Chapter 11:

Efferent Peripheral NS: The Autonomic & Somatic Motor Divisions

Running Problem: Smoking
Review (again)
Homeostasis and the **Autonomic Division**

- BP, HR, Resp., H₂O balance, Temp. . .
- Mostly dual reciprocal innervation
  - i.e., agonist/antagonist or excitatory/inhibitory
- **Sympathetic:**
  - AKA Thoracolumbar
  - flight-or-fight
- **Parasympathetic:**
  - AKA Craniosacral
  - rest and digest
Autonomic Targets

- Smooth Muscle
- Cardiac Muscle
- Exocrine Glands
- Some Endocrine glands
- Lymphoid Tissue
- Adipose
Autonomic pathway: **Two Efferent Neurons in Series**

Preganglionic neuron cell body in CNS

Synapse in autonomic ganglion outside CNS (often divergence!)

Postganglionic neurons

Target cells
Thoracolumbar division (T1 to L2)
- Preganglionic neurons (N1) from thoracolumbar region of spinal cord
- Pre and paravertebral ganglia
- Long postganglionic neurins (N2) secrete NE onto adrenergic receptors
Craniosacral Division

- Long preganglionic axons from brain & S2-S4
- Intramural ganglia
- Postganglionic (nonmyelinated) neurons secrete ACh onto cholinergic muscarinic receptors
Most Common Autonomic NTs:

- **Acetylcholine (ACh)**
  ACh neurons & ACh receptors are called **cholinergic** (**nicotinic or muscarinic**). Located at autonomic preganglionic & para-sympathetic postganglionic synapses

- **Norepinephrine (NE)**
  NE neurons & receptors are called (nor) **adrenergic** (**α and β**). Located at sympathetic postganglionic synapses
NTs of Autonomic NS

Compare to Fig 11-7

α and β

N1

N2

N1

N2
Neuroeffector Junction

= Synapse between postganglionic cell and target

- Most are different from model synapse *(compare to Fig 8-20, p. 270)*

- ANS synapse: axon has **varicosities** containing neurotransmitter
  - May supply many cells, resulting in less specific communication
  - Synthesis of NT is in the varicosity

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**Fig 11-8**
Summary: Pre- & Postganglionic Parasympathetic Neurons Release ACh

- Cholinergic nicotinic receptors
- Cholinergic muscarinic receptors

Receptors:
- nicotinic
- muscarinic

Neurons:
- Cholinergic preganglionic neuron
- Autonomic ganglion
- Cholinergic postganglionic neuron
- Target tissue
Two Types of Cholinergic Receptors: Nicotinic and Muscarinic

1) Nicotinic cholinergic receptor

1. Nicotine = agonist
2. In autonomic ganglia & somatic NS
3. Directly opens a Na⁺ & K⁺ channel: ⇒ ?
4. Curare = antagonist
2) Muscarinic cholinergic receptor

- **Muscarine** = agonist
- Found in neuro-effector junctions of parasympathetic branch
- **G-protein coupled mechanisms**
- **Atropine** = antagonist
Adrenergic Receptors

- Found in neuroeffector junctions of sympathetic branch
- G protein linked, with various 2\textsuperscript{nd} mess. Mech
- NT is NE
- \(\alpha\) - and \(\beta\) - Receptors
Sympathetic Receptors (α & β)

α Receptors:

• NT is NE
• $\alpha_1$: (most common) $\Rightarrow$ Excitation $[\text{Ca}^{2+}]$ In$\uparrow$ $\Rightarrow$ muscle contraction or secretion by exocytosis.
• $\alpha_2$ $\Rightarrow$ Inhibition of GI tract and pancreas


**Sympathetic Receptors**

**β – Receptors** Clinically more important

- $\beta_1 \Rightarrow$ Excitation heart ($[E] = [NE]$)
  - “β - blockers” = Antagonists (e.g.: Propranolol)
- $\beta_2$ usually inhibitory: smooth muscle relaxation of some blood vessels and bronchioles ($[E] > [NE]$)
- $\beta_3$ Adipose; $[NE] > [E]$
- “β -blockers” = Antagonists (e.g.: Propranolol)
Termination of NT Activity

- ACh:
  - ACh esterase

- Catecholamine reuptake
  - Repackaging
  - Degradation (MAO)
  - Blocked by cocaine
Somatic Motor Division

- Pathway consists of single neuron from CNS to target
- Neuromuscular junction: **nicotinic cholinergic receptors**
  - Similar to synapse; post–synaptic membrant called Motor End Plate
  - Recall Motor Unit
- Always excitatory $\Rightarrow$ muscle contracts
- All ACh mediated
  - Degraded by ACh esterase

(a) Acetylcholine (ACh) combines with nicotinic receptors or is metabolized by acetylcholinesterase (AChE).

