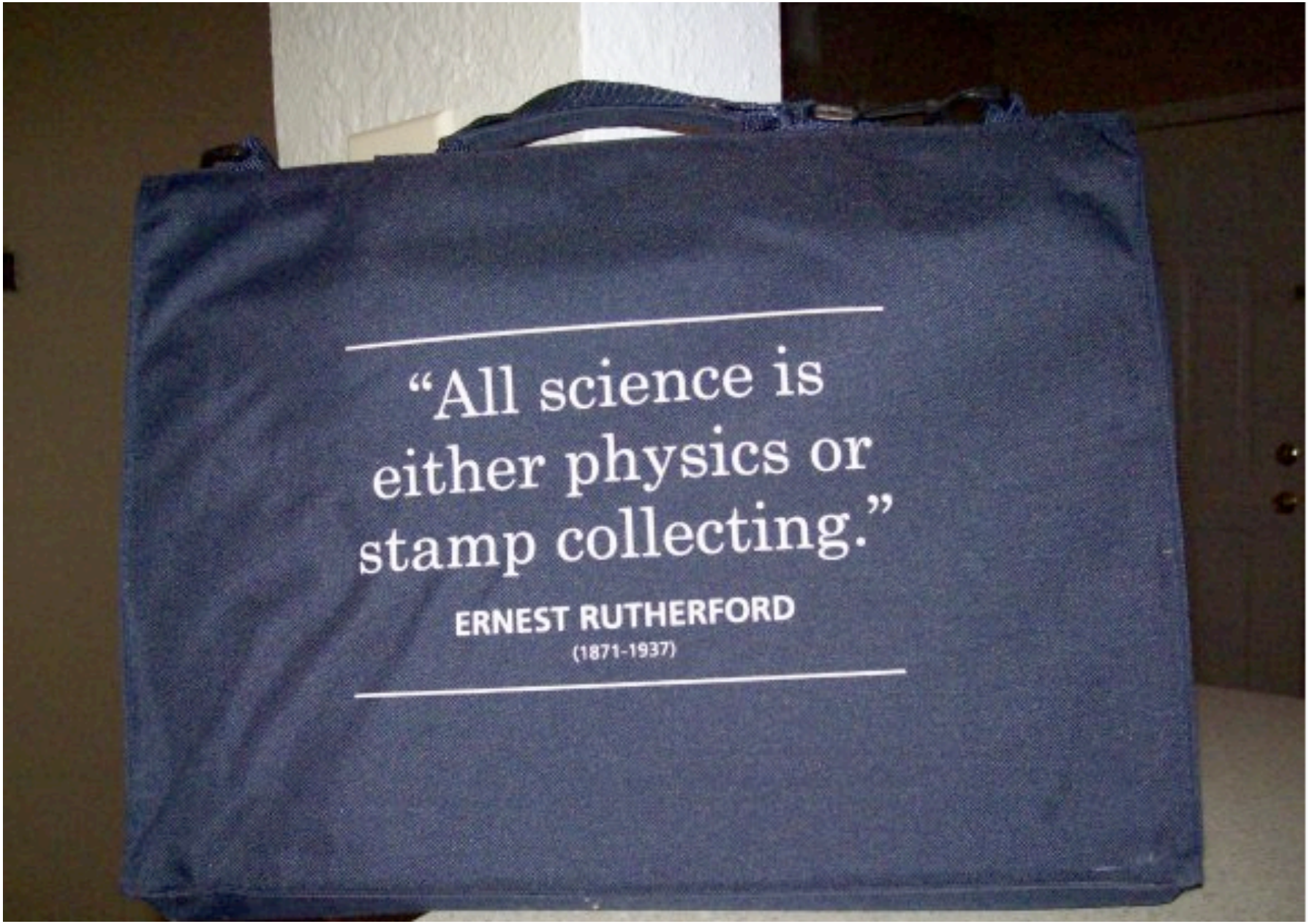
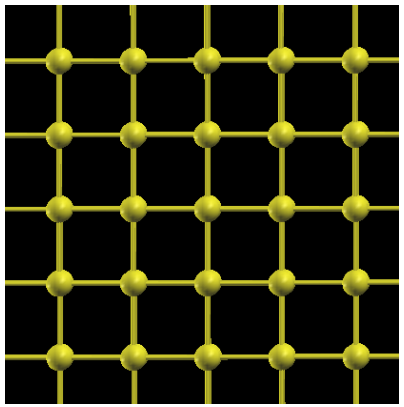
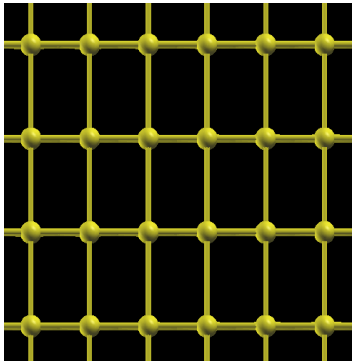
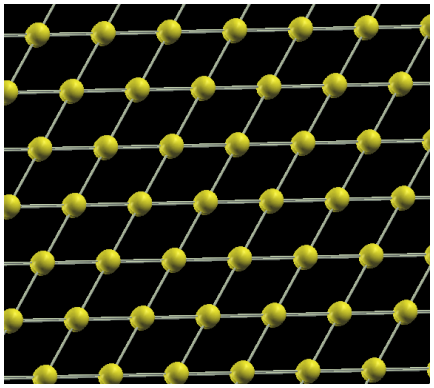
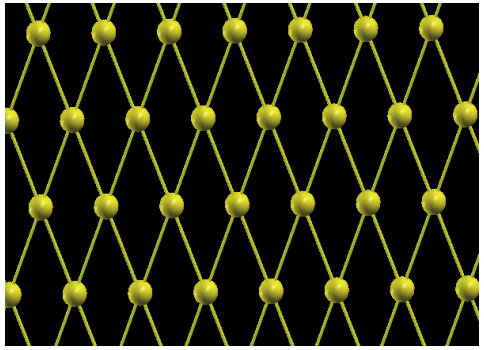

"All science is
either physics or
stamp collecting."
ERNEST RUTHERFORD
(1871-1937)

