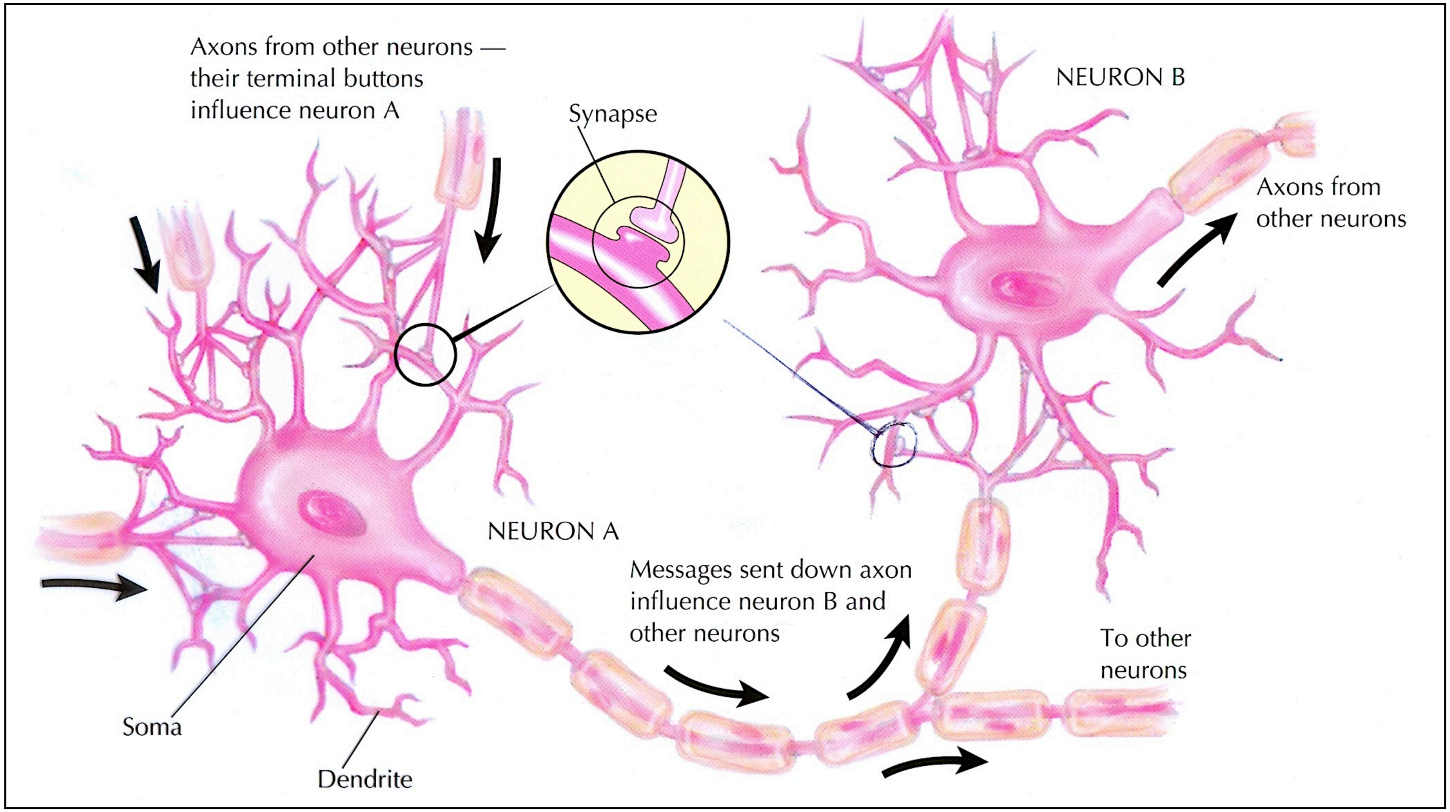
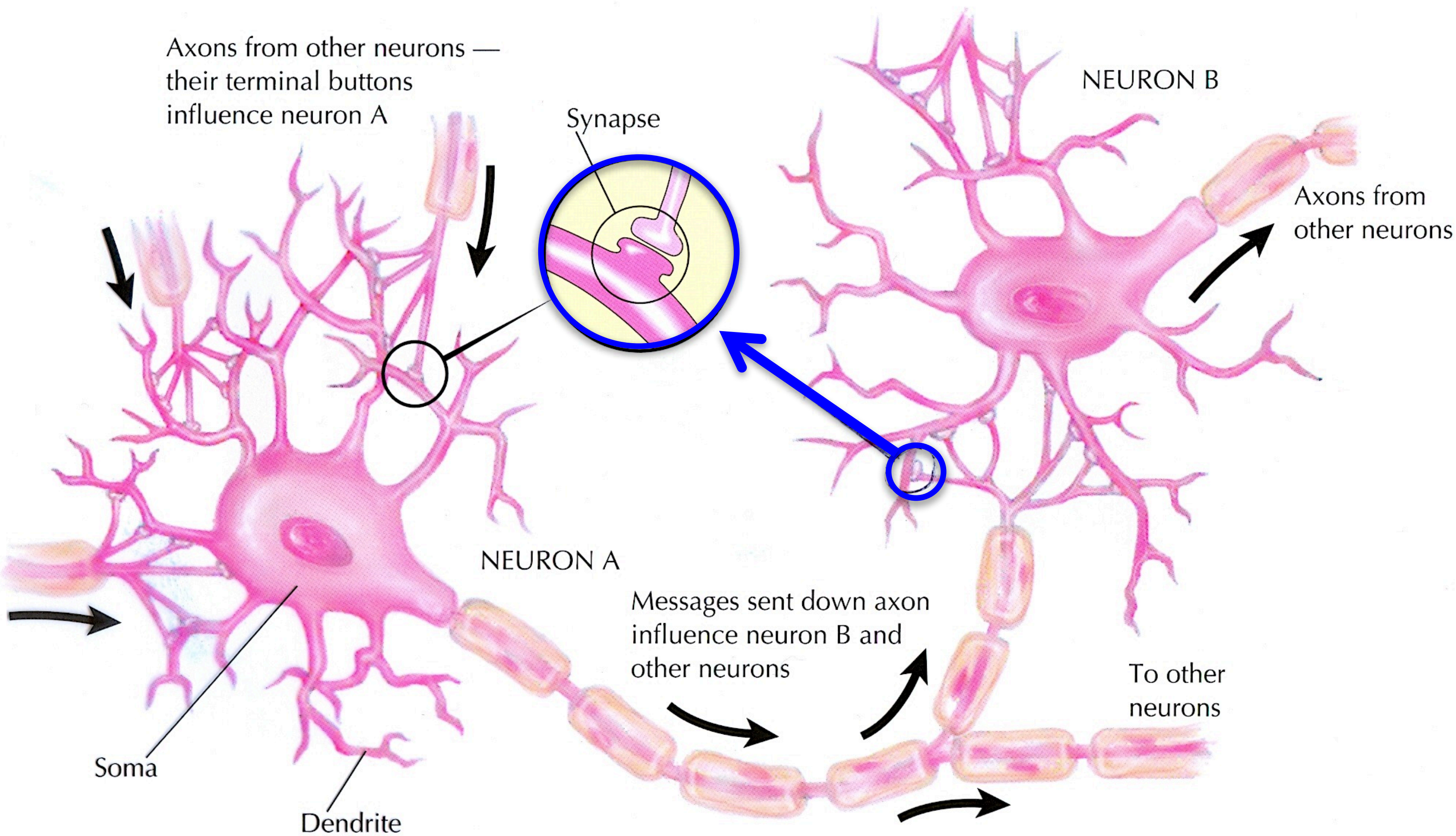
Lec 2b

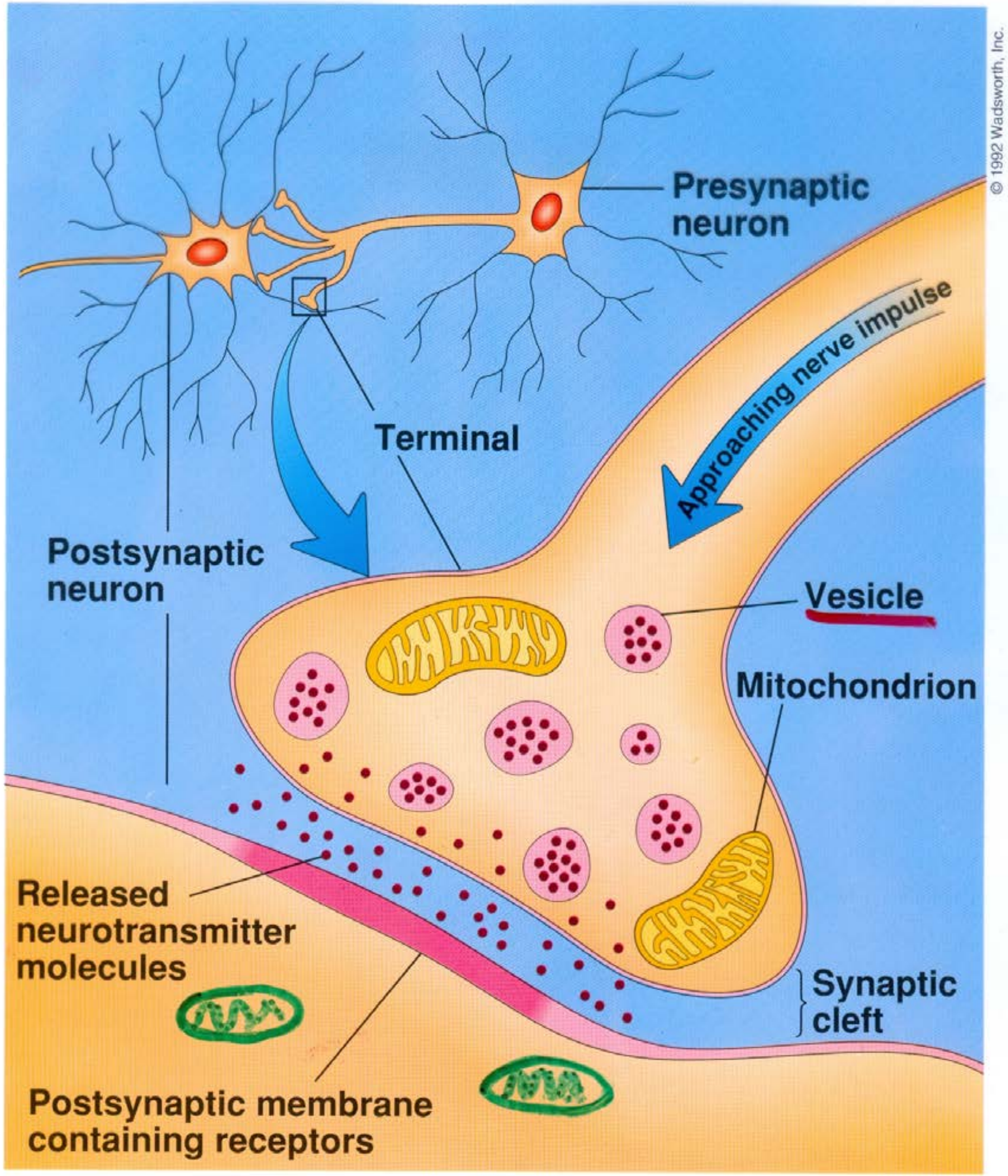
Structure and Function of Cells



Cogs17 Cognitive Neuroscience UCSD

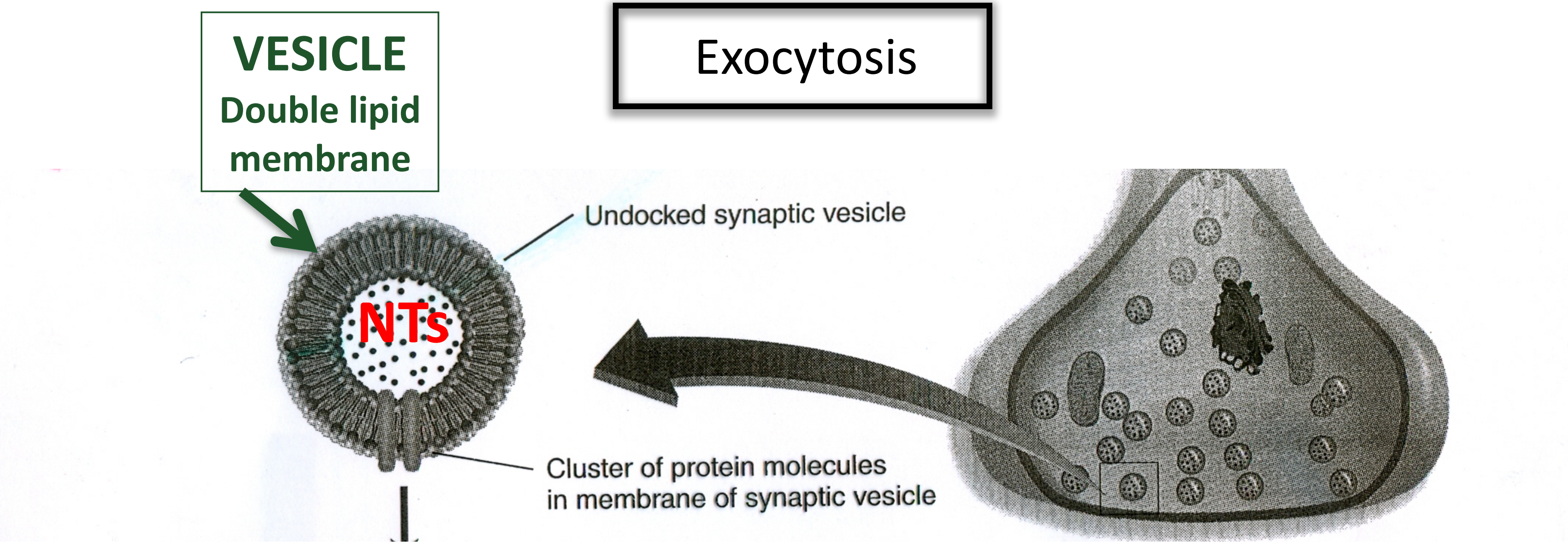
THE SYNAPSE – Communication between cells



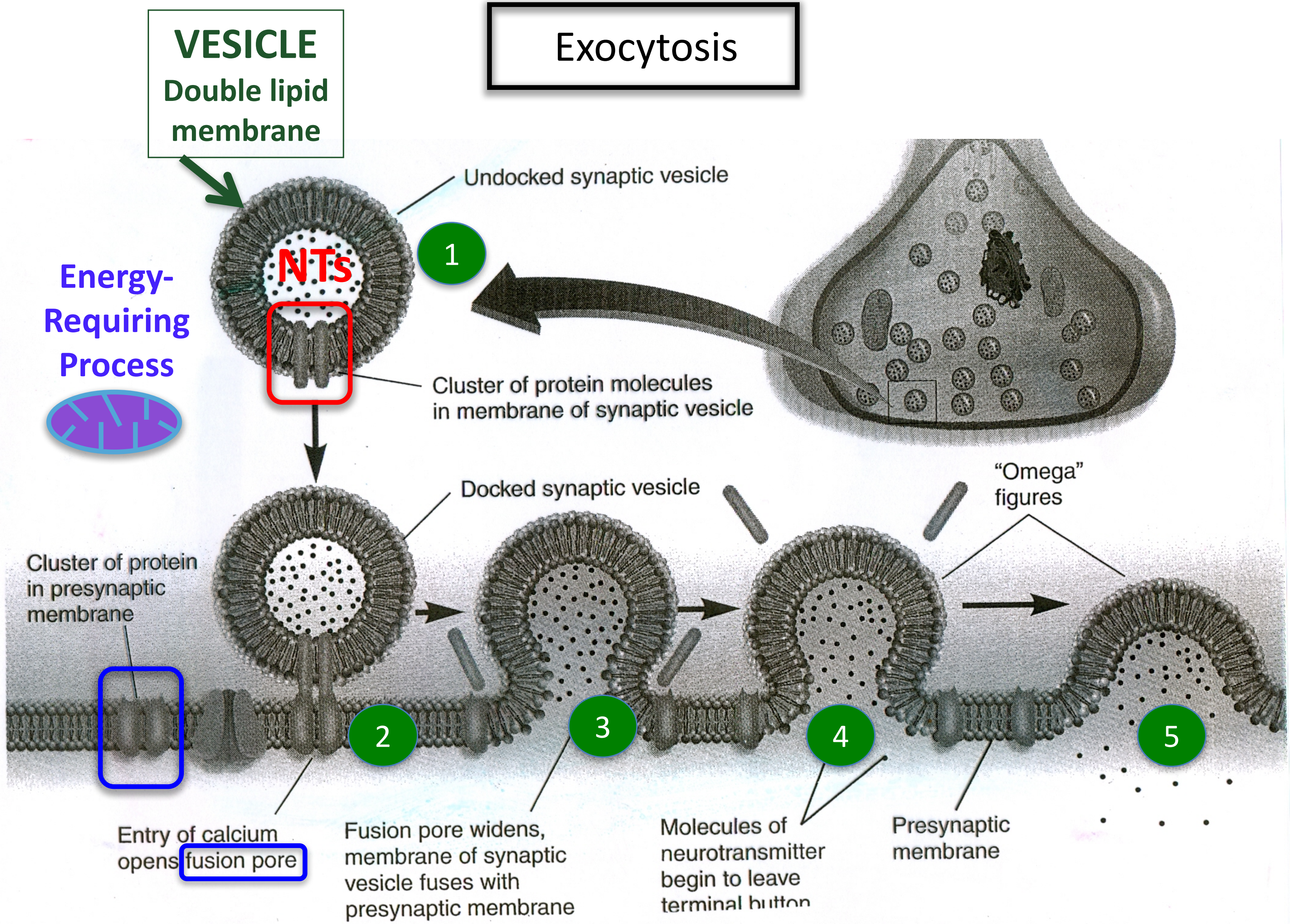

Presynaptic
neuron
Approaching nerve impulse
Terminal
Postsynaptic
neuron
Vesicle
Mitochondrion
Released
neurotransmitter
molecules
Synaptic
cleft
Postsynaptic membrane
containing receptors
© 1992 Wadsworth, Inc.

Synapse

Exocytosis


VESICLE
Double lipid membrane
NTs
Undocked synaptic vesicle
Cluster of protein molecules in membrane of synaptic vesicle

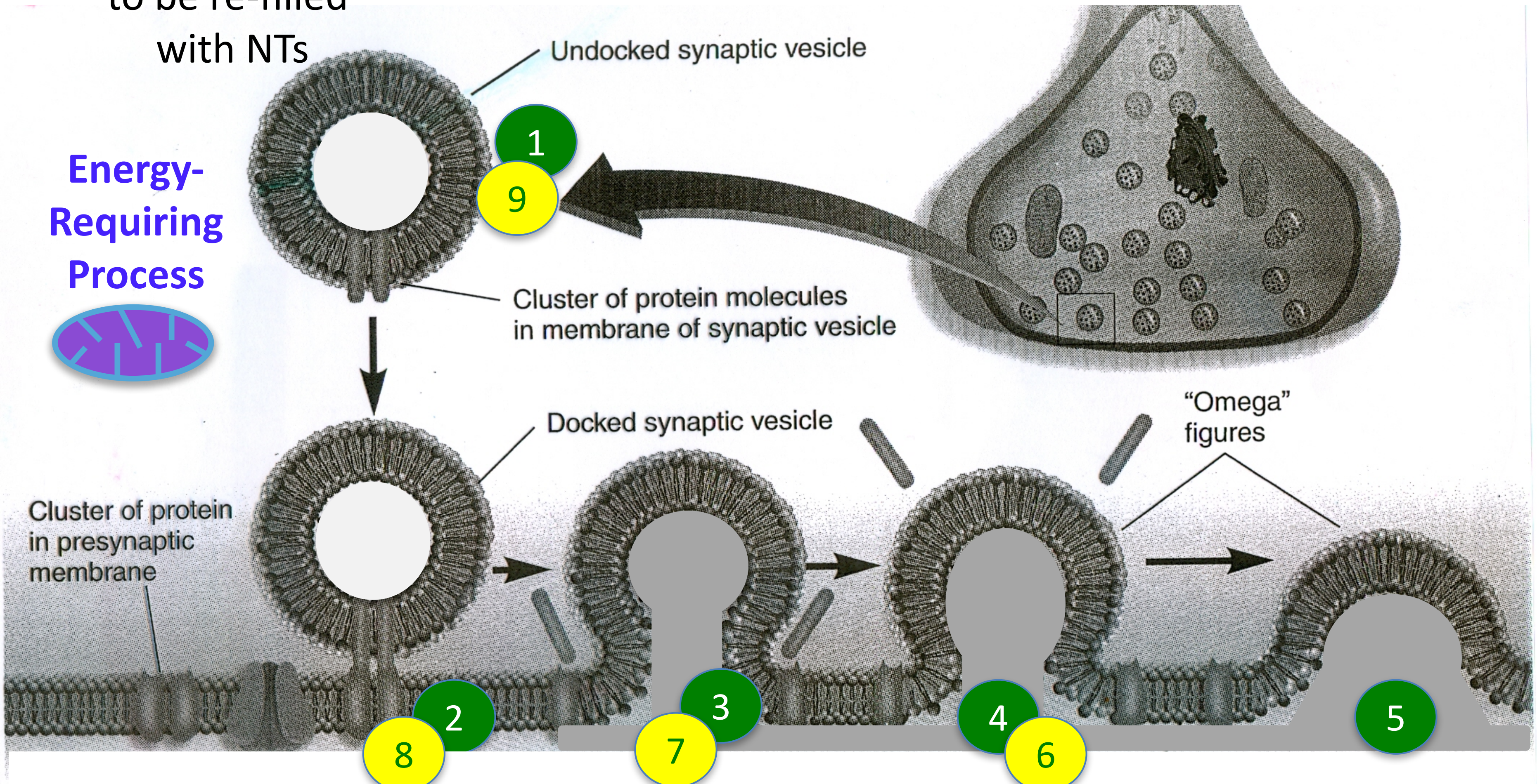
Exocytosis


VESICLE
Double lipid membrane
Energy-Requiring Process
NTs
1
Undocked synaptic vesicle
Cluster of protein molecules in membrane of synaptic vesicle
Docked synaptic vesicle
"Omega" figures
Cluster of protein in presynaptic membrane
2
3
4
5
Entry of calcium opens fusion pore
Fusion pore widens, membrane of synaptic vesicle fuses with presynaptic membrane
Molecules of neurotransmitter begin to leave terminal button
Presynaptic membrane

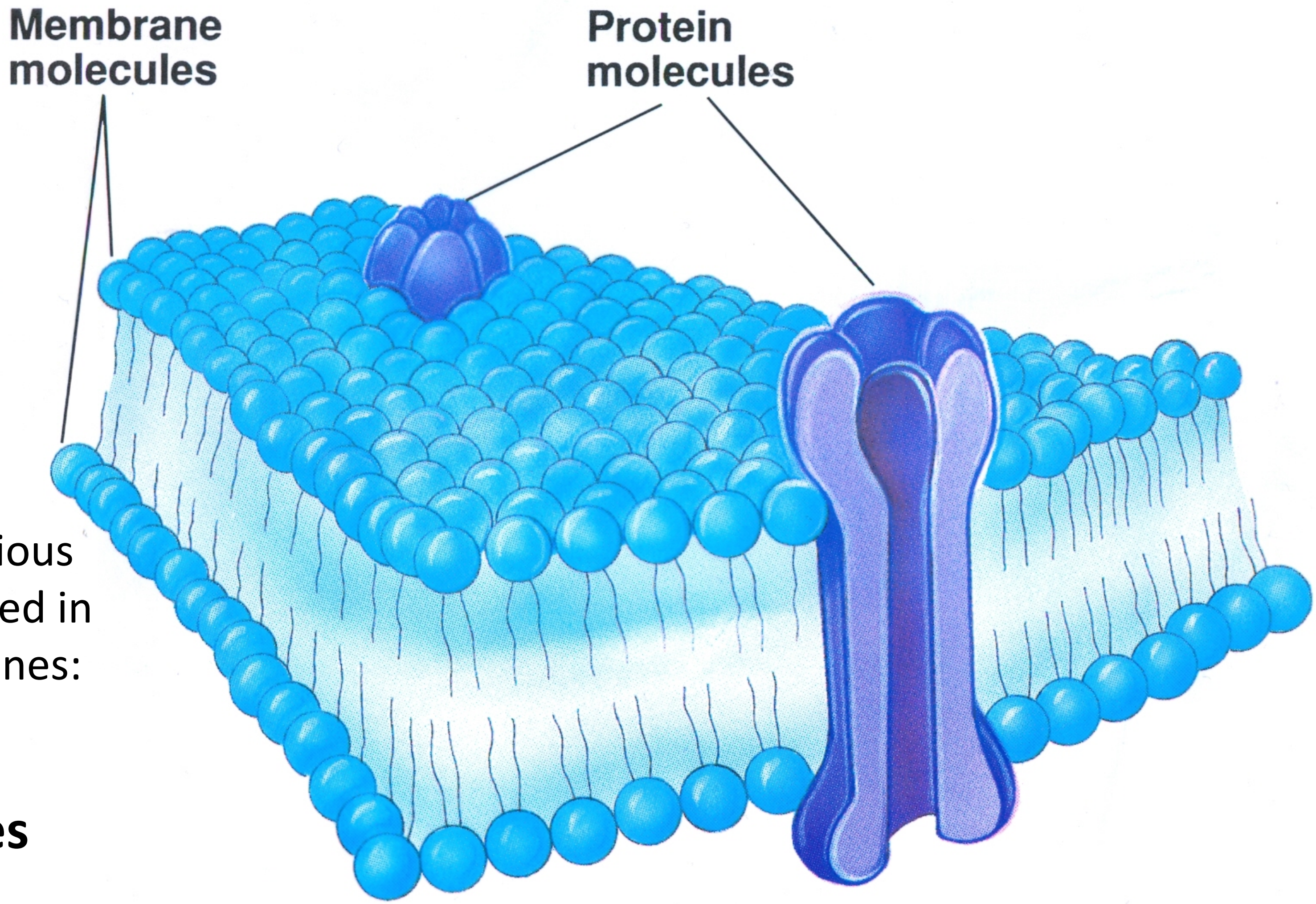
Exocytosis

Reclaimed empty vesicle
to be re-filled
with NTs

Energy-Requiring Process



After the NTs have drifted into the cleft . . .



