The Channel Builder

Voltage- and ligand-gated channels

Kinetic schemes, HH-style differential equations

Optional stochastic gating mode for point processes

Faster than equivalent NMODL mechanisms

Much easier to use than writing NMODL code

Limited to channels

- NMODL needed for pumps, buffers, diffusion, event-driven synaptic mechanisms, artificial spiking cells

Tutorial: see Documentation at NEURON's home page http://www.neuron.yale.edu/

Conceptualize the task

Ion selectivity	na, k, other, nonspecific i
I/V relationship	ohmic / GHK (constant field)
Description of dynamics	HH style / kinetic scheme
Gates	independent identical subunits fractional openness
Sensitivity	voltage / ligand
Transition style	alpha, beta / inf, tau functions / tables

Implementing the HH sodium channel with the Channel Builder

$i_{Na} = g_{Na} (V - E_{Na})$ where

$g_{Na} = gbar_{Na}\ m^3h$

$gbar_{Na} = 0.12\ S/cm^2$

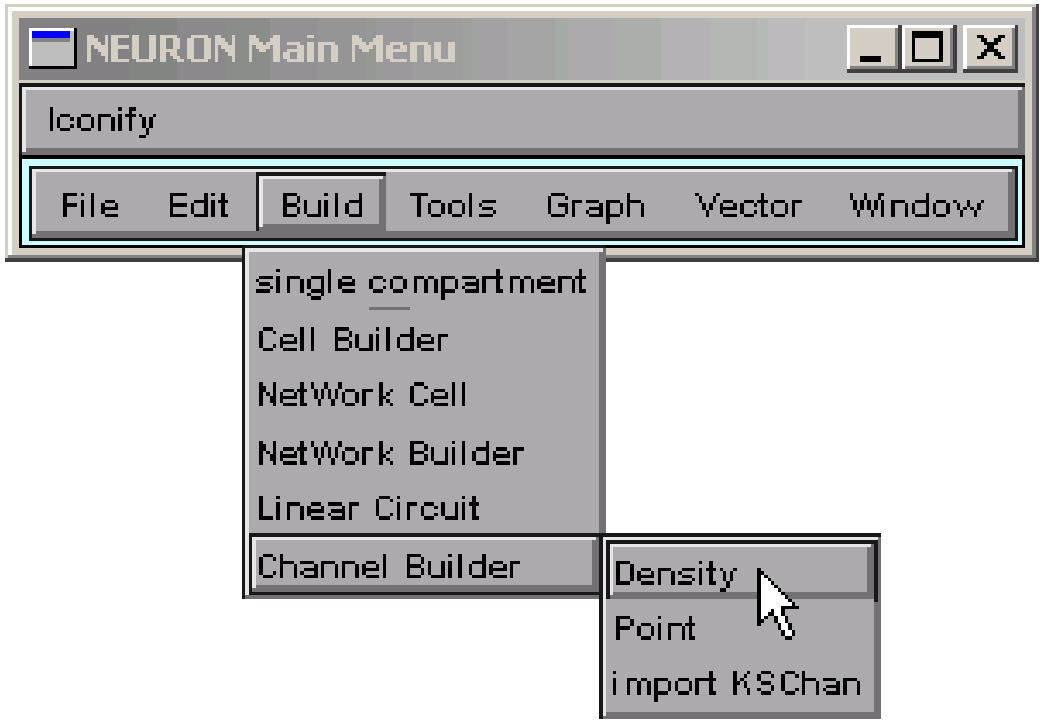
m and h are described by DEs of the form

$dx/dt = alpha\ (1 - x) - beta\ x$

How to proceed

1. Bring up a Channel Builder
2. Specify channel's basic properties
3. Specify channel gating
    - states
    - transitions (if a kinetic scheme)
    - effects of voltage and ligands

