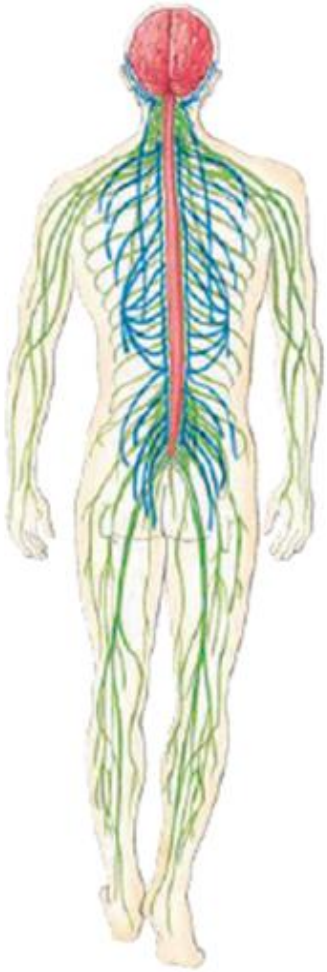
SISTEM SARAF OTONOM



Central nervous system (CNS)

Brain and spinal cord

Input to CNS from periphery

Output from CNS to periphery

Peripheral nervous system (PNS)

Afferent division

Efferent division

Sensory stimuli

Visceral stimuli

Somatic nervous system

Autonomic nervous system

Stimuli in digestive tract

Motor neurons

Sympathetic nervous system

Parasympathetic nervous system

Enteric nervous system

Skeletal muscles

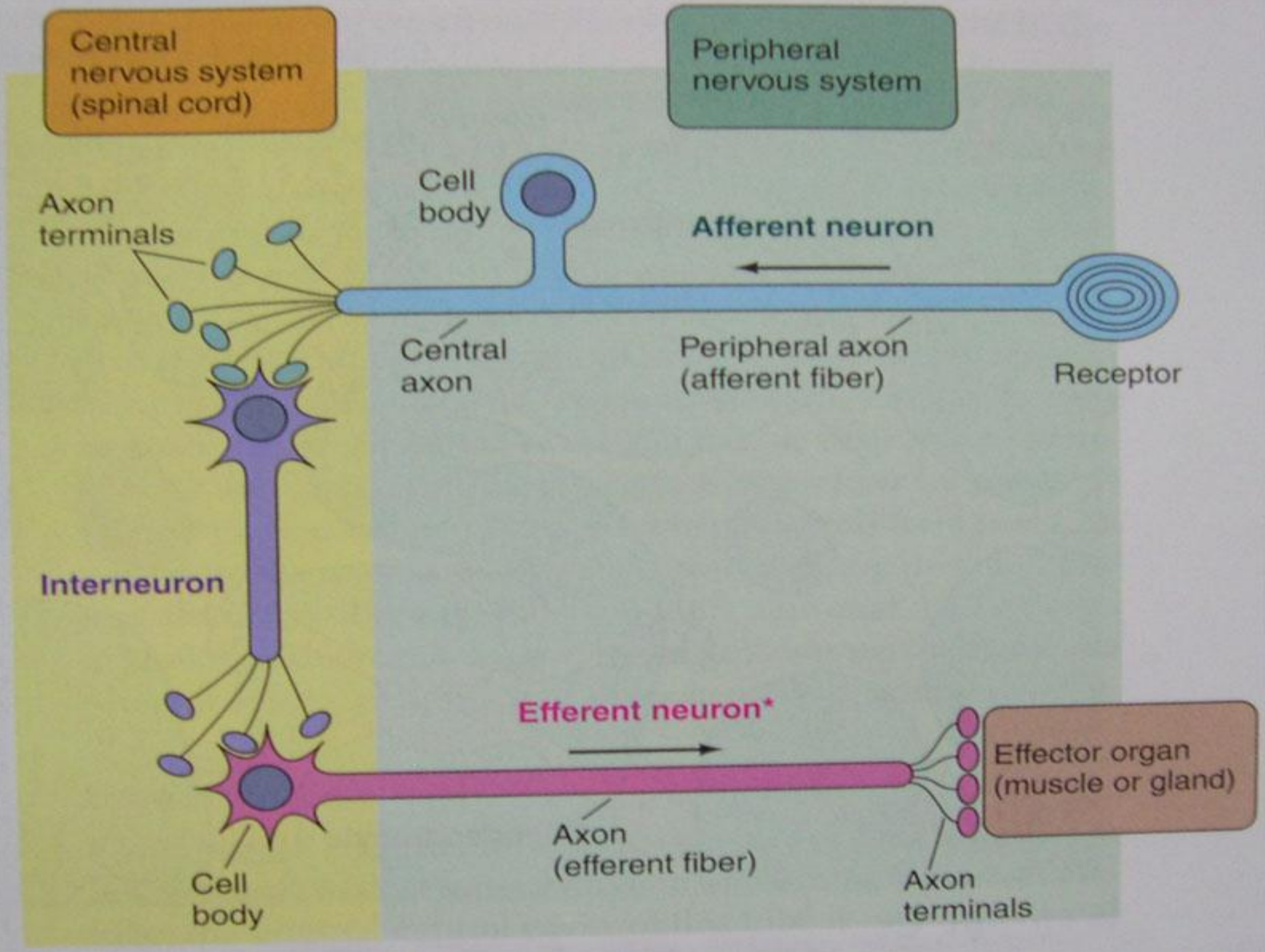
Smooth muscle
Cardiac muscle
Exocrine glands
Some endocrine glands

Digestive organs only

Effector organs
(made up of muscle and gland tissue)

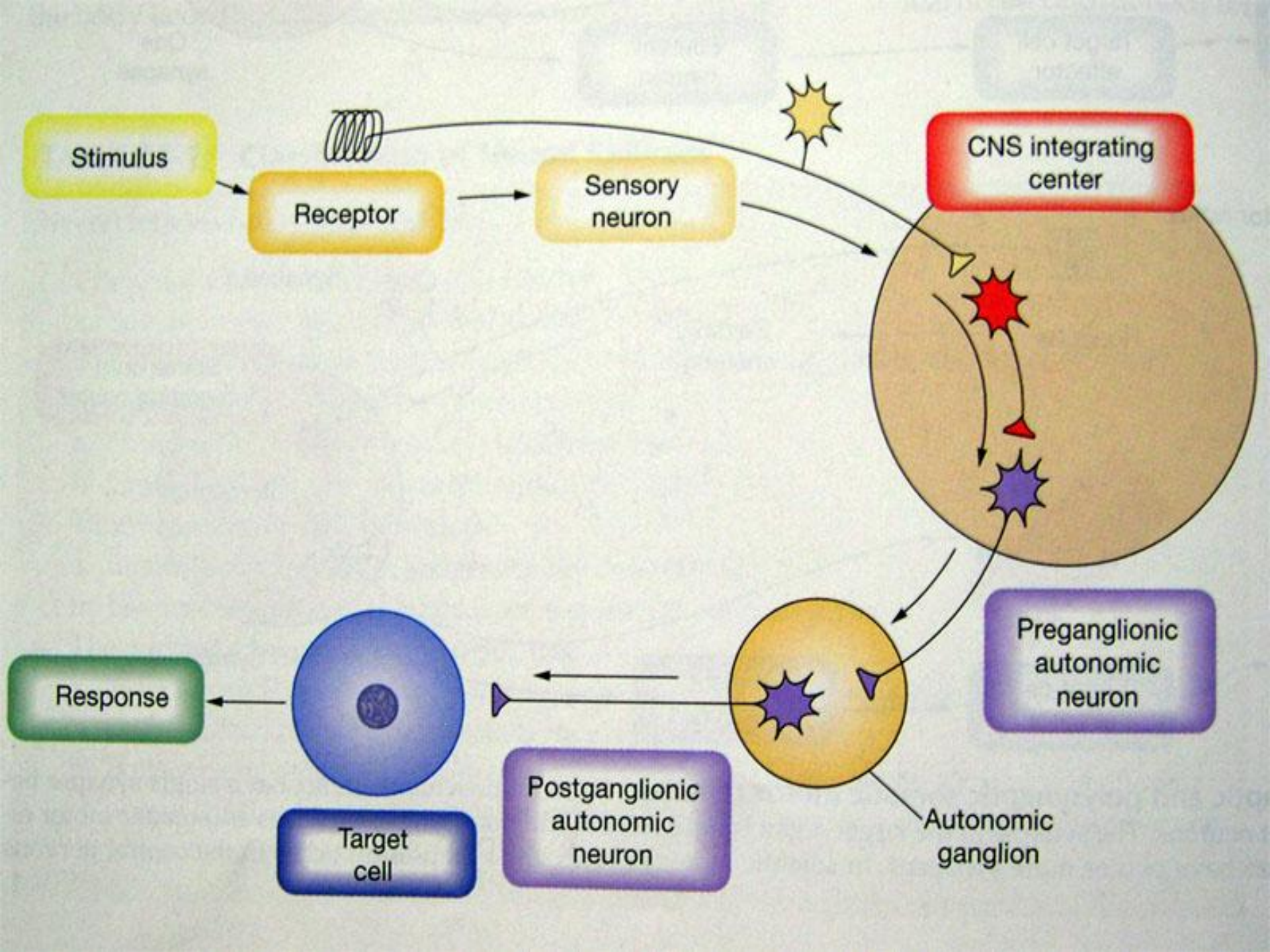
KEY

- Central nervous system
- Peripheral nervous system
  - Afferent division of PNS*
  - Efferent division of PNS
    - Somatic nervous system
    - Autonomic nervous system
- Enteric nervous system*


Central nervous system (spinal cord)
Peripheral nervous system
Axon terminals
Cell body
Afferent neuron
Central axon
Peripheral axon (afferent fiber)
Receptor
Interneuron
Efferent neuron*
Effector organ (muscle or gland)
Axon (efferent fiber)
Cell body
Axon terminals

