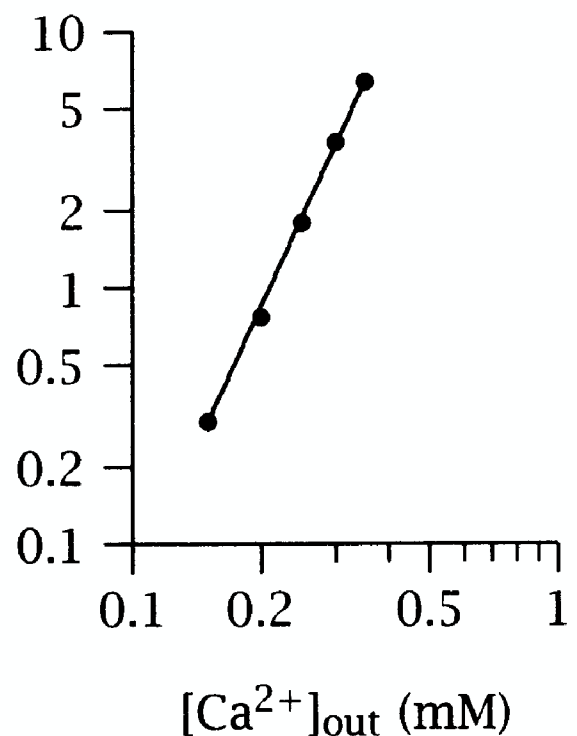
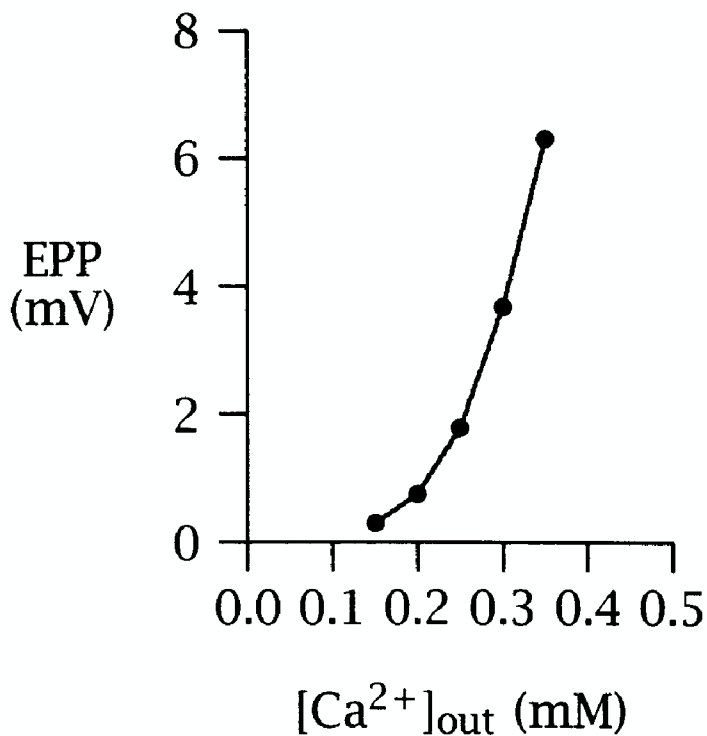
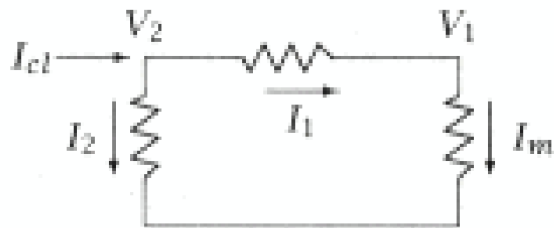
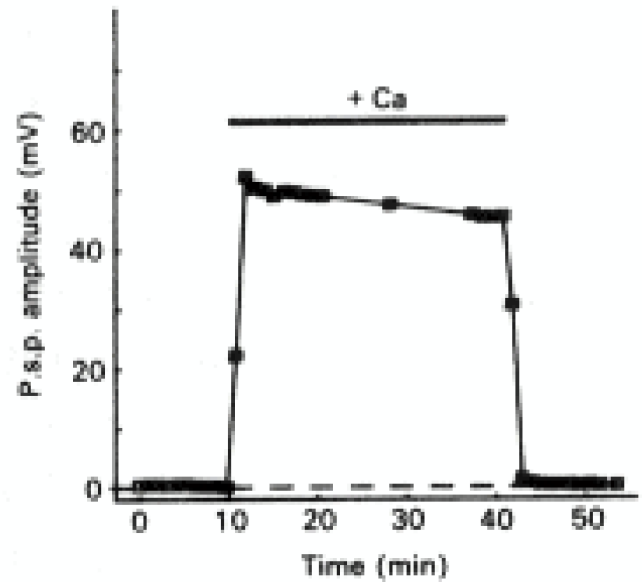
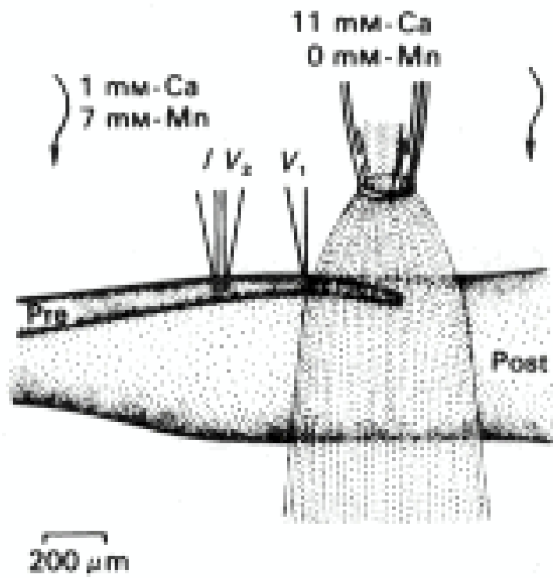
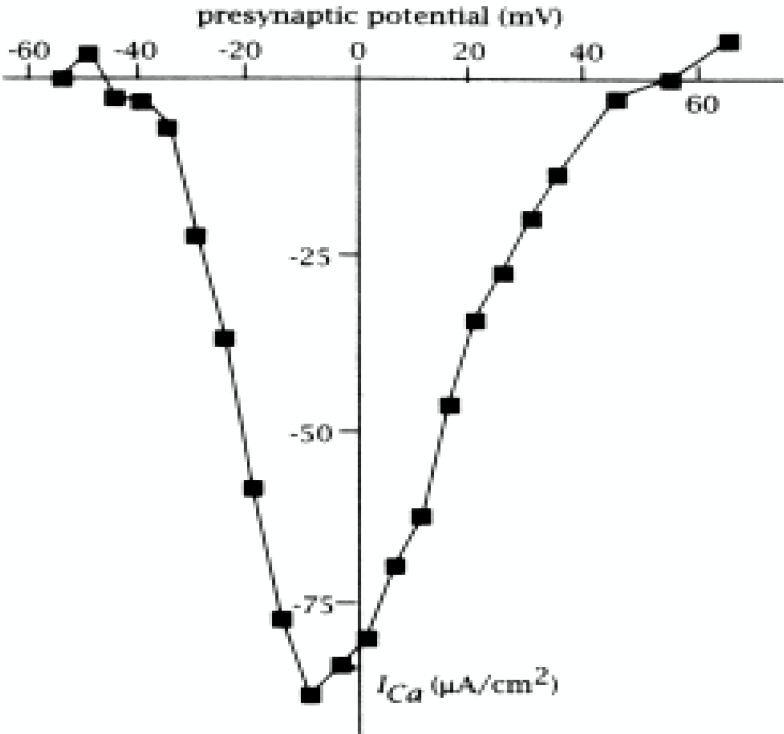
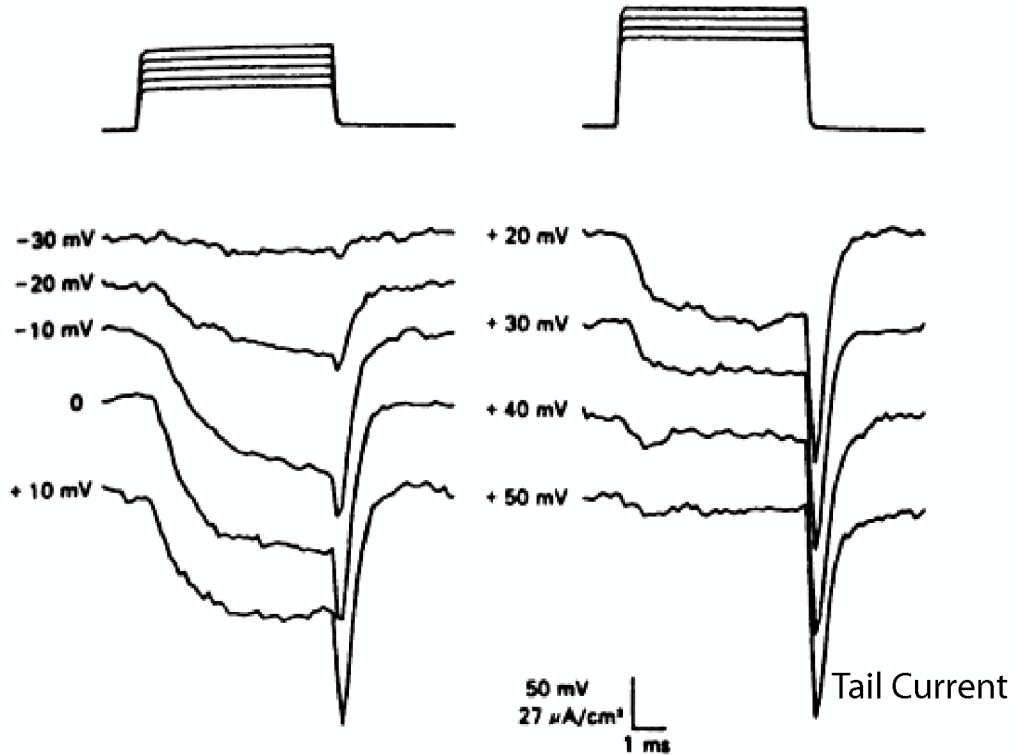
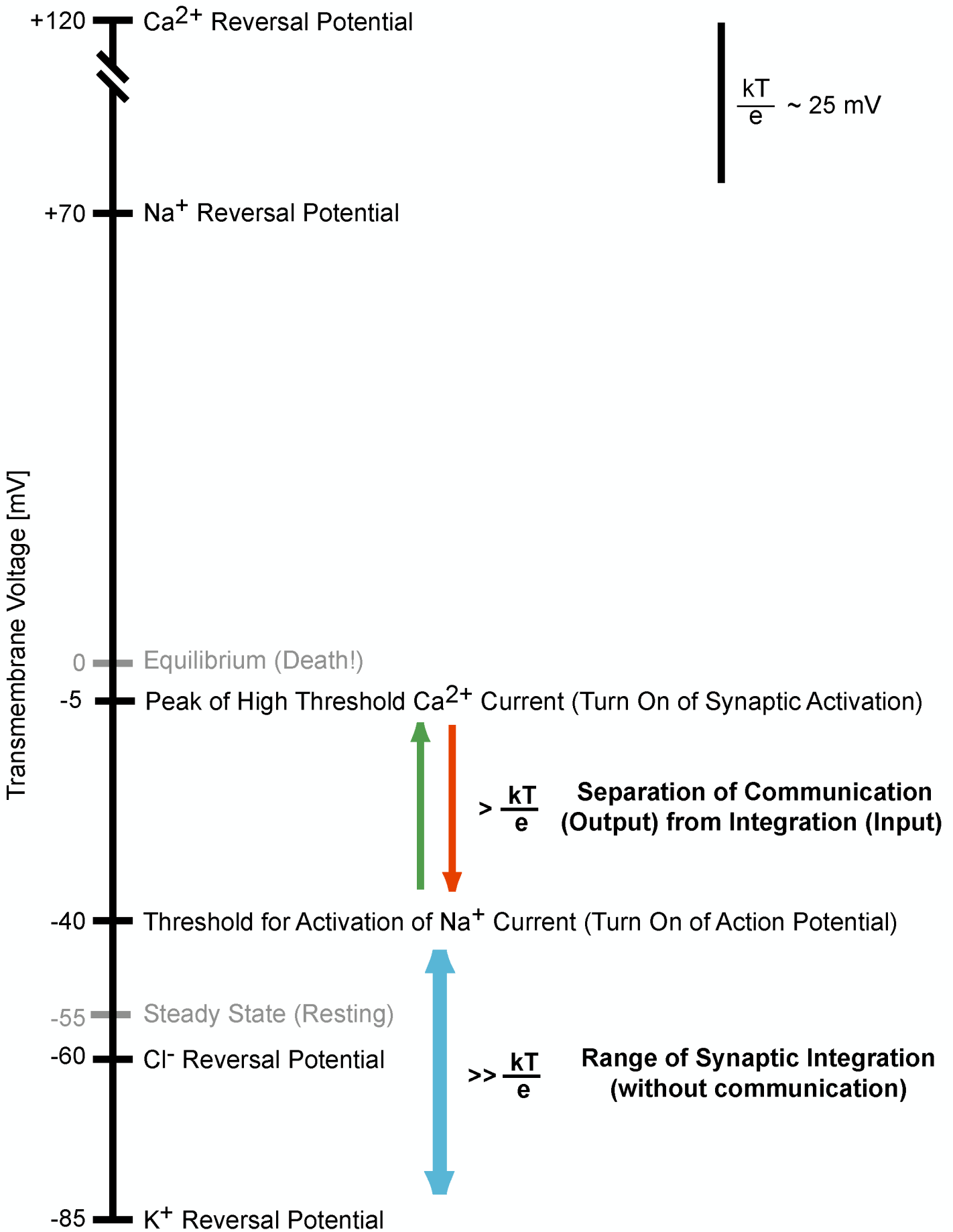


Obligatory role of Ca^{2+} in Synaptic Transmission

