

# **MSE200**

## **Lecture 13 (CH. 8.9-8.11, 9.2)**

### **Phase Diagrams III/Engineering Alloys**

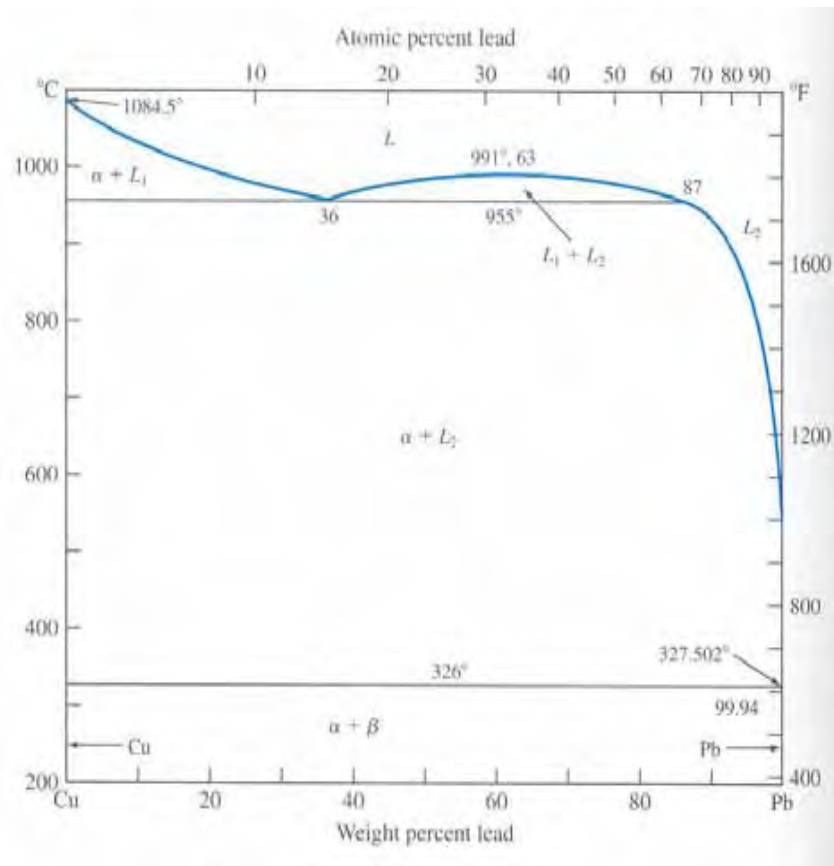
**Instructor: Yuntian Zhu**

**Objectives/outcomes: You will learn the following:**

- **6 three phase reactions**
- **Cu-Zn system**
- **Al-Zn system**
- **Fe-Fe<sub>3</sub>C system**
- **Structure of pearlite**
- **Major phases in the Fe-Fe<sub>3</sub>C system**
- **Major reactions of the Fe-Fe<sub>3</sub>C system**

