

## INTRODUCTION

### A. Divisions of the Peripheral Nervous System

1. Somatic nervous system (voluntary)
  - a. tissues innervated: skeletal muscle
  - b. action: always excitatory (cause muscle contraction)
  - c. CNS (central nervous system) control: voluntary (but has involuntary components; e.g. reflexes)
  - d. no peripheral efferent ganglia or synapses
  - e. effect of denervation: complete loss of function, paralysis; also atrophy
2. Autonomic nervous system (ANS, involuntary)
  - a. tissues innervated: cardiac muscle, smooth muscle (e.g. viscera, blood vessels), glands (most, but not all)
  - b. action: may be excitatory or inhibitory
  - c. CNS control: involuntary in general
  - d. peripheral efferent ganglion and synapse
  - e. effect of denervation: generally continues to function, still subject to local and circulating influences, but loss of CNS coordination
  - f. divisions
    - 1) sympathetic
    - 2) parasympathetic
3. Enteric: innervation contained within the wall of the alimentary tract (sometimes considered as a part of the autonomic system)

Note: The following is limited to the Autonomic Nervous System



## FUNCTIONAL ANATOMY (motor/efferent fibers)

### B. Characteristics

#### 1. Common features

- two neurons and a peripheral synapse generally in a ganglion
- first neuron has its cell body in the CNS, is termed *preganglionic*, and its axon is myelinated
- second neuron has its cell body in the peripheral synapse, is termed *postganglionic*, is unmyelinated, and innervates the end organ

#### 2. Parasympathetic pathway

- leaves the CNS in certain cranial nerves (III, VII, IX, X) and spinal sacral nerves; termed cranio-sacral
- peripheral synapse is generally in or near the organ innervated

#### 3. Sympathetic pathway

- leaves the CNS in thoracic and certain lumbar spinal nerves; termed thoraco-lumbar
- peripheral synapses are generally in a separate ganglia (paravertebral or peripheral)
- exception: the sympathetic innervation of the adrenal medulla has only a preganglionic fiber (no postganglionic fiber)

## AUTONOMIC TRANSMITTERS

### A. Parasympathetic

- preganglionic-postganglionic synapse: acetylcholine (ACh)
- neuroeffector synapse: acetylcholine (ACh)

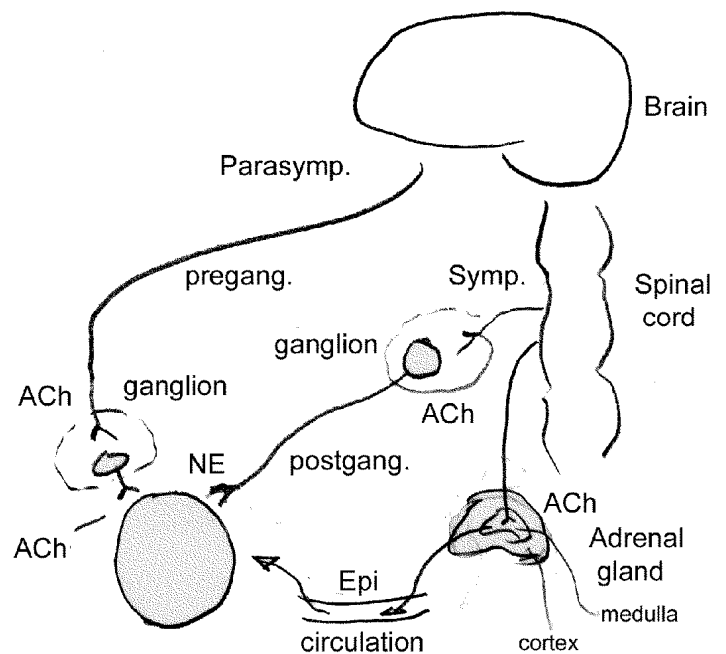
### B. Sympathetic

- preganglionic-postganglionic synapse: acetylcholine (ACh)
- neuroeffector synapse: norepinephrine (NE, noradrenalin)

Note exceptions (among several): neurotransmitter released at sweat glands and piloerector muscles is ACh, even though innervation is exclusively sympathetic

### C. Adrenal Medulla (endocrine gland, part of sympathetic system)

- preganglionic-neuroeffector synapse: acetylcholine (ACh)
- secretion (into circulation): epinephrine (mainly; E, adrenalin) and norepinephrine (noradrenalin)



