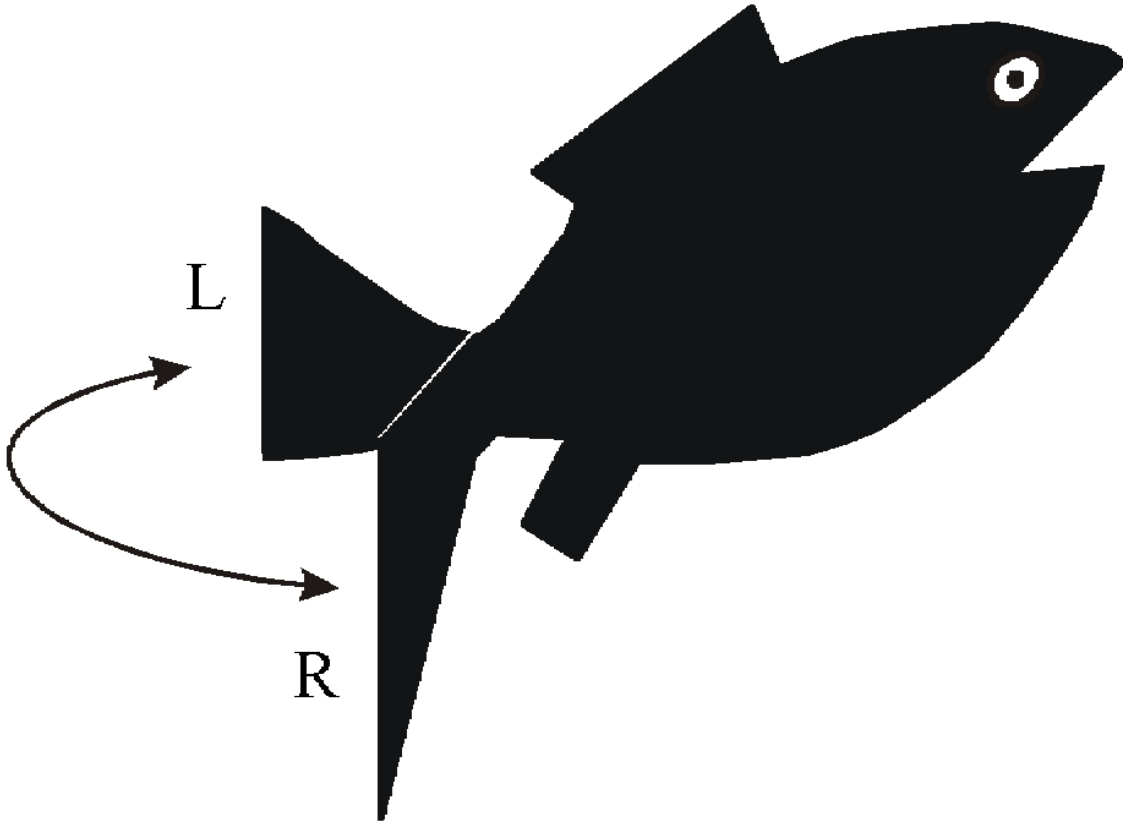
Swimmy



Advantages of Swimmy

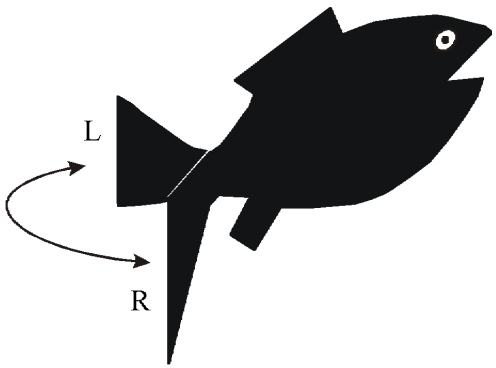
1) Very faithful simulation of neural activity

2) Flawless electrode placement.

3) No extraneous noise issues--including extraneous biological noise.

4) No need to troubleshoot
   --no impedence mismatches
   --ground loops
   --no wiring problems
   --etc., etc

5) No need for expensive amps, oscilloscopes, A-D converters, etc

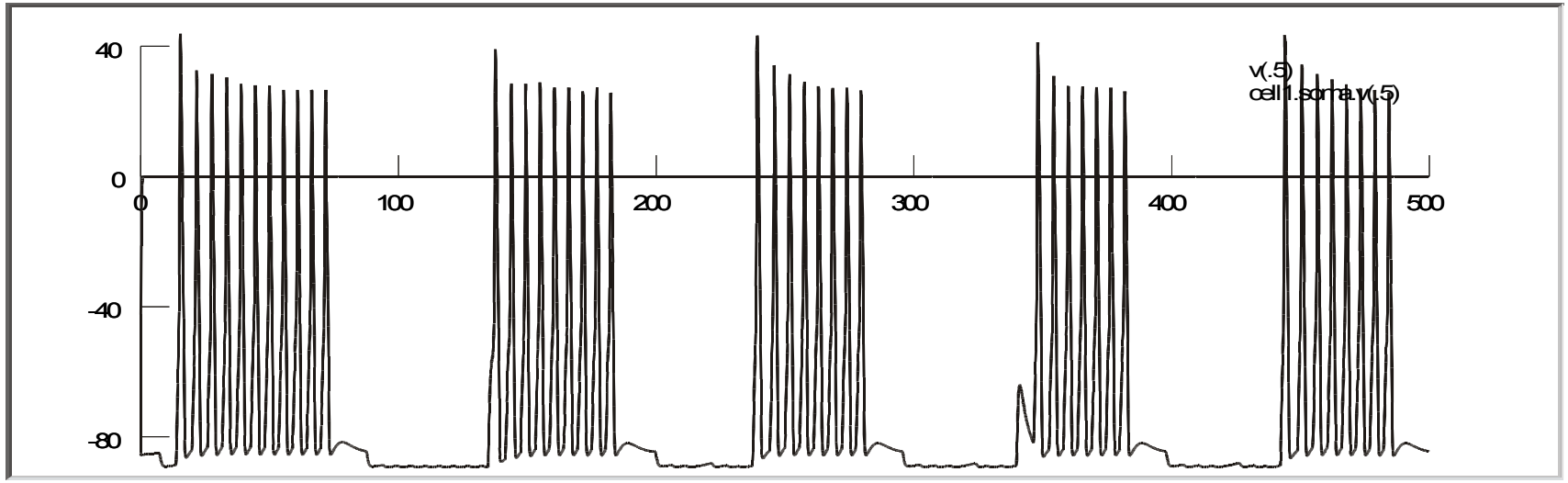


Swimmy

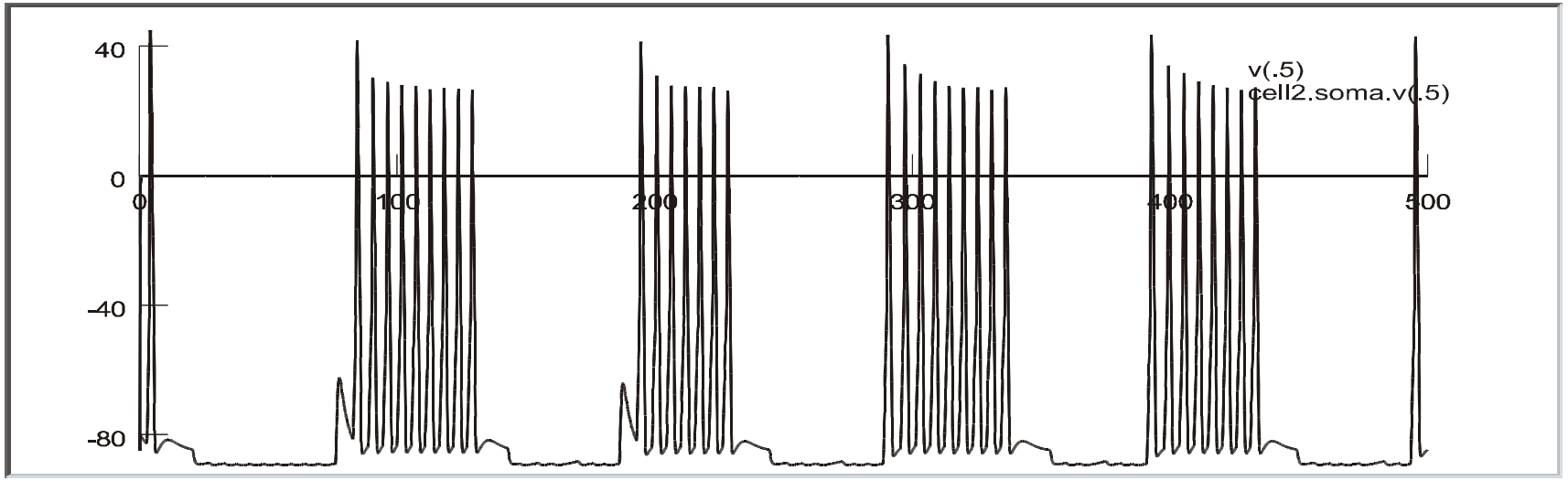
A remarkably faithful

simulation of neural activity

Left flexor motor neuron



Right flexor motor neuron



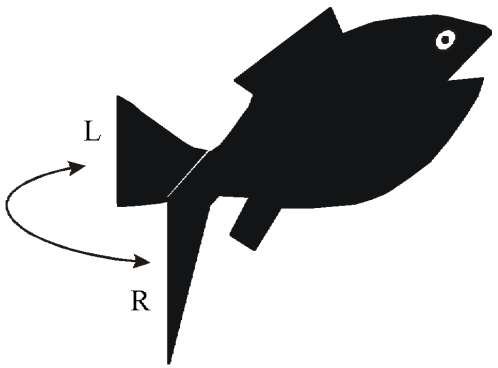
Why do the action potentials get smaller if they are later in the flurry?

The all-or-none-law

isn’t quite

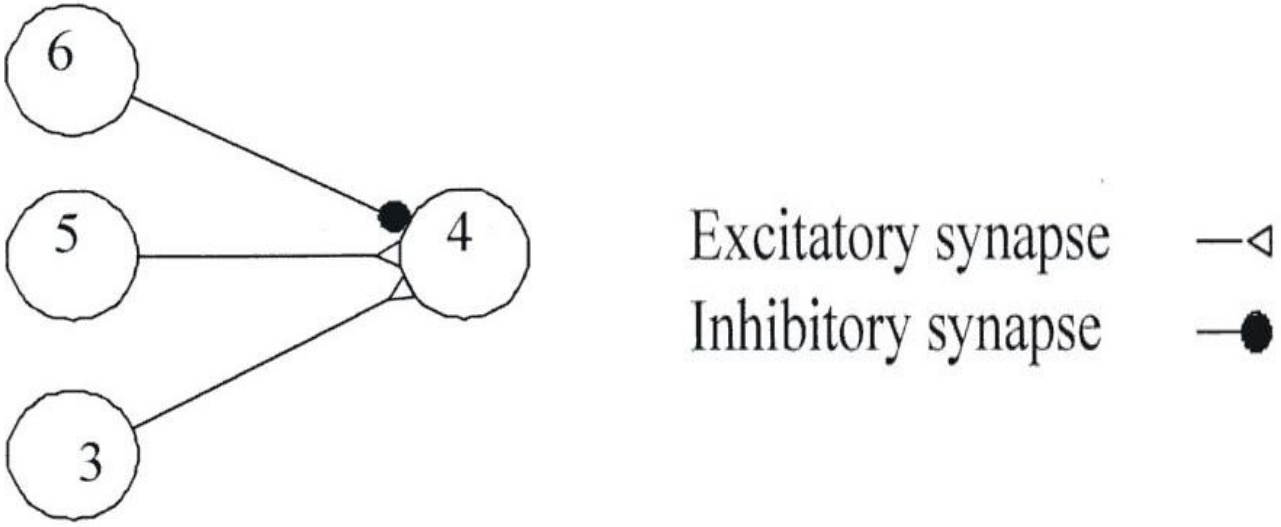
ALL true!

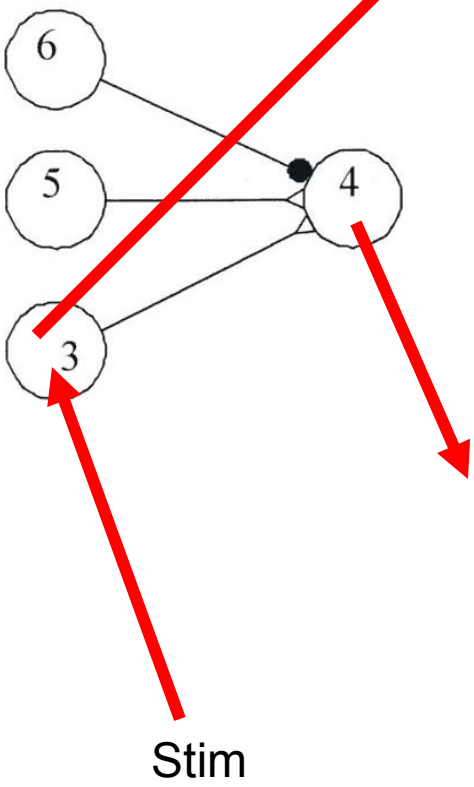
Swimmy

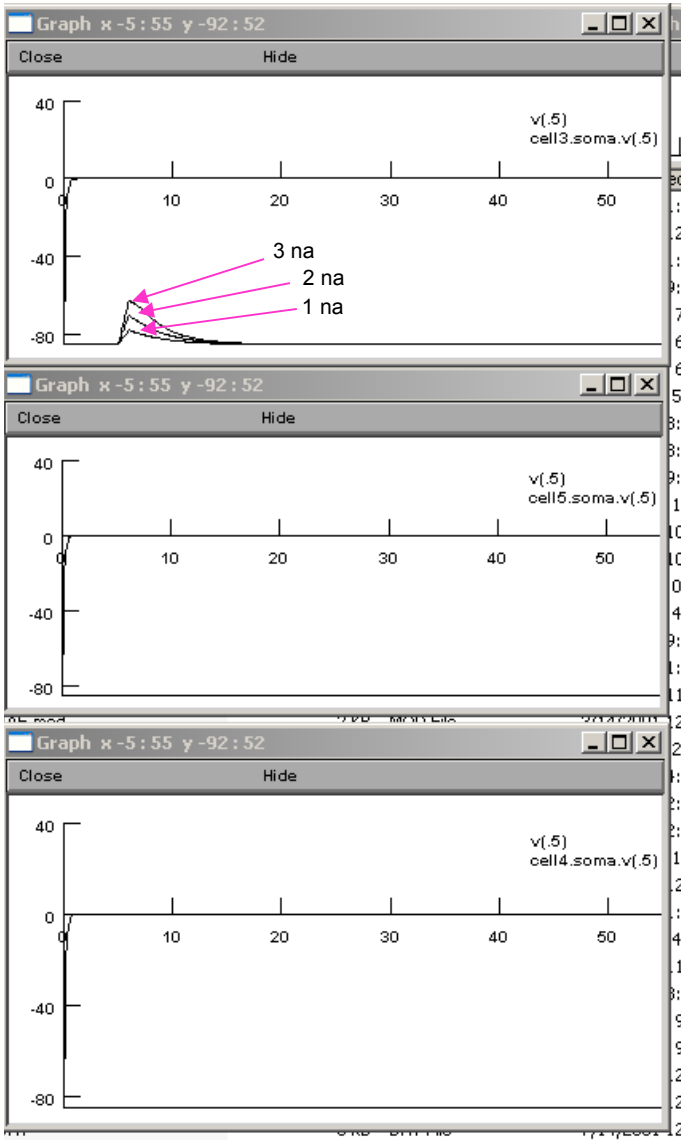


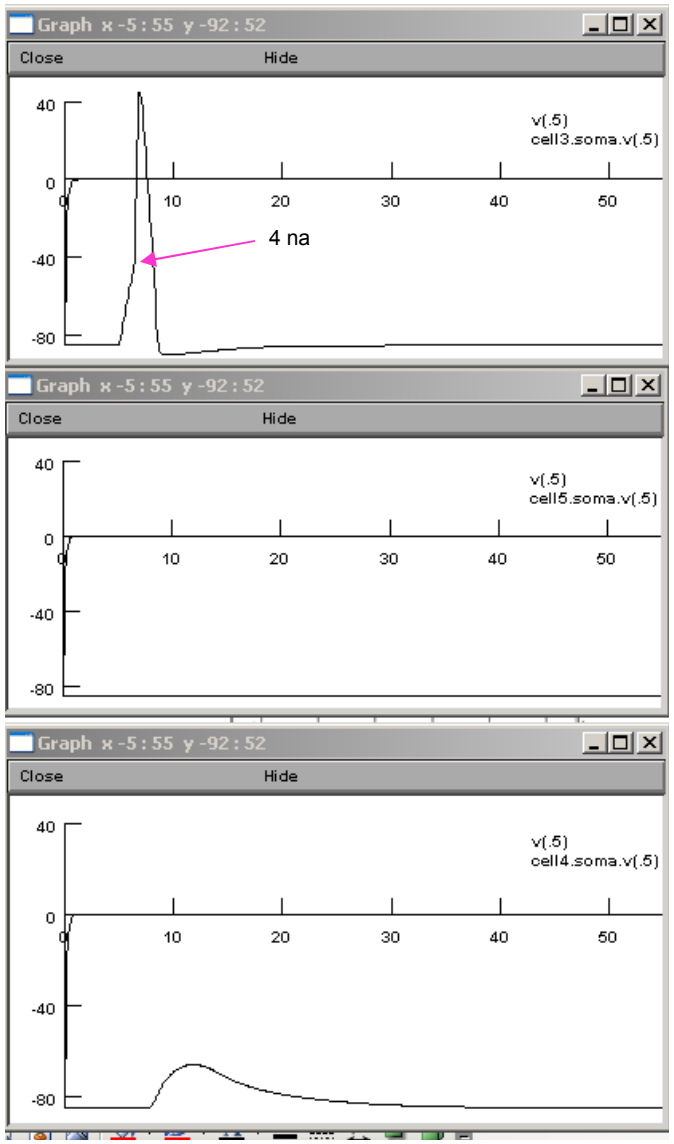
SWIMMY is a virtual exercise for exploring Central Pattern Generators

