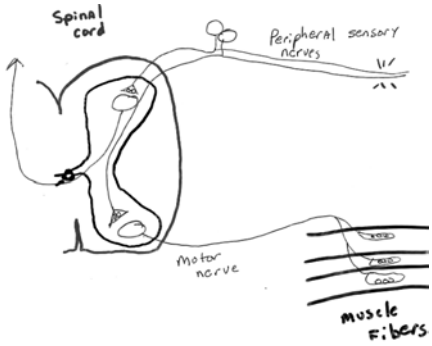
Monosynaptic reflex



Physiology G6001

Nerve and Synapse

Amy MacDermott,
Department of Physiology and Cellular Biophysics and the Center for Neurobiology and Behavior
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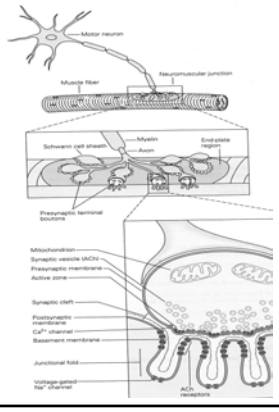
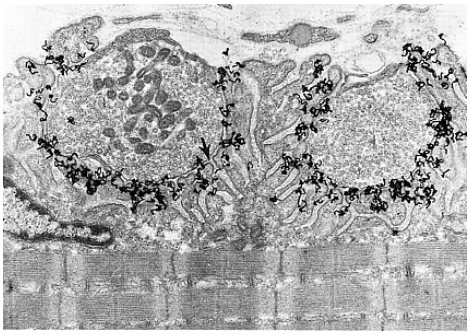
- **Classical elements of synaptic transmission: Neuromuscular junction**
  - Transmitter release
  - Synaptic currents
  - Synaptic potentials
- Nerve-nerve synapses
- Synaptic integration
  - Summation
  - Facilitation

Schematic of the NMJ



The Neuromuscular Junction



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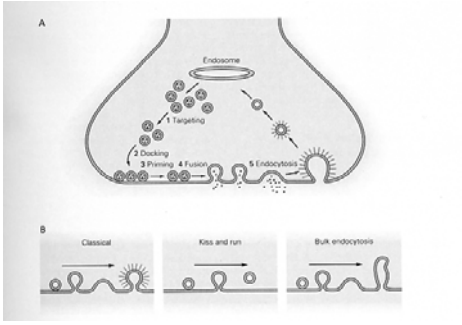
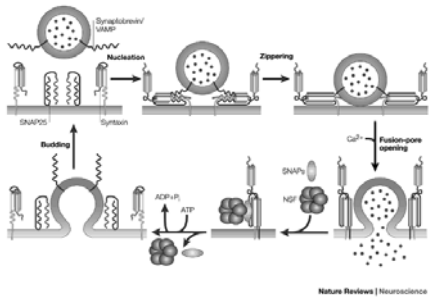
Exocytosis and transmitter release at the nerve terminal

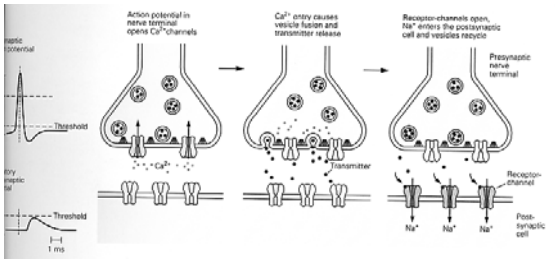


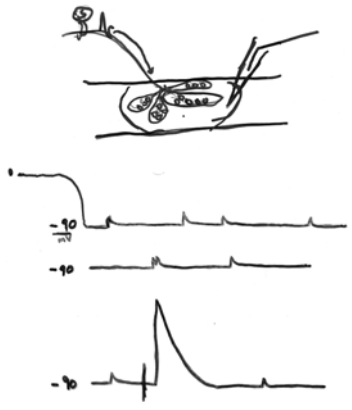
Protein machinery for vesicle release



Rizo and Sudhof Nature Reviews Neuroscience **3**; 641-653 (2002);