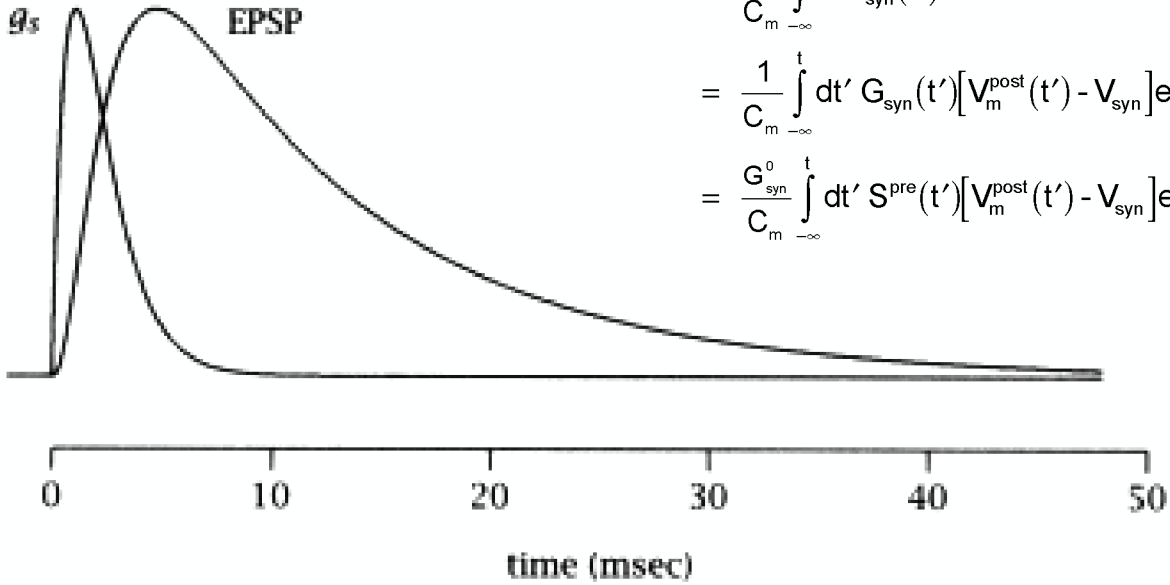


The High Threshold Ca^{2+} Current is Activated by Spikes

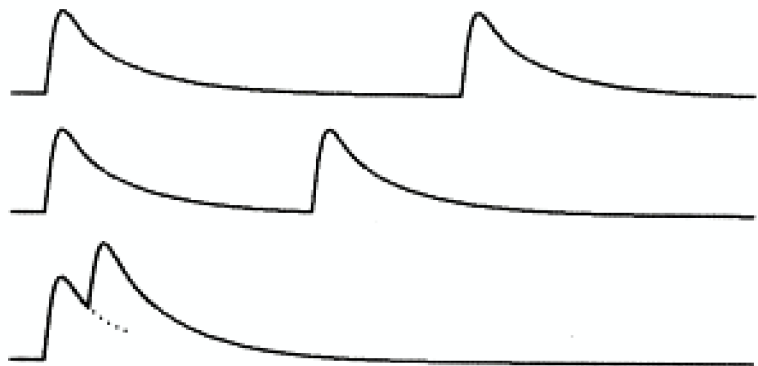
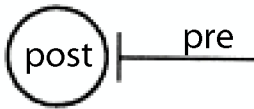




Basic Synaptic Physiology



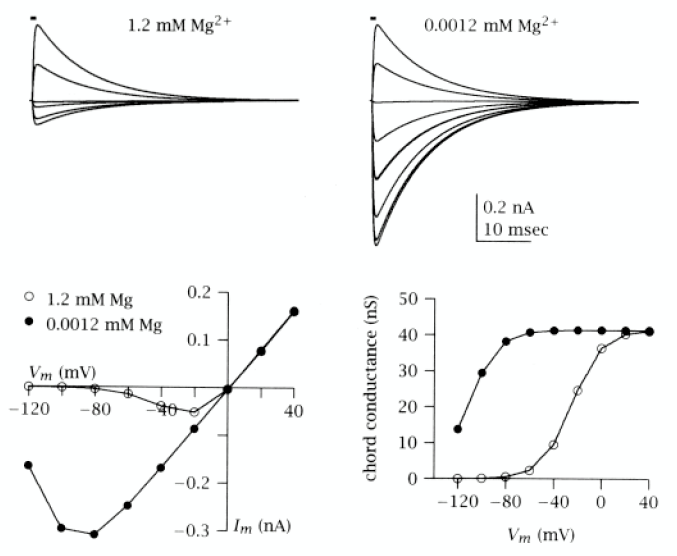
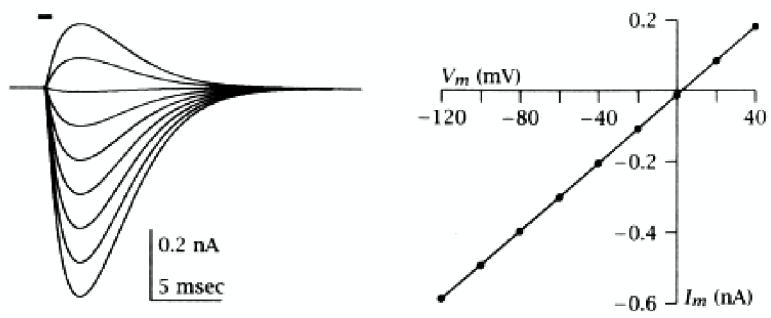
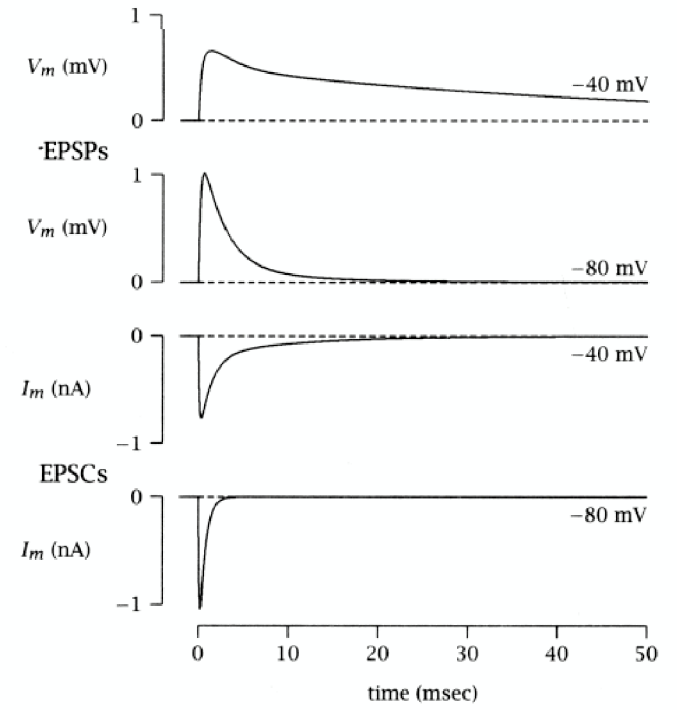