Basic Facts of Neurophysiology





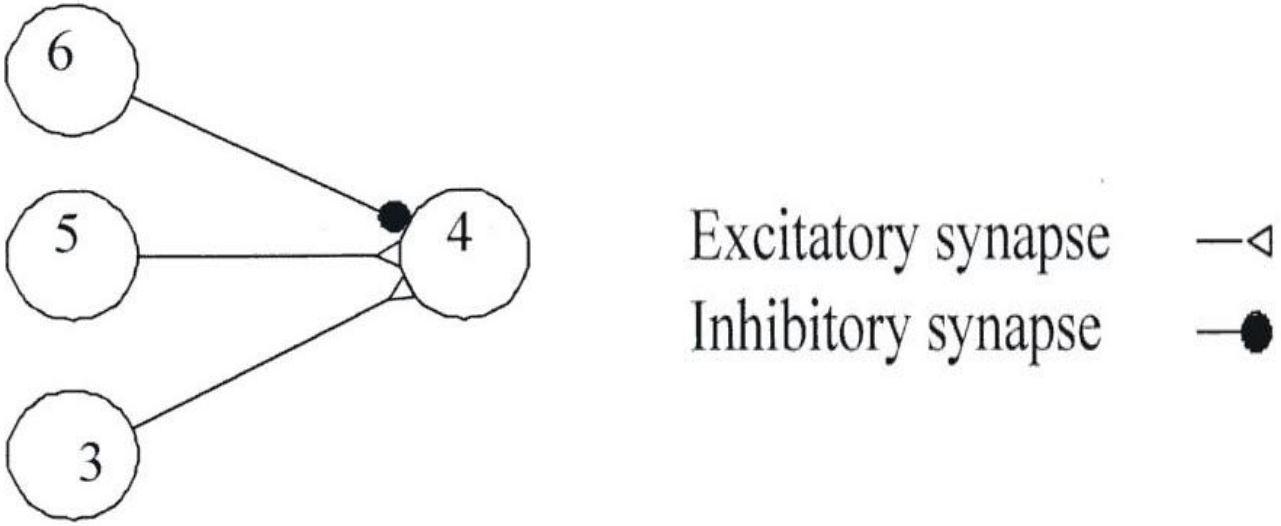




Subthreshold

Suprathreshold

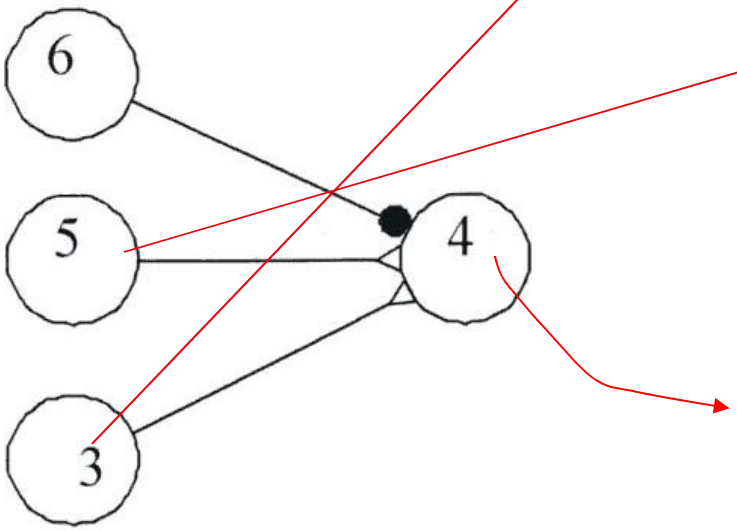
Basic Facts of Neurophysiology

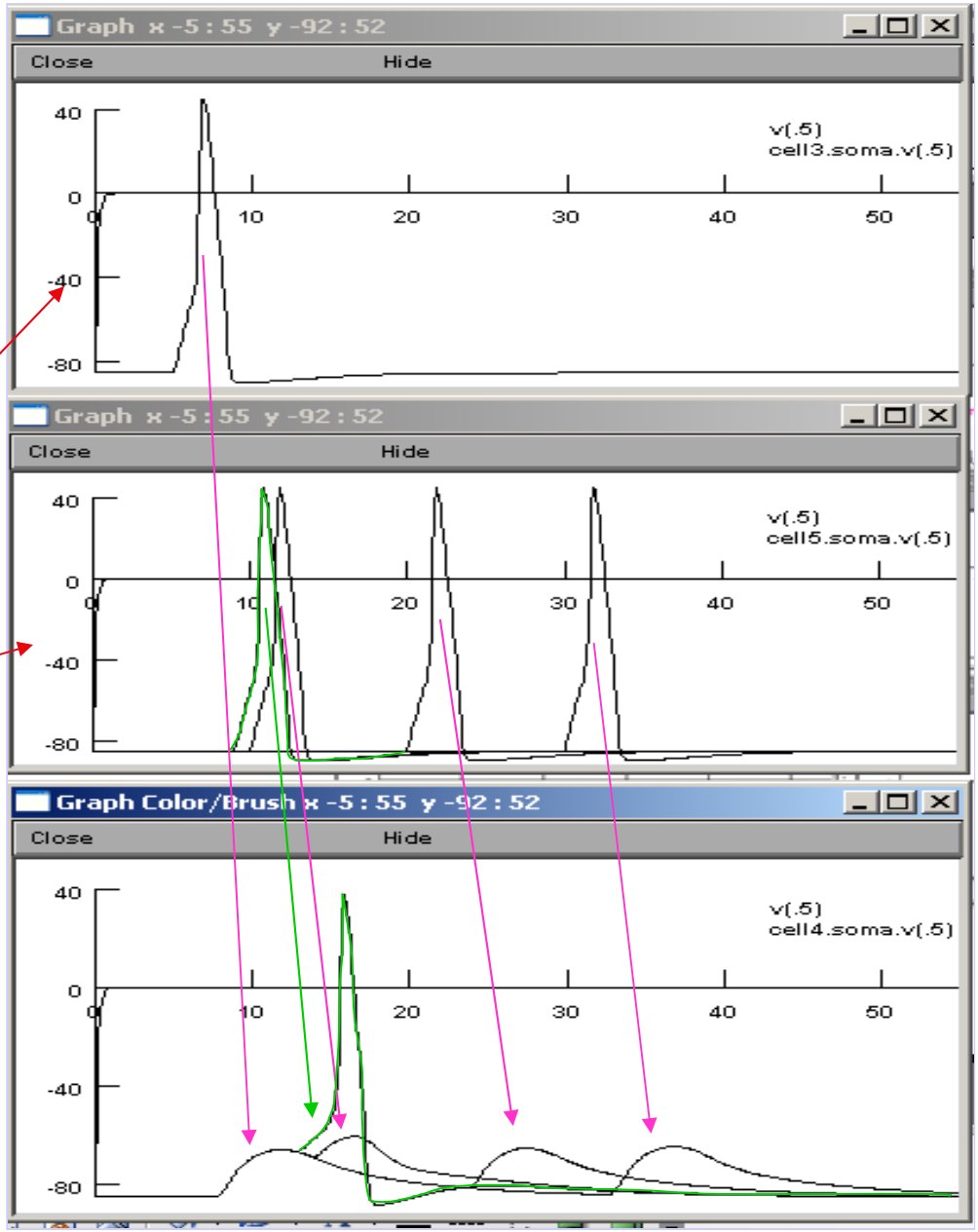


Neurons exhibit spatial and temporal summation:

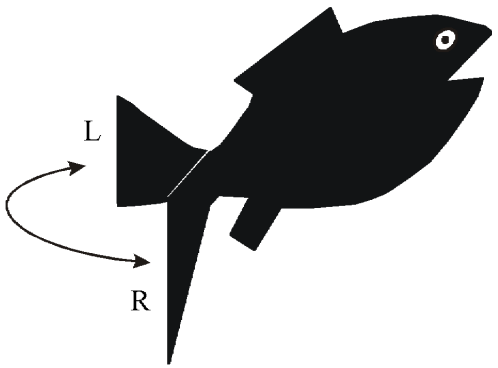
- Spatial involves more than one input
- Temporal involves time interval

Spatial and Temporal Summation

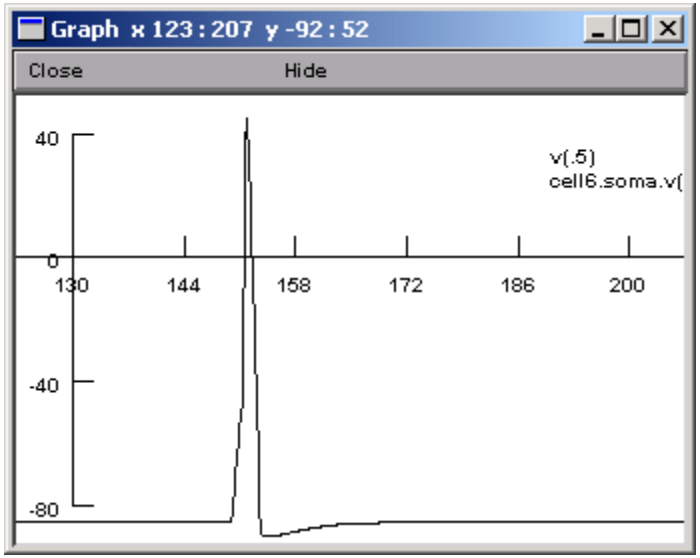


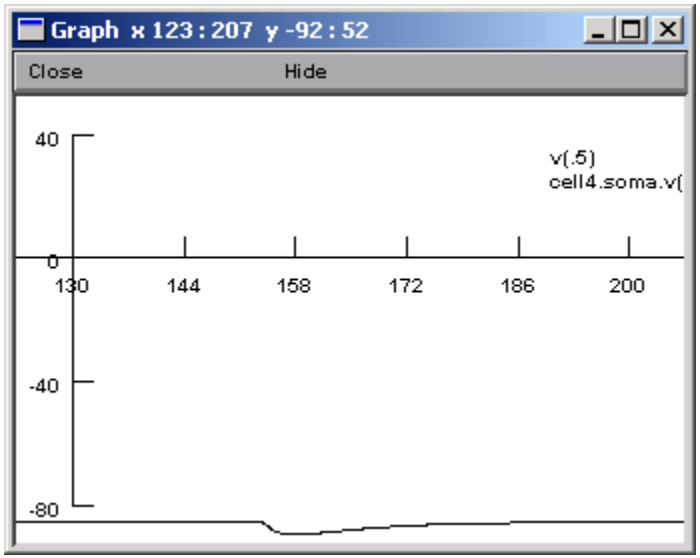


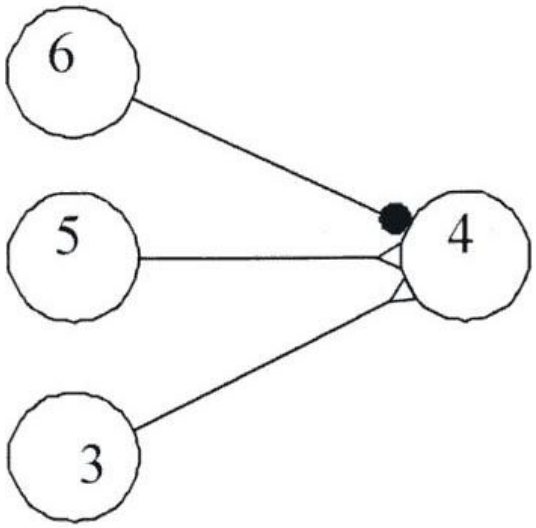
Swimmy



The True Nature
of
Inhibition

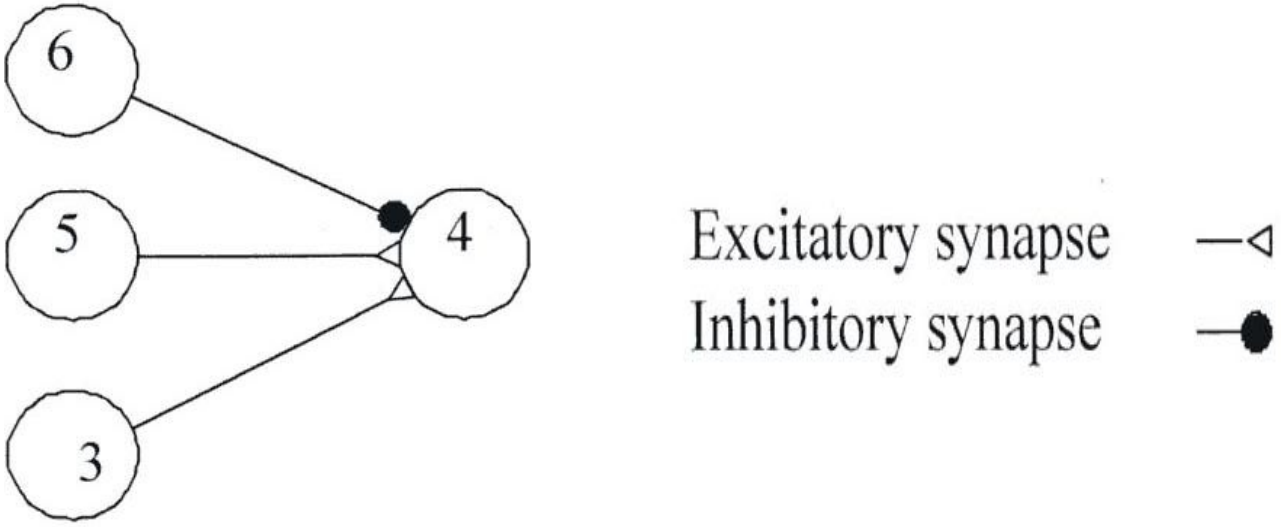


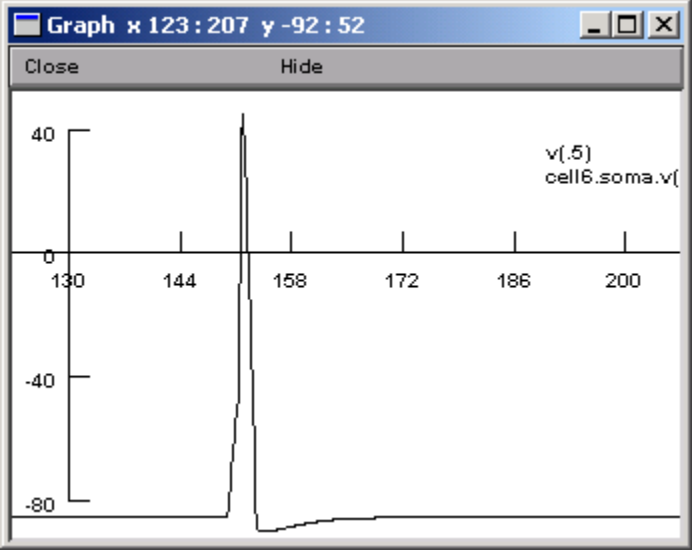


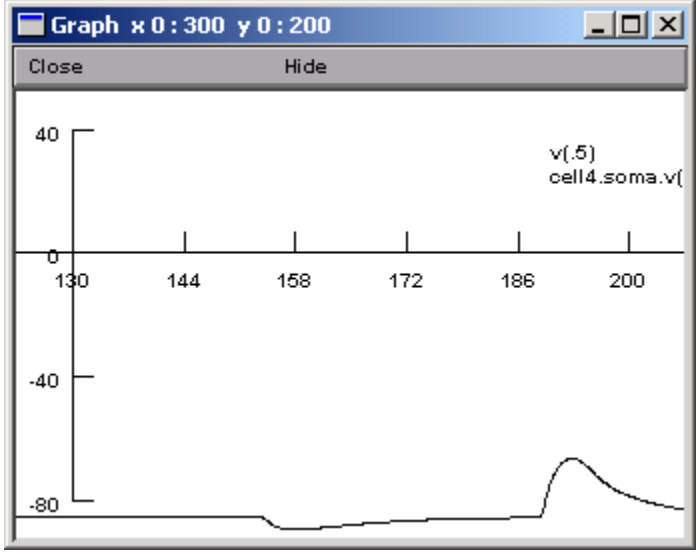


Inhibition--note IPSPs tend to be small in amplitude.

