260-2017-02-10

Rick Gilmore

2017-02-12 11:54:38

Today's Topics

- How neurons talk to one another
- Synaptic communication

In the beginning

- Soma receives input from dendrites
- Axon hillock sums/integrates
- If sum > threshold, AP "fires"

Illustration of summation

Steps in synaptic transmission

- Rapid change in voltage triggers neurotransmitter (NT) release
- *Voltage-gated calcium Ca++ channels* open
- Ca++ causes *synaptic vesicles* to bind with presynaptic membrane, merge, *exocytosis*
- NTs diffuse across *synaptic cleft*

Steps in synaptic transmission

- NTs bind with *receptors* on *postsynaptic membrane*
- Receptors respond
- NTs unbind, are inactivated

Synaptic transmission

Exocytosis

http://dx.doi.org/doi:10.1038/nrn2948

Why do NTs move from presynaptic terminal toward postsynaptic cell?

- Electrostatic force pulls them
- Force of diffusion

Why do NTs move from presynaptic terminal toward postsynaptic cell?

- Electrostatic force pulls them
- Force of diffusion

Postsynaptic receptor types

- *Ionotropic* (receptor + ion channel)
  - Ligand-gated
  - Open/close ion channel
  - Ions flow in/out depending on membrane voltage and ion type
  - Faster, but short-acting effects

Postsynaptic receptor types

- *Metabotropic* (receptor only)
  - Trigger 2nd messengers
  - G-proteins
  - Open/close adjacent channels, change metabolism
  - Slower, but longer-lasting effects

Receptor types

Receptors generate postsynaptic potentials (PSPs)

- Small voltage changes
- Amplitude scales with # of receptors activated
- *Excitatory PSPs (EPSPs)*
  - Depolarize neuron (make more +)
- *Inhibitory (IPSPs)*
  - Hyperpolarize neuron (make more -)

NTs inactivated

- *Buffering*
  - e.g., glutamate into astrocytes (Anderson and Swanson 2000)
- *Reuptake* via *transporters*
  - molecules in membrane that move NTs inside
  - e.g., serotonin via serotonin transporter (SERT)
- *Enzymatic* degradation
  - e.g., AChE degrades ACh

Questions to ponder

- Why must NTs be inactivated?

Questions to ponder

- Why must NTs be inactivated?
  - Keeps messages discrete, localized in time and space

What sort of PSP would opening a Na+ channel produce?

- Excitatory PSP, Na+ flows in
- Excitatory PSP, Na+ flows out
- Inhibitory PSP, Na+ flows in
- Inhibitory PSP, Na+ flows out

What sort of PSP would opening a Na+ channel produce?

- Excitatory PSP, Na+ flows in
- Excitatory PSP, Na+ flows out
- Inhibitory PSP, Na+ flows in
- Inhibitory PSP, Na+ flows out

What sort of PSP would opening a Cl- channel produce?

Remember [Cl-out]>>[Cl-in]; Assume resting potential ~60 mV

- Excitatory PSP, Cl- flows in
- Excitatory PSP, Cl- flows out
- Inhibitory PSP, Cl- flows in
- Inhibitory PSP, Cl- flows out

What sort of PSP would opening a Cl- channel produce?

Remember [Cl-out]>>[Cl-in]; Assume resting potential ~60 mV

- Excitatory PSP, Cl- flows in
- Excitatory PSP, Cl- flows out
- Inhibitory PSP, Cl- flows in
- Inhibitory PSP, Cl- flows out

Types of synapses

Types of synapses

- Axodendritic (axon to dendrite)
- Axosomatic (axon to soma)
- Axoaxonic (axon to axon)
- Axosecretory (axon to bloodstream)

Synapses on

- dendrites
  - usually excitatory
- cell bodies
  - usually inhibitory
- axons
  - usually modulatory (change p(fire))

Summary of chemical transmission

Neurotransmiters

Family	Neurotansmitter
Amino acids	**Glutamate (Glu)**
	Gamma aminobutyric acid (GABA)
	Glycine
	Aspartate

Glutamate

- Primary excitatory NT in CNS
- Role in learning (via NMDA receptor)
- Transporters on neurons and glia (astrocytes and oligodendrocytes)
- Linked to umami (savory) taste sensation, think monosodium glutamate (MSG)
- Dysregulation in schizophrenia? (Javitt 2010)

Glutamate

Type	Receptor	Esp Permeable to
Ionotropic	**AMPA**	Na+, K+
	Kainate	
	NMDA	Ca++
Metabotropic	mGlu	

GABA

- Primary inhibitory NT in CNS
- Excitatory in developing CNS, [Cl-] in >> [Cl-] out
- Binding sites for benzodiazepines (e.g., Valium), barbiturates, ethanol, etc.

Type	Receptor	Esp Permeable to
Ionotropic	**GABA-A**	Cl-
Metabotropic	**GABA-B**	K+

GABA

"GABAA-receptor-protein-example" by Chemgirl131 at English Wikipedia - Transferred from en.wikipedia to Commons by Sreejithk2000 using CommonsHelper.. Licensed under Public Domain via Commons.

Next time...

- More on NTs!

References

Anderson, Christopher M., and Raymond A. Swanson. 2000. "Astrocyte Glutamate Transport: Review of Properties, Regulation, and Physiological Functions." *Glia* 32 (1). John Wiley & Sons, Inc.: 1–14. doi:10.1002/1098-1136(200010)32:1<1::AID-GLIA10>3.0.CO;2-W.

Javitt, Daniel C. 2010. "Glutamatergic Theories of Schizophrenia." *Israel Journal of Psychiatry and Related Sciences* 47 (1): 4.