Spinal Cord & Spinal Nerves

1. Provide a pathway for impulses
2. Mediate spinal reflexes
3. Integrate sensory and motor impulses
Gross anatomy of the spinal cord

- extends from medulla oblongata in the brainstem to L2
- conus medullaris
  - end of cord at L2
- cauda equina
  - spinal nerve roots that descend through lower part of vertebral canal

Gross anatomy of the spinal cord

- filum terminale
  - extension of pia mater
  - strand of connective tissue
  - anchors cord to sacrum
- 2 enlargements
  - cervical enlargement
  - lumbar enlargement
  - Points of entry/exit for dorsal and ventral roots for limbs
Segmental Anatomy of Spinal Cord

- 31 horizontal segments
  - based on origins of the 31 paired spinal nerves
  - C4, T8, L2, etc.
- segments
  - Designated C1, T7, L2, etc
- dorsal root ganglion
- spinal nerve, formed by fusion of
  - dorsal root
  - ventral root

Spinal Meninges (singular, meninx)

- meningitis…
- dura mater
  - dense irregular CT
- arachnoid mater
  - collagen and elastic fibers
- pia mater
  - thin CT layer
Meningeal spaces

- epidural space
  - fat filled space
  - protects spinal cord
- subdural space
  - thin space ICF
- subarachnoid space
  - filled with CSF
  - CSF absorbs shock, protects the spinal cord
Gray matter
- organized into
  - horns
  - gray commissure
- Contains
  - somas- organized in nuclei (see figure)
  - unmyelinated fibers
  - neuroglia

White matter
- myelinated tracts
  - 3 paired columns (funiculi)
  - Anterior
  - Posterior
  - Lateral
- anterior white commissure
  - connects left and right white matter
Columns

- contain tracts (fasciculi)
  - bundles of neurons with common origins/destinations
- spinal cord tracts are continuous with tracts in the brainstem
- sensory tracts (ascending)
- motor tracts (descending)

Spinal nerves

- 31 paired nerves
- run between CNS and periphery
- are mixed nerves
  - contain both
    - afferent fibers
    - efferent fibers
Spinal Nerve Roots

- ventral (motor) root
- dorsal (sensory) root
- dorsal root ganglion
  - Somas of sensory neurons

Spinal nerves
Connective Tissue coverings of nerves

- epineurium
  - covers entire nerve
  - confluent with the dura mater
- perineurium
  - bundles groups of axons into fascicles
- endoneurium
  - wraps individual axons

Distribution of spinal nerves

- This image is from Netter’s atlas
Distribution of Spinal Nerves for T1 to T12:

- 4 branches (rami)
  - 1. dorsal ramus
    - deep muscles back
    - skin of dorsal trunk
  - 2. ventral ramus
    - Muscles and skin of limbs and anterolateral trunk
  - 3. rami communicantes
    - Visceral receptors
    - Visceral effectors
  - 4. meningeal branch
    - *not visible here
    - Vertebrae
    - vertebral ligaments
    - spinal cord vessels
    - meninges

Sources of sensory input
Destinations of motor output

Dermatomes

- areas of the skin that provides input to a single spinal nerve
- overlap of regions varies
Plexuses

- networks of interconnecting nerves
- formed by the ventral rami
- pictured: brachial plexus

Plexuses

- cervical
- brachial
- lumbar
- sacral
Brachial plexus

Cervical plexus
### Lumbar & Sacral Plexus

**TABLE 13-2 The Brachial Plexus**

<table>
<thead>
<tr>
<th>Nerve(s)</th>
<th>Spinal Segments</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nerve to subclavius</td>
<td>C5-C6</td>
<td>Subclavius muscle</td>
</tr>
<tr>
<td>Dorsal scapular nerve</td>
<td>C5</td>
<td>Rhomboid and levator scapulae muscles</td>
</tr>
<tr>
<td>Long thoracic nerve</td>
<td>C5-T1</td>
<td>Serratus anterior muscle</td>
</tr>
<tr>
<td>Suprascapular nerve</td>
<td>C5, C6</td>
<td>Supraspinatus and infraspinatus muscles; sensory from shoulder joint and scapula</td>
</tr>
<tr>
<td>Pectoral nerves (medial and lateral)</td>
<td>C5, C6</td>
<td>Pectoralis muscles</td>
</tr>
<tr>
<td>Subscapular nerves</td>
<td>C5, C6</td>
<td>Subscapularis and teres major muscles</td>
</tr>
<tr>
<td>Thoracodorsal nerve</td>
<td>C5-C8</td>
<td>Latissimus dorsi muscle</td>
</tr>
<tr>
<td>Axillary nerve</td>
<td>C5, C6</td>
<td>Deltoid and teres minor muscles; sensory from the skin of the shoulder</td>
</tr>
<tr>
<td>Medial antebraclial cutaneous nerve</td>
<td>C5, T1</td>
<td>Sensory from skin over anterior, medial surface of arm and forearm</td>
</tr>
</tbody>
</table>

