Chapter 14

The Nervous System

The Spinal Cord and Spinal Nerves

Lecture Presentation by
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Introduction

• The Central Nervous System (CNS) consists of:
  • The **spinal cord**
    • Integrates and processes information
    • Can function with the brain
    • Can function independently of the brain
  • The **brain**
    • Integrates and processes information
    • Can function with the spinal cord
    • Can function independently of the spinal cord
Gross Anatomy of the Spinal Cord

• Features of the Spinal Cord
  • 45 cm in length
  • Passes through the foramen magnum
  • Extends from the brain to L₁
• Consists of:
  • Cervical region
  • Thoracic region
  • Lumbar region
  • Sacral region
  • Coccygeal region
Gross Anatomy of the Spinal Cord

• Features of the Spinal Cord
  • Consists of (continued):
    • Cervical enlargement
    • Lumbosacral enlargement
    • Conus medullaris
    • Cauda equina
    • Filum terminale: becomes a component of the coccygeal ligament
    • Posterior and anterior median sulci
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, however, extends from the brain only to the level of vertebrae L₁–L₂.
Gross Anatomy of the Spinal Cord

• Features of the Spinal Cord
  • Consists of (continued):
    • 31 spinal segments
  • Each segment consists of:
    • Dorsal root
    • Dorsal root ganglia
    • Ventral root
    • Spinal nerve
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, however, extends from the brain only to the level of vertebrae L₁–L₂.
Inferior views of cross sections through representative segments of the spinal cord showing the arrangement of gray and white matter.
Gross Anatomy of the Spinal Cord

• Features of the Spinal Cord
  • Transverse view
    • White matter
    • Gray matter
    • Central canal
    • Anterior median fissure
    • Posterior median sulcus
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, however, extends from the brain only to the level of vertebrae L1–L2.
Inferior views of cross sections through representative segments of the spinal cord showing the arrangement of gray and white matter.
Gross Anatomy of the Spinal Cord

• Features of the Spinal Nerves
  • Classified as mixed nerves
    • **Sensory nerves** (afferent nerves)
      • Transmit impulses toward the spinal cord
    • **Motor nerves** (efferent nerves)
      • Transmit impulses away from the spinal cord
Spinal Meninges

• Features of Spinal Meninges
  • Specialized membranes that provide protection, physical stability, and shock absorption
  • Continuous with the cranial (cerebral) meninges
  • Denticulate ligaments help anchor the spinal cord in position
Anterior view of spinal cord shows meninges and spinal nerves. For this view, the dura and arachnoid membranes have been cut longitudinally and retracted (pulled aside); notice the blood vessels that run in the subarachnoid space bound to the outer surface of the delicate pia mater.
Spinal Meninges

• Features of Spinal Meninges
  • Made of three layers
    • **Dura mater**
      • Tough, fibrous outermost layer
    • **Arachnoid mater**
      • Middle layer
    • **Pia mater**
      • Innermost layer
a Posterior view of the spinal cord shows the meningeal layers, superficial landmarks, and distribution of gray and white matter.
Spinal Meninges

• The Dura Mater
  • Tough fibrous outermost layer of the meninges
    • Stabilizes the spinal cord within the vertebral canal
    • Cranial and sacral attachments stabilize the longitudinal axis of the spinal cord
Spinal Meninges

• The Arachnoid Mater
  • Middle meningeal layer
    • Separated from the pia mater by the subarachnoid space
    • Cerebrospinal fluid flows within this space
    • Arachnoid trabeculae extend from the arachnoid to the outer layer of the pia mater

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Spinal Meninges

• The Pia Mater
  • Deepest meningeal layer
    • Blood vessels are found in this layer
    • Firmly bound to the brain tissue and the spinal cord tissue
Sectional Anatomy of the Spinal Cord

• **Gray Matter**
  • Central canal
  • Consists of somas (cell bodies) surrounding the central canal
  • Consists of glial cells

• **White Matter**
  • Consists of axons
  • Nerves are organized into tracts or columns
  • Located outside the gray matter area
Sectional Anatomy of the Spinal Cord

• Organization of Gray Matter
  • Somas are organized into groups called nuclei
    • Sensory nuclei
    • Motor nuclei
  • Transverse view shows:
    • Posterior gray horns
    • Lateral gray horns
    • Anterior gray horns
    • Gray commissure
Sectional Anatomy of the Spinal Cord

