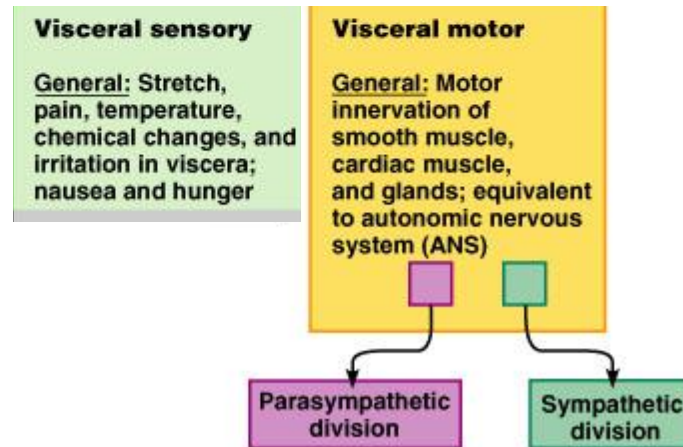
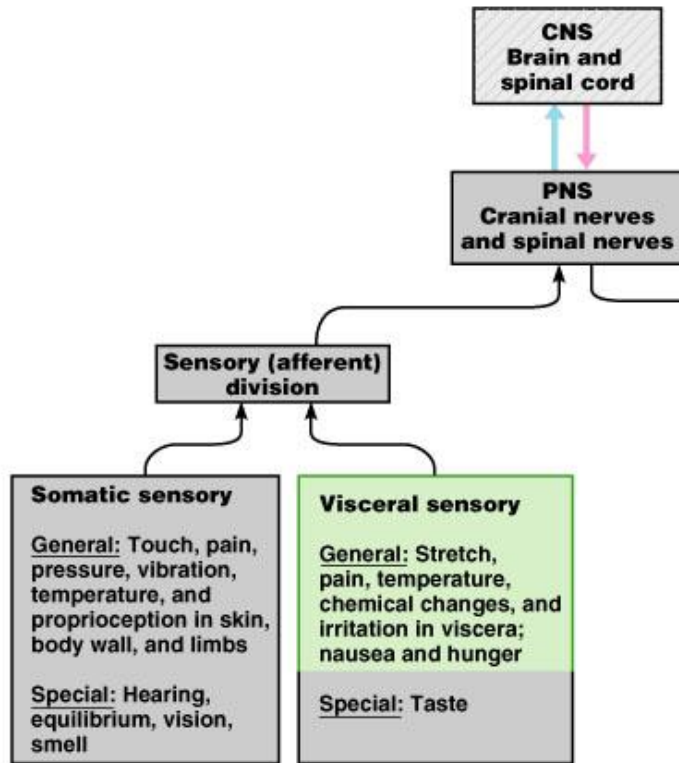


# The Autonomic Nervous System

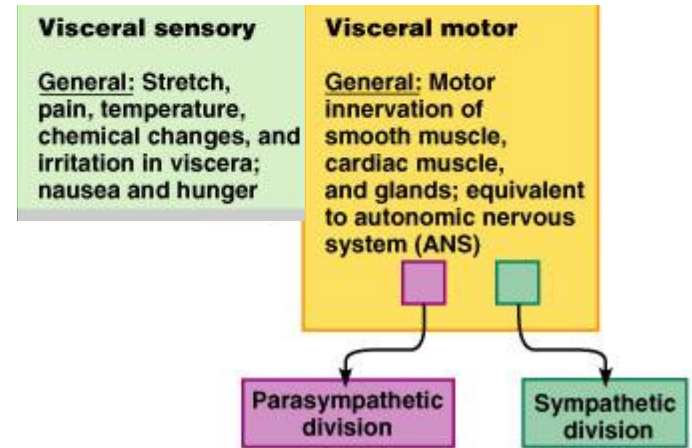


# The Autonomic Nervous System

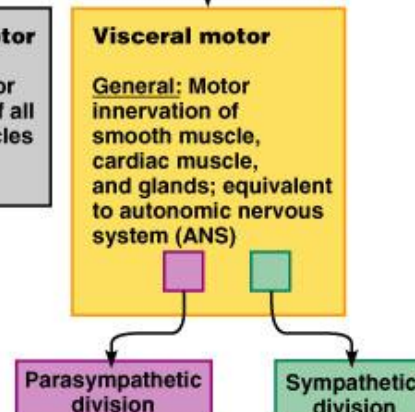
## Visceral sensory



&



## Visceral motor



# Autonomic nervous system

- The autonomic nervous system is the subdivision of the peripheral nervous system that regulates body activities that are generally not under conscious control
- **Visceral motor** innervates non-skeletal (non-somatic) muscles
- **Visceral sensory** will be covered later

To repeat...

- ANS is the subdivision of the peripheral nervous system that regulates body activities that are generally ***not under conscious control***
- ***Visceral motor*** innervates ***non-skeletal (non-somatic) muscles***
- Composed of a special group of neurons serving:
  - Cardiac muscle (the heart)
  - Smooth muscle (walls of viscera and blood vessels)
  - Internal organs
  - Skin

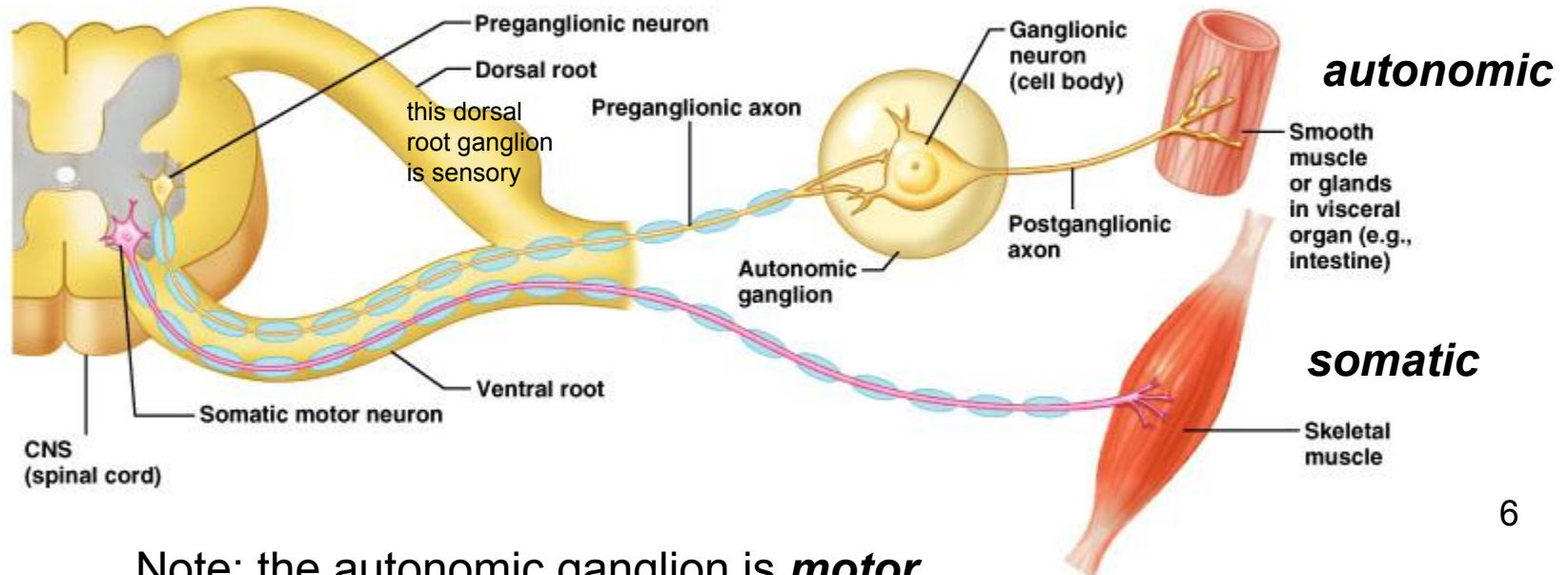
*Basic anatomical difference between the motor pathways of the voluntary somatic nervous system (to skeletal muscles) and those of the autonomic nervous system*