Functions of various <u>proteins</u> embedded in neuron membranes:

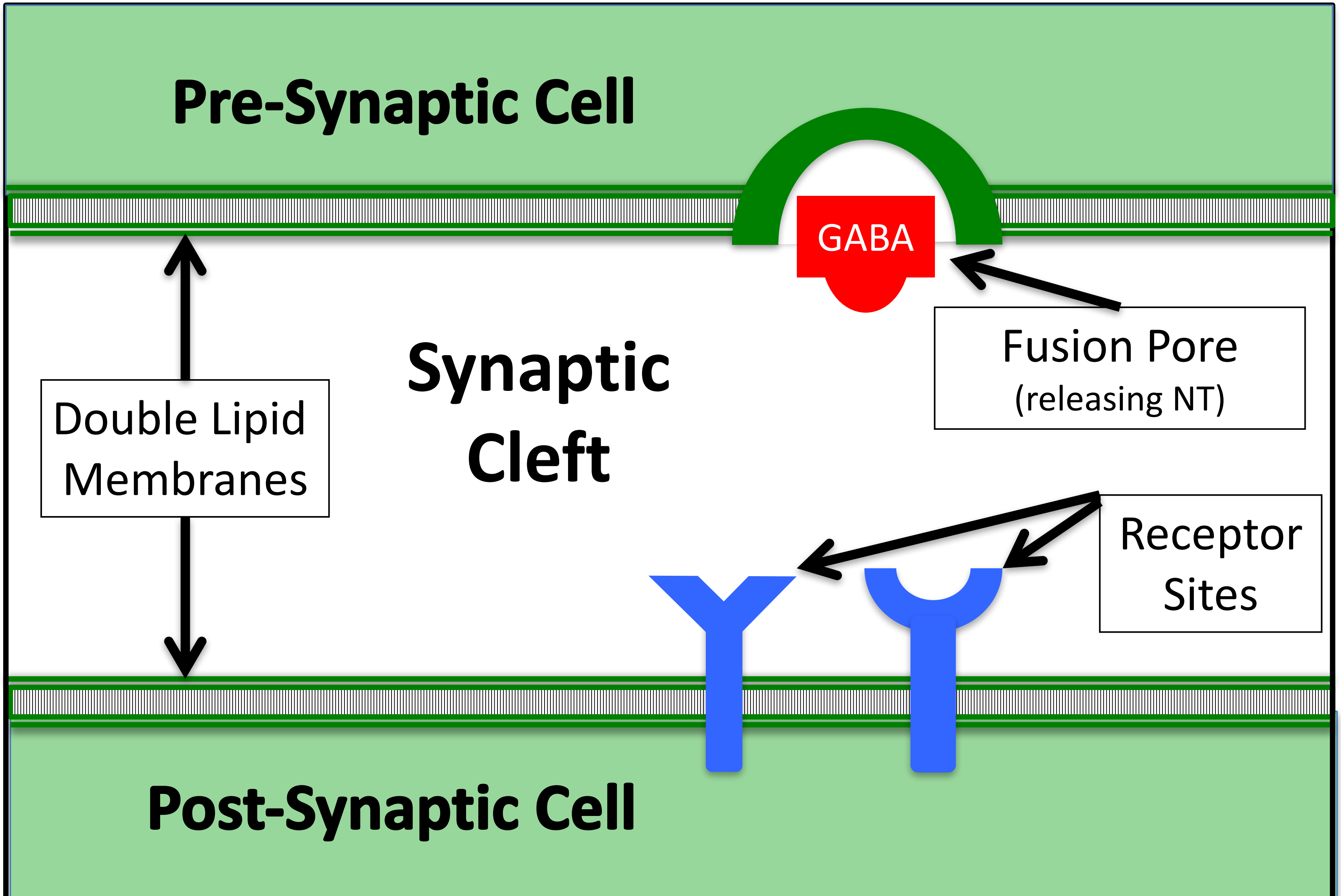
Ion Gates

Fusion Pores

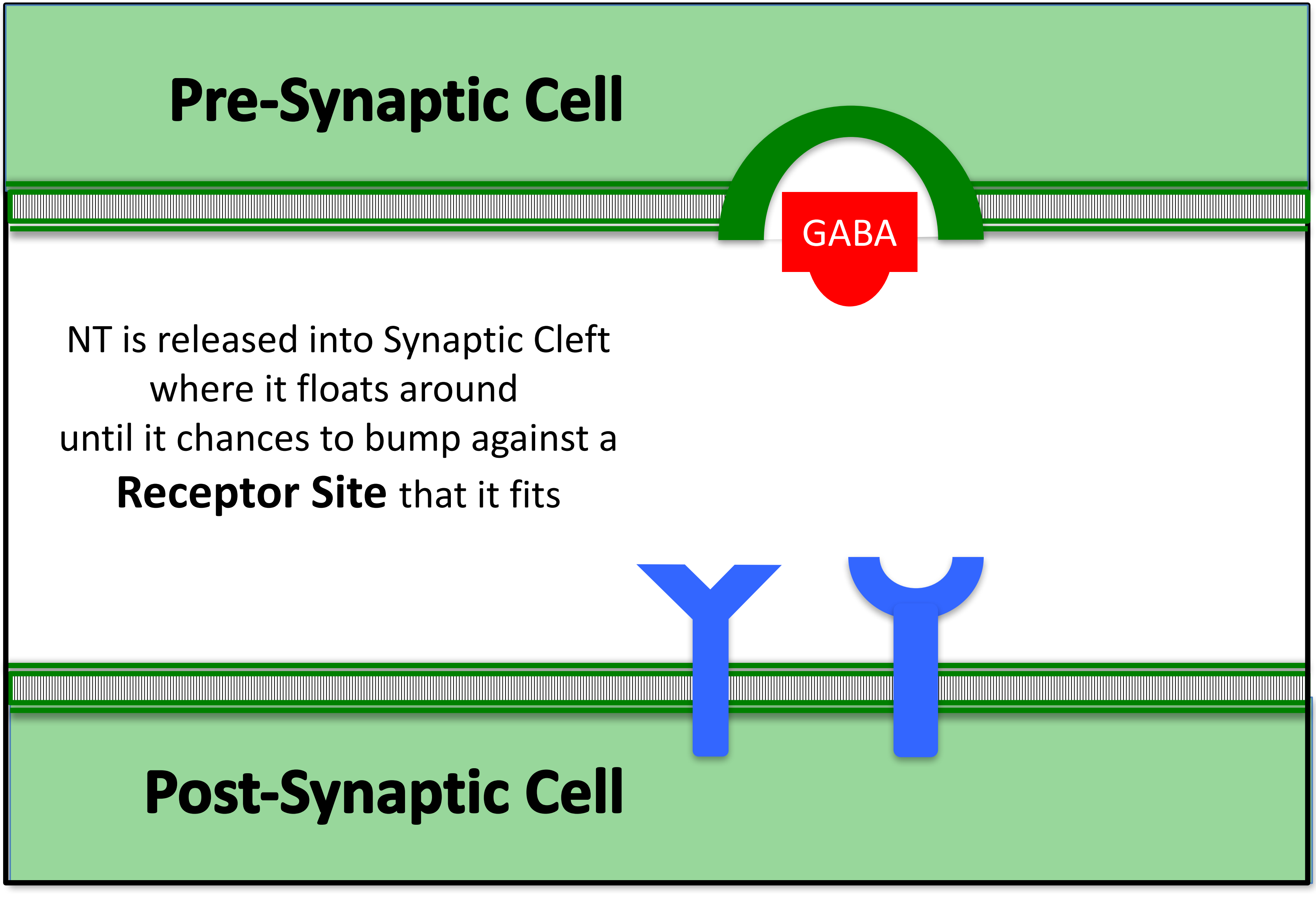
Receptor Sites

Each is specialized for only one function

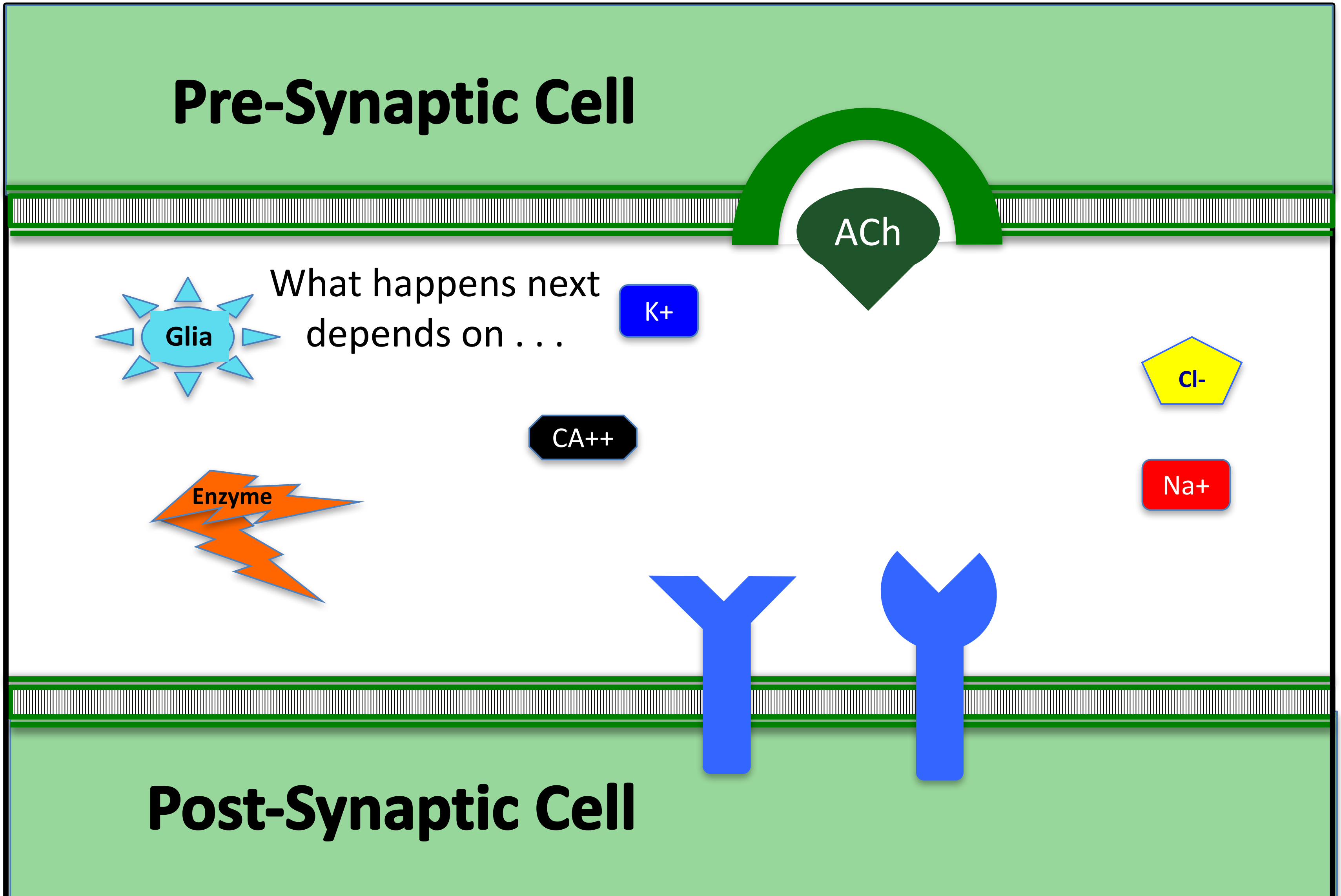
The Synapse


Pre-Synaptic Cell
GABA
Fusion Pore
(releasing NT)
Synaptic
Cleft
Double Lipid
Membranes
Receptor
Sites
Post-Synaptic Cell

The Synapse

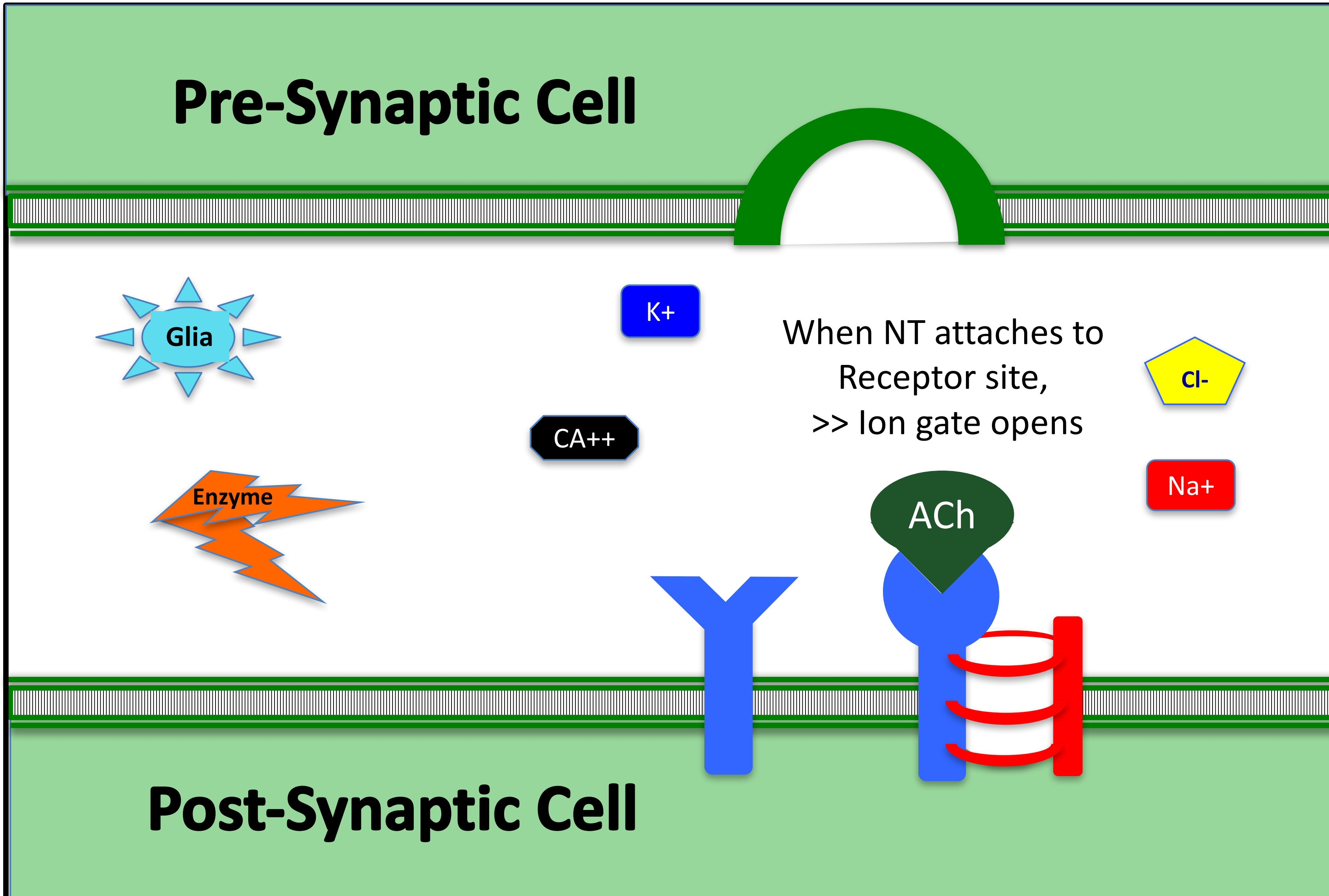

Pre-Synaptic Cell
GABA
NT is released into Synaptic Cleft
where it floats around
until it chances to bump against a
Receptor Site that it fits
Post-Synaptic Cell

The Synapse

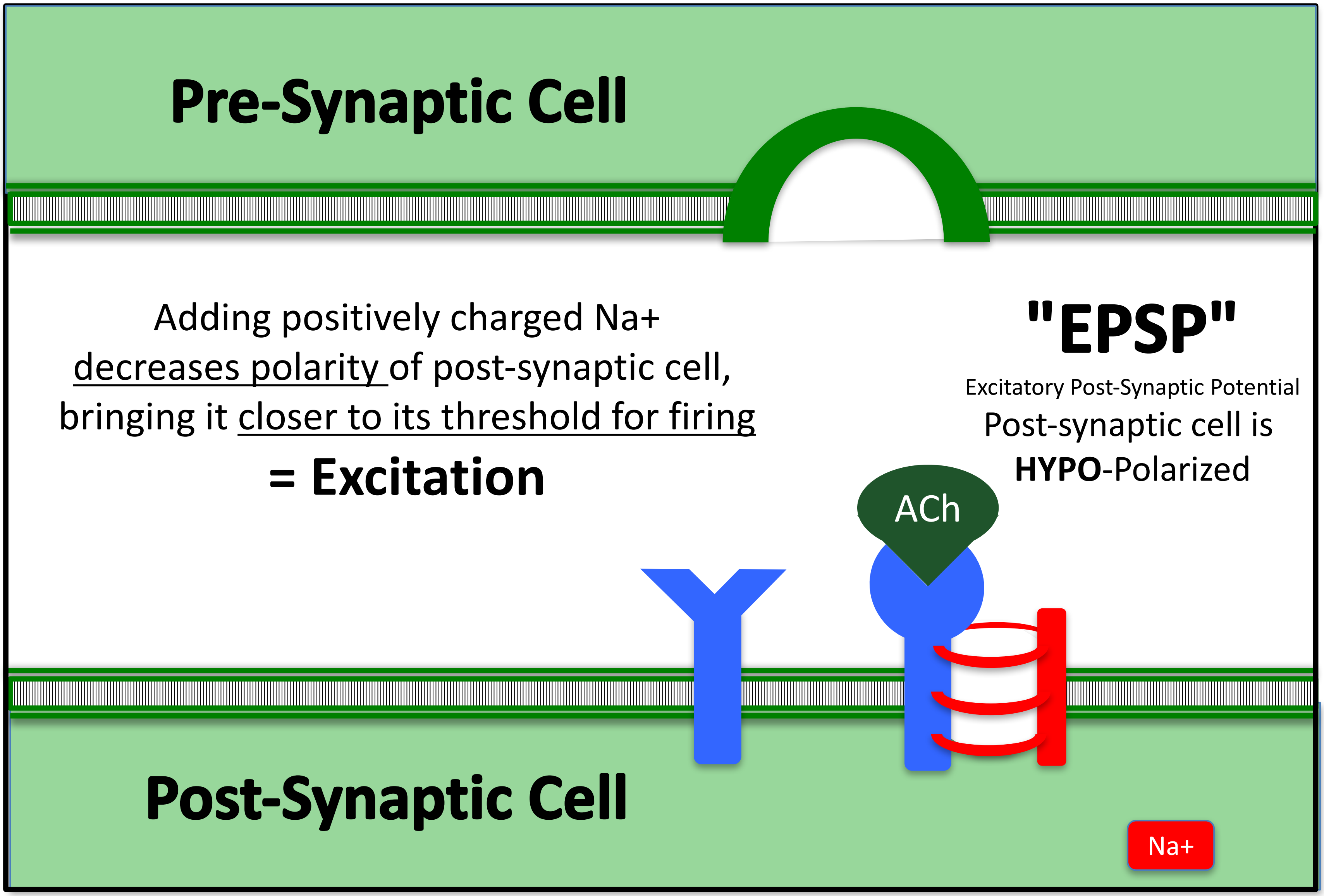


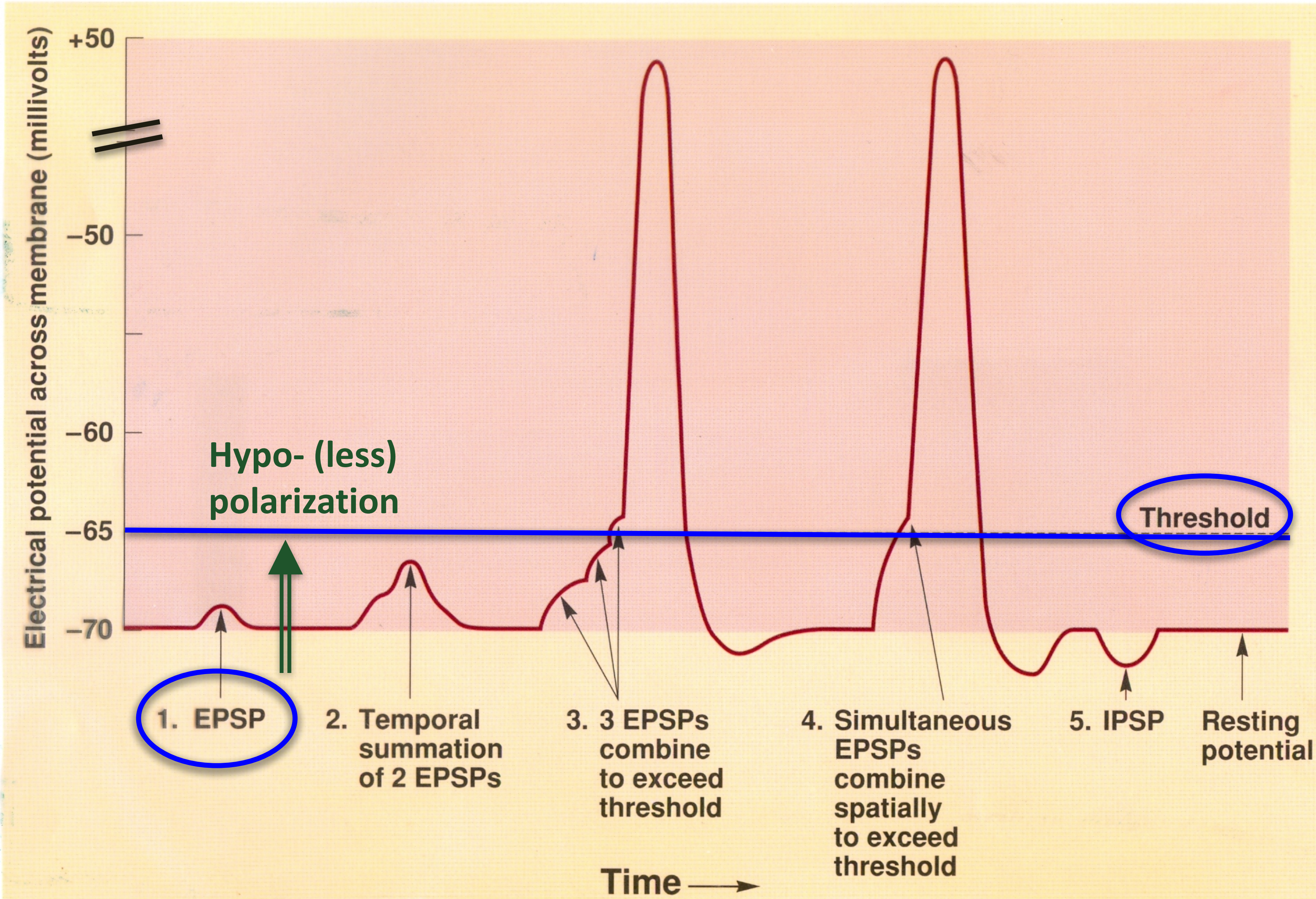
Pre-Synaptic Cell
ACh
Glia
What happens next
depends on . . .
K+
Cl-
CA++
Enzyme
Na+
Post-Synaptic Cell

The Synapse


Pre-Synaptic Cell
Glia
K+
When NT attaches to
Receptor site,
>> Ion gate opens
Cl-
CA++
Enzyme
Na+
ACh
Post-Synaptic Cell

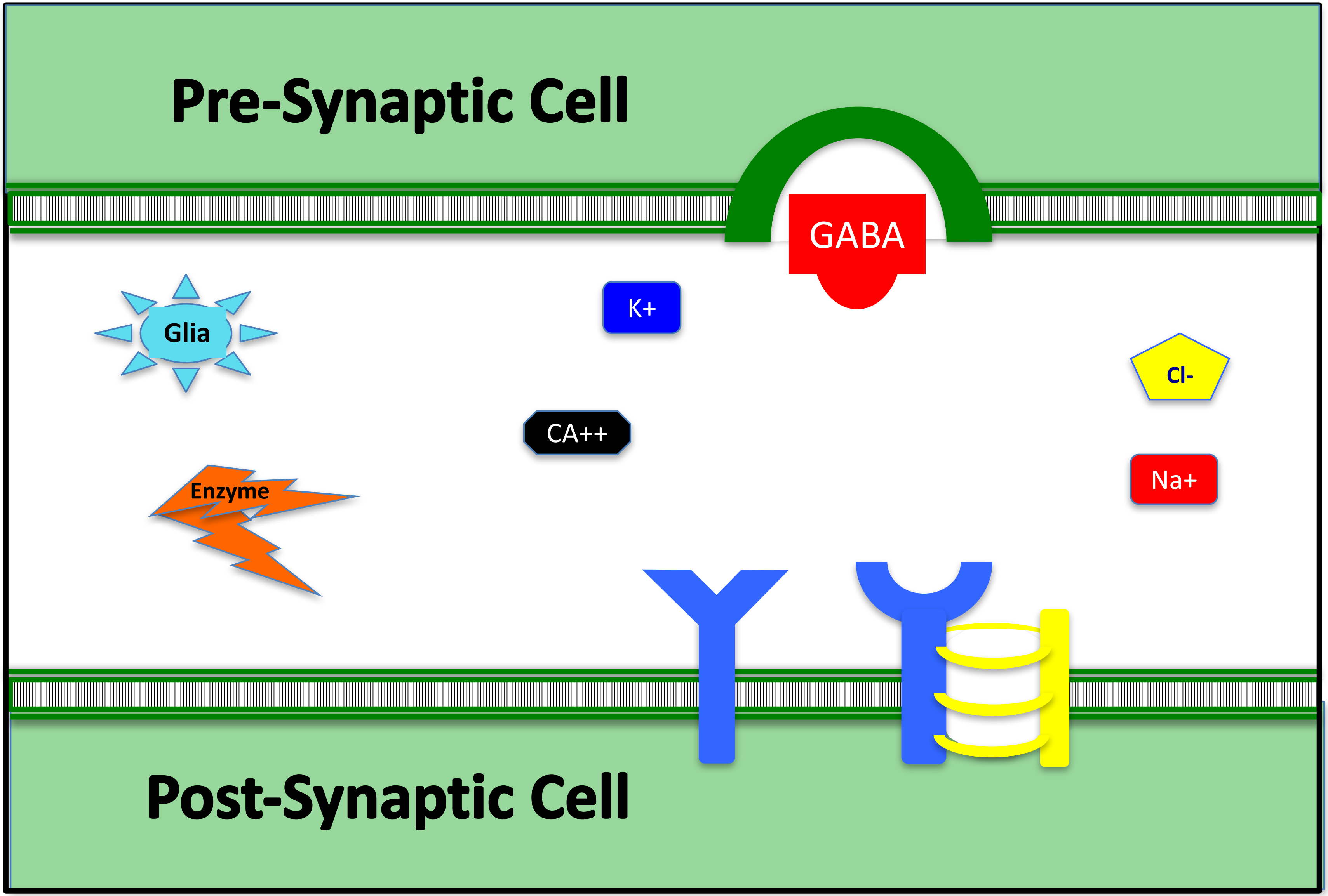
The Synapse


Pre-Synaptic Cell
Adding positively charged Na+ decreases polarity of post-synaptic cell, bringing it closer to its threshold for firing
= Excitation
"EPSP"
Excitatory Post-Synaptic Potential
Post-synaptic cell is HYPO-Polarized
ACh
Post-Synaptic Cell
Na+



