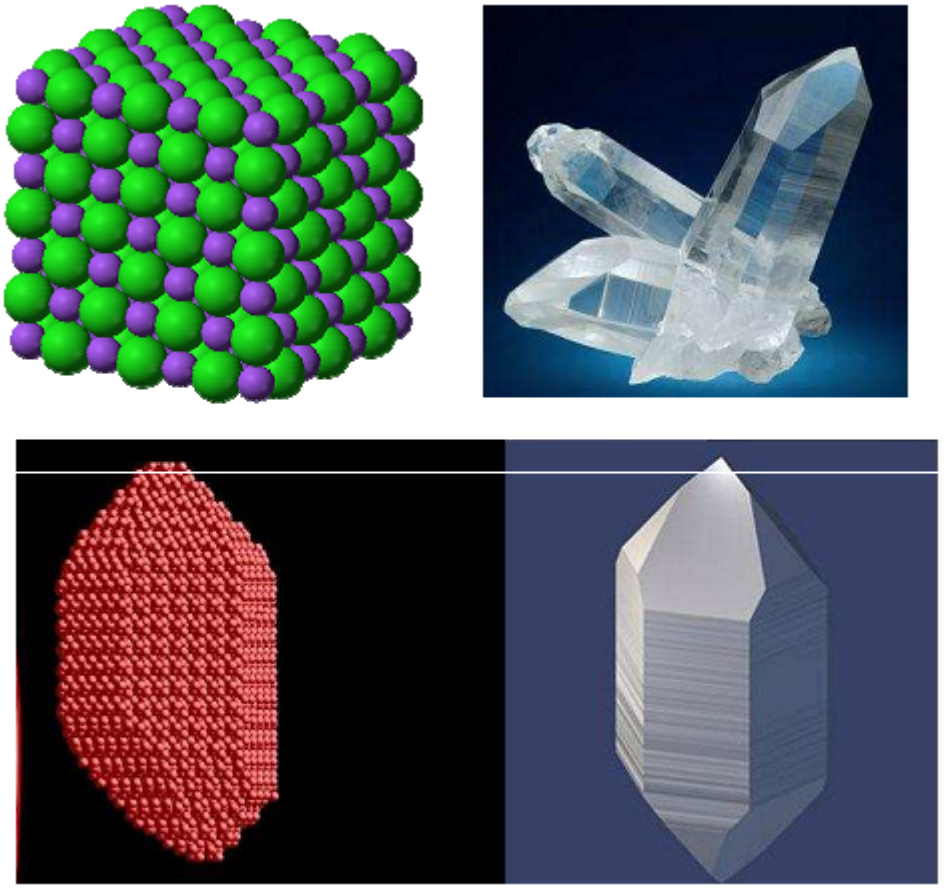
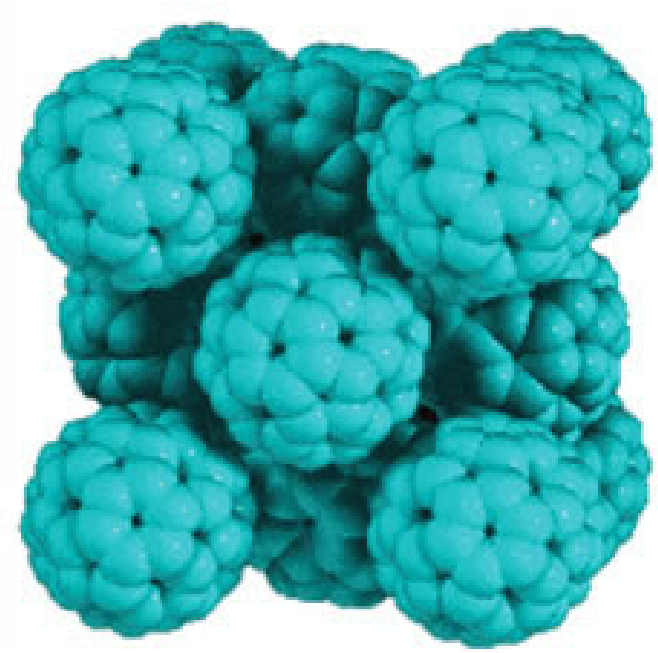
Slides
Condensed Matter Physics
Lecture 9

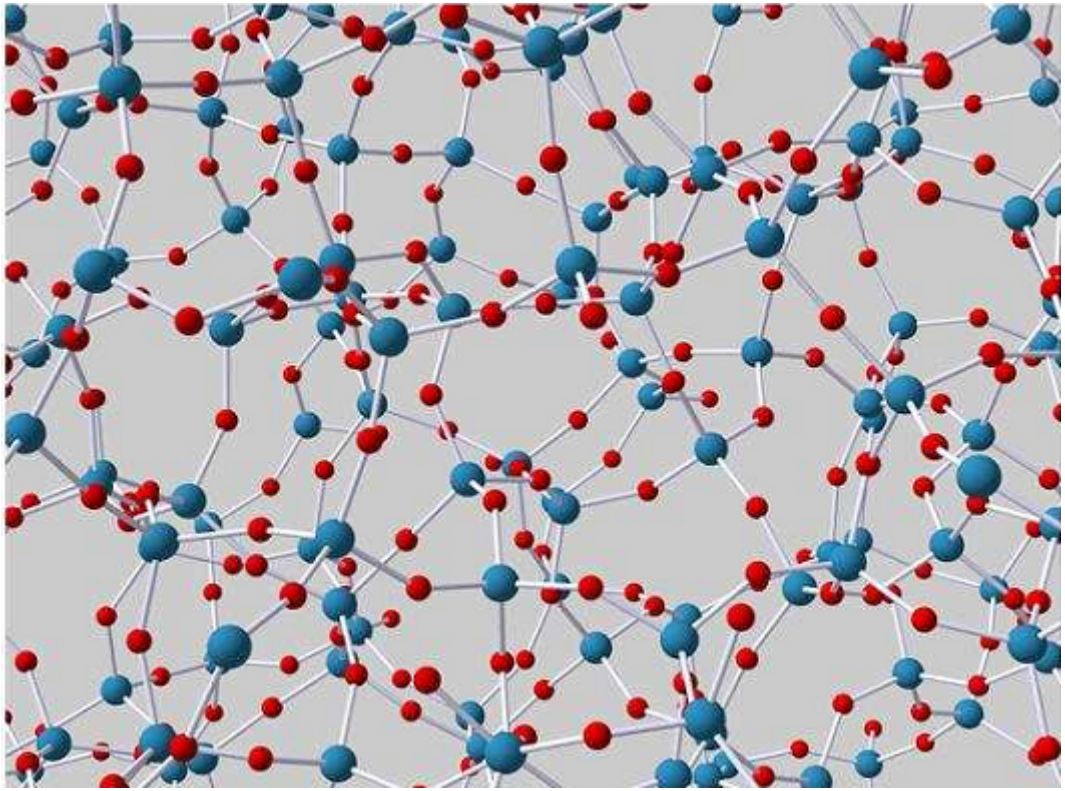
Just a few examples of condensed matter…



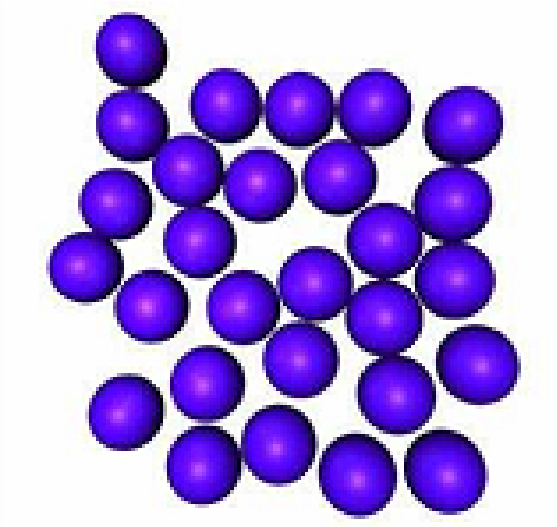
Crystalline Solids



Molecular Crystals



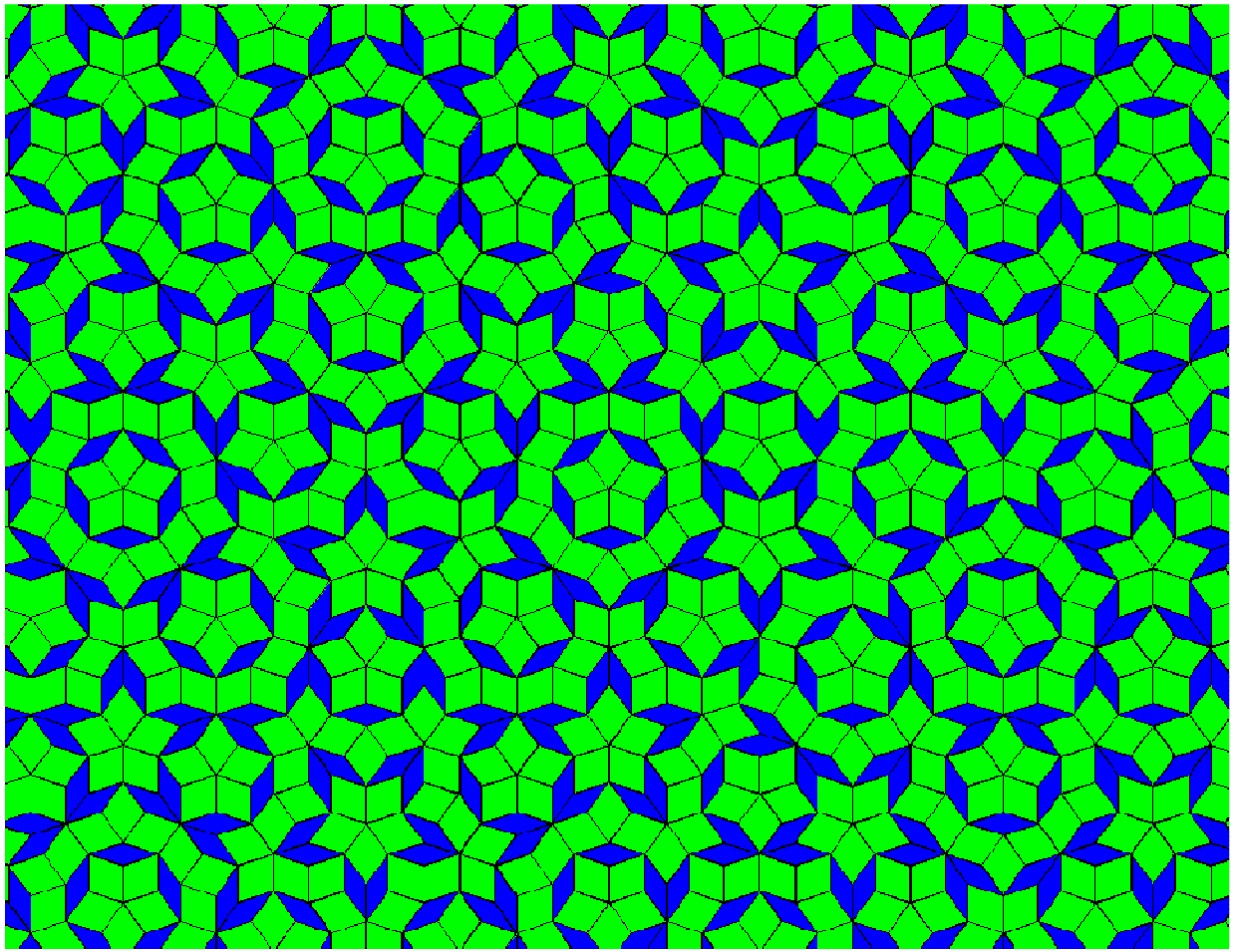
Amorphous Solids



Liquids

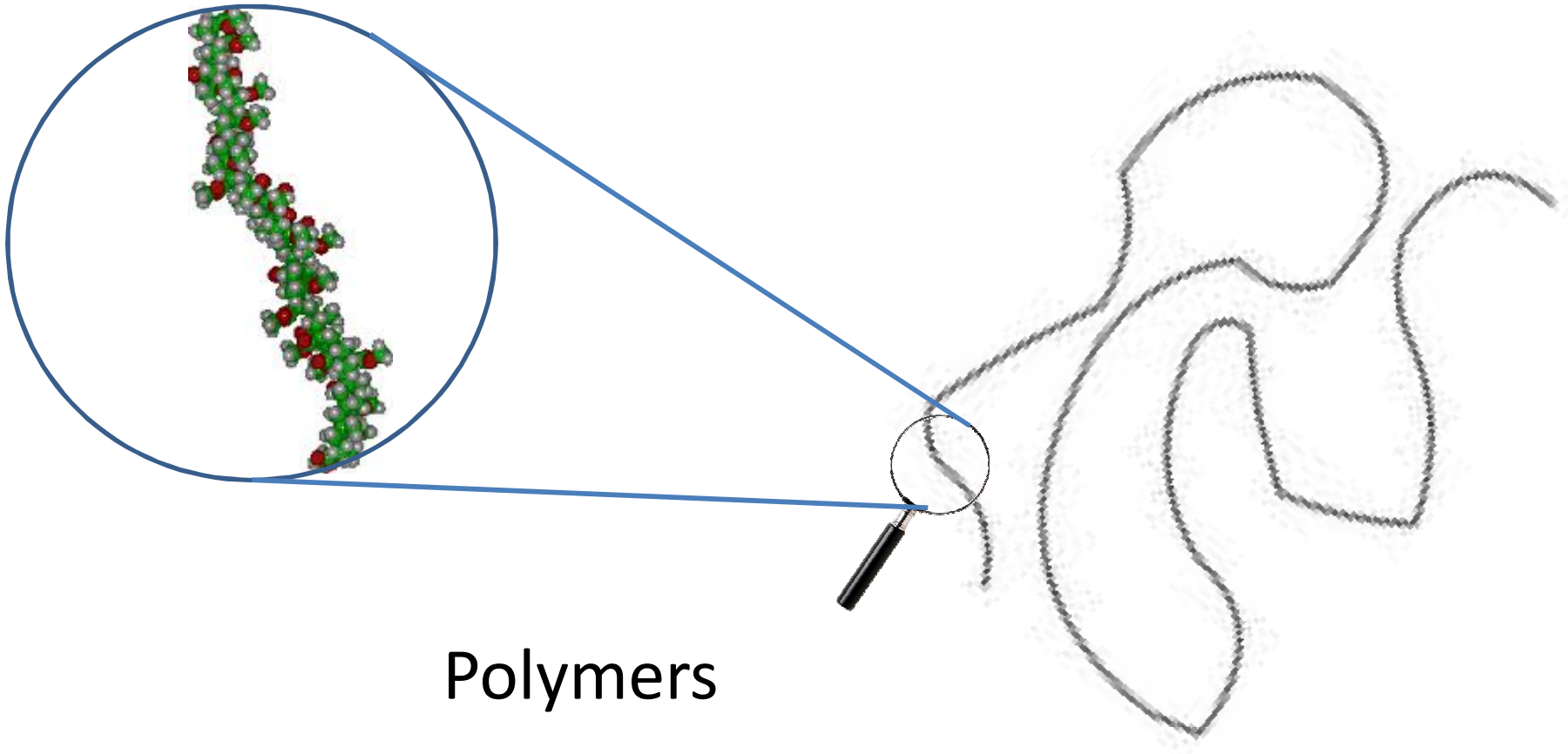
Liquid Crystals

(Partial Order)



