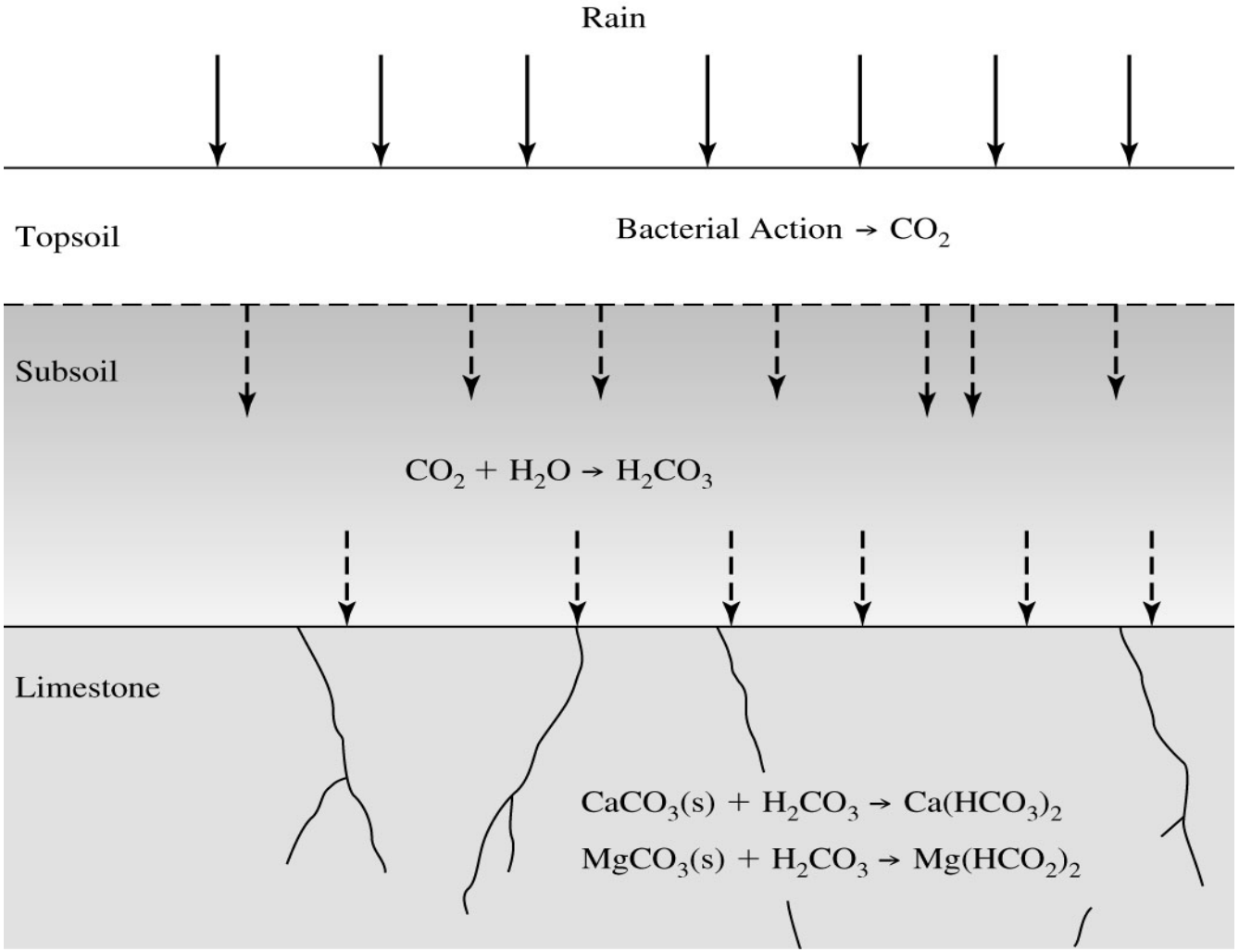
Announcements

- No 11am to noon office hours today—every other week committee meeting
- Memo for Lab 6 due Tuesday (Oct 22) before lab **via email**.
- Pset 5 due Wednesday (Oct. 23) by 5pm
  - First part—midterm self reflection
  - I will respond to each of you
- Blog Post 3 due Friday Oct 25 by 11:59pm
- Quizz on Friday—on water quality and lecture content from M and W this week
  - Students only receive credit for a quiz if they take it during their assigned class period
- Engineering Alumni Dinner this Saturday!

