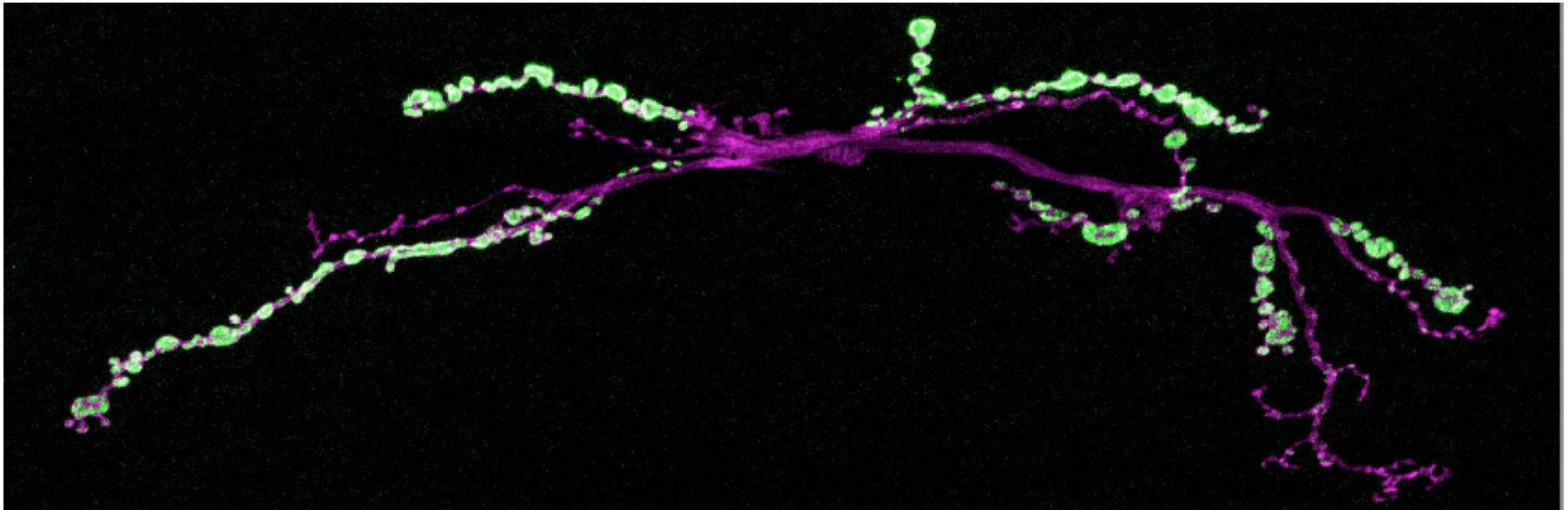


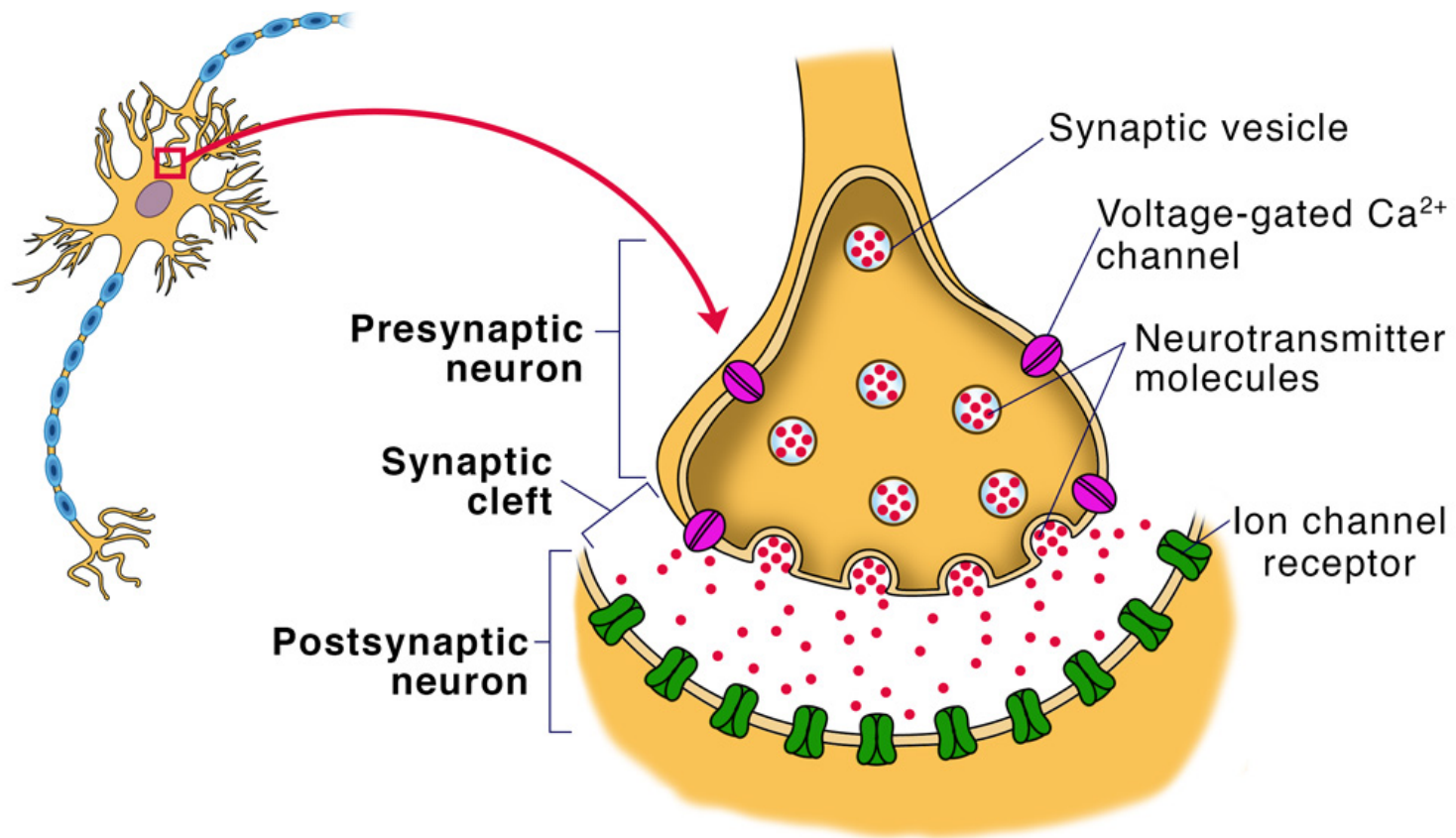
# Models of Synaptic Transmission

# The Chemical Synapse is Key to Neural