- Organization of Gray Matter
  - **Posterior gray horns**
    - Somatic sensory and visceral nuclei
  - **Lateral gray horns**
    - Visceral motor nuclei
  - **Anterior gray horns**
    - Somatic motor nuclei
  - **Gray commissure**
    - Consists of axons crossing from one side to the other
The left half of this sectional view shows important anatomical landmarks; the right half indicates the functional organization of the gray matter in the anterior, lateral, and posterior gray horns.
Sectional Anatomy of the Spinal Cord

• Organization of White Matter
  • Consists of columns of nerves (funiculi)
  • Posterior white column
  • Anterior white column
  • Lateral white column
  • Columns convey either:
    • Sensory tracts (ascending tracts)
    • Motor tracts (descending tracts)
The left half of this sectional view shows the major columns of white matter. The right half indicates the anatomical organization of sensory tracts in the posterior white column for comparison with the organization of motor nuclei in the anterior gray horn. Note that both sensory and motor components of the spinal cord have a definite regional organization.
Spinal Nerves

• There are 31 pairs of spinal nerves
  • 8 cervical nerves
  • 12 thoracic nerves
  • 5 lumbar nerves
  • 5 sacral nerves
  • 1 coccygeal nerve
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, however, extends from the brain only to the level of vertebrae L₁–L₂.
Spinal Nerves

- Spinal Nerves
  - Each peripheral nerve consists of:
    - **Epineurium**
      - Outer layer—becomes continuous with the dura mater
    - **Perineurium**
      - Layer surrounding a fascicle—a *fascicle* is a bundle of axons
    - **Endoneurium**
      - Layer surrounding a single axon
Figure 14.5a Anatomy of a Peripheral Nerve

A typical peripheral nerve and its connective tissue wrappings

Connective Tissue Layers

- Epineurium covering peripheral nerve
- Perineurium (around one fascicle)
- Endoneurium

Blood vessels

Myelinated axon

Schwann cell

Fascicle

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Spinal Nerves

• Peripheral Distribution of Spinal Nerves
  • Spinal nerves from two branches
    • Dorsal ramus
    • Ventral ramus
  • Spinal nerves T_1 to L_2 have two additional branches
    • White ramus
    • Gray ramus
      • White and gray rami are collectively called rami communicantes
Spinal Nerves

- Peripheral Distribution of Spinal Nerves
  - Motor impulses leave the spinal cord via the ventral root
  - Sensory information enters the spinal cord via the dorsal root
    - **Rami communicantes (white and gray rami)**
      - Innervates smooth muscles, glands, and organs
    - **Dorsal ramus**
      - Innervates skeletal muscles of the neck and back
    - **Ventral ramus**
      - Innervates skeletal muscles of the limbs
Figure 14.6a Peripheral Distribution of Spinal Nerves

**Motor Commands**

- **Postganglionic fibers to smooth muscles, glands, etc., of back**
  - To skeletal muscles of back
  - Dorsal root ganglion
  - Dorsal root
  - Visceral motor
  - Somatic motor

- **To skeletal muscles of body wall, limbs**
  - Ventral root
  - Ventral ramus

- **Postganglionic fibers to smooth muscles, glands, etc., of body wall, limbs**
  - Rami communicantes
  - White ramus (preganglionic)
  - Gray ramus (postganglionic)

- **Postganglionic fibers to smooth muscles, glands, visceral organs in thoracic cavity**
  - Sympathetic nerve

- **Preganglionic fibers to sympathetic ganglia innervating abdominopelvic viscera**

**KEY**

- Somatic motor commands
- Visceral motor commands

The distribution of motor neurons in the spinal cord and motor fibers within the spinal nerve and its branches

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Figure 14.6b Peripheral Distribution of Spinal Nerves

**Sensory Information**

- From interoceptors of back
- From exteroceptors, proprioceptors of back
- Dorsal root
- Ventral root
- Dorsal root ganglion
- Rami communicantes
- From interoceptors of body wall, limbs
- From exteroceptors, proprioceptors of body wall, limbs
- Visceral sensory
- Somatic sensory

**KEY**

- Somatic sensations
- Visceral sensations

A comparable view detailing the distribution of sensory neurons and sensory fibers

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Spinal Nerves

• Dermatomes
  • Each pair of spinal nerves monitors specific surface areas
  • These are clinically important areas regarding surgery
Figure 14.7 Dermatomes
Nerve Plexuses

- There are four nerve plexuses
  - Cervical plexus
  - Brachial plexus
  - Lumbar plexus
  - Sacral plexus
    - Sometimes the lumbar and sacral are combined to form the **lumbosacral plexus**
Nerve Plexuses