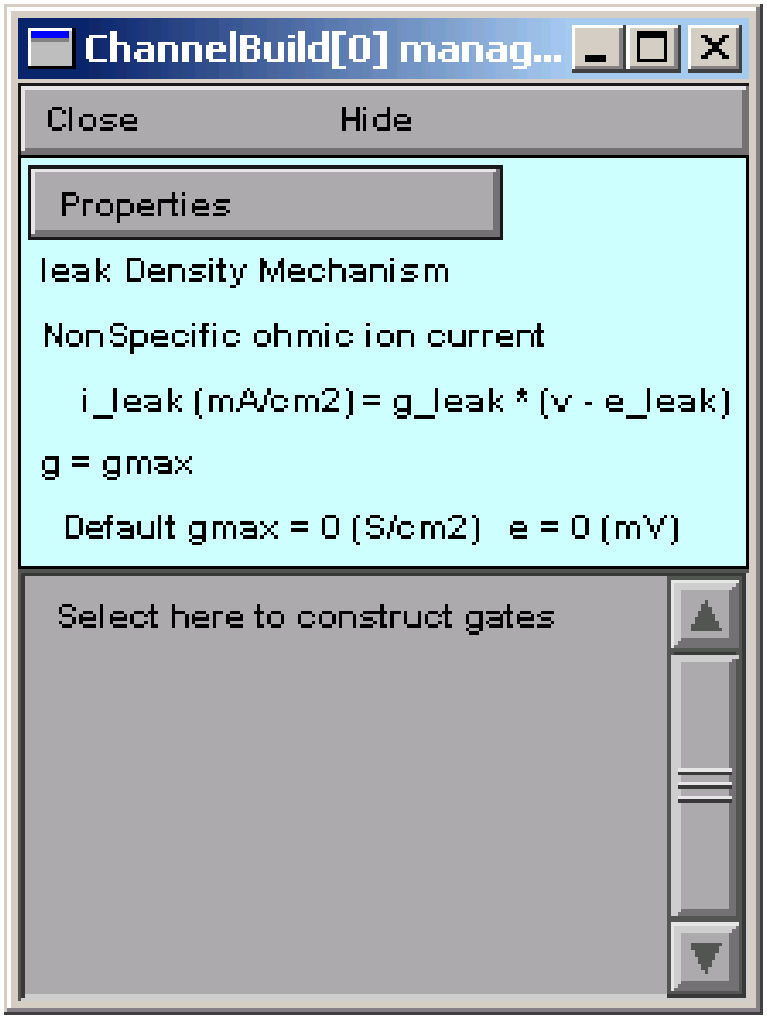
1. Bring up a Channel Builder



NEURON Main Menu / Build
/ Channel Builder / Density

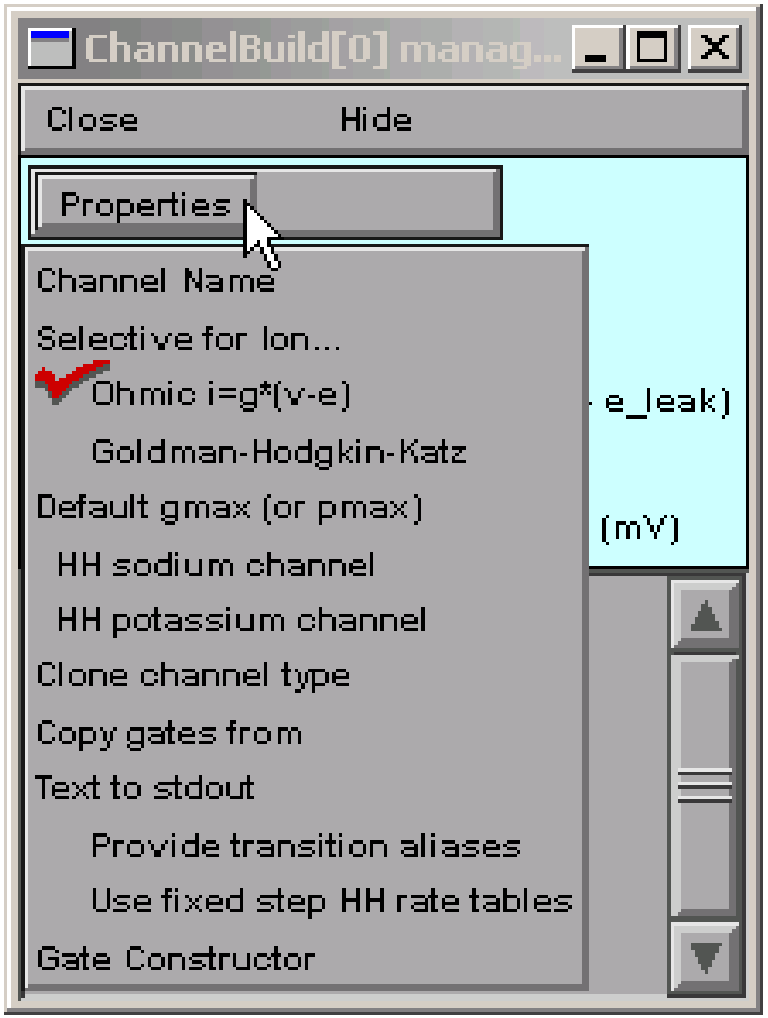
The Channel Builder

We need to change its name,
ion selectivity,
default conductance,
and equilibrium potential



2. Specify channel's basic properties

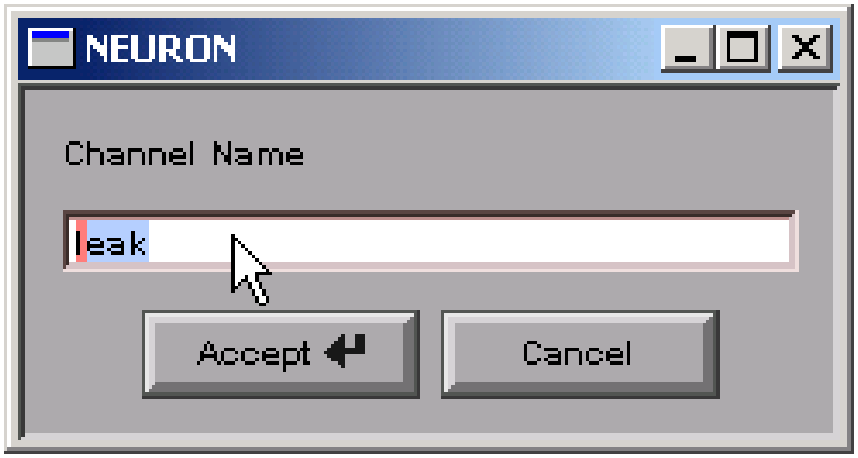
Click on Properties,
then select item to change