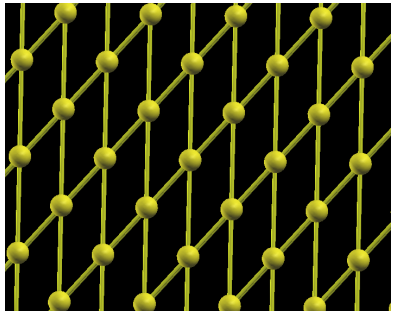
Refresh: 2D Lattices

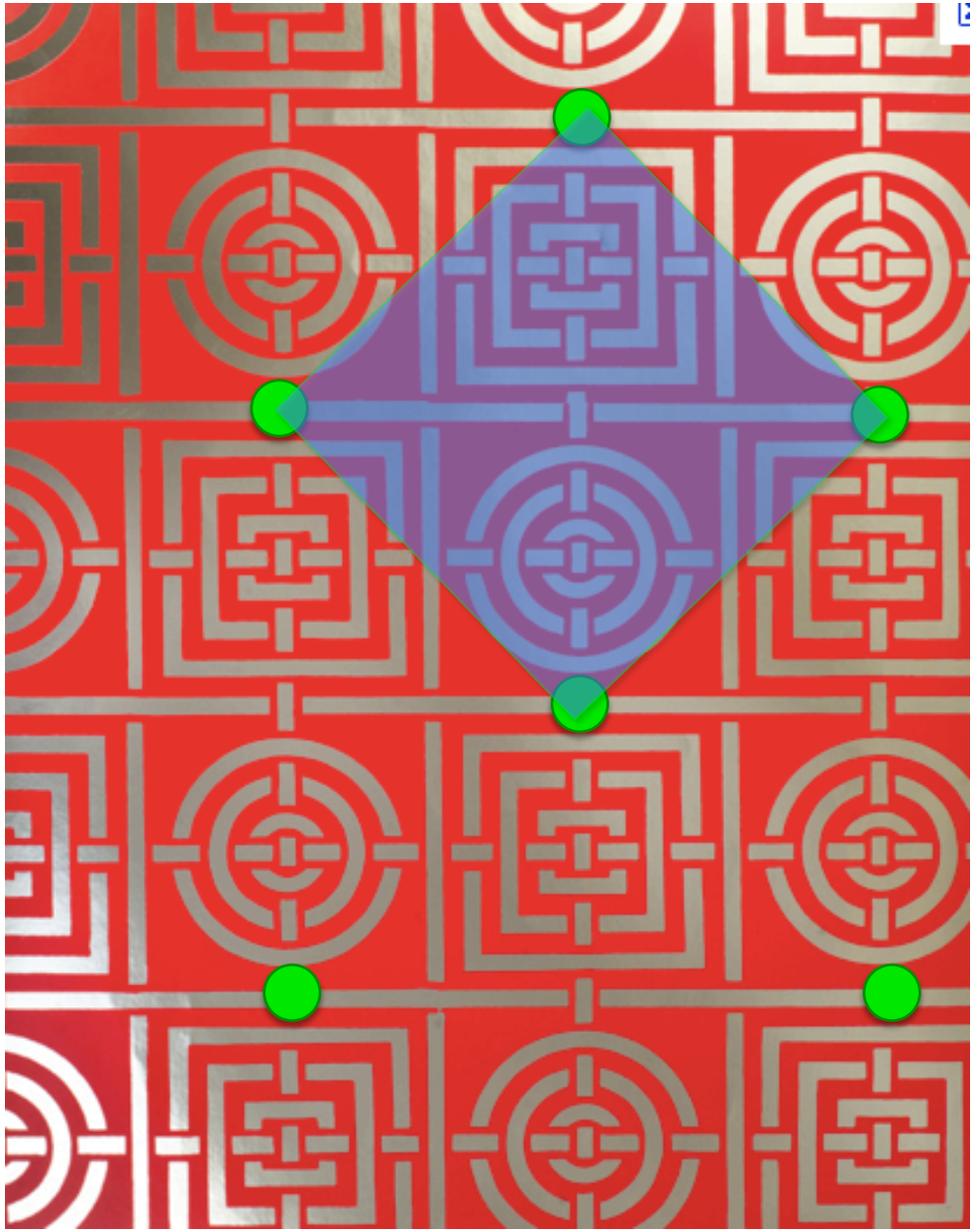




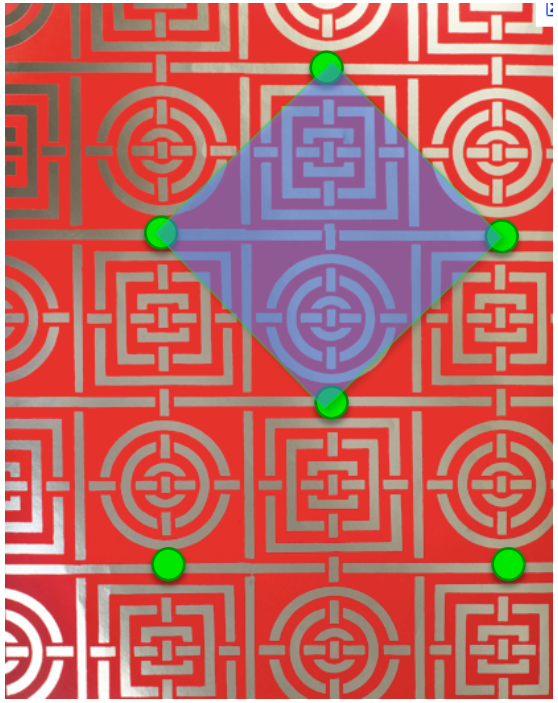


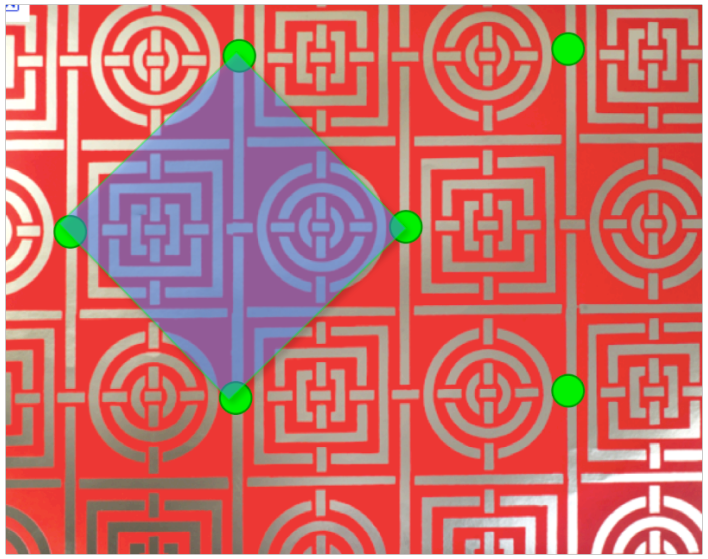


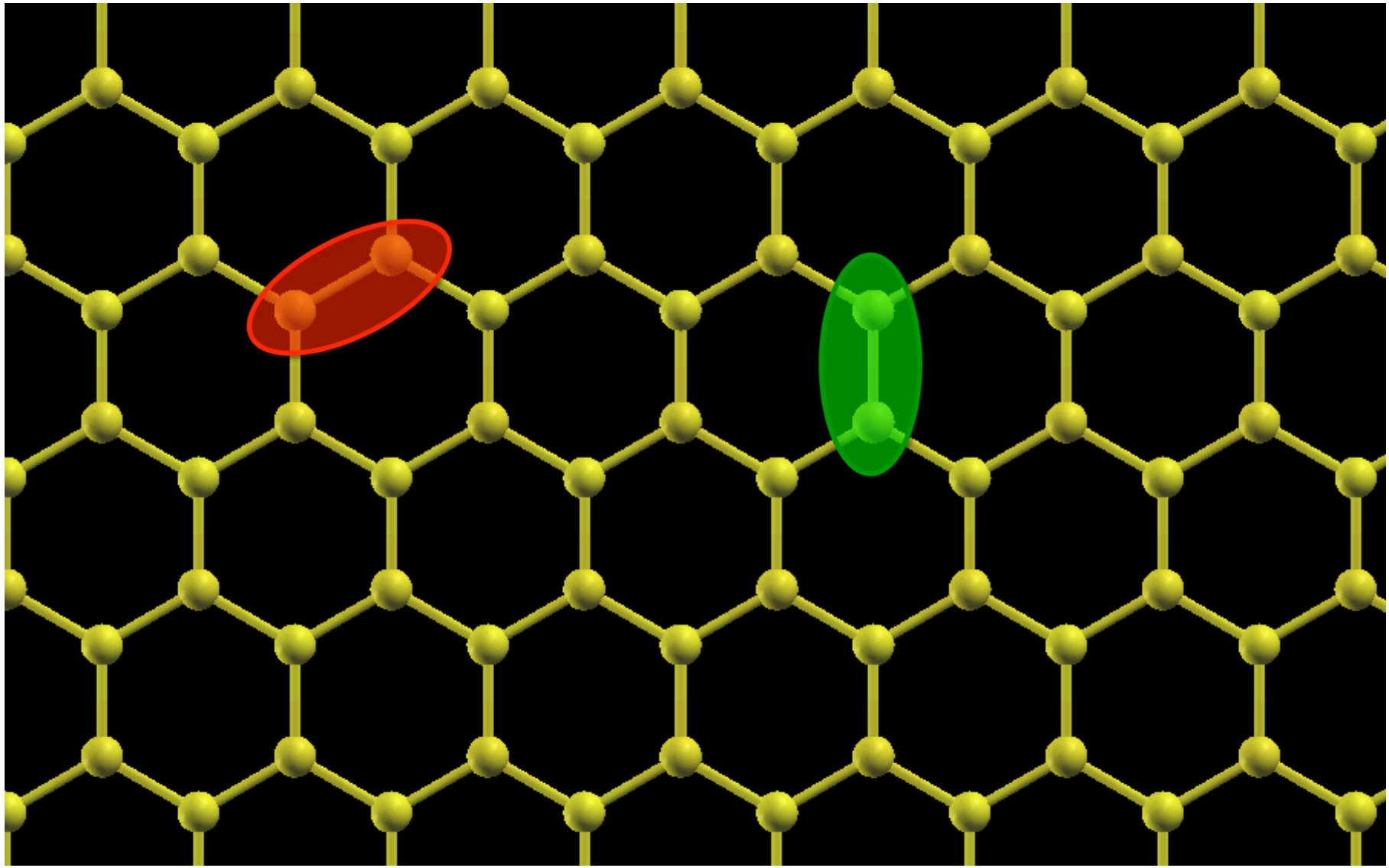


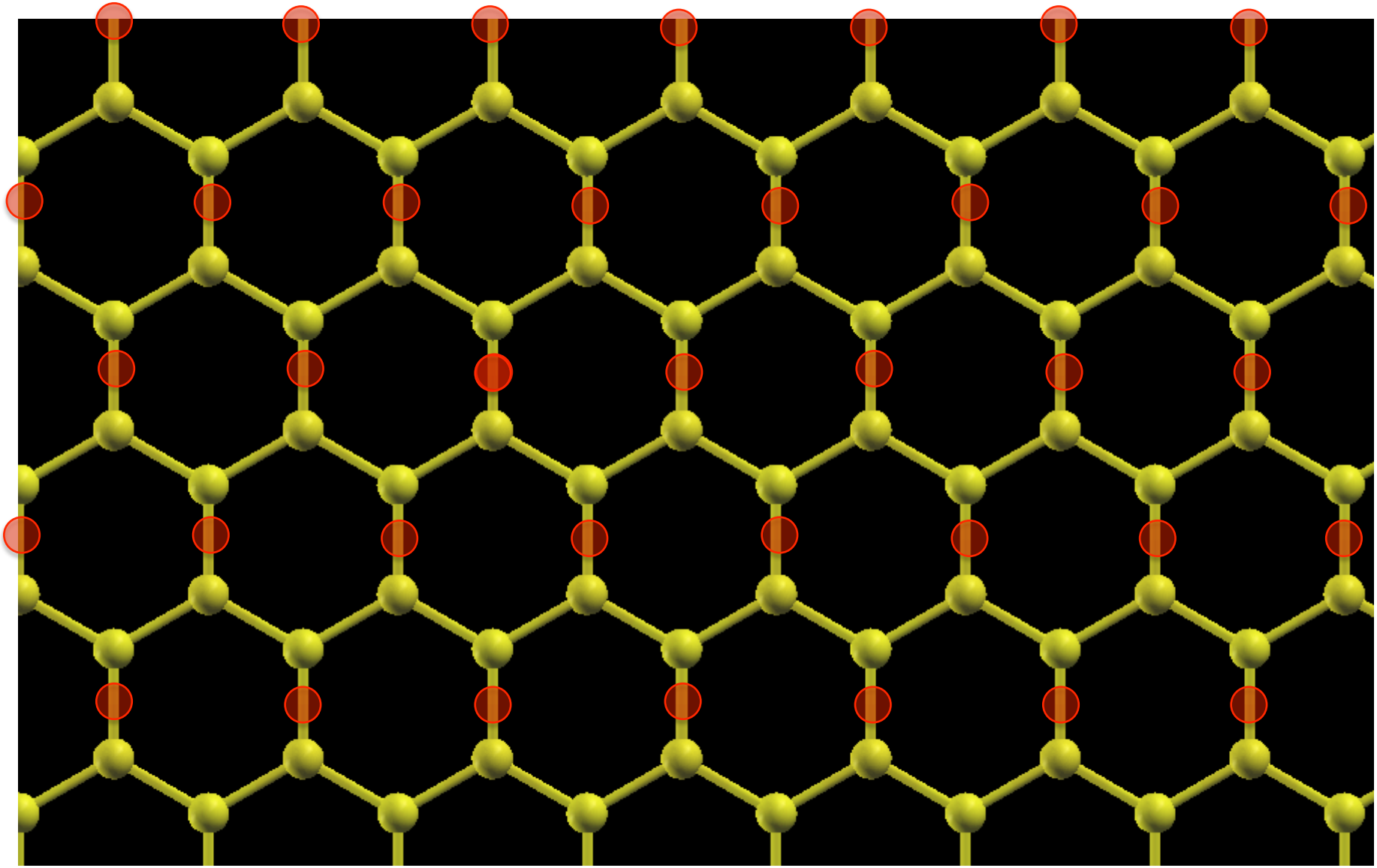


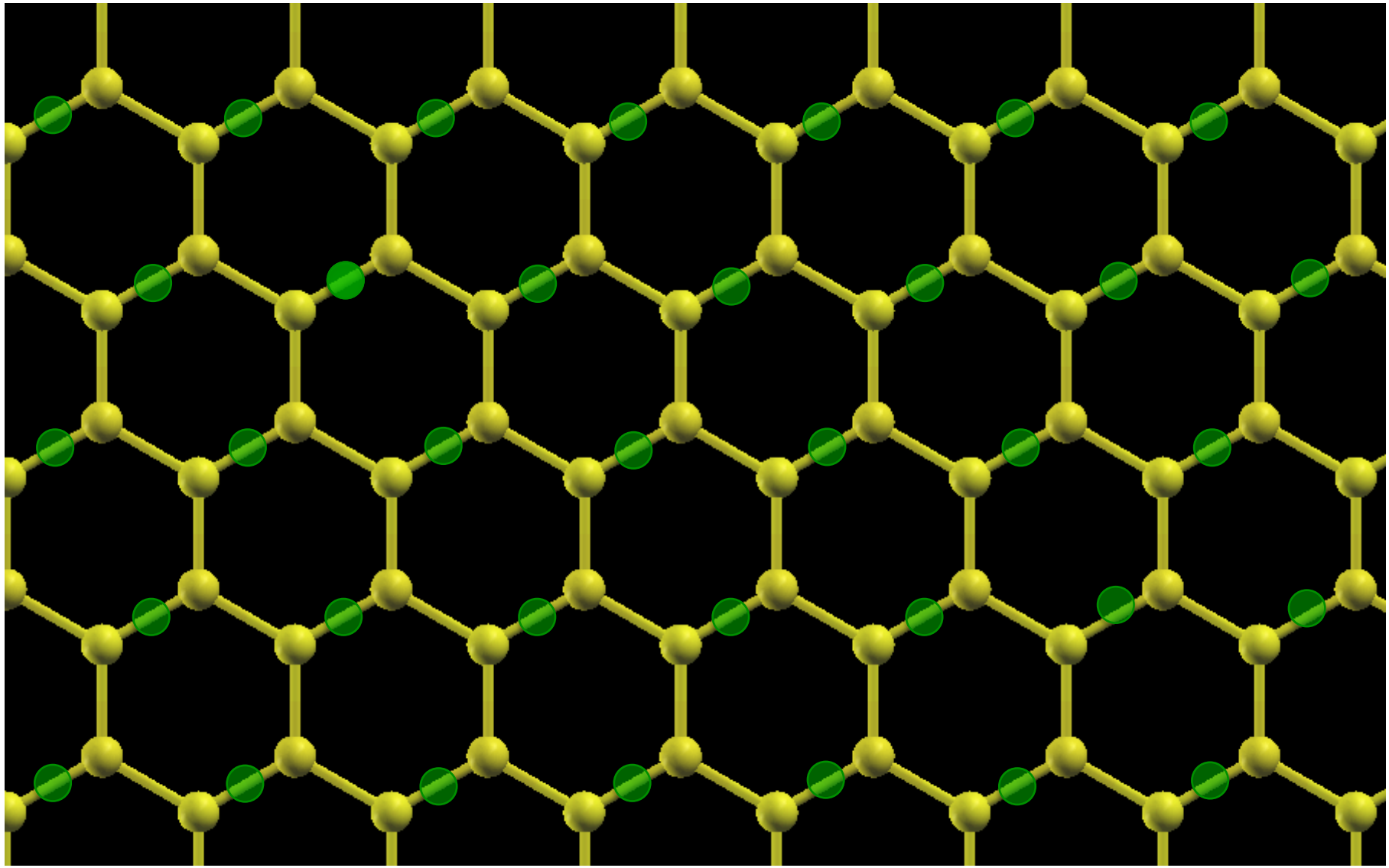
90 Degree Rotational Symmetry ?????











Three-Dimensional Lattices

Classification of Lattices by Symmetry:

Similar to the case in 2D, what we are doing here is trying to find out ways to pack the 3D space. (more like tiling the 2D space)

In 3D, the lattice point in the space can be described by the primitive vectors:

$$R = n1\mathbf{a} + n2\,\mathbf{b} + n3\,\mathbf{c}$$

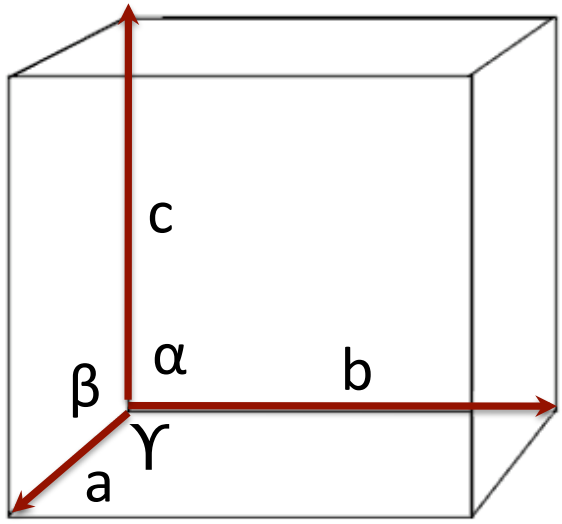
a, b & **c** are primitive vectors

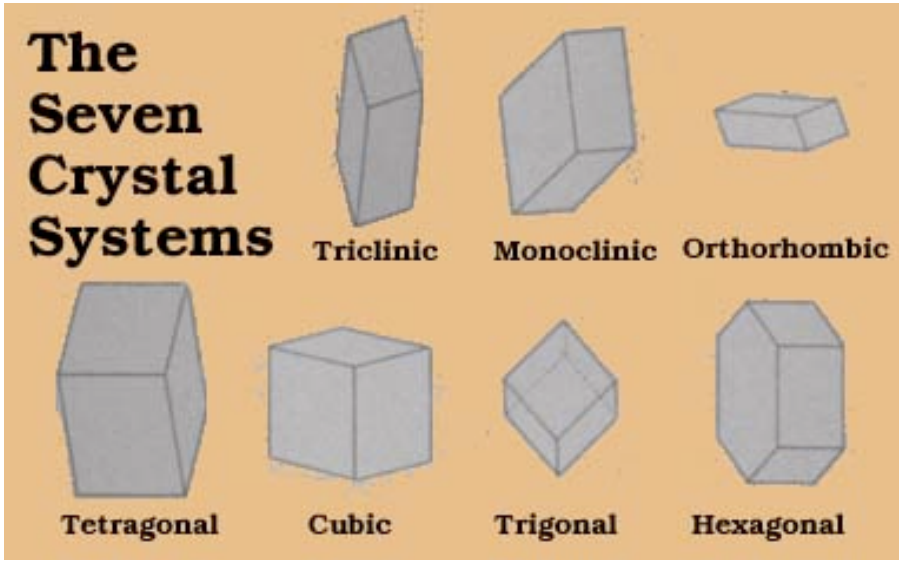
Depending on different combinations of the primitive vectors and the angles in between them:

There are 7 crystal systems

There are 7 crystal systems

- $a = b = c$; $\alpha = \beta = \Upsilon = 90$ Cubic *All sides equal: all right angles*
- $a = b \neq c$; $\alpha = \beta = \Upsilon = 90$ Tetragonal *Two sides equal: all right angles*
- $a \neq b \neq c$; $\alpha = \beta = \Upsilon = 90$ Orthorhombic *No sides equal: all right angles*
- $a \neq b \neq c$; $\alpha \quad \Upsilon = 90 : \beta \neq 90$ Monoclinic *No sides equal: Two right angles*
- $a \neq b \neq c$; $\alpha, \beta, \Upsilon \neq 90$ Triclinic *No sides equal: No right angles*
- $a = b \neq c$; $\alpha = \beta = 90, \Upsilon = 120$ Hexagonal *Two sides equal:Two right angles, One 120*
- $a \neq b \neq c$; $\alpha, \beta, \Upsilon \neq 90$ Rhombohedral *All sides equal: Two right angles*

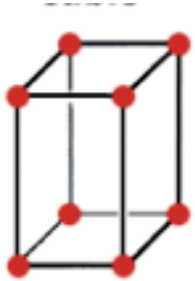




Within this 7crystal symmetries: there are 7 Primitive Lattices and 7 centered lattices: Which gives the 14 Bravais Lattices in nature

