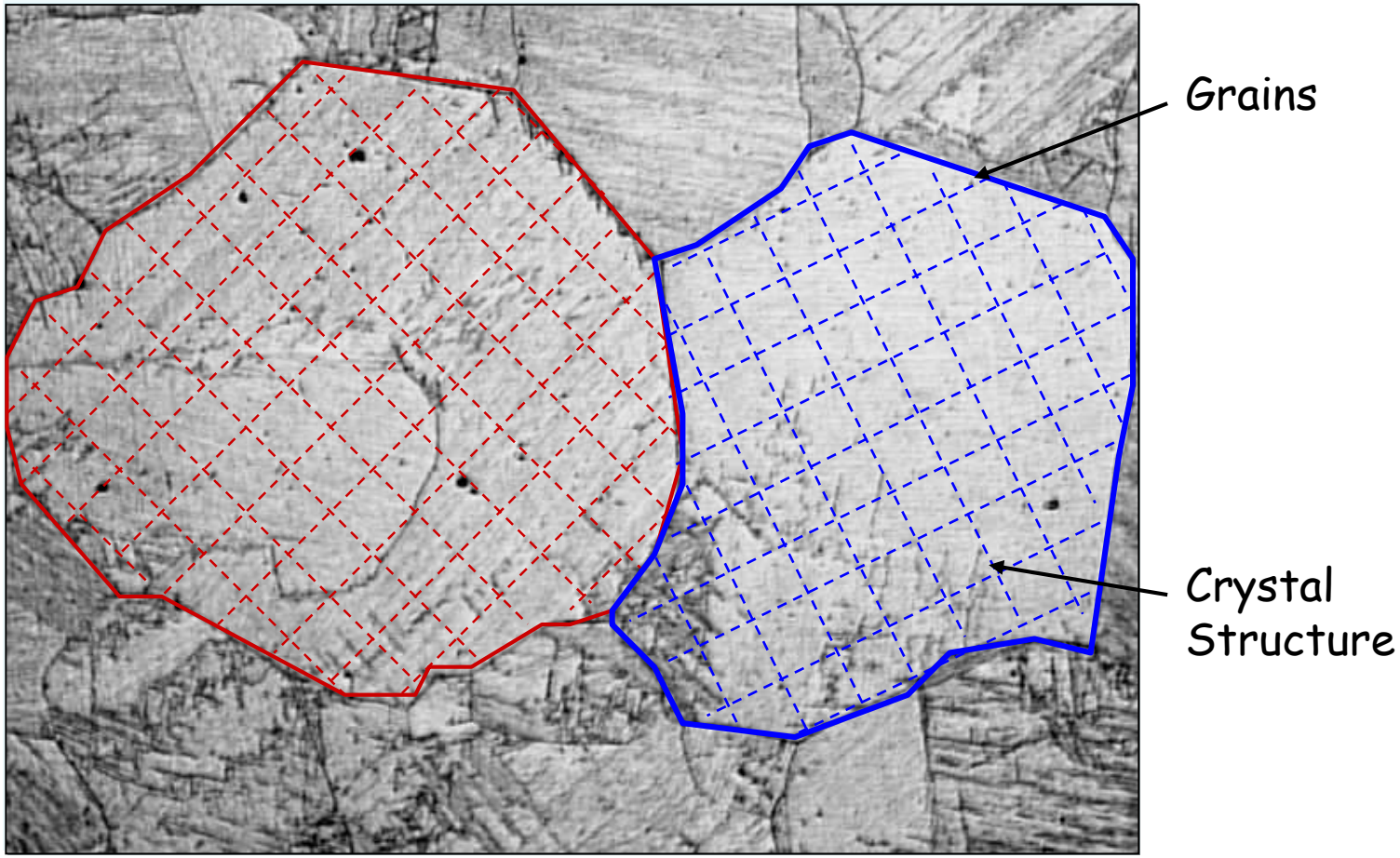
METALLURGICAL STRUCTURES

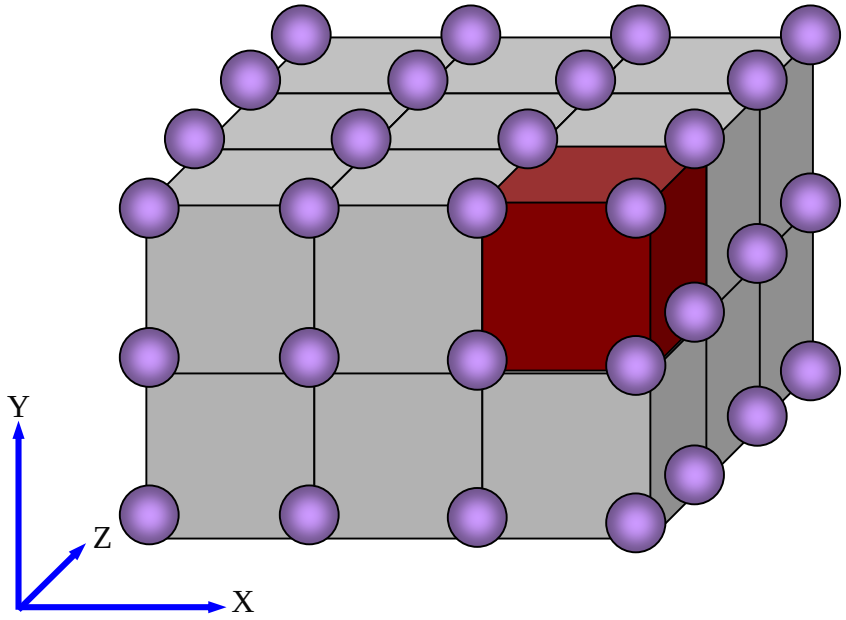
Ilyas (15006)
Mithun (15010)

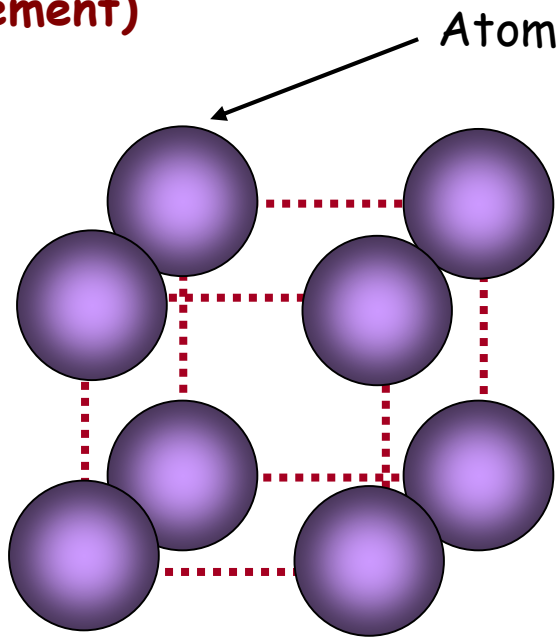
Basic Metallurgy



Crystal Structure

(Atomic Arrangement)