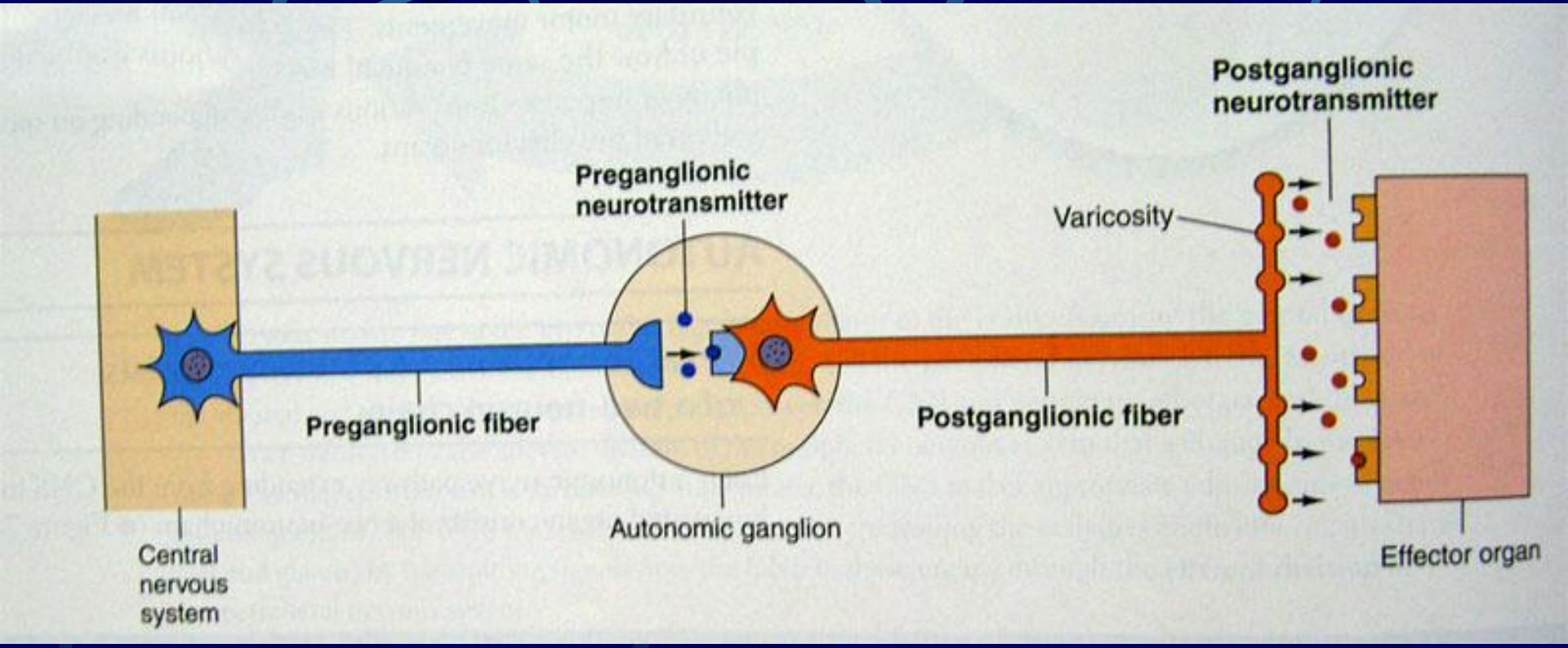
Sistem saraf otonom

- Sistem saraf vegetatif / involunter
- Fungsi :
  - Mempertahankan homeostasis
  - Mengkoordinasikan respons tubuh
  - Berperan dalam sistem reproduksi
- Bekerja berdasarkan refleks


Stimulus
Receptor
Sensory neuron
CNS integrating center
Preganglionic autonomic neuron
Autonomic ganglion
Postganglionic autonomic neuron
Target cell
Response

SSO

- Pusat SSO :
  - Hipotalamus
  - Batang otak
  - Medulla spinalis
- Serabut eferen terdiri dari 2 rantai :
  - Preganglion
  - Postganglion
- Mempunyai ganglion otonom

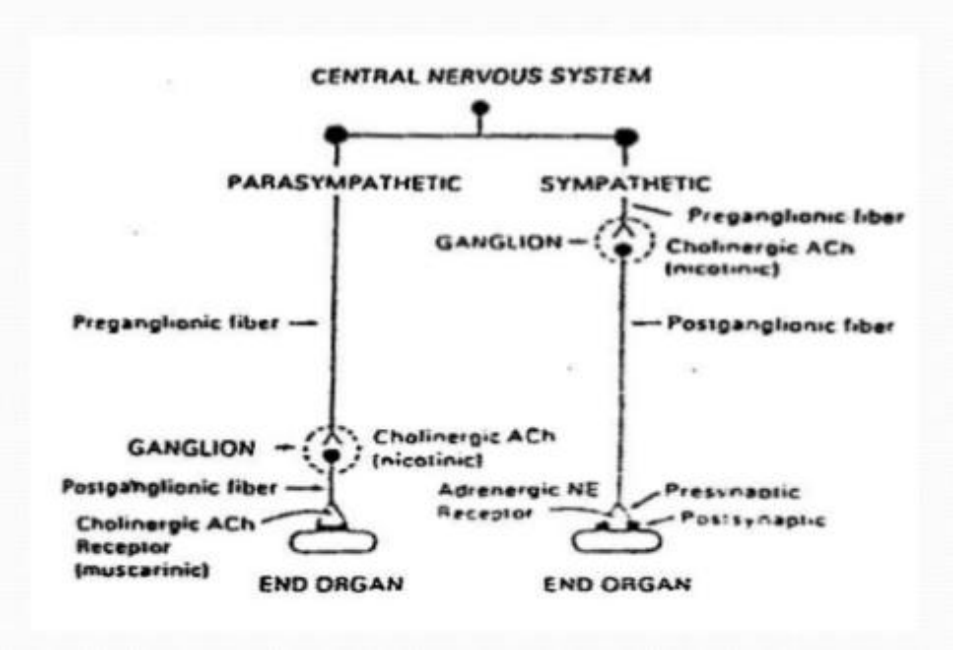

Postganglionic neurotransmitter
Preganglionic neurotransmitter
Varicosity
Preganglionic fiber
Postganglionic fiber
Autonomic ganglion
Central nervous system
Effector organ

SSO

- Eferen SSO :
  - Simpatis
  - Parasimpatis
- Neurotransmitter :
  - Asetilkolin
  - Norepinefrin

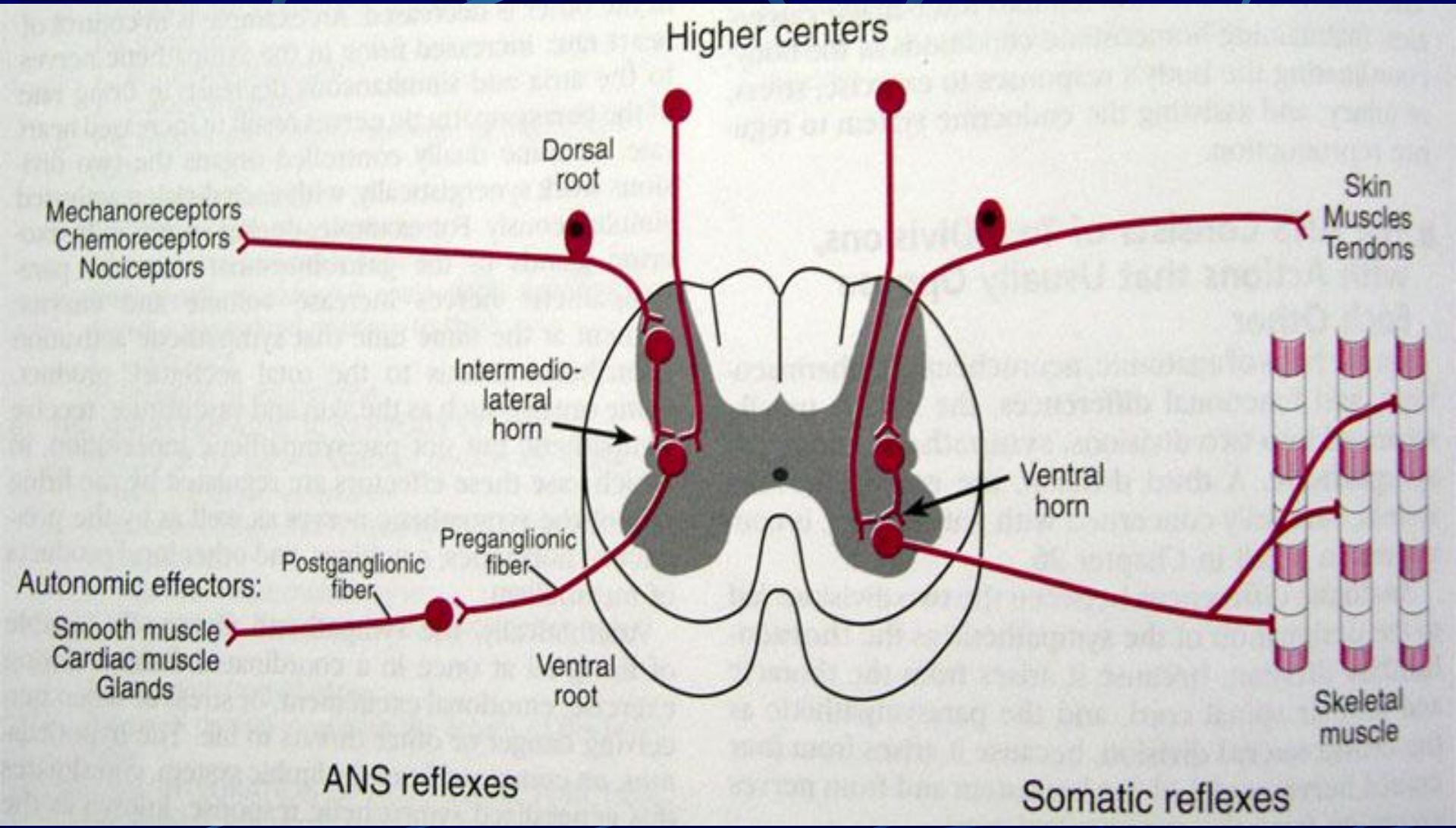
SSO

- Reseptor neurotransmitter :
  - Asetil kolin :
    - Nikotinik
    - Muskarinik
  - Norepinefrin :
    - Alfa : alfa1, alfa2
    - Beta : beta1, beta2



