The ANS and Visceral Sensory Neurons

- The ANS—a system of motor neurons
- Innervates
  - Smooth muscle
  - Cardiac muscle
  - Glands

Autonomic and Somatic Motor Systems

Figure 15.2
Divisions of the Autonomic Nervous System

- Sympathetic – “fight, flight, or fright”
  - Activated during exercise, excitement, and emergencies
- Parasympathetic – “rest and digest”
  - Concerned with conserving energy

- Sympathetic and parasympathetic divisions
  - Chains of two motor neurons
    - Innervate mostly the same structures
    - Cause opposite effects

Issue from different regions of the CNS
- Sympathetic—also called the thoracolumbar division
- Parasympathetic—also called the craniosacral division

Anatomical Differences in Sympathetic and Parasympathetic Divisions

Figure 15.3
# Anatomical Differences in Sympathetic and Parasympathetic Divisions

- **Length of postganglionic fibers**
  - Sympathetic – *long postganglionic fibers*
  - Parasympathetic – *short postganglionic fibers*
- **Branching of axons**
  - Sympathetic axons – *highly branched*
    - Influences many organs
  - Parasympathetic axons – *few branches*
    - Localized effect

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# Anatomical Differences in Sympathetic and Parasympathetic Divisions

- **Neurotransmitter released by postganglionic axons**
  - Sympathetic – most release norepinephrine (adrenergic)
  - Parasympathetic – release acetylcholine

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# Parasympathetic division

- **Preganglionic neurons in the brainstem and sacral segments of spinal cord**
- **Ganglionic neurons in peripheral ganglia located within or near target organs**
The Parasympathetic Division

- Cranial outflow
  - Comes from the brain
  - Innervates organs of the head, neck, thorax, and abdomen
- Sacral outflow
  - Supplies remaining abdominal and pelvic organs

Figure 15.4

Cranial Outflow

- Preganglionic fibers run via:
  - Oculomotor nerve (III)
  - Facial nerve (VII)
  - Glossopharyngeal nerve (IX)
  - Vagus nerve (X)
- Cell bodies located in cranial nerve nuclei in the brain stem
## Sacral Outflow

- Emerges from S₂-S₄
- Innervates organs of the pelvis and lower abdomen
- Preganglionic cell bodies
  - Located in visceral motor region of spinal gray matter
- Axons run in ventral roots to ventral rami
  - Form splanchnic nerves
  - Run through the inferior hypogastric plexus

## Sympathetic Pathways to Thoracic Organs

![Figure 15.7](image)

## The Sympathetic Division

- Basic organization
  - Issues from T₁-L₂
  - Preganglionic fibers form the lateral gray horn
  - Supplies visceral organs and structures of superficial body regions
  - Contains more ganglia than the parasympathetic division
**Sympathetic ganglia**

- **Sympathetic chain ganglia** (paravertebral ganglia)
- **Collateral ganglia** (prevertebral ganglia)

**Sympathetic Trunk Ganglia**

- Located on both sides of the vertebral column
- Linked by short nerves into sympathetic trunks
- Joined to ventral rami by white and gray rami communicantes
- Fusion of ganglia → fewer ganglia than spinal nerves

**Figure 15.6**
**Sympathetic Pathways to Thoracic Organs**

- Superior cervical ganglion
- Middle cervical ganglion
- Inferior cervical ganglion

**Sympathetic trunk (chain) ganglia**

**Pons**

**T1**

**Lesser splanchnic nerve**

**Greater splanchnic nerve**

**Eye**

- Lacrimal gland
- Nasal mucosa
- Blood vessels; skin (arrector pili muscles and sweat glands)
- Salivary glands

**Heart**

**Lung**

- Cardiac and pulmonary plexuses

**Liver and gallbladder**

**Stomach**

**Spleen**

**Kidney**

**Adrenal medulla**

**Small intestine**

**Large intestine**

**Genitalia (uterus, vagina, and penis) and urinary bladder**

**Celiac ganglion**

**Inferior mesenteric ganglion**

**Superior mesenteric ganglion**

**Lumbar splanchnic nerves**

**Rectum**

**Sacral splanchnic nerves**

**Spinal cord:**

- T8–L1

**Sympathetic trunk**

**Ventral root**

**Thoracic splanchnic nerves**

**Adrenal Medulla**

- Typical adrenal medulla cells
- Epinephrine and norepinephrine
- Adrenal gland
- Adrenal medulla capillaries

**Visceral Sensory Neurons**

- General visceral sensory neurons monitor:
  - Stretch, temperature, chemical changes, and irritation
- Cell bodies are located in the dorsal root ganglion
- Visceral pain:
  - No pain results when visceral organs are cut
  - Visceral pain results from chemical irritation or inflammation
  - Visceral pain often perceived to be of somatic origin
  - Phenomenon of referred pain
A Map of Referred Pain

Visceral Reflexes

- Visceral sensory and autonomic neurons
  - Participate in visceral reflex arcs
    - Defecation reflex
    - Micturition reflex
  - Some are simple spinal reflexes
  - Others do not involve the CNS
    - Strictly peripheral reflexes

Visceral Reflex Arc
Central Control of the ANS

- Control by the brain stem and spinal cord
  - Reticular formation exerts most direct influence
    - Medulla oblongata
    - Periaqueductal gray matter
  - Control by the hypothalamus and amygdala
    - Hypothalamus—the main integration center of the ANS
    - Amygdala—main limbic region for emotions
  - Control by the cerebral cortex

**Figure 15.12**

Central Control of the ANS

Communication at subconscious level

- Cerebral cortex (frontal lobe)
- Limbic system (emotional input)
- Hypothalamus
  - Overall integration of ANS, the base
- Brain stem
  - Reticular formation, etc.
  - Regulation of pupil size, respiration, heart, blood pressure, swallowing, etc.
- Spinal cord
  - Urination, defecation, erection, and ejaculation reflexes