BIO 211; Anatomy and Physiology I — Dr. Lawrence Altman
REFERENCE: ***Hole's CHAPTER 11*** **(10th edition)** — Naugatuck Valley Community College

LECTURE TOPICS OUTLINE

NERVOUS SYSTEM II (2 of 3)

PERIPHERAL NERVOUS SYSTEM & REFLEXES

I. NERVES, NERVE FIBERS, AND GANGLIA

A. Anatomy of a Nerve See Hole's TEXT: Figure 11.23, p.397 (10th edition for helpful diagram).

1. A **nerve** is an organ composed of *multiple* nerve fibers bound together by sheaths of connective tissue.
2. The sheath *adjacent to the neurilemma* is the **endoneurium**, which houses blood capillaries that feed nutrients and oxygen to the nerve.
3. In large nerves, fibers are bundled into **fascicles**, and wrapped in a fibrous **perineurium**.
4. The *entire* nerve is covered with a fibrous **epineurium.**

B. Functional Classes of Nerve Fibers and Nerves

1. **Fibers** are classified for the direction in which signals are transmitted (**afferent** and **efferent**), the types of organs they innervate (somatic and visceral), and for how widespread or local the distribution of innervated organs (general or special). Remember **S-A-M-E!**
2. **Mixed nerves** contain both motor and sensory fibers. Sensory nerves (optic and olfactory) contain mostly sensory fibers. Motor nerves contain motor fibers.

C. Ganglia

A **ganglion** is a *cluster* of nerve cell bodies generally **outside the CNS.**

II. THE CRANIAL NERVES

1. The **cranial nerves** emerge from the base of the brain and lead to muscles and sense organs located in the head and neck for the most part. There are **twelve pairs.**
2. Each of the twelve pairs of cranial nerves is listed and described in Hole: **Table 11.9, p. 402**, as mentioned before. Recall that the spinal and cranial nerves are *NOT* part of the CNS.

III. THE SPINAL NERVES **(See slide 18 in the Ch 11-a Slideshow; AND next page here)**

A. There are **31 pairs of spinal nerves**: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal.

B. Proximal Branches

1. Each **spinal nerve** branches into a **dorsal root** and a **ventral root**.
   The **dorsal root ganglion** is occupied by **cell bodies** from afferent neurons.
   The convergence (coming together) of dorsal and ventral roots forms the **spinal nerve**.
2. The **cauda equina** is formed by the roots arising from segments L2 to Cx of the spinal region.

C. Distal Branches

1. After emerging from the vertebral column, the spinal nerve divides into a **dorsal root**, and **ventral root**, and a small meningeal branch that leads to the meninges and vertebral column.
2. The **dorsal ramus** innervates the **muscles and joints of the spine and the skin of the back.**
3. The **ventral ramus** innervates the **ventral and lateral skin and muscles of the trunk,** ***plus gives rise to nerves leading to the extremities.***

D. Nerve Plexuses

The **ventral rami** merge to form **nerve plexuses** (networks) in all areas (except thoracic region). These nerve plexuses are defined on pages 405 (just know as **cervical**, **brachial**, **lumbosacral**).

E. Cutaneous Innervation and Dermatomes

Each spinal nerve except C-1 receives sensory input from a specific area of skin (**dermatome**).

SPINAL CORD

Gives rise to 31 pairs of SPINAL NERVES,
From foramen magnum to 2nd lumbar vertebra;
(end = **conus medullaris**);
Pia mater continues as **filum terminale**; attaches to coccyx.
Spinal nerves extending downward from conus: **cauda equina**.

Two SC bulges: Cervical (nerves to arms), Lumbar (nerves to legs).
Two grooves that extend length of Spinal cord
1.) **anterior medial fissure** (deeper), 2) **posterior median sulcus**

