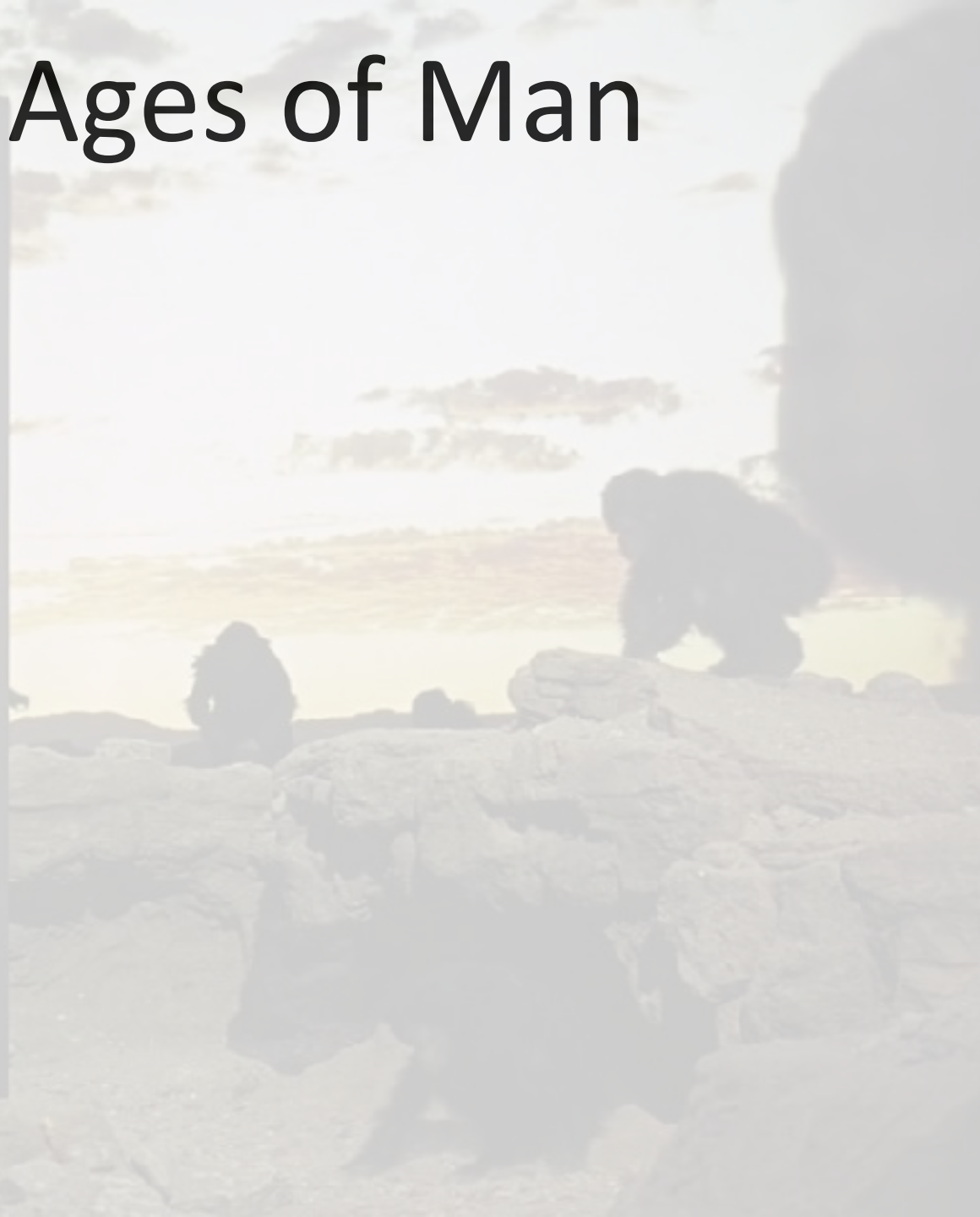# Different Ages of Man
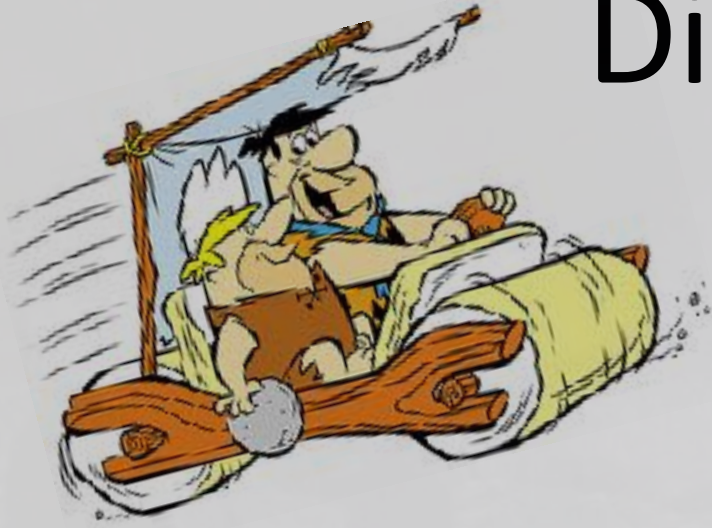