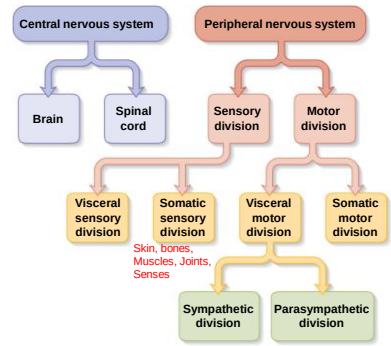
Autonomic Nervous System (Chapter 9)

- **Autonomic Nervous System (ANS)**
  - general properties
  - anatomy
- **Autonomic Effects on Target Organs**

- **Who Controls Autonomic Function**
- **Somatic Nervous System**

Subdivisions of Nervous System



General Properties of ANS

- **autonomic nervous system (ANS)** – a ***motor*** nervous system that controls **glands, cardiac muscle, and smooth muscle**

- **Maintains homeostasis**
- **Primary effectors of the ANS**
  - **viscera of thoracic and abdominal cavities**
    - **cutaneous blood vessels**
    - **some exocrine glands**
    - **piloerector muscles**
    - **eyes**
    - **some endocrine glands**
- **carries out actions involuntarily – no intent/awareness**
- visceral effectors do not depend on the ANS to function

Role of the Autonomic Division in

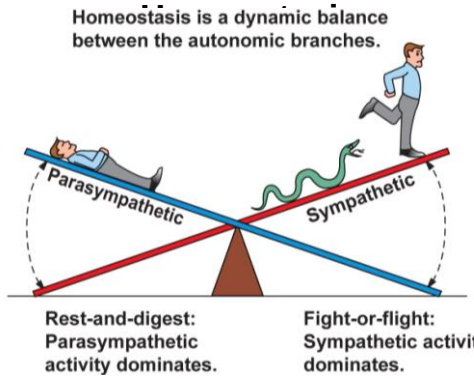


Figure 11-1

Divisions of ANS

- **2 Divisions dualing innervate most organs**

sympathetic division (Fight or Flight)

– prepares body for physical activity: exercise, trauma, arousal, competition, anger, or fear
  - increases heart rate, BP, airflow
  - reduces blood flow to skin and digestive tract
  - increases blood to skeletal muscle
  - Glycogen to glucose (blood glucose)
  - Fat breakdown
  - Pupil dilation
  - Salivation increased

parasympathetic division (Rest and digest)

– calms many body functions reducing energy expenditure and assists in bodily maintenance
  - digestion and waste elimination

Divisions of ANS

- **2 Divisions dualing innervate most organs**

parasympathetic division (Rest and digest)

– calms many body functions reducing energy expenditure and assists in bodily maintenance

– **Constricts pupils and bronchioles**

– **Slows heart**

– **Stimulates**
  - **Digestion**
  - **Insulin release**
  - **Urination**

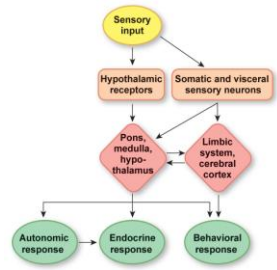
Autonomic tone

- **autonomic tone** - represents the balance of the two systems according to the body's changing needs
  - **parasympathetic tone**
    - maintains smooth muscle tone in intestines
    - holds resting heart rate down to about 70 – 80 beats per minute
  - **sympathetic tone**
    - keeps most blood vessels partially constricted and maintains blood pressure

15-7

Neural Pathways

- ANS has components in both the central and peripheral nervous systems
  - nuclei in the **hypothalamus** and other brainstem regions
  - motor neurons in the spinal cord and peripheral ganglia
  - nerve fibers that travel through the cranial and spinal nerves



15-8

Autonomic Control Centers in the Brain

- **Hypothalamus**
  - **Water balance, temperature, and hunger**
- **Pons**
  - **Respiration**
- **Medulla oblongata**
  - **Respiration**
  - **Cardiac**
  - **Vomiting**
  - **Swallowing**

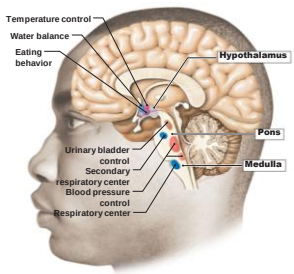
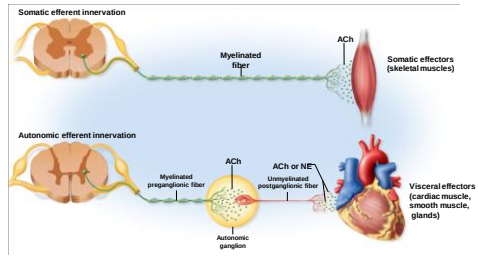


