Autonomic Nervous System

I. Divisions

A. Sympathetic

- fight or flight response

B. Parasympathetic

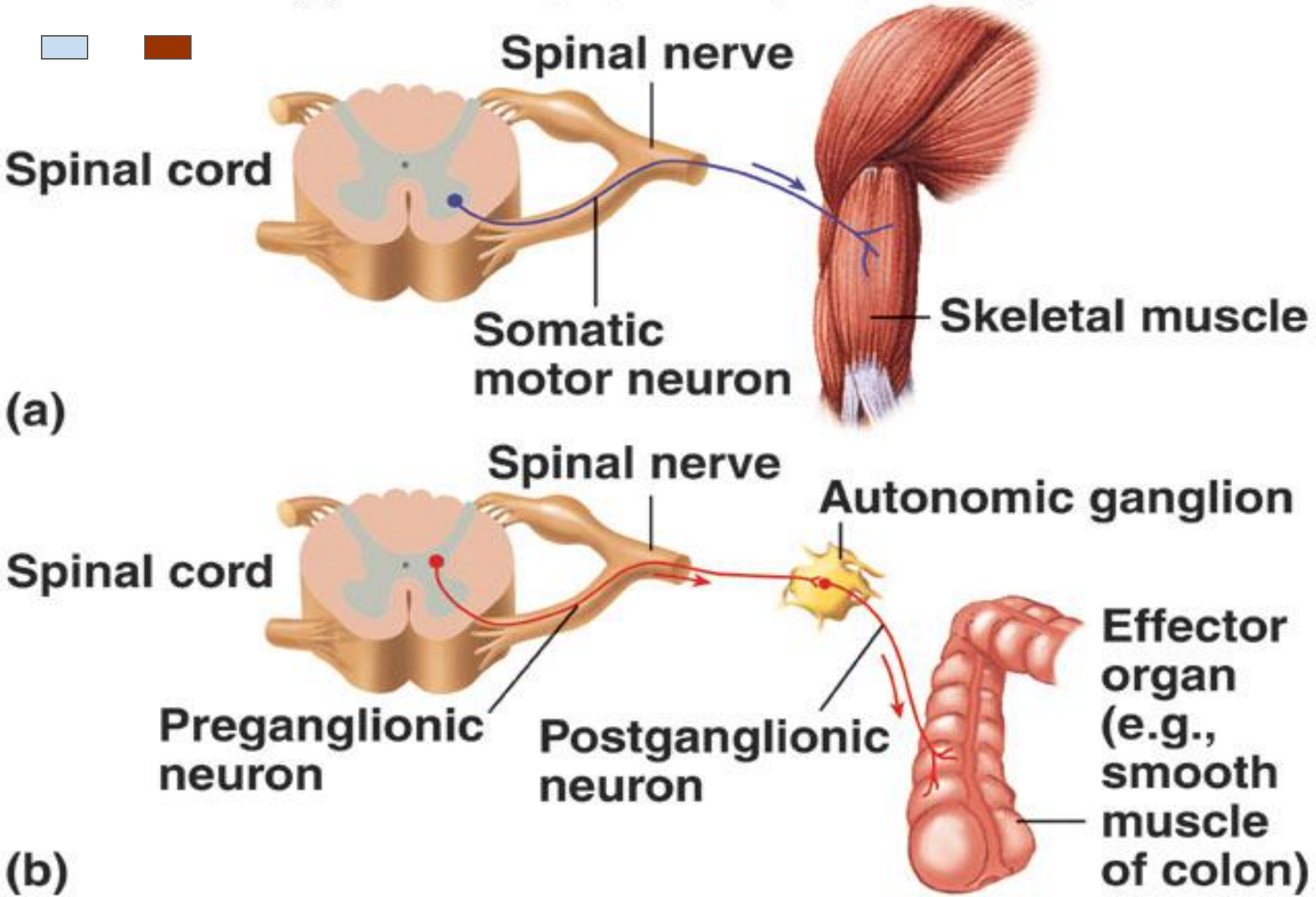
- rest and digestion

II. Involuntary Motor System

A. Autonomic vs. Somatic motor systems

