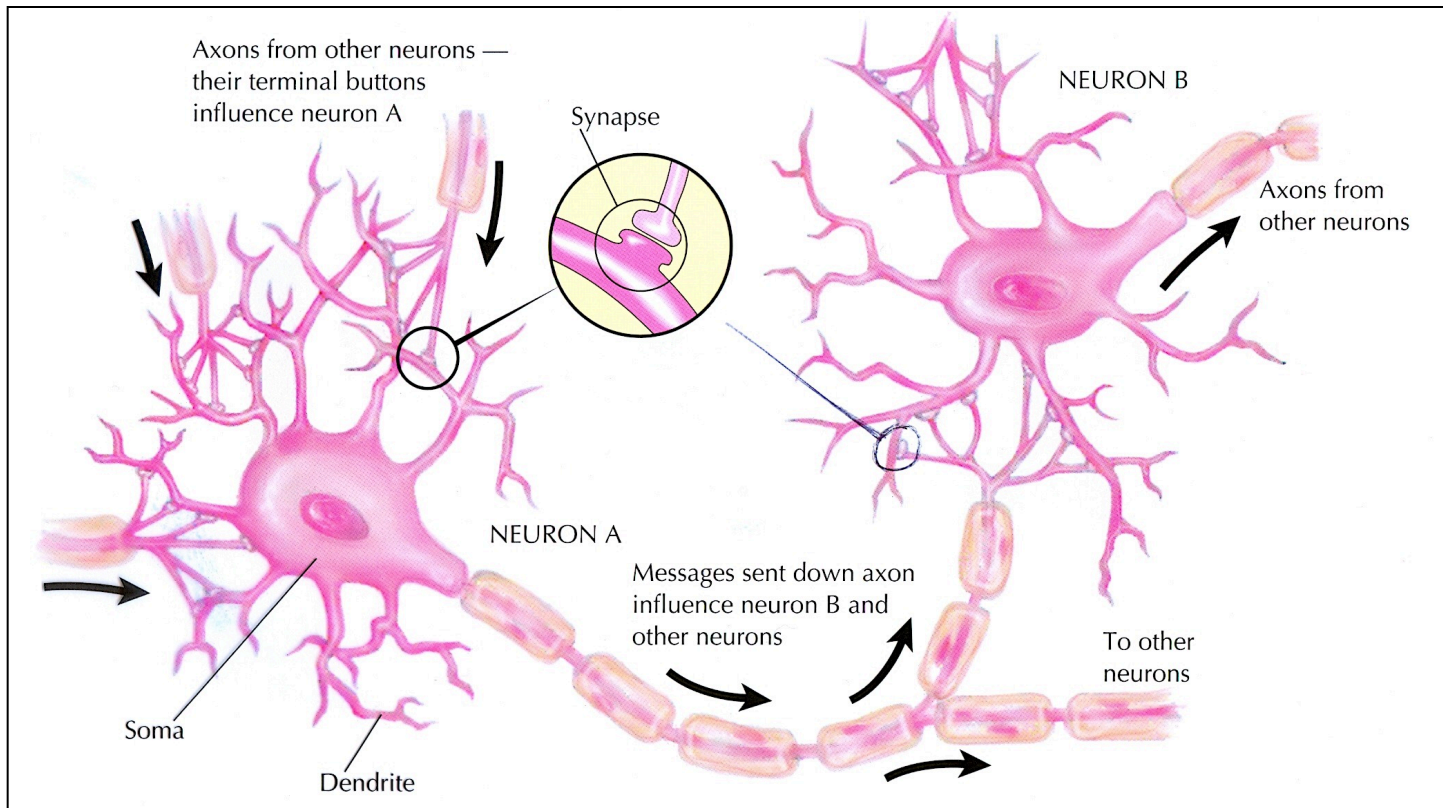
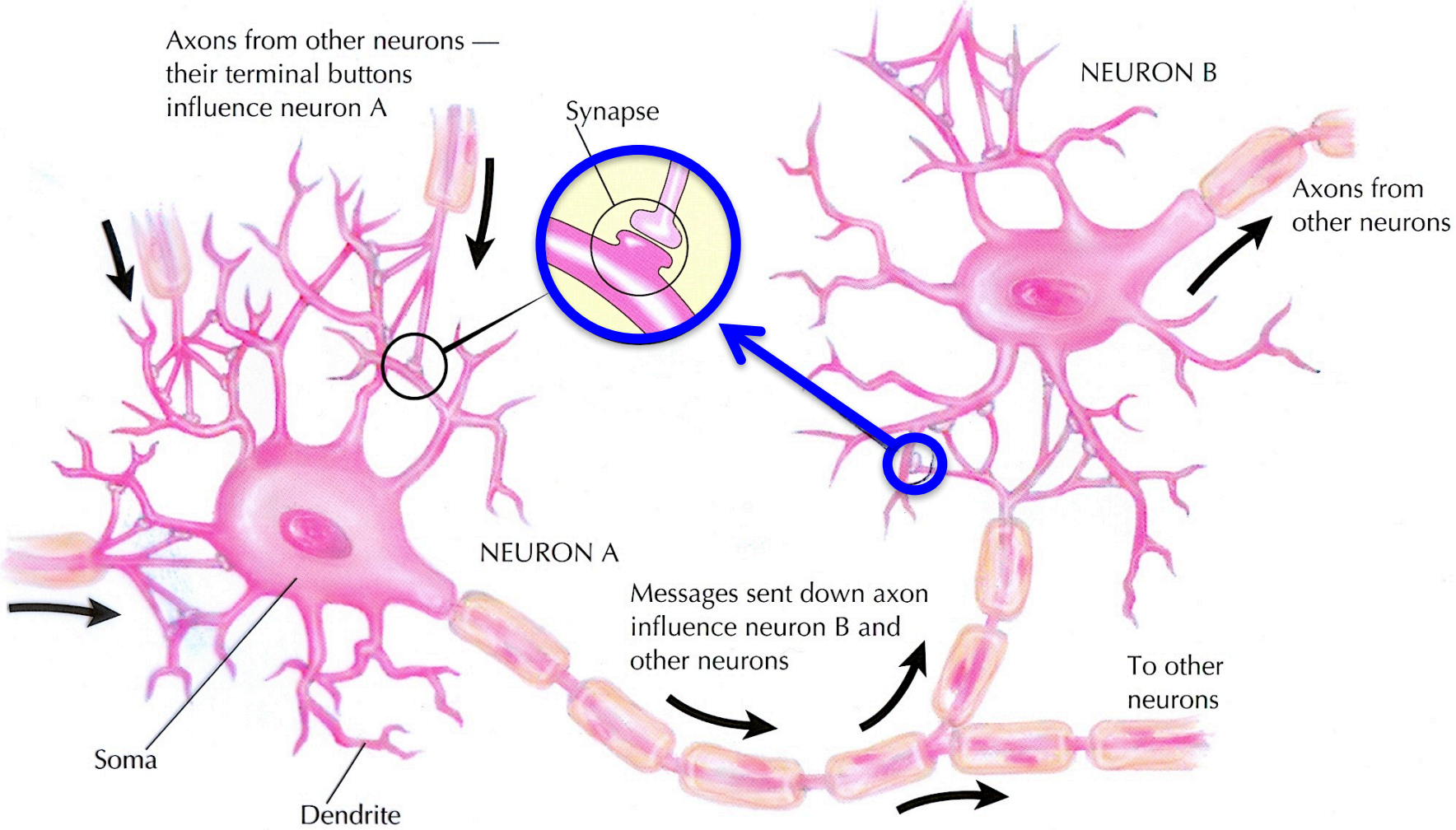


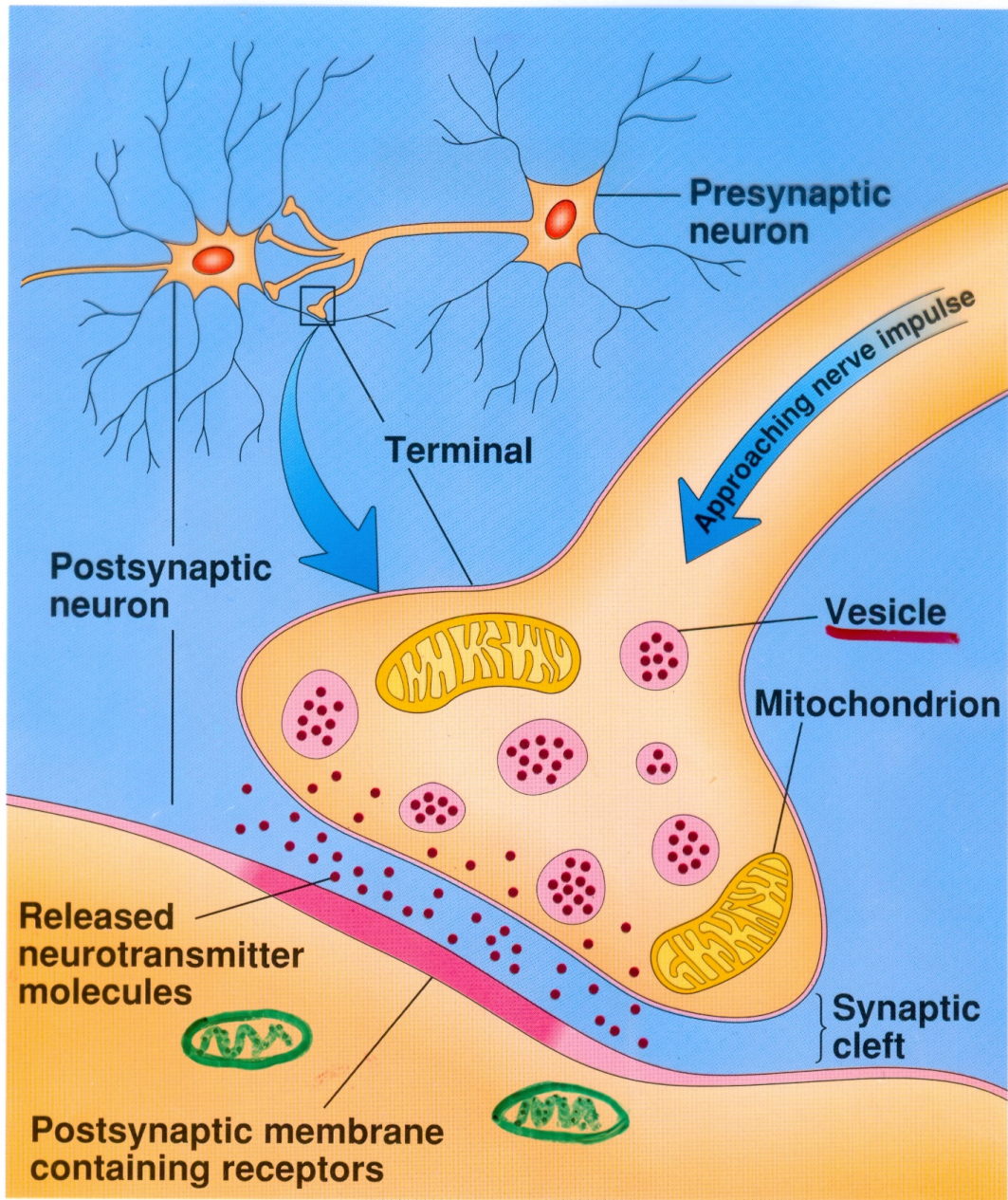
Lec 2b

Structure and Function of Cells



THE SYNAPSE – Communication between cells

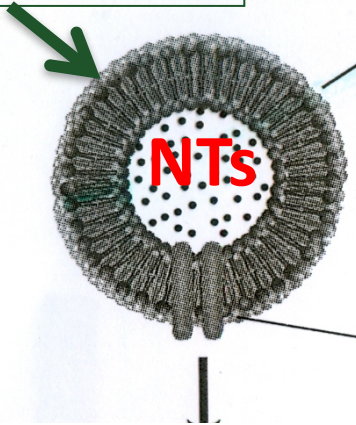




Synapse

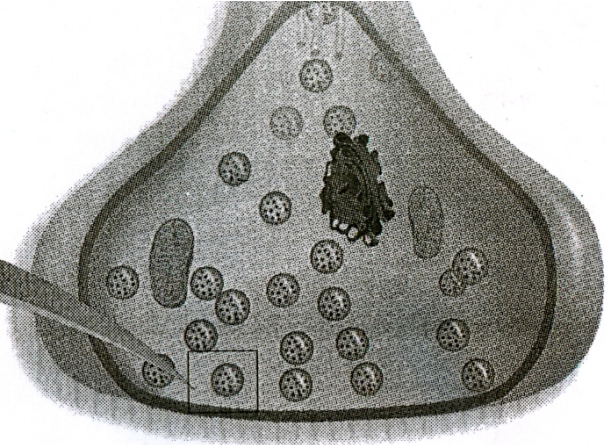
Exocytosis

VESICLE
Double lipid
membrane



Undocked synaptic vesicle

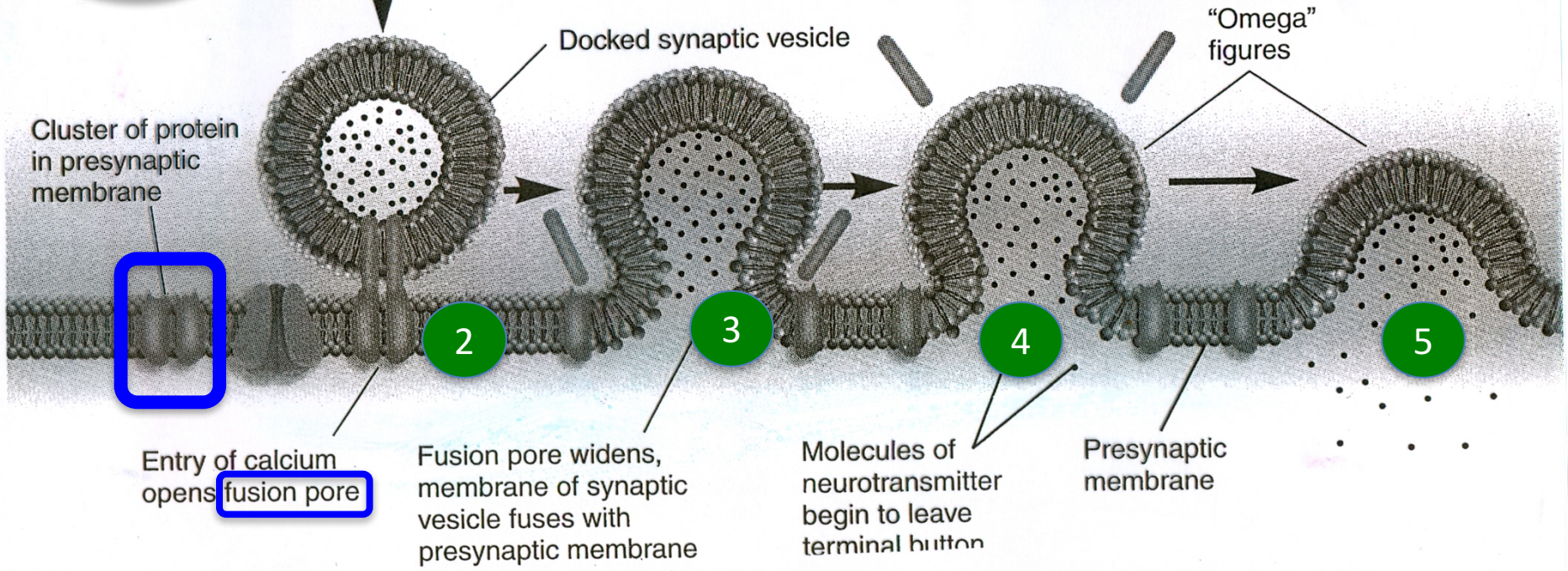
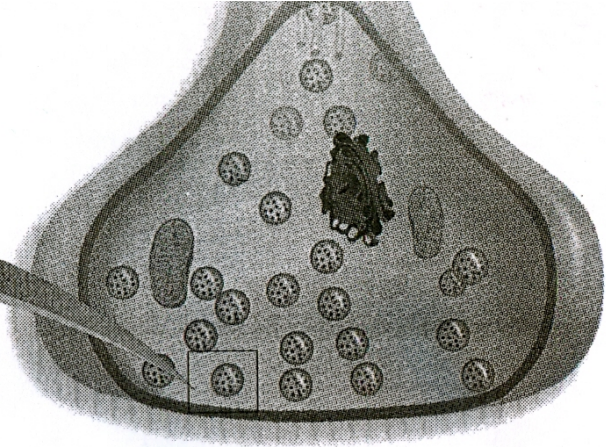
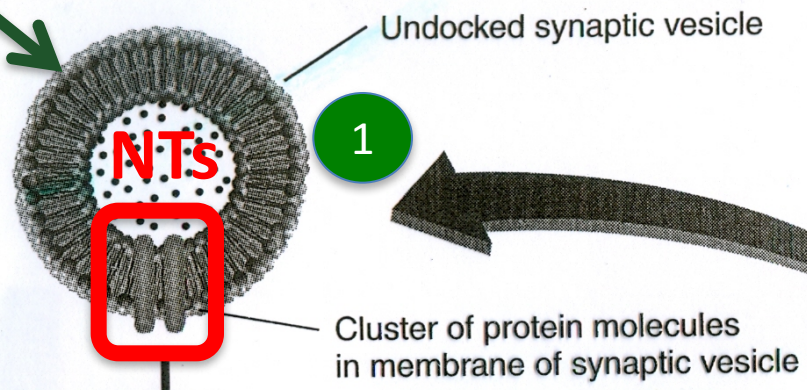
Cluster of protein molecules
in membrane of synaptic vesicle



VESICLE
Double lipid
membrane

Exocytosis

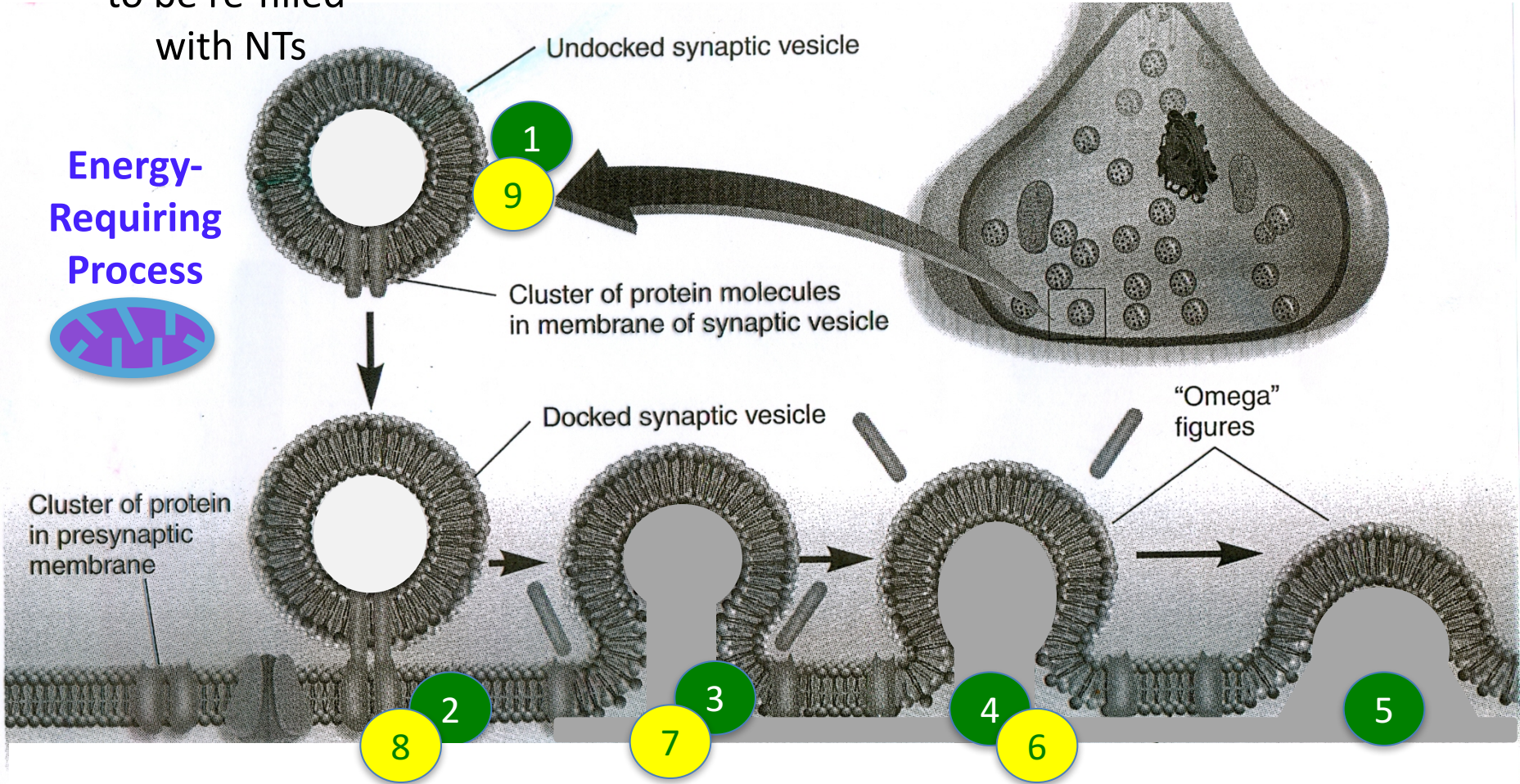
Energy-
Requiring
Process



Exocytosis

Reclaimed empty vesicle
to be re-filled
with NTs

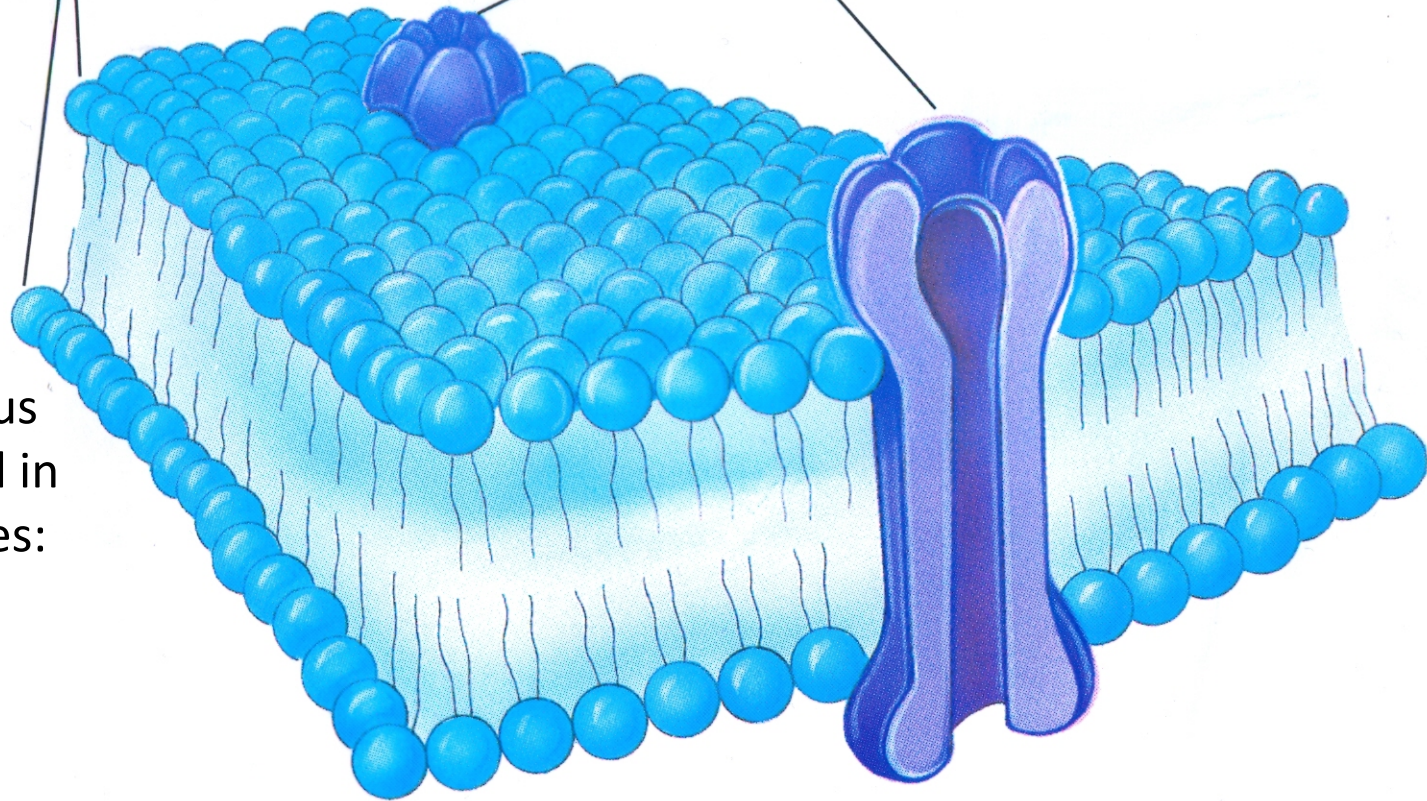
Energy-
Requiring
Process



After the NTs have drifted into the cleft . . .