Communication



Staining of synapses (green) on a neuron.

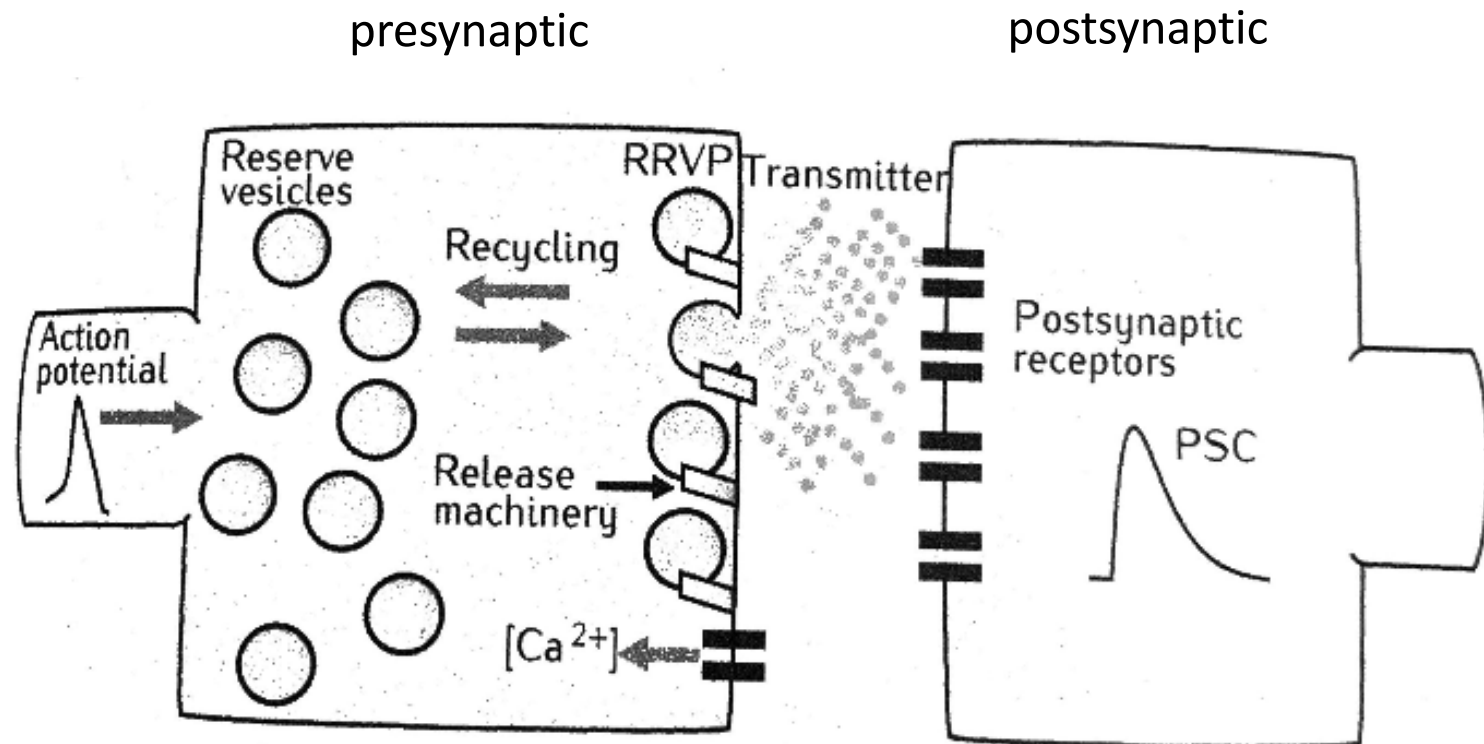
# The Chemical Synapse is Key to Neural Communication



