Peripheral Nervous System 2: The Autonomic System

1 August 2016

Reading: Moore’s ECA5 33–39
ECA4 36–43

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## Somatic vs. Visceral

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

**Illustration:**
- **Somatic System:**
  - Amnion
  - Neural groove
  - Parietal mesoderm layer
  - Visceral mesoderm layer
  - Visceral mesoderm layer
  - Intermediate mesoderm
  - Intra-embryonic body cavity
  - Endoderm

- **Visceral System:**
  - Somite

*Langman’s Embryo 9 2004*
### Sensory/Motor + Somatic/Visceral

<table>
<thead>
<tr>
<th></th>
<th>Somatic</th>
<th>Visceral</th>
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</thead>
<tbody>
<tr>
<td><strong>Sensory</strong></td>
<td><em>somatic sensory</em></td>
<td><em>visceral sensory</em></td>
</tr>
<tr>
<td>(Afferent)</td>
<td>[General Somatic Afferent (GSA)]</td>
<td>[General Visceral Afferent (GVA)]</td>
</tr>
<tr>
<td><strong>Motor</strong></td>
<td><em>somatic motor</em></td>
<td><em>visceral motor</em></td>
</tr>
<tr>
<td>(Efferent)</td>
<td>[General Somatic Efferent (GSE)]</td>
<td>[General Visceral Efferent (GVE)]</td>
</tr>
</tbody>
</table>

**Somatic Nervous System** (July 18)  

**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

![Diagram of the Autonomic Nervous System]

- CNS
- Ganglion
- Preganglionic neuron
- Postganglionic neuron
- 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

Sympathetic

CNS → ganglion → target
short preganglionic neuron → long postganglionic neuron

Parasympathetic

CNS → ganglion → target
long preganglionic neuron → short postganglionic neuron

Relative Lengths of Neurons
Overview of the Autonomic Nervous System

Differences between Sympathetic & Parasympathetic

**Neurotransmitters**

**Sympathetic**

- ACh, +

**Parasympathetic**

- ACh, +

**Neurotransmitters**

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

**Potential for pharmacologic modulation of autonomic responses**

- 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
## Overview of the Autonomic Nervous System

### Differences between Sympathetic & Parasympathetic

#### Target Tissues

<table>
<thead>
<tr>
<th>Sympathetic</th>
<th>Parasympathetic</th>
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<tr>
<td>Organs of head, neck, trunk, &amp; external genitalia</td>
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</tr>
<tr>
<td>Adrenal medulla</td>
<td></td>
</tr>
<tr>
<td>Sweat glands in skin</td>
<td></td>
</tr>
<tr>
<td>Arrector muscles of hair</td>
<td></td>
</tr>
<tr>
<td>ALL vascular smooth muscle</td>
<td></td>
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</tbody>
</table>

- 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
- ventral root
- somatic sensory nerve (GSA)
- somatic motor nerve (GSE)
- ventral ramus
- gray ramus communicans
- white ramus communicans
- sympathetic ganglion

Mixed Spinal Nerve
Structure of spinal nerves: Sympathetic pathways

- Spinal nerve
- Dorsal ramus
- Ventral ramus
- Gray ramus communicans
- White ramus communicans
- Sympathetic ganglion
- Intermediolateral gray column
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
1. Paravertebral ganglia
- Located along sides of vertebrae
- United by preganglionic neurons 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

**visceral tissues**
( organs )

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 parasympathetic 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

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

Dorsal root ganglion
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
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