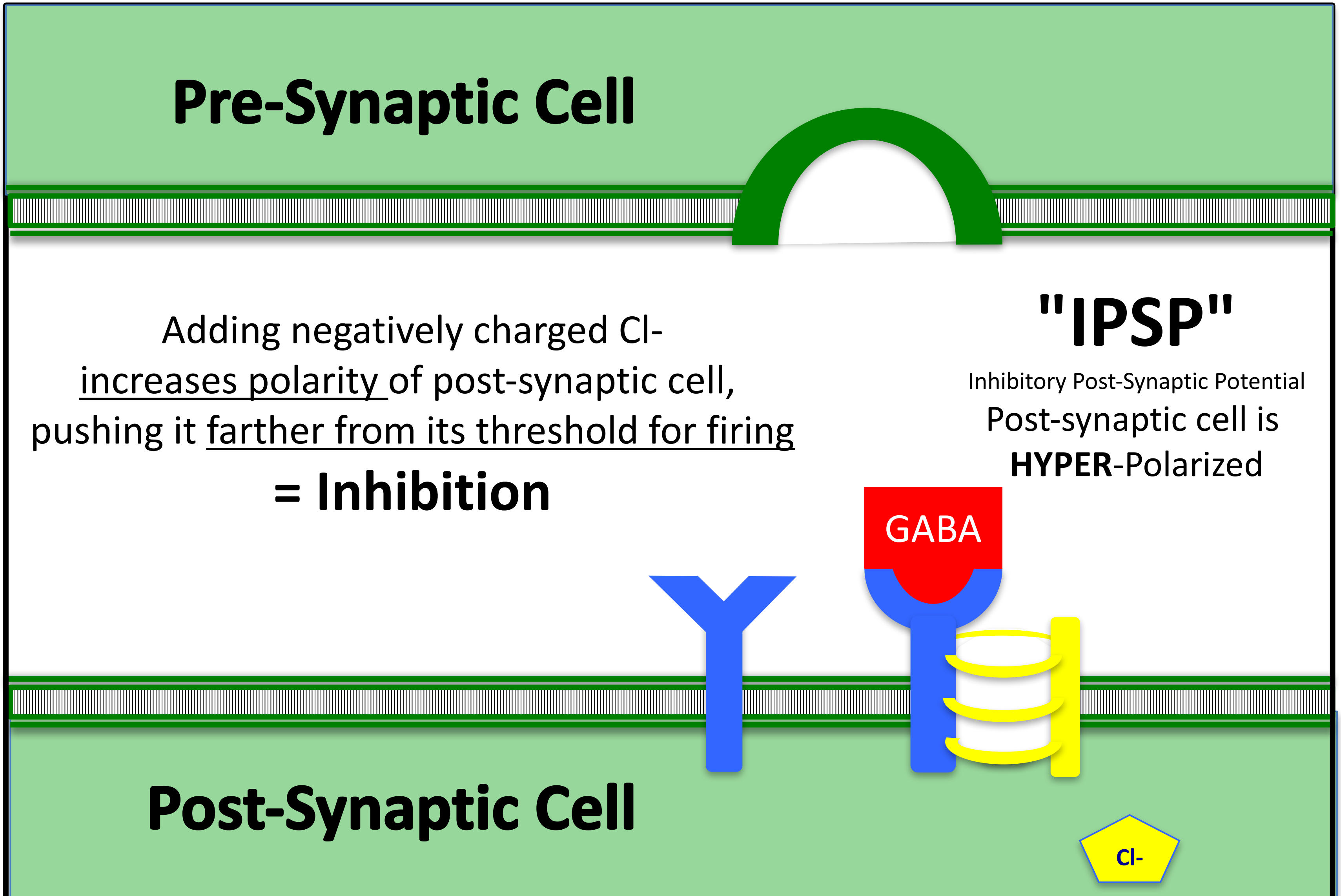
Recording from postsynaptic neuron

The Synapse

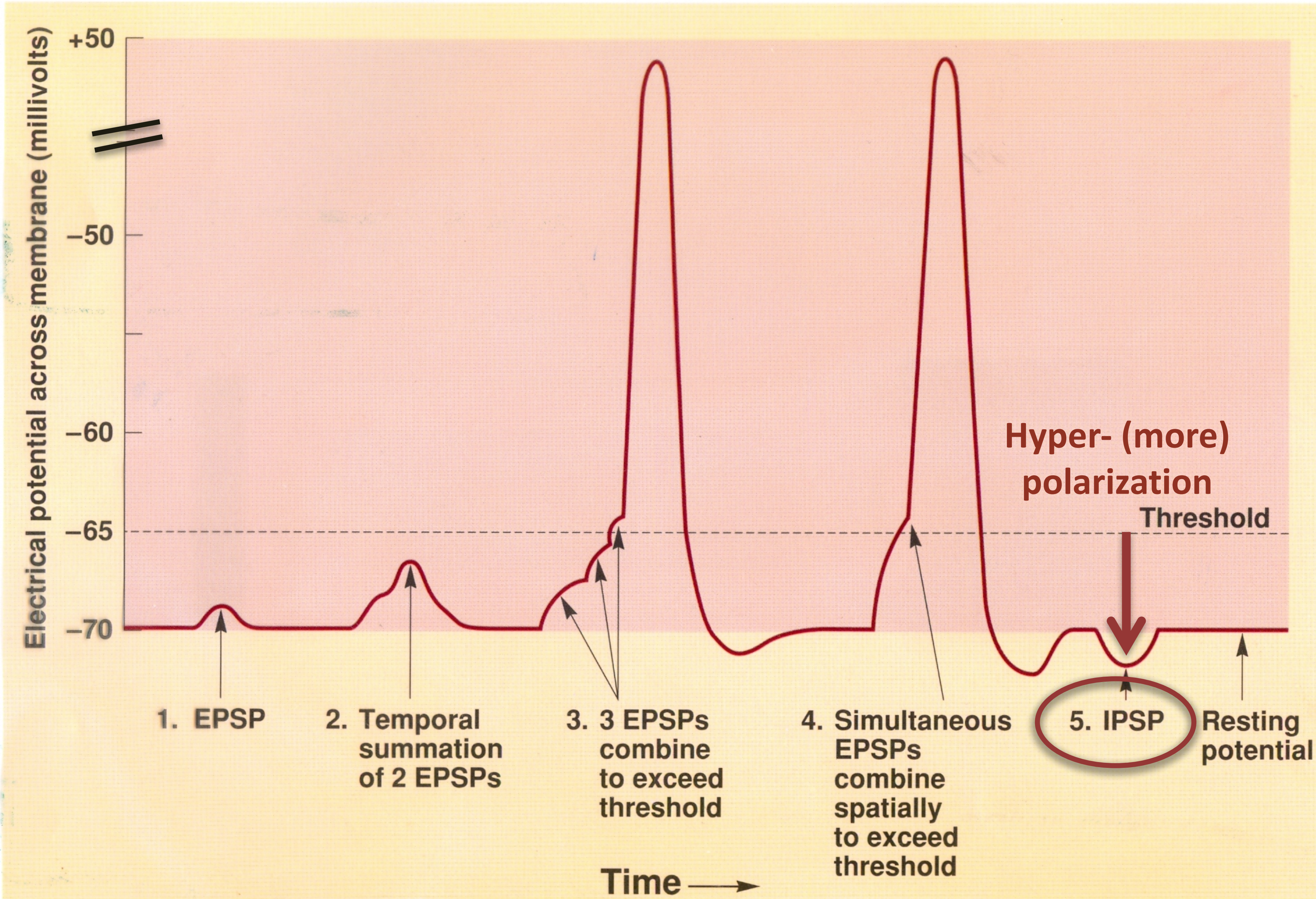


Pre-Synaptic Cell
GABA
K+
Glia
Cl-
CA++
Na+
Enzyme
Post-Synaptic Cell

The Synapse



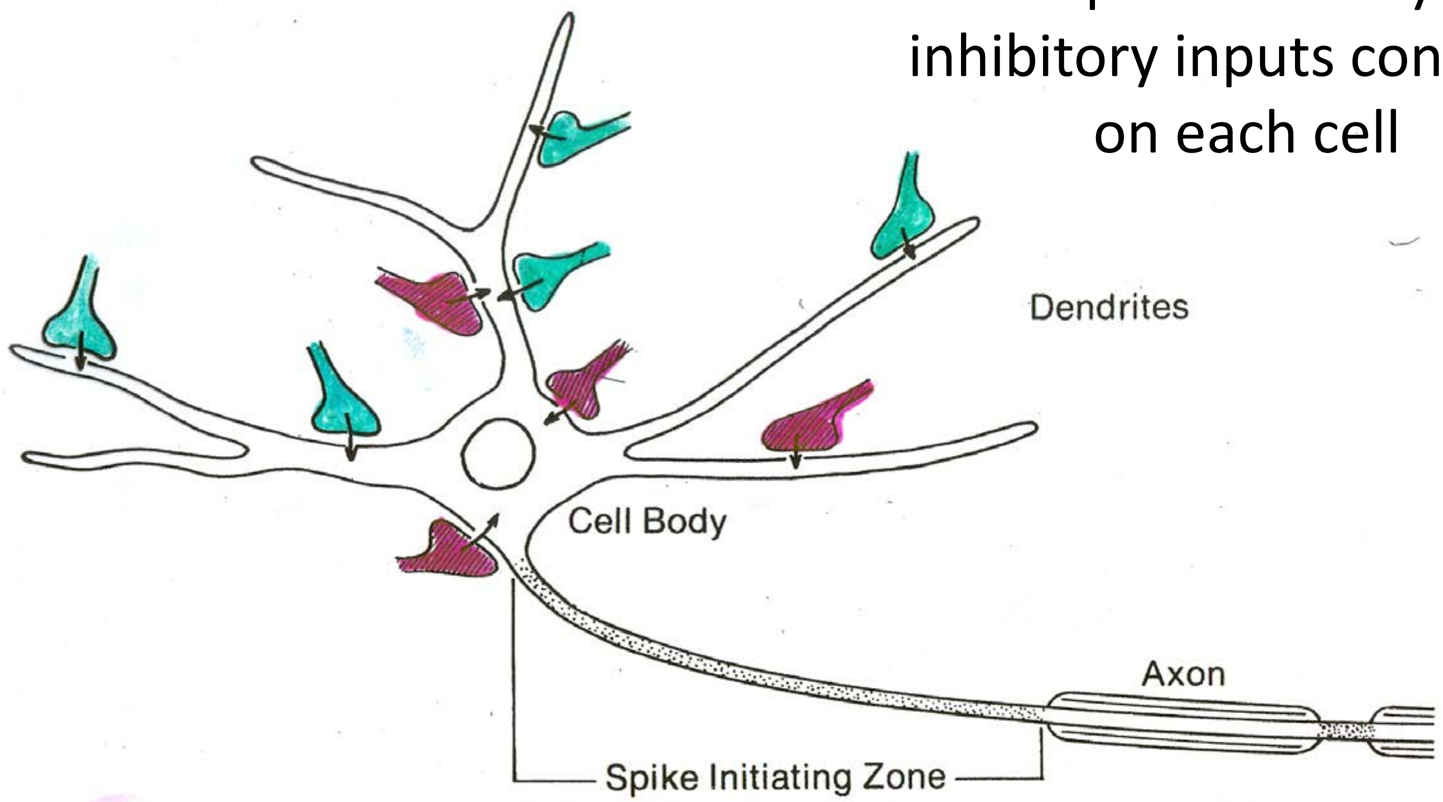
Pre-Synaptic Cell
Adding negatively charged Cl-
increases polarity of post-synaptic cell,
pushing it farther from its threshold for firing
= Inhibition
"IPSP"
Inhibitory Post-Synaptic Potential
Post-synaptic cell is
HYPER-Polarized
GABA
Post-Synaptic Cell
Cl-



Recording from postsynaptic neuron

Summation

Multiple excitatory and inhibitory inputs converge on each cell

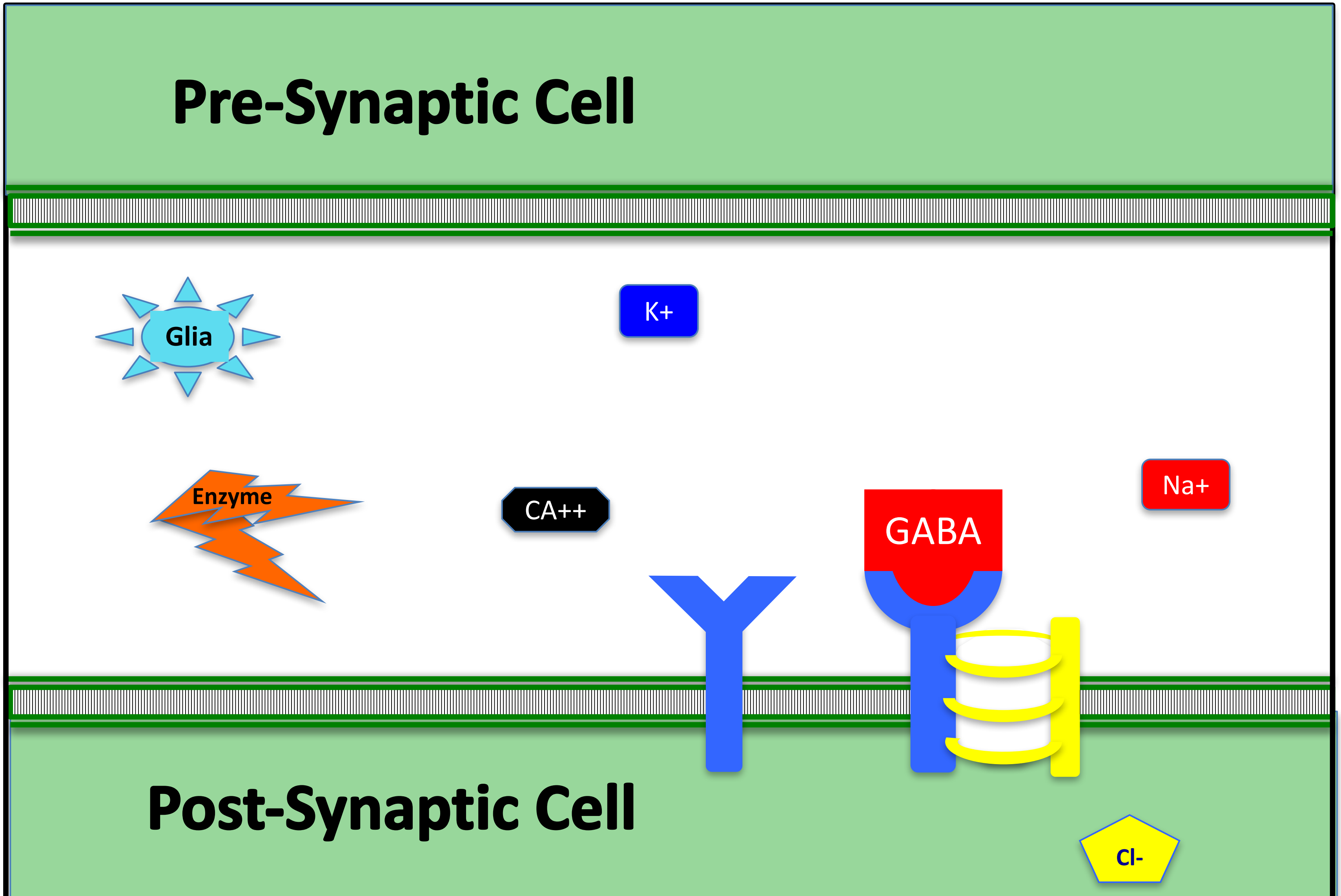


MNEMONIC: EPSP & IPSP

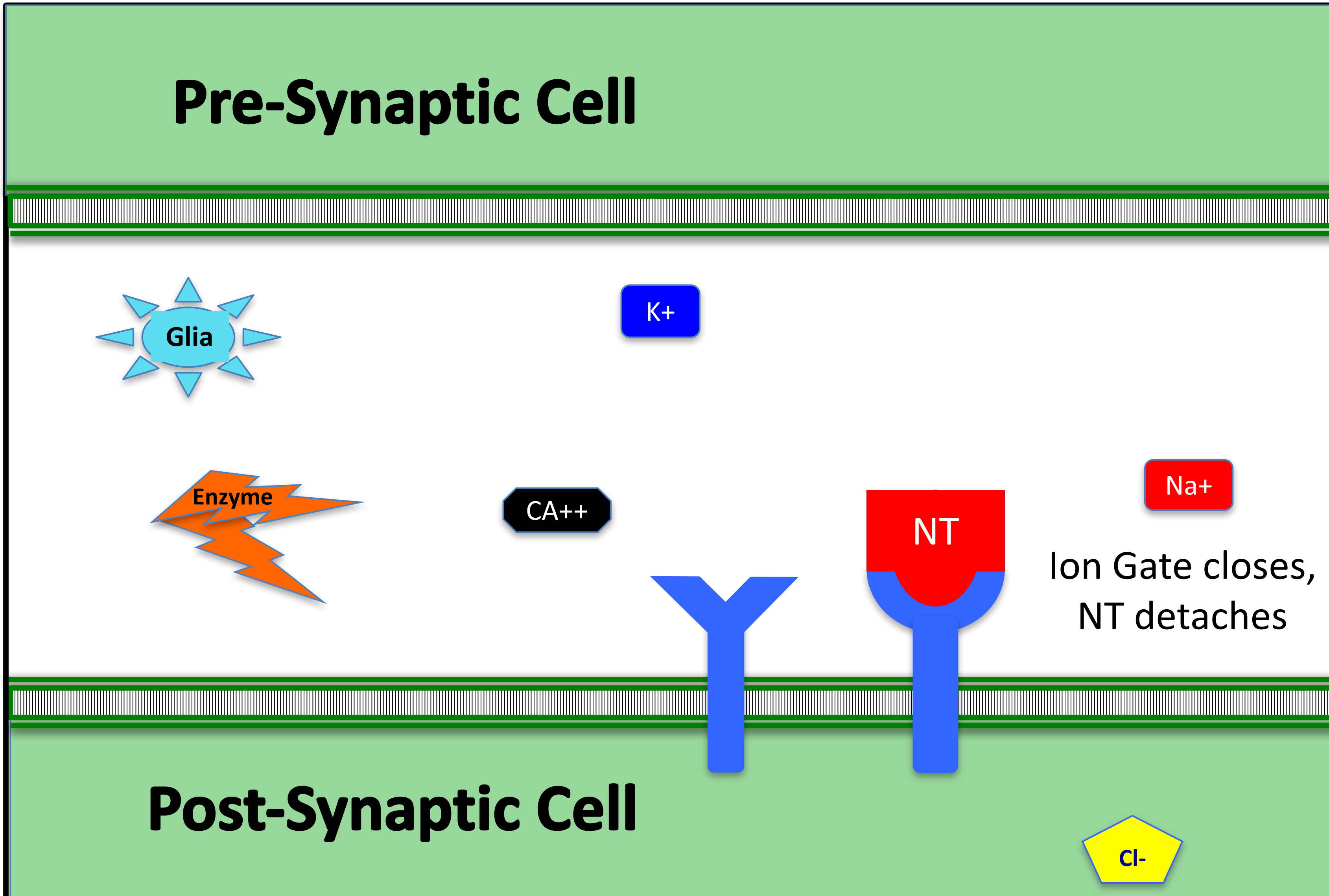
- *E*PSP = ***Excitatory*** Post-Synaptic Potential
  - Cell is HYP**O**-Polarized
  - When you are excited, you say "**O!**"

- *I*PSP = ***Inhibitory*** Post-Synaptic Potential
  - Cell is HYP**ER**-Polarized
  - When you are inhibited, you say "**ER…**"

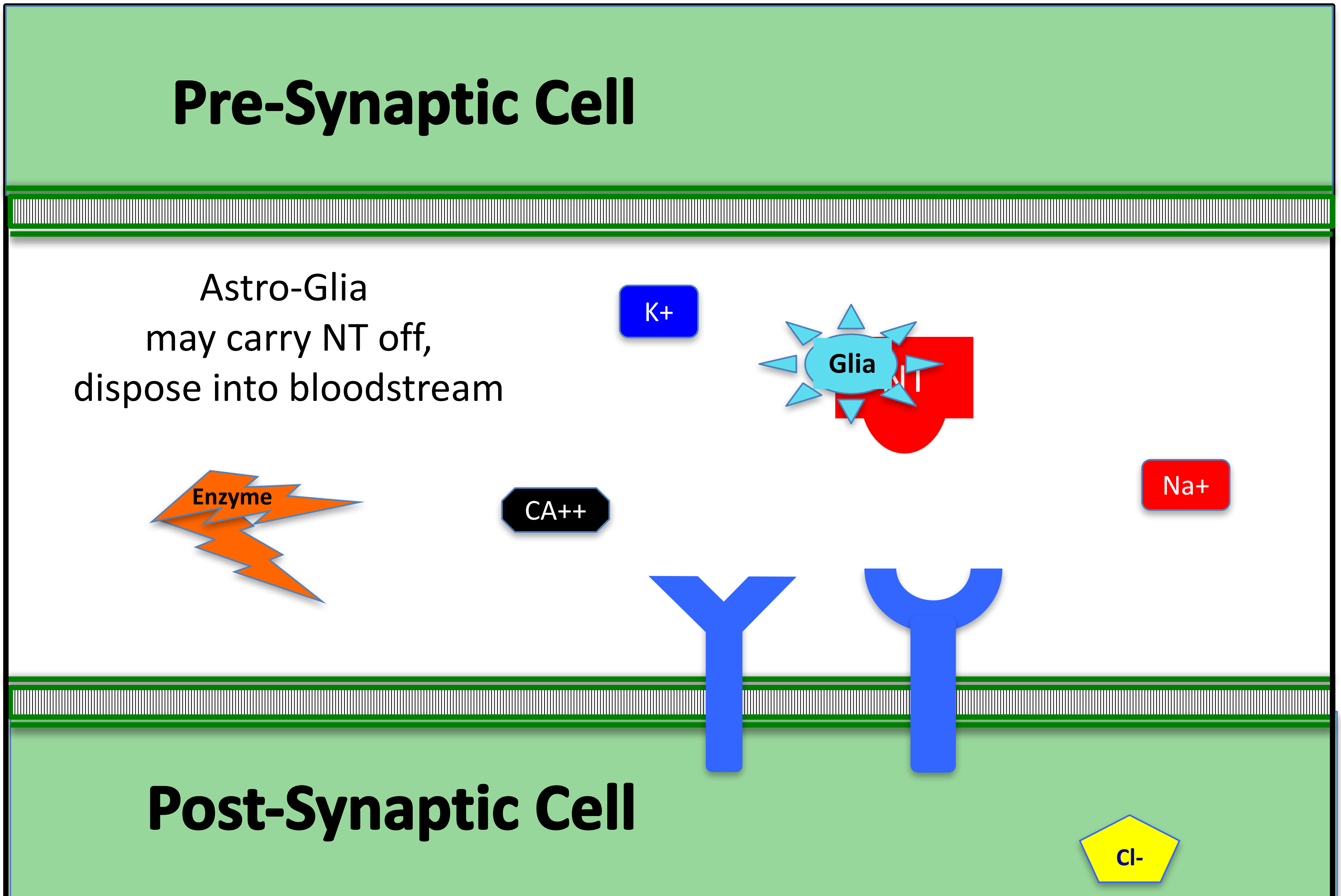
AFTER the Synapse . . .



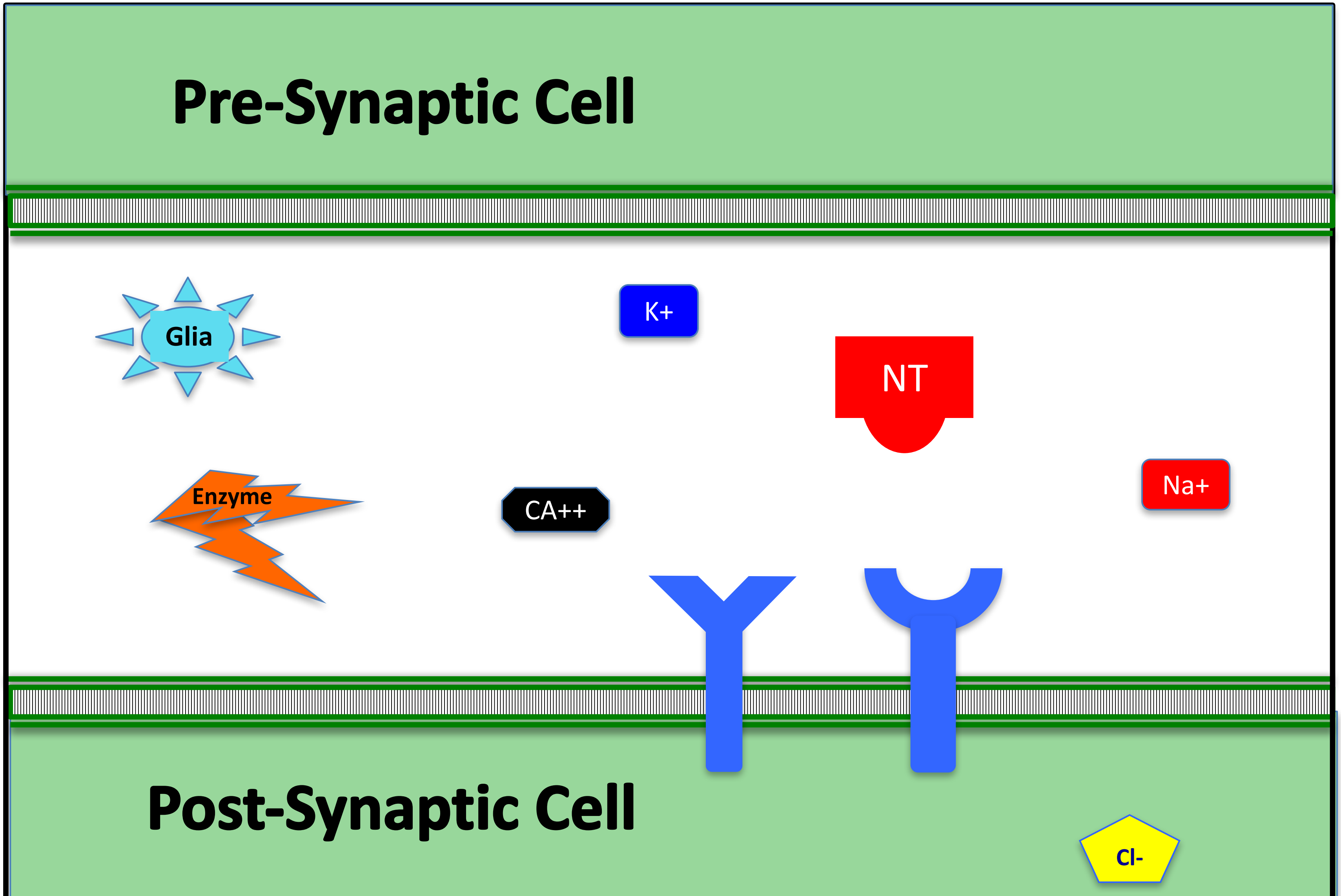
AFTER the Synapse . . .



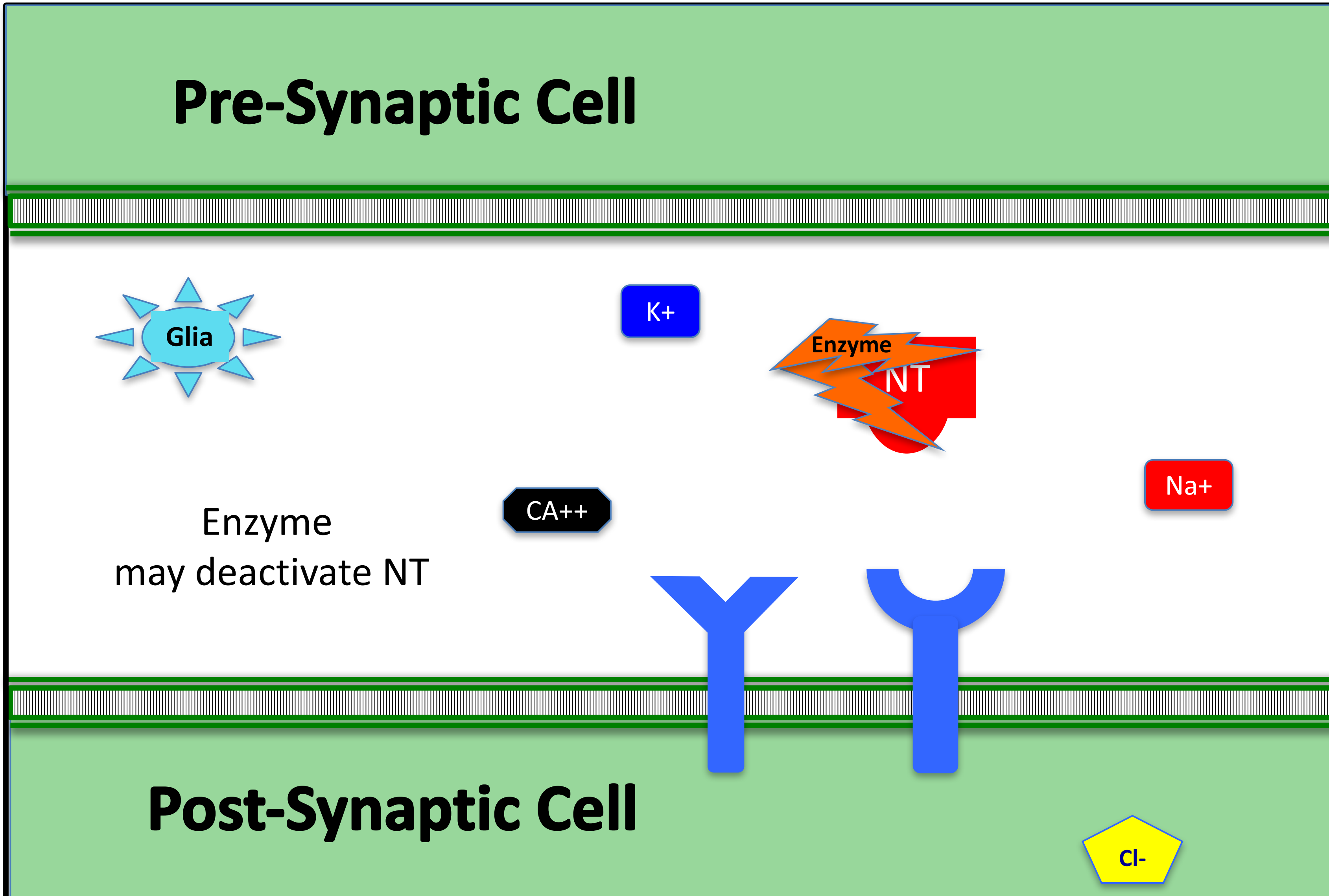
AFTER the Synapse . . .



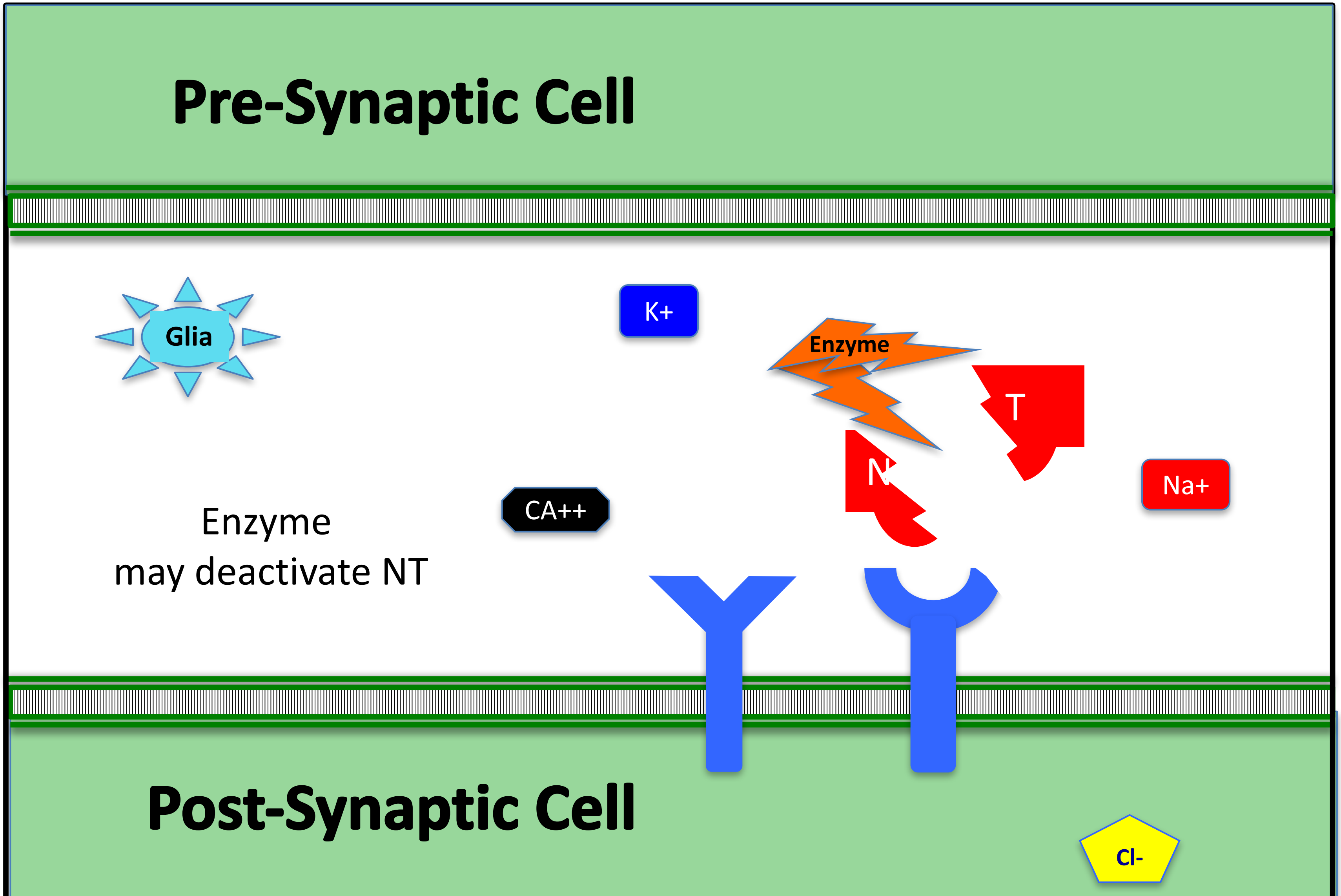
AFTER the Synapse . . .