**TABLE 13-3 The Brachial Plexus**

<table>
<thead>
<tr>
<th>Nerve(s)</th>
<th>Spinal Segments</th>
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</tr>
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<tbody>
<tr>
<td>Radial nerve</td>
<td>C5-T1</td>
<td>Many extensor muscles on the arm and forearm (brachii, anconaeus, extensor carpi radialis, extensor carpi ulnaris, and brachioradialis muscles); supinator muscle, digital extensor muscles, and abductor pollicis muscle via the deep branch; sensory from skin over the posteioralateral surface of the limb through the posterior brachial cutaneous nerve (arm), posterior antebraclial cutaneous nerve (forearm), and the superficial branch (radial half of hand)</td>
</tr>
<tr>
<td>Musculocutaneous nerve</td>
<td>C5-T1</td>
<td>Flexor muscles on the arm (brachii, triceps, and coracobraclial muscles); sensory from skin over lateral surface of the forearm through the lateral antebraclial cutaneous nerve</td>
</tr>
<tr>
<td>Median nerve</td>
<td>C5-T1</td>
<td>Flexor muscles on the forearm (flexor carpi radialis and palmaris longus muscles); pronator quadratus and pronator teres muscles; digital flexors through the anterior interosseous nerve; sensory from skin over anterolateral surface of the hand</td>
</tr>
<tr>
<td>Ulnar nerve</td>
<td>C6, T1</td>
<td>Flexor carpi ulnaris muscle, flexor digitorum profundus muscle, adductor pollicis muscle, and small digital muscles via the deep branch; sensory from skin over medial surface of the hand through the superficial branch</td>
</tr>
</tbody>
</table>

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### Lumbar Plexus

- **Intercostal nerve**
- **Hypogastric nerve**
- **Iliinguinal nerve**
- **Genitofemoral nerve**
- **Lateral femoral cutaneous nerve**
- **Femoral nerve**
- **Oburator nerve**
- **Lumbar plexus, anterior view**

### Sacral Plexus

- **Lumbosacral trunk**
- **Superior gluteal nerve**
- **Sacral plexus, posterior view**
Intercostal nerves (T1-T12) innervate

- structures of intercostal spaces
  - intercostal muscles
  - intercostal arteries and veins
- abdominal wall muscles
- skin
  - anterolateral trunk
  - posterior trunk
  - axillae
  - posteriomedial arm

Neuronal Pools/Circuit patterns
Neuronal Pools

- located in the CNS
- hundreds exist
- functions (output of neuronal pools)
  - stimulate or depress activity in part of CNS
  - effects of neuronal pool output
    - interpretation of sensory information
    - coordination of motor commands

Divergence

- permits broad distribution of information
- example
  - visual sensory information
Convergence

- several neurons synapse on a single postsynaptic neuron
- example
  - motor neurons controlling respiratory muscles

Serial processing

- linear sequence of neurons
- example
  - Peripheral sensations travelling to CNS
Parallel processing

- several neurons/pools process same info simultaneously
- example
  - reflexes associated with pain

Reverberation

- axon collaterals stimulate presynaptic neuron (example of a positive feedback mechanism)
- function until
  - synaptic fatigue or inhibition of initial neuron occurs
- examples
  - consciousness, memory, muscular coordination, breathing
Neural Reflexes

- automatic response to
  - a specific stimulus
- provide rapid adjustments to homeostatic imbalances
- may be used to assess nervous system function/damage

Reflex arc

- pathway
  - route followed by a series of impulses through the nervous system
- reflex arcs
  - simplest pathways
  - begin at a receptor
  - end at an effector
Events in a neural reflex

Classifications of Reflexes

- **Innate Reflexes**
  - Genetically determined

- **Acquired Reflexes**
  - Learned

- **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

- **Monosynaptic**
  - One synapse

- **Polysynaptic**
  - Multiple synapses (two to several hundred)

- **Spinal Reflexes**
  - Processing in the spinal cord

- **Cranial Reflexes**
  - Processing in the brain
Monosynaptic reflexes

- little delay in pathway
- control rapid responses to specific stimuli
- stretch reflex
  - rapid stretch
  - elicits contraction
- Receptor
  - muscle spindle

Muscle spindles

- monitor tension in muscles
- stretch results in contraction
- rapid stretch -> rapid contraction
Polysynaptic reflexes

- complicated responses
- interneurons control multiple muscle groups involved
- stimulation of some muscles and inhibition of others
- flexor reflex pictured

Polysynaptic reflexes; characteristics

- crossed extensor reflex pictured here
- pools of interneurons are involved
- Intersegmental
- reciprocal inhibition
- reverberating circuits prolong response
- multiple reflexes provide the response
Voluntary movements and Reflex motor patterns

- Human movements are due to sets of neurons
- These movements are either
  - Reflexive (below consciousness)
  - Initiated by brain (voluntary)
- Preexisting patterns exist and are handled by neuronal pools in the spinal cord
  - Walking, jumping
  - May be modified by brain

Reinforcement/Inhibition

- Read this section
Reflexes – clinically used for diagnostic testing of nervous system

- Sensory function
- Motor function