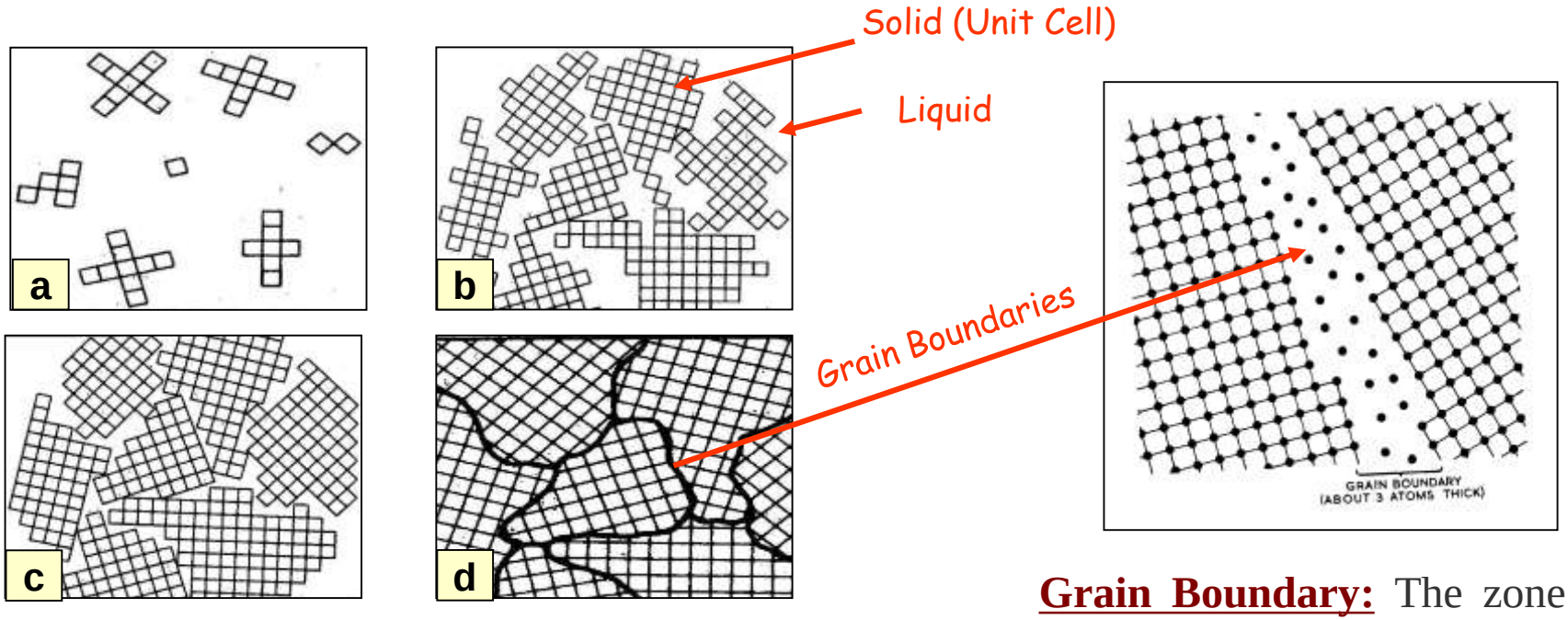




Space Lattice: A collection of points that divided space into smaller sized segments.

Unit Cell: A subdivision of the lattice that still retains the overall characteristics of the entire lattice.