• The Cervical Plexus (C₁–C₅)
  • Consists of **cutaneous** and **muscular** branches
  • Cutaneous branch innervates:
    • Head
    • Neck
    • Chest
Nerve Plexus

• The Cervical Plexus
  • Consists of cutaneous and muscular branches
  • Muscular branch innervates:
    • Omohyoid, sternohyoid, geniohyoid, thyrohyoid, sternothyroid
    • Rhomboids
    • Serratus anterior
    • Sternoceleidomastoid
    • Diaphragm (controlled by the phrenic nerve of the cervical plexus)
The Cervical Plexus

The cervical plexus consists of cutaneous and muscular branches from the ventral rami of spinal nerves C1-C4 and some fibers from C5. The plexus lies deep to the sternocleidomastoid muscle, and anterior to the middle scalene and levator scapulae muscles. The cutaneous branches of this plexus innervate areas on the head, neck, and chest. The muscular branches innervate five of the extrinsic muscles of the larynx via the ansa cervicalis.

Craniad Nerves
The cervical plexus supplies small branches to the hypoglossal nerve and the accessory nerve through C1.

Great Auricular Nerve
The great auricular nerve arises from C2 and C3 and crosses anteriorly to the sternocleidomastoid muscle and travels toward the parotid salivary gland, where it divides. This nerve receives sensory information from the skin over the gland, the posterior aspect of the ear, and skin of the neck.

Nerves to Rhomboidei and Serratus Anterior
Motor fibers originating at C1 innervate the rhomboidei (major and minor) and a portion of the serratus anterior muscle.

Transverse Cervical Nerve
The transverse cervical nerve arises from C4 and C5 and receives sensory input from the skin of the anterior triangle of the neck.

Nerves to Rhomboidei and Serratus Anterior
Motor fibers originating at C1 innervate the rhomboidei (major and minor) and a portion of the serratus anterior muscle.

Supraclavicular Nerves
The supraclavicular nerves arise from C3 and C4 as a common trunk. This trunk receives sensory input from the skin of the neck and shoulder.

Phrenic Nerve
The phrenic nerve, which provides sensory information from, and motor innervation to, the diaphragm, originates from C4, with minor contributions from C3 and C5.
Nerve Plexus

• The Brachial Plexus (C<sub>5</sub>–T<sub>1</sub>)
  • Innervates the pectoral girdle and upper limbs
  • The ventral rami emerging from C<sub>5</sub> to T<sub>1</sub> form the trunks
    • Superior trunk
    • Middle trunk
    • Inferior trunk
Nerve Plexus

• The Brachial Plexus (C₅–T₁)
  • The trunks form the divisions
    • Anterior
    • Posterior
  • The divisions form the cords
    • Posterior
    • Lateral
    • Medial
  • The cords form the spinal nerves
The Brachial Plexus

The brachial plexus is larger and more complex than the cervical plexus. It is formed by the ventral rami of spinal nerves C8-T1, and innervates the pectoral girdle and upper limb. The ventral rami converge to form the superior, middle, and inferior trunks.

**Nerves**
The nerves of the brachial plexus arise from one or more trunks or cords whose names indicate their positions relative to the axillary artery, a large artery supplying the upper limb.

- Dorsal scapular nerve
- Nerve to subclavius muscle
- Suprascapular nerve

The lateral cord forms the musculocutaneous nerve exclusively and, together with the medial cord, contributes to the median nerve. The ulnar nerve is the other major nerve of the medial cord. The posterior cord gives rise to the axillary nerve and the radial nerve.

**Cords**
All three posterior divisions unite to form the posterior cord, while the anterior divisions of the superior and middle trunks unite to form the lateral cord. The medial cord is formed by a continuation of the anterior division of the intermediate trunk.

**Divisions**
Each of these trunks then divides into an anterior division and a posterior division.

**Trunks**
The ventral rami converge to form the superior, middle, and inferior trunks.

**Ventral Rami (Roots)**
The roots of the brachial plexus are formed by the ventral rami of spinal nerves C8-T1.
In this anterior view of the brachial plexus and upper limb, the distribution of major peripheral nerves can be seen.
This posterior view of the brachial plexus shows the location and distribution of the nerves.
Nerve Plexus

- The Cords of the Brachial Plexus (details)
  - **Lateral cord**: extends to form the musculocutaneous nerve
  - The lateral cord and medial cord extend to form the **median nerve**
  - **Medial cord** extends to form the **ulnar nerve**
  - **Posterior cord**: branches to form the **radial nerve and axillary nerve**
Figure 14.9 The Cervical and Brachial Plexuses

The Brachial Plexus

The brachial plexus is larger and more complex than the cervical plexus. It is formed by the ventral rami of spinal nerves C5–T1 and innervates the pectoral girdle and upper limb. The ventral rami converge to form the superior, middle, and inferior trunks.