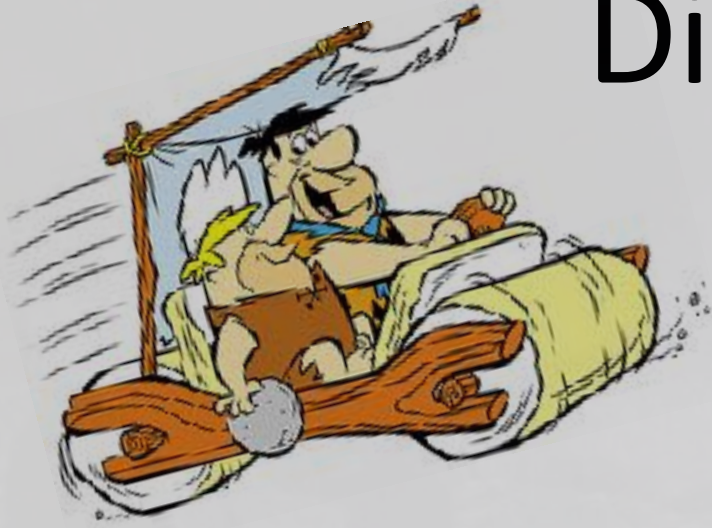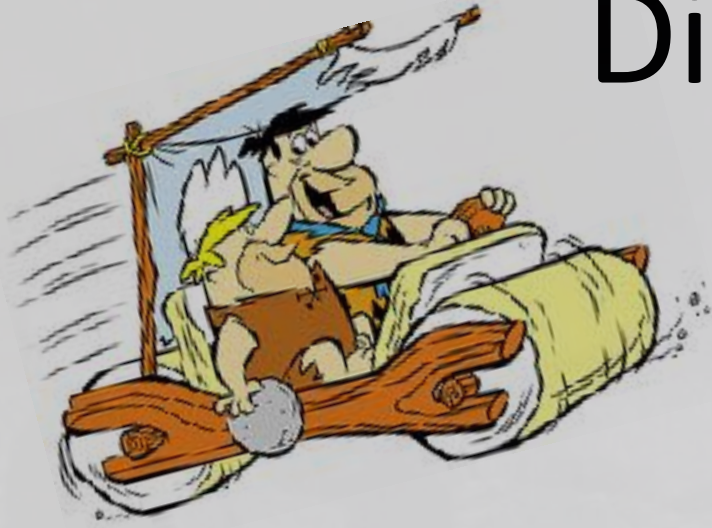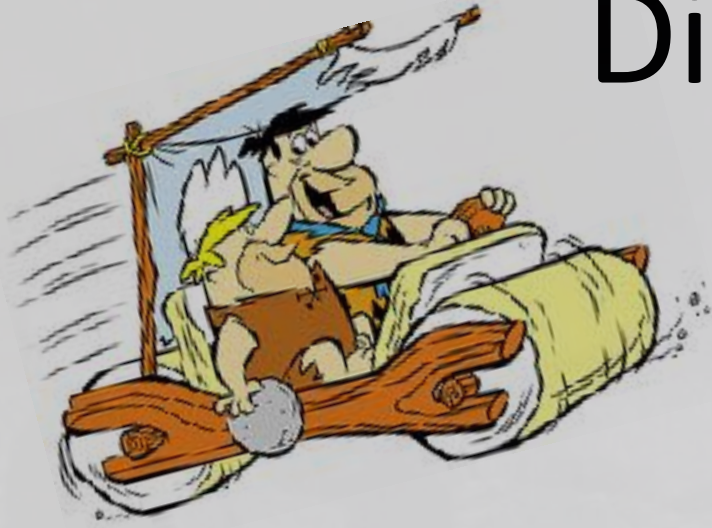
Different Ages of Man