Basic Facts of Neurophysiology




Graph x 123 : 207 y -92 : 52
Close
Hide
40
0
-40
-80
130
144
158
172
186
200
v(.5)
cell6.soma.v(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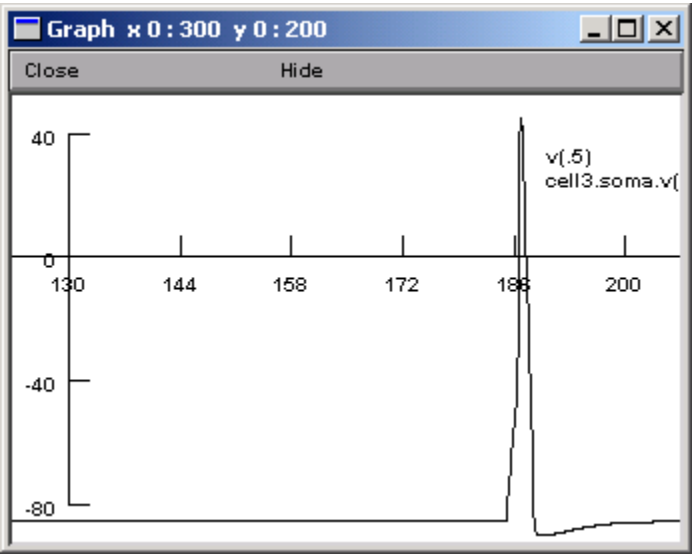
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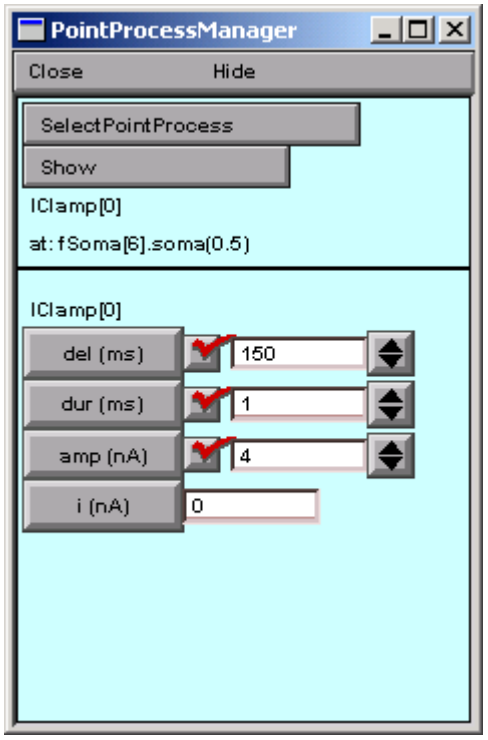
PointProcessManager
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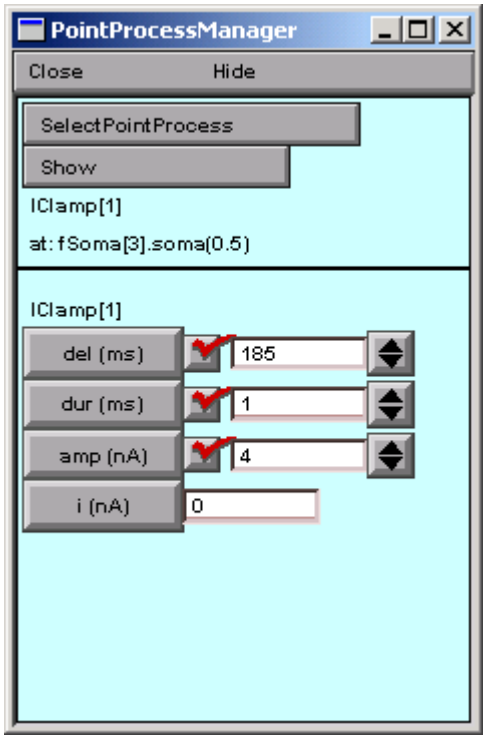
Hide
SelectPointProcess
Show
IClamp[0]
at: fSoma[6].soma(0.5)
IClamp[0]
del (ms)
150
dur (ms)
1
amp (nA)
4
i (nA)
0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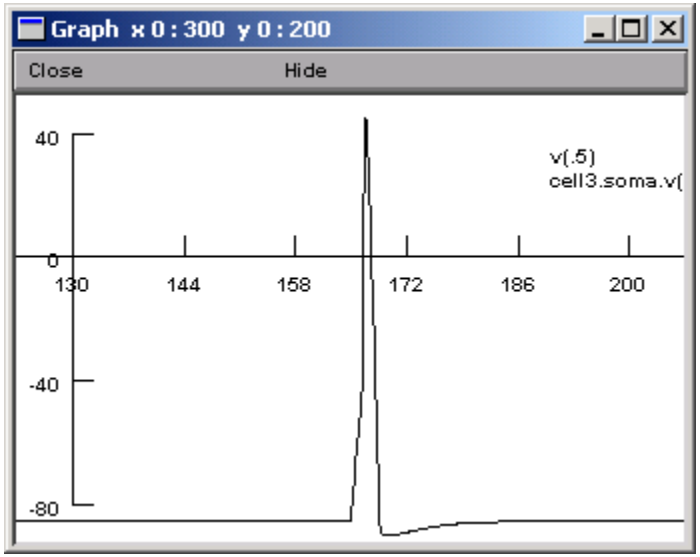
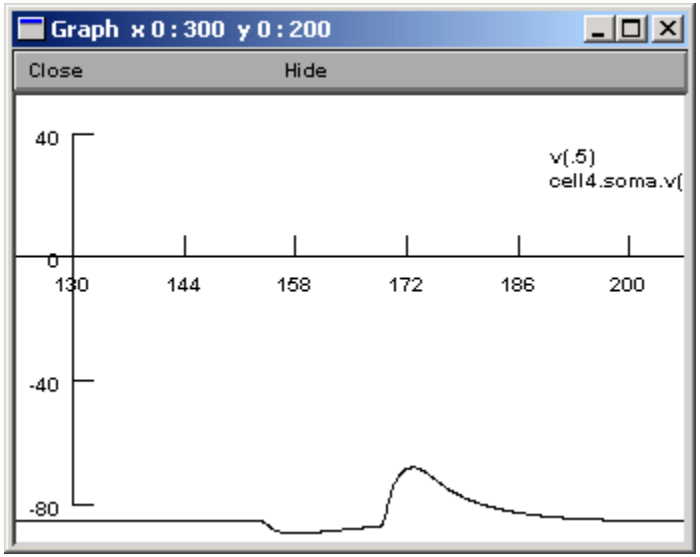
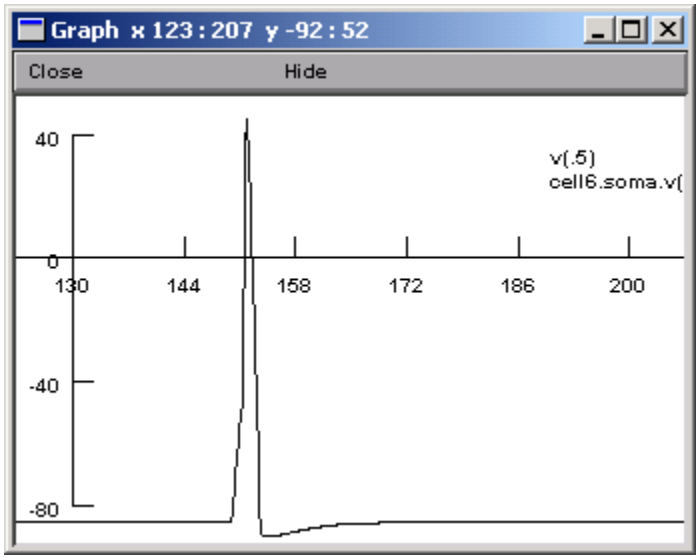
dur (ms)
1
amp (nA)
4
i (nA)
0

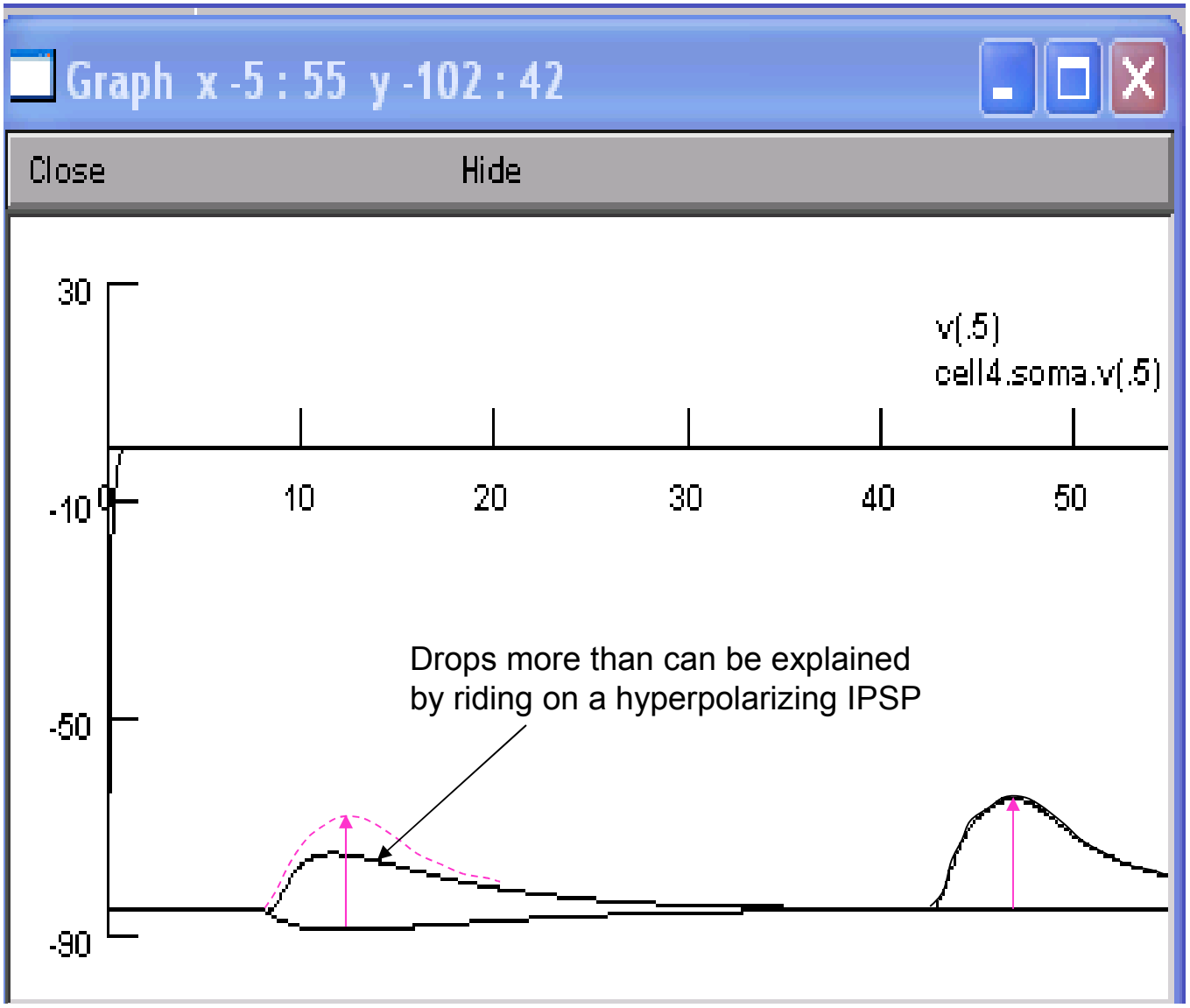




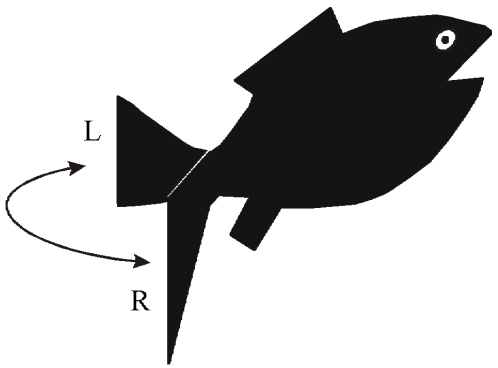


IPSP is 3 mV below baseline.

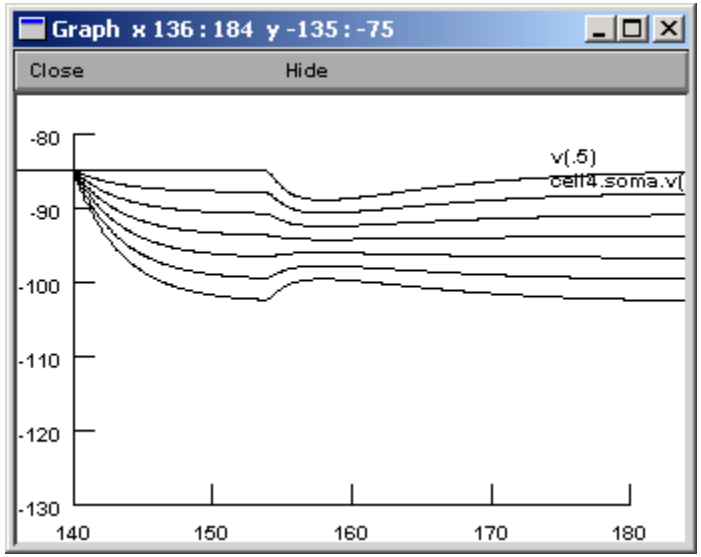
Inhibition works in two ways

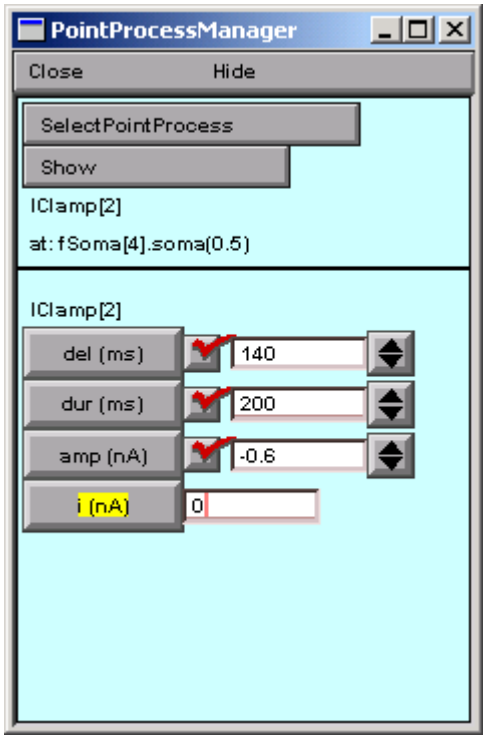


Swimmy

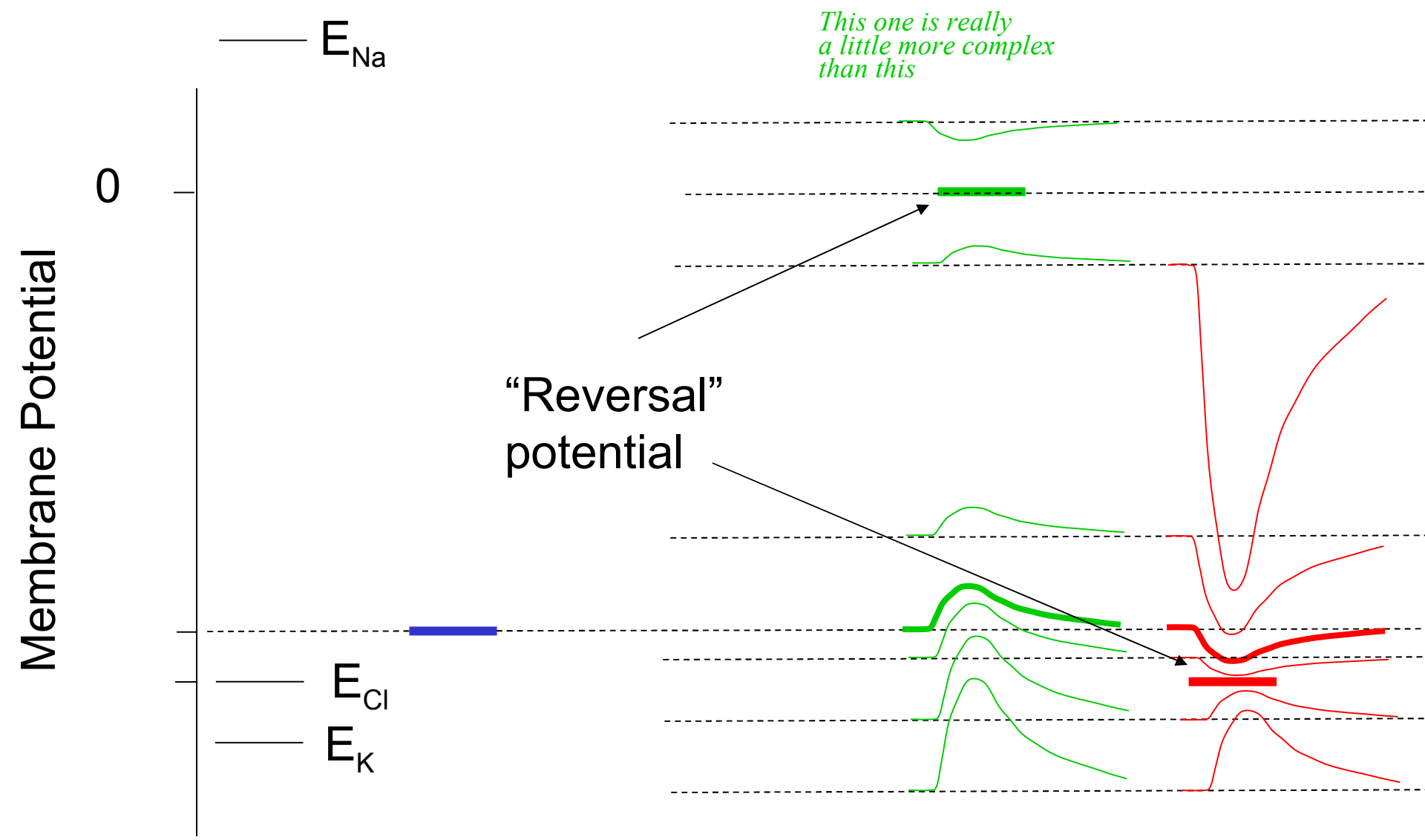


Reversal Potentials





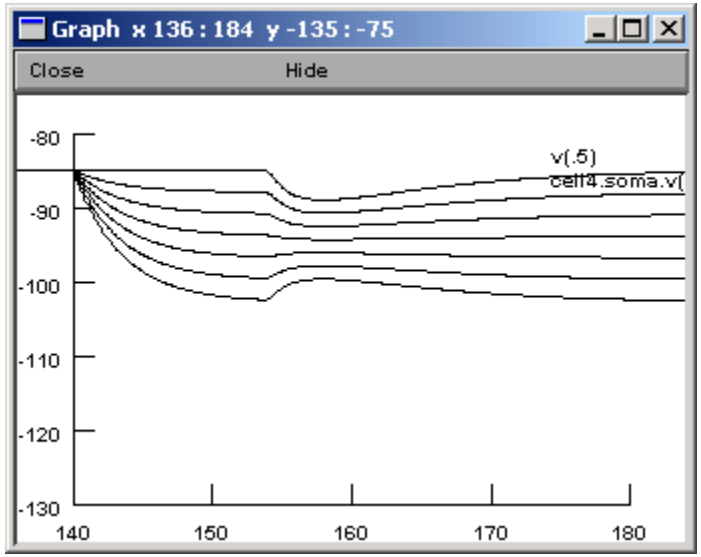
Reversal potential and flipping over IPSPs into “EPSPs.”