- Somatic division:
  - Cell bodies of motor neurons reside in CNS (brain or spinal cord)
  - Their axons (sheathed in spinal nerves) extend all the way to their skeletal muscles
- Autonomic system: chains of two motor neurons
  - 1<sup>st</sup> = preganglionic neuron (in brain or cord)
  - 2<sup>nd</sup> = ganglionic neuron (cell body in ganglion outside CNS)
  - Slower because lightly or unmyelinated

*(see next diagram)*

- Axon of 1<sup>st</sup> (*preganglionic*) neuron leaves CNS to synapse with the 2<sup>nd</sup> (*ganglionic*) neuron
- Axon of 2<sup>nd</sup> (*ganglionic*) neuron extends to the organ it serves

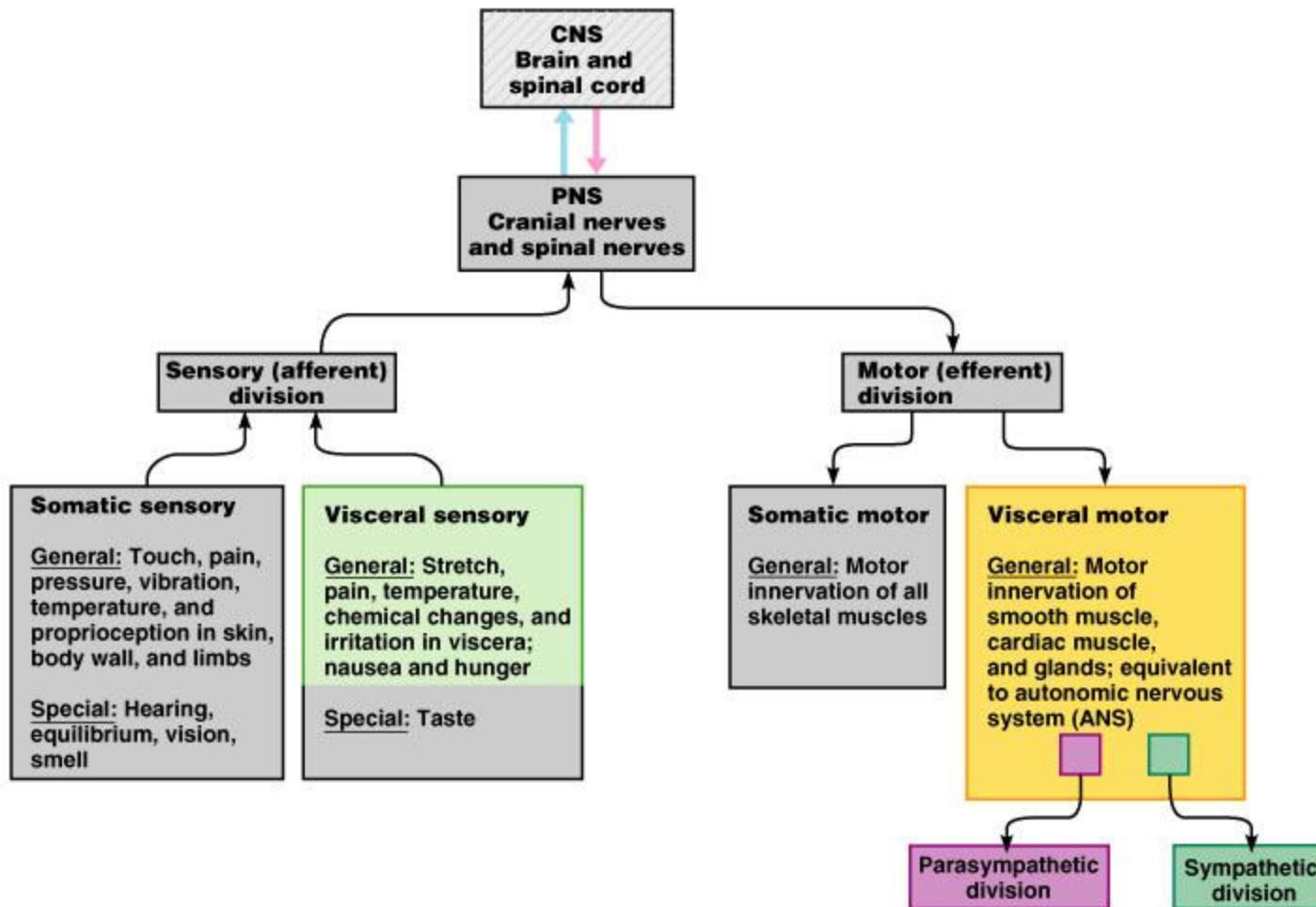
Diagram contrasts somatic (lower) and autonomic:



Note: the autonomic ganglion is *motor*

# Divisions of the autonomic nervous system (visceral motor part of it)

- Parasympathetic division
- Sympathetic division



# Divisions of the autonomic nervous system

- Parasympathetic division
- Sympathetic division

***Serve most of the same organs but cause opposing or antagonistic effects***

**Parasympathetic:** routine maintenance

***“rest & digest”***

**Sympathetic:** mobilization & increased metabolism

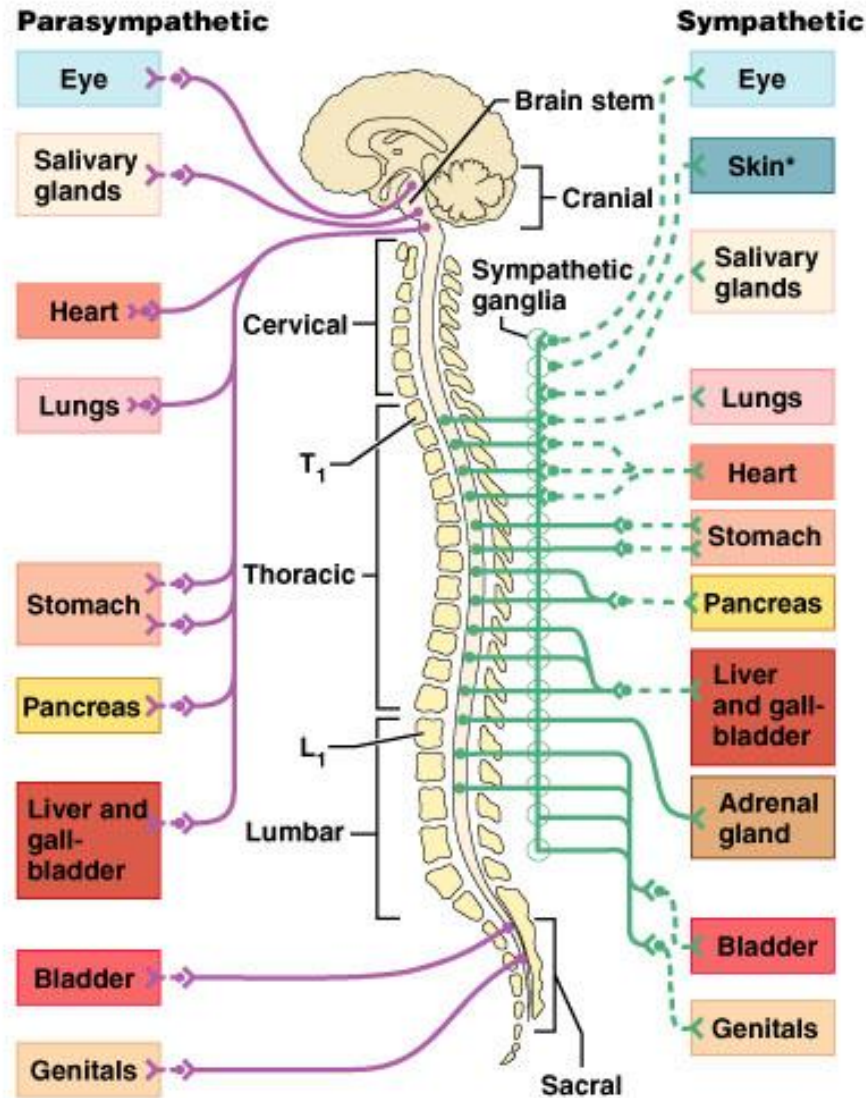
***“fight, flight or fright” or “fight, flight or freeze”***



# Where they come from

Parasympathetic:  
craniosacral

Sympathetic:  
thoracolumbar



# Parasympathetic nervous system

*“rest & digest”*

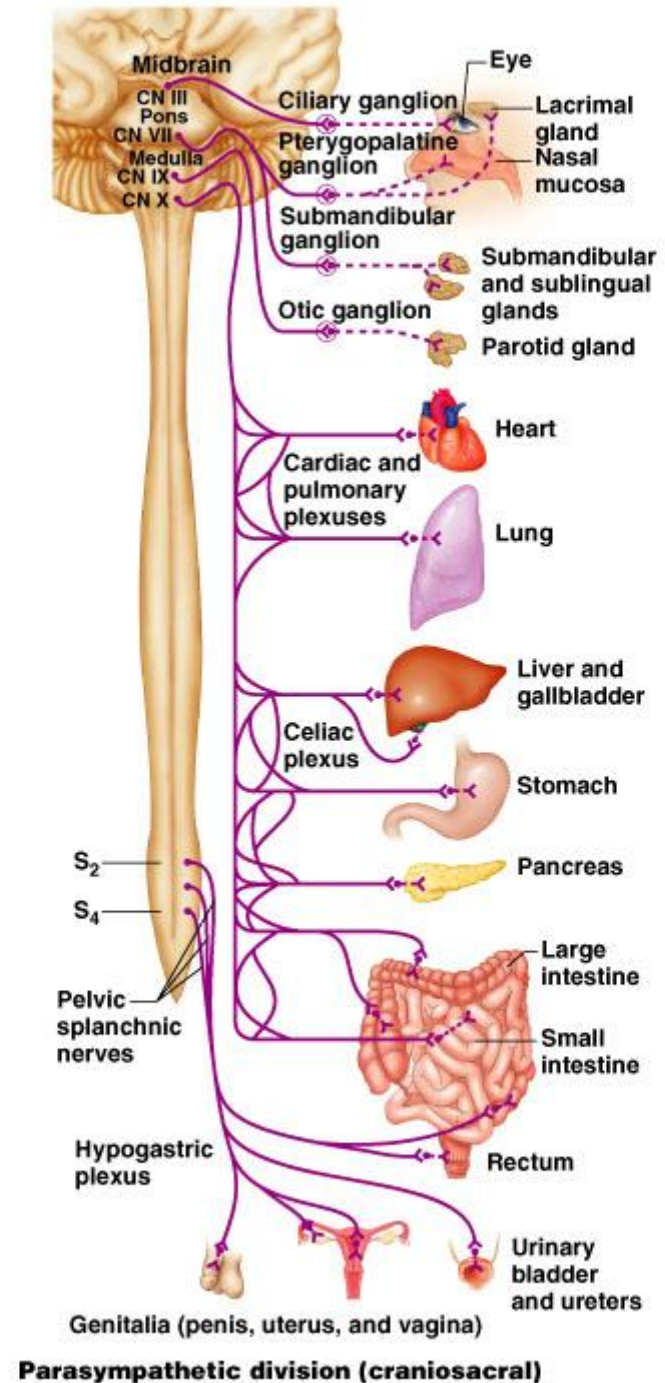
- Also called the ***craniosacral*** system because all its preganglionic neurons are in the brain stem or sacral levels of the spinal cord
  - Cranial nerves III, VII, IX and X
  - In lateral horn of gray matter from S2-S4
- Only innervate internal organs (not skin)
- ***Acetylcholine*** is neurotransmitter at end organ as well as at preganglionic synapse: “cholinergic”

# Parasympathetic continued

- Cranial outflow
  - III - pupils constrict
  - VII - tears, nasal mucus, saliva
  - IX – parotid salivary gland
  - X (Vagus n) – visceral organs of thorax & abdomen:
    - Stimulates digestive glands
    - Increases motility of smooth muscle of digestive tract
    - Decreases heart rate
    - Causes bronchial constriction
- Sacral outflow (S2-4): form pelvic splanchnic nerves
  - Supply 2<sup>nd</sup> half of large intestine
  - Supply all the pelvic (genitourinary) organs

# Parasympathetic

(only look at this if it helps you)

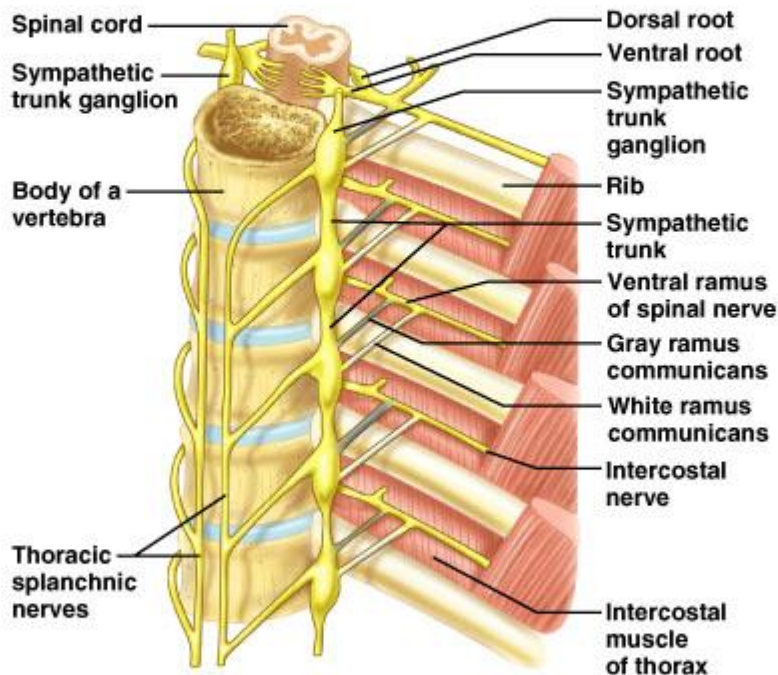


# Sympathetic nervous system

*“fight, flight or fright”*

- Also called ***thoracolumbar*** system: all its neurons are in lateral horn of gray matter from T1-L2
- Lead to every part of the body (unlike parasymp.)
  - Easy to remember that when nervous, you sweat; when afraid, hair stands on end; when excited blood pressure rises (vasoconstriction): these sympathetic only
  - Also causes: dry mouth, pupils to dilate, increased heart & respiratory rates to increase O<sub>2</sub> to skeletal muscles, and liver to release glucose
- ***Norepinephrine*** (aka noradrenaline) is neurotransmitter released by most postganglionic fibers (acetylcholine in preganglionic): “adrenergic”