Different Ages of Man

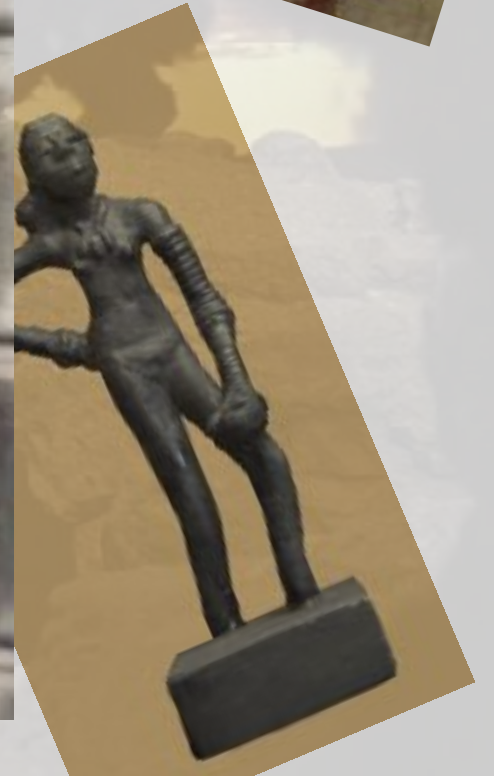# Different Ages of Man

Different Ages of Man
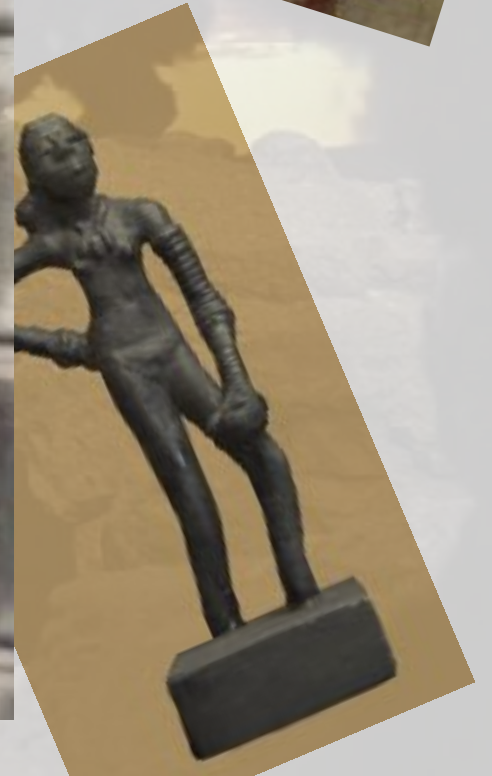
Different Ages of Man
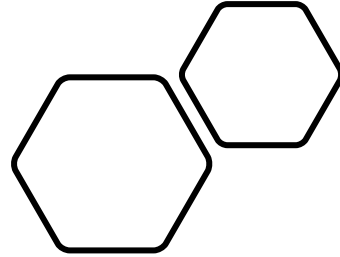
Different Ages of Man

"One shouldn't work on semiconductors, that is a filthy mess; who knows whether any semiconductors exist."

- Wolfgang Pauli

Crystal Structures

Additional Reference Books:
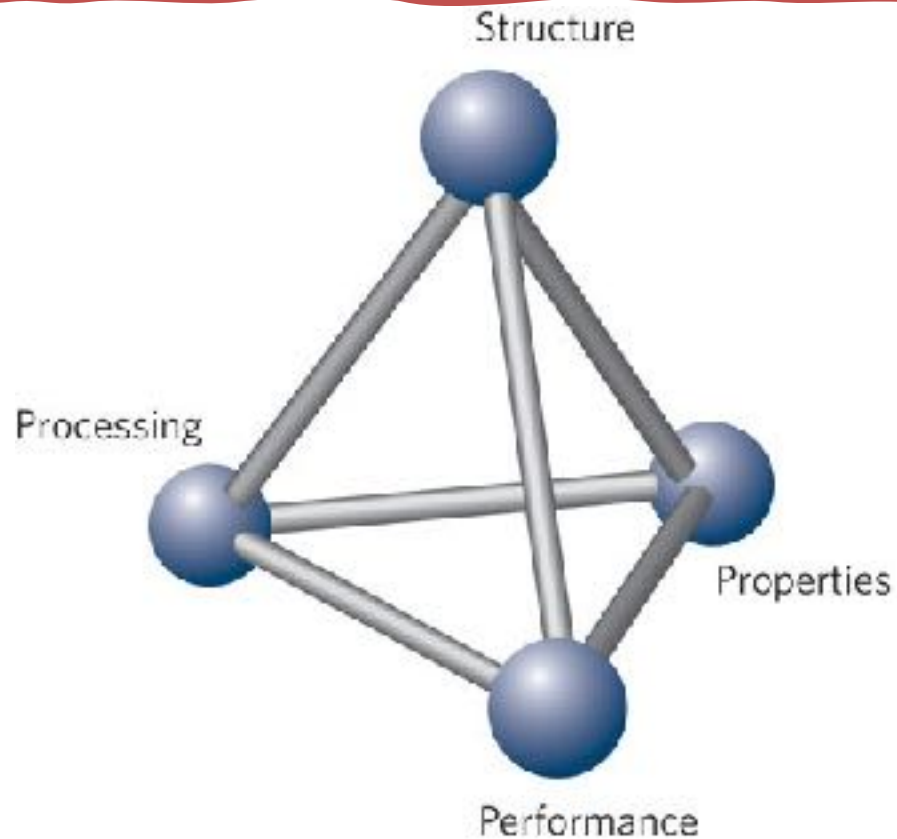
Structure of Materials

