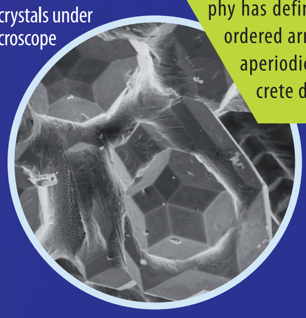


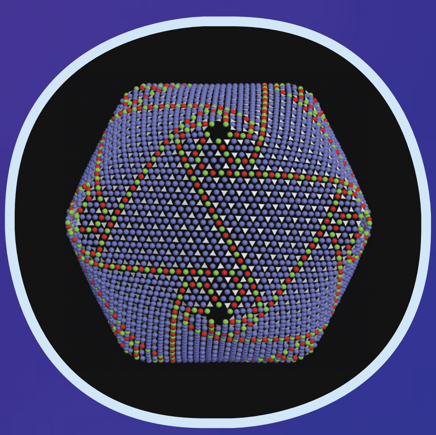
Quasi-crystal symmetry revealed by electron diffraction. © A.P. Tsai

Shechtman, Blech, Cahn and Gratias discovered quasi-crystals by cooling down metals very fast. They found fine pentagonal faces under the microscope.

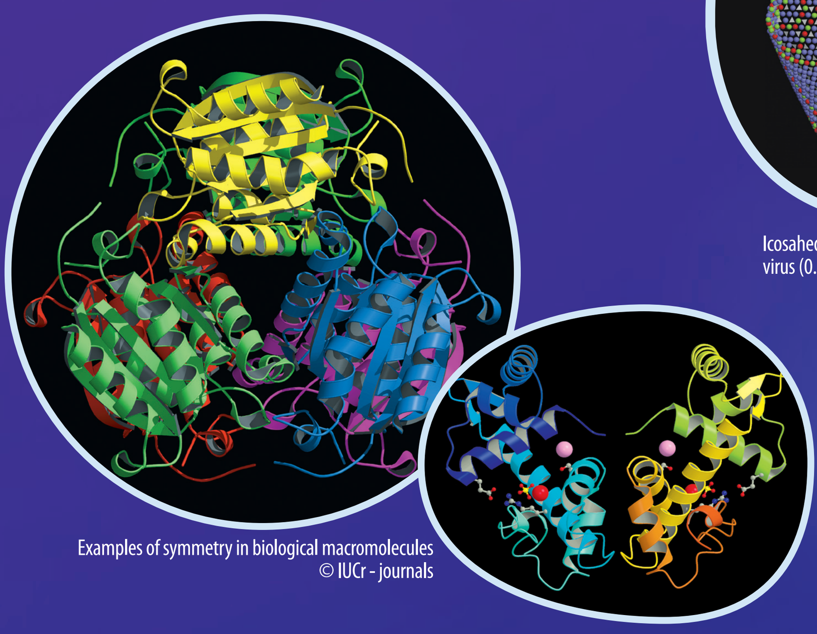
The discovery implied the existence of a new ordered state in matter; i.e. a strict arrangement of atoms over a long range, but without periodicity. This quasi-crystalline regular order is revealed by the fine diffraction spots observed, like in crystals, but with symmetry of order 5 or 10. Since 1992 the International Union of Crystallography has defined a crystal as a material with an ordered arrangement of matter, periodic or aperiodic, manifested by relatively discrete diffraction spots.

Quasi-crystals under the microscope

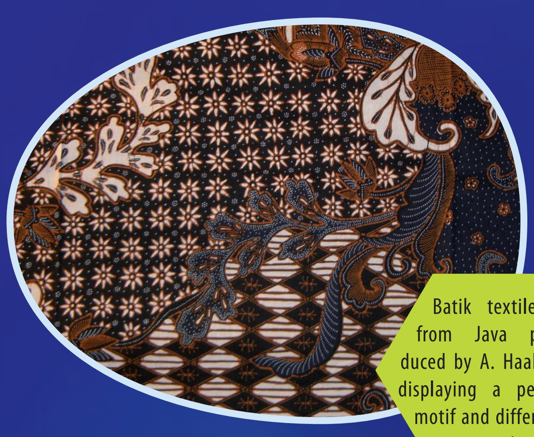




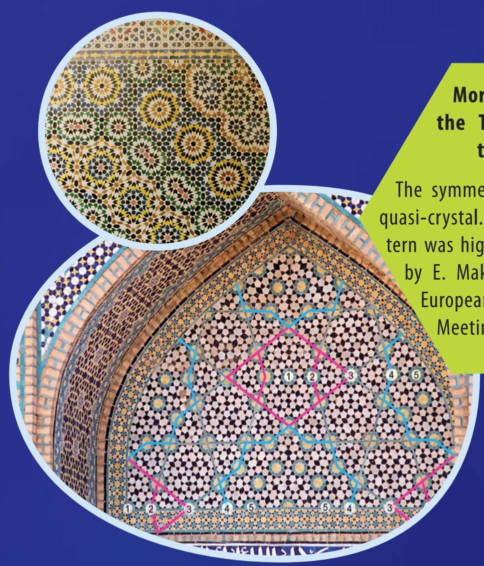
Icosahedron symmetry in a very large virus (0.19 µm) © IUCr - journals



Examples of symmetry in biological macromolecules © IUCr - journals



Batik textiles from Java produced by A. Haake ©, displaying a periodic motif and different symmetries.



**Moroccan mosaic in the Telouet casbah in the High Atlas.**

The symmetry is close to that of a quasi-crystal. The quasi-crystalline pattern was highlighted in blue and black by E. Makovicky during the 24th European Crystallographic Meeting in 2007. ©AAAS.

Pseudo-symmetry of Arab mosaics © IUCr - journals

The arch of a door in Marrakesh: a different symmetry in every sector of the vault.