

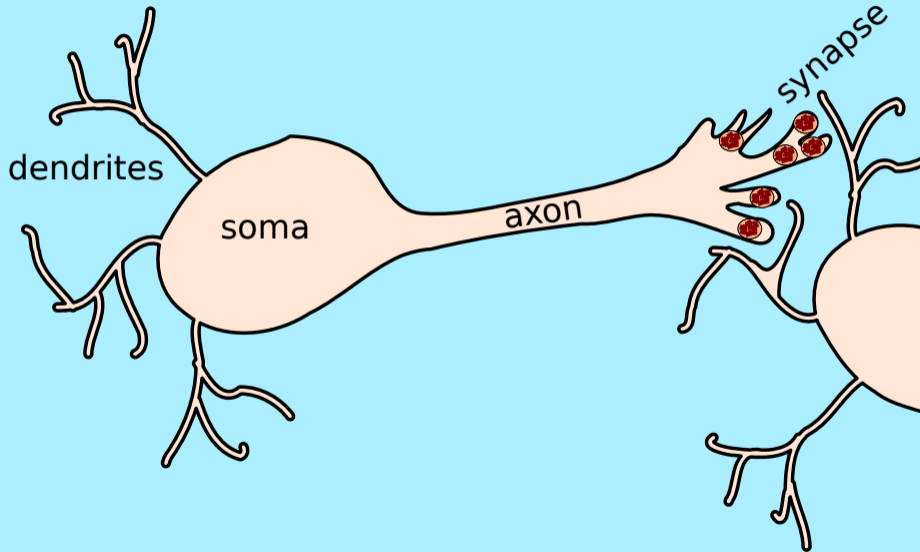
Evolving adaptive coincidence-detecting neurons