Quasicrystal

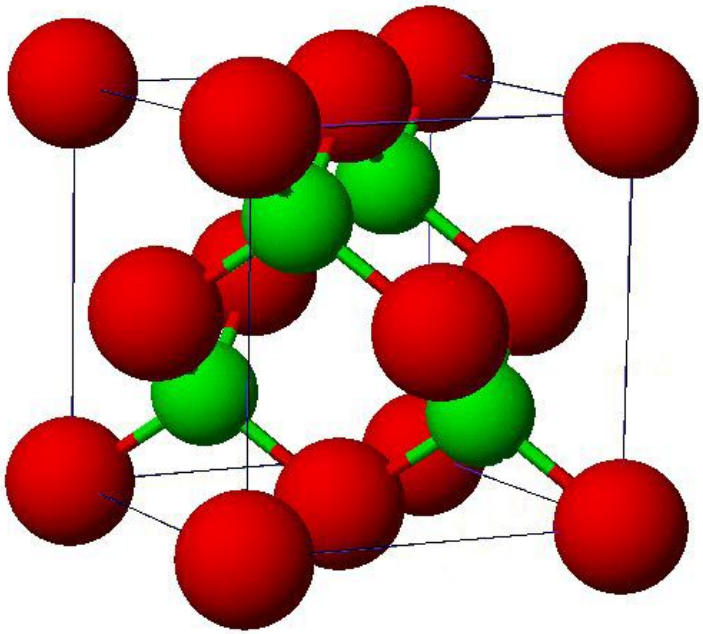
Order but not periodic

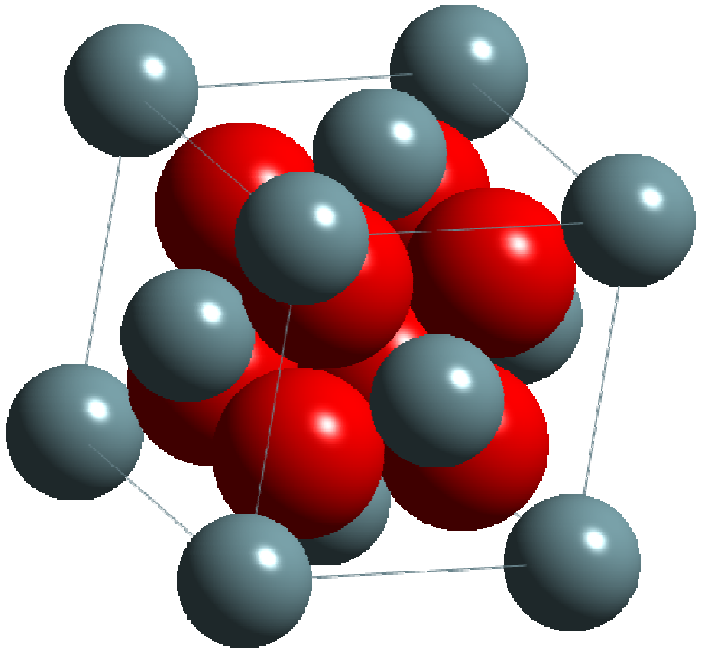


Polymers

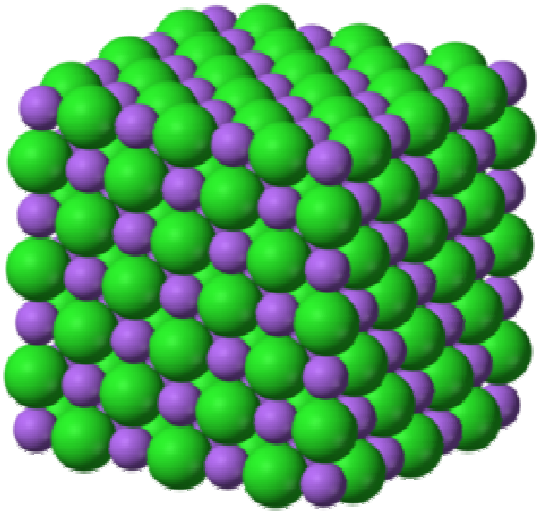
Crystal Structure Etc…

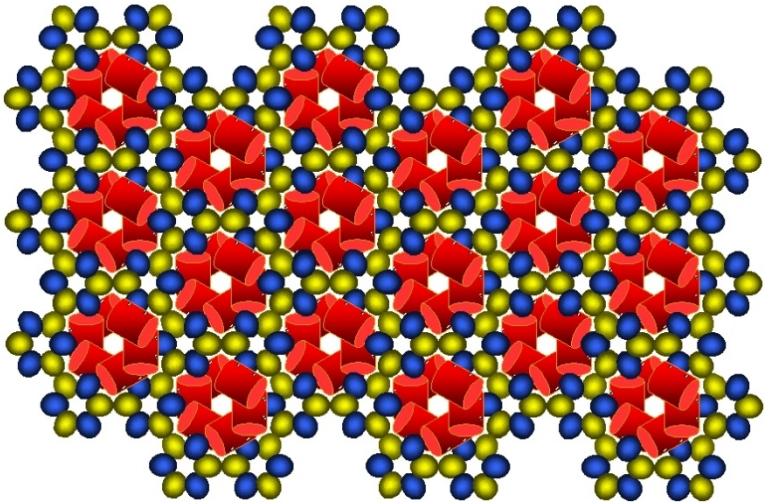
I can’t draw this on the chalkboard….

