Here is your one-page guide to the knowledge that will be tested in Exam 1:

We have covered ten core concepts so far: These concepts are interrelated and central to the function of neural cells in the brain and body. Last year's Exam 1 and study guide for Exam 1 are the best guides as to how your exam will look. I created the lectures, quizzes, simulations, and homeworks to help (force) you to master these concepts. These are the things you should focus on:

1. Four principles of electricity (three if you recognize that R = 1/G): Voltage (it is a force that moves charge), Resistance (restricts the movement of charge), Conductance (allows charge movement), and Current (the rate of charge movement if you have a force and a path)

2. Ohms law is ***everywhere*** in neurobiology. It looks like this:

$V = IR$ $I = V/R$ $I = V*G$ $R = V/I$ $G = I/V$

3. Passive membrane properties (resistance and capacitance) influence the magnitude and rate of membrane voltage changes in the subthreshold range (below the threshold for action potential). Know what resistance does. Know what capacitance does. Know what they do together.

4. The uneven distribution of ions across the membrane (esp. Na^+ and K^+) creates a driving force on these ions. This driving force is determined by the membrane potential (voltage) and the equilibrium potential for an ion type: Driving force = Membrane Voltage – Equilibrium potential ($V_M - E_{ion}$)

When membrane voltage is very far from E_{ion}, driving force on that ion is big. As membrane voltage approaches E_{ion}, driving force gets small, and becomes zero when $V_M = E_{ion.}$ When driving force changes, the current for that ion will change, independent of conductance.

5. Increasing conductance for any ion will pull the membrane toward the equilibrium potential for that ion. When the cell is permeable to both Na^+ and K^+, the membrane will settle at a voltage between E_K and E_{Na}. If it is more permeable to Na then the membrane voltage will be closer to E_{Na}; more permeable to K^+ then membrane will settle closer to E_K.

6. When ion channels selective for a particular ion species open, they increase the conductance (G) for that ion. The current that flows through those ion channels is this: $I_{ion} = (V_m – E_{ion})*G_{ion}$ (quick review: where does E_{ion} come from? What happens as the distance between E_{ion} and V_m changes?

7. This equation $I_{ion} = (V_m – E_{ion})*G_{ion}$ describes a very dynamic relationship during the action potential because I, V, and G are all changing at the same time, for different ions. Do you get this?

8. The action potential initiates (the cell reaches threshold) when Na^+ current exceeds K^+ current. Important corollary: if you increase K^+ current – it will take longer to reach threshold. The action potential ends when K^+ current exceeds Na^+ current.

9. Repeat of #8: as K^+ conductance increases, it will take longer for the cell to reach threshold, and the action potential will end sooner. This principle regulates firing pattern!

10. Some ionic currents inactivate, many of them inactivate at or near resting potential. Some activate slowly, some deactivate slowly. How does this impact neuronal firing patterns?

In preparing for the exams, the simulations and homeworks are your best guides (I put in a LOT of effort developing them for a reason!). Quizzes are secondary, but important. The simulations and homeworks are designed to give you essential facts and show you what the above ten principles look like in action. The exam will be heavily weighted toward asking you about what neurons do when they are in action, and the ionic mechanisms that produce a given outcome.