

Purpose

1. To develop a simulation that would allow students to explore the physiological mechanisms associated with the Action Potential.
2. To create a simulation that would allow students to overcome observed student difficulties. (Described below and observed in the Integrative Physiology Department major courses and literature)
3. To create opportunities for students to visualize cellular properties governing the action potential.

GOALS/STUDENT DIFFICULTIES

Goals of Simulation are to help students establish that:

1. changes in ion concentration are quite small during each action potential
2. leak channels are the major contributing factor to establishing the resting membrane potential
3. during a temporary change in membrane potential the Na/K ATPase is not necessary for re-establishing the V_m rest

STUDENT DIFFICULTY DOCUMENTATION

1. Noted from observations in in class and out of class activities (clicker questions, homework, help room, discussions, exams)
2. Literature (FB: ADD CITATION)

FUTURE DIRECTIONS

- Additional tabs exploring:
 - Passive properties
 - Graded potentials
 - Neuron-neuron signalling
- Develop validated curriculum for grades K-16
- Measure that the simulation helps student achieve goals and overcome observed difficulties

Neuron Simulation Design & Features

Sim Goal # 1

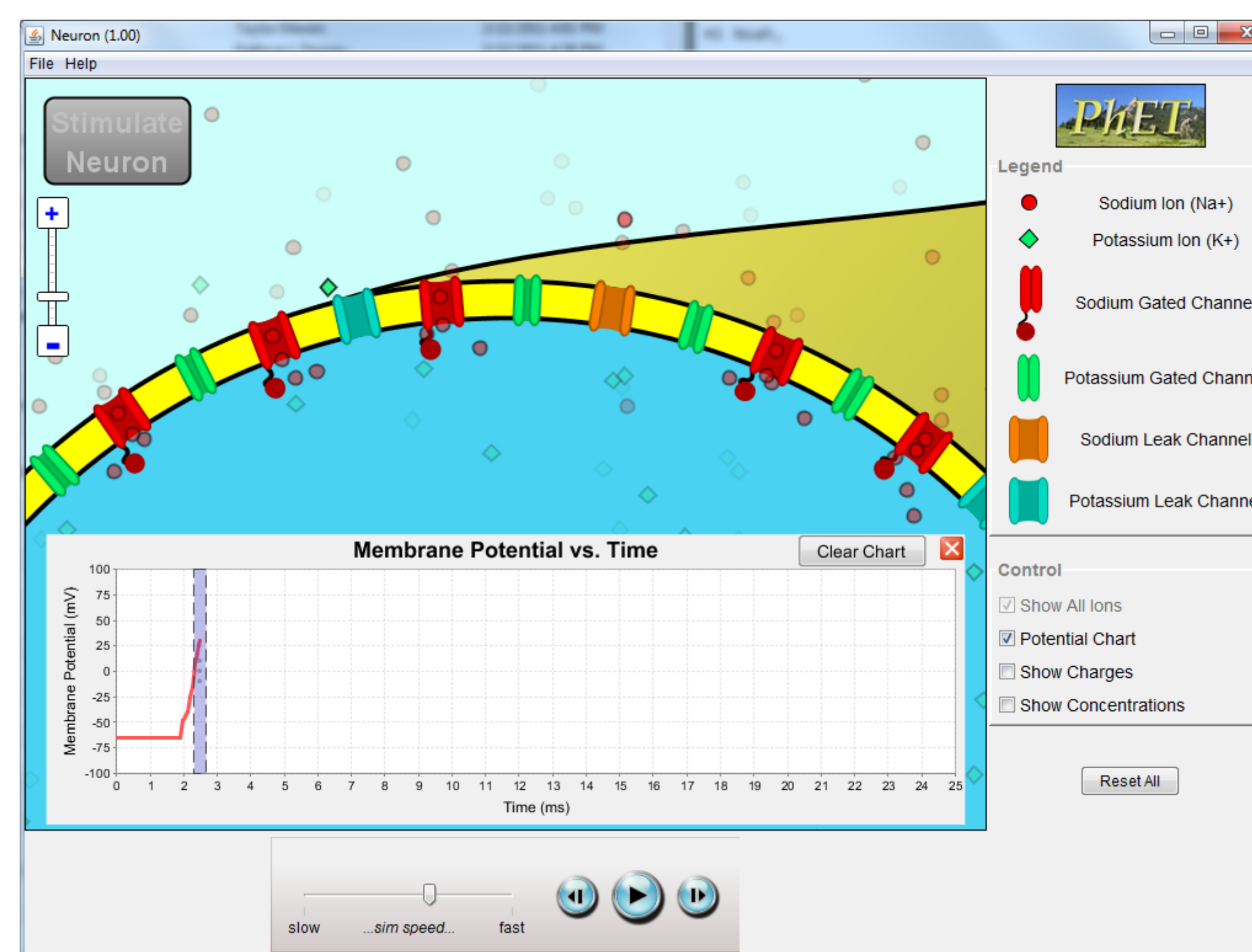
Changes in ion concentration are quite small during each action potential