Figure 11-3

Somatic versus Autonomic Pathways

(the 2 major pathways of motor neurons)



Preganglionic cell bodies in grey matter

15-10

Sympathetic Nervous System

- Aka **thoracolumbar division (T1 – L2)**
- relatively **short preganglionic** and **long postganglionic** fibers
- **preganglionic cell bodies** in lateral horns & gray matter of spinal cord
  - lead to
  1. **sympathetic chain of ganglia (paravertebral ganglia)**
  2. **collateral (prevertebral) ganglia**

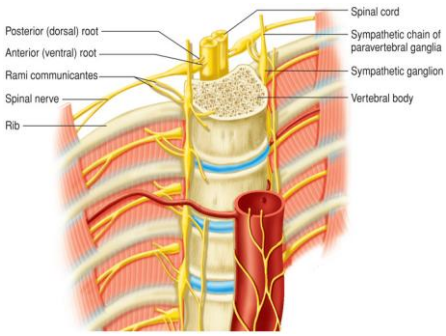
15-11

Sympathetic Nervous System

- each paravertebral ganglion is connected to a spinal nerve by two branches – **communicating rami (rami communicants)**
- **preganglionic fibers** are **small myelinated fibers** that travel from spinal nerve to the ganglion via **white communicating ramus (myelinated)**
- **postganglionic fibers** leave the ganglion via **gray communicating ramus (unmyelinated)**
  - forms a bridge back to the spinal nerve
- **postganglionic fibers** extend to the target organ

15-12

Sympathetic Chain Ganglia



Other ganglia of Sympathetic Nervous System

- collateral ganglia (prevertebral ganglia)
- Some preganglionic fibers pass thru sympathetic chain
  - splancic nerves
  - synapse in collateral (prevertebral ganglia)

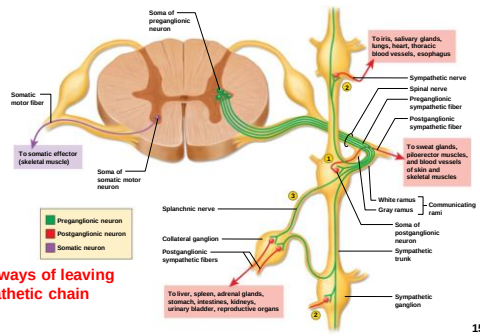
contribute to network called the **abdominal aortic plexus**

- 3 major collateral ganglia in this plexus
  - **celiac**, **superior mesenteric**, and **inferior mesenteric**
  - postganglionic fibers accompany these arteries and their branches to their target organs
- **solar plexus** – collective name for the celiac and superior mesenteric ganglia
  - nerves radiate from ganglia like rays of the sun

15-14

Preganglionic Pathways

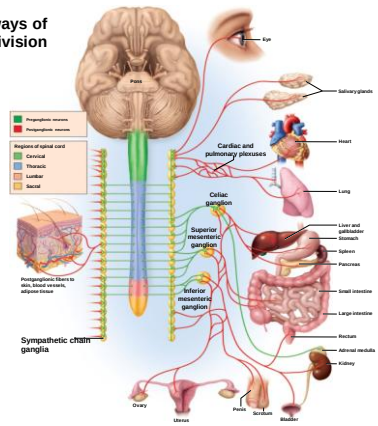
3 pathways of preganglionic neurons entering sympathetic chain



3 pathways of leaving sympathetic chain

15-15

Efferent Pathways of sympathetic division



Summary of Sympathetic Innervation

- **effectors in body wall** are innervated by **sympathetic fibers in spinal nerves**
- **effectors in head and thoracic cavity** are innervated by **fibers in sympathetic nerves**
- **effectors in abdominal cavity** are innervated by **sympathetic fibers in splanchnic nerves**