Key elements of transmitter release



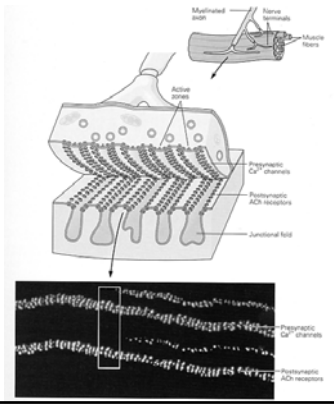


Recording from the neuromuscular junction (NMJ).

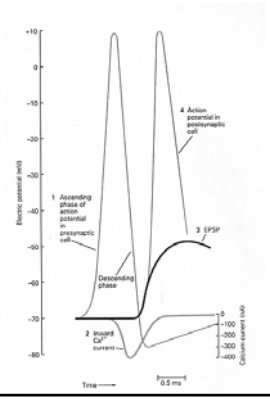
Spontaneous release of a vesicle of Ach causes a miniature endplate potential or MEPP

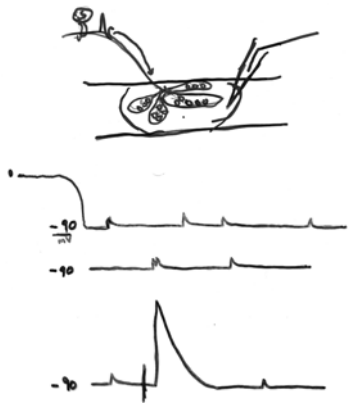
Evoked release following stimulation of the motor neuron causes an endplate potential or EPP

Presynaptic calcium channels at the neuromuscular junction (NMJ)



Pre and postsynaptic changes in membrane potential during transmitter release





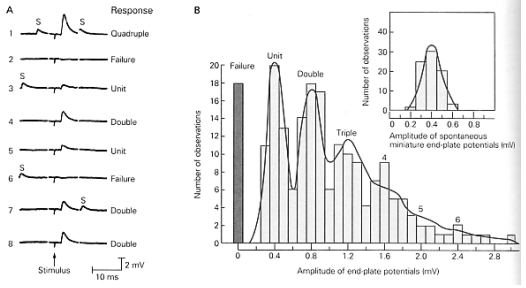
Recording from the neuromuscular junction (NMJ).

Spontaneous release of a vesicle of Ach causes a miniature endplate potential or MEPP

Evoked release following stimulation of the motor neuron causes an endplate potential or EPP

The quantal nature of transmitter release.

Decrease the amplitude of evoked release by recording in low Ca2+ bath.



Physiology G6001 Nerve and Synapse

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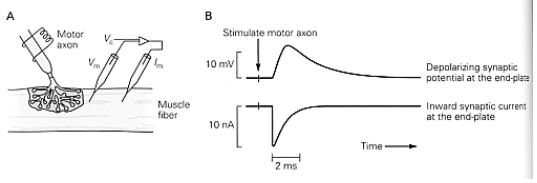
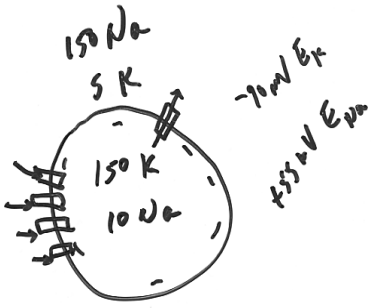
NMJ – an inward current drives the change in membrane potential