# The Main Neurotransmitters

- Glutamate – Excitatory
- GABA -- Typically inhibitory
- Dopamine – Can be either, depending on receptor type
- Adrenaline (epinephrine) -- Typically excitatory
- Serotonin – Typically inhibitory, involved in mood
- Oxytocin – Typically modulates other synapses
- Acetylcholine – Typically excitatory

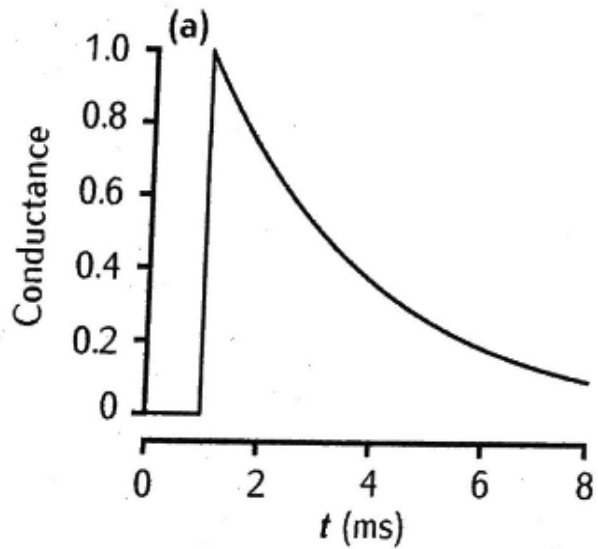
# Some Basic Features of the Synapse



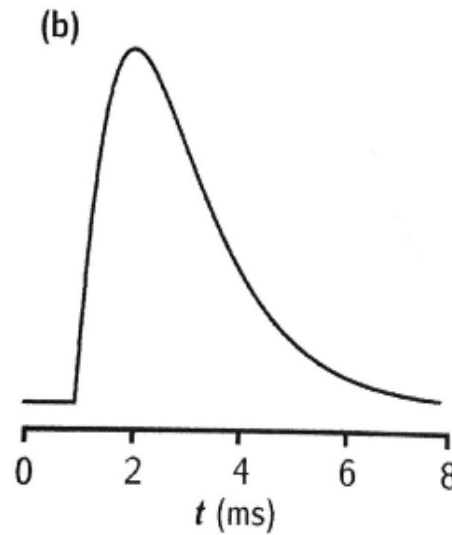
RRVP = Readily Releasable Vesicle Pool

PSC = Postsynaptic Current

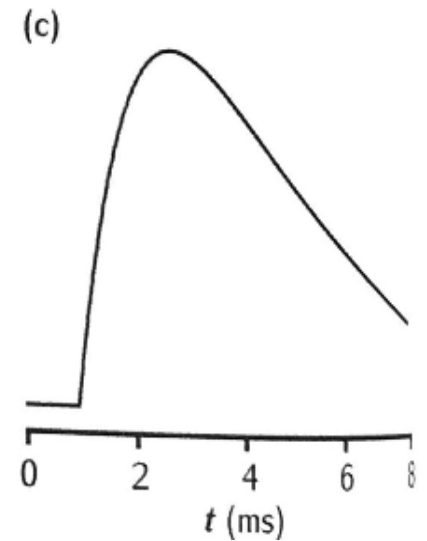
# Three Models for Postsynaptic Conductance