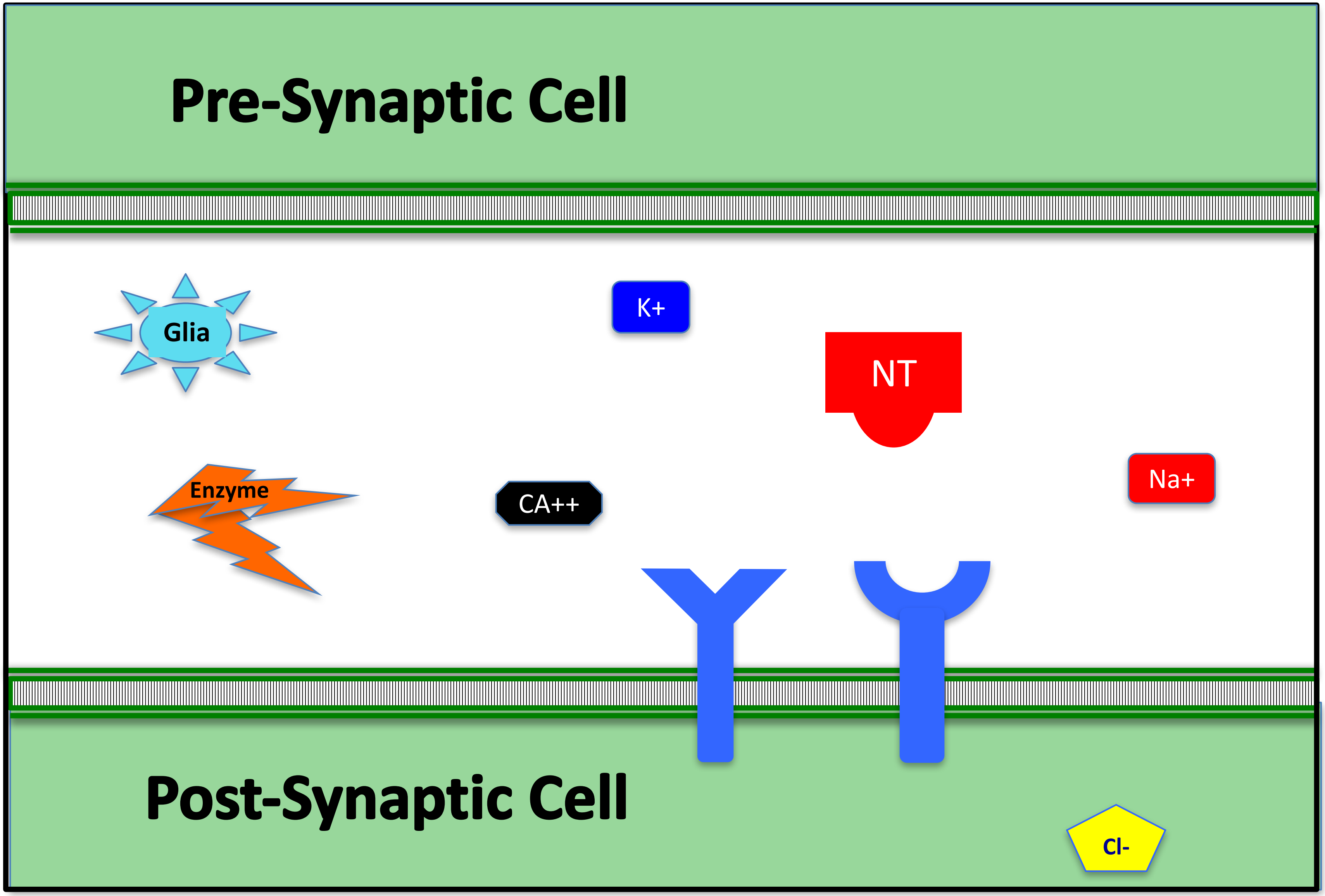
AFTER the Synapse . . .



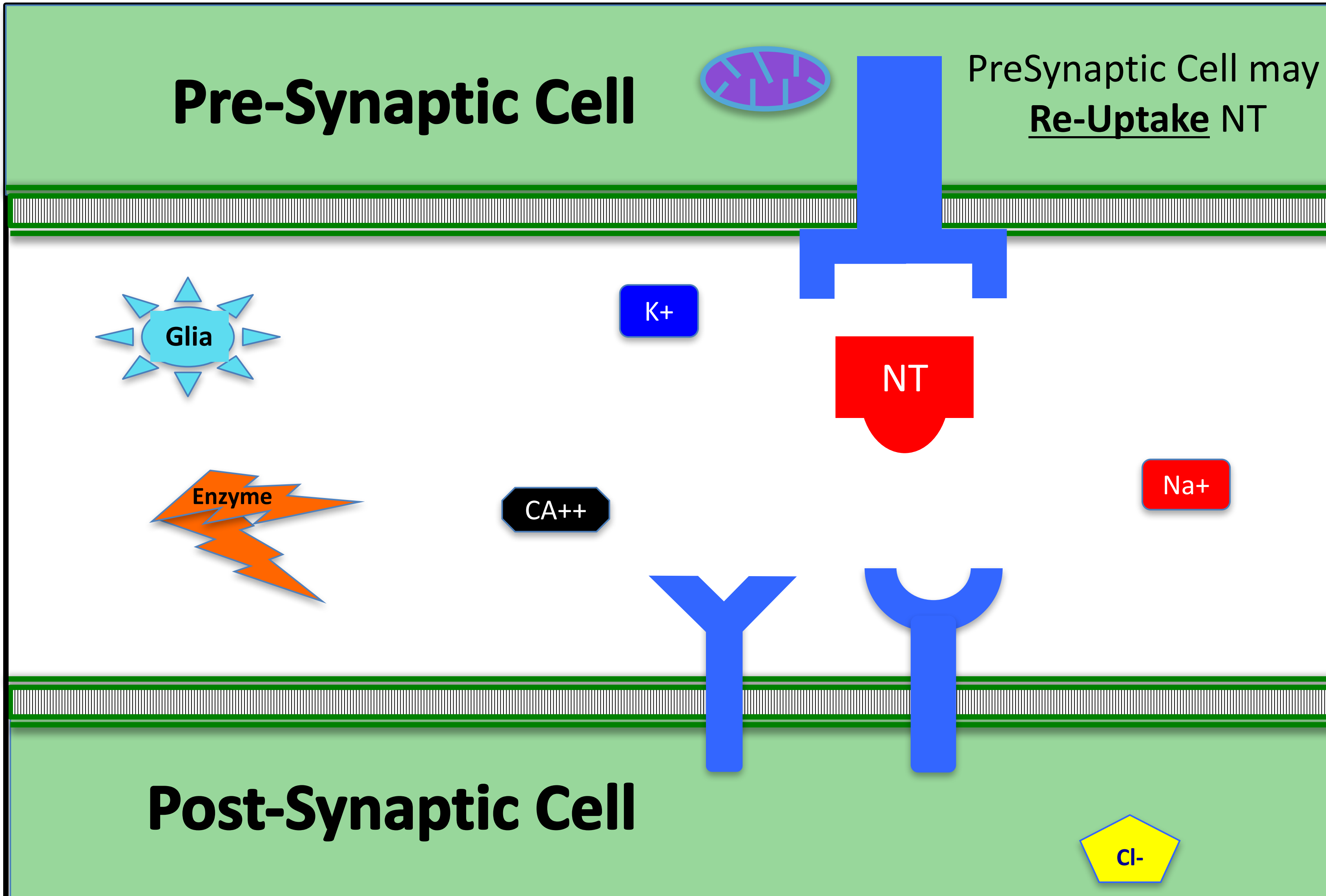
AFTER the Synapse . . .



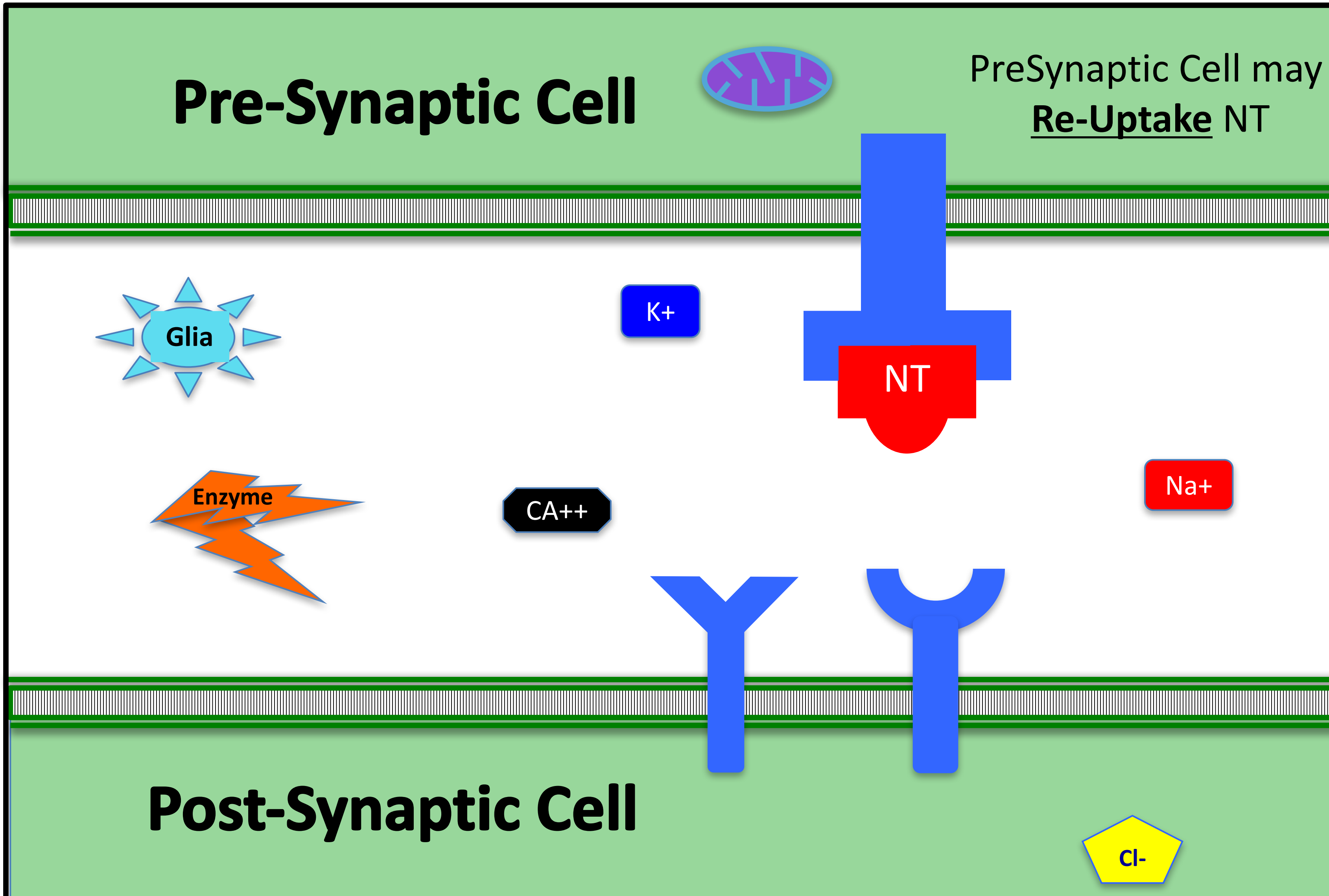
AFTER the Synapse . . .



<u>AFTER</u> the Synapse . . .



AFTER the Synapse . . .

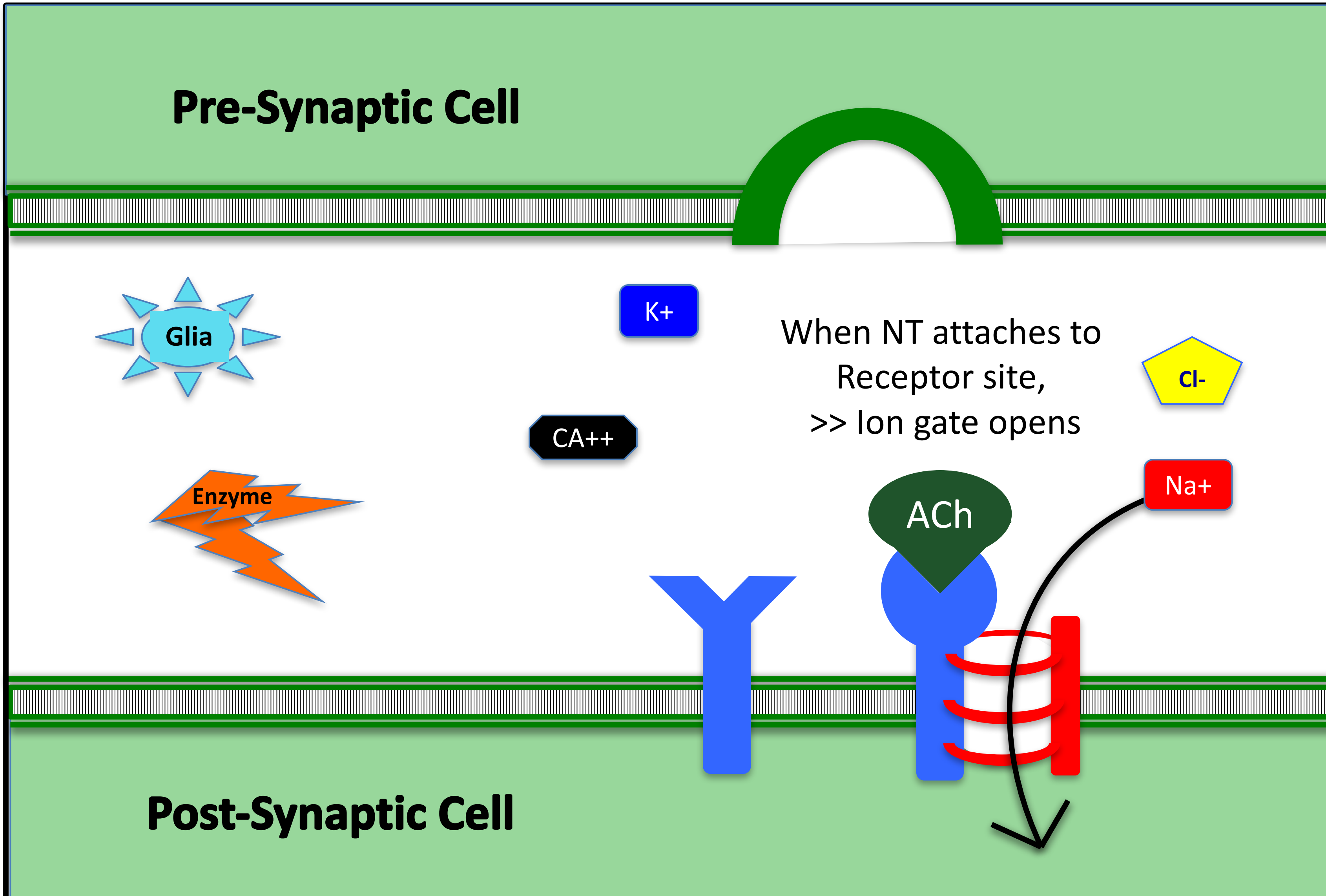


MNEMONIC

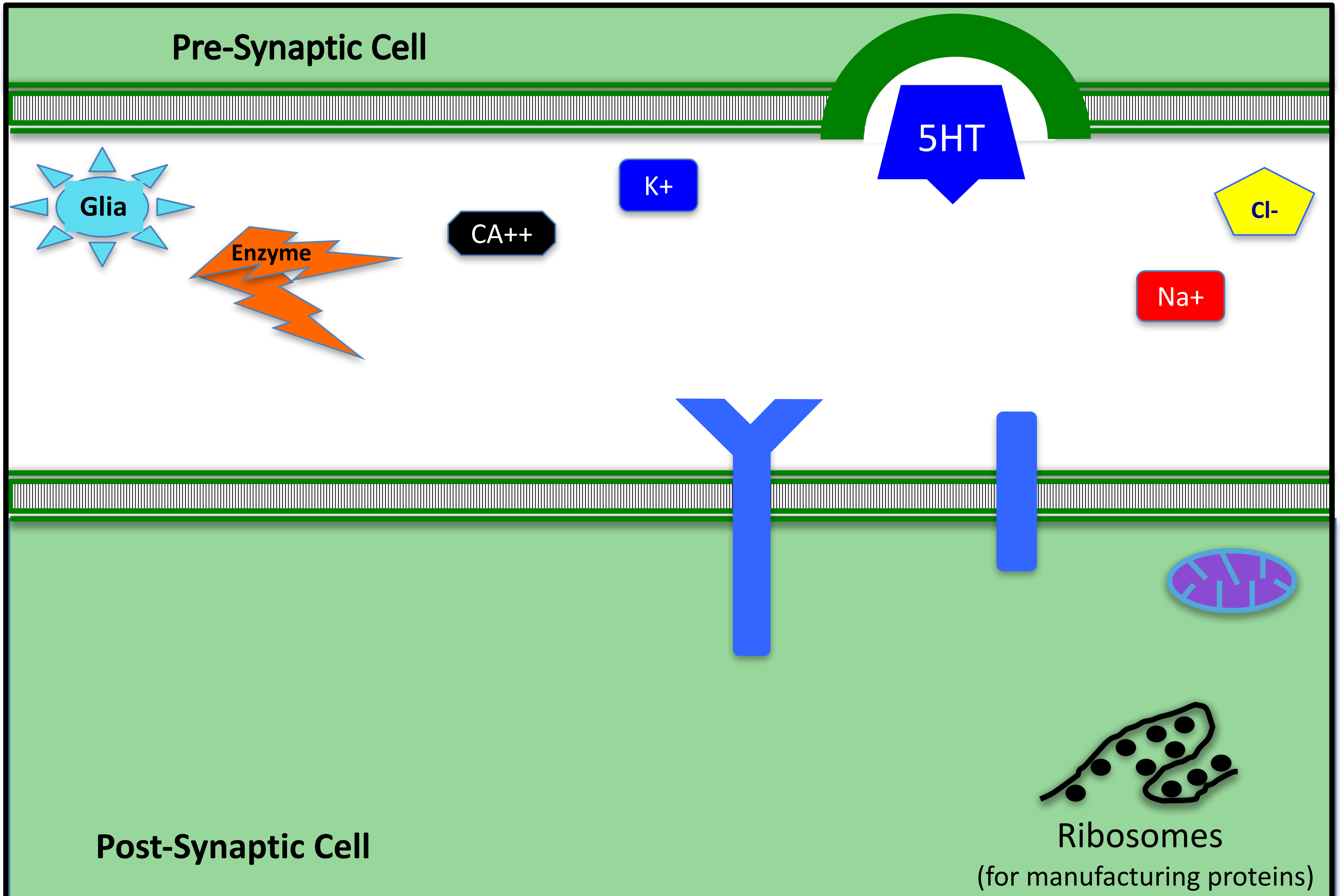
Neurotransmitter

Binds to the post,
but doesn’t go in,
floats back home
to be used again.