Membrane molecules

Protein molecules



Functions of various proteins embedded in neuron membranes:

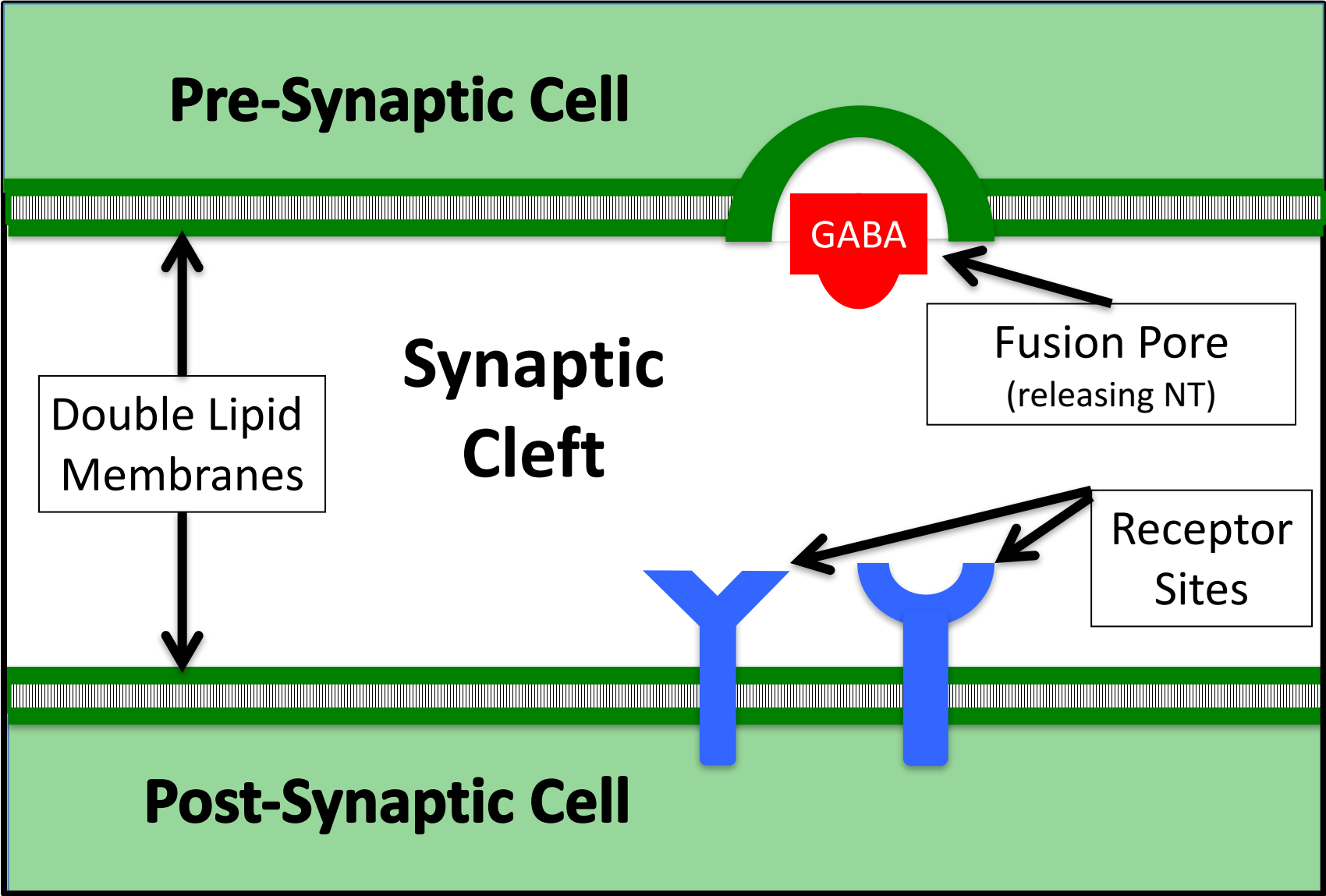
Ion Gates

Fusion Pores

Receptor Sites

Each is specialized for only one function

The Synapse



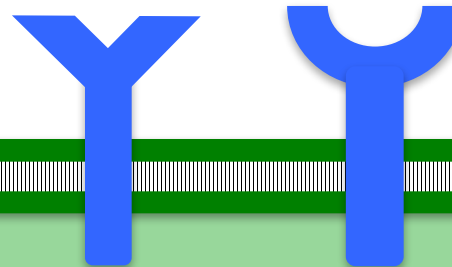
The Synapse

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

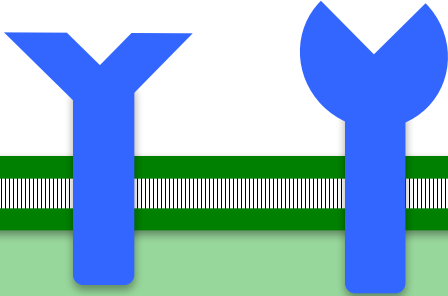


The Synapse

Pre-Synaptic Cell

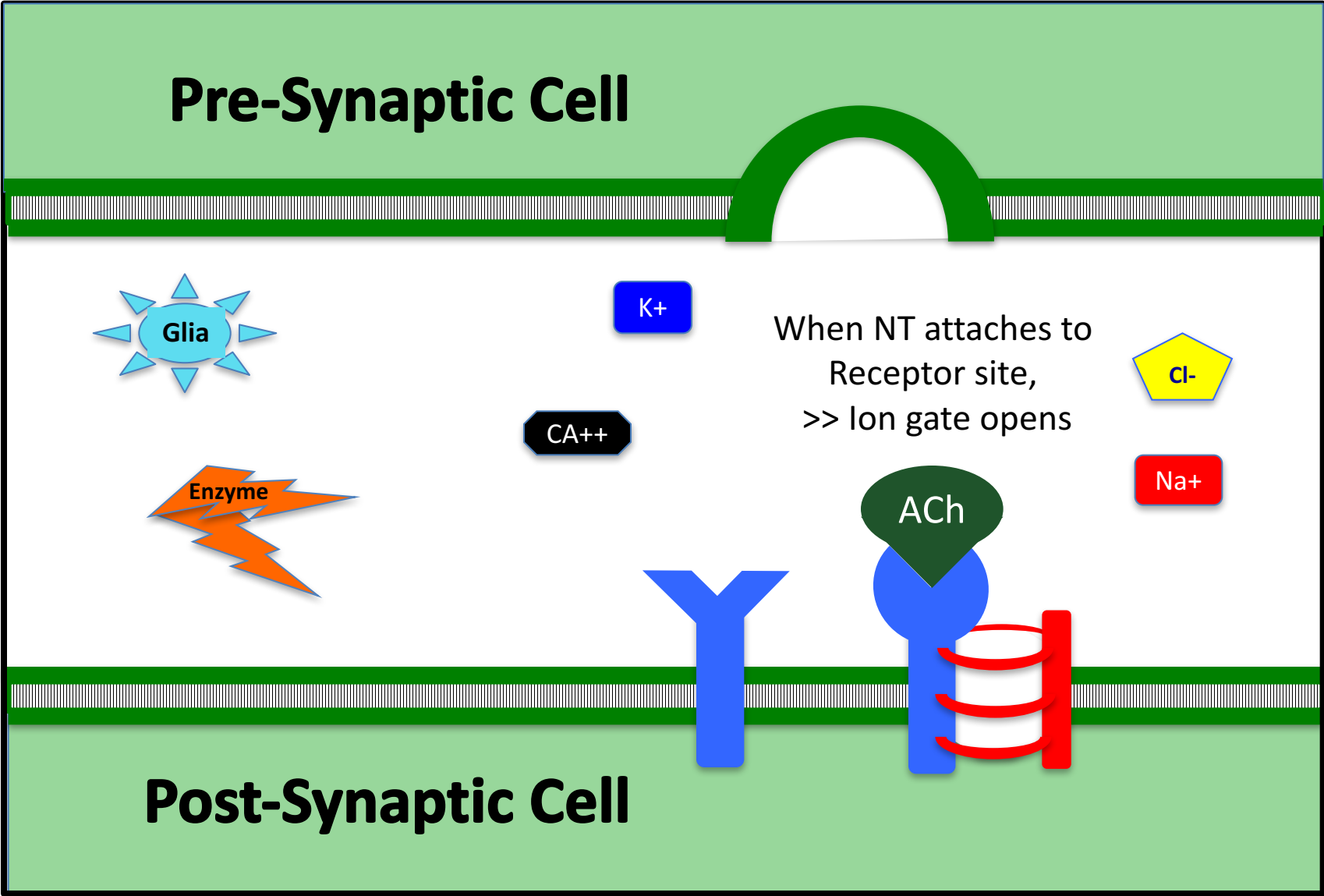


What happens next depends on . . .



Post-Synaptic Cell

The Synapse



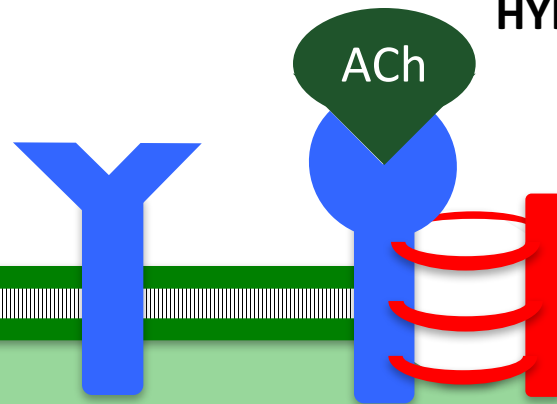
The Synapse

Pre-Synaptic Cell

Adding positively charged Na⁺
decreases polarity of post-synaptic cell,
bringing it closer to its threshold for firing
= Excitation

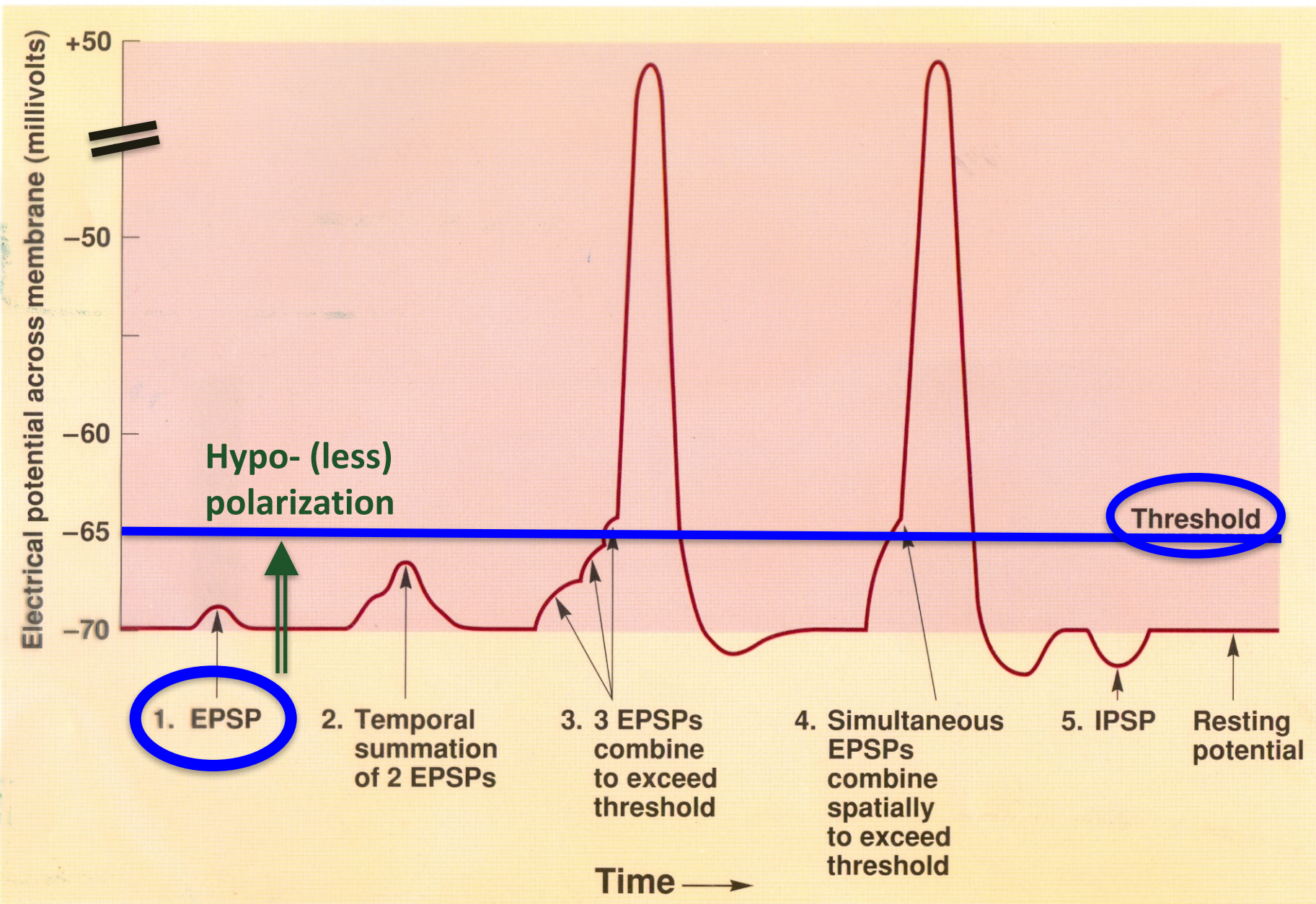
"EPSP"

Excitatory Post-Synaptic Potential
Post-synaptic cell is
HYPO-Polarized



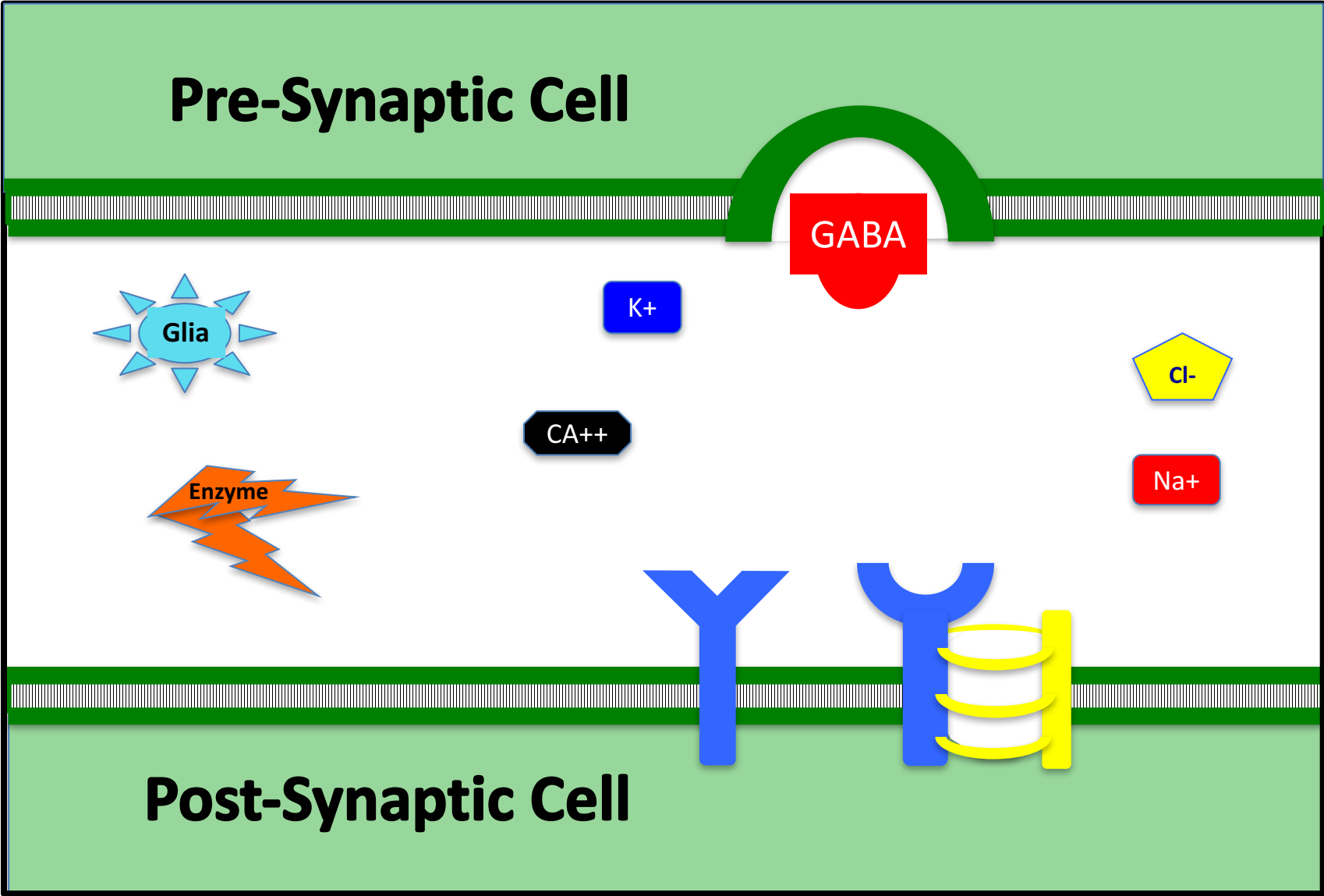
Post-Synaptic Cell

Na⁺



Recording from postsynaptic neuron

The Synapse



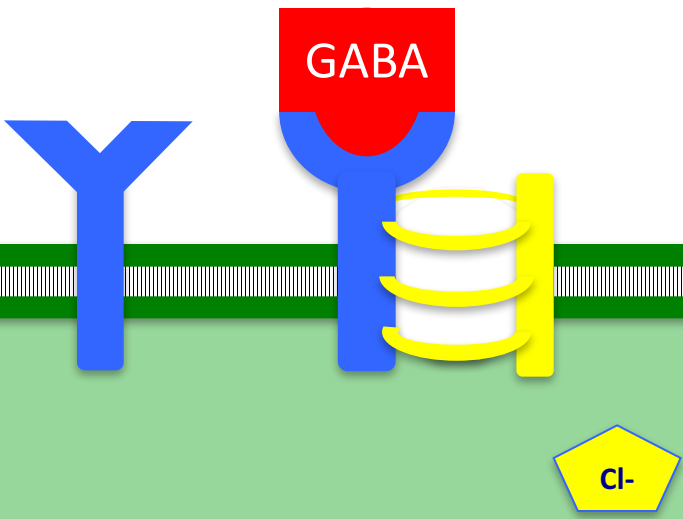
The Synapse

Pre-Synaptic Cell

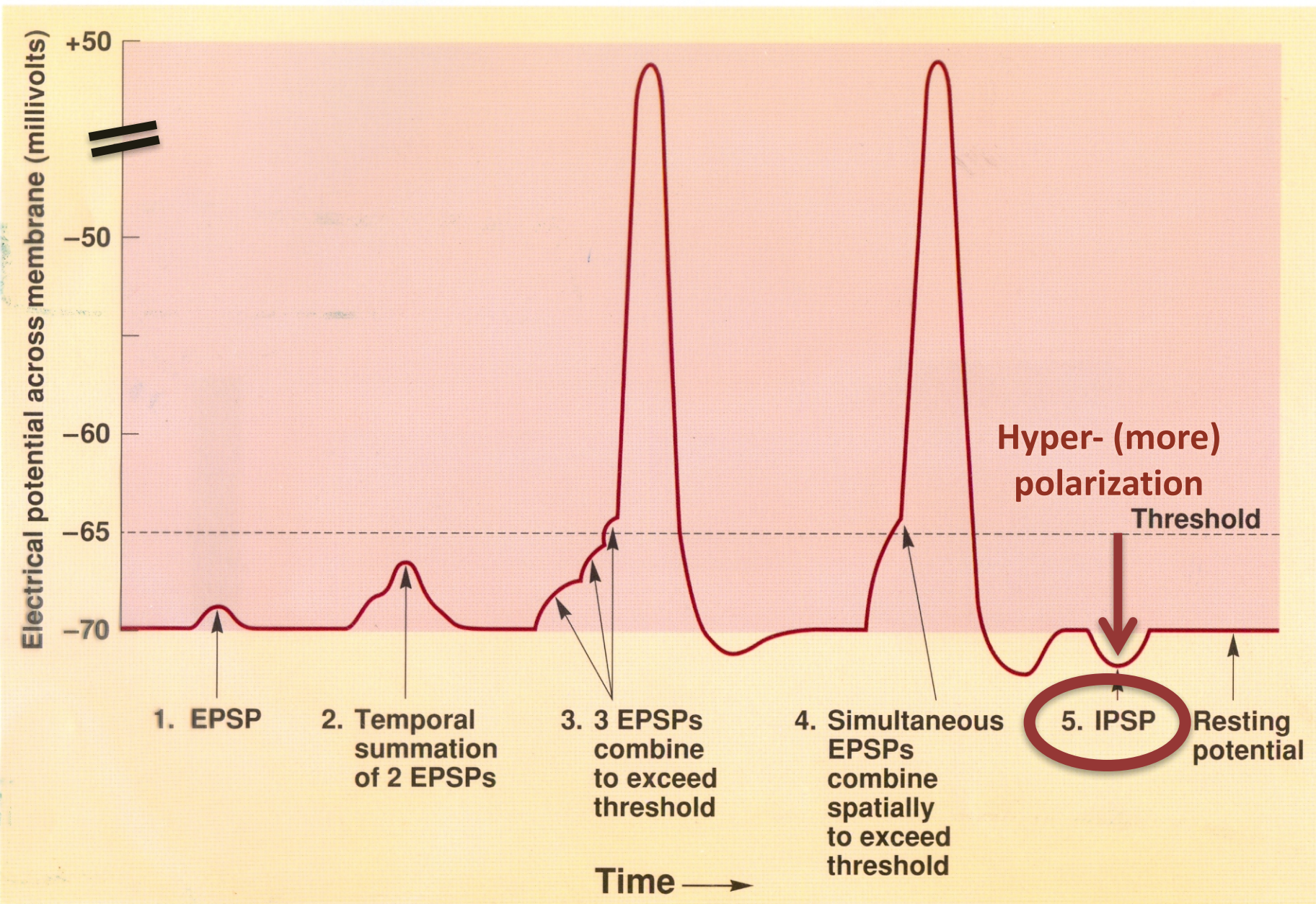
Adding negatively charged Cl⁻ increases polarity of post-synaptic cell, pushing it farther from its threshold for firing
= Inhibition

"IPSP"