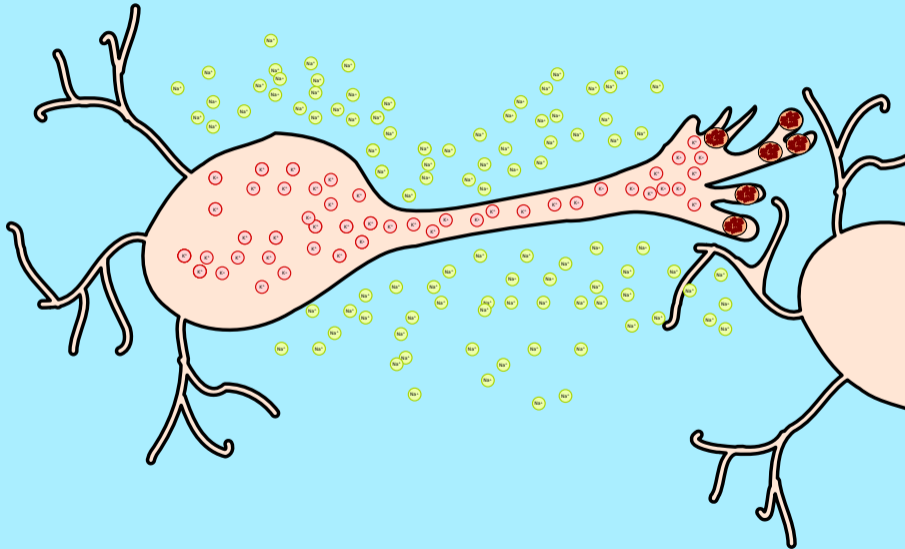
W. Garrett Mitchener

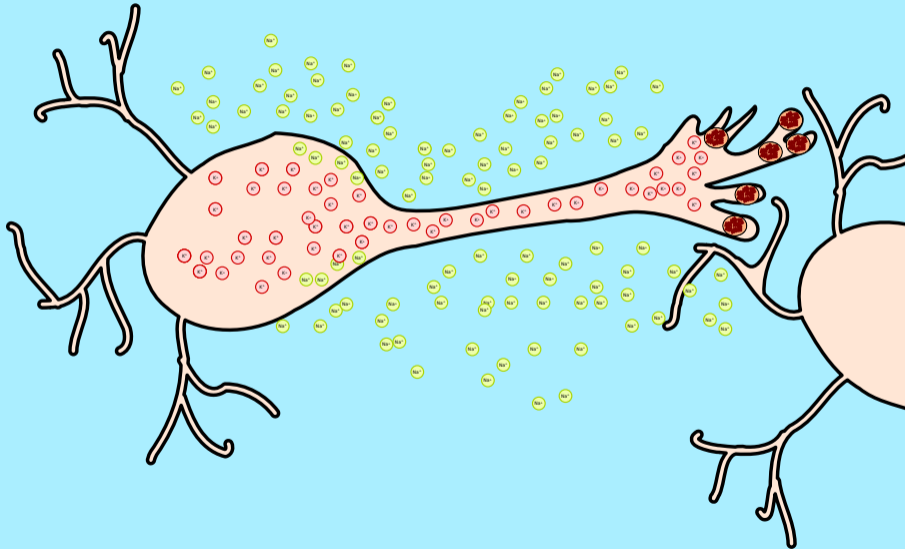
College of Charleston

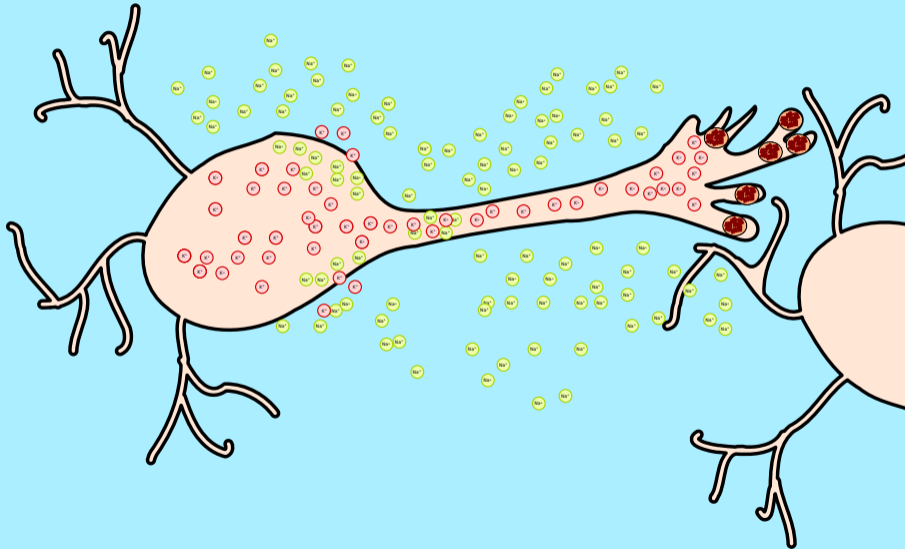
January 10, 2015

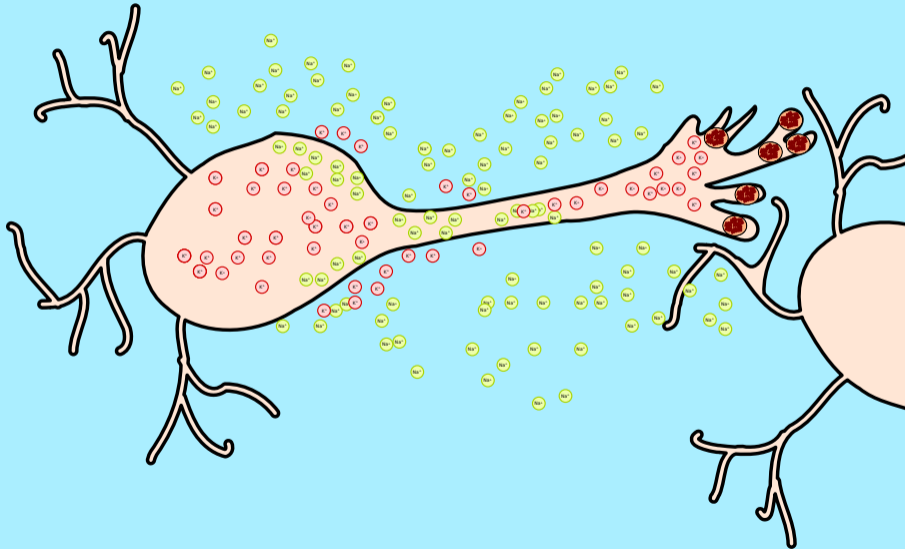
