Making Connections

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UCSD

① announcements:

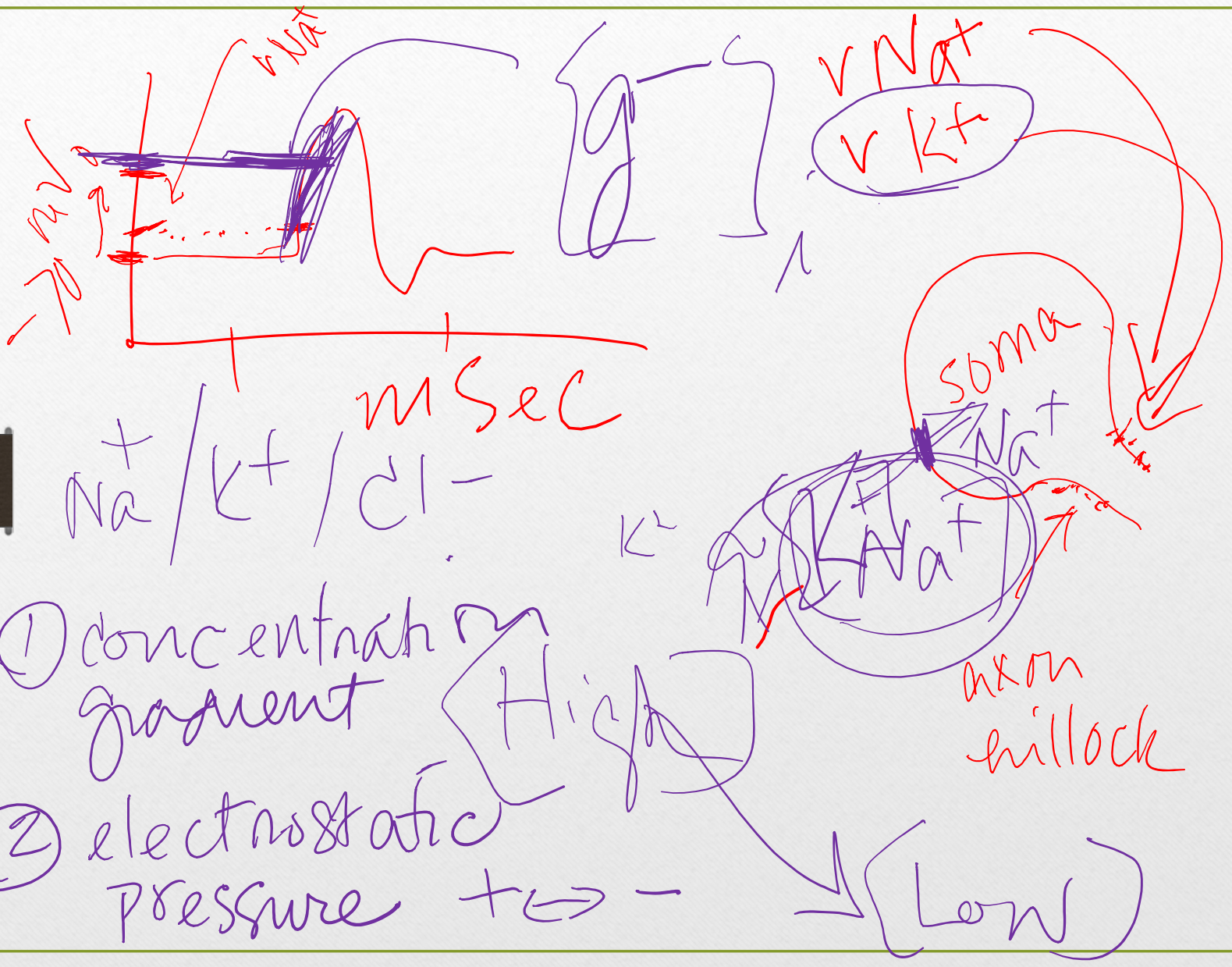
② Review

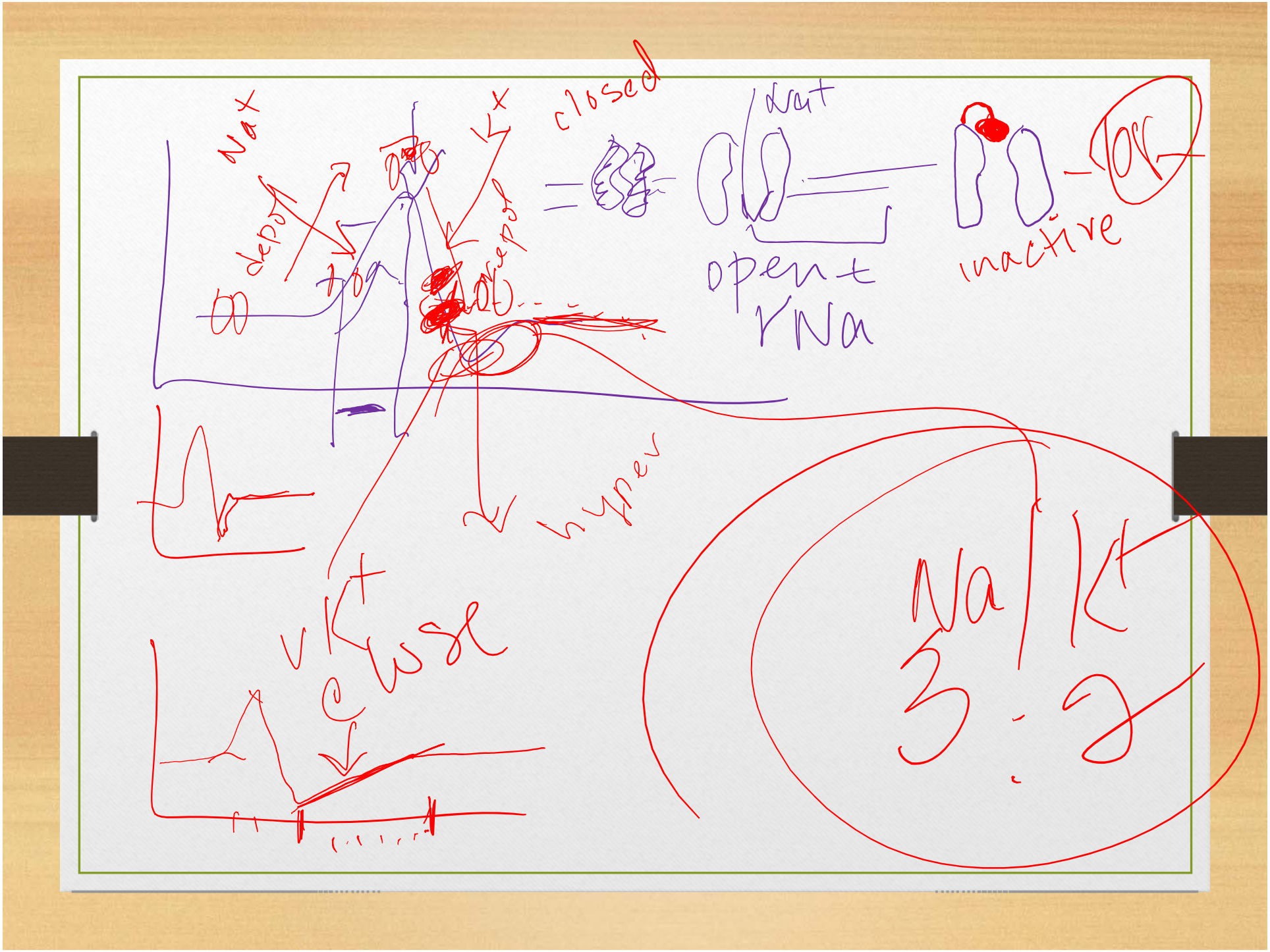
③ order reader

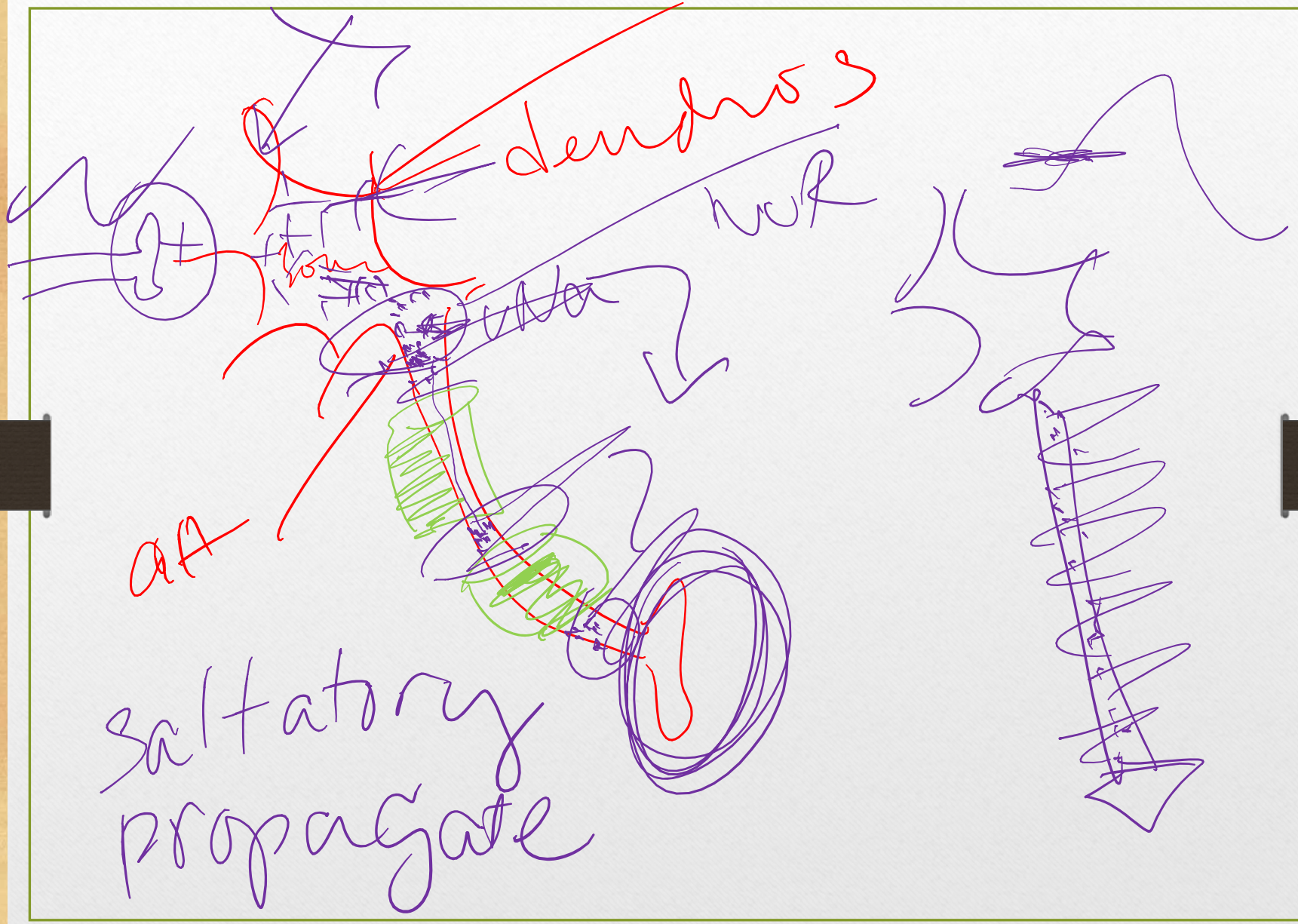
④ Quiz 4

⑤ EC quiz Thursday

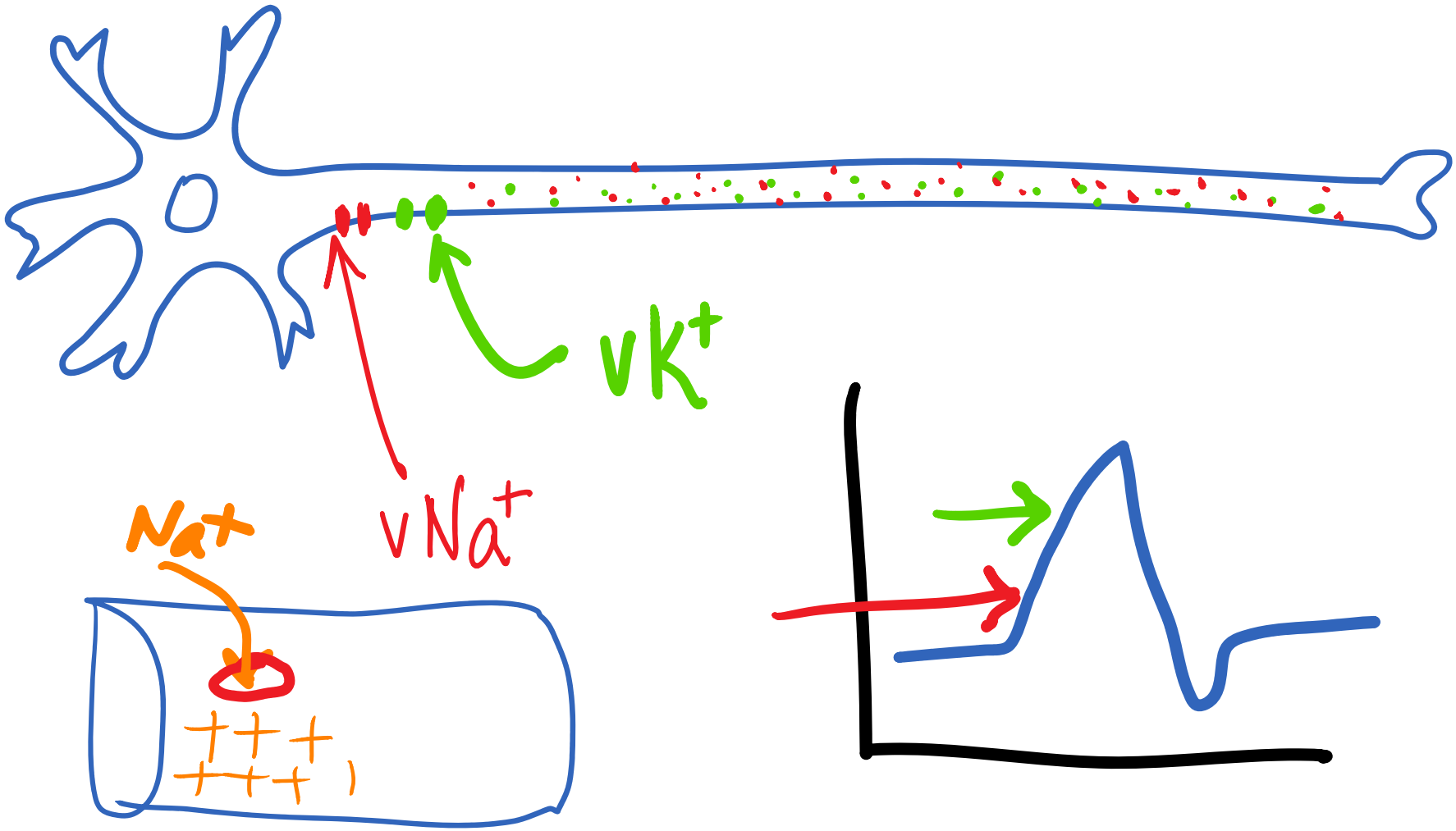
⑥ updated website etc.


vNa+
-70 mV
msec
Na+/K+/Cl-
