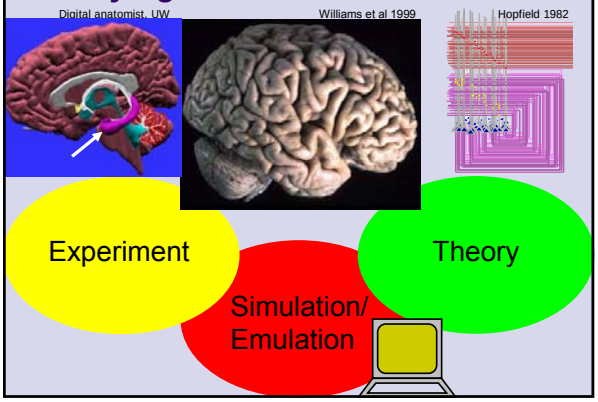
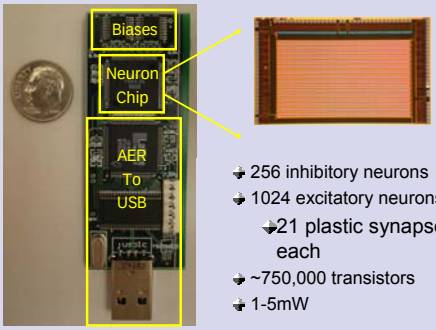
Neuromorphic VLSI Tutorial

john arthur

Studying the brain

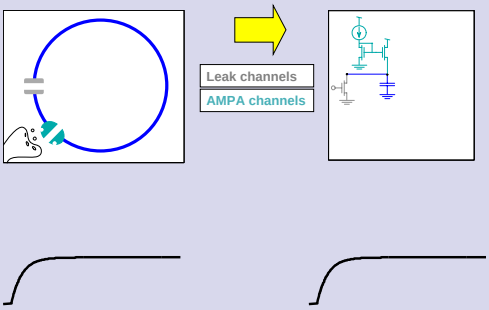


A Neuron Chip

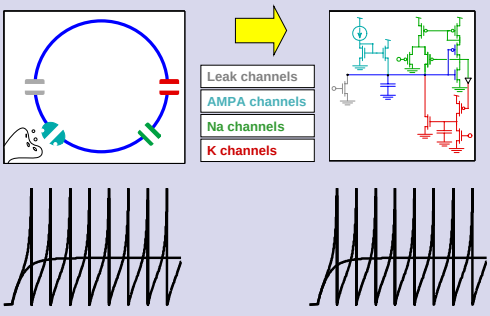


- 256 inhibitory neurons
- 1024 excitatory neurons
  - 21 plastic synapses each
- ~750,000 transistors
- 1-5mW

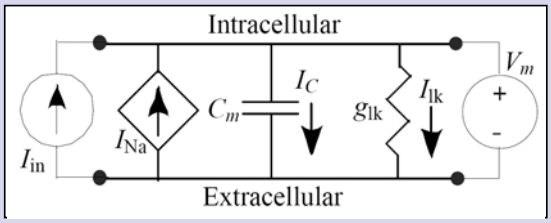
Neuron engineering

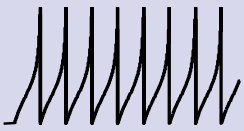


Neuron engineering



Spiking neuron

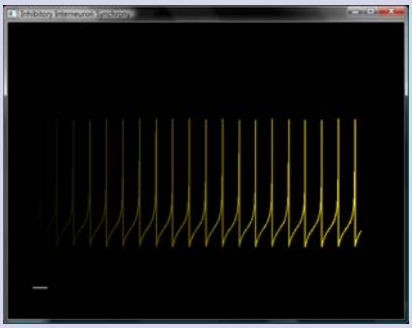




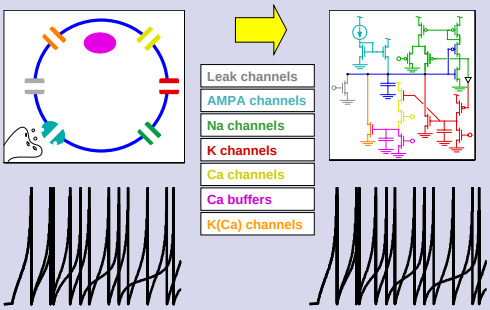
$$\tau \frac{dv}{dt} = -v + r + \frac{v^3}{3}$$