<table>
<thead>
<tr>
<th>Nerves</th>
<th>Cords</th>
<th>Divisions</th>
<th>Trunks</th>
<th>Ventral Rami (Roots)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorsal scapular nerve</td>
<td>All three posterior divisions unite to form the posterior cord, while the anterior divisions of the superior and middle trunks unite to form the lateral cord. The medial cord is formed by a continuation of the anterior division of the interior trunk.</td>
<td>Each of these trunks then divides into an anterior division and a posterior division.</td>
<td>The ventral rami converge to form the superior, middle, and inferior trunks.</td>
<td>The roots of the brachial plexus are formed by the ventral rami of spinal nerves C5–T1.</td>
</tr>
</tbody>
</table>

The lateral cord forms the musculocutaneous nerve exclusively and, together with the medial cord, contributes to the median nerve. The ulnar nerve is the other major nerve of the medial cord. The posterior cord gives rise to the axillary nerve and the radial nerve.

Lateral pectoral nerve
Medial pectoral nerve
Subscapular nerve
Axillary nerve
Thoracodorsal nerve
Musculocutaneous nerve
Long thoracic nerve
Medial antebrachial cutaneous nerve
Median nerve
Ulnar nerve
Radial nerve
Posterior brachial cutaneous nerve

KEY

Roots (ventral rami)
Trunks
Divisions
Cords
Nerves

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In this anterior view of the brachial plexus and upper limb, the distribution of major peripheral nerves can be seen.
This dissection shows the major nerves arising from the cervical and brachial plexuses.
Nerve Plexus

• The Lumbar and Sacral Plexuses ($T_{12}$–$S_4$)
  • Also called the **lumbosacral plexus**
  • Lumbar plexus arises from $L_1$ to $L_4$
  • Sacral plexus arises from $L_4$ to $S_4$
The lumbar plexus arises from the ventral rami of spinal nerves L₁ to L₄ (with a small contribution from T₁₂); the sacral plexus arises from the ventral rami of spinal nerves L₄ to S₅. Because the ventral rami of both plexuses are distributed to the lower limb, and because spinal nerves L₄ and L₅ are involved in both the lumbar and sacral plexuses, these two plexuses are often collectively referred to as the lumbosacral plexus.

**The Lumbar Plexus**

The lumbar plexus is formed by the ventral rami of T₁₂-L₄. The major nerves of the plexus are the lateral femoral cutaneous nerve, the genitofemoral nerve, and the femoral nerve.

- **Iliohypogastric Nerve**
  - The iliohypogastric nerve is formed by the ventral rami of T₁₂ and L₁. It innervates the external and internal oblique and transversus abdominis muscles. It receives sensory information from skin over the inferior abdomen and the buttocks.

- **Iliohypogastric Nerve**
  - The iliohypogastric nerve is formed by the ventral rami of L₁. It innervates the external and internal oblique and transversus abdominis muscles. It receives sensory information from skin over the superior and medial thigh and portions of the external genitalia.

- **Lateral Femoral Cutaneous Nerve**
  - The lateral femoral cutaneous nerve is formed by the ventral ramus of L₂ and L₃. It receives sensory information from the skin over the anterior, lateral, and posterior thigh.

- **Genitofemoral Nerve**
  - The genitofemoral nerve is formed by the ventral rami of L₁ and L₂. It receives sensory information from skin over the anteromedial surface of the thigh and portions of the external genitalia.

  Branches of genitofemoral nerve:
  - Femoral branch
  - Genital branch

- **Femoral Nerve**
  - The femoral nerve is formed by the ventral rami of L₂-L₄. It innervates the quadriceps, sartorius, pectineus, and iliopsoas muscles. It receives sensory information from the skin of the anteromedial surface of the thigh and the medial surface of the leg and foot.

- **Obturator Nerve**
  - The obturator nerve is formed by the ventral rami of L₂-L₄. It innervates the gracilis and obturator externus muscles, and the adductor magnus, brevis, and longus muscles. It receives sensory information from the medial surface of the thigh.
The Sacral Plexus

The sacral plexus is formed by the ventral rami of L₄-S₂. Part of the ventral ramus of L₄ and the ventral ramus of L₅ form the lumbosacral trunk, which joins the sacral plexus. The five major nerves of the sacral plexus are discussed below.