Marc DeGraef

Michael McHenry

Structure and Bonding in Crystalline Materials

G.S. Rohrer

Structure–Property Relation

Structure–Property Relation
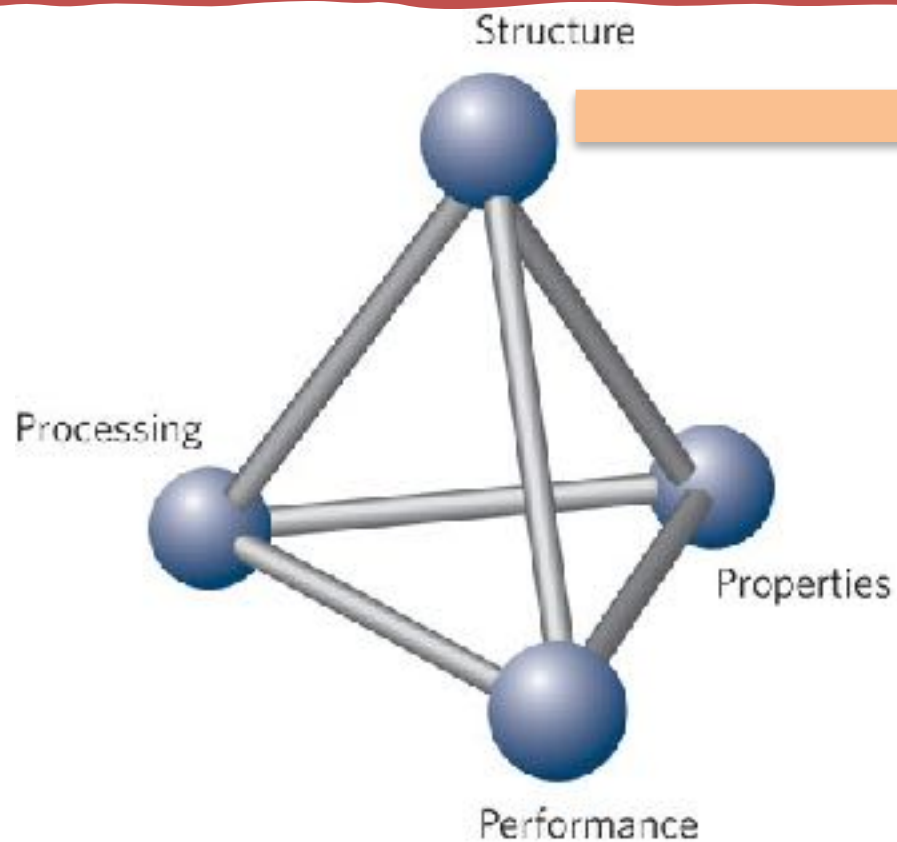
Structure

Processing

Properties

Performance

Why is this material transparent ?
Electronic structure

How is the transparency affected ?
Defect structure

What induces complete opacity ?
Microstructure

Structure–Property Relation
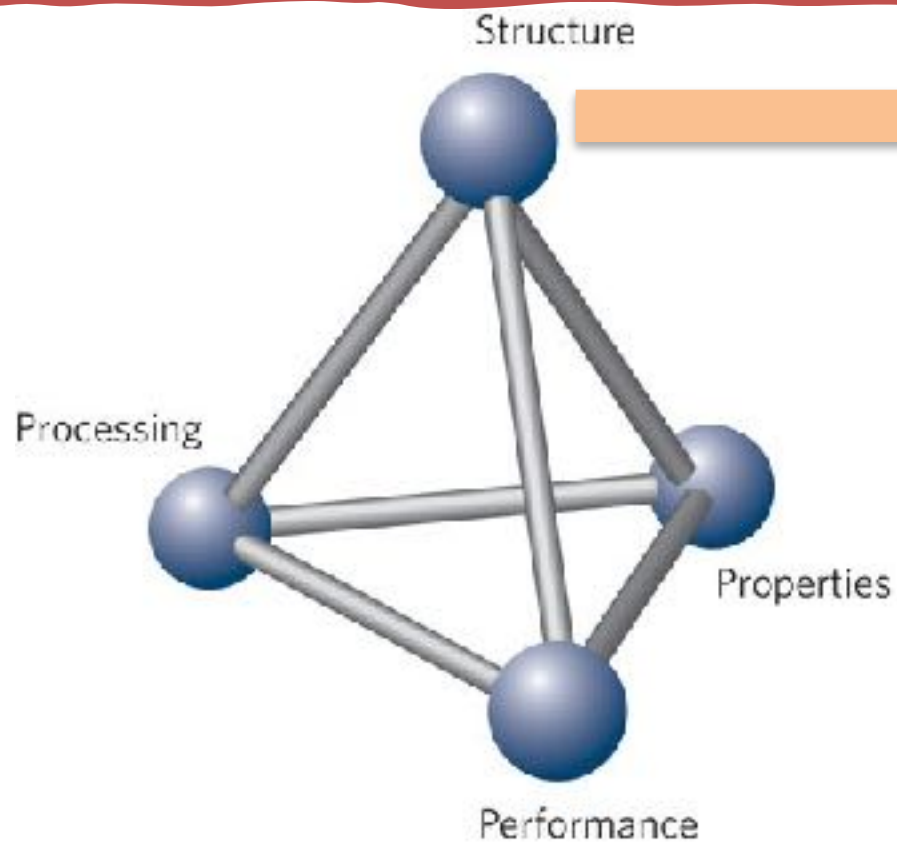
Starting point is the idealization called a perfect crystal structure