Single exponential decay

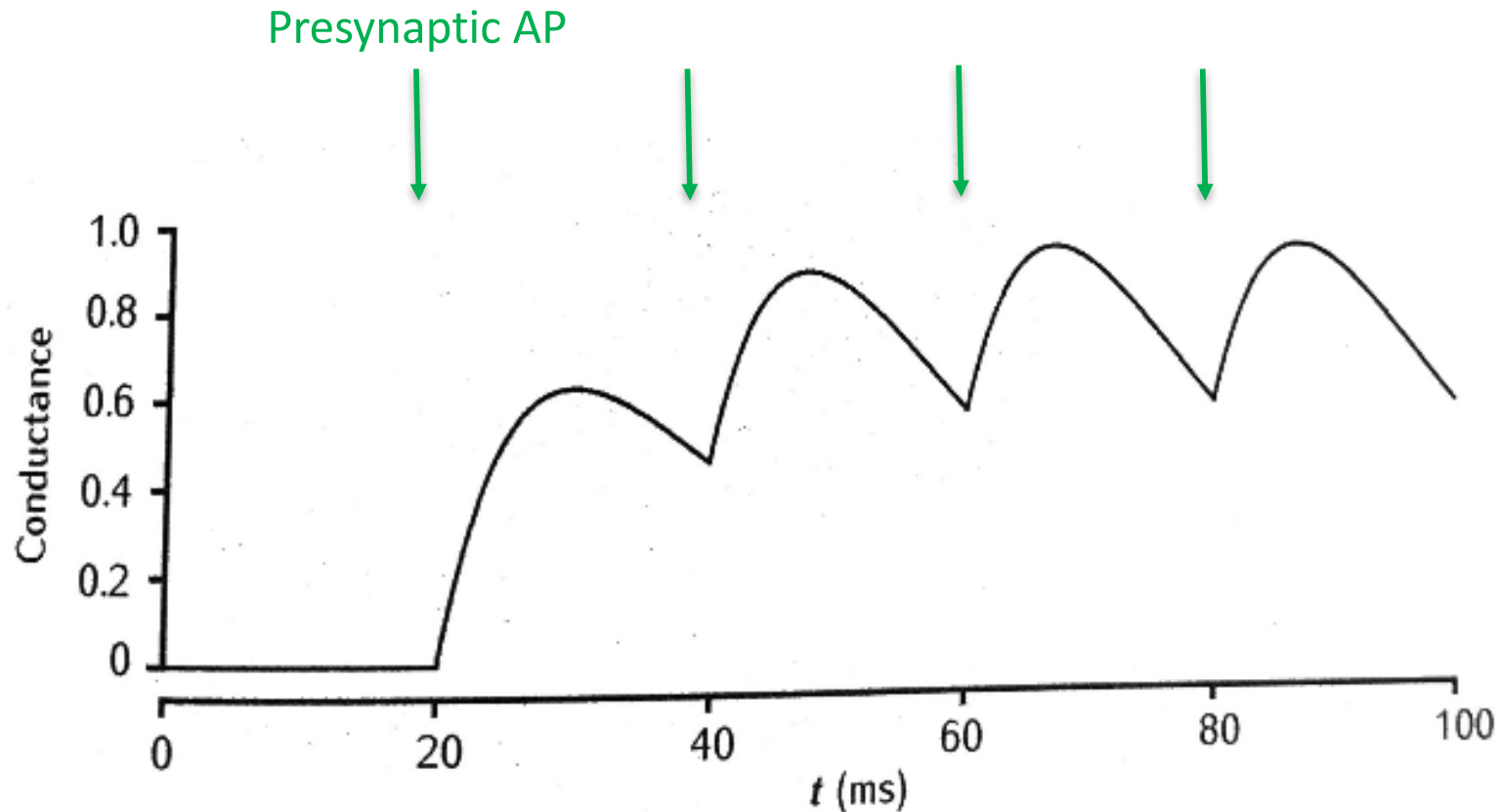


Alpha function



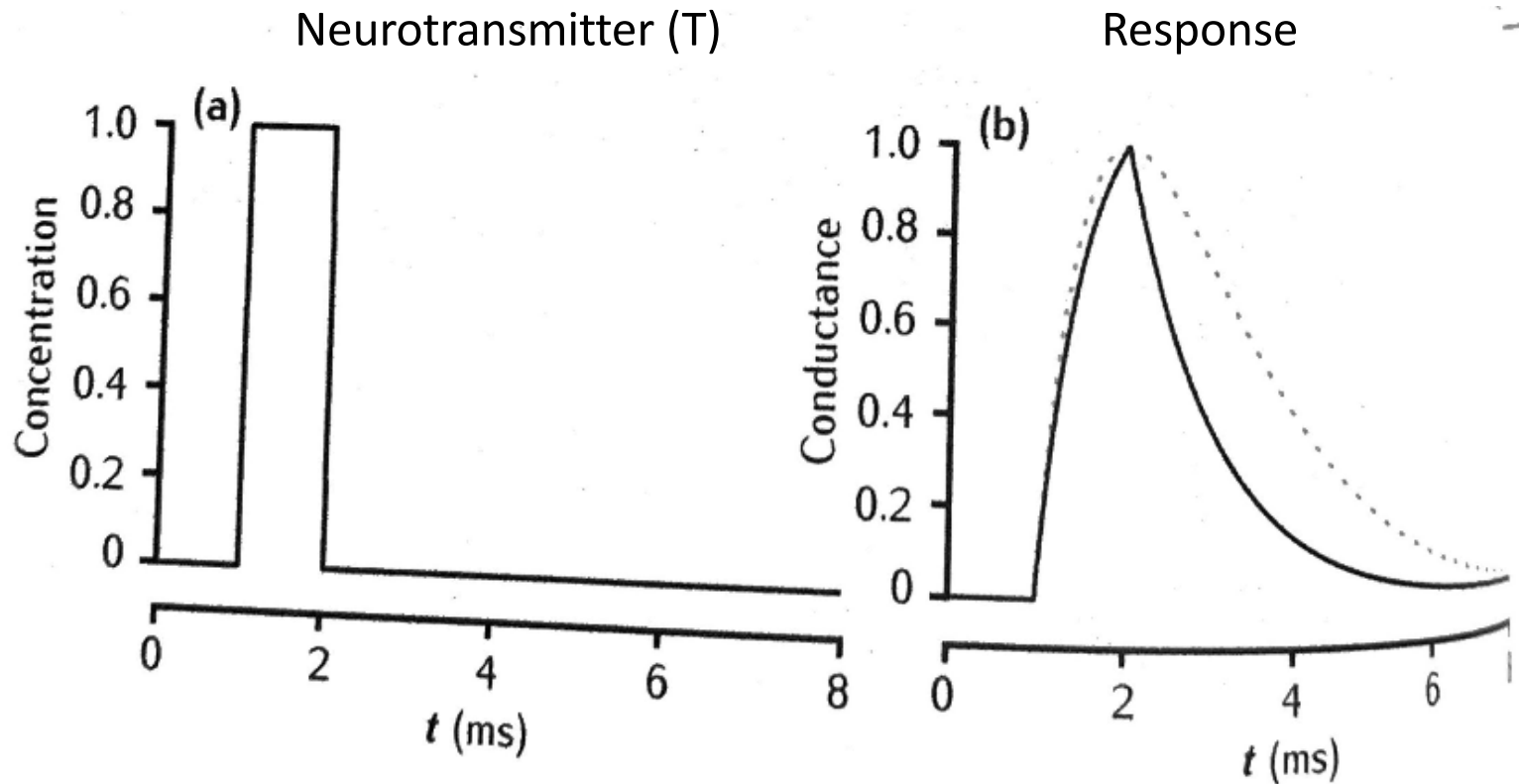
Dual exponential

# Conductance Can Accumulate During