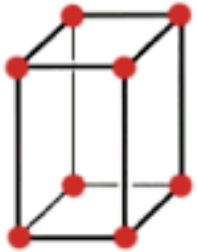
Simple cubic

- a = b = c
- α = β = Υ = 90



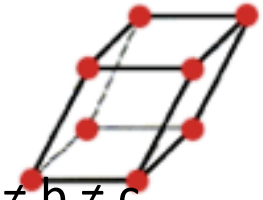
Simple tetragonal

- a = b ≠ c
- α = β = Υ = 90



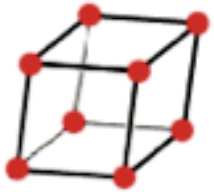
Simple orthorhombic

- a ≠ b ≠ c
- α = β = Υ = 90



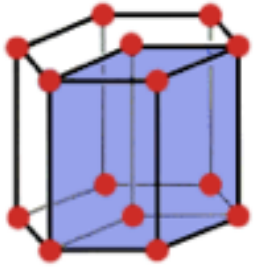
Simple Monoclinic

- a ≠ b ≠ c
- α = Υ = 90 :β≠ 90



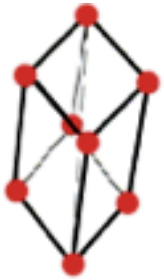
Triclinic

- a ≠ b ≠ c
- α,β ,Υ≠ 90



Hexagonal

- a = b ≠ c
- α=β=90 ,Υ=120

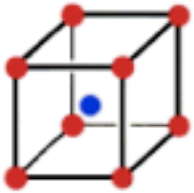


Rhombohedral

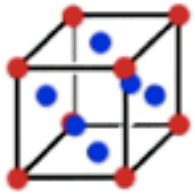
- a ≠ b ≠ c
- α,β ,Υ≠ 90

For the 7 primitive lattices, these unit cells are primitive

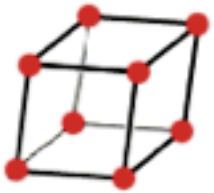
Simple cubic



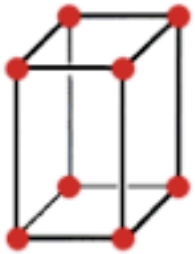
Body-centered cubic



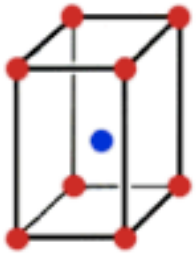
Face-centered cubic



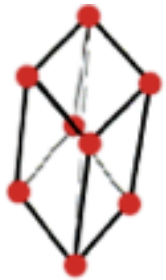
Triclinic



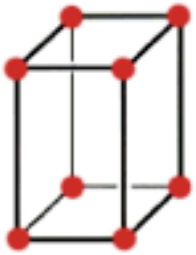
Simple tetragonal



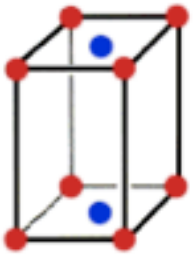
Body-centered tetragonal



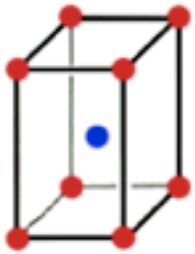
Rhombohedral



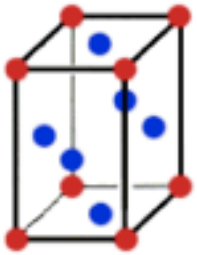
Simple orthorhombic



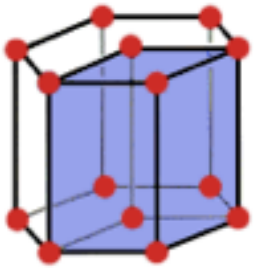
Base-centered orthorhombic



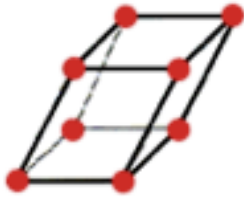
Body-centered orthorhombic



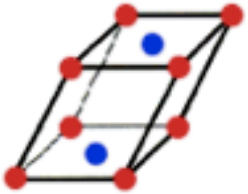
Face-centered orthorhombic



Hexagonal



Simple Monoclinic

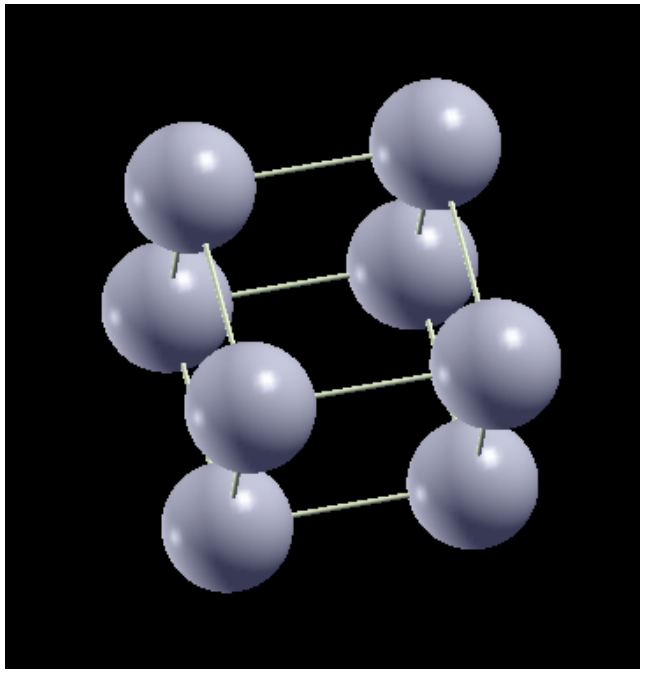


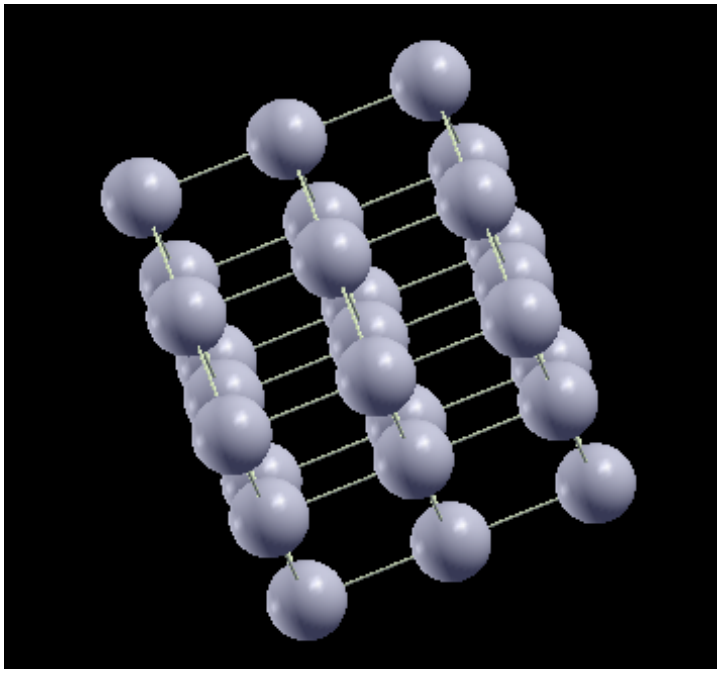
Base-centered monoclinic

14 Bravais Lattices

Examples: Simple Cubic

Not many Lattices come in this symmetry in Nature: One Example is Polonium.





