**Ch. 6: Peripheral Nervous System**

**Objectives:**

1. Communication between CNS & PNS: afferent (sensory) pathway versus efferent (motor) pathway of information

2. Junction between CNS (spinal cord) and PNS (cranial nerves & spinal nerves)

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**Part 1: Communication between CNS & PNS**

![Diagram showing communication between CNS and PNS](image)

- CNS → Descending info. → PNS
- PNS → Ascending info. → CNS
Part 1: Communication between CNS & PNS

CNS

Descending info.

PNS

Ascending info.

Somatic Motor

Voluntary Motor responses

Autonomic

Involuntary Motor responses

Skeletal Muscles

Smooth muscle
cardiac muscle
glands

1. Somatic sensory
   - Skin, fascia,
     joints, skeletal
     muscle

2. Visceral sensory
   (organs)

3. Special senses
   (sight, sound,
     taste)

All voluntary motor movement
involves 
Ach

neurotransmitter binding to
nicotinic
cholinergic

Parasympathetic Motor responses

Vagus nerves

heart rate
BP
bronchioles
Gi peristalsis
Gi secretions
Gi arterioles

Sacral nerves

urination
defecation

All parasympathetic motor
responses work by

Ach__

muscarinic cholinergic

Sympathetic Motor responses

Thoracic nerves

heart rate
BP
bronchioles
Gi peristalsis
Gi secretions
Gi arterioles
skeletal muscle arterioles

Lumbar nerves

urination
defecation

All sympathetic motor responses work by

Ach

Epinephrine

β1 adrenergic
β2 adrenergic
α adrenergic

rest & digest

Fight/Flight

for vacation

Tense you up

branchial
branchial
vasodilation
vasodilation

soothing

let’s get the hell out

1/26/2018
Part 1: Communication between CNS & PNS

Fig 6.12

ALL Spinal cord preganglionic neurons release ACh at ganglion of PNS.

Visceral effectors = smooth muscle, cardiac muscle, and glands.

Influenced by NE from postganglion neurons or E secreted by adrenal medulla into bloodstream.

Or ACh from postganglion neurons

NE = norepinephrine
E = epinephrine
Sympathetic (epi/norepi.)
Parasympathetic (ACh)

Fig 6.10

Thoracic spinal nerves
Lumbar Spinal nerves
Sacral spinal nerves

Fig 6.13

Autonomic Control of Cardiac and Smooth Muscles:

ALL autonomic receptors are G-protein or muscarinic receptors!
### TABLE 6.4 Effects of Acetylcholine (ACh) in the PNS

<table>
<thead>
<tr>
<th>Neurons Releasing ACh</th>
<th>Location</th>
<th>Type of ACh Receptor</th>
<th>Response</th>
<th>Physiological Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Somatic motor</td>
<td>Skeletal muscles</td>
<td>Nicotinic</td>
<td>Depolarization, producing action potentials</td>
<td>Muscle contraction</td>
</tr>
<tr>
<td>preganglionic neurons of ANS</td>
<td>Autonomic ganglia</td>
<td>Nicotinic</td>
<td>Depolarization, producing action potentials</td>
<td>Stimulates preganglionic neurons of the ANS</td>
</tr>
<tr>
<td>postganglionic parasympathetic neurons</td>
<td>Smooth muscles, glands</td>
<td>Muscarinic</td>
<td>Depolarization, producing action potentials</td>
<td>Contraction of smooth muscles; secretion of glands</td>
</tr>
<tr>
<td>postganglionic parasympathetic neurons</td>
<td>Heart</td>
<td>Muscarinic</td>
<td>Hyperpolarization, slowing the rate of automatic production of action potentials</td>
<td>Slowing of heart rate</td>
</tr>
</tbody>
</table>

