**Biophysics I** (BPHS 3090)

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Figure 2.19
Electrical Responses in the Sensory Systems

Figure 1.3

Photoreceptors

Figure 1.5

Auditory Hair Cells
Electrical properties of cells are important!
Now we will consider the effect of solutes having charge.
Basic E&M Review (well, the E part....)

- Charge

- Electric Potential (i.e., voltage)

- Circuit Elements: resistors, conductors, inductors, batteries, etc....

- Circuit Basics (e.g., Kirchoff’s laws)

- RLC circuit
Duality here! River water has:

1. Kinetic energy (due to flow)
2. Potential energy (due to gravity)

**Question**: What's the ‘battery’?
Basic E&M Review (well, the E part....)

- Circuit Basics (e.g., Kirchoff’s laws)

**Junction rule**
(conservation of charge)

\[
\sum_{n} I_{in}^{n} = \sum_{n} I_{out}^{n}
\]

**Loop rule**
(conservation of energy)

\[
\Delta V_{loop} = \sum_{n} \Delta V^{n} = 0
\]
Review
Using Kirchoff's Laws, find the current through each of the three resistors
Kirchhoff's Laws

Use the loop rule to determine the currents $I_1, I_2, \text{ and } I_3$

Note: We arbitrarily chose the direction of the currents. This provides a reference and the ultimate direction of the current should correctly emerge from our solution.

Left loop: $E_1 - I_1 R_1 + I_3 R_3 = 0$

Right loop: $-I_3 R_3 - I_2 R_2 - E_2 = 0$

(Note that we went counter-clockwise through both loops)

Junction rule: $I_1 + I_3 - I_2 = 0$

Now we have three eqns. w/ three unknowns. Algebraically we can solve for the currents in terms of the resistances and potential diffs.

$I_1 = \frac{E_1 (R_2 + R_3) - E_2 R_3}{R_1 R_2 + R_2 R_3 + R_1 R_3}$

$I_2 = \frac{E_1 R_3 - E_2 (R_1 + R_3)}{R_1 R_2 + R_2 R_3 + R_1 R_3}$

$I_3 = \frac{-E_1 R_2 - E_2 R_1}{R_1 R_2 + R_2 R_3 + R_1 R_3}$

Note: $I_3 < 0$ (so we chose the ref. direction wrong no matter what $E$ and $R$ values are)
RLC Circuits as an example
RLC circuit = Damped, Driven Harmonic Oscillator