NERVOUS SYTEM
WEEK 4

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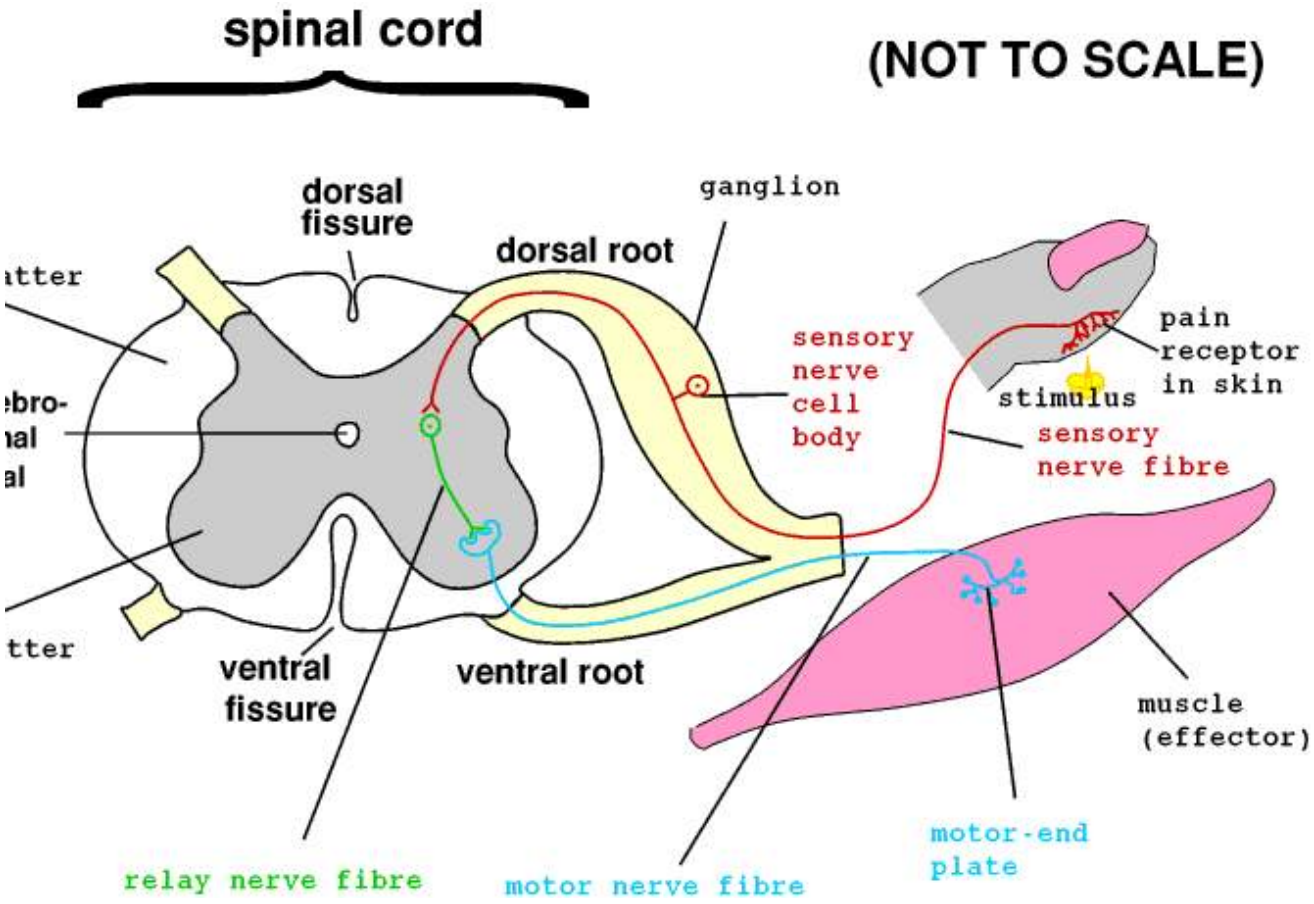
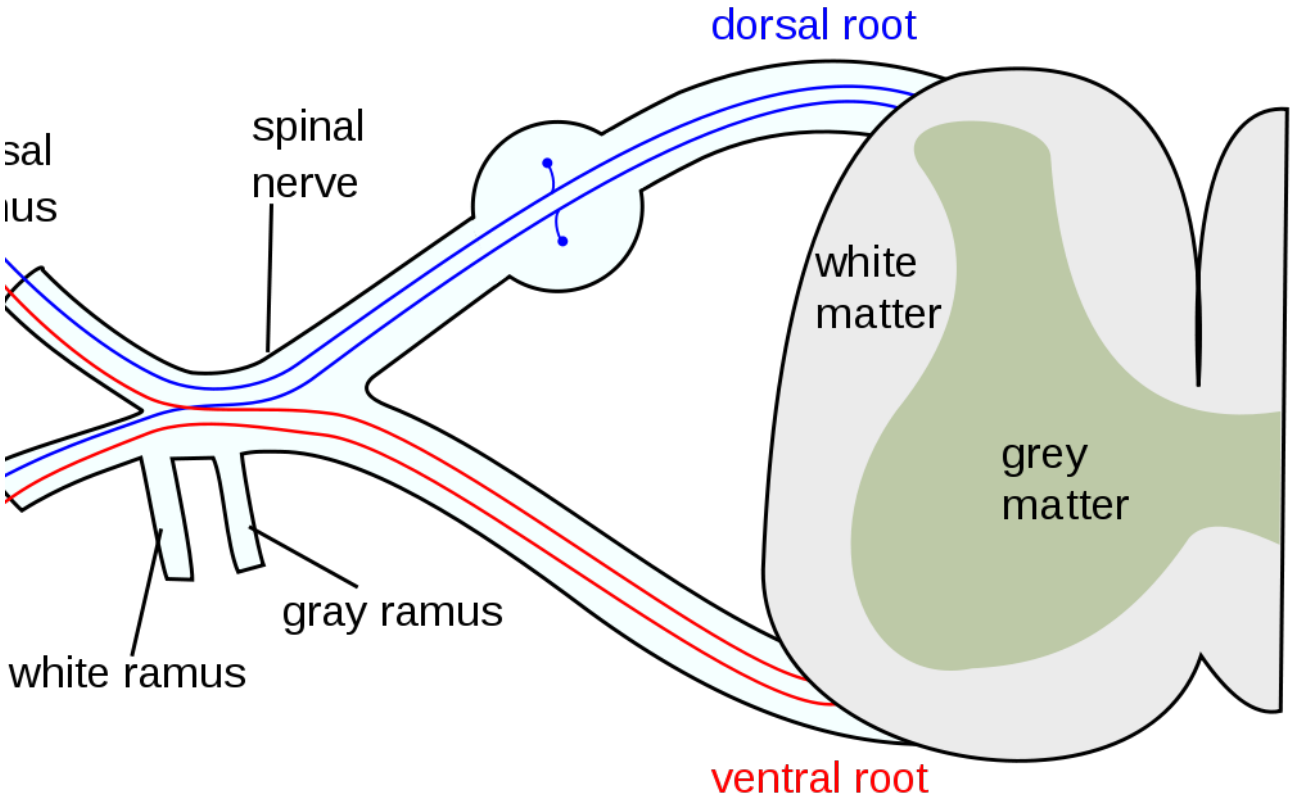
SPINAL CORD

- The spinal cord lies within the bony vertebral column.
- It is a slender cylinder of soft tissue about as big around as the little finger.
- The central butterfly-shaped area of gray matter is composed of **interneurons, the cell bodies and dendrites of efferent neurons, the entering fibers of afferent neurons, and glial cells**.
- It is called gray matter because there are more cells than myelinated fibers, and the cells appear gray.
- The gray matter is surrounded by white matter, which consists of groups of myelinated axons of interneurons



