

M A S A R Y K O V A
U N I V E R Z I T A

M U N I
M E D

Autonomic nervous system

TAKE HOME MESSAGES

ANS vs. somatic NS

Comparison of Somatic Motor and Autonomic Divisions		
	SOMATIC MOTOR	AUTONOMIC
Number of neurons in efferent path	1	2
Neurotransmitter/receptor at neuron-target synapse	ACh/nicotinic	ACh/muscarinic or NE/ α - or β -adrenergic
Target tissue	Skeletal muscle	Smooth and cardiac muscle; some endocrine and exocrine glands; some adipose tissue
Neurotransmitter released from	Axon terminals	Varicosities and axon terminals
Effects on target tissue	Excitatory only: muscle contracts	Excitatory or inhibitory
Peripheral components found outside the CNS	Axons only	Preganglionic axons, ganglia, postganglionic neurons
Summary of function	Posture and movement	Visceral function, including movement in internal organs and secretion; control of metabolism

Autonomic nervous system

AUTONOMIC PATHWAYS

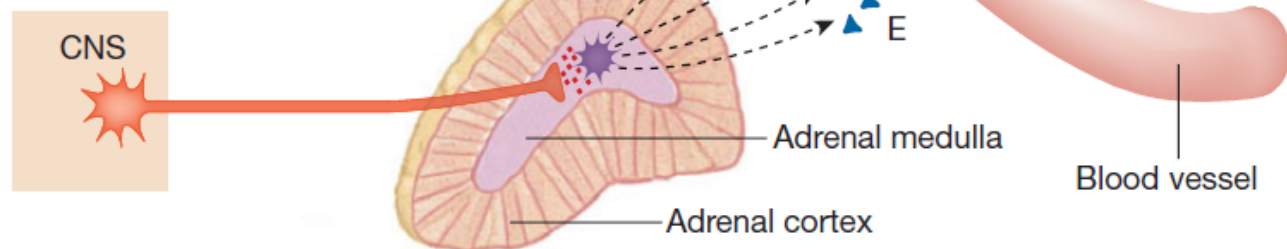