## AUTONOMIC ACTIONS

### A. General Principles

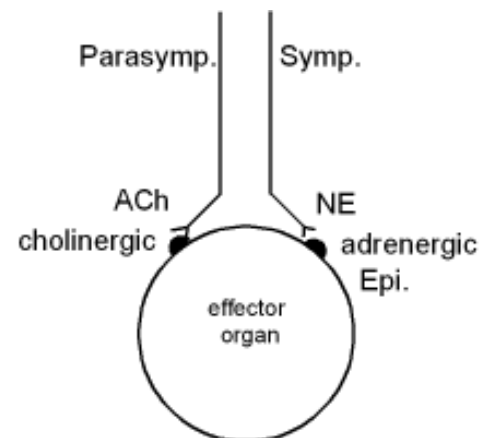
1. Sympathetic system: responses associated with vigorous, often emotional, activity ("fight or flight")
2. Parasympathetic system: homeostatic ("vegetative") activities to maintain body internal environment (e.g. digestion and absorption)
3. In organs innervated by both the sympathetic and parasympathetic divisions, their effects are usually (but not always) opposite

Note: often both divisions are active and the state of the organ is determined by the balance between the two

4. Some organs are innervated by only one division
5. Sympathetic effects are generally augmented by secretion from the adrenal medulla
6. Sympathetic effects are sometimes general throughout the body; parasympathetic effects are mainly localized

### B. Sequence of Events

1. Preganglionic cell excited within the CNS
2. AP travels to ganglion
3. ACh released, exciting postganglionic cell
4. AP travels to nerve endings
5. Transmitter (ACh or NE) released from vesicles in postganglionic ending
6. Transmitter diffuses to end organ (slow compared with neuromuscular transmission); order of seconds
7. Transmitter binds to end organ receptor and induces characteristic effect (e.g. muscle contraction or relaxation, gland secretion or inhibition)
  - a. cholinergic receptor: binds Ach
  - b. adrenergic receptor: binds E and/or NE
8. Transmitter is removed from receptor by a combination of the following (note: relatively slow)
  - a. chemical breakdown (ACh by acetylcholine esterase, NE by COMT or MAO)
  - b. diffuses away
  - c. uptake into the postsynaptic cell (to be repackaged into vesicles for later release)



AUTONOMIC ACTIONS (continued)

C. Specific Actions (selected organs)

<u>Organ</u>	<u>Parasympathetic</u>	<u>Sympathetic</u>
Eye		
pupil	constriction	dilation
accommodation	near vision	distant vision
Heart		
heart rate	decrease (bradycardia)	increase (tachycardia)
contractility		increase
Vascular System		
arterioles	generally small effect, but dilation, particularly in secretory organs	constriction, except dilation in certain organs such as skeletal muscle
veins		venoconstriction
Alimentary Tract		
motility	increase	decrease
sphincters	relaxation	contraction
secretion	stimulation	inhibition
Skin		
sweat glands		Stimulation (cholinergic)
piloerection		Stimulation (cholinergic)
Liver		glucose release
Salivary glands		
secretion	profuse, watery	thick, viscous

## AUTONOMIC RECEPTORS

### A. Cholinergic receptors

1. Normal agonist: acetylcholine
2. Subtypes
  - a. nicotinic-neuromuscular
    - 1) location: neuromuscular junction (end plate) of skeletal muscle
    - 2) agonist: ACh
    - 3) antagonist: curare, neuromuscular blocking agents
    - 4) agonist action: excitation of skeletal muscle fiber
  - b. nicotinic-ganglionic
    - 1) location: autonomic ganglia, adrenal medulla
    - 2) agonist: ACh
    - 3) antagonist: ganglionic blocking agents
    - 4) agonist action: excitation of postganglionic autonomic neuron; adrenal secretion of epinephrine and NE
  - c. muscarinic
    - 1) location: tissues innervated by the parasympathetic system; also sweat glands; also other tissues
    - 2) agonist: ACh, muscarine
    - 3) antagonist: atropine (belladonna, deadly nightshade)
    - 4) agonist action: stimulation or inhibition, depending upon organ

### B. Adrenergic

1. Normal agonists: epinephrine and norepinephrine
2. Subtypes
  - a. alpha-1 ( $\alpha$ -1)
    - 1) location: pupil of eye, blood vessel arterioles, veins, alimentary tract sphincters, liver
    - 2) agonist: E, NE, phenylephrine
    - 3) antagonist: alpha blocking agents
    - 4) agonist action: excitatory
  - b. alpha-2 ( $\alpha$ -2) (will not consider further here)
  - c. beta-1 ( $\beta$ -1)
    - 1) location: heart
    - 2) agonist: E, NE
    - 3) antagonist: beta-1 blockers
    - 4) agonist action: excitatory, increases heart rate and contractility (force of contraction)
  - d. beta-2 ( $\beta$ -2)
    - 1) location: lung airways, other places
    - 2) agonist: E, isoproteranol
    - 3) antagonist:
    - 4) agonist action: generally inhibitory