

Warm Up!

Take out your 11C Notes

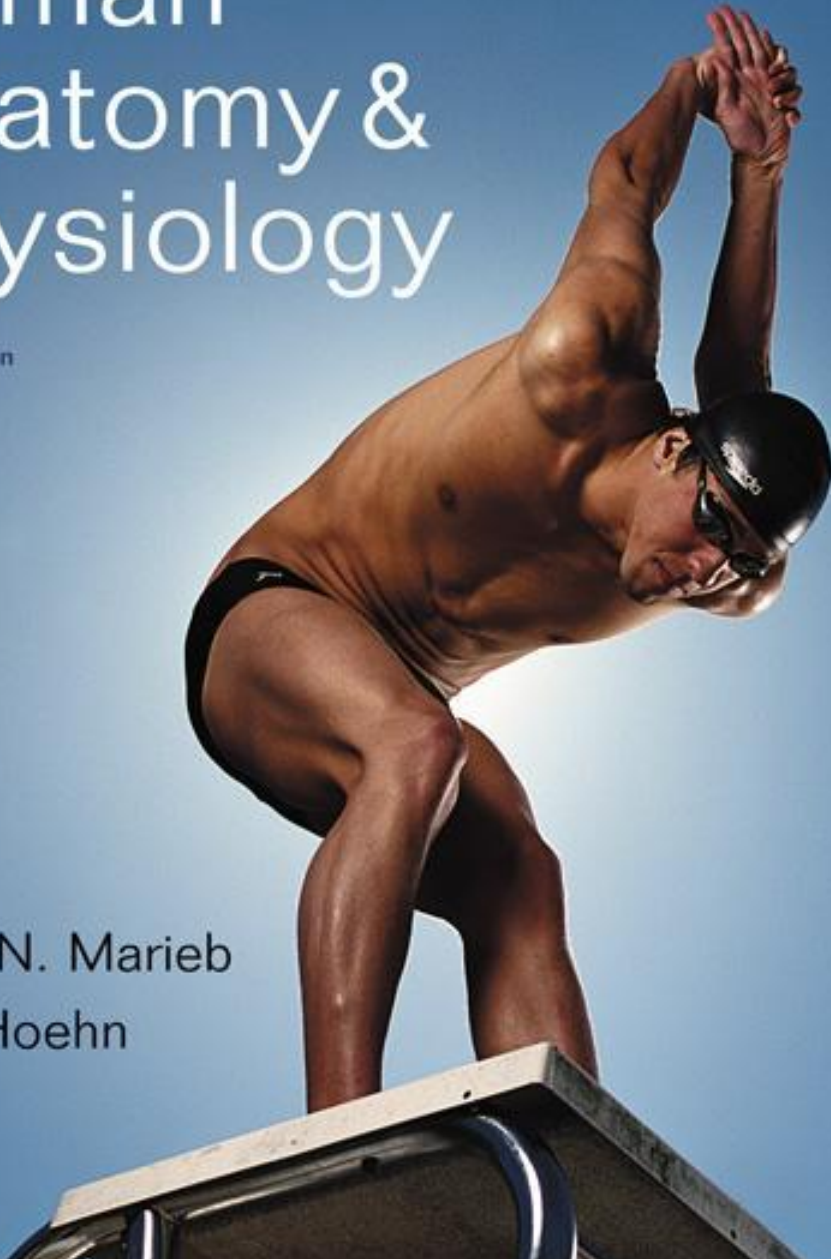
What are the 6 types of **neuroglia** and their functions?!

Astrocytes	Support, brace, & nutrient transfer
Microglia	Clean up crew!
Ependymal Cells	Ciliated - filter fluid
Satellite Cells	No function!
Schwann Cells	Myelin in the PNS
Oligodendrocytes	Myelin in the CNS

Human Anatomy & Physiology

Eighth Edition

Elaine N. Marieb
Katja Hoehn



PowerPoint® Lecture Slides
prepared by
Janice Meeking,
Mount Royal College

CHAPTER 11

Fundamentals of the Nervous System and Nervous Tissue: Part C

Chemical Classes of Neurotransmitters

Acetylcholine	Muscle Contraction
Biogenic Amines	Behavior/ Biological Clock
Amino Acids	Excitatory/ Inhibitory
Peptides	Reduce pain perception
Purines	Provoke pain perception
Gases and Lipids	Learning and memory

The Synapse

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

The Synapse

- Presynaptic neuron—conducts impulses toward the synapse
- Postsynaptic neuron—transmits impulses away from the synapse

PLAY

Animation: Synapses

Synaptic Cleft

- Fluid-filled space 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 chemical event (as opposed to an electrical one)
 - Involves release, diffusion, and binding of neurotransmitters
 - Ensures unidirectional communication between neurons