SSO

- Efektor SSO :
  - Otot polos
  - Otot jantung
  - Kelenjar


Higher centers
Dorsal root
Mechanoreceptors
Chemoreceptors
Nociceptors
Skin
Muscles
Tendons
Intermedio-lateral horn
Ventral horn
Preganglionic fiber
Postganglionic fiber
Autonomic effectors:
Smooth muscle
Cardiac muscle
Glands
Ventral root
Skeletal muscle
ANS reflexes
Somatic reflexes

▲ TABLE 7-6
Comparison of the Autonomic Nervous System and the Somatic Nervous System

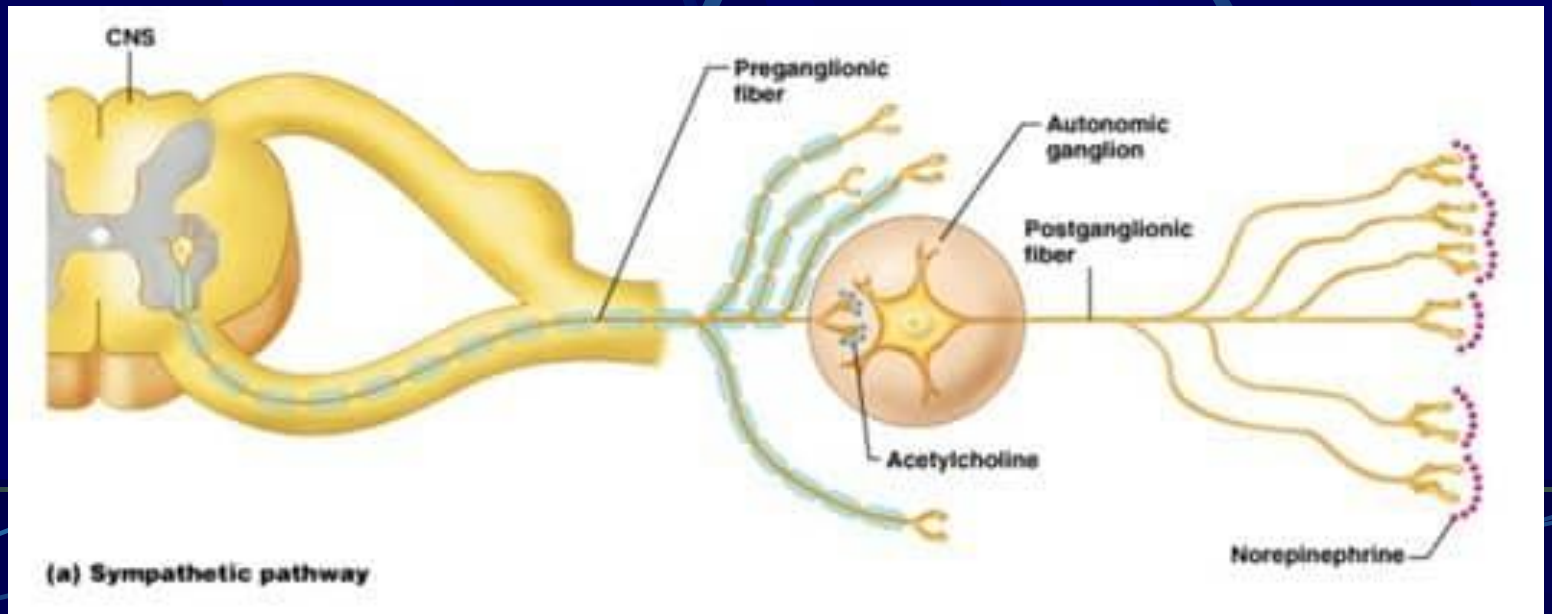
Feature	Autonomic Nervous System	Somatic Nervous System
Site of Origin	Brain or lateral horn of spinal cord	Ventral horn of spinal cord for most; those supplying muscles in head originate in brai
Number of Neurons from Origin in CNS to Effector Organ	Two-neuron chain (preganglionic and postganglionic)	Single neuron (motor neuron)
Organs Innervated	Cardiac muscle, smooth muscle, exocrine and some endocrine glands	Skeletal muscle
Type of Innervation	Most effector organs dually innervated by the two antagonistic branches of this system (sympathetic and parasympathetic)	Effector organs innervated only by motor neurons
Neurotransmitter at Effector Organs	May be acetylcholine (parasympathetic terminals) or norepinephrine (sympathetic terminals)	Only acetylcholine
Effects on Effector Organs	Either stimulation or inhibition (antagonistic actions of two branches)	Stimulation only (inhibition possible only centrally through IPSPs on cell body of motor neuron)
Types of Control	Under involuntary control; may be voluntarily controlled with biofeedback techniques and training	Subject to voluntary control; much activity subconsciously coordinated
Higher Centers Involved in Control	Spinal cord, medulla, hypothalamus, prefrontal association cortex	Spinal cord, motor cortex, basal nuclei, cerebellum, brain stem

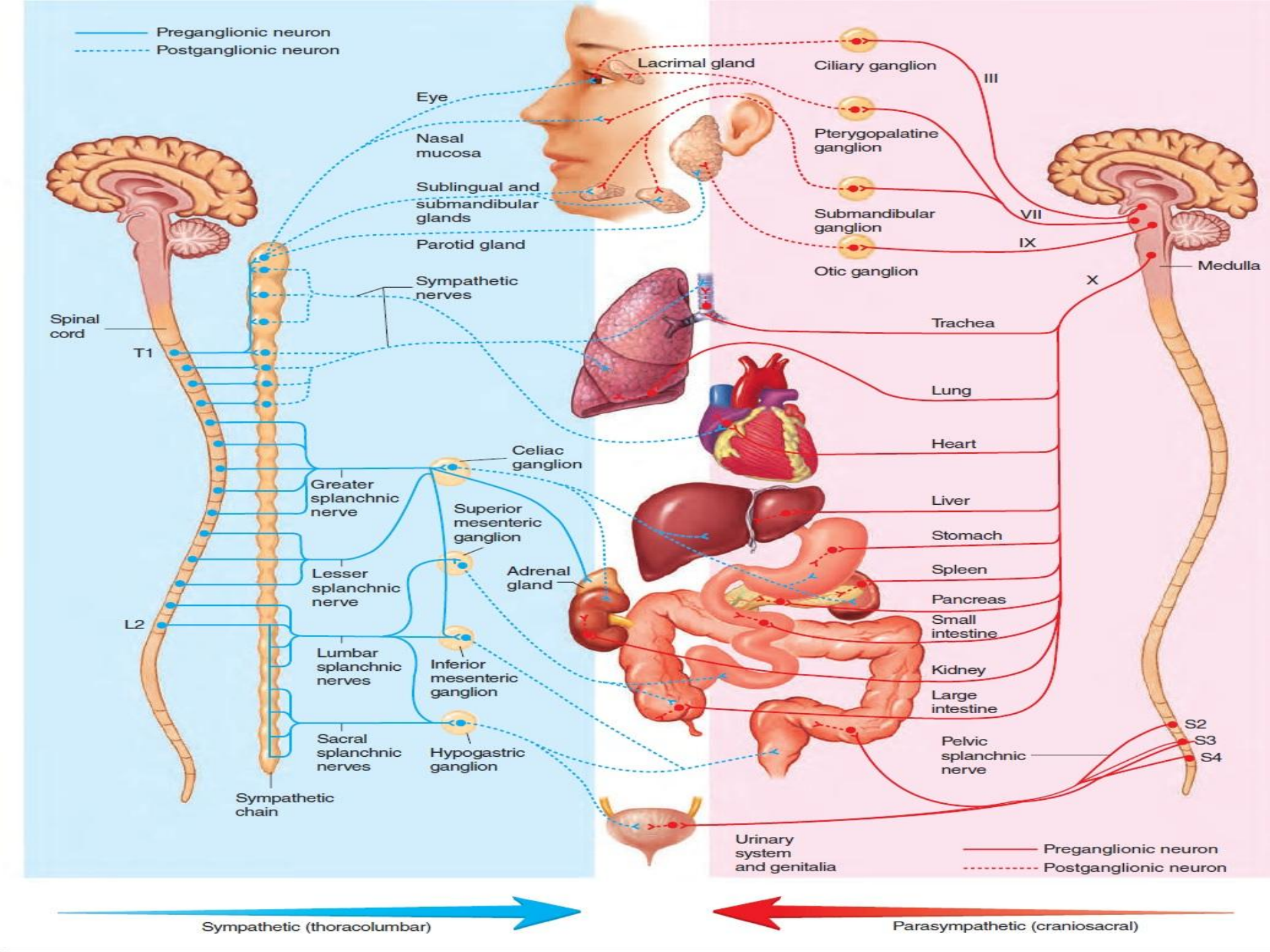
Sistem simpatis

- Berasal dari :
  - Thorakolumbal
    - T1 – T12
    - L1 – L3
- Preganglion berakhir pada :
  - Trunkus simpatikus
  - Ganglion kolateral
  - Medulla adrenal