vNa+
vK+
soma
Na+
Na+
K+
axon hillock
(1) concentration gradient
(2) electrostatic pressure + ↔ -
High
Low

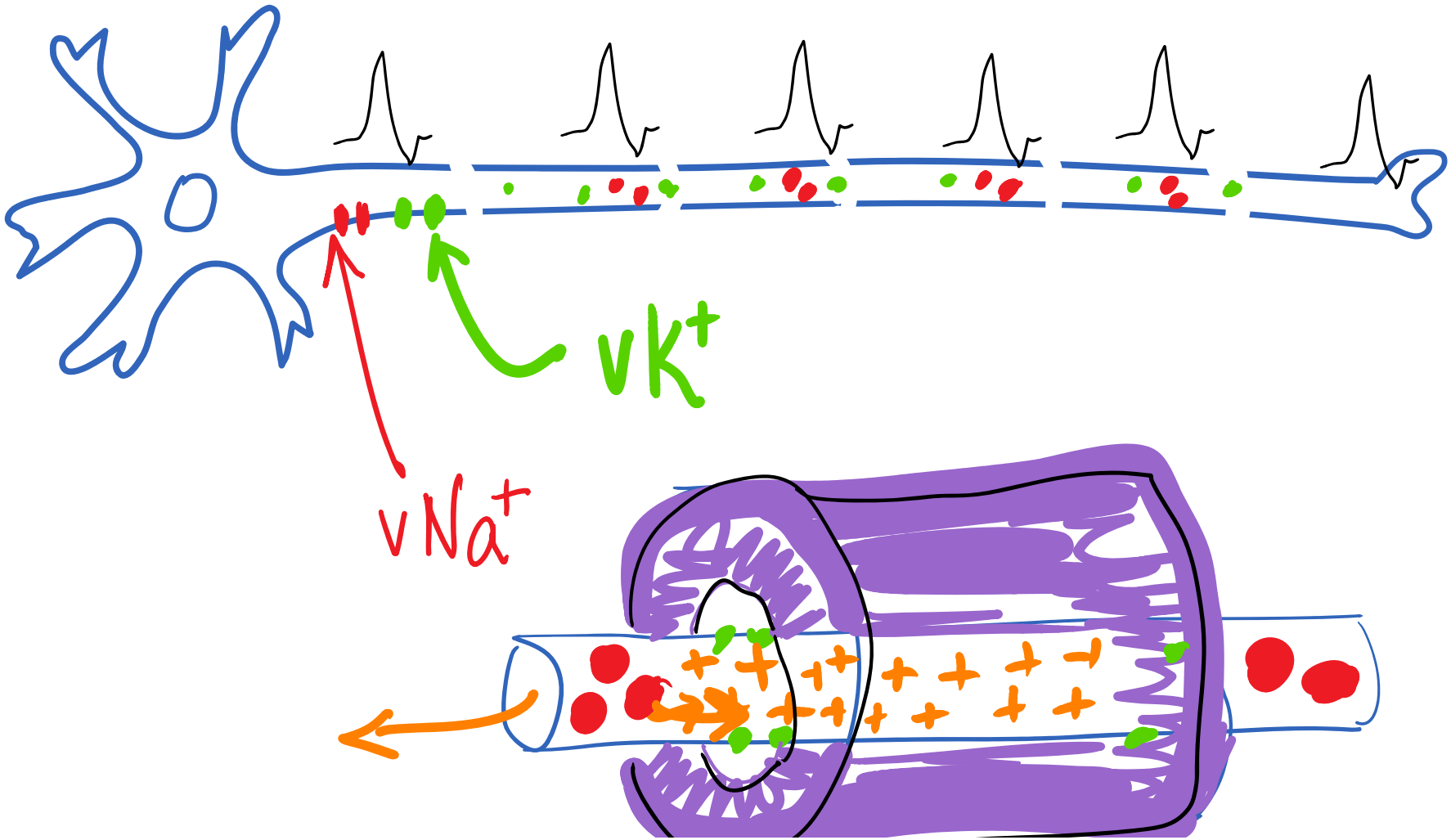

Nat
depol
Kt
repol
closed
Nat
open
INa
inactive
hyper
Kt
close
Na
K
3 : 2


dendrites
nucl
axon
saltatory
propagate

impulse propagation along the axon



impulse propagation myelinated axon



Test your understanding:

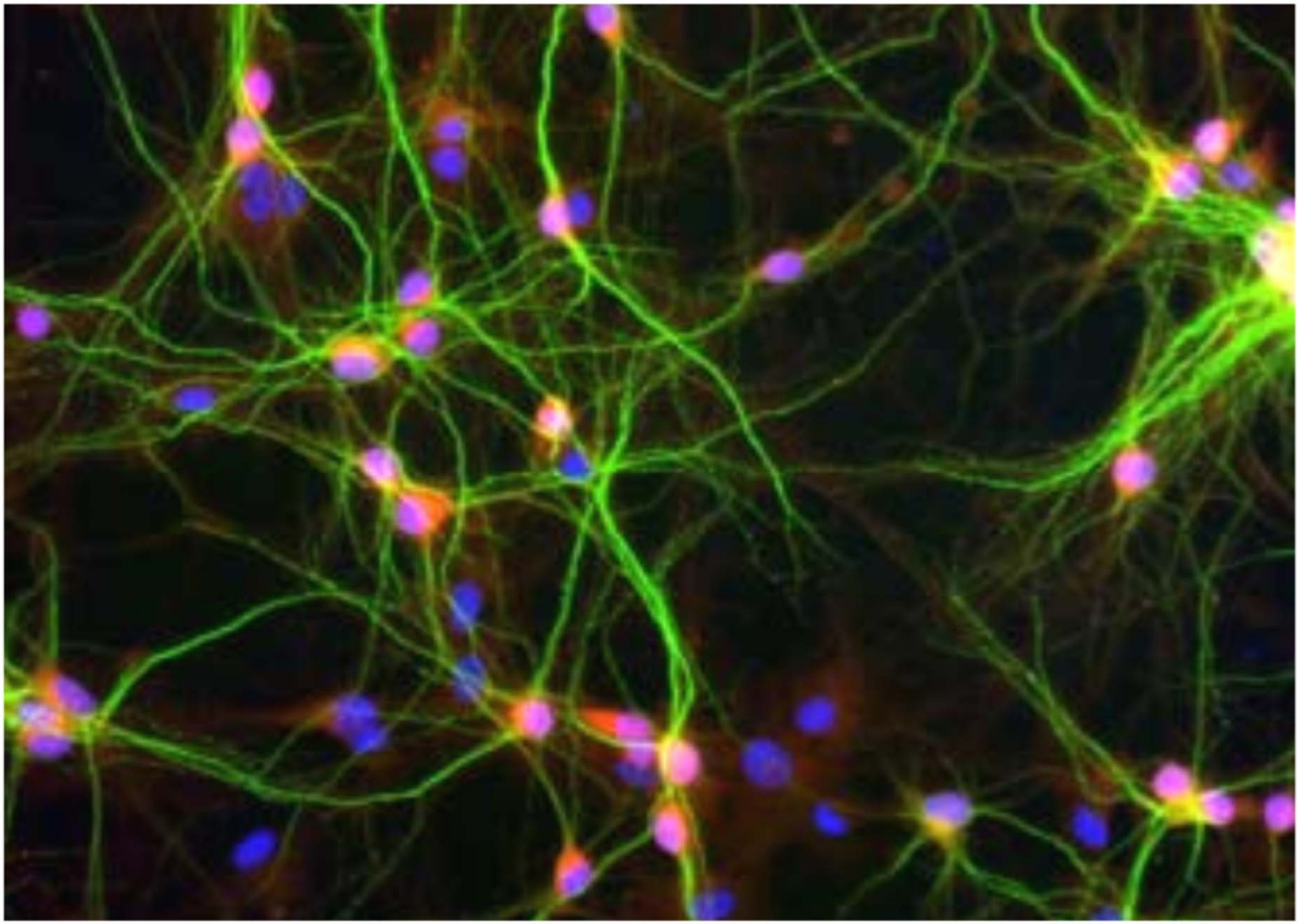
given the following equilibrium potentials:

EK^+ = -90mV

ENa^+ = +60mV

ECl^- = -70mV

Suppose that in a neuron E_{Cl^-} is -70 mV and the resting membrane potential is -75 mV. Given a typical distribution of the ion, then if chloride channels are opened in this neuron by the action of a transmitter substance, there will be:



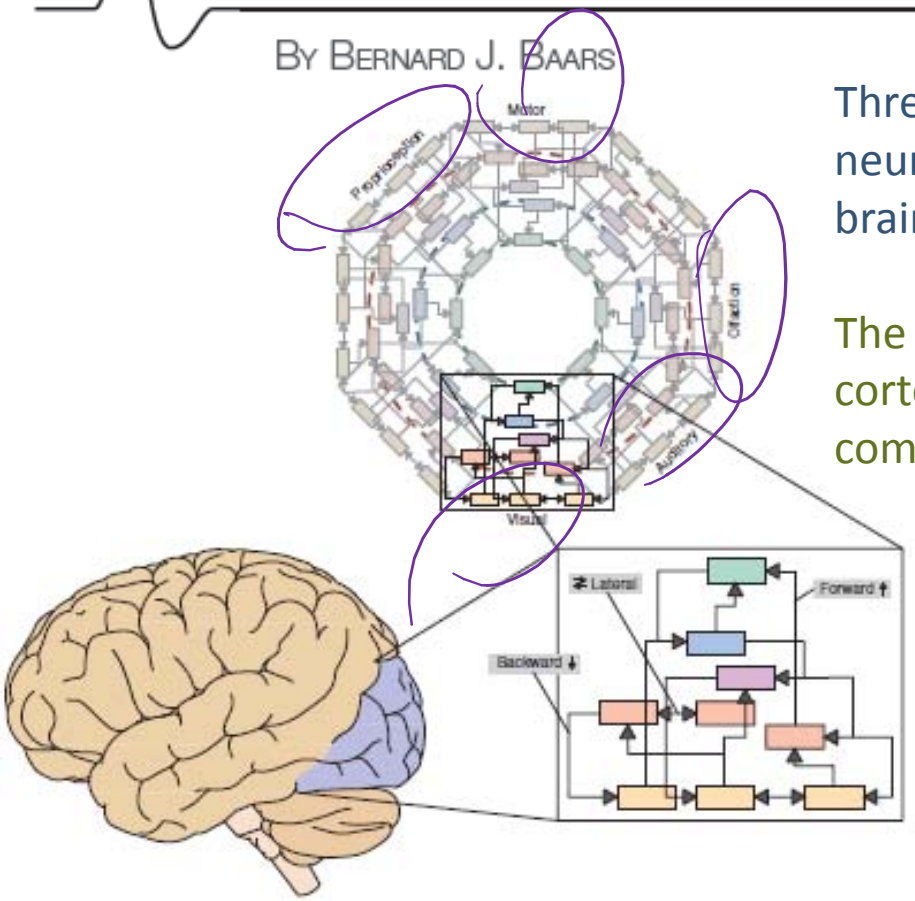
What do we really know?
Who is in control?

Brain

Mind

Neurons and Their Connections

By Bernard J. Baars



Three levels of description – neurons, networks and the brain.

The overall architecture of the cortex is to go from simple to complex representations.

MINDS AND BRAINS

Introductory Readings

Figure adapted Boyle, Mary ET (Ed.) (2012) Minds and Brains: Introductory Readings

Neurons

- Differ in size, shape, and function.
- Specialized for electrical communication.
- Some neurons excite while others inhibit.

Glial Cells

- Means "glue" in Greek
- Facilitate & participate in communication
- Care and feed neurons
- Clean up debris

Circuit

- Sets of neurons that affect one another.
- Withdrawal reflex – an example of a simple neural circuit.

sensory neurons

- Detect changes in the external environment and send information about these changes to the central nervous system.

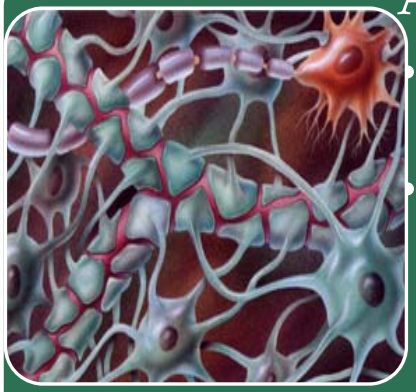
motor neurons

- These neurons, located within the central nervous system, control the contraction of a muscle or the secretion of a gland.

interneurons

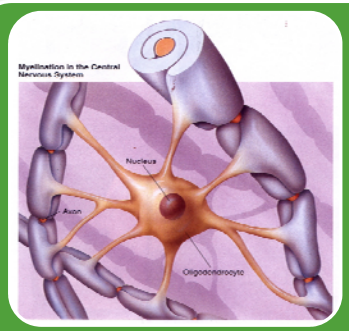
- Are between neurons that register what's out there and those that control movement (or between other interneurons)
- Most of the neurons in the brain are of this type.

Astrocytes/Astroglia



- Astrocyte "star cell" – provide physical support to neurons and clean up debris.
- Some of the astrocyte's processes are wrapped around blood vessels; other processes are wrapped around parts of neurons.

Oligodendrocytes ("white matter")

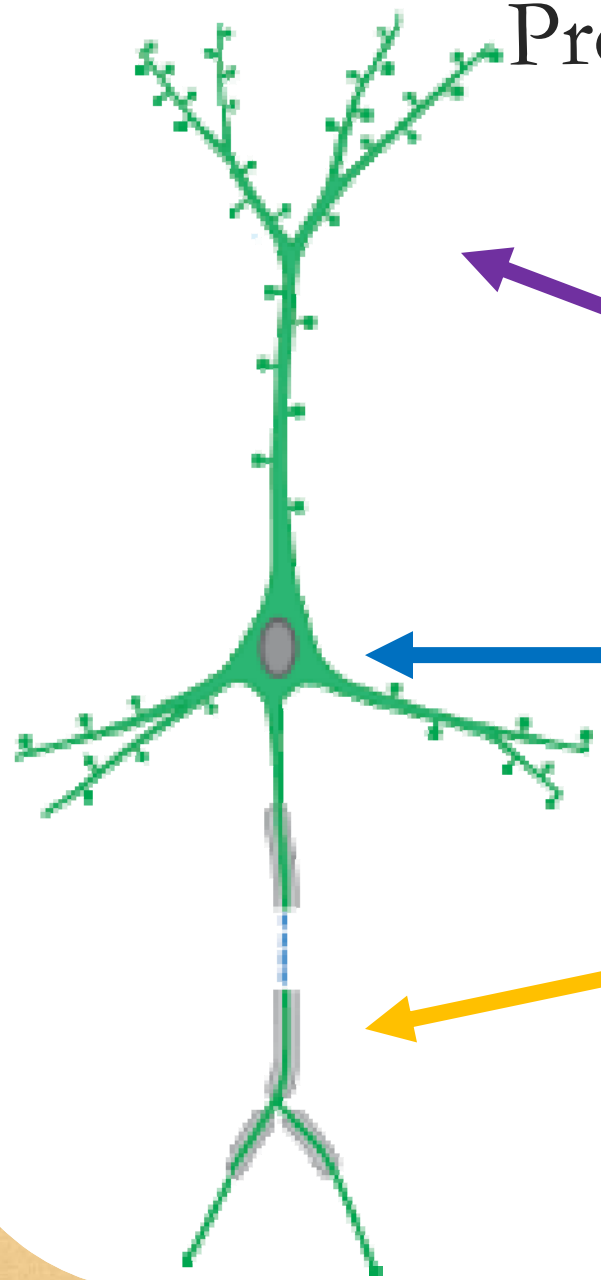


- Provide support to axons and to produce the myelin sheath which electrically insulates the axons.
- Found only in the central nervous system (CNS)

Schwann Cells

- Performs the same function as oligodendrocytes in the peripheral nervous system (PNS).
- Each myelin segment is a single Schwann cell.