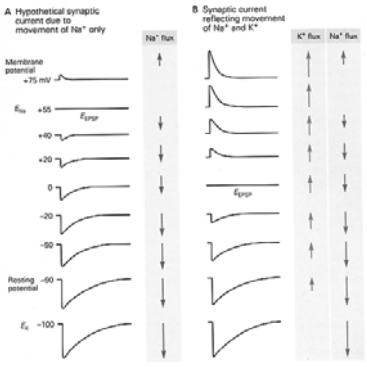




Membrane potential and driving force– brief review

$Vm = (RT/F) \ln [K]_o/[K]_i$

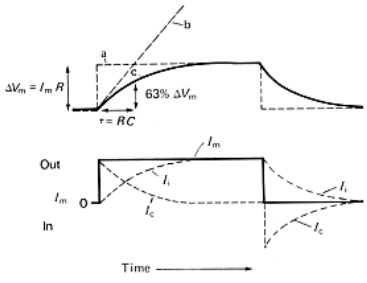
$Vm = (RT/F) \ln Na]_o/[Na]_i$



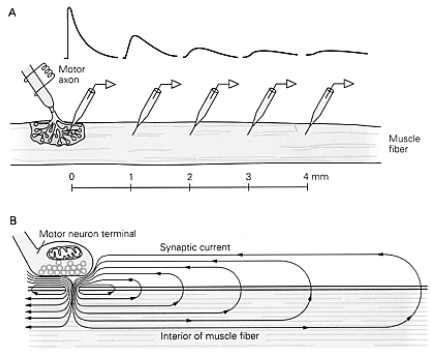
Reversal potential

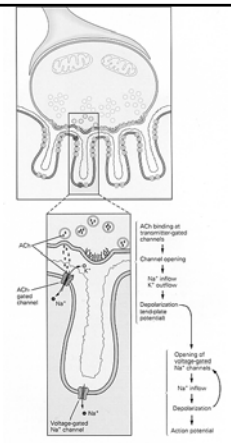
$I_{EPSP} = g_{EPSP} \times (Vm\text{-}E_{EPSP})$

Membrane time constant – a review



Synaptic potential is not actively propagated

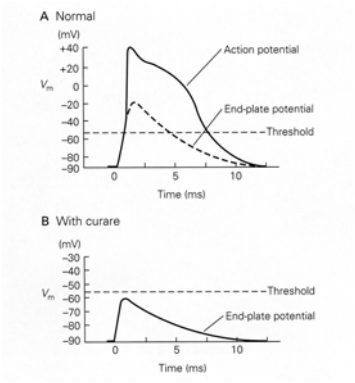




ACh binds to the nicotinic ACh receptor, causing it to gate open. The channel is permeable to both Na^+ and K^+.

The end-plate potential causes voltage gated Na^+ channels to open and an action potential to fire.

An EPP in normal muscle is super-threshold for firing action potential



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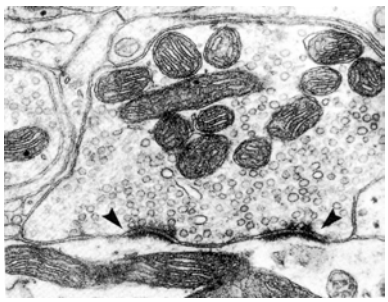
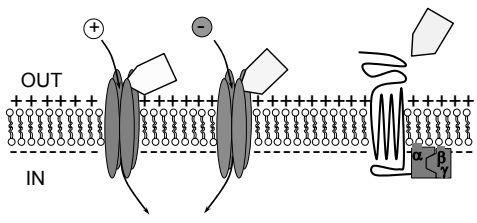
Heuser and Reese – two synapses in the cerebellum