Sistem simpatis

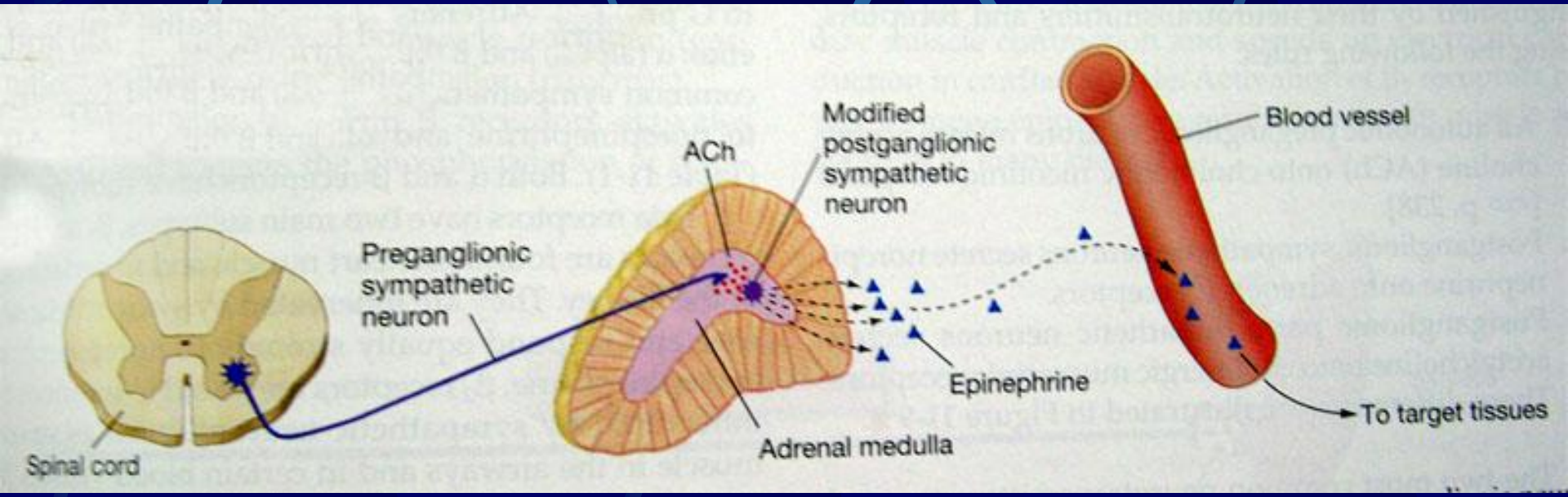
- Serabut preganglion :
  - Pendek
  - Kolinergik
- Serabut postganglion :
  - Adrenergik (sebagian besar)
  - Cholinergik (kel. keringat, M. pilloerector, Pembuluh darah kulit)

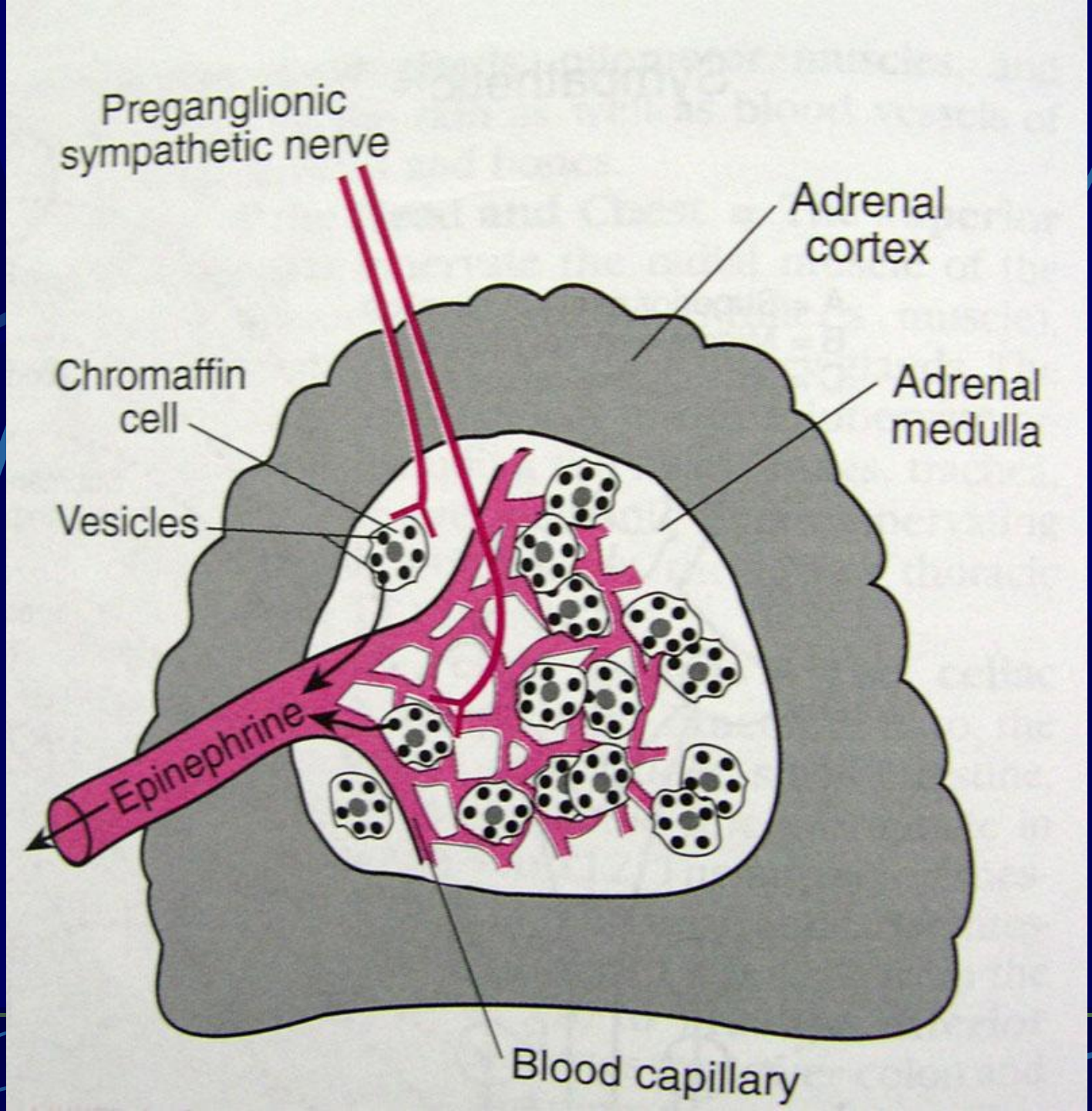



Preganglionic neuron
Postganglionic neuron
Lacrimal gland
Ciliary ganglion
III
Eye
Nasal mucosa
Pterygopalatine ganglion
Sublingual and submandibular glands
Submandibular ganglion
VII
IX
Parotid gland
Otic ganglion
Medulla
X
Sympathetic nerves
Spinal cord
T1
Trachea
Lung
Heart
Celiac ganglion
Greater splanchnic nerve
Liver
Superior mesenteric ganglion
Stomach
Adrenal gland
Lesser splanchnic nerve
Spleen
Pancreas
L2
Small intestine
Lumbar splanchnic nerves
Inferior mesenteric ganglion
Kidney
Large intestine
S2
S3
S4
Sacral splanchnic nerves
Hypogastric ganglion
Pelvic splanchnic nerve
Sympathetic chain
Urinary system and genitalia
Preganglionic neuron
Postganglionic neuron
Sympathetic (thoracolumbar)
Parasympathetic (craniosacral)

Medulla Adrenal

Medulla Adrenal



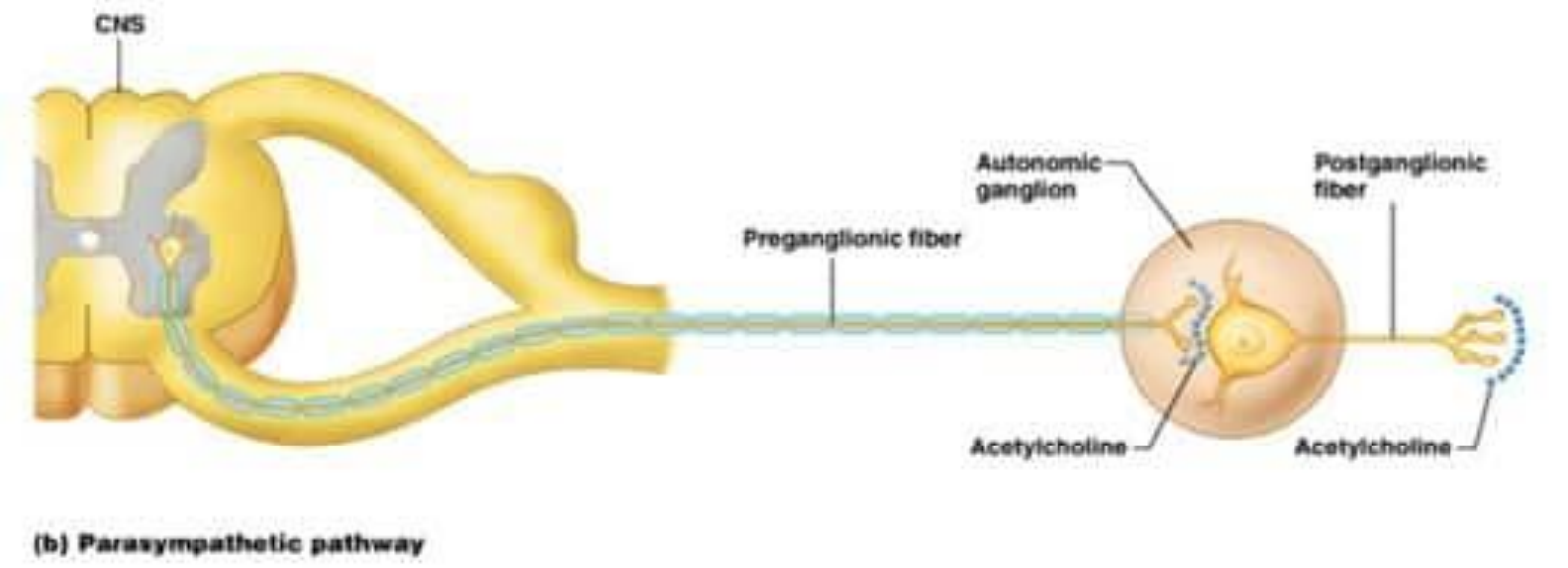

Preganglionic sympathetic nerve
Adrenal cortex
Chromaffin cell
Adrenal medulla
Vesicles
Epinephrine
Blood capillary

