

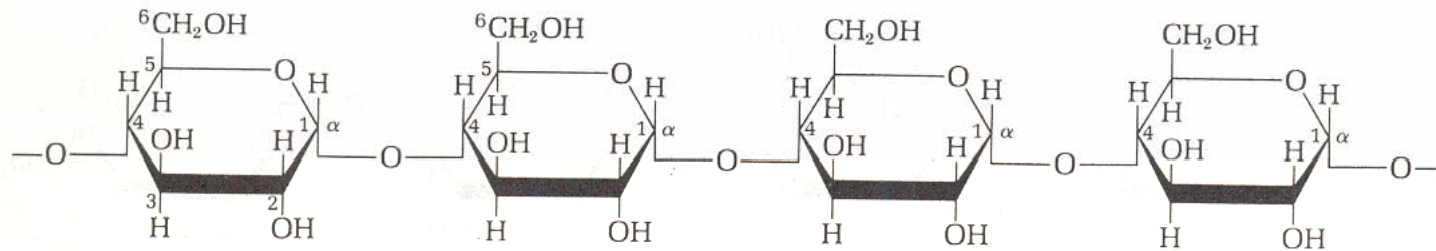
2.3 Cell Nutrients

- **Macronutrient**
 - Necessary in concentrations $> 10^{-4}$ M
 - C, N, O, H, S, P, Mg^{2+} , K^{2+}
- **Micronutrient**
 - Necessary in concentrations $< 10^{-4}$ M
 - Trace elements such as Mo^{2+} , Zn^{2+} , Cu^{2+} , Mn^{2+} , Ca^{2+} , Na^{+}

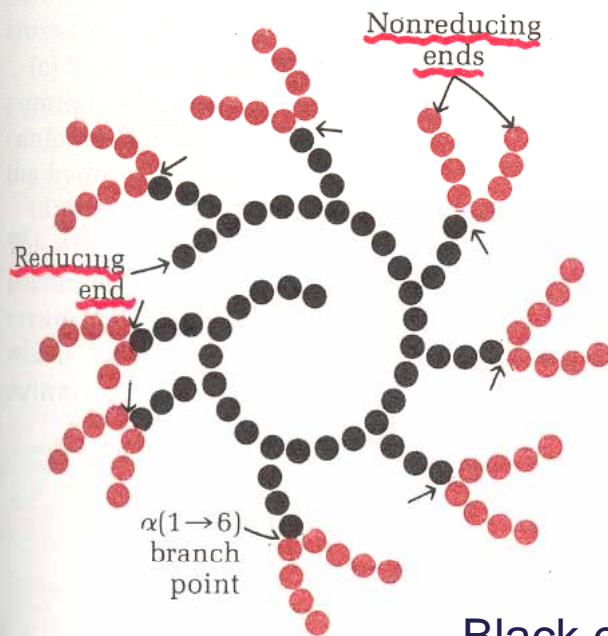
2.3.2. Macronutrients

- Carbon
- Microorganisms are classified in two categories on the basis of their carbon source.
 - Heterotroph --- organic compounds as a carbon source
 - Autotroph --- CO_2 as a carbon source
 - Mixotroph --- grows under both autotrophic and heterotrophic conditions
- Chemoautotroph --- CO_2 as a carbon source, energy from inorganic compounds such as H_2 , CO , NH_3 , NO_2^- , Fe^{2+} , H_2S , S , $\text{S}_2\text{O}_3^{2-}$
- Photoautotroph --- CO_2 as a carbon source, energy from light

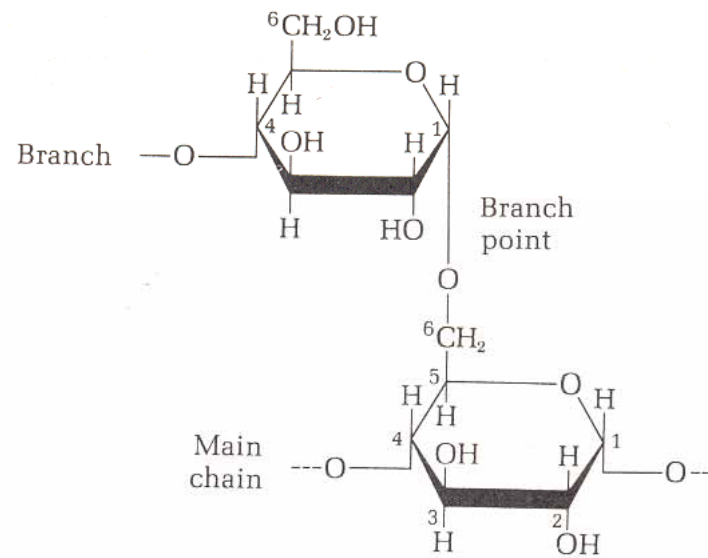
Amylose & Amylopectin



(a)



Black circle: dextrin



(c)

Carbon sources

- Common carbon sources in the laboratory fermentation
 - Glucose, sucrose, fructose
- Common carbon sources in industrial fermentation
 - Molasses (sucrose), starch (glucose, dextrin), corn syrup, waste sulfite liquor (glucose)
- In aerobic condition
 - 50% carbon → cell material, 50% carbon → energy
- In anaerobic condition
 - Small fraction of C → cell material, Large fraction of C → product

Nitrogen Sources

- Inorganic Nitrogen Sources
 - Ammonia
 - Ammonium salts (NH_4Cl , $(\text{NH}_4)_2\text{SO}_4$, NH_4NO_3)
- Organic Nitrogen Sources
 - Yeast extract, peptone --- amino acids
- Nitrogen Sources in Industrial Fermentation
 - Table 2.8

2.3.3. Micronutrients

- Most widely needed trace elements
 - Fe, Zn, Mn
- Trace elements needed under specific growth conditions
 - Cu, Co, Mo, Ca, Na, Cl, Ni, Se, Cu
- Rarely needed trace elements
 - B, Al, Si, Cr, V, Sn, Be, F, Ti, Ga, Ge, Br, Zr, W, Li