Prototypical Neuron



Dendrites with spines

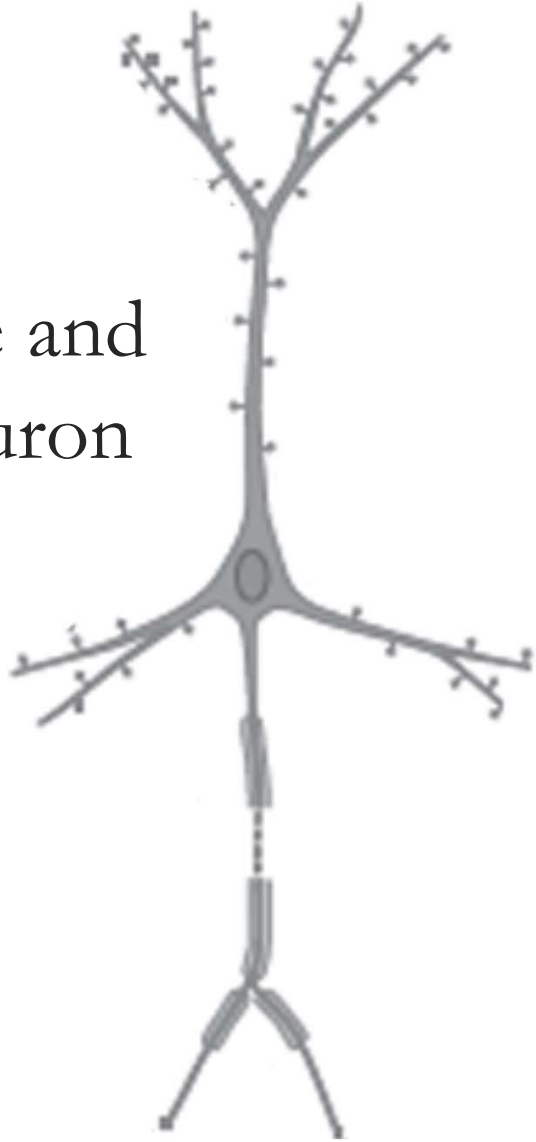
Cell body (soma)

Axon with myelin

Integrate and Fire Neuron

Figure adapted Boyle, Mary ET (Ed.) (2012) Minds and Brains: Introductory Readings

Integrate and Fire Neuron

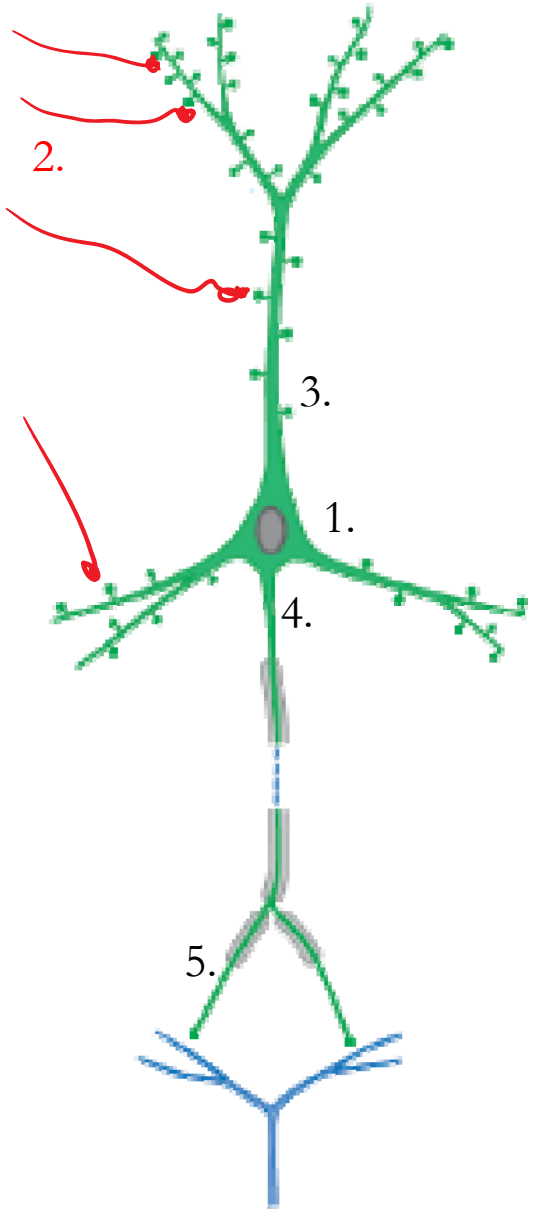


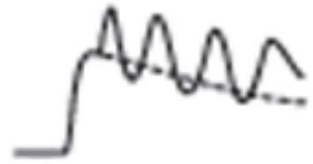
Receive synaptic input & evoke graded potentials

Integration of all the inputs are added together over a short period of time.

Encoding occurs when the input is above a threshold and triggers a spike down the axon.

Figure adapted Boyle, Mary ET (Ed.) (2012) Minds and Brains: Introductory Readings





2. reception

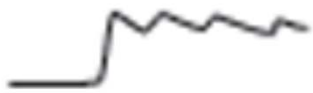
Dendrites receive synaptic input that evoke graded membrane potentials (2).

3. integration

1. intrinsic

When dendritic potentials rise above threshold in a very brief interval (3) and are added to the intrinsic membrane potentials (1) an action potential can be triggered (4) down the axon.

4. encoding



5. output

Spikes cause the release of neurochemicals at the axon terminals (5).

Figure adapted Boyle, Mary ET (Ed.) (2012) Minds and Brains: Introductory Readings

Types of synapses:

- axosomatic
- axodendritic
- axoaxonic

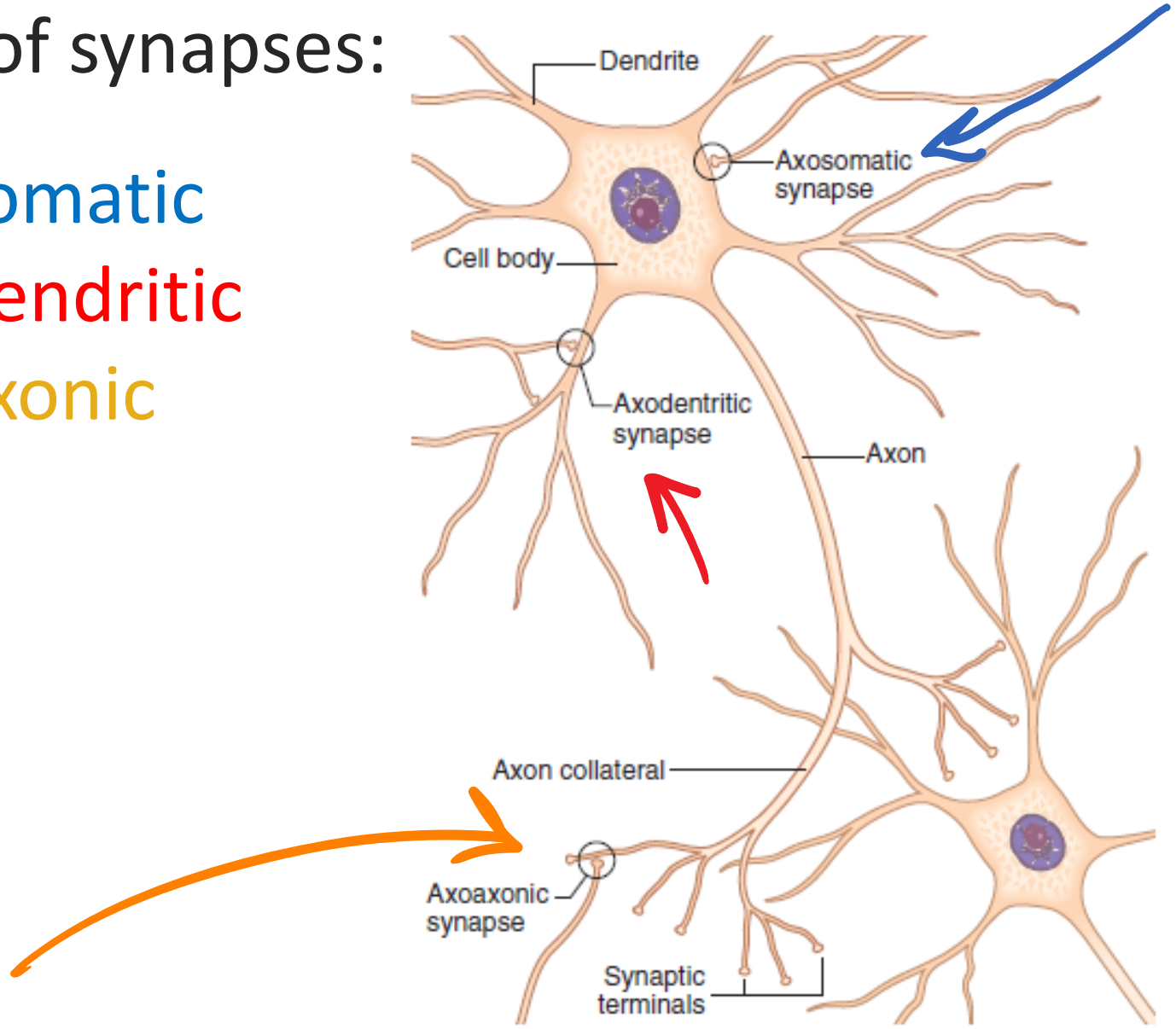
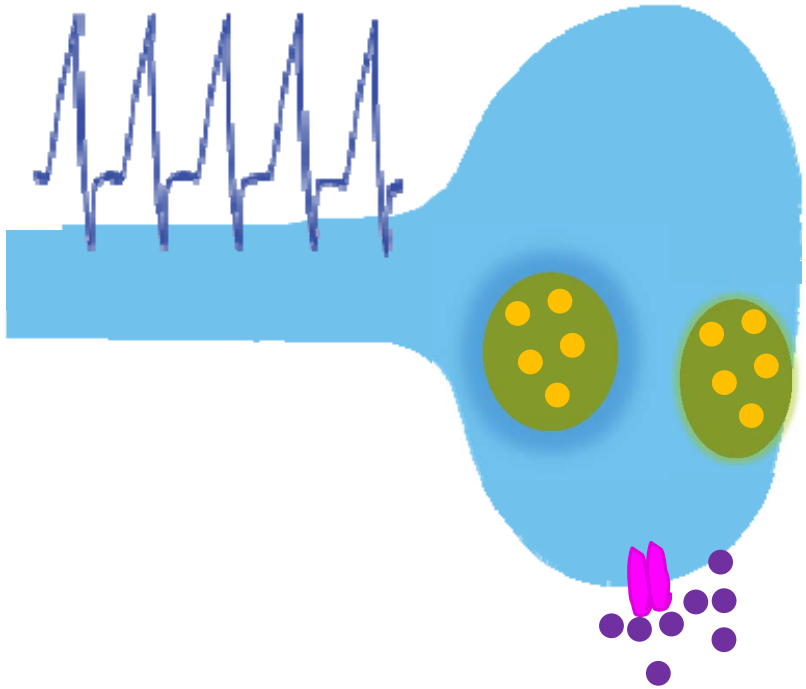