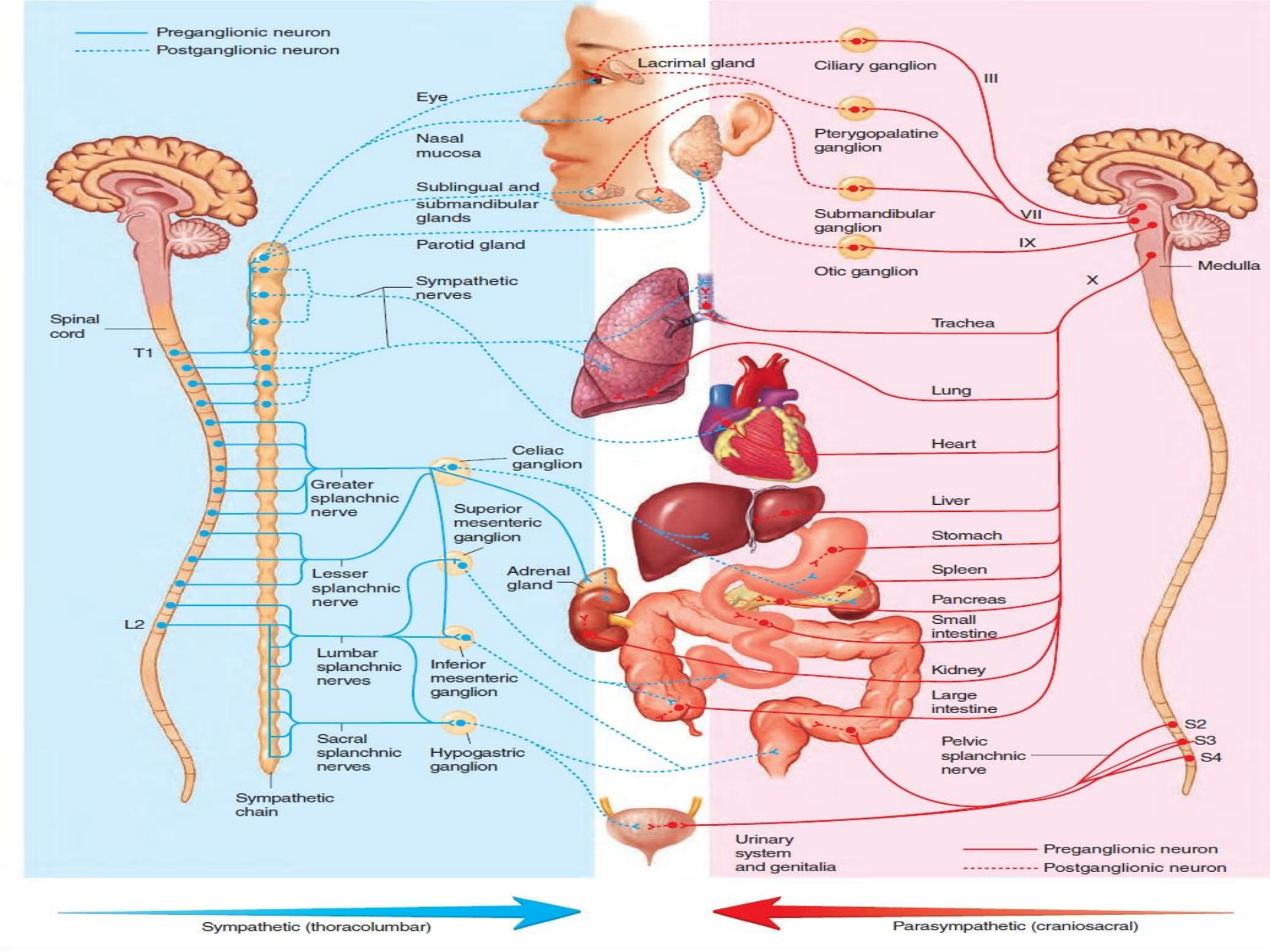
Sistem Parasimpatis

- Berasal dari :
  - Kraniosakral
    - N III, VII, IX, X
    - S2 – S4
- Serabut preganglion :
  - Panjang
  - Kolinergik

Sistem Parasimpatis

- Preganglion berakhir pada ganglion terminalis
- Serabut postganglionnya kolinergik