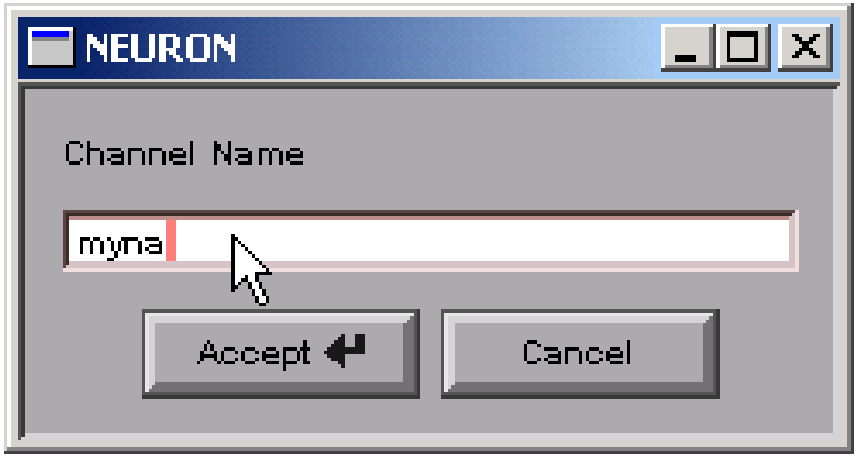


Name

Properties / Channel Name

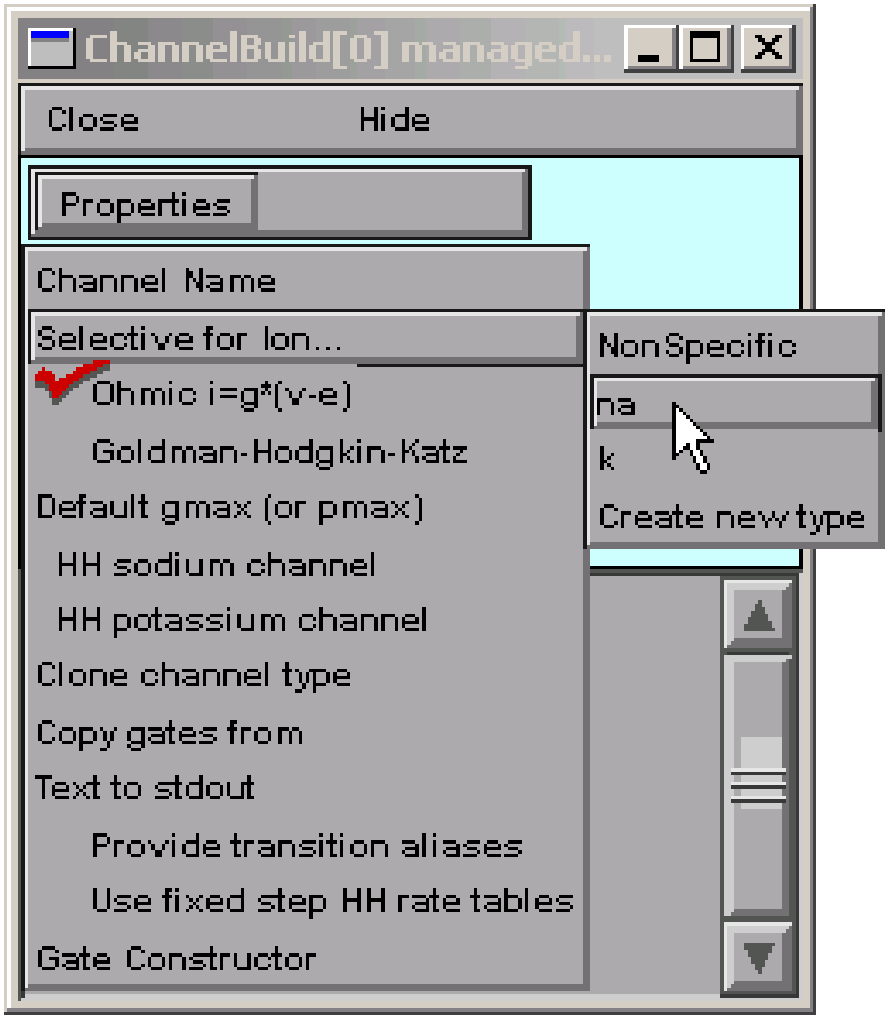
Then change leak to myna





Ion selectivity

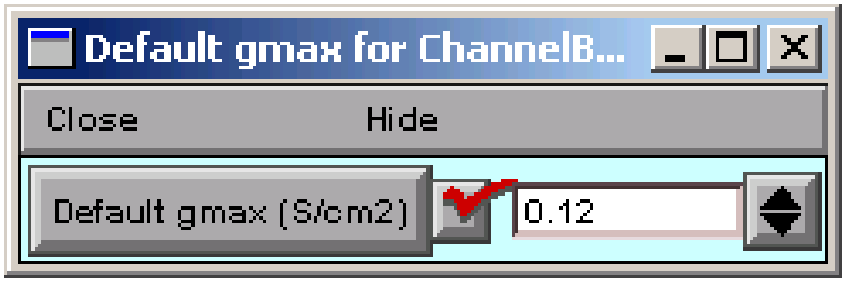
Properties
/ Selective for Ion... / na