Neurons and action potentials

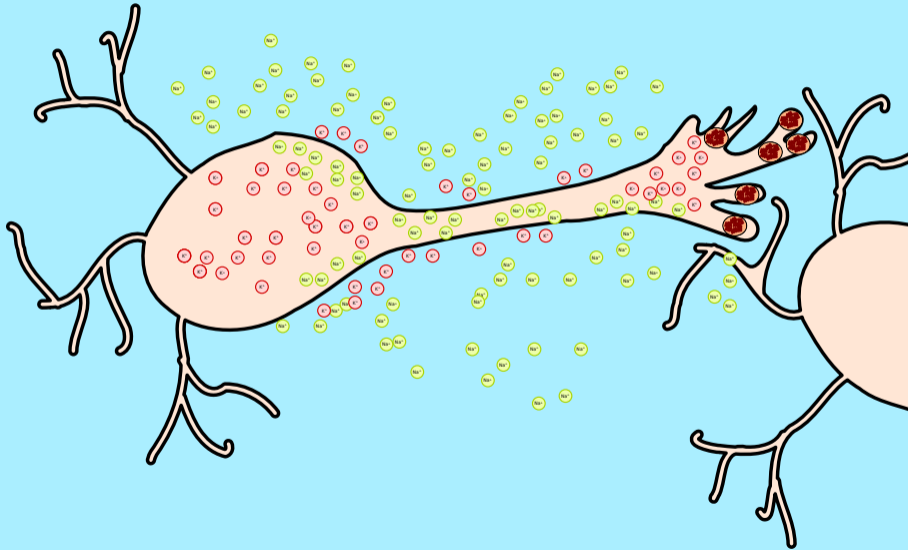


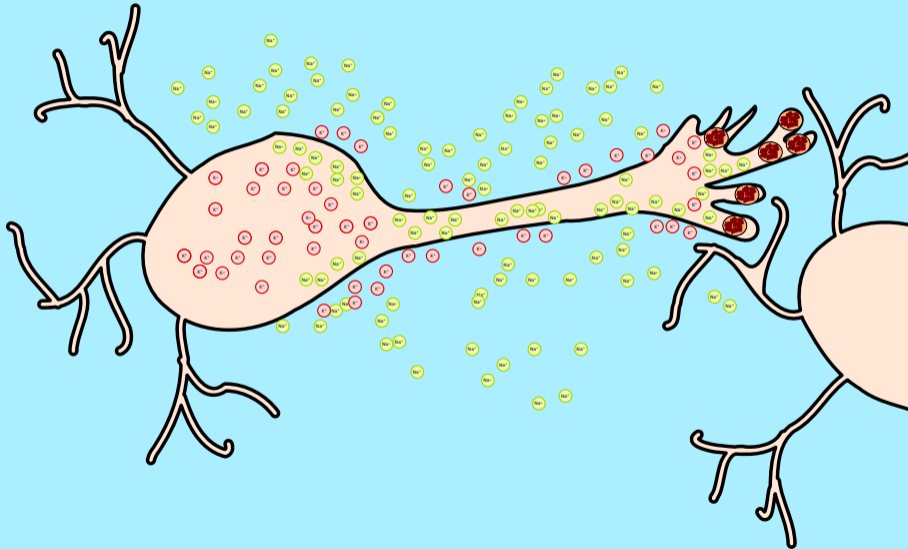


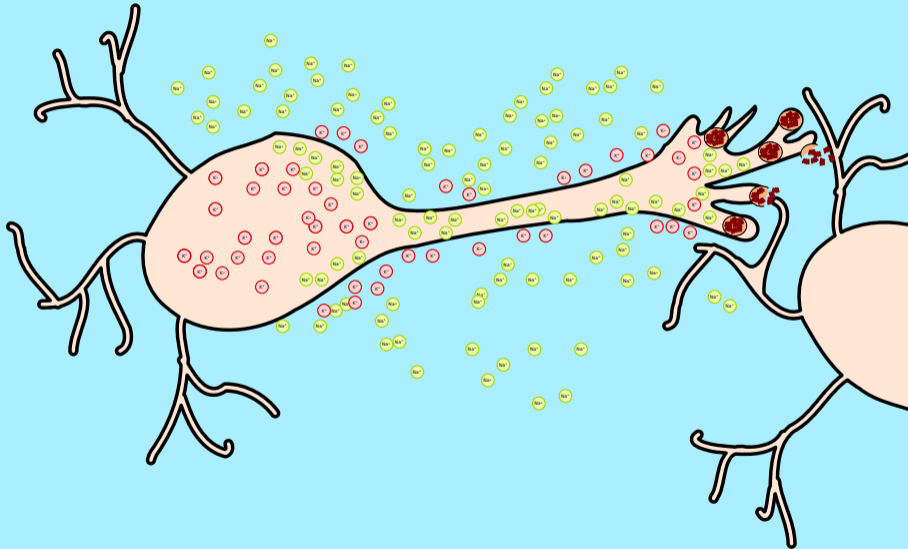


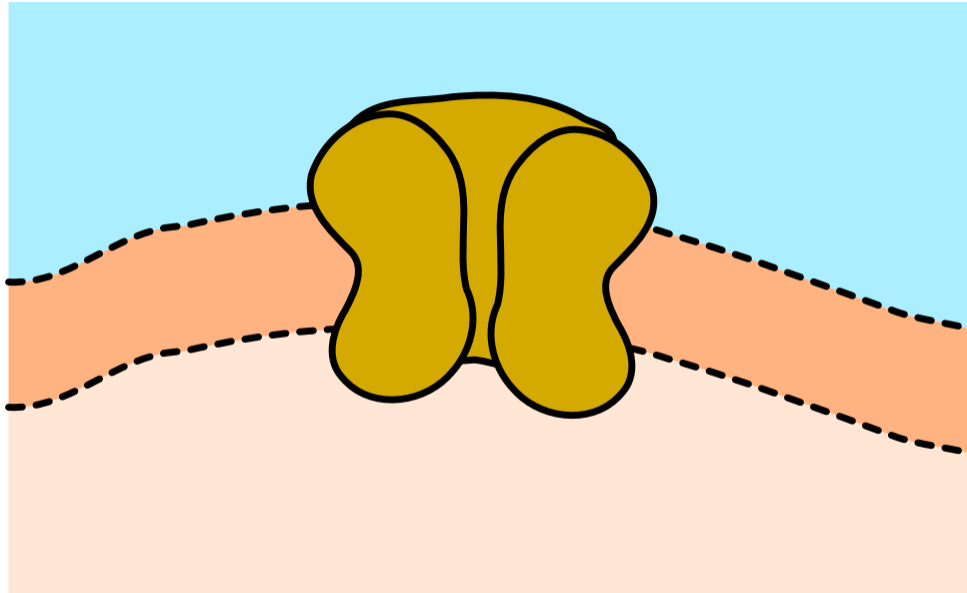


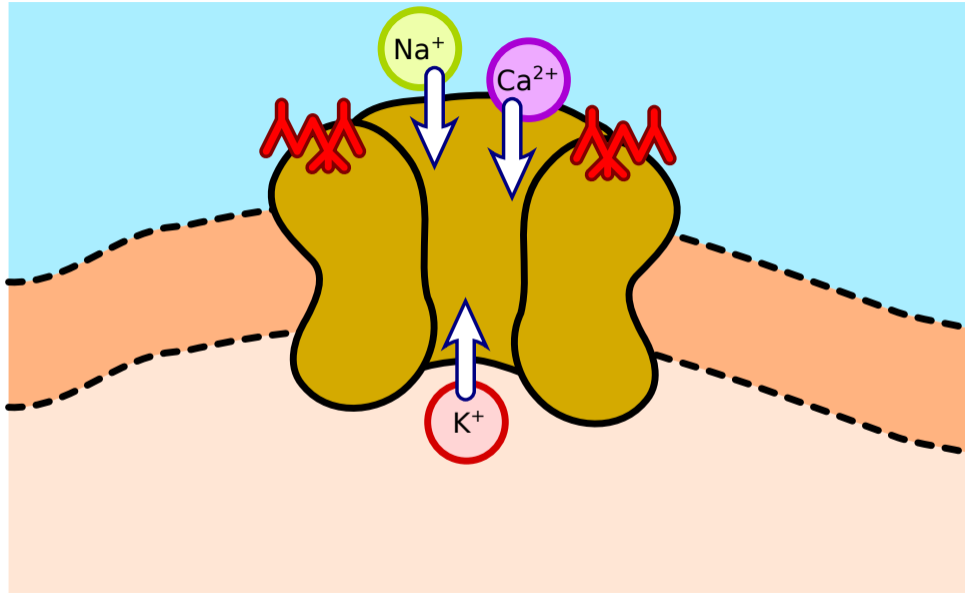