Student Belief

Students indicate that changes in concentration are much larger than actually occur during the action potential (X% in IPHY Courses:FB TO ADD)

Feature in Sim

Real time reveal button for concentration



Sim Goal #3

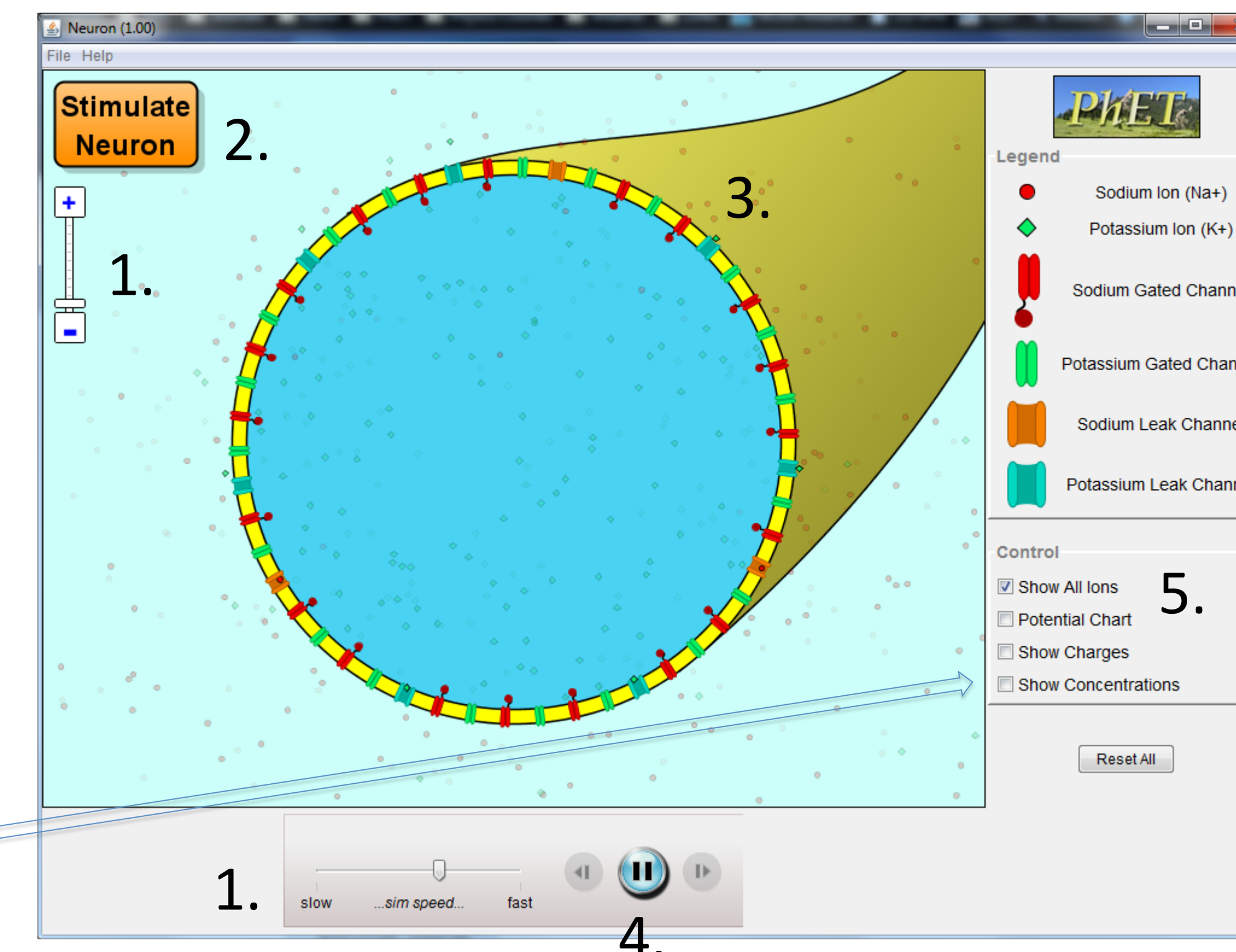
During a temporary change in membrane potential the Na/KATPase is not necessary for re-establishing the V_m rest

Student Belief

That the Na/K ATPase is the sole contributor to re-establishing the V_{mrest} after n action potential. X%

Feature in Sim

No Na/K ATPase visible in simulation and the ability to slow down the refractory period and visualize membrane events.