Why is this material transparent ?
Electronic structure

How is the transparency affected ?
Defect structure

What induces complete opacity ?
Microstructure

Crystalline Materials

- Standardized description of crystal structures
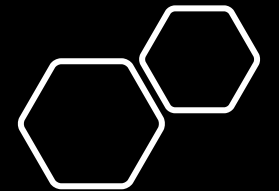
- Symmetry to create classifications

- Mathematical techniques
  - Unambiguous and clear description
  - Rules and tools for computations
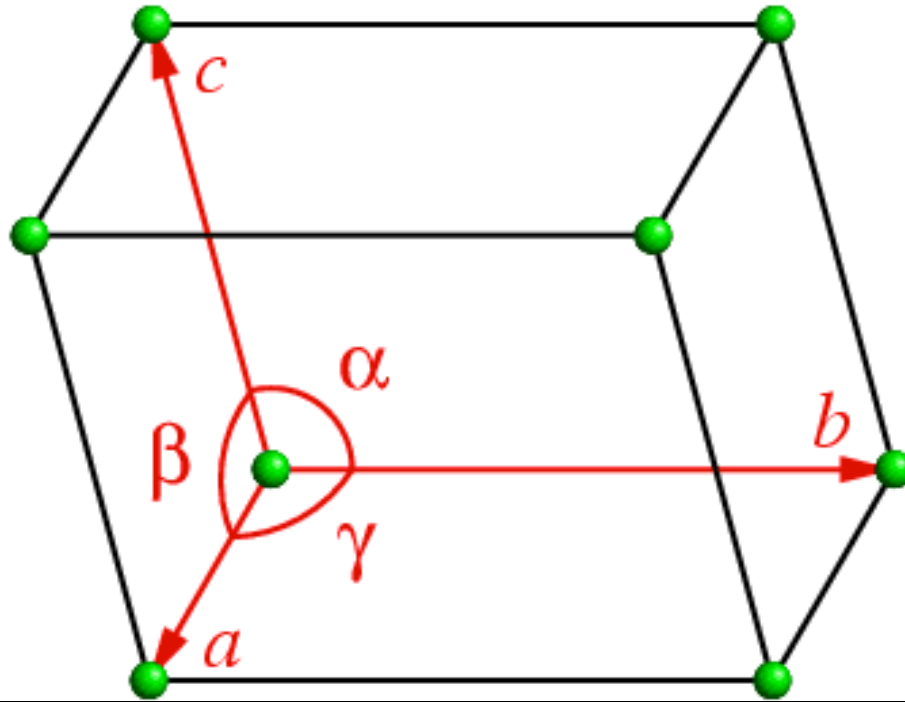
3-D arrangement

