# Extra Class 1 – Fundamentals of Mineralogy

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# What is a mineral?

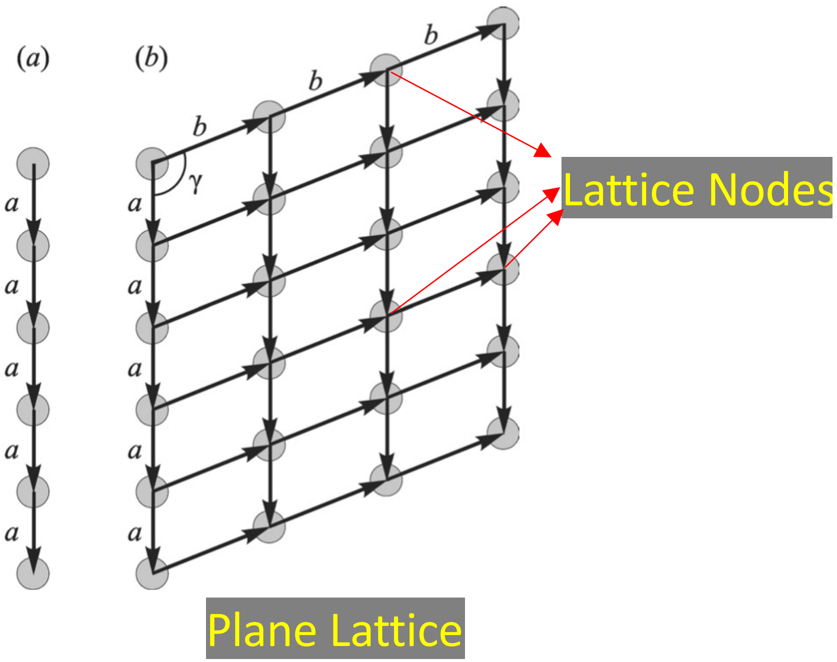
- Naturally occurring crystalline solid with a definite, but not necessarily fixed, chemical composition.
- Naturally occurring – formed without the benefit of human action
- Crystalline solids – atoms/ions are bonded regularly and repeatedly; amorphous substances, like glass, are usually not considered minerals
- Definite, but not fixed, chemical composition – $SiO_2$, $(Mg,Fe)_2SiO_4$; definite physical properties; mutually interdependent
- Inorganic and organic origin – calcite, apatite, pyrite
- Mineraloids– mineral like materials lacking long crystalline structures - amorphous substances; metamict; glasses – natural, pseudotachylites, fulgurite, clinker
- *Commission on New Minerals and New Mineral Names* of the **International Mineralogical Association**; *American Mineralogist* published by the **Mineralogical Society of America**

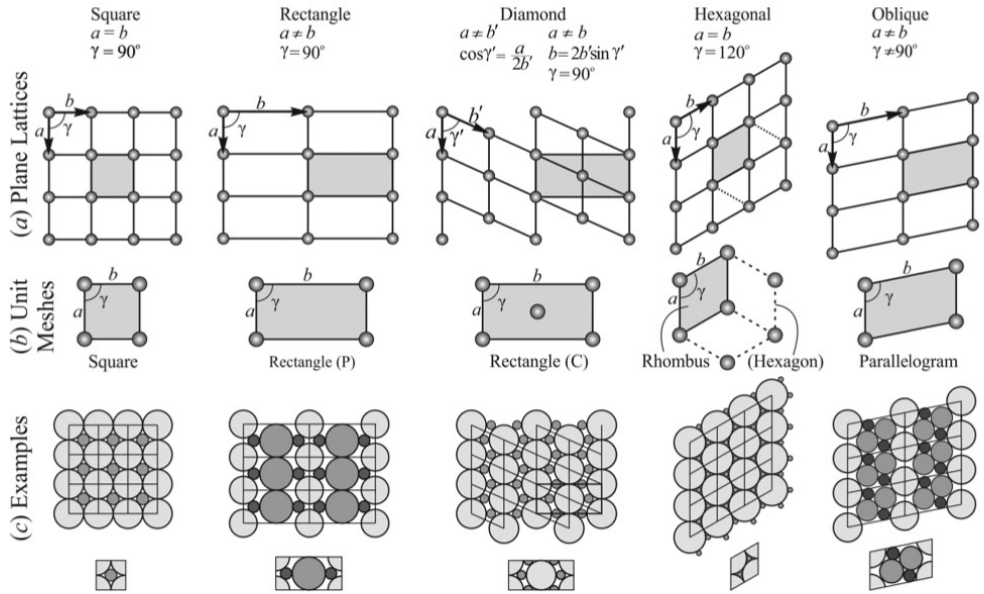
# Xlography

- Symmetry of crystals – regular and repeating structure, called as **motifs**
- Translational symmetry
  - Two-dimensions – plane lattices
  - Three-dimensions – space lattice, unit cells, crystal axes and crystal systems
- Conventional view – symmetry consists of two halves that are mirror images of each other; symmetry involves more than mirror images
  - Systematic repetition in three dimensions - manifested in the symmetrical arrangements of crystal faces and the internal structure of the crystals that control cleavage and the diffraction of X-rays.