Default conductance and equilibrium potential

Properties / Default gmax

Specify 0.12 S/cm2

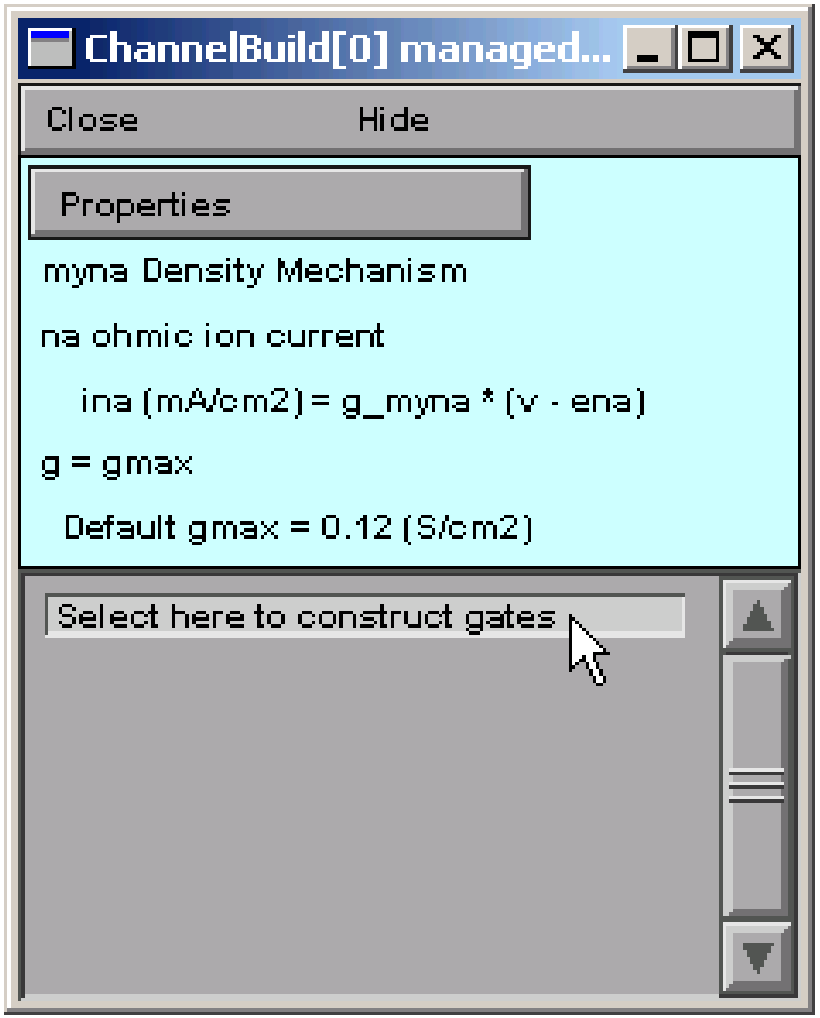


Equilibrium potential:

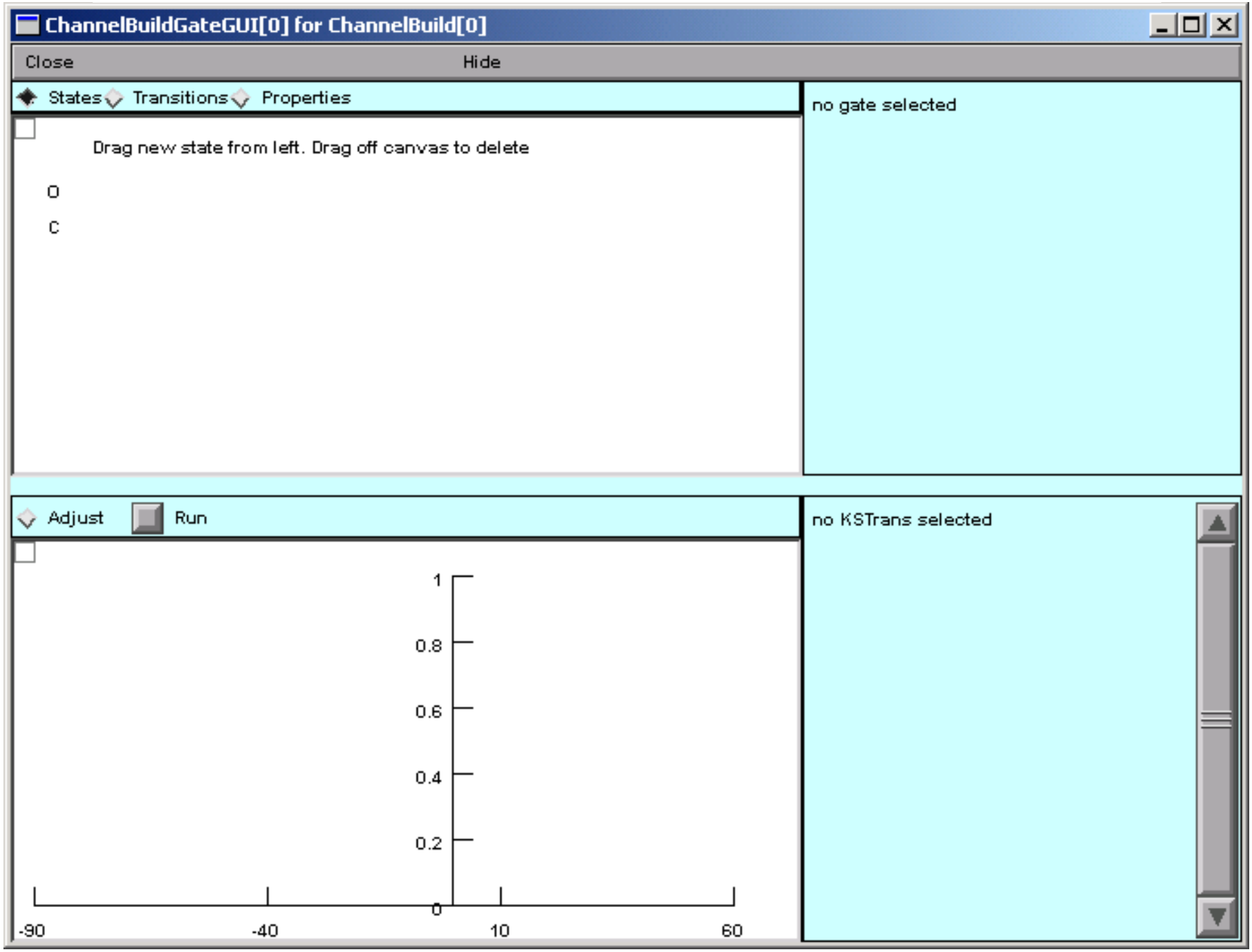
na has its own ena,
so nothing to do!