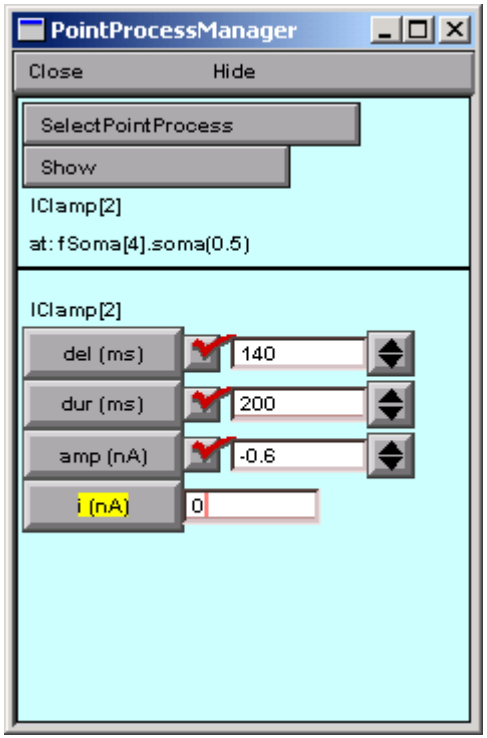


Rest:
P_K moderate
P_{Cl} moderate
P_{Na} v. small

EPSP:
P_K high
P_{Cl} high
P_{Na} high

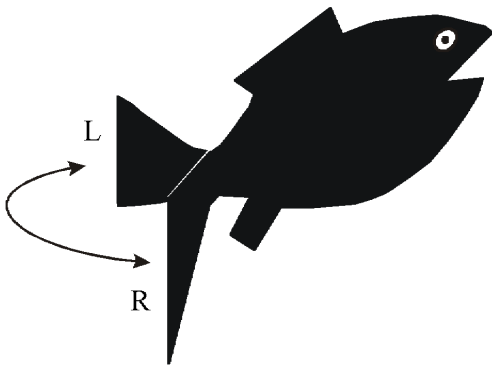
IPSP:
P_K mod (hi)
P_{Cl} high (lo)
P_{Na} v. small





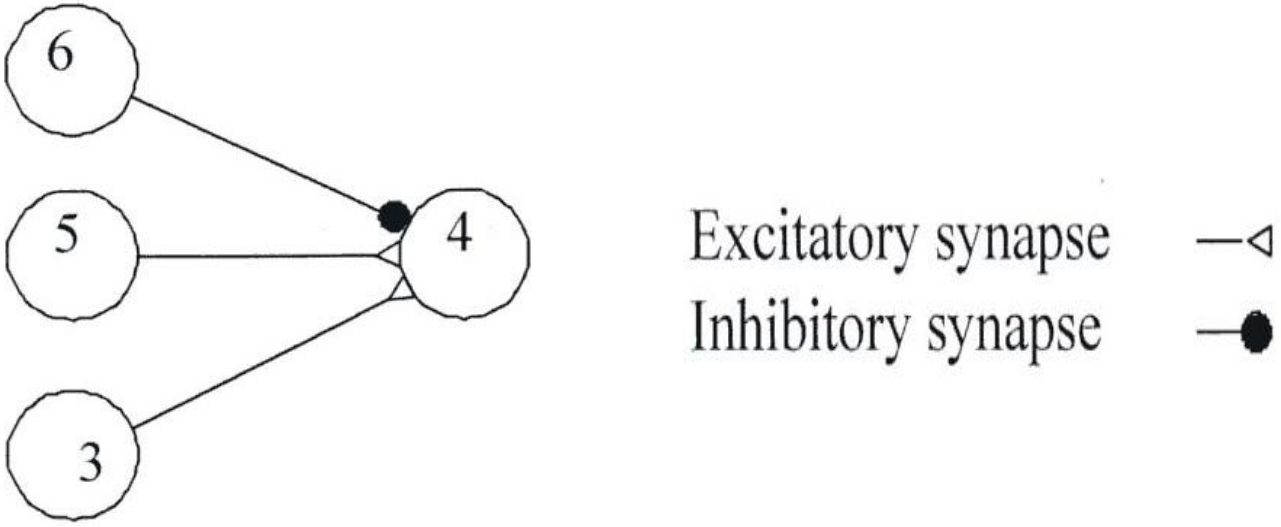
Reversal potential and flipping over IPSPs into “EPSPs.”

Swimmy



Facilitation
and
Depression

Basic Facts of Neurophysiology



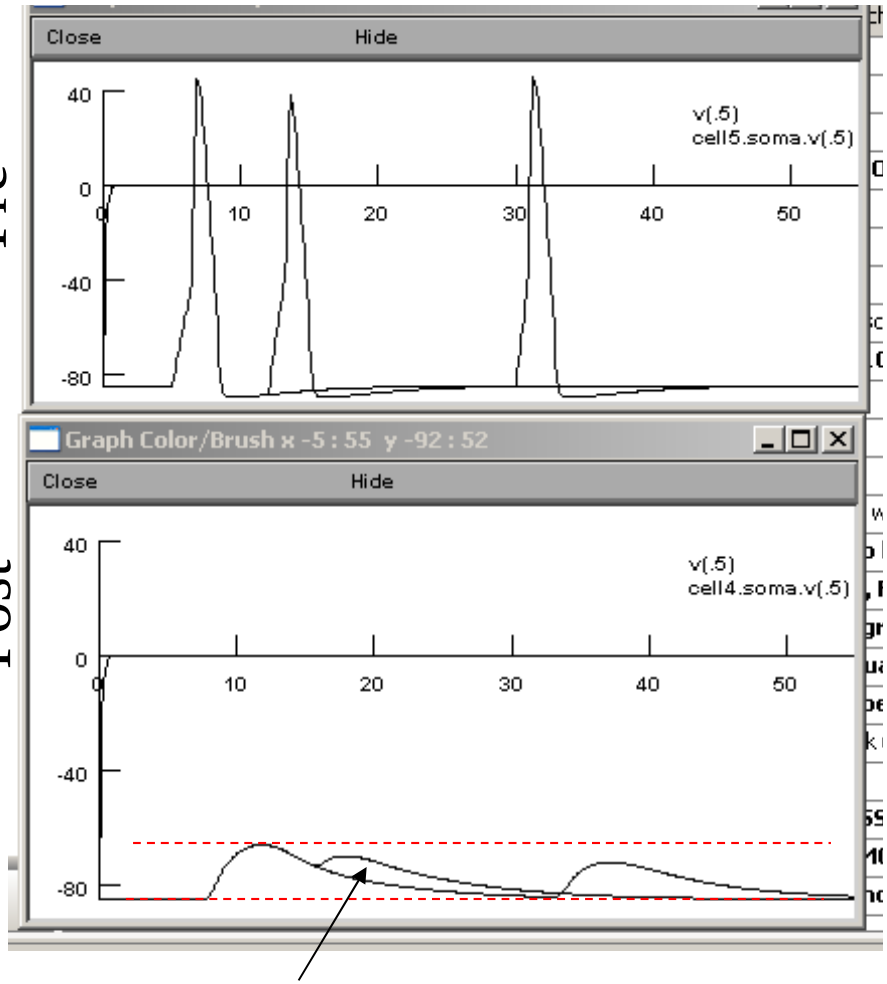
Depression and Facilitation: Kinds of synaptic plasticity

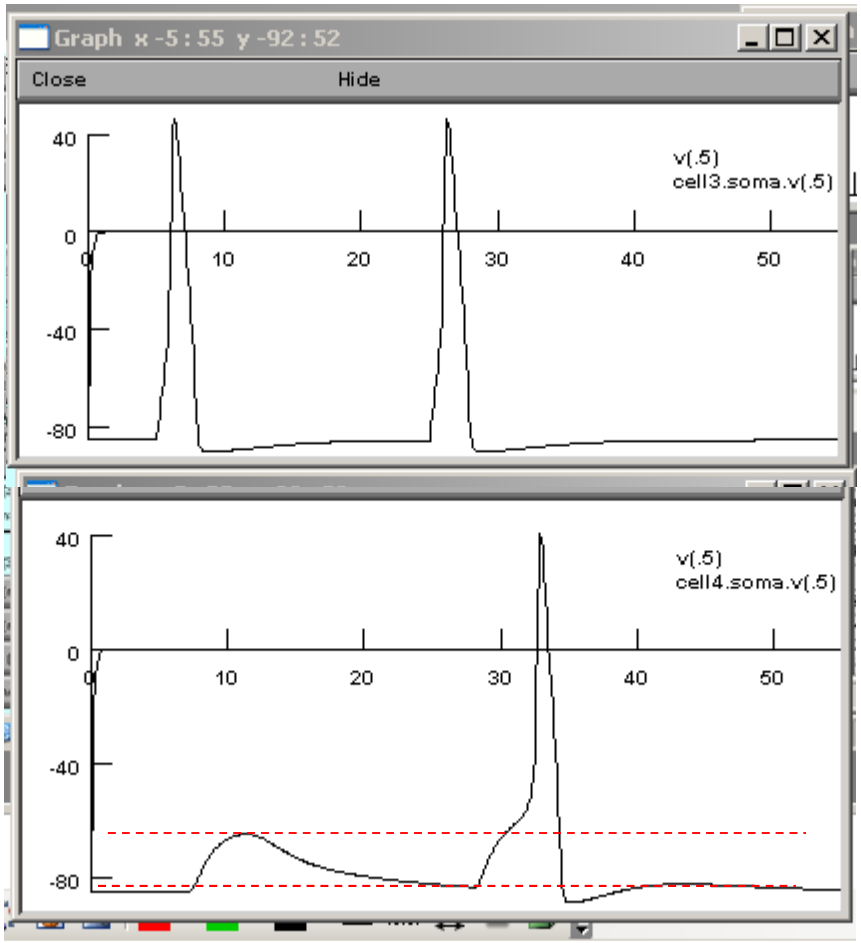
Depression

Facilitation

Pre

Post





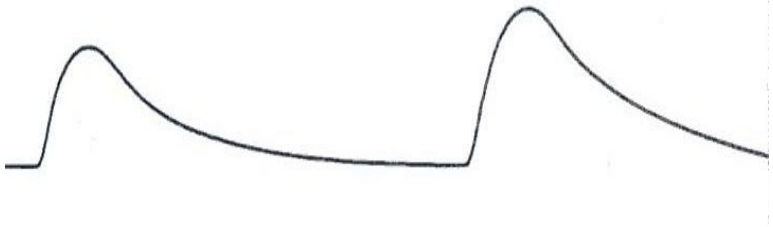
Watch out. This may be small due to shunting.

Facilitation vs. Depression

Both are properties of synapses and are referred to as neural plasticity.

In facilitation, the synapse is more effective while in depression it is less effective.

Facilitation:



Depression:

Depression vs. Summation with Inhibition

Depression occurs when a synapse produces a smaller PSP the second time it is stimulated. This phenomenon is due to presynaptic changes.

Inhibition of a neuron may cause an EPSP to decrease in size due to summation with an IPSP. This phenomenon is completely postsynaptic and does not constitute depression.

Facilitation vs. Summation

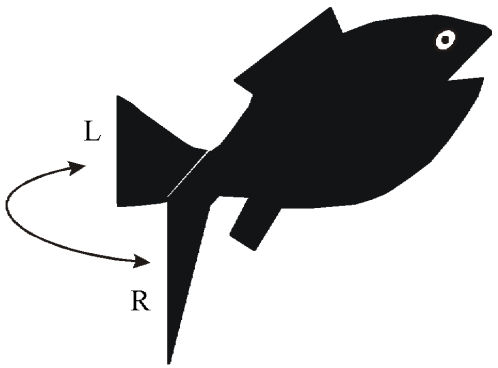
Facilitation occurs when one a synapse exhibits a larger PSP the second time it is stimulated. The change is due to presynaptic phenomena.

Summation is when post synaptic potentials combine--This is completely postsynaptic and does not constitute facilitation.

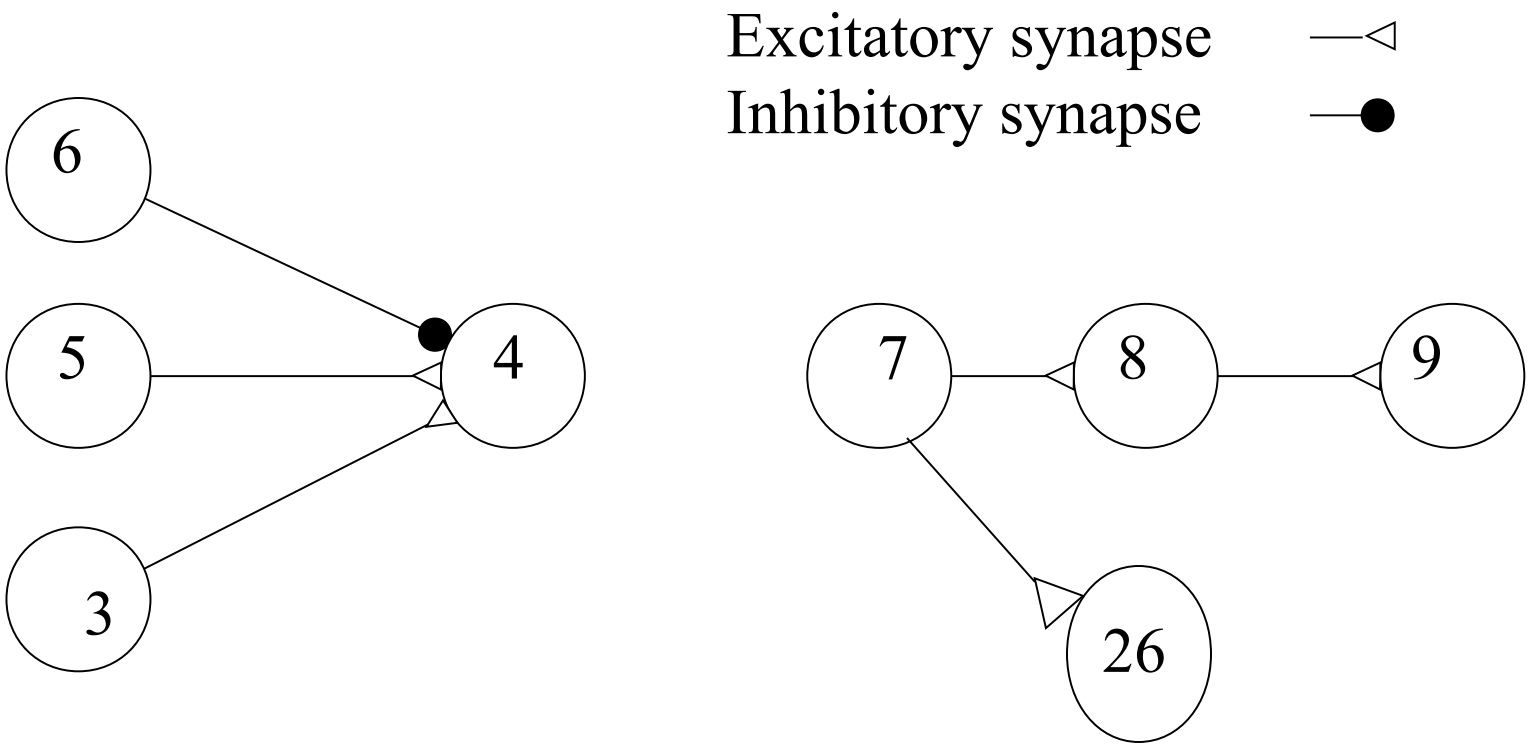
Facilitation and depression are both forms of synaptic plasticity that are NOT related to LTP.