# Translational Symmetry – 2-dimensions

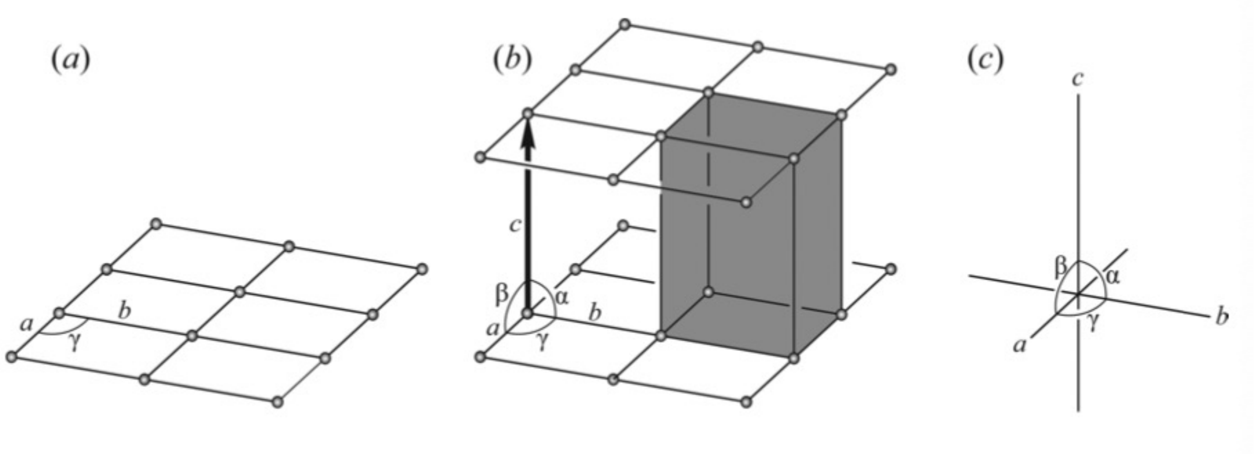
- Consider a spot of an atom that repeats by translating parallel to vector ‘a’ towards bottom of page again and again.



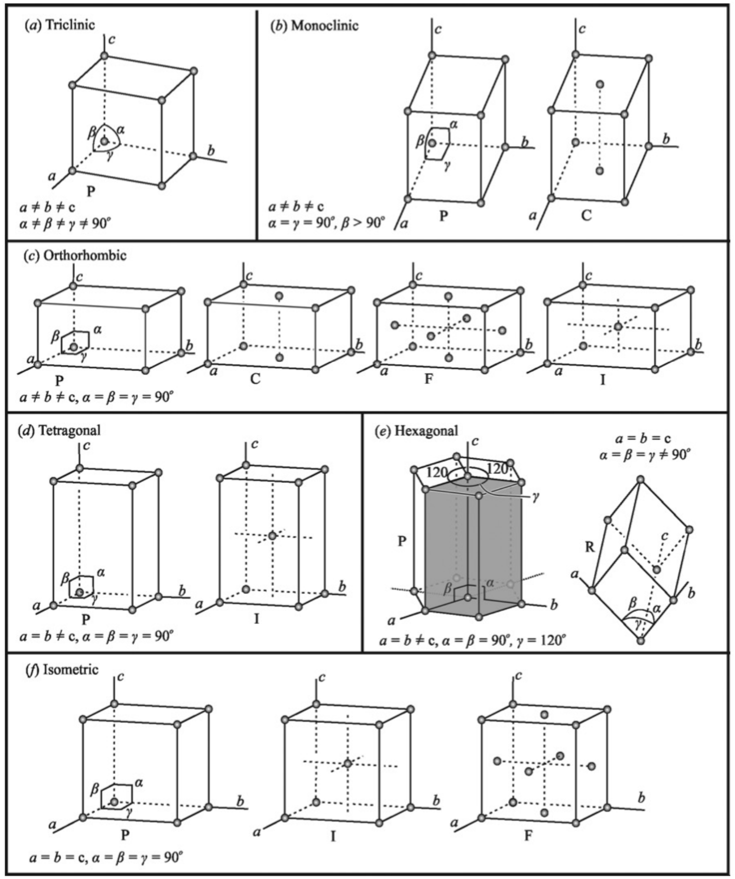



# Translational Symmetry – 3-dimensions

- If the 2-d plane lattices are systematically repeated one above the other, the result is the formation of a **space lattice**