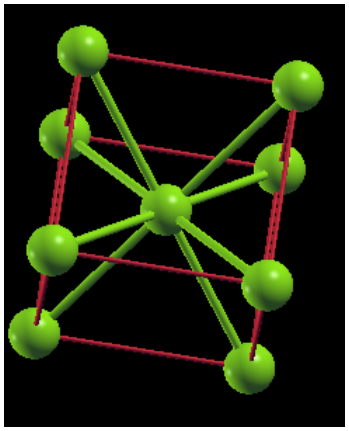
Unit Cell has only one unit

Six Nearest Neighbors

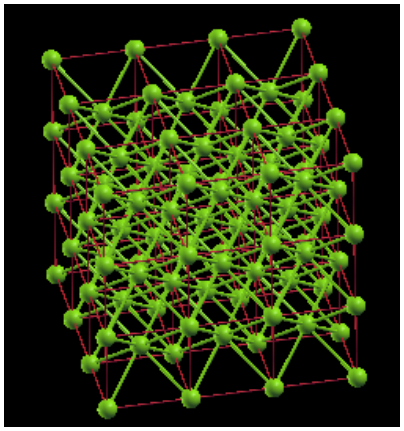
Examples: Body Centered Cubic – Li a=3.49 A

8 Nearest Neighbors

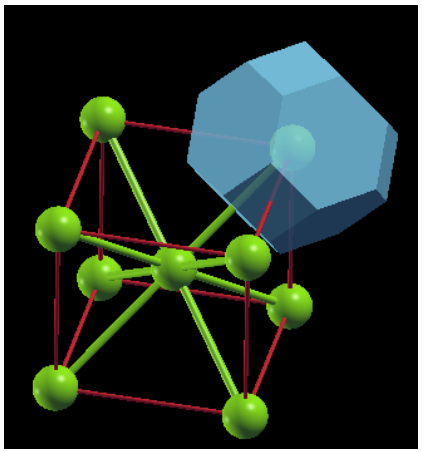
Conventional Cell



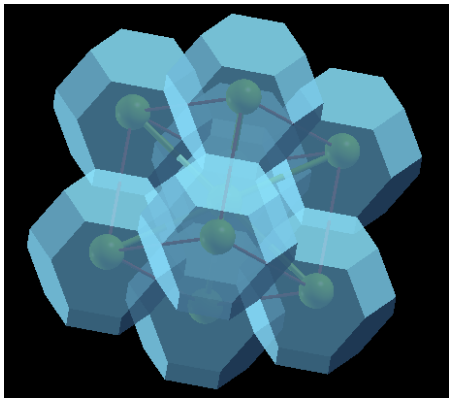
Repeating Conventional Cells



Wigner-Seitz Cell

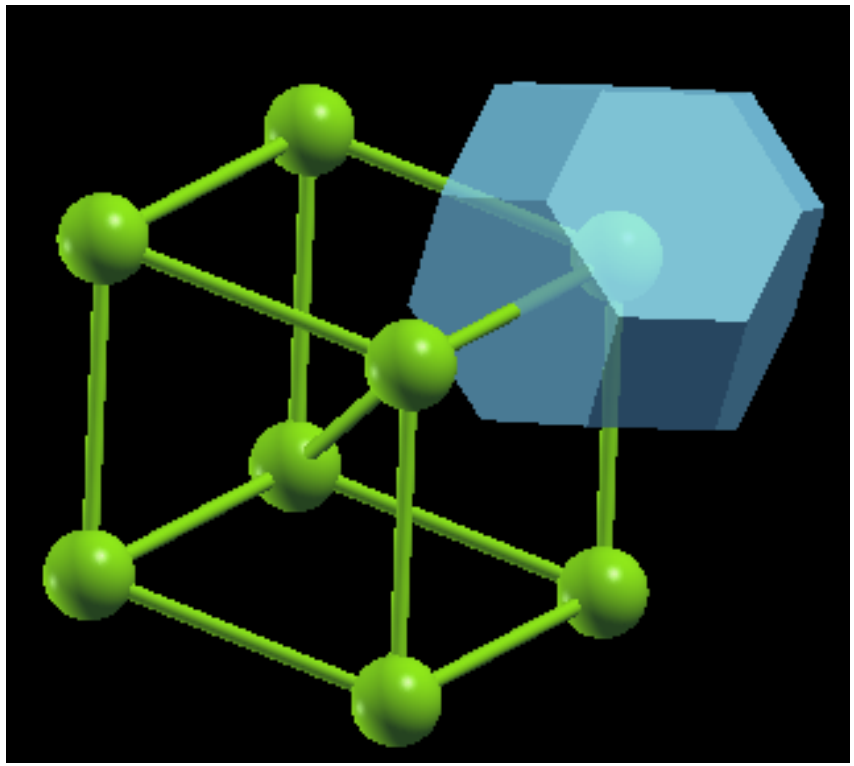


Repeating Wigner-Seitz Cells

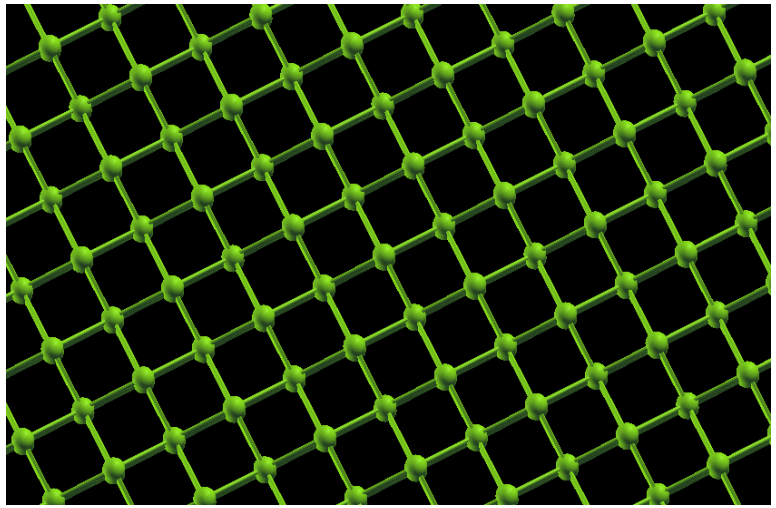


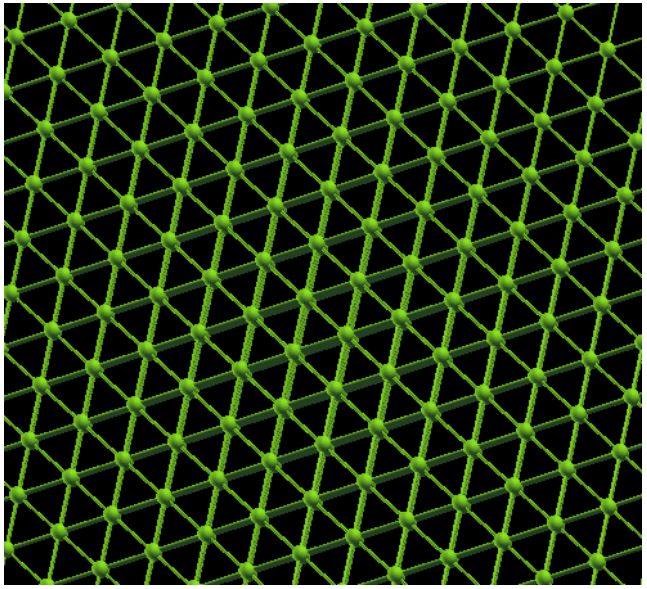
