The Nervous System

PNS continued

Peripheral Nerve Regeneration

• Possible if cell body has not been damaged
• Axon underlying myelin sheath can regenerate

1. The axon becomes fragmented at the injury site.
2. Macrophages clean out the dead axon distal to the injury.
3. Axon sprouts, or filaments, grow through a regeneration tube formed by Schwann cells.
4. The axon regenerates and a new myelin sheath forms.
Neuritis
- Inflammation of a nerve
  - Sciatica
  - Bell's Palsy

Shingles
- Varicella Zoster virus
- Dorsal root ganglia
- Consistent with dermatome
- Vaccine

Multiple Sclerosis
- Loss of myelin in CNS → scleroses
  - Visual disturbances
  - Muscle weakness
- Autoimmune disorder
- Remissions
- Progressive

Autonomic Nervous System (ANS)
- Involuntary
- Sensory (afferent) pathways
- Motor (efferent) pathways
- Visceral reflex system

Structure of the ANS
- Sensory (afferent) pathway
  - Visceral interoceptors (visceroreceptors)
    - Osmolarity
    - Pressure
    - Temperature
    - Blood gases
    - Chemical composition of plasma and body fluids
Structure of the ANS

- Sensory (afferent) pathway
  - Single sensory neuron from organ to CNS
    - Cell body in dorsal root ganglion
    - Synapse with association neurons in spinal cord

![Figure 12.32](image)

Autonomic Nervous System (ANS)

- ANS Motor (efferent) neurons
  - Innervate smooth muscle, cardiac muscle and glands
  - Operate via subconscious control

Autonomic Nervous System (ANS)

- Efferent (motor) pathway
  - Two motor neurons between CNS and effector
    - Preganglionic neuron
      - Cell body in CNS
    - Postganglionic neuron
      - Cell body in autonomic ganglion (outside CNS)

Motor Pathways

Autonomic Nervous System (ANS)

- Visceral reflex system
  - E.g., coughing, sneezing, swallowing, vomiting
Divisions at a Glance

- Sympathetic
  - “Fight or Flight”
  - NE and acetylcholine
  - Thoracolumbar

- Parasympathetic
  - “Rest and Digest”
  - Acetylcholine
  - Craniosacral

Dual Innervation

### Parasympathetic Division Outflow

<table>
<thead>
<tr>
<th>Cranial Outflow</th>
<th>Nerve</th>
<th>Ganglia (Terminal Ganglia)</th>
<th>Effector Organ(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oculomotor (III)</td>
<td>Ciliary</td>
<td></td>
<td>Eye</td>
</tr>
<tr>
<td>Facial (VII)</td>
<td>Pterygopalatine, Submaxillar</td>
<td></td>
<td>Salivary, nasal, and lacrimal glands</td>
</tr>
<tr>
<td>Glossopharyngeal (IX)</td>
<td>Cricopharyngeal</td>
<td></td>
<td>Parotid salivary glands</td>
</tr>
<tr>
<td>Vagus (X)</td>
<td>Within the walls of target organs</td>
<td></td>
<td>Heart, lungs, and most visceral organs</td>
</tr>
<tr>
<td>S2-S4 (Sacral)</td>
<td>Within the walls of target organs</td>
<td>Large intestine, urinary bladder, ureters, and reproductive organs</td>
<td></td>
</tr>
</tbody>
</table>
The Sympathetic Division

1) Preganglionic fibers leave through ventral root of spinal cord
   2) Fibers join spinal nerve
   3) Spinal nerve divides at ventral rami
   4) Rami branch immediately into white rami communicans
   5) Join sympathetic (paravertebral) ganglia

The Sympathetic Division

- Preganglionic neurons originate in the spinal cord from T1 – L2
- Thoracolumbar division
- FYI: Lateral horns

The Sympathetic Division

- Craniosacral
- Parasympathetic Division
- Peripheral nervous system (PNS)
- Central nervous system (CNS)