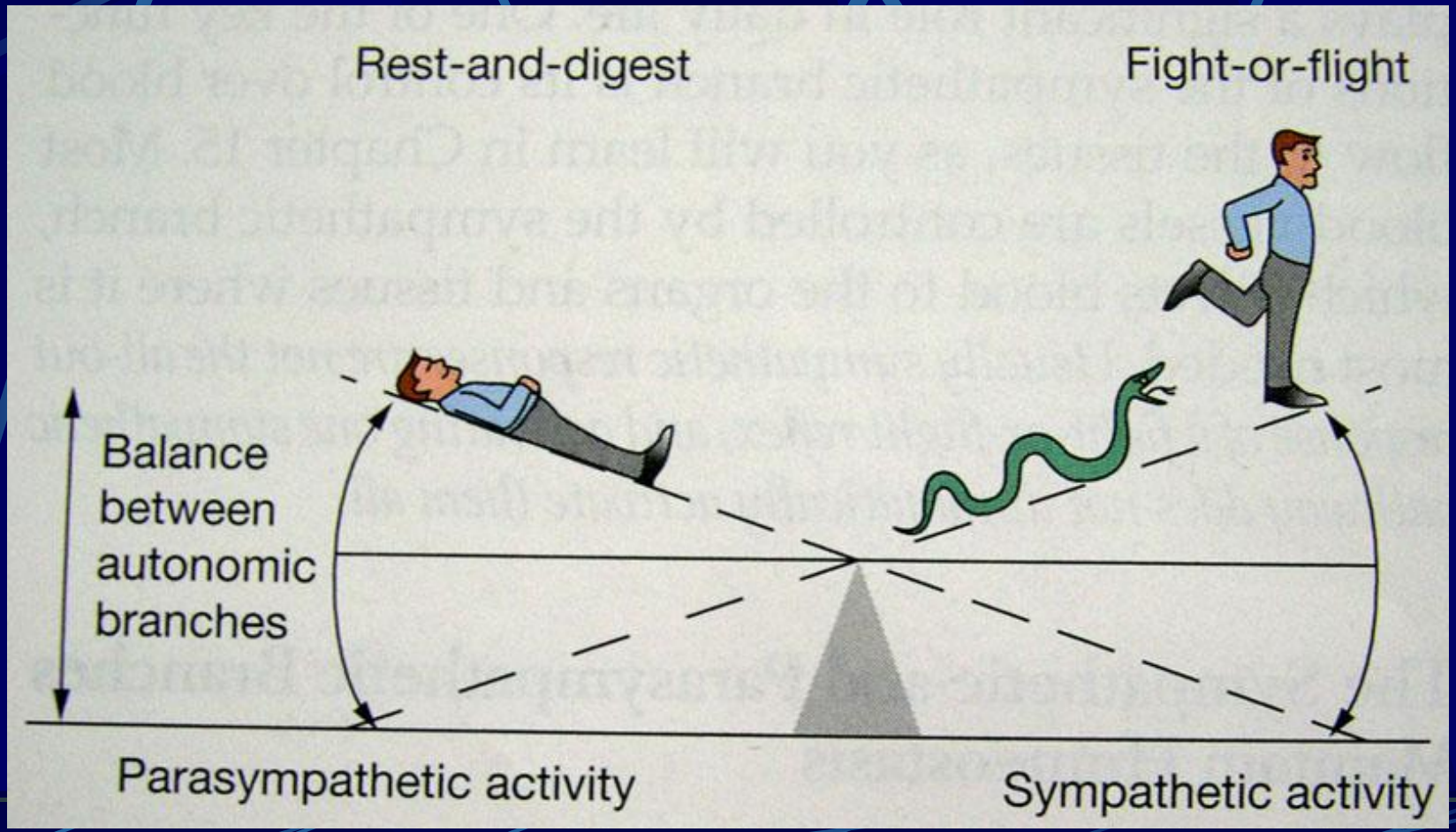


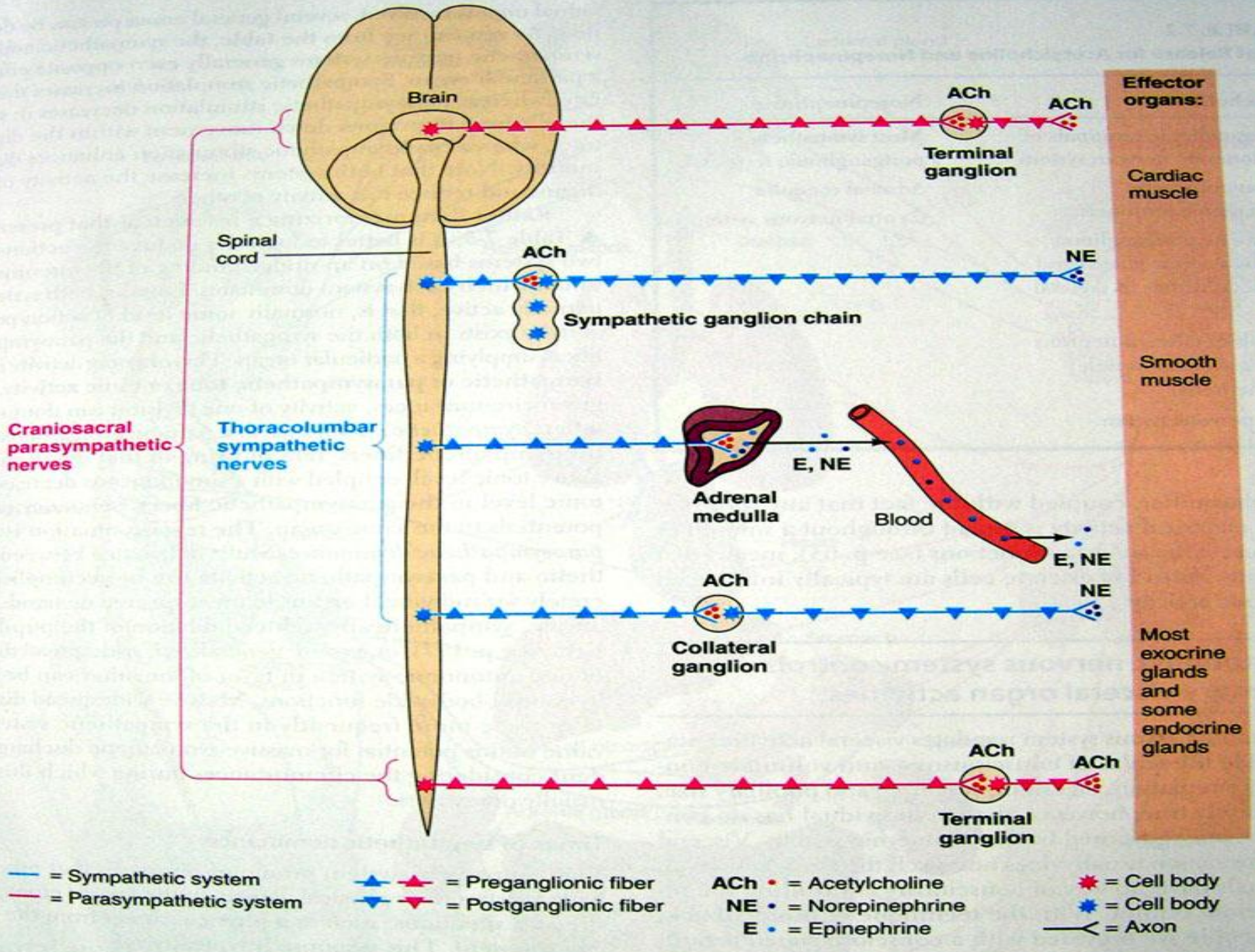

Preganglionic neuron
Postganglionic neuron
Lacrimal gland
Ciliary ganglion
III
Eye
Nasal mucosa
Pterygopalatine ganglion
Sublingual and submandibular glands
Submandibular ganglion
VII
IX
Parotid gland
Otic ganglion
Medulla
X
Sympathetic nerves
Spinal cord
T1
Trachea
Lung
Heart
Celiac ganglion
Greater splanchnic nerve
Liver
Superior mesenteric ganglion
Stomach
Adrenal gland
Lesser splanchnic nerve
Spleen
Pancreas
L2
Small intestine
Lumbar splanchnic nerves
Inferior mesenteric ganglion
Kidney
Large intestine
S2
S3
S4
Sacral splanchnic nerves
Hypogastric ganglion
Pelvic splanchnic nerve
Sympathetic chain
Urinary system and genitalia
Preganglionic neuron
Postganglionic neuron
Sympathetic (thoracolumbar)
Parasympathetic (craniosacral)

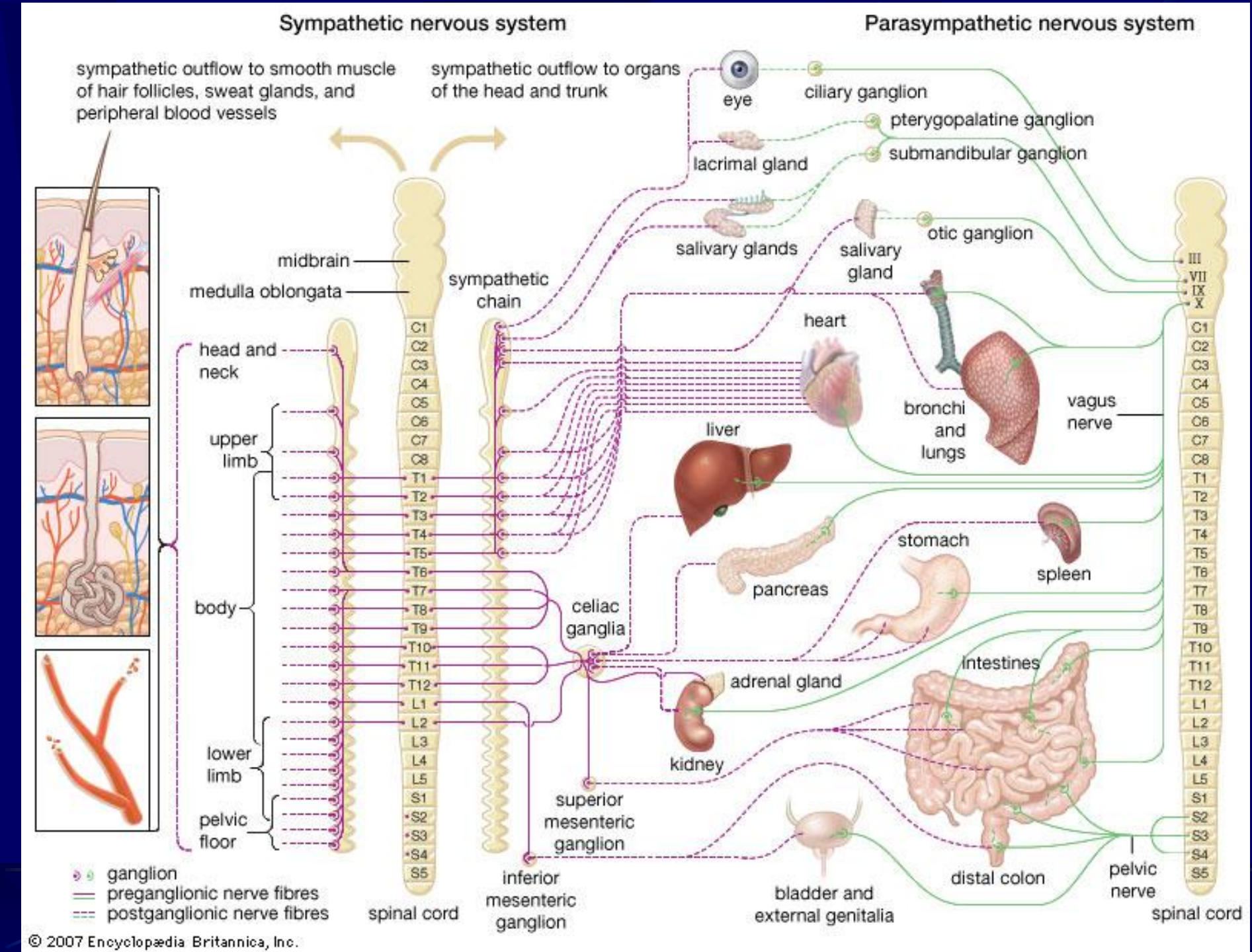
ORGAN	TYPE OF SYMPATHETIC RECEPTOR	EFFECT OF SYMPATHETIC STIMULATION	EFFECT OF PARASYMPATHETIC STIMULATION
Heart	β_1	Increased rate, increased force of contraction (of whole heart)	Decreased rate, decreased force of contraction (of atria only)
Blood vessels	α (most organs)	Constriction	Dilation of vessels supplying the penis and clitoris only
	β_2 (heart and skeletal-muscle vessels)	Dilation	
	*Cholinergic (skeletal-muscle vessels)	Dilation	
Lungs	β_2 (airways)	Dilation of bronchioles (airways)	Constriction of bronchioles
	? (gland cells)	Inhibition (?) of mucus secretion	Stimulation of mucus secretion
Digestive tract	α, β_2 (organs)	Decreased motility (movement)	Increased motility
	α (sphincters)	Contraction of sphincters (to prevent forward movement of contents)	Relaxation of sphincters (to permit forward movement of contents)
	? (gland cells)	Inhibition (?) of digestive secretions	Stimulation of digestive secretions
Gallbladder	?	Relaxation	Contraction (emptying)
Urinary bladder	β_2	Relaxation	Contraction (emptying)
Eye	α (iris)	Dilation of pupil	Constriction of pupil
	β_2 (ciliary muscle)	Adjustment of eye for far vision	Adjustment of eye for near vision
Liver (glycogen stores)	β_2	Glycogenolysis (glucose released)	None
Adipose cells (fat stores)	β_2	Lipolysis (fatty acids released)	None

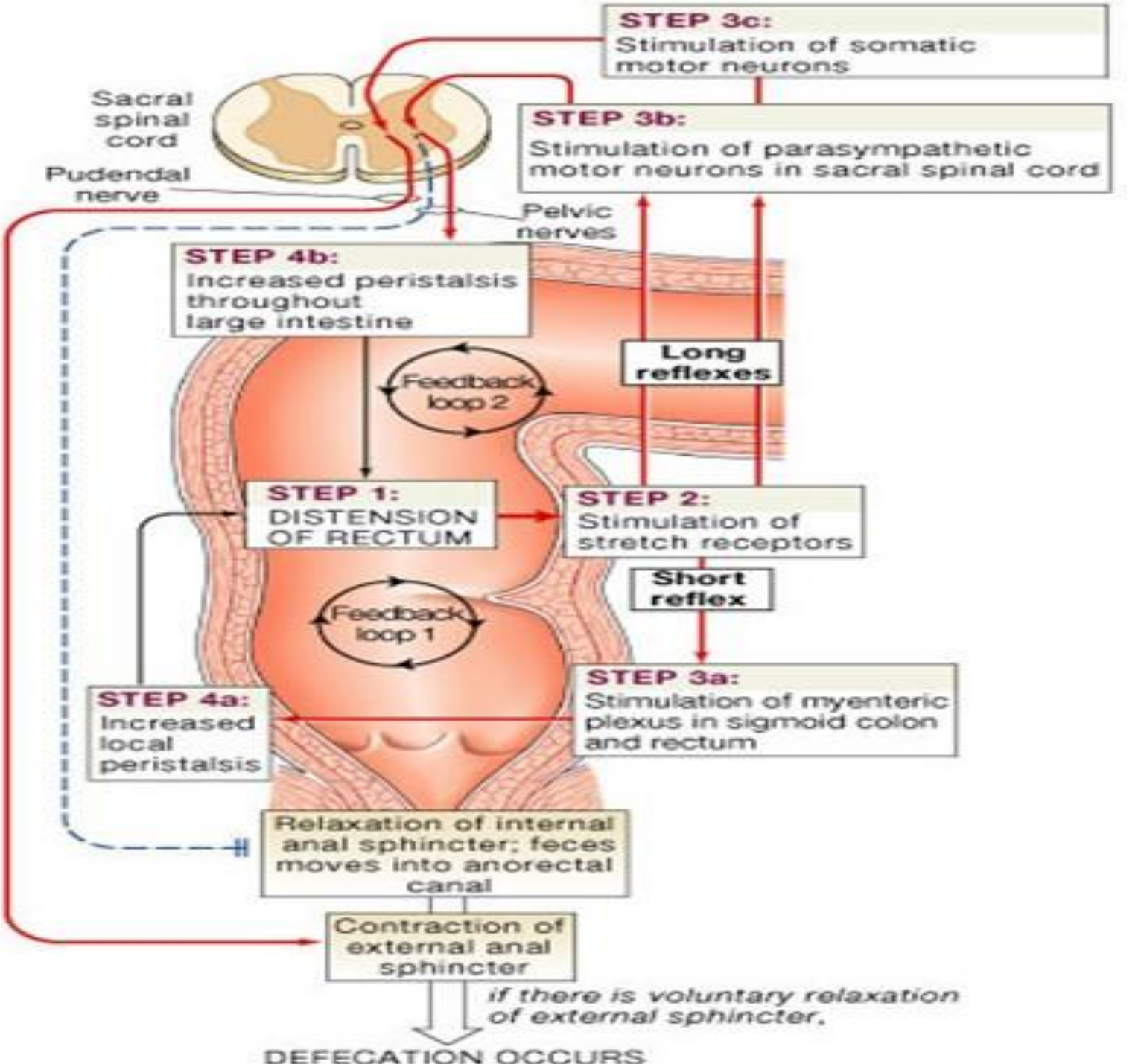
ORGAN	TYPE OF SYMPATHETIC RECEPTOR	EFFECT OF SYMPATHETIC STIMULATION	EFFECT OF PARASYMPATHETIC STIMULATION
Exocrine glands			
Exocrine pancreas	α	Inhibition of pancreatic exocrine secretion	Stimulation of pancreatic exocrine secretion (important for digestion)
Sweat glands	α, cholinergic	Stimulation of secretion by sweat glands	None
Salivary glands	α	Stimulation of small volume of thick saliva rich in mucus	Stimulation of large volume of watery saliva rich in enzymes
Endocrine glands			
Adrenal medulla	Cholinergic	Stimulation of epinephrine and norepinephrine secretion	None
Endocrine pancreas	α	Inhibition of insulin secretion; stimulation of glucagon secretion	Stimulation of insulin and glucagon secretion
Genitals	α	Ejaculation and orgasmic contractions (males); orgasmic contractions (females)	Erection (caused by dilation of blood vessels in penis [male] and clitoris [female])
Brain activity	?	Increased alertness	None