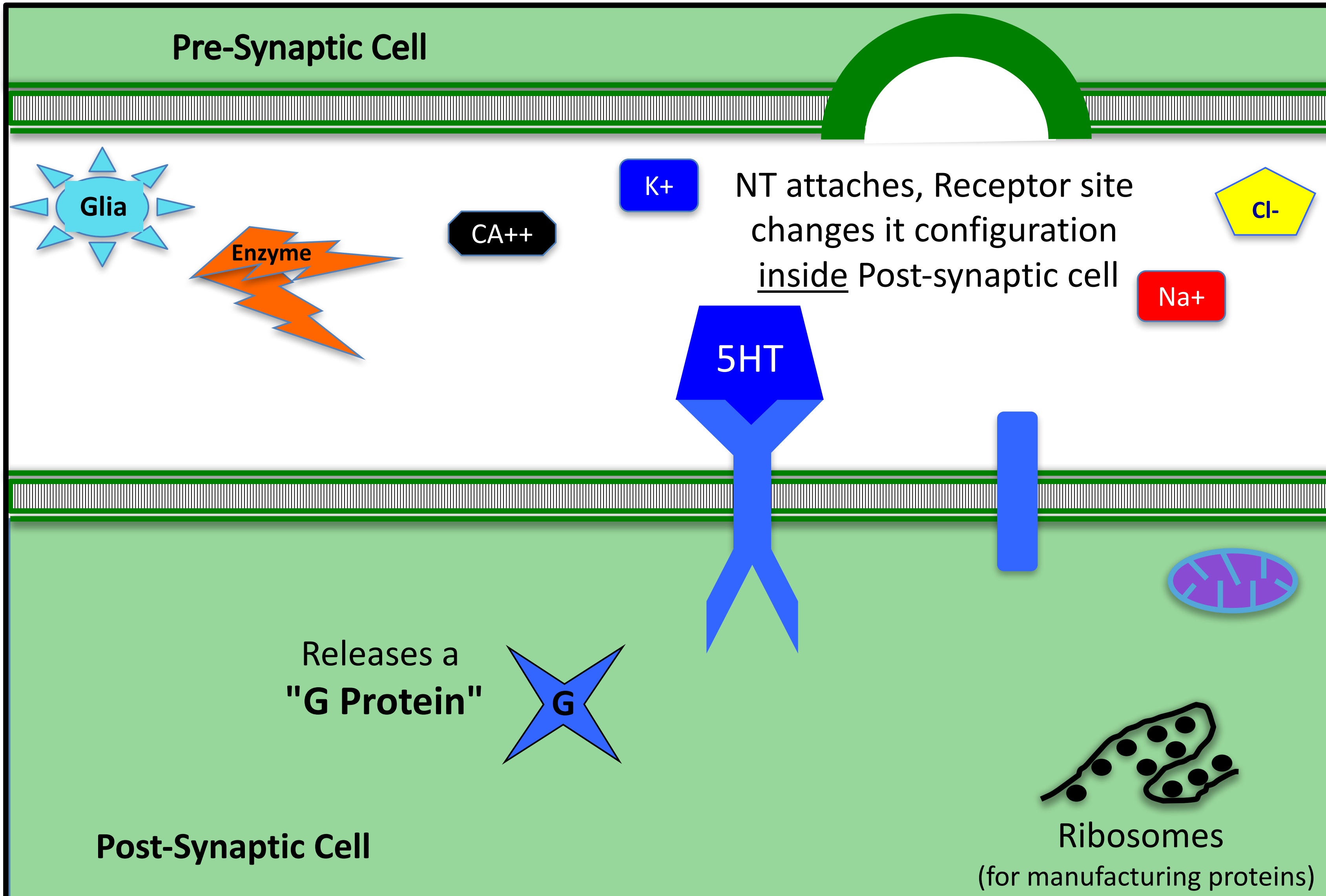
Ionotrophic Synapse



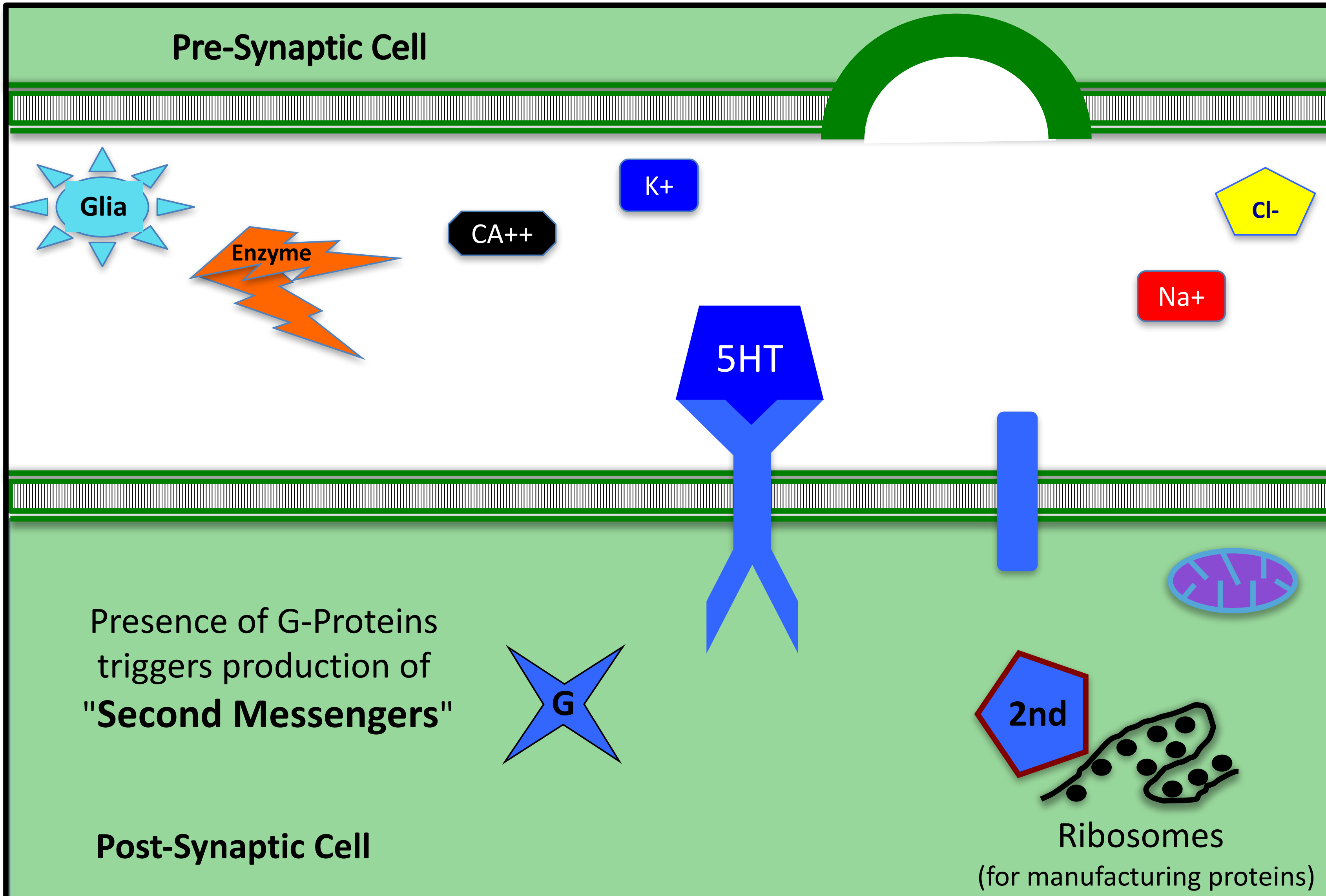
Metabotrophic Synapse



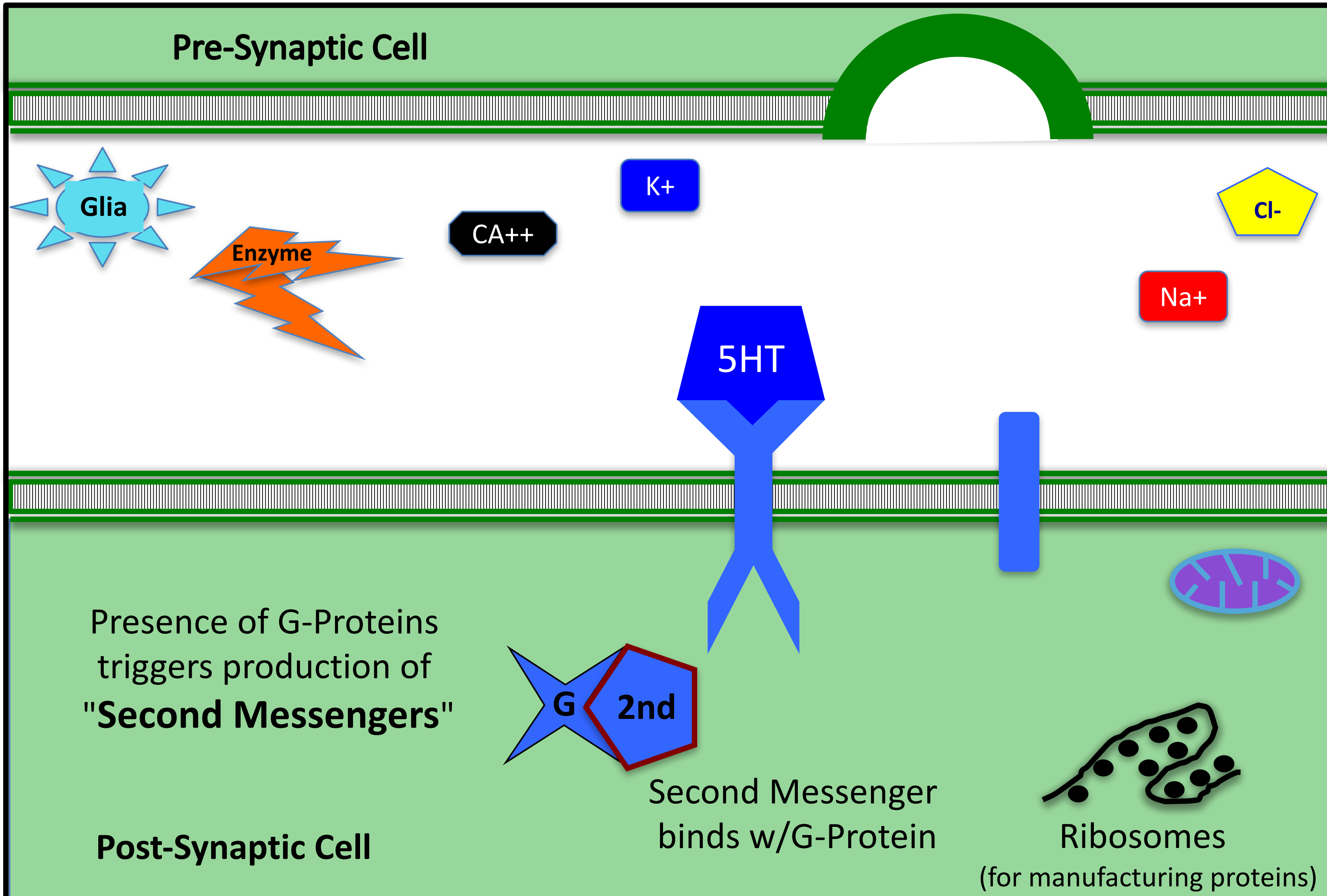
Metabotrophic Synapse



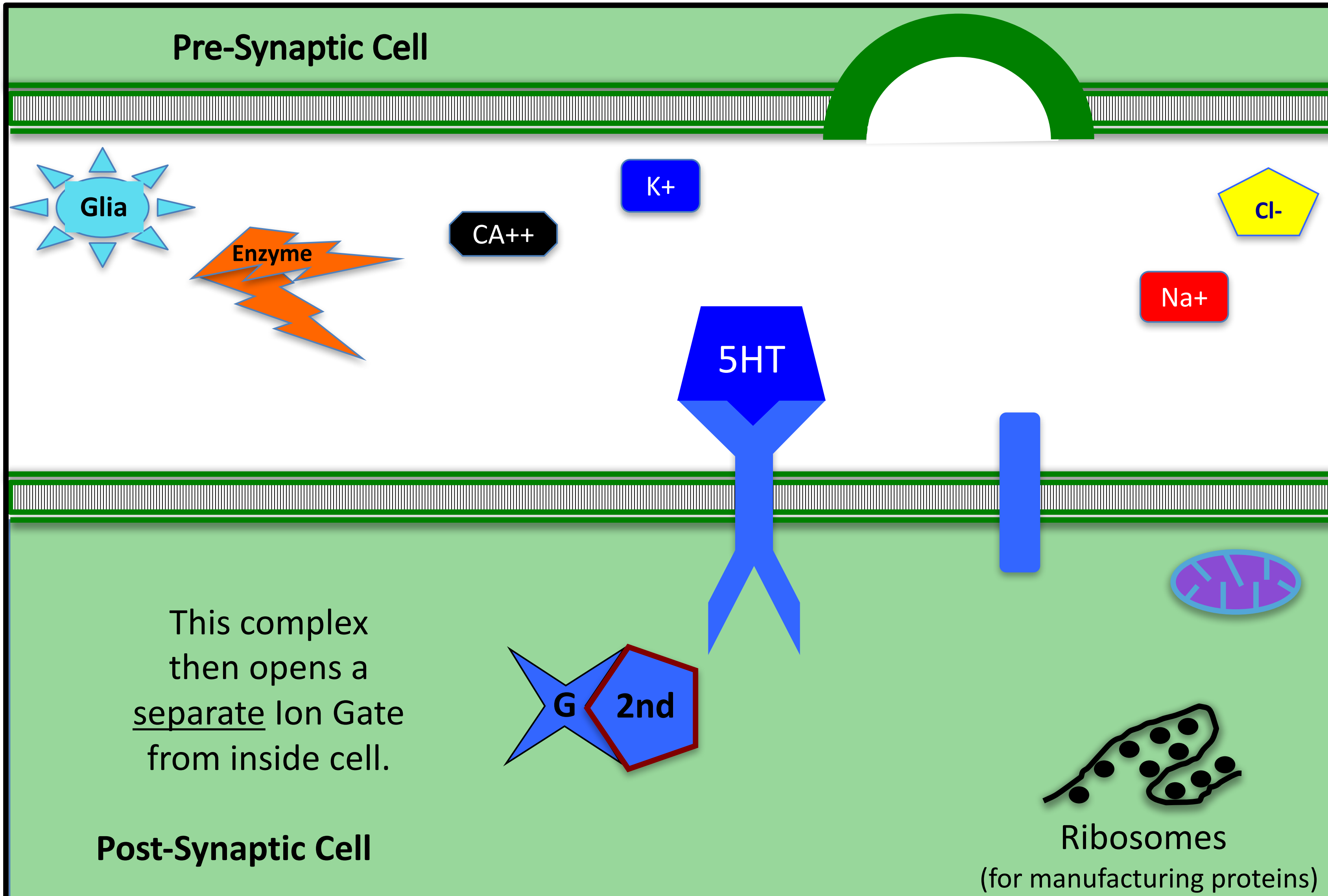
Metabotrophic Synapse



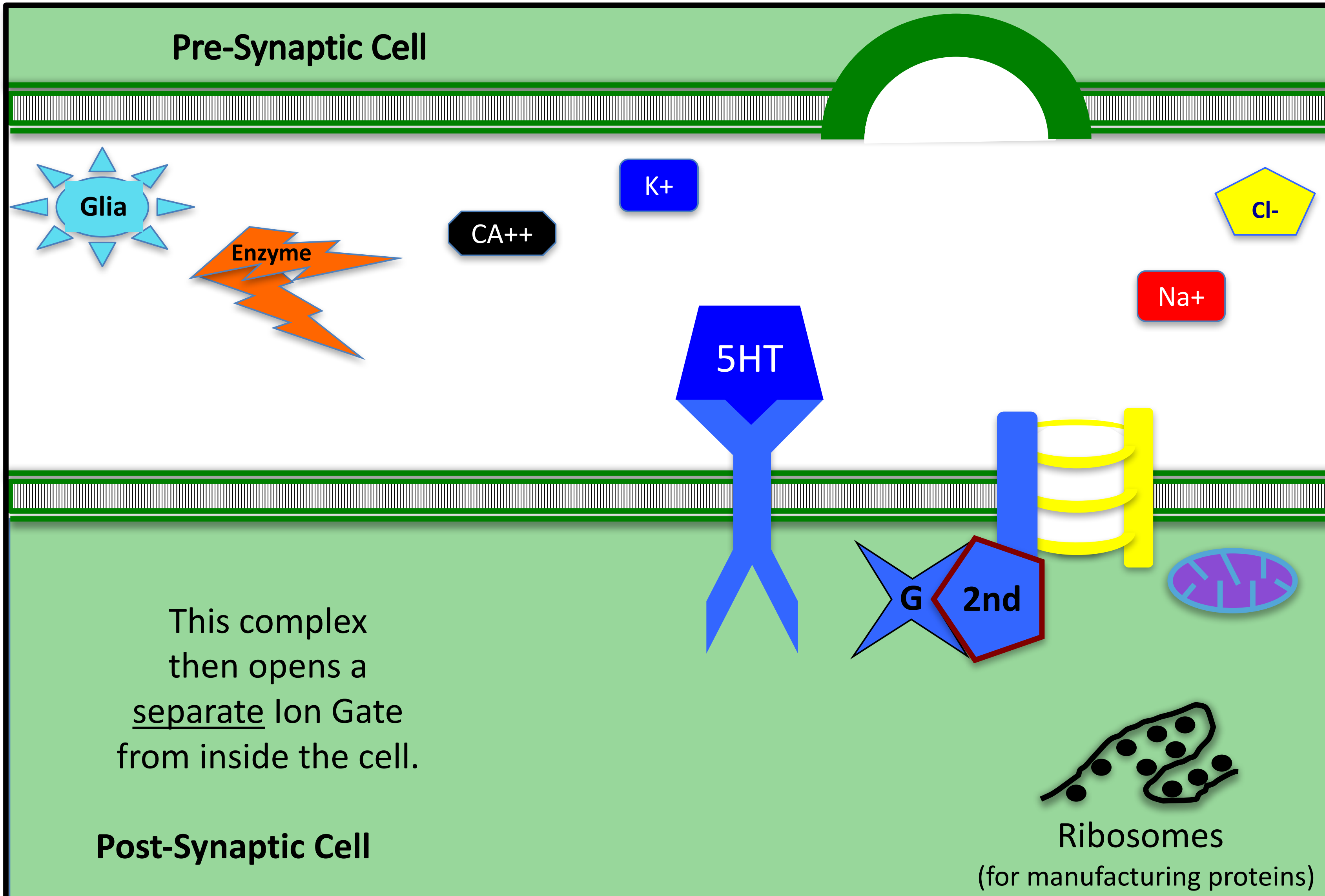
Metabotrophic Synapse



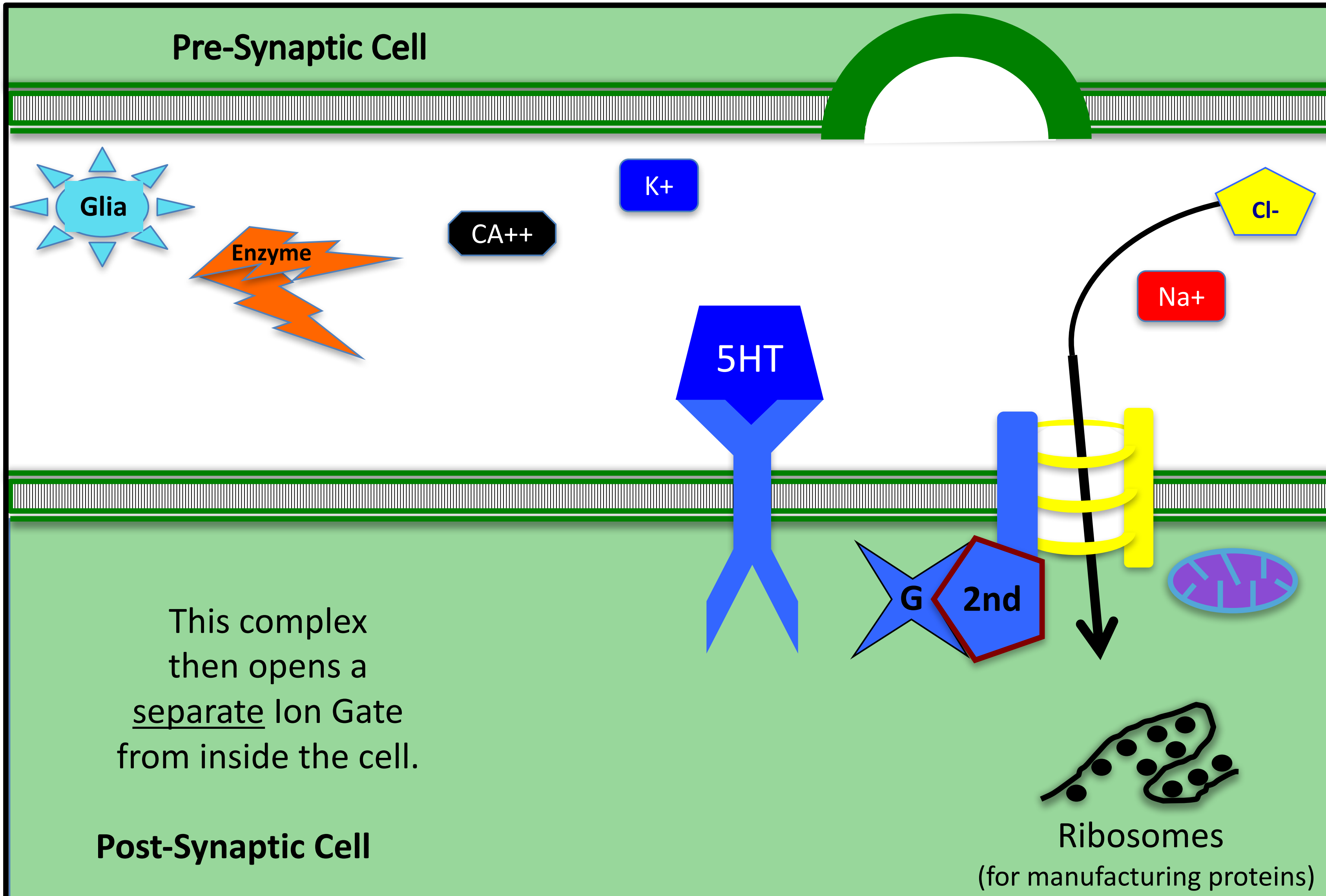
Metabotrophic Synapse



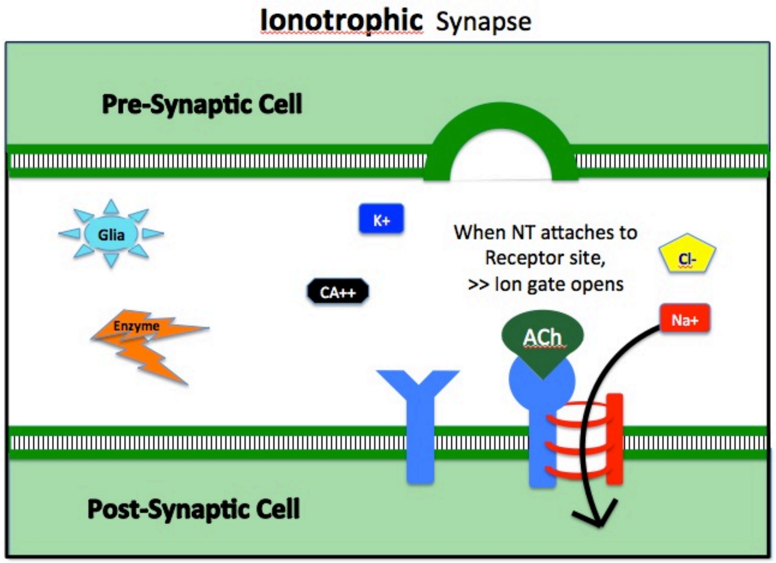
Metabotrophic Synapse

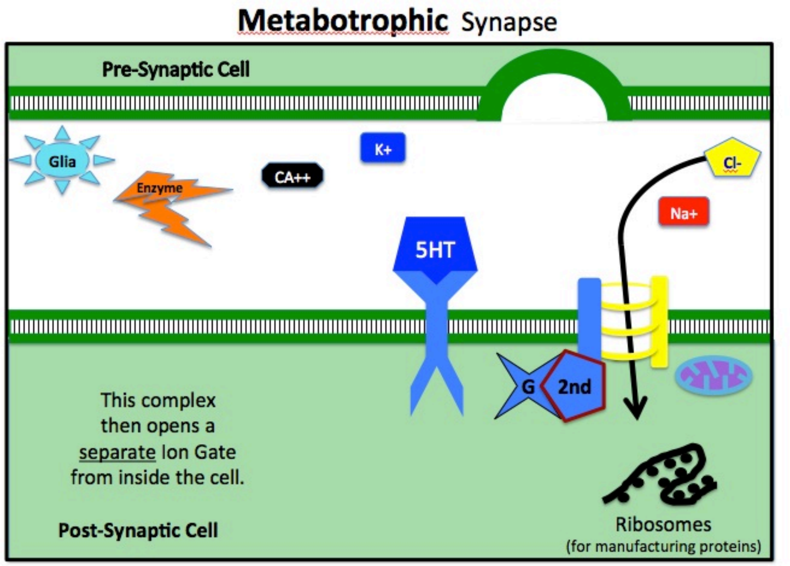


Metabotrophic Synapse



Ionotrophic vs. Metabotrophic





- Rapid response
- Very short-lived
- For sending message along a pathway

- Slow response
- Long lasting
- For setting conditions (e.g. mood, attention)

Neurotransmitters

SOME NTs:	SOME FUNTIONS:
Acetylcholine (ACh)	All neuro-muscular junctions; Cortical arousal...
GABA	Suppress cortical activity; Regulate anxiety...
Glutamate	Most common + ; Learning, Perception, Schiz...
Serotonin (5HT)	Often a neuromodulator; Mood, Sleep, Percep...
Dopamine	Reinforcement; Atten; Motor control (Parkinsons)...
Norepinephrine	Arousal; Attention...
Epinephrine (Adrenalin)	Arousal; Attention...
Substance P	Pain (damage, itch, extreme temp, etc)
Endorphins	Counter effects of Substance P
Hormones	e.g. Testosterone, Estrogen, Oxytocin, Insulin, CCK, Cortisol, Adrenalin,. . .

Agonists vs. Antagonists

AGONIST

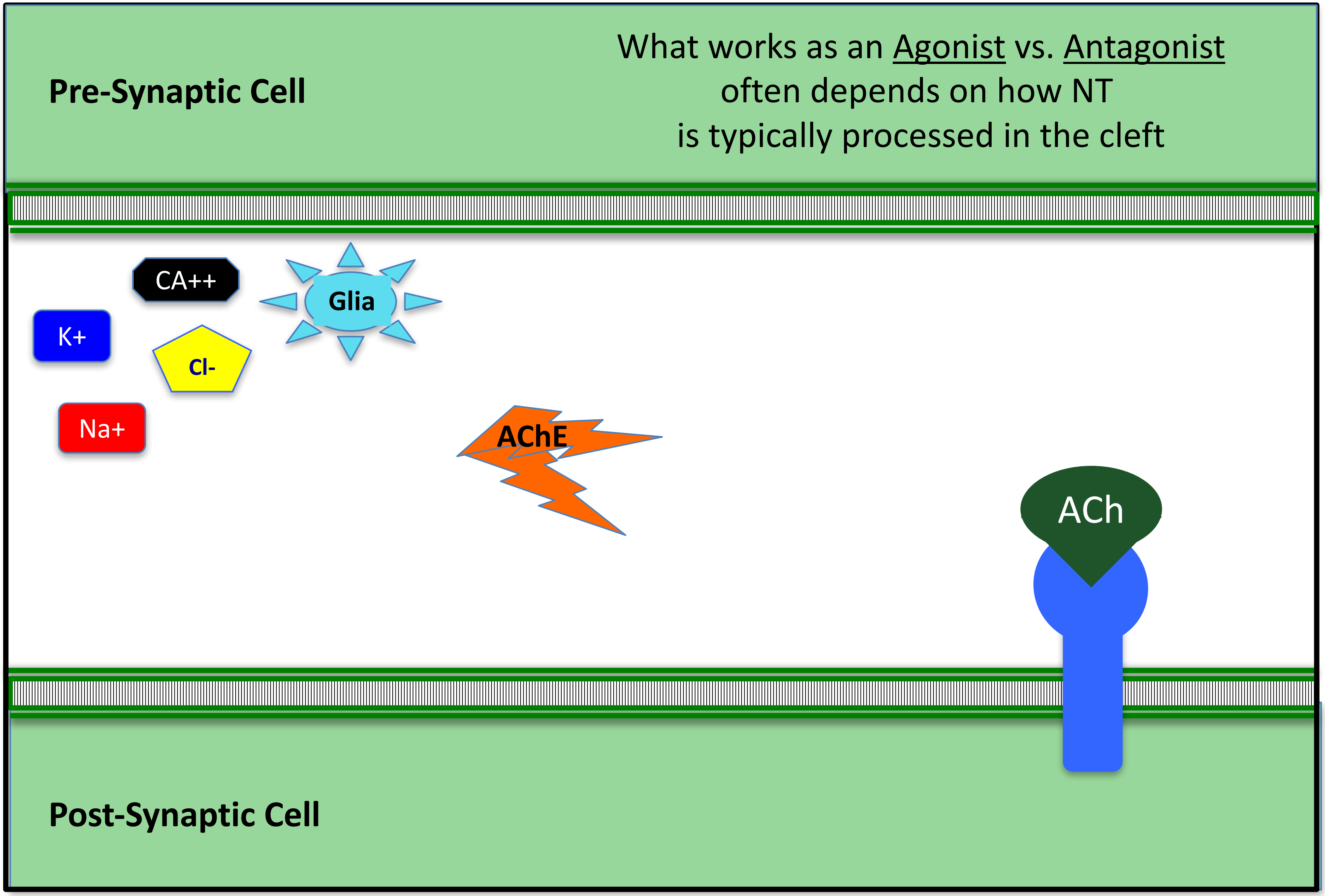
- Increases the likelihood of a Neurotransmitter having its effect (+ or -)

ANTAGONIST

- Decreases the likelihood of a Neurotransmitter having its effect (+ or -)

