Spinal Cord, Nerves & Reflexes
Chapter 13
The superficial anatomy and orientation of the adult spinal cord. The numbers to the left identify the spinal nerves and indicate where the nerve roots leave the vertebral canal. The spinal cord extends from the brain only to the level of vertebrae L₁-L₂. The spinal segments found at representative locations are indicated in the cross sections.
Anatomy

A posterior view of the spinal cord, showing the meningeal layers, superficial landmarks, and distribution of gray matter and white matter.

A sectional view through the spinal cord and meninges, showing the peripheral distribution of spinal nerves.

- Anterior median fissure
- Pia mater
- Denticulate ligaments
- Dorsal root
- Ventral root, formed by several “rootlets” from one cervical segment
- Arachnoid mater (reflected)
- Dura mater (reflected)
- Spinal blood vessel
Sectional Organization

The left half of this sectional view shows important anatomical landmarks, including the three columns of white matter. The right half indicates the functional organization of the nuclei in the anterior, lateral, and posterior gray horns.

Functional Organization of Gray Matter
The cell bodies of neurons in the gray matter of the spinal cord are organized into functional groups called nuclei.
- Sensory nuclei
- Motor nuclei

Structural Organization of Gray Matter
The projections of gray matter toward the outer surface of the spinal cord are called horns.
- Posterior gray horn
- Lateral gray horn
- Anterior gray horn

A micrograph of a section through the spinal cord, showing major landmarks in and surrounding the cord.

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Spinal Nerve: Organization

1. The sympathetic nerve carries sensory information from the visceral organs.
2. The ventral ramus carries sensory information from the ventrolateral body surface, structures in the body wall, and the limbs.
3. The dorsal ramus carries sensory information from the skin and skeletal muscles of the back.
4. The dorsal root of each spinal nerve carries sensory information to the spinal cord.

From interoceptors of back
From exteroceptors, proprioceptors of back
From exteroceptors, proprioceptors of body wall, limbs
From interoceptors of body wall, limbs

Somatic sensory nuclei
Ventral root
Rami communicantes
Dorsal root ganglion
Visceral sensory nuclei

= Somatic sensations
= Visceral sensations
Spinal Nerves: Organization

1. The ventral root of each spinal nerve contains the axons of somatic motor and visceral motor neurons.

2. The spinal nerve forms just lateral to the intervertebral foramen, where the dorsal and ventral roots unite.

3. The dorsal ramus contains somatic motor and visceral motor fibers that innervate the skin and skeletal muscles of the back.

4. The axons in the relatively large ventral ramus supply the ventrolateral body surface, structures in the body wall, and the limbs.

5. The white ramus is the first branch from the spinal nerve and carries visceral motor fibers to a nearby sympathetic ganglion. Because these preganglionic axons are myelinated, this branch has a light color and is therefore known as the white ramus.

6. The gray ramus contains postganglionic fibers that innervate glands and smooth muscles in the body wall or limbs. These fibers are unmyelinated and have a dark gray color.

7. A sympathetic nerve contains preganglionic and postganglionic fibers innervating structures in the thoracic cavity.

- Somatic motor commands
- Visceral motor commands

Postganglionic fibers to smooth muscles, glands, visceral organs in thoracic cavity

Preganglionic fibers to sympathetic ganglia innervating abdominopelvic viscera

To skeletal muscles of back

Postganglionic fibers to smooth muscles, glands, etc., of back

Sympathetic ganglion

Rami communicantes

To skeletal muscles of body wall, limbs

Postganglionic fibers to smooth muscles, glands, etc., of body wall, limbs
**SENSORY INFORMATION**

A spinal nerve collects sensory information from peripheral structures and delivers it to sensory nuclei in the thoracic or superior lumbar segments of the spinal cord. The dorsal, ventral, and white rami also contain sensory fibers.

- The dorsal ramus carries sensory information from the skin and skeletal muscles of the back.
- The ventral ramus carries sensory information from the ventral lateral body surface, structures in the body wall, and the limbs.
- The spinal nerve forms just lateral to the intervertebral foramen, where the dorsal and ventral roots unite.
- The spinal nerve contains somatic and visceral motor fibers that innervate the skin and skeletal muscles of the back.
- The axons in the relatively large ventral ramus supply the ventrolateral body surface, structures in the body wall, and the limbs.
- The spinal nerve contains preganglionic and postganglionic fibers that innervate the body wall or limbs. These fibers are unmyelinated and have a dark gray color.

**MOTOR COMMANDS**

A spinal nerve distributes motor commands that originate in motor nuclei of the thoracic or superior lumbar segments of the spinal cord.

- The spinal nerve forms just lateral to the intervertebral foramen, where the dorsal and ventral roots unite.
- The spinal nerve contains somatic and visceral motor fibers that innervate the skin and skeletal muscles of the back.
- The axons in the relatively large ventral ramus supply the ventrolateral body surface, structures in the body wall, and the limbs.
- The spinal nerve contains preganglionic and postganglionic fibers that innervate the body wall or limbs. These fibers are unmyelinated and have a dark gray color.

Together, the white and gray rami are known as the rami communicantes (RA-ku kom-mu-ni-KAY-kuhn), or “communicating branches” (singular, ramus communicans).
Dermatomes
Nerve Plexuses
## Neuronal Pools

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Divergence</strong></td>
<td>A mechanism for spreading stimulation to multiple neurons or neuronal pools in the CNS</td>
</tr>
<tr>
<td><strong>Convergence</strong></td>
<td>A mechanism for providing input to a single neuron from multiple sources</td>
</tr>
<tr>
<td><strong>Serial processing</strong></td>
<td>A mechanism in which neurons or pools work sequentially</td>
</tr>
<tr>
<td><strong>Parallel processing</strong></td>
<td>A mechanism in which neurons or pools process the same information simultaneously</td>
</tr>
<tr>
<td><strong>Reverberation</strong></td>
<td>A positive feedback mechanism</td>
</tr>
</tbody>
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![Diagram of neuronal pools](image-url)
Reflex Arc

1. Arrival of stimulus and activation of receptor
   - Stimulus

2. Activation of a sensory neuron
   - Dorsal root
   - Sensation relayed to the brain by axon collaterals

3. Information processing in the CNS

4. Activation of a motor neuron
   - Ventral root
   - REFLEx ARC

5. Response by effector
   - Effector

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Reflex Classification

Reflexes can be classified by:

**Development**
- Innate Reflexes
  - Genetically determined
- Acquired Reflexes
  - Learned

**Response**
- Somatic Reflexes
  - Control skeletal muscle contractions
  - Include superficial and stretch reflexes
- Visceral (Autonomic) Reflexes
  - Control actions of smooth and cardiac muscles, glands, and adipose tissue

**Complexity of Circuit**
- Monosynaptic
  - One synapse
- Polysynaptic
  - Multiple synapses (two to several hundred)

**Processing Site**
- Spinal Reflexes
  - Processing in the spinal cord
- Cranial Reflexes
  - Processing in the brain
Reflexes

- Stretch
- Muscle Spindles
- Tendon
- Withdrawal
- Crossed Extensor