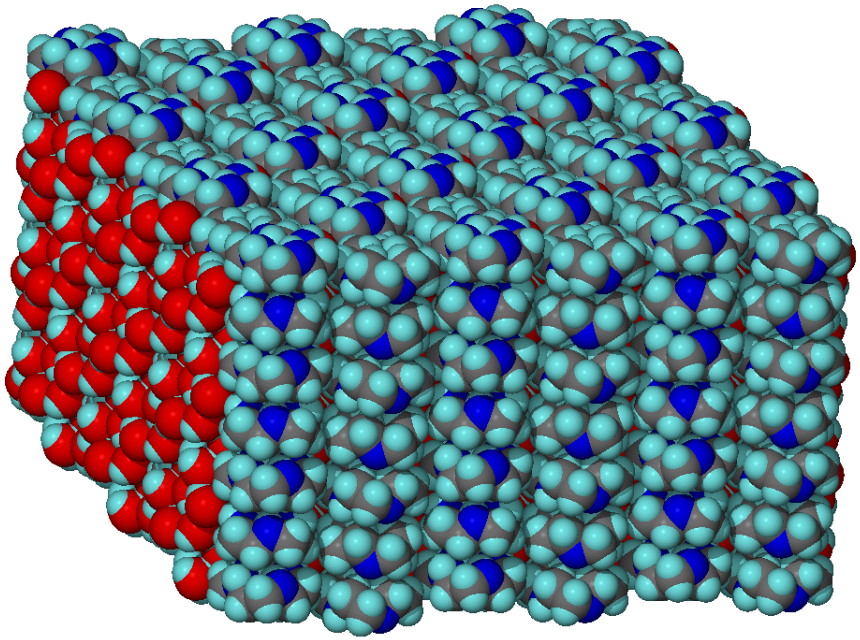


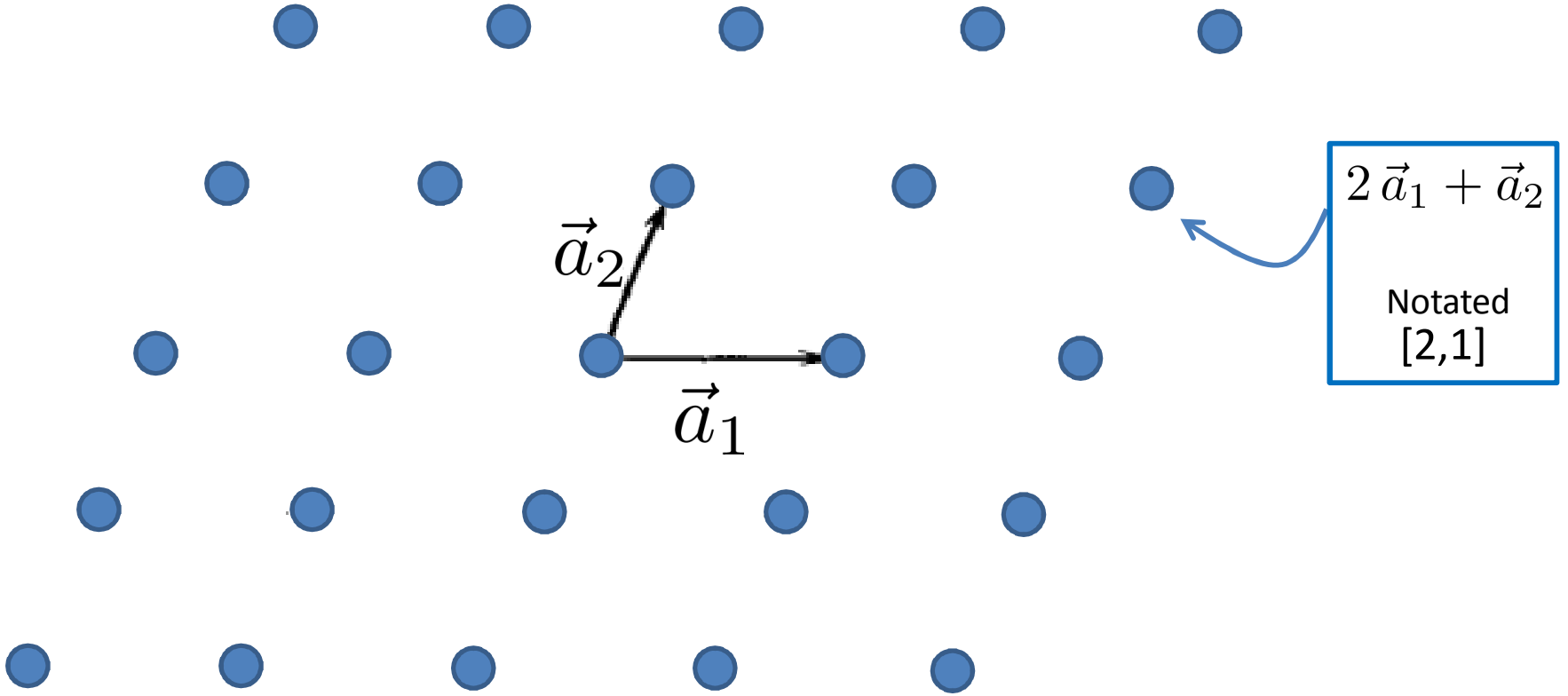


Crystals

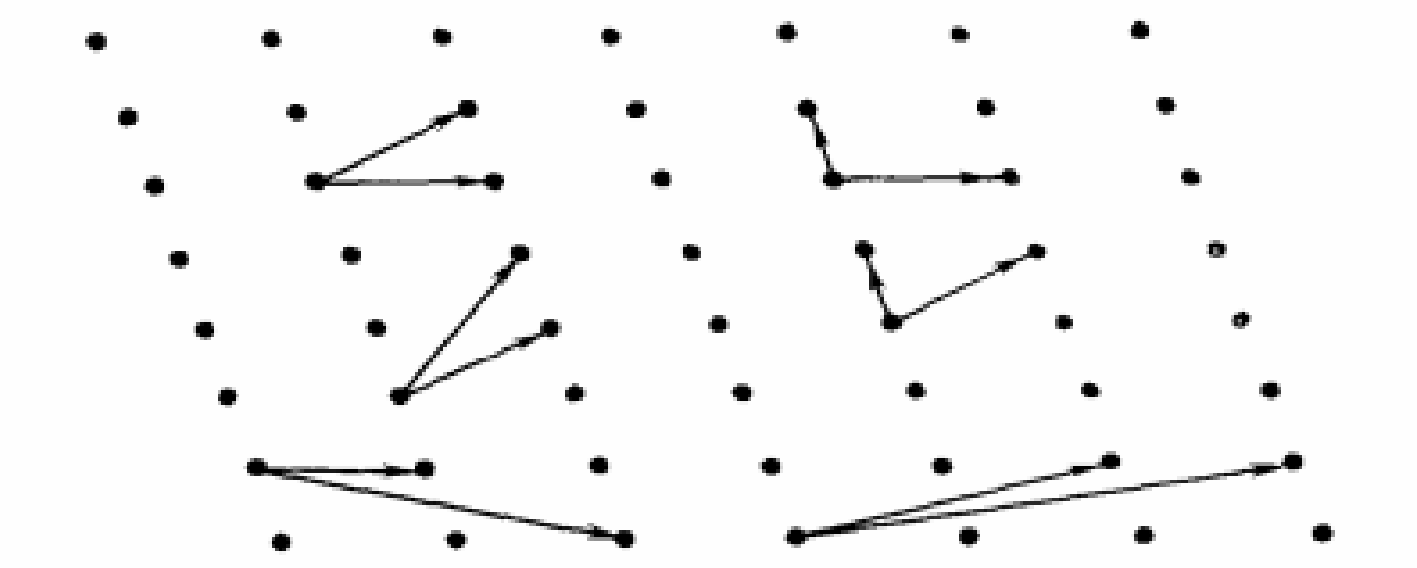




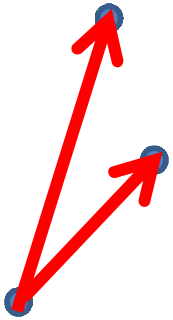




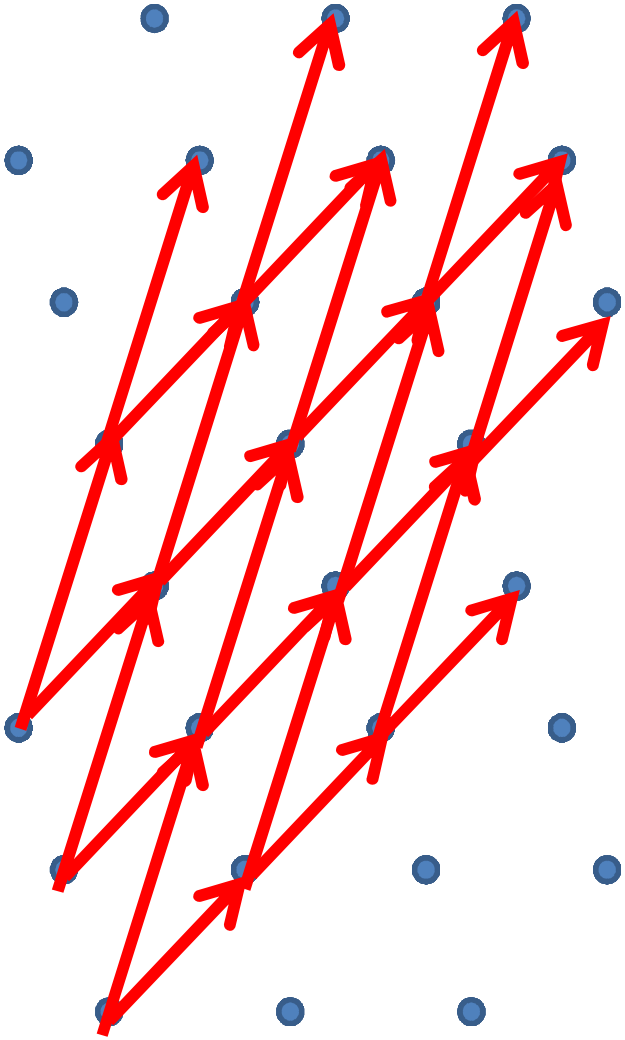
A lattice is defined as all points that are integer sums of primitive lattice vectors ([primitive/principle] [basis/translation] vectors).



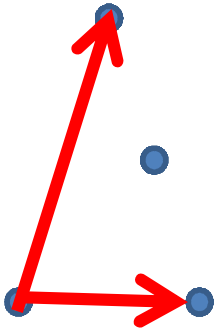
The choice of primitive lattice (basis) vectors for a lattice is not unique



Are these primitive lattice vectors for the lattice ?



Yes !



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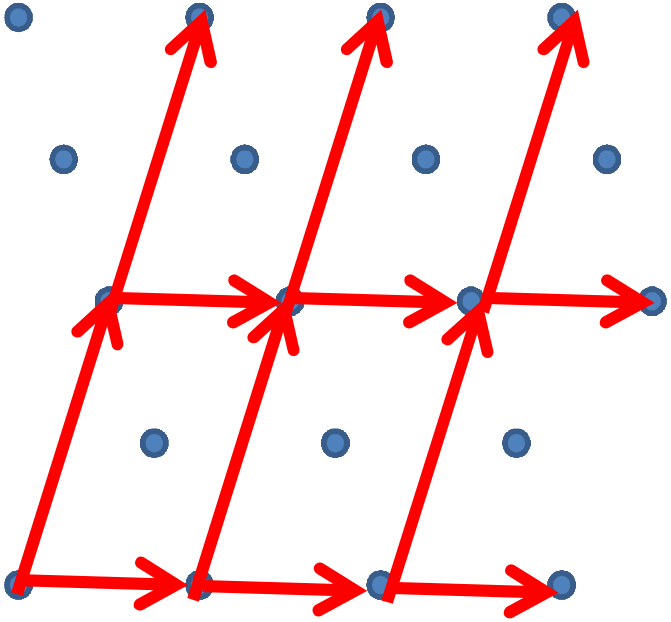
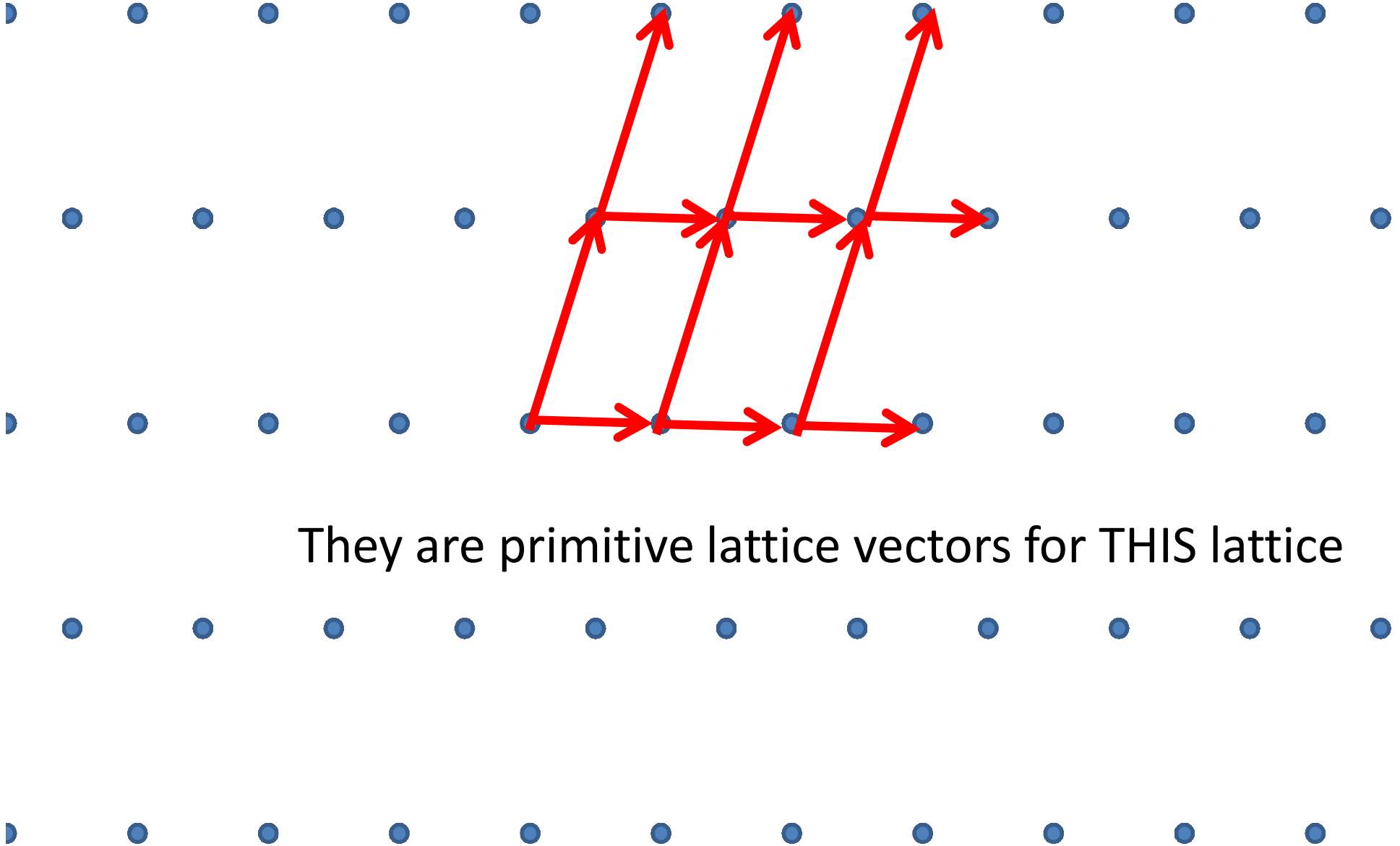
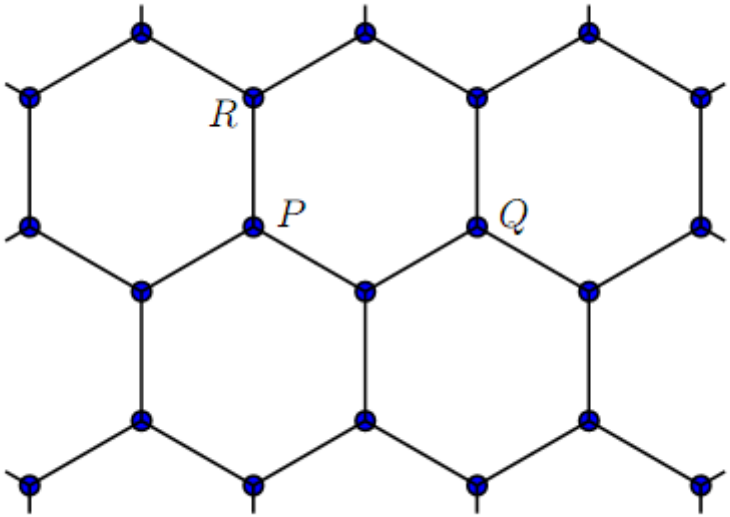


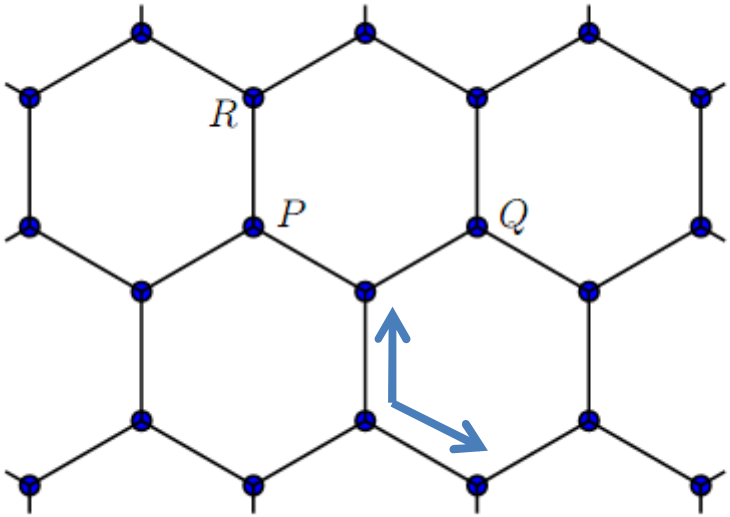
No ! (They miss every other lattice point!)



They are primitive lattice vectors for THIS lattice

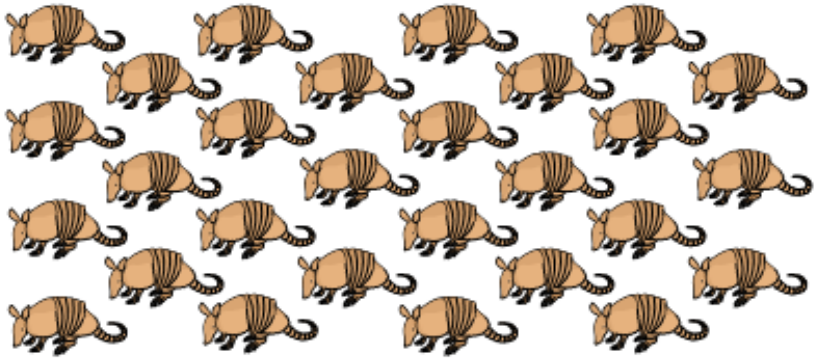


is this a lattice?

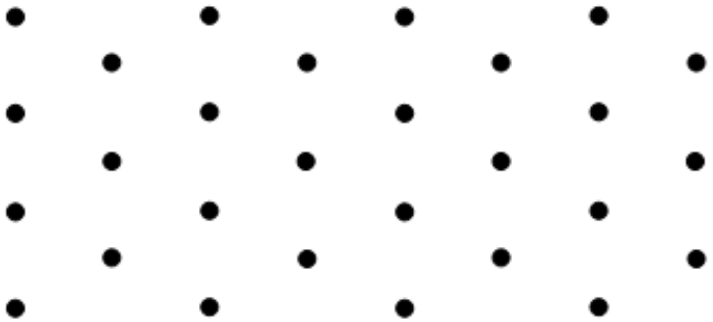


- No primitive lattice vectors exist which will give exactly these points (and only these points) when summed with integer coefficients.
- Sum of the two blue vectors gives a point in the center of a hexagon.
- Environment of R is not the same as that of P:
  (Note P *is* equivalent to Q).

Periodic Structure



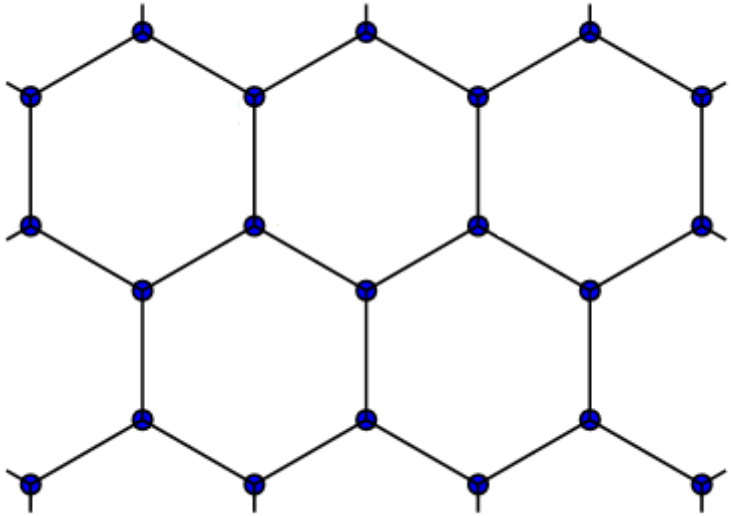
Lattice

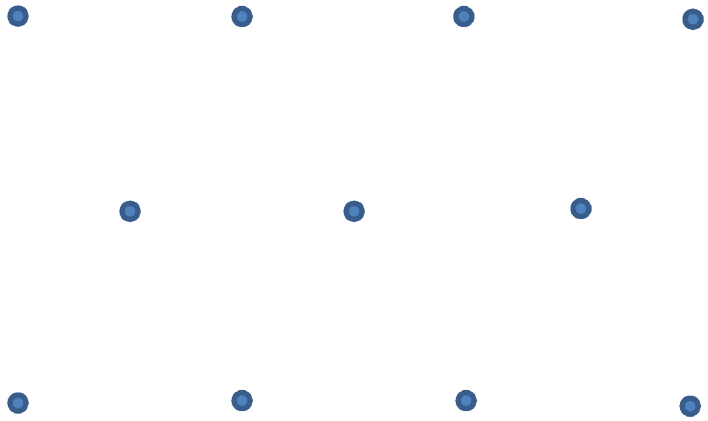


Repeating object

Any periodic structure is a lattice * repeating object

What about
This periodic
Structure?





