Peripheral Nervous System 2: The Autonomic System

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

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# Somatic vs. Visceral

<table>
<thead>
<tr>
<th>attribute</th>
<th>Somatic System</th>
<th>Visceral System</th>
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</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>
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</tbody>
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**Diagram Description:**

- **Amnion**
- **Neural groove**
- **Parietal mesoderm layer**
- **Visceral mesoderm layer**
- **Intermediate mesoderm**
- **Intra-embryonic body cavity**
- **Somite**
- **Endoderm**

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

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

**Somatic Nervous System** (July 20)

**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 → target

- Short preganglionic neuron
- Long postganglionic neuron

Parasympathetic

CNS → ganglion → target

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

**Neurotransmitters**

**Sympathetic**
- ACh, +

**Parasympathetic**
- ACh, +

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

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

ACh, + / -

muscarinic receptors
### 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
- ventral root
- dorsal ramus
- ventral ramus
- somatic sensory nerve (GSA)
- somatic motor nerve (GSE)
- CNS inter-neuron
- 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

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

**Visceral tissues** (organs)

- Head, salivary glands (T1–3)
- Heart, lungs, esophagus (T4–6)
- Stomach, liver, gallbladder, pancreas (T7–9)
- Small intestine (T8–10)
- Appendix, colon (T10–11)
- Kidney (T11–L1)
- Rectum, bladder, uterus (T12–L2(3))

**Intermediolateral gray columns**

- Posterior horn
- Anterior horn
- Lateral horn

**Diagrams showing the distribution of the sympathetic system**
Sympathetic System: Postganglionic Cell Bodies

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

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

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

**Somatic tissues** (body wall, limbs)
- postganglionics via 31 spinal nerves to somatic tissues of neck, body wall, and limbs
- sympathetic trunk

**Visceral tissues** (organs)
- Prevertebral ganglia

*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
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
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
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


