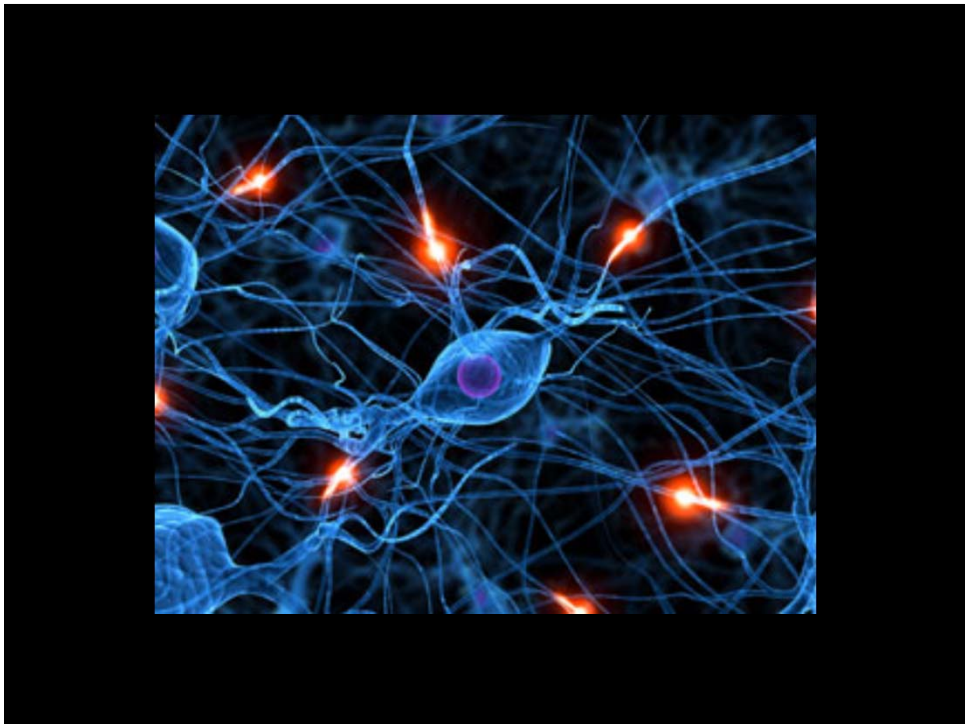
BIOL3833

Week 10: Synaptic transmission – Part 1

What's Next?

- Understanding the functional properties of *Neural Systems*
  - Examining the nature of communication between two neurons
  - Understanding the behavior of neural networks (Not as easy as many once believed)

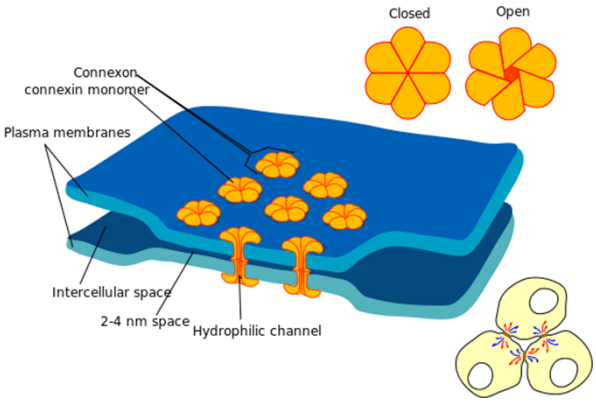


Communication between neurons

- The point of communication is the synapse
- Initial theory (1890s) was that all communication was electrical transmission
- 1920s - evidence for chemical transmission emerged
- By 1950s – acceptance of both types of synapse in the nervous system

Easiest way to transmit signal from one cell to another?