15-17

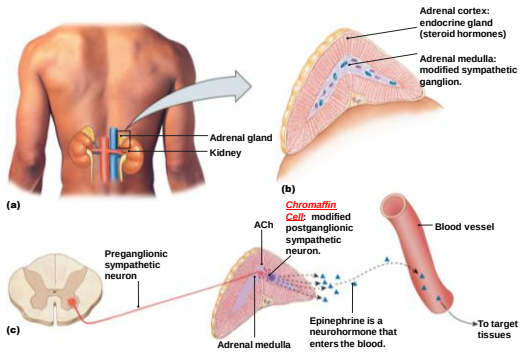
Adrenal Glands

- **essentially a sympathetic ganglion**

  secretes **catecholamine**s:
  - 85% **epinephrine** (adrenaline)
  - 15% **norepinephrine** (noradrenaline)
- **sympathoadrenal system** is **adrenal medulla** and **sympathetic nervous system**

15-18

The Adrenal Medulla

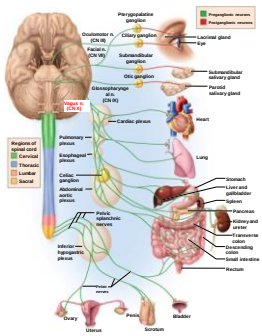


Parasympathetic Division

- **parasympathetic division** (aka **craniosacral division)**
- origin preganglionic neurons
  - midbrain, pons, and medulla (III, VII, IX, X)
  - sacral spinal cord segments S2-S4
- **terminal ganglia** in or near target organs
  - long preganglionic, short postganglionic fibers

15-20

Parasympathetic Cranial Nerves



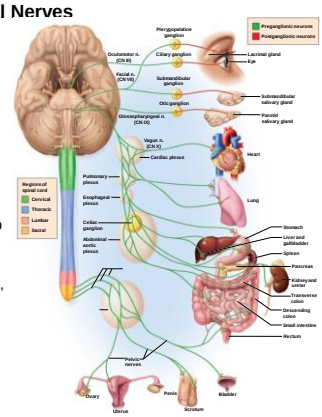
- **Oculomotor nerve (III)**
  - pupil constriction/lens focus
- **Facial nerve (VII)**
  - tear, nasal and salivary glands
- **Glossopharyngeal nerve (IX)**
  - parotid salivary gland
- **Vagus nerve (X)**
  - viscera as far as proximal half of colon
  - cardiac, pulmonary, and esophageal plexus
  - 75% of all Parasympathetic fibers

15-21

Parasympathetic Sacral Nerves

Arise from levels S2 to S4 of the spinal cord

- form **pelvic splanchnic nerves** that lead to the **inferior hypogastric plexus**
- most form **pelvic nerves** to their terminal ganglion on the target organs
  - distal half of colon, rectum, urinary bladder, and reproductive organs



Enteric Nervous System

- **enteric nervous system** – nervous system in wall of digestive tract
  - does not arise from the brainstem or spinal cord
  - innervates smooth muscle and glands
- semiautonomous
- has its own reflex arcs
- **regulates motility** of esophagus, stomach, and intestines and secretion of digestive enzymes and acid
- normal digestive function also requires regulation by sympathetic and parasympathetic systems

15-23

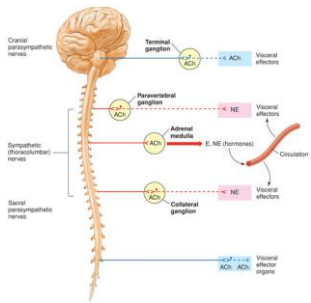
Neurotransmitters and Receptors

- What determines if an autonomic neuron is excitatory or inhibitory
- **Effects determined by**
  1. **type of neurotransmitter released**
  2. **type of receptors found on target cells**
- *2 things to remember:*
  - sympathetic (NE) and parasympathetic fibers (Ach) secrete different neurotransmitters
  - target cells respond to the same neurotransmitter differently depending upon the ***type of receptor*** they have for it
    - **all autonomic fibers secrete either Ach or NE**
    - there are 2 classes of receptors for each of these neurotransmitters

15-24

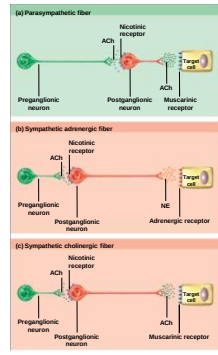
ANS Neurotransmitters

- **Both Symp and Parasymp preganglionics release ACh**
- **Parasymp postganglionics also release ACh**
  - **Called cholinergic synapses**
- **Most Sympathetic postganglionics release Norepinephrine**
  - **Called adrenergic synapses**
  - **A small number release ACh**