Formation of Polycrystalline Material



a) Small crystalline nuclei

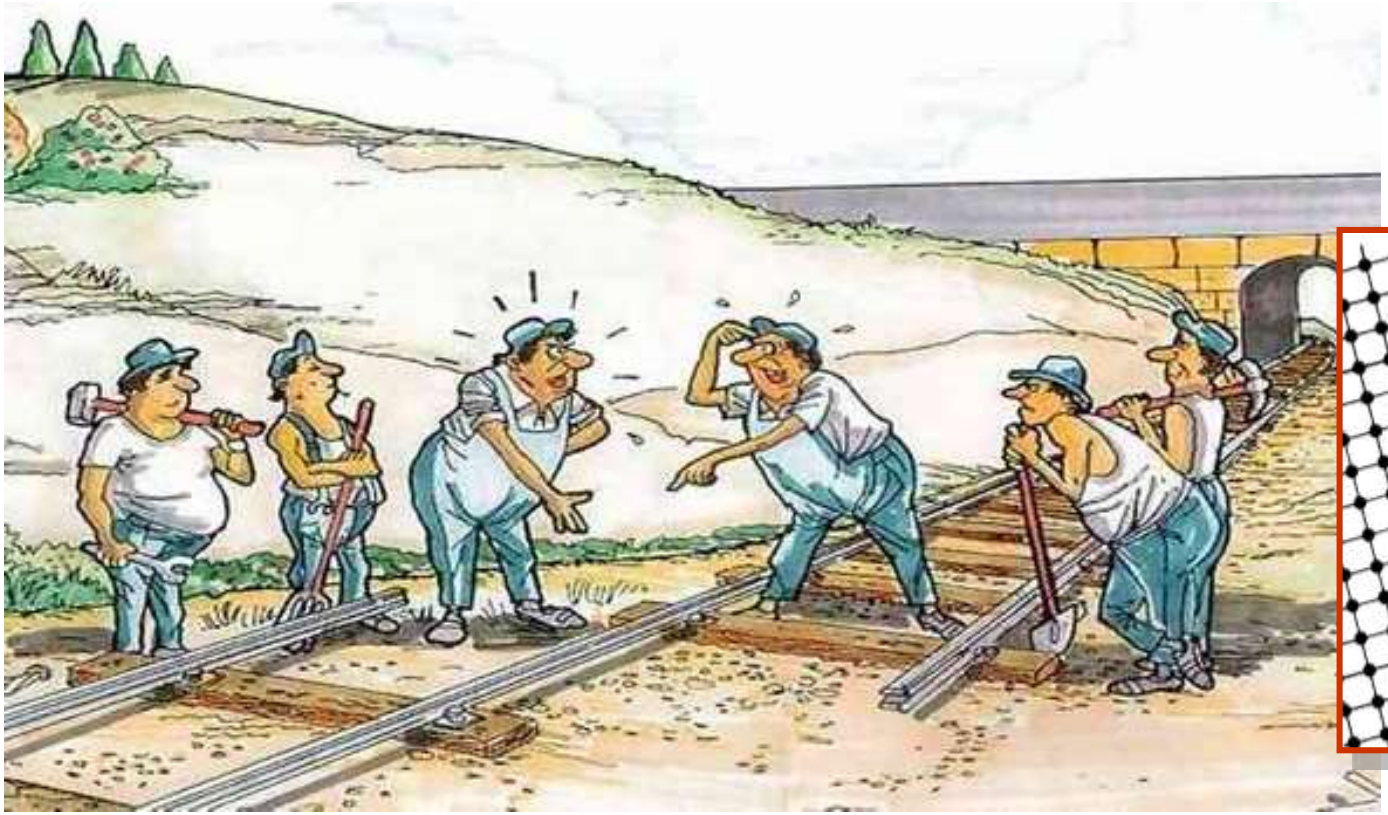
b) Growth of Crystals

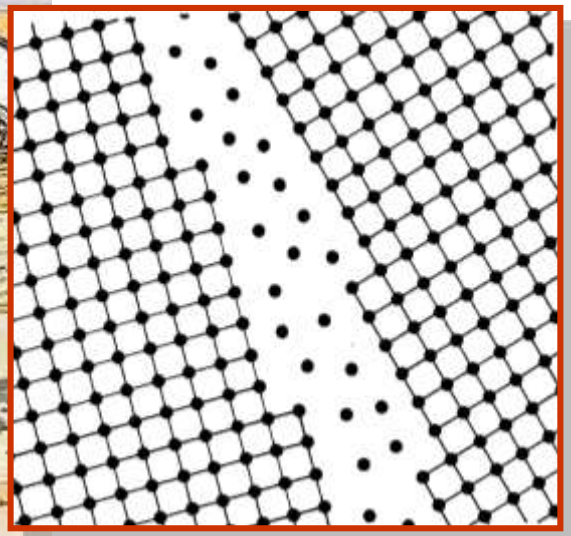
c) Irregular grain shapes formed upon completion of solidification

d) Final grain structure

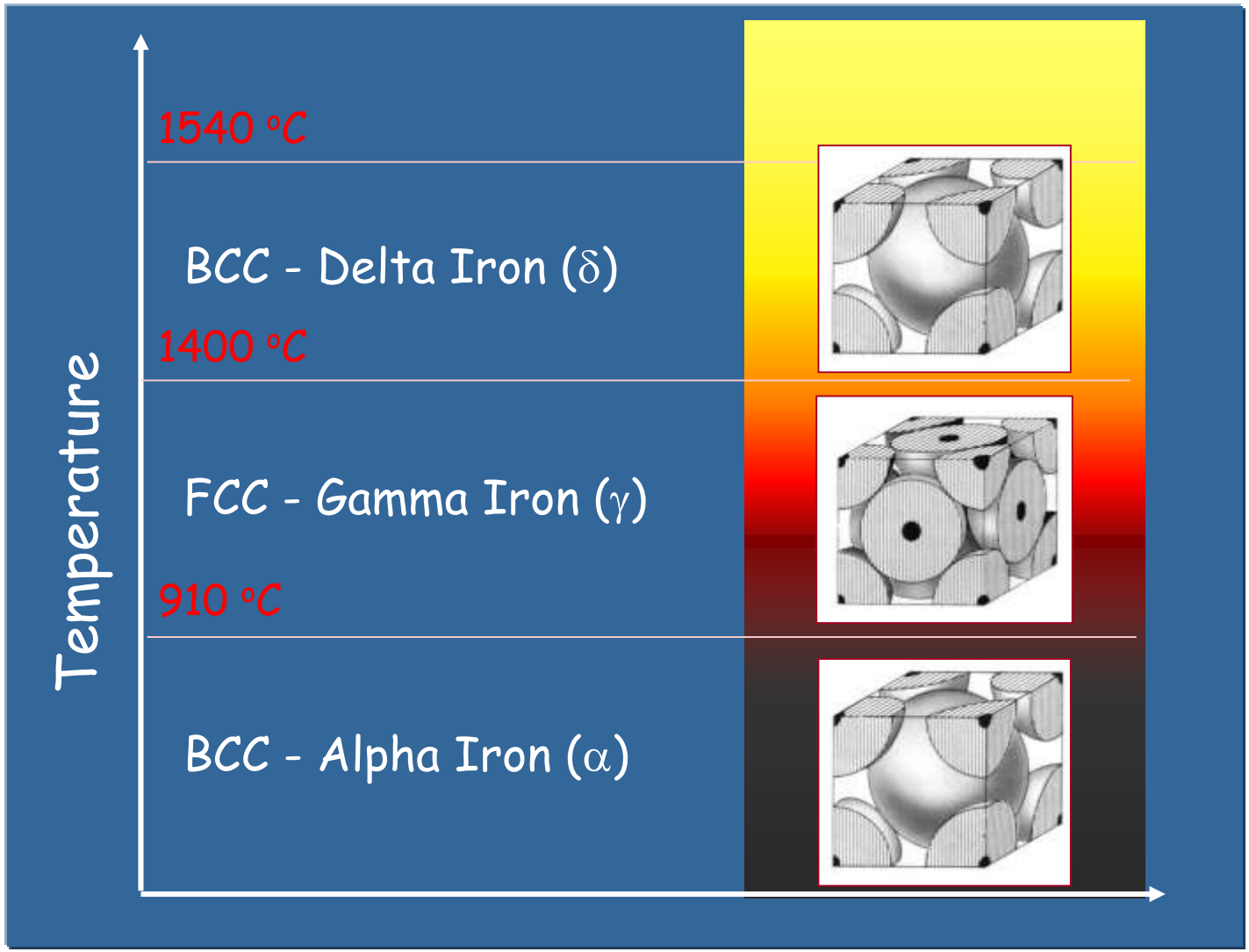
Grain Boundary: The zone of crystalline mismatch between adjacent grains. The lattice has different orientation on either side of the grain boundary

Grain Boundary

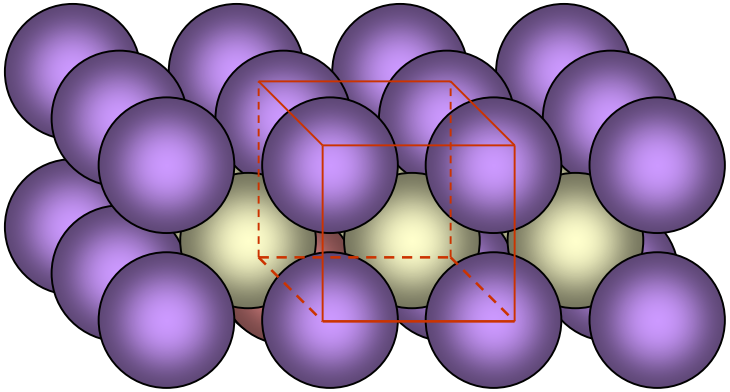


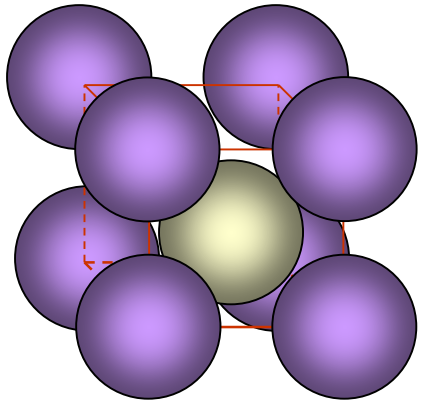


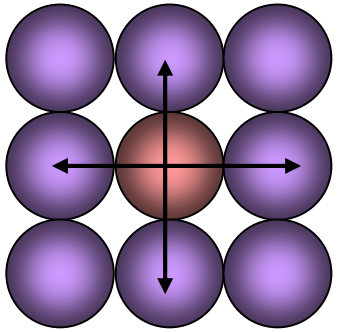
Atomic Packing in Iron (Allotropic)