### TABLE 6.2 Examples of Sympathetic and Parasympathetic Effects of the Autonomic Nervous System

<table>
<thead>
<tr>
<th>Organ or Function Affected</th>
<th>Sympathetic Effects</th>
<th>Parasympathetic Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td>Increased</td>
<td>Decreased</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>Increased</td>
<td>Slightly decreased</td>
</tr>
<tr>
<td>Urinary bladder</td>
<td>Increased</td>
<td>Decreased sphincter tone for urinating</td>
</tr>
<tr>
<td>Intestinal contractions</td>
<td>Decreased</td>
<td>Increased</td>
</tr>
<tr>
<td>Lungs</td>
<td>Dilation of bronchioles</td>
<td>Constriction of bronchioles</td>
</tr>
<tr>
<td>Pupils</td>
<td>Dilation</td>
<td>Constriction</td>
</tr>
<tr>
<td>Sexual function</td>
<td>Ejaculation and orgasm</td>
<td>Erection</td>
</tr>
<tr>
<td>Sweat glands</td>
<td>Sweating</td>
<td>No effect</td>
</tr>
<tr>
<td>Lacrimal glands</td>
<td>No effect</td>
<td>Tearing</td>
</tr>
<tr>
<td>Parotid glands</td>
<td>No effect</td>
<td>Salivation</td>
</tr>
</tbody>
</table>
**B1 agonist = Dobutamine**
- ↑ HR and cardiac output
- good for heart failure patients

**B1 & B2 agonist = isoproteronol**
- ↑ HR and cardiac output & Bronchodilate

**B2 agonist = Albuterol & Terbutaline**
- Bronchodilates
- good for people w/respiratory prob.

**B1 & B2 blocker = Propanolol**
- ↓ HR and BP & bronchoconstrict
- good for hypertension BUT not people w/respiratory prob. (it will cause bronchoconstriction!)

**B1-specific blocker = Atenolol**
- ↓ HR and BP
- no effect on bronchioles
- good For hypertension WITH respiratory problems (won’t cause bronchoconstriction)

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**Review**

- Communication between CNS & PNS.
  1. Sensory division of PNS (special senses, visceral senses, somatic senses)
  2. Motor division of PNS
     - Somatic motor division
       - = voluntary control skeletal muscles with ACh & nicotinic cholinergic receptors
     - Autonomic motor division
       - Sympathetic regulation (norepineph. & epineph. & adrenergic receptors) can speed some things up and slow other things down.
       - Parasympathetic regulation (ACh and muscarinic cholinergic receptors) can slow some things down and speed other things up.
Part 2: Junction between CNS (spinal cord) and PNS

- PNS communicates between the CNS and remainder of the body
- Consists of:
  - 11 pairs cranial nerves
    *(Except Optic cranial nerve is NOT part of PNS but diencephalon)*
  - 31 pairs spinal nerves

Anatomy Review
Review of Cranial Nerves:

What is the mnemonic devices for remember the list of 12 pairs cranial nerves?

Oh__________Very__________
Once__________Good__________
One__________Vacations_______
Takes__________Are___________
The__________Heavenly_______
Anatomy
Final___________

What is the mnemonic devices for remember which cranial nerves are sensory (S), motor (M), or both (B)?

Some__________Says___________
Say__________Big_____________
Marry_________Brains_________
Money_________Matter_________
But__________Most__________
My__________
Brother__________

31 Pairs of Spinal Nerves in PNS

- **Sensory tracts** (axons) enter spinal cord at dorsal side.
- **Motor tracts** (axons) exit spinal cord at ventral side.
31 Pairs of Spinal Nerves in PNS

31 Spinal Nerve Pairs divided into:
1. Cervical spinal nerves (C1-C8)
2. Thoracic spinal nerves (T1-T12)
3. Lumbar spinal nerves (L1-L5)
4. Sacral spinal nerves (S1-S5)
5. Coccygeal spinal nerve (Co1)
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These spinal nerves branch out into dorsal & ventral rami, and form a nerve plexus.