3. Specify channel gating

"Select here to construct gates"

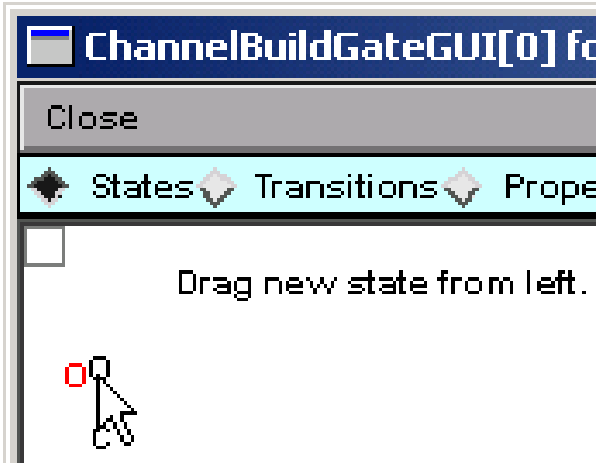


"GateGUI": States page



Spawn states

Click and drag O ("open") from palette . . .



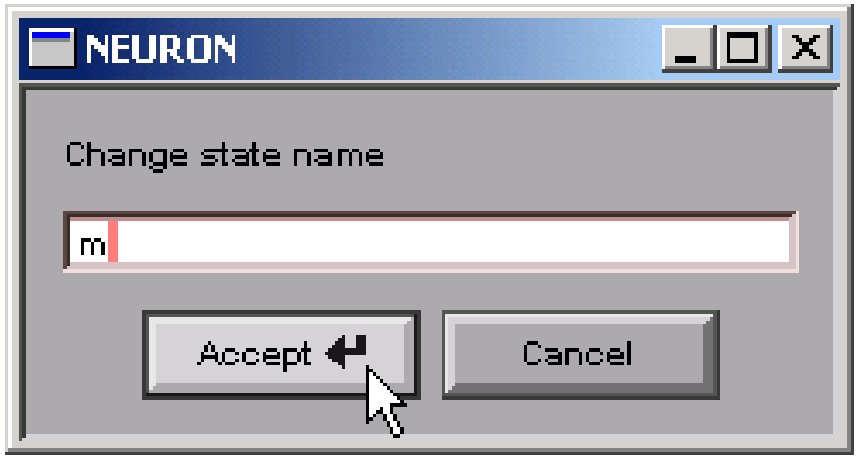
. . . to canvas.

Repeat for C ("closed")

