Chapter 15: The Autonomic Nervous System

Chapter Objectives

COMPARISON OF SOMATIC AND AUTONOMIC NERVOUS SYSTEMS
1. Compare the structural and functional differences between the somatic and autonomic nervous systems.

ANATOMY OF AUTONOMIC PATHWAYS
2. Distinguish between the pre- and postganglionic neurons, in terms of location.
3. Specify the different origins and destination ganglia for the sympathetic (thoracolumbar) and parasympathetic (craniosacral) preganglionic neurons.
4. Describe the differing locations of the ganglia of the sympathetic and parasympathetic systems and their relative distance from the CNS.
5. Describe the location of the rami communicantes.
6. List the names and locations of the different sympathetic ganglia.

PHYSIOLOGICAL EFFECTS OF THE ANS
7. Discuss the primary purpose of the sympathetic division and the general body functions it directs.
8. Describe specific responses of effectors due to increased sympathetic stimulation.
9. Discuss the primary purpose of the parasympathetic division and the general body functions it directs.
10. Describe specific responses of effectors due to increased sympathetic stimulation.

ANS NEUROTRANSMITTERS AND RECEPTORS
11. Identify the chemical nature of the autonomic neurotransmitter receptors and their location.
12. Identify the cholinergic neurons, receptors, and neurotransmitters.
13. Describe the effects of acetylcholine as a cholinergic neuron neurotransmitter.
14. Identify the adrenergic neurons, receptors, and neurotransmitters.
15. Describe the effects of norepinephrine as an adrenergic neuron neurotransmitter.

Chapter Lecture Notes

Characteristics of the Autonomic Nervous System

Involuntary control

Somatic – voluntary control
Sensory input mostly from interoceptors

Somatic - exteroceptors

Motor functional pathways are divided into sympathetic and parasympathetic divisions

Motor outputs through a two neuron pathway (Fig 15.1 & Table 15.1)

Somatic – single motor neuron

Preganglionic

Postganglionic

Neurotransmitters

Preganglionic – acetylcholine

Postganglionic – acetylcholine (parasympathetic and sympathetic to sweat glands, blood vessels in skeletal muscle and arrector pili muscles) or norepinephrine (remainder of sympathetic)

Effects smooth muscle (contraction or relaxation), cardiac muscle (increased or decreased rate and force) and glands (increased or decrease secretion)

Anatomical and Physiological Differences between the Parasympathetic and Sympathetic Divisions (Table 15.3)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Parasympathetic</th>
<th>Sympathetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Origin (Fig 15.2 &amp; 15.3)</td>
<td>Craniosacral outflow: brainstem nuclei of cranial nerves III, VII, IX and X; spinal cord segments S2-S4</td>
<td>Thoracolumbar outflow: lateral horn of gray matter of spinal cord segments T1-L2</td>
</tr>
<tr>
<td>Location of ganglia (Fig 15.2 &amp; 15.3)</td>
<td>Ganglia in or close to visceral organ served (intramural = terminal) (Fig 15.6)</td>
<td>Ganglia within a few cm of CNS: alongside vertebral column (paravertebral ganglia) and anterior to vertebral column (prevertebral ganglia)</td>
</tr>
<tr>
<td>Relative length of pre- and postganglionic fibers</td>
<td>Long preganglionic; short postganglionic</td>
<td>Short preganglionic; long postganglionic</td>
</tr>
<tr>
<td>Rami communicantes (Fig 15.4)</td>
<td>None</td>
<td>Gray and white rami communicantes; white contain myelinated preganglionic fibers; gray contain unmyelinated postganglionic fibers</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Degree of branching of preganglionic fibers</td>
<td>Minimal</td>
<td>Extensive</td>
</tr>
<tr>
<td>Neurotransmitters</td>
<td>All fibers release acetylcholine (cholinergic fibers)</td>
<td>All preganglionic fibers release acetylcholine; most post-ganglionic fibers release norepinephrine (adrenergic fibers); some postganglionic fibers (e.g., those serving the sweat glands, blood vessels of skeletal muscles and arrector pili muscles) release acetylcholine; neurotransmitter activity augmented by release of adrenal medullary hormones (norepinephrine and epinephrine)</td>
</tr>
<tr>
<td>Functional goal</td>
<td>Maintenance functions; conserves and stores energy</td>
<td>Prepares body to cope with emergencies and intense muscular activity</td>
</tr>
</tbody>
</table>