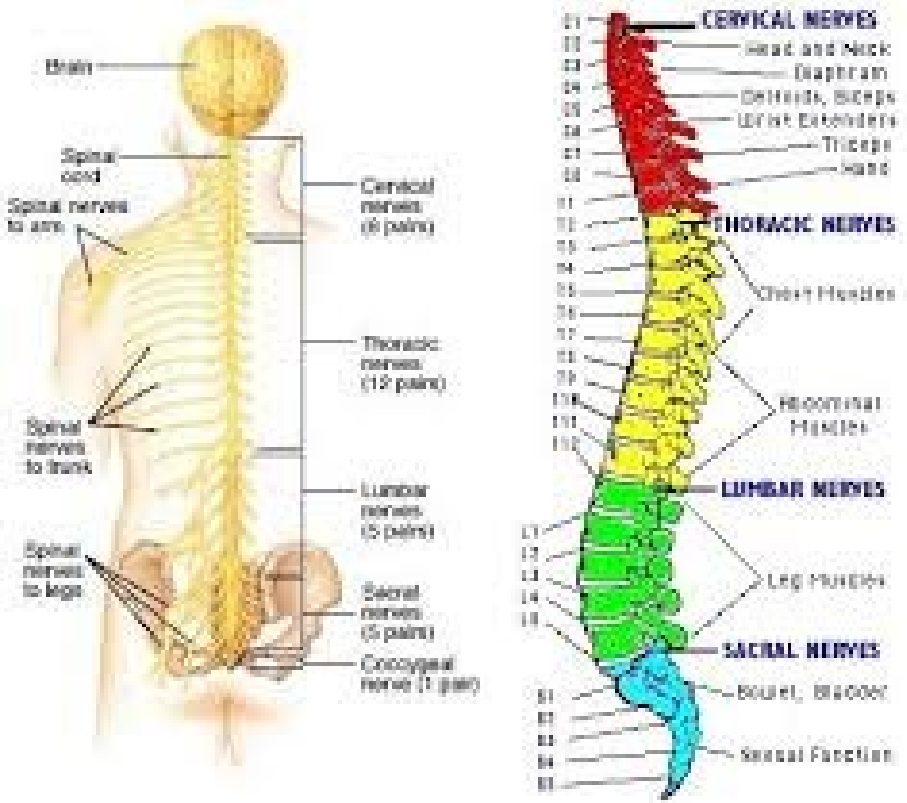
SPINAL CORD

- Groups of **afferent fibers** enter on the dorsal side of the cord via the **dorsal roots**.
- The axons of **efferent neuron**s leave the spinal cord on the **ventral side** via the ventral roots.
- A short distance from the cord, the dorsal and ventral roots from the same level combine to form a **spinal nerve**, one on each side of the spinal cord.
- The 31 pairs of spinal nerves are designated by the four vertebral levels: from which they exit: **cervical, thoracic, lumbar, and sacral**



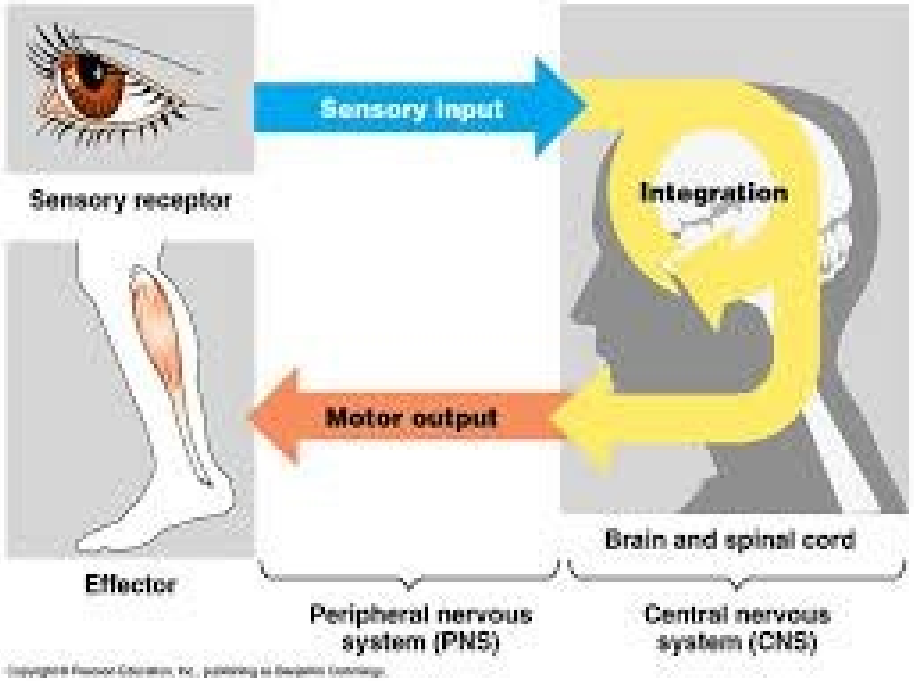
PERIPHERAL NERVOUS SYSTEM

- Nerve fibers in the peripheral nervous system transmit signals between the CNS and receptors and effectors in all other parts of the body.
- The nerve fibers are grouped into bundles called **nerves**.
- The peripheral nervous system consists of 43 pairs of nerves: **12 pairs of cranial nerves** and **31 pairs that connect with the spinal cord as the spinal nerves.**



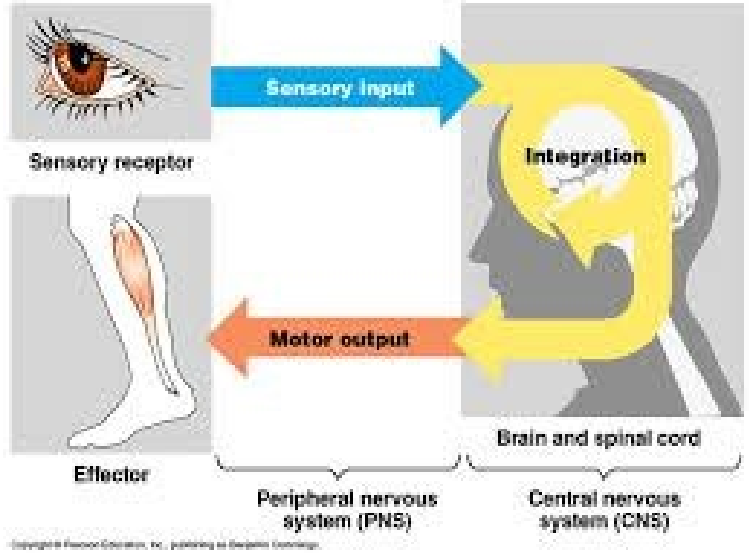
PERIPHERAL NERVOUS SYSTEM

- A nerve contains nerve fibers that are the axons of efferent neurons or afferent neurons or both.
- Accordingly, fibers in a nerve may be classified as belonging to the **efferent** or the **afferent division** of the peripheral nervous system .