(a) Parasympathetic Pathway



(b) Sympathetic Pathway



(c) Adrenal Sympathetic Pathway



Autonomic nervous system

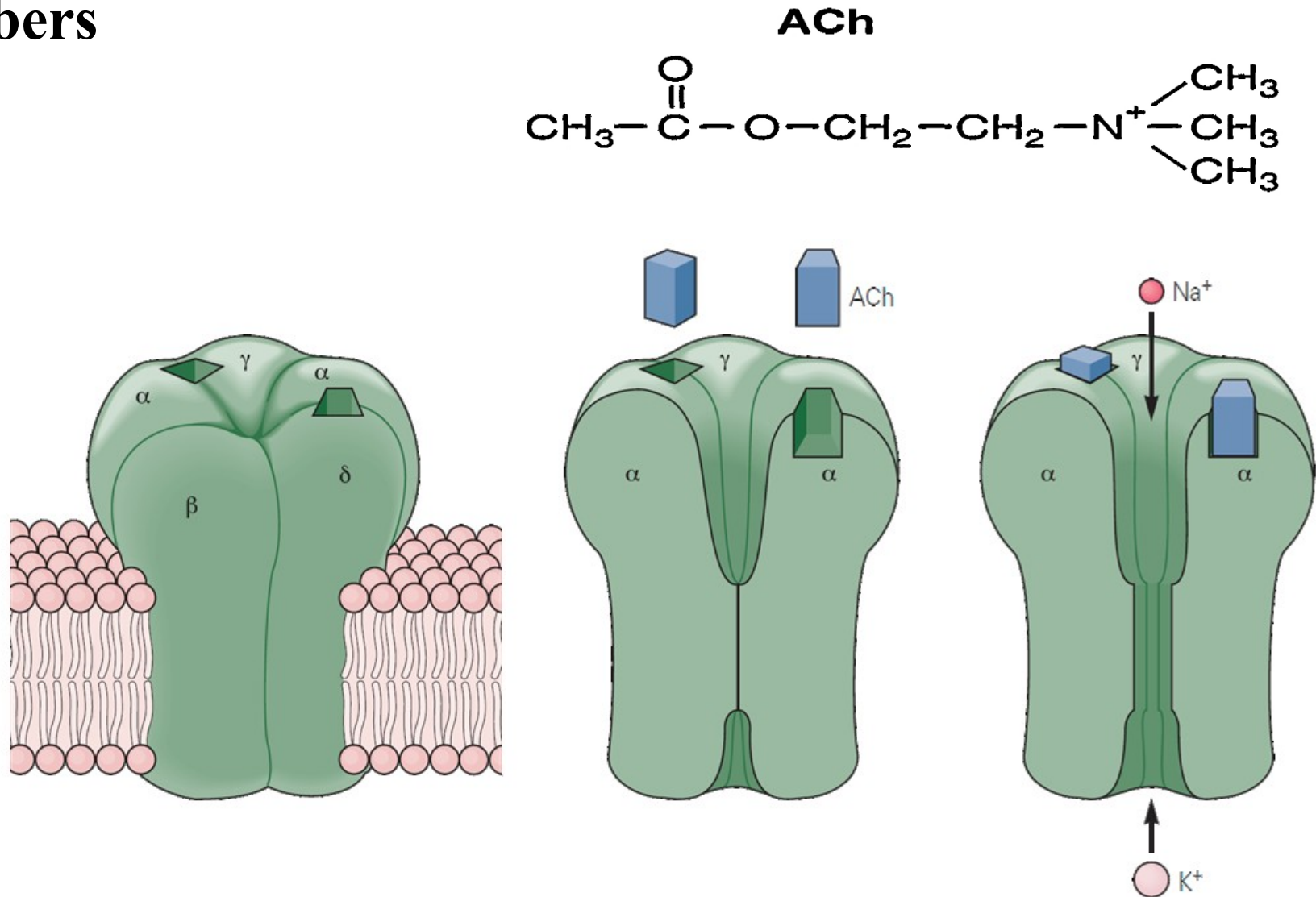
Preganglionic fibers

SNS, PNS

Nicotinic recep

N_N type and N_M type

Excitatory receptors



Autonomic nervous system

Postganglionic fibers

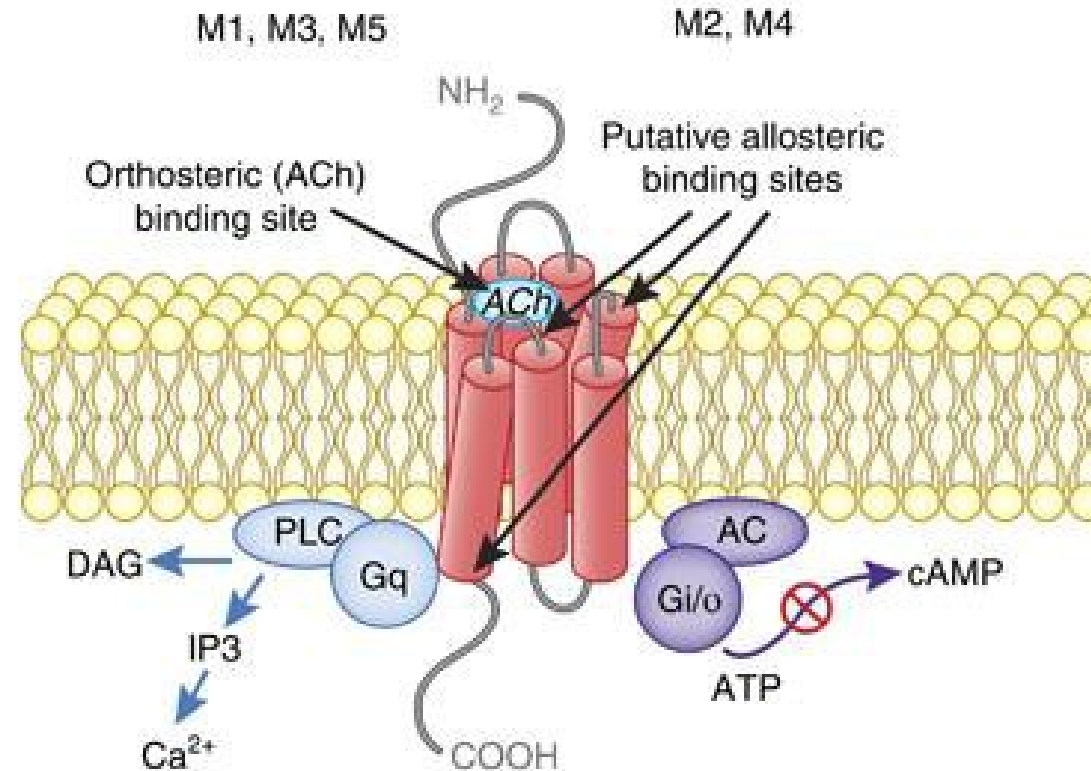
- PNS

- *Muscarinic receptor*

 - G-protein coupled

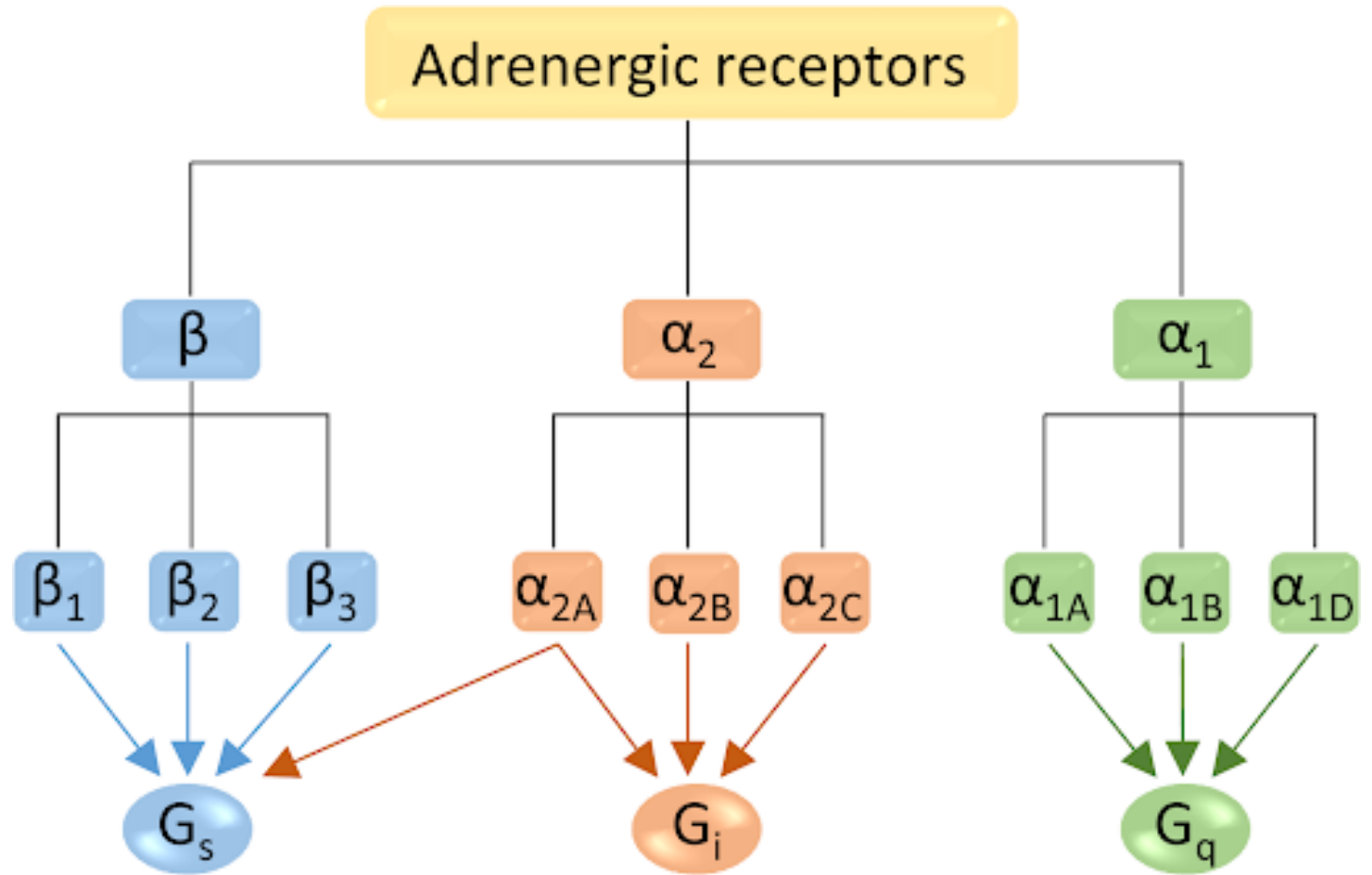
 - Excitatory receptors (M_1 , M_3 , M_5)

