Somatic Nervous System

- Coordinates *Conscious Nervous Activity*
  - Effector: **Skeletal Muscle**
    - Neurons *initiate tissue activity*
  - Neurotransmitter: **Acetylcholine**

- **Denervation**: Stimulates *flaccid paralysis* & *Atrophy* (*Muscle degeneration*)
  - Skeletal muscle activity completely controlled by Nervous System
Autonomic Nervous System

- Coordinates *Unconscious* Nervous Activity
- **Effectors:** Cardiac & Smooth muscle & Glands
  - Viscera: Organs w/in body cavities
- **Neurotransmitters:**
  - Acetylcholine & Norepinephrine

**Denervation:** Tissue *maintains a baseline activity* (resting tone)

- **Autonomic Nervous System** *moderates* tissue activity
1. **Somatic Nervous System**:
   - **Efferent (Motor) Pathway**
     - ONE Somatic Motor Neuron
     - Exit: CNS & directly innervate skeletal muscle

   - **Effect**: Motor neuron **ALWAYS Excitatory**
     - Produce: **Depolarization (EPSP)**
     - Receptor & Neurotransmitter:
       - *Nicotinic receptor: ACh*
2. **Autonomic Nervous System**
   - **Efferent (Motor) Pathway:**
     - TWO Autonomic Motor Neurons
     - Exit: CNS & indirectly innervate target tissue

   ![Autonomic Motor Nerve](image)

   a. **Pre-ganglionic Motor Neuron**
      - *Soma within* CNS Gray Matter
      - *Synapses onto* postganglionic neuron

   b. **Post-ganglionic Motor Neuron**
      - *Soma w/in* Peripheral Ganglion
      - *Synapses onto* target tissue

   ![Autonomic Motor Neuron](image)

   - **Effect:** Excitatory or Inhibitory
     - Produce:
       - Depolarization (EPSP) or Hyperpolarization (IPSP)
     - Receptors & Neurotransmitters:
       a. Alpha and Beta receptors: NE
       b. Muscarinic receptors: ACh

   ![Parasympathetic](image)
   ![Sympathetic](image)
Ganglion: Collection of neuron soma outside the CNS
Autonomic Nervous System:

2 Functional Divisions:

1. Sympathetic Nervous System (SNS):
   
   * Function: Tissue preparation for real or perceived physical activity & stress

   “Fight or Flight”

   * Effects mediated by Sympathetic NS:
     a. Heart Rate: ↑
     b. Breathing Rate: ↑
     c. Gut motility: ↓

   * Spinal Nerves: Thoracolumbar

   [Graphic of Spinal Nerves]

   [Graphic of Sympathetic and Parasympathetic Nervous System]
**Ganglia location:** Most are close to CNS

- Ganglia Arrangement: Linear

  - **Sympathetic Chain**

  ![Diagram of the sympathetic chain with ganglia](image)

  - Spinal nerve
  - Preganglionic neuron
  - Sympathetic nerve (postganglionic fibers)
  - Sympathetic ganglion of left sympathetic chain
  - Intercostal visceral in thoracic cavity
  - Paravertebral visceral

**Autonomic Motor Reflex**

- Dorsal Root Ganglion
- Preganglionic Neuron
- Postganglionic Neuron
- Sensory Neuron
- Viscera

**Midbrain Hindbrain**

- Cranial nerve III
- Cranial nerve VII
- Cranial nerve IX
- Cranial nerve X
- Sympathetic chain ganglion
- Celiac ganglion
- Superior mesenteric ganglion
- Inferior mesenteric ganglion
- Pelvic nerves
- Heart
- Liver and gallbladder
- Spleen
- Stomach
- Pancreas
- Large intestine
- Small intestine
- Adrenal gland and kidney
- Urinary bladder
- Reproductive organs
b. Parasympathetic Nervous System:
   ★ Function: Antagonize (oppose) sympathetic effects

   “Rest & Digest”

★ Effects mediated by Parasympathetic NS
   a. Heart Rate: ↓
   b. Breathing Rate: ↓
   c. Gut motility: ↑

★ Spinal Nerves: Craniosacral
★ Ganglia location: Close (most) to Target Organ
   • Ganglia Arrangement: Terminal
1. **Acetylcholine: ACh**
   a. Released from: **ALL Pre-ganglionic Neurons**  
      *Parasympathetic & Sympathetic Fibers*