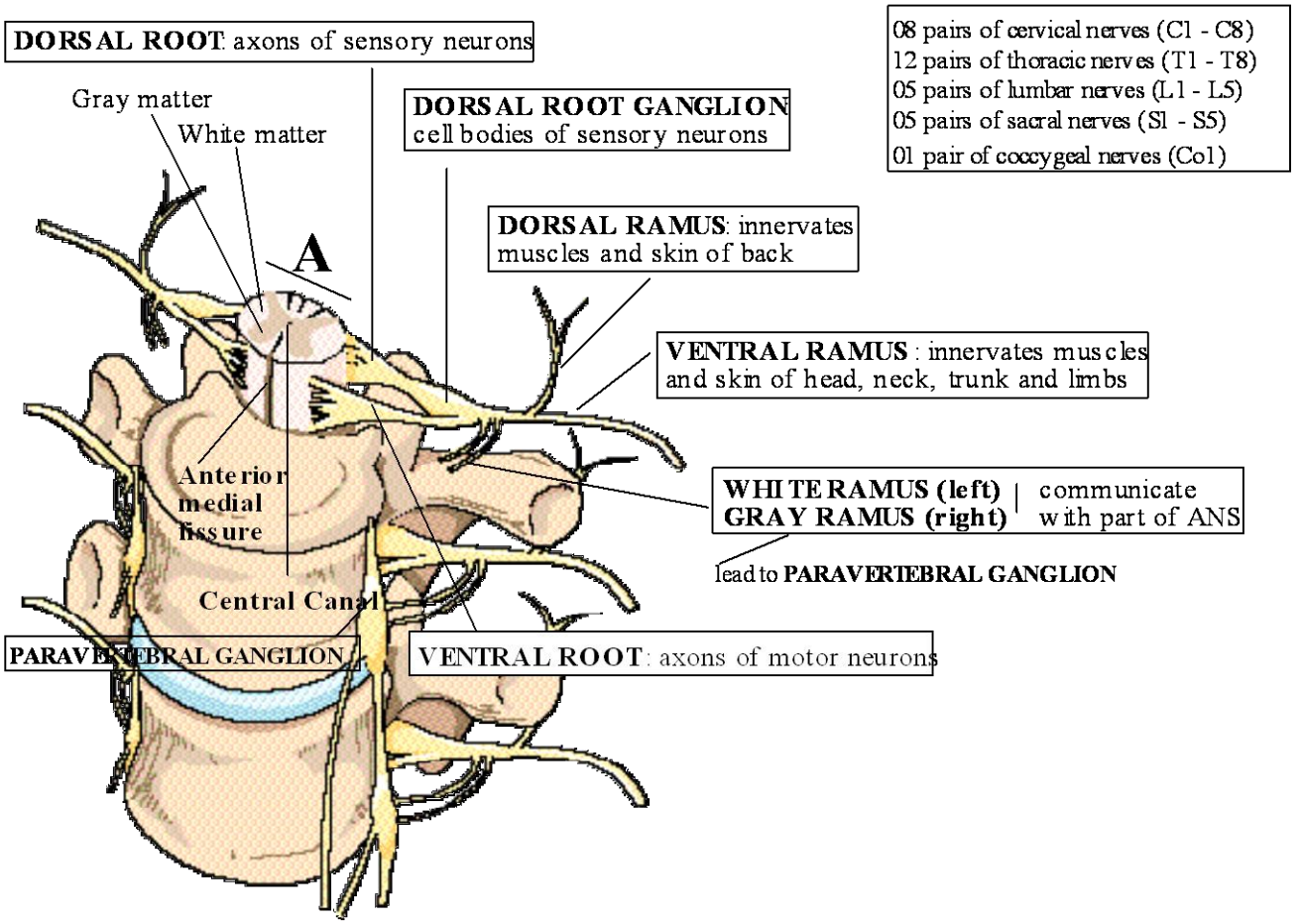
Central canal: continuous with brain ventricles (contains CSF fluid).

Cross-section of spinal cord (SC): See A *on diagram below*
Butterfly shape:
gray matter (unmyelinated cell bodies + axons + dendrites).
Central canal is in the center of the gray matter.
Surrounding gray matter: **white matter** (myelinated axons).

Spinal Cord Functions: impulse conduction, spinal reflexes.

Impulse Conduction
- Ascending tracts : SC to brain.
- Descending tracts : brain to SC.
- Spinal nerves : to/from body.

SC is divided into 31 segments - each giving rise to a pair of spinal nerves. Each pair (except first) monitors a specific region on surface of body called a **dermatome** (30), Clinically significant: damage to spinal nerves will produce a characteristic loss of sensation in skin.



IV. SOMATIC REFLEXES (Examples)

A. The Nature of Reflexes

1. **Reflexes** are quick, involuntary, stereotyped reactions of **peripheral effectors** to stimulation.
2. A spinal reflex is made up of a **reflex arc**, including ***somatic receptors, afferent nerve fibers, interneurons (association neurons), efferent nerve fibers, and skeletal muscles***.