# Sympathetic nervous system continued



- Regardless of target, all begin same
- Preganglionic axons exit spinal cord through ventral root and enter spinal nerve
- Exit spinal nerve via communicating ramus
- Enter sympathetic trunk/chain where postganglionic neurons are
- Has three options...

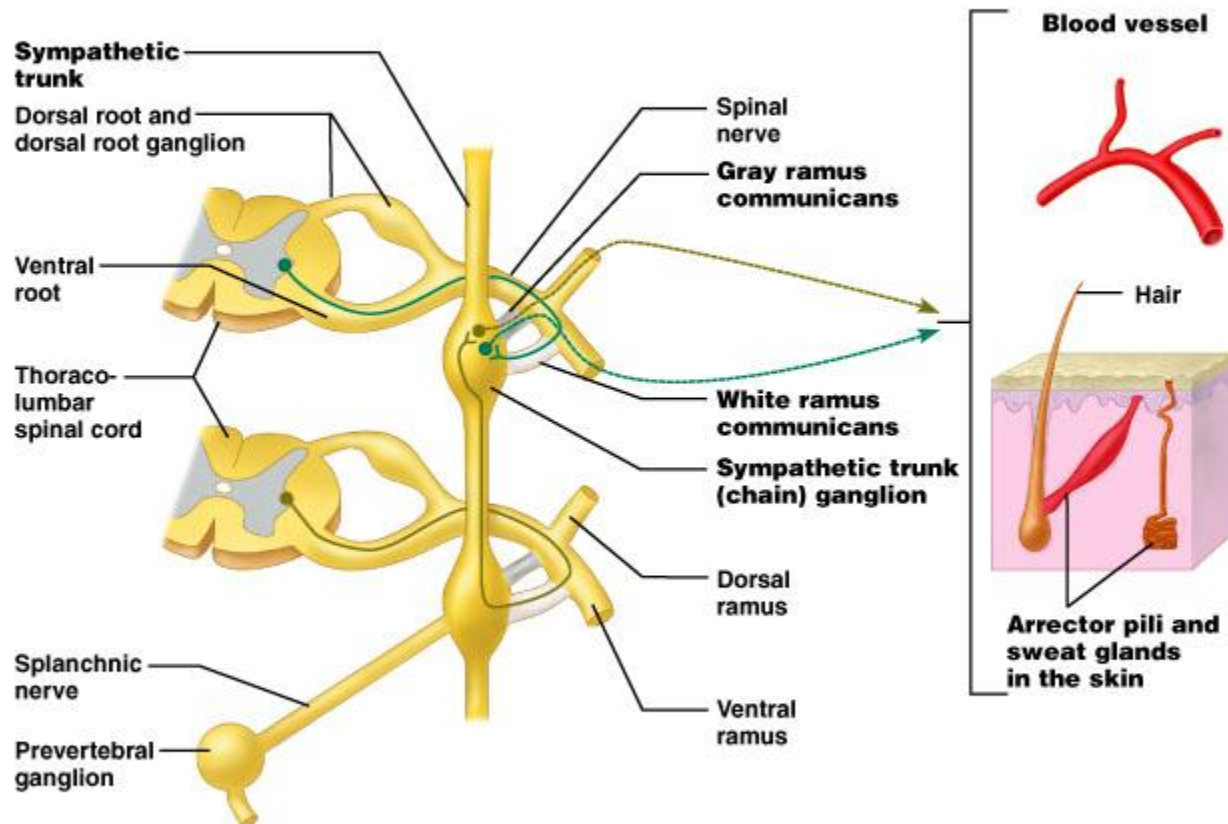
# Options of preganglionic axons in sympathetic trunk

(see next slides for drawing examples)

1. Synapse on postganglionic neuron in **chain ganglion** then return to spinal nerve and follow its branch to the skin
2. Ascend or descend within sympathetic trunk, synapse with a postganglionic neuron within a chain ganglion, and return to spinal nerve at that level and follow branches to skin
3. Enter sympathetic chain, pass through without synapsing, form a **splanchnic nerve** that passes toward thoracic or abdominal organs
  - These synapse in **prevertebral ganglion** in front of aorta
  - Postganglionic axons follow arteries to organs