Body Centered Cubic (BCC)







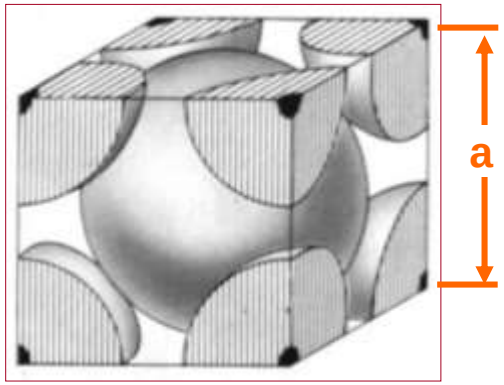
Squared Packed Layer

Alpha & Delta Iron (α , δ)

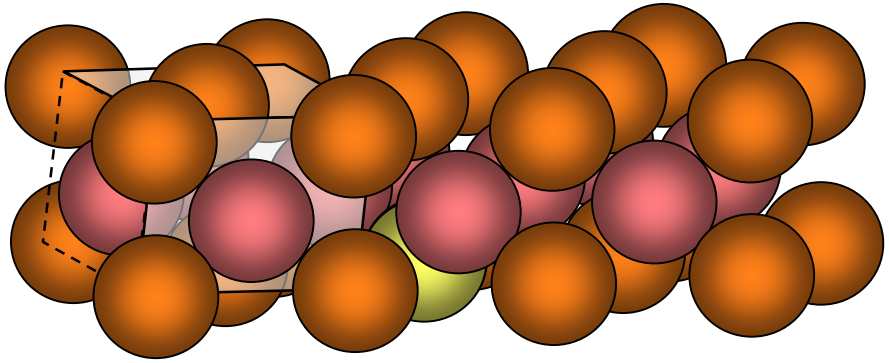
Total 2 Atoms/Unit Cell

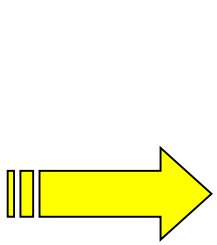
α Lattice Parameter (a) = 0.287 nm

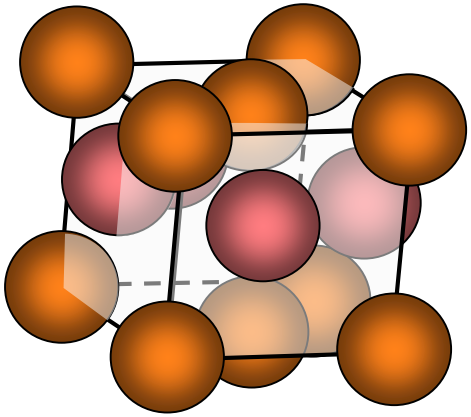
δ Lattice Parameter (a) = 0.293 nm

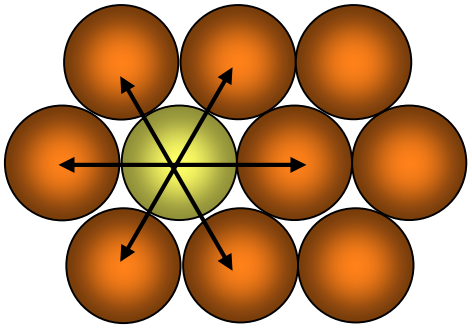


Face Centered Cubic (FCC)







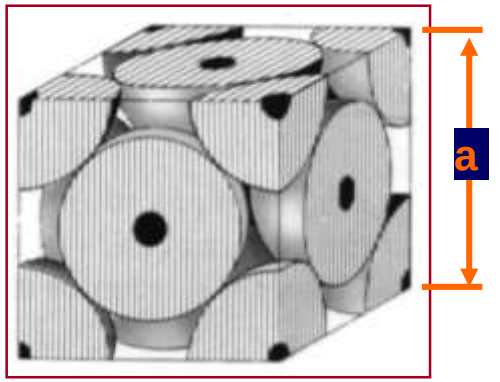


Close Packed Layer

Gamma Iron (γ)

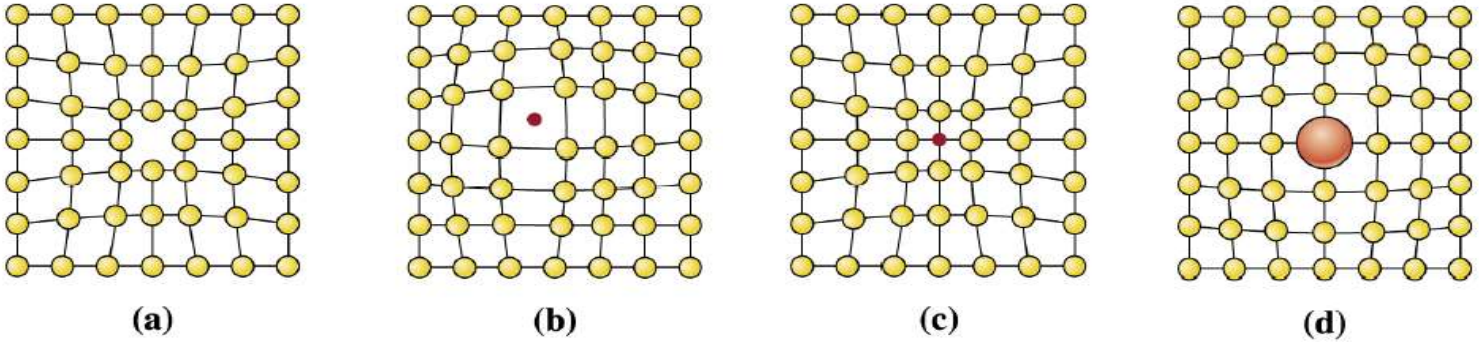
Total 4 Atoms/Unit Cell

γ Lattice Parameter (a) = 0.359 nm

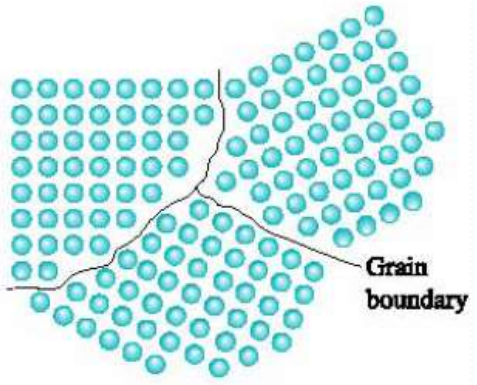


Microstructural Defects

1) **Point defects:** a) vacancies, b) interstitial atoms, c) small substitional atoms, d) large substitional atoms, … etc.