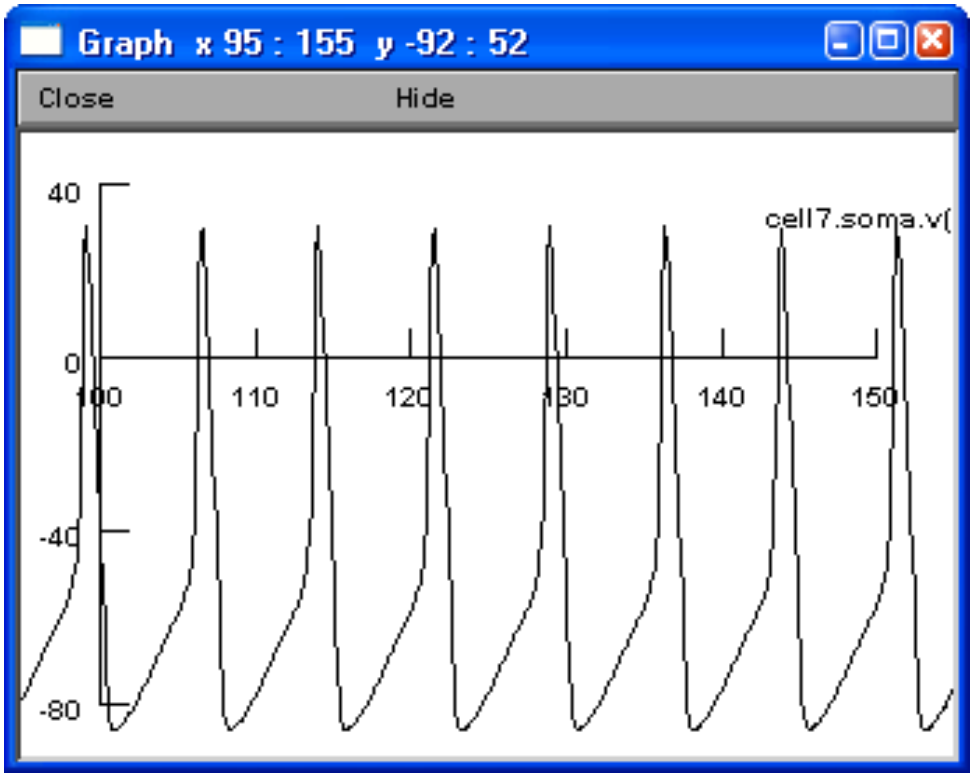
1) Facilitation and depression are believed to be presynaptic whereas LTP is believed to be postsynaptic.
2) Facilitation and depression have much shorter time courses than LTP.

Swimmy

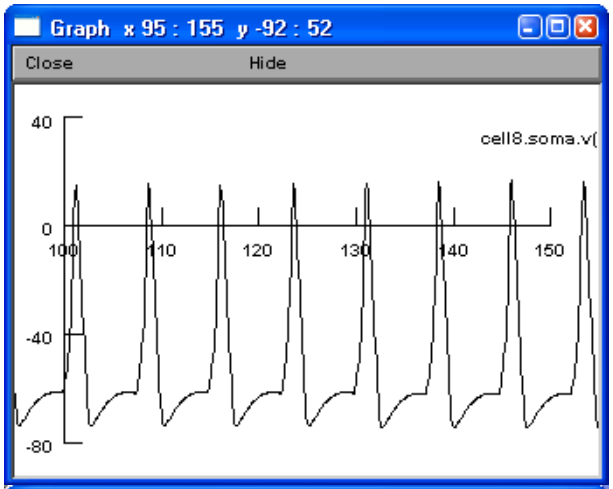


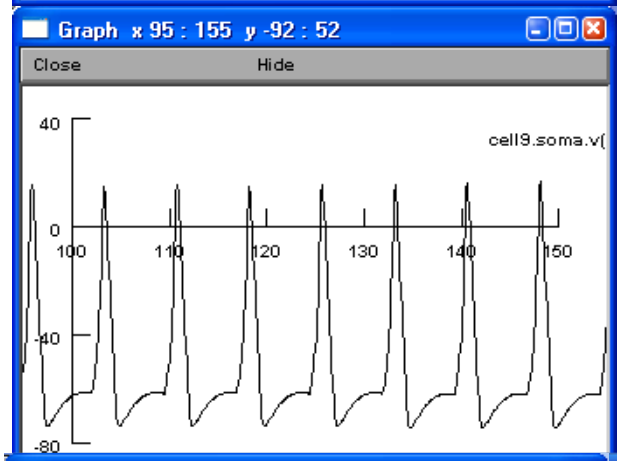
Endogenous
Properties
of
Neurons

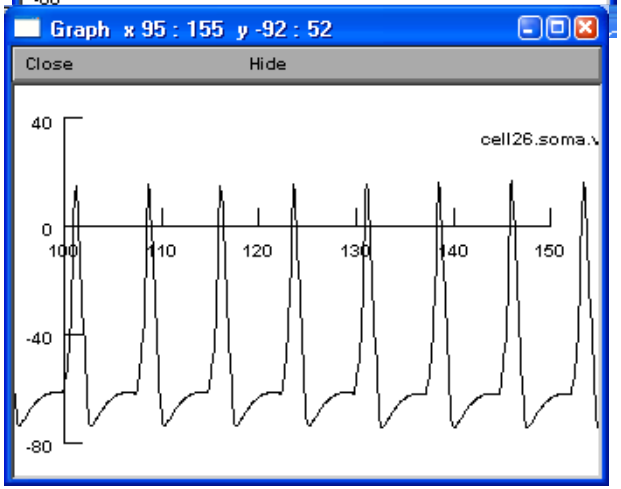

Excitatory synapse
Inhibitory synapse
6
5
3
4
7
8
9
26

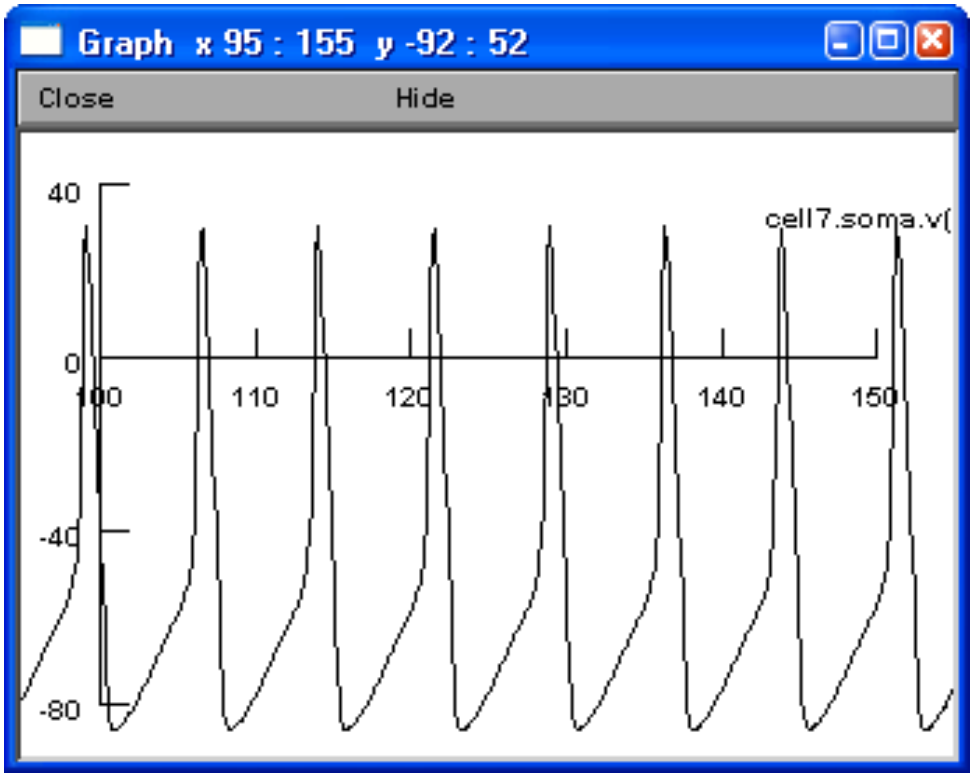


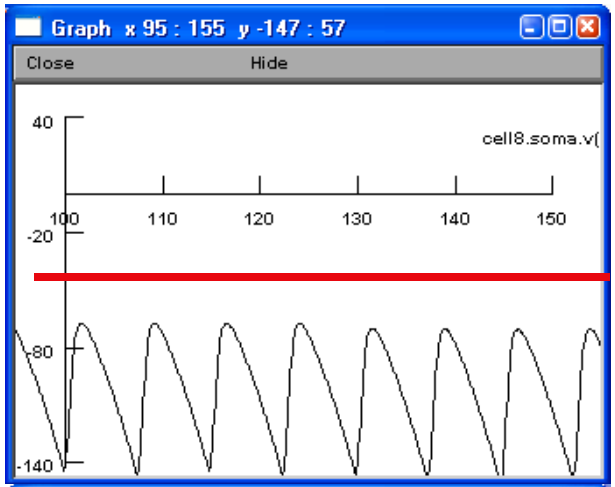
Cell 7 is spontaneously active.
What about cells 8, 9, & 26?

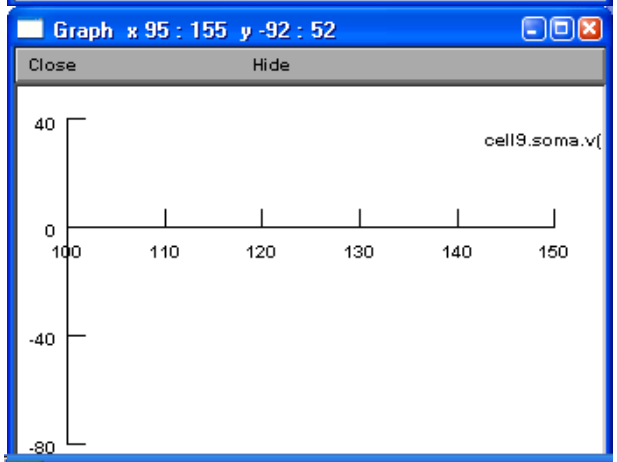


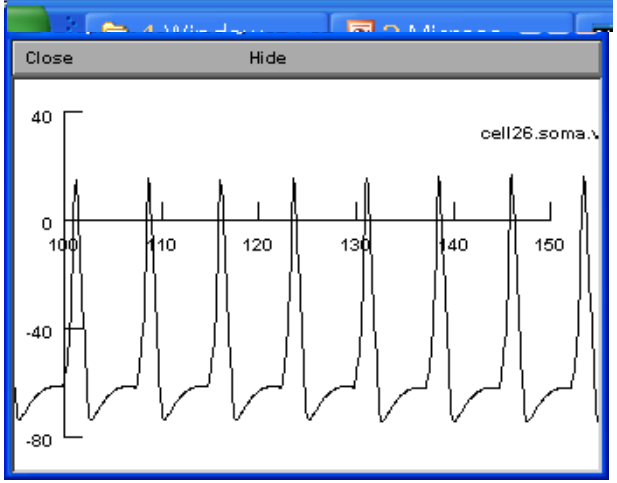




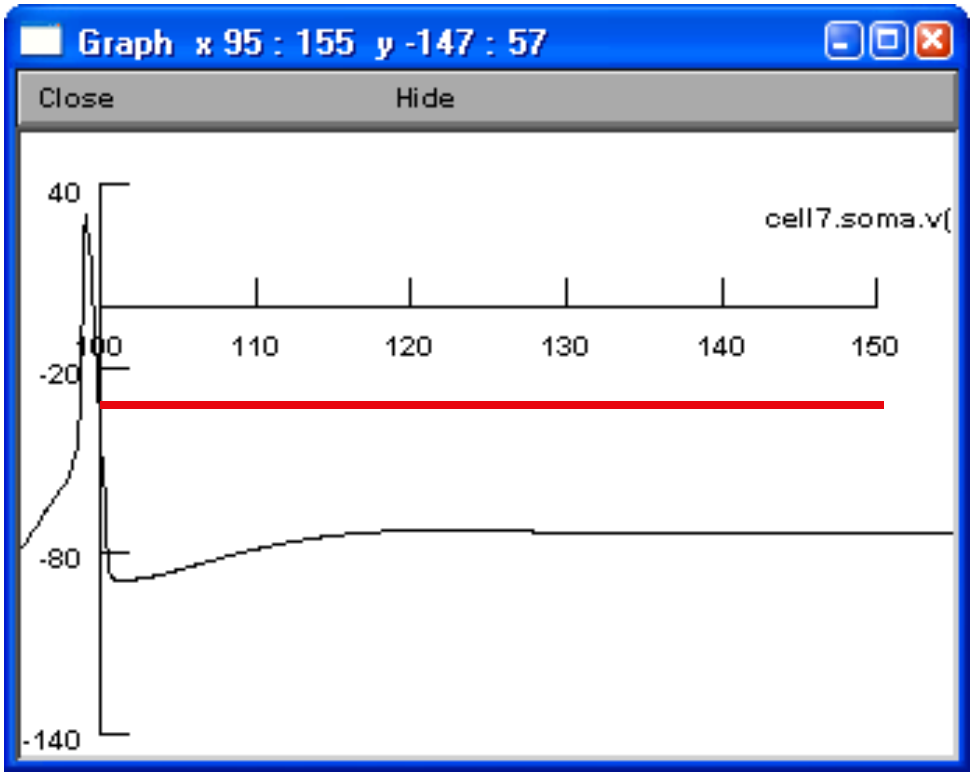


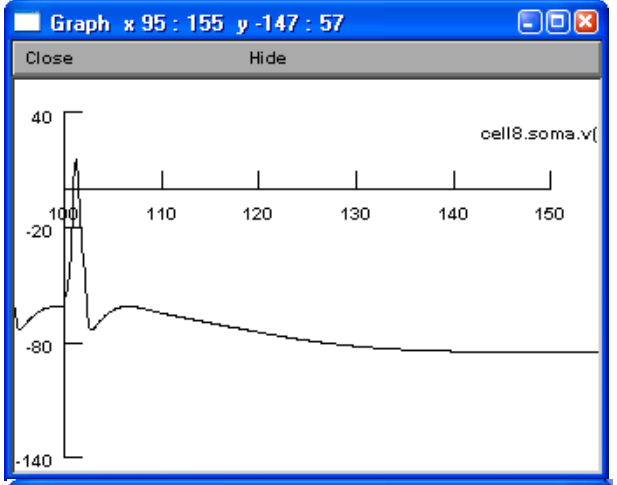


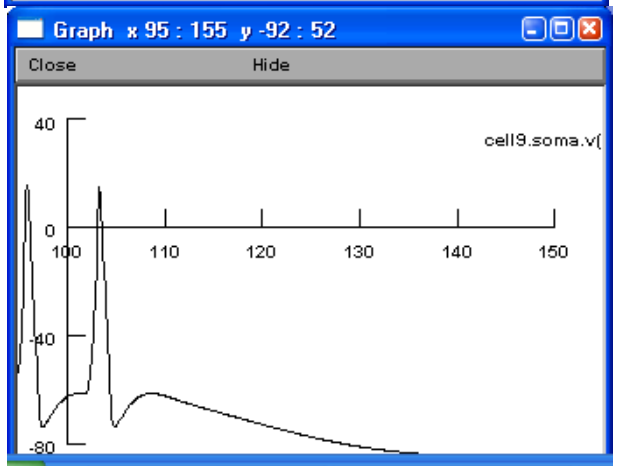


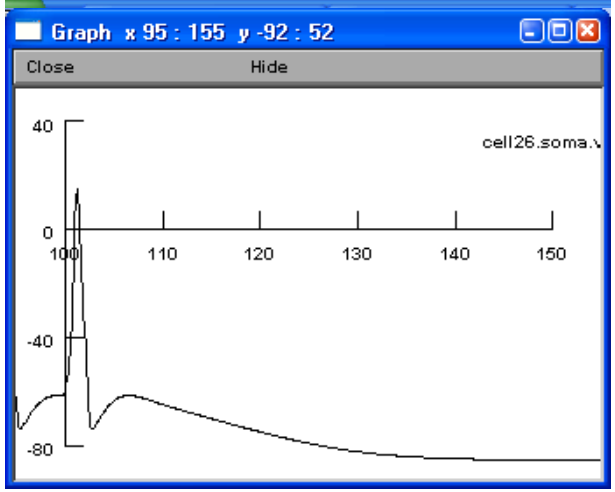


Hyperpolarizing Cell 8 causes Cell 9 to flatline—Cell 26 is unaffected.