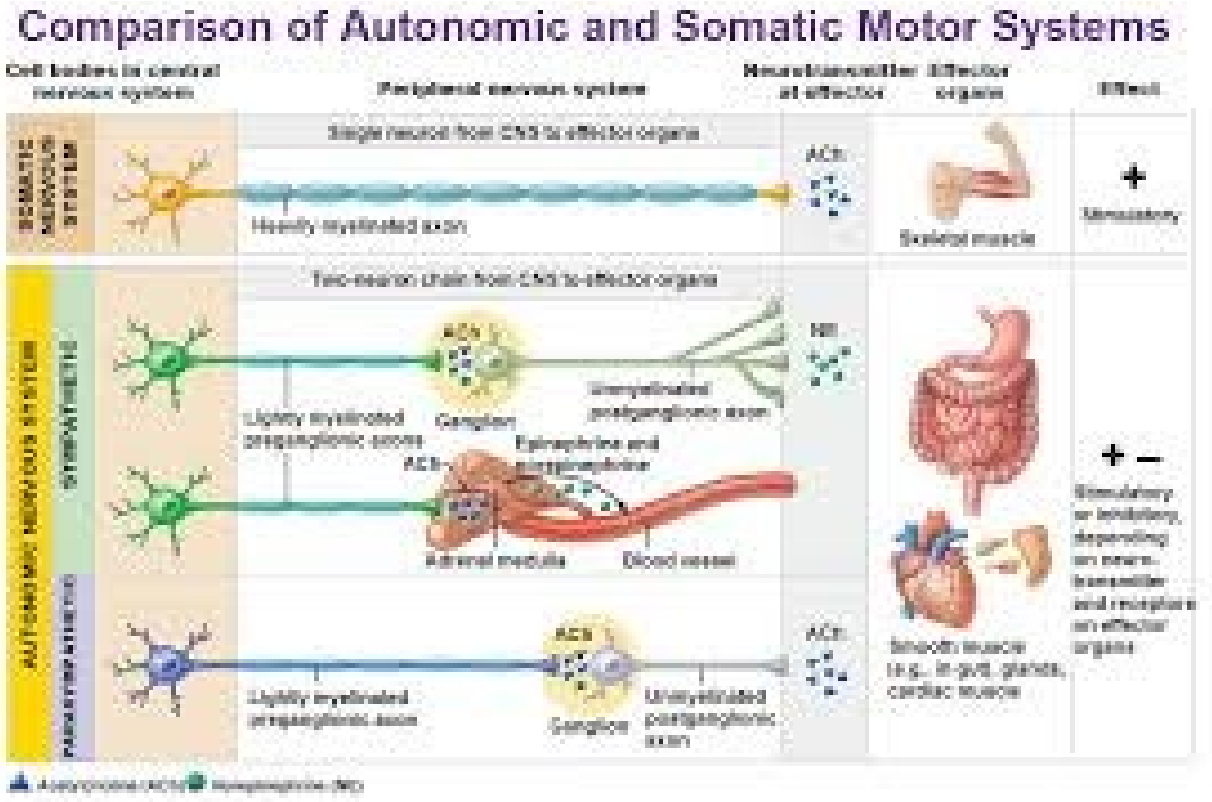
PERIPHERAL NERVOUS SYSTEM

- Afferent neurons convey information from sensory receptors to the central nervous system.
- The long part of their axon is outside the CNS and is part of the peripheral nervous system.
- Efferent neurons carry signals out from the central nervous system to muscles or glands.
- The efferent division of the peripheral nervous system is more complicated than the afferent: being subdivided into a **somatic nervous system** and an **autonomic nervous system.**



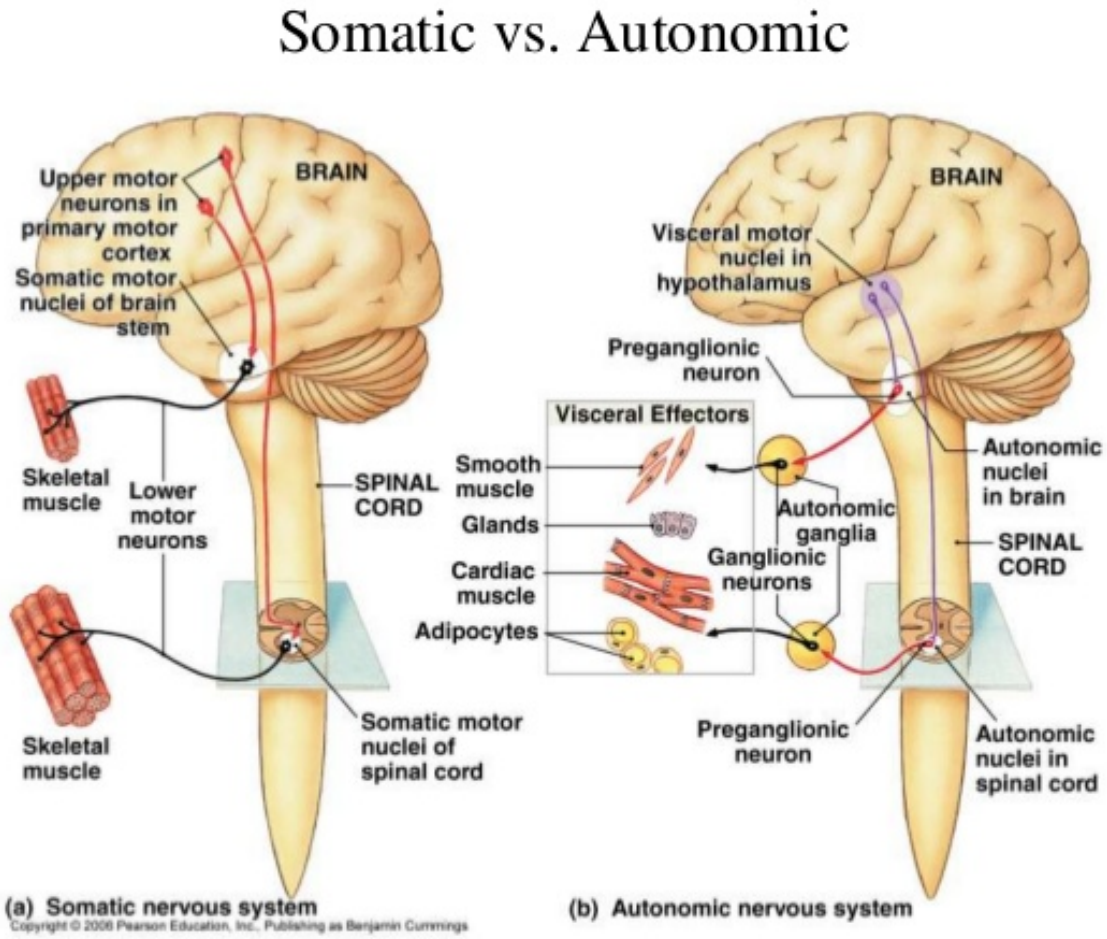
PERIPHERAL NERVOUS SYSTEM

- The simplest distinction between the **somatic** and **autonomic systems** is that the neurons of the somatic division innervate skeletal muscle,
- The autonomic neurons innervate smooth and cardiac muscle, glands, and neurons in the gastrointestinal tract.