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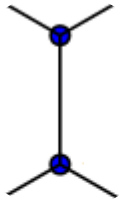
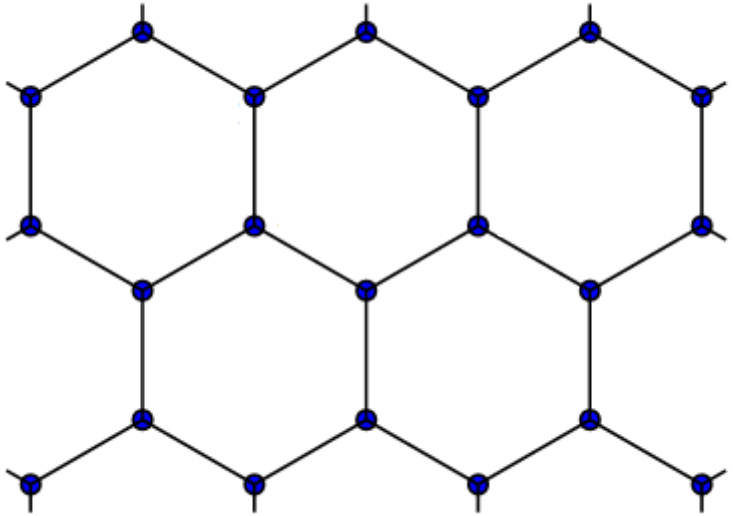
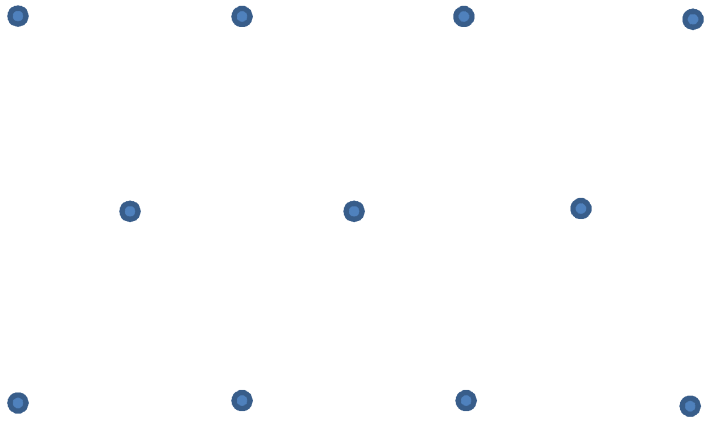


What about
This periodic
Structure?





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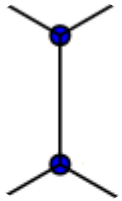
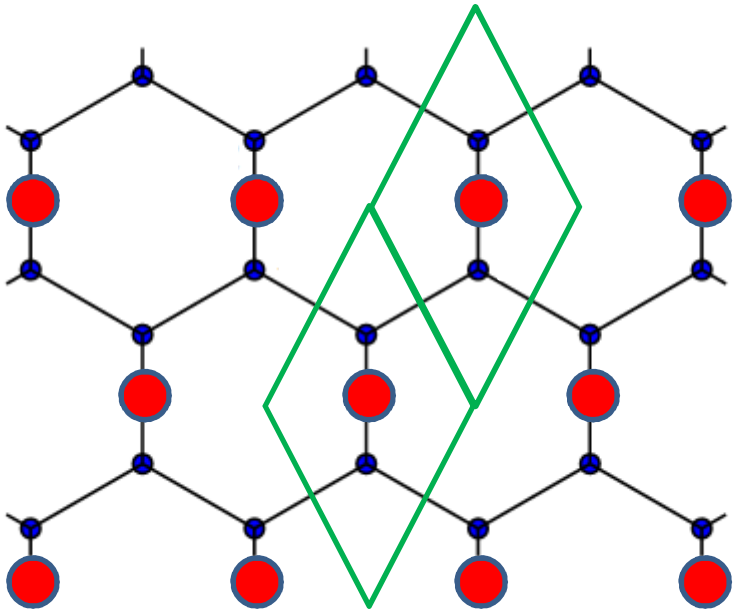
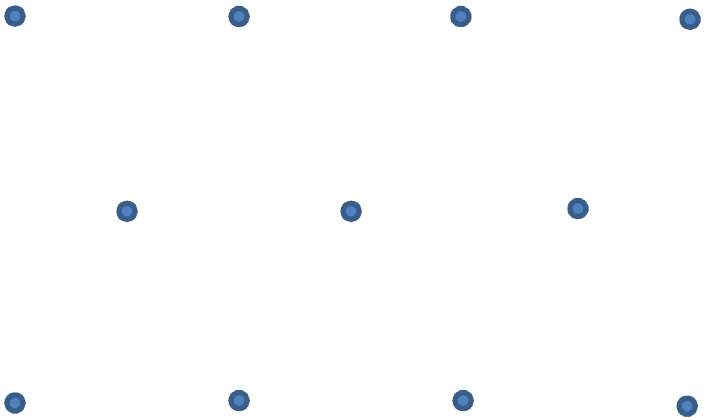


What about
This periodic
Structure?





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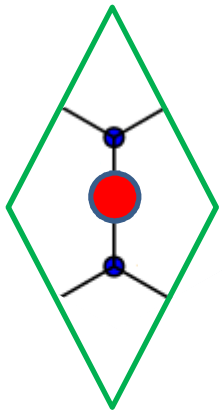
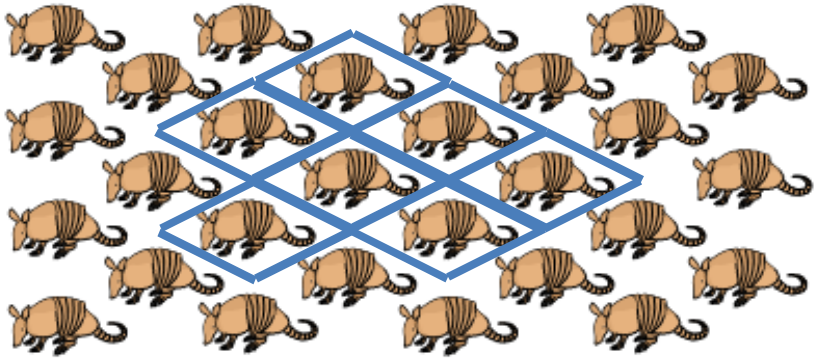
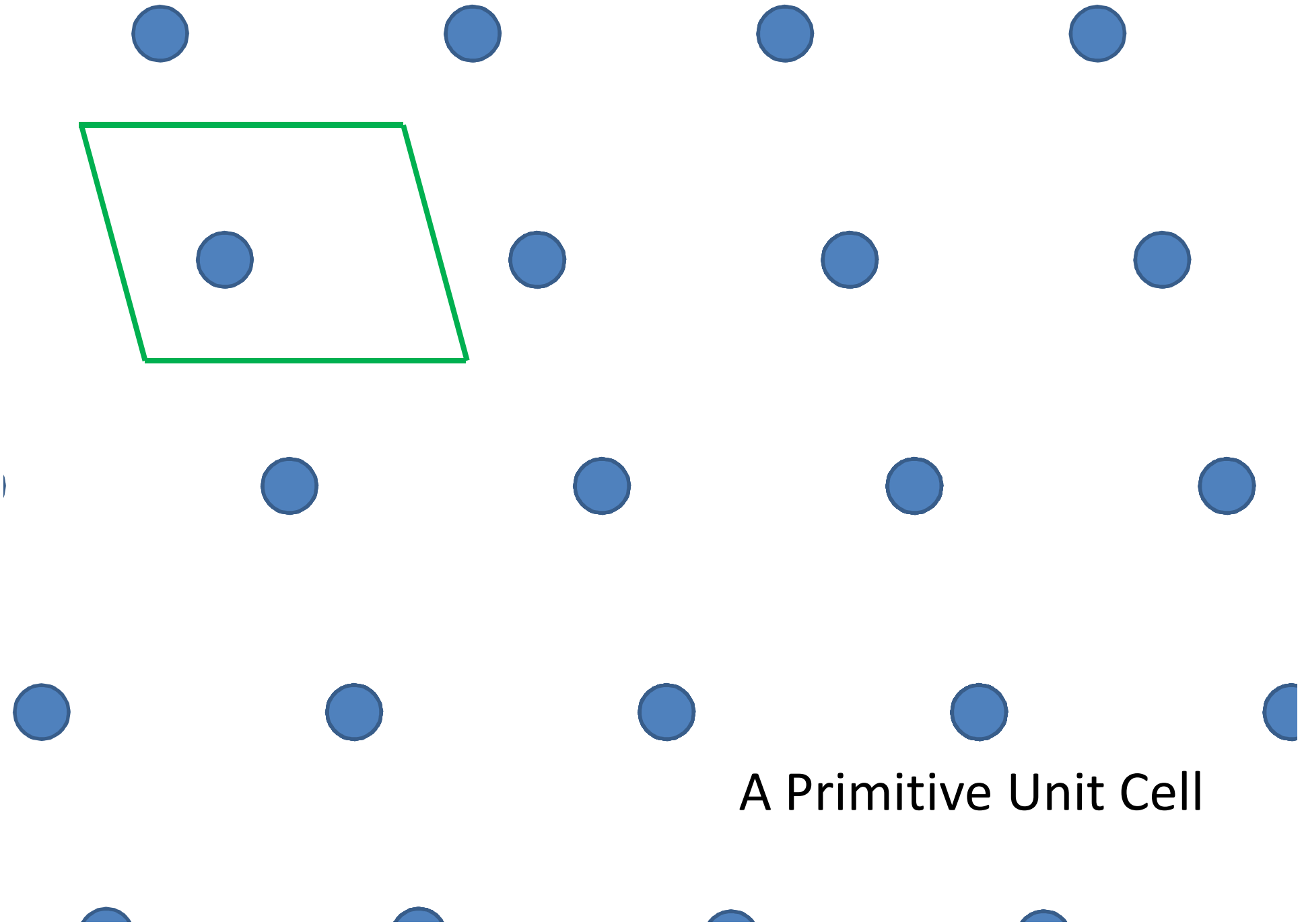


Periodic Structure

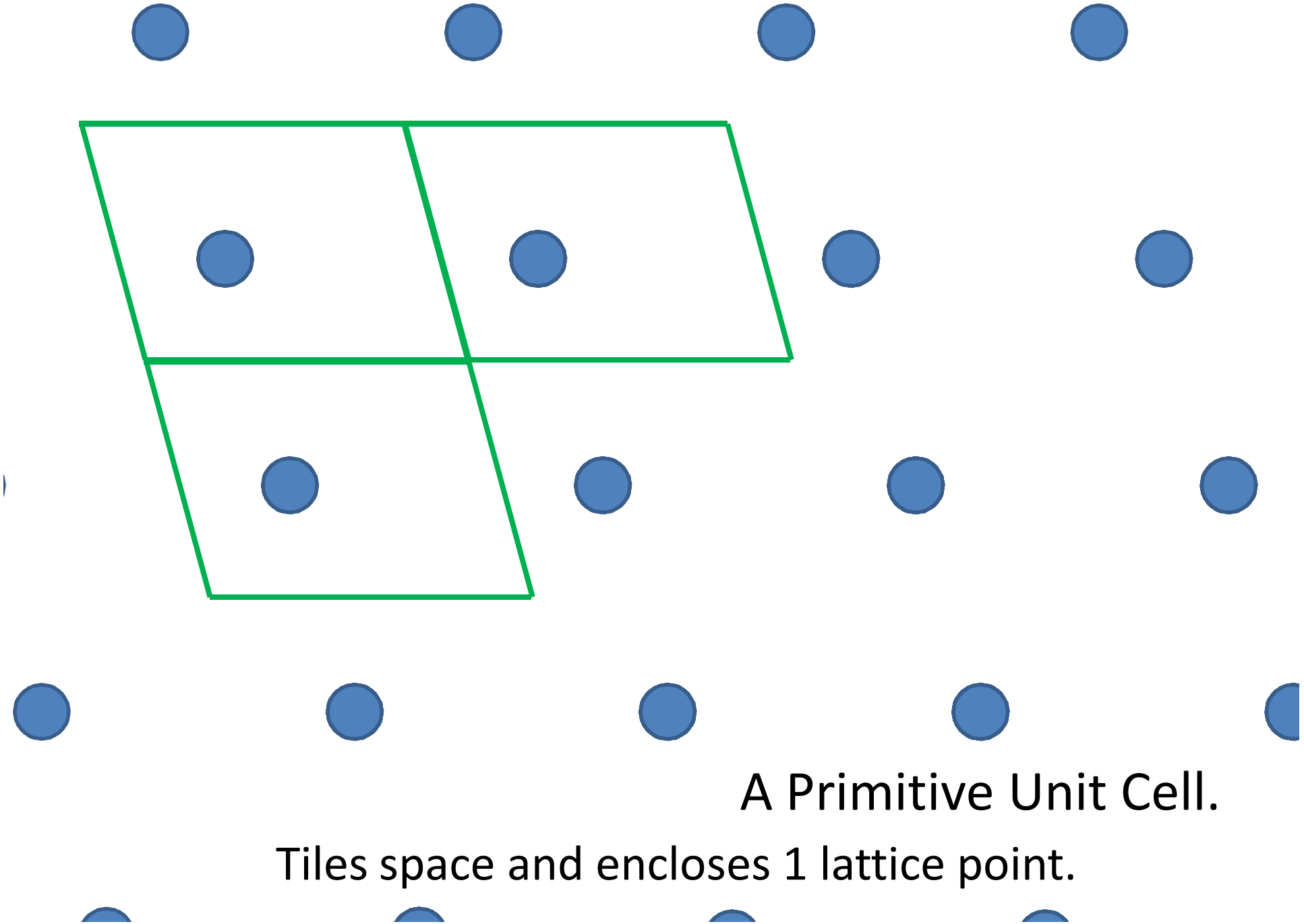


Unit Cell

The unit cell tiles space and reproduces the periodic structure



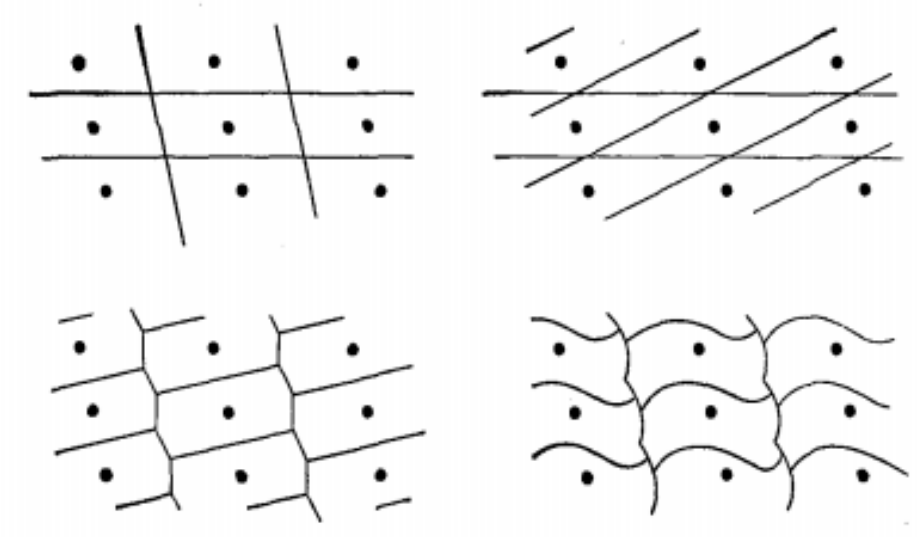
A Primitive Unit Cell



A Primitive Unit Cell.