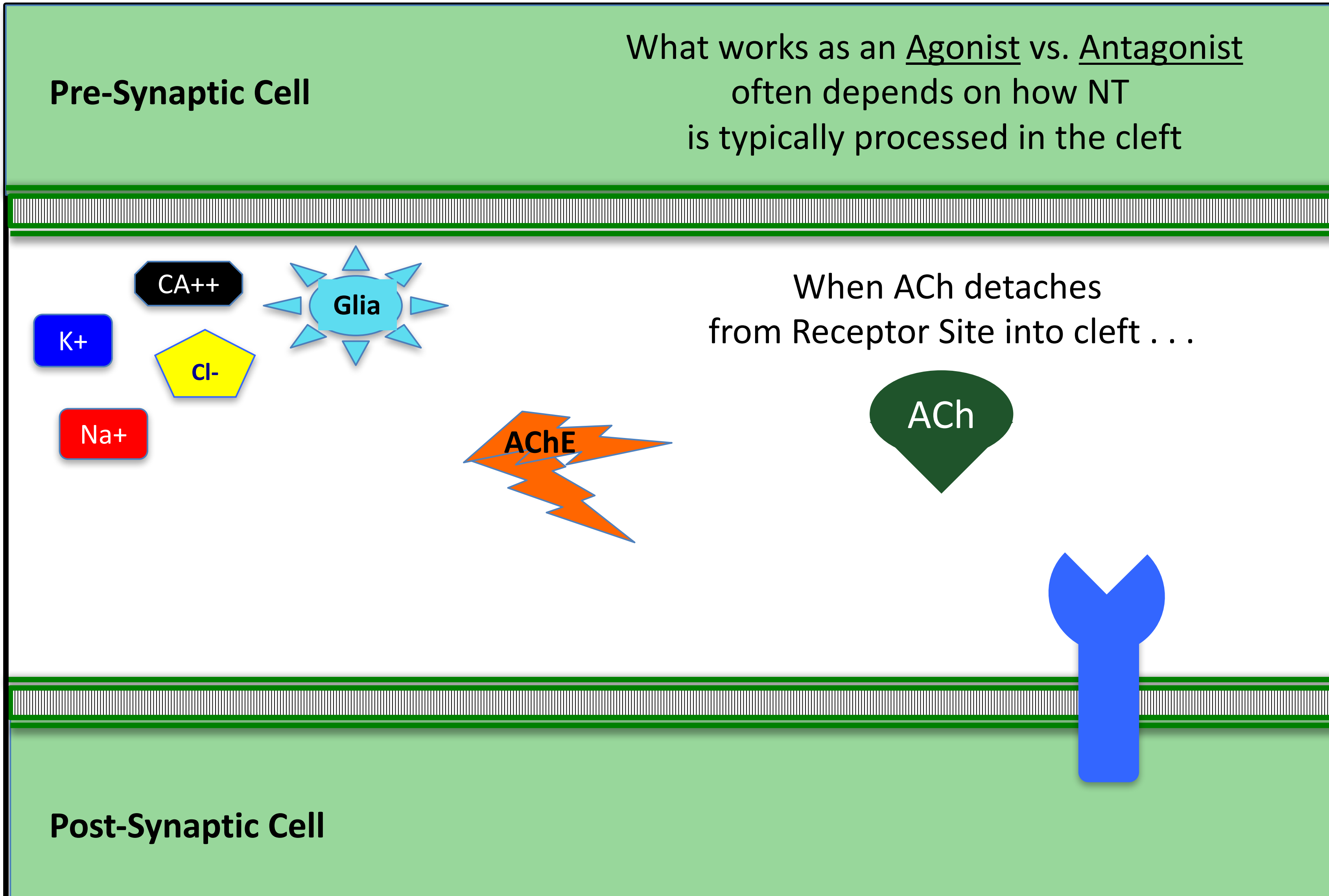
Agonists vs. Antagonists

Acetylcholine (ACh) in the Cleft



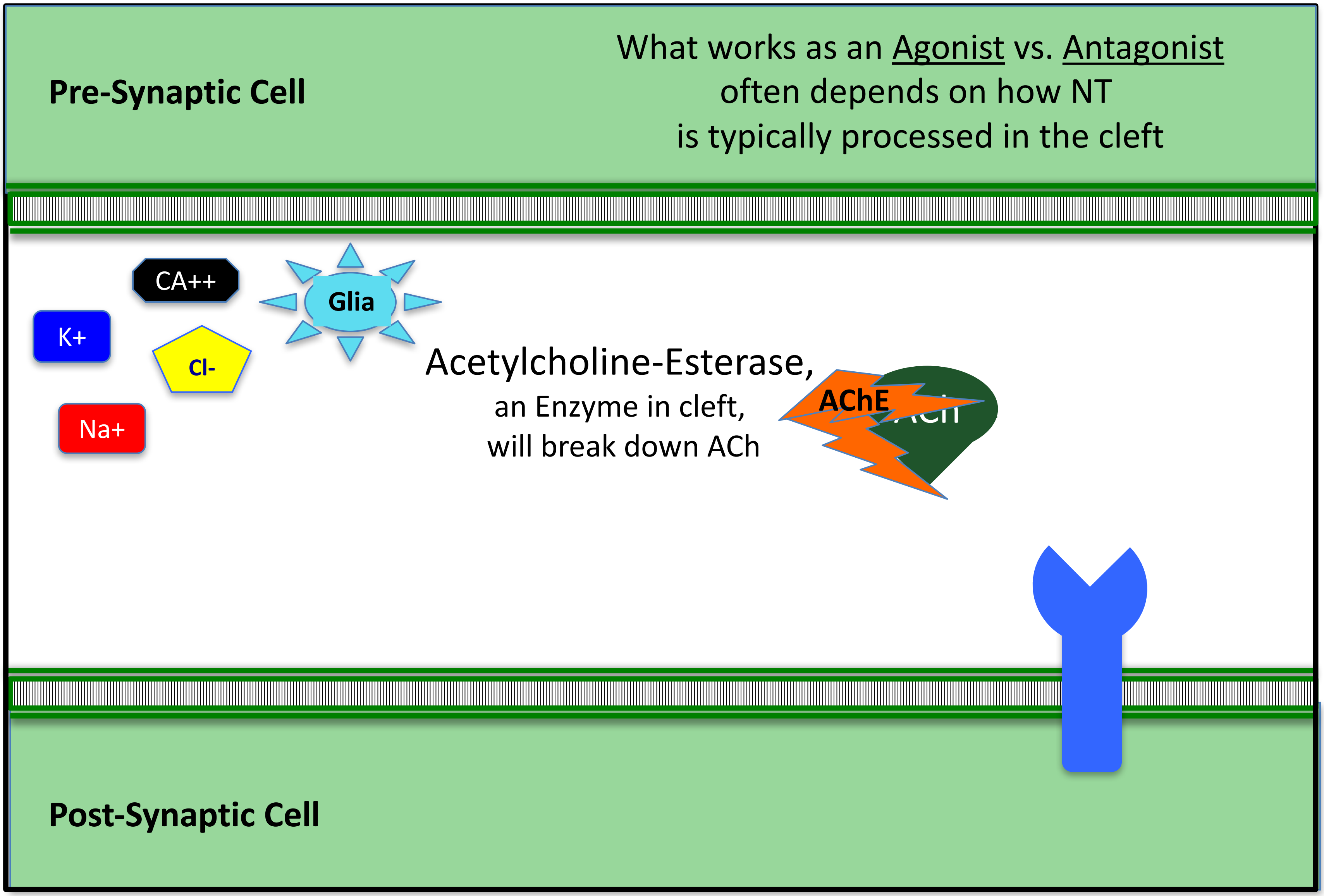
Agonists vs. Antagonists

Acetylcholine (ACh) in the Cleft



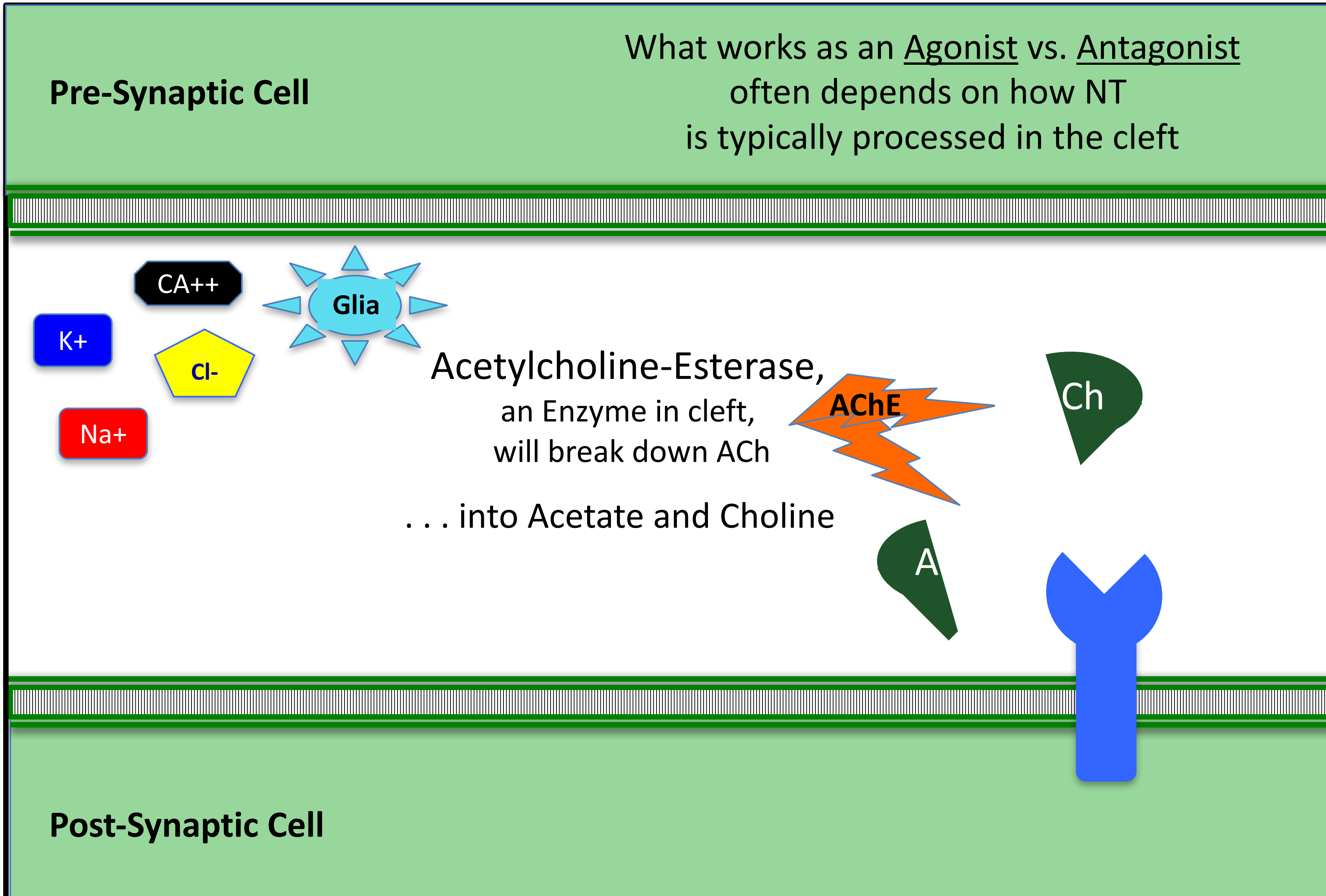
Agonists vs. Antagonists

Acetylcholine (ACh) in the Cleft



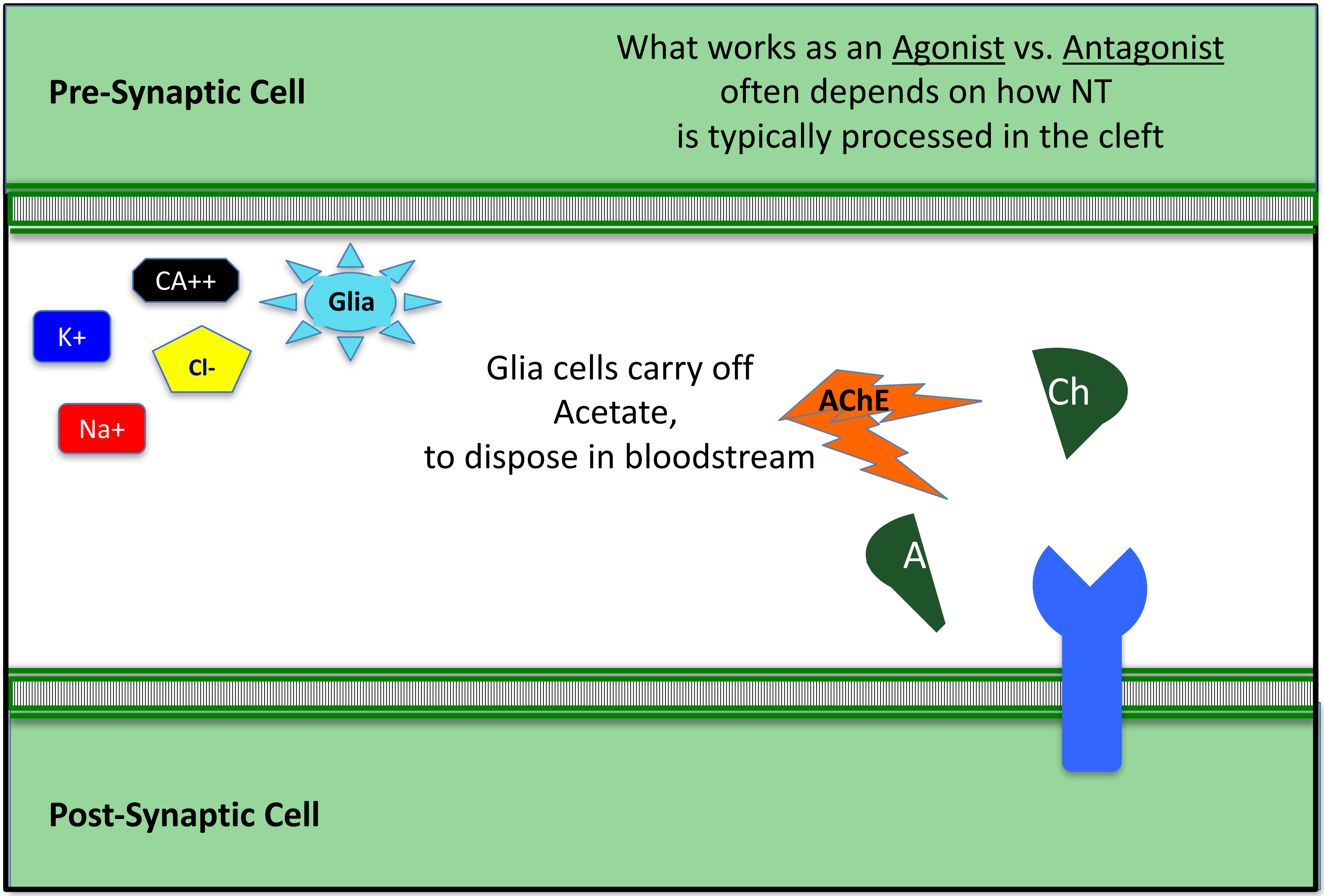
Agonists vs. Antagonists

Acetylcholine (ACh) in the Cleft



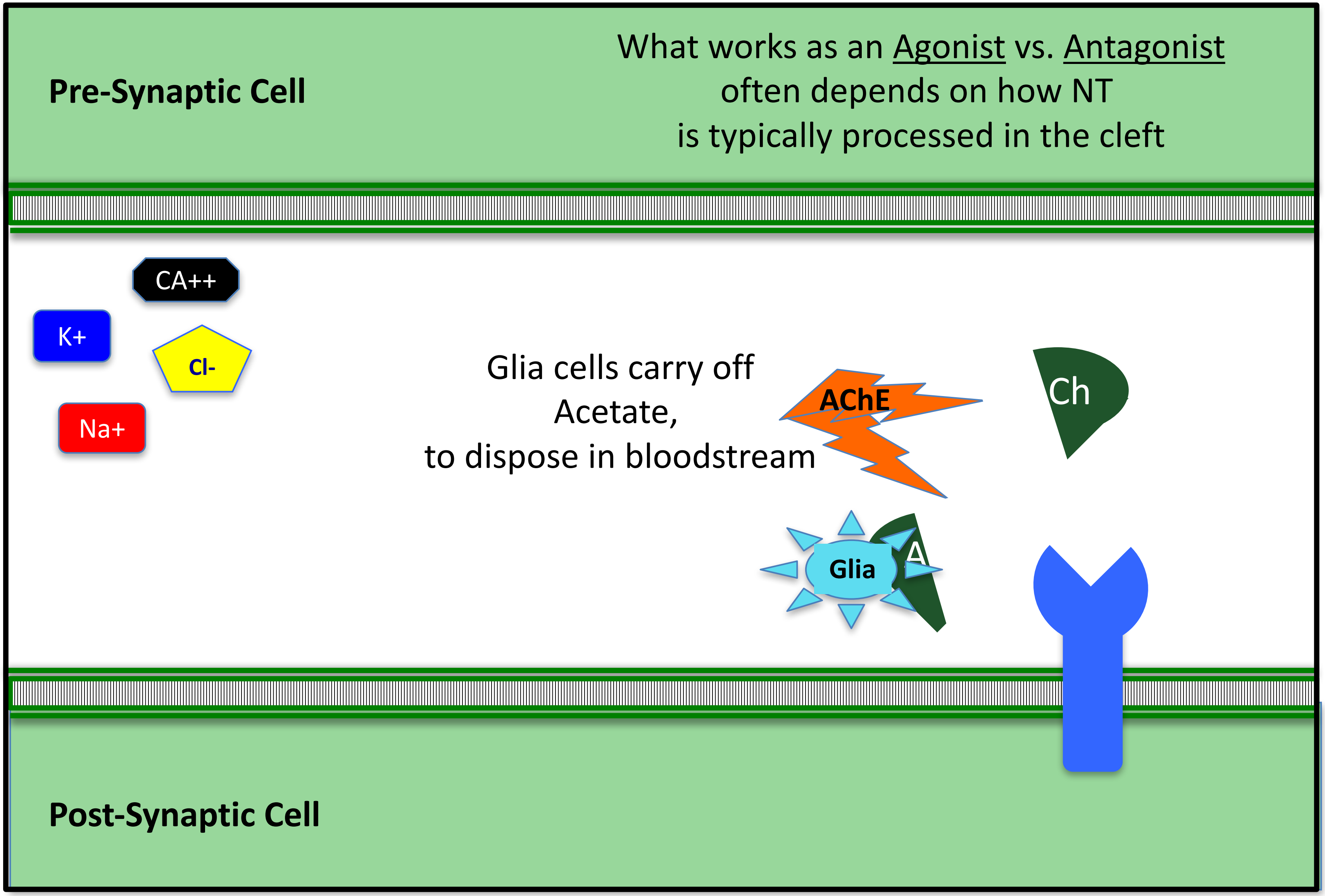
Agonists vs. Antagonists

Acetylcholine (ACh) in the Cleft



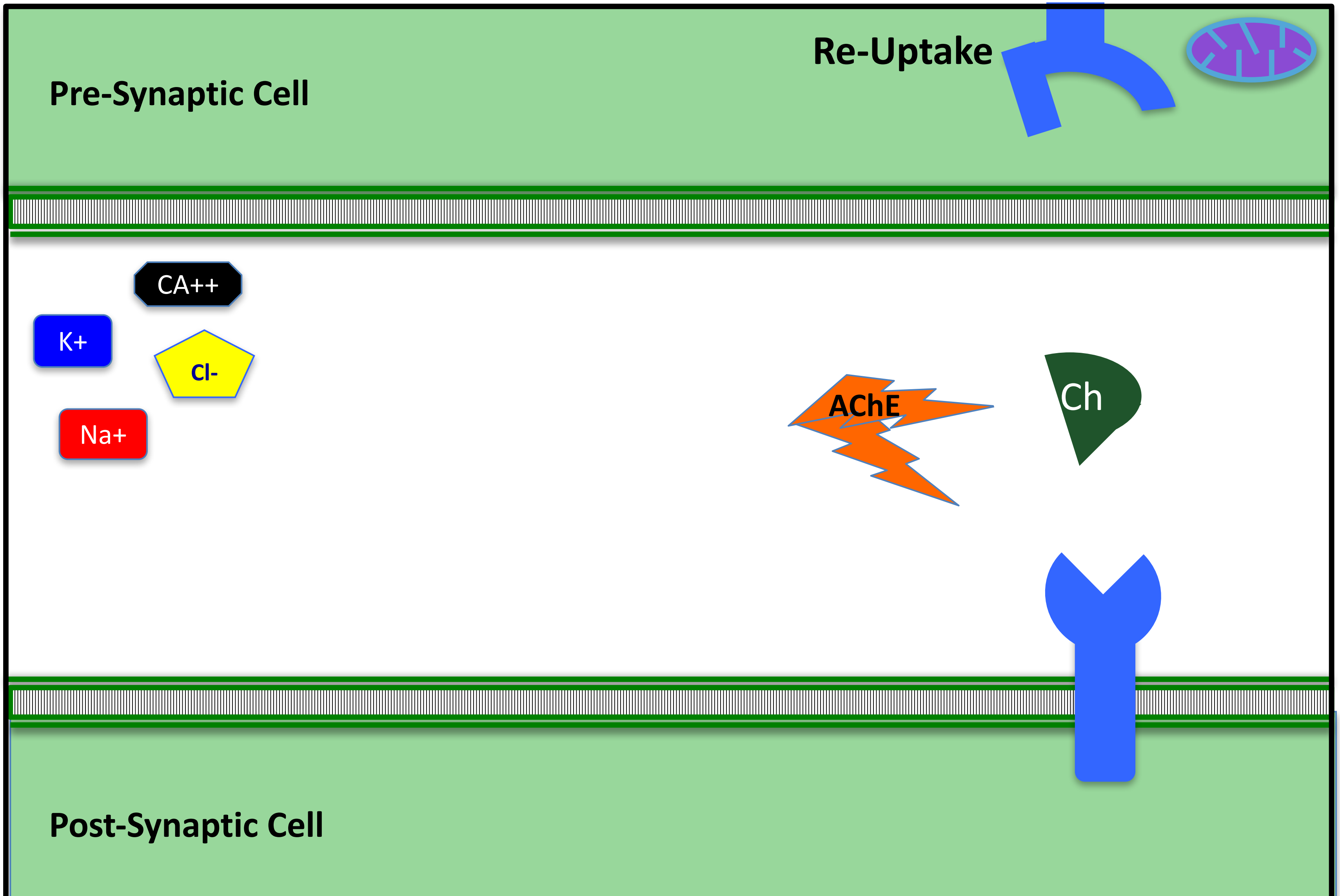
Agonists vs. Antagonists

Acetylcholine (ACh) in the Cleft



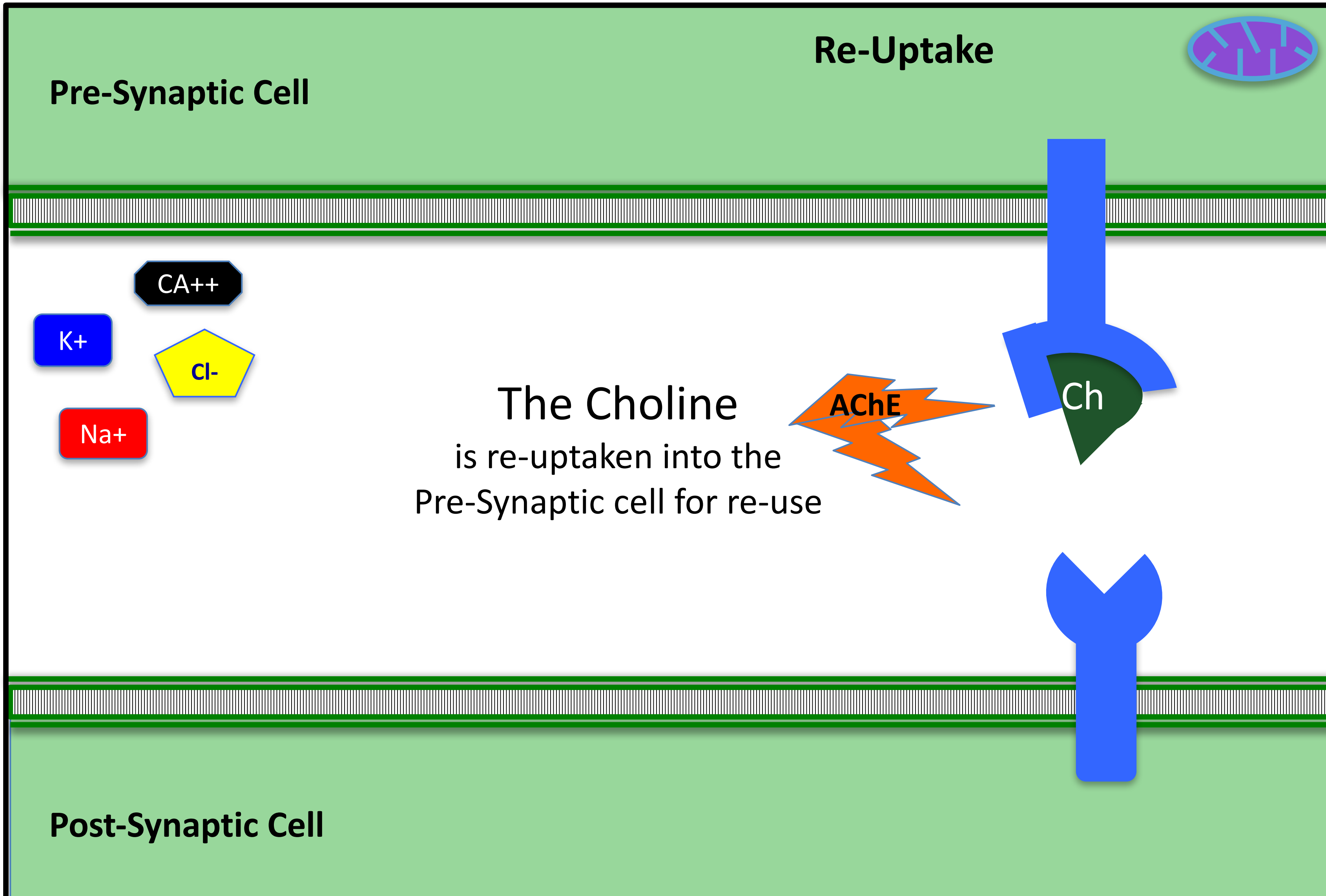
Agonists vs. Antagonists

Acetylcholine (ACh) in the Cleft



Agonists vs. Antagonists

Acetylcholine (ACh) in the Cleft

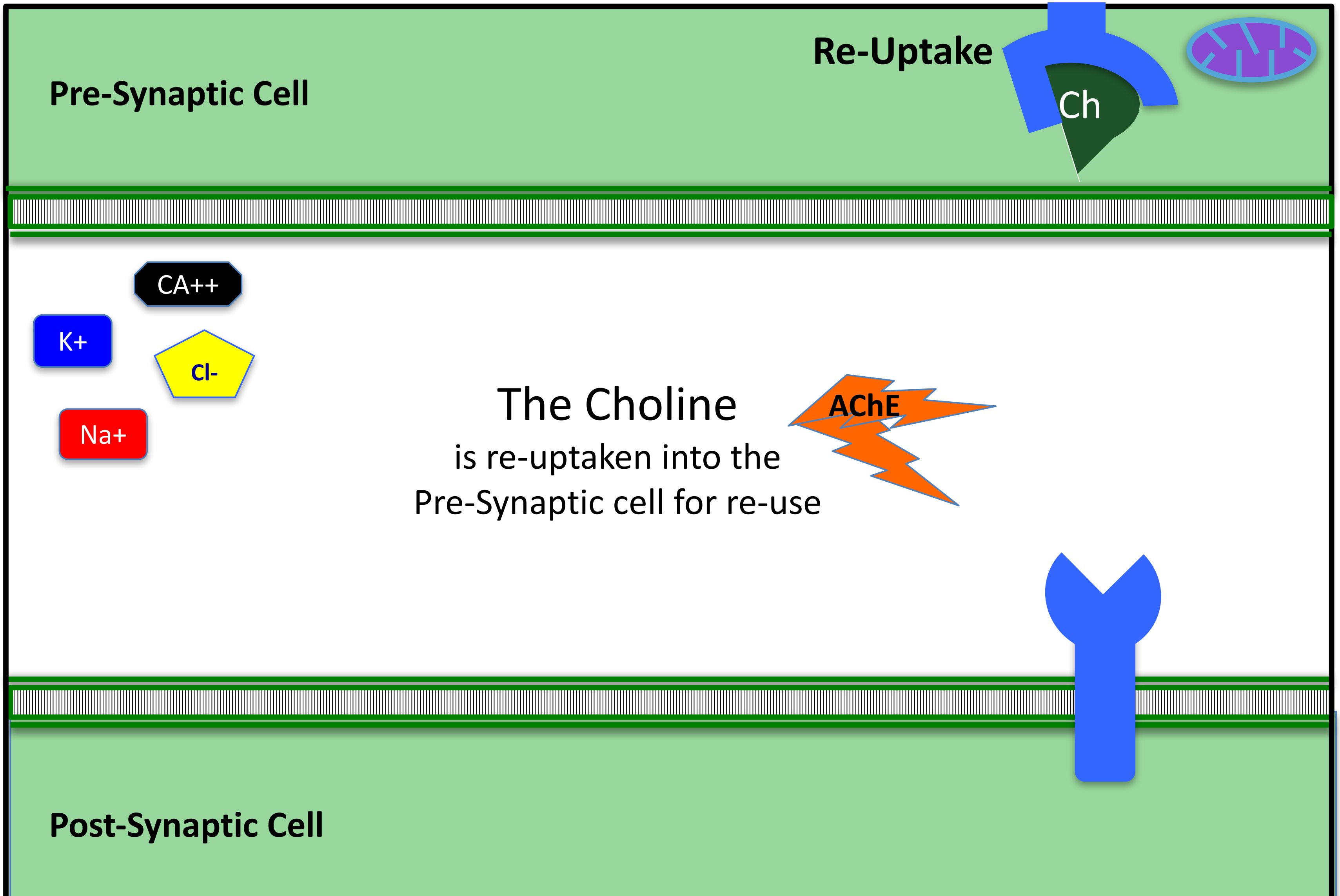


The Choline

is re-uptaken into the Pre-Synaptic cell for re-use

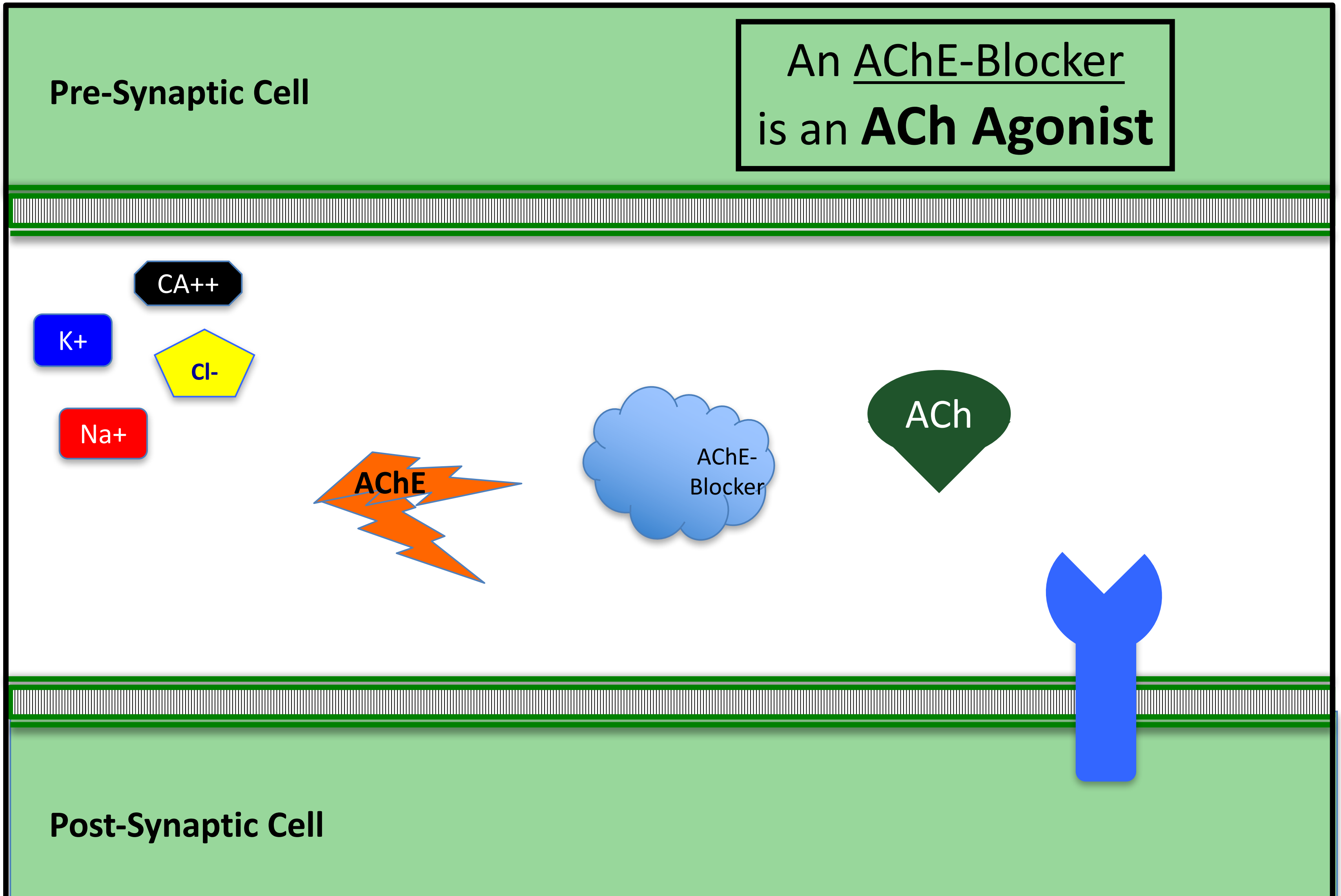