9-23

Neurotransmitters and Receptors



MOST

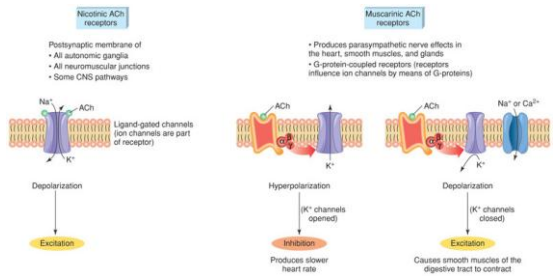
15-26

Acetylcholine (ACh)

- **ACh is secreted by all preganglionic neurons in both divisions and the postganglionic parasympathetic neurons**
  - **called cholinergic fibers**
  - **any receptor that binds it is called cholinergic receptor**
- **2 types of cholinergic receptors**
  - **muscarinic receptors**
    - **all cardiac muscle, smooth muscle, and gland cells have muscarinic receptors**
    - **excitatory or inhibitory due to subclasses of muscarinic receptors**
  - **nicotinic receptors**
    - **on all ANS postganglionic neurons, adrenal medulla, and neuromuscular junctions of skeletal muscle**
    - **excitatory when ACh binding occurs**

15-27

Comparison of nicotinic and muscarinic ACh receptors



5 types of muscarinic receptors!!

9-28

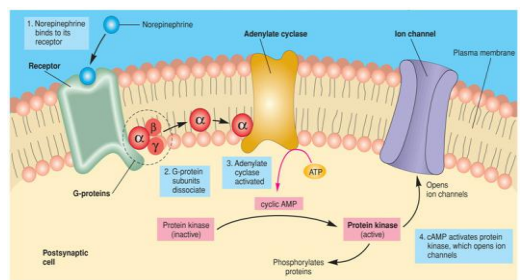
Norepinephrine (NE)

- **NE is secreted by nearly all sympathetic postganglionic neurons**
  - **called adrenergic fibers**
  - **receptors for it called adrenergic receptors**
    - **alpha-adrenergic receptors**
      - **usually excitatory**
      - **2 subclasses use different second messengers (α_1 & α_2)**
    - **beta-adrenergic receptors**
      - **usually inhibitory**
      - **2 subclasses with different effects, but both act through cAMP as a second messenger (β_1 & β_2)**

15-29

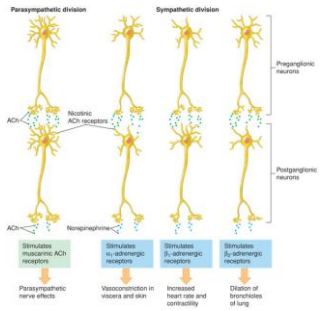
Monoamine NTs (Catecholamines)

- **Use G-proteins and Second Messengers**



7-65

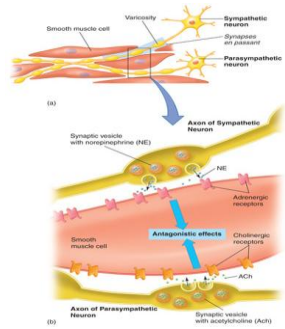
- **Many drugs have been developed to affect ANS receptors**
  - **Drugs that promote actions of a NT are agonists**
  - **Drugs that inhibit actions of a NT are antagonists**



9-26

ANS

- **Postganglionics have unusual synapses called varicosities**
  - **release NTs along a length of axon**
  - **Target cell doesn't have clusters of receptors at specific sites**
  - **Neuroatransmitters diffuses to receptors**



Dual Innervation

- **dual innervation** - most viscera receive fibers from both parasympathetic and sympathetic divisions

cooperative effects – two divisions act on different effectors to produce a unified overall effect

- parasympathetics increase salivary serous cell secretion
- sympathetics increase salivary mucous cell secretion

15-33

Dual Innervation

- **antagonistic effects** - oppose each other
  - exerted through dual innervation of same effector cells
    - heart rate decreases (parasympathetic)
    - heart rate increases (sympathetic)
  - exerted because each division innervates different cells

15-34

Dual Innervation of the Iris

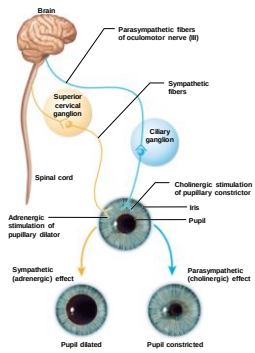


Figure 15.9

15-35

Sympathetic and Vasomotor Tone

sympathetic division prioritizes blood vessels to skeletal muscles and heart in times of emergency

blood vessels to skin vasoconstrict to minimize bleeding if injury occurs during stress or exercise