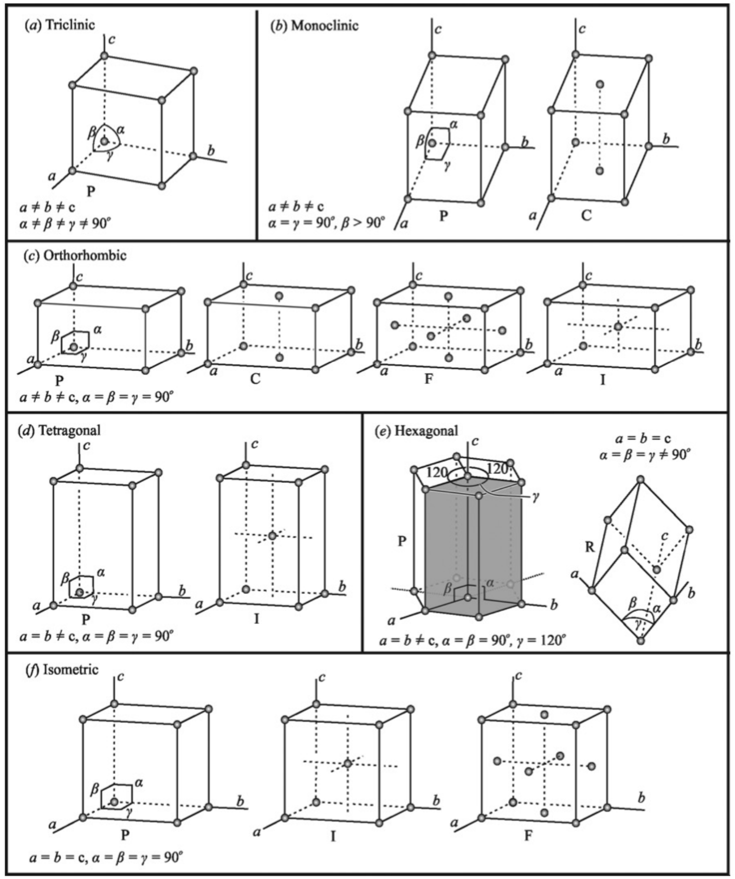


# Translational Symmetry – Bravais Lattices and Crystal Systems



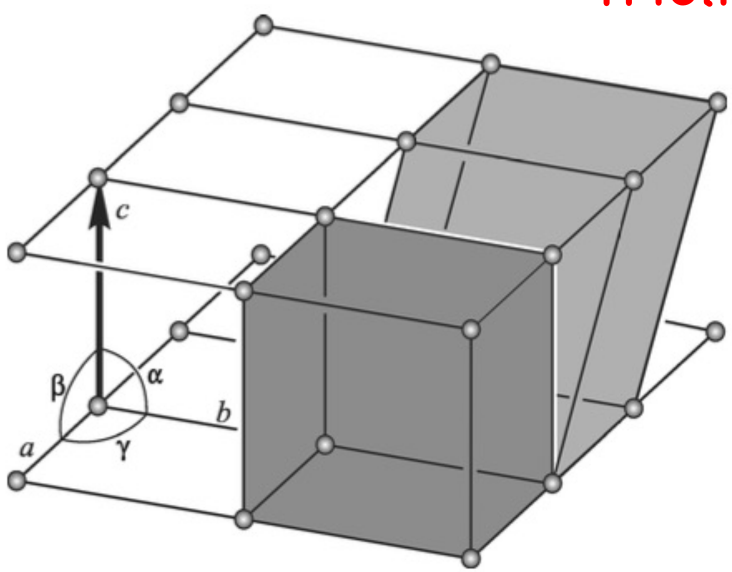

- 5 plane lattices can be repeated in three dimensions to produce 14 different space lattices, known as **Bravais Lattices** (*Auguste Bravais, 1811-1863*)
- 14 Bravais lattices are divided into 6 groups based on the shape of the unit cell
- 6 unit cell shapes are identified with **6-crystal systems**: ***triclinic, monoclinic, orthorhombic, hexagonal, tetragonal and isometric***
- **Primitive (P)** unit cells – lattice nodes only; **body-centered (I)** unit cells – additional node at the center; **face-centered (C)** unit cells – nodes on the corners and 2 opposite sides; **face centered (F)** unit cells – nodes at the corners and at the center of each face