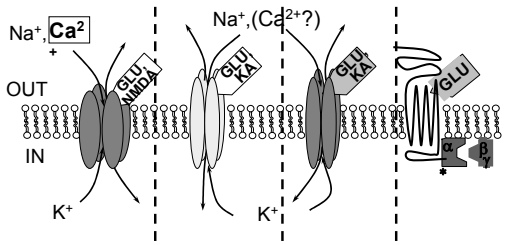


Classes of neurotransmitter receptors



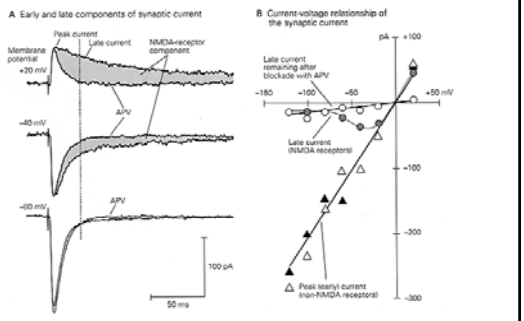
IONOTROPIC METABOTROPIC

Excitatory synaptic transmission is mediate by glutamate receptors

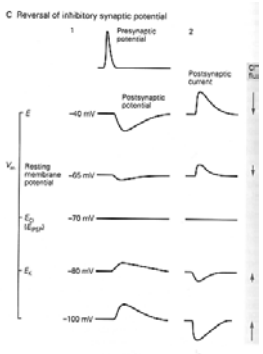


NMDA receptors (NMDARs) | AMPA receptors | Kainate receptors | metabotropic Glu receptors

Current-voltage relationship for synaptic currents mediated by AMPA and NMDA receptors



Inhibitory synaptic transmission is mediated by GABA and glycine receptors



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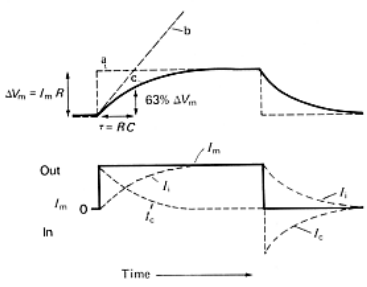
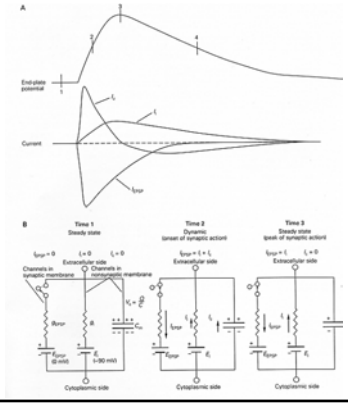
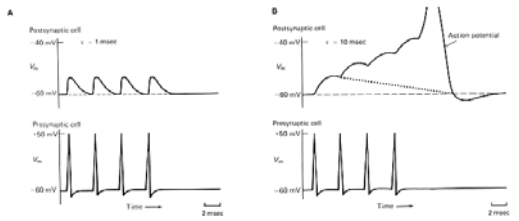
Membrane time constant – a review



What determines the time course of the synaptic potential?

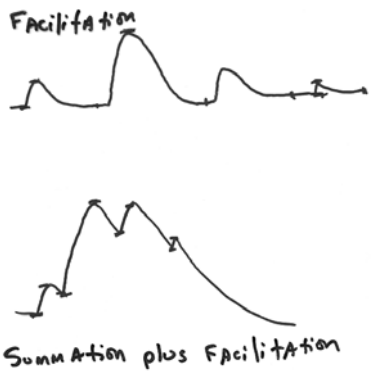


Temporal summation depends on the passive membrane properties of the neuron or muscle

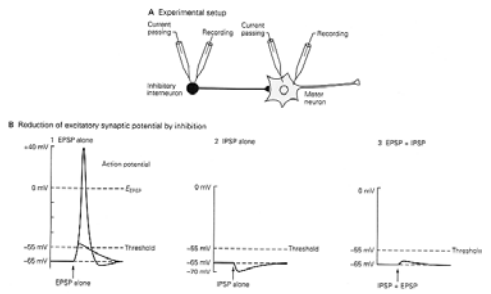


Tau or $\tau = C \times R$

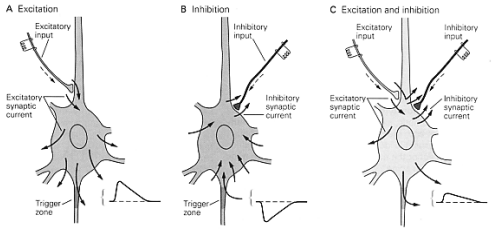
Summation is postsynaptic while facilitation is usually presynaptic