 - Inhibitory receptors (M_2 , M_4)

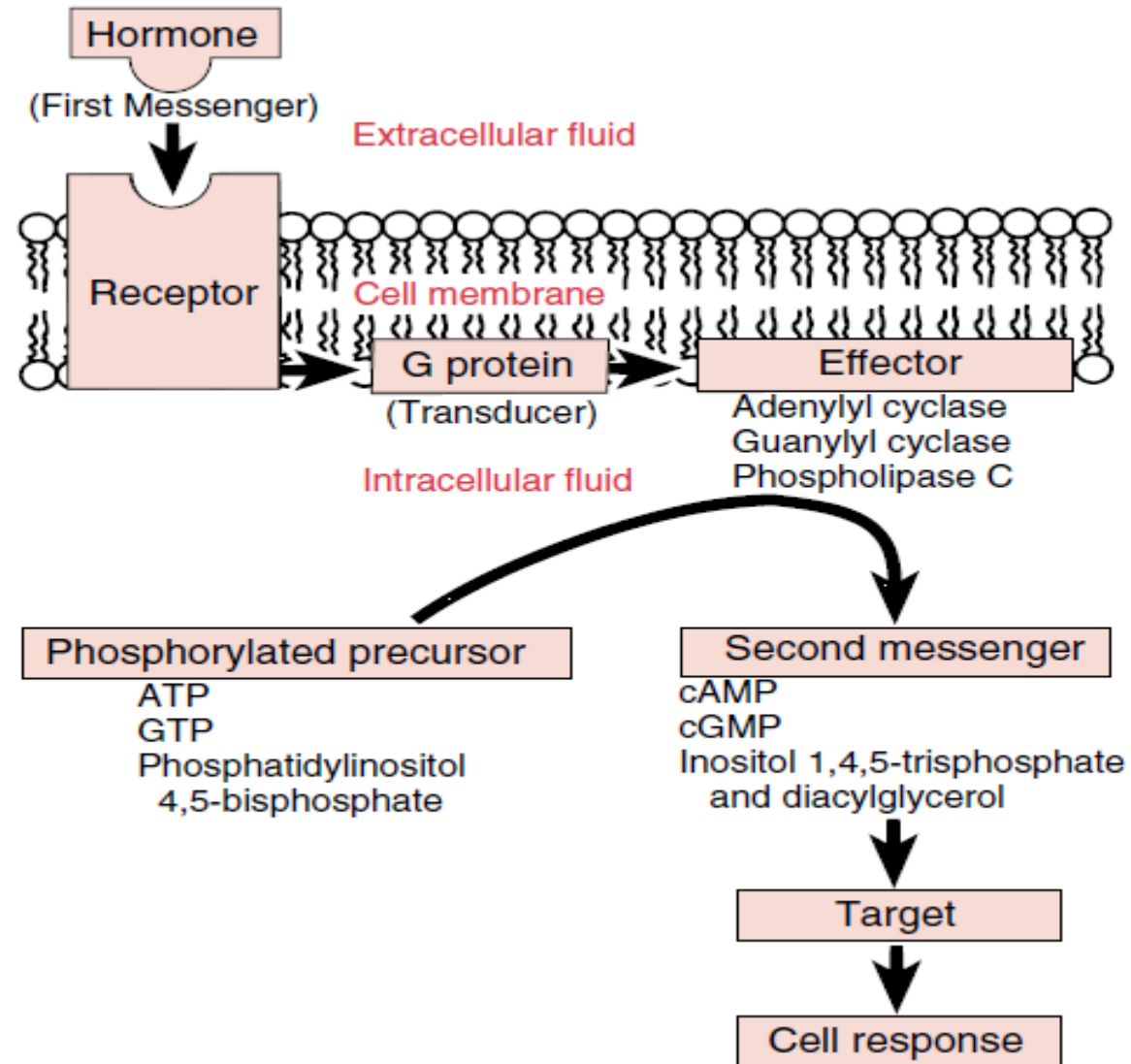


Autonomic nervous system

- Postganglionic fibers
- SNS
- *Adrenergic receptor*
 - G-protein coupled



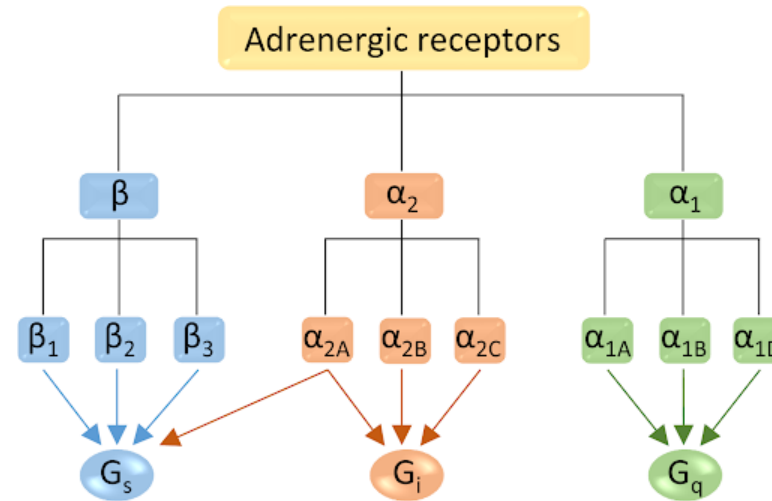
Second messenger systems



Autonomic nervous system

Adrenergic receptor

- G-protein coupled
- Type α – Excitatory receptors
- Type β – Inhibitory receptors



Receptor Type	Primary Mechanism of Action	Examples of Tissue Distribution	Examples of Action
α_1	\uparrow IP3 and Ca^{++} , DAG	Sympathetic postsynaptic nerve terminals	Increase vascular smooth muscle contraction
α_2	\downarrow cAMP	Sympathetic presynaptic nerve terminals, beta cell of pancreatic islets	Inhibit norepinephrine release, inhibit insulin release
β_1	\uparrow cAMP	Heart	Increase cardiac output
β_2	\uparrow cAMP	Liver; smooth muscle of vasculature, bronchioles, and uterus	Increase hepatic glucose output; decrease contraction of blood vessels, bronchioles, and uterus
β_3	\uparrow cAMP	Liver, adipose tissue	Increase hepatic glucose output, increase lipolysis