Termination of Neurotransmitter Effects

- Within a few milliseconds, the neurotransmitter effect is terminated
 - 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 bind 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
- 50 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 (γ)-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 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

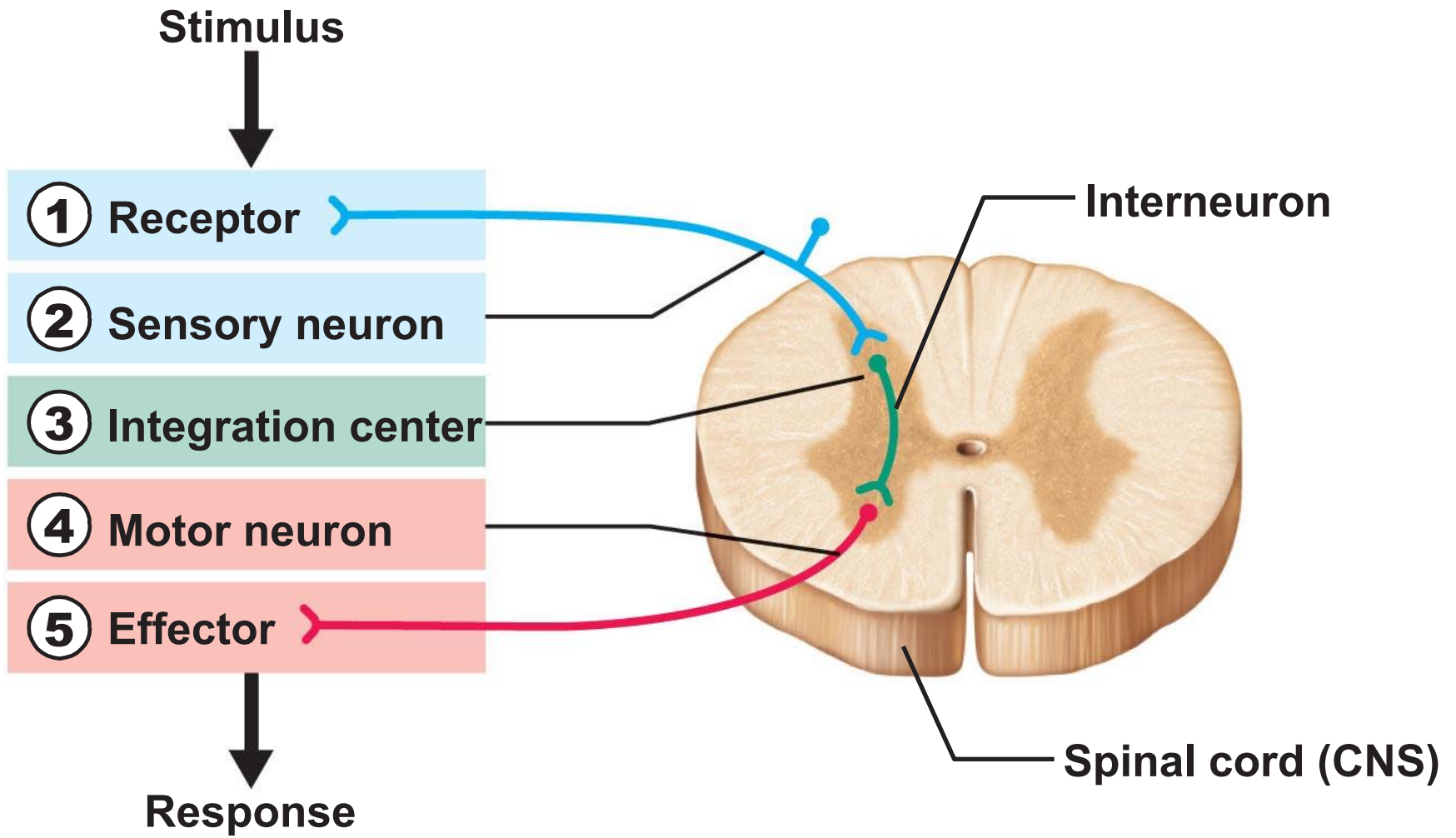
- Indirect action
 - Neurotransmitter binds to a G protein-linked receptor and acts through an intracellular second messenger
 - Promotes long-lasting effects
 - Examples: biogenic amines, neuropeptides, and dissolved gases

Patterns of Neural Processing

- Serial (or Linear) 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

- Serial 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

- Parallel 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 ectoderm
- The neural tube becomes the CNS
 - 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)
 - Neurotropins that attract or repel the growth cone
 - Nerve growth factor (NGF), which keeps the neuroblast alive
- Astrocytes provide physical support and cholesterol essential for construction of synapses

Cell Death

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