Peripheral Nervous System 2: The Autonomic System

Lawrence M. Witmer, PhD
Professor of Anatomy
Dept. of Biomedical Sciences
Heritage College of Osteopathic Medicine, Ohio University
Athens, Ohio 45701
witmerL@ohio.edu

12 August 2013
Reading: Moore’s ECA4 36–43
### Somatic vs. Visceral

#### attribute

<table>
<thead>
<tr>
<th>Somatic System</th>
<th>Visceral System</th>
</tr>
</thead>
<tbody>
<tr>
<td>embryological origin of tissue</td>
<td>“organs:” splanchnic (visceral) mesoderm, endoderm</td>
</tr>
<tr>
<td>“body wall:” somatic (parietal) mesoderm (dermatome, myotome)</td>
<td></td>
</tr>
<tr>
<td>examples of adult tissues</td>
<td>glands, cardiac muscle, smooth muscle</td>
</tr>
<tr>
<td>dermis of skin, skeletal muscles, connective tissues</td>
<td>unconscious, involuntary</td>
</tr>
<tr>
<td>perception</td>
<td></td>
</tr>
<tr>
<td>conscious, voluntary</td>
<td></td>
</tr>
</tbody>
</table>

---

**Diagrams**: Illustrations of embryonic stages, showing parietal and visceral mesoderm layers, amnion, neural groove, and somites. 

*Langman’s Embryo 9 2004*
<table>
<thead>
<tr>
<th>Somatic</th>
<th>Visceral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory (Afferent)</td>
<td><strong>somatic sensory</strong></td>
</tr>
<tr>
<td></td>
<td>[General Somatic Afferent (GSA)]</td>
</tr>
<tr>
<td>Motor (Efferent)</td>
<td><strong>somatic motor</strong></td>
</tr>
<tr>
<td></td>
<td>[General Somatic Efferent (GSE)]</td>
</tr>
</tbody>
</table>

**Somatic Nervous System** (July 29)  
**Autonomic Nervous System** (today)
Overview of the Autonomic Nervous System

Similarities between Sympathetic & Parasympathetic

• Both are efferent (motor) systems: “visceromotor”
• Both involve regulation of the “internal” environment generally outside of our conscious control: “autonomous”
• Both involve 2 neurons that synapse in a peripheral ganglion
• Innervate glands, smooth muscle, cardiac muscle
Overview of the Autonomic Nervous System
Differences between Sympathetic & Parasympathetic

Location of Preganglionic Cell Bodies

Sympathetic
Thoracolumbar
T1 – L2/L3 levels of the spinal cord

Parasympathetic
Craniosacral
Brain: CN III, VII, IX, X
Spinal cord: S2 – S4
**Overview of the Autonomic Nervous System**
**Differences between Sympathetic & Parasympathetic**

**Relative Lengths of Neurons**

**Sympathetic**
- CNS
- Ganglion
  - Short preganglionic neuron
  - Long postganglionic neuron
- Target

**Parasympathetic**
- CNS
- Ganglion
  - Long preganglionic neuron
  - Short postganglionic neuron
- Target
Overview of the Autonomic Nervous System
Differences between Sympathetic & Parasympathetic

**Neurotransmitters**

**Sympathetic**
- ACh, +
- NE (ACh at sweat glands), + / -, α & β receptors

- All preganglionics release acetylcholine (ACh) & are excitatory (+)
- Symp. postgangl. — norepinephrine (NE) & are excitatory (+) or inhibitory (-)
- Parasymp. postgangl. — ACh & are excitatory (+) or inhibitory (-)
- Excitation or inhibition is a receptor-dependent & receptor-mediated response

**Parasympathetic**
- ACh, +

Potential for pharmacologic modulation of autonomic responses
Overview of the Autonomic Nervous System
Differences between Sympathetic & Parasympathetic

Target Tissues

**Sympathetic**
- Organs of head, neck, trunk, & external genitalia
- Adrenal medulla
- Sweat glands in skin
- Arrector muscles of hair
- *ALL* vascular smooth muscle

**Parasympathetic**
- Organs of head, neck, trunk, & external genitalia

» Sympathetic system is distributed to essentially all tissues (because of vascular smooth muscle)