a Spike Train



Simulation done using an alpha function with  $\tau = 10$  ms

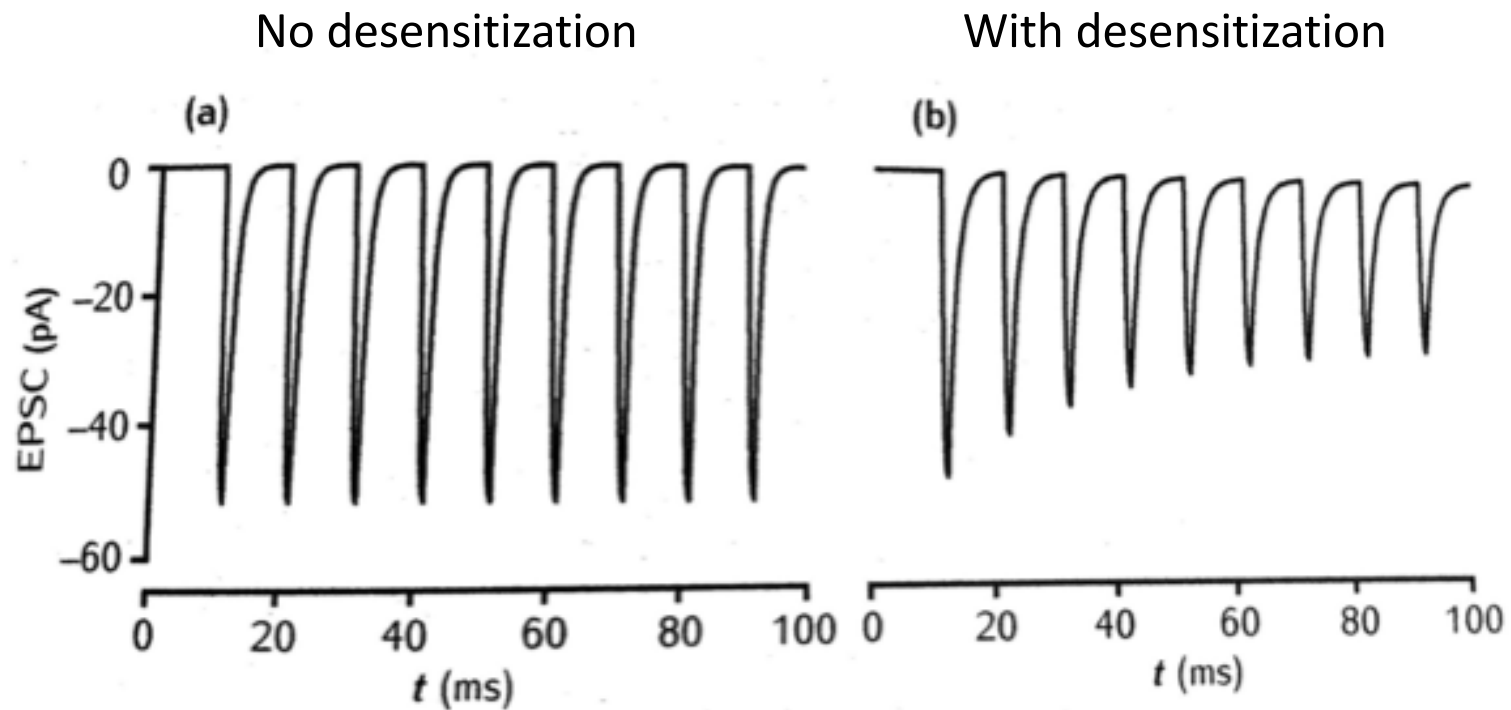
# Postsynaptic Conductance Using a Two-State Kinetic Model