# Binary Monotectic Systems

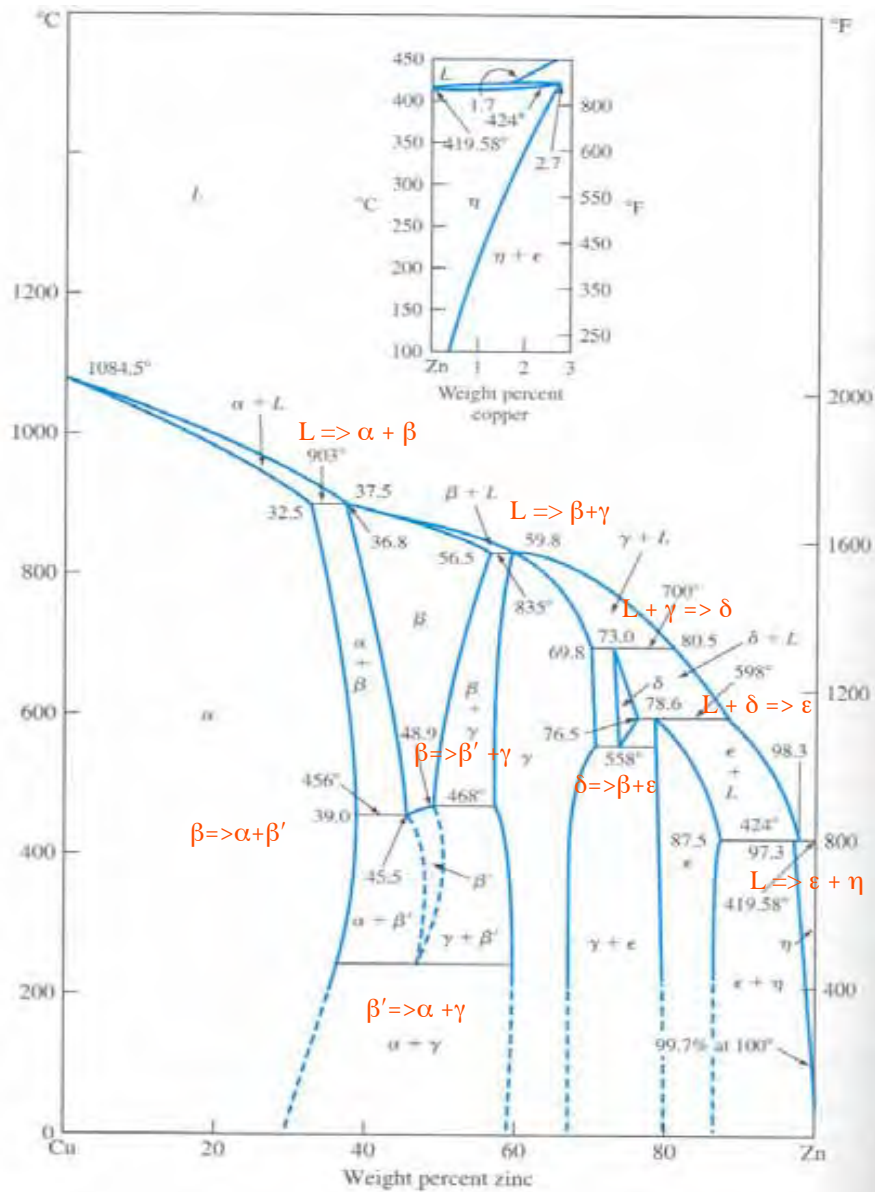
- **Monotectic Reaction:** Liquid phase transforms into solid phase and another liquid (Two liquids are immiscible).



**Table 8.1** Types of Three-Phase Invariant Reactions Occurring in Binary Phase Diagrams

Name of reaction	Equation	Phase-diagram characteristic
Eutectic	$L \xrightarrow{\text{cooling}} \alpha + \beta$	$\alpha \rangle \text{---} \langle \beta$
Eutectoid	$\alpha \xrightarrow{\text{cooling}} \beta + \gamma$	$\beta \rangle \text{---} \langle \gamma$
Peritectic	$\alpha + L \xrightarrow{\text{cooling}} \beta$	$\alpha \rangle \text{---} \langle \beta$
Peritectoid	$\alpha + \beta \xrightarrow{\text{cooling}} \gamma$	$\alpha \rangle \text{---} \langle \beta$
Monotectic	$L_1 \xrightarrow{\text{cooling}} \alpha + L_2$	$\alpha \rangle \text{---} \langle L_2$