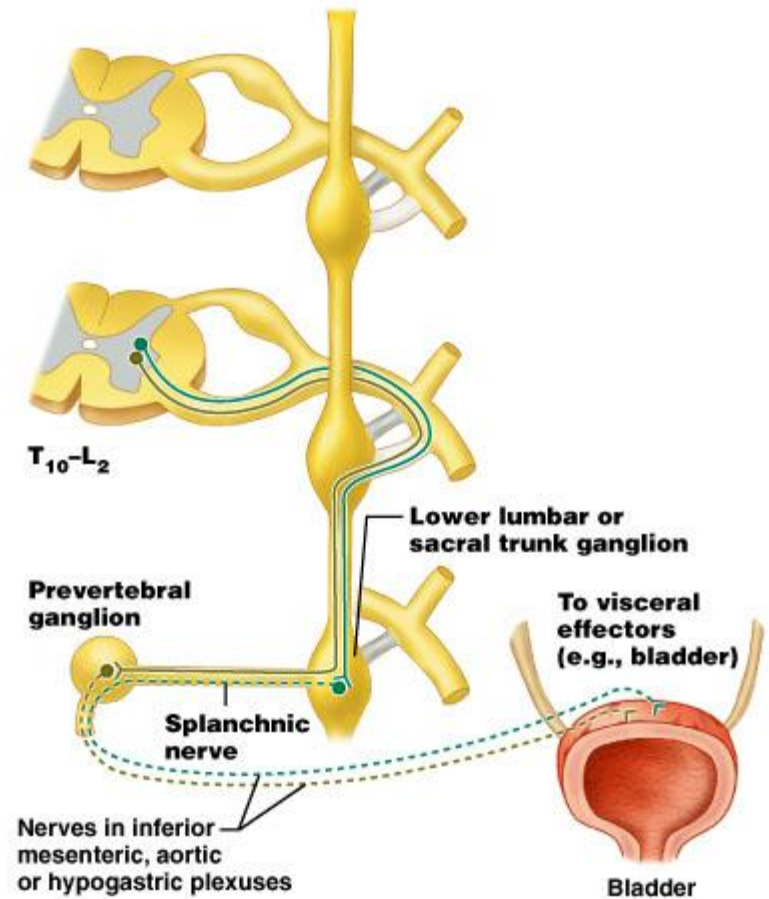
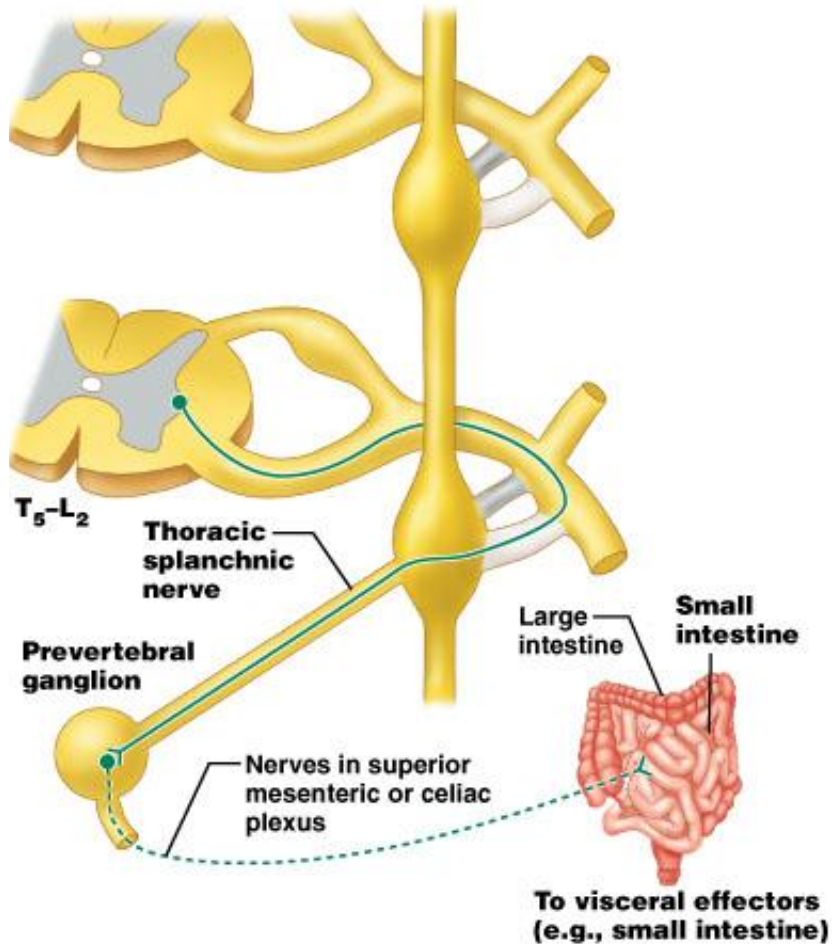


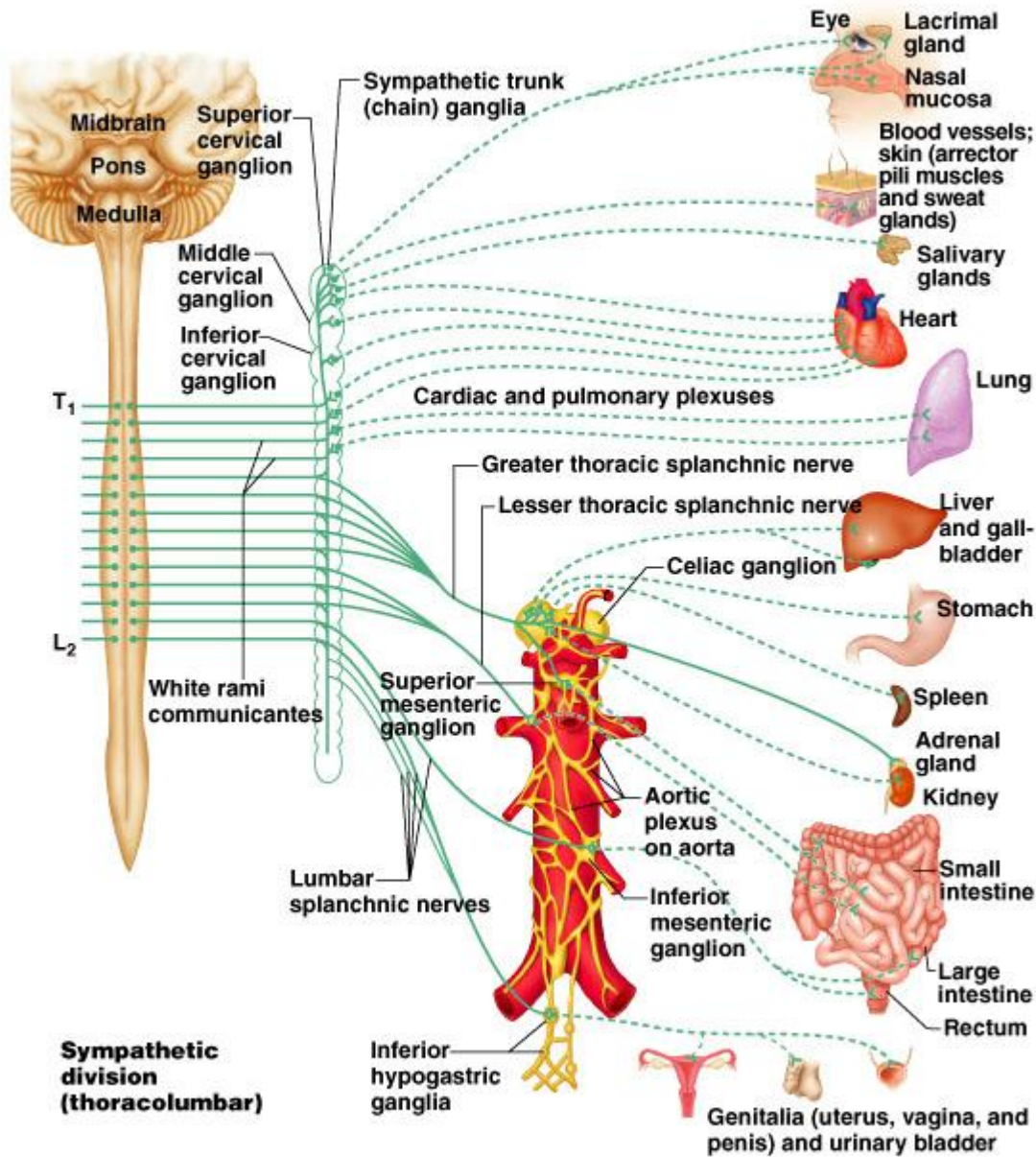
# Synapse in chain ganglia at same level or different level