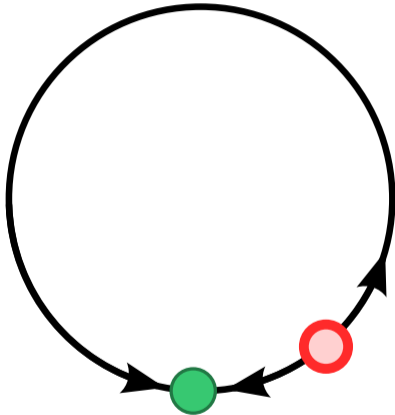












In: -----|-----
 Out: -----

In: -----|-----|-----
 Out: -----

In: -----||-----
 Out: -----|-----

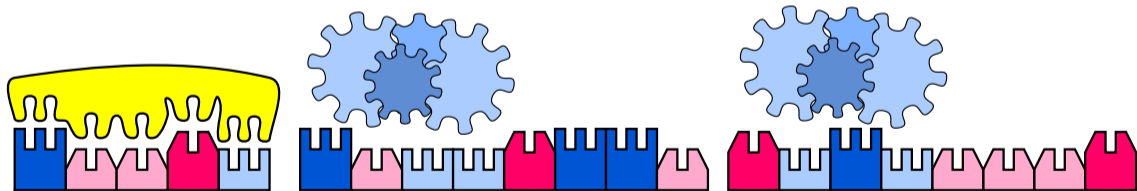
In: -----|-----|-----|-----|-----
 Out: -----|-----

