Cell communication

- will come up often in development half of course

**How we know that cells must signal to each other**
- Direct manipulations of cells
- Ablation of cells
- Genetic evidence for signaling

**General principles of how cells signal to each other**
- Signals can act over short or long range
- How many signals a cell can respond to
- How receptors relay signals to affect cell behavior: signal transduction
- Signals that enter cells
  - Steroid hormones
    - Cortisol
    - Estradiol
    - Testosterone
    - Thyroxine
- Nitric oxide (NO)

Cell surface receptors
- Ion channel-linked receptors
- Molecular switches

**Signal transduction**

(A) Signaling by Phosphorylation
(B) Signaling by GTP-Binding Protein
How G-protein-linked receptors work

Activation of G protein subunits

1. **Activation of G protein subunits**
   - **(A)**
     - Receptor protein
     - Inactive G protein
     - Signal molecule
     - Plasma membrane
   - **(B)**
     - Extracellular space
     - Cytosol
     - Activated G-protein subunits
   - **(C)**
     - Activated α subunit
     - Activated βγ complex

Regulation of ion channels

1. **Regulation of ion channels**
   - **(A)**
     - Acetylcholine
     - Closed K⁺ channel
   - **(B)**
     - Activated βγ complex
     - Open K⁺ channel
     - Channel opening
   - **(C)**
     - Inactive G protein
     - Closed K⁺ channel

Activation of membrane bound enzymes

1. **Activation of membrane bound enzymes**
   - Activated βγ complex
   - Activated enzyme
   - Many intracellular messenger molecules diffuse widely to act on target proteins and other signaling proteins in various parts of the cell
The cyclic-AMP pathway

Phospholipase C

Calcium as a signal

Enzyme-linked receptors
Receptor tyrosine kinases
The GTP-binding protein Ras
cell signaling and cancer
Protein kinase networks