Synaptic Transmission

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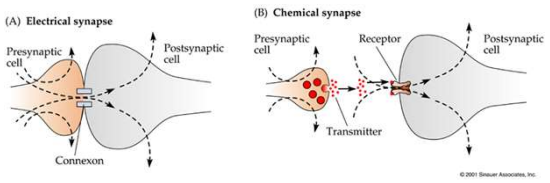
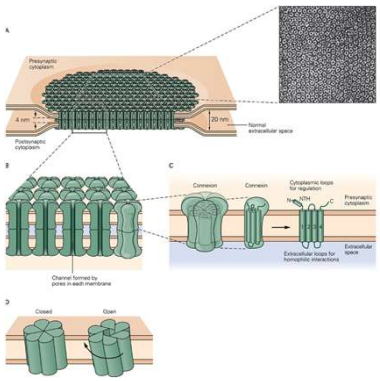
1. **Electrical vs. chemical synapses**
2. **Calcium dependence of transmitter release**
3. **Quanta release of transmitter**
4. **SNARE and vesicle release**

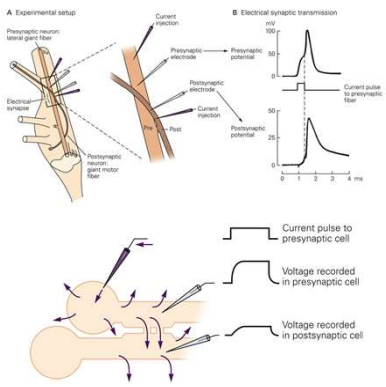
Electrical and Chemical Synapses



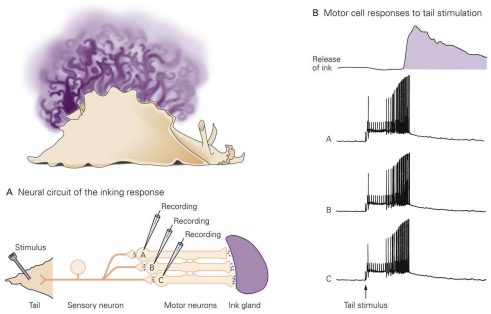
Connexin and Electrical Synapse



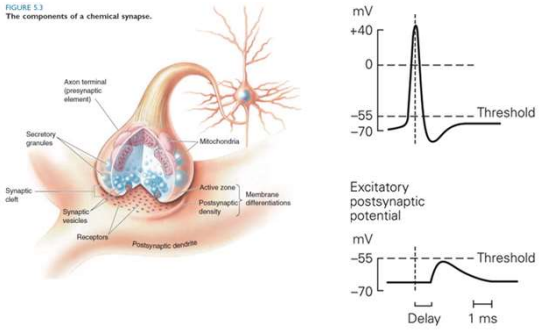
Electrical Synaptic Transmission



Synchronization by Electrical Communications



Delay of Chemical Synaptic Transmission



Features of Synaptic Transmission

Type of synapse	Distance between pre- and postsynaptic cell membranes	Cytoplasmic continuity between pre- and postsynaptic cells	Ultrastructural components	Agent of transmission	Synaptic delay	Direction of transmission
Electrical	4 nm	Yes	Gap-junction channels	Ion current	Virtually absent	Usually bidirectional
Chemical	20–40 nm	No	Presynaptic vesicles and active zones; postsynaptic receptors	Chemical transmitter	Significant: at least 0.3 ms, usually 1–5 ms or longer	Unidirectional

Chemical Synapses Are Dominant in the Brain.

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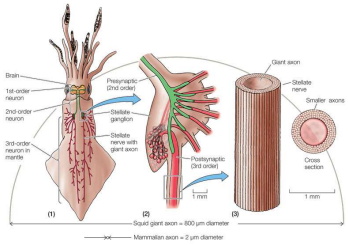
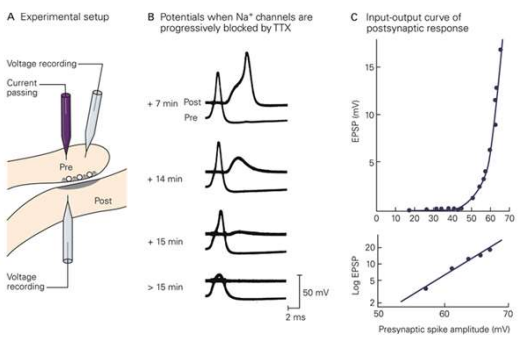
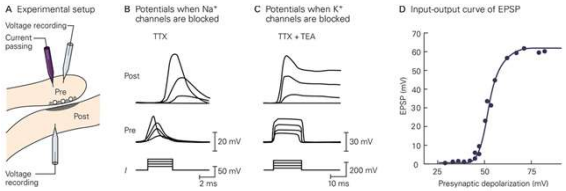
Bernard Katz (1911-2003)
Nobel Prize in Physiology or Medicine (1970)



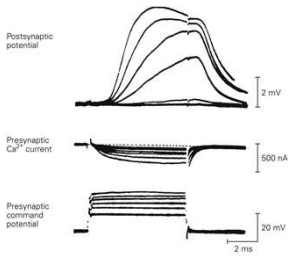
Depolarization and Transmitter Release



Independence of Na^+/K^+ in Transmitter Release



Ca^{2+} and Transmitter Release



Presynaptic Calcium Increase

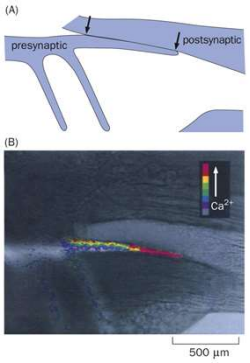
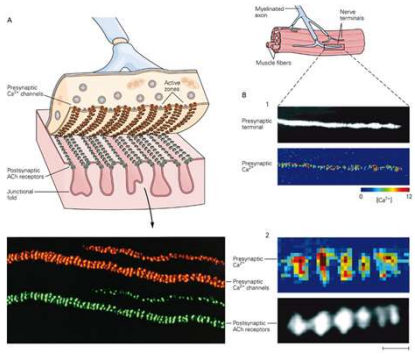


Figure 3-6 Principles of Neurobiology (© Garland Science 2016)

Active Zone at Neuromuscular Junction (NMJ)



Kinetics of Transmitter Release: Synaptic Delay

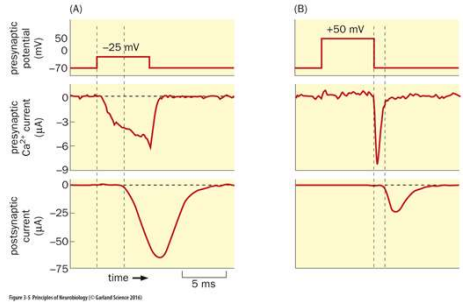
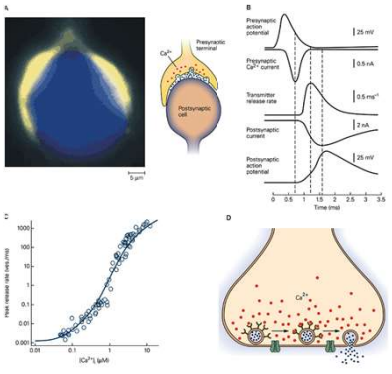


Figure 3-5 Principles of Neurobiology (© Garland Science 2016)

Central Synapse (calyx of Held)



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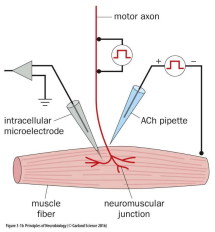
End-Plate Potential (EPP) at NMJ



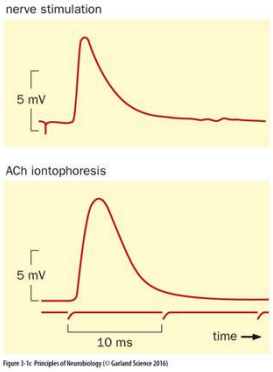
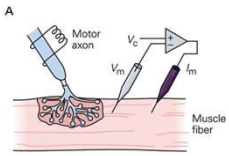
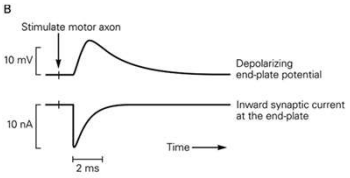


Figure 3-1c Principles of Neurobiology (© Garland Science 2016)

EPP and EPC at NMJ





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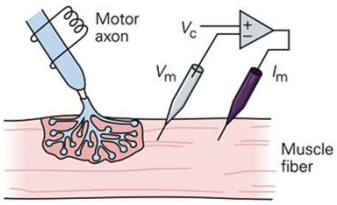
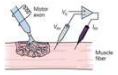
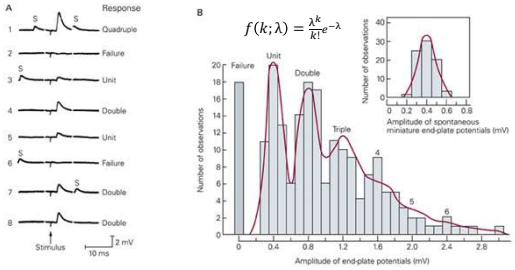


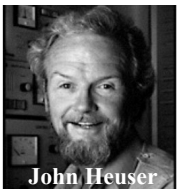


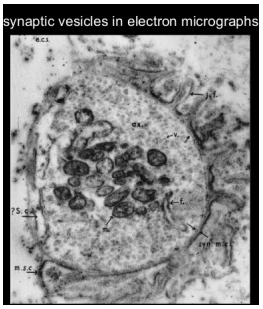
Chemical Synapses: Quantal Release



Del Castillo J and Katz B (1954). *J. Physiol.*
Liley AW (1956). *J. Physiol.*
Boyd IA and Martin AR (1956). *J. Physiol.*

Quantal Release



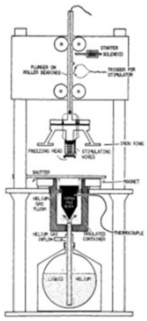


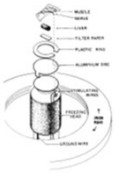
Robertson JD, 1956, J. Biophys Biochem Cytol

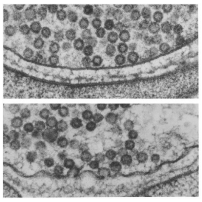
Quantal Release

Thomas S Reese **John Heuser**

Quantal Release = Vesicle Release

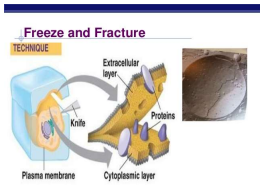


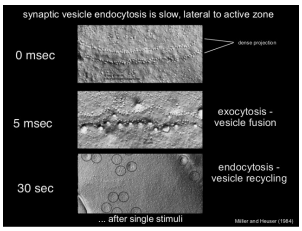




Heuser JE and Reese TS, 1981, J. Cell Biol.

Quantal Release

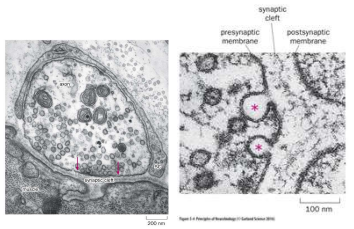




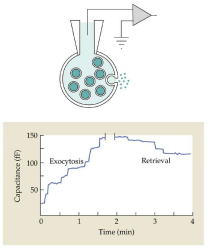
Miller TM and Reese TS, 1984, J. Cell Biol.

Quantal Release: Supporting Evidence

Synaptic Vesicles



Capacitance Increase



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2013 Nobel Prize
Physiology or Medicine

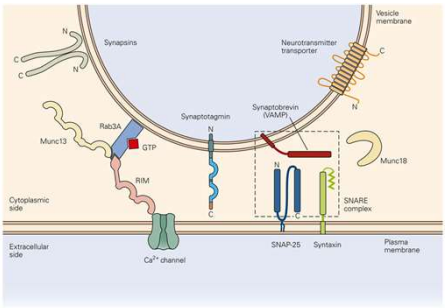
For their discoveries of machinery regulating vesicle traffic, a major transport system in our cells.

Thomas C. Südhof
Stanford University

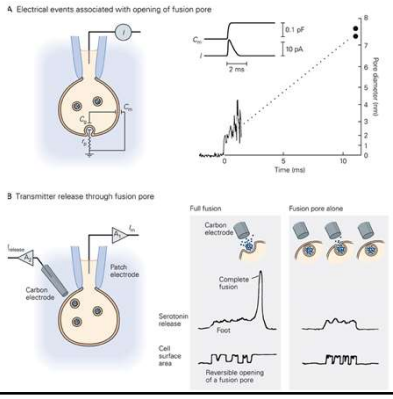
Randy W. Schekman
UC Berkerley

James E. Rothman
Yale University

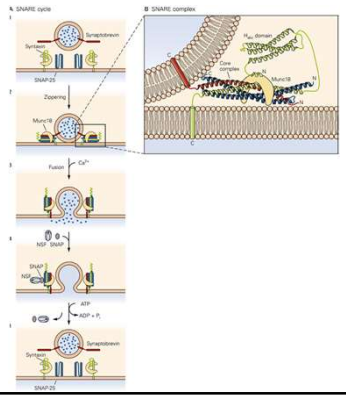
SNARE Complex



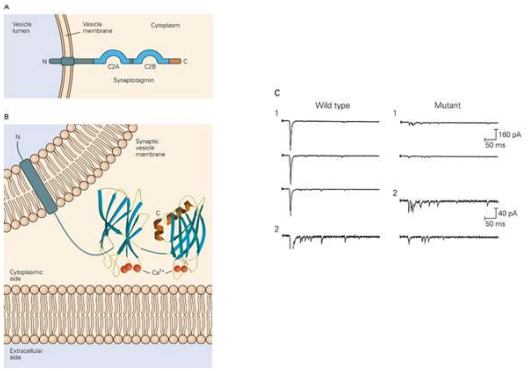
Vesicle Fusion Pore



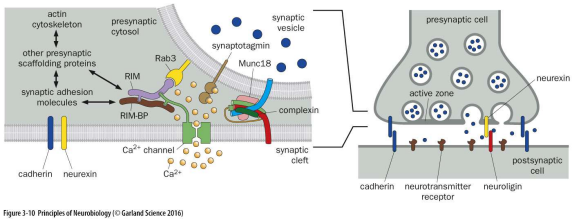
SNARE Drives Membrane Fusion



Synaptotagmin as a Ca^{2+} Sensor in Synaptic Transmission



Molecular Organization of the Presynaptic Terminal



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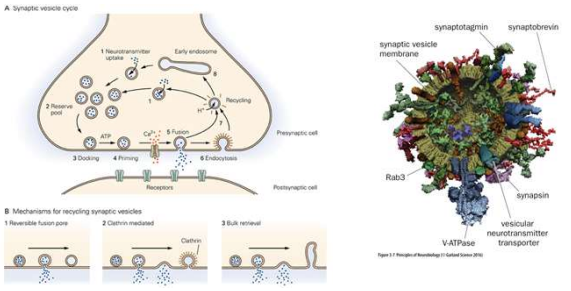
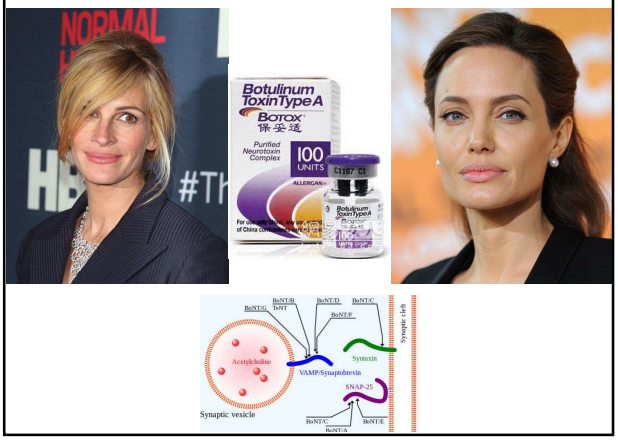
Synaptic Vesicle Cycle





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