1. Somatic

- voluntary
- direct synapse
- excitatory



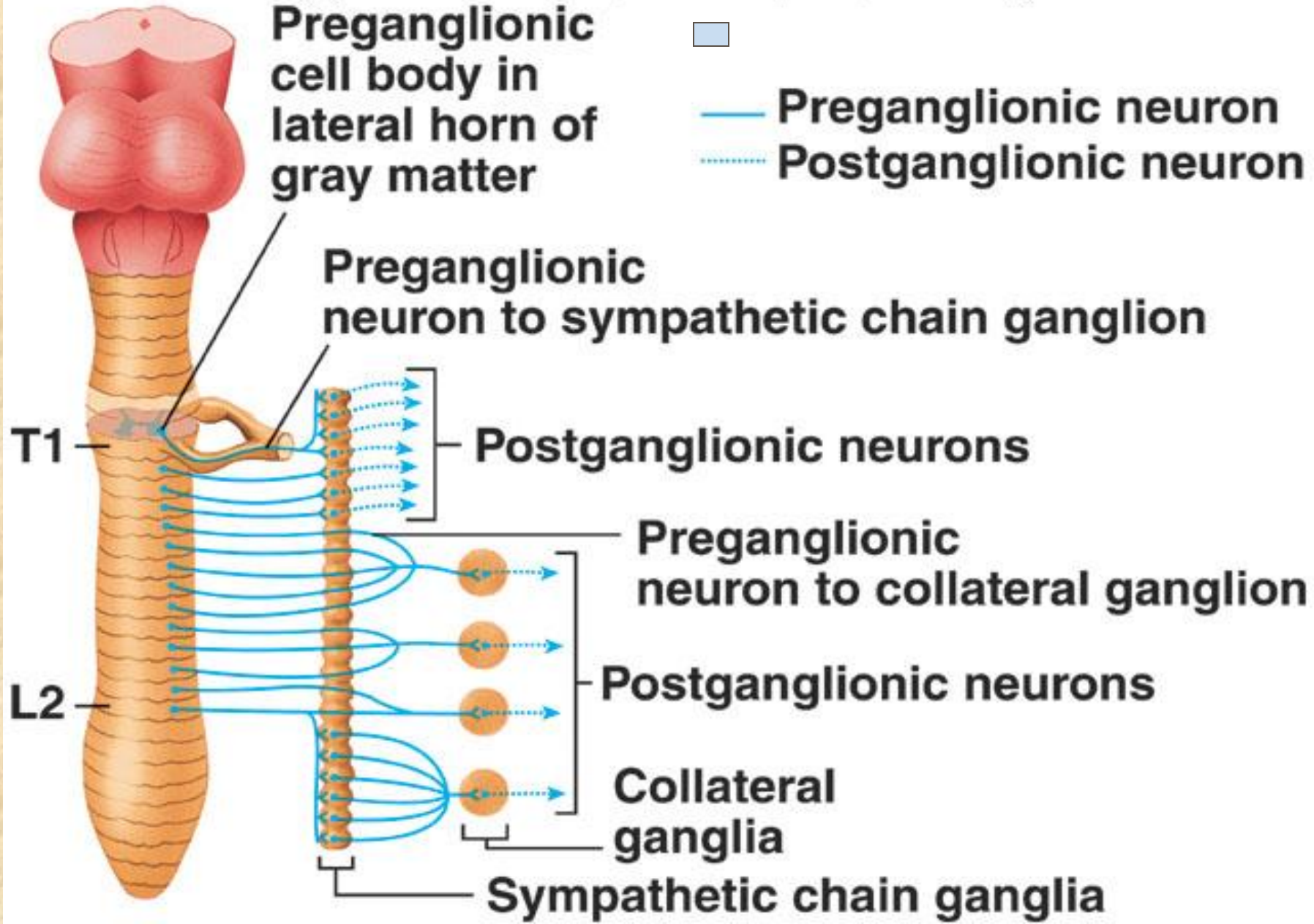
2. Autonomic

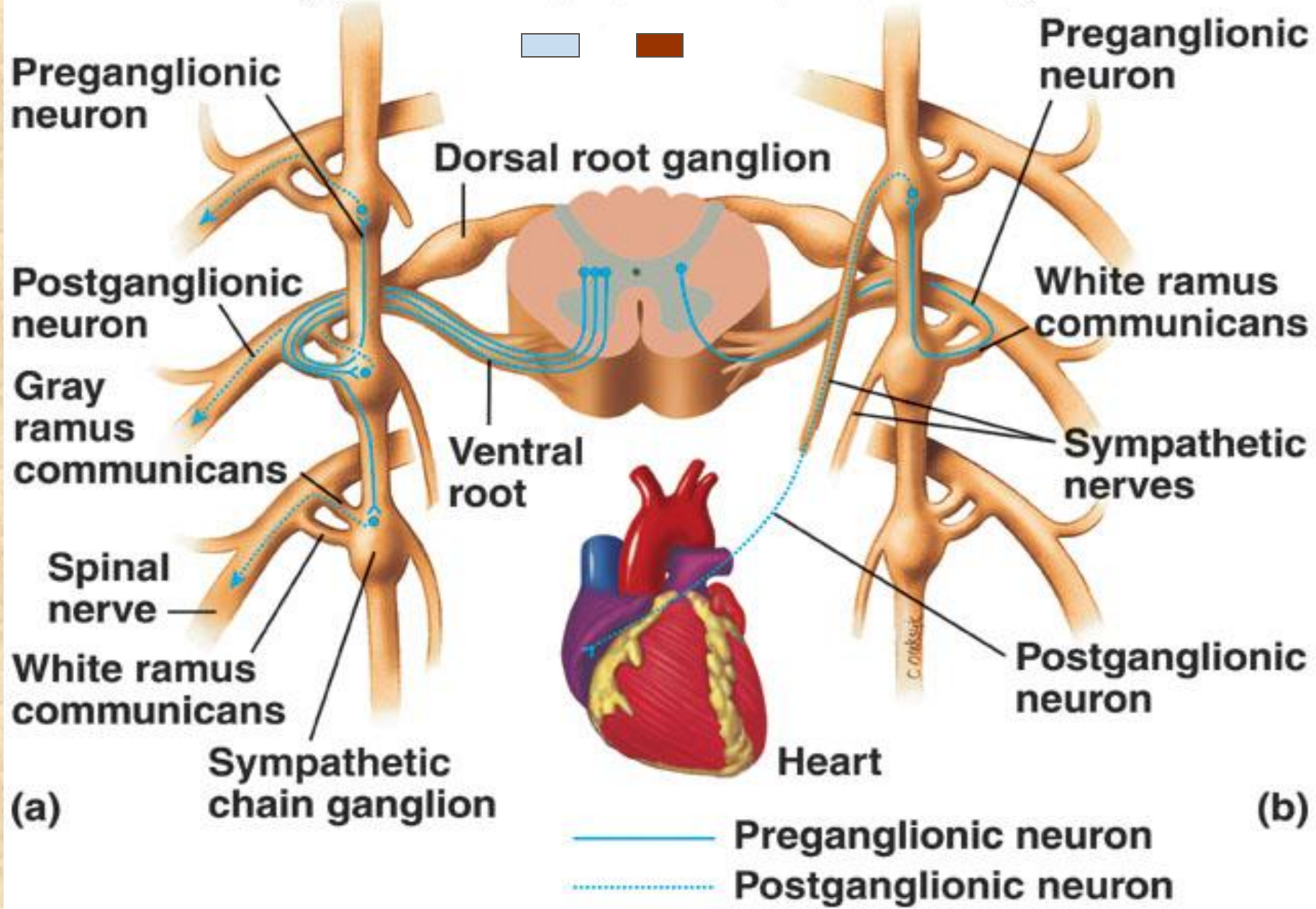
- involuntary
- disynaptic (preganglion, postganglion)
- Excitatory and inhibitory

III General nerve pathways

A. Sympathetic

- Preganglion cell body – gray matter
- axons move through ventral root of spinal nerve
- synapse w/ postganglion at sympathetic chain ganglion