Sim Goal #2

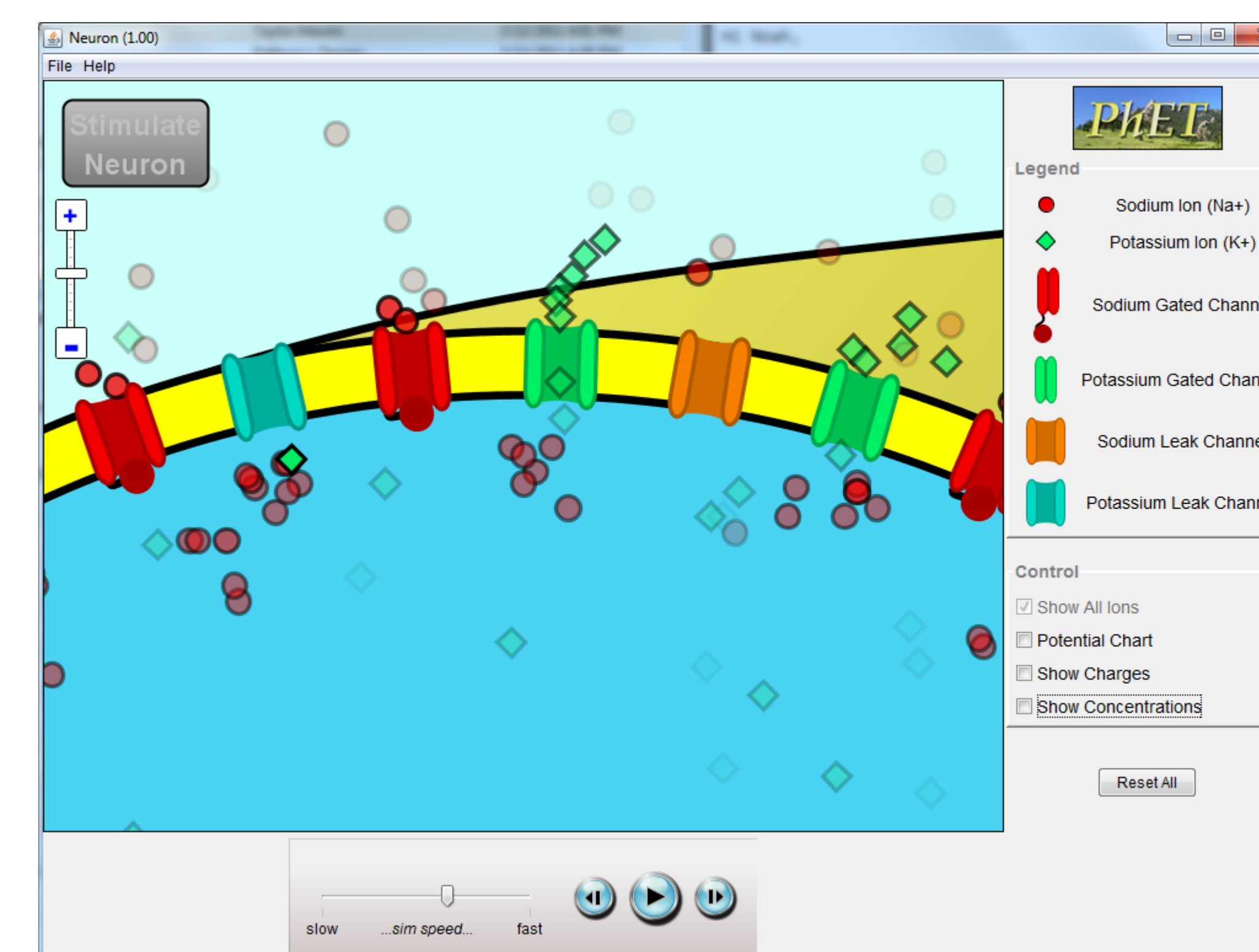
Leak channels are the major contributing factor to establishing the membrane potential

Student Belief

Students often state that the Na/K ATPase is responsible for establishing the membrane potential and do not discuss the role of the leak channels, particularly potassium leak channels (X% in IPHY Courses (n =FB TO ADD))