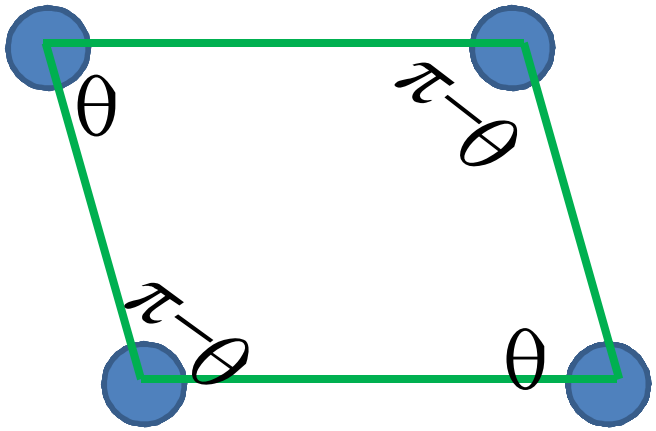
Tiles space and encloses 1 lattice point.

Primitive unit cell is not unique



This is a good primitive unit cell too!

The one lattice point enclosed is split into 4 pieces, but they add up to 1 point.



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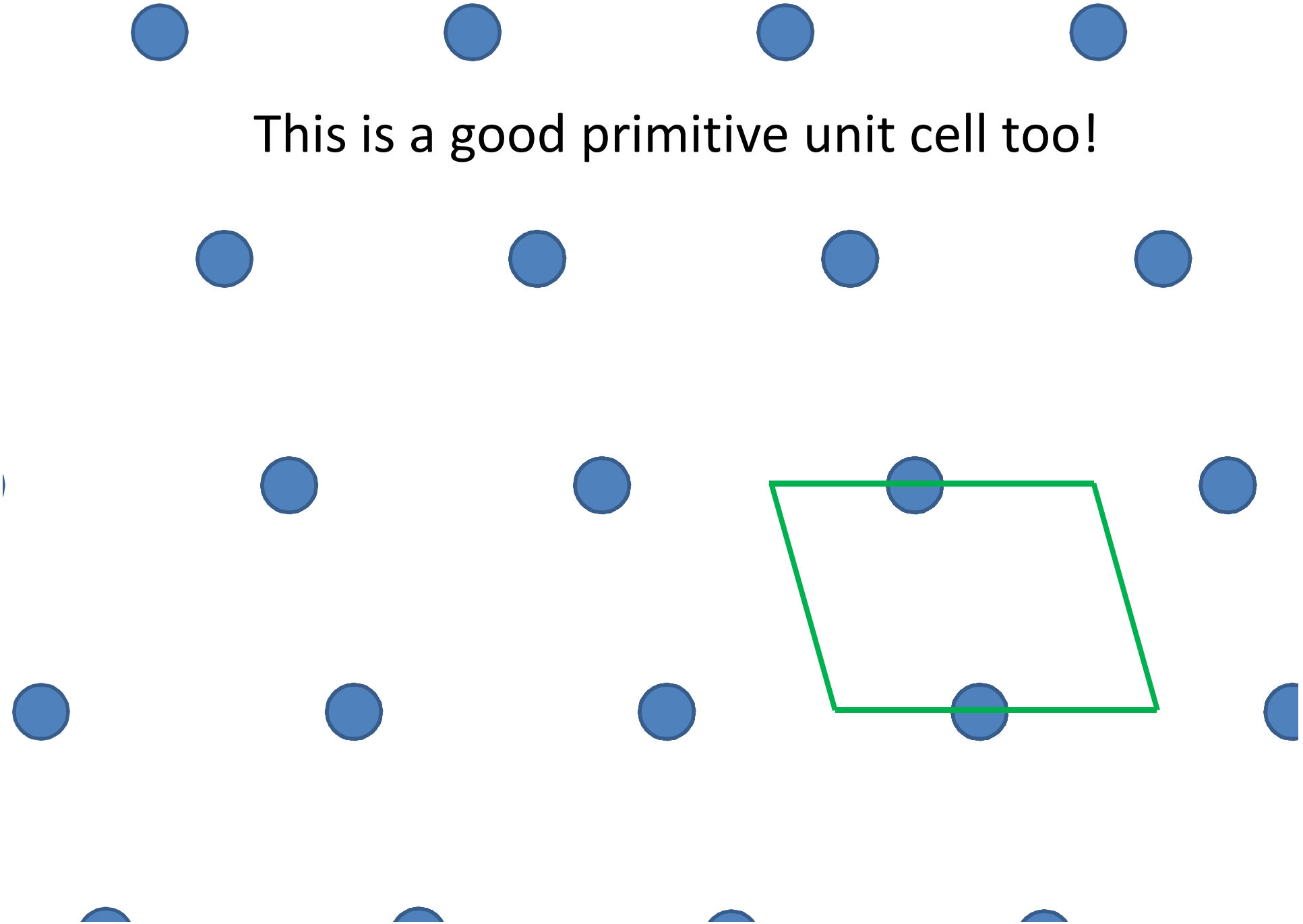

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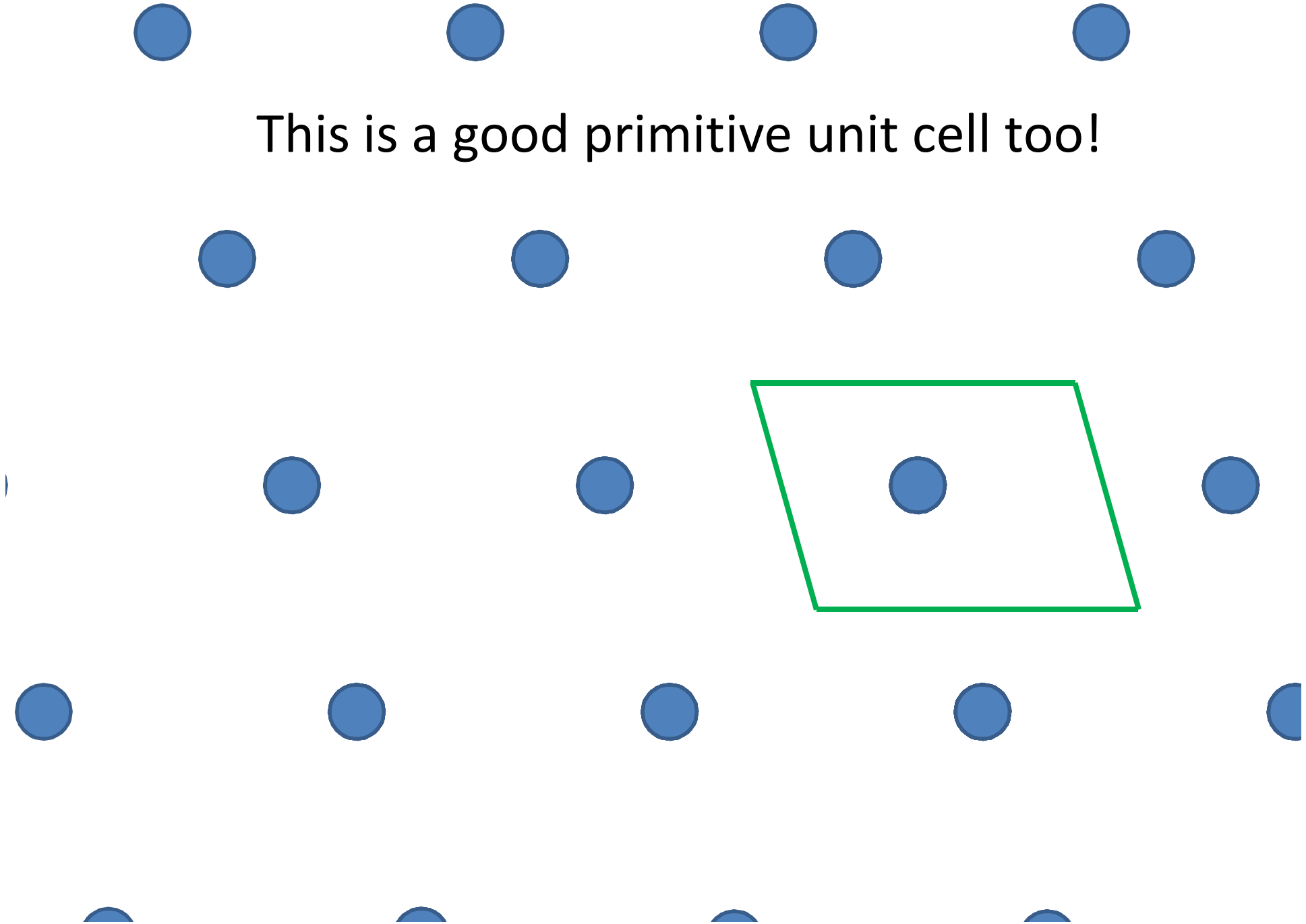
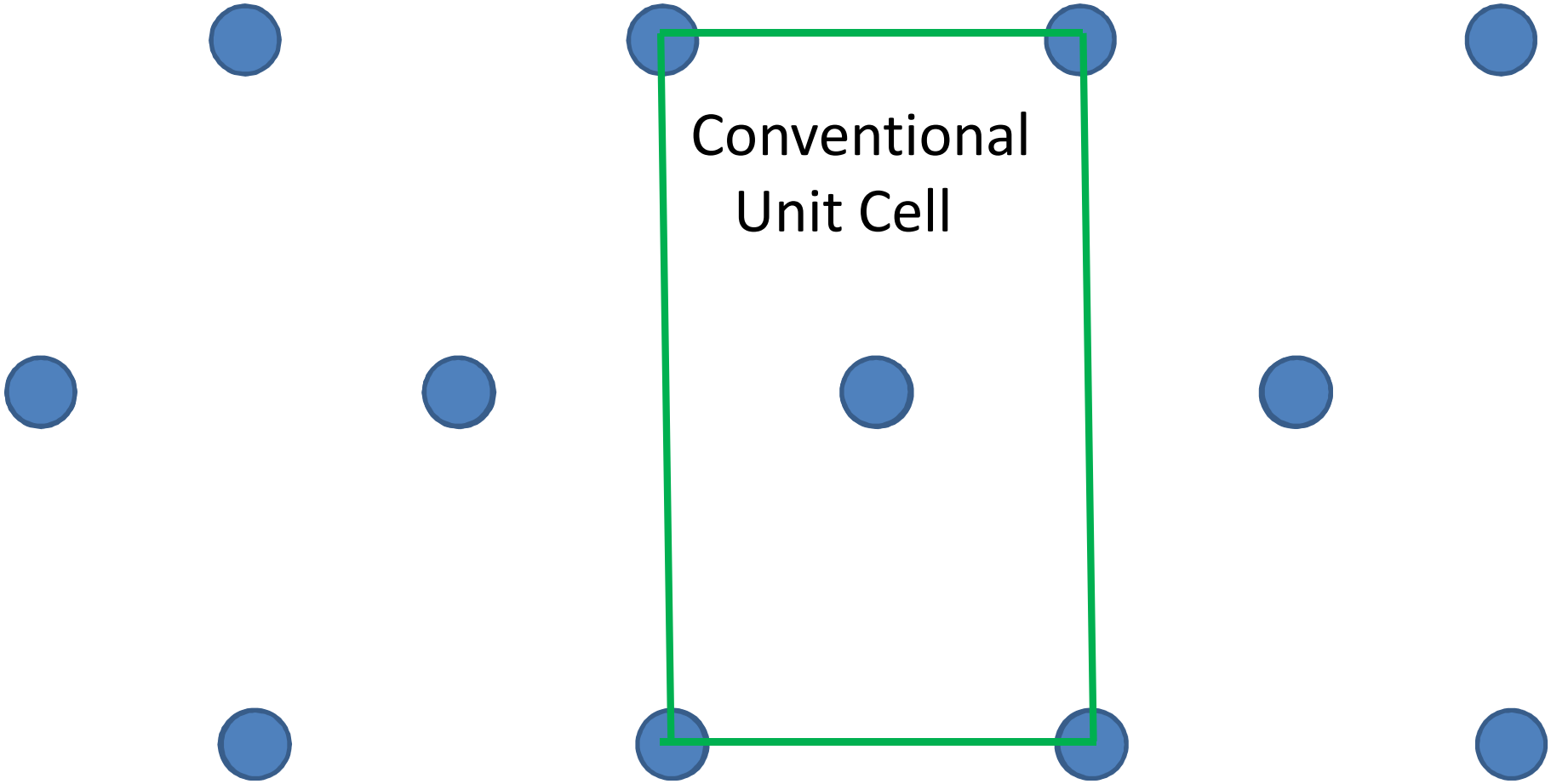
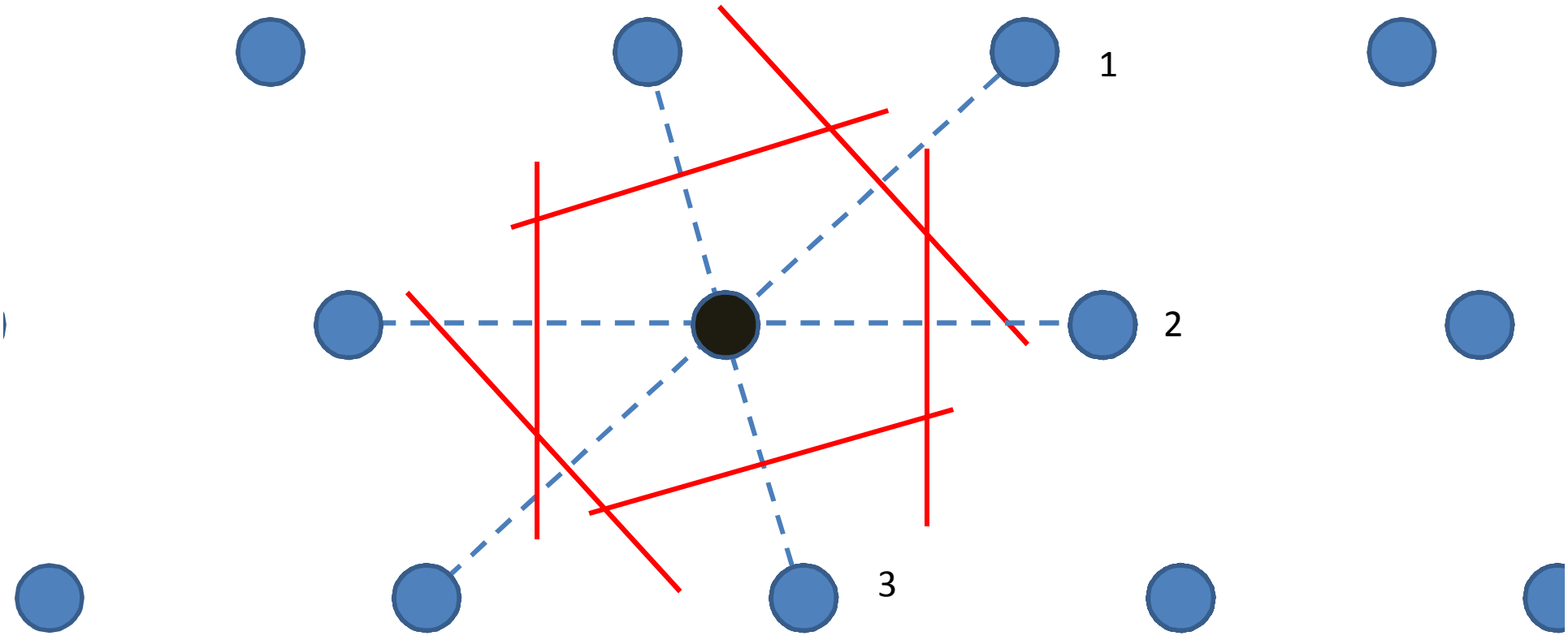