- **axons of postganglions exit via**

  Spinal nerve

  Sympathetic nerve

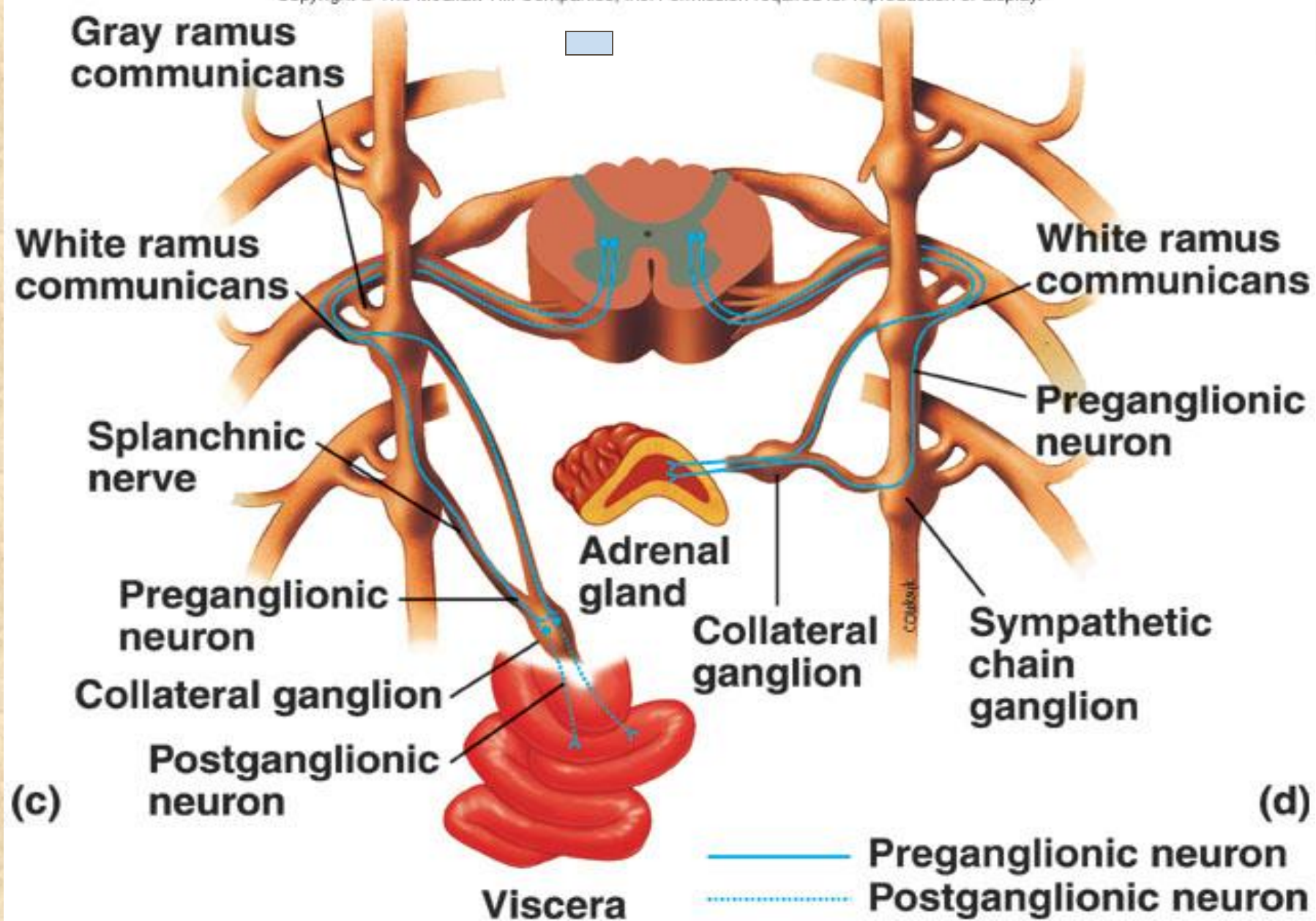
Exceptions: some pre do not synapse at symp chain

Splanchnic nerve

axons of preganglion exit Splanchnic nerve and synapse at collateral ganglion w/post