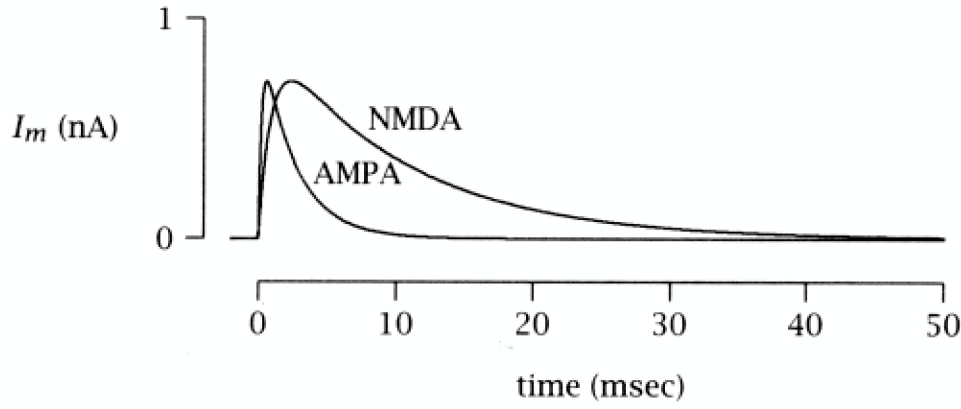
$$\begin{aligned}
 \text{PSP} &\equiv V_{\text{syn}}(t) \\
 &= \frac{1}{C_m} \int_{-\infty}^t dt' I_{\text{syn}}(t') e^{-(t-t')/\tau_m} \\
 &= \frac{1}{C_m} \int_{-\infty}^t dt' G_{\text{syn}}(t') [V_m^{\text{post}}(t') - V_{\text{syn}}] e^{-(t-t')/\tau_m} \\
 &= \frac{G_{\text{syn}}^0}{C_m} \int_{-\infty}^t dt' S^{\text{pre}}(t') [V_m^{\text{post}}(t') - V_{\text{syn}}] e^{-(t-t')/\tau_m}