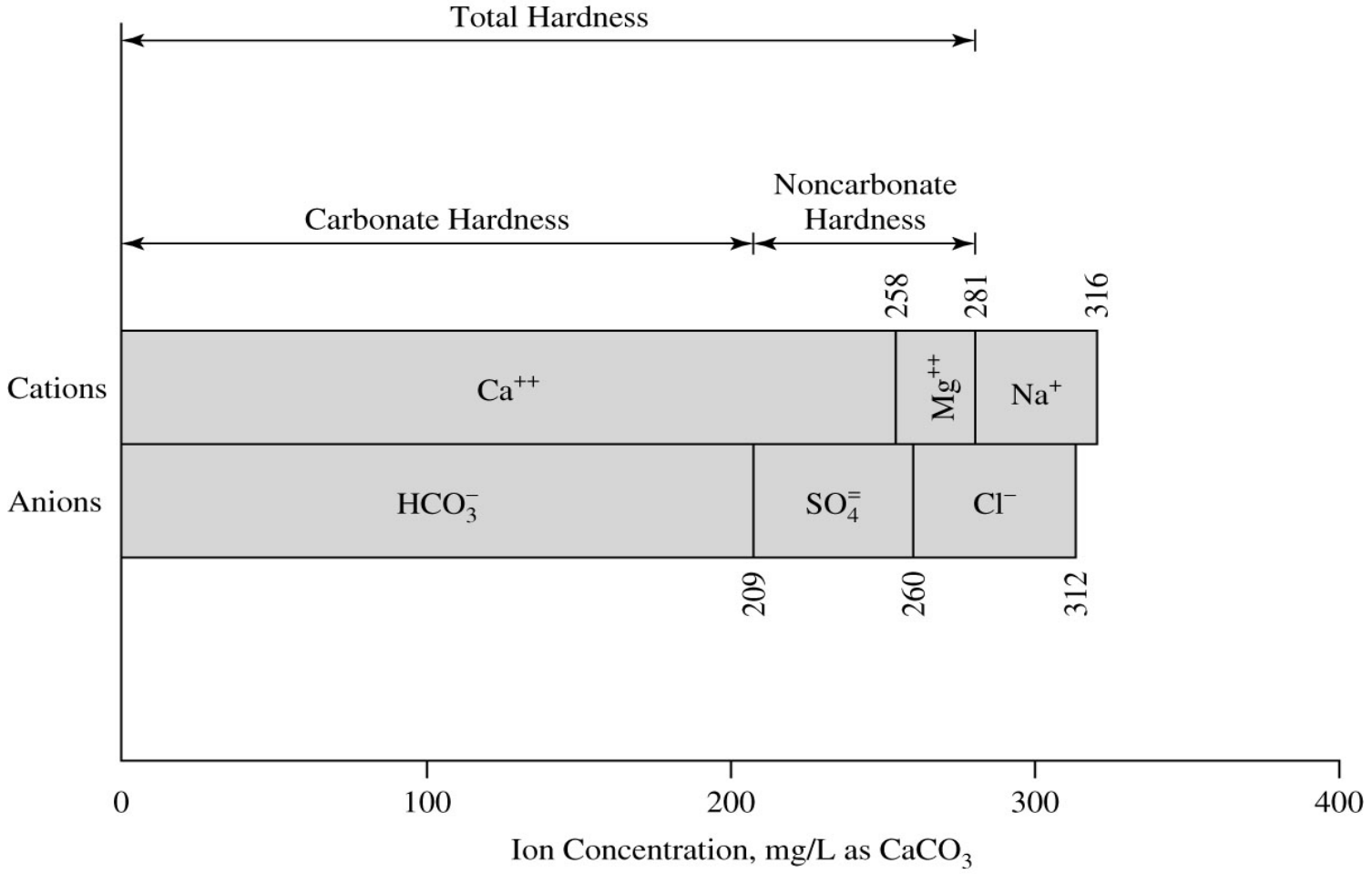
Natural Sources of Hardness

Dissolved CO_2 combines with limestone to form soluble $Ca(HCO_3)_2$, $Mg(HCO_3)_2$, $CaSO_4$, $MgSO_4$



From Introduction to Environmental Engineering by Cornwall and Davis

Bar Graph of Hard Water Constituents



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Summary of Softening Reactions

Hardness removed by raising pH

Lime in Rxns: $Ca(OH)_2$, but lime purchased as CaO.

Neutralization of Carbonic Acid

$$CO_2 + \mathbf{Ca(OH)_2} \rightleftharpoons CaCO_3(s) + H_2O$$

1 eq of $Ca(OH)_2$ per eq of CO_2

Precipitation of Carbonate Hardness

$$Ca^{2+} + 2HCO_3^- + \mathbf{Ca(OH)_2} \rightleftharpoons 2CaCO_3(s) + 2H_2O$$

1 eq of $Ca(OH)_2$ per eq Ca^{2+} that is CH

$$Mg^{2+} + 2HCO_3^- + \mathbf{Ca(OH)_2} \rightleftharpoons MgCO_3 + CaCO_3(s) + 2H_2O$$

$$MgCO_3 + \mathbf{Ca(OH)_2} = Mg(OH)_2(s) + CaCO_3(s)$$

2 eq of $Ca(OH)_2$ per eq Mg^{2+} that is CH

Precipitation of Noncarbonate Hardness Due to Calcium

$$Ca^{2+} + \mathbf{Na_2CO_3} \rightleftharpoons CaCO_3(s) + 2Na^+$$

1 eq Na_2CO_3 per eq Ca^{2+} that is NCH

Precipitation of Noncarbonate Hardness Due to Magnesium

$$Mg^{2+} + \mathbf{Ca(OH)_2} \rightleftharpoons Mg(OH)_2(s) + Ca^{2+}$$

$$Ca^{2+} + \mathbf{Na_2CO_3} \rightleftharpoons CaCO_3(s) + 2Na^+$$

1 eq Na_2CO_3 + 1 eq of $Ca(OH)_2$ per eq Mg^{2+} that is NCH

Chemical that is added is in bold

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