2) **Surface defects:** Imperfections, such as grain boundaries, that form a two-dimensional plane within the crystal.



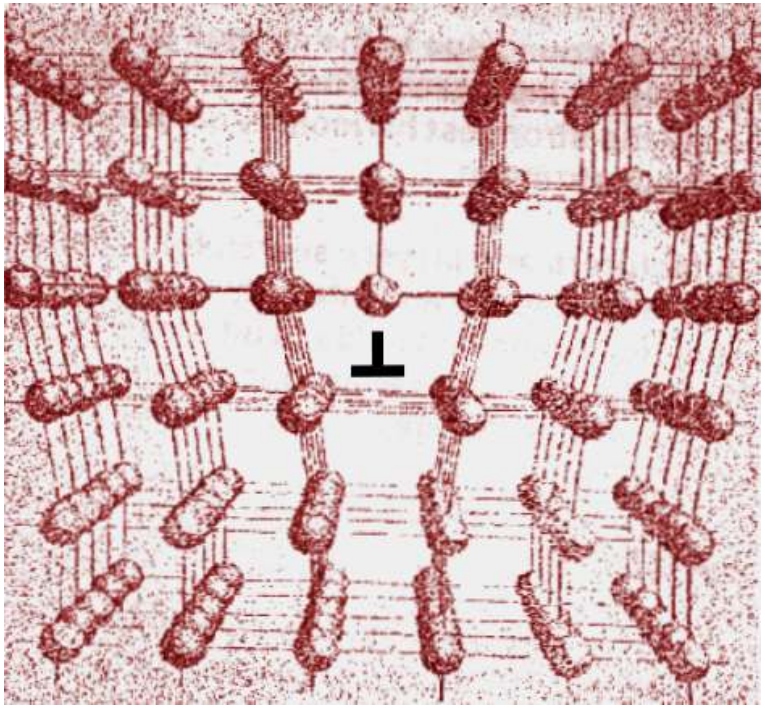
Microstructural Defects

3) Line defects: dislocations (edge, screw, mixed)

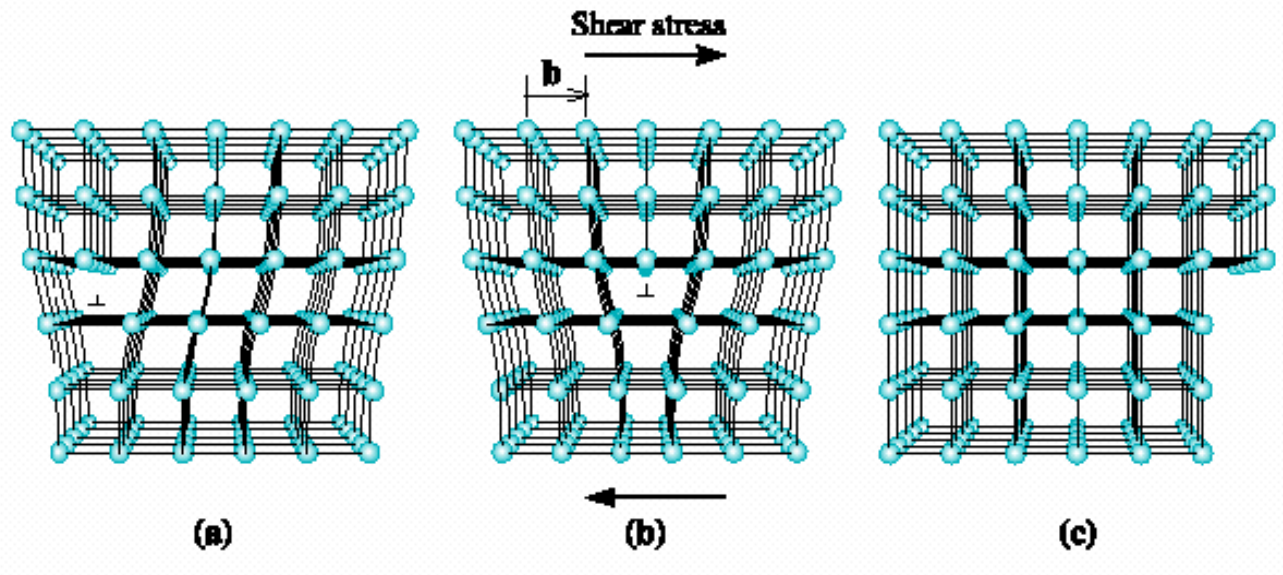
Dislocation: ***A line imperfection in the lattice or crystalline material***

They are typically introduced into the lattice during solidification of the material or when the material is deformed.

Movement of dislocations helps to explain how materials deform. Interface with movement of dislocations helps explain how materials are strengthened.



Motion of Dislocation



When a shear stress is applied to the dislocation in (a), the atoms displaced, causing the dislocation to move one step (Burger's vector) in the slip (b). Continued movement of the dislocation eventually creates a step (deformation) direction (C)