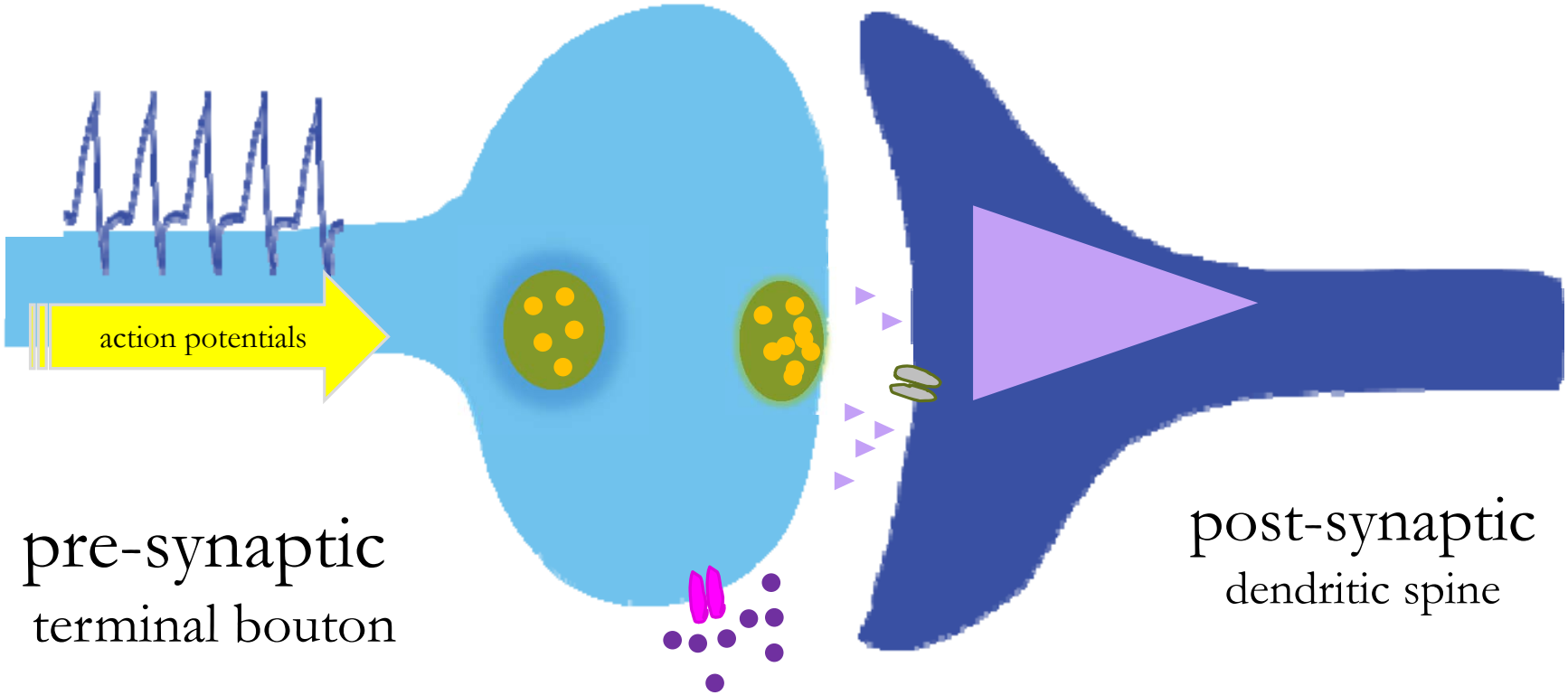
Figure from Boyle, Mary ET (Ed.) (2012) Minds and Brains: Introductory Readings