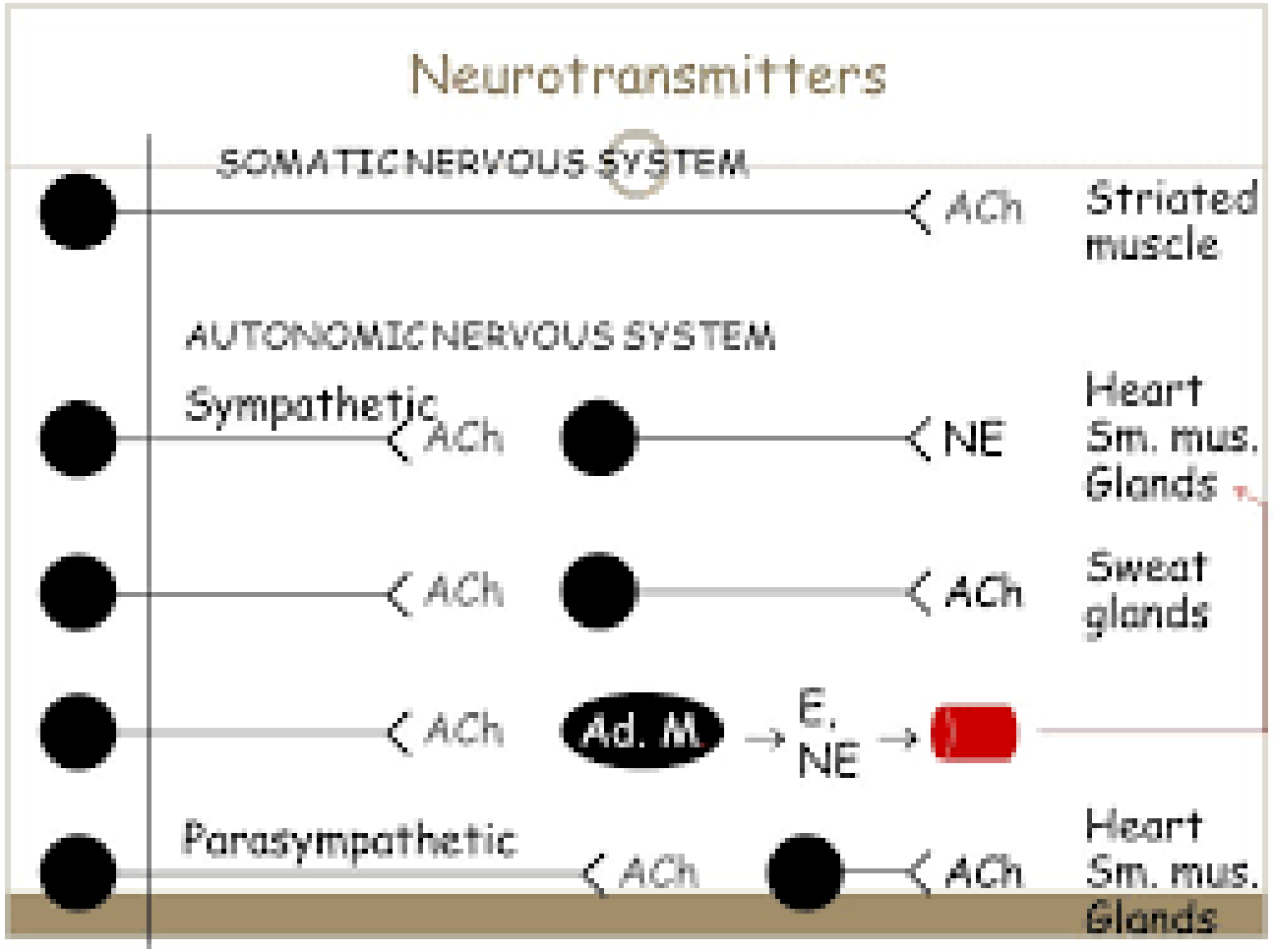
SOMATIC NERVOUS SYSTEM

- The somatic portion of the PNS is made up of all the nerve fibers going from the central nervous system to skeletal muscle cells.
- The cell bodies of these neurons are located in groups in the **brainstem** or **spinal cord.**
- Their large diameter, myelinated axons leave the central nervous system and pass **without any synapses** to skeletal-muscle cells.



SOMATIC NERVOUS SYSTEM

- The neurotransmitter released by **somatic neurons** is **acetylcholine**.
- Because activity in the somatic neurons leads to contraction of the innervated skeletal-muscle cells, these neurons are called **motor neurons**.
- Excitation of motor neurons leads only to the contraction of skeletal-muscle cells; **there are no somatic neurons that inhibit skeletal muscles.**

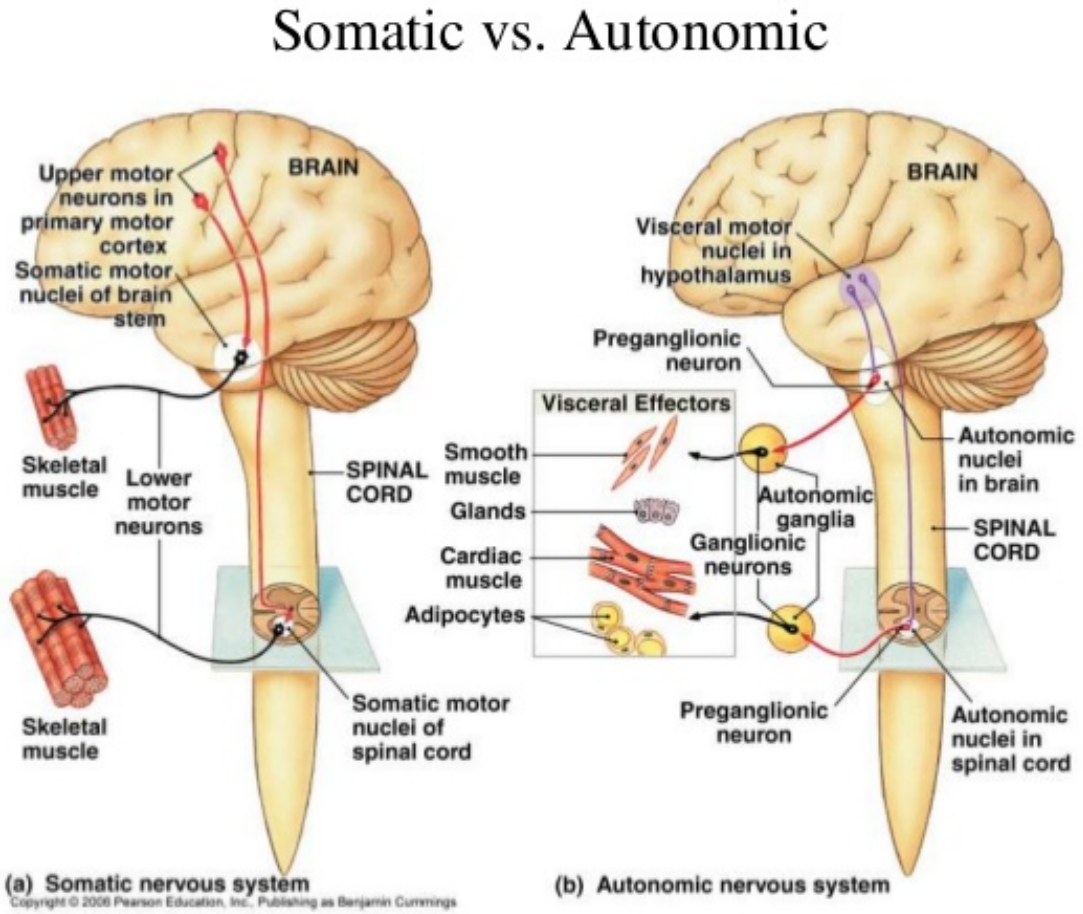


DIFFERENCES BETWEEN SOMATIC AND AUTONOMIC DIVISIONS

- **Somatic:**
- 1. Consists of a single neuron between central nervous system and skeletal-muscle cells
- 2. Innervates skeletal muscle
- 3. Can lead only to muscle excitation
- **Autonomic:**
- 1. Has two-neuron chain (connected by a synapse) between central nervous system and effector organ
- 2. Innervates smooth and cardiac muscle, glands, and GI neurons
- 3. Can be either excitatory or inhibitory

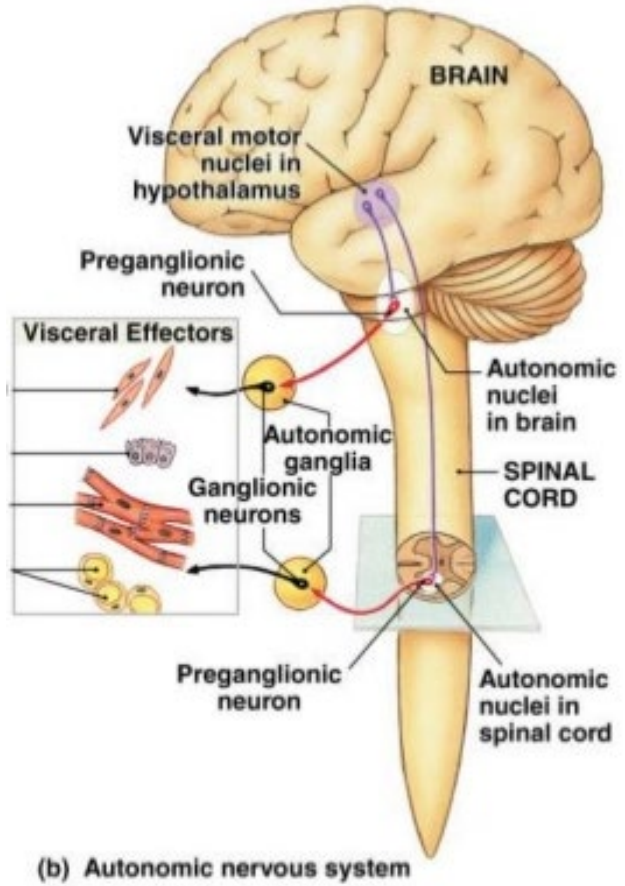
AUTONOMIC NERVOUS SYSTEM

- The efferent innervation of all tissues other than skeletal muscle is by way of the autonomic nervous system.
- A special case occurs in the gastrointestinal tract, where autonomic neurons innervate a nerve network in the wall of the intestinal tract.
- This network, termed the **enteric nervous system**



AUTONOMIC NERVOUS SYSTEM

- In the autonomic nervous system, parallel chains connect the central nervous system and the effector cells
- The first neuron has its cell body in the central nervous system.
- **The synapse** between the two neurons is outside the central nervous system, in a cell cluster called an **autonomic ganglion**.
- The nerve fibers passing between the central nervous system and the ganglia are called **preganglionic fibers**; those passing between the ganglia and the effector cells are **postganglionic fibers**.



