THE SYNAPSE & NEUROTRANSMITTERS

1. **The Synapse**

Is the point of connection between two neurons, one the "sending" neuron and one the "receiving" neuron

Usually an **axodendritic** or **axosomatic** synapse
but can be an **axoaxonal** or **dendrodritic** synapse
presynaptic inhibition

Basic elements of a synapse: **presynaptic membrane**, **postsynaptic membrane**, **synaptic cleft, presynaptic vessicles** & **postsynaptic receptor sites** (= chemically gated channels)

Activation of the postsynaptic sites --- postsynaptic graded potentials (EPSPs & IPSPs) on surface of receiving neuron

"**directed**" vs. "**nondirected**" synapses (**axonal varicosities**)
local vs. diffuse release of NTs

2**. Receptor Site Subtypes**

Ionotropic	**Metabotrophic**
Very rapid onset of PSP	Very slow onset of PSP
Short duration PSP	Longer duration of PSP
Direct opening of ion channel	Activation of a **G-protein**, which then opens ion channel, or sends messages to nucleus via a **2nd messenger**

Postsynaptic receptor sites

Presynaptic receptor sites ("**autoreceptors**"), a feedback system
are metabotrophic

3**. Steps involved in Synaptic Transmission**

l. **synthesis** of NT molecules (in soma or axon terminal)

2**. storage** of NT molecules in vesicles

3. vesicle may need to be transported from soma to axon terminal

4. in axon terminal, any NT molecule found outside of a vesicle is subject to "attack" by enzymes (e.g. **MAO**, monoamine oxidase)

5. NT is released from vesicle into synaptic cleft via process of "**exocytosis**"
   action potential arrives down axon to axon terminal
   Ca++ ion channels open in presynaptic membrane
   Ca++ ions enter axon terminal
   Vesicle(s) nearest to presynaptic membrane move over to the membrane and fuse with it
   Cell membrane ruptures, releasing the NT molecules into the cleft
   NT molecules diffuse into cleft, some of them reaching the postsynaptic membrane & **binding temporarily to the postsynaptic receptor sites**

6. NT molecules are released from the postsynaptic receptor site and again diffuse into the cleft

7. NT molecules (a) **can rebind** to the postsynaptic receptor site, (b) can be **destroyed by enzymes in the synaptic cleft**, or (c) can be taken back into the axon terminal through the presynaptic membrane by a "**transporter" protein** and then either destroyed by MAO or restored in a vesicle for re-release

8. note: fragments of NTs found outside a neuron are taken back into the neuron and used to build new NT molecules

9. note: NT molecule released by presynaptic membrane can also bind to a **presynaptic autoreceptor** (activating a negative feedback loop that decreases the synthesis and/or release of that NT by the neuron)

10. note: name of enzyme in synaptic cleft is **COMT** (catechol-O-methly-transferase) for most NTs, **AChE** (acetlycholinesterase) for ACh

11. note: process of transporting NT back into presynaptic neuron is sometimes called “reuptake”; this is the process by which the action of most NTs on the postsynaptic receptor sites is terminated

12. note: field of **pharmacology** uses all of the above steps to design drugs that alter synaptic function --- change behavior

4. **<u>Neurotransmitters</u>**

a. Amino Acids

Glutamate
Aspartate
Glycine
GABA (gamma-aminobuteric acid)

b. Monoamines

Catecholarines: Dopamine, Norepinephrine, Epinephrine
Indolamines: Serotonin

c. Acetylcholine

d. Neuropeptides (short-chain proteins made of amino acids)

Endorphins: dynorphin, beta-endorphin, met & leu enkephalins
Pituitary peptides (corticotropin, growth hormone, oxytocin, prolactin, vasopressin)
Hypothalamic peptides (luteinizing hormone RF, somatostatin, thyrotropin RF)
GI Tract peptides (cholecystokinin, substance P, etc.)
Others (angiotensin, bradykinin, glucagon, insulin, neuropeptide Y, and many others)

d. Soluble Gases

Nitric oxide
Carbon monoxide