Utrecht machine

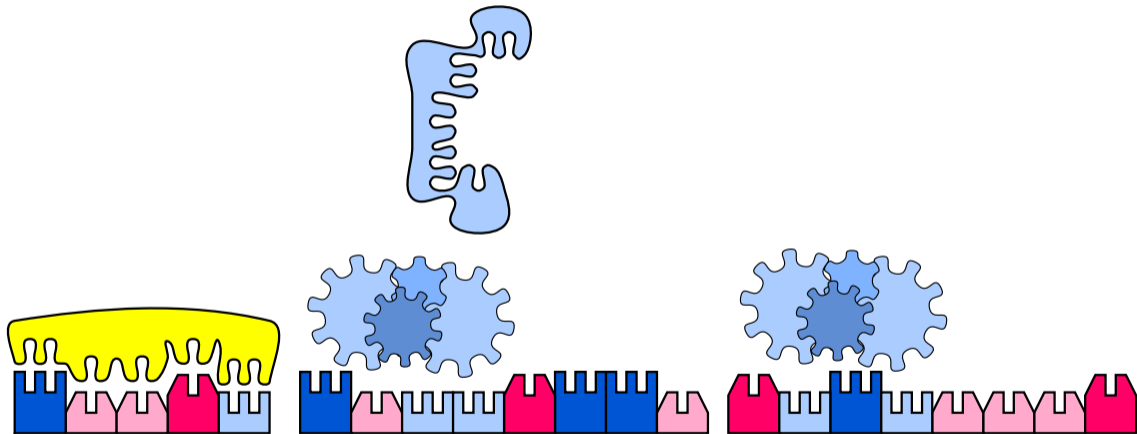
Design of discrete biochemistry



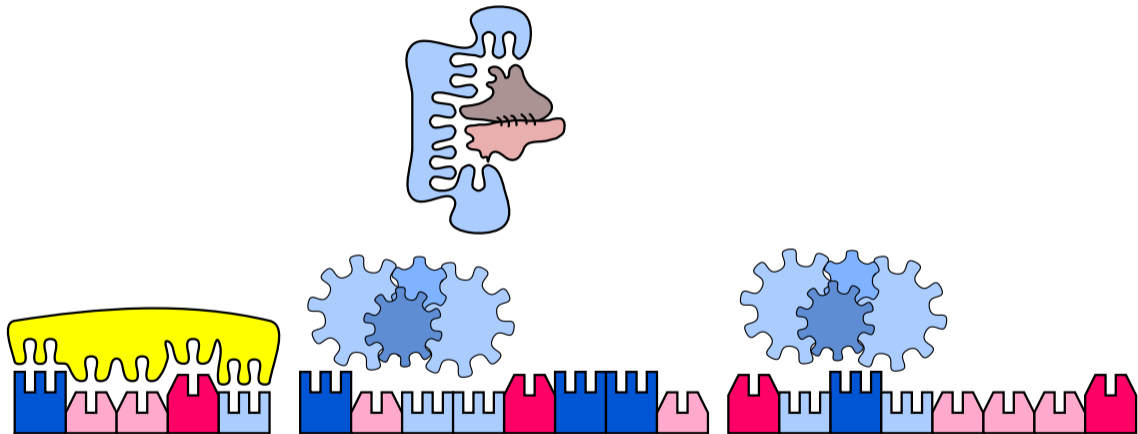
Design of discrete biochemistry



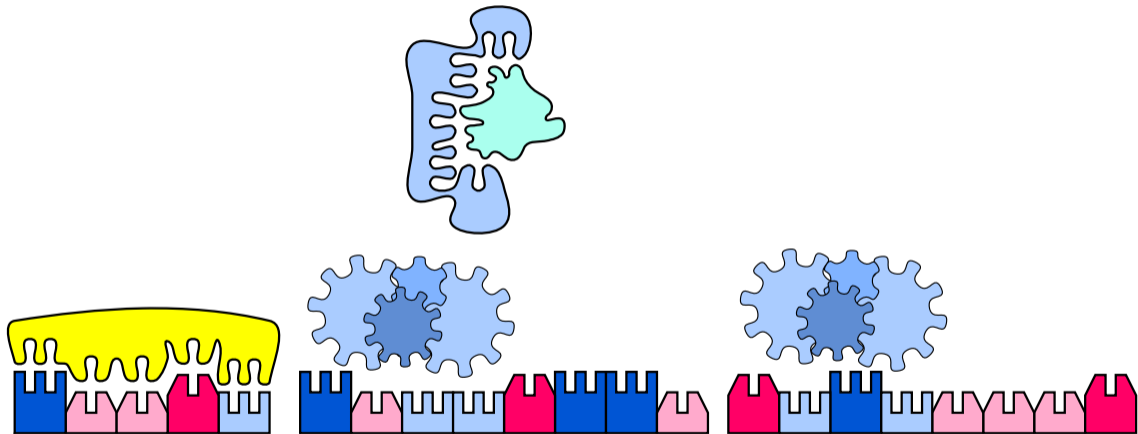
Design of discrete biochemistry



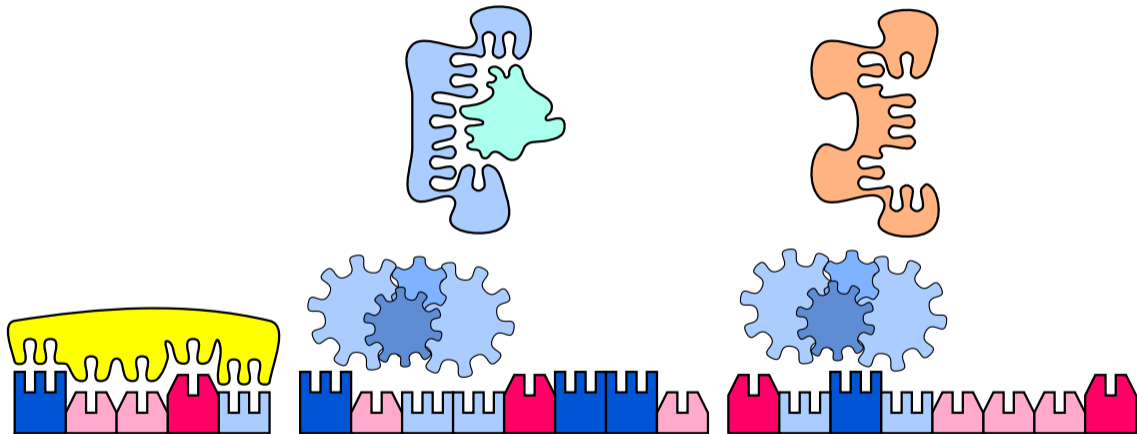
Design of discrete biochemistry



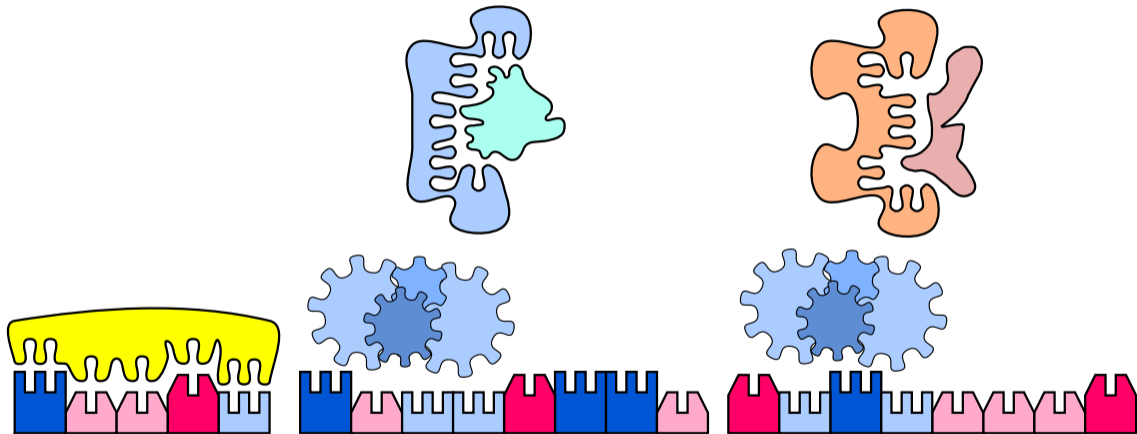
Design of discrete biochemistry



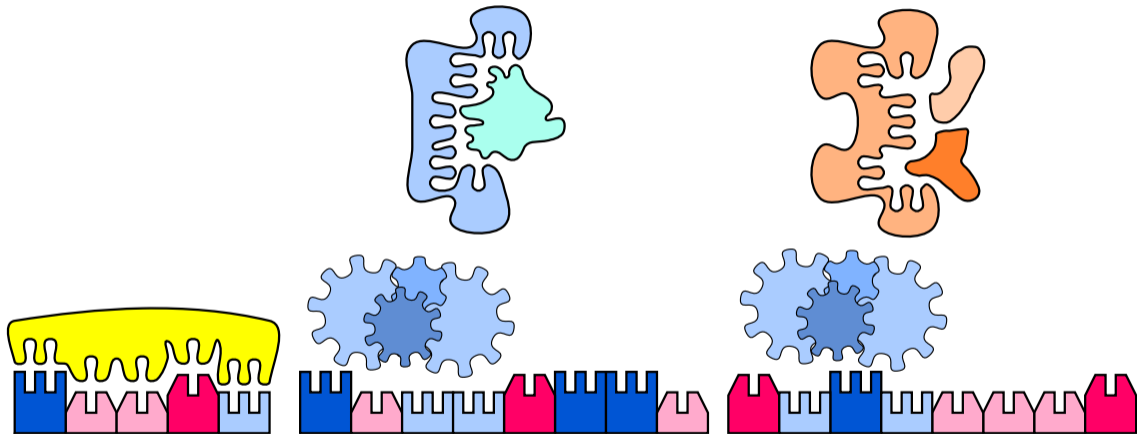
Design of discrete biochemistry



Design of discrete biochemistry



Design of discrete biochemistry



Utrecht machine

Activation array:

$$A[0] = 0$$

⋮

$$A[3] = 11$$

⋮

$$A[41] = 1$$

⋮

$A[p]$ = how many molecules of type p

Think transcription factors matching promoter pattern in DNA

Utrecht machine

Activation array:

$$A[0] = 0$$

⋮

$$A[3] = 11$$

⋮

$$A[41] = 1$$

⋮

Input:

If input is *on* then
add 8 to $A[3]$

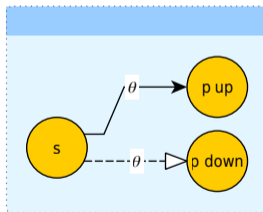
Utrecht machine

Activation array:

