Symmetry

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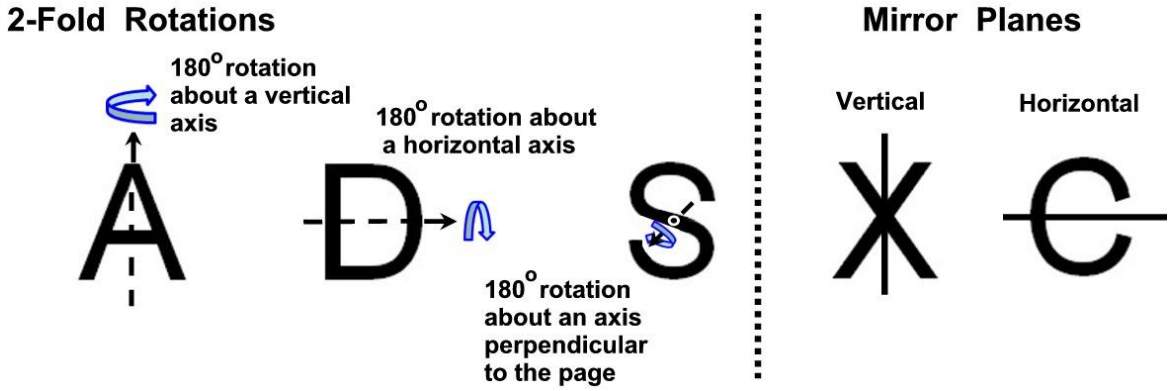
Symmetry is integral to understanding crystals and crystallography. Something is symmetrical when it has similar parts: e.g. one part is the same as another part. The most common forms of symmetry are rotation axes and mirror planes. Symmetry can be observed all around us, even in our alphabet!



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Now consider the alphabet shown below:

1) How many letters have no symmetry? ____. Place an "X" in the upper left box of letters with no symmetry.
2) How many letters have a vertical axis of symmetry? ____. Draw a vertical arrow indicating the symmetry axis.
3) How many letters have a horizontal axis of symmetry? ____. Draw a horizontal arrow indicating the symmetry axis.
4) How many letters are symmetrical about a 2-fold rotation axis perpendicular to the plane of the page? ____ Place a (☑) mark in the upper right box of those letters with a perpendicular 2-fold rotation axis, and a "dot" indicating the location of the rotation axis.
5) Now identify the symmetry present in the two words in the last two frames.

Answers are given on next sheet, but note results can vary with the font used!

A	B	C	D	E	F	G
H	I	J	K	L	M	N
O	P	Q	R	S	T	U
V	W	X	Y	Z	MOM	MOW

Unit Cells and Lattices

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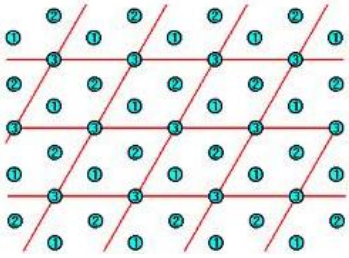
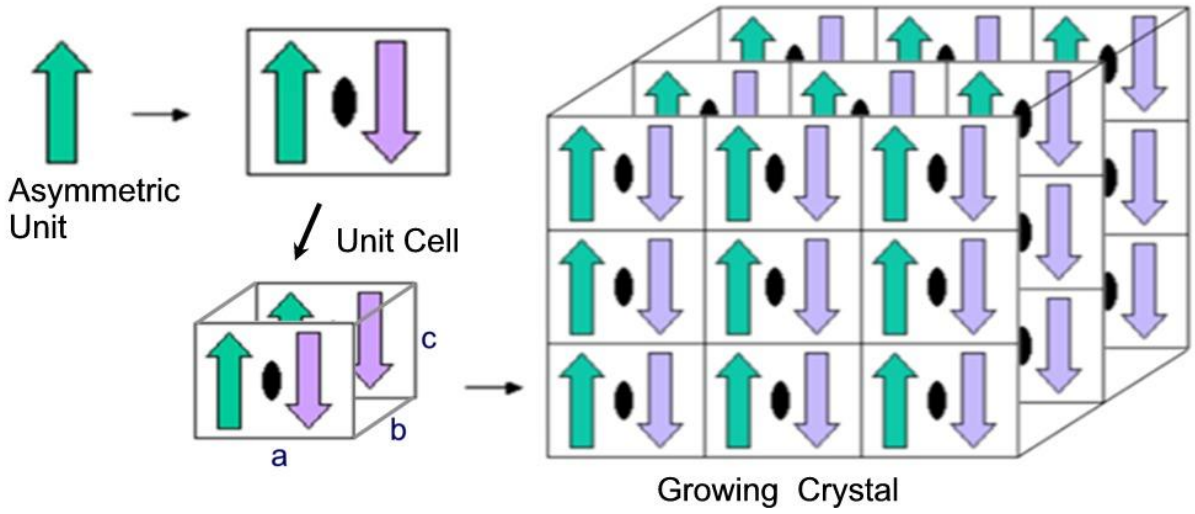
You probably have observed symmetry and two-dimensional lattices in nature and around your house in wallpaper, tile floors, sheets, dress ties, or art work. They often display some form of symmetry and a repeating lattice. Below is a simple two dimensional lattice, a sample of wall paper, and two prints by M. C. Escher.




Three dimensional lattices are also common. Many materials including simple salts (NaCl), metals, organic compounds, even proteins, nucleic acids and viruses crystallize by arranging themselves into regular, repeating structures. If you examine any repeating structure, you can draw a box around the part that repeats – this is the **unit cell** (the simplest repeat unit). Note that the unit cell must repeat exactly in each direction. In the example below, one unit cell is shown containing two "objects" that are related by 2-fold symmetry. The unique part of the unit cell is called the asymmetric unit, so in this case the asymmetric unit is one-half of the unit cell. The unit cells then repeat in space to form the crystal. There are many potential options for the choice of the unit cell, but it is best to define the unit cell to take advantage of any symmetry present. This unit cell definition allows easier descriptions of atomic positions within the cell. The corners of the unit cell define the **crystal lattice**, where each corner of each unit cell is called a **lattice point**.



References:
International Year of Crystallography: http://iycr2014.org/
Alphabet symmetry: many sources; http://www.misterteacher.com/alphabetgeometry/lettersymmetry.html
M.C. Escher: http://www.mescher.com/
Escher web sketch: http://skuld.bmsc.washington.edu/~merritt/bc530/local_copies/escher/
http://escher.epfl.ch/escher/

Answers quiz: 1) BFGJKLPQR 2) AHIMOTUVWXY 3) CDEHIOX 4) HINOSXZ 5) vertical mirror, 2-fold