 \end{aligned}$$

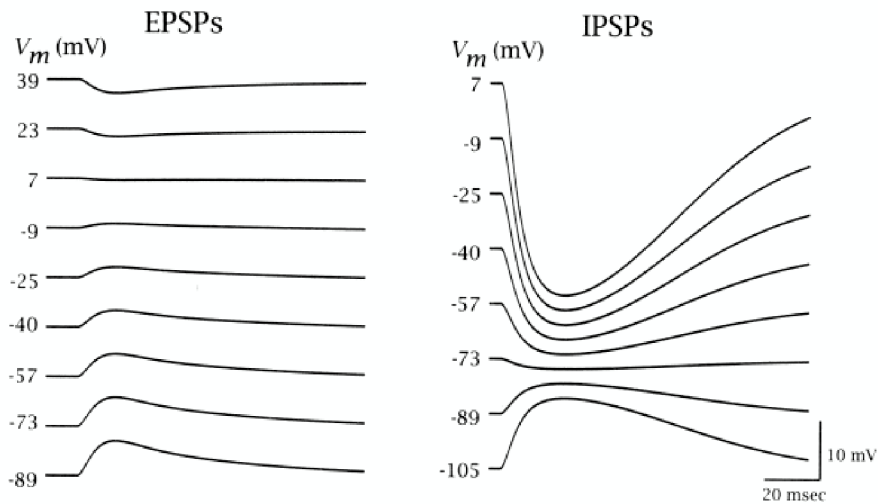


$$\begin{aligned}
 V_m(t) &= \sum_{\text{syn}} V_{\text{syn}}(t) \\
 &= \sum_{\text{presynaptic spike times, } t_s} V_{\text{syn}}(t - t_s)
 \end{aligned}$$



Mammalian CNS Excitatory Transmission

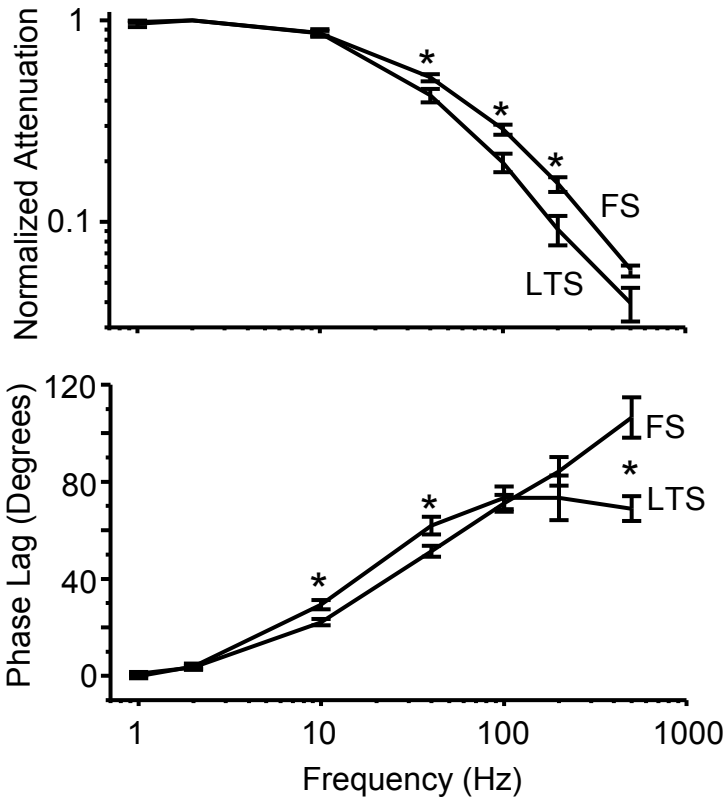