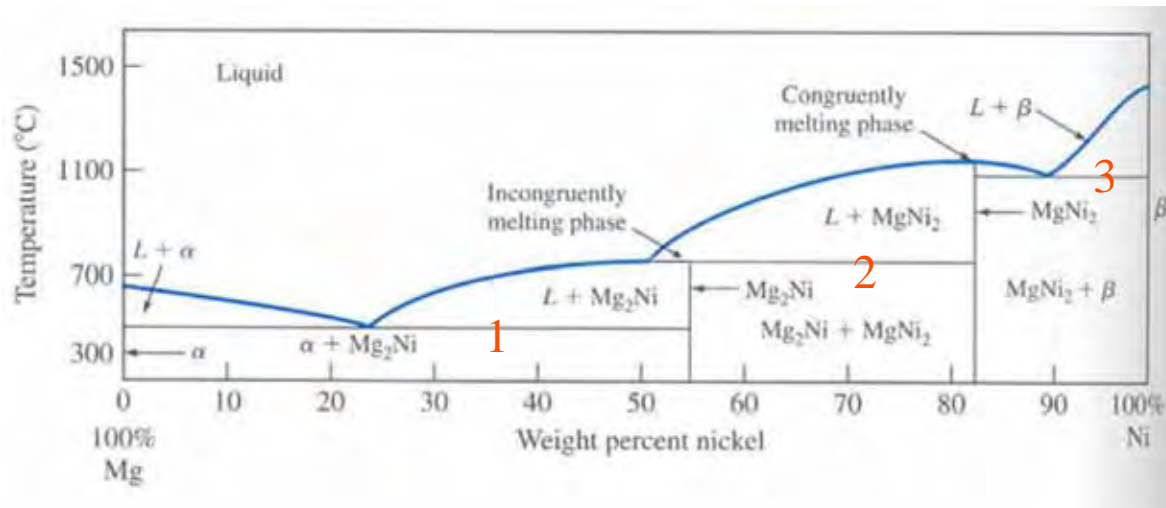
# Intermediate Phases and Compounds



- **Terminal phases:** Phases occur at the end of phase diagrams.
- **Intermediate phases:** Phases occur in a composition range inside phase diagram.
- **Phase # Rule:**

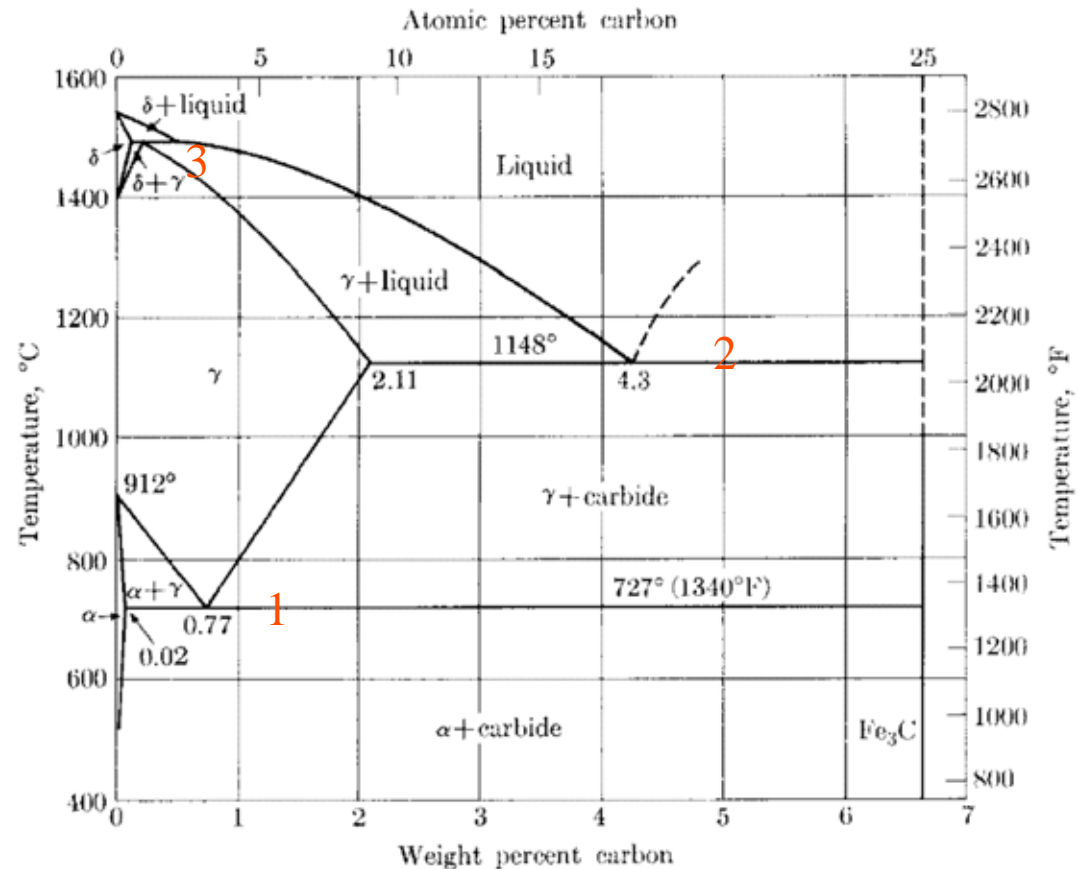
# Intermediate Compounds

- Stoichiometric intermediate compound
- Congruently melting compound
- Incongruently melting compound
- 3-phase reactions