Agonists vs. Antagonists

Acetylcholine (ACh) in the Cleft



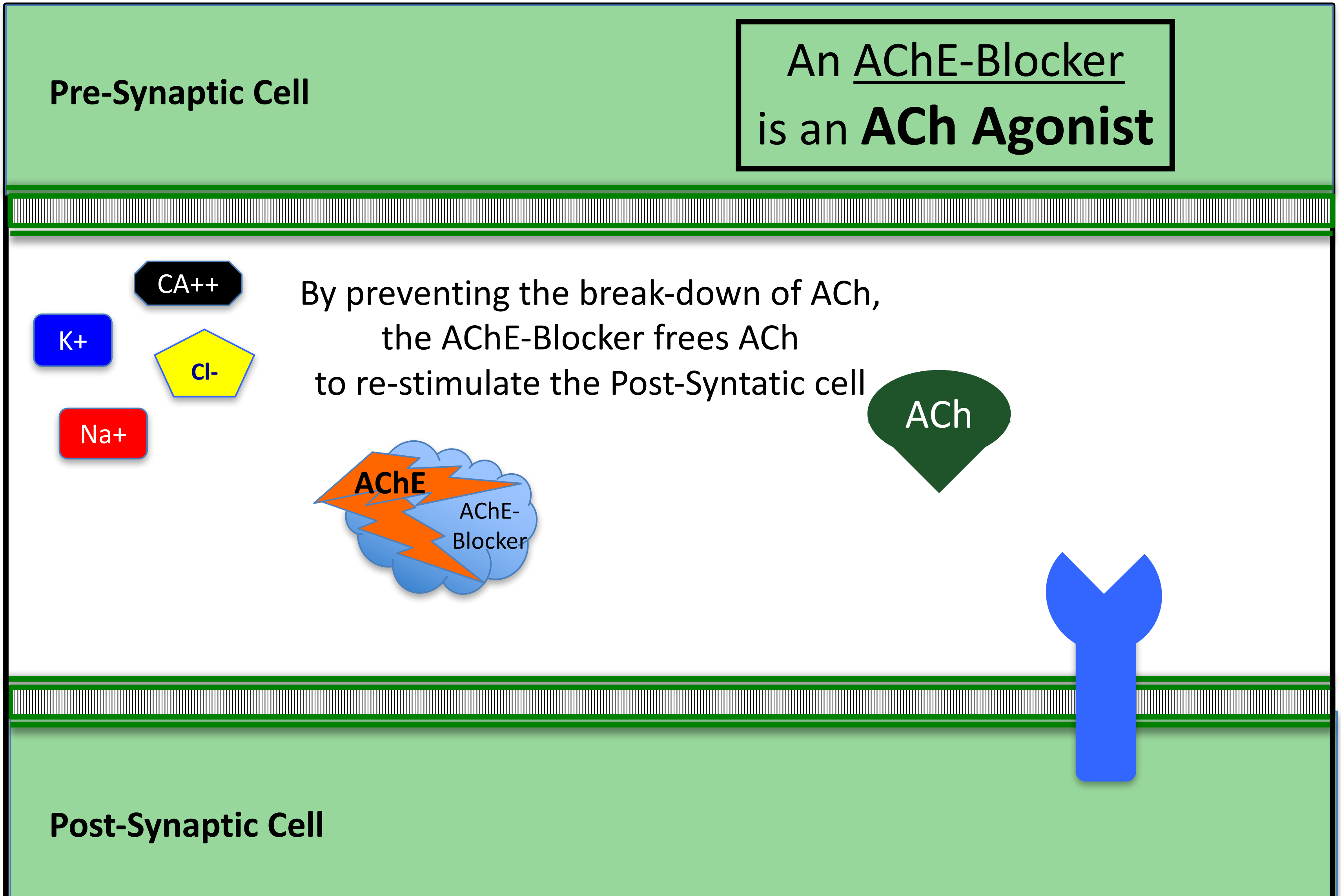
Agonists vs. Antagonists

Acetylcholine (ACh) in the Cleft



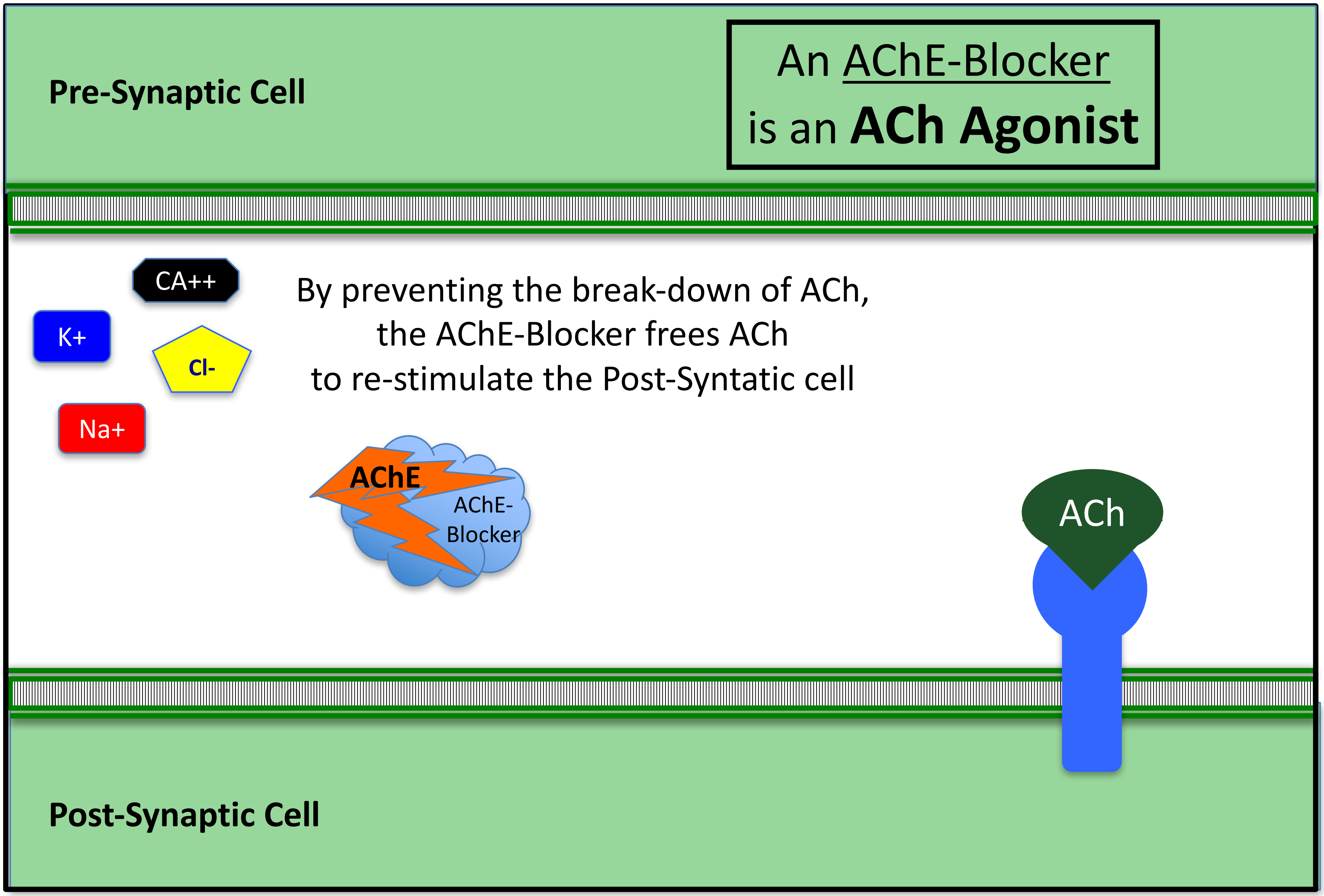
Agonists vs. Antagonists

Acetylcholine (ACh) in the Cleft



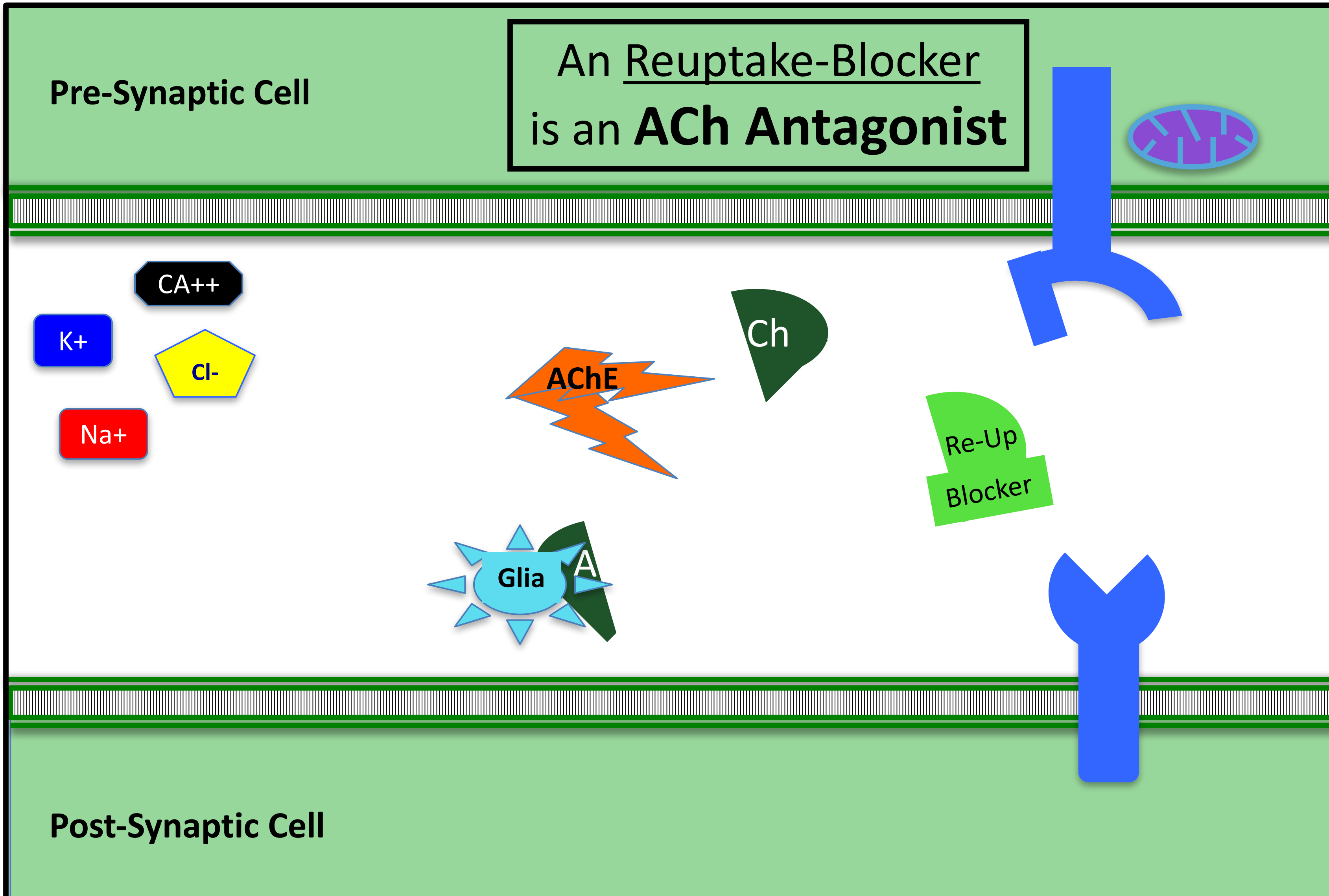
Agonists vs. Antagonists

Acetylcholine (ACh) in the Cleft



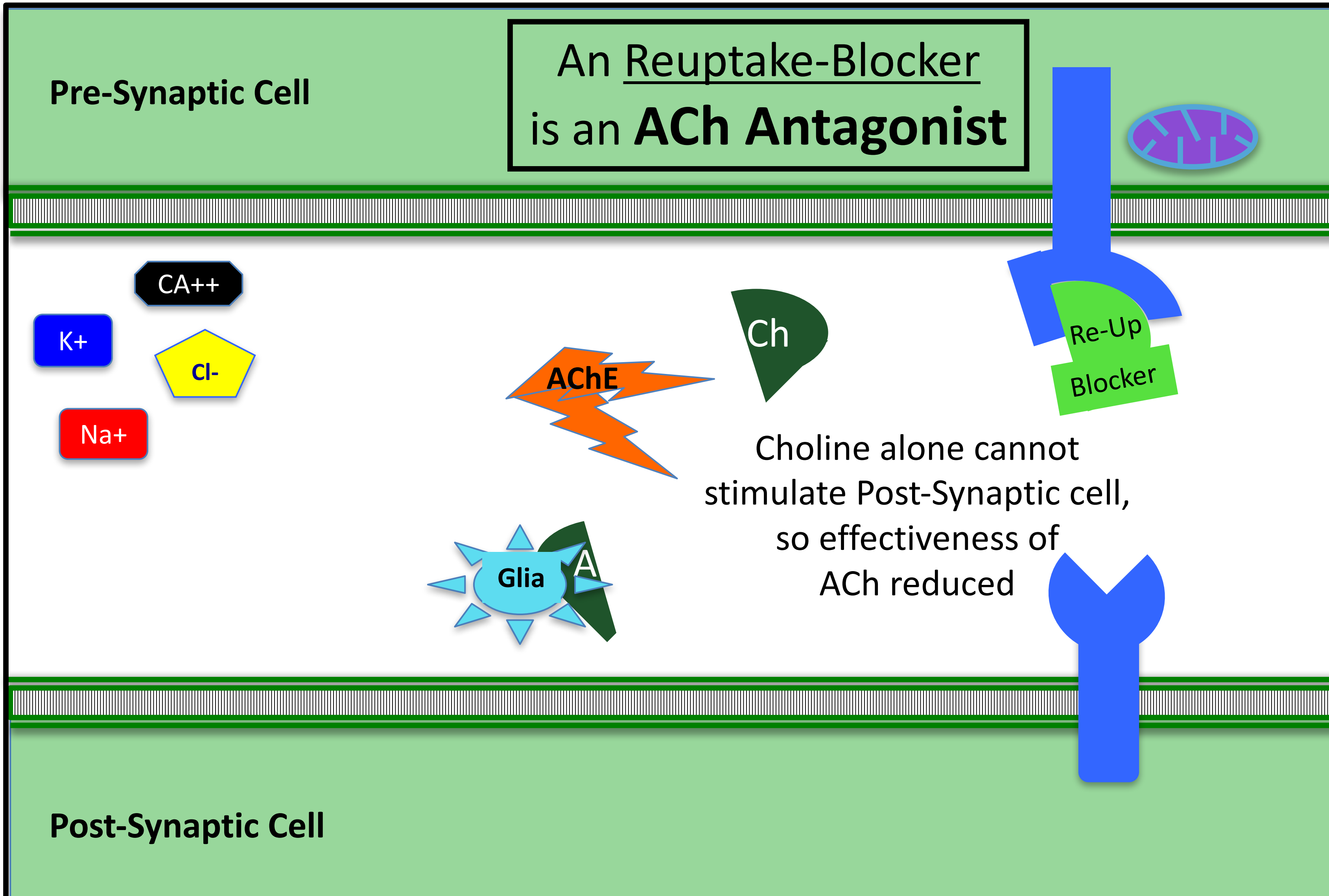
Agonists vs. Antagonists

Acetylcholine (ACh) in the Cleft



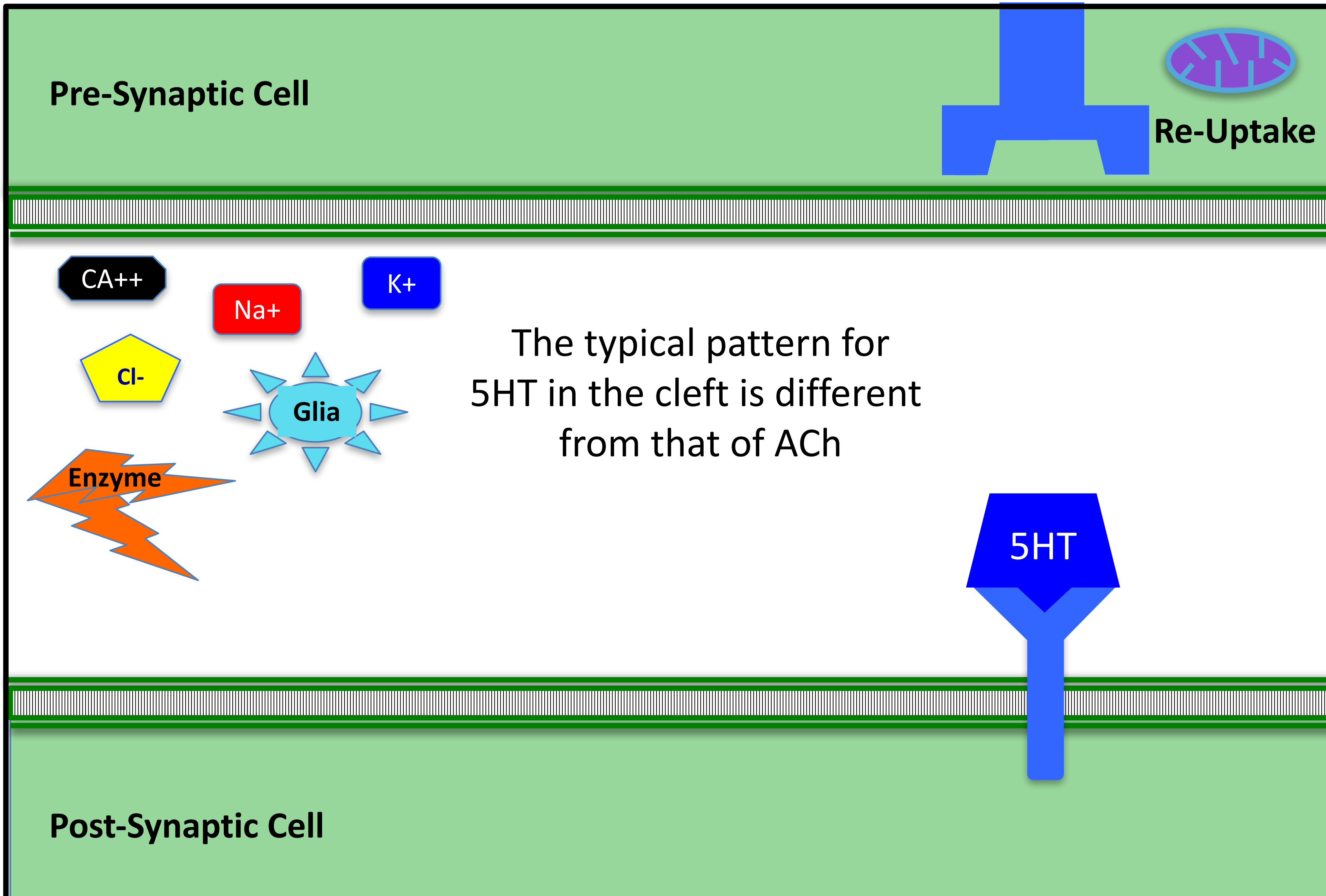
Agonists vs. Antagonists

Acetylcholine (ACh) in the Cleft



Agonists vs. Antagonists

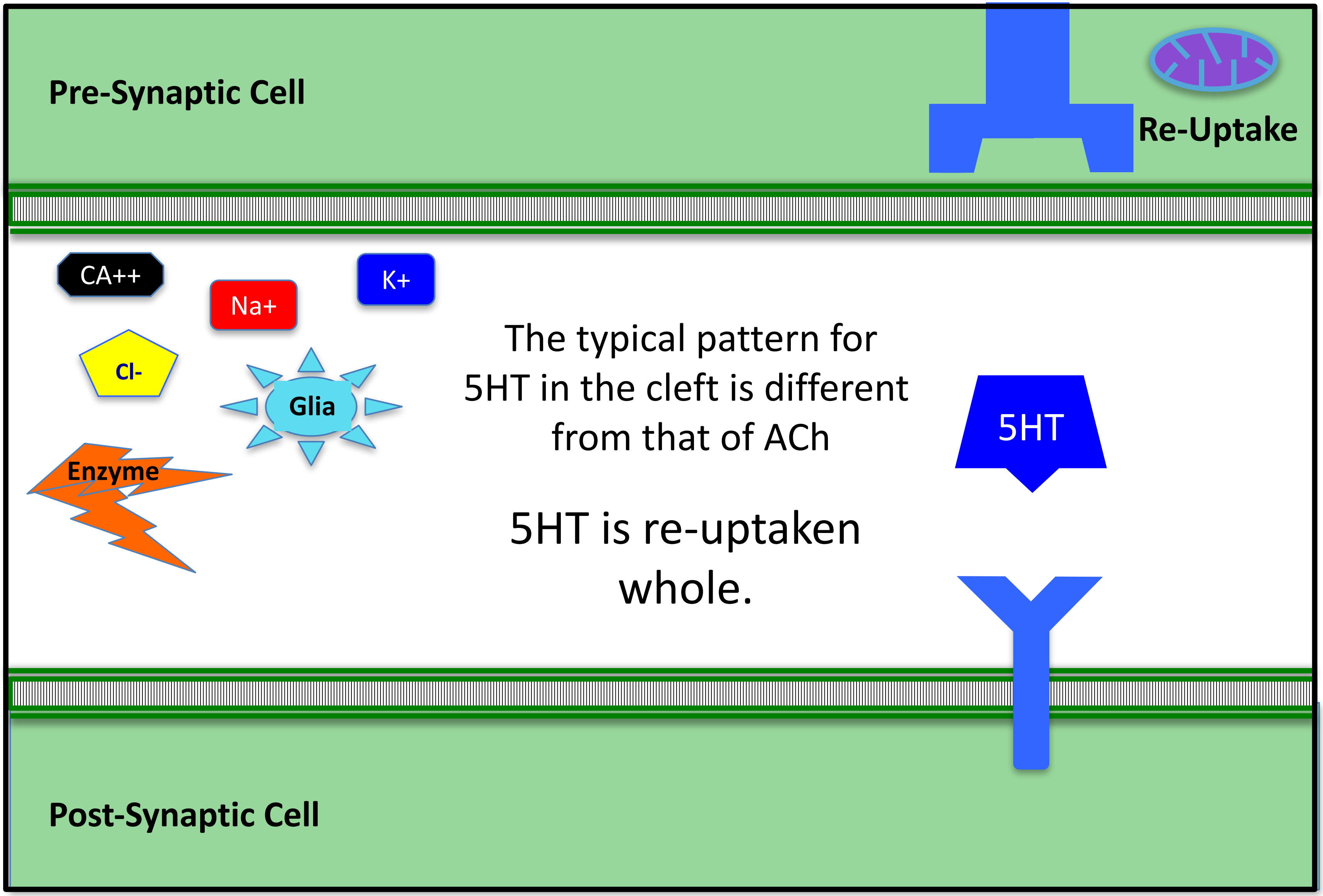
Serotonin (5HT) in the Cleft



The typical pattern for 5HT in the cleft is different from that of ACh

Agonists vs. Antagonists

Serotonin (5HT) in the Cleft

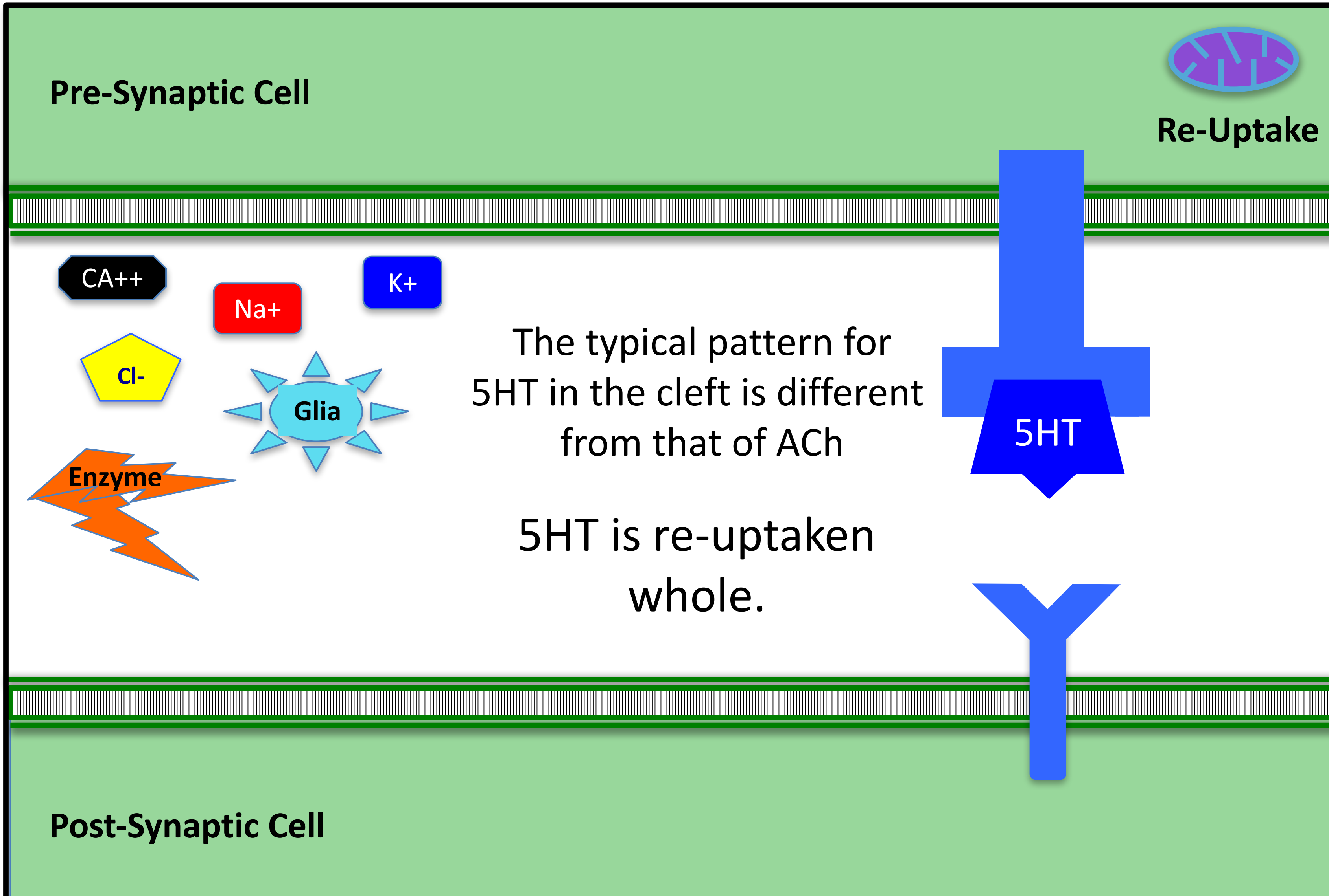


The typical pattern for 5HT in the cleft is different from that of ACh

5HT is re-uptaken whole.