Comparison of kinetic model response with an alpha function ( $\tau = 1$  ms, dashed)

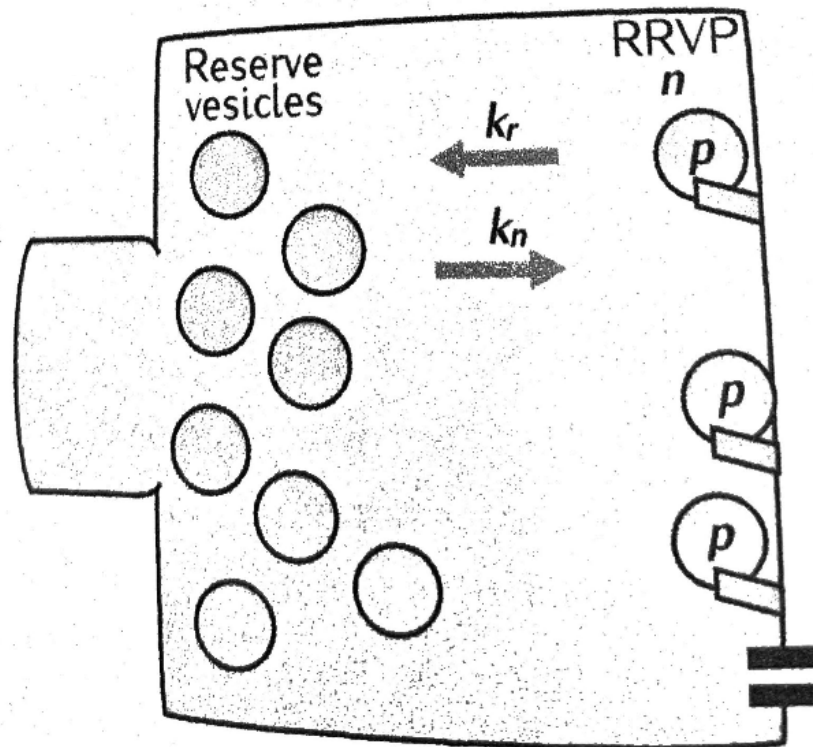


# Response to a Train of Impulses



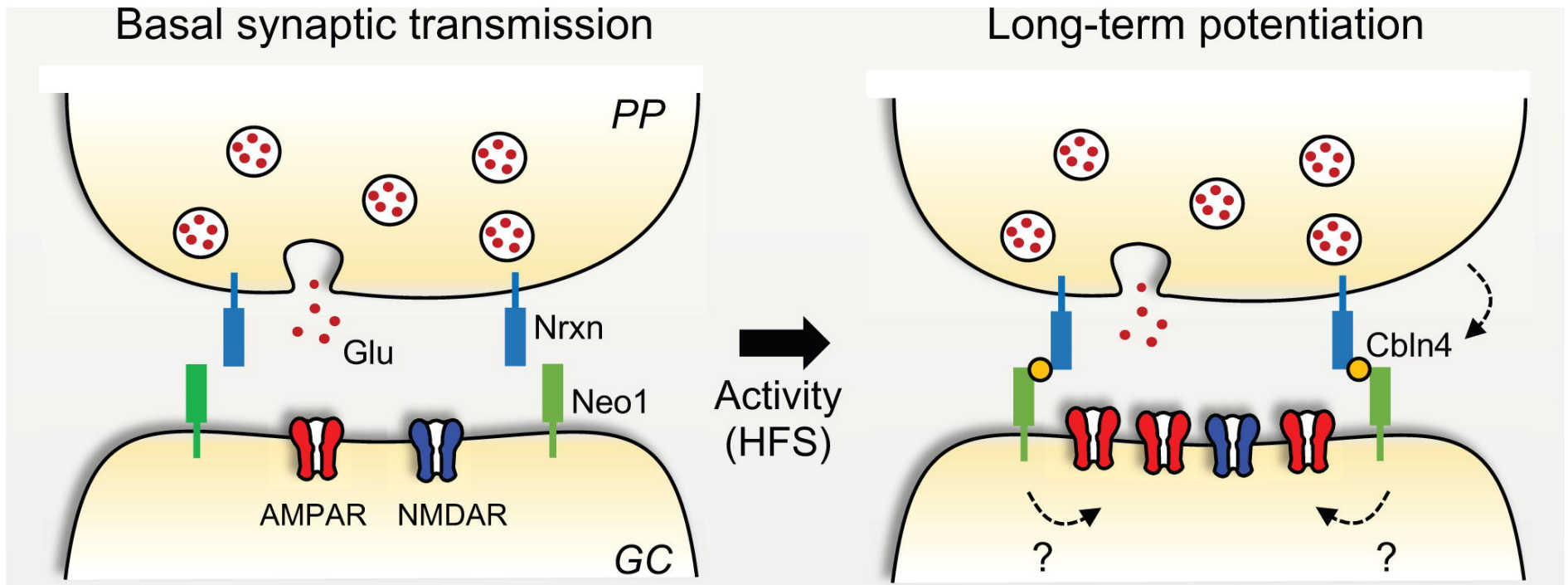
Computed with the kinetic model of Eq. 7.10 in the text

