Central nervous system (CNS)

Peripheral nervous system (PNS)

Sensory (afferent) division

Motor (efferent) division

Somatic nervous system

Autonomic nervous system (ANS)

Sympathetic division

Parasympathetic division
ANS

• Innervates:
ANS vs. SNS
ANS vs. SNS

Cell bodies in central nervous system | Peripheral nervous system | Neurotransmitter at effector | Effector organs | Effect
--- | --- | --- | --- | ---
**SOMATIC NERVOUS SYSTEM**
Heavily myelinated axon | Single neuron from CNS to effector organs | ACh | Skeletal muscle | +

**AUTONOMIC NERVOUS SYSTEM**
Lightly myelinated preganglionic axons | Two-neuron chain from CNS to effector organs | NE | Stomach, intestines, blood vessels | + -
Stimulatory or inhibitory, depending on neurotransmitter and receptors on effector organs

**PARASYMPATHETIC**
Lightly myelinated preganglionic axon | | ACh | Smooth muscle (e.g., in gut), glands, cardiac muscle | 

Acetylcholine (ACh) | Norepinephrine (NE)
ANS – Dual Innervation

- Most visceral organs
ANS – Antagonistic Control

Parasympathetic stimulation
Heart rate decreases

Sympathetic stimulation
Heart rate increases
Parasympathetic = D Division

- Digestion
- Defecation
- Diuresis
Sympathetic = E Division

- Exercise
- Excitement
- Embarrassment
- Emergency
Craniosacral vs. Thoracolumbar
Sympathetic vs. Parasympathetic
Parasympathetic Cranial Outflow

- **Eye**: Lacrimal gland, Nasal mucosa
- **Submandibular and sublingual glands**
- **Parotid gland**
- **Heart**
- **Lung**

**Nerves**:
- **CN III**: Ciliary ganglion
- **CN VII**: Pterygopalatine ganglion
- **CN IX**: Submandibular ganglion
- **CN X**: Otic ganglion

**Nerve Fibers**:
- **Preganglionic**
- **Postganglionic**

**Cranial Nerves**:
- CN III
- CN VII
- CN IX
- CN X
Parasympathetic Cranial & Sacral Outflow

- Preganglionic
- Postganglionic
- CN Cranial nerve

- Liver and gallbladder
- Stomach
- Pancreas
- Large intestine
- Small intestine
- Rectum
- Urinary bladder and ureters

- Pelvic splanchnic nerves
- Inferior hypogastric plexus
- Genitalia (penis, clitoris, and vagina)
Sympathetic Division

• More organs
  – Viscera
  – Sweat glands
  – Arrector pili
  – Vascular smooth muscle

• More complex pathway
Sympathetic Pathway - the Ganglia

- Spinal cord
- Dorsal root
- Ventral root
- Rib
- Sympathetic trunk ganglion
- Sympathetic trunk
- Ventral ramus of spinal nerve
- Gray ramus communicans
- White ramus communicans
- Thoracic splanchnic nerves
**Sympathetic Pathway #1**

- **Skin (arrector pili muscles and sweat glands)**
- **Blood vessels**
- **Dorsal ramus of spinal nerve**
- **Ventral ramus of spinal nerve**
- **Gray ramus communicans**
- **White ramus communicans**
- **Lateral horn (visceral motor zone)**
- **Ventral root**
- **Sympathetic trunk ganglion**
- **Sympathetic trunk**

1. Synapse at the same level
Sympathetic Pathway #2

Skin (arrector pili muscles and sweat glands)

Blood vessels

To effector

2 Synapse at a higher or lower level
Sympathetic Pathway #3

Splanchnic nerve

Collateral ganglion (such as the celiac)

Target organ in abdomen (e.g., intestine)

③ Synapse in a distant collateral ganglion anterior to the vertebral column
Certain splanchnic nerves synapse on hormone-producing cells of the adrenal medulla – the interior of the adrenal glands which sit upon the kidneys.
Nicotinic Receptors
Muscarinic Receptors
The Effect of ACh
Adrenergic Receptors

Alpha and Beta
The Effect of NE/Epi
The Effect of NE/Epi
Distribution of the Parasympathetic Response

One to one
Distribution of the Sympathetic Response

Sympathetic Division

Preganglionic neuron

Long postganglionic axon

Ganglionic neuron

Autonomic ganglion (close to the vertebral column)

One to many
Distribution of the Sympathetic Response
Duration of the Parasympathetic Response

- **Parasympathetic pathway**
  - CNS
  - Cholinergic preganglionic neuron
  - Cholinergic nicotinic receptor
  - Autonomic ganglion
  - Cholinergic postganglionic neuron
  - Cholinergic muscarinic receptor
  - Target tissue

- Acetylcholine (ACh)
  - Transmitting Neuron
  - Receiving Neuron
  - Acetylcholinesterase

*Works fast*
Duration of the Sympathetic Response

S-l-o-w
Duration of the Sympathetic Response
An Exception to the Antagonism