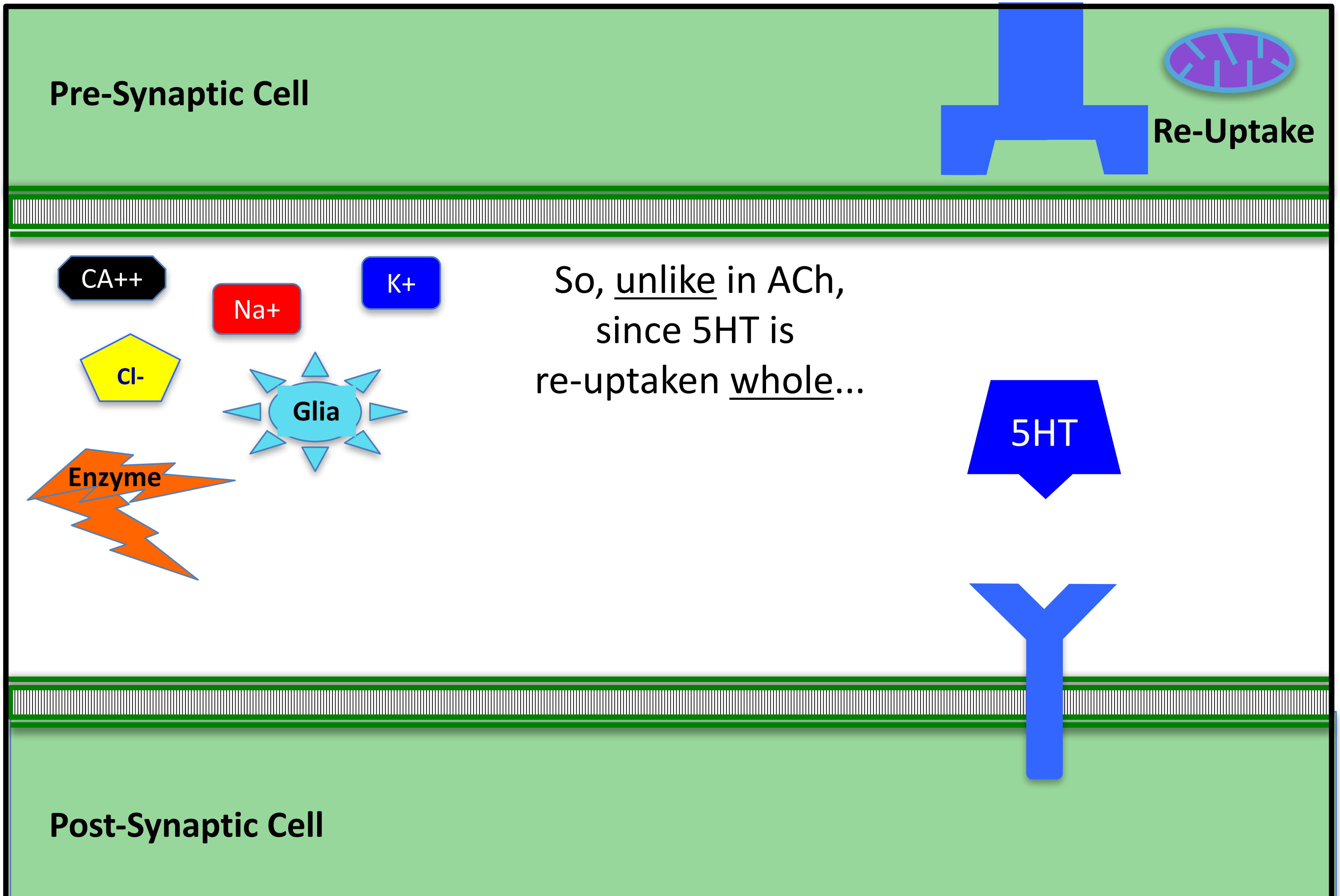
Agonists vs. Antagonists

Serotonin (5HT) in the Cleft



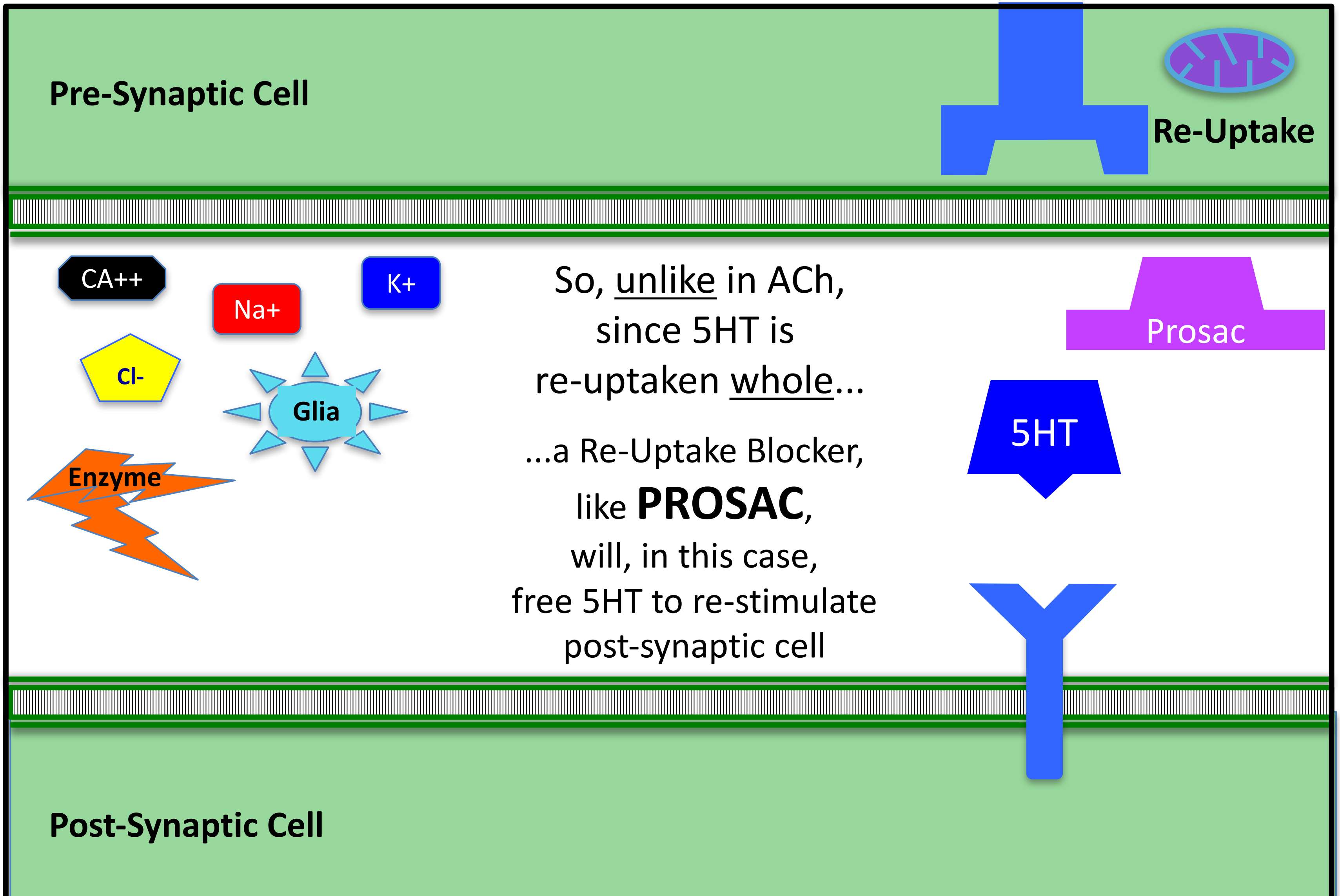
Agonists vs. Antagonists

Serotonin (5HT) in the Cleft



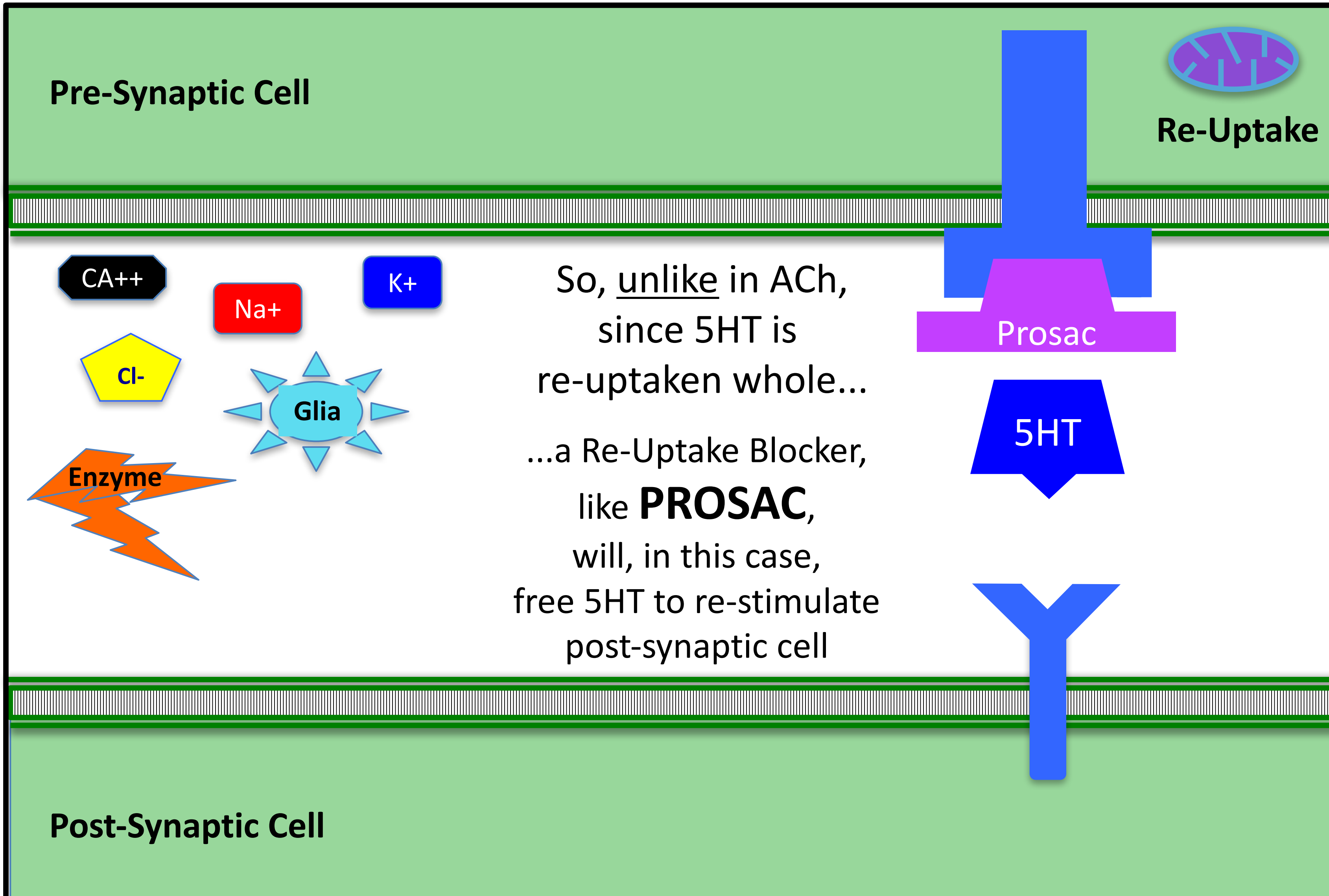
Agonists vs. Antagonists

Serotonin (5HT) in the Cleft



Agonists vs. Antagonists

Serotonin (5HT) in the Cleft

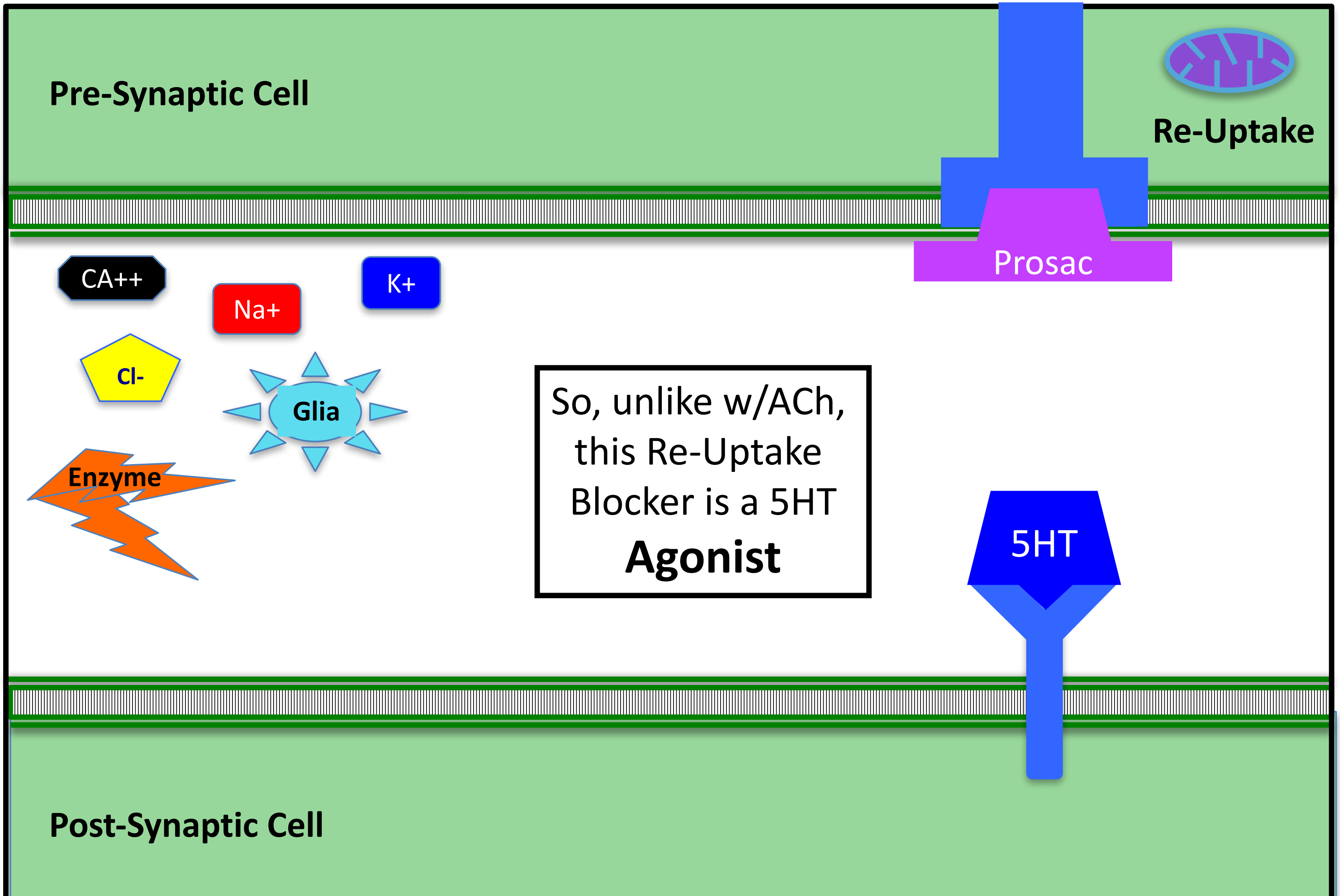


So, unlike in ACh,
since 5HT is
re-uptaken whole...

...a Re-Uptake Blocker,
like **PROSAC**,
will, in this case,
free 5HT to re-stimulate
post-synaptic cell

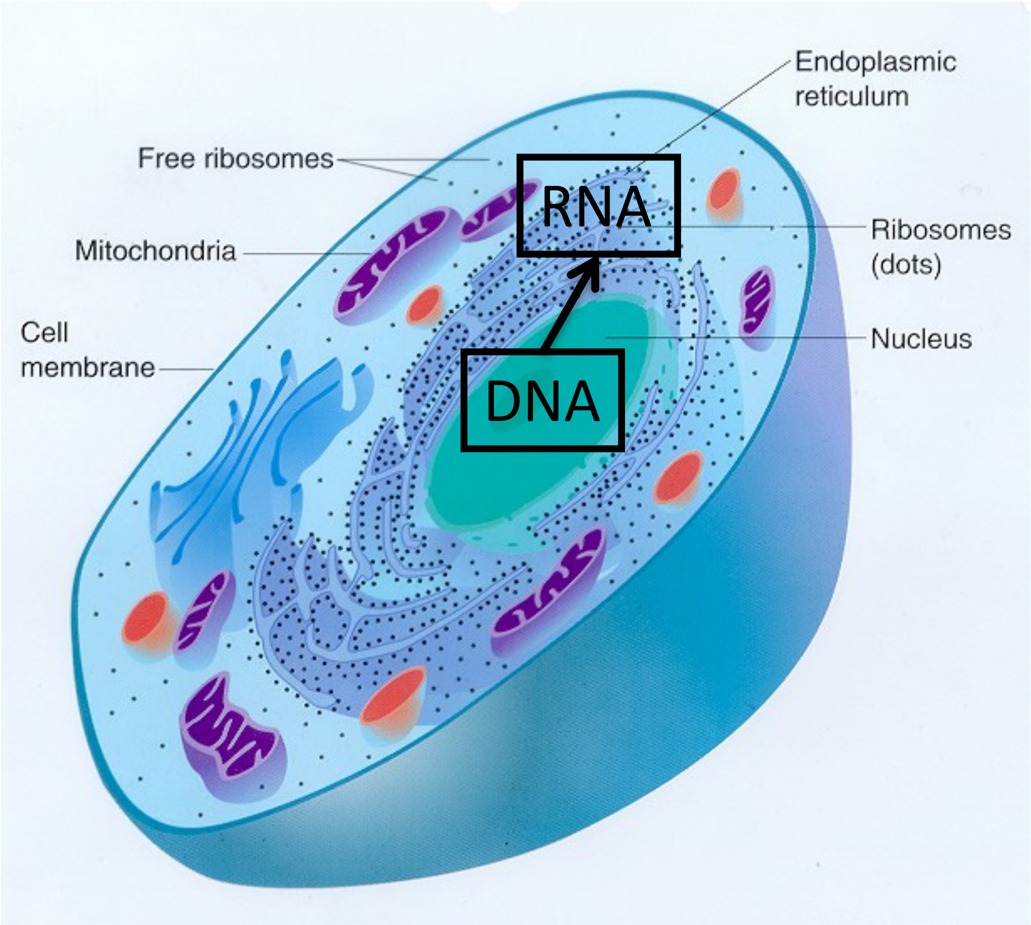
Agonists vs. Antagonists

Serotonin (5HT) in the Cleft



So, unlike w/ACh, this Re-Uptake Blocker is a 5HT **Agonist**

Other Factors that Modify Function



GENE TRANSCRIPTION

Copies of segments of DNA (= RNA) are made, to code for protein production

Dendritization – Increase # of dendritic spines

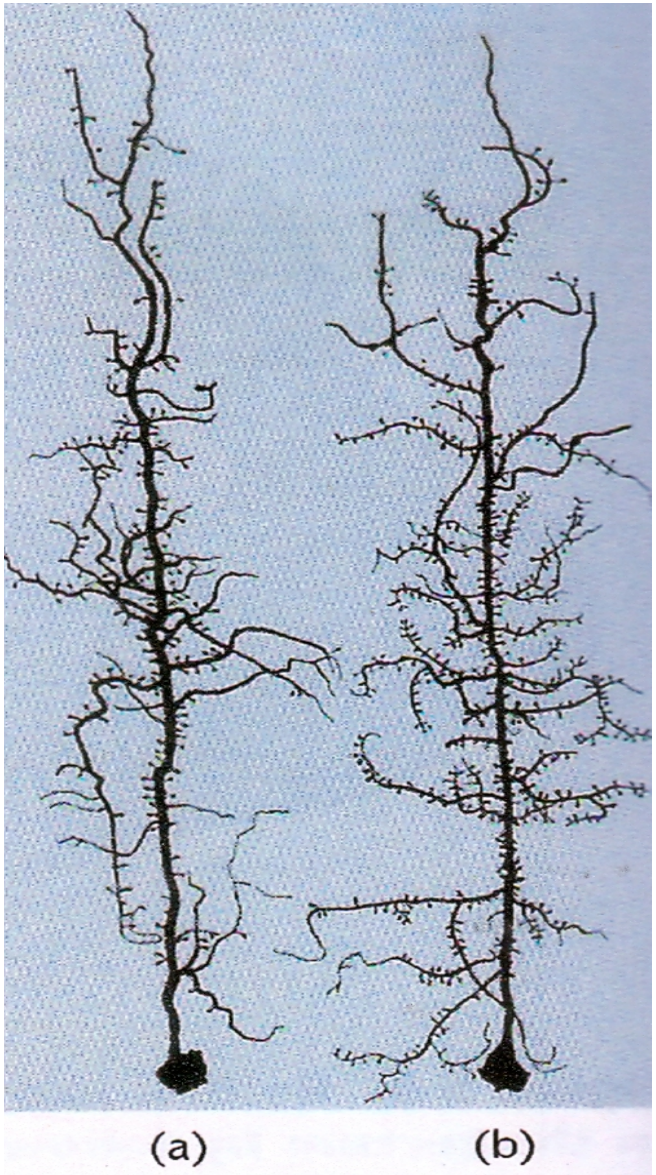


Figure 5.10 Effect of a stimulating environment on neuronal branching
(**a**) A jewel fish reared in isolation develops neurons with fewer branches. (**b**) A fish reared with others has more neuronal branches.

Availability of NT Components

via DIET...

e.g. Choline
(for making ACh)
from milk or nuts & seeds

e.g. Tryptophan
(for making 5HT)
from turkey

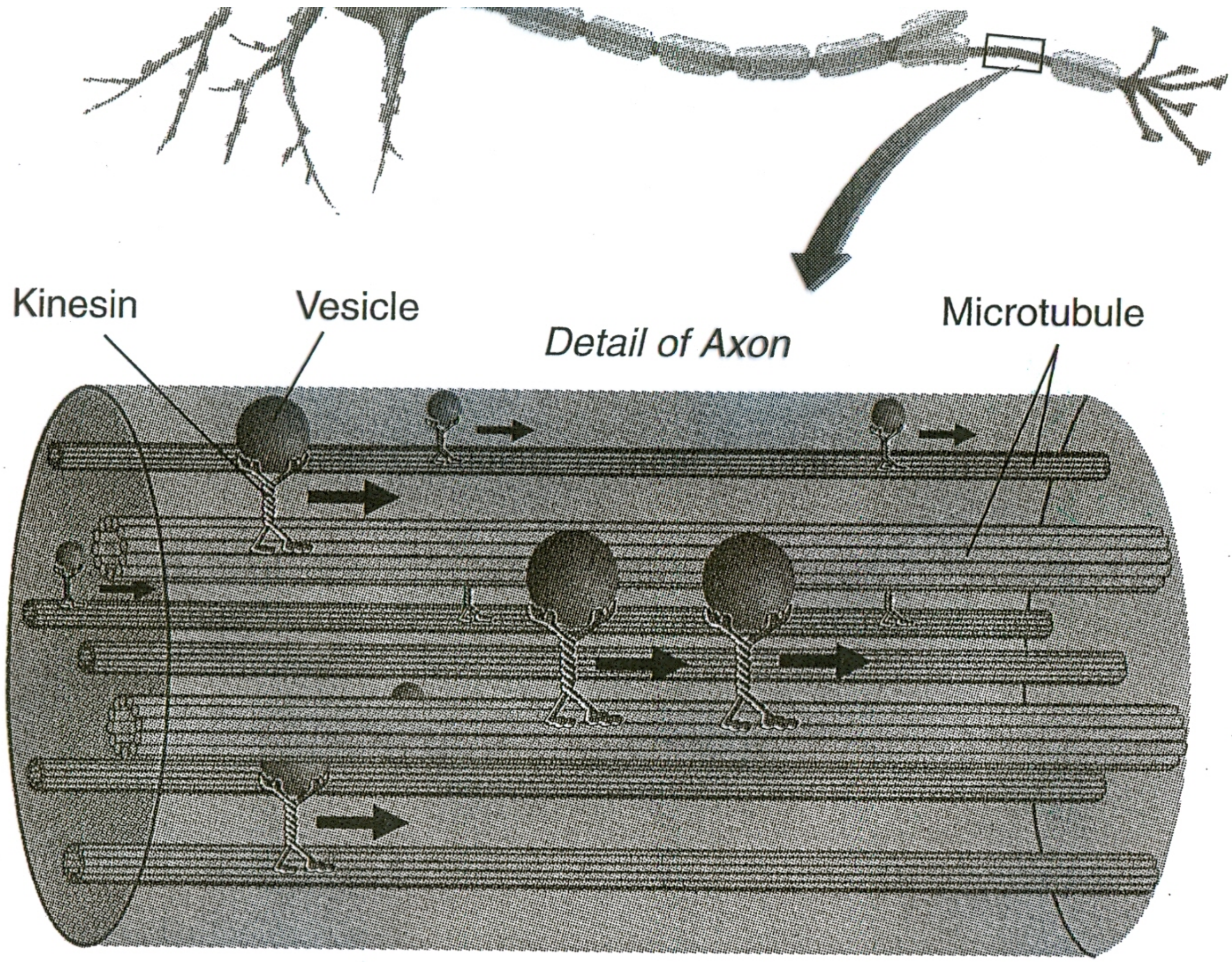
via administering DRUGS...

e.g. L-DOPA (a Dopamine precursor) that crosses blood-brain barrier

e.g. Fat-soluble drugs (heroin, canobinol, LSD) cross barrier and mimic NTs

Kinesin Molecules

transporting NT to Terminal



EXCEPTIONS

Auto-Receptor

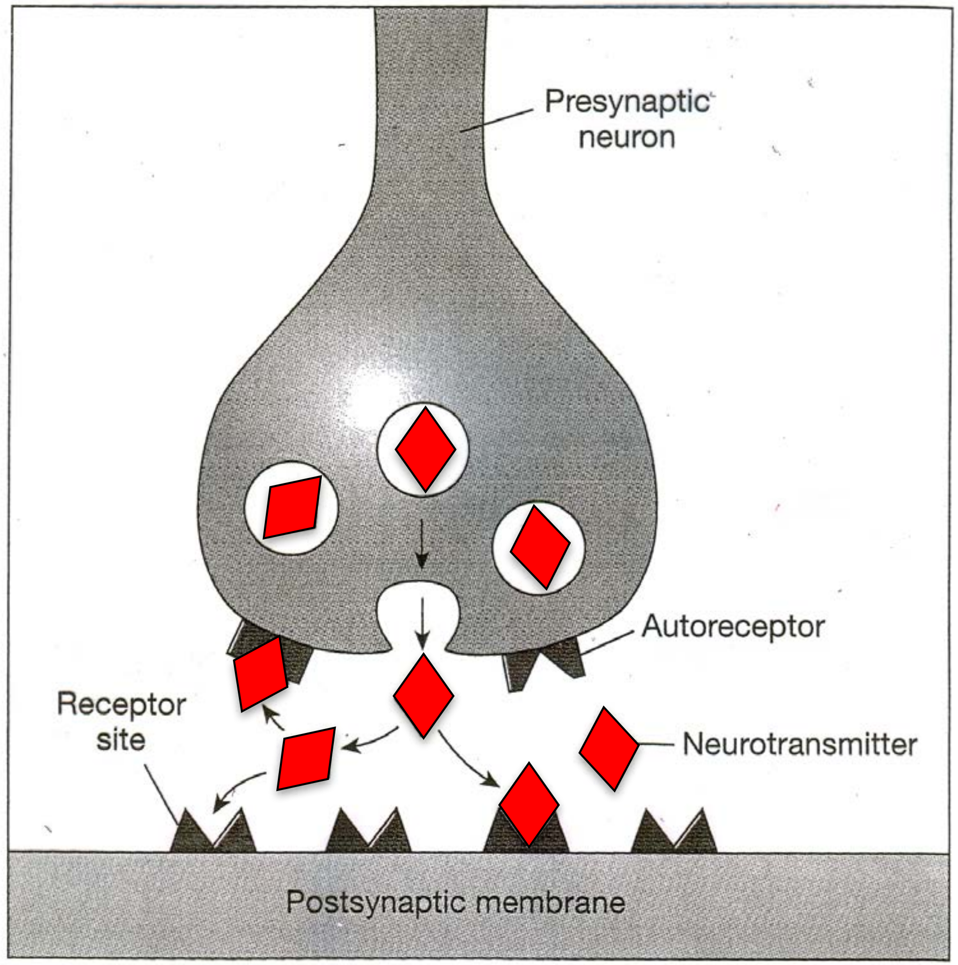
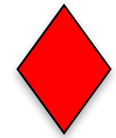


Figure 4.16 Autoreceptor. Released neurotransmitter can act on an autoreceptor to inhibit subsequent neurotransmitter release.



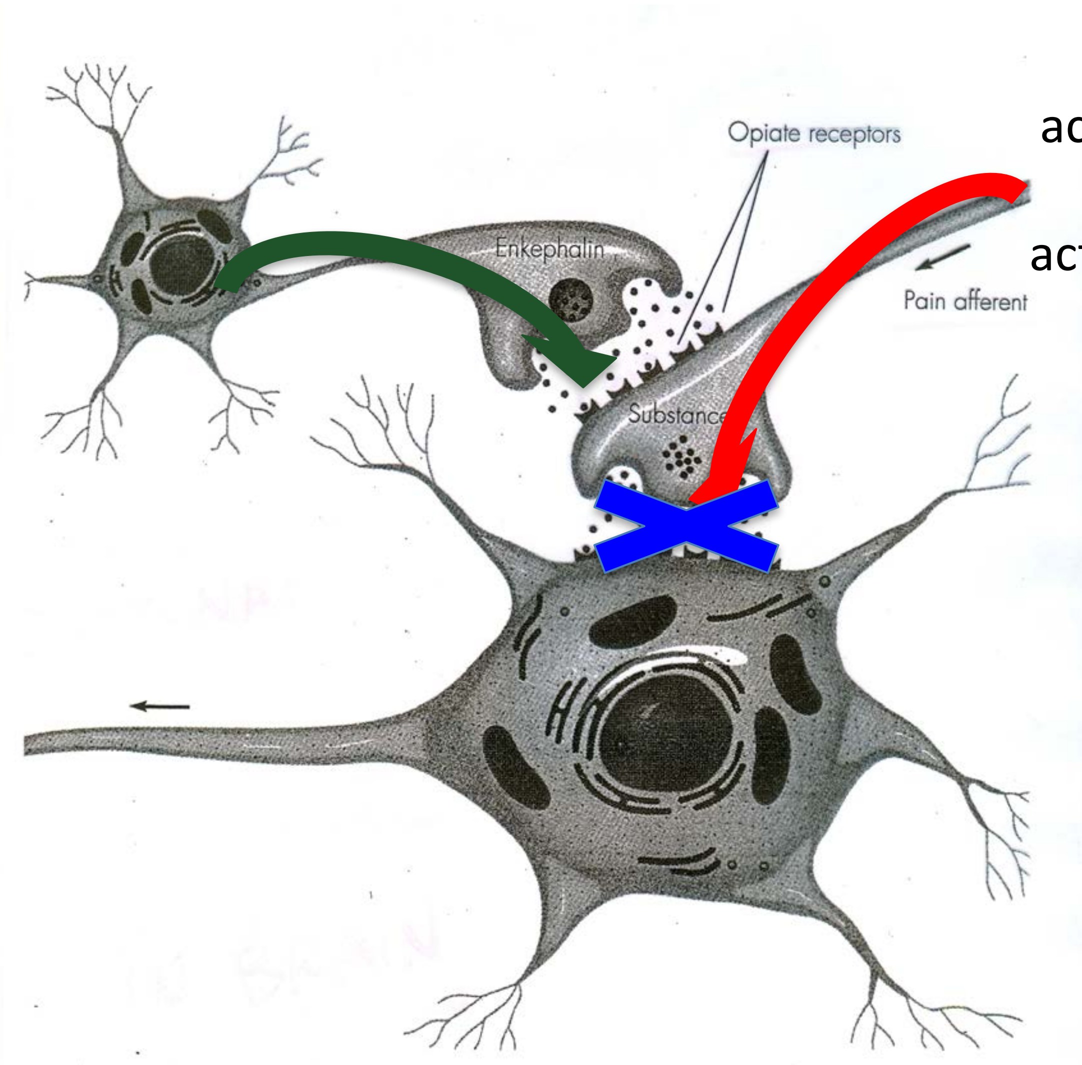
Inhibitory Neurotransmitter

In cells with
"Auto-Receptors"
the presynaptic cell
<u>inhibits itself</u>,
as well as the post-synaptic cell

(i.e. Limits how much NT presym will release)

EXCEPTIONS

Axo-Axonal Synapses



In brain,
activity along Pain pathways
provokes
activity from Endorphin cells.

Receptor sites
on <u>Terminal</u> of pain cell
responds to endorphins,
reducing release of
Substance P