Rename states

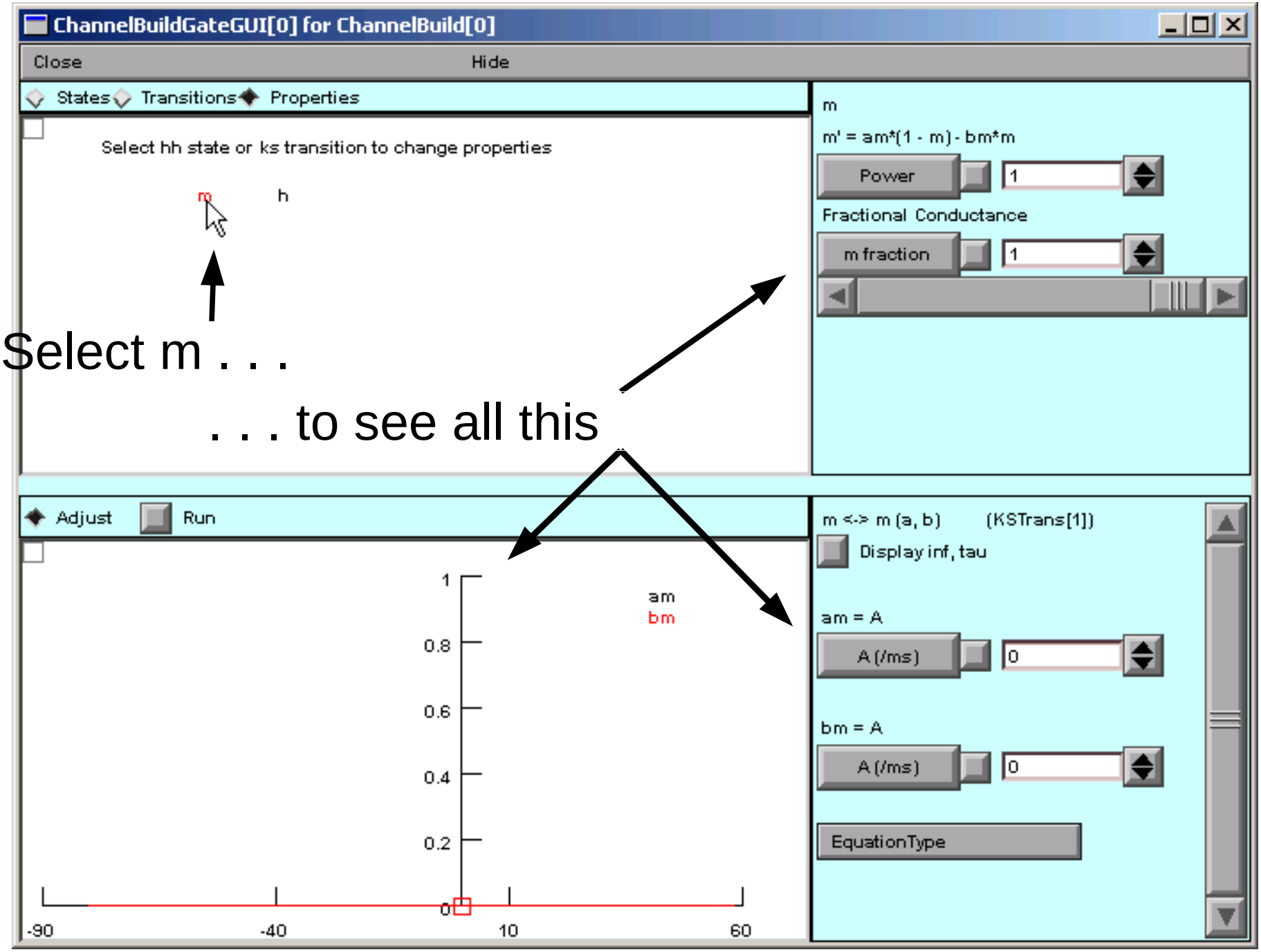
Click O without dragging

Change to m



Change C to h

"GateGUI": Properties page

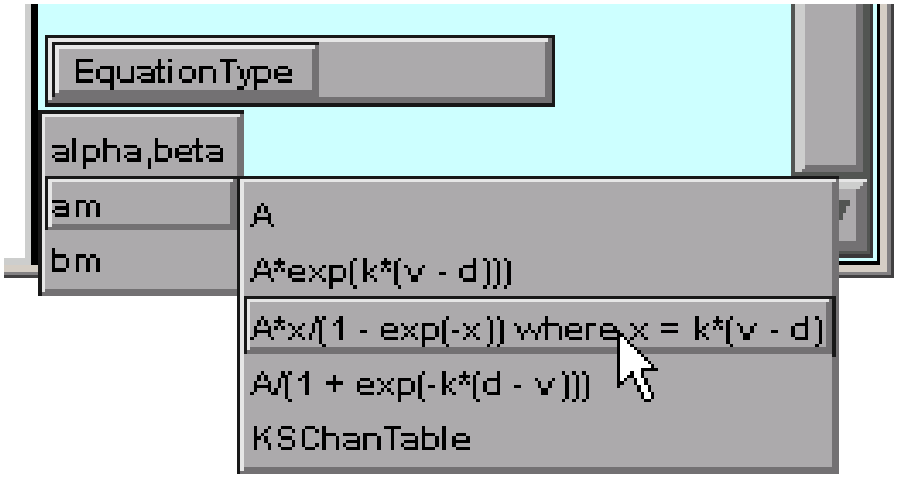


Set m exponent

Change Power to 3

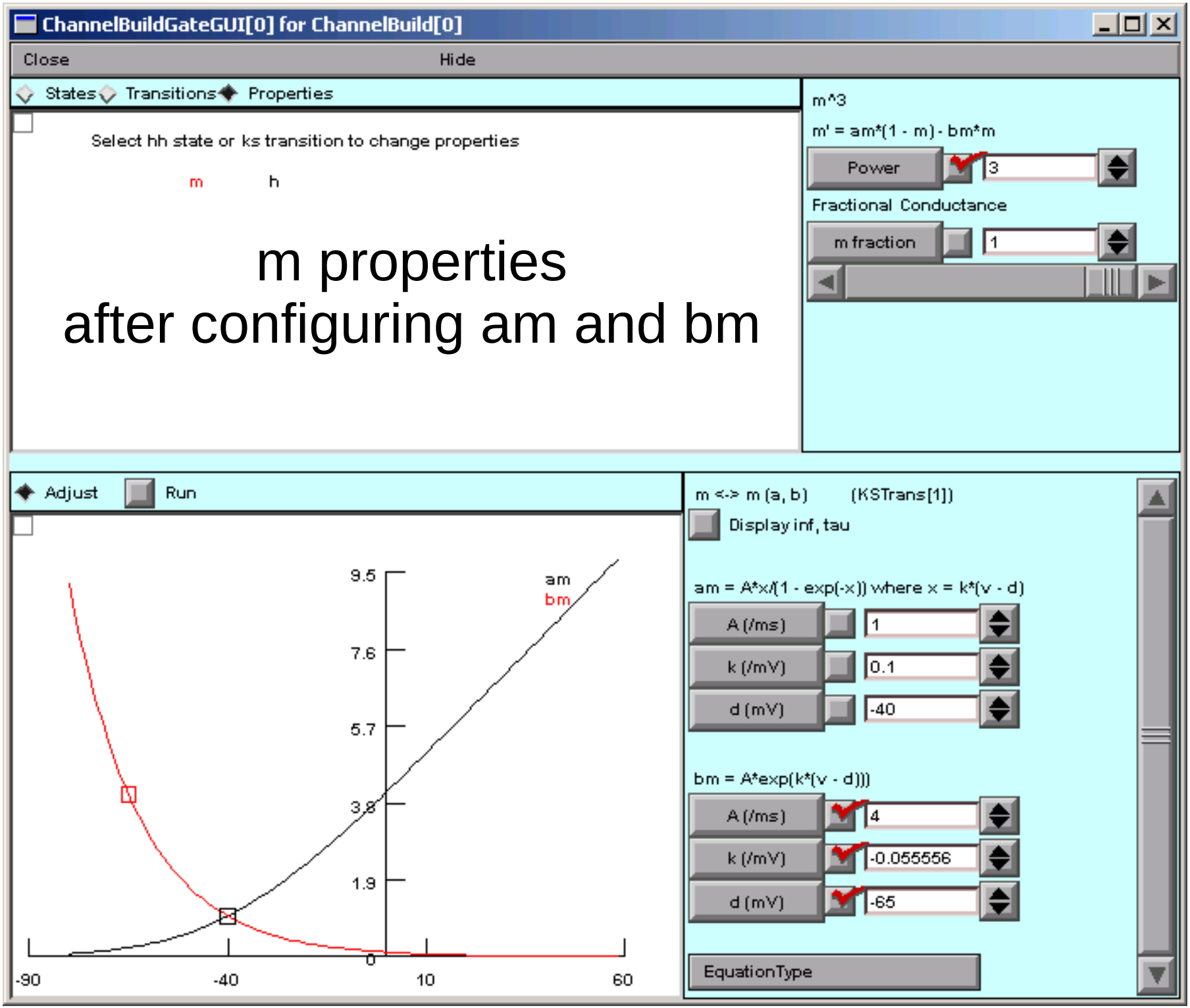
Specify voltage dependence of am and bm

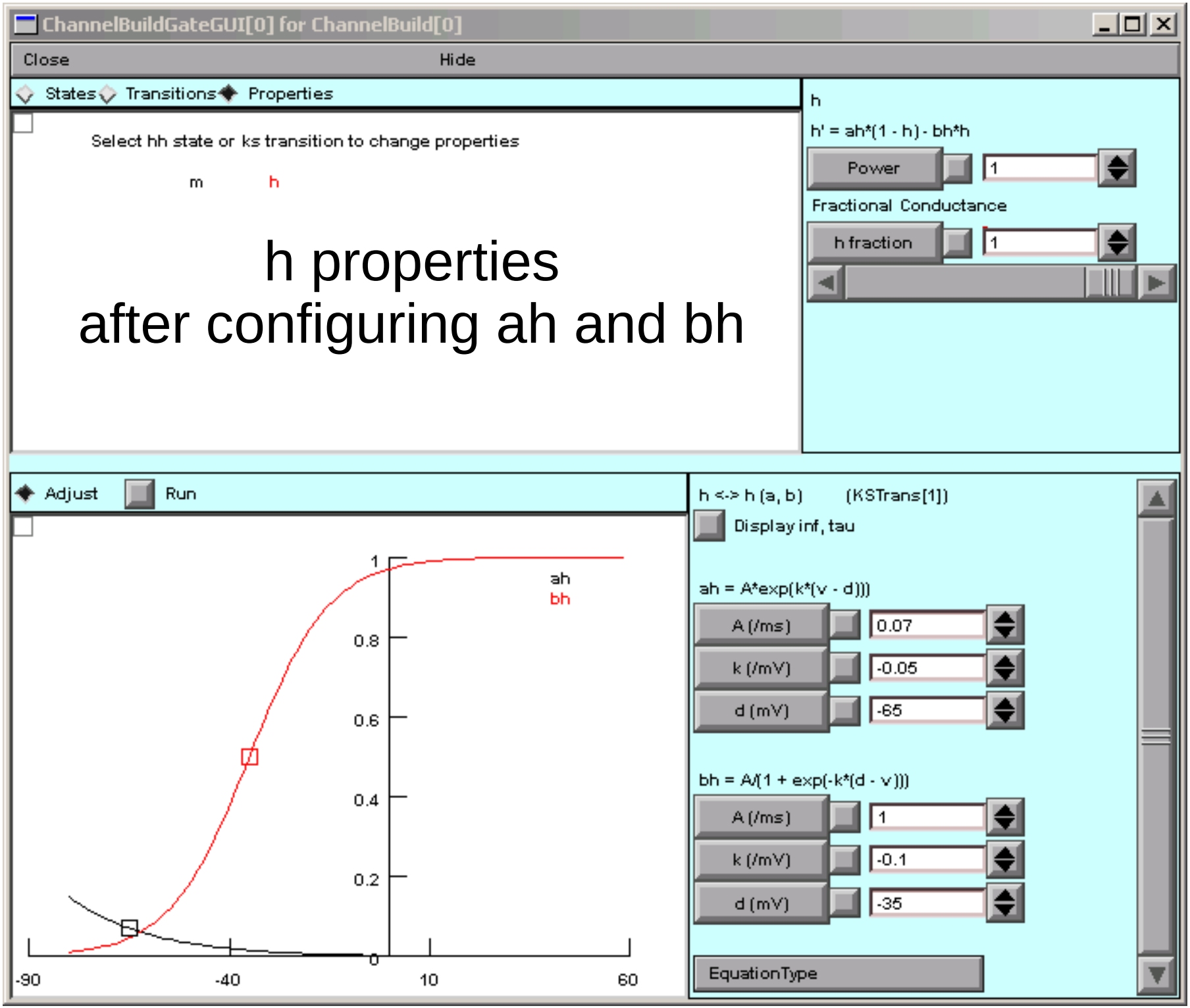
Choose functional form for am



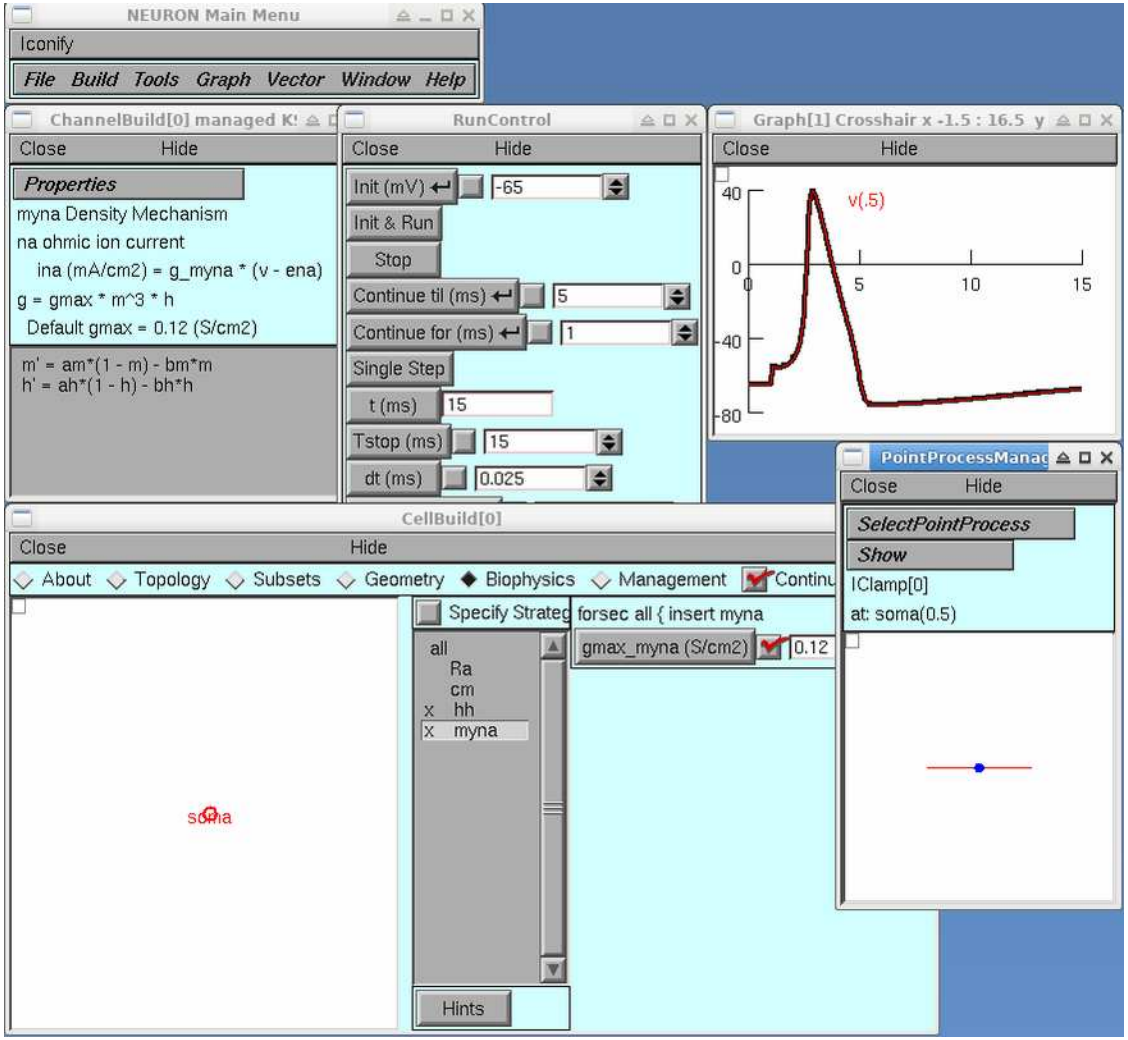
Set parameter values

Do same for bm


ChannelBuildGateGUI[0] for ChannelBuild[0]
Close
Hide
States
Transitions
Properties
Select hh state or ks transition to change properties
m
h
m properties
after configuring am and bm
m^3
m' = am*(1 - m) - bm*m
Power
3
Fractional Conductance
m fraction
1
Adjust
Run
9.5
7.6
5.7
3.8
1.9