# Pass through ganglia and synapse in prevertebral ganglion



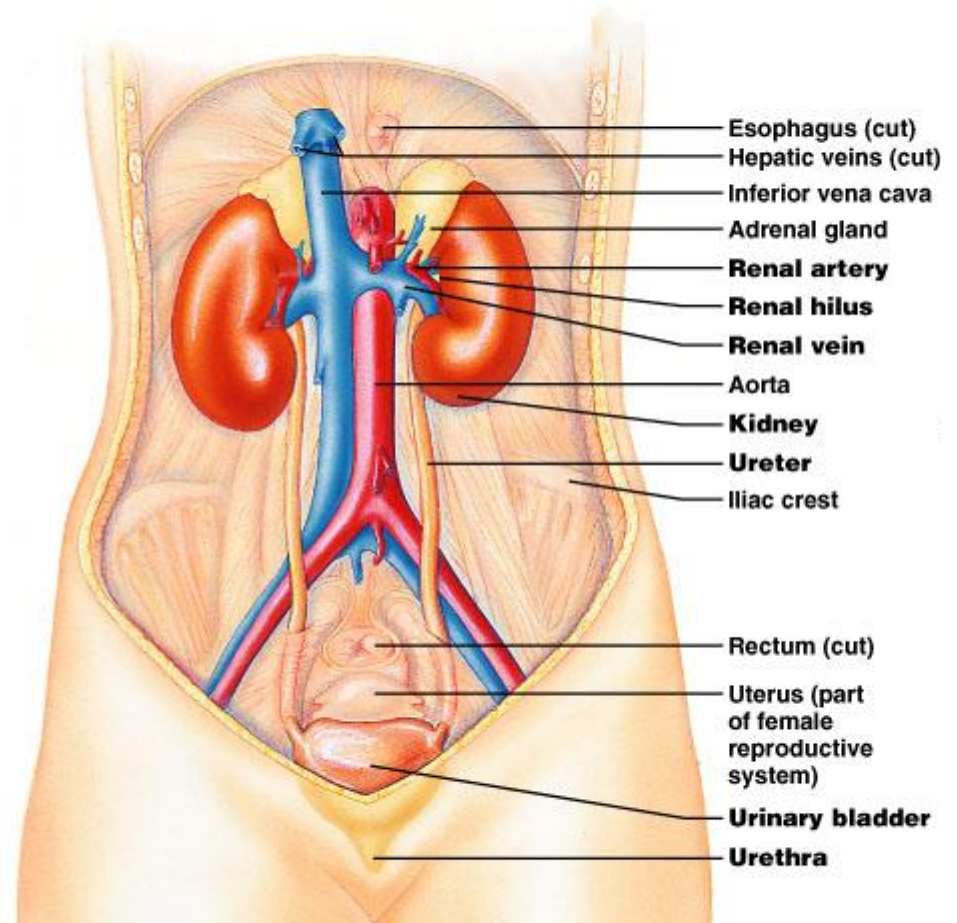


# Sympathetic

# Adrenal gland is exception

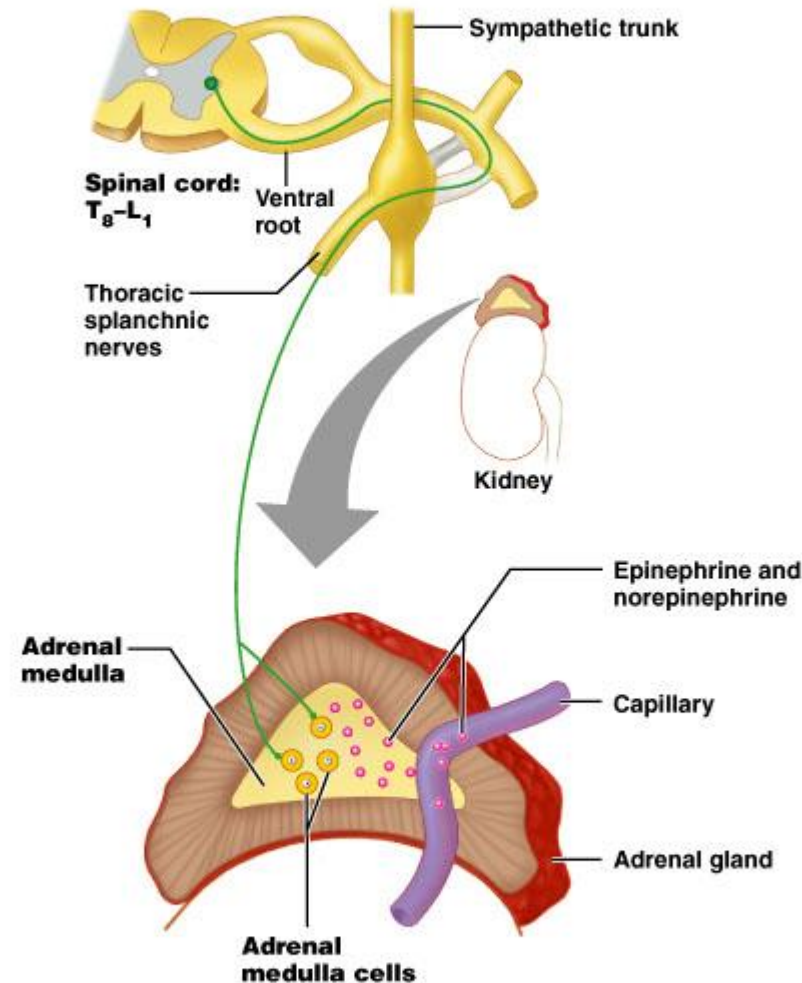
On top of kidneys

Adrenal medulla (inside part) is a major organ of the sympathetic nervous system



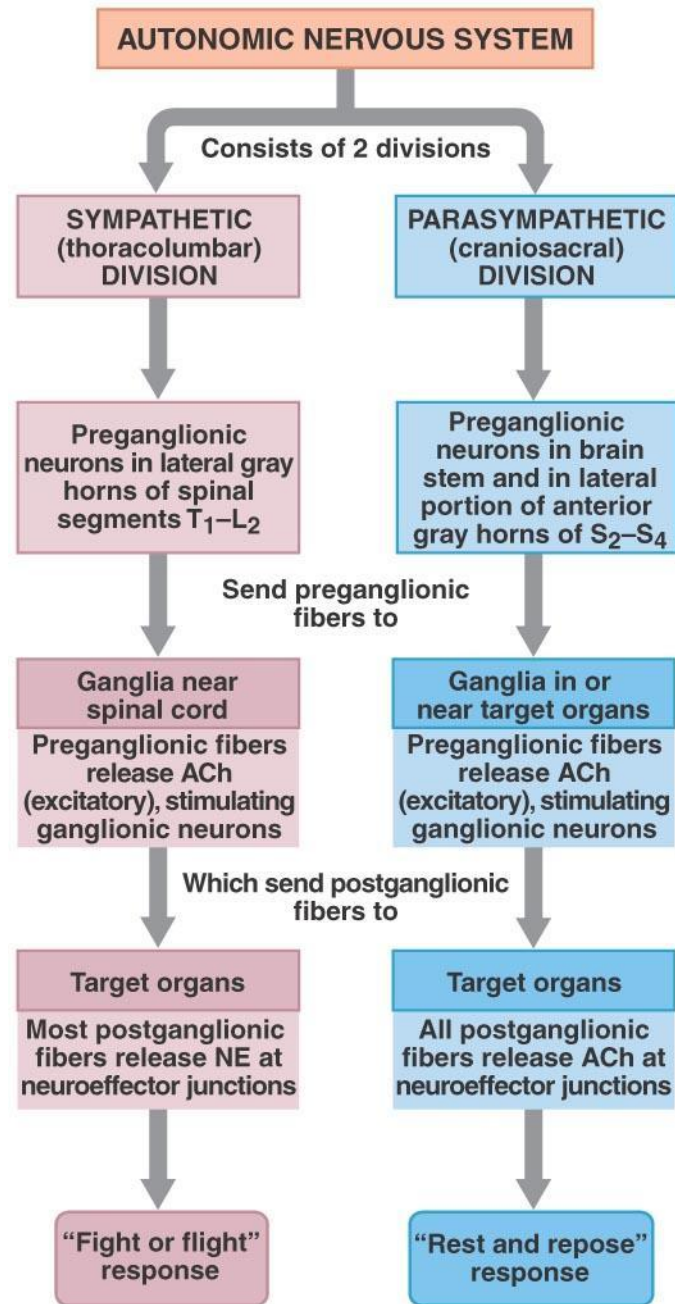
# Adrenal gland is exception

- Synapse in gland
- Can cause body-wide release of epinephrine aka adrenaline and norepinephrine in an extreme emergency (adrenaline “rush” or surge)