**Fig 11-13**

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Myasthenia gravis

**MG:** Antibodies block, alter, or destroy the receptors for acetylcholine at the neuromuscular junction

<table>
<thead>
<tr>
<th>RECEPTOR</th>
<th>AGONISTS</th>
<th>ANTAGONISTS</th>
<th>INDIRECT AGONISTS/A NTAGONISTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholinergic</td>
<td>Acetylcholine</td>
<td></td>
<td><em>AChE</em> inhibitors, neostigmine, botulinus toxin</td>
</tr>
<tr>
<td>Muscarinic</td>
<td>Muscarine, scopolamine</td>
<td>Atropine, α-bungarotoxin (muscle only), tetraethylammonium (TEA) (ganglia only) curare</td>
<td></td>
</tr>
<tr>
<td>Nicotinic</td>
<td>Nicotine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adrenergic</td>
<td>Norepinephrine, epinephrine</td>
<td>&quot;Alpha-blockers&quot;</td>
<td>&quot;Beta-blockers&quot;: propranolol (β₁ and β₂), metoprolol (β₁ only)</td>
</tr>
<tr>
<td>Alpha (α)</td>
<td>Phenylephrine</td>
<td>&quot;Beta-blockers&quot;: propranolol (β₁ and β₂), metoprolol (β₁ only)</td>
<td></td>
</tr>
<tr>
<td>Beta (β)</td>
<td>Isoproterenol</td>
<td>&quot;Alpha-blockers&quot;</td>
<td>&quot;Beta-blockers&quot;: propranolol (β₁ and β₂), metoprolol (β₁ only)</td>
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</table>

* AChE = acetylcholinesterase.
Direct (Ant)agonist = mimic or block the NT receptor
(Ant)agonist = mimic or block secretion, reuptake or degradation of NT

![Table 11-3: Agonists and Antagonists of Neurotransmitter Receptors](chart.png)

<table>
<thead>
<tr>
<th>RECEPTOR TYPE</th>
<th>NEUROTRANSMITTER</th>
<th>AGONIST</th>
<th>ANTAGONISTS</th>
<th>INDIRECT AGONISTS/ANTAGONISTS</th>
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<td>Cholinergic</td>
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<td>Nicotinic</td>
<td>Nicotine</td>
<td></td>
<td>α-bungarotoxin (muscle only), TEA (tetraethylammonium; ganglia only), curare</td>
<td></td>
</tr>
<tr>
<td>Adrenergic</td>
<td>Norepinephrine (NE), epinephrine</td>
<td>Phenylephrine</td>
<td>“Alpha-blockers”</td>
<td>Stimulate NE release: ephedrine, amphetamines Prevents NE uptake: cocaine</td>
</tr>
<tr>
<td>Alpha</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beta</td>
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*AChE = acetylcholinesterase.
Direct Antagonists

- **Atropine** → muscarinic
- Curare → nicotinic
- Propranolol → $\beta_1$ and $\beta_2$
- Metoprolol → $\beta_1$
Indirect (Ant)agonists

- **Botulinum toxin**
  - → inhibits ACh release

- **Parathion, malathion**
  - organophosphate insecticides → inhibit AChE (anticholinesterases)

- **Cocaine**
  - → prevents NE reuptake

- **Amphetamines**
  - → stimulates NE release
Summary of Efferent NS

AUTONOMIC PATHWAYS

Somatic motor pathway
Parasympathetic pathway
Sympathetic pathways
Adrenal sympathetic pathway

KEY
- ACh = acetylcholine
- E = epinephrine
- NE = norepinephrine

KEY
- ACh = acetylcholine
- E = epinephrine
- NE = norepinephrine

Autonomic effectors:
- Smooth and cardiac muscles
- Some endocrine and exocrine glands
- Some adipose tissue

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