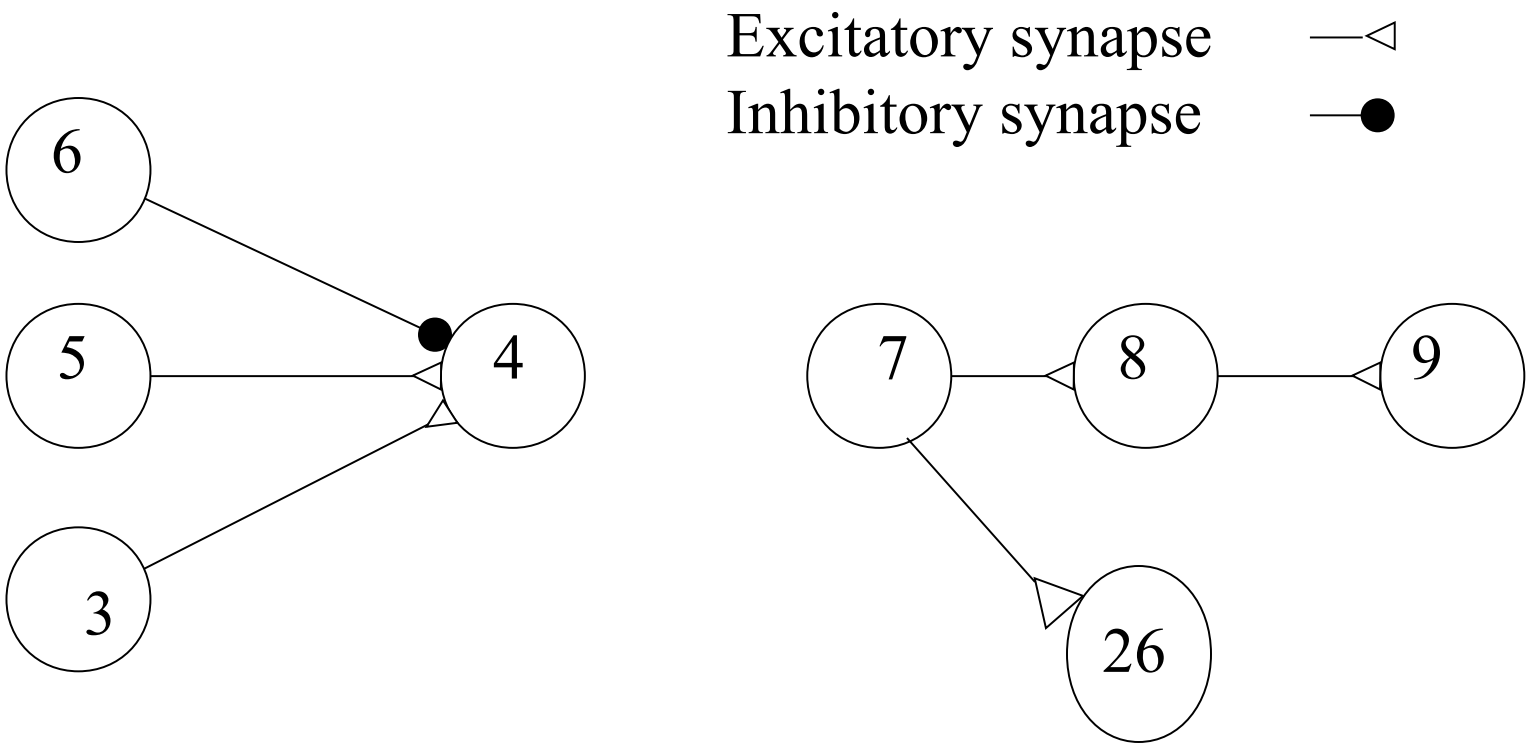


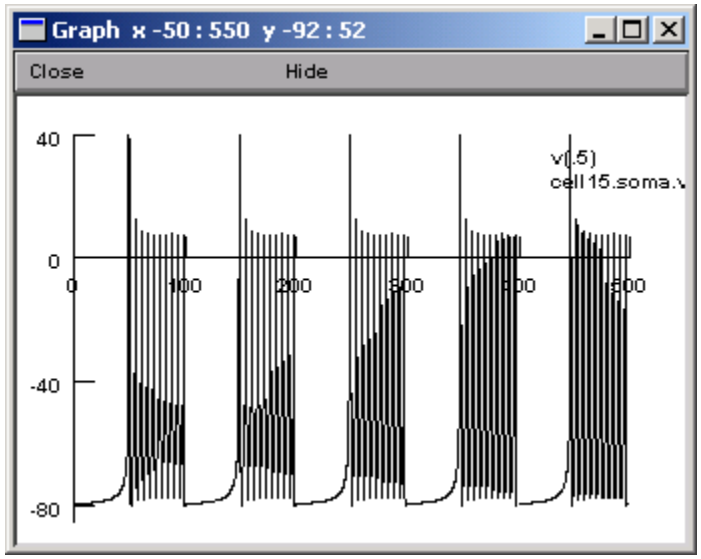


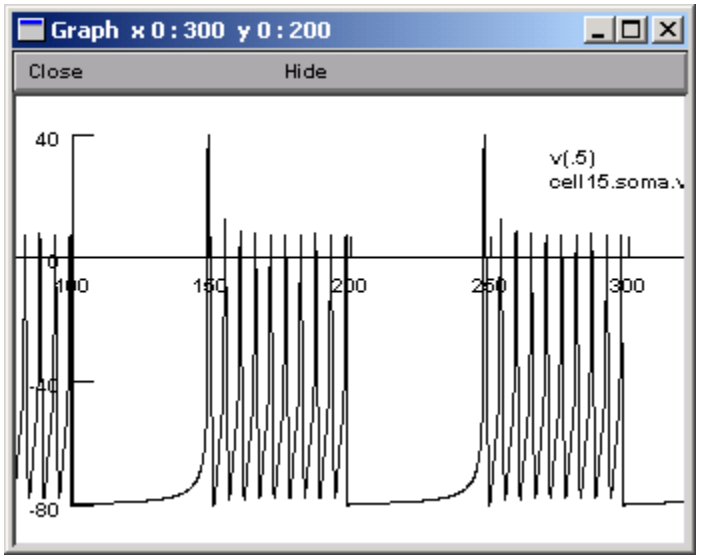


Hyperpolarizing Cell 7 causes all other cells to flatline. Cell 7 is the *generator* of the pattern of activity in this simple circuit. All other cells Are followers.

Temporal Correlation does not Necessarily Imply Causation







Another type of cell with intrinsic activity is a *Spontaneous burster*. This pattern of activity is not produced By other cells driving it.

Objectives

(1) Determine what the circuit is: find all the cells that belong in the circuit.

(2) Prove how they are connected.

(3) Determine how the circuit functions: find out how the circuit functions by determining the nature of the cells.

Homework
(Bring answers to lab Next week)

(1) Determine what the circuit is: find all the cells that belong in the circuit.

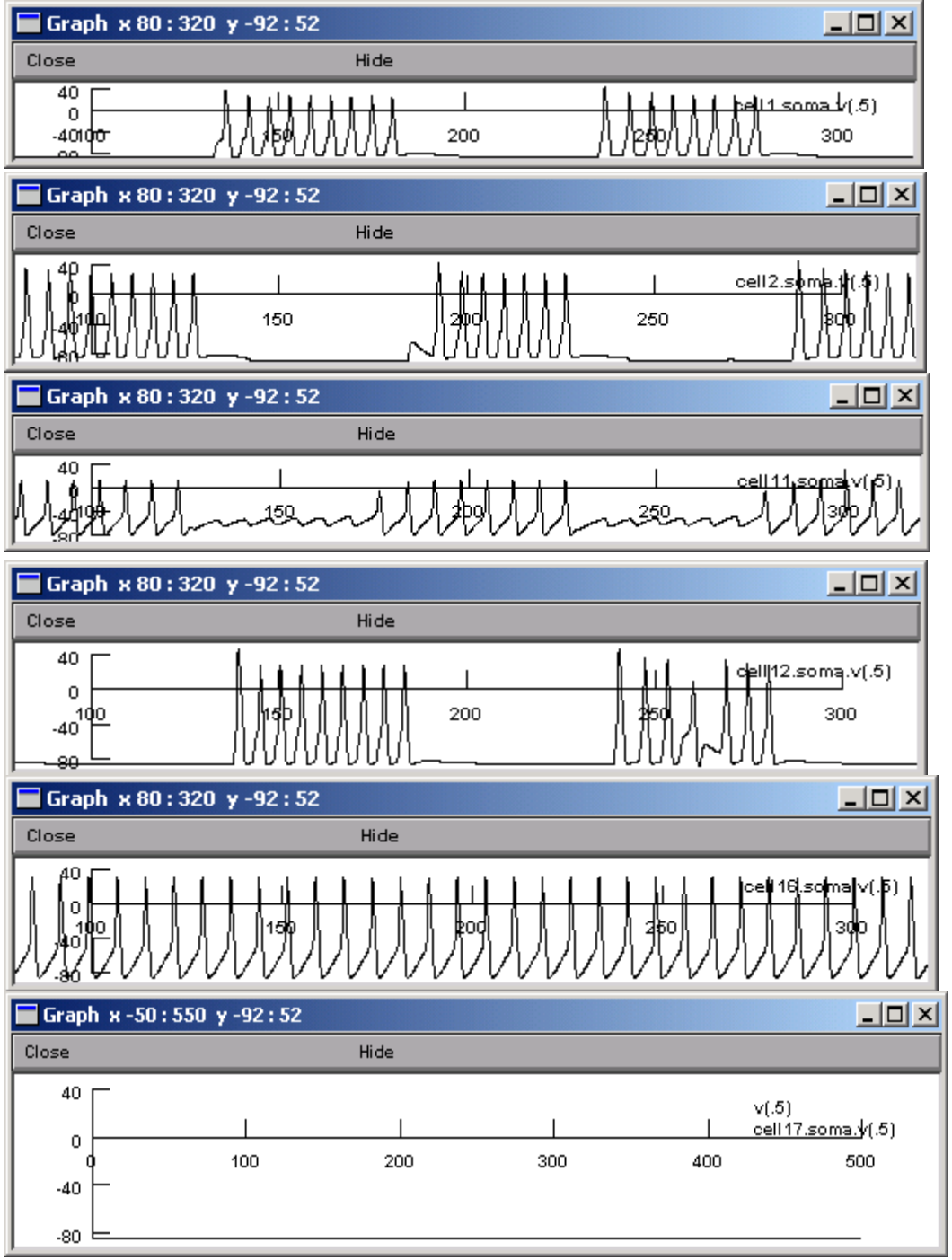
(2) Determine the cells that have direct (monosynaptic) inhibitory and direct (monosynaptic) excitatory input into Cell 1 and Cell 2 (the motor neurons)

The Swimmy Program

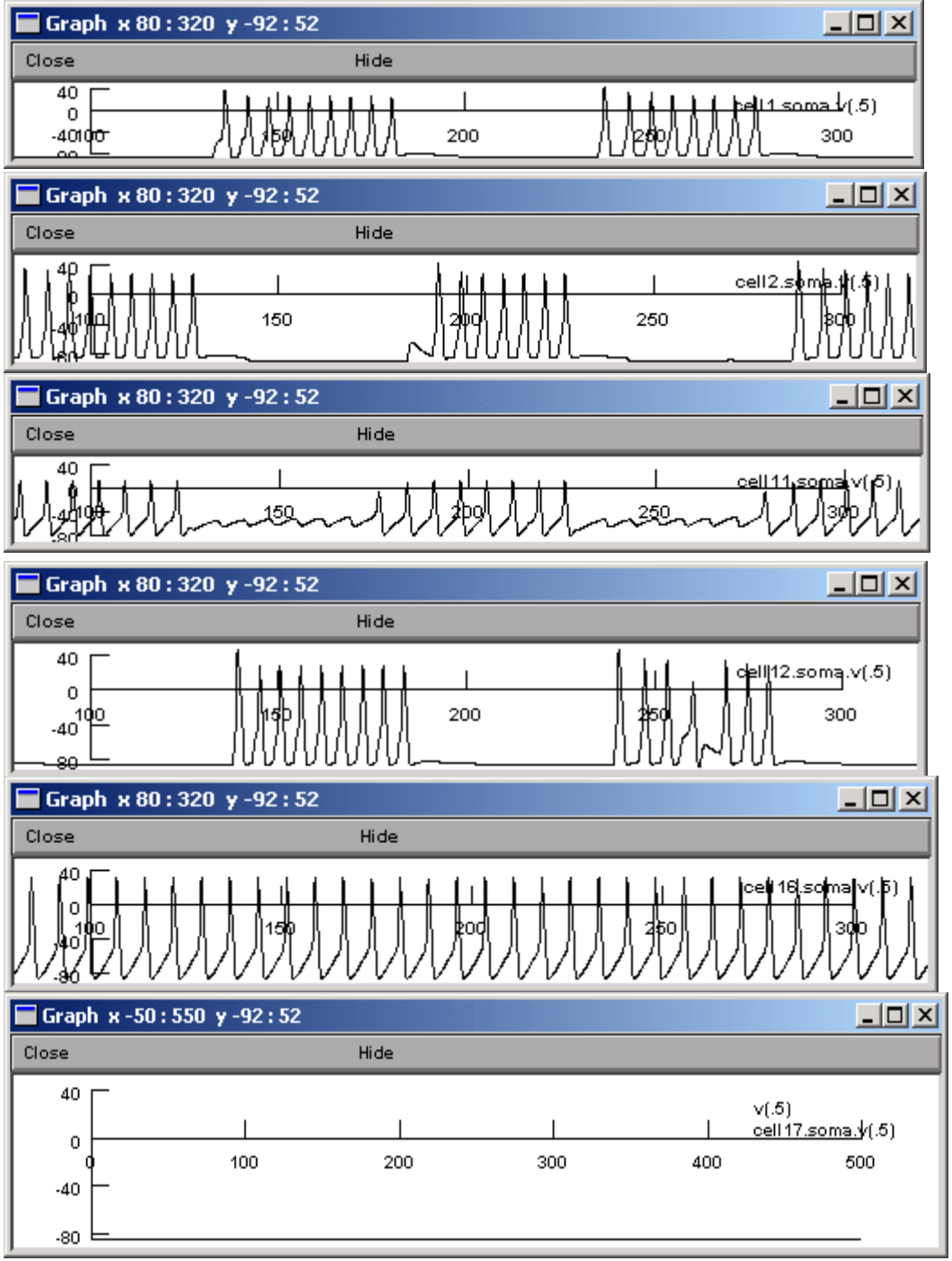
Swimmy has 26 neurons, two of which are motor neurons (cells 1 and 2) which are responsible for directly stimulating the muscles involved in swimming. Not all of these 26 neurons are involved in the swimming circuit. You already know that

Cells 3-9 and 26 are N OT part of the Swimmy circuit.

How do you know?



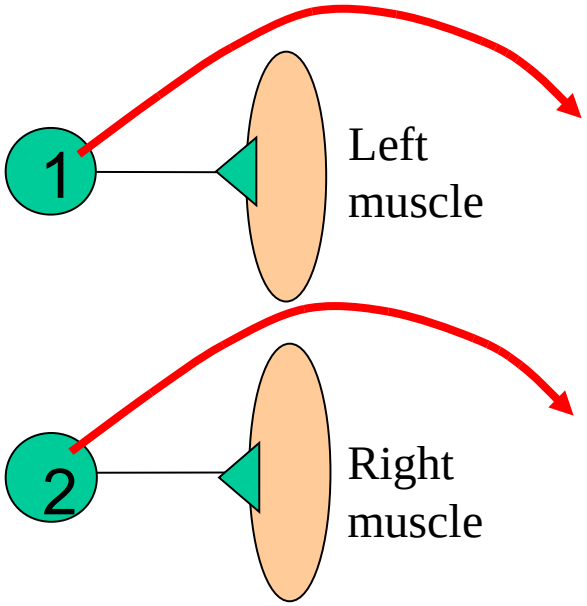
Some of Swimmy's neurons participate in the swimming behavior but some do not.

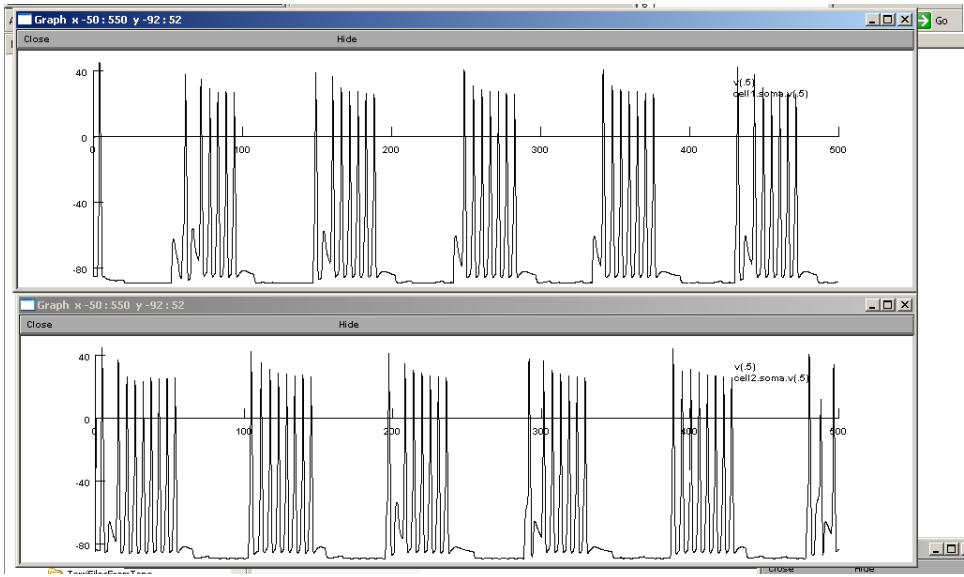


Neurons that show a similar rhythmic pattern as the motor neurons are good candidates.

Circuitry for locomotor pattern

One motor neuron contracts the muscle on the right side of the body, and the other motor neuron contracts the left side of the body.