of atoms or molecules

on a lattice

Crystal structure

Einstein summation convention

6

Summation implied over every subscript that occurs twice on the same side

$$t = u_i a_i = u_1 a_1 + u_2 a_2 + u_3 a_3$$

Einstein summation convention

6

Summation implied over every subscript that occurs twice on the same side

$$t = u_i a_i = u_1 a_1 + u_2 a_2 + u_3 a_3$$

$$??? = \epsilon_{ijk} p_i q_j r_k$$

Einstein summation convention

6

Summation implied over every subscript that occurs twice on the same side

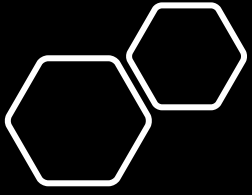$$t = u_i a_i = u_1 a_1 + u_2 a_2 + u_3 a_3$$

$$??? = \epsilon_{ijk} p_i q_j r_k$$

$$??? = b_j u_i a_i$$

$$\tau = \{t | t = u_i \vec{a_i}, u_i \in \mathbb{Z}\}$$

The space lattice

- Collection (or set) of all corner points
- Each corner point is called a lattice point
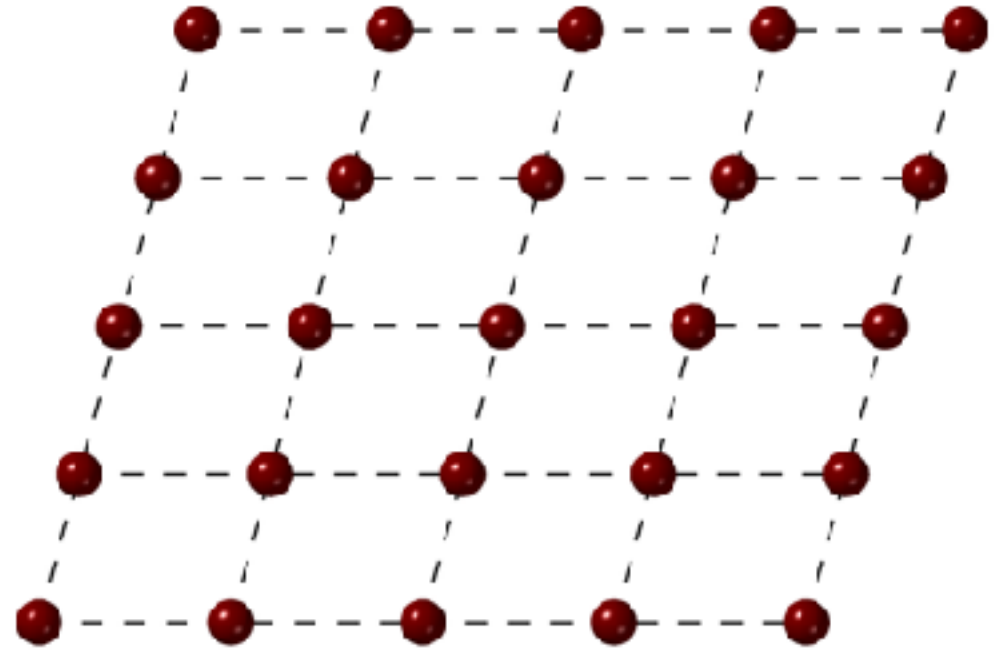- Lattice points are related by translation vectors

The space lattice

- All lattice points are identical
— lattice is **invariant** under **translation**

- Set of 6 numbers characterizes it
— **lattice parameters**

- Volume defined by the 3 basis vectors
— **unit cell**

$$\left(a_1, a_2, a_3, \alpha_3, \alpha_1, \alpha_2 \right)$$

$$\left(\overrightarrow{a_1} \times \overrightarrow{a_2} \right) \cdot \overrightarrow{a_3}$$

Problem

A lattice is described by the following lattice parameters:

$(2, 3, 4, 90, 98.30, 90)$

- Sketch a projection of the lattice as viewed along the a_2 axis

- Calculate the volume of the unit cell