# Presynaptic Plasticity



Another source of short-term plasticity is a use-dependent change in the number of vesicles in the RRVP ( $n$ ), or in the probability of release ( $p$ )

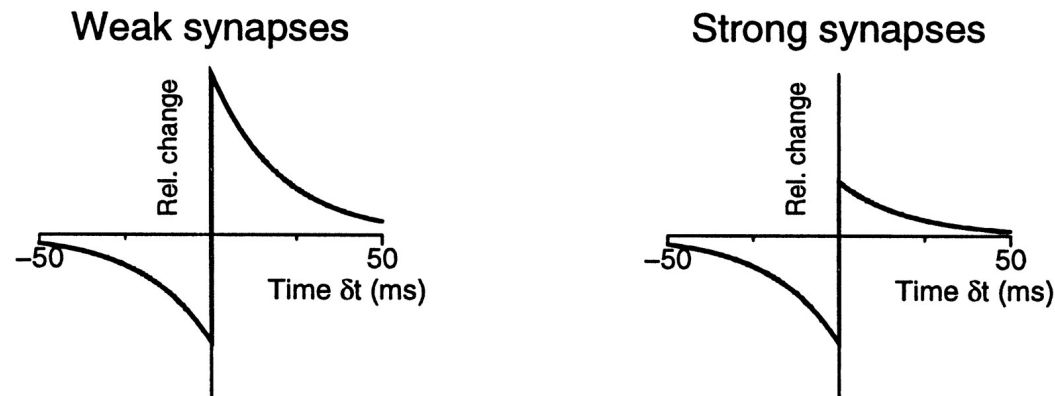
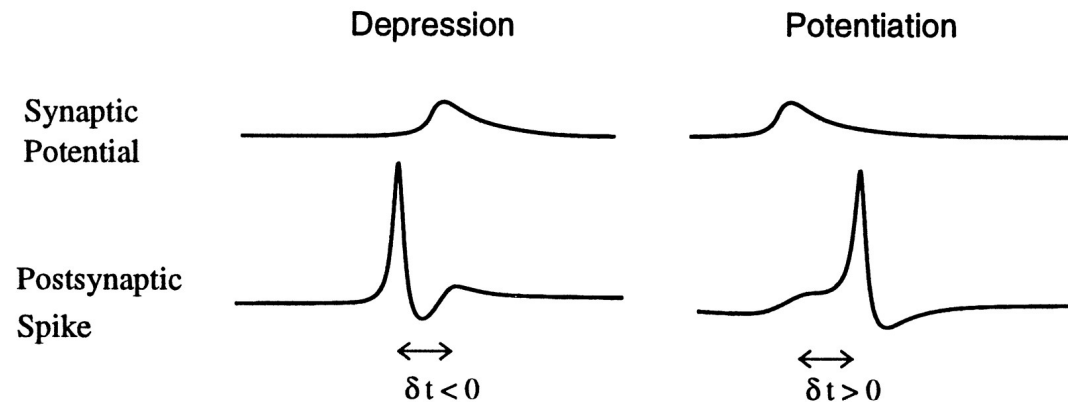
# Long-term Potentiation