Adrenal gland

preganglion synapses directly w/adrenal



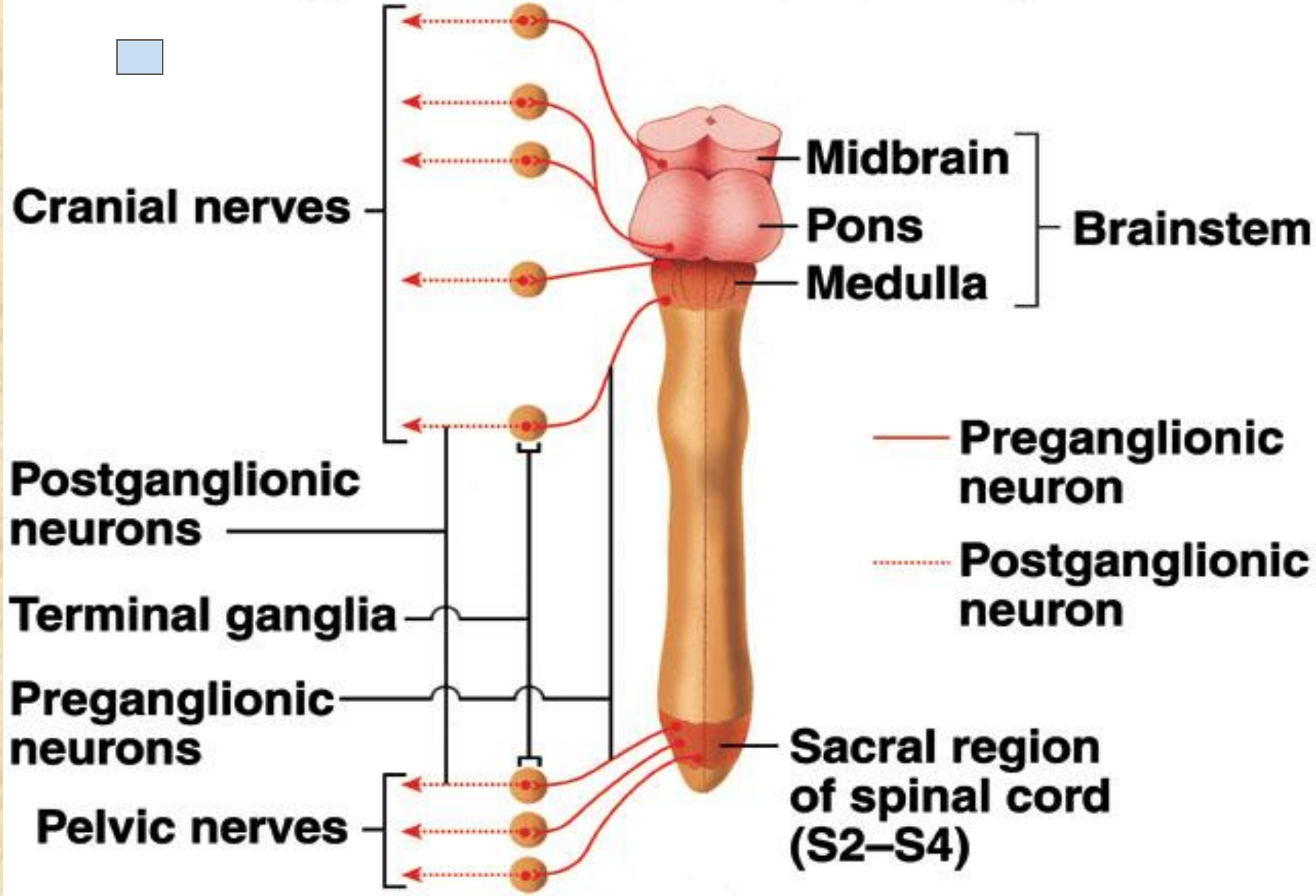
B. Parasympathetic

- cell bodies of preganglion – brainstem (nuclei)
  and sacral region of spinal cord
- axons move through cranial nerves
  and through spinal nerves
- synapse w/ postganglion at ganglia near or in the target

IV. Signal transmission

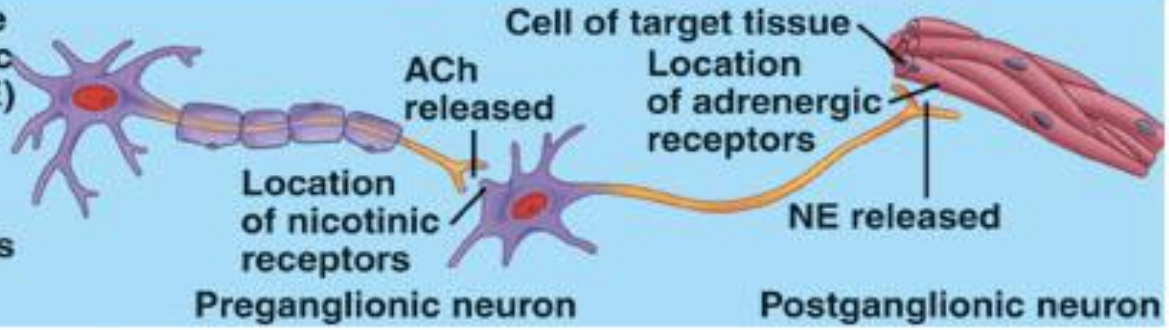
A. Sympathetic

- Preganglion secretes Acetylcholine (Cholinergic)
- Postganglion – receptor = Nicotinic
- Postganglion secretes Norepinephrine (Adrenergic)