$A[0] = 0$
 \vdots
 $A[3] = 11$
 \vdots
 $A[41] = 1$
 \vdots

General instruction format:

If $A[s] \geq \theta$ then
 add 1 to $A[p_{up}]$
 subtract 1 from $A[p_{dn}]$



Utrecht machine

Activation array:

$A[0] = 0$
:
 $A[3] = 11$
:
 $A[41] = 1$
:

Instructions from genes:

If $A[54] \geq 2$ then
 add 1 to $A[47]$
 subtract 1 from $A[54]$

If $A[10] \geq 4$ then
 add 1 to $A[54]$
 subtract 1 from $A[3]$
:
:

Utrecht machine

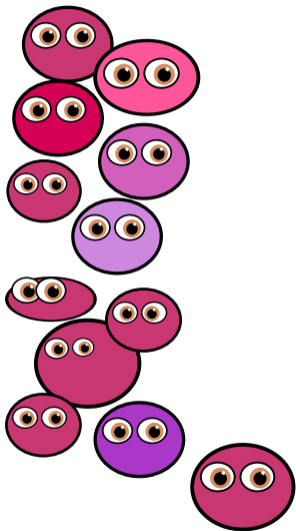
Activation array:

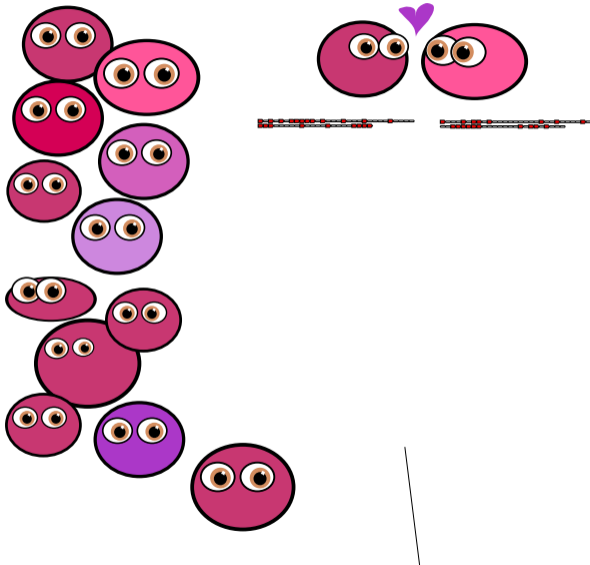
$A[0] = 0$
:
 $A[3] = 11$
:
 $A[41] = 1$
:

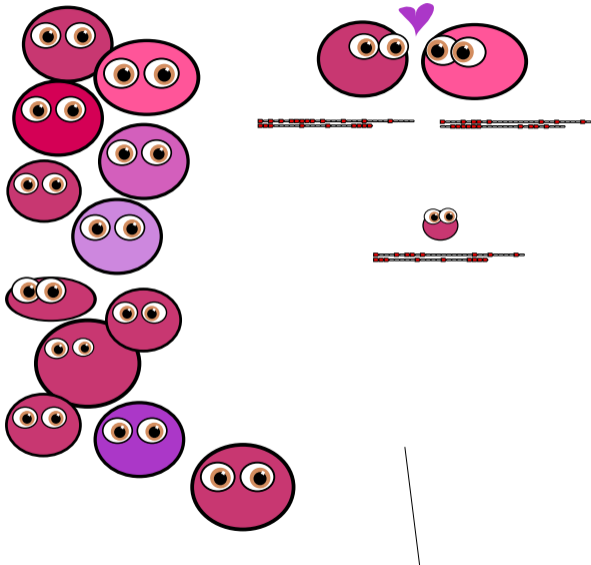
Output:

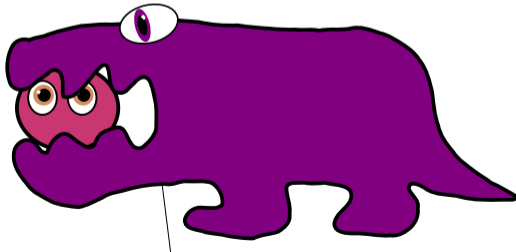
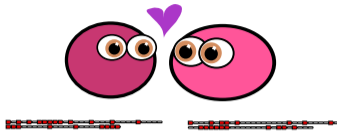
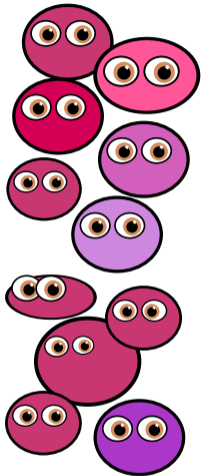
If $A[41] \geq 2$ then
 subtract 2 from $A[41]$
 turn output *on*
else
 turn output *off*