Inhibitory Post-Synaptic Potential
Post-synaptic cell is **HYPER**-Polarized



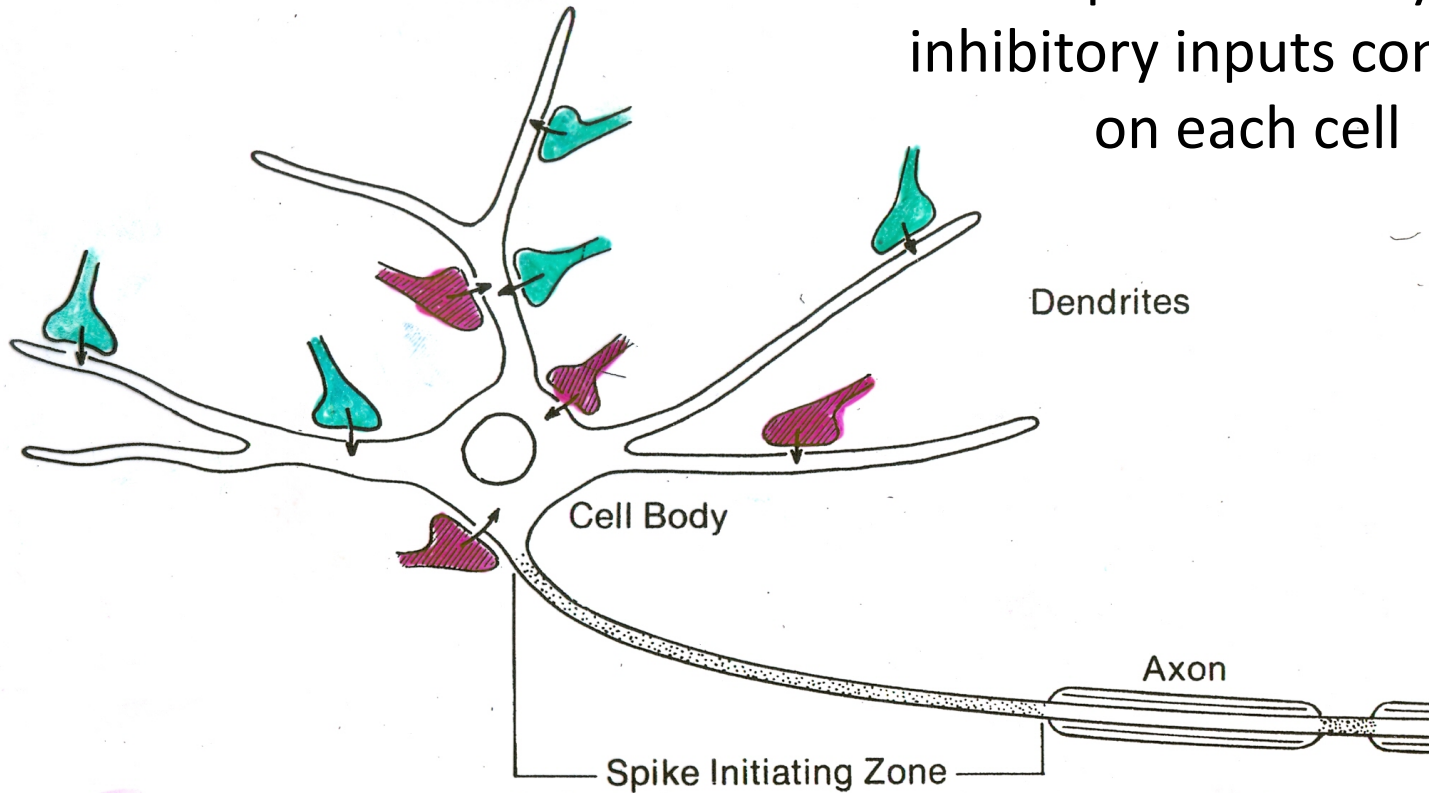
Post-Synaptic Cell



Recording from postsynaptic neuron

Summation

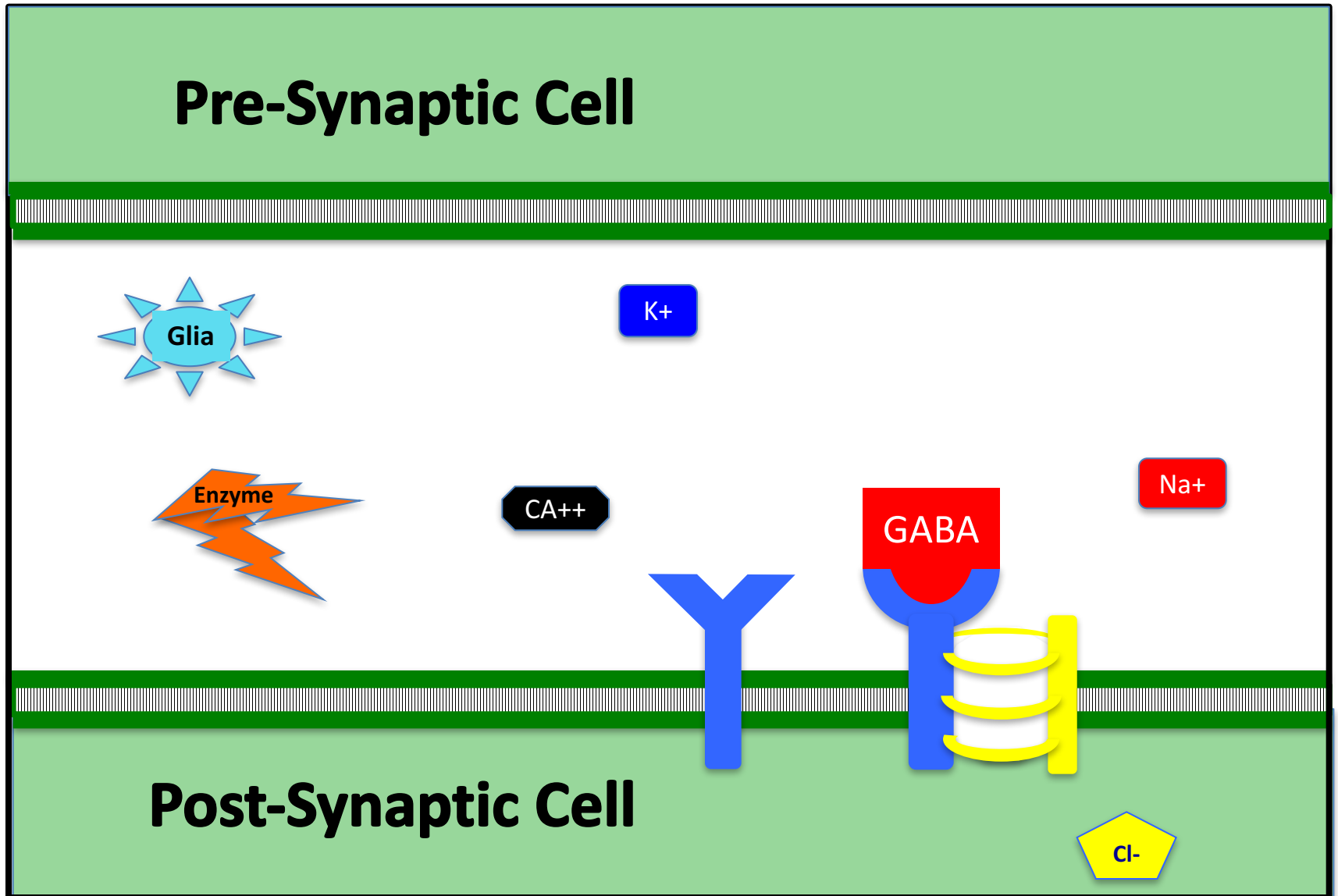
Multiple excitatory and inhibitory inputs converge on each cell



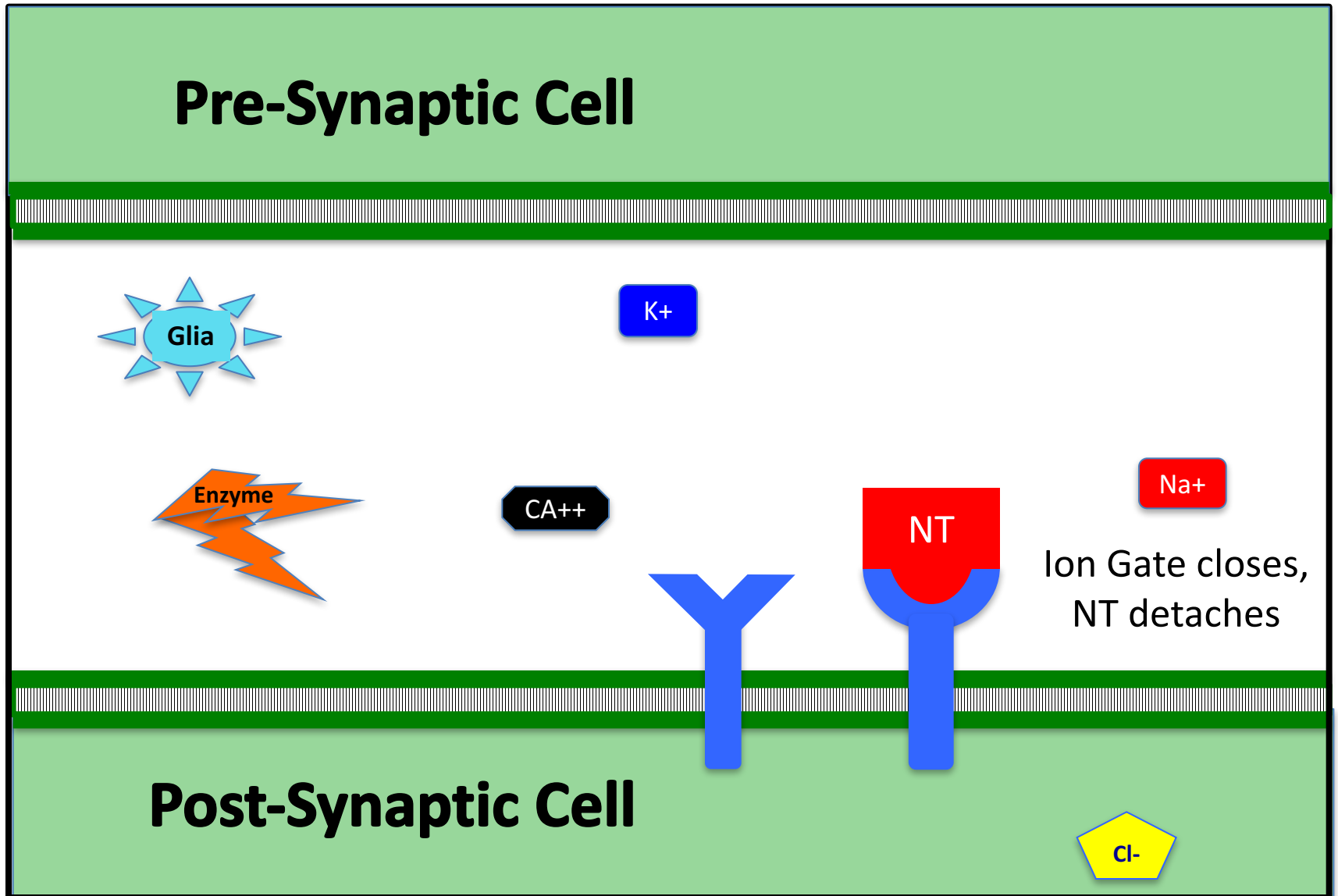
MNEMONIC: EPSP & IPSP

- EPSP = *Excitatory* Post-Synaptic Potential
 - Cell is HYP**O**-Polarized
 - When you are excited, you say “**O!**”
- IPSP = *Inhibitory* Post-Synaptic Potential
 - Cell is HYP**ER**-Polarized
 - When you are inhibited, you say “**ER...**”

AFTER the Synapse . . .



AFTER the Synapse . . .



Pre-Synaptic Cell



Ion Gate closes,
NT detaches

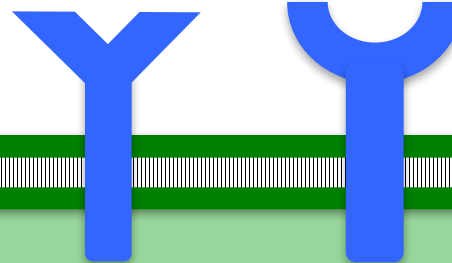
Post-Synaptic Cell



AFTER the Synapse . . .

Pre-Synaptic Cell

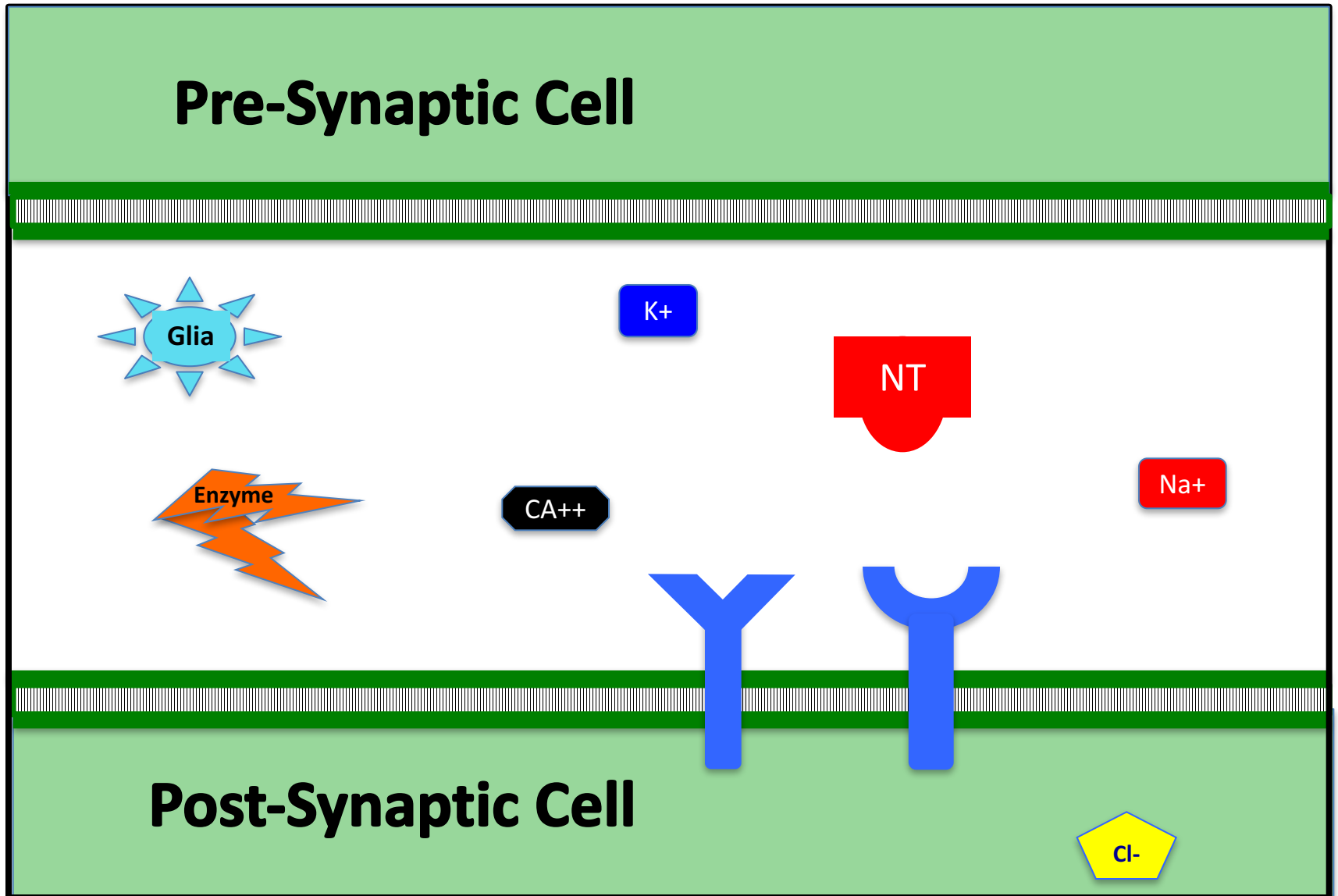
Astro-Glia
may carry NT off,
dispose into bloodstream



Post-Synaptic Cell

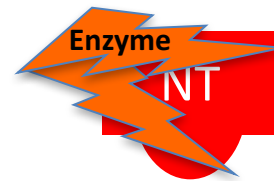


AFTER the Synapse . . .

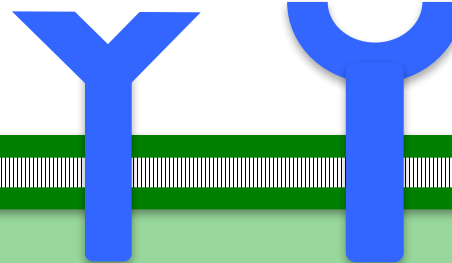


AFTER the Synapse . . .