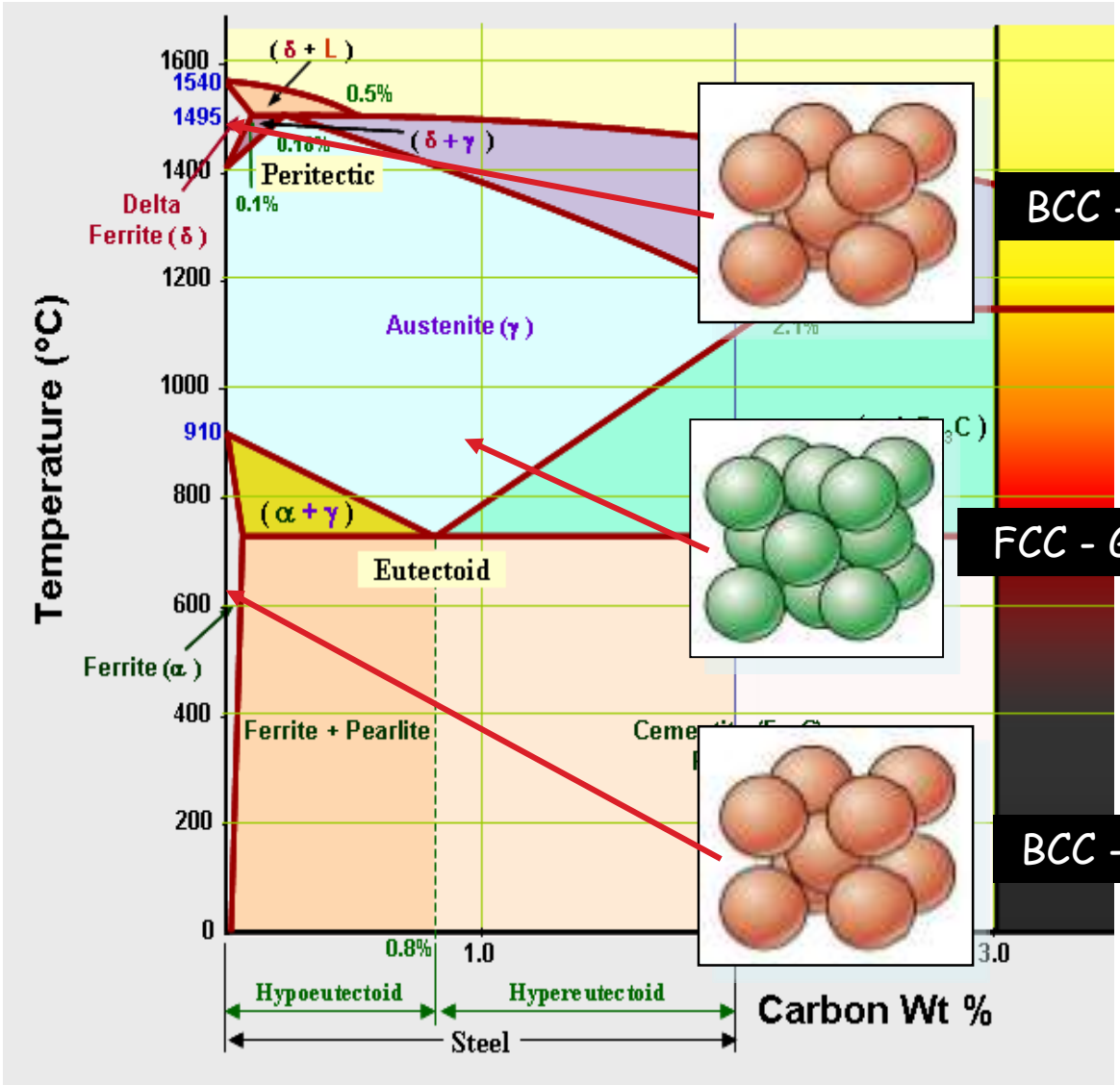
STEEL = IRON + Alloying Elements (C + Mn, Si, Ni, …)

What is the difference between "STEEL" and "CAST IRON" ?