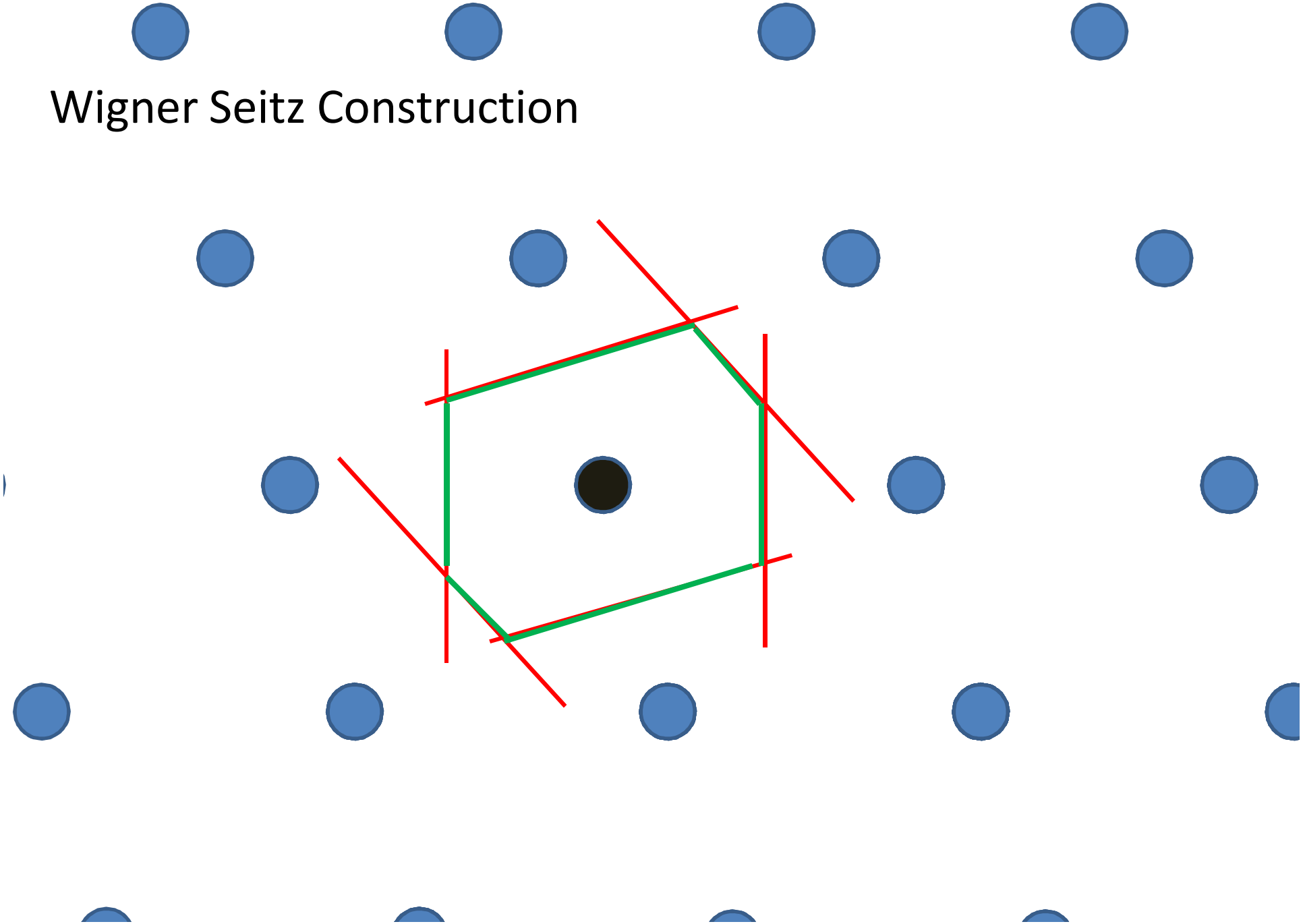
(Triangular Lattice)