Castillo, PNAS, 119:e2206429119, 2022

In response to a high-frequency stimulation (HFS), additional glutamate receptors (AMPA) are inserted into the membrane of the postsynaptic cell

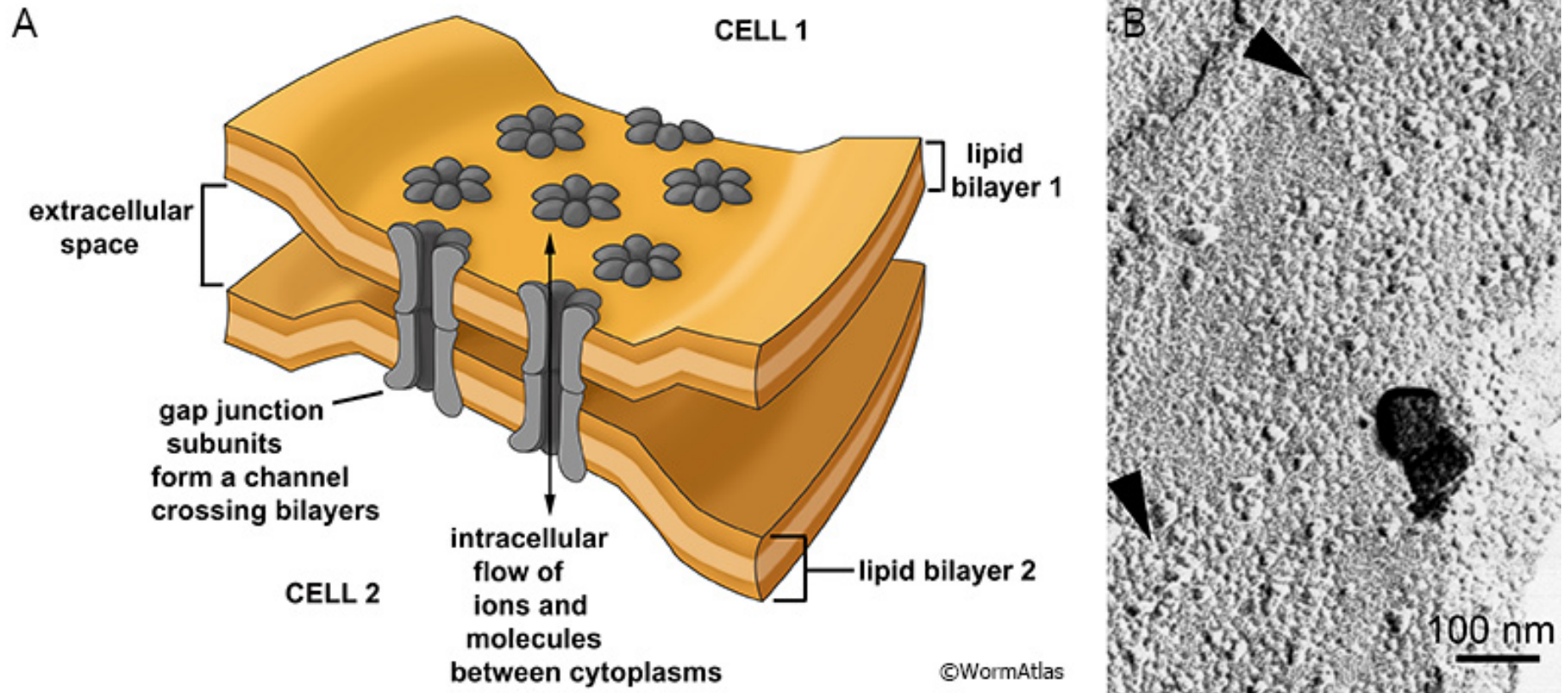
# Spike-timing-dependent Plasticity



Van Rossum et al, J. Neurosci., 20:8812, 2000

STDP can increase or decrease synaptic strength, depending on whether the presynaptic spike occurs before or after the postsynaptic spike

# Gap-junctional Coupling Between Cells



A **connexon** is composed of 6 **connexin** proteins, and forms a gap junction. Ions and small molecules can move through these junctions.