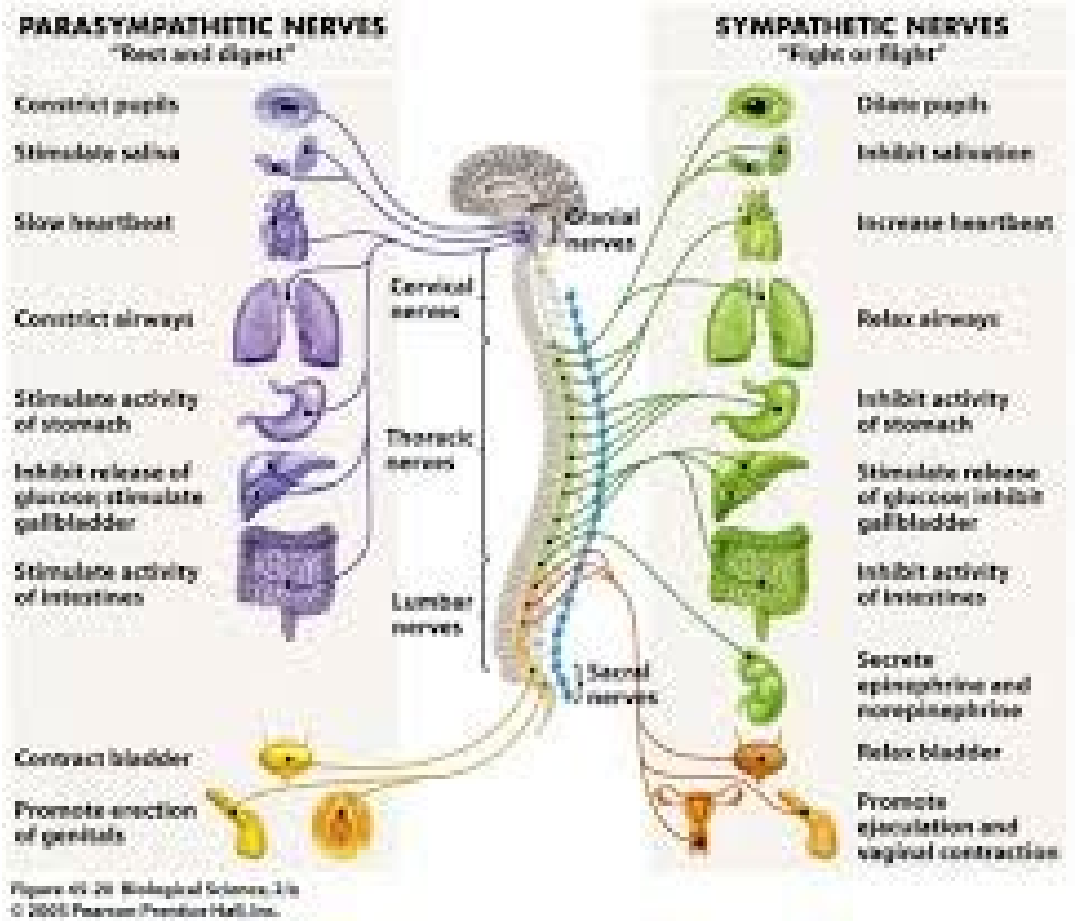
AUTONOMIC NERVOUS SYSTEM

- Anatomical and physiological differences within the autonomic nervous system are the basis for its further subdivision into **sympathetic** and **parasympathetic** components
- The nerve fibers of the sympathetic and parasympathetic components leave the central nervous system at different levels;

✓the sympathetic fibers from the thoracic (chest) and lumbar regions of the spinal cord,

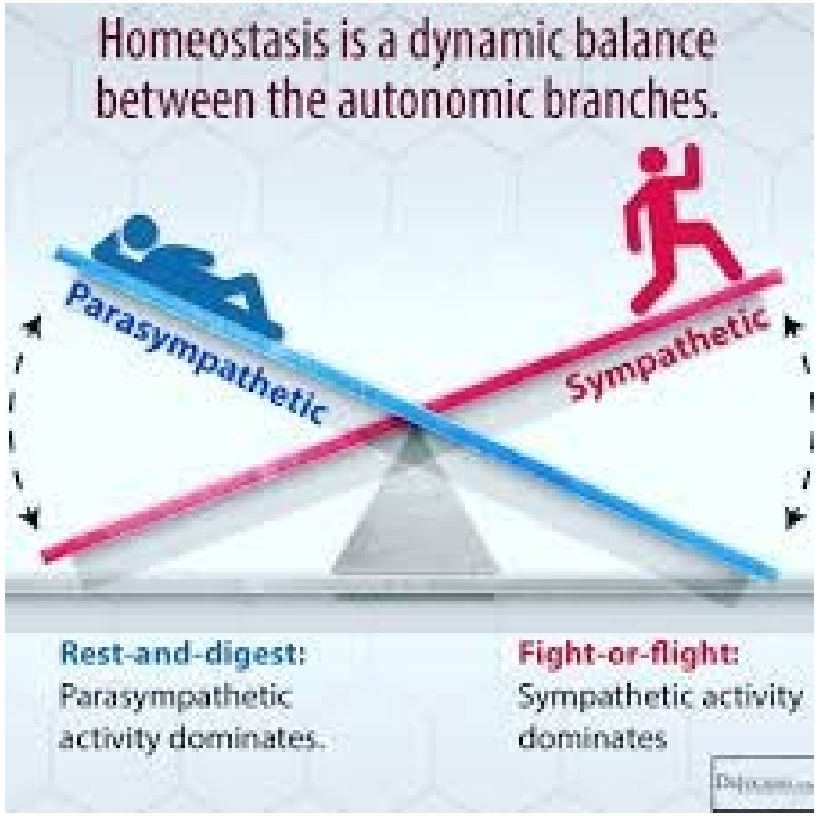
✓and the parasympathetic fibers from the brain and the sacral portion of the spinal cord

- Therefore, **the sympathetic division is also called the thoracolumbar division, and the parasympathetic is called the craniosacral division**