# Iron Carbide Phase Diagram

- **$\alpha$  Ferrite:** Very low solubility of carbon. Max 0.02 % at 723°C and 0.005% at 0°C.
- **Austenite:** Interstitial solid solution of carbon in  $\gamma$  iron. Solubility of C is 2.08% at 1148°C and 0.8% at 0°C.
- **Cementite:** Intermetallic compound. 6.67% C and 93.3% Fe.

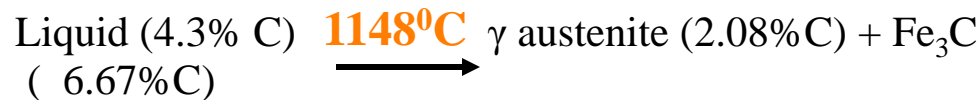


# 3-phase Invariant reactions

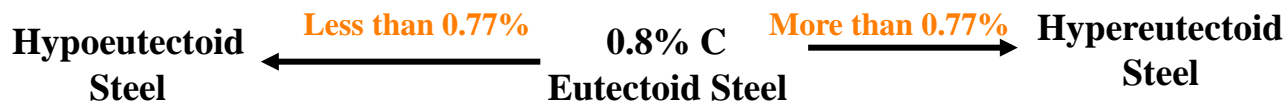
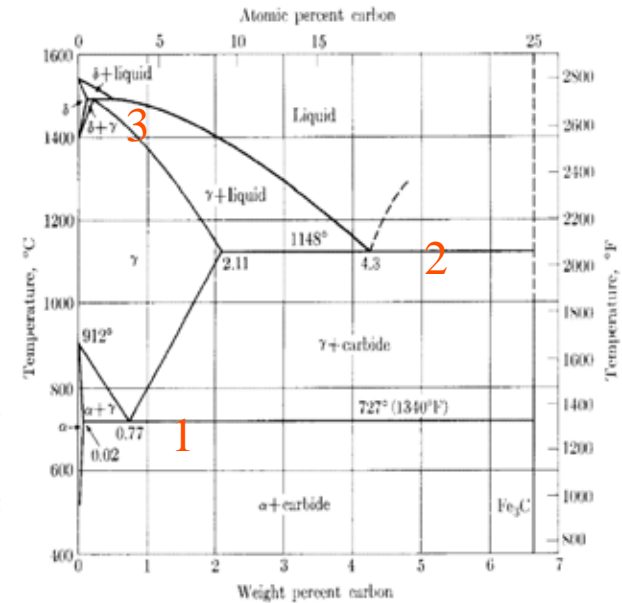
- Peritectic reaction:



- Eutectic reaction:

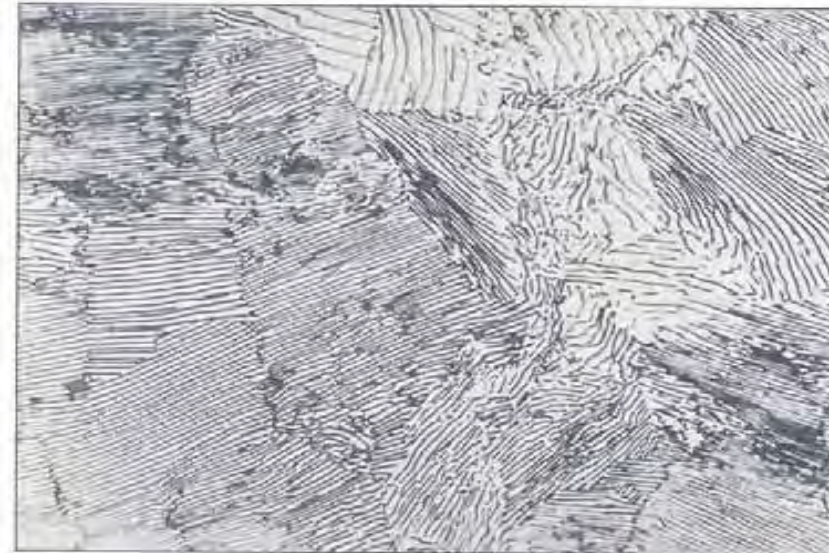
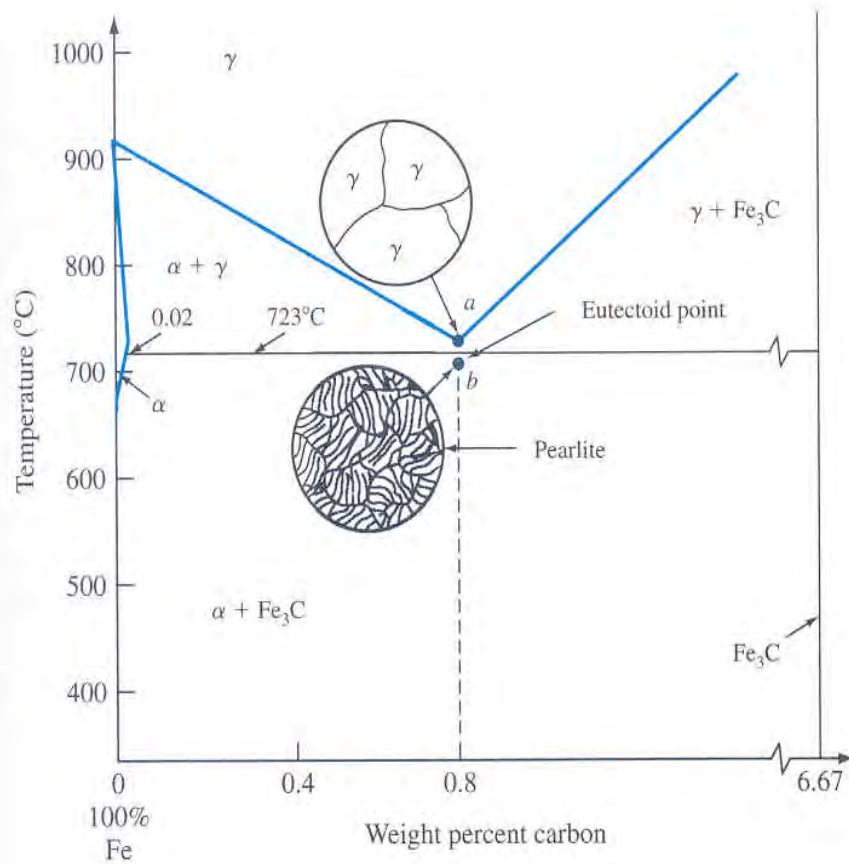


- Eutectoid reaction:



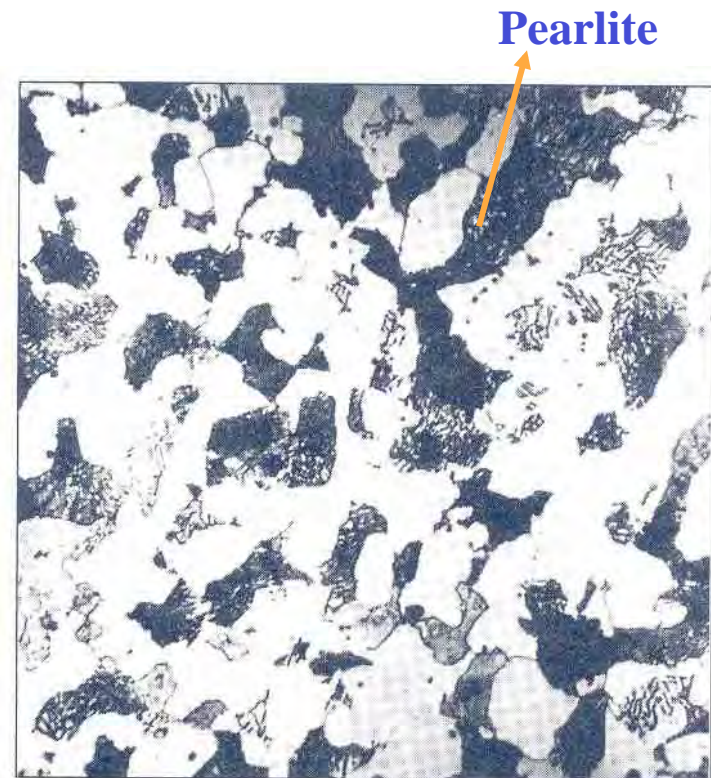
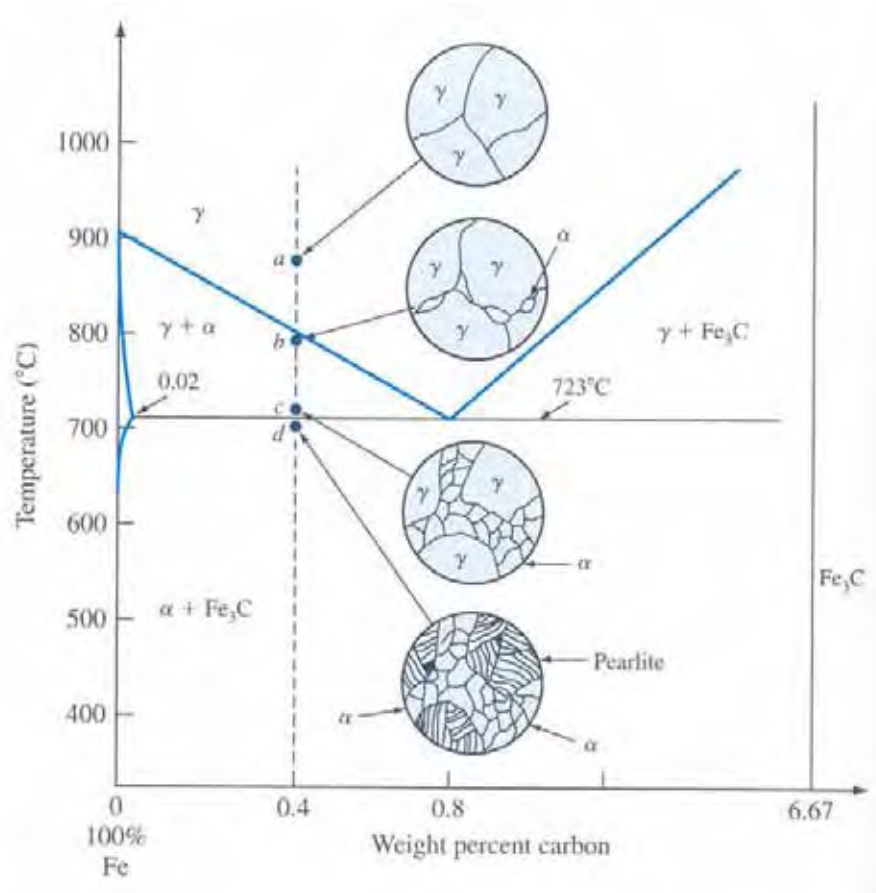
# Slow Cooling of Plain Carbon Steel

- Eutectoid plain carbon steel, Pearlite structure:



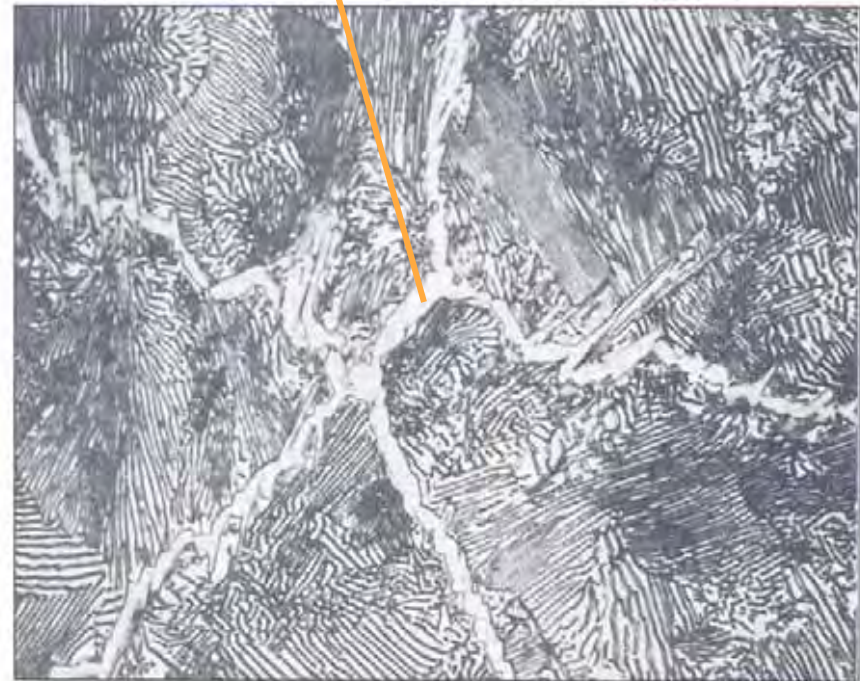
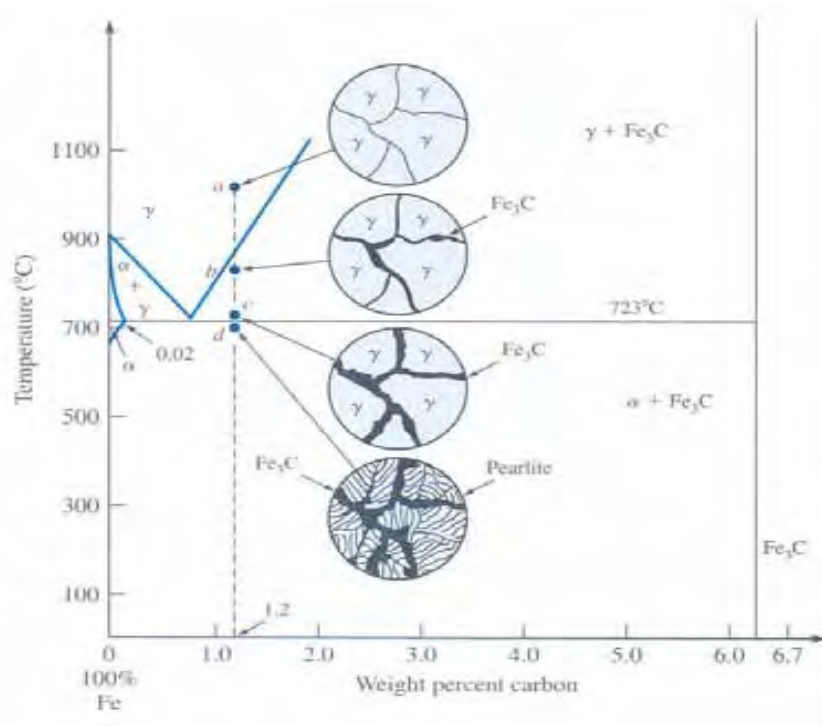
## Slow Cooling of Plain Carbon Steel (Cont..)

- **Hypoeutectoid plain carbon steel:** If a sample of 0.4% C is heated up to 900°C, it gets austenitized.
- Further cooling gives rise to  $\alpha$  and pearlite.



## Slow Cooling of Plain Carbon Steel (Cont..)

- **Hypereutectoid plain carbon steel:** If a 1.2% C sample is heated up to 950°C and held for sufficient time, it entirely gets austenitized.
- Further cooling results results in **eutectoid cementite** and pearlite.



# Homework

Example problems: 8.8, 9.1, 9.2, 9.3

Chapter 8: 24, 26, 29, 31, 38,

Chapter 9: 12, 13, 14, 15, 16, 21, 22,25,

Reading assignment: 9.3