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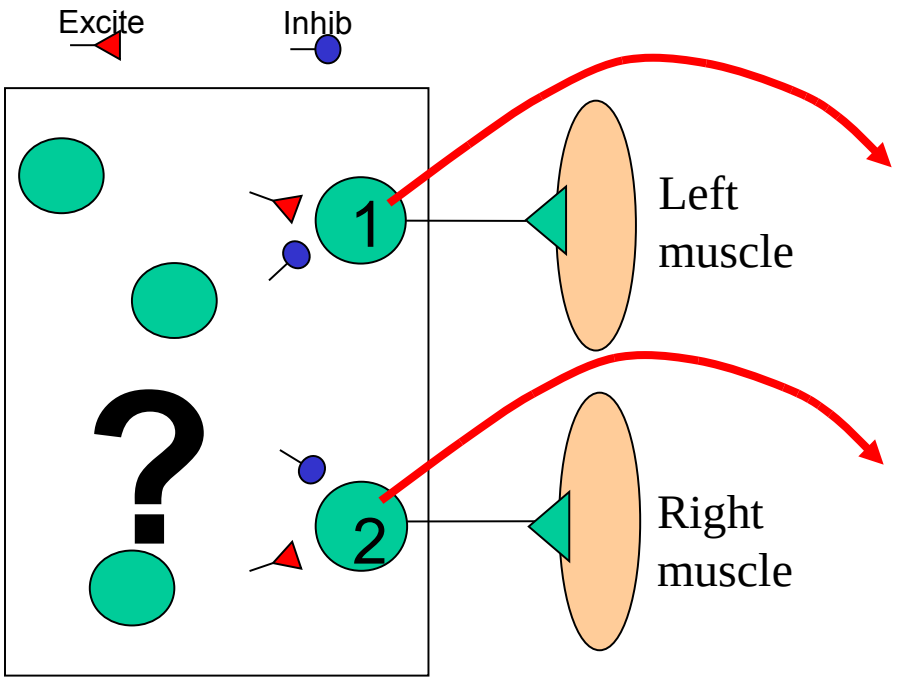
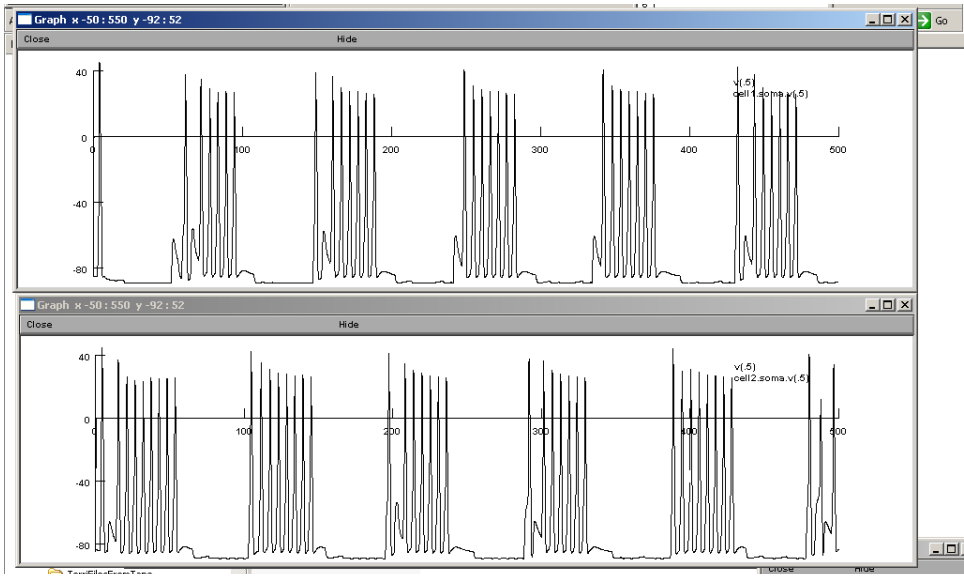
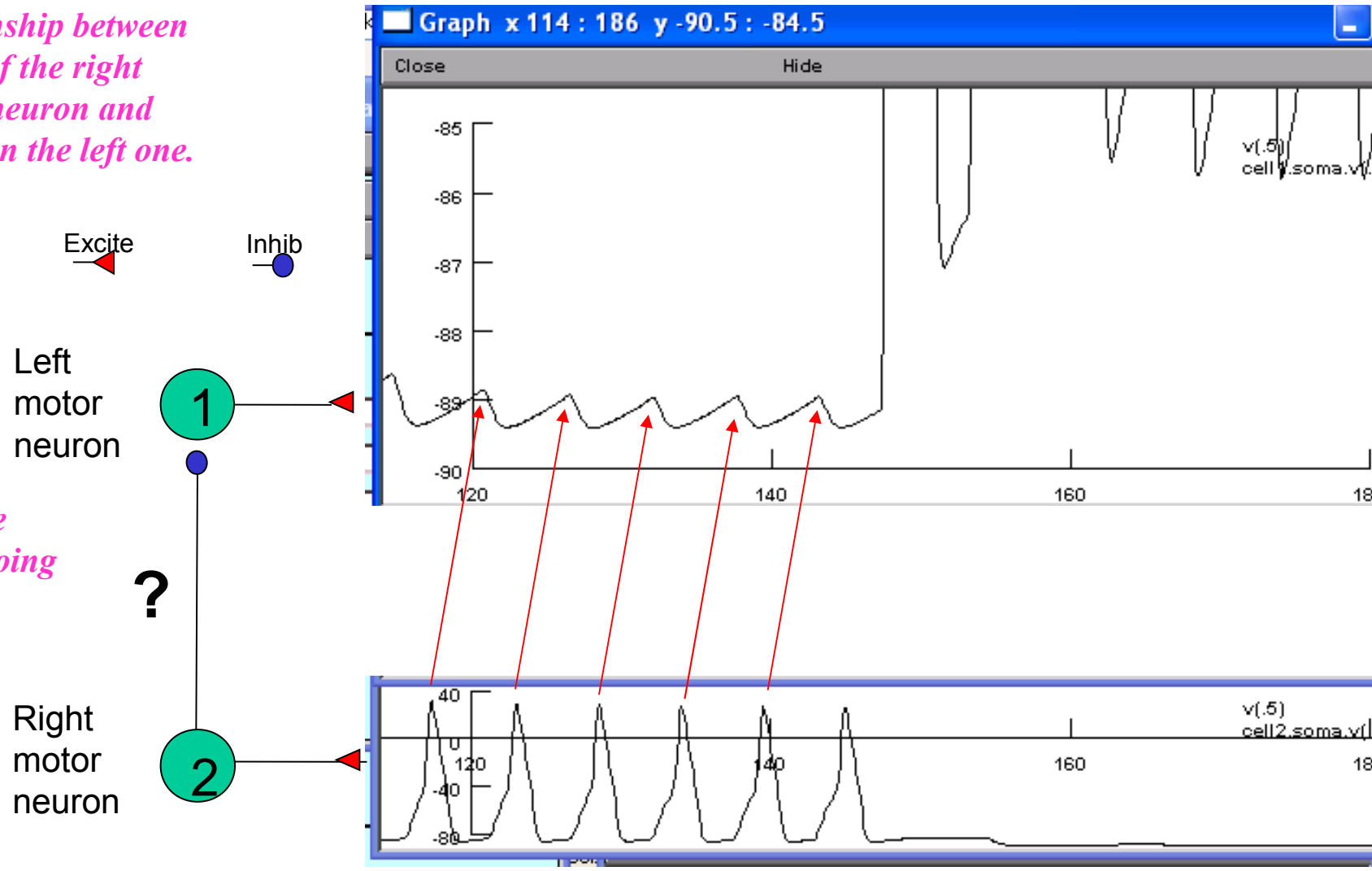
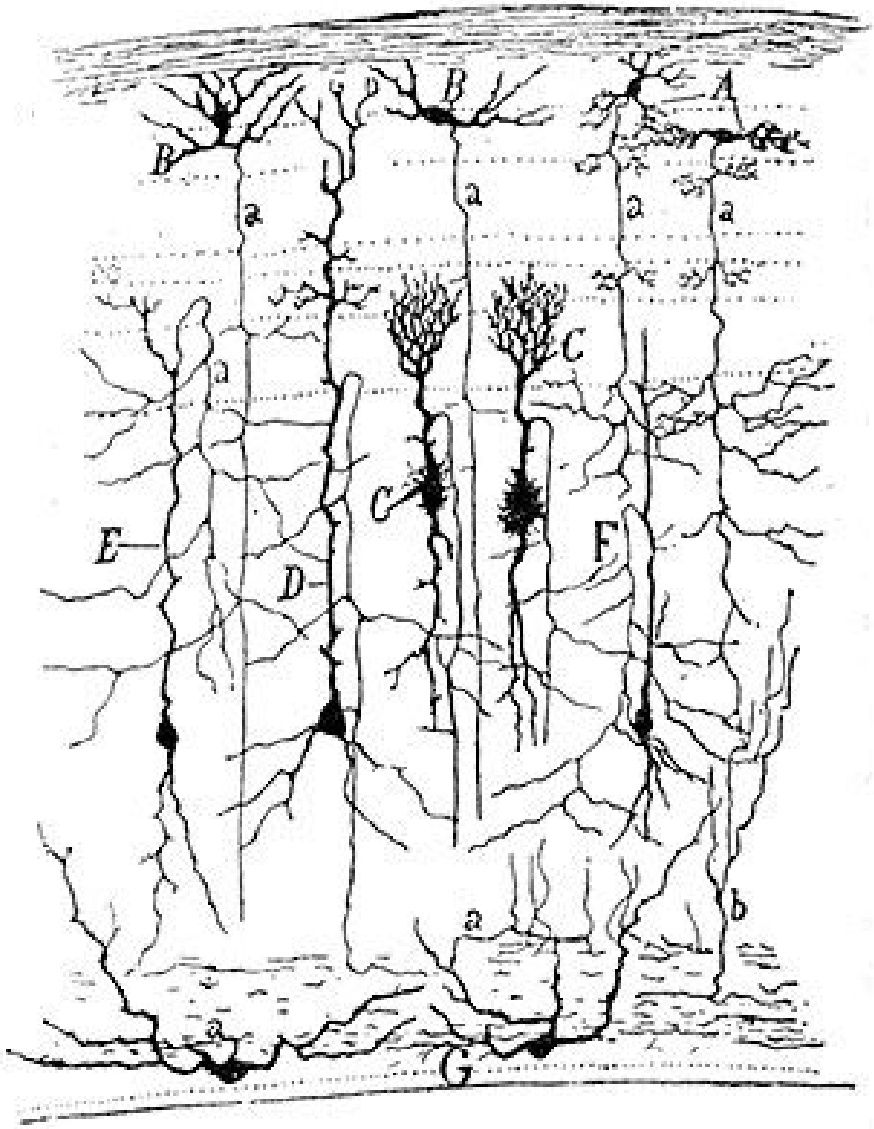


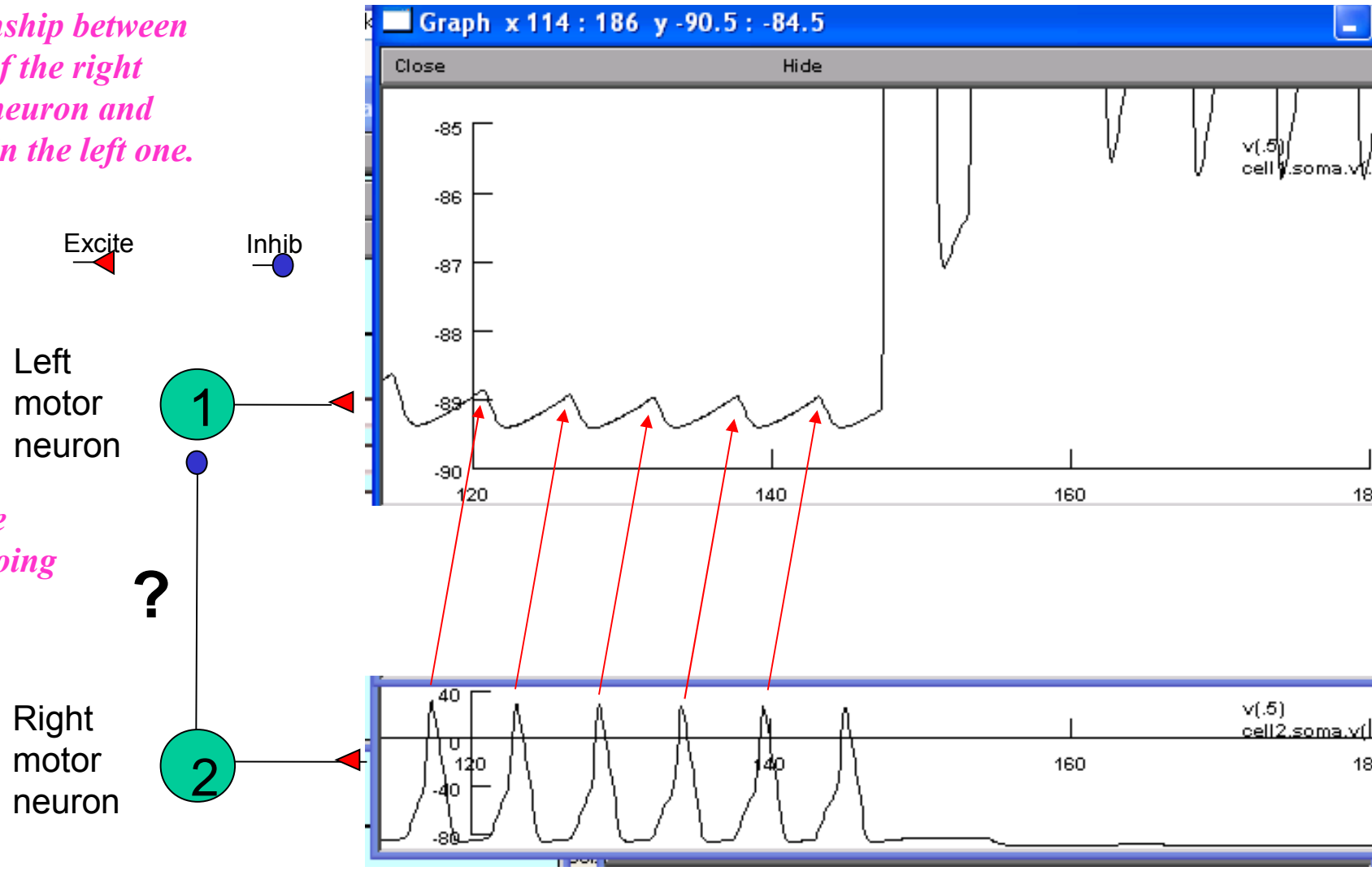


There is a 1 to 1 relationship between firing of the right motor neuron and IPSPs in the left one.




B
B
A
a
a
a
a
C
C
E
D
F
a
b
a
G

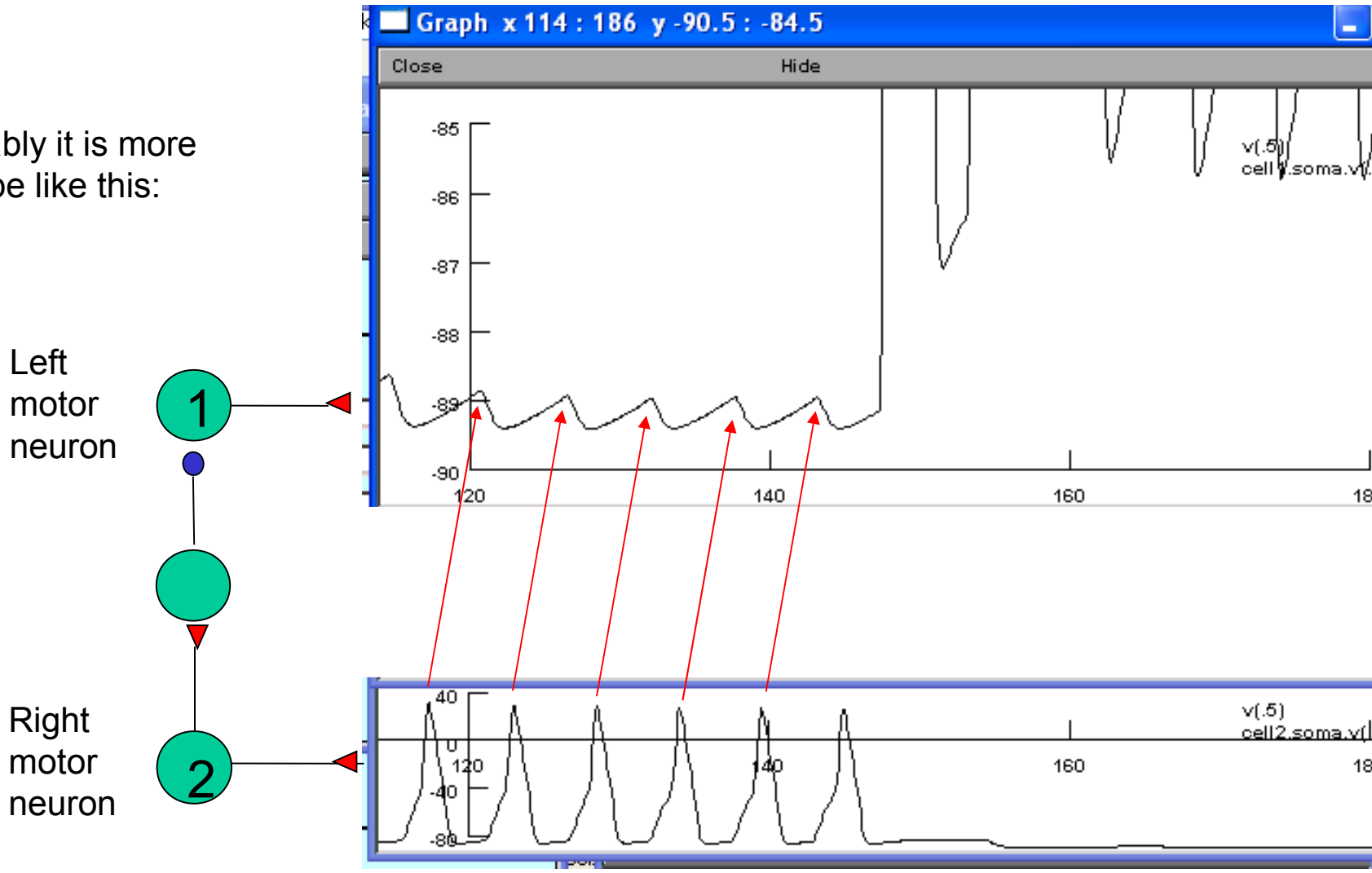
There is a 1 to 1 relationship between firing of the right motor neuron and IPSPs in the left one.