Pre-Synaptic Cell



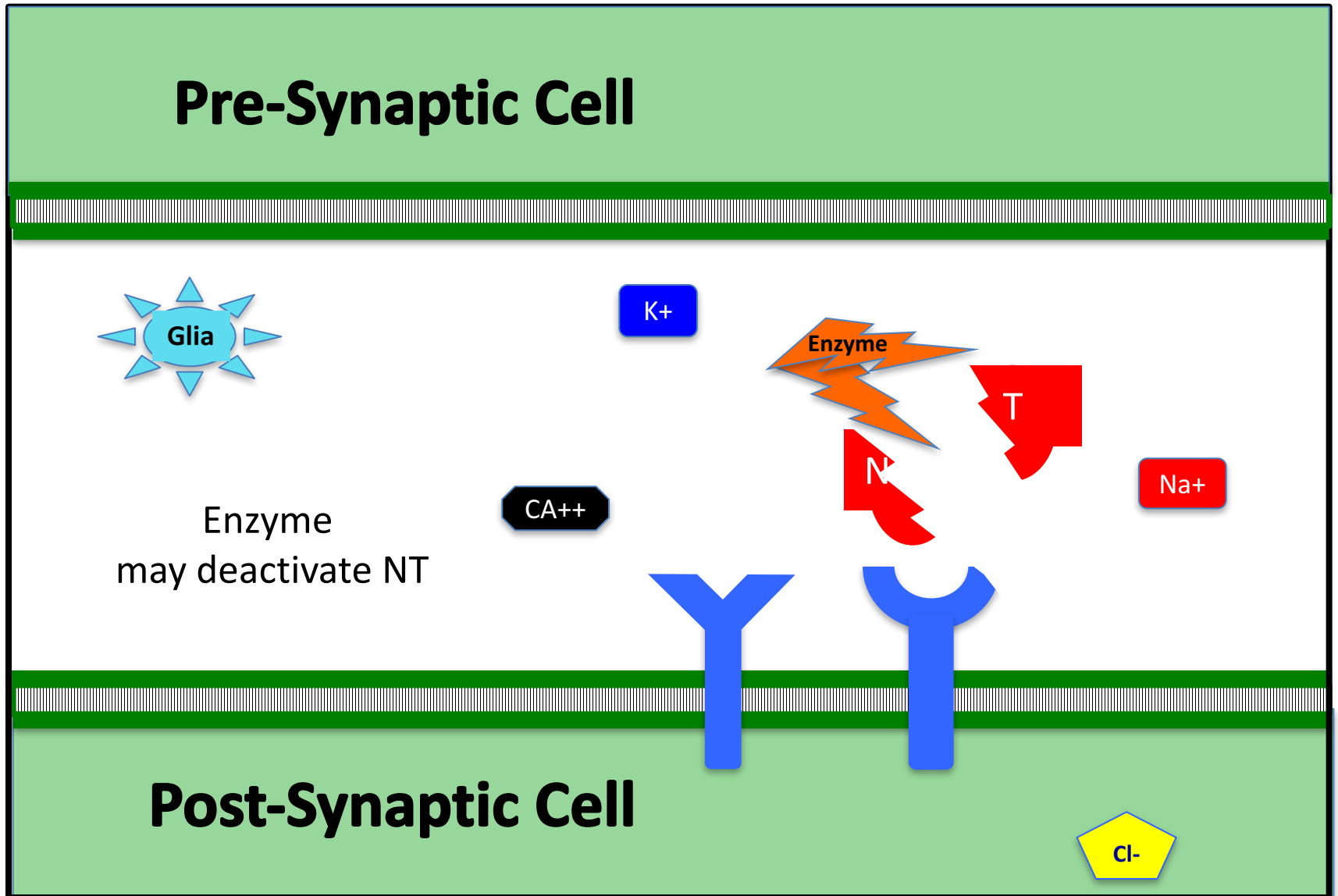
Enzyme
may deactivate NT



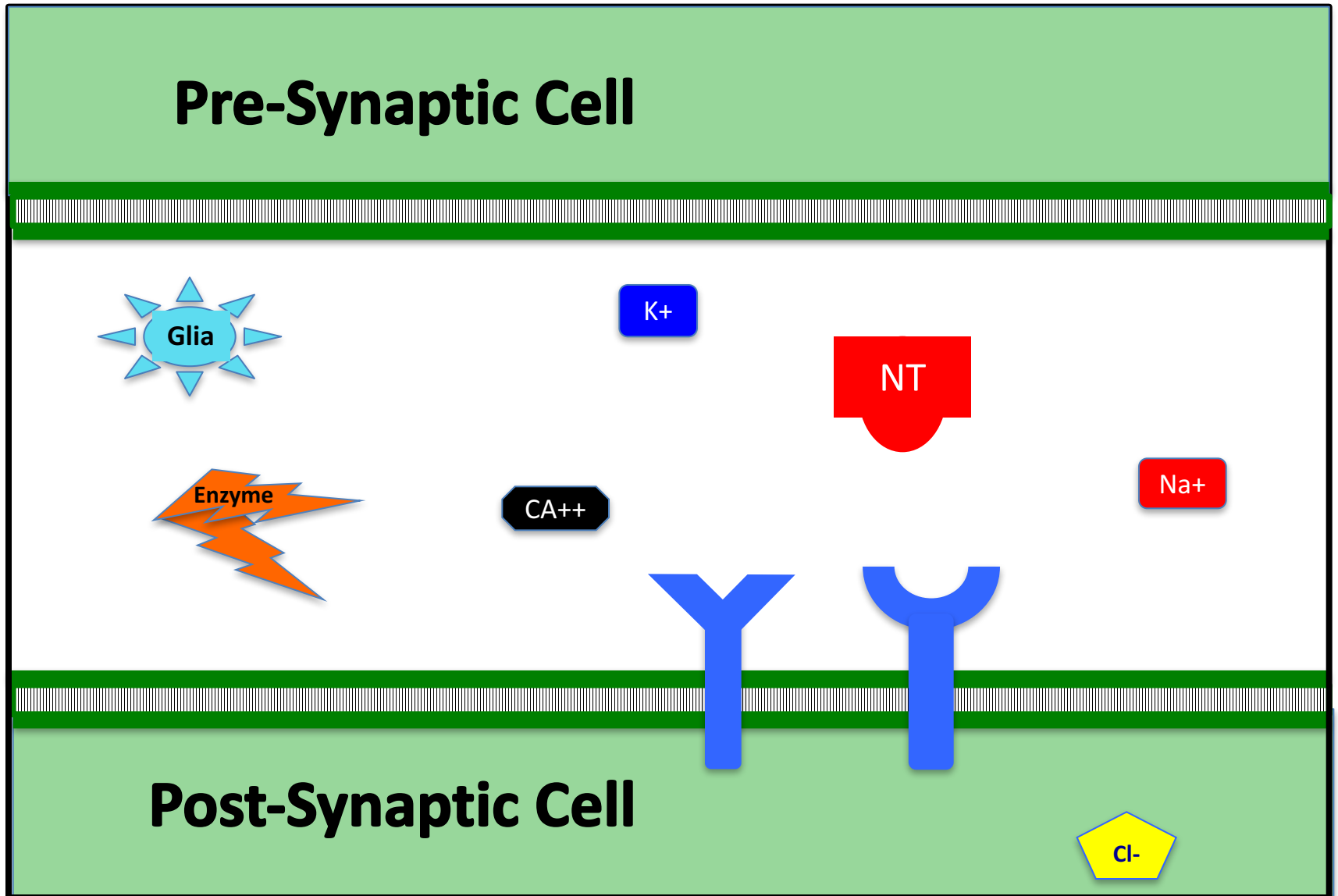
Post-Synaptic Cell



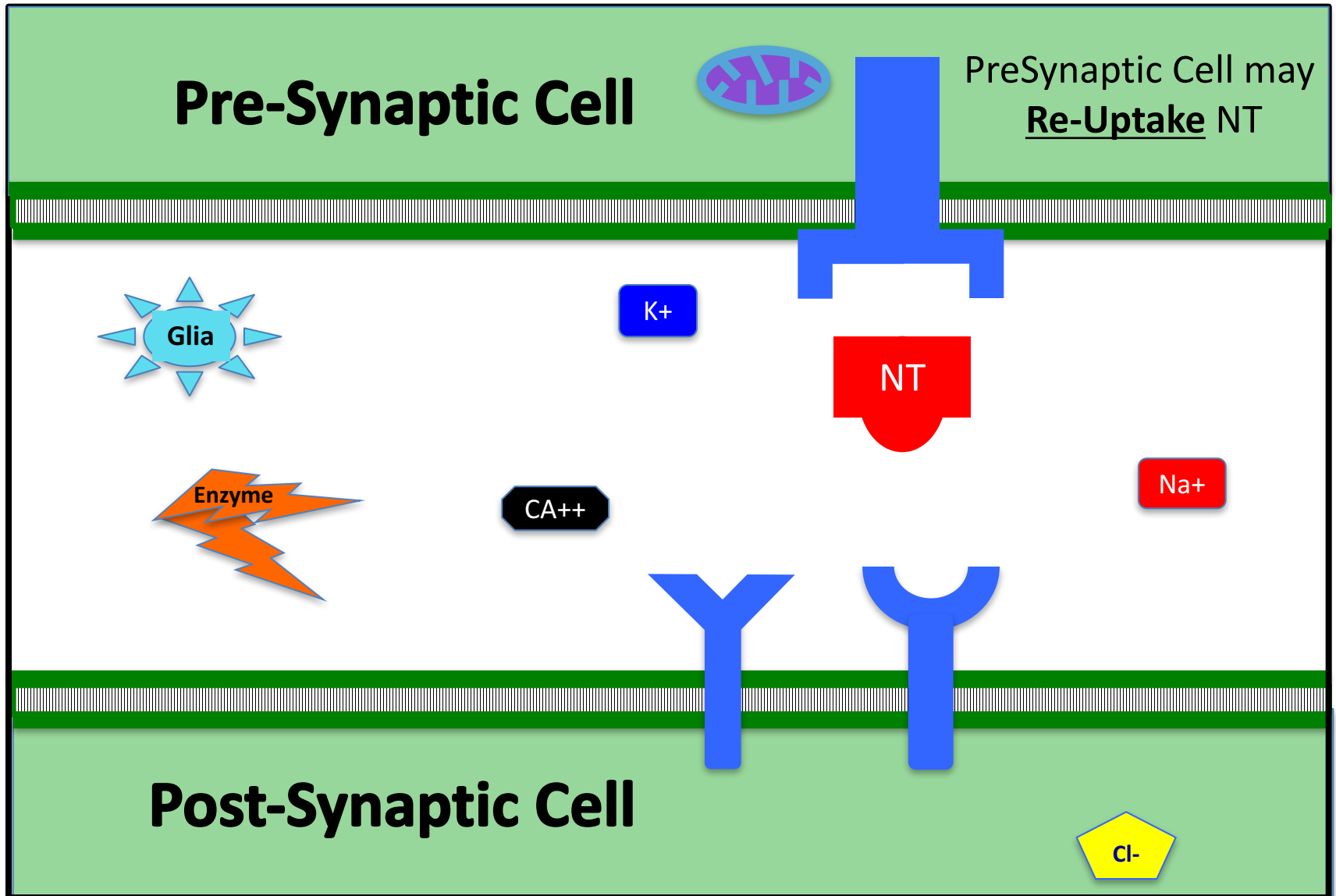
AFTER the Synapse . . .



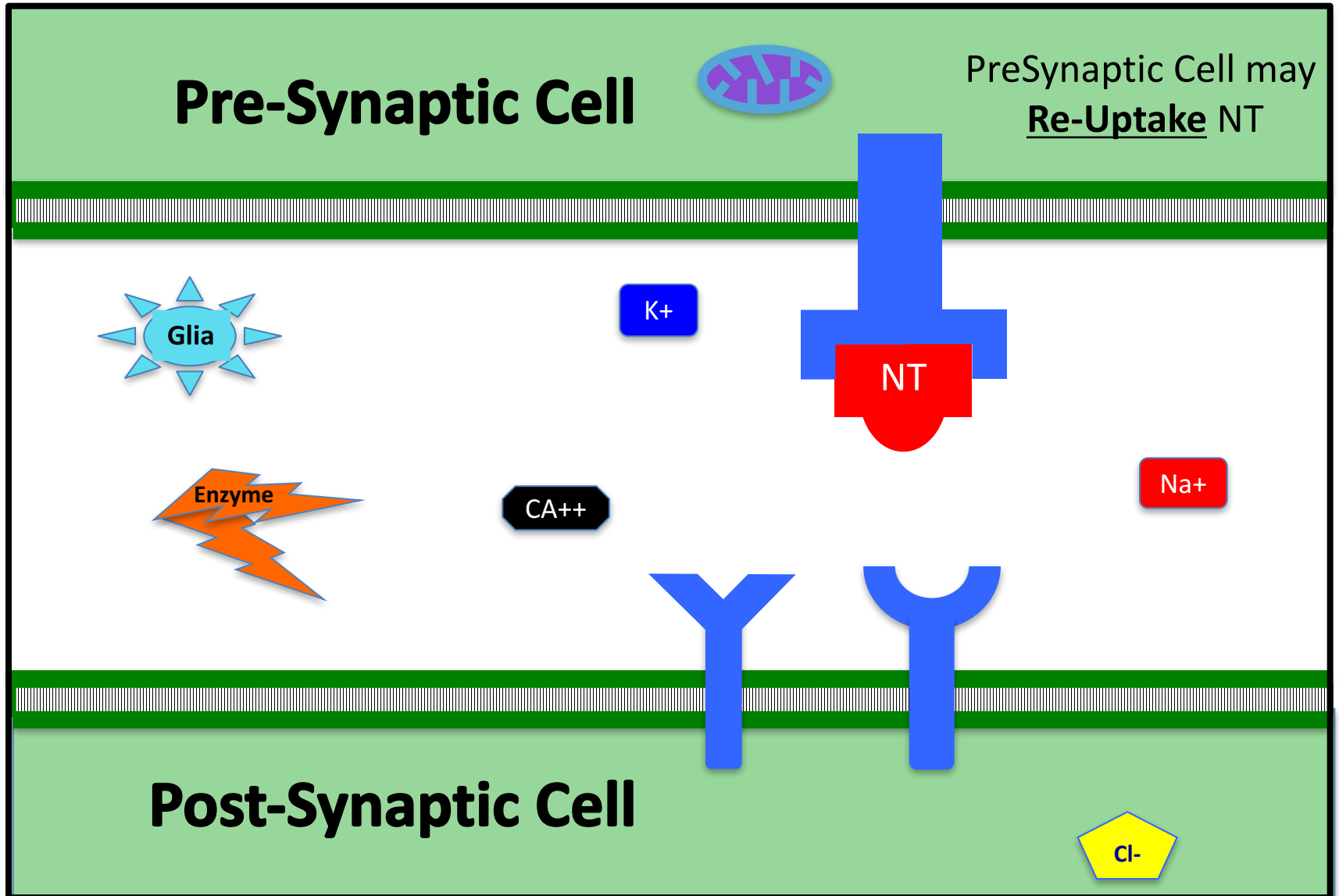
AFTER the Synapse . . .



AFTER the Synapse . . .



AFTER the Synapse . . .

