

## Recitation 1 Worksheet

### Practice Problems

1. **Cloning the first neurotransmitter receptor.** Reorder the steps below obtain the sequence of experiments which scientists did to successfully clone the first neurotransmitter receptor, the nicotinic acetylcholine receptor.
  1. Separate into protein fractions, identify fractions which bind a-bungarotoxin
  2. If the receptor is composed of more than one gene product, can try to find others by sequence homology.
  3. Homogenize electric organs containing electroplaques cells from electric fish and add radioactive a-bungarotoxin
  4. Label a-bungarotoxin radioactively with tritium
  5. Determine oligonucleotides, and create labeled oligonucleotide probes
  6. Digest protein fraction, obtain protein sequence using mass spectrometry
  7. Hybridize oligonucleotides to a cDNA library so can pull out entire gene
2. Explain what makes the  $K^+$  and  $Na^+$  channels selectively permeable only to their respective ions.

### Review of terms and concepts

**voltage** -  $V_m$  (Volts)

- The electrical potential across the plasma membrane, due to separation of charge

$$V_m = V_{in} - V_{out}$$

**current** -  $I$  (Amps)

- Rate of movement of positive charge
- Amp = 1 Coulomb / sec

**resistance** -  $R$  (ohms)

- Opposition to current flow

**conductance** -  $g$  (Siemens)

- Measure of ability to conduct electricity - in the membrane, permeability to ions
- Any object through which electrical current can flow is called a conductor
- Lipids are poor conductors, they are good insulators
- Conductance proportional to area, inversely proportional to length  $C \propto \frac{A}{l}$

$$g = \frac{1}{R}$$

**capacitance**  $C$  (Farad = Coulomb/Volt)

- A capacitor is composed of 2 conductive surfaces with an insulator between them, and it has the capacity to store charge (positive on one side, negative on the other side)
  - This creates a potential difference between the two surfaces
- Depends on geometry of plates and separation
  - Proportional to area, inversely proportional to separation distance  $C \propto \frac{A}{D}$

$$C = \frac{Q}{V} = \frac{Q}{IR}$$

**Ohm's law**

$$V = IR$$

## Circuits

resistor



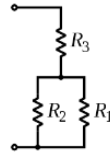
variable resistor



short circuit (zero resistance)



Resistances in series add  
Resistances in parallel add reciprocally



$$R_{total} = R_3 + R_4$$

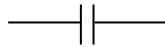
$$\frac{1}{R_4} = \frac{1}{R_1} + \frac{1}{R_2}$$

**current** – arrow shows direction of net movement of positive charge

- Current flows through across a resistor from positive to negative

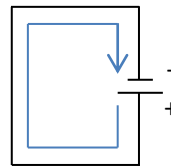


capacitor



**potential difference (battery)**

- Longer pole is positive, shorter pole is negative
- Current flows from positive to negative



## Answers to practice problems

1. 4, 3, 1, 6, 5, 7, 2
2. The selectivity of ion channels is established based on pore size as well as chemical interactions between the ions and the amino acids lining the pore. The Na ion is smaller than K, however, since smaller ions have stronger electrostatic attraction for water, the Na ion is surrounded by a larger shell of hydration compared to K. Therefore, the K channel can in principle extrude Na based on size. Furthermore, channel pores are lined with amino acid side chains that imitate waters of hydration. The Na channel has negatively charged residues that will make it energetically favorable for Na to lose its waters of hydration. These residues will selectively bind the naked Na ion which has a smaller radius, rather than K with a bigger radius, because electrostatic interactions are governed by Coulomb's inverse square law. Conversely, the K channel has less negative side chains protruding, like carbonyl or hydroxyl oxygen atoms. It would not be energetically favorable for Na to strip off its waters of hydration in this channel, but it is favorable for K.

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