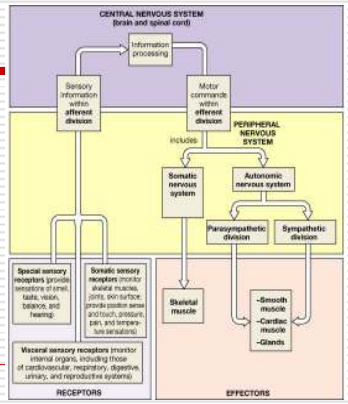
Chapter 11:

Efferent Peripheral NS: The Autonomic & Somatic Motor Divisions

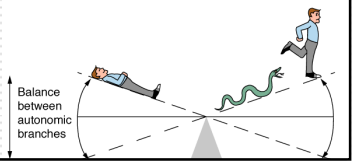
Running Problem: Smoking

Review (again)



Homeostasis and the Autonomic Division

- BP, HR, Resp., H_2O 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

⇩

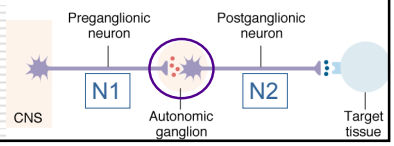
Synapse in autonomic ganglion outside CNS (often divergence!)

⇩

Postganglionic neurons

⇩

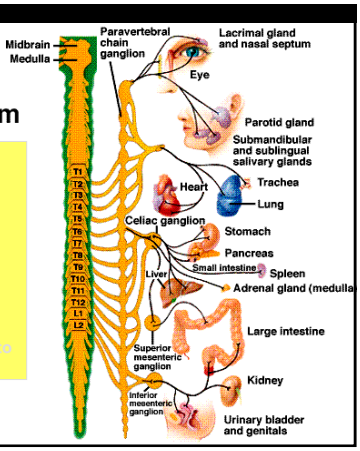
target cells



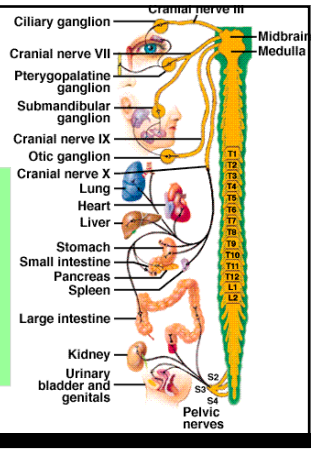
Sympathetic Division of the Autonomic Nervous System

= Thoracolumbar division (T1 to L2)

- Preganglionic neurons (N1)from thoracolumbar region of spinal cord
- Pre and paravertebral ganglia
- Long postganglionic neurons (N2) secrete NE onto adrenergic receptors



Parasympathetic Division of the Autonomic Nervous System



= Craniosacral Division

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

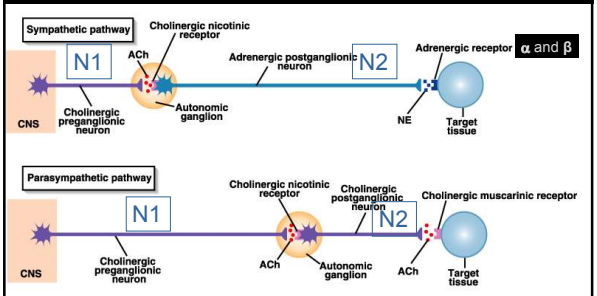
Most Common Autonomic NTs:

- **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**

Fig 11-7

NTs of Autonomic NS

Compare to *Fig 11-7*



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**

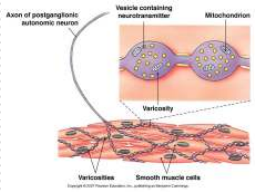
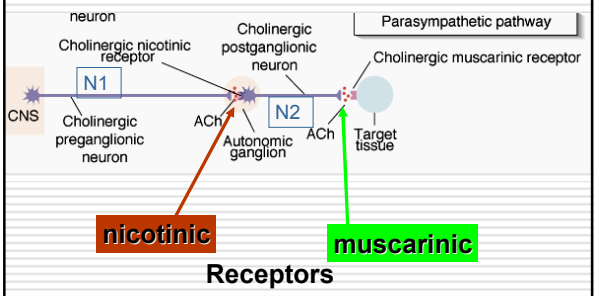


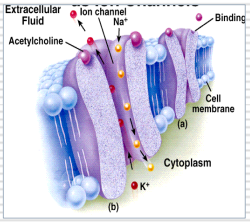
Fig 11-8

Summary: **Pre- & Postganglionic Parasympathetic Neurons Release ACh**



Two Types of Cholinergic Receptors: Nicotinic and Muscarinic

1) Nicotinic cholinergic receptor

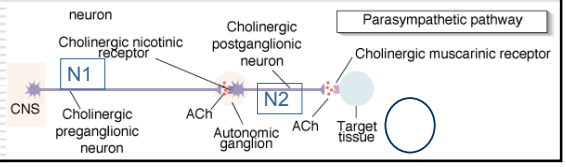


1. **Nicotine = agonist**
2. **In autonomic ganglia & somatic NS**
3. **Directly opens a Na^+ & K^+ channel: ⇒ ?**
4. **Curare = antagonist**