   - **Effect Produced:** *Excitatory effect*
   - **Target cell:** Postganglionic Neuron
   - **Target Receptor:** Nicotinic ACh

   ![Diagram of Neurotransmitters of ANS: Acetylcholine (ACh)](image)
b. Released from: **ALL Parasympathetic Post-ganglionic Neurons**

 Effects Produced: **Excitatory or Inhibitory**

 - Target cells: Muscle or Glands
 - Target Receptor: Muscarinic

**ALL tissue effects mediated by ACh are called:** Cholinergic
2. **Norepinephrine**: NE (noradrenaline)
   a. Released from: **Sympathetic Post-ganglionic neurons**

   * Effects Produced: **Excitatory or Inhibitory**
     - Target cells: **Muscle or Glands**
     - Target Receptors: **Alpha & Beta**

   * **ALL** tissue effects mediated by NE are termed: **Adrenergic**

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**Adrenal Gland:**

- **Endocrine extension** of sympathetic nervous system
- Sympathetic pre-ganglionic neurons release: **ACh**
- **ACh**: Stimulates adrenal to release **Epinephrine**
Neurotransmitter Receptors

1. **Nicotinic Receptors**: (N)
   - **Location**: **ALL Autonomic Ganglia**
   - Present on **ALL Post-ganglionic neurons**
     - Sympathetic & Parasympathetic

   ![Diagram of neuronal connections and neurotransmitter release](image)

   - **Mechanism**: Direct Ligand Operated Channel
   - **Result**: EPSP

   ![Diagram illustrating ion channel and neurotransmitter binding](image)
2. **Muscarinic Receptors**: 

- **Location**: Parasympathetic target tissue
- **Mechanism**: G-Protein Operated Channel
- **Result**: IPSP or EPSP
  - Heart: IPSP (K⁺ Efflux)
  - GI Smooth Muscle: EPSP (Ca²⁺ or Na⁺ Influx)

**Significance:**

- Parasympathetic NS uses exclusively ACh
Adrenergic (NE) Receptors: Alpha & Beta

- **Location:** Target tissue cells
- **Mechanism:** G-Protein moderated Second Messenger Channel Operated

- **Result:** IPSP or EPSP
  - Heart: EPSP (Na$^+$ / Ca$^{2+}$ influx)
  - GI Smooth Muscle: IPSP (K$^+$ efflux)

- **Significance:** Sympathetic NS uses both ACh and NE
1. **Beta Blockers**: Block effects of NE
   - $\beta_1$ Heart: Increases heart rate & force
   - $\beta_2$ Bronchioles: Relaxes (Dilation)
   - $\beta_2$ Smooth muscle blood vessels: Relaxes

- **Propanolol**: Synthetic Beta Blocker
  - Mechanism: Blocks $\beta_1$ & $\beta_2$ receptors
Effects:

a. Desired: Decreased heart rate & blood pressure
   - Treatment: Hypertension
   - Blocks β receptor in Heart & blood vessels

b. Complication:
   - Increased Bronchiole constriction
   - β2 Bronchioles: Constriction
   - New drugs (Atenolol):
     - More specific for β₁

2. Beta Agonist: Stimulate β₁ & β₂ receptor
   - Epinephrine Nasal Spray
     - Mechanism: Stimulates β₁ & β₂ receptors
     - Effects:
       a. Desired: Decreased bronchiole constriction
         - Treatment: Asthma
         - Binds β₂ receptor in Bronchiole
b. Complication: Increased Heart rate
   ✓ \( \beta_1 \) Heart: Increased rate

  ➔ New drugs (Terbutaline): More specific for \( \beta_2 \)

**Dual Innervation:**

- **Organ innervation:** Most organs are innervated by *both* Sympathetic & Parasympathetic NS

  *= Mechanism:*
  - Effects are predominately **Antagonistic**
  - Tissue activity: Controlled by a Complex balance between Autonomic NS activity
• Exceptions:
  - Some organs receive ONLY sympathetic innervation
  - Most Blood Vessels
  - Arrector Pili Muscles
  - Sweat Glands in skin
  - Adrenal Medulla

• Mechanism of Control:
  - Alterations in sympathetic neuron activity
  - ie: Blood vessels:
    - Constriction: Increased sympathetic activity
    - Dilation: Decreased sympathetic activity
Beautiful Brain