Summation of EPSP and IPSP

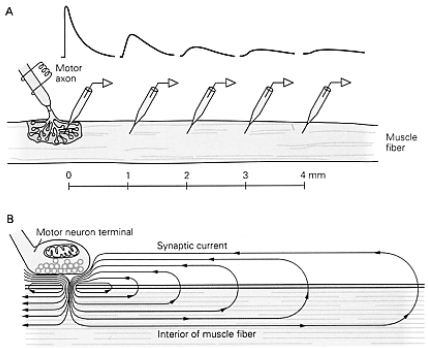


The trigger zone

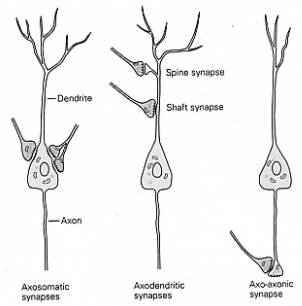


The synaptic potential is not actively propagated. The rate of decay with distance is exponential:

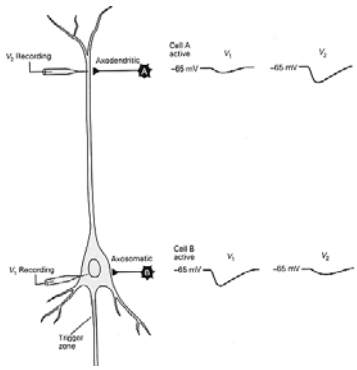
$\Delta V(x) = \Delta V_0 e^{-x/\lambda}$ and $\lambda \sim (r_m/r_a)$



Different synaptic configurations including axo-somatic, axodendritic and axo-axonic



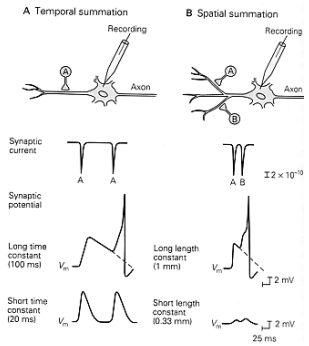
Implications of synapse location



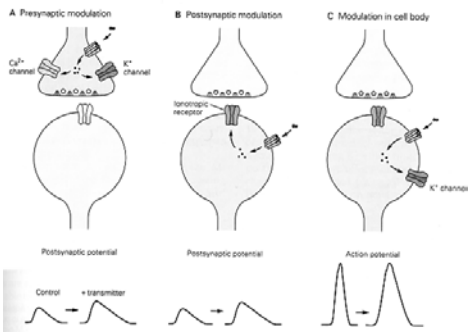
Length constant

$\lambda \sim Rm/Ra$

Temporal and spatial summation: importance of time constant τ and length constant λ



Three forms of modulation of synaptic transmission mediated by metabotropic receptors



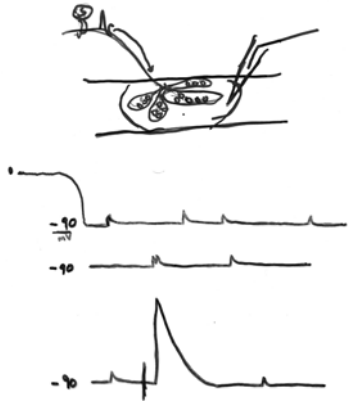
Berne and Levy – chapter 4

or

Kandel, Schwartz, and Jessell – chapters 11 and 12

or

Kandel, Schwartz, and Jessell – chapters 10-15



Recording from the neuromuscular junction (NMJ).

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Evoked release following stimulation of the motor neuron causes an endplate potential or EPP

The reversal potential is determined by the concentrations of ions flowing through the synaptic channel.