**Superior Gluteal Nerve**
The superior gluteal nerve is formed by the ventral rami of L₄-S₁. It innervates the gluteus maximus, gluteus medius, and tensor fasciae latae muscles.

** Inferior Gluteal Nerve**
The inferior gluteal nerve is formed by the ventral rami of L₅-S₂. It innervates the gluteus medius muscle.

**Sciatic Nerve**
The sciatic nerve is the largest nerve in the human body. It is formed by the ventral rami of L₄-S₃ and innervates the semimembranosus, semitendinosus, and adductor magnus muscles.

**Posterior Femoral Cutaneous Nerve**
The posterior femoral cutaneous nerve is formed by the ventral rami of S₁-S₃. It receives sensory information from the perineum and the posterior surface of the thigh and leg.

**Pudendal Nerve**
The pudendal nerve is formed by the ventral rami of S₂-S₃. It innervates muscles of the perineum, including the external anal sphincter, and the external genitalia and related skeletal muscles (the bulbocavernosus and ischiocavernosus muscles).

**Branches of the Sciatic Nerve**
The sciatic nerve branches into the tibial and fibular nerves as it approaches the popliteal fossa. (See Figure 14.12)

- **Tibial Nerve:** Innervates the muscles of the lower leg, foot, and skin over the posterior surface of the leg and the plantar surface of the foot.
- **Fibular Nerve:** Innervates the short head of the biceps femoris muscle, the interossei muscles, the extensor muscles of the toes, and the skin over the lateral portion of the leg and the lateral surface of the foot (through the sural nerve).
Nerve Plexus

• The Lumbar and Sacral Plexuses ($T_{12}$–$S_4$)
  • Lumbar plexus nerves $L_1$ to $L_4$
    • Genitofemoral nerve
    • Lateral femoral cutaneous nerve
    • Femoral nerve
    • Iliohypogastric nerve
    • Ilioinguinal nerve
    • Obturator nerve
Nerve Plexus

• The Lumbar and Sacral Plexuses ($T_{12}$–$S_4$)
  • Sacral plexus nerves $L_4$ to $S_4$
    • **Sciatic nerve** (branches to form the common fibular nerve and the tibial nerve)
  • Pudendal nerve
  • Superior gluteal nerve
  • Inferior gluteal nerve
  • Posterior femoral cutaneous nerve
Figure 14.12a Peripheral Nerves Originating from the Lumbar and Sacral Plexuses

**Nerves Originating from the Lumbar Plexus**
- Iliohypogastric nerve
- Illioinguinal nerve
- Genitofemoral nerve
- Lateral femoral cutaneous nerve
- Femoral nerve
- Obturator nerve

**Nerves Originating from the Sacral Plexus**
- Subcostal nerve
- Superior gluteal nerve
- Inferior gluteal nerve
- Posterior femoral cutaneous nerve
- Pudendal nerve
- Sciatic nerve

**Common Fibular Nerve and Its Branches**
- Common fibular nerve
- Superficial fibular nerve
- Deep fibular nerve

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Figure 14.12b Peripheral Nerves Originating from the Lumbar and Sacral Plexuses

- Superior gluteal nerve
- Inferior gluteal nerve
- Posterior femoral cutaneous nerve
- Pudendal nerve
- Sciatic nerve

**Nerves Originating from the Sacral Plexus**

**Branches of the Sciatic Nerve**

- Tibial nerve
- Common fibular nerve
- Medial sural cutaneous nerve
- Lateral sural cutaneous nerve
- Sural nerve
- Medial plantar nerve
- Lateral plantar nerve

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Nerve Plexus

• Summary of the Spinal Nerves
  • **Cervical spinal nerves** emerge from C₁–C₈
  • **Thoracic spinal nerves** emerge from T₁–T₁₂
  • **Lumbar spinal nerves** emerge from L₁–L₅
  • **Sacral spinal nerves** emerge from S₁–S₅
  • **Coccygeal spinal nerves** emerge from Co₁
Nerve Plexus

• Summary of the Nerve Plexuses
  • **Cervical plexus** nerves emerge from C₁–C₅
  • **Brachial plexus** nerves emerge from C₅–T₁
  • There is not a thoracic plexus
  • **Lumbar plexus** nerves emerge from T₁₂–L₄
  • **Sacral plexus** nerves emerge from L₄–S₄
  • There is not a coccygeal plexus
Figure 14.3 Posterior View of Vertebral Column and Spinal Nerves