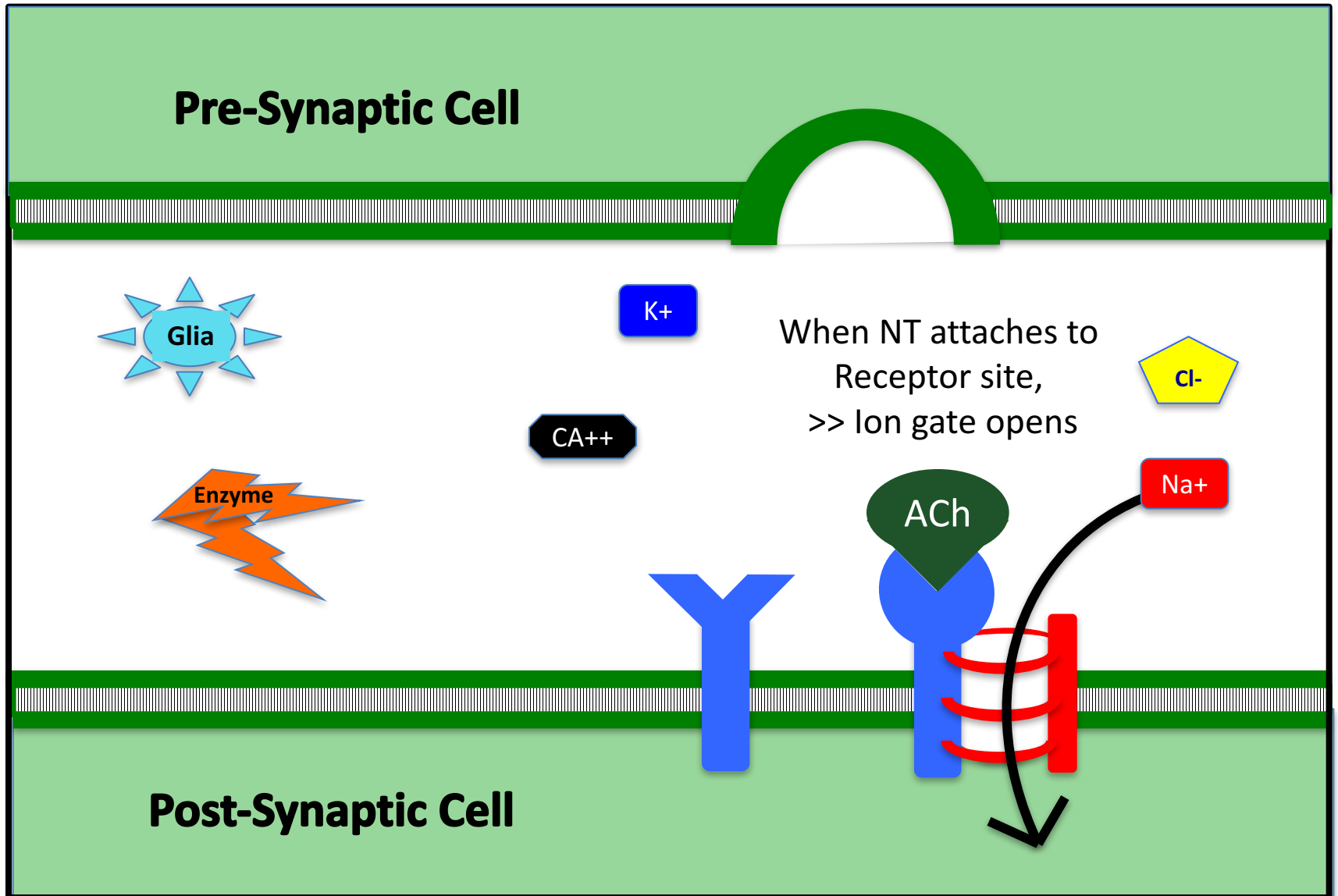


MNEMONIC

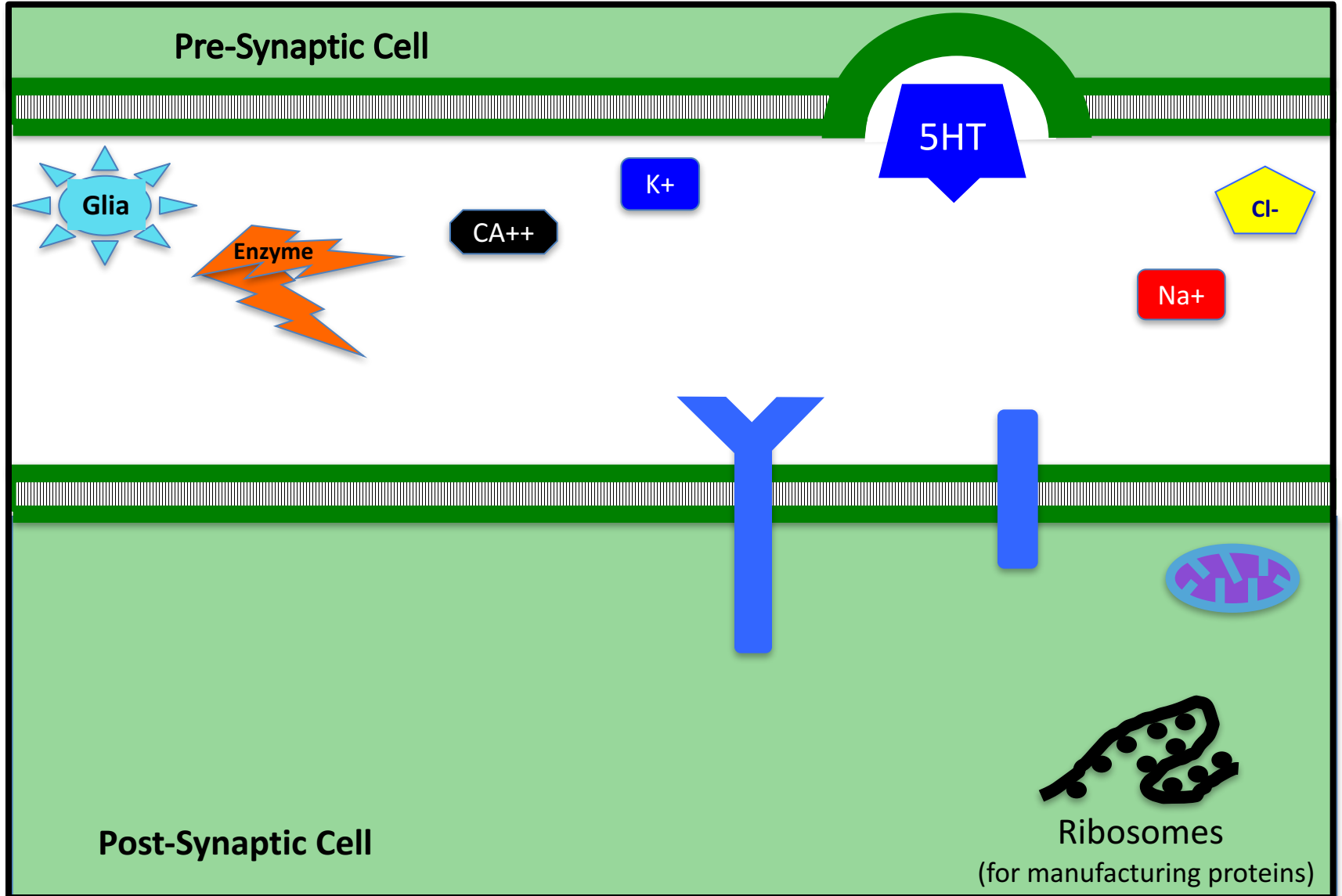
Neurotransmitter

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

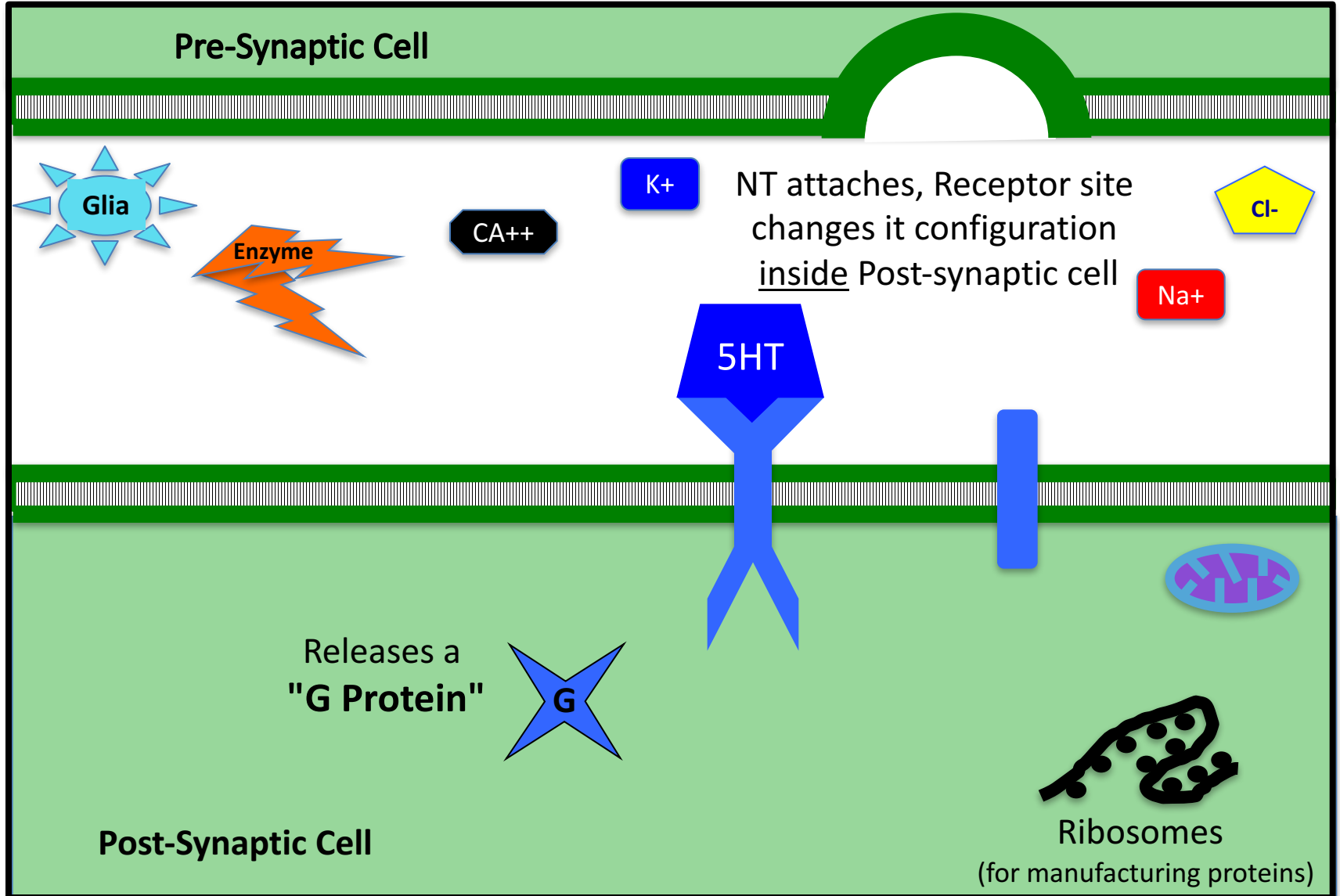
Ionotropic Synapse



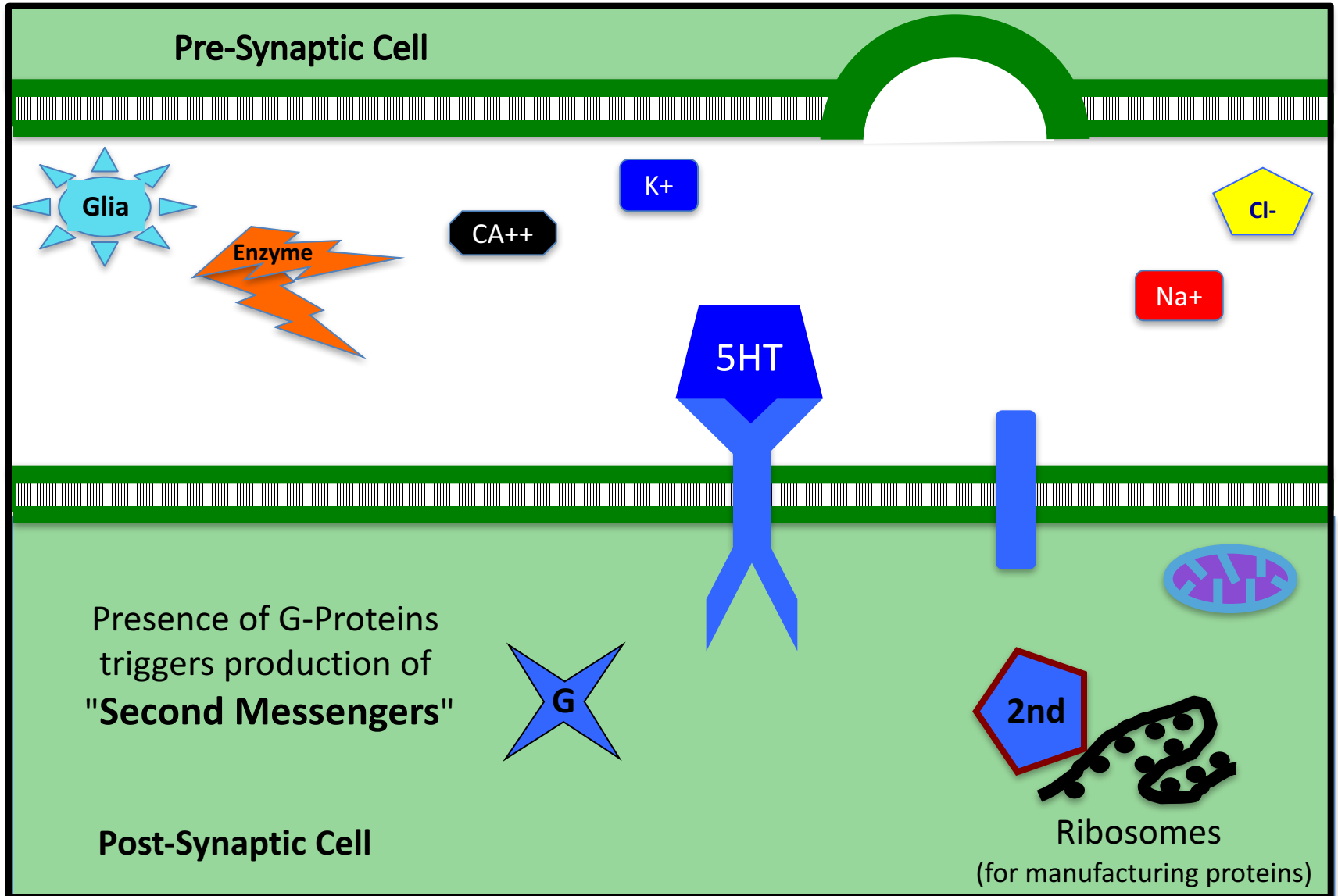
Metabotropic Synapse



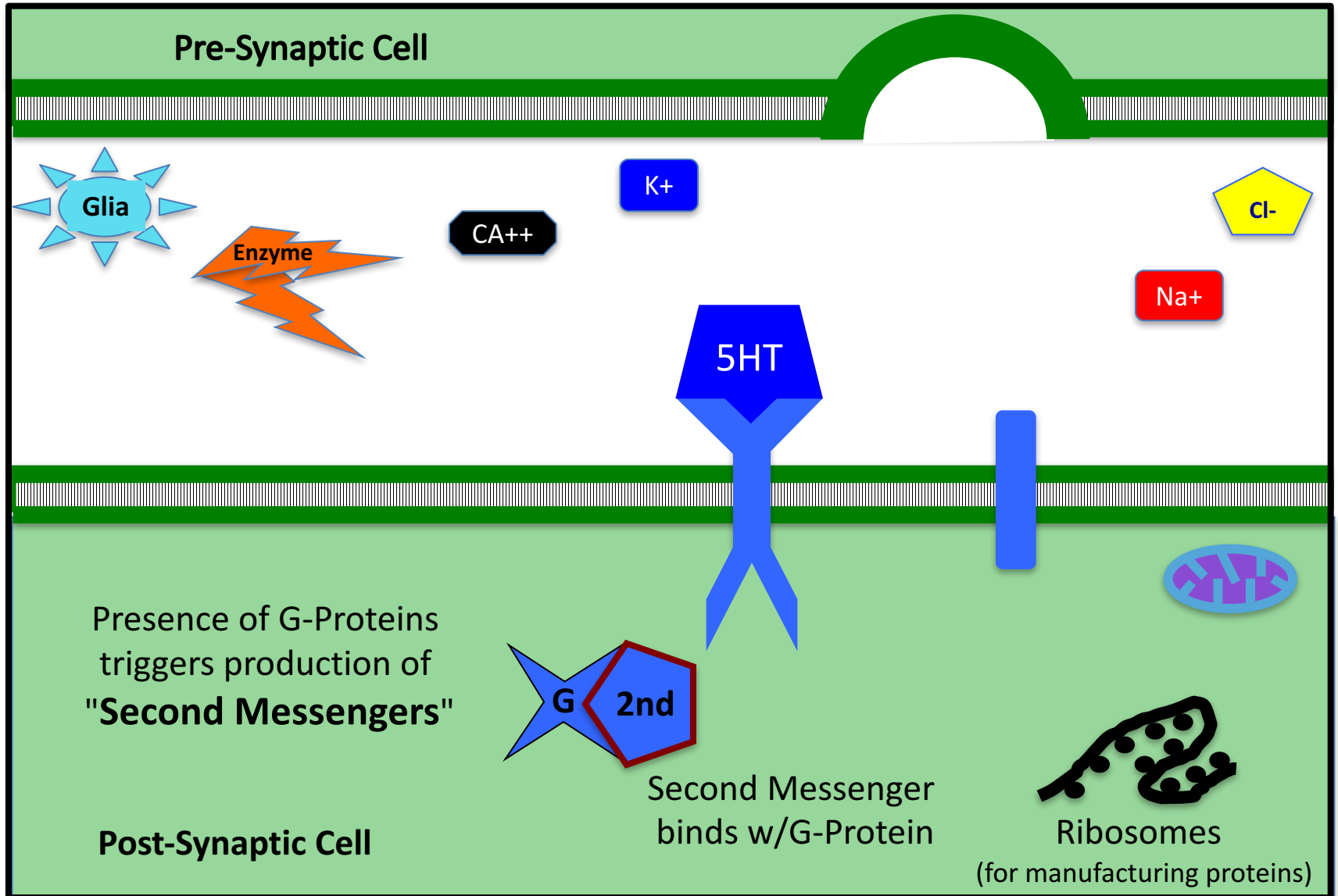
Metabotropic Synapse



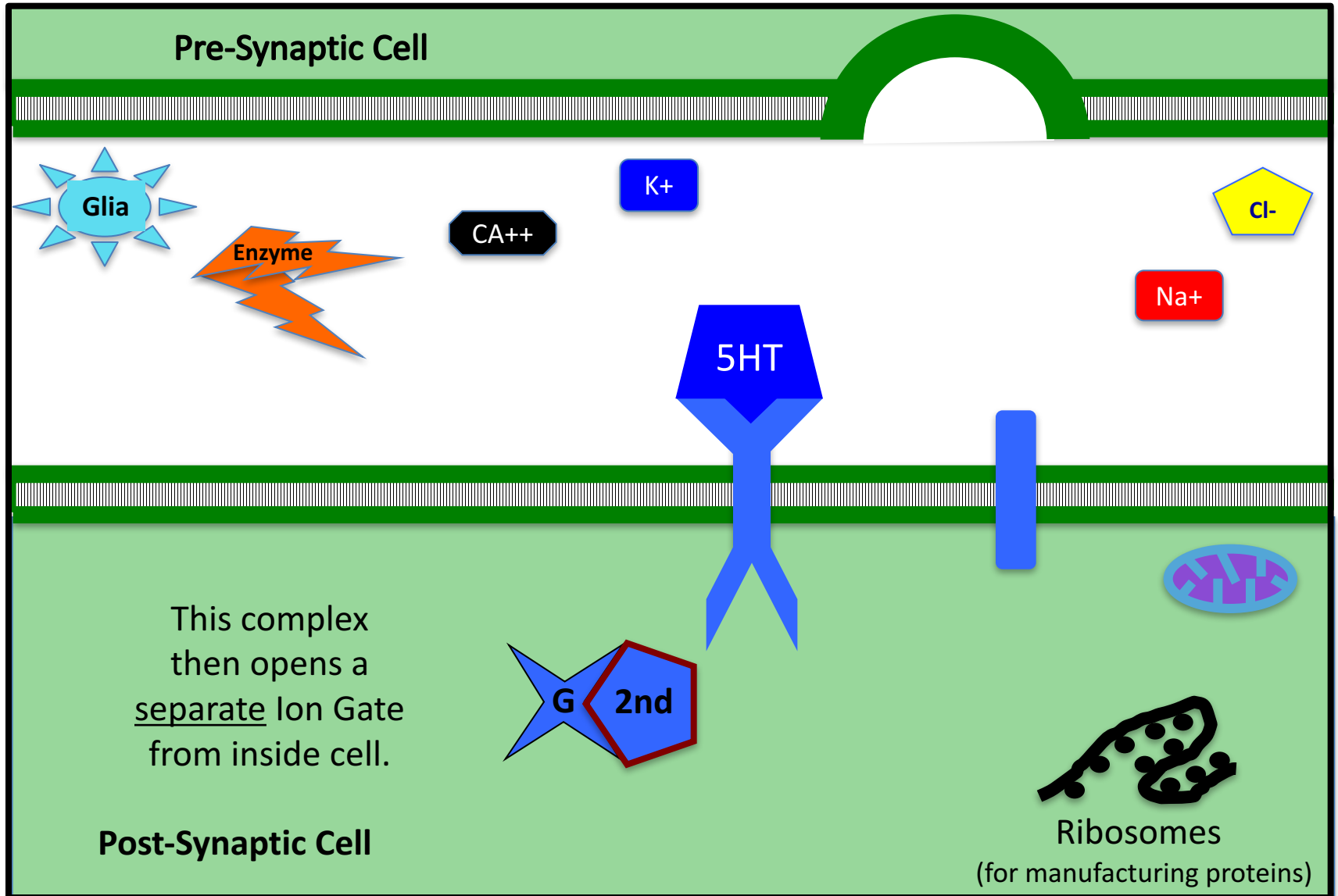
Metabotropic Synapse



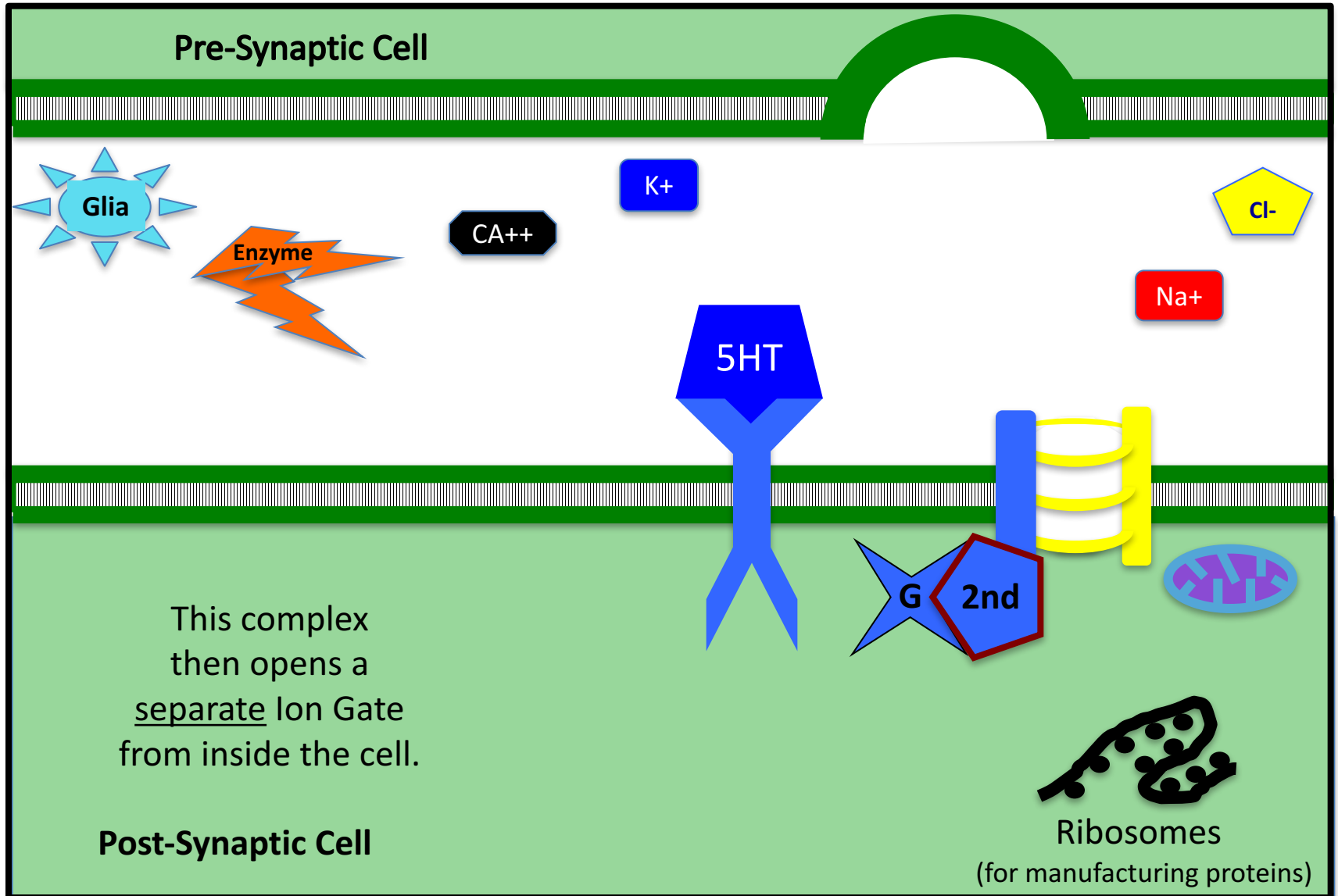
Metabotropic Synapse



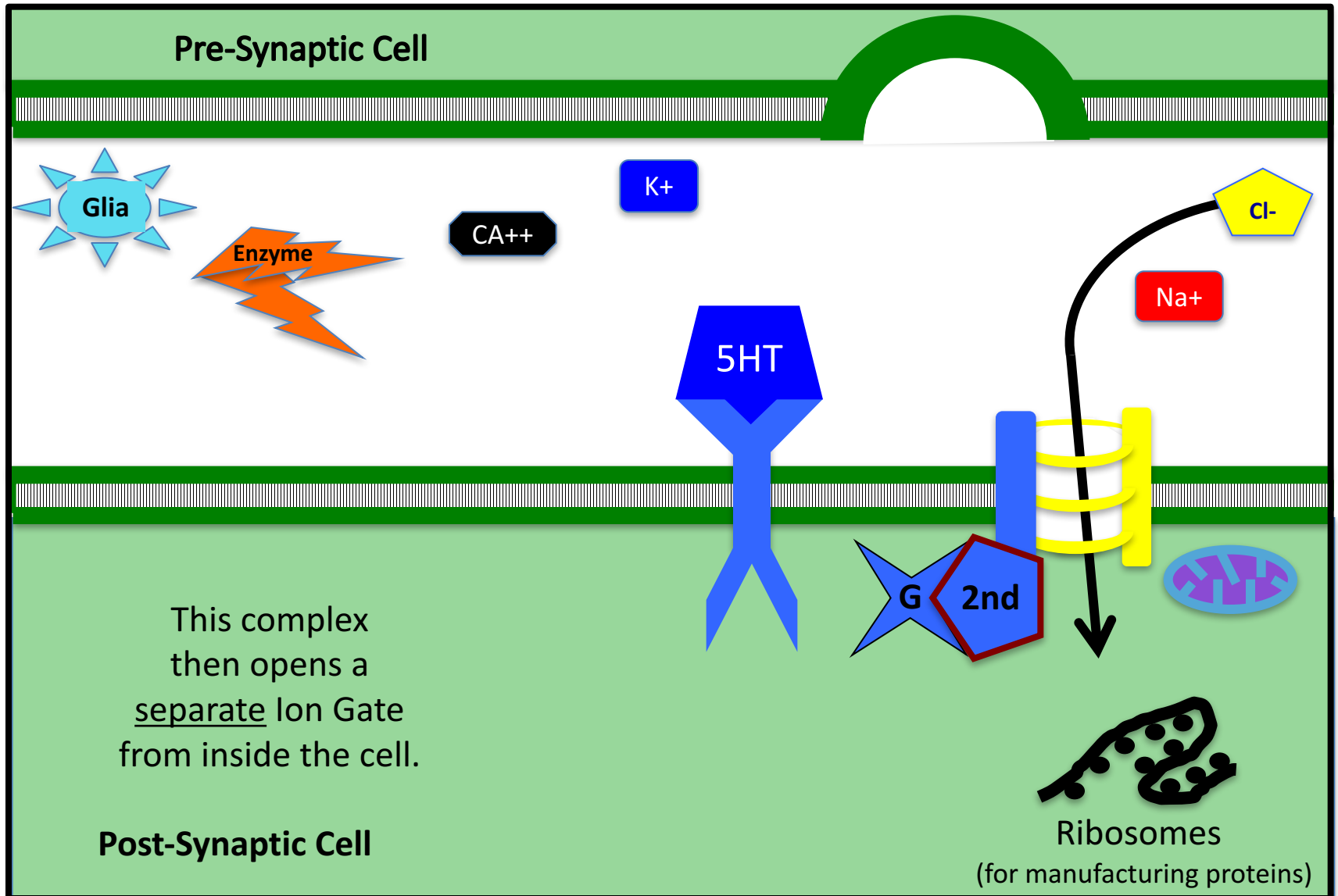
Metabotropic Synapse



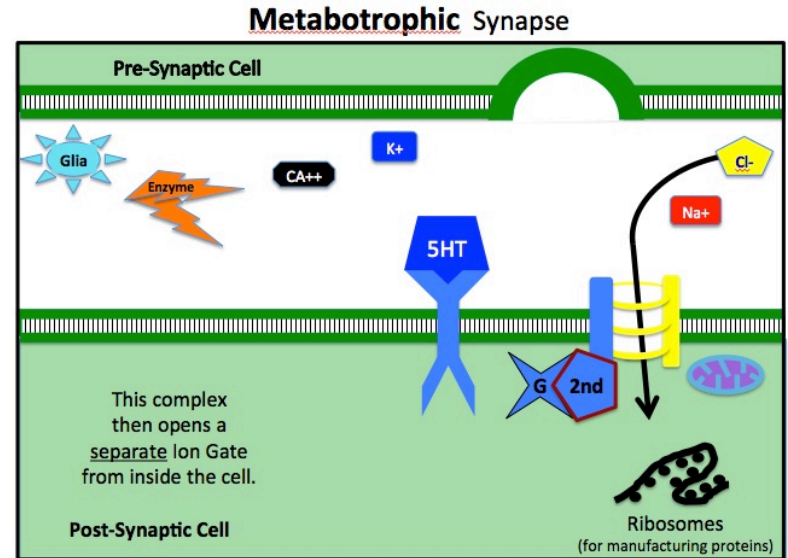
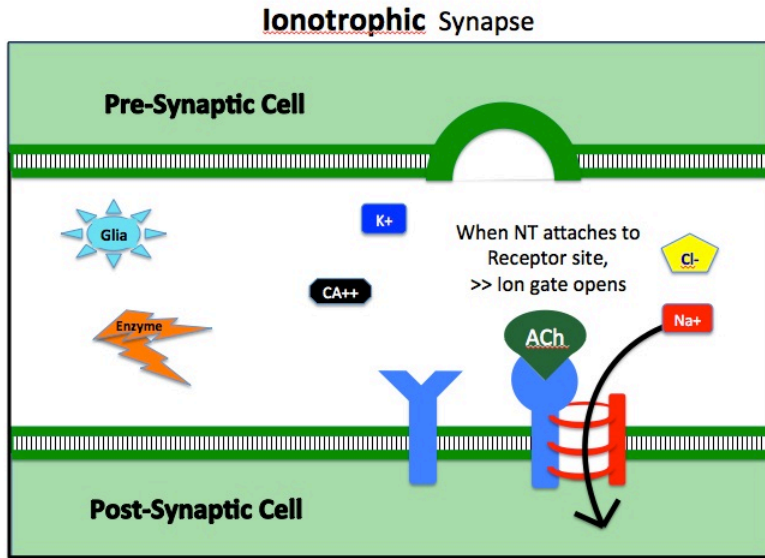
Metabotropic Synapse



Metabotropic Synapse



Ionotropic vs. Metabotropic



- 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:

- Acetylcholine (ACh)
- GABA
- Glutamate
- Serotonin (5HT)
- Dopamine
- Norepinephrine
- Epinephrine (Adrenalin)
- Substance P
- Endorphins
- Hormones

SOME FUNCTIONS:

- All neuro-muscular junctions; Cortical arousal...
- Suppress cortical activity; Regulate anxiety...
- Most common + ; Learning, Perception, Schiz...
- Often a neuromodulator; Mood, Sleep, Percep...
- Reinforcement; Atten; Motor control (Parkinsons)...
- Arousal; Attention...
- Arousal; Attention...
- Pain (damage, itch, extreme temp, etc)
- Counter effects of Substance P
- e.g. Testosterone, Estrogen, Oxytocin, Insulin, CCK, Cortisol, Adrenalin, . . .

Agonists vs. Antagonists

AGONIST

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



ANTAGONIST

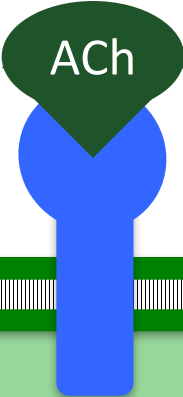
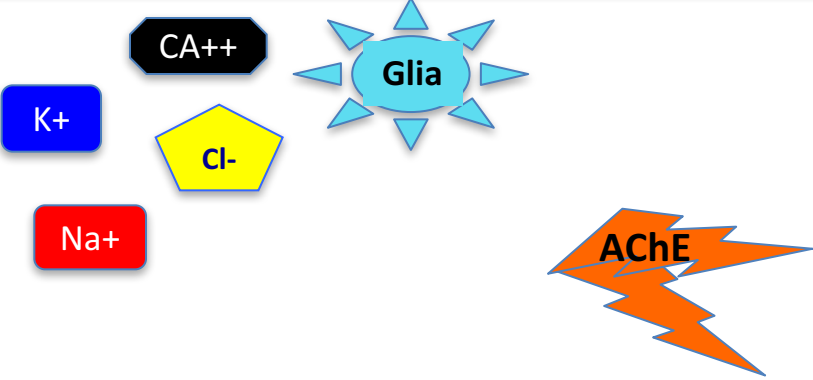
- Decreases the likelihood of a Neurotransmitter having its effect (+ or -)



Acetylcholine (ACh) in the Cleft

What works as an Agonist vs. Antagonist often depends on how NT is typically processed in the cleft

Pre-Synaptic Cell

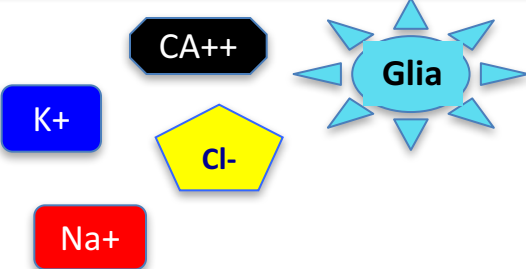


Post-Synaptic Cell

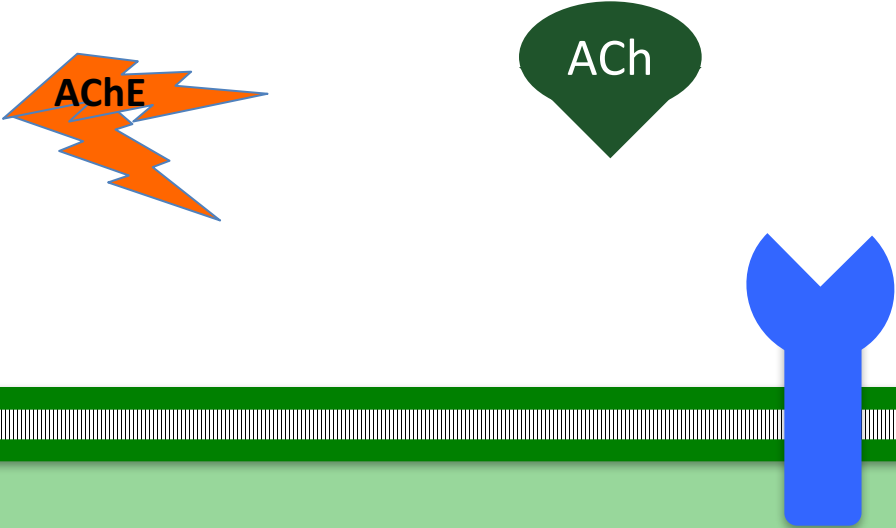
Acetylcholine (ACh) in the Cleft

What works as an Agonist vs. Antagonist often depends on how NT is typically processed in the cleft

Pre-Synaptic Cell



When ACh detaches from Receptor Site into cleft . . .