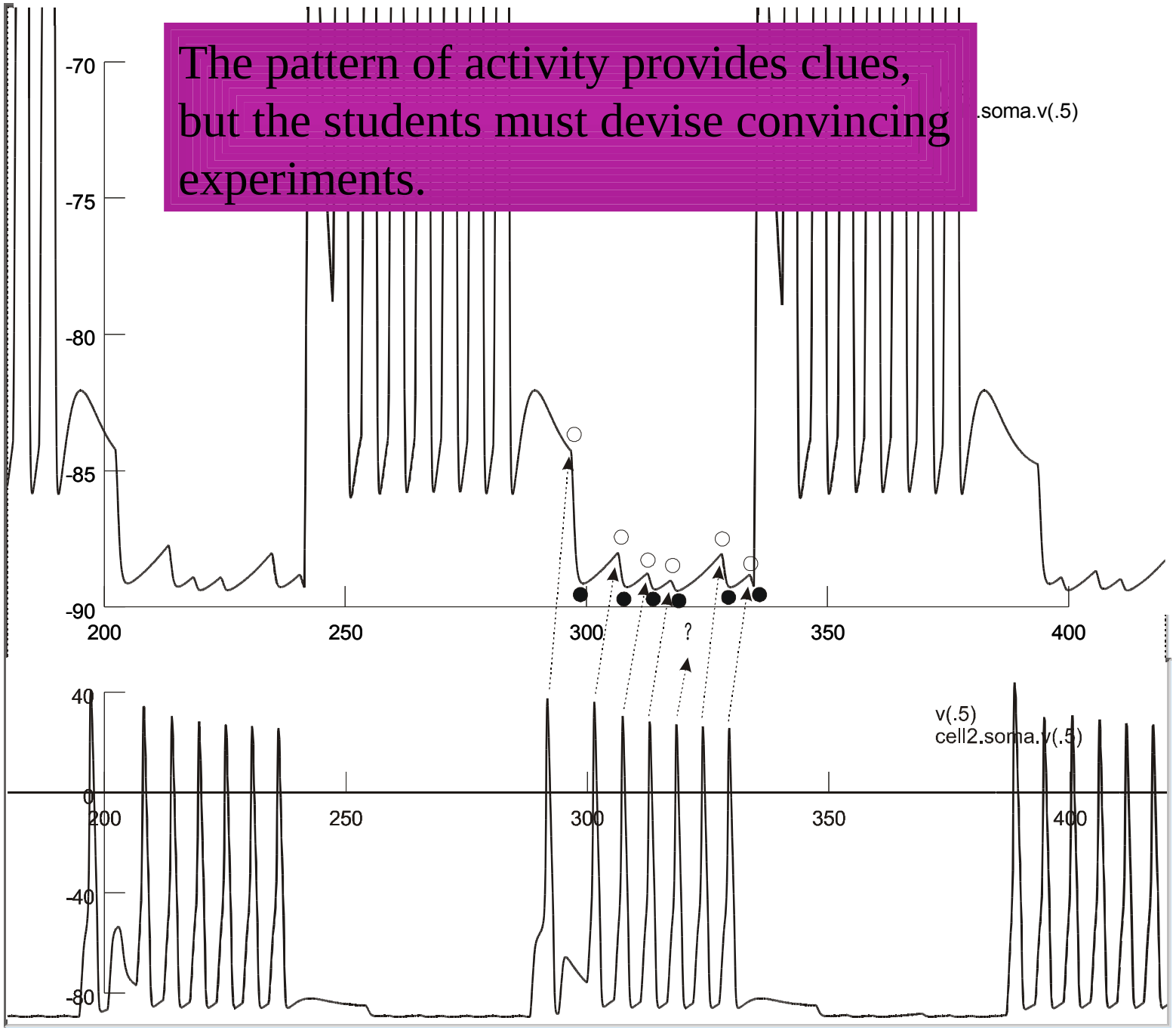
Dale's Law:

A given neuron uses the same neurotransmitter at every synapse.

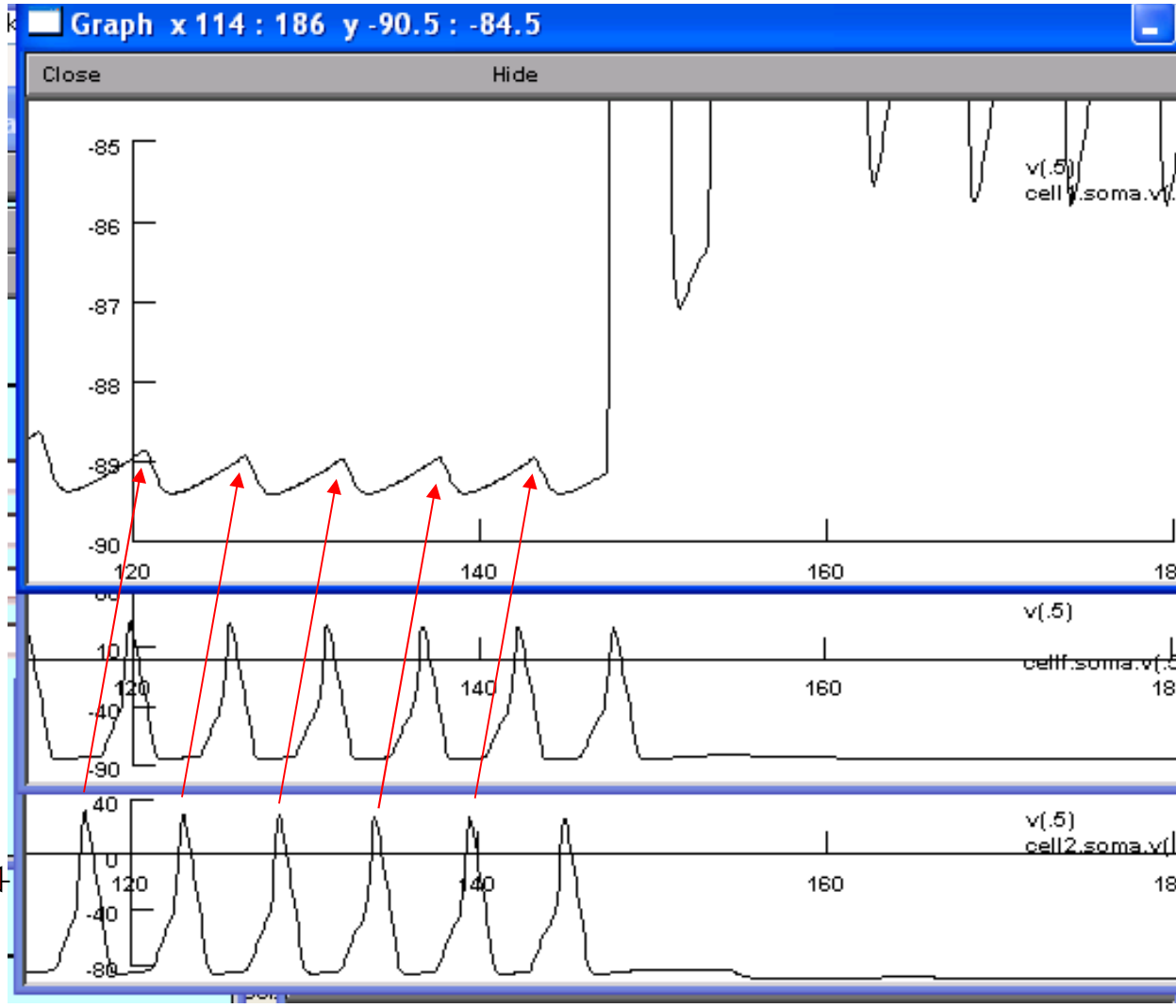
So probably it is more likely to be like this:



But in that case there should be another neuron in between.


The pattern of activity provides clues, but the students must devise convincing experiments.
.soma.v(.5)
-70
-75
-80
-85
-90
200
250
300
?
350
400
40
0
-40
-80
v(.5)
cell2.soma.v(.5)
200
250
300
350
400

And there is!!



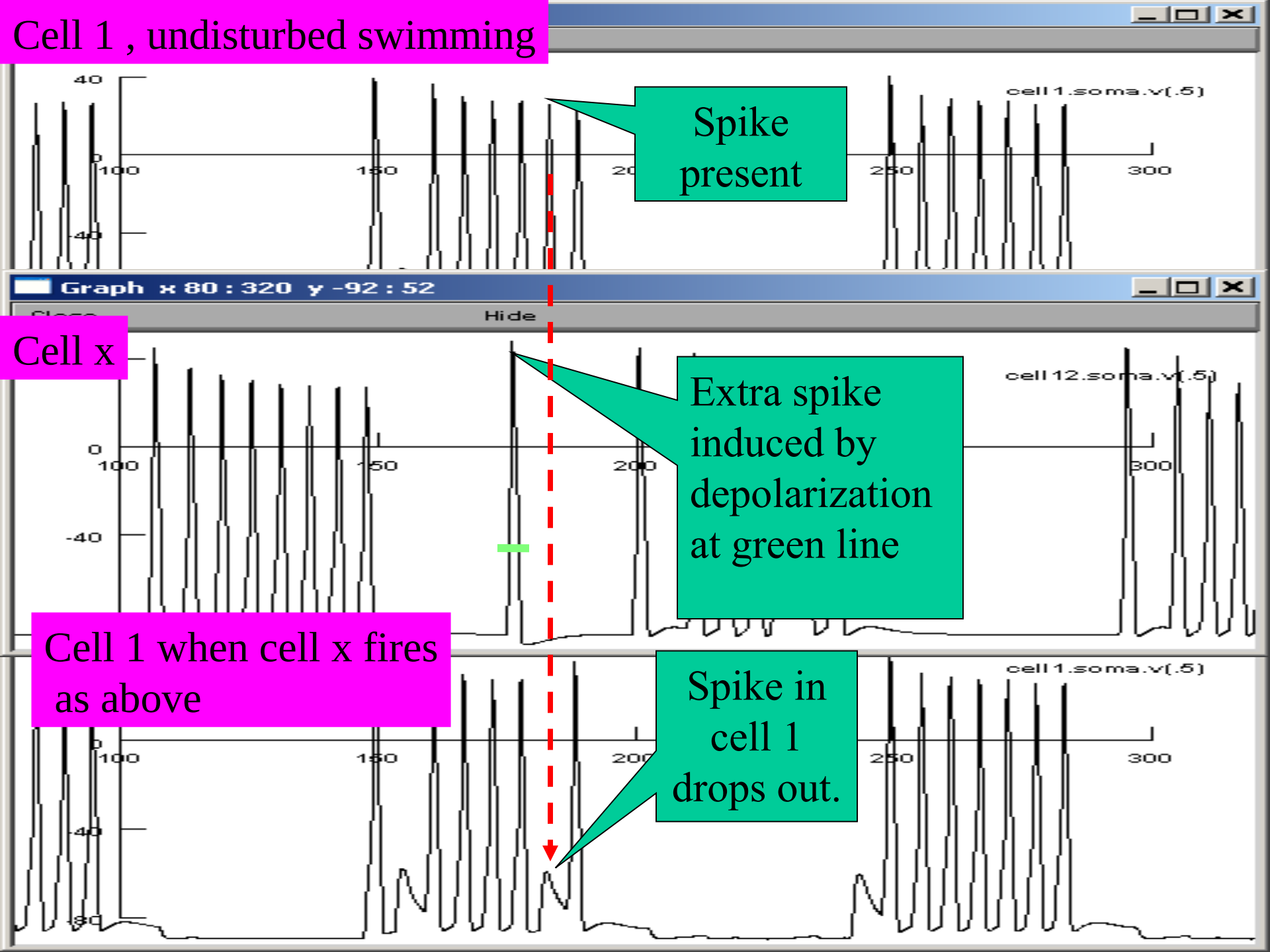
Left motor neuron

1

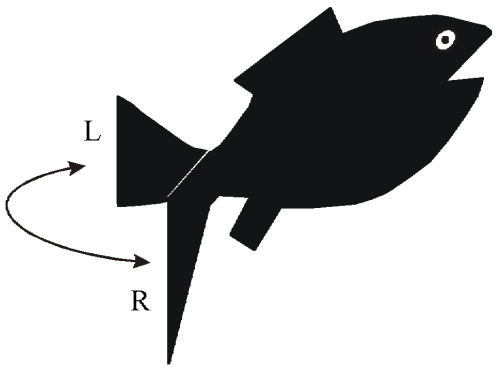
Right motor neuron

2

Also the same arrangement in reverse.
"**Reciprocal inhibition**" between antagonistic neurons"


Cell 1 , undisturbed swimming
Spike present
Graph x 80 : 320 y -92 : 52
Hide
Cell x
Extra spike induced by depolarization at green line
Cell 1 when cell x fires as above
Spike in cell 1 drops out.
cell1.soma.v(.5)
cell12.soma.v(.5)

Swimmy

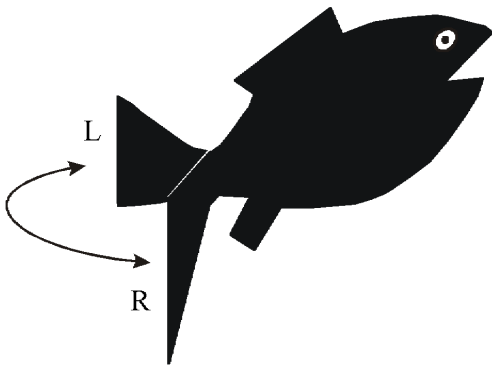


To find neurons that provide monosynaptic input

1) Stimulate putative presynaptic neuron and note effect on post-synaptic neuron.

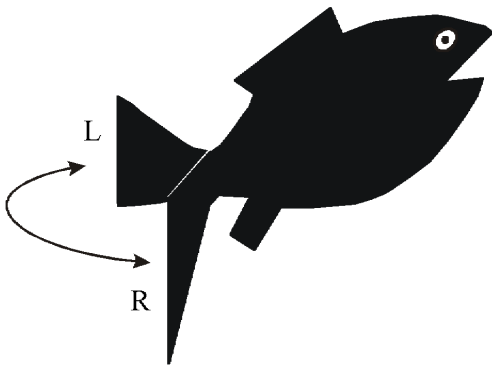
2) Look for evidence of a 1msec synaptic delay.

Swimmy



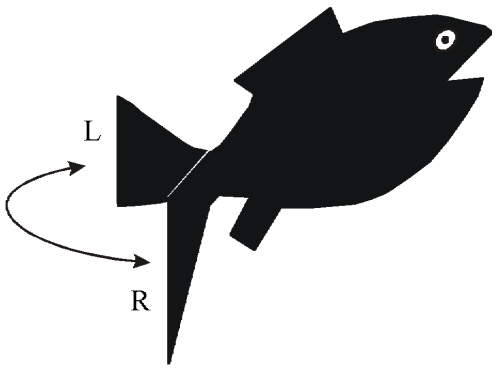
Today you learned about Dale's Law.

Swimmy



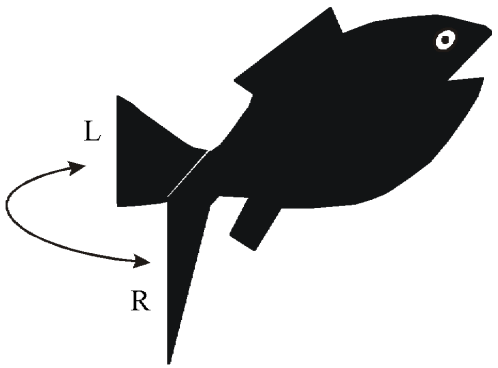
Today you learned about different endogenous properties of neurons…

Swimmy



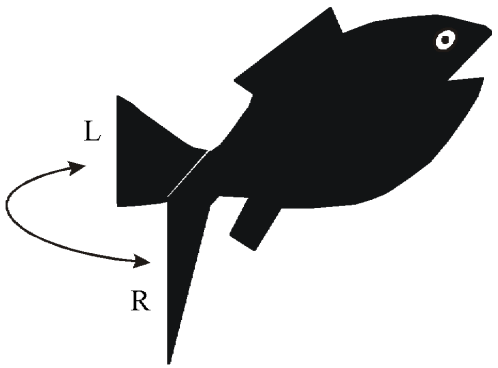
Today you learned about facilitation and depression of synapses.

Swimmy



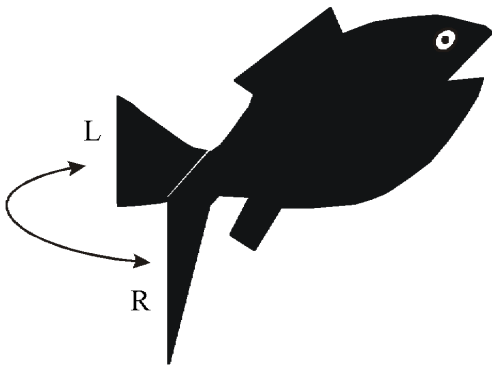
Today you learned about reversal potentails.

Swimmy



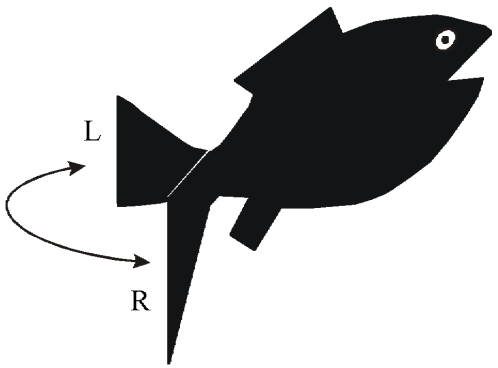
Today you learned about the true nature of inhibition.

Swimmy



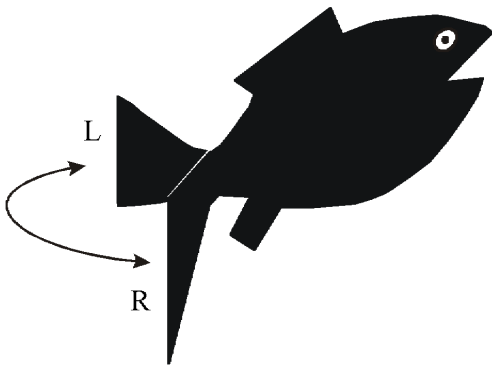
…and how these neurons
could link together
to create a rhythmic pattern
of activity.

Swimmy



Today you learned about how to identify which cells are involved in the behavior.

Swimmy



Enjoy the remains of the day.
Perhaps you'll go fishing!