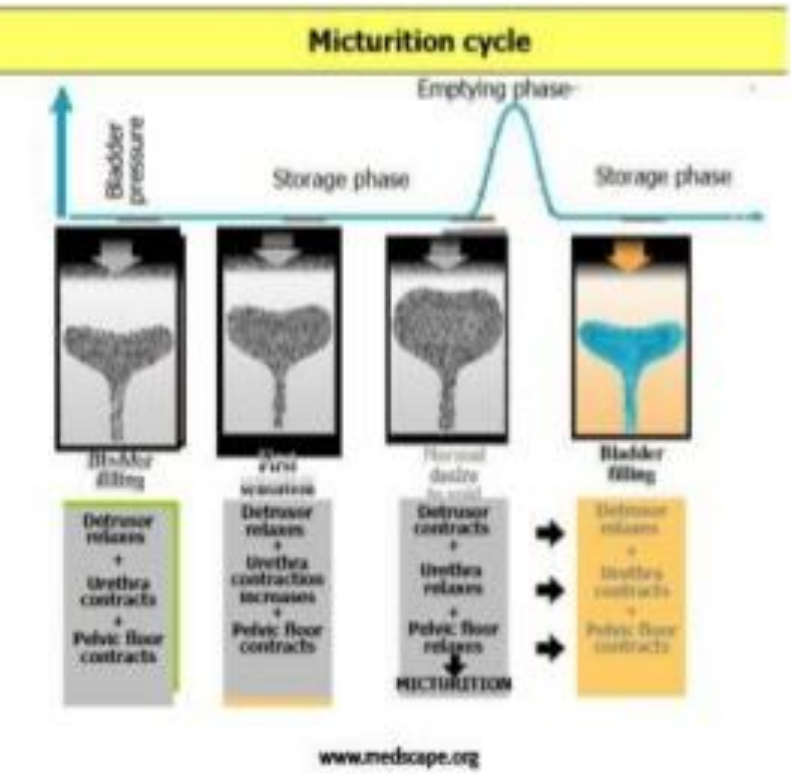
GAMBAR KESEIMBANGAN SSO




Brain
Spinal cord
Craniosacral parasympathetic nerves
Thoracolumbar sympathetic nerves
ACh
ACh
Terminal ganglion
ACh
NE
Sympathetic ganglion chain
Adrenal medulla
E, NE
Blood
E, NE
ACh
NE
Collateral ganglion
ACh
ACh
Terminal ganglion
Effector organs:
Cardiac muscle
Smooth muscle
Most exocrine glands and some endocrine glands
= Sympathetic system
= Parasympathetic system
= Preganglionic fiber
= Postganglionic fiber
ACh = Acetylcholine
NE = Norepinephrine
E = Epinephrine
= Cell body
= Cell body
= Axon




STEP 3c:
Stimulation of somatic motor neurons
Sacral spinal cord
STEP 3b:
Stimulation of parasympathetic motor neurons in sacral spinal cord
Pudendal nerve
Pelvic nerves
STEP 4b:
Increased peristalsis throughout large intestine
Long reflexes
Feedback loop 2
STEP 1:
DISTENSION OF RECTUM
STEP 2:
Stimulation of stretch receptors
Short reflex
Feedback loop 1
STEP 3a:
Stimulation of myenteric plexus in sigmoid colon and rectum
STEP 4a:
Increased local peristalsis
Relaxation of internal anal sphincter; feces moves into anorectal canal
Contraction of external anal sphincter
if there is voluntary relaxation of external sphincter,
DEFECATION OCCURS


Micturition cycle
Emptying phase
Bladder pressure
Storage phase
Storage phase
Bladder filling
Detrusor relaxes + Urethra contracts + Pelvic floor contracts
Detrusor relaxes + Urethra contraction increases + Pelvic floor contracts
Detrusor contracts + Urethra relaxes + Pelvic floor relaxes
MICTURITION
Bladder filling
www.medscape.org