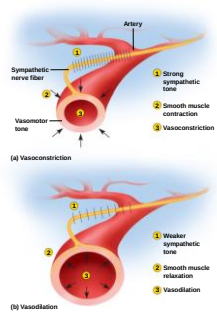


Figure 15.10

15-36

Somatic Motor Division

- Single neuron
  - CNS origin
  - Myelinated
- Terminus
  - Branches
  - Neuromuscular junction

Somatic Motor Division

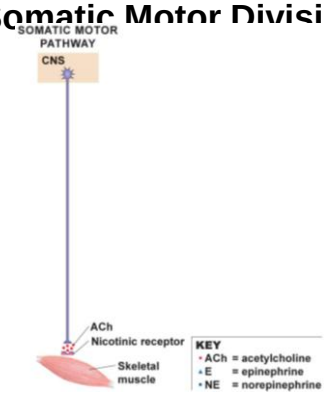


Figure 11-11 (1 of 5)

Anatomy of the Neuromuscular Junction

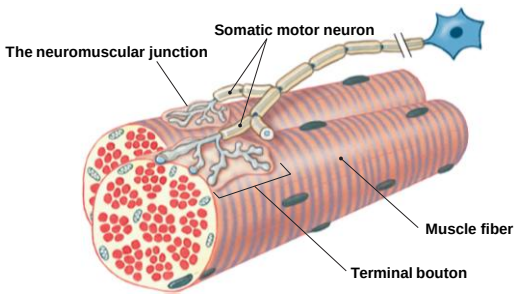


Figure 11-12 (1 of 3)

Anatomy of the Neuromuscular Junction

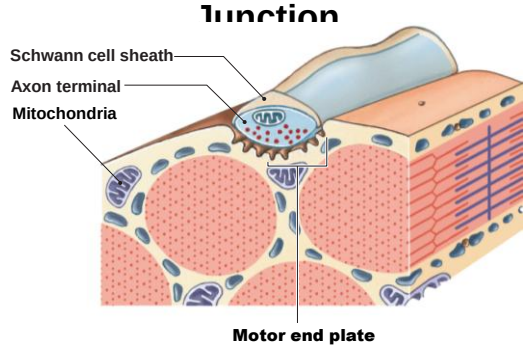


Figure 11-12 (2 of 3)

Anatomy of the Neuromuscular Junction

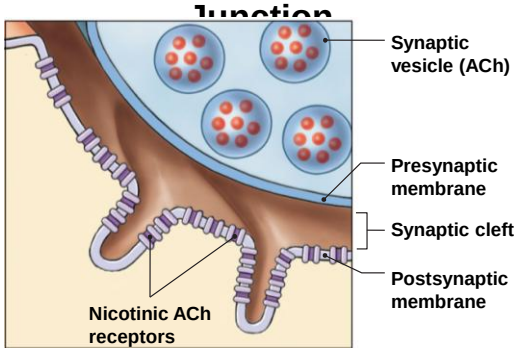


Figure 11-12 (3 of 3)

Events at the Neuromuscular

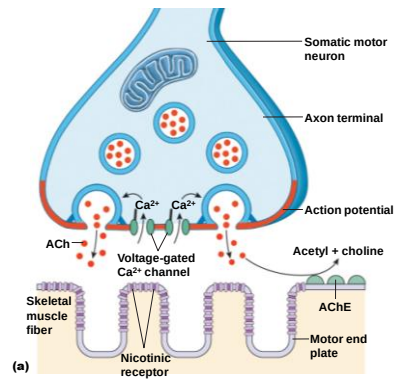


Figure 11-13a

Events at the Neuromuscular Junction

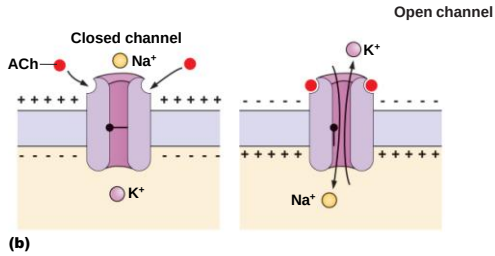


Figure 11-13b