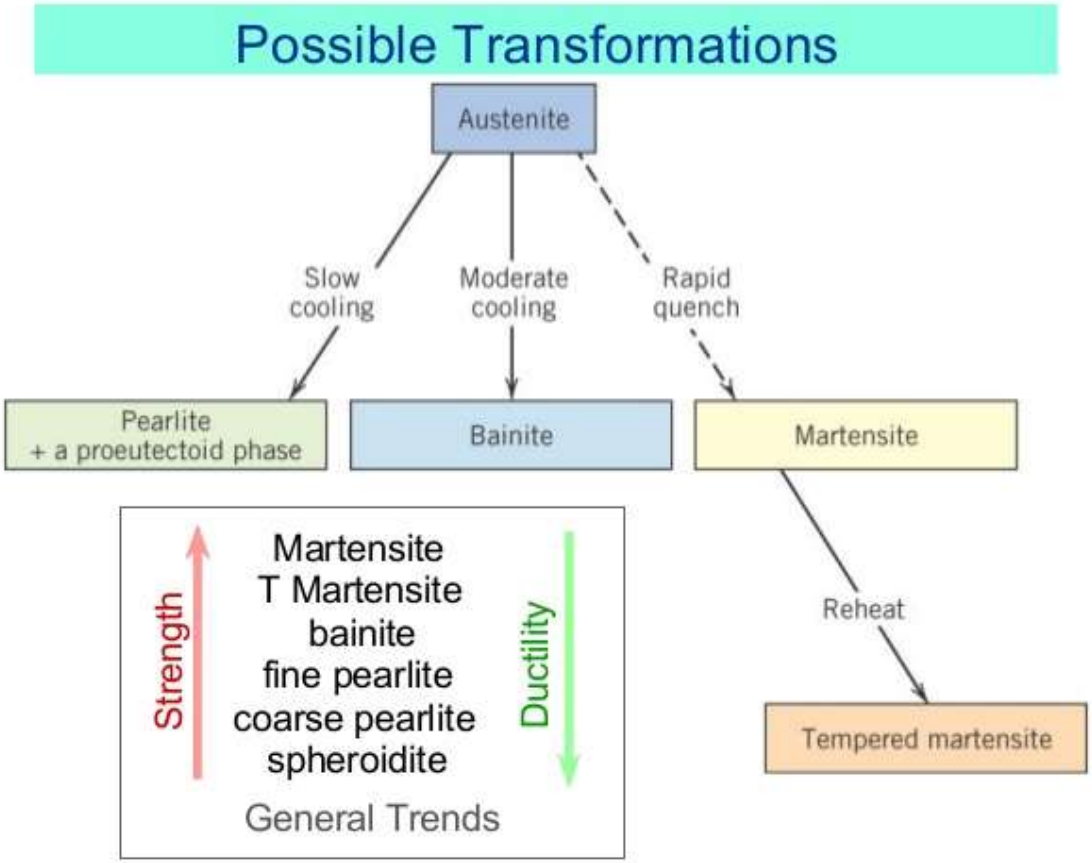
IRON + < 2 % Carbon = STEEL

IRON + > 2 % Carbon = CAST IRON

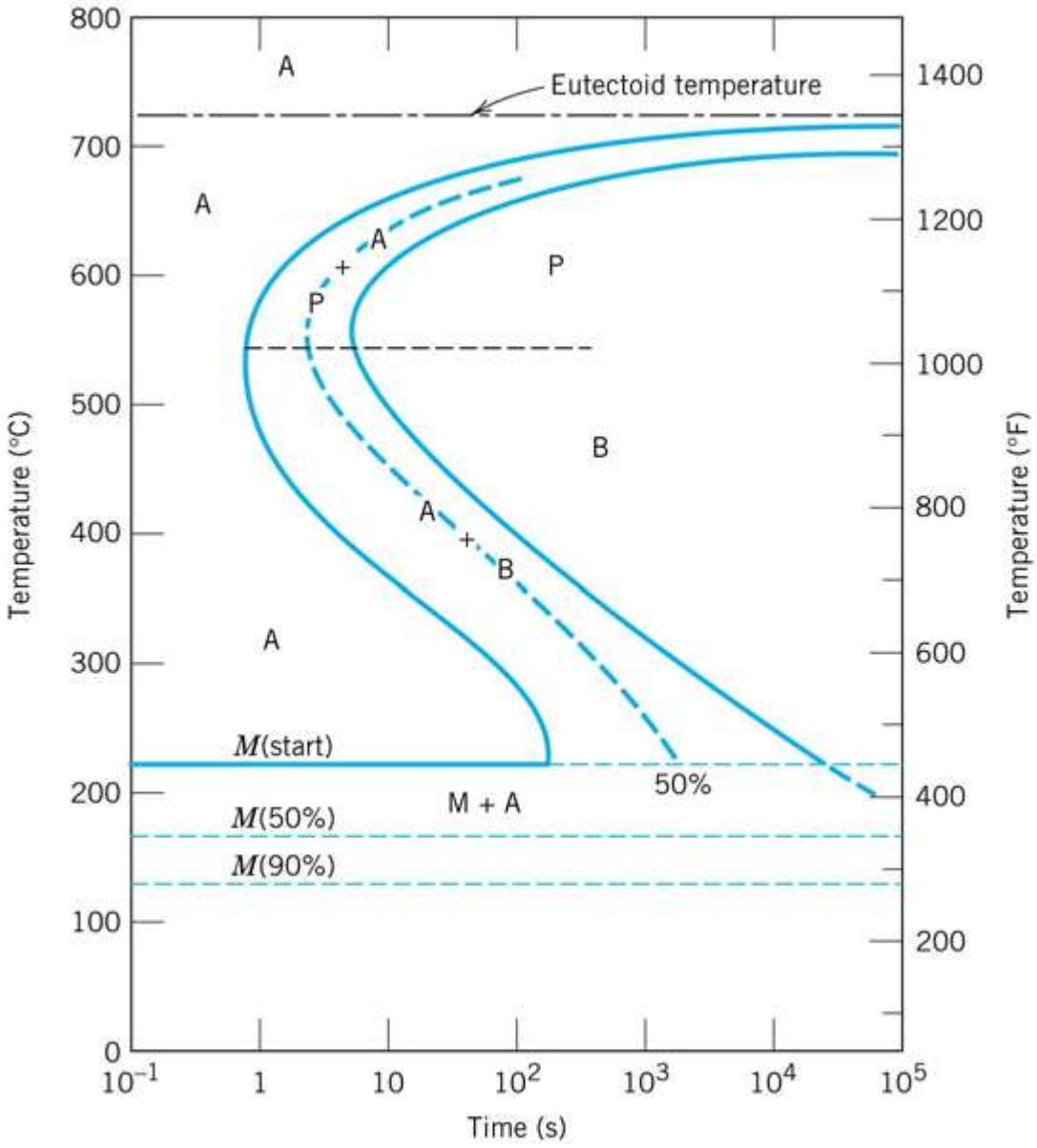
Atomic Packing in Iron (Allotropic)