Run Neuron Lab – neuron.exe

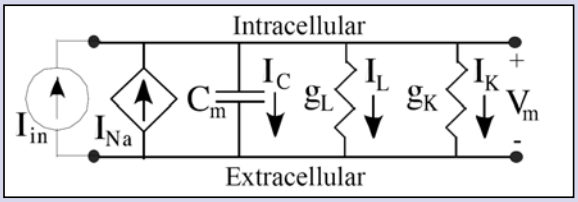
- ‘r’ key increases current to neuron
- ‘shift’ + ‘r’ decreases current
- ‘t’ key increases neuron time constant
- ‘shift’ + ‘t’ decreases time constant
- Try ‘f4’ if nothing happens (big board)

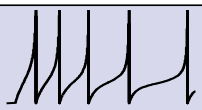


Neuron engineering



Adaptive neuron



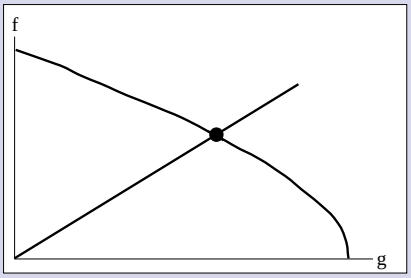


$$\tau \frac{dv}{dt} = -v(1+g) + r + \frac{v^3}{3}$$

$$\tau_g \frac{dg}{dt} = -g$$

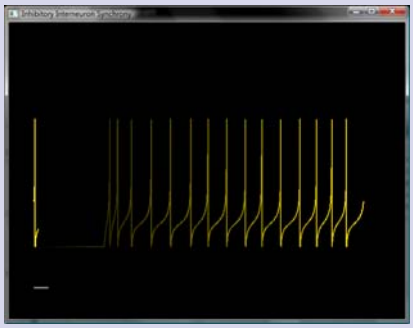
$$g \rightarrow g + \Delta g, t \rightarrow t_{spk}$$

Adaptive neuron frequency

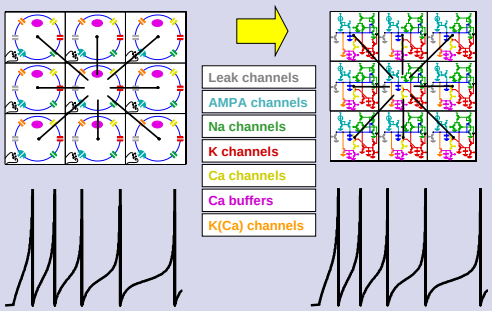


Run Adapting Lab – adapting.exe

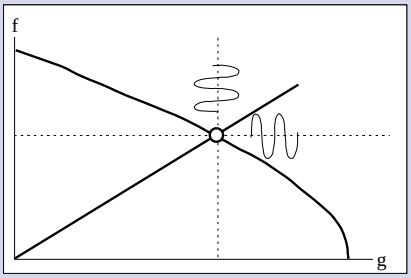
- ‘s’ key turns on current step to neuron
- ‘shift’ + ‘s’ turns off current
- ‘g’ key increases K+ strength
- ‘shift’ + ‘g’ key decreases K+
- Try ‘f4’ if nothing happens (big board)



Neuron engineering

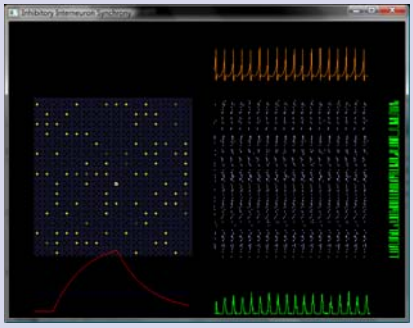


Synchrony



Run Synchrony Lab – synchrony.exe

- '+' key turns up inhibition
- '-' key turns downs inhibition
- '→' key increases decay time
- '←' key decreases decay time
- '↑' key increases rise time
- '↓' key decreases rise time



A future chip: Neurogrid