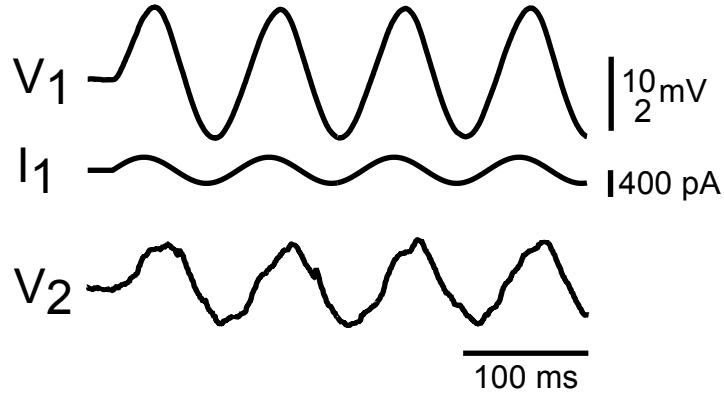




Ionotropic		
Neurotransmitter	Receptor	Ion
Glutamate	AMPA	Na ⁺ /K ⁺ /Ca ²⁺ (some)
	Kainate	Na ⁺ /K ⁺ /Ca ²⁺ (some)
	NMDA	Na ⁺ /K ⁺ /Ca ²⁺
Acetylcholine (ACh)	nicotinic	Na ⁺ /K ⁺ /Ca ²⁺ (some)
Serotonin (5-HT)	5-HT ₃	Na ⁺ /K ⁺
ATP	Purine P1	Na ⁺ /K ⁺
γ-aminobutyric acid (GABA)	A	Cl ⁻
Glycine		Cl ⁻

Metabotropic		
Neurotransmitter	Receptor	Ion
Glutamate	Quisqualate	G-coupled ↓ K ⁺
ACh	muscarinic (M1-5)	G-coupled ↓ K ⁺ (M-current), ↓ K ⁺ (AHP) ↑ K ⁺ (Inward rectifier) ↓ Cl ⁻ ↓ Ca ²⁺ (N & L), ↑ Ca ²⁺ (T)
GABA	B	G-coupled ↑ K ⁺ , ↓ Ca ²⁺ (N)
Norepinephrine (NE) (α, β)	β α α ₂	G-coupled ↓ K ⁺ (AHP), ↑ Ca ²⁺ (L & N) ↓ Ca ²⁺ (N) ↑ K ⁺
Dopamine (DA)	(D ₁ , D ₂ , ...)	G-coupled ↓ K ⁺ (AHP)
5-HT	5-HT ₂ 5-HT _{1A}	G-coupled ↓ K ⁺ (M-current) ↓ K ⁺ ↑ K ⁺
Histamine	(H ₁ , ...)	G-coupled ↓ K ⁺ (AHP)
Adenosine	(A ₁ , ...)	G-coupled ↑ K ⁺ , ↓ Ca ²⁺
Opioids (μ, δ, κ)	μ μ κ	G-coupled ↑ K ⁺ (inward rectifier) ↑ K ⁺ (voltage-dependent) ↓ Ca ²⁺
Substance P		G-coupled ↓ K ⁺ (M-current)
Somatostatin		G-coupled ↑ K ⁺ (M-current)
Bradykinin		G-coupled ↓ K ⁺ (M-current), ↓ K ⁺ (AHP)
VIP		G-coupled
Cholecystokinin		G-coupled
NPY		G-coupled ↓ Ca ²⁺ (N)
Neurotensin		G-coupled
TRH		G-coupled
Vasopressin		G-coupled
Oxytocin		G-coupled
CRF		G-coupled
LHRH		G-coupled ↓ K ⁺ (M-current)

Attenuation across electrical synapses



Bode plots, paired whole-cell, current-clamp recordings from FS and LTS inhibitory interneurons in neocortex (Gibson & Connors, unpublished)