Body Centered Cubic - Cu

A Primitive Cell and the Wigner Seitz Cell



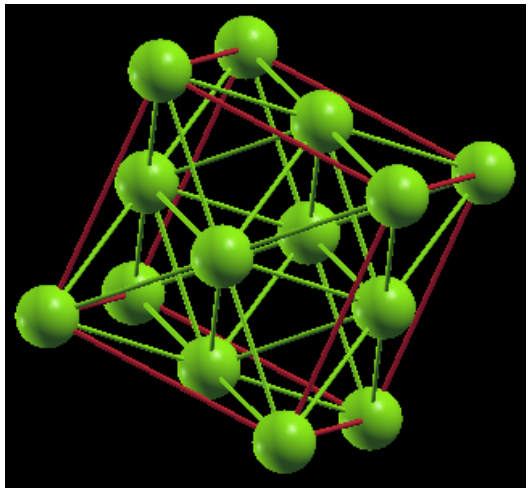
Different Planes in a BCC lattice



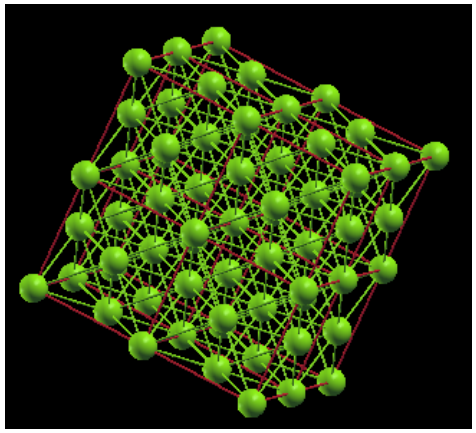


Examples: Face Centered Cubic - Cu a=3.61

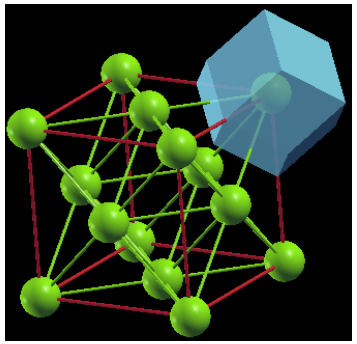
Conventional Cell



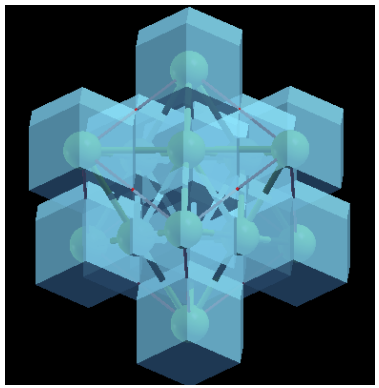
Repeating Conventional Cells



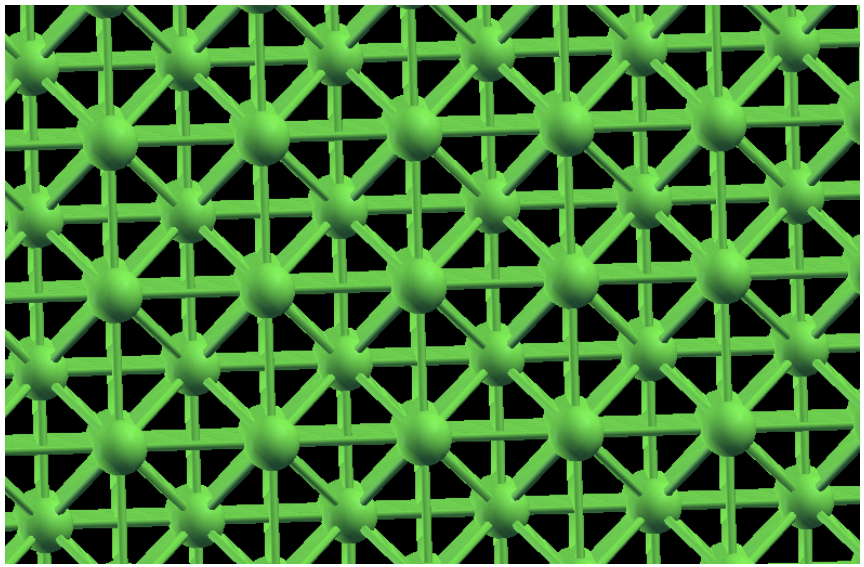
Wigner-Seitz Cell

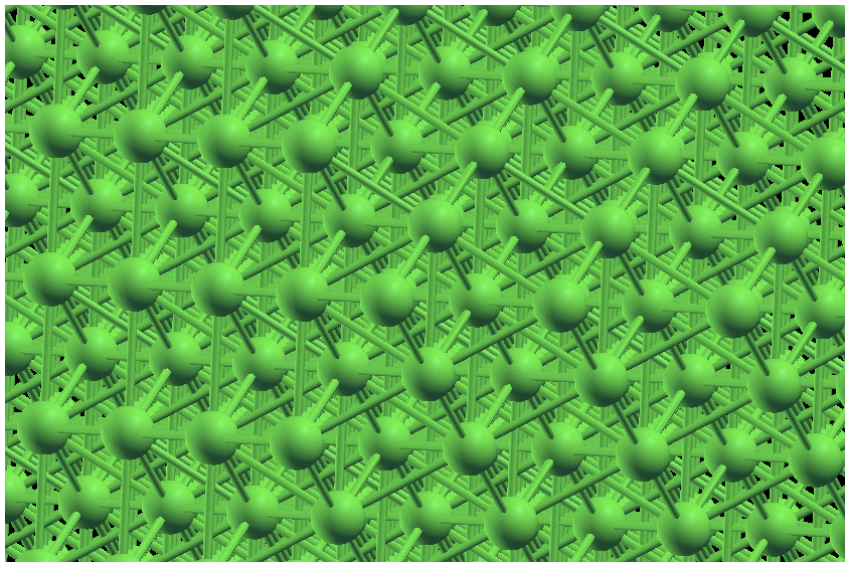