Selective breeding

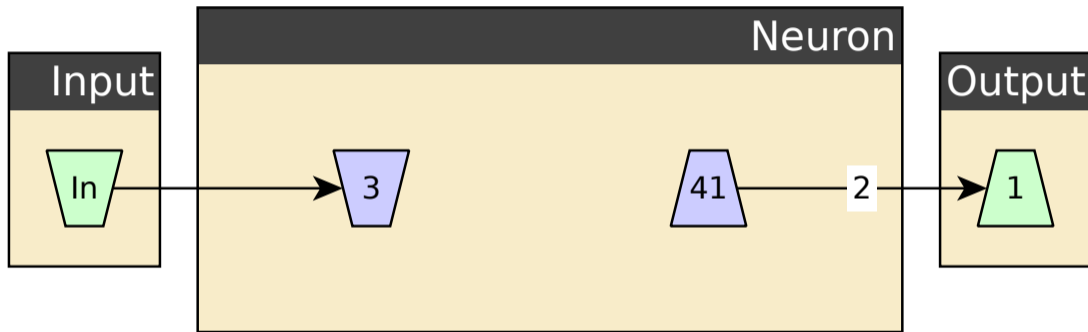




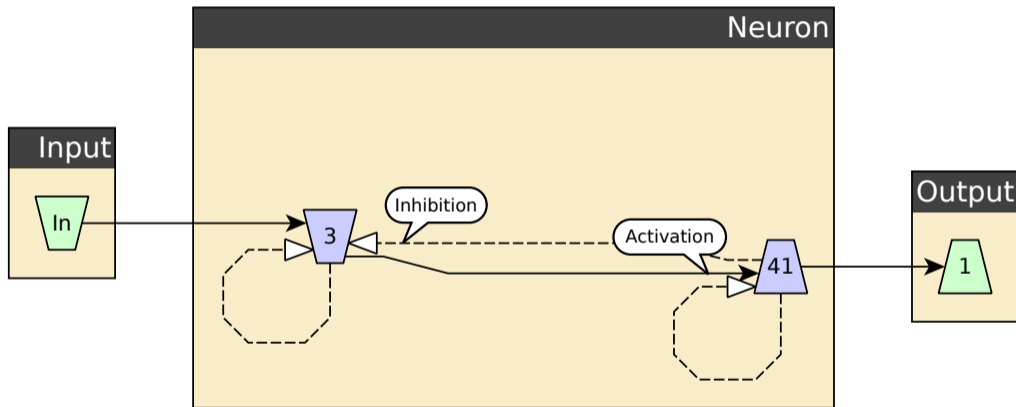





Example solution: Setup

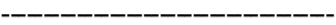


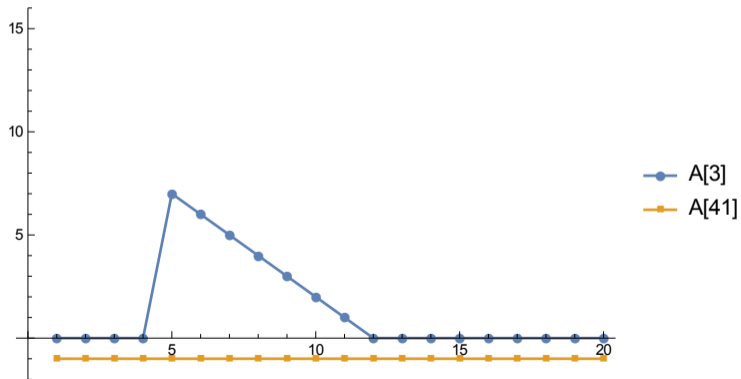
Example solution: Basic operation




Isolated input spike, no output spike

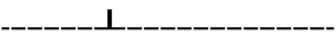
In: 

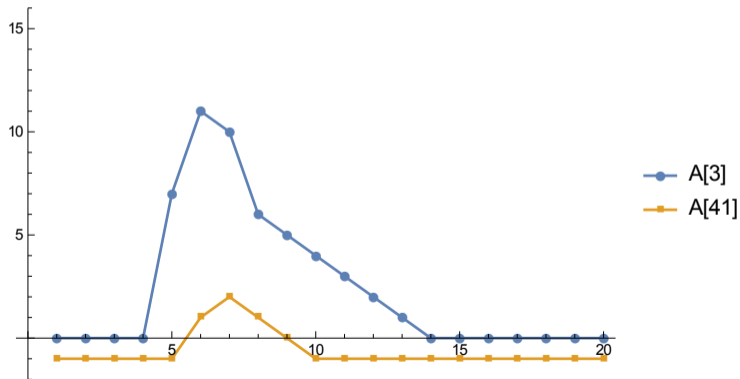
Out: 



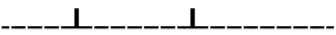
Near coincident input spikes, output spike

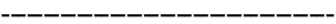
In: 

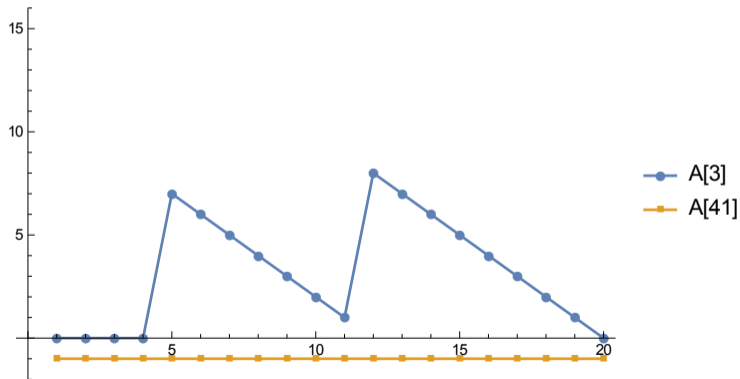
Out: 



Distant input spikes, no output spike

In: 

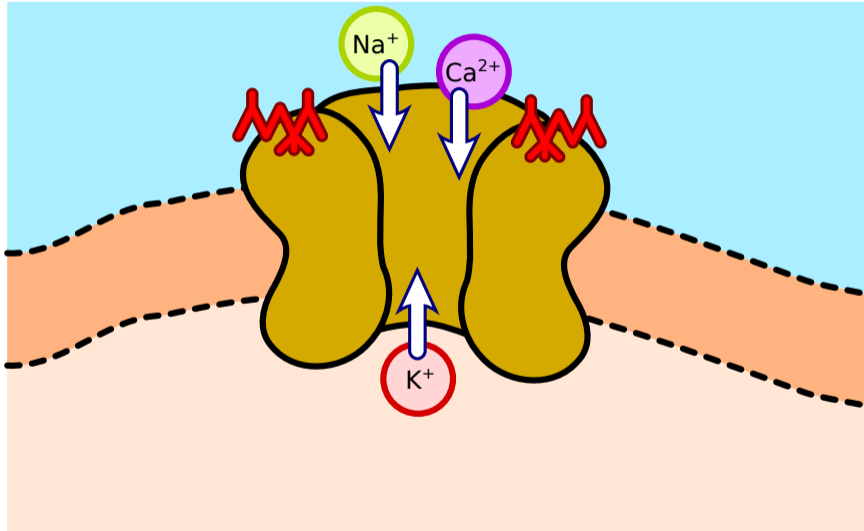
Out: 



