Monosynaptic reflex

Classical elements of synaptic transmission:
- Neuromuscular junction
- Transmitter release
- Synaptic current
- Synaptic potentials
- Nerve-nerve synapses
- Synaptic integration
- Summation
- Facilitation

Schematic of the NMJ
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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.

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NMJ – an inward current drives the change in membrane potential
Membrane potential and driving force—brief review

\[ V_m = \left(\frac{RT}{F}\right) \ln \frac{[K_o]}{[K_i]} \]

\[ V_m = \left(\frac{RT}{F}\right) \ln \frac{[Na_o]}{[Na_i]} \]

Reversal potential

\[ I_{rev} = g_{rev} \times (V_m - E_{rev}) \]

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
Physiology G6001  Nerve and Synapse

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Heuser and Reese – two synapses in the cerebellum

Classes of neurotransmitter receptors

IONOTROPIC  METABOTROPIC
Excitatory synaptic transmission is mediated by glutamate receptors.

Inhibitory synaptic transmission is mediated by GABA and glycine receptors.
Physiology G6001                  Nerve and Synapse

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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

\[ \tau = C \times R \]

Summation is postsynaptic while facilitation is usually presynaptic

Summation plus Facilitation

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 \( \lambda \sim (rm/ra) \)

Different synaptic configurations including axo-somatic, axodendritic, and axo-axonic
Implications of synapse location

Length constant

\[ \lambda \sim \frac{R_m}{R_a} \]

Temporal and spatial summation: importance of time constant \( \tau \) and length constant \( \lambda \).

Three forms of modulation of synaptic transmission mediated by metabotropic receptors.
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 reversal potential is determined by the concentrations of ions flowing through the synaptic channel.