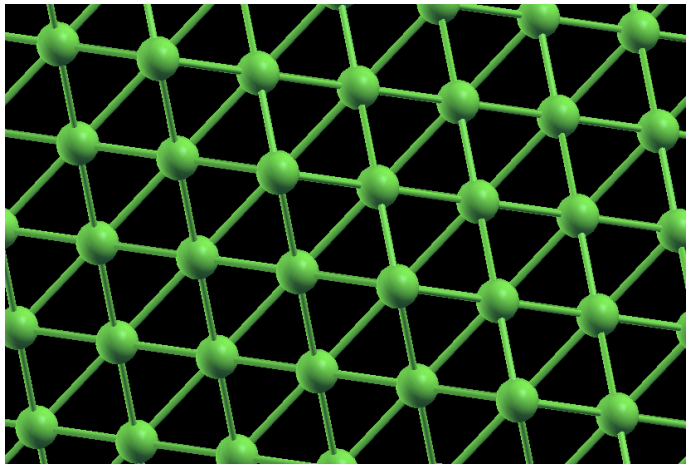
Repeating Wigner-Seitz Cells



Different Crystal Planes of FCC

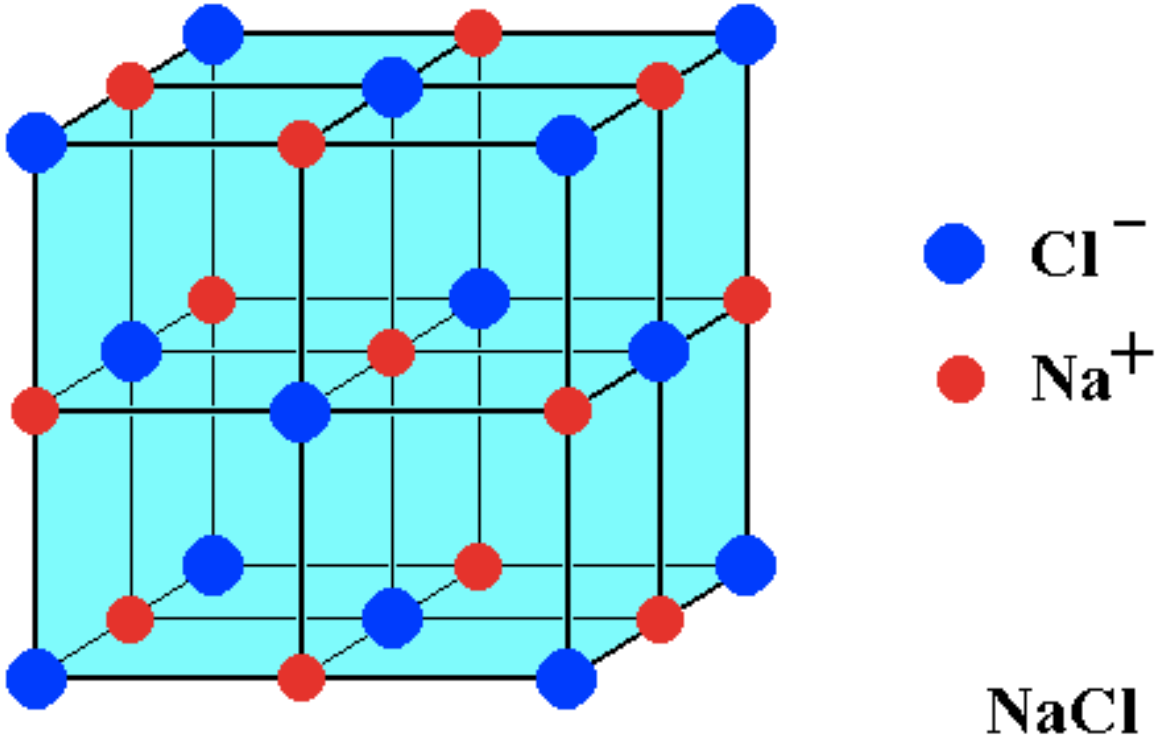






Compounds

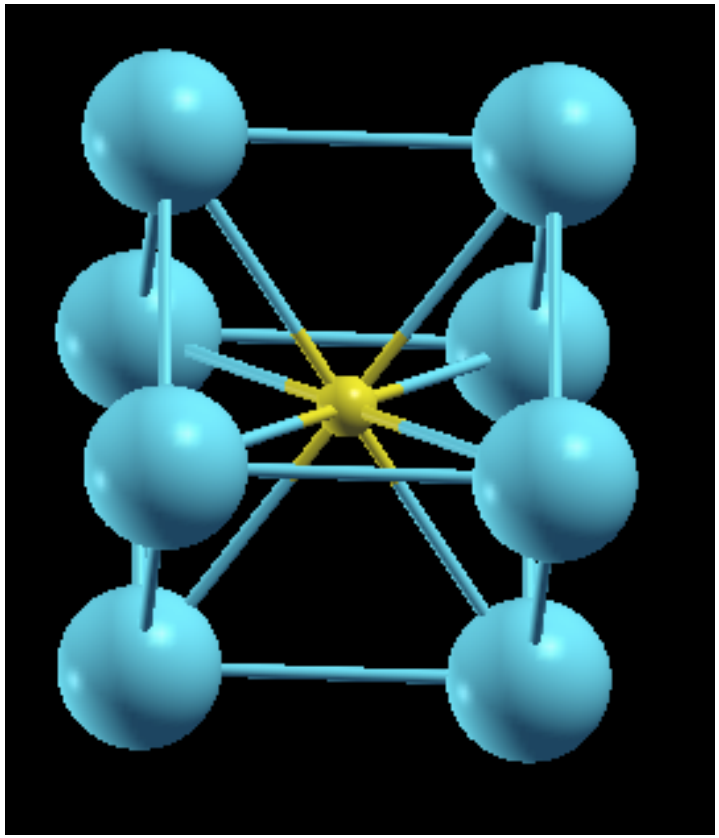
Rock Salt – Sodium Chloride



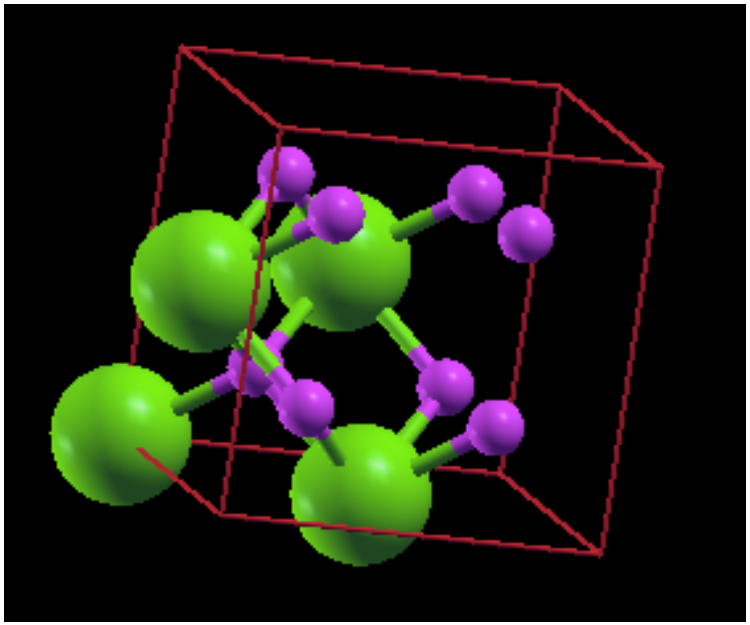
Examples for the structures with Sodium Chloride Structure

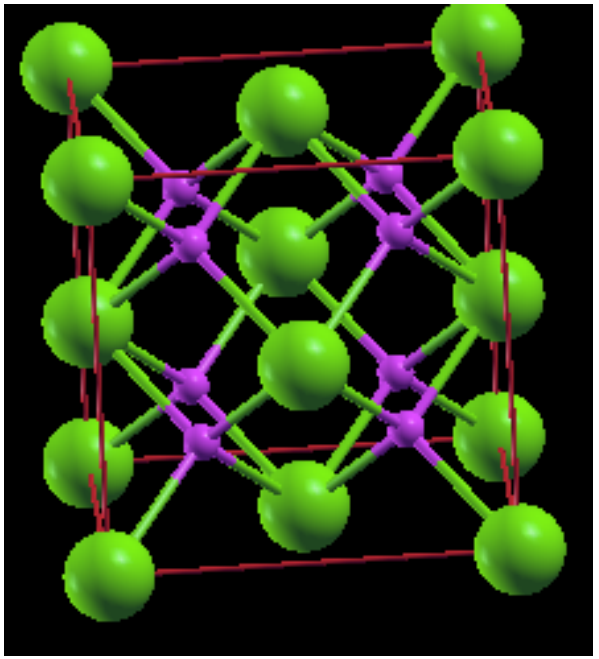
AgBr, LiI, NaI, BaS, AgF, AgCl

Cesium Chloride



Fluorites – Cesium Fluoride Structure





Diamond Structure – Single Atomic Structure