Topic 3 – Synaptic Communication

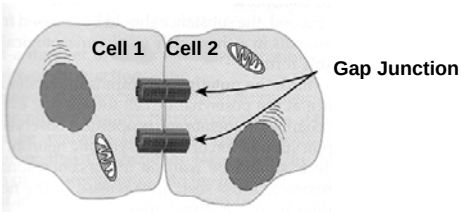
1) Types of synapses
2) Post-synaptic receptors
3) Post-synaptic potentials
4) Post-synaptic integration and summation

Types of Synapses

- Electrical (gap junctions)
- Chemical

Gap Junctions

Electrical synapses

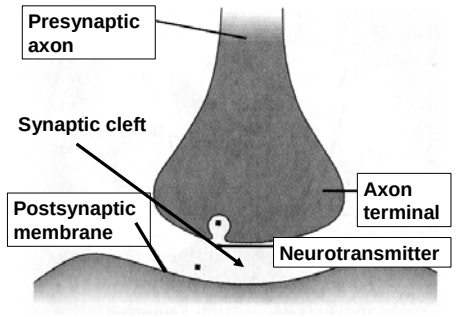


-**very small space between membranes**

-**Tubular proteins connect 2 cells**

-**Bidirectional transmission**

Chemical Synapses



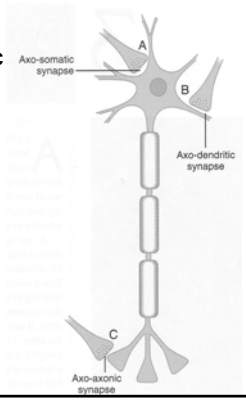
Source: Lundy-Ekman, Neuroscience: Fundamentals for Rehabilitation, Saunders, 2002

Types of Chemical Synapses

Axo-somatic

Axo-dendritic

Axo-axonic

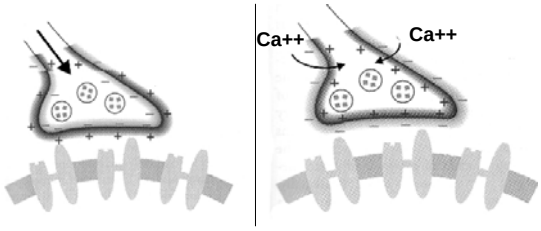


Source: Lundy-Ekman, Neuroscience: Fundamentals for Rehabilitation, Saunders, 2002

Chemical Synapses

1. AP reaches terminal

2. Ca^{++} enters

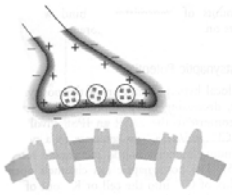


- **AP reaches bouton**
- **voltage-gated Ca2+ channels open**

Source: Lundy-Ekman, Neuroscience: Fundamentals for Rehabilitation, Saunders, 2002

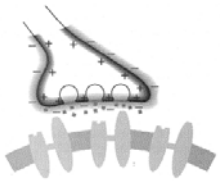
Chemical Synapses

3. vesicles move



- **vesicles contain quanta of chemical (neurotransmitter)**

4. NT release

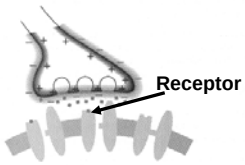


- **released by exocytosis**

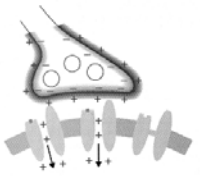
Source: Lundy-Ekman, Neuroscience: Fundamentals for Rehabilitation, Saunders, 2002

Chemical Synapses

5. NT binds to R



6. induces effect



Source: Lundy-Ekman, Neuroscience: Fundamentals for Rehabilitation, Saunders, 2002

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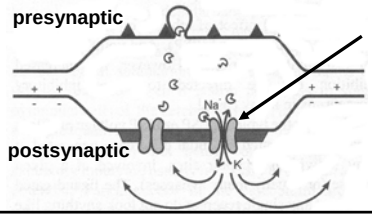
How do Neurotransmitters affect the post-synaptic neuron?

Depends on

1. Type of NT
2. Type of Receptor

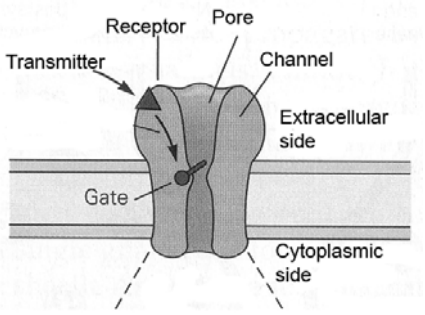
Post-synaptic Receptors

1. Ionotropic – trigger ion channels to open
2. Metabotropic – triggers an enzymatic cascade that leads to changes in membrane permeability



Source: MacKay, Neuro 101, Sefalotek Ltd., 1999

Ionotropic Receptors

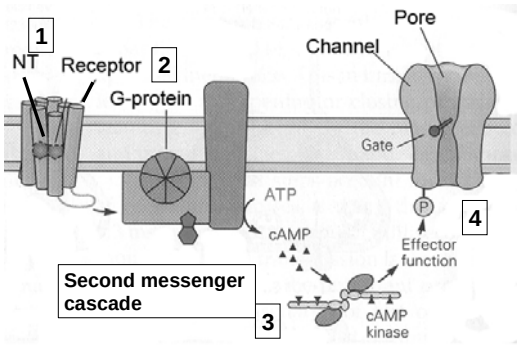


Source: Kandel et al., Principles of Neural Science, McGraw Hill, 2000

Ionotropic Receptors

- **Produces fast post-synaptic potential**
- **Main job is to either cause or inhibit an action potential**

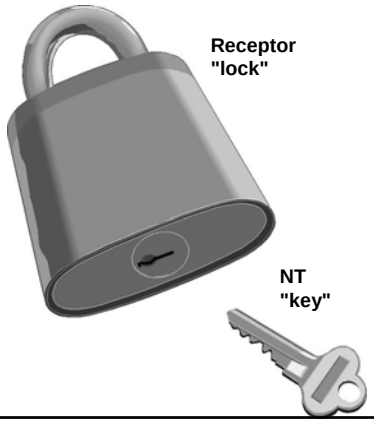
Metabotropic Receptors



Source: Kandel et al., Principles of Neural Science, McGraw Hill, 2000

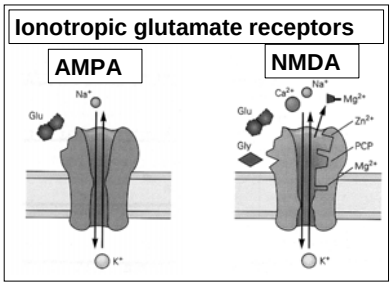
Metabotropic Receptors

- **Receptor is distinct from the channel it regulates**
- **Produces slow change**
- **Influences electrophysiological properties (“modulatory”)**



A given Neurotransmitter binds to many different receptor sub-types

→ e.g. Glutamate receptors



Source: Kandel et al., Principles of Neural Science, McGraw Hill, 2000

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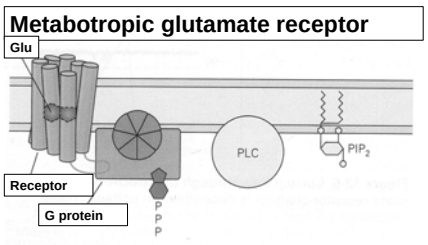

- the effect of the NT depends on the R it binds to

Source: Kandel et al., Principles of Neural Science, McGraw Hill, 2000

Topic 3 – Synaptic Communication

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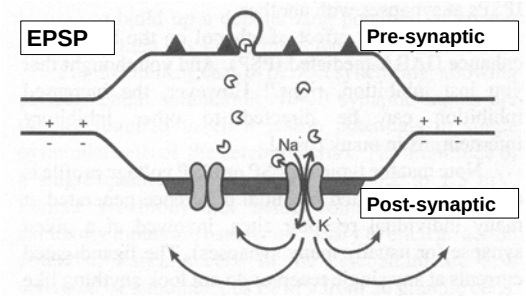
Post-Synaptic Potentials

- Binding of NT to post-synaptic Rs results in local changes in ion concentration on the post-synaptic membrane (either hyperpolarization or depolarization).

Excitatory Post-Synaptic Potential (EPSP)

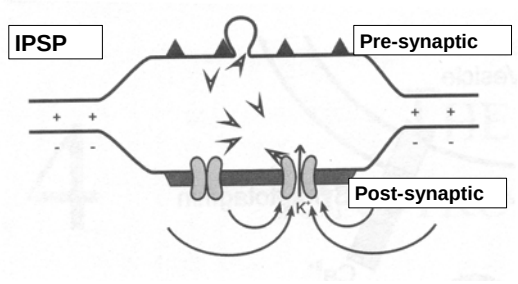
(depolarization)



Source: MacKay, Neuro 101, Sefalotek Ltd., 1999

Inhibitory Post-Synaptic Potential (IPSP)

(hyperpolarization)



Source: MacKay, Neuro 101, Sefalotek Ltd., 1999

Topic 3 – Synaptic Communication

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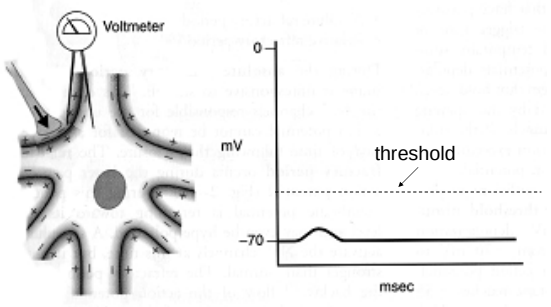
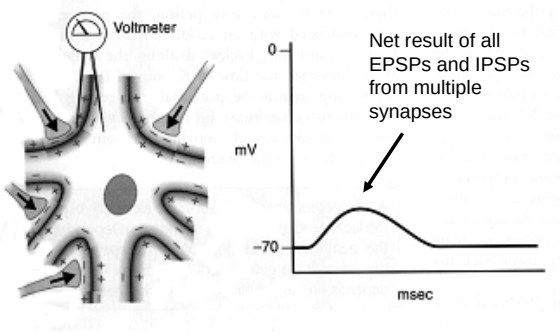
An individual EPSP isn't always enough to trigger an AP…



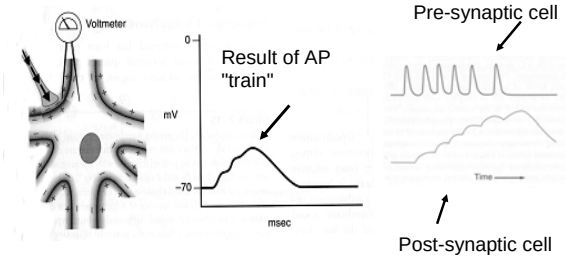
Source: Lundy-Ekman, Neuroscience: Fundamentals for Rehabilitation, Saunders, 2002

Spatial Summation



Source: Lundy-Ekman, Neuroscience: Fundamentals for Rehabilitation, Saunders, 2002

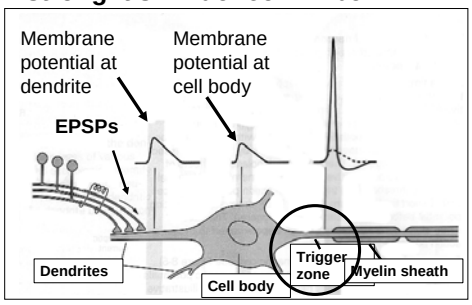
Temporal Summation



EPSP duration is in the range 5-30 ms

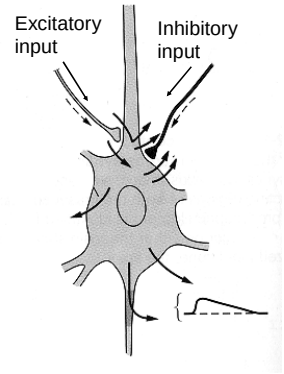
Source: Lundy-Ekman, Neuroscience: Fundamentals for Rehabilitation, Saunders, 2002

The location of an EPSP or IPSP effects how strong it's influence will be…



- **current degrades with distance**

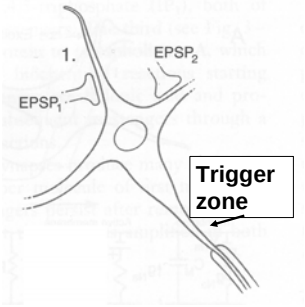
Source: Kandel et al., Principles of Neural Science, McGraw Hill, 2000



Excitatory and inhibitory currents have competitive effects.

Source: Kandel et al., Principles of Neural Science, McGraw Hill, 2000

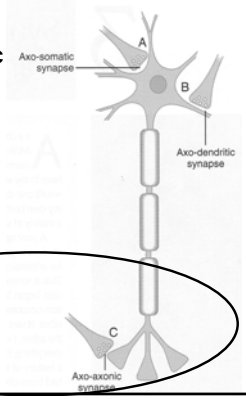
The net result of EPSP's and IPSP's summate at the trigger zone.



Source: Haines, Fundamental Neuroscience, Churchill-Livingstone, 2002

Types of Chemical Synapses

Axo-somatic

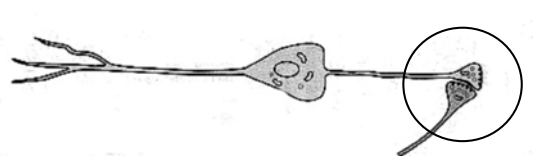


Axo-dendritic

Axo-axonic

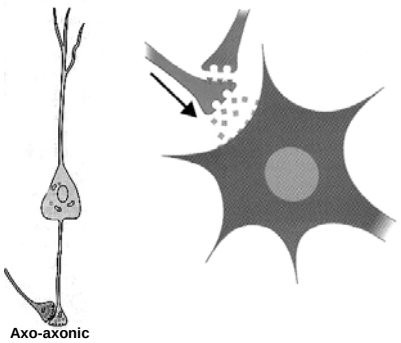
Source: Lundy-Ekman, Neuroscience: Fundamentals for Rehabilitation, Saunders, 2002

One axon can influence the amount of NT released by another…



Axo-axonic synapse

Pre-synaptic Facilitation

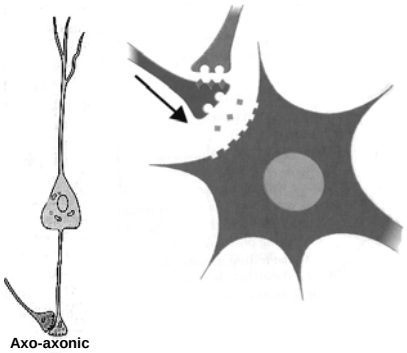


Axo-axonic synapse

- more NT released from facilitated neuron

Source: Lundy-Ekman, Neuroscience: Fundamentals for Rehabilitation, Saunders, 2002

Pre-synaptic Inhibition



Axo-axonic synapse

- less NT released from inhibited neuron

Source: Lundy-Ekman, Neuroscience: Fundamentals for Rehabilitation, Saunders, 2002