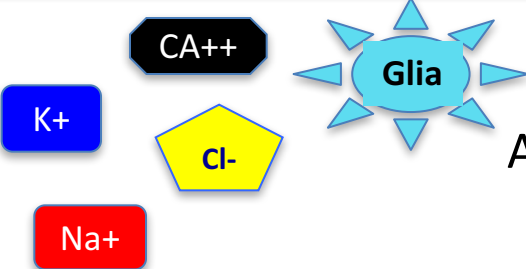


Post-Synaptic Cell

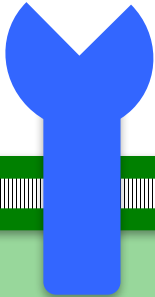
Acetylcholine (ACh) in the Cleft

What works as an Agonist vs. Antagonist often depends on how NT is typically processed in the cleft

Pre-Synaptic Cell



Acetylcholine-Esterase,
an Enzyme in cleft,
will break down ACh

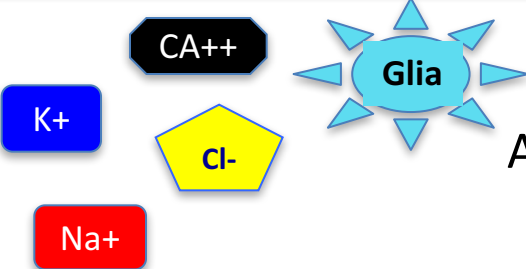


Post-Synaptic Cell

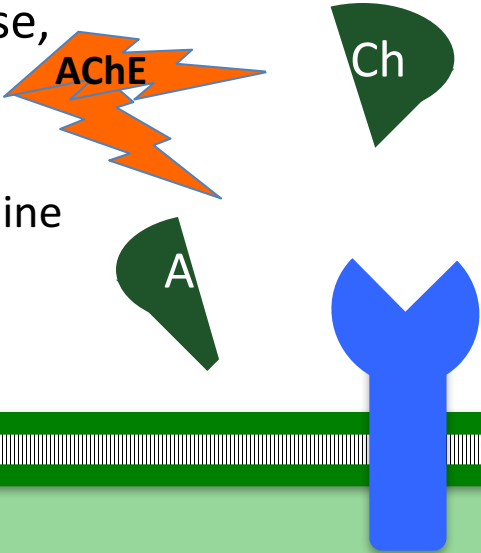
Acetylcholine (ACh) in the Cleft

What works as an Agonist vs. Antagonist often depends on how NT is typically processed in the cleft

Pre-Synaptic Cell



Acetylcholine-Esterase,
an Enzyme in cleft,
will break down ACh
... into Acetate and Choline

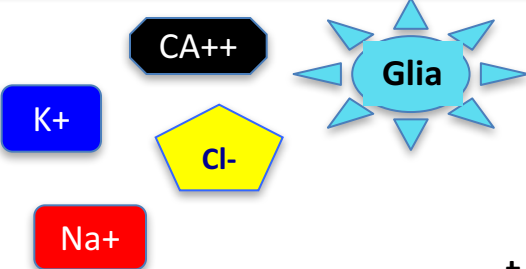


Post-Synaptic Cell

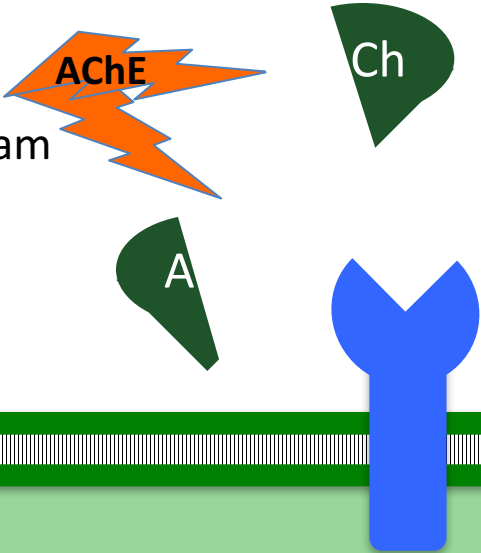
Acetylcholine (ACh) in the Cleft

What works as an Agonist vs. Antagonist often depends on how NT is typically processed in the cleft

Pre-Synaptic Cell



Glia cells carry off Acetate, to dispose in bloodstream

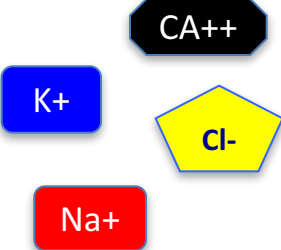


Post-Synaptic Cell

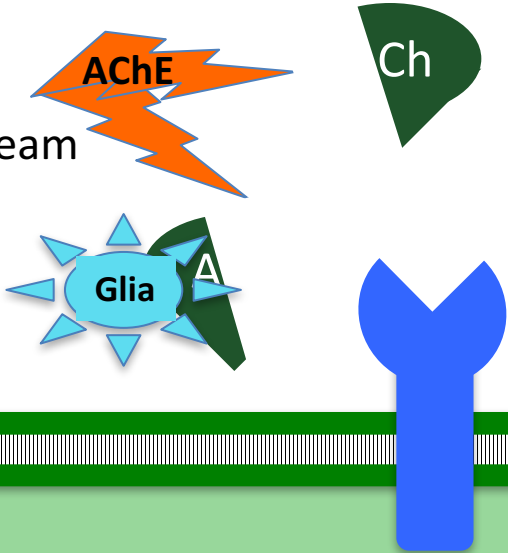
Acetylcholine (ACh) in the Cleft

What works as an Agonist vs. Antagonist often depends on how NT is typically processed in the cleft

Pre-Synaptic Cell

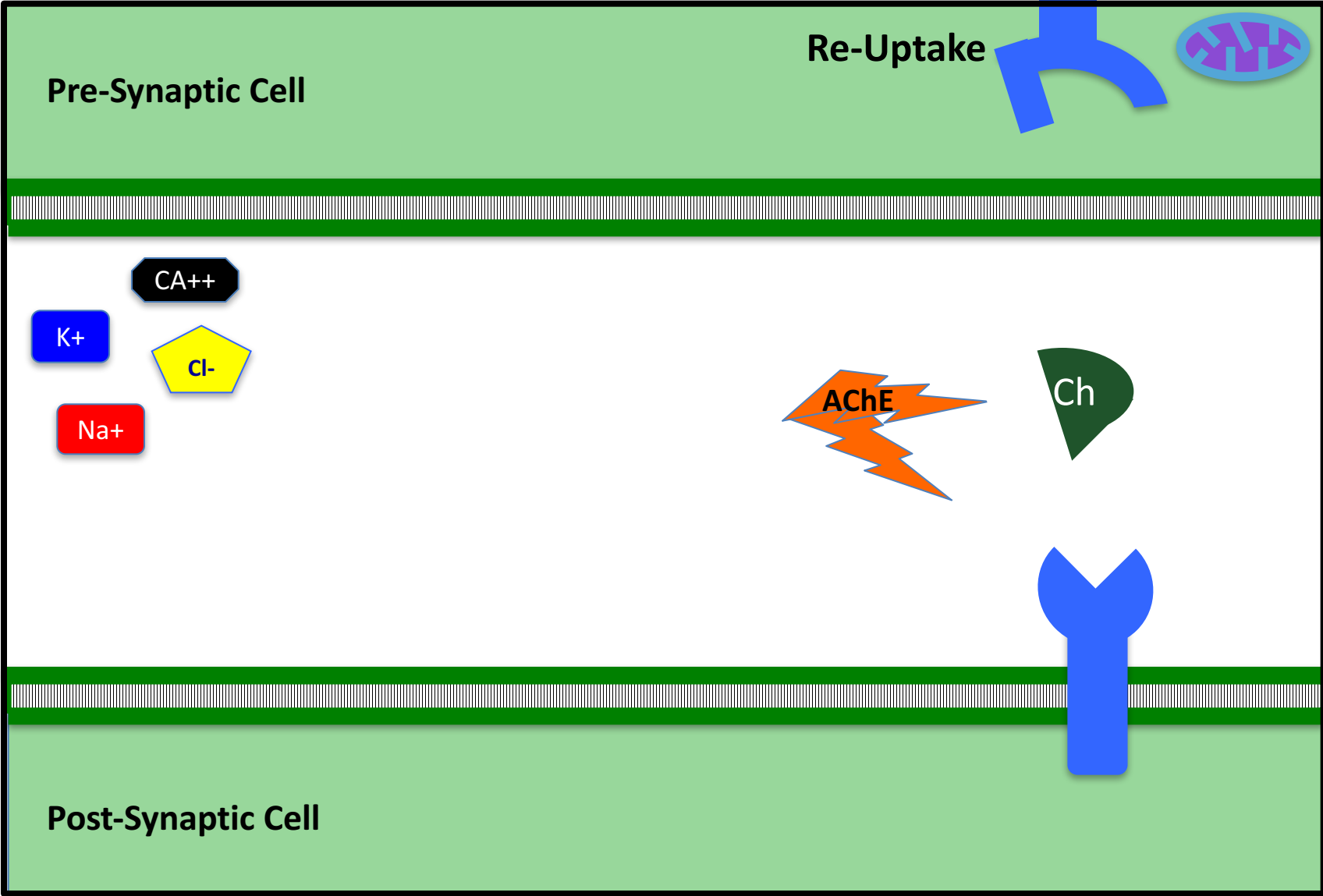


Glia cells carry off Acetate, to dispose in bloodstream

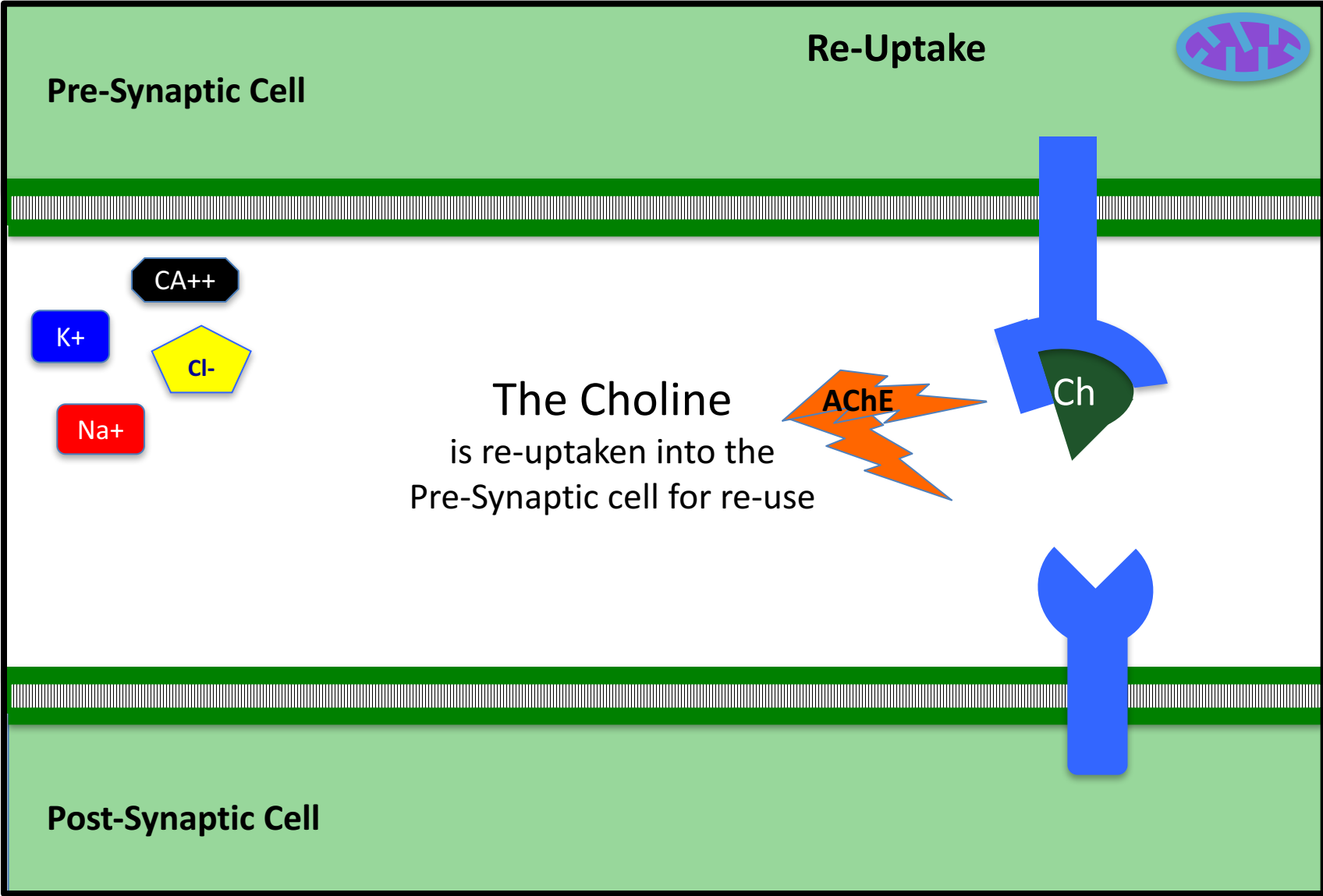


Post-Synaptic Cell

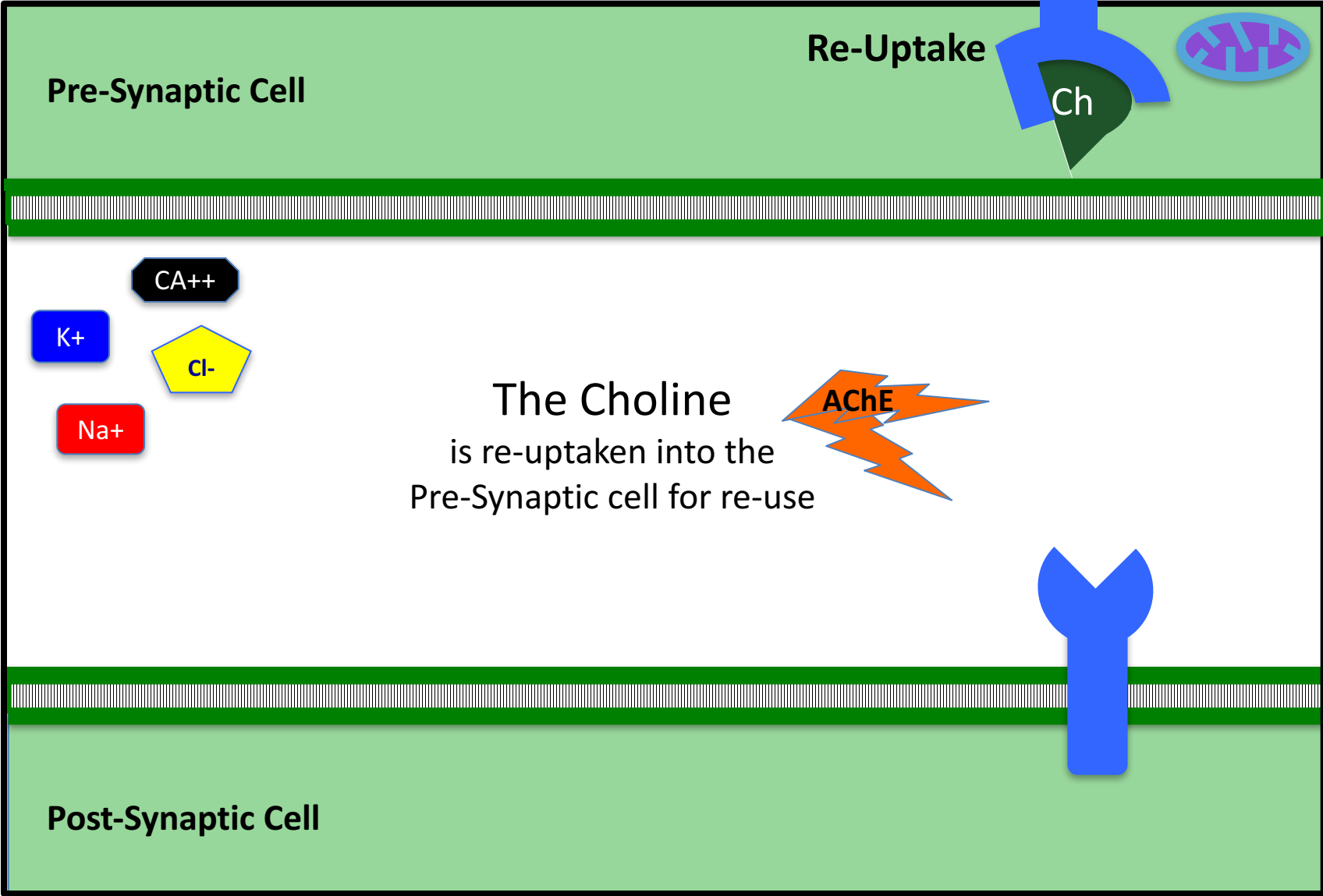
Acetylcholine (ACh) in the Cleft



Acetylcholine (ACh) in the Cleft

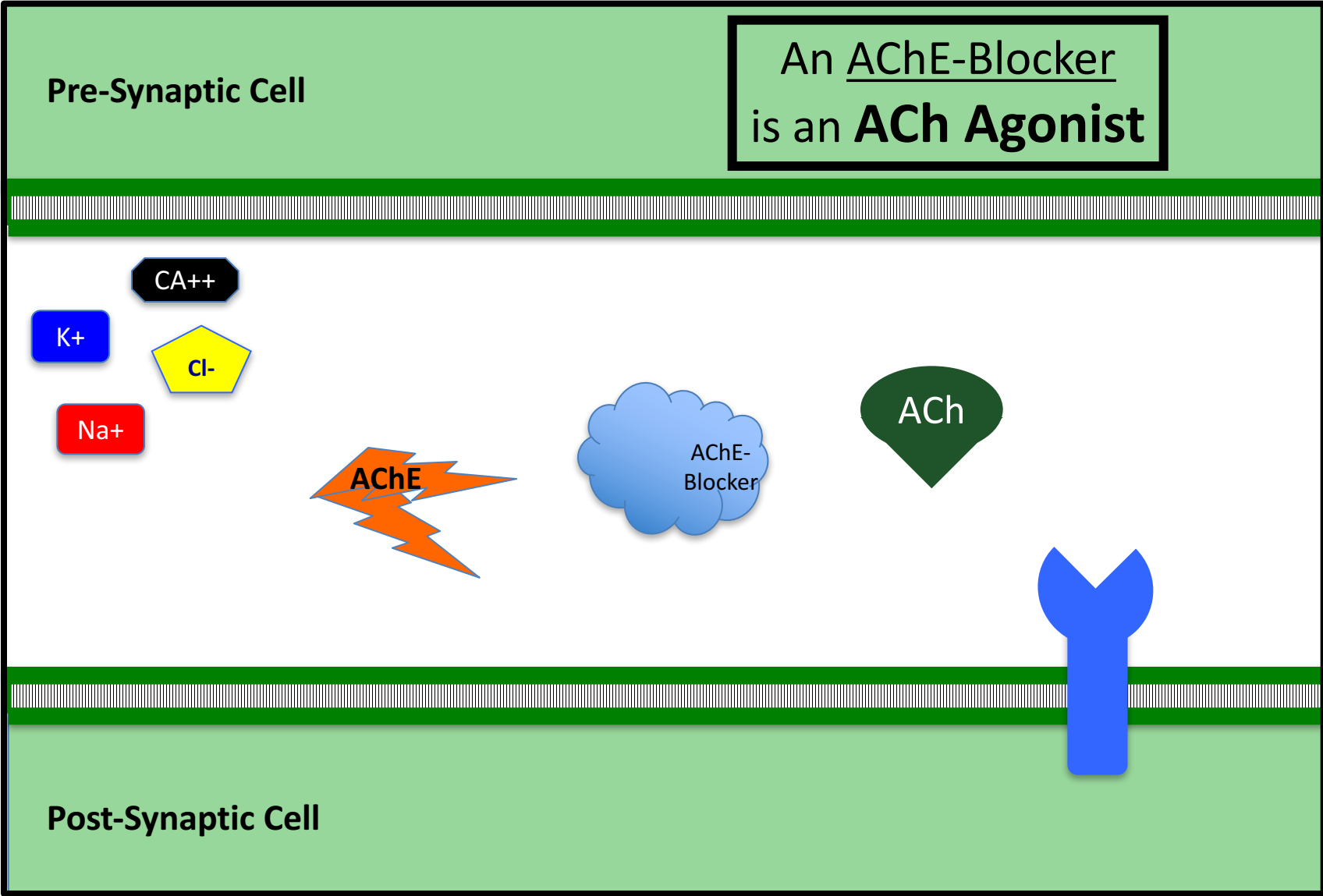


Acetylcholine (ACh) in the Cleft



Acetylcholine (ACh) in the Cleft

An AChE-Blocker
is an **ACh Agonist**



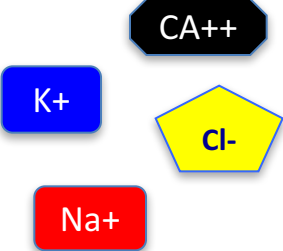
Pre-Synaptic Cell

Post-Synaptic Cell

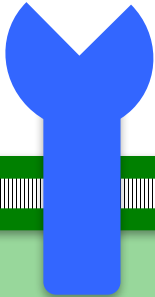
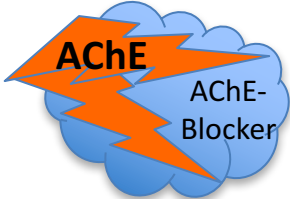
Acetylcholine (ACh) in the Cleft

An AChE-Blocker
is an **ACh Agonist**

Pre-Synaptic Cell



By preventing the break-down of ACh,
the AChE-Blocker frees ACh
to re-stimulate the Post-Synaptic cell

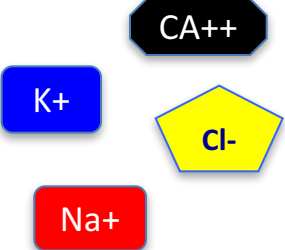


Post-Synaptic Cell

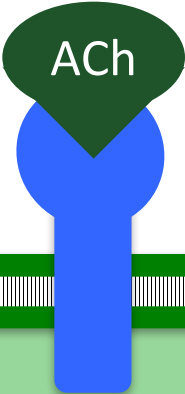
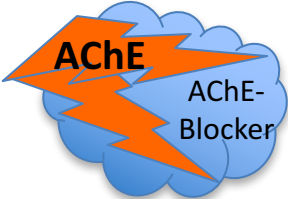
Acetylcholine (ACh) in the Cleft

An AChE-Blocker
is an **ACh Agonist**

Pre-Synaptic Cell

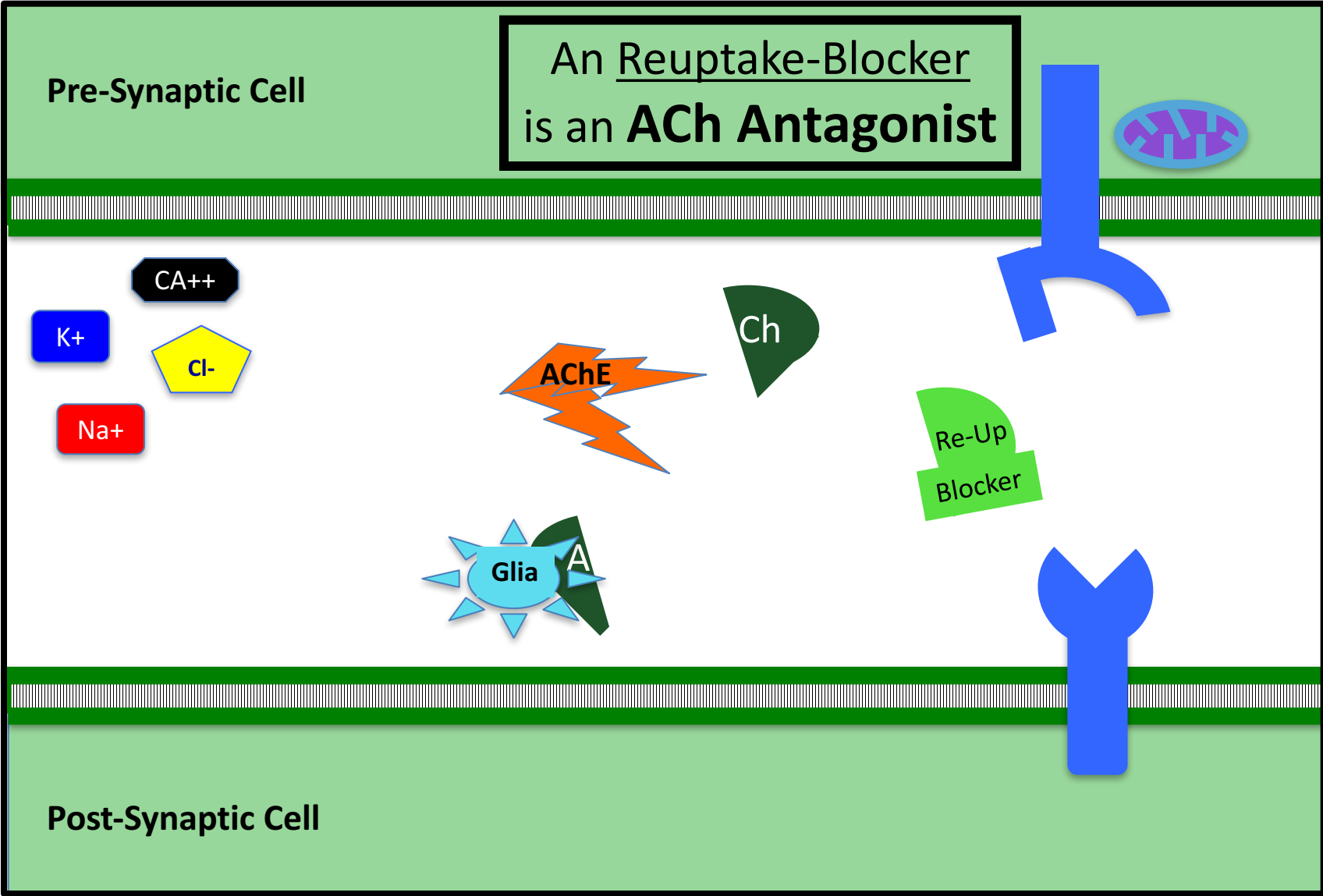


By preventing the break-down of ACh,
the AChE-Blocker frees ACh
to re-stimulate the Post-Synaptic cell

