

## Objectives

- Know ANS divisions and organization
  - Functional units
  - Principal neurotransmitters
  - Receptor types
- Identify sensory input to ANS
  - Explain how it integrates function (BP)
- List main physiological responses under ANS control
  - Distinguish SNS from PSNS mediated responses
- Understand the consequences of ANS dysregulation

## Autonomic vs. Somatic Nervous System

- **AUTONOMIC**
  - Effectors: cardiac & smooth muscle, viscera & glands
  - Efferent: 2-neuron chain
  - Neurotransmitter (NT) effects
    - Stimulatory or inhibitory dependent on NT & receptor type
- **SOMATIC**
  - Effectors: skeletal muscles
  - Efferent: Heavily myelinated axons from CNS to muscle
  - Neurotransmitter Effects:
    - Acetylcholine excitatory effect in nicotinic (N<sub>1</sub>) receptors

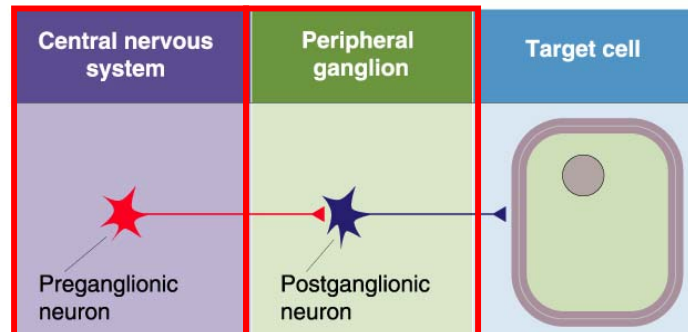


- Autonomic Nervous System
- Efferent motor neurons: innervate viscera & involuntary muscle
- Afferent sensory neurons respond to:
  - Stretch (heart, arteries)
  - Glucose,  $\text{PCO}_2$ ,  $\text{PO}_2$  (blood)
  - Osmolarity & pH (blood & intestinal content)
  - Temperature (skin & internal organs)

## SNS & PSNS Functional unit



### 2 neuron pathway



## Sympathetic



- **Preganglionic neurons**
  - Thoracolumbar spinal cord: T1-L3
- **Postganglionic neurons**
  - Paravertebral or prevertebral ganglia
    - Distant to target organ
- **Preganglionic: Cholinergic neuron; Nicotinic receptor (N<sub>2</sub>)**
- **Postganglionic: Adrenergic neuron; Adrenergic receptor**
  - $\alpha$  1: vasculature
  - $\alpha$  2: presynaptic
  - $\beta$  1: heart, adipose
  - $\beta$  2 : bronchioles, vasculature
  - $\beta$  3: adipose-thermogenic

## Parasympathetic



- **Preganglionic neurons**
  - Brainstem: cranial nerve nuclei
    - **III oculomotor**
    - **VII facial**
    - **IX glossopharyngeal**
    - **X Vagus**
  - Sacral spinal cord
- **Postganglionic neurons**
  - Parasympathetic ganglia
    - Near or in wall of target organ
- **Preganglionic: Cholinergic neuron; Nicotinic (N<sub>2</sub>) receptor**
  - Nicotinic: ion-gated
- **Postganglionic: Cholinergic neuron; Muscarinic receptor**
  - G-protein coupled
- **Effect on cell**
  - Excitatory or inhibitory: receptor & organ specific

## Neurotransmitters



- Principal: Acetylcholine & norepinephrine
- Non traditional
  - ATP
    - Colocalized with NE in SNS
    - Purinoceptors (i.e., smooth muscle cells)
  - Nitric oxide
    - Pre & postganglionic neurons SNS & PSNS

## Enteric nervous system

- 2 networks of neurons
  - Myenteric
    - Motility
  - Submucous
    - Secretions
- 3 types of neurons
  - Motor
  - Sensory
    - mechanical, thermal, osmotic & chemical
  - Interneurons

## Enteric nervous system



- Part of the PNS
- Operates largely independently of the CNS
- Coordinates gastrointestinal function
- Monitors the state of lumen and gut wall
- Responds appropriately
  - Activating intrinsic reflexes
    - Mixing and propulsive & peristaltic movements
    - Change blood flow & secretions of water & electrolytes

## Enteric nervous system



- Neurons & glia organized into ganglia
- Neurotransmitters:
  - Acetylcholine
    - ↑ motility
    - ↑ intestinal secretions
    - ↑ enteric hormone release
  - Norepinephrine
    - ↓ acetylcholine effects
  - Others: VIP, opioids, 5-HT, Substance P, NO, etc.

## SNS: “fight or flight”



- Dilation of pupils
- ↑ HR, contractility & BP
- Blood flow
  - ↓ non-essential organs
- ↑ Bronchial dilation
- ↑ Respiratory rate
- ↑ Fuel mobilization
  - Glucose & FFA

**E** Exercise  
Excitement  
Embarrassment

## PSNS: “rest-digest”



- Conserve & restore energy
  - Normally PSNS tone > SNS
- **SLUDD** responses:
  - salivation, lacrimation, urination, digestion & defecation
- 3 “decreases”
  - ↓ HR, airway & pupil diameter
- Paradoxical fear
  - No escape/“No win situation”
  - Massive PSNS activation
    - Loss of urination & defecation control
    - ↓HR & BP

**D** Digestion  
Defecation  
Diuresis

## SNS/PSNS



- Dual/antagonistic: GI, CV
- Exclusive SNS
  - Adrenal medulla
  - Sweat glands
  - Erector pili muscles
  - Kidneys: RAS → ↑ MABP
  - Most blood vessels
- Exclusive PSNS
  - Erectile tissues

## SNS/PSNS: Dual/antagonistic modulation of CV function.



- Carotid sinus & aortic arch pressure
  - Afferent signals integrated in brainstem
- ↑ Pressure
  - ↓ SNS activity & ↓ BP
  - ↑ PSNS activity & ↓ HR
- ↓ Pressure
  - ↑ SNS activity & ↑ HR & BP

## SNS & PSNS: Dual/antagonistic modulation of GI function



- **PSNS favors digestive processes**
  - Increased gut motility, acid & enzyme secretions
  - Relaxation of sphincters
- **SNS inhibits digestive processes**
  - Contraction of sphincters
    - Pyloric, ileo-cecal & internal anal
  - Inhibition of motor neurons throughout the gut

## SNS: Exclusive modulation of thermoregulation



- ↑ Environmental temperature
  - Sweat gland activation
  - Skin vasodilation
    - Warm blood to surface
- ↓ Environmental temperature
  - Skin vasoconstriction
    - Blood retained in vital organs
  - Shivering
  - Piloerection



## ANS during fever

- Increased body temperature 1-4°C
- Upregulation of thermostatic set point
- Body “feels cold”
- Autonomics kick in
  - Skin vasoconstriction
    - Blood retained in vital organs
  - Shivering
  - Piloerection
  - No sweating



## SNS/PSNS: Cooperative control of sexual function

- **Erection**
  - PSNS: Vasodilation of penile blood vessels
    - ACh & NO
  - SNS: ↓ tone during erection
- **Emission (ejaculation)**
  - SNS: smooth muscle contraction distal epididymis
    - Emission



## Autonomic nervous system

- ANS divisions and organization
  - Functional units
  - Principal neurotransmitters
  - Receptor types
- Sensory input to ANS & role in control of BP
- Main physiological responses under SNS & PSNS control
  - Coordinated/antagonistic/exclusive
- ANS dysfunction?
  - Examples? Manifestations?