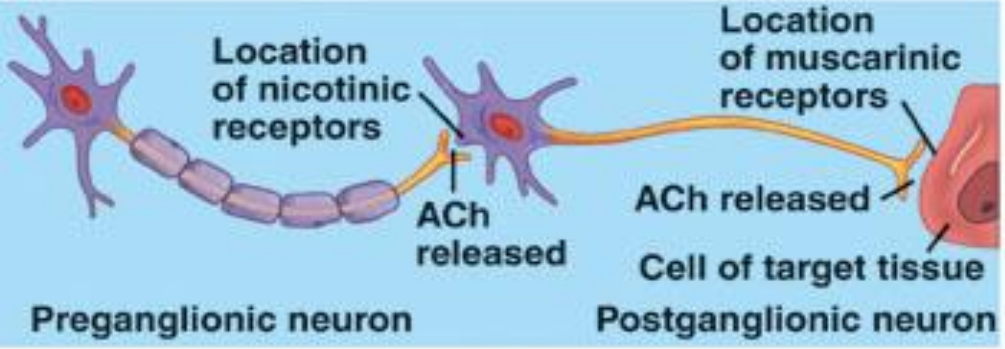
Sympathetic division

Most target tissues innervated by the sympathetic division have adrenergic receptors. When norepinephrine (NE) binds to adrenergic receptors, some target tissues are stimulated, and others are inhibited. For example, smooth muscle cells in blood vessels are stimulated to constrict, and stomach glands are inhibited.



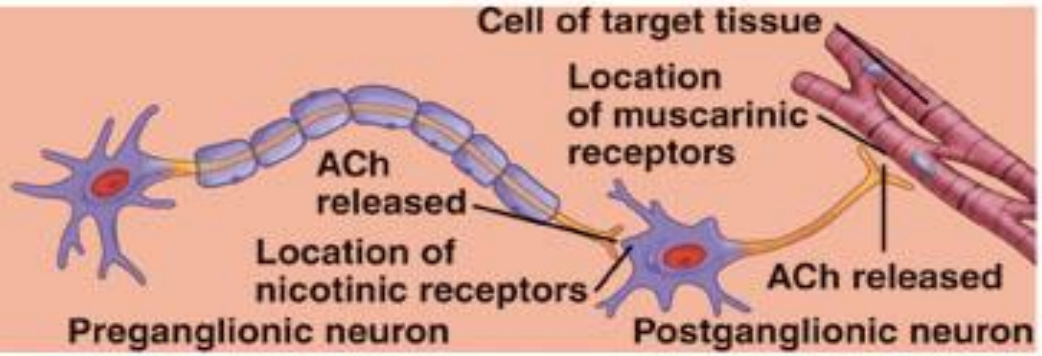
Sympathetic division

Some sympathetic target tissues, such as sweat glands, have muscarinic receptors, which respond to acetylcholine (ACh). Stimulation of sweat glands results in increased sweat production.



Parasympathetic division

All parasympathetic target tissues have muscarinic receptors. The general response to ACh is excitatory, but some target tissues, such as the heart, are inhibited.



- **Target (smooth muscle, cardiac, glands)**

  Receptor = Adrenergic (α,β)

Sweat Glands

- **Preganglion secretes Acetylcholine**
- **Postganglion – nicotinic receptor**
- **Postganglion secretes Acetylcholine**
- **Sweat gland – muscarinic receptor**

B. Parasympathetic

- Preganglion secretes Acetylcholine (Cholinergic)
- Postganglion – receptor = nicotinic
- Postganglion secretes Acetylcholine
- Target (Smooth muscle, heart, glands)

receptor = muscarinic

V. ANS generalized

A. Regulated

B. Excitatory and inhibitory

- depends on the target organ

C. Opposite effects

VI. Autonomic control

A. Cardiovascular function

- Sympathetic: Norepinephrine -

  Increases cardiac muscle contractions

  Increases blood pressure

- Parasympathetic: Acetylcholine

  Decrease in cardiac output due to decrease in calcium influx

Table 16.3 Effects of the Sympathetic and Parasympathetic Divisions on Various Tissues