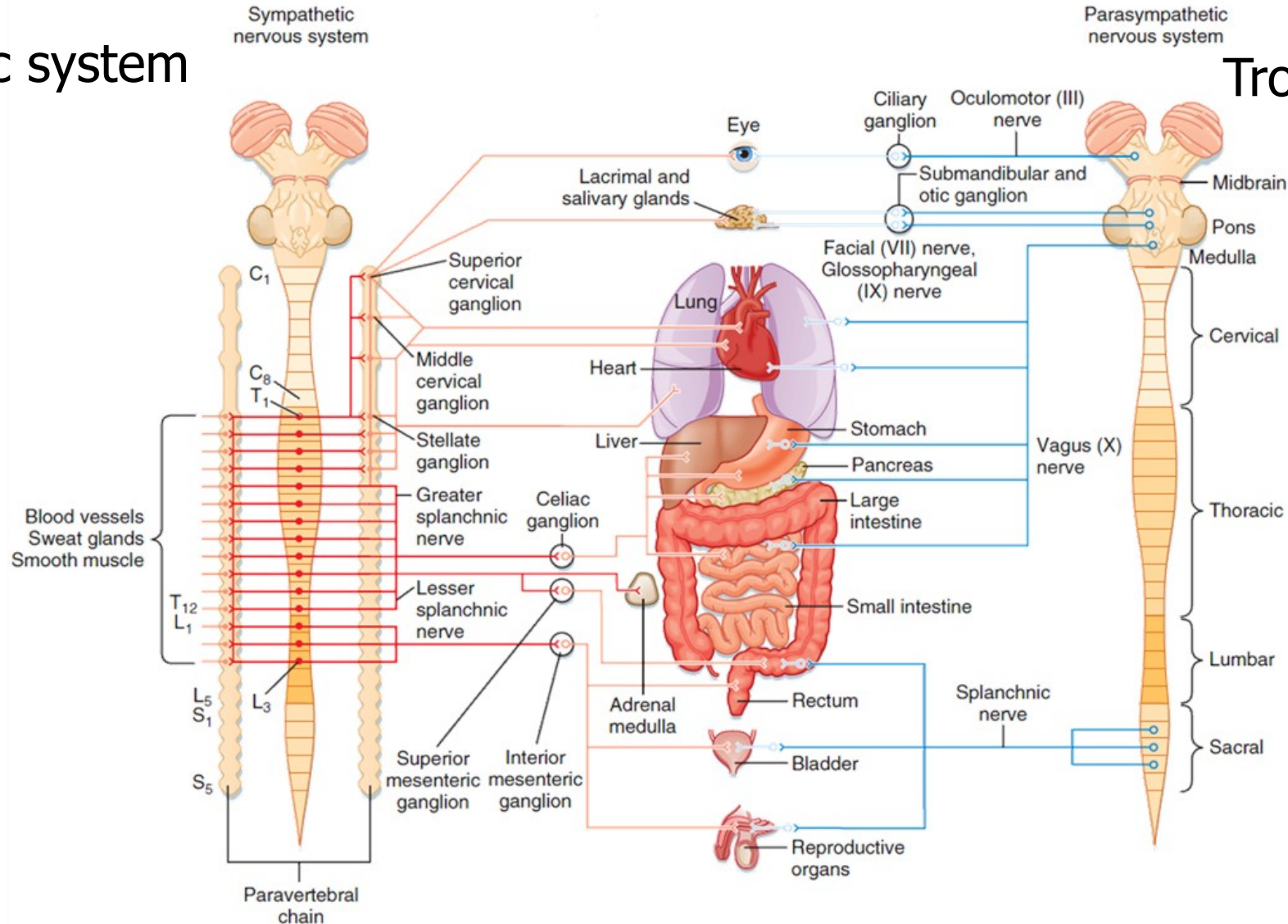
Autonomic nervous system

Ergotropic system

Trophotropic system

FIGHT OR FLIGHT

REST OR DIGEST



ANS innervates

- The secretory glands (salivary, sweat, tear, and various mucus-producing glands; smooth muscles, cardiac muscles)
- The heart and blood vessels to control blood pressure and flow
- The bronchi of the lungs to meet the oxygen demands of the body
- **ANS regulates:**
- The digestive and metabolic functions of the liver, GIT, pancreas
- The functions of the kidney, urinary bladder, large intestine, rectum
- ANS is essential to the sexual responses of the genitals and reproductive organs
- Interacts with the body's immune system

- Mnemonic used:
- The sympathetic division tends to Fs: fight, flight, fright, and sex
- The parasympathetic division facilitates various non-fourF processes – as digestion, growth, immune response, energy storage
- In most cases the activity levels of the 2 ANS divisions are reciprocal- when one is high, the other tends to be low, and vice versa.