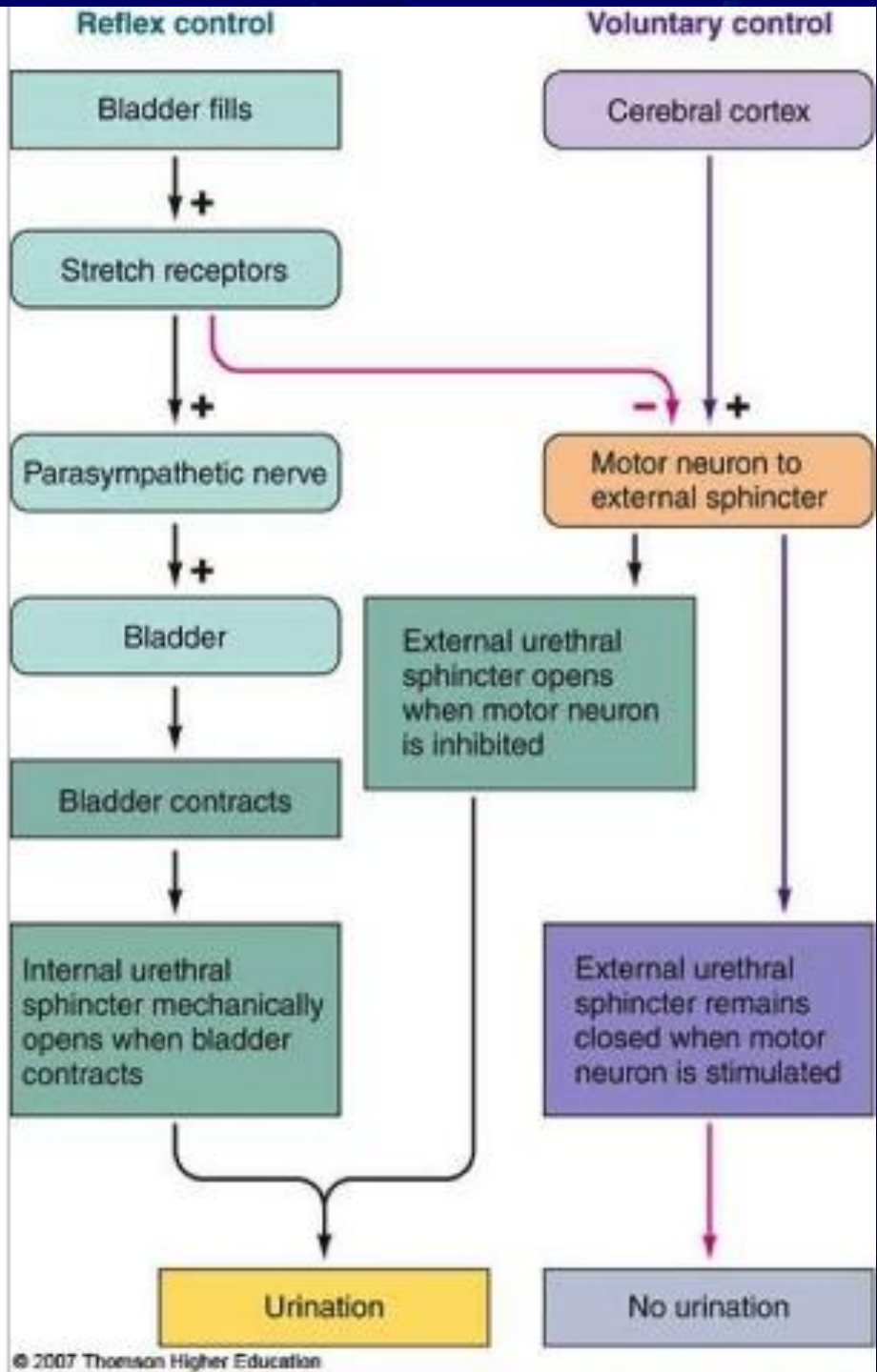

Reflex control
Voluntary control
Bladder fills
Cerebral cortex
Stretch receptors
Parasympathetic nerve
Motor neuron to external sphincter
Bladder
External urethral sphincter opens when motor neuron is inhibited
Bladder contracts
Internal urethral sphincter mechanically opens when bladder contracts
External urethral sphincter remains closed when motor neuron is stimulated
Urination
No urination
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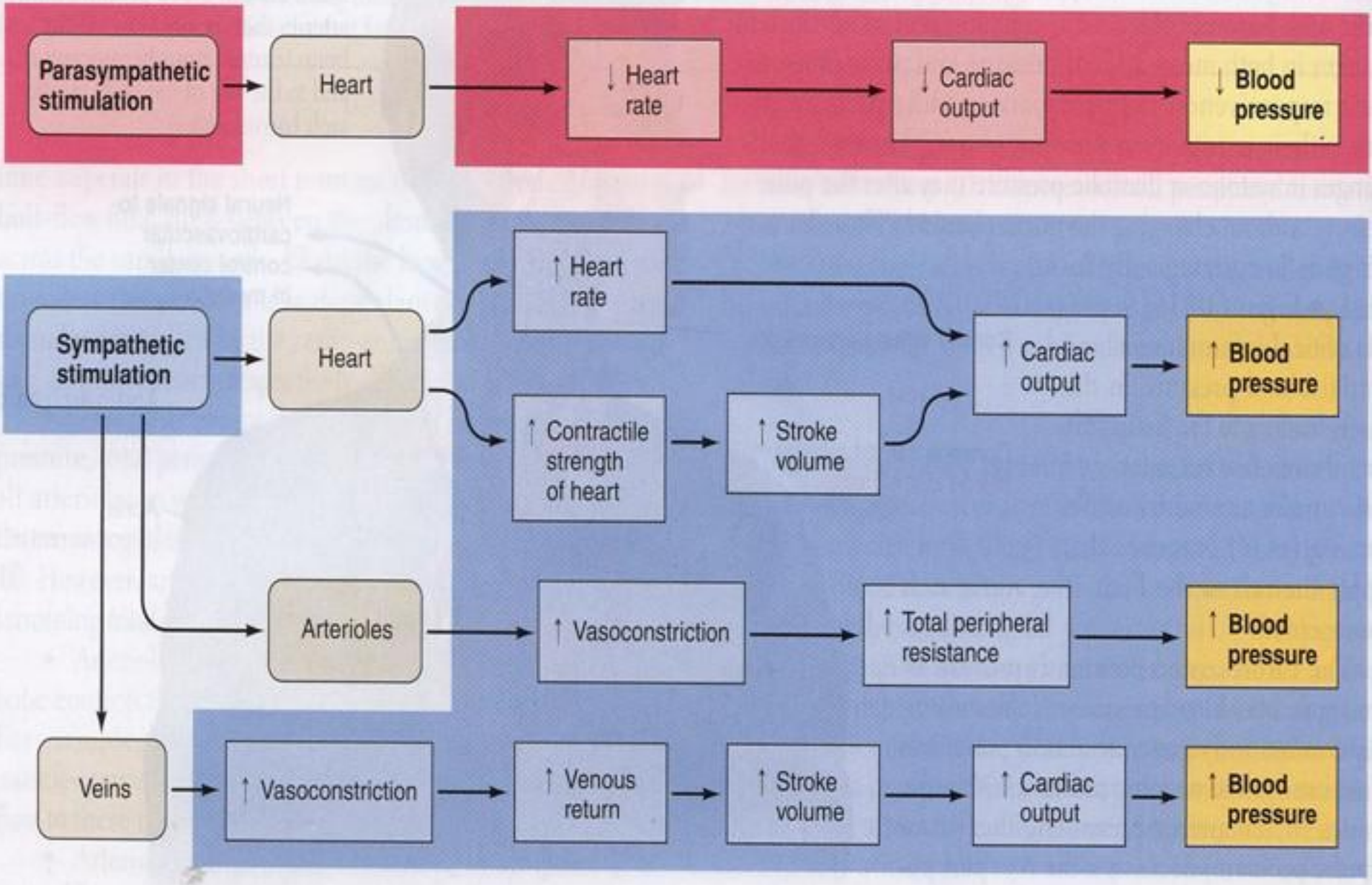
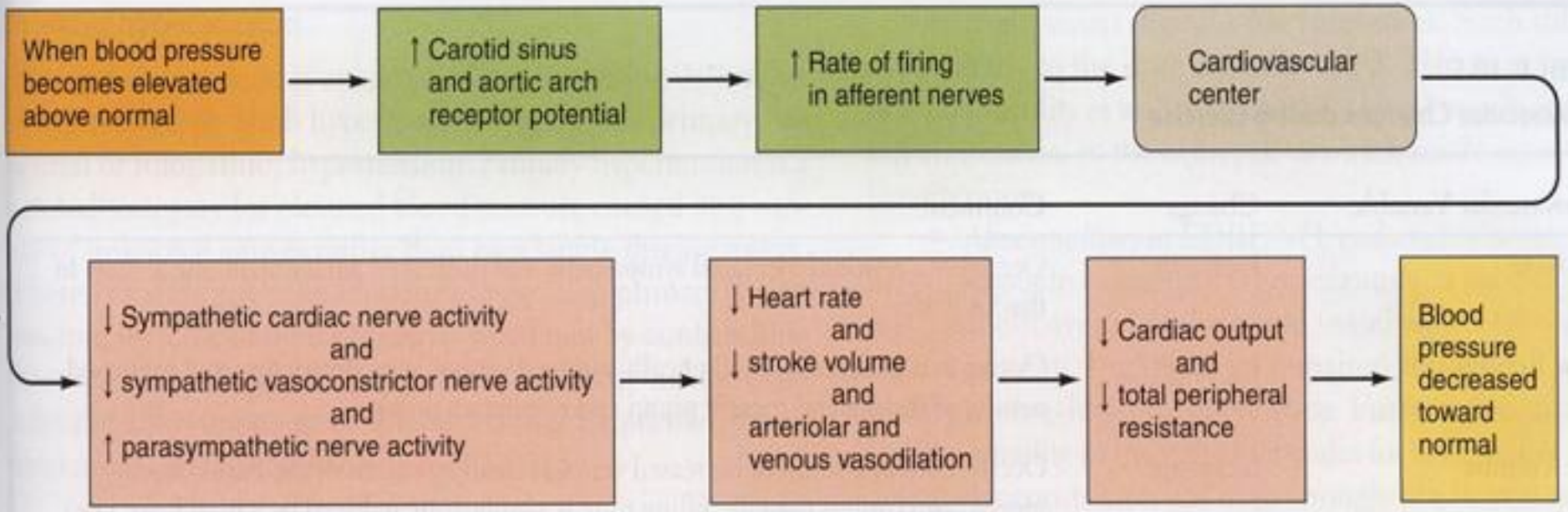
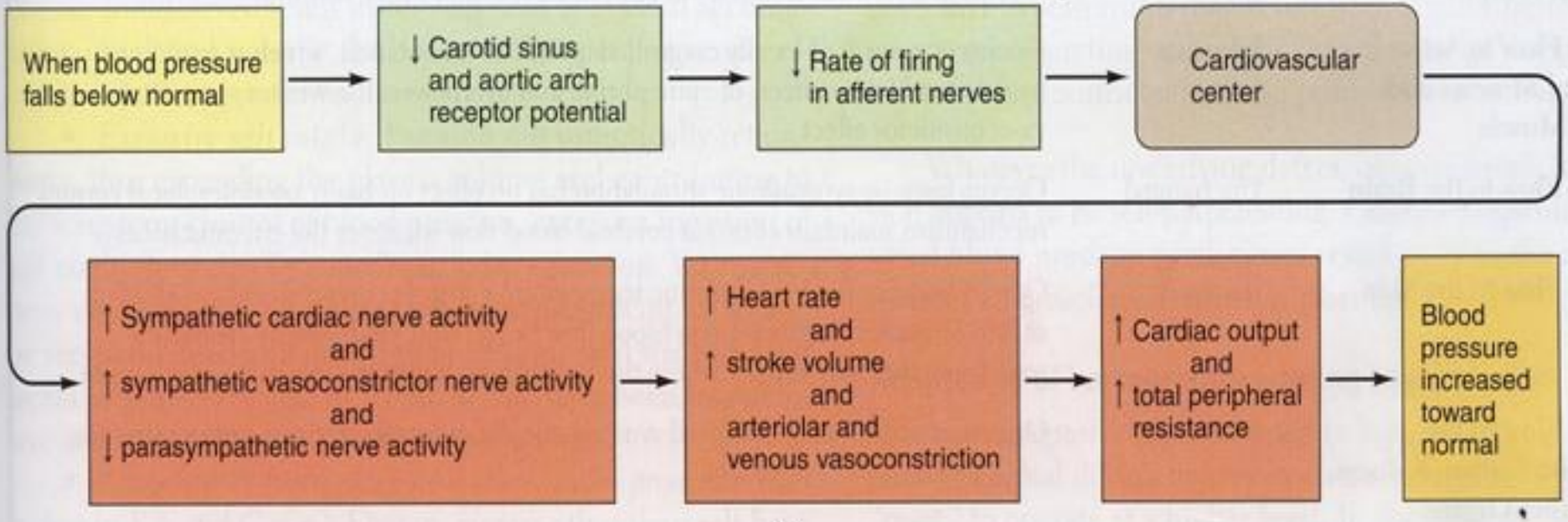
FIGURE 10-38

Summary of the effects of the parasympathetic and sympathetic nervous systems on factors that influence mean arterial blood pressure




When blood pressure becomes elevated above normal
↑ Carotid sinus and aortic arch receptor potential
↑ Rate of firing in afferent nerves
Cardiovascular center
↓ Sympathetic cardiac nerve activity and ↓ sympathetic vasoconstrictor nerve activity and ↑ parasympathetic nerve activity
↓ Heart rate and ↓ stroke volume and arteriolar and venous vasodilation
↓ Cardiac output and ↓ total peripheral resistance
Blood pressure decreased toward normal

(a)


When blood pressure falls below normal
↓ Carotid sinus and aortic arch receptor potential
↓ Rate of firing in afferent nerves
Cardiovascular center
↑ Sympathetic cardiac nerve activity and ↑ sympathetic vasoconstrictor nerve activity and ↓ parasympathetic nerve activity
↑ Heart rate and ↑ stroke volume and arteriolar and venous vasoconstriction
↑ Cardiac output and ↑ total peripheral resistance
Blood pressure increased toward normal

(b)

THANK YOU

Physiology Department
Medical Faculty of Trisakti University
Jakarta