The Sympathetic Division

- Figure 14.2
- Figure 14.3
- Figure 14.5a
- Figure 14.6
Sympathetic Trunk Ganglia

- Form longitudinal pathways adjacent to vertebral column
- Each spinal nerve has an associated ganglion (except in cervical region, where several ganglia fuse)

![Image of sympathetic trunk ganglia]

The Sympathetic Division

- Sympathetic trunks and pathways
  - Upon entering a sympathetic trunk ganglion a preganglionic fiber may do one of the following:
    1. Synapse with a ganglionic neuron within the same ganglion
    2. Ascend or descend the sympathetic trunk to synapse in another trunk ganglion

![Diagram of sympathetic division and pathways]

Sympathetic Trunks and Pathways

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![Diagram of sympathetic trunks and pathways]
Sympathetic Trunks and Pathways
• Sympathetic trunks and pathways
  – Upon entering a sympathetic trunk ganglion a preganglionic fiber may do one of the following:
    3. Pass through the trunk ganglion and emerge without synapsing
      - Eventually synapse with post-ganglionic neurons in collateral ganglia, enter an autonomic plexus, and innervate abdominal viscera
      - Form splanchnic nerves

Sympathetic Trunks and Pathways
• Sympathetic trunks and pathways
  – Upon entering a sympathetic trunk ganglion a preganglionic fiber may do one of the following:
    3. Pass through the trunk ganglion and emerge without synapsing

Differences Between the Divisions
<table>
<thead>
<tr>
<th>Division</th>
<th>Origin of Fibers</th>
<th>Length of Fibers</th>
<th>Location of Ganglia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sympathetic</td>
<td>Thoracolumbar region of the spinal cord</td>
<td>Short preganglionic and long postganglionic</td>
<td>Close to spinal cord</td>
</tr>
<tr>
<td>Parasympathetic</td>
<td>Brain and sacral spinal cord (craniosacral)</td>
<td>Long preganglionic and short postganglionic</td>
<td>In visceral effector organs</td>
</tr>
</tbody>
</table>

Neurotransmitters in the ANS
• Cholinergic fibers release the neurotransmitter ACh
  – All ANS preganglionic axons
  – All parasympathetic postganglionic axons
• Adrenergic fibers release the neurotransmitter NE
  – Most sympathetic postganglionic axons
  – Exceptions: sympathetic postganglionic fibers secrete ACh at sweat glands and some blood vessels in skeletal muscles
**Receptors for Neurotransmitters**

- Cholinergic receptors for ACh
- Adrenergic receptors for NE

**Cholinergic Receptors**

- **Nicotinic receptors**
  - Blocked with curare
  - Poison arrows and blow darts
  - Used as a muscle relaxant for surgery (safer alternatives now available)
  - Effect of ACh at nicotinic receptors
    - Always stimulatory

**Clarification, PNS 8: 2d.**

Acetylcholine is not always stimulatory. It is always stimulatory at nicotinic and somatic receptors. It may be inhibitory or excitatory at muscarinic receptors.
Adrenergic Receptors

- Two types
  - Alpha (α) (subtypes α₁, α₂)
  - Beta (β) (subtypes β₁, β₂, β₃)
- Effects of NE depend on which subclass of receptor predominates on the target organ

Cardiovascular Pharmacology

- Heart
  - β₁ - Excitatory in heart
    - increases heart rate, conduction velocity, and contraction strength
  - Major blood vessels
    - β₂ – Inhibitory
      - Vasodilation
    - α₁ – Excitatory
      - Vasoconstriction

Cardiovascular Pharmacology

- Adrenergic blockers
  - Used to treat hypertensive disease
  - α₁ blockers - produce vasodilation
  - β₁ blockers - decrease heart rate and blood pressure

Interactions of the Autonomic Divisions

- Most visceral organs have dual innervation
- Dynamic and precise control of visceral activity
  - Sympathetic division increases heart and respiratory rates, and inhibits digestion and elimination
  - Parasympathetic division decreases heart and respiratory rates, and allows for digestion and the discarding of wastes