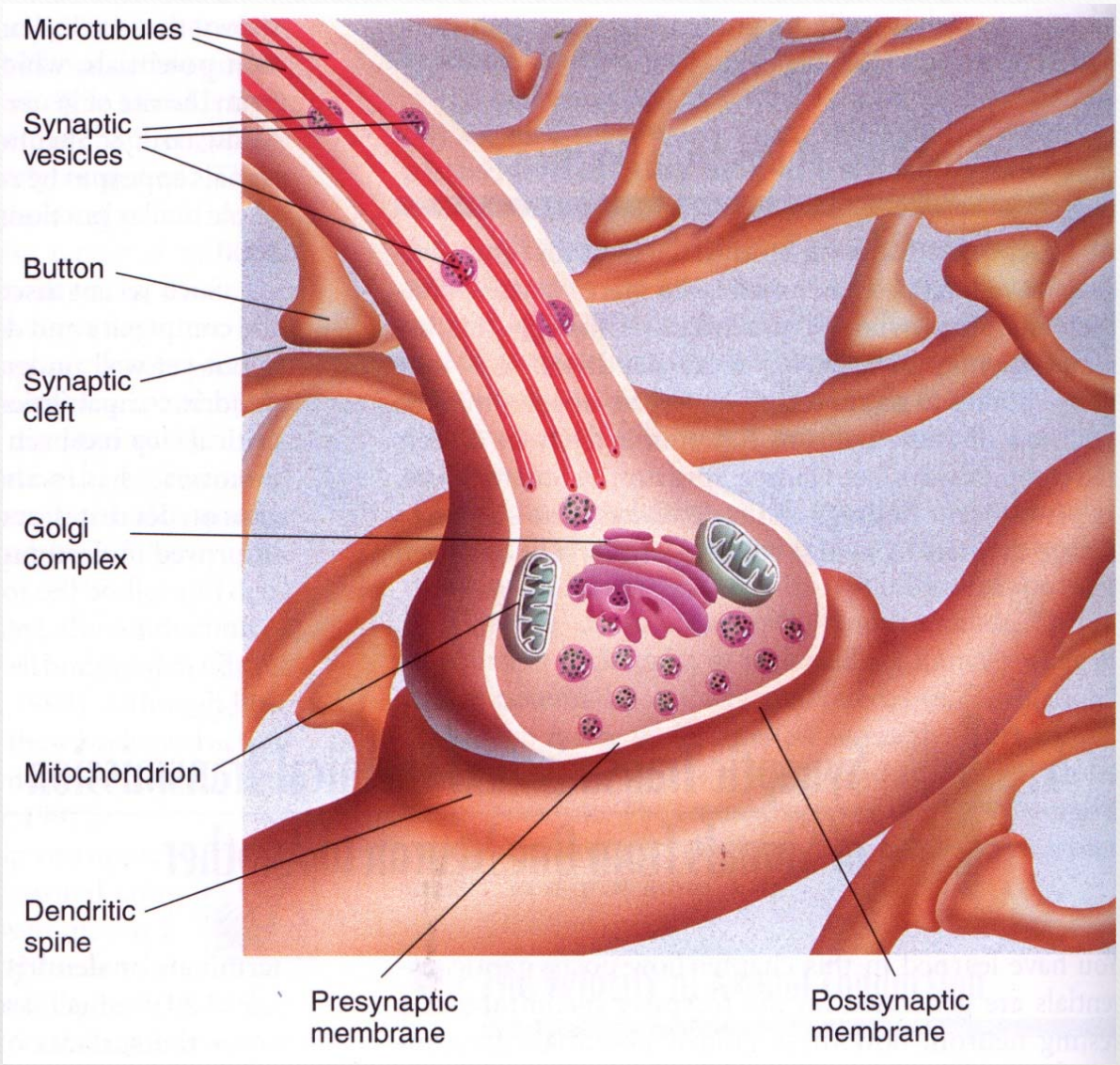


pre-synaptic

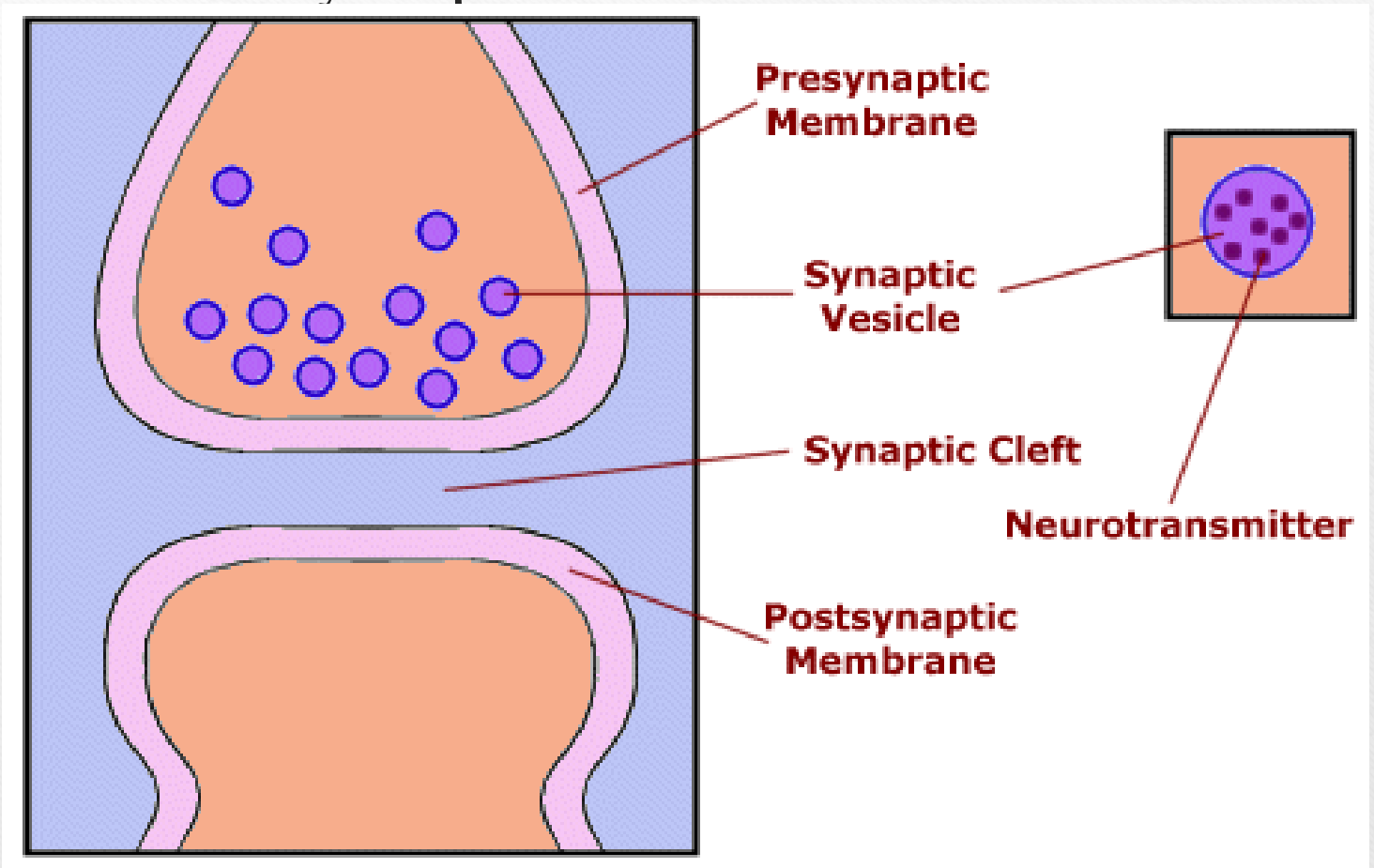
terminal bouton

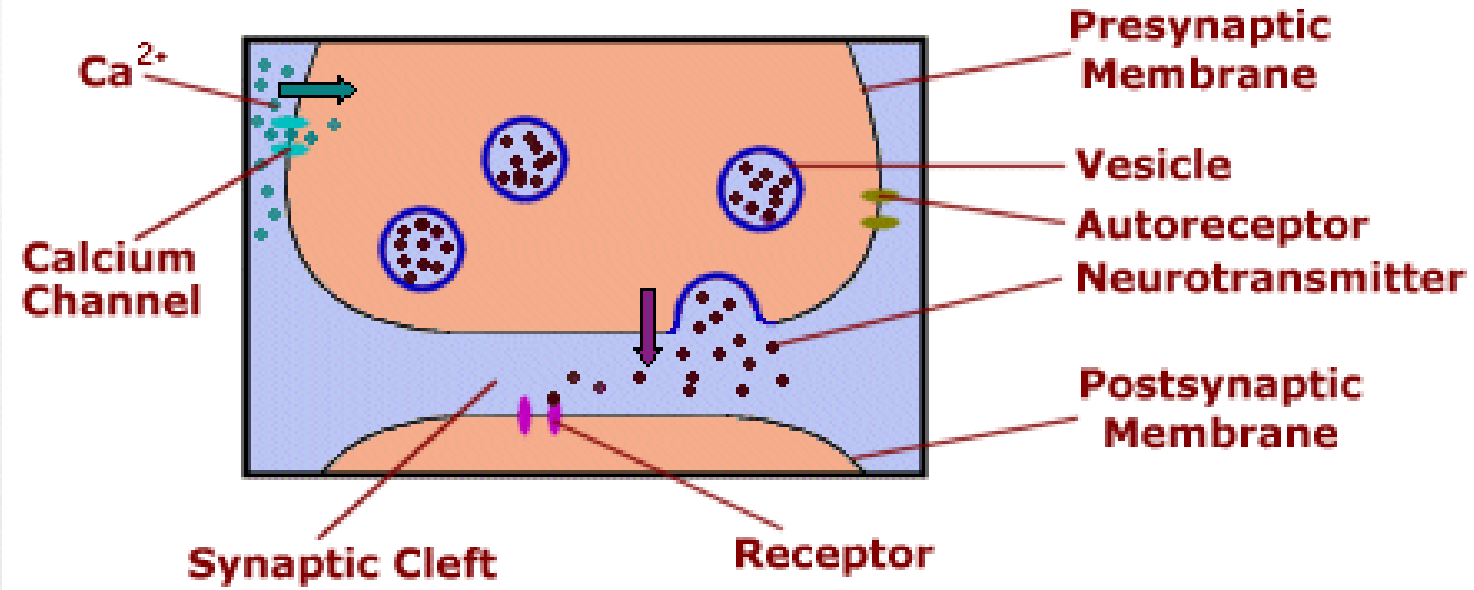
Neurotransmitter is released from a **docked vesicle** as a result of Ca^{++} entry at the pre-synaptic terminal.

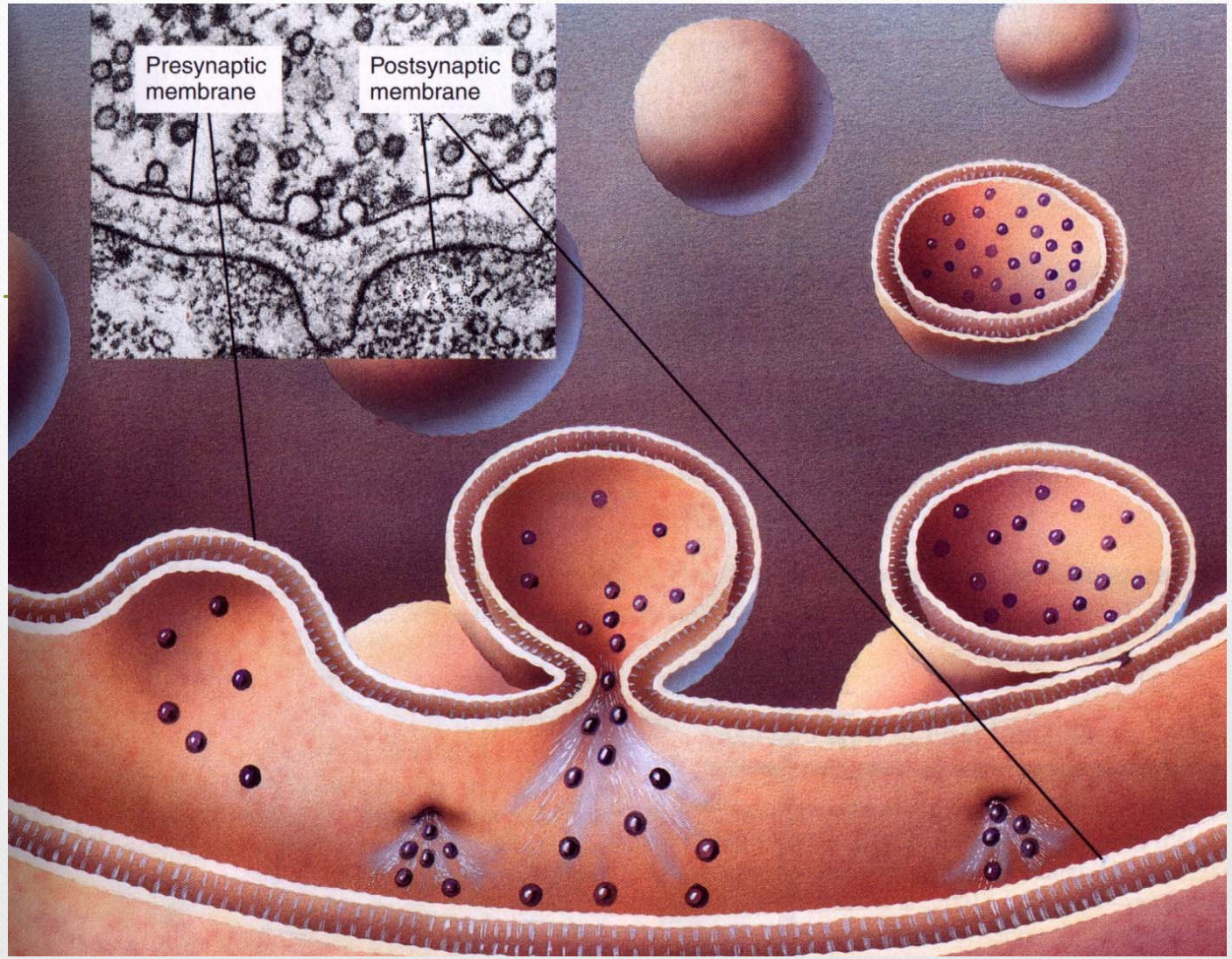



Microtubules
Synaptic vesicles
Button
Synaptic cleft
Golgi complex
Mitochondrion
Dendritic spine
Presynaptic membrane
Postsynaptic membrane