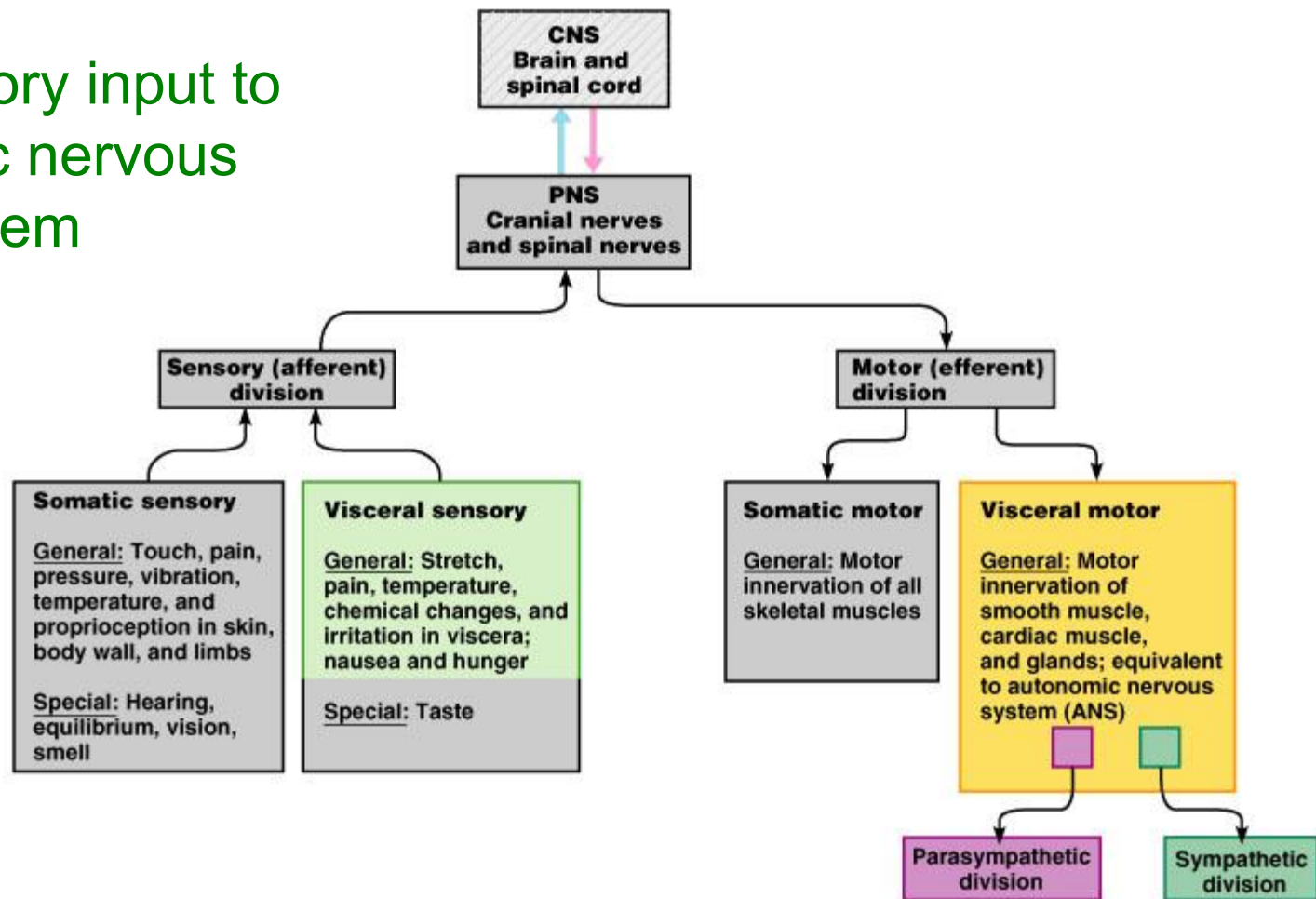
# Summary



(a)

# Visceral sensory system

Gives sensory input to  
autonomic nervous  
system

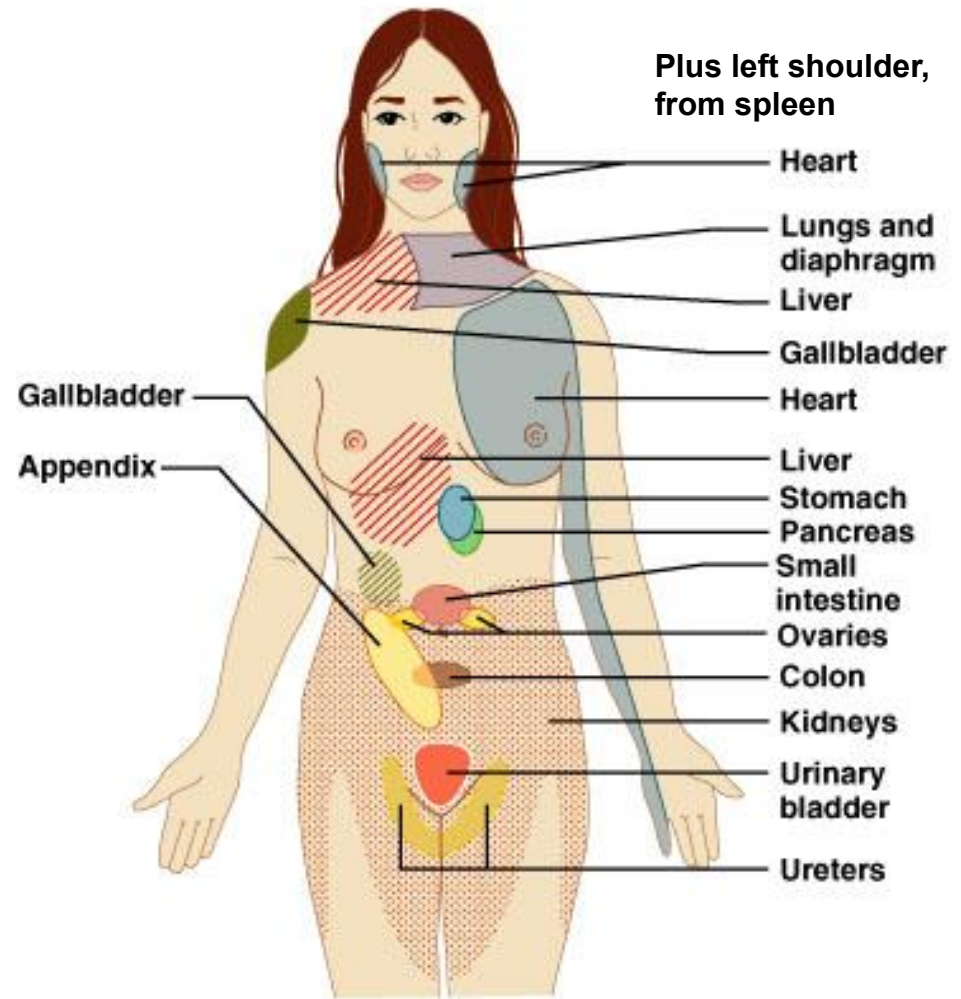


# Visceral sensory neurons

- Monitor temperature, pain, irritation, chemical changes and stretch in the visceral organs
  - Brain interprets as hunger, fullness, pain, nausea, well-being
- Receptors widely scattered – localization poor (e.g. which part is giving you the gas pain?)
- Visceral sensory fibers run within autonomic nerves, especially vagus and sympathetic nerves
  - Sympathetic nerves carry most pain fibers from visceral organs of body trunk
- Simplified pathway: sensory neurons to spinothalamic tract to thalamus to cerebral cortex
- Visceral pain is induced by stretching, infection and cramping of internal organs but seldom by cutting (e.g. cutting off a colon polyp) or scraping them