Dorsal and ventral rami of remaining spinal nerves form 4 major nerve plexuses of the PNS: that carry efferent (motor) info & sensory afferent info. pertaining to our limbs:
1. Cervical Plexus (C1-C4)
2. Brachial Plexus (C5 – T1)
3. Lumbar Plexus (L1 – L4)
4. Sacral Plexus (L5 – S5)
4 major nerve plexuses of the PNS:

1. **Cervical Plexus (C1-C4)**
   - motor control of deep neck muscles
   - sensation in neck skin.

   **Phrenic nerve** of cervical plexus = C3, C4, & C5 has motor control of diaphragm!

   "The primary danger of a ‘broken neck’ is that the phrenic nerve may have been severed above C3, leading to paralysis, cessation of breathing and death …"

2. **Brachial plexus (C5 – T1)**
   – motor control of muscles of shoulder/arm
   – sensory perception in skin of those areas.

   1) **Musculocutaneous nerve** – motor control of arm & forearm flexors.
   Ex: biceps brachii, brachialis, coracobrachialis

   2) **Axillary nerve** – motor control of shoulder muscles. Ex: deltoid muscle, subscapularis

   3) **Radial nerve** – motor control of extensor muscles of the arm, forearm & hand.
   Ex: triceps brachialis, anconeus, brachioradialis, extensor carpi radialis longus and brevis

   4) **Median nerve** – motor control of flexor muscles in forearm & several muscles in lateral hand. Ex. Palmaris longus, flexor carpi radialis, flexor digitorum superficialis

   5) **Ulnar nerve** – motor control of flexor carpi ulnaris muscle & intrinsic hand muscles.
3. Lumbar plexus (L1 – L4)
- motor control of muscles lower abdomen and anterio-medial thigh.
- sensory perception of those areas.

1) femoral nerve - innervates the anterior thigh muscles, lower abdomen, buttocks.

Ex. Quadriceps femoris (vastus lateralis, vastus medialis, vastus intermedius, and rectus femoris)

2) obturator nerve - innervates medial thigh adductor muscles.

Ex. Adductor magnus, adductor longus, adductor brevis, gracilis.

4. Sacral plexus (L4 – S5)
- Motor control of posterior thigh (hamstrings) and posterior leg.
- Sensation in those areas.

Leads to sciatic nerve - largest nerve of the human body!

Ex. Of hamstrings = biceps femoris, semitendinosus, semimembranosus

- Sciatic damage leads to inability to extend hip and flex the knee -> “sciatica”.

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1/26/2018
4. Sacral plexus (L4 – S5)
- Motor control of posterior thigh (hamstrings) and posterior leg.
- Sensation in those areas.

- Sciatic subdivides in the popliteal region:
  i) Common fibular nerve – motor control of lateral leg and foot dorsiflexors & everters
  - damage leads to inability to dorsiflex the foot or “footdrop”.
  
  Ex. Extensor digitorum longus, extensor hallucis longus, fibularis longus & brevis.

  ii) Tibial nerve – motor control of posterior leg and foot plantar flexors.
  - damage leads to inability to plantar flex and invert the foot -> “shuffling gait”;

  Ex. Gastrocnemius, soleus, flexor digitorum longus, flexor hallucis longus

Review

- Organization of the PNS.
  1) 12 pairs cranial nerves
  2) 31 pairs spinal nerves (divided into 5 vertebral regions)

- Paired spinal nerves give rise to 4 groups of nerve plexuses (cervical, brachial, lumbar, & sacral), which carry afferent sensory and efferent motor signals to body.
  Know examples of spinal nerves that come from:
  > cervical plexus (phrenic n.)
  > brachial plexus (axillary, musculocutaneous, radial, median, ulnar n.)
  > lumbar plexus (femoral, obturator n.)
  > sacral plexus (sciatic, which becomes fibular and tibial n. in leg)