Synaptic Transmission

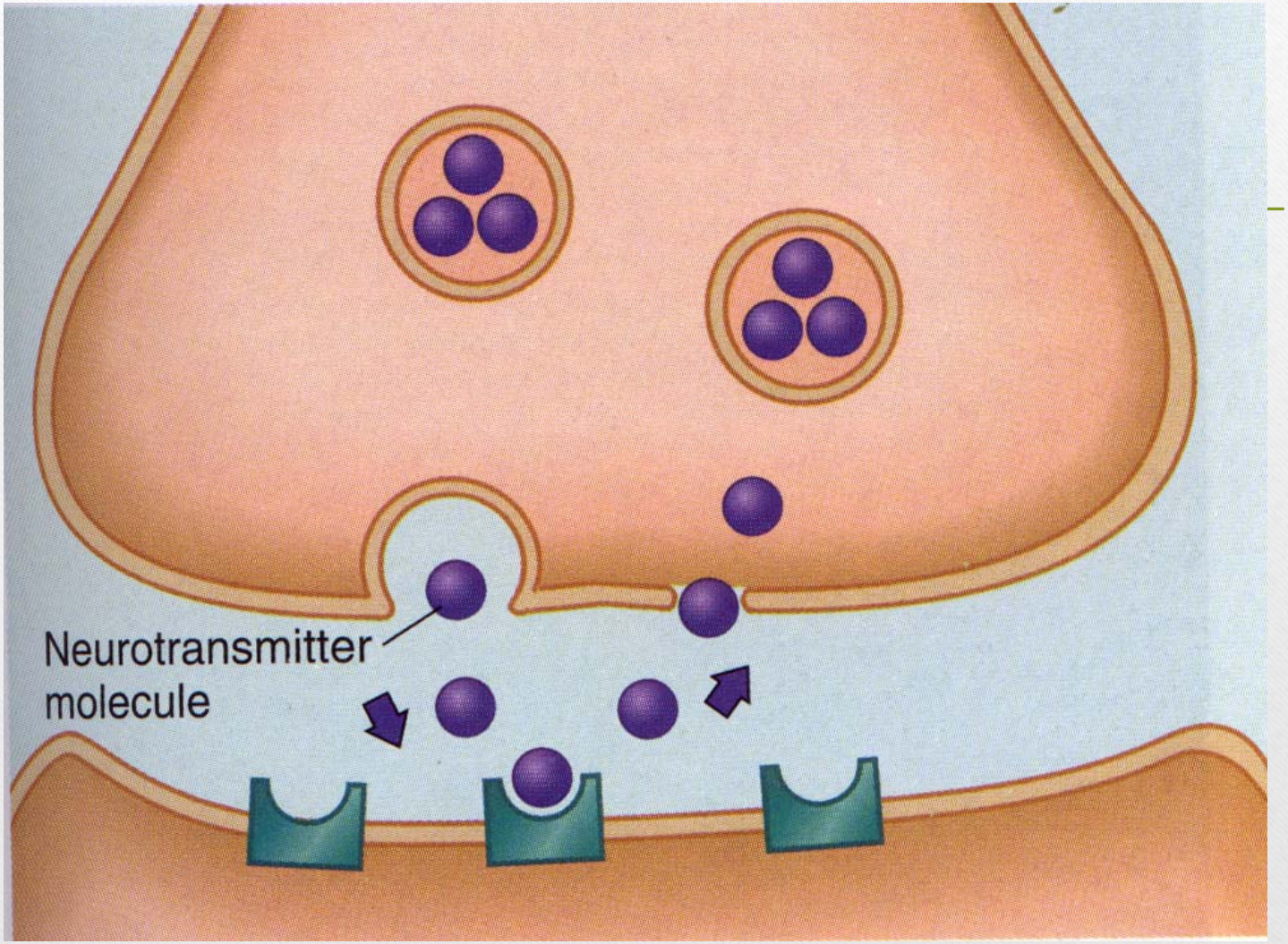



Ca2+
Presynaptic Membrane
Vesicle
Autoreceptor
Calcium Channel
Neurotransmitter
Postsynaptic Membrane
Synaptic Cleft
Receptor

