

# 11

Fundamentals of the Nervous System  
and Nervous Tissue: Part C

## The Synapse

- A junction that mediates information transfer from one neuron:
  - To another \_\_\_\_\_, or
  - To an effector cell

## The Synapse

- Presynaptic neuron—conducts impulses \_\_\_\_\_ the synapse
- Postsynaptic neuron—transmits impulses \_\_\_\_\_ from the synapse

## Synaptic Cleft

- Fluid-filled \_\_\_\_\_ separating the presynaptic and postsynaptic neurons
- Prevents nerve impulses from directly passing from one neuron to the next

## Synaptic Cleft

- Transmission across the synaptic cleft:
  - Is a \_\_\_\_\_ event (as opposed to an electrical one)
  - Involves release, diffusion, and binding of \_\_\_\_\_
  - Ensures unidirectional communication between neurons

## Termination of Neurotransmitter Effects

- Within a few milliseconds, the neurotransmitter effect is \_\_\_\_\_
  - Degradation by enzymes
  - Reuptake by astrocytes or axon terminal
  - Diffusion away from the synaptic cleft

## Synaptic Delay

- Neurotransmitter must be released, diffuse across the synapse, and \_\_\_\_\_ to receptors
- Synaptic delay—time needed to do this (0.3–5.0 ms)
- Synaptic delay is the rate-limiting step of neural transmission

## Neurotransmitters

- Most neurons make two or more neurotransmitters, which are released at different stimulation frequencies
- \_\_\_\_\_ or more neurotransmitters have been identified
- Classified by chemical structure and by function

### Chemical Classes of Neurotransmitters

- Acetylcholine (ACh)
  - Released at neuromuscular junctions and some ANS neurons
  - Synthesized by enzyme choline acetyltransferase
  - Degraded by the enzyme acetylcholinesterase (AChE)

### Chemical Classes of Neurotransmitters

- Biogenic amines include:
  - Catecholamines
    - Dopamine, norepinephrine (NE), and epinephrine
  - Indolamines
    - Serotonin and histamine
- Broadly distributed in the brain
- Play roles in emotional behaviors and the biological clock

### Chemical Classes of Neurotransmitters

- Amino acids include:
  - GABA—Gamma ( $\gamma$ )-aminobutyric acid
  - Glycine
  - Aspartate
  - Glutamate

### Chemical Classes of Neurotransmitters

- Peptides (neuropeptides) include:
  - Substance P
    - Mediator of pain signals
  - Endorphins
    - Act as natural opiates; reduce pain perception
  - Gut-brain peptides
    - Somatostatin and cholecystokinin

## Chemical Classes of Neurotransmitters

- Purines such as ATP:
  - Act in both the CNS and PNS
  - Produce fast or slow responses
  - Induce  $\text{Ca}^{2+}$  influx in astrocytes
  - Provoke pain sensation

## Chemical Classes of Neurotransmitters

- Gases and lipids
  - Nitric oxide (NO)
    - Synthesized on demand
    - Activates the intracellular receptor guanylyl cyclase to cyclic GMP
    - Involved in learning and memory
  - Carbon monoxide (CO) is a regulator of cGMP in the brain

## Chemical Classes of Neurotransmitters

- Gases and lipids
  - Endocannabinoids
    - Lipid soluble; synthesized on demand from membrane lipids
    - Bind with G protein-coupled receptors in the brain
    - Involved in learning and memory

## Functional Classification of Neurotransmitters

- Neurotransmitter effects may be excitatory (depolarizing) and/or inhibitory (hyperpolarizing)
  - Determined by the receptor type of the postsynaptic neuron
  - GABA and glycine are usually inhibitory
  - Glutamate is usually excitatory
  - Acetylcholine
    - Excitatory at neuromuscular junctions in skeletal muscle
    - Inhibitory in cardiac muscle

## Neurotransmitter Actions

- Direct action
  - Neurotransmitter binds to channel-linked receptor and opens ion channels
  - Promotes rapid responses
  - Examples: ACh and amino acids