B. The Stretch Reflex

1. When a muscle is stretched, it contracts to maintain **tone**. This is the stretch reflex.
2. The **tendon reflex** (knee jerk) is an example of a **monosynaptic reflex arc**.

C. The Golgi Tendon Reflex

1. **Golgi tendon organs** are located at the junction of a muscle and its tendon.
2. Golgi tendon organs produce an inhibitory response called the Golgi tendon reflex *when muscle contracts too tightly.* This prevents damage to the tendon.

The additional ANS SLIDESHOW (part C of this chapter) is VERY helpful. Review it FIRST!!!! ☺

V. THE AUTONOMIC NERVOUS SYSTEM: INTRODUCTION AND ANATOMY

A. General Properties

1. The visceral reflexes are mediated by **the autonomic nervous system (ANS),** which has two branches (**sympathetic** and **parasympathetic**).
2. Its target organs are *glands, cardiac muscle, and smooth muscle*; it operates to maintain homeostasis.
3. Control over the ANS is, for the most part, **involuntary.**
4. The ANS differs structurally from the somatic nervous system in that there are **two neurons** leading from the *ANS to the effector*: a **preganglionic neuron** and a **postganglionic neuron.**

B. Divisions

1. **Sympathetic** branch prepares the body for **"fight or flight"** situations.
2. **Parasympathetic** branch functions to maintain normal operating conditions **("resting and digesting")**.

C. Anatomy of the Sympathetic Division

1. The **sympathetic division** is also called the ***thoracolumbar division*** because of the spinal nerves it employs.
2. **Paravertebral ganglia** are close to the vertebral column. **Preganglionic neurons** are *short*, while **postganglionic neurons**, traveling to their effector, are *long*.
3. When one preganglionic neuron fires, it can excite multiple postganglionic fibers that lead to different **target** organs (mass activation).

D. The Adrenal Glands

1. The pyramid-shaped **adrenal glands** lie *atop each kidney* and consist of a glandular adrenal cortex surrounding an adrenal medulla made of modified sympathetic neurons.
2. When stimulated, the **adrenal medulla** produces **catecholamines** (as hormones) that *complement* the action of sympathetic postganglionic neurotransmitters.

E. Anatomy of the Parasympathetic Division

1. The **parasympathetic division** is also referred to as the **craniosacral division** because its fibers travel in some cranial and sacral nerves

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VI. The Autonomic Nervous System: Physiology

A. Neurotransmitters and Receptors

1. The autonomic nervous system has **cholinergic fibers** that secrete **ACh**, and **adrenergic fibers**, that secrete **norepinephrine** (NE).
   Preganglionic fibers of *both divisions* are **cholinergic**, as are the **postaganglionic fibers** of the **parasympathetic branch**.
   Postganglionic fibers of the *sympathetic branch* are usually **adrenergic**.
2. **Cholinergic Receptors**
   a. ACh binds to **muscarinic** and **nicotinic receptors**.
   b. **Nicotinic receptors** occur on all postganglionic somas of the ANS, on the adrenal medulla, and at neuromuscular junctions.
   c. **Muscarinic receptors** occur on all *postganglionic cholinergic receptors of the ANS*.
3. **Adrenergic Receptors**
   a. Different receptors account for the *different effects* of norepinephrine at its targets cells.
   b. Binding to **alpha-adrenergic receptors** is *usually* excitatory.
   binding to **beta-adrenergic recpetors** is *usually* inhibitory.

B. Dual Innervation

1. Both divisions have nerves leading to most of the visceral organs (dual innervation).
2. The sympathetic and parasympathetic branches may have **antagonistic** effects or **cooperative** effects.

C. Control Without Dual Innervation

Control of organ function can be achieved *without* dual innervation. Impulses from sympathetic fibers can increase vasoconstriction, while cessation of impulses slows contractions.

D. Central Control of Autonomic Function

1. Control of the ANS is accomplished by *several* levels of the CNS.
2. **Cerebral Control**
   Conscious processes in the cerebrum can produce autonomic effects.
3. **Hypothalamic Control**
   a. The **hypothalamus** is the *most important area for integrating autonomic function.*
   b. It has **centers (nuclei)** for numerous functions, such as ***sweating, vasodilation, and cardiac and pulmonary function, among others.***
4. **Brainstem Control**
   The reticular formation contains centers for cardiac, vasomotor, respiratory, and gastrointestinal function.
5. **Spinal Control**
   Urination and defecation reflexes are centered in the *spinal cord.*