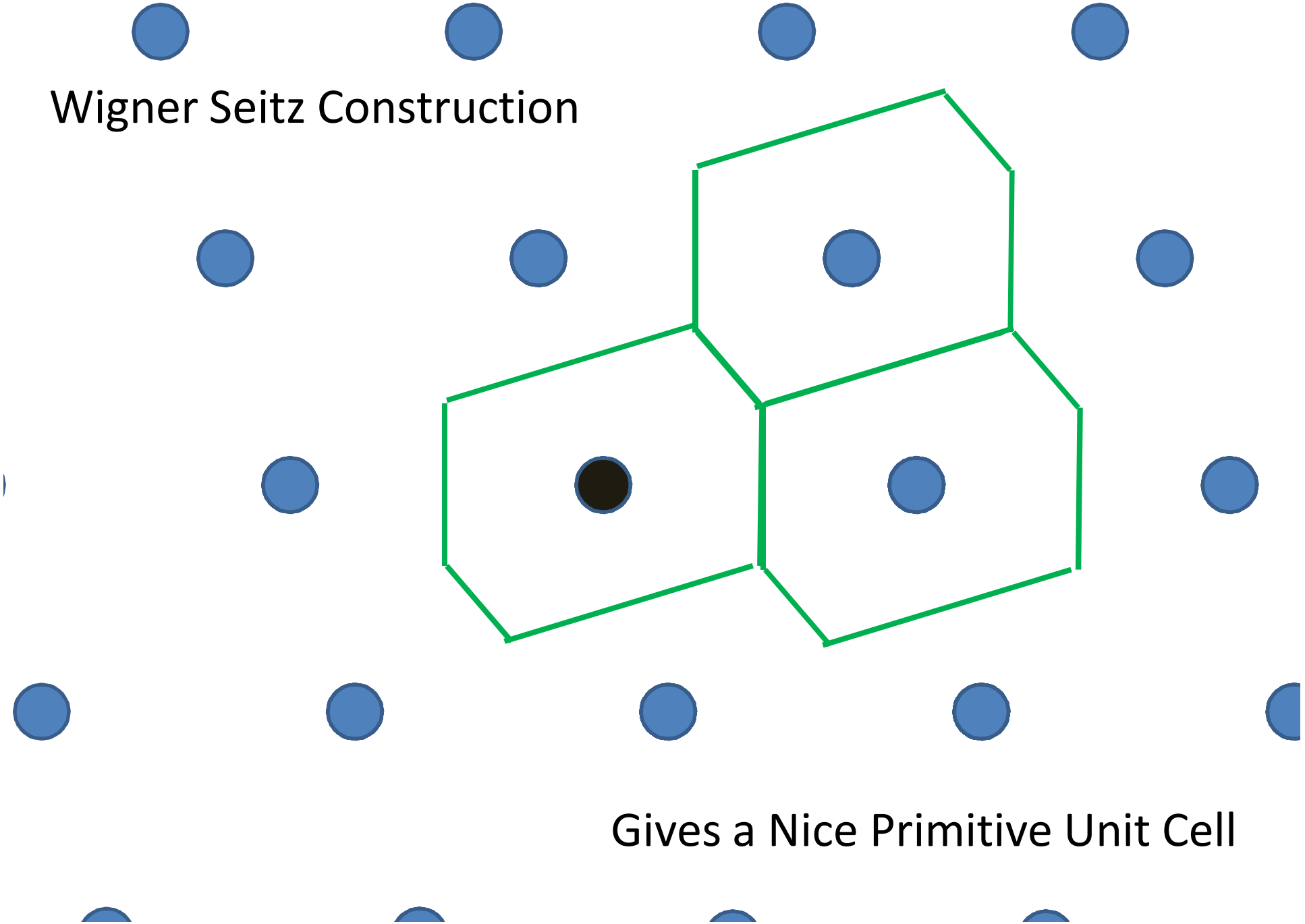
Wigner Seitz Construction



Wigner Seitz Construction

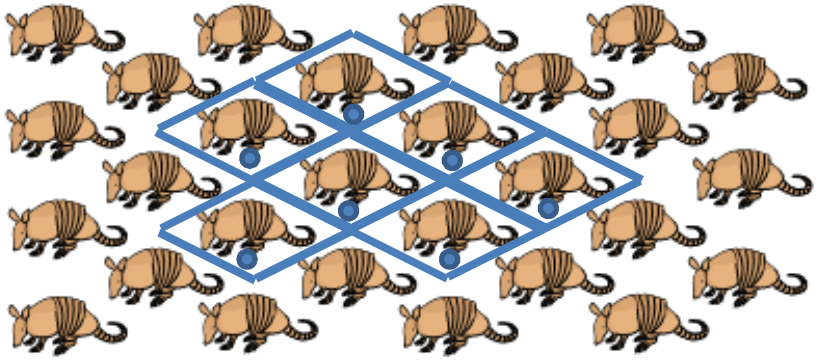


Wigner Seitz Construction



Gives a Nice Primitive Unit Cell

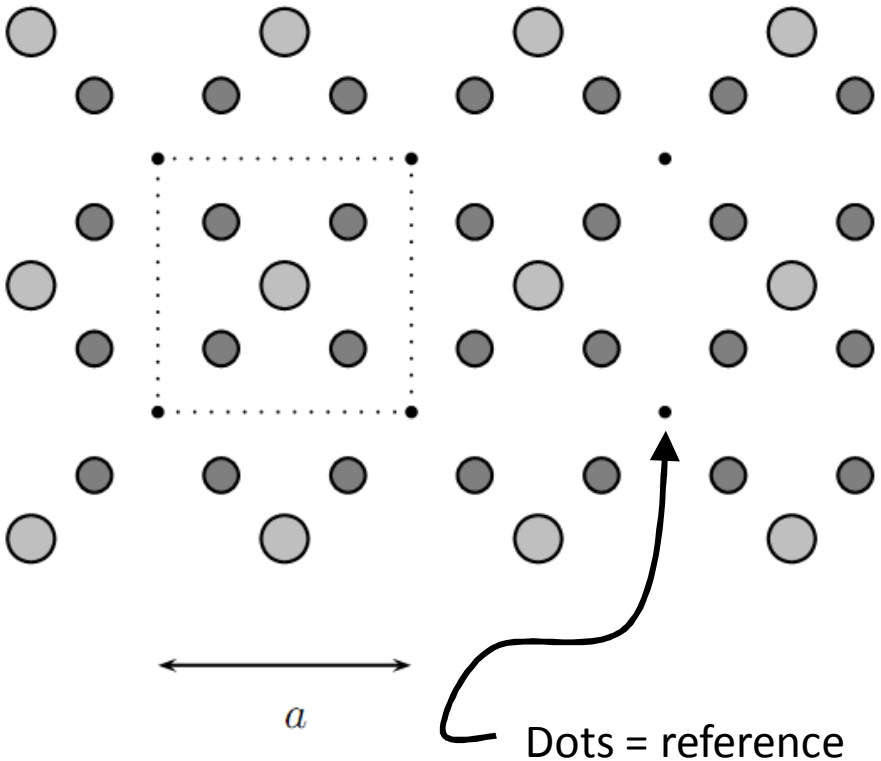
Periodic Structure



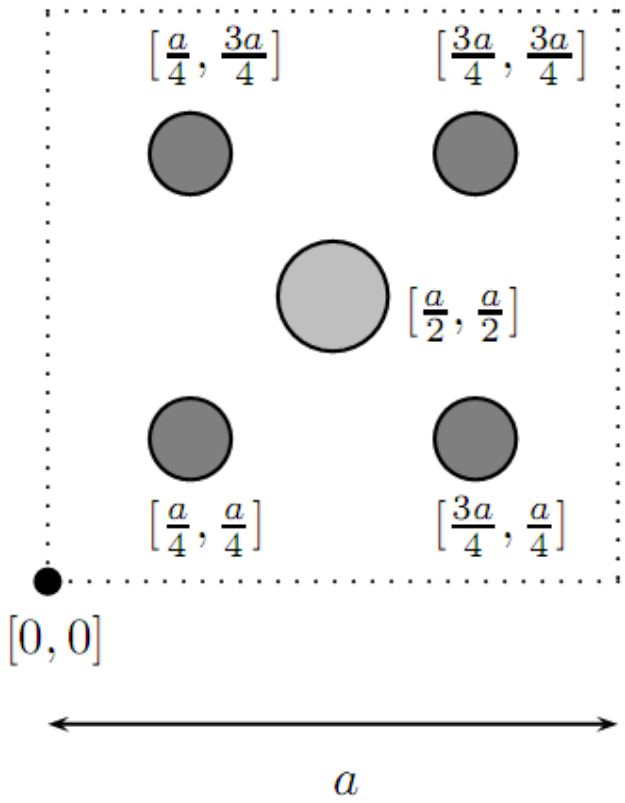
Unit Cell

Basis is a description of the unit cell
With respect to a reference lattice

Crystal



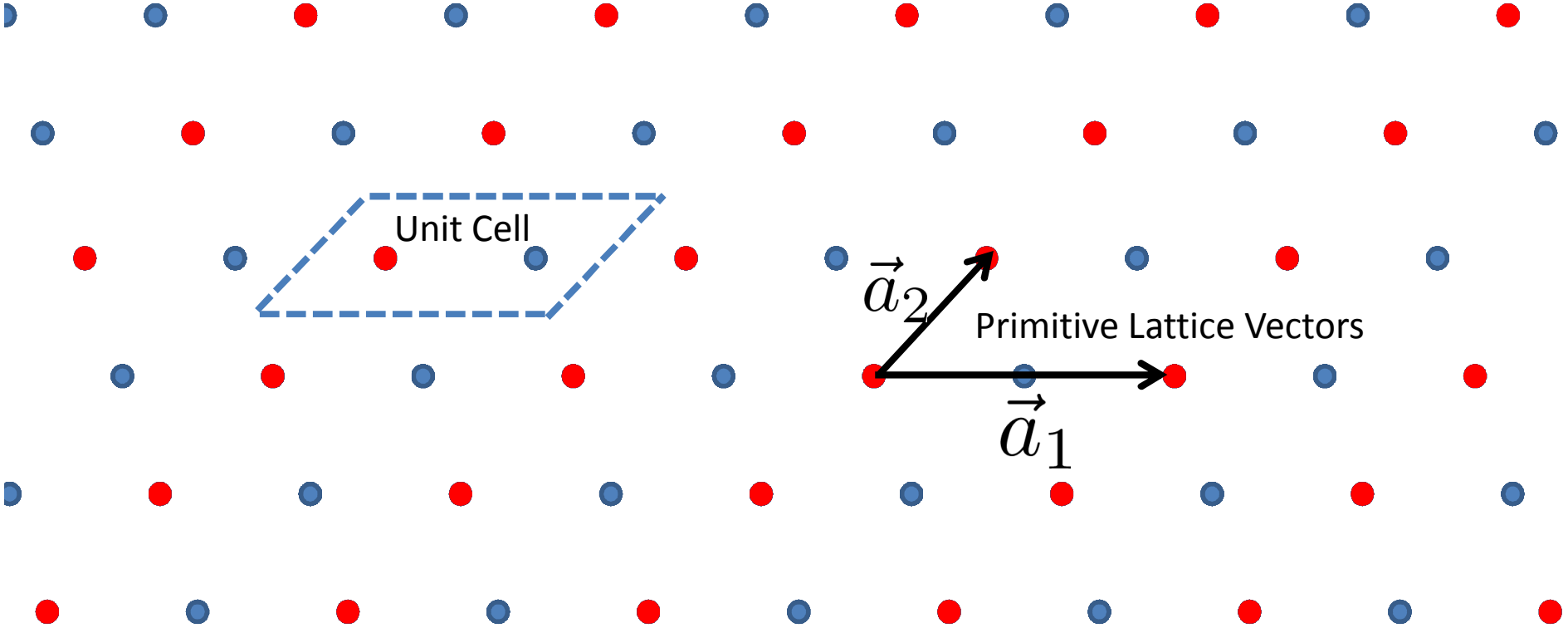
Unit Cell



Basis =

Large Light Gray Atom	Position=	$[a/2, a/2]$
Small Dark Gray Atoms	Position=	$[a/4, a/4]$ $[a/4, 3a/4]$ $[3a/4, a/4]$ $[3a/4, 3a/4]$

Reference Lattice is often taken coincident with some atom

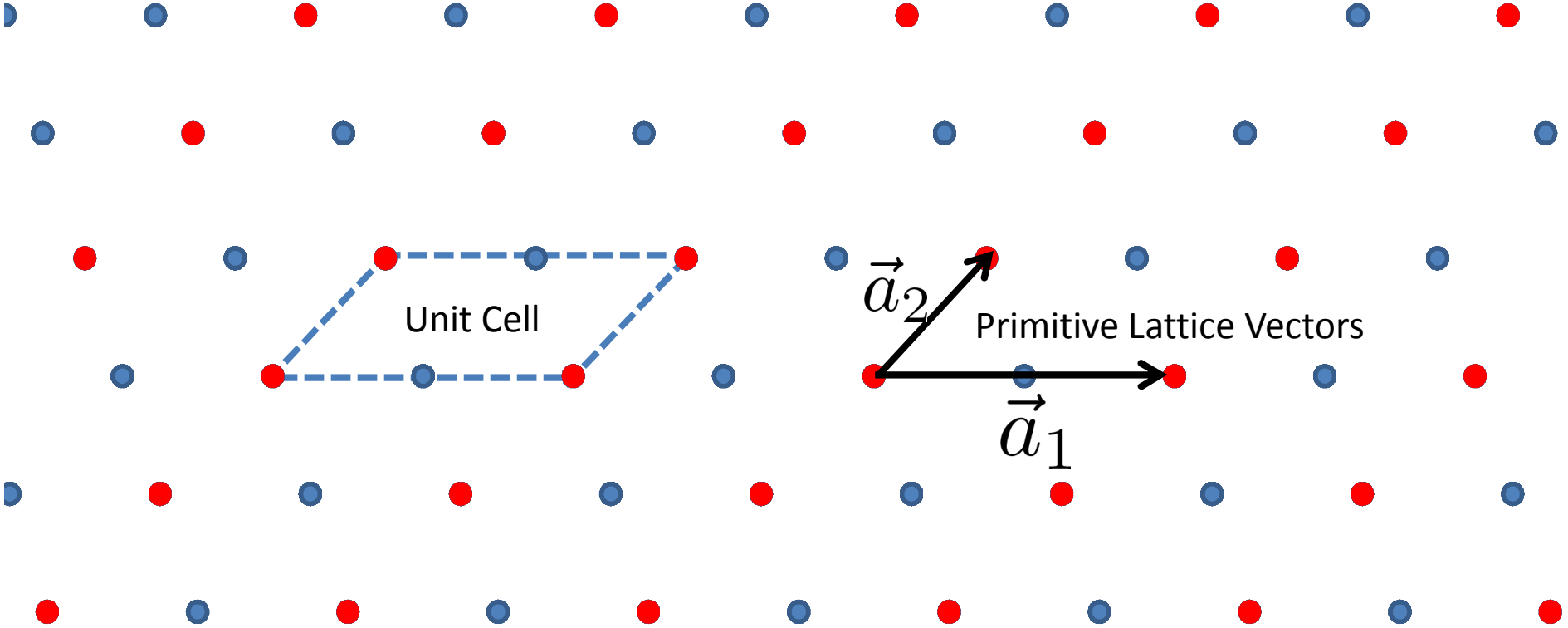


Put Reference Lattice on the Red Atoms:

Basis is: Red atom at [0,0]
Blue atom at [1/2,0]

note [1/2,0] = $(1/2)\vec{a}_1$

Reference Lattice is often taken coincident with some atom



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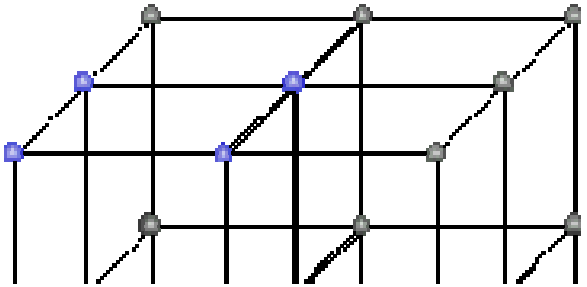
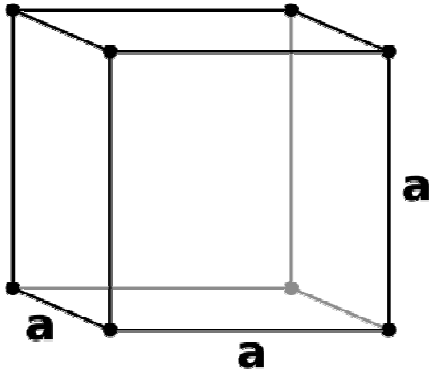
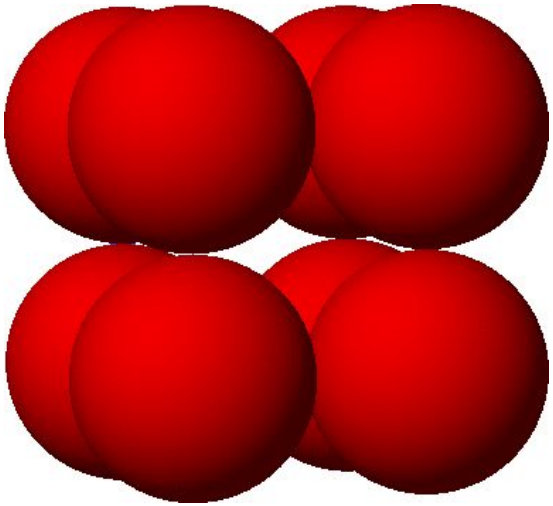
Simple (Primitive) Cubic Lattice

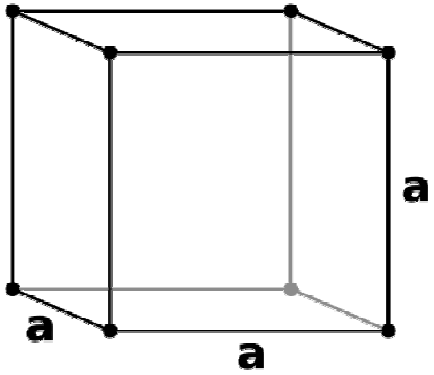


Simple Cubic Unit Cell



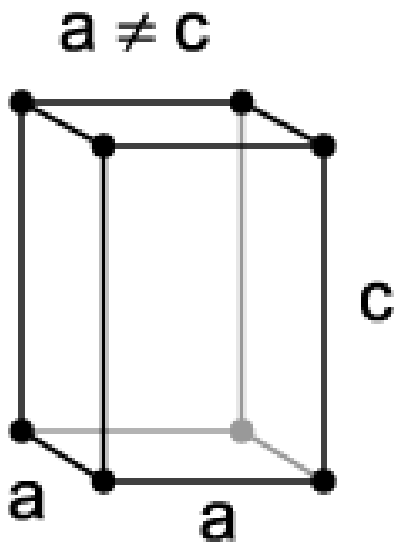


Atoms arranged in Simple Cubic Lattice (very unusual)