# Referred pain: **important to know**

*Pain in visceral organs is often perceived to be somatic in origin: referred to somatic regions of body that receive innervation from the same spinal cord segments*

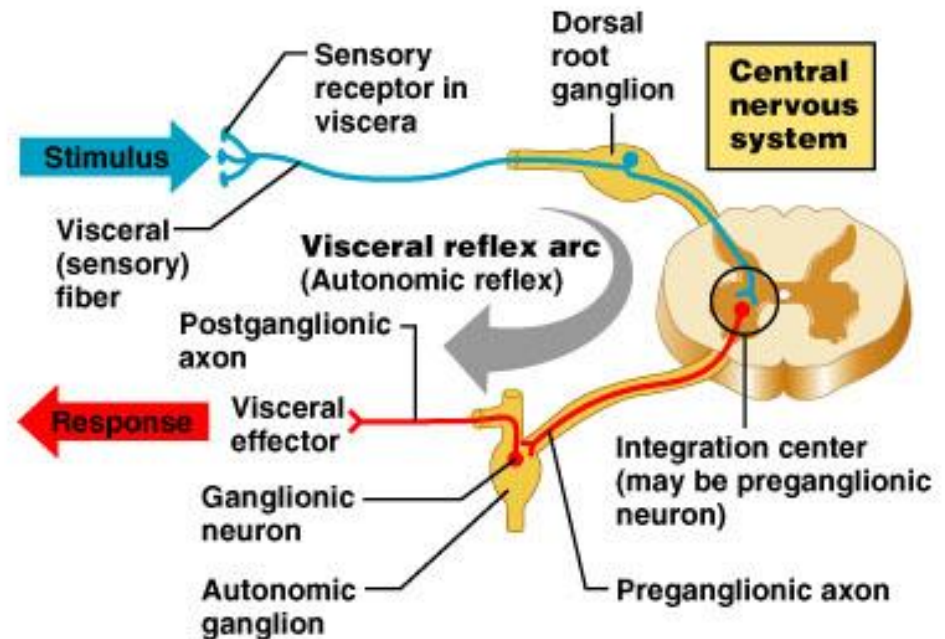


Anterior skin areas to which pain is referred from certain visceral organs



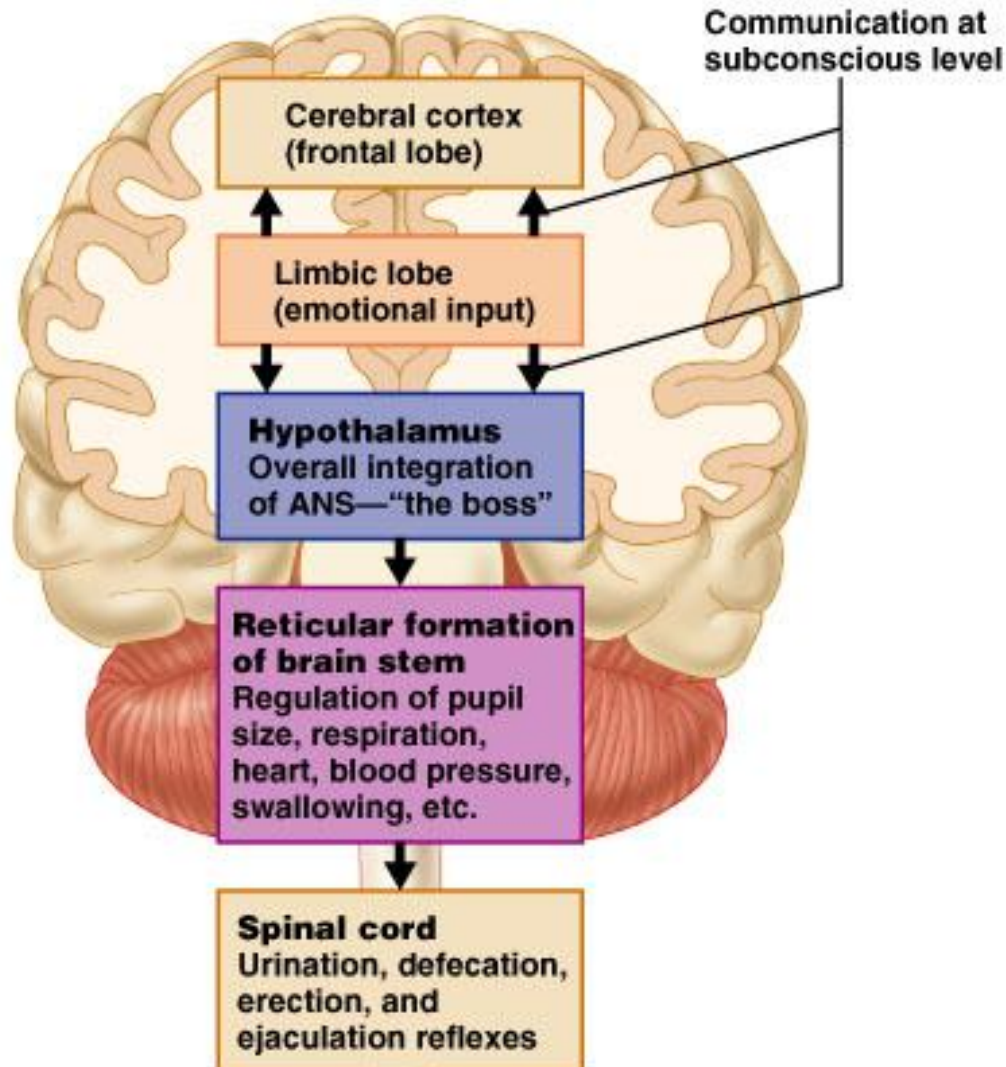
# Visceral sensory and autonomic neurons participate in *visceral reflex arcs*

- Many are spinal reflexes such as defecation and micturition reflexes
- Some only involve peripheral neurons: spinal cord not involved (not shown)\*



\*e.g. "enteric" nervous system: 3 neuron reflex arcs entirely within the wall of the gut

# Central control of the Autonomic NS



**Amygdala:** main limbic region for emotions

- Stimulates sympathetic activity, especially previously learned fear-related behavior
- Can be voluntary when decide to recall frightful experience - cerebral cortex acts through amygdala
- Some people can regulate some autonomic activities by gaining extraordinary control over their emotions

**Hypothalamus:** main integration center

**Reticular formation:** most direct influence over autonomic function