**Sympathetic Ganglia**

**Paravertebral ganglion** = chain ganglion or trunk ganglion (Fig 15.5)

Innervate organs above the diaphragm like the heart and lungs

**Prevertebral ganglia** = collateral ganglia

Prevertebral ganglia surround the following arteries that branch from the aorta

- Celiac artery (celiac ganglia forms the solar plexus)
- Superior mesenteric artery
- Inferior mesenteric artery

**Physiological Effects of the Autonomic Nervous System** *(Table 15.4)*

Sympathetic – “E” situations (exercise, emergency, excitement and embarrassment) - fight or flight response

- Pupils dilate
- Heart rate, force of contraction and blood pressure increase
Airways dilate
Blood vessels to kidneys and gastrointestinal tract constrict
Blood vessels to skeletal muscles, cardiac muscle, liver and adipose tissue dilate
Liver cells perform glycogenolysis and release glucose to bloodstream
Adipocytes perform lipolysis

Parasympathetic – rest and digest response
Increased salivation, lacrimation, urination, digestion and defecation
Decreased heart rate, diameter of airways and diameter of pupils (constriction)

**Neurotransmitters and Receptors (Table 15.2 & 15.4 & Fig 15.7)**

Cholinergic neurons – release acetylcholine
all preganglionic neurons
all parasympathetic postganglionic neurons
sympathetic neurons that innervate most sweat glands, arrector pili muscle and blood vessels in skeletal muscle

Cholinergic receptors – receptors on the postsynaptic membrane that bind acetylcholine
Nicotinic receptor
dendrites and cell bodies of sympathetic and parasympathetic postganglionic neurons
excitation – stimulates action potential
motor end plate in the neuromuscular junction
excitation – contraction of muscle
adrenal medullary cells
excitation - release of epinephrine and norepinephrine
Is mimicked by nicotine

Muscarinic receptor
all parasympathetic target organs
smooth muscle (excitation; contraction)
gland (excitation; secretion)
sweat glands (excitation; sweat production)
cardiac muscle (inhibition; slows contraction)
some blood vessels in skeletal muscle (inhibition; vasodilation)

Is mimicked by muscarine (a mushroom poison)

Adrenergic neurons – release norepinephrine
most sympathetic postganglionic neurons

Adrenergic receptors – bind norepinephrine and epinephrine

$\alpha_1$

- Smooth muscle of blood vessels (excitation; vasoconstriction)
- radial muscles of eye (dilation of pupil)
- sphincter muscles of stomach and urinary bladder (closing)
- salivary gland cells (decreased salivation)
- sweat glands on palms and soles (increased sweating)

$\alpha_2$

- Smooth muscle in some blood vessels (inhibition; vasodilation)
- beta cells in pancreatic islets (decrease insulin secretion)
- pancreatic acinar cells (inhibition of digestive enzyme secretion)
- blood platelets (aggregation)

$\beta_1$

- Cardiac muscle (excitation; increased force and rate of contraction)
- posterior pituitary (secretion of antidiuretic hormones)
- adipose cells (breakdown of triglycerides)

$\beta_2$

- Smooth muscle in airways (relaxation; bronchodilation)
- blood vessels (relaxation; vasodilation)
walls of internal organs (relaxation)
ciliary muscles (inhibition; relaxation)
hepatocytes (glycogenolysis)

$\beta_3$ – Brown adipose tissue (thermogenesis)