2) Muscarinic receptor

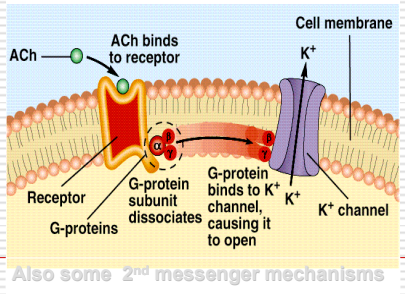
Amanita muscarina

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



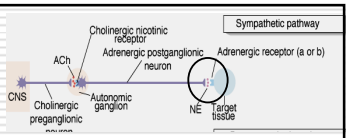
Muscarinic ACh are G-protein Mediated

Receptor Mechanism of Sweat Glands:



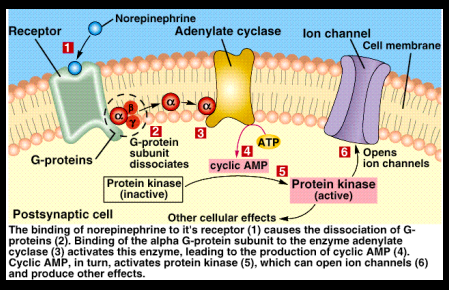
Also some 2nd messenger mechanisms

Adrenergic Receptors



- **Found in neuroeffector junctions of sympathetic branch**
- **G protein linked, with various 2nd mess. Mech**
- **NT is NE**
- **α- and β- Receptors**

NE Action



The binding of norepinephrine to it's receptor (1) causes the dissociation of G-proteins (2). Binding of the alpha G-protein subunit to the enzyme adenylate cyclase (3) activates this enzyme, leading to the production of cyclic AMP (4). Cyclic AMP, in turn, activates protein kinase (5), which can open ion channels (6) and produce other effects.

Sympathetic Receptors

α Receptors:

•NT is NE

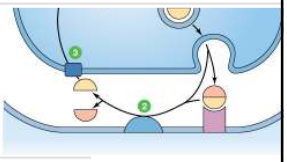
•(most common) ⇒ **Excitation [Ca2+] In↑ ⇒ muscle contraction or secretion by exocytosis.**

•⇒ **Inhibition of GI tract and pancreas**

β – Receptors **Clinically more important**

- β_1 ⇒ **Excitation heart** ([E] = [NE])
  - **"β - blockers" = Antagonists** (e.g.: Propranolol)
- β_2 **usually inhibitory: smooth muscle relaxation of some blood vessels and bronchioles** ([E] > [NE])
- β_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

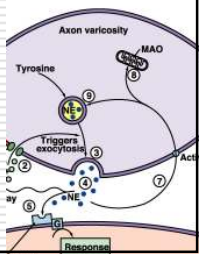


Fig 11-9

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 ⇒ muscle contracts
- All Ach mediated
  - Degraded by Ach esterase

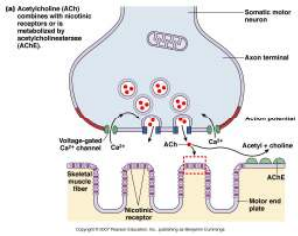


Fig 11-13

Myasthenia gravis

Table 11-3: Agonists and Antagonists of Neurotransmitter Receptors

RECEPTOR	AGONISTS	ANTAGONISTS	INDIRECT AGONISTS/ANTAGONISTS
Cholinergic	Acetylcholine		*AChE* inhibitors*: neostigmine, parathion *Inhibit ACh release*: botulinus toxin
Muscarinic	Muscarine	Atropine, scopolamine	
Nicotinic	Nicotine	α-bungarotoxin (muscle only), tetraethylammonium (TEA) (ganglia only), curare	
Adrenergic	Norepinephrine, epinephrine		*Stimulate NE release*: ephedrine, amphetamines *Prevent NE uptake*: cocaine
Alpha (α)	Phenylephrine	"Alpha-blockers"	
Beta (β)	Isoproterenol	"Beta-blockers": propranolol (β_1 and β_2), metoprolol (β_1 only)	

* AChE = acetylcholinesterase.

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

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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

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Cholinergic	Acetylcholine			AChE* *inhibitors*: neostigmine,
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Alpha		Phenylephrine	"Alpha-blockers"	
Beta		Isoproterenol	"Beta-blockers": propranolol (β_1 and β_2), metoprolol (β_1 only)	

*AChE = acetylcholinesterase.

Direct **Antagonists**

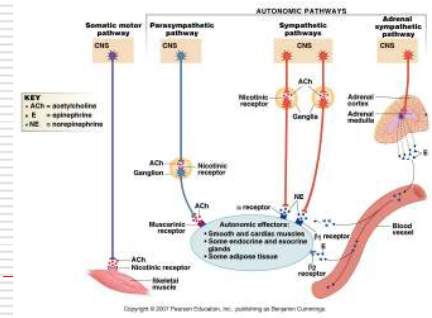
- Atropine → muscarinic
- Curare → nicotinic
- Propranolol → β_1 and β_2
- Metoprolol → β_1

Strychnos Toxifera (Curare) from *Koehler's Medicinal-Plants* 1887

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



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