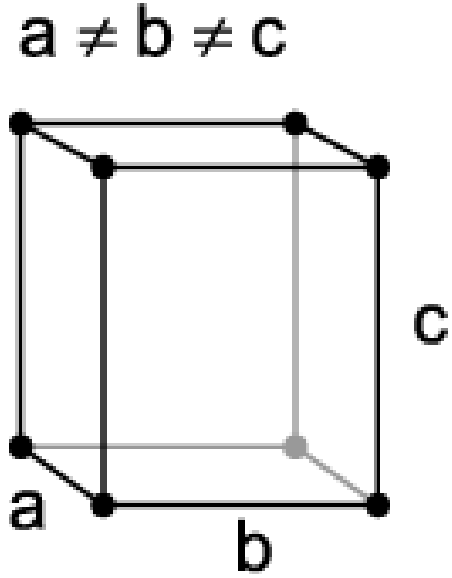


Simple Cubic
Unit Cell

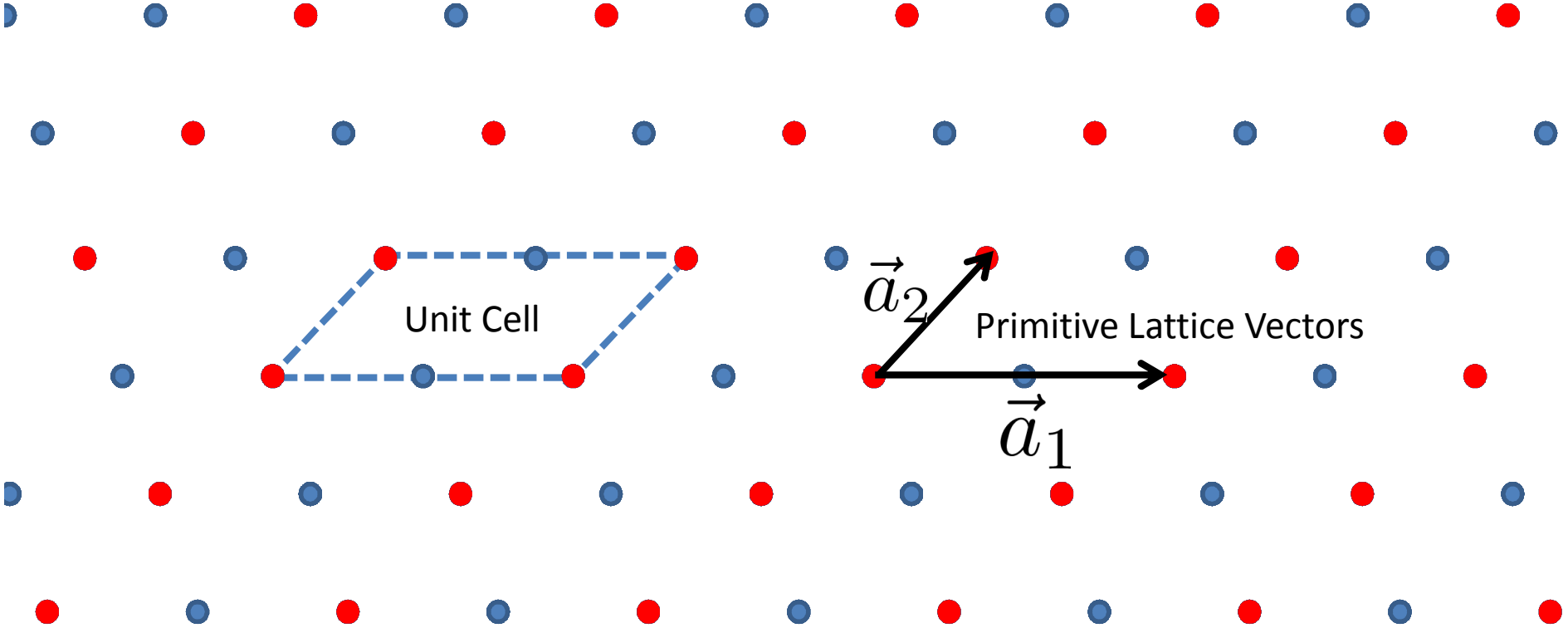
Simple
Tetragonal
Unit Cell



Simple
Orthorhombic
Unit Cell



Reference Lattice is often taken coincident with some atom



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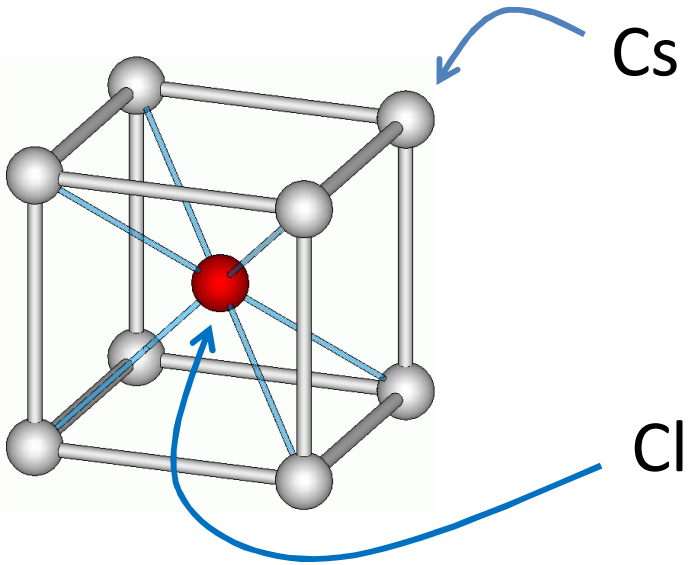
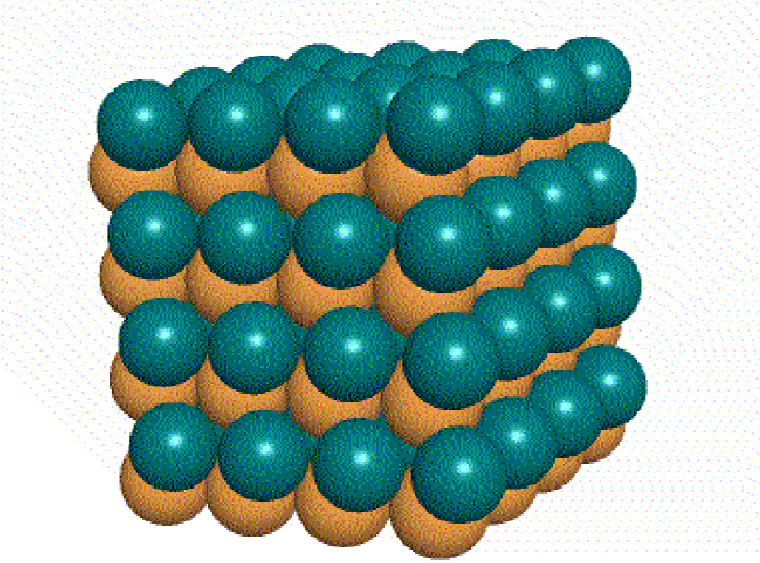
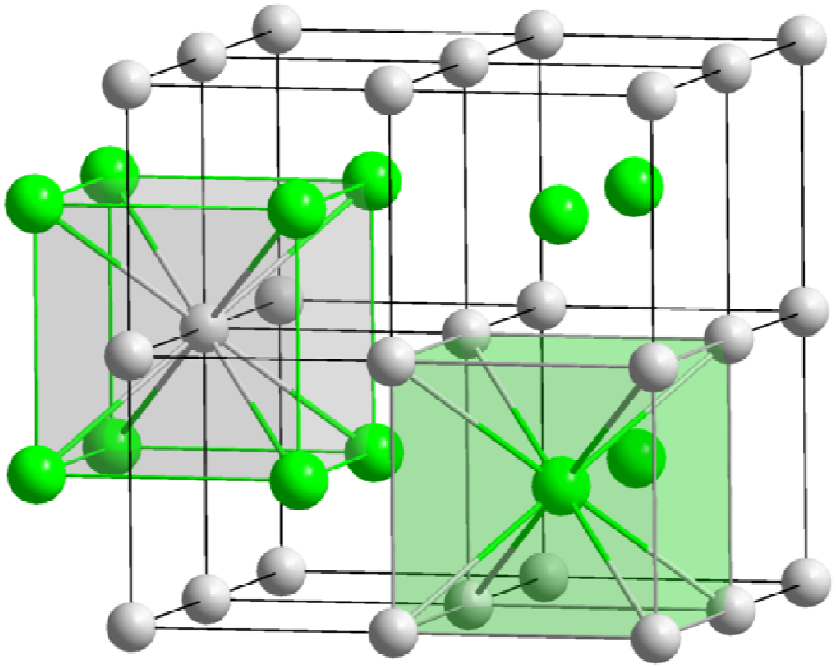


Cesium Chloride (CsCl): A simple cubic Lattice with a Basis

Basis:

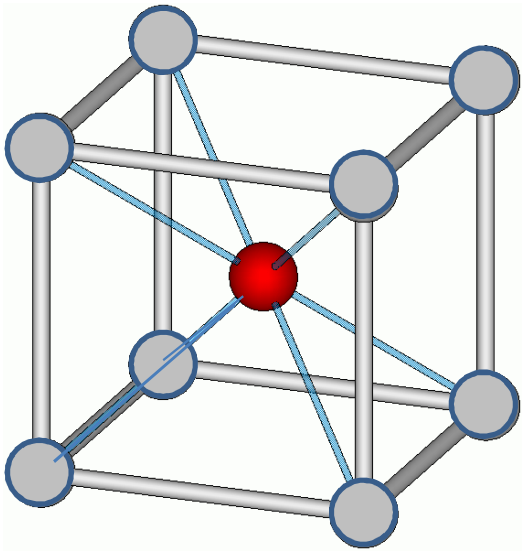
Cs at[0, 0, 0] (i.e., on the simple cubic)
Cl at [½, ½, ½] (i.e., in the middle of each cube)





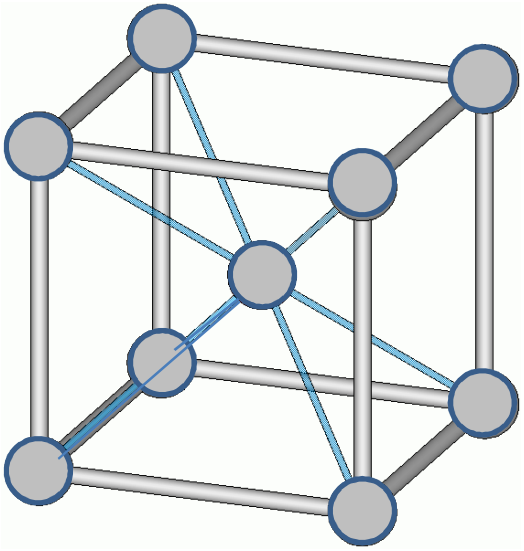
Two depictions of the CsCl lattice structure =

Two interlocking simple cubics



CsCl =Simple Cubic
with Basis

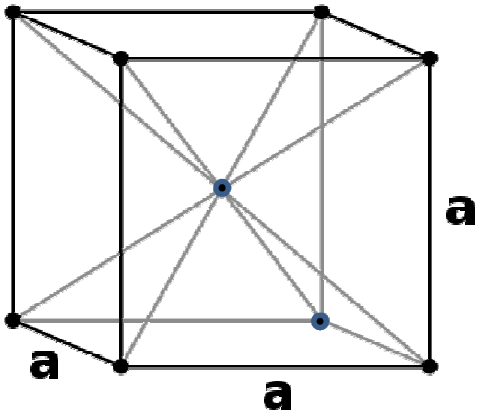
Cs at [0, 0, 0]
Cl at [½, ½, ½]



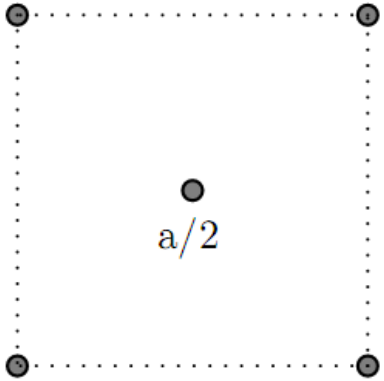
Cs = Simple Cubic
with Basis?

Cs at [0, 0, 0]
Cs at [½, ½, ½]

Unit cell of Body Centered Cubic Lattice (BCC) (Notated cubic-I)

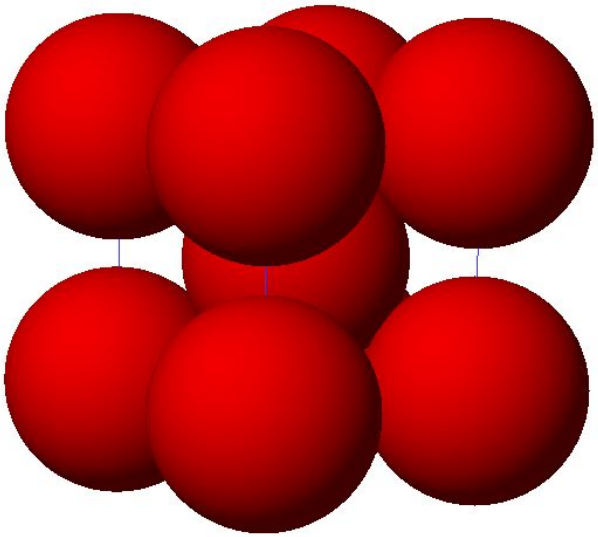


Conventional Unit Cell

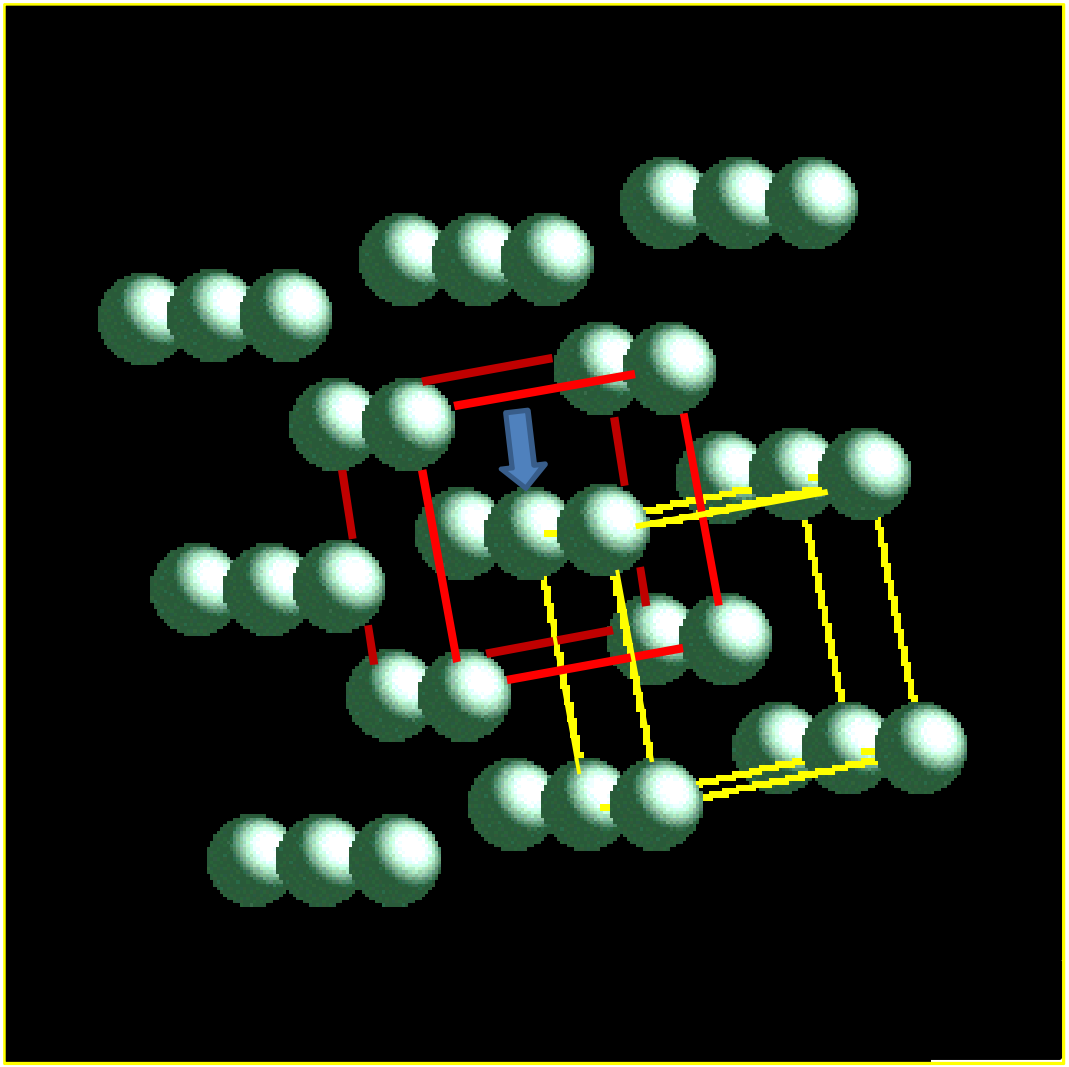


Plan View

(unlabeled points at height 0 and a)



(More efficient sphere packing)



BCC Lattice