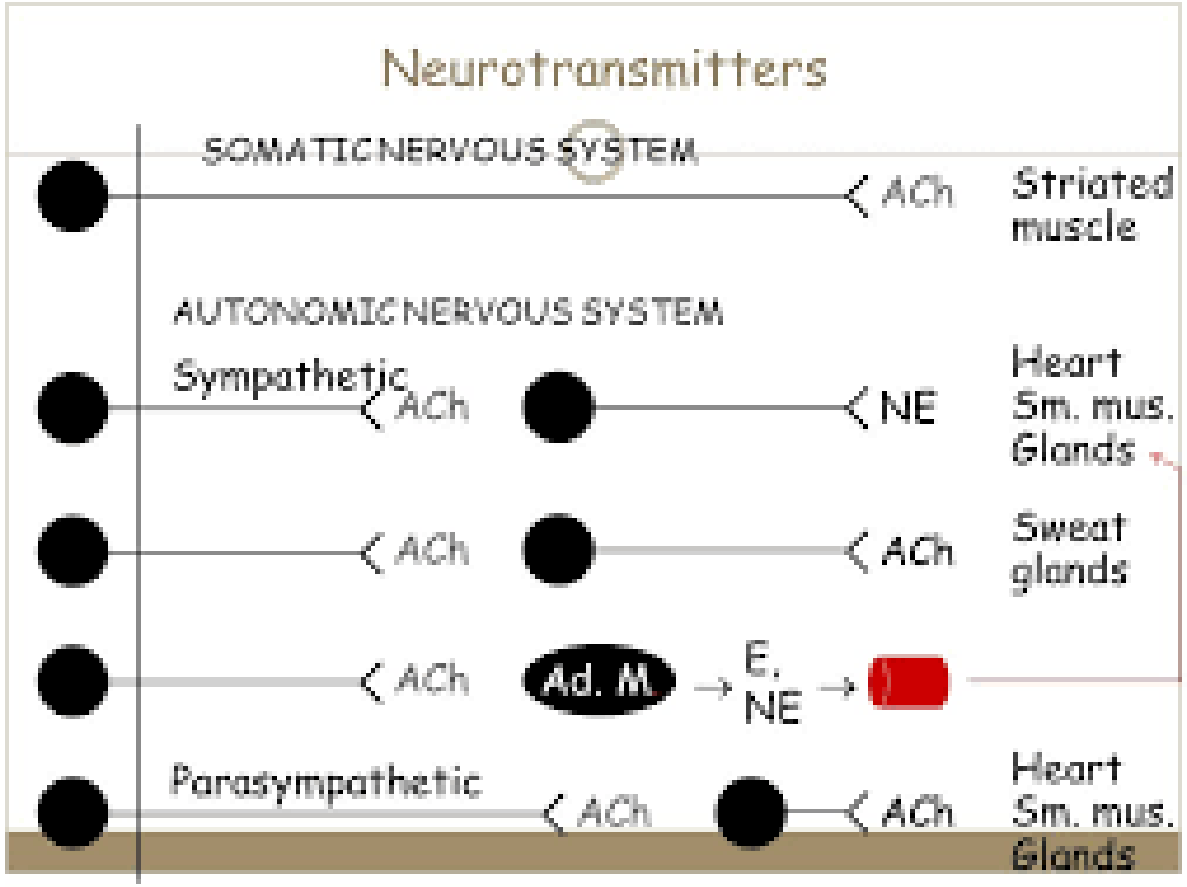
AUTONOMIC NERVOUS SYSTEM

System/function	Parasympathetic	Sympathetic
Cardiovascular	Decreased cardiac output and heart rate	Increased contraction and heart rate; increased cardiac output
Pulmonary	Bronchial constriction	Bronchial dilatation
Musculoskeletal	Muscular relaxation	Muscular contraction
Pupillary	Constriction	Dilatation
Urinary	Increased urinary output; sphincter relaxation	Decreased urinary output; sphincter contraction
Gastrointestinal	Increased motility of stomach and gastrointestinal tract; increased secretions	Decreased motility of stomach and gastrointestinal tract; decreased secretions
Glycogen to glucose conversion	No involvement	Increased
Adrenal gland	No involvement	Release epinephrine and norepinephrine



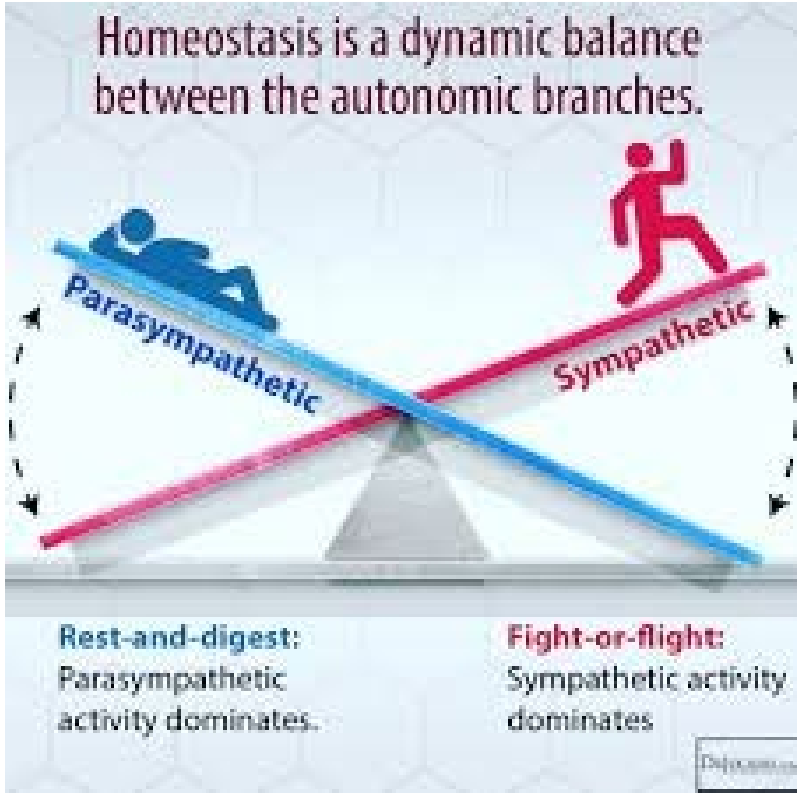
AUTONOMIC NERVOUS SYSTEM

- In both sympathetic and parasympathetic divisions, **acetylcholine is the major neurotransmitter** released between pre- and postganglionic fibers **in autonomic ganglia**
- In the parasympathetic division, acetylcholine is also the major neurotransmitter between the postganglionic fiber and the effector cell.
- In the sympathetic division, norepinephrine is usually the major transmitter between the postganglionic fiber and the effector cell.



AUTONOMIC NERVOUS SYSTEM

- A useful generalization is that the sympathetic system increases its response under conditions of physical or psychological stress.
- Indeed, a full-blown sympathetic response is called **the fight-or-flight response**, describing the situation of an animal forced to challenge an attacker or run from it.
- All resources are mobilized: heart rate and blood pressure increase; blood flow to the skeletal muscles, heart, and brain increase; the liver releases glucose; and the pupils dilate.
- Simultaneously, activity of the gastrointestinal tract and blood flow to the skin are decreased by inhibitory sympathetic effects.



AUTONOMIC NERVOUS SYSTEM

- The two divisions of the autonomic nervous system rarely operate independently, and autonomic responses generally represent the regulated interplay of both divisions.
- Autonomic responses usually occur without conscious control or awareness, as though they were indeed autonomous