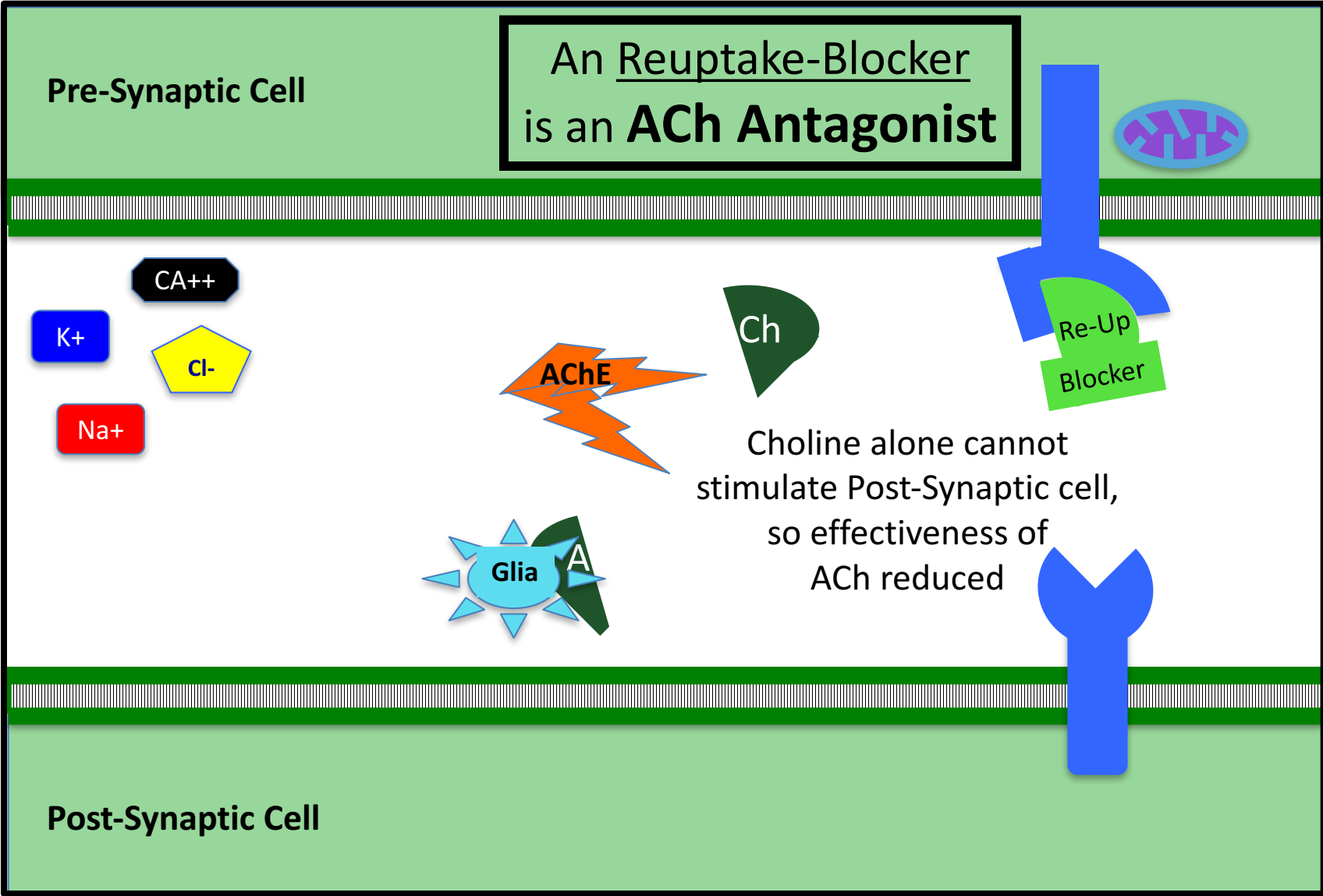


Post-Synaptic Cell

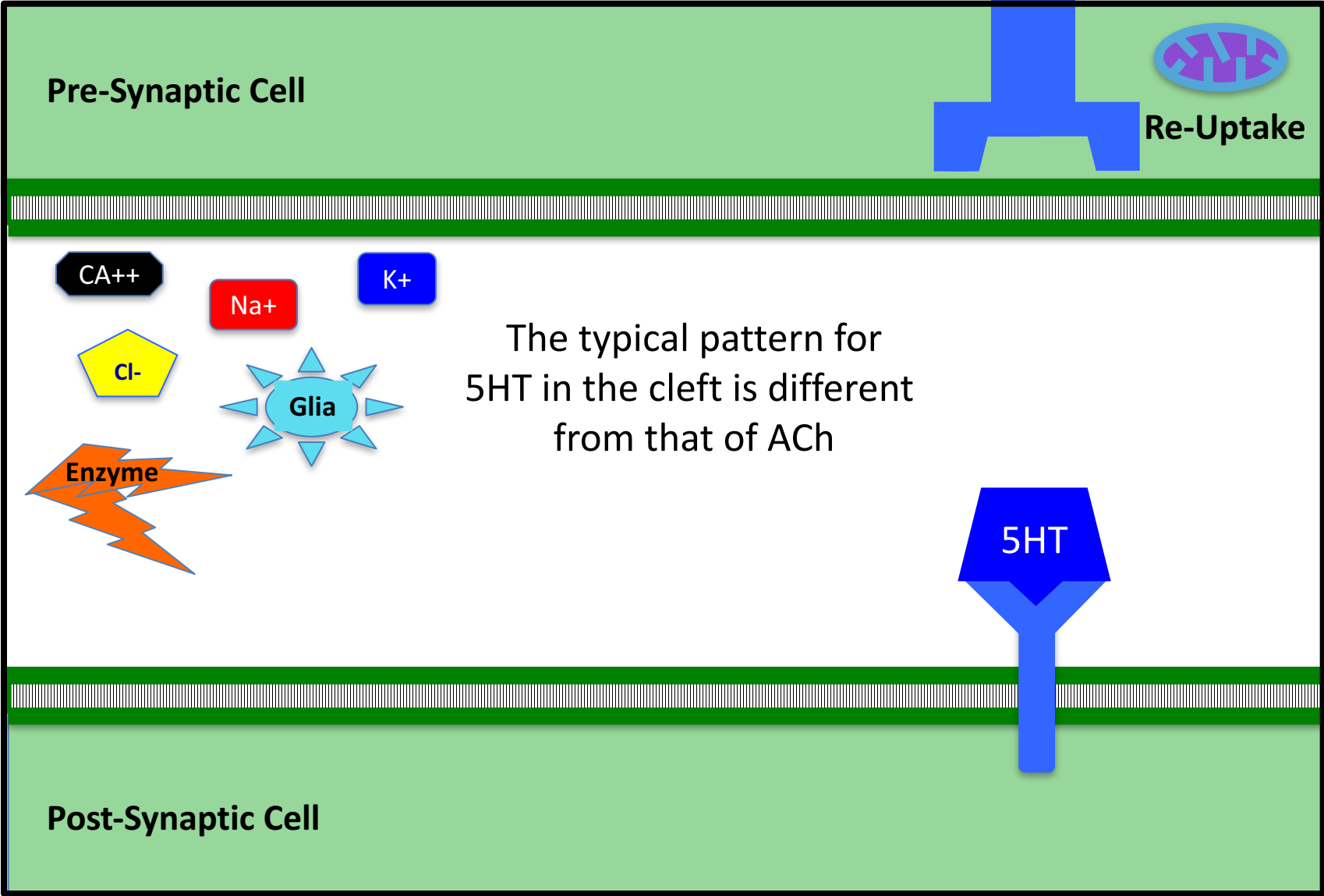
Acetylcholine (ACh) in the Cleft



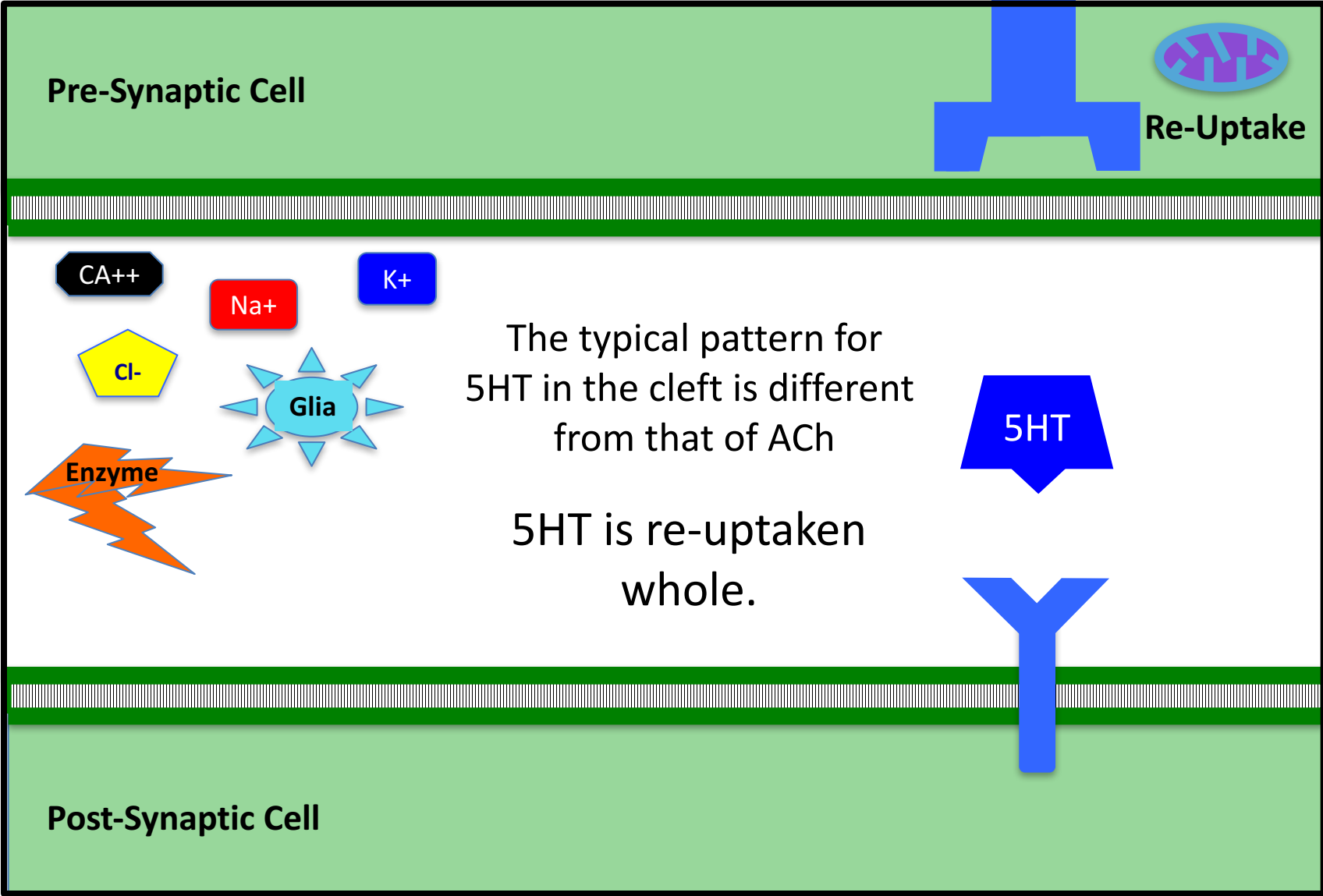
Acetylcholine (ACh) in the Cleft



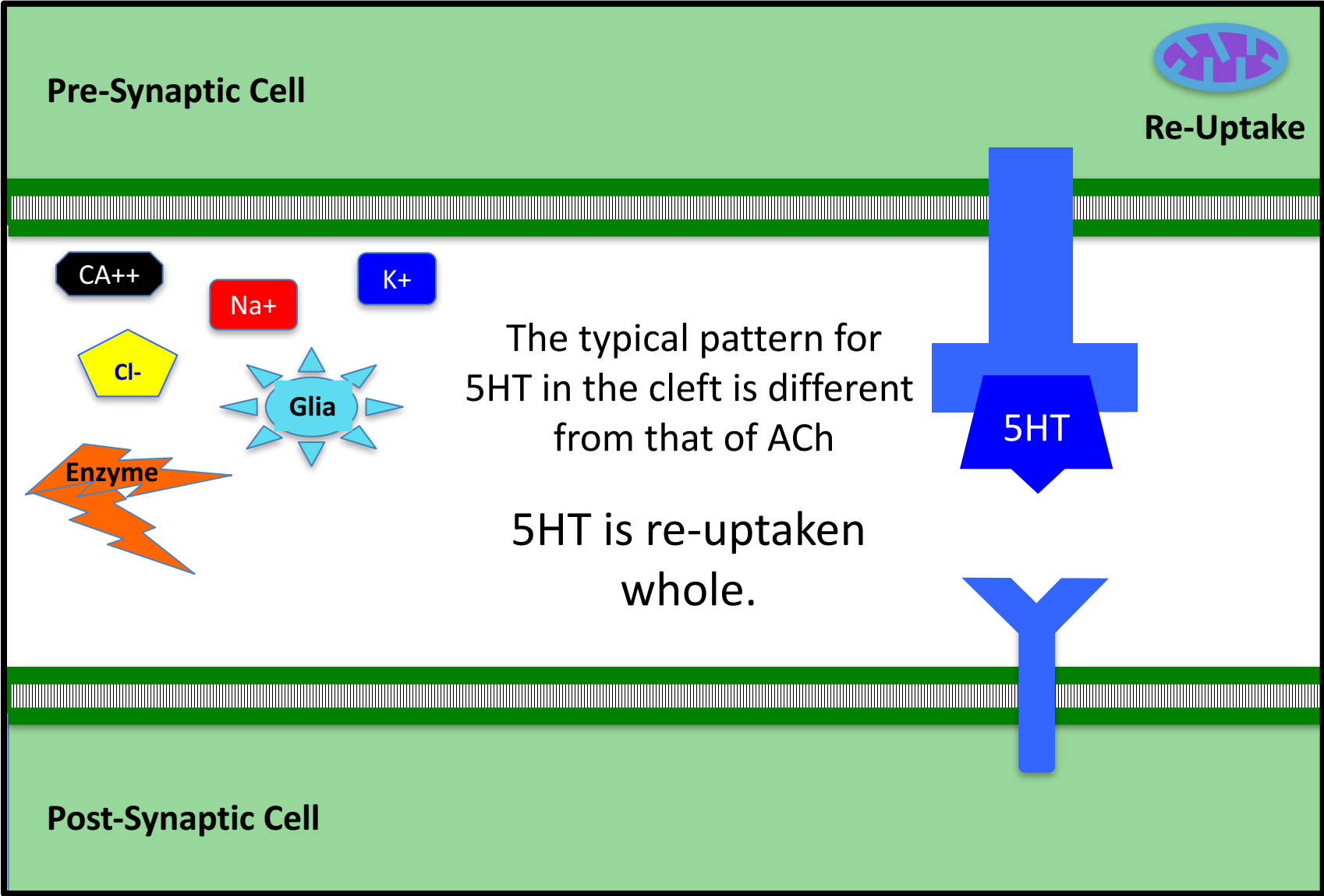
Serotonin (5HT) in the Cleft



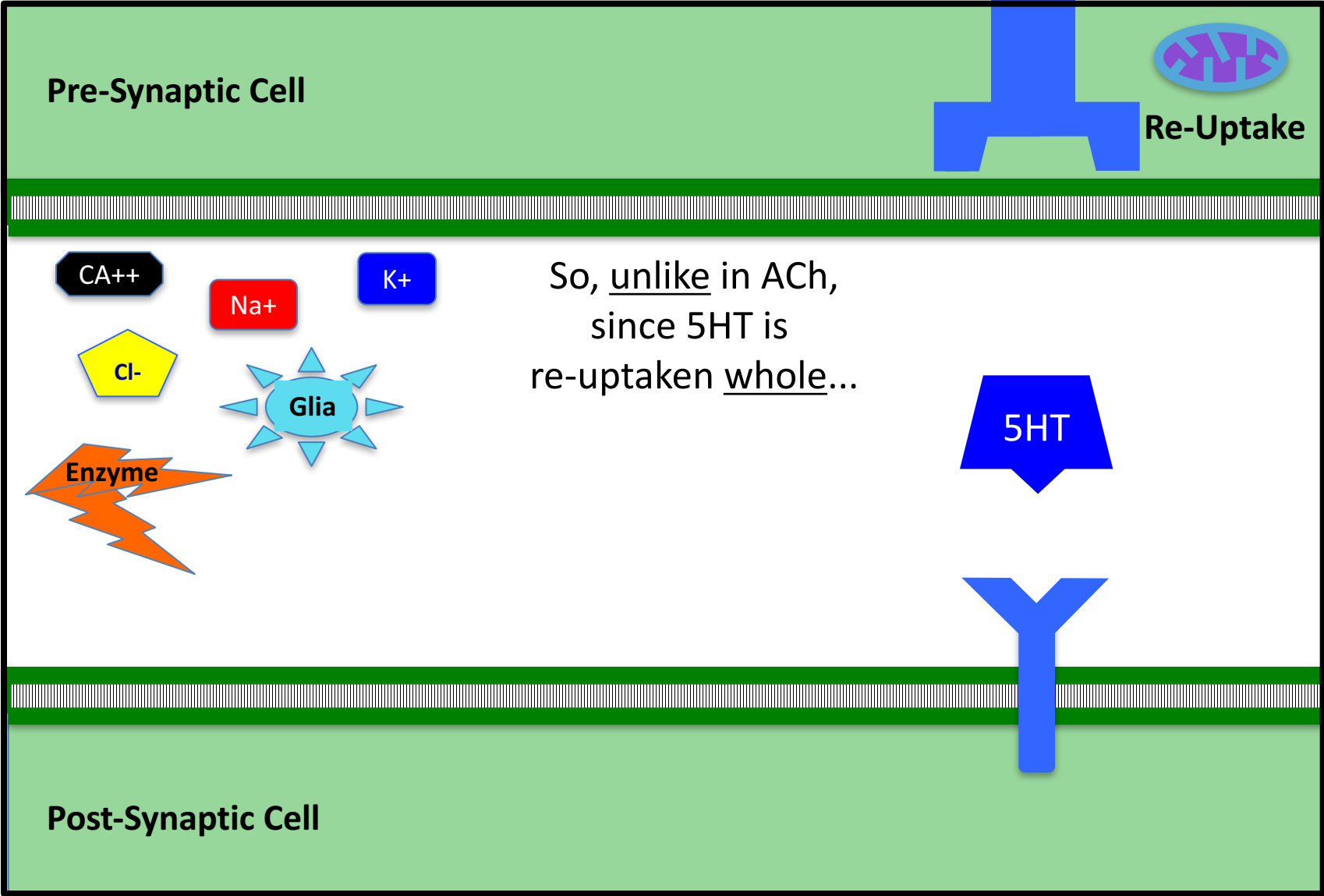
Serotonin (5HT) in the Cleft



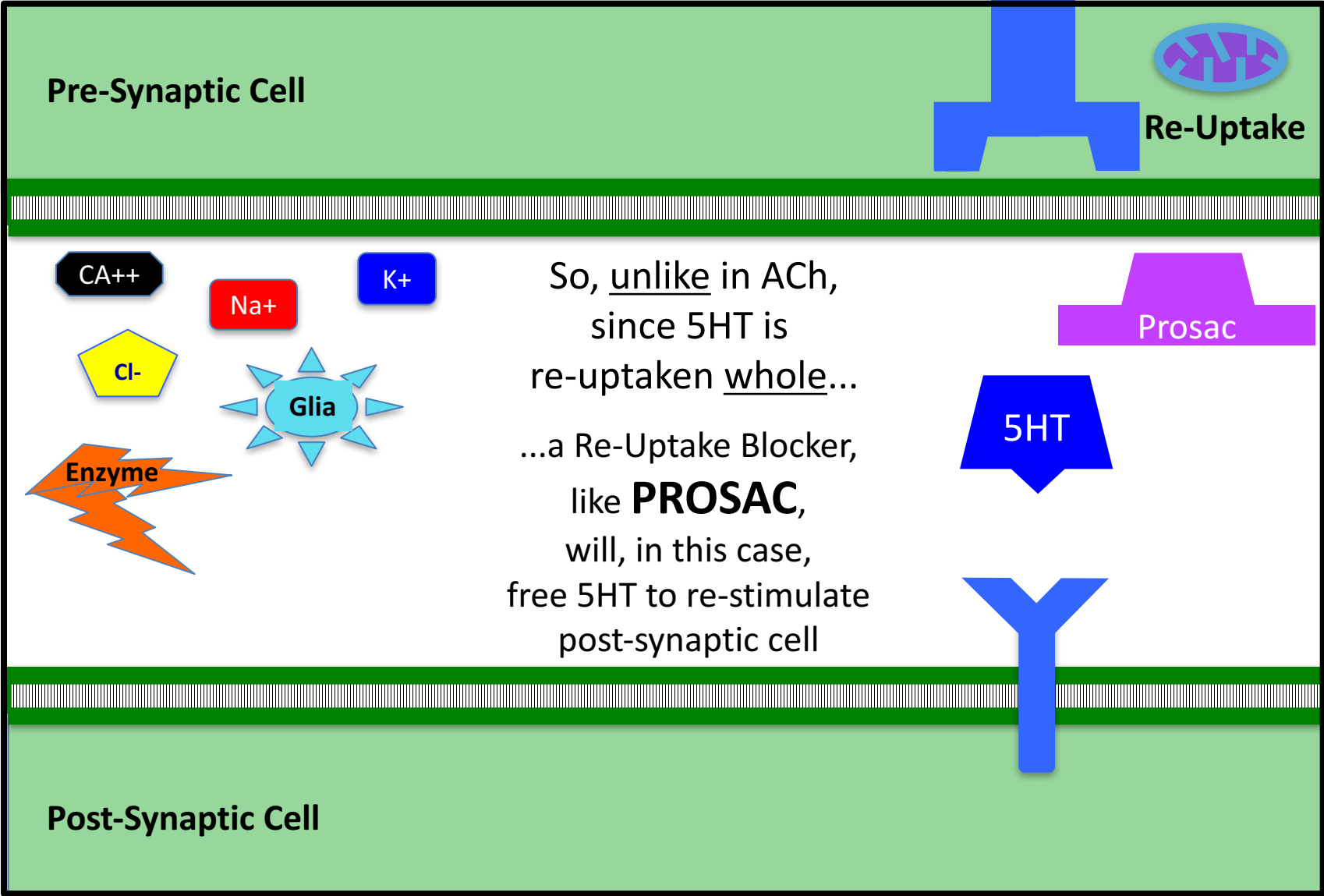
Serotonin (5HT) in the Cleft



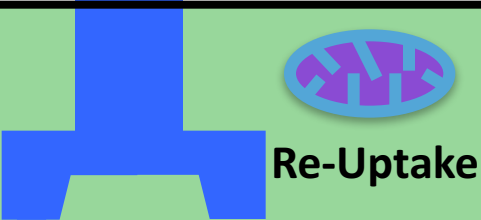
Serotonin (5HT) in the Cleft



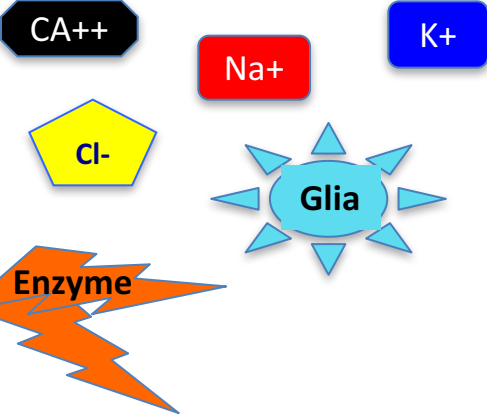
Serotonin (5HT) in the Cleft



Pre-Synaptic Cell



Re-Uptake



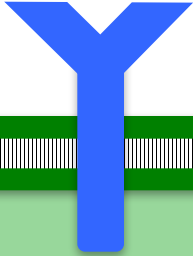
So, unlike in ACh, since 5HT is re-uptaken whole...
...a Re-Uptake Blocker, like **PROSAC**, will, in this case, free 5HT to re-stimulate post-synaptic cell