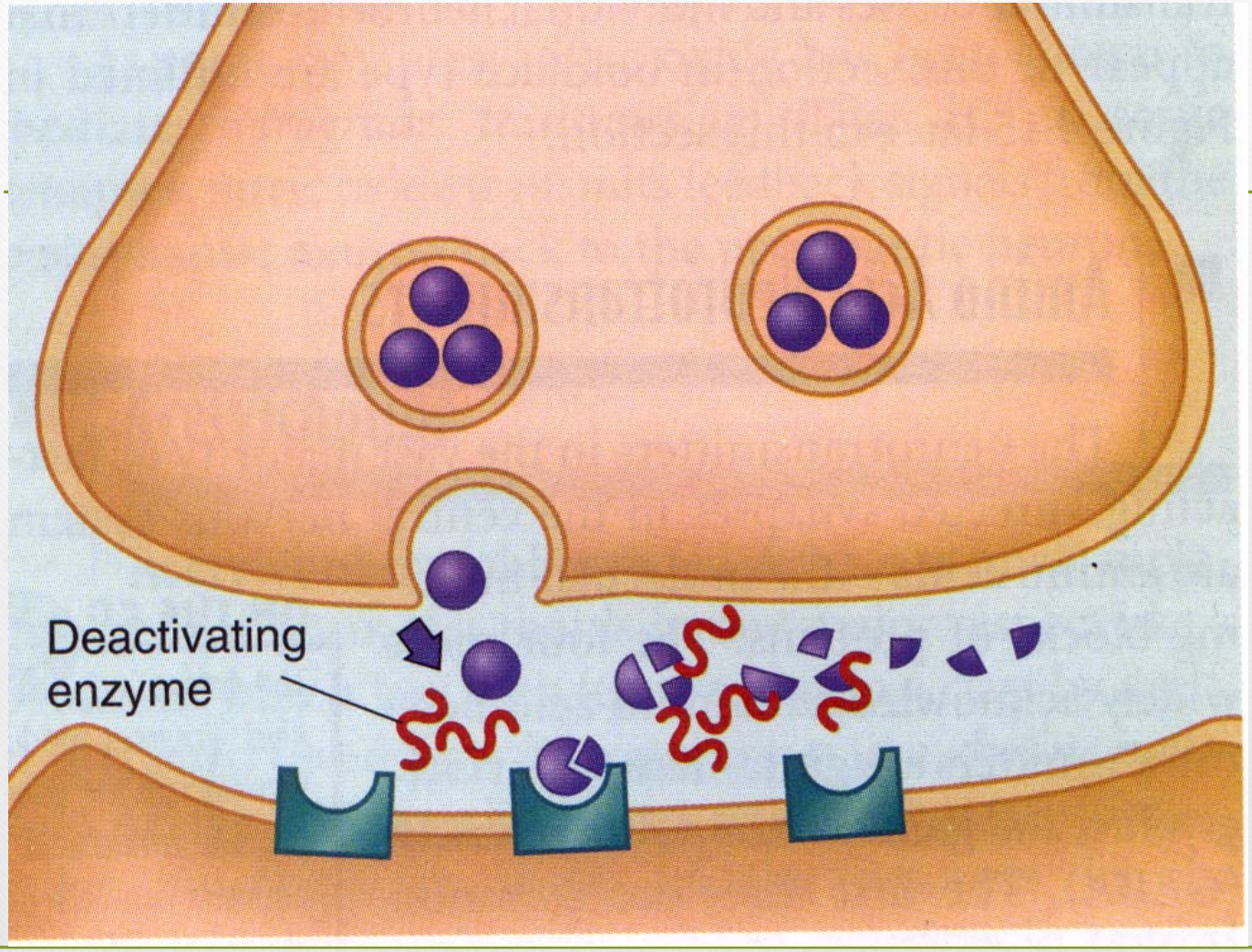


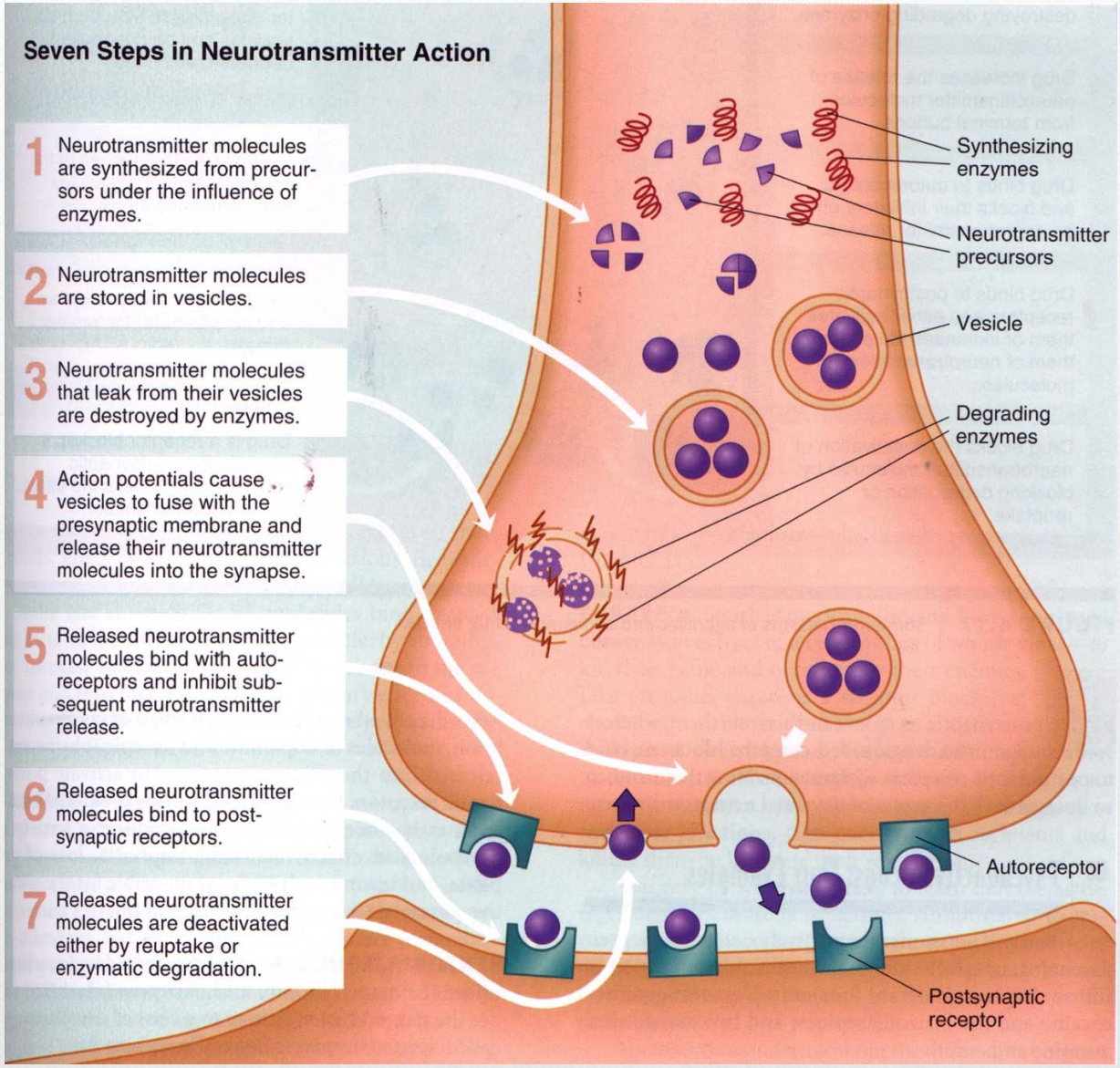
exocytosis

Neurotransmitter deactivation: reuptake

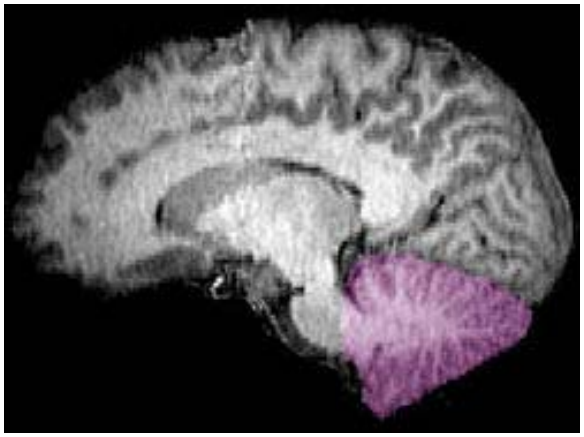


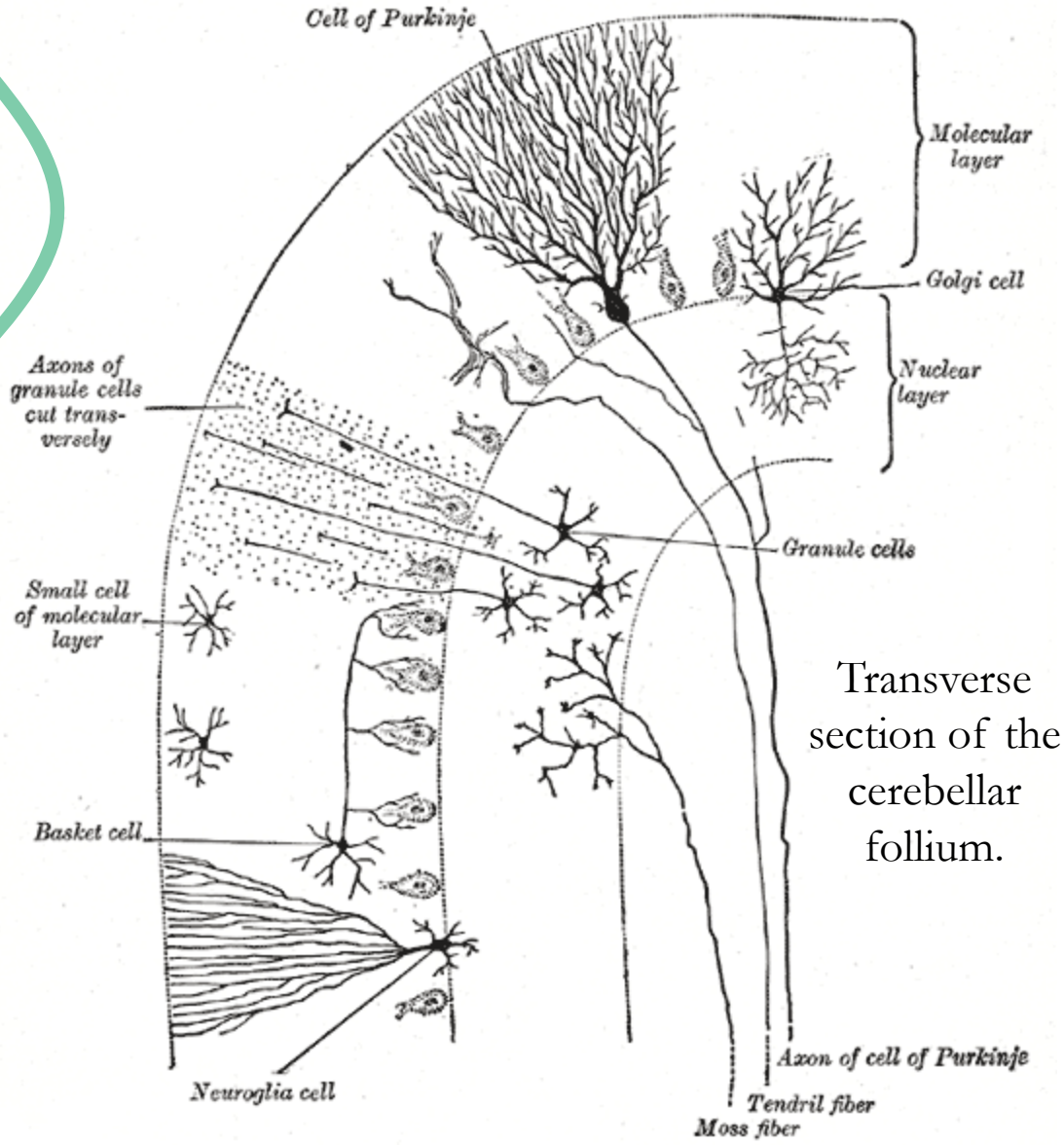
Neurotransmitter deactivation: degradation



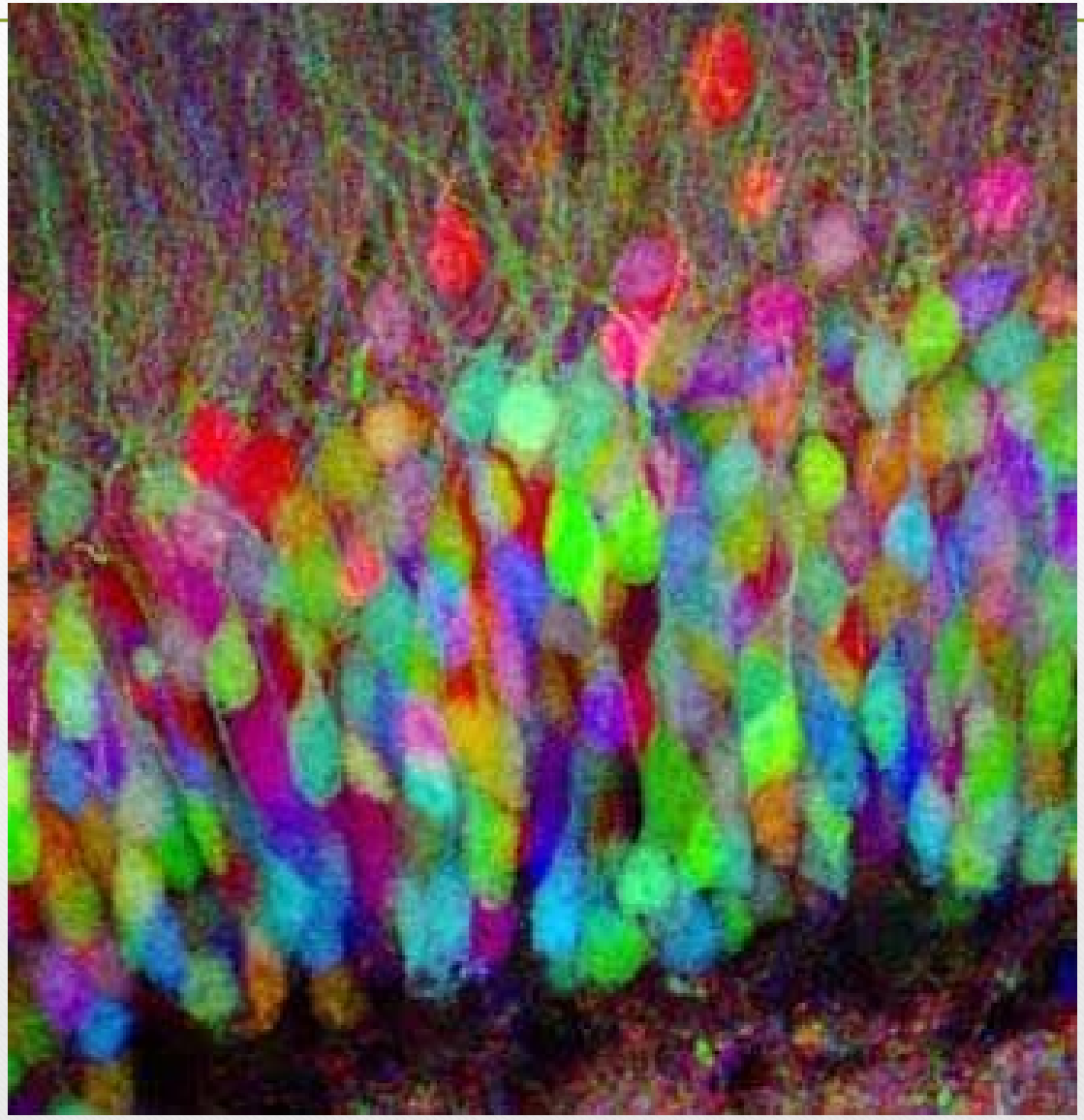

Seven Steps in Neurotransmitter Action
1 Neurotransmitter molecules are synthesized from precursors under the influence of enzymes.
2 Neurotransmitter molecules are stored in vesicles.
3 Neurotransmitter molecules that leak from their vesicles are destroyed by enzymes.
4 Action potentials cause vesicles to fuse with the presynaptic membrane and release their neurotransmitter molecules into the synapse.
5 Released neurotransmitter molecules bind with autoreceptors and inhibit subsequent neurotransmitter release.
6 Released neurotransmitter molecules bind to postsynaptic receptors.
7 Released neurotransmitter molecules are deactivated either by reuptake or enzymatic degradation.
Synthesizing enzymes
Neurotransmitter precursors
Vesicle
Degrading enzymes
Autoreceptor
Postsynaptic receptor

The cerebellum





Transverse section of the cerebellar follium.



Brainbow – Roger Tsien work in green fluorescent protein contributed to this work.