0
am
bm
-90
-40
10
60
m <-> m (a, b)
(KSTrans[1])
Display inf, tau
am = A*x/(1 - exp(-x)) where x = k*(v - d)
A (/ms)
1
k (/mV)
0.1
d (mV)
-40
bm = A*exp(k*(v - d)))
A (/ms)
4
k (/mV)
-0.055556
d (mV)
-65
EquationType


ChannelBuildGateGUI[0] for ChannelBuild[0]
Close
Hide
States
Transitions
Properties
Select hh state or ks transition to change properties
m
h
h properties
after configuring ah and bh
h
h' = ah*(1 - h) - bh*h
Power
1
Fractional Conductance
h fraction
1
Adjust
Run
ah
bh
1
0.8
0.6
0.4
0.2
0
-90
-40
10
60
h <-> h (a, b)
(KSTrans[1])
Display inf, tau
ah = A*exp(k*(v - d)))
A (/ms)
0.07
k (/mV)
-0.05
d (mV)
-65
bh = A/(1 + exp(-k*(d - v)))
A (/ms)
1
k (/mV)
-0.1
d (mV)
-35
EquationType

Testing


NEURON Main Menu
Iconify
File Build Tools Graph Vector Window Help
ChannelBuild[0] managed K!
Close Hide
Properties
myna Density Mechanism
na ohmic ion current
ina (mA/cm2) = g_myna * (v - ena)
g = gmax * m^3 * h
Default gmax = 0.12 (S/cm2)
m' = am*(1 - m) - bm*m
h' = ah*(1 - h) - bh*h
RunControl
Close Hide
Init (mV) -65
Init & Run
Stop
Continue til (ms) 5
Continue for (ms) 1
Single Step
t (ms) 15
Tstop (ms) 15
dt (ms) 0.025
Graph[1] Crosshair x -1.5 : 16.5 y
Close Hide
v(.5)
40
0
-40
-80
0
5
10
15
PointProcessManag
Close Hide
SelectPointProcess
Show
IClamp[0]
at: soma(0.5)
CellBuild[0]
Close Hide
About Topology Subsets Geometry Biophysics Management Continu
Specify Strateg
forsec all { insert myna
all
Ra
cm
x hh
x myna
gmax_myna (S/cm2) 0.12
Hints
soma