## Neurotransmitter Actions

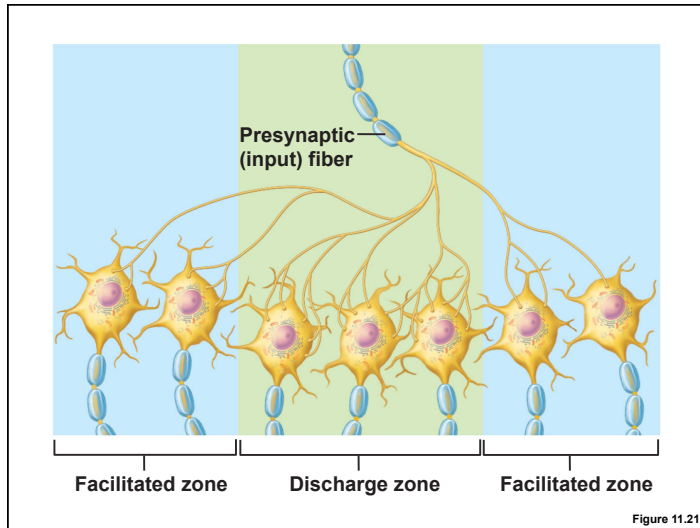
- Indirect action
  - Neurotransmitter binds to a G protein-linked receptor and acts through an intracellular second messenger
  - Promotes long-lasting effects
  - Examples: biogenic amines, neuropeptides, and dissolved gases

## Neural Integration: Neuronal Pools

- Functional groups of neurons that:
  - \_\_\_\_\_ incoming information
  - Forward the processed information to other destinations

## Neural Integration: Neuronal Pools

- \_\_\_\_\_ neuronal pool
  - Single presynaptic fiber branches and synapses with several neurons in the pool
  - Discharge zone—neurons most closely associated with the incoming fiber
  - Facilitated zone—neurons farther away from incoming fiber

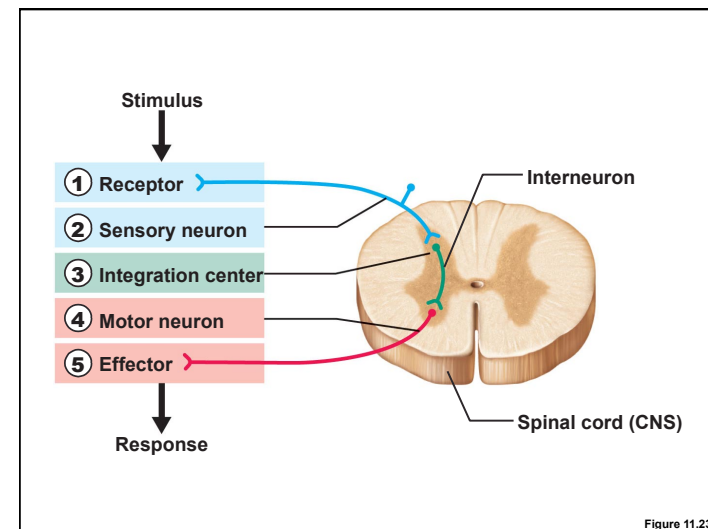


## Patterns of Neural Processing

- \_\_\_\_\_ processing
  - Input travels along one pathway to a specific destination
  - Works in an all-or-none manner to produce a specific response

## Patterns of Neural Processing

- \_\_\_\_\_ processing
  - Example: reflexes—rapid, automatic responses to stimuli that always cause the same response
  - Reflex arcs (pathways) have five essential components: receptor, sensory neuron, CNS integration center, motor neuron, and effector



## Patterns of Neural Processing

- \_\_\_\_\_ processing
  - Input travels along several pathways
  - One stimulus promotes numerous responses
  - Important for higher-level mental functioning
- Example: a smell may remind one of the odor and associated experiences

## Developmental Aspects of Neurons

- The nervous system originates from the neural tube and neural crest formed from \_\_\_\_\_
- The neural tube becomes the \_\_\_\_\_
  - Neuroepithelial cells of the neural tube undergo differentiation to form cells needed for development
  - Cells (neuroblasts) become amitotic and migrate
  - Neuroblasts sprout axons to connect with targets and become neurons

## Axonal Growth

- Growth cone at tip of axon interacts with its environment via:
  - Cell surface adhesion proteins (laminin, integrin, and nerve cell adhesion molecules or N-CAMs)
  - Neurotrophins that attract or repel the growth cone
  - Nerve growth factor (NGF), which keeps the neuroblast alive
- \_\_\_\_\_ provide physical support and cholesterol essential for construction of synapses

## Cell Death

- About 2/3 of neurons \_\_\_\_\_ before birth
  - Death results in cells that fail to make functional synaptic contacts
  - Many cells also die due to \_\_\_\_\_ (programmed cell death) during development