Introduction: Synapse Types
- Based on signal types
  - Electrical synapses
  - Chemical synapses (more common)

8.1. Electrical Synapses
- Electrical synapses are synapses pass ___________ signals (local current) from a presynaptic cell to a postsynaptic cell through a gap junction
- Where to find electrical synapses?
  - Mainly in neurons of CNS
  - In retina, certain region of cortex
  - In smooth and cardiac muscle
  - Some are between neurons and glial cells
- Components of an Electrical Synapses
  - Presynaptic cell
  - Gap junction
  - Postsynaptic cell
- Features and Functions
  - Rapid communication
    - No synaptic delay in transmission of current from cell to cell.
    - Synchronization of many cells quickly (e.g., cardiac muscle)
  - Bidirectional (some may have gated gap junctions)
  - Excitation and inhibition at same synapse

8.2. Chemical Synapses
- Chemical synapses are synapse operate through the use of ___________ called neurotransmitters (NTs) from the presynaptic cell to the postsynaptic cell
- Components of a Chemical Synapse (Figure 8.2)
  - Presynaptic neuron
  - Synaptic cleft
  - Postsynaptic neuron
- Features of a Chemical Synapse
  - Unidirectional
  - Synaptic delay
    - 0.5–5 msec between arrival of AP and change in postsynaptic Vm
    - Caused by the influx of Ca²⁺ to trigger the exocytosis of neurotransmitter
- Neuron-to-Neuron Chemical Synapses Types (Figure 8.1)
  - ________________ synapses
  - ________________ synapses
  - ________________ synapses
- Communication across a Synapse (Figure 8.2)
  1. An AP arrives at the axon terminal of the presynaptic cell. It depolarizes the axon terminal.
  2. Voltage-gated Ca²⁺ channels open
  3. Influx of Ca²⁺ triggers the exocytosis of NT
  4. NT diffuses across the synaptic cleft and binds to receptor in postsynaptic cell
5. Response produced by the postsynaptic cell
Response terminated by removing NT from synaptic cleft via
6. Degradation: Enzyme breaks down NT
7. Reuptake: NT is taken up by the presynaptic cell
8. Diffusion: NT or degraded NT moves away from the synaptic cleft

- **Signal Transduction Mechanisms at Chemical Synapses**
  - Signal transduction is the process by which the binding of chemical messenger to receptors triggers a response in a target cell.

- **NT Receptors on the Postsynaptic Membrane**
  - Channel-linked (or Ionotropic) receptors: fast response (Figure 8.3a)
    - Ligand-gated channels
  - G-protein linked (or metabotropic) receptors: slow response (Figure 8.3 b)
    - G-protein mediated
    - Direct coupling (Figure 8.3 b):
      - Second messenger system (Figure 8.3 c)

- **Postsynaptic Potential (PSP)**
  - Change in membrane potential in response to receptor-neurotransmitter binding
  - Graded potential
  - Depolarization: Excitatory postsynaptic potential (EPSP)
  - Hyperpolarization: Inhibitory postsynaptic potential (IPSP)

- **Excitatory and Inhibitory Neurotransmitter**
  - Most common excitatory neurotransmitter: glutamate
  - Most common inhibitory neurotransmitter: GABA

- **Excitatory Synapses Mechanism (Figure 8.4)**
  - At fast excitatory synapses (Figure 8.4 a)
    - K⁺ moves out, more Na⁺ moves in
    - Net effect: depolarization
  - At slow excitatory synapses (Figure 8.4 b)
    - Many mechanisms
    - A typical one is the closing of leakage K⁺ channels, less potassium leak out, depolarization occurs

- **Inhibitory Synapses Mechanism**
  - Neurotransmitter binds to receptor
    - Channels for either K⁺ or Cl⁻ open
      - If K channels open: K⁺ moves out → IPSP (Figure 8.5)
      - If Cl⁻ channels open, Cl⁻ moves in → IPSP (Figure 8.6). Cl⁻ stabilizes membrane potential

8.3. Neural Integration
- The summing of input from various synapses at the _______ _________ of the postsynaptic neuron to determine whether the neuron will generate action potentials

- **Divergence and Convergence**
  - In divergence, a single neuron communicates with several other neurons
  - In convergence, a neuron receives signals from other neurons.
  - Which diagram depicts divergence in Figure 8.7? _____ (a or b)

- **Summation**
  - IPSPs and EPSPs are graded potentials and can be summed
  - Types of summation (Chapter 7 or Figure 8.8)
• **Frequency Coding**
  o The degree of depolarization at the axon hillock is signaled by the frequency of action potentials
  o More action potentials result in more neurotransmitter released and, consequently, a greater IPSP or EPSP in the next neuron

8.4. **Presynaptic Modulation**
  • The regulation of communication across a synapse
    o __________ synapses function as modulatory synapses
    o Presynaptic facilitation (Figure 8.9 a): The release of neurotransmitter is __________ under the influence of the modulating neuron.
    o Presynaptic inhibition (Figure 8.9 b): The release of neurotransmitter is __________ under the influence of the modulating neuron.

8.5. **Neurotransmitters: Structure, Synthesis, and Degradation**
  • **Neurotransmitters (Table 8.1)**
    o Are chemical messengers of neurons
    o Communicate by binding to specific receptors.
    o Produce different responses depending on receptor types and signal transduction pathway
  • **Acetylcholine (Figure 8.10)**
    o Found in PNS and CNS; most abundant in PNS
    o Cholinergic receptors (Figure 8.11)
      - Nicotinic
      - Muscarinic
  • **Biogenic Amines**
    o Are derived from amino acids.
    o Contains an amine group
    o Are made in the cytosol of the axon terminal and packaged in synaptic vesicles
  • **Amino Acid Neurotransmitters**
    o At excitatory synapses
      - Aspartate and glutamate
    o At inhibitory synapses
      - Glycine
      - GABA (gamma-aminobutyric acid)
        - Most commonly released in the CNS
        - Alcohol enhances the action of GABA by opening up chloride channels.
  • **Neuropeptides**
    o Short chains of amino acids
    o Most are co-located with other neurotransmitters
    o Modulate response caused by other neurotransmitter of co-location
      - Vasopressin
  • **Other Neurotransmitters**
    o Purines: ATP
    o Gas: NO=nitric oxide