- Occipital bone
- Spinal cord emerging from foramen magnum
- Cervical plexus (C1–C8)
- Cervical spinal nerves (C1–C8)
- Thoracic spinal nerves (T1–T12)
- Brachial plexus (C5–T1)
- Lumbar plexus (T12–L4)
- Lumbar spinal nerves (L1–L5)
- Sacral plexus (L4–S4)
- Sacral spinal nerves (S1–S5)
- Sciatic nerve
- Coccygeal nerves (Co1)
- Sacral spinal nerves (S1–S5) emerging from sacral foramina
Reflexes

• Reflex
  • An immediate involuntary motor response

• Reflex Arc
  • The neural “wiring” of a single reflex
  • Begins at a sensory receptor and ends at a peripheral receptor
Reflexes

• Pathway of a Reflex Arc
  1. Activation of a sensory receptor
  2. Relay of information to the CNS
  3. Information processing
  4. Activation of a motor neuron
  5. Response by the effector
Reflexes

• Classification of Reflexes
  • Reflexes are classified according to:
    • Their development
      • Innate or acquired
    • The site where information is processed
      • Spinal or cranial (cerebral)
    • The nature of the resulting motor response
      • Somatic, visceral, or autonomic
    • The complexity of the neural circuit
      • Monosynaptic or polysynaptic
Figure 14.13 A Reflex Arc

1. Arrival of stimulus and activation of receptor

2. Activation of a sensory neuron

3. Information processing in CNS

4. Activation of a motor neuron

5. Response by effector

KEY
- Sensory neuron (stimulated)
- Excitatory interneuron
- Motor neuron (stimulated)
### Reflexes

**Figure 14.14 The Classification of Reflexes**

Reflexes can be classified by:

<table>
<thead>
<tr>
<th>Development</th>
<th>Response</th>
<th>Complexity of Circuit</th>
<th>Processing Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innate Reflexes</td>
<td>Somatic Reflexes</td>
<td>Monosynaptic</td>
<td>Spinal Reflexes</td>
</tr>
<tr>
<td>• Genetically</td>
<td>• Control skeletal</td>
<td>• One synapse</td>
<td>• Processing in</td>
</tr>
<tr>
<td>determined</td>
<td>muscle contractions</td>
<td></td>
<td>the spinal cord</td>
</tr>
<tr>
<td></td>
<td>• Include superficial and stretch reflexes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acquired Reflexes</td>
<td>Visceral (Autonomic) Reflexes</td>
<td>Polysynaptic</td>
<td>Cranial Reflexes</td>
</tr>
<tr>
<td>• Learned</td>
<td>• Control actions of smooth and cardiac muscles, glands</td>
<td>• Multiple synapses (two to several hundred)</td>
<td>• Processing in the brain</td>
</tr>
</tbody>
</table>

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Reflexes

• Classification of Reflexes

• Spinal reflexes can be:
  • **Monosynaptic**
    • Involves a single segment of the spinal cord
  • **Polysynaptic**
    • Integrates motor output from several spinal segments
A monosynaptic reflex circuit involves a peripheral sensory neuron and a central motor neuron. In this example, stimulation of the receptor will lead to a reflexive contraction in a skeletal muscle.

A polysynaptic reflex circuit involves a sensory neuron, interneurons, and motor neurons. In this example, the stimulation of the receptor leads to the coordinated contractions of two different skeletal muscles.
Reflexes

• Spinal Reflexes
  • Stretch reflex
    1. Stimulus stretches a muscle
    2. Activates a sensory neuron
    3. Information is processed in the spinal cord
    4. Motor neurons are activated
    5. Muscle (effector) contracts
Figure 14.16a Stretch Reflexes

1. **Stimulus.** Stretching of muscle stimulates muscle spindles

2. **Activation of a sensory neuron**

3. **Information processing at motor neuron**

4. **Activation of motor neuron**

5. **Response.** Contraction of muscle

**Steps 1–5 are common to all stretch reflexes.**
The patellar reflex is controlled by muscle spindles in the quadriceps muscle group. The stimulus is a reflex hammer striking the muscle tendon, stretching the spindle fibers. This results in a sudden increase in the activity of the sensory neurons, which synapse on spinal motor neurons. The response occurs upon the activation of motor units in the quadriceps group, which produces an immediate increase in muscle tone and a reflexive kick.