Sympathetic nervous system

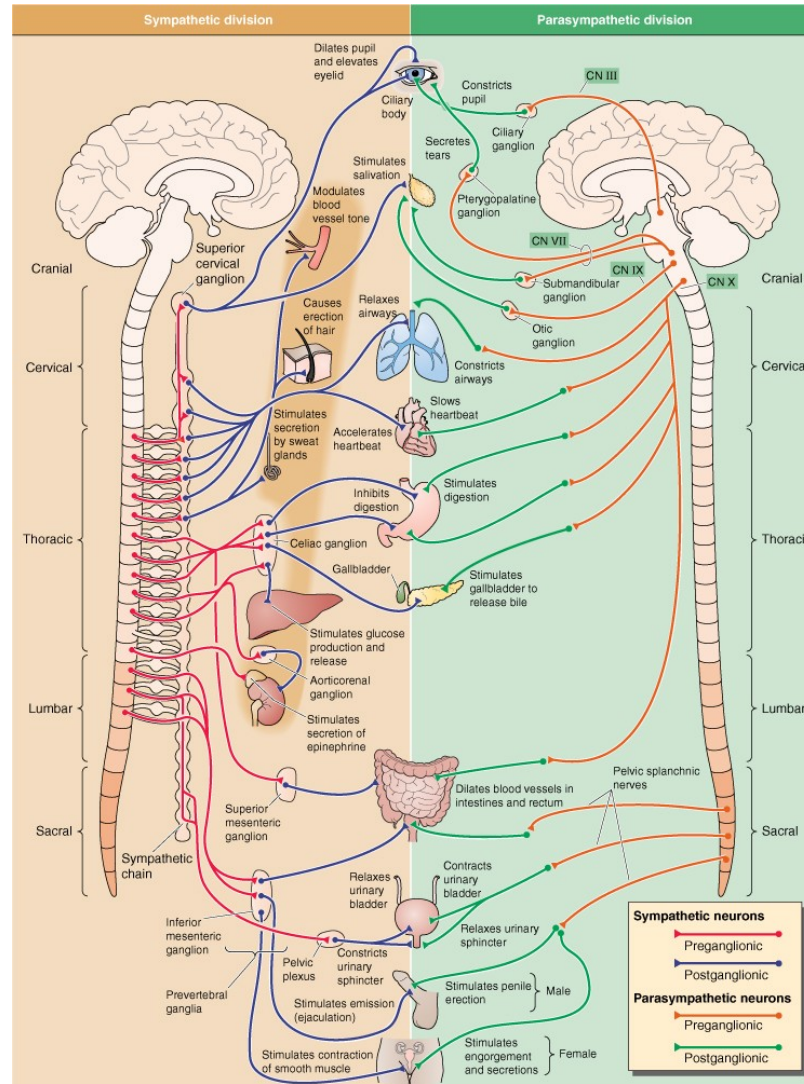
Fight or flight response

Energy/store consumption

Preganglionic neuron
 – Spinal cord
 -Thoraco - lumbar system

Ganglia
Paravertebral
 -Truncus sympathicus
 - Majority
Prevertebral
 -Plexus aorticus

Mostly diffuse effect



Parasympathetic nervous system

Rest and digest response

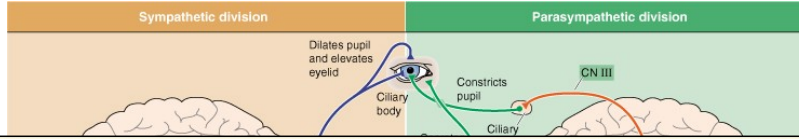
Energy conservation/en. store production

Preganglionic neuron
 – Brain stem and spinal cord
 – cranio-sacral system

Ganglia
Close to target organs or intramurally

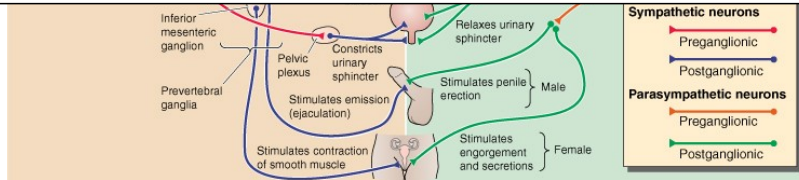
Mostly local effect

Sympathetic nervous system



Parasympathetic nervous system

	System/function	Parasympathetic	Sympathetic	
Fight or flight response	Cardiovascular	Decreased cardiac output and heart rate	Increased contraction and heart rate; increased cardiac output	digestive
Energy consumption	Pulmonary	Bronchial constriction	Bronchial dilatation	ly
	Musculoskeletal	Muscular relaxation	Muscular contraction	on/ene
Preganglionic neurons	Pupillary	Constriction	Dilatation	ore
	