# Translational Symmetry – Bravais Lattices and Crystal Systems



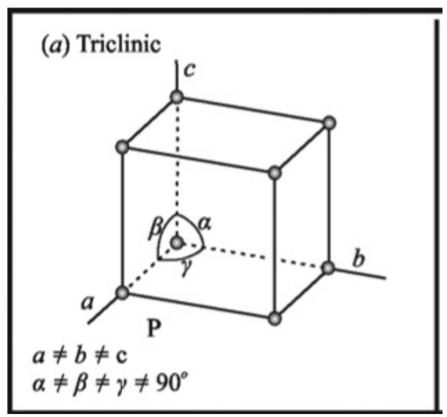

- Except Triclinic, each crystal system has more than one Bravais lattice
- Impossible to distinguish Bravais lattice within a crystal system in a hand sample; X-ray diffraction (XRD) techniques are required
- Pay particular attention to the differences among the crystal systems and the geometries of the 6-different unit cells

# Triclinic Bravais Lattices

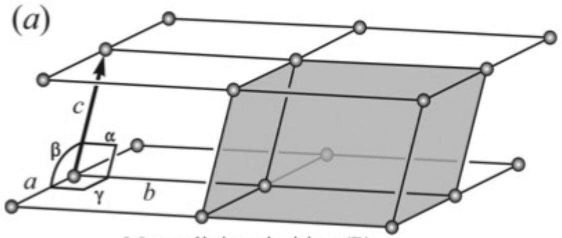



- Produced from **oblique plane lattice**
- No universally adopted convention to guide the assignment of crystal axes to the edges of the unit cell
- Generally, ***c-axis*** is placed parallel to elongated crystal face; ***b-axis*** is placed down and to the right; ***a-axis*** is placed down and to the front

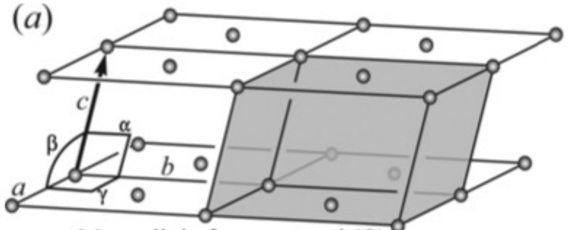
- Triclinic Bravais lattice is produced by translating an oblique plane lattice distance equal to **c** in a direction that is not at right angles to either **a** or **b**
- $a \neq b \neq c$, $\alpha \neq \beta \neq \gamma \neq 90°$



# Monoclinic Bravais Lattices

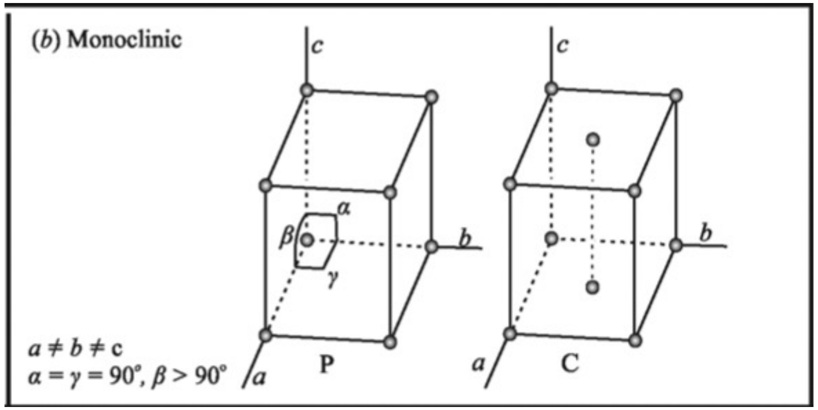


Monoclinic primitive (P)



Monoclinic face centered (C)

- Derived from either a **rectangle (P)** or **rectangle (C) plane lattice**
- Unit cell dimensions are different; **a ≠ b ≠ c**; any axis may be the longest
- **b** and c axes are at right angles, and the **a axis** is at right angles to **b** but not to **c** (α = γ = 90°, β > 90°)
- Note that the axes are arranged so that the angle between the positive ends of the **a** and **c axes** is greater than 90°.




- **Monoclinic primitive (P) lattice** is produced by translating primitive rectangle plane lattice distance equal to **c** so that angle β > 90° and angle α = 90°
- **Monoclinic centered (C) lattice** is produced by translating a centered rectangle plane lattice a distance equal to **c** so that angle β > 90° and angle α = 90°

Try yourself!

Orthorhombic, Hexagonal, Tetragonal and Isometric Bravais Lattices