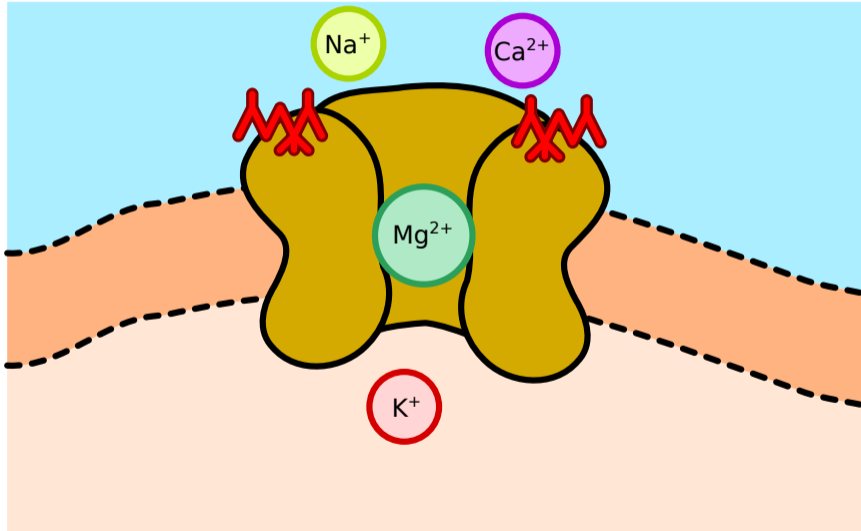
Hebbian learning

Also known as spike-timing-dependent plasticity

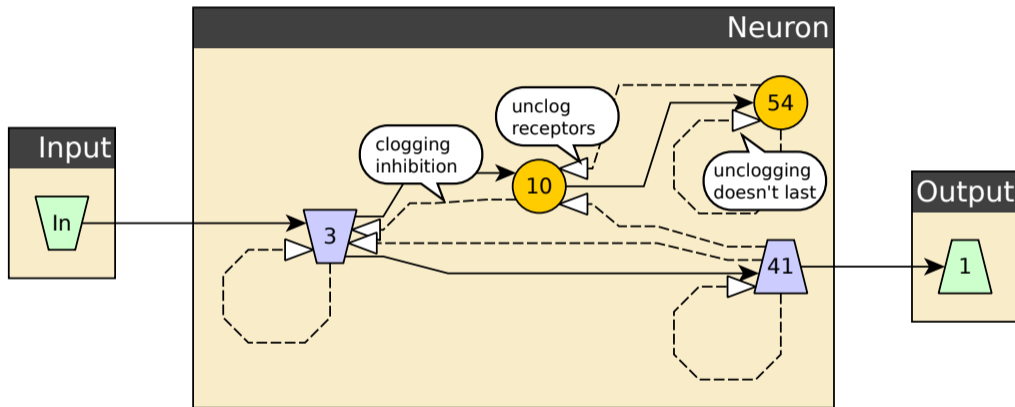
Hebbian learning: NMDA receptor



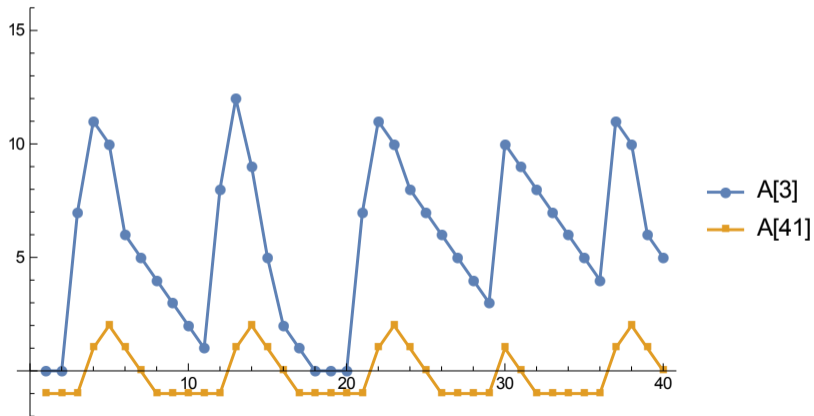
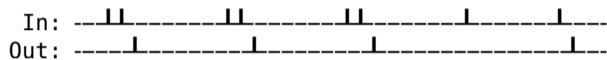
Hebbian learning: NMDA receptor

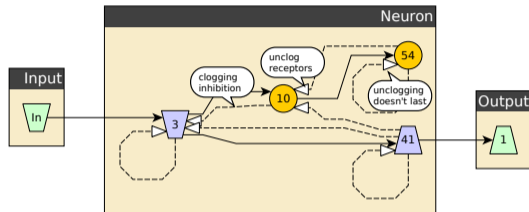
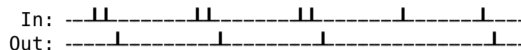
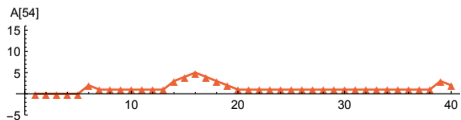
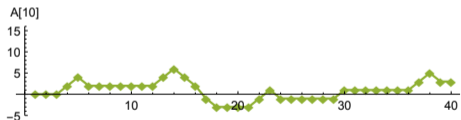
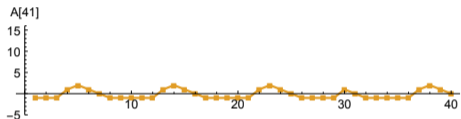
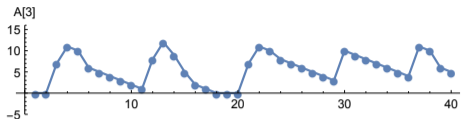


Hebbian learning: Double inhibition



Learning eagerness





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