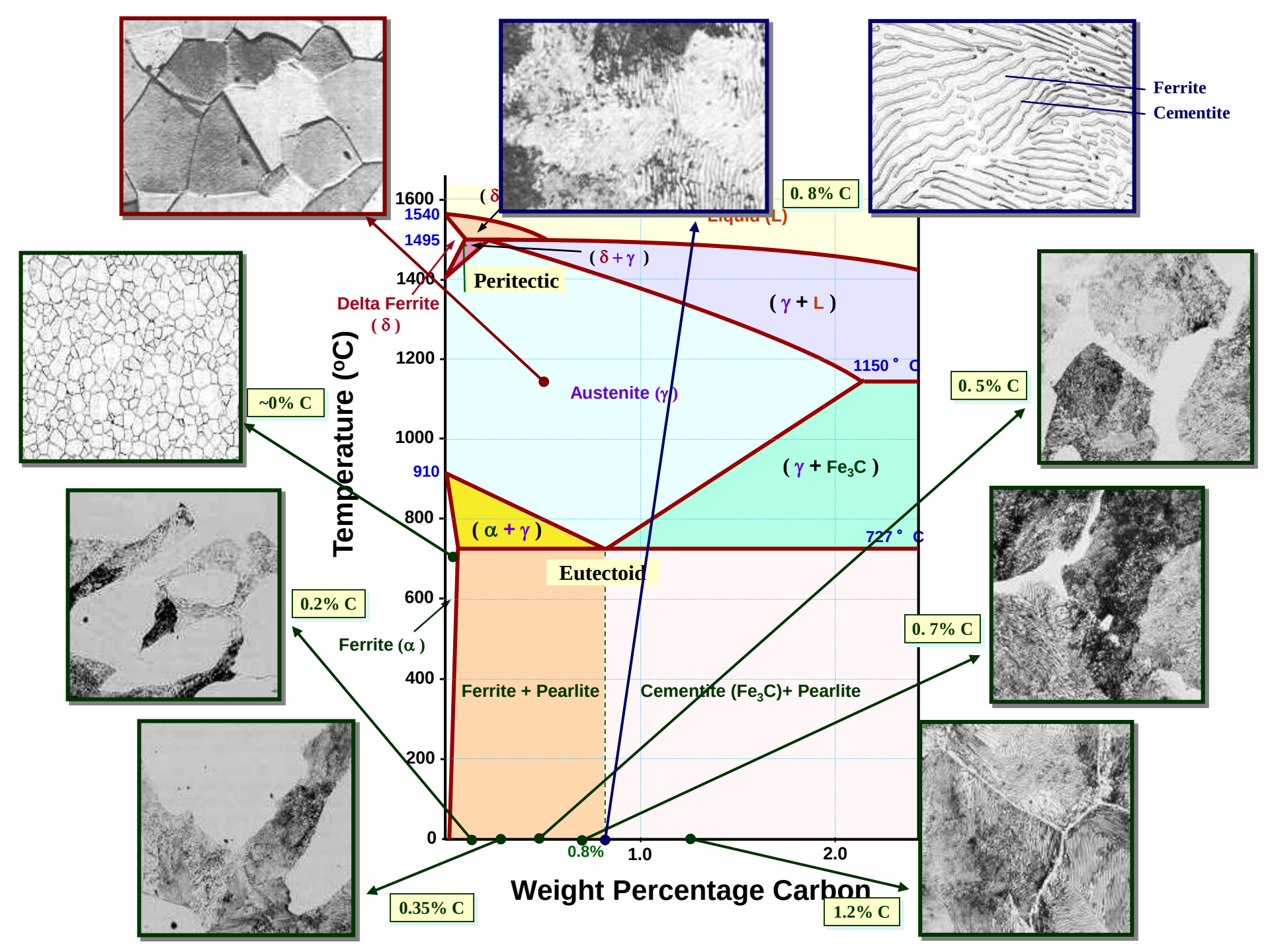


Tranformations

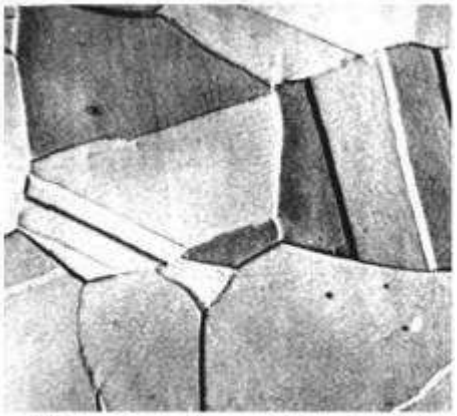


TTT Diagram

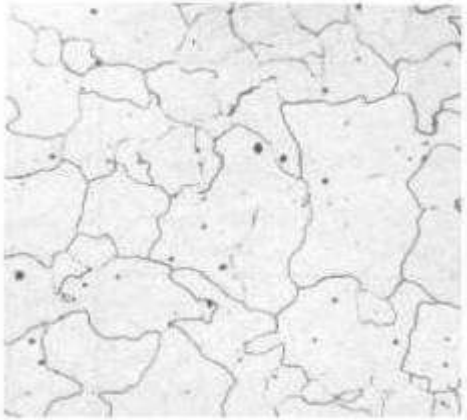

Eutectoid temperature
A
A
P
A + P
B
A + B
A
M(start)
50%
M + A
M(50%)
M(90%)
Temperature (°C)
Temperature (°F)
Time (s)
800
700
600
500
400
300
200
100
0
1400
1200
1000
800
600
400
200
10^{-1}
1
10
10^2
10^3
10^4
10^5


Ferrite
Cementite
0. 8% C
Liquid (L)
(δ
(δ + γ)
Peritectic
Delta Ferrite
(δ)
(γ + L)
1150 ° C
Austenite (γ)
~0% C
0. 5% C
(γ + Fe3C)
910
(α + γ)
727 ° C
Eutectoid
0.2% C
Ferrite (α)
0. 7% C
Ferrite + Pearlite
Cementite (Fe3C)+ Pearlite
0.35% C
1.2% C
Temperature (°C)
1600
1540
1495
1400
1200
1000
800
600
400
200
0
0.8%
1.0
2.0
Weight Percentage Carbon

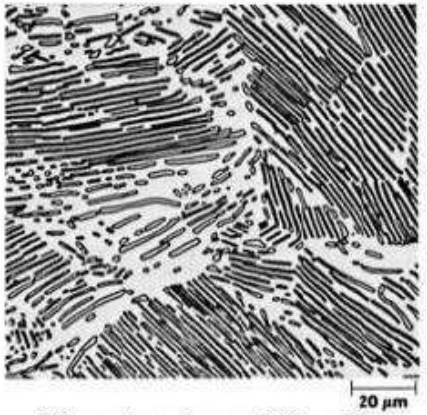
Microstructures in Fe-C Diagram



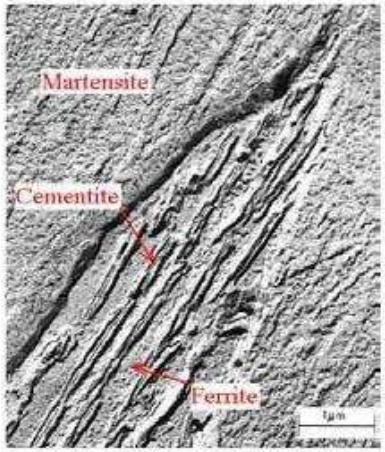
Microstructure of Austenite



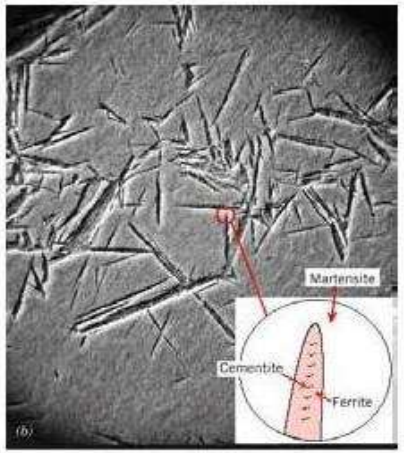
Microstructure of Ferrite



Microstructure of Pearlite

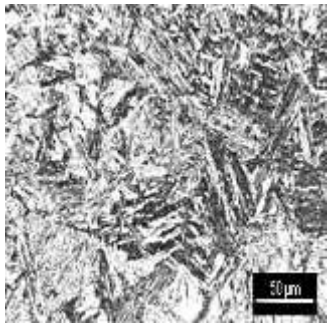


Upper Bainite

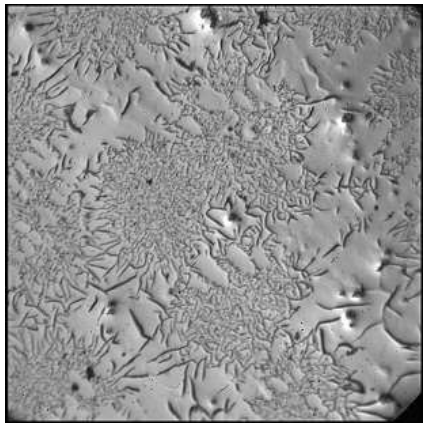


Lower Bainite

Microstructure of Upper Bainite and Lower Bainite

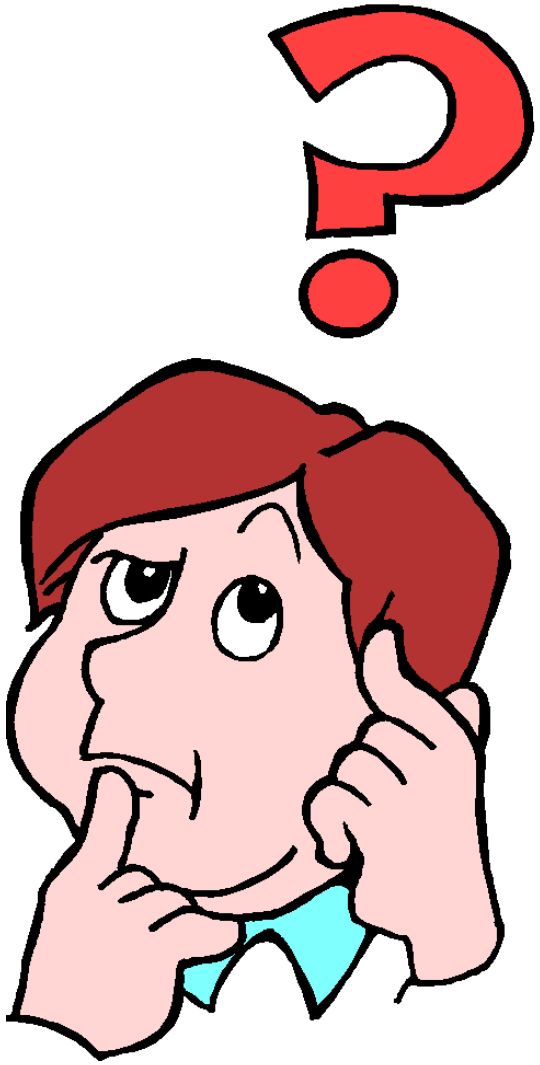


Martensite



Gray Cast Iron

Questions..?



Thank you..!