Organ	Sympathetic Effects and Receptor Type*	Parasympathetic Effects and Receptor Type*
Adipose tissue	Fat breakdown and release of fatty acids (α_2, β_1)	None
Arrector pili muscle	Contraction (α_1)	None
Blood (platelets)	Increases coagulation (α_2)	None
Blood vessels		
Arterioles (carry blood to tissues)		
Digestive organs	Constriction (α_1)	None
Heart	Dilation (β_2), constriction (α_1)†	None
Kidneys	Constriction (α_1, α_2); dilation (β_1, β_2)	None
Lungs	Dilation (β_2), constriction (α_1)	None
Skeletal muscle	Dilation (β_2), constriction (α_1)	None
Skin	Constriction (α_1, α_2)	None
Veins (carry blood away from tissues)	Constriction (α_1, α_2), dilation (β_2)	
Eye		
Ciliary muscle	Relaxation for far vision (β_2)	Contraction for near vision (m)
Pupil	Dilated (α_1)‡	Constricted (m)‡
Gallbladder	Relaxation (β_2)	Contraction (m)
Glands		
Adrenal	Release of epinephrine and norepinephrine (n)	None
Gastric	Decreases gastric secretion (α_2)	Increases gastric secretion (m)
Lacrimal	Slight tear production (α)	Increases tear secretion (m)
Pancreas	Decreases insulin secretion (α_2)	Increases insulin secretion (m)
	Decreases exocrine secretion (α)	Increases exocrine secretion (m)

Table 16.3 Effects of the Sympathetic and Parasympathetic Divisions on Various Tissues

Organ	Sympathetic Effects and Receptor Type*	Parasympathetic Effects and Receptor Type*
Salivary	Constriction of blood vessels and slight production of a thick, viscous saliva (α_1)	Dilation of blood vessels and thin, copious saliva (m)
Sweat		
Apocrine	Thick, organic secretion (m)	None
Merocrine	Watery sweat from most of the skin (m); sweat from the palms and soles (α_1)	None
Heart	Increases rate and force of contraction (β_1, β_2)	Decreases rate of contraction (m)
Liver	Glucose released into blood (α_1, β_2)	None
Lungs	Dilates air passageways (β_2)	Constricts air passageways (m)
Metabolism	Increases up to 100% (α, β)	None
Sex organs	Ejaculation (α_1), erection§	Erection (m)
Skeletal muscles	Breakdown of glycogen to glucose (β_2)	None
Stomach and intestines		
Wall	Decreases tone (α_1, α_2, β_2)	Increases motility (m)
Sphincter	Increases tone (α_1)	Decreases tone (m)
Urinary bladder		
Wall (detrusor)	None	Contraction (m)
Neck of bladder	Contraction (α_1)	Relaxation (m)
Internal urinary sphincter	Contraction (α_1)	Relaxation (m)

*When known, receptor subtypes are indicated. The receptors are α_1- and α_2-adrenergic, β_1- and β_2-adrenergic, nicotinic cholinergic (n), and muscarinic cholinergic (m).
†Normally blood flow increases through coronary arteries because of increased demand by cardiac tissue for oxygen (local control of blood flow is discussed in chapter 21). In experiments that isolate the coronary arteries, sympathetic nerve stimulation, acting through α-adrenergic receptors, causes vasoconstriction. The β-adrenergic receptors are relatively insensitive to sympathetic nerve stimulation but can be activated by epinephrine released from the adrenal gland and by drugs. As a result, coronary arteries vasodilate.
‡Contraction of the radial muscles of the iris causes the pupil to dilate. Contraction of the circular muscles causes the pupil to constrict (see chapter 15).
§Decreased stimulation of alpha receptors by the sympathetic division can cause vasodilation of penile blood vessels, resulting in an erection.

B. Pupillary light reflex

1. Parasympathetic

- constricts pupil

2. Sympathetic

- Dilates pupil

C. Salivary glands

1. Sympathetic

- viscous secretion/ vasoconstriction of blood vessels

2. Parasympathetic

- watery secretion/ vasodilation of blood vessels