» Parasympathetic system never reaches limbs or body wall (except for external genitalia)
Overview of ANS

Functional Differences

**Sympathetic**
- “Fight or flight”
- Catabolic (expend energy)

**Parasympathetic**
- “Feed & breed”, “rest & digest”
- Homeostasis

» Dual innervation of many organs — having a brake and an accelerator provides more control
Structure of spinal nerves: Somatic pathways

- dorsal root
- dorsal root ganglion
- spinal nerve
- dorsal ramus
- dorsal horn
- ventral horn
- ventral root
- gray ramus communicans
- white ramus communicans
- sympathetic ganglion
- CNS interneuron
- somatic sensory nerve (GSA)
- somatic motor nerve (GSE)

Mixed Spinal Nerve
Structure of spinal nerves: Sympathetic pathways

- Spinal nerve
- Dorsal ramus
- Ventral ramus
- Gray ramus communicans
- White ramus communicans
- Intermediolateral gray column
- Sympathetic ganglion
Sympathetic System: Preganglionic Cell Bodies

- Preganglionic cell bodies in intermediolateral gray
- T1 – L2/L3
- Somatotopic organization

Clinical Relevance
- dysfunction due to cord injury
- spinal nerve impingement & OMM
- referred pain

Somatic tissues (body wall, limbs)
- Visceral tissues (organs)

Intermediolateral gray columns

Moore’s COA6 2010
1. Paravertebral ganglia
   • Located along sides of vertebrae
   • United by preganglionics into Sympathetic Trunk
   • Preganglionic neurons are thoracolumbar (T1–L2/L3) but postganglionic neurons are cervical to coccyx
   • Some preganglionics ascend or descend in trunk

Moore’s COA6 2010
2. Prevertebral (preaortic) ganglia

- Located anterior to abdominal aorta, in plexuses surrounding its major branches
- Preganglionics reach prevertebral ganglia via abdominopelvic splanchnic nerves
Sympathetic System: Summary

**Somatic tissues**
(body wall, limbs)

Postganglionics via 31 spinal nerves to somatic tissues of neck, body wall, and limbs

**Sympathetic trunk**

**Prevertebral ganglia**

**Visceral tissues**
(organisms)

**Cardiopulmonary Splanchnics:**
postganglionic fibers to thoracic viscera

**Abdominopelvic Splanchnics:**
preganglionic fibers to prevertebral ganglia, postganglionic fibers to abdominopelvic viscera

Moore’s COA6 2010
Parasympathetic Pathways

Cranial outflow
- CN III, VII, IX, X
- Four ganglia in head
- Vagus nerve (CN X) is major preganglionic parasymp. supply to thorax & abdomen
- Synapse in ganglia within wall of the target organs (e.g., enteric plexus of GI tract)

Sacral outflow
- S2–S4 via pelvic splanchnics
- Hindgut, pelvic viscera, and external genitalia

Clinical Relevance
- Surgery for colorectal cancer puts pelvic splanchnics at risk
- Damage causes bladder & sexual dysfunction

Moore’s COA6 2010
Visceral Afferents and Referred Pain

Visceral sensory nerves [GVA]
- run with sympathetic & parasympathetic nerves
- cell bodies in dorsal root ganglion
- nerve ending in viscera

Somatic sensation:
- conscious, sharp, well-localized
- touch, pain, temperature, pressure, proprioception

Visceral sensation:
- often unconscious; if conscious: dull, poorly-localized
- distension, blood gas, blood pressure, cramping, irritants
Visceral Afferents and Referred Pain

Referred Pain:
- Pain originating in a visceral structure perceived as being from an area of skin innervated by the same segmental level as the visceral afferent.
- Results from convergence of somatic & visceral afferents on the same segmental level of the spinal cord.
- “Cross-talk” in the dorsal horn.

Kandel et al. 2000

www.merck.com
Visceral Afferents and Referred Pain

Maps of Referred Pain

- Liver, gallbladder, and duodenum (resulting from irritation of diaphragm)
- Duodenum, head of pancreas
- Gallbladder
- Liver
- Appendix
- Cecum and ascending colon
- Stomach
- Spleen
- Small intestine (pink)
- Sigmoid colon
- Kidney and ureter

Anterior View

Posterior View

Grant’s Atlas 12 2009
References