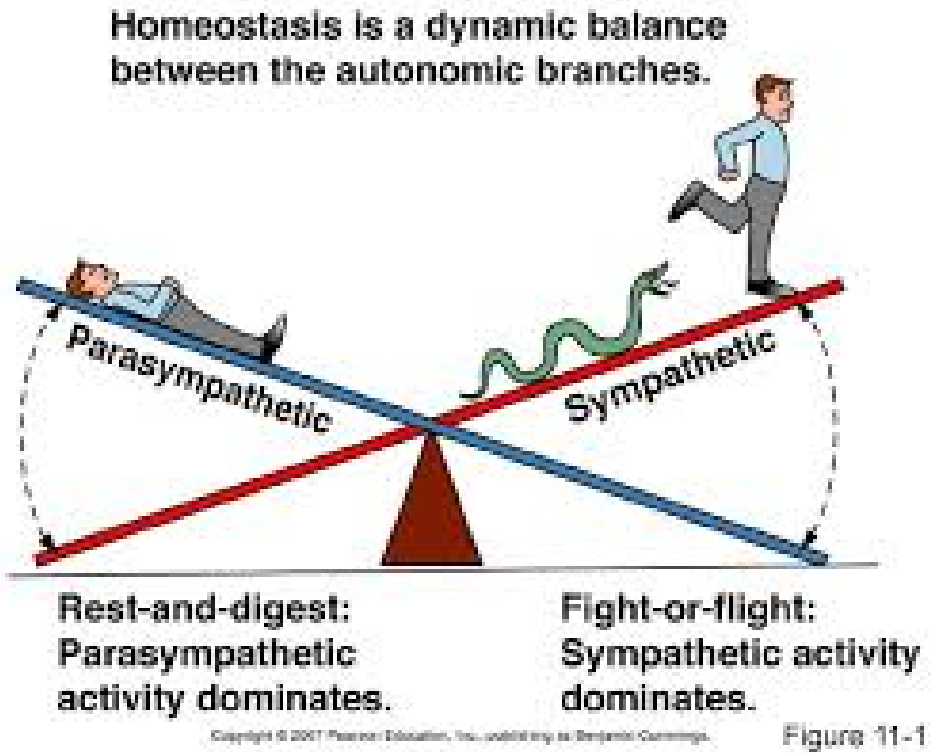


Figure 11-1

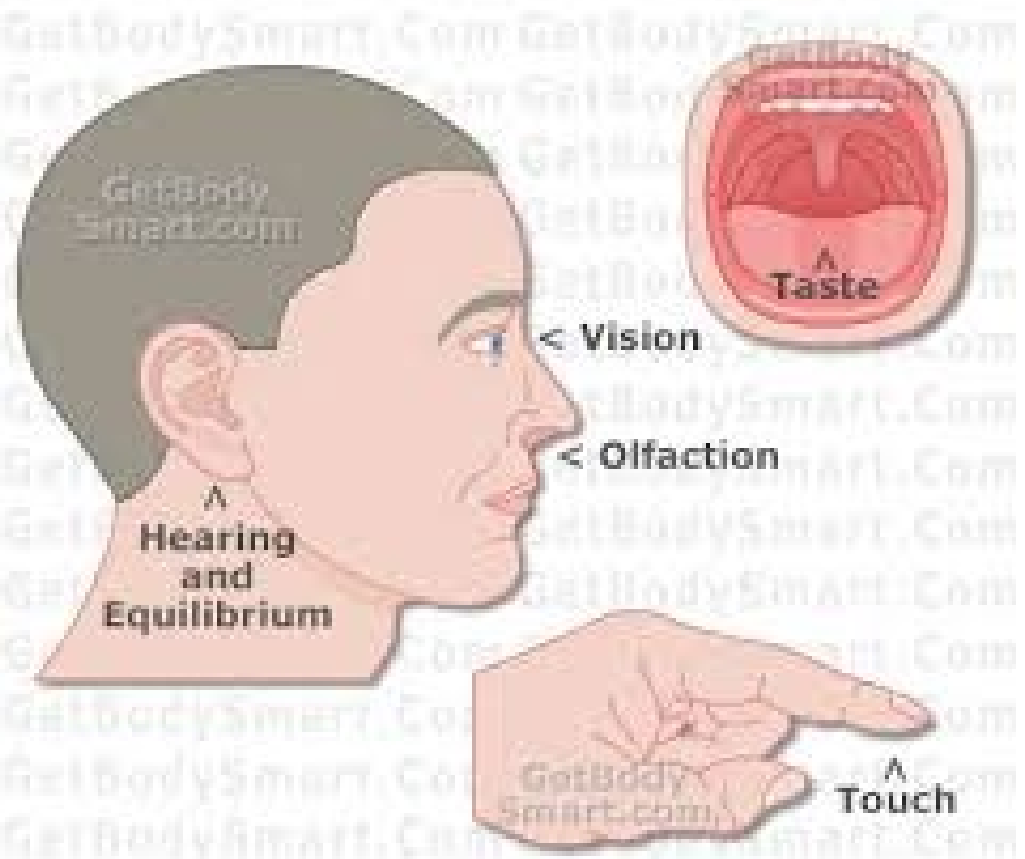
THE SENSORY SYSTEM

- A sensory system is a part of the nervous system that consists of:

✓ **sensory receptors** that receive stimuli from the external or internal environment,

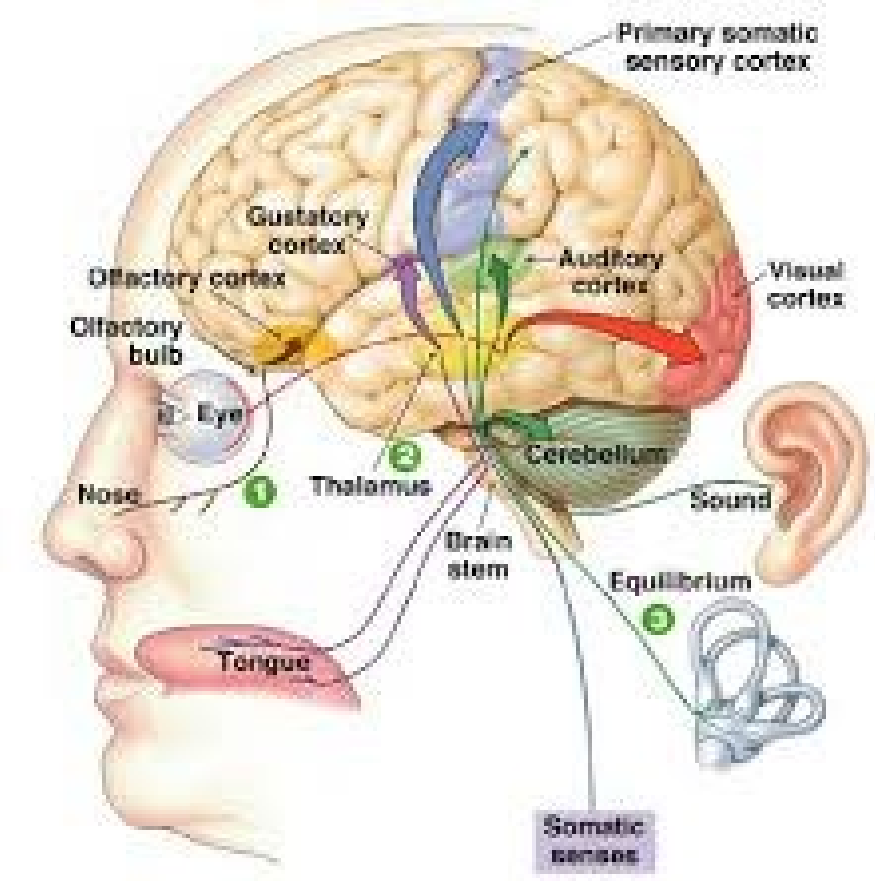
✓**the neural pathways** that conduct information from the receptors to the brain, and

✓those **parts of the brain** that deal primarily with processing the information.



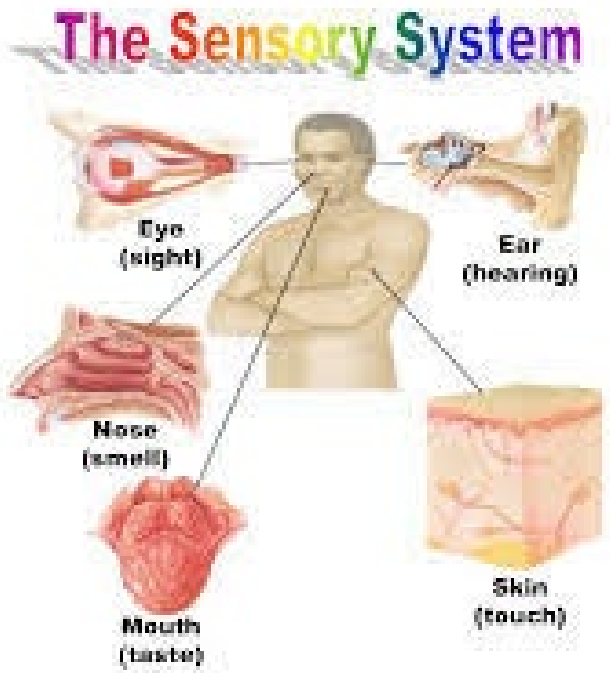
Properties of Sensory Systems

1. **Stimulus - energy source**
• Internal
• External
2. **Receptors**
• Sense organs - structures specialized to respond to stimuli
• Transducers - stimulus energy converted into action potentials
3. **Conduction**
• Afferent pathway
• Nerve impulses to the CNS
4. **Translation**
• CNS integration and information processing
• Sensation and perception – your reality