Prozac

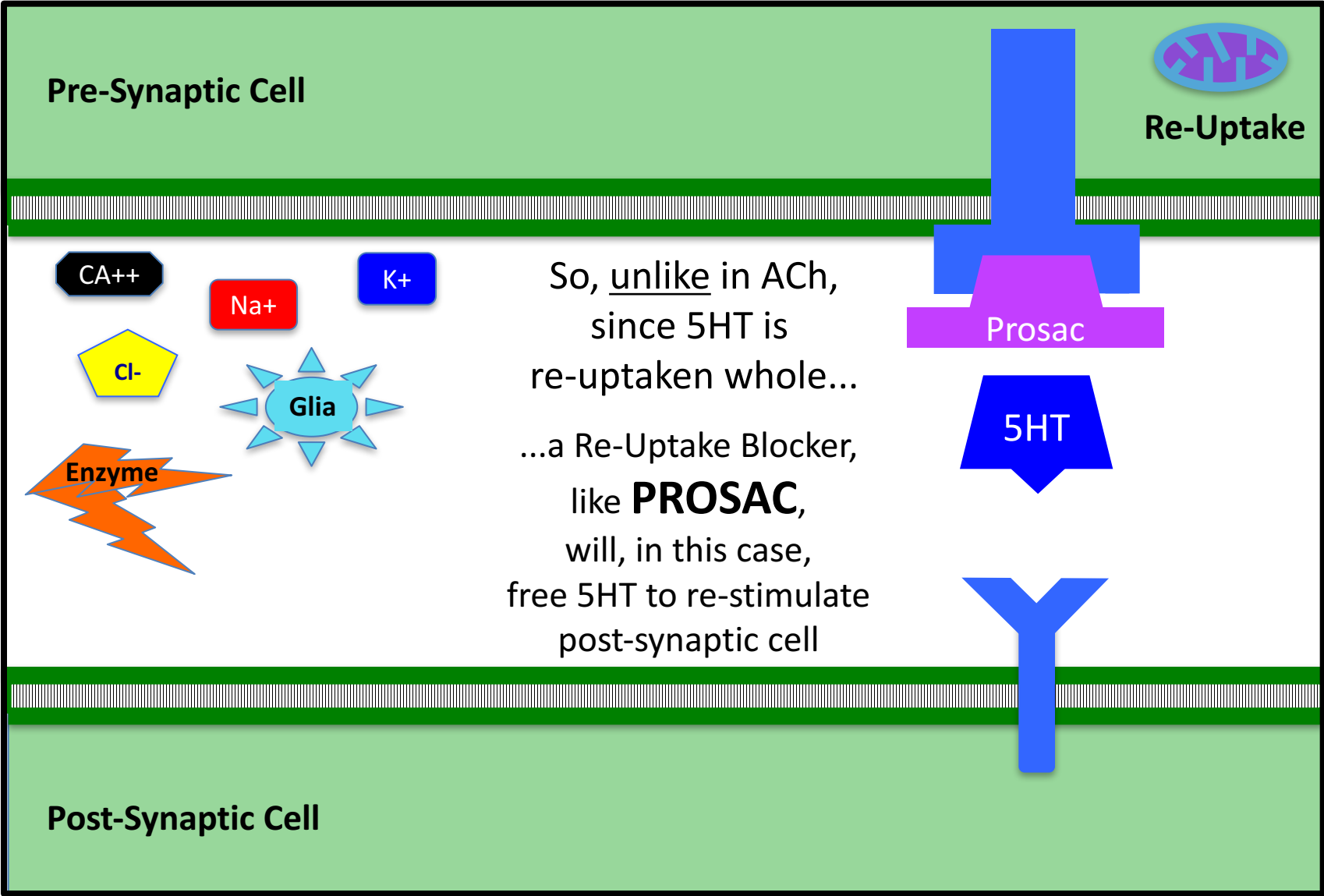


5HT

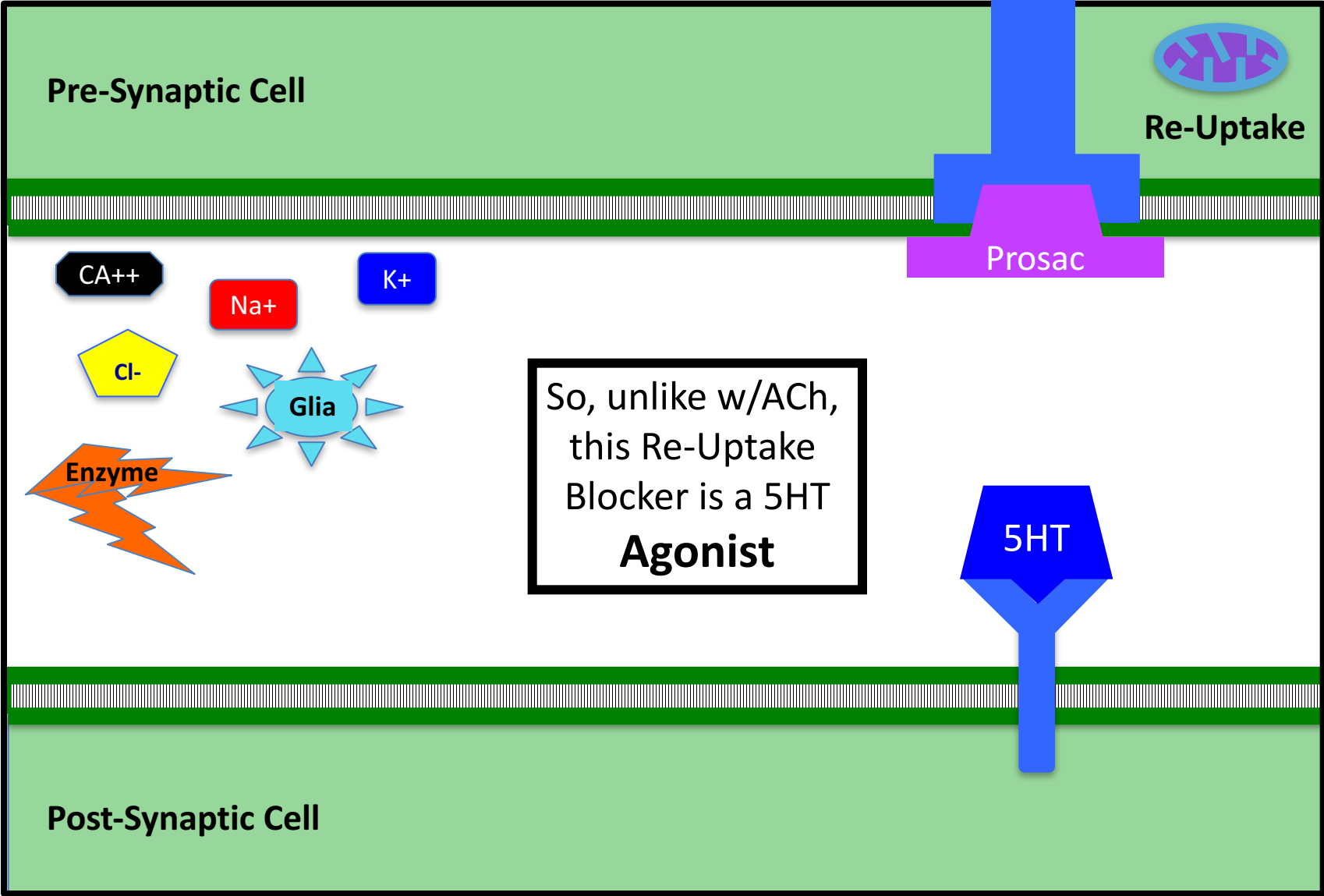


Post-Synaptic Cell

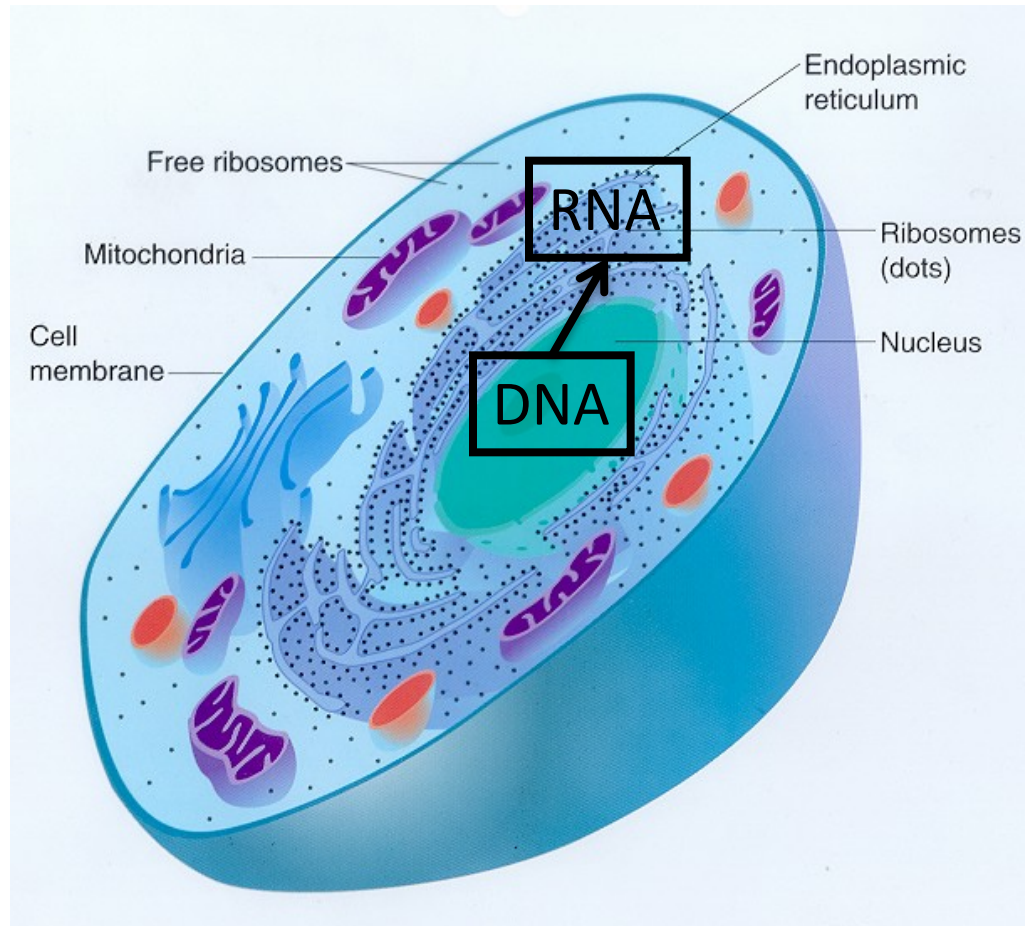
Serotonin (5HT) in the Cleft



Serotonin (5HT) in the Cleft



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

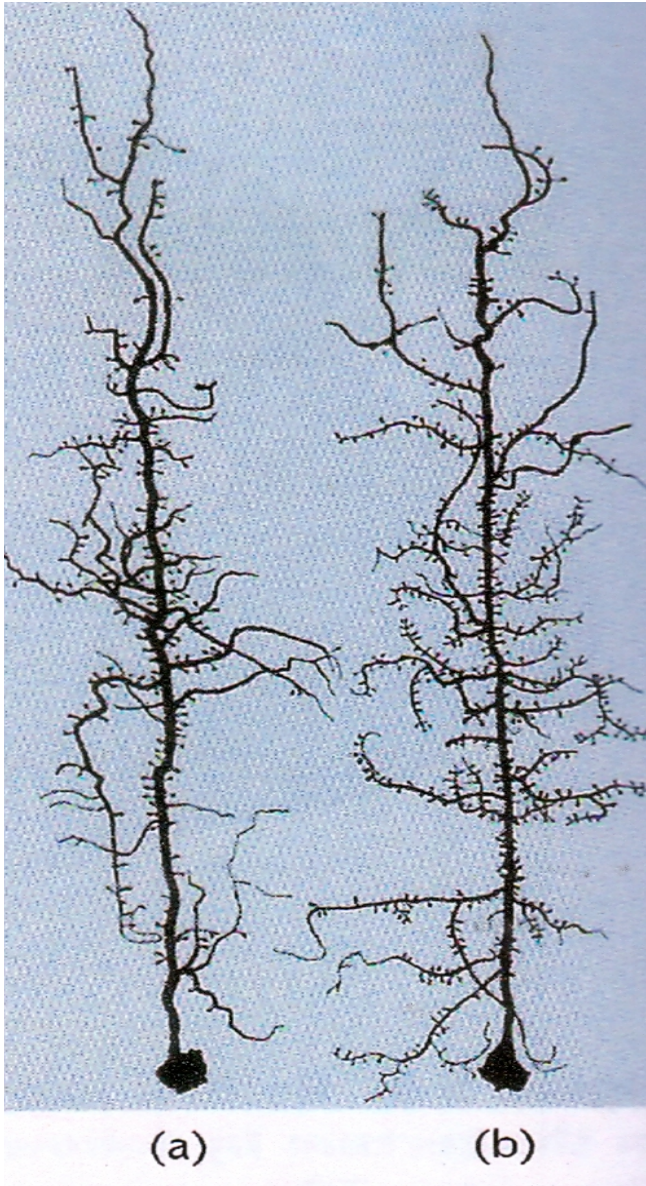


Figure 5.10 Effect of a stimulating environment on neuronal branching

(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



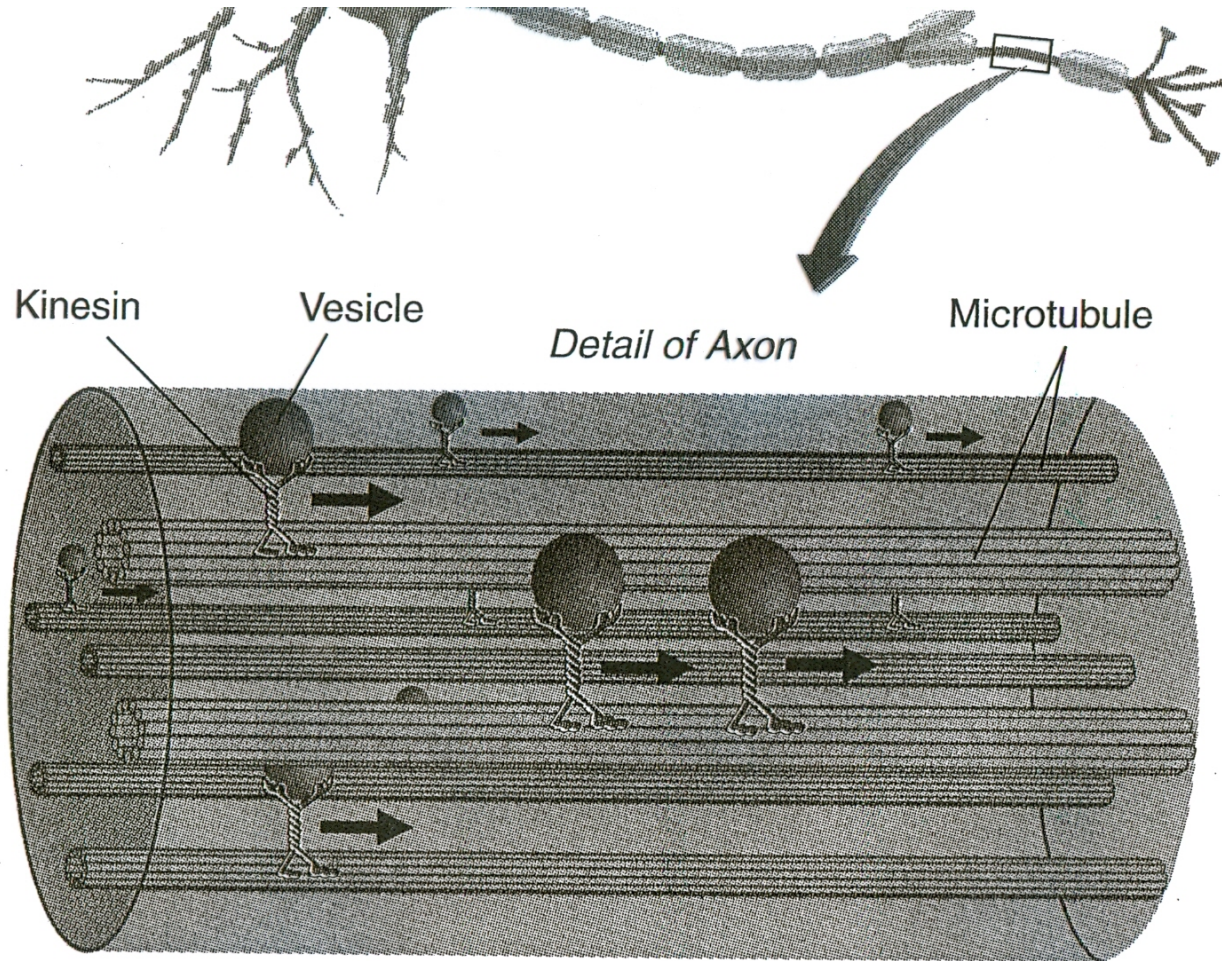
via administering DRUGS...

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

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

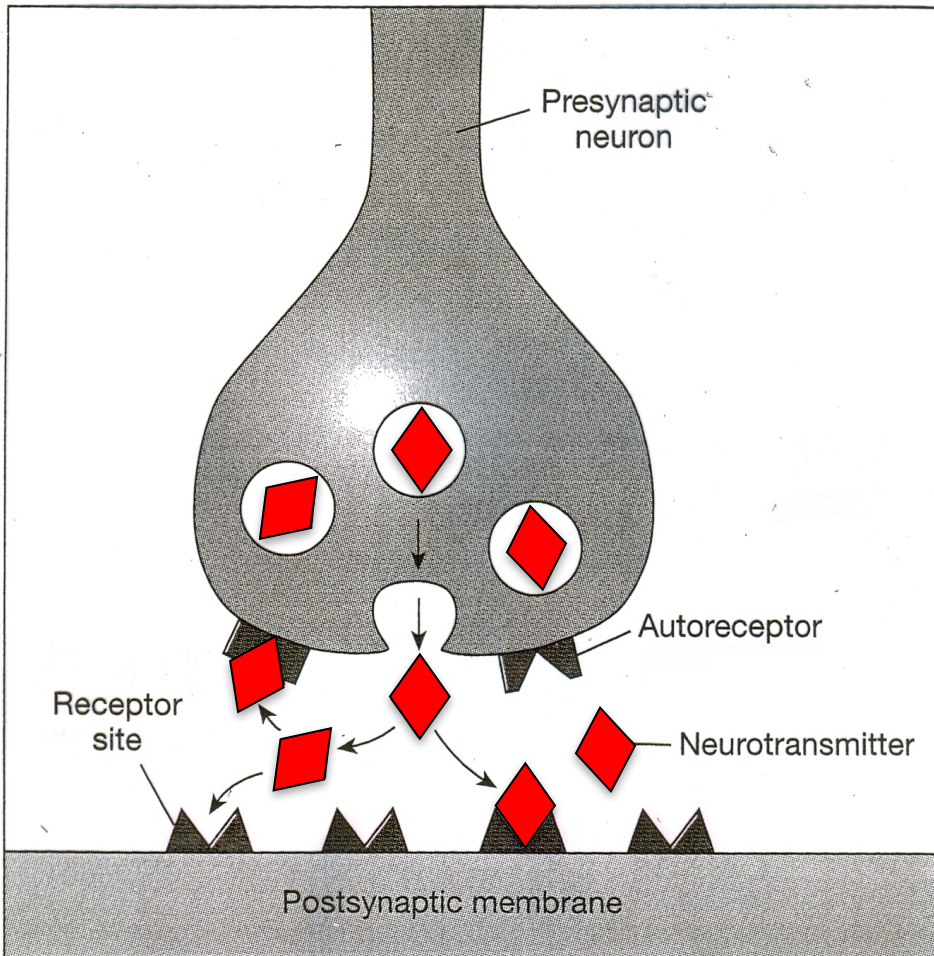
Kinesin Molecules

transporting NT to Terminal



EXCEPTIONS

Auto-Receptor



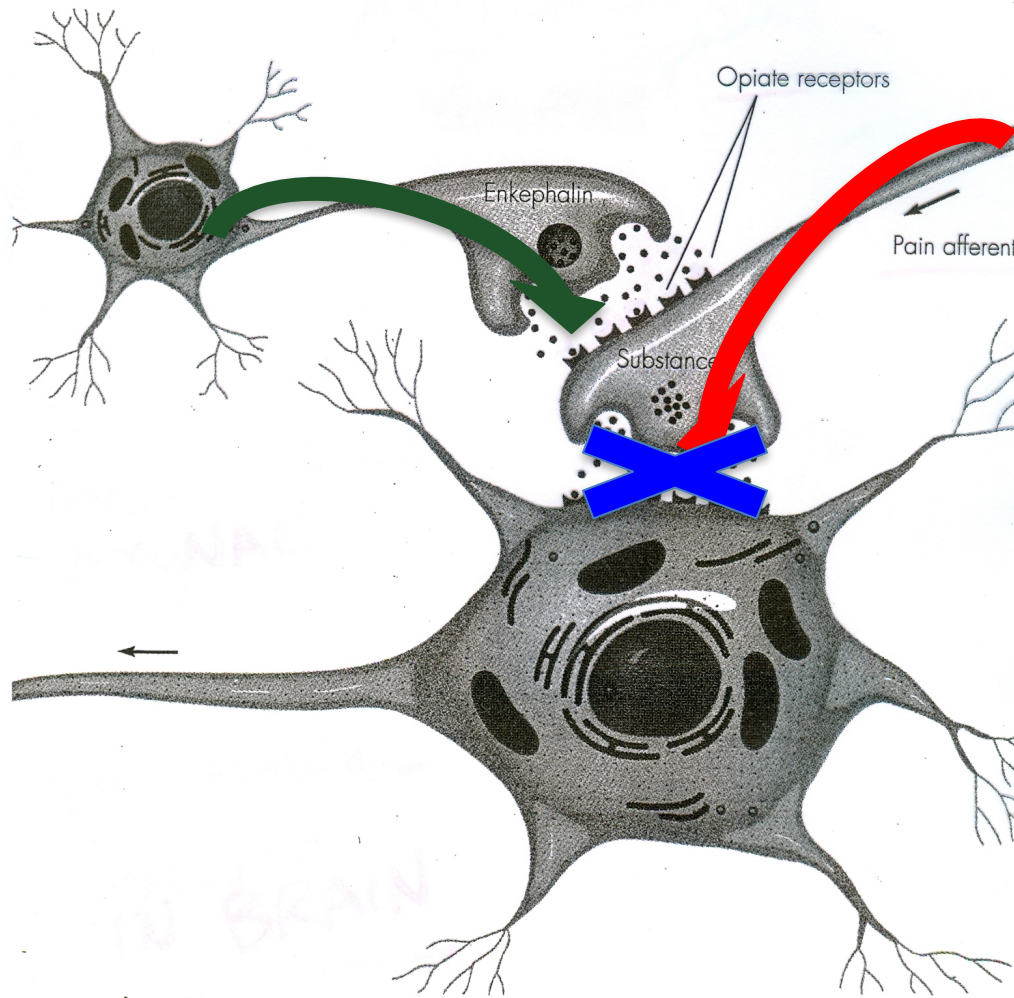
◆ Inhibitory
Neurotransmitter

In cells with
"Auto-Receptors"
the presynaptic cell
inhibits itself,
as well as the post-synaptic cell
(i.e. Limits how much NT
presym will release)

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

EXCEPTIONS

Axo-Axonal Synapses



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

Receptor sites
on Terminal of pain cell
responds to endorphins,
reducing release of
Substance P