Feature in Sim

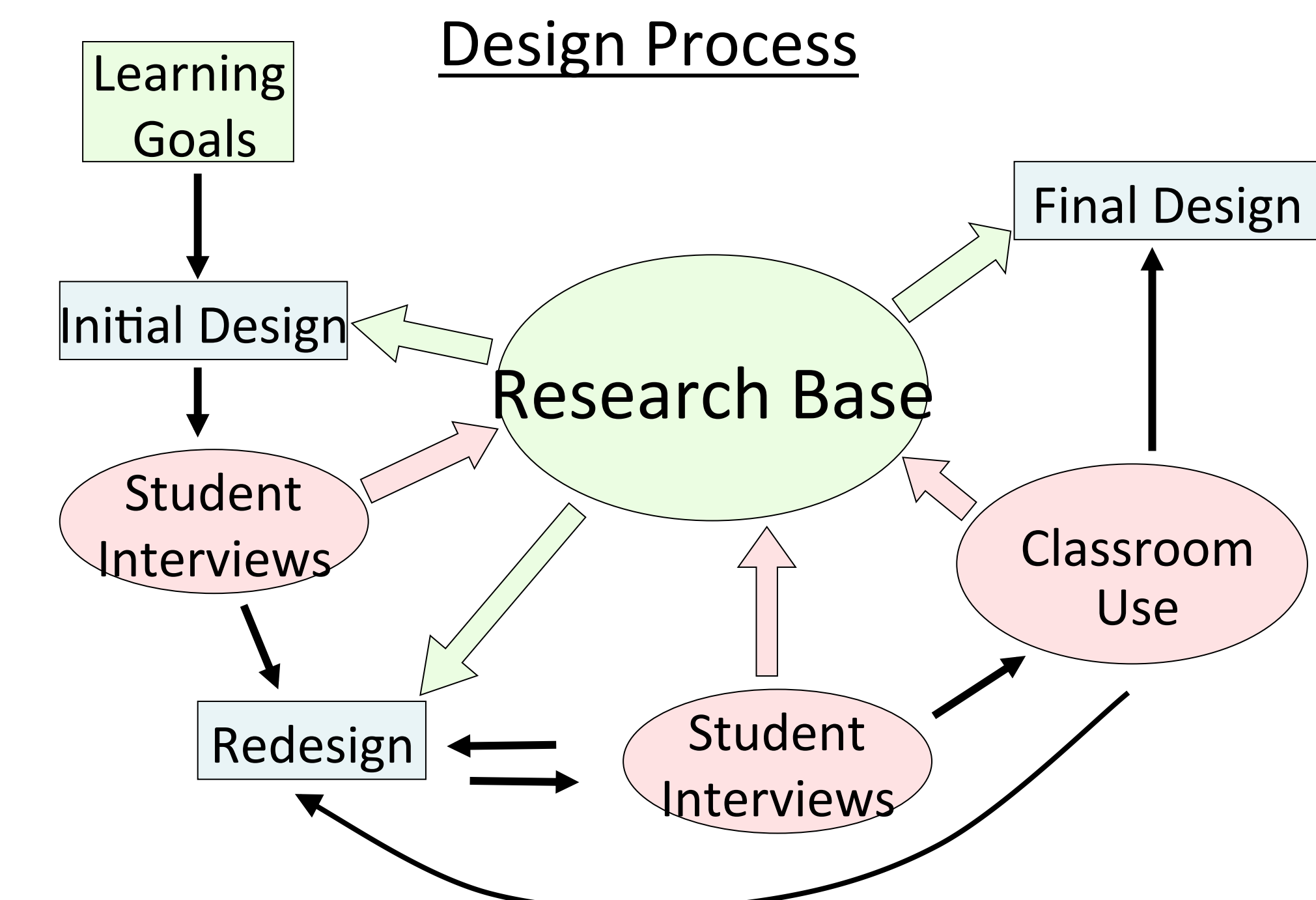
A physiologically relevant distribution of leak channels in the membrane, particularly potassium leak channels. Also no Na/K ATPase channels are visible in this simulation.



Research-Based Simulation Development

Design Features

1. Interactive sliders to zoom in and out of membrane and change speed of V_m trace.
2. Time sensitive to regenerate Action Potential
3. Visual representations of leak and gated ion channels, ions, and voltage trace
4. Pause functionality to see small changes in ion concentration throughout action potential and V_m
5. Ability to hide ion concentrations and voltage trace



Student Interviews

- **Think-aloud protocol** – “Play with everything and talk as you go”
- **Tests:** Interface design
Representational Interpretation
Engagement (scientist-like exploration)
Progress towards learning goals
- ~1 hour each
~4-8 interviews/round

FUNDING

- Hewlett Foundation, JILA, King Saud University. NSF CCLI Grant #0817582
- University of Colorado, Boulder Science Education Initiative