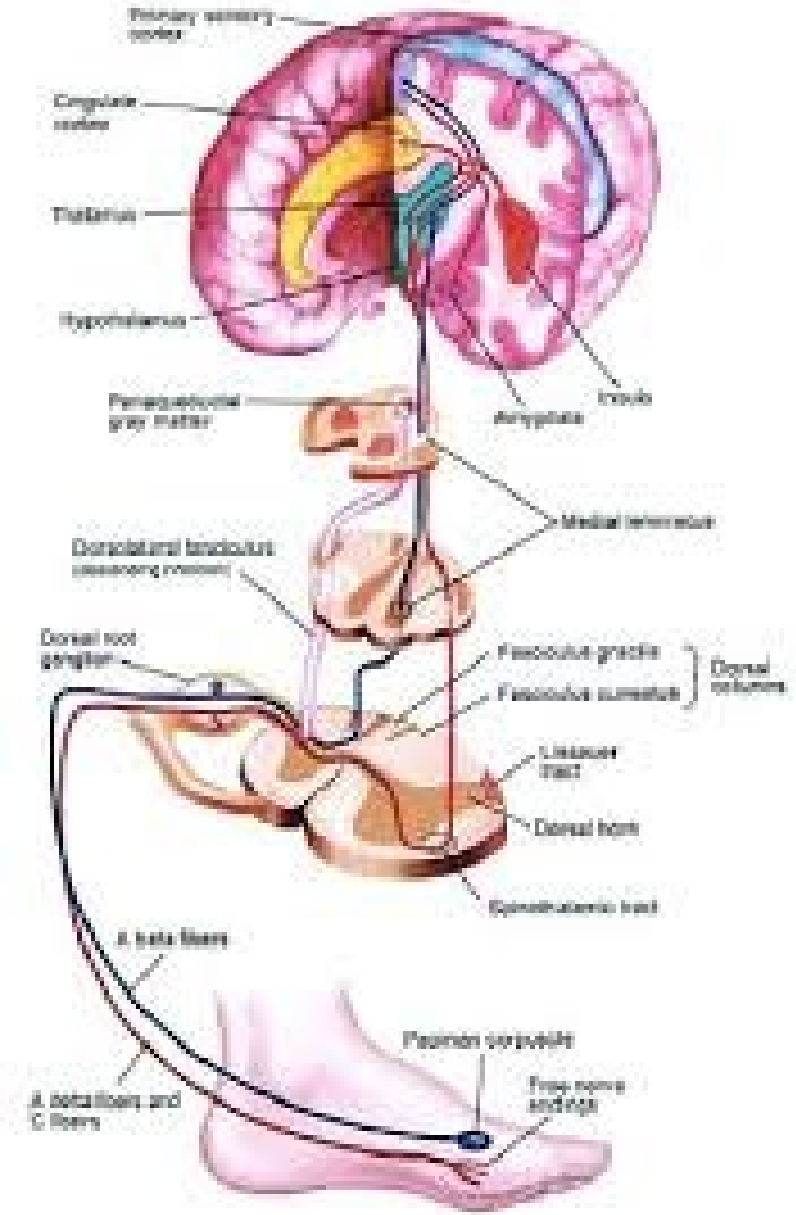
THE SENSORY SYSTEM

- Information processed by a sensory system may or may not lead to conscious awareness of the stimulus.
- Regardless of whether the information reaches consciousness, it is called **sensory information.**
- If the information does reach consciousness, it can also be called a **sensation.**
- A person's understanding of the sensation's meaning is called **perception**



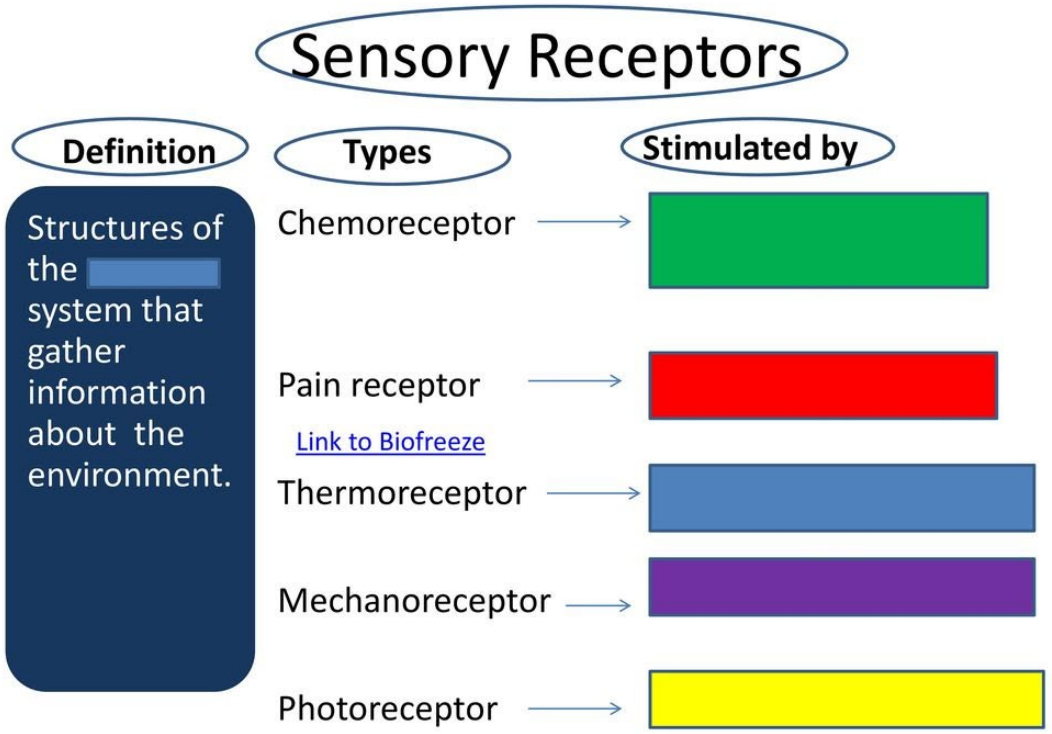
THE SENSORY SYSTEM

- **For example**, feeling pain is a sensation, but my awareness that my tooth hurts is a perception.
- Perceptions are the result of the neural processing of sensory information.



Receptors

- Receptors respond to changes in environment
- A photon of light or the mechanical stretch of a tissue transformed into an electrical response is known as **stimulus transduction**.
- There are many types of sensory receptors, each of which is specific; that is, each type responds much more readily to one form of energy than to others.
- The type of energy to which a receptor responds in normal functioning is known as its **adequate stimulus**.



Classification by Function (Stimuli)

Mechanoreceptors – respond to touch, pressure, vibration, stretch, and itch

Thermoreceptors – sensitive to changes in temperature

Photoreceptors – respond to light energy (e.g., retina)

Chemoreceptors – respond to chemicals (e.g., smell, taste, changes in blood chemistry)

Nociceptors – sensitive to pain-causing stimuli

Osmoreceptors – detect changes in concentration of solutes, osmotic activity

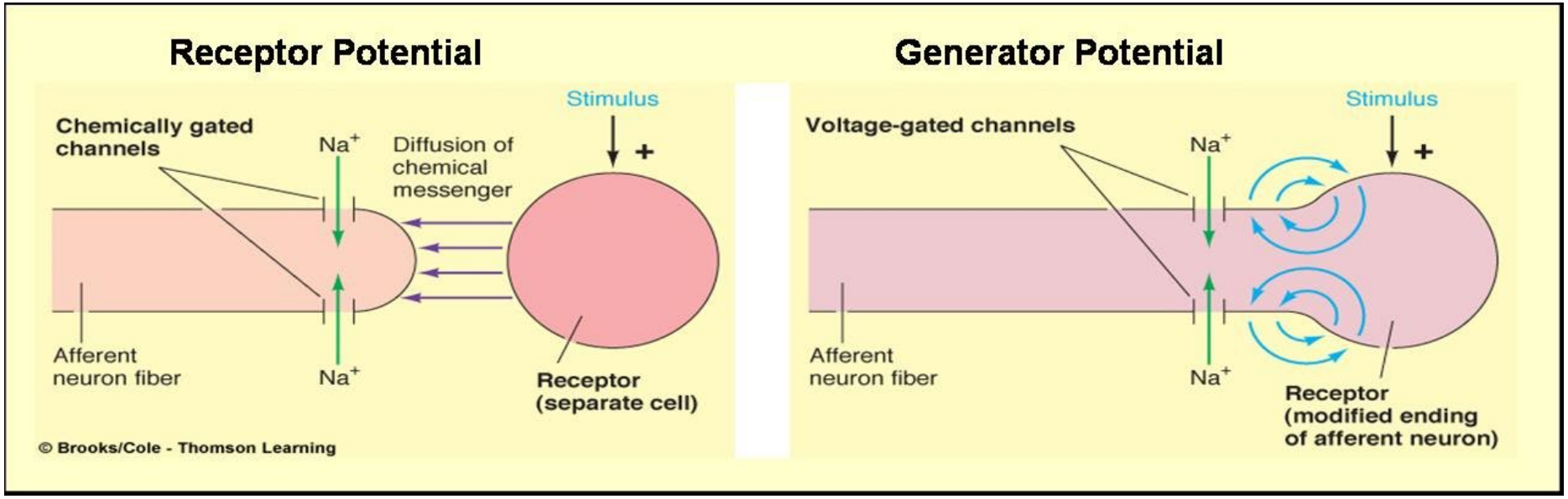
Baroreceptors – detect changes in fluid pressure

Classification by Location

- **Exteroceptors** – sensitive to stimuli arising from outside the body • Located at or near body surfaces • Include receptors for touch, pressure, pain, and temperature
- **Interoceptors** – (visceroceptors) receive stimuli from internal viscera • Monitor a variety of stimuli
- **Proprioceptors** – monitor degree of stretch • Located in musculoskeletal organs

The Generator Potential

- The transduction process in all sensory receptors involves the opening or closing of ion channels that receive—either directly or through a second-messenger system—information about the outside world.
- The ion channels occur in a specialized receptor membrane and not on ordinary plasma membranes.
- The gating of these ion channels allows a change in the ion fluxes across the receptor membrane, which in turn produces a change in the membrane potential there.
- This change in potential is a graded potential called a **generator potential.**



ANY QUESTIONS?