Let ions move directly between cells

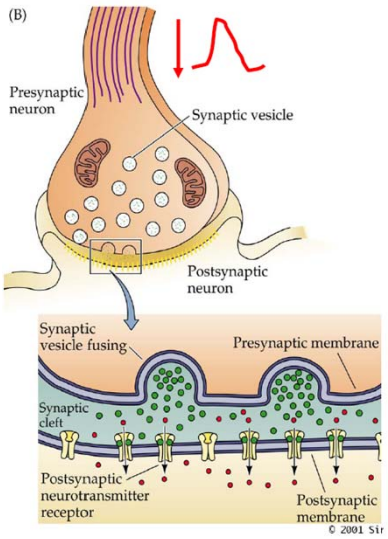


“Gap Junction” or “Electrical” synapses

- Advantages
  - Fast transmission
- Disadvantages
  - Loss of signal strength
  - Cannot change polarity
  - Restricted to voltage changes only
- Useful for
  - Synchronizing activity between neurons
  - Responses that require high speed: For example, escape

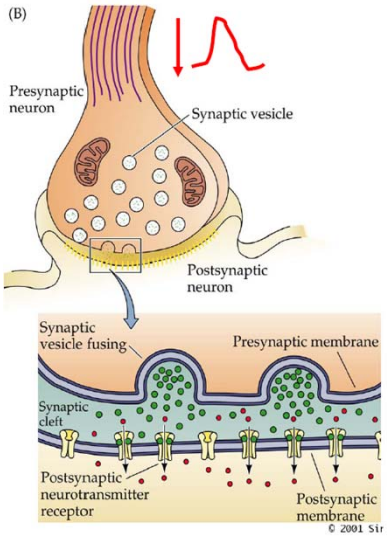
A more flexible way to transmit signal from one cell to another?

Chemical transmission



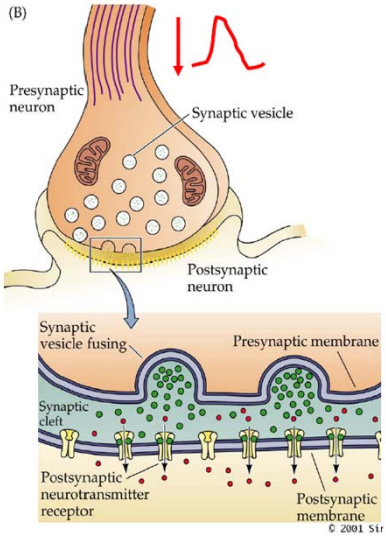
Presynaptic Events

1. Action potential invades axon terminal
2. Activates voltage gated calcium channels
3. ***Calcium influx*** *increases* ***probability*** of vesicle release
4. Vesicles are transferred to the plasma membrane at active zones
5. Vesicle fuses with membrane, releasing neurotransmitter
6. Neurotransmitter diffuses across the synaptic cleft
7. Transmitter binds to postsynaptic cell (more later)
8. Transmitter action is terminated by reuptake or enzymatic degradation



Postsynaptic events

1. Transmitter binds to receptor
2. The receptor
   1. Directly opens ion channel (ionotropic) or
   2. Activates 2nd messenger pathway (metabotropic)
3. The effects of any neurotransmitter are determined by the properties of the receptor, not the transmitter



Chemical synapses

- Advantages
  - Can amplify signals
  - Can transform signals (e.g., change polarity, duration)
  - Wide range of effects on postsynaptic cell (excite, inhibit, change metabolism, alter the function of existing ion channels, etc.)
  - Prolong the effects of the signal
- Disadvantages
  - Slower than gap junctions
- Useful for
  - All kinds of stuff

Glutamate receptors are excitatory

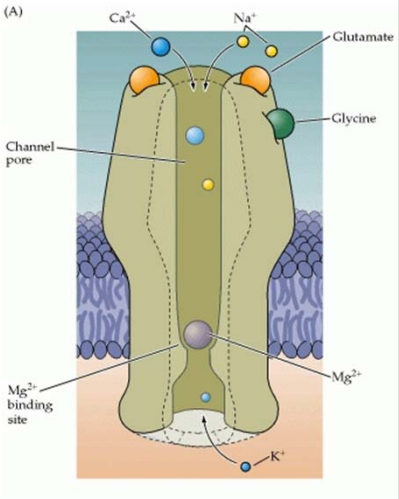
1. Most prevalent excitatory receptors in the CNS
2. Three general classes: AMPA, NMDA, and Kainate
3. Numerous variations within each class

<u>AMPA receptors:</u>

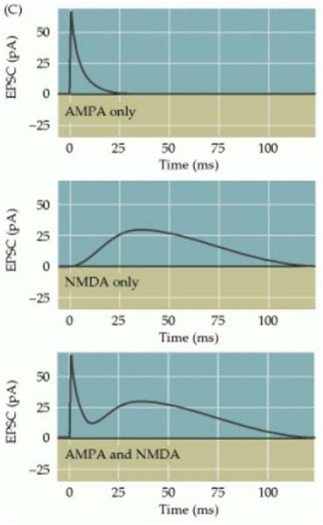
1. Fast, transient currents, permeable to sodium *and* potassium

<u>NMDA receptors</u>

1. Slow persistent currents, permeable to sodium, potassium *and* calcium
2. Require Glycine as co-transmitter
3. Magnesium block must be removed for activation



Glutamate receptor currents



What happens when receptors are permeable to more than one ion?

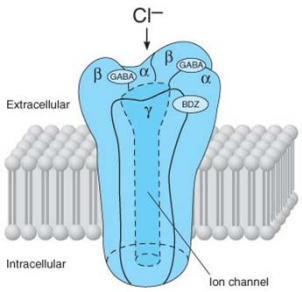
Return of the GHK Equation

- The concept of reversal potential
- Activating a particular type of receptor will move the membrane toward $E_{receptor}$
- So: activating a population of AMPA receptors will pull the membrane potential toward E_{AMPA}
- And - Just like with ion channels:

$$I_{AMPA} = (V_M - E_{AMPA})*g_{AMPA}$$

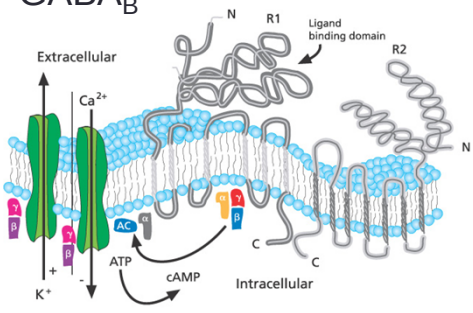
GABA receptors are inhibitory (usually)

$GABA_A$

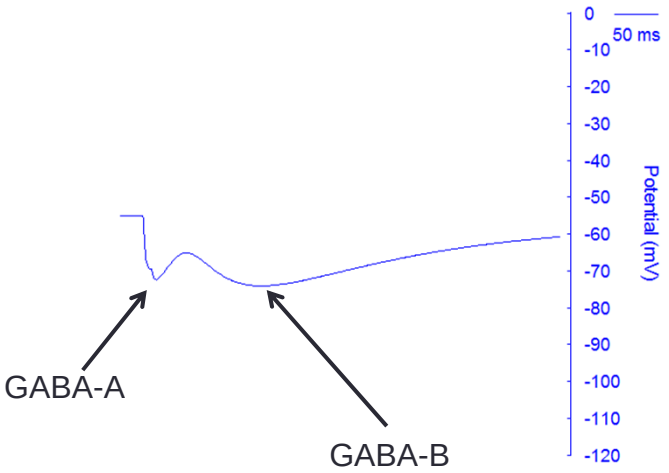


1. Ionotropic
2. Fast
3. Chloride permeable
4. *Usually* inhibitory

$GABA_B$



1. 2nd Messenger targets ion channels
2. Slow
3. Opens nearby K+ channels
4. Always inhibitory



Discuss, debate, conclude (15 minutes):

How can a receptor that opens chloride channels be excitatory?

Discuss, debate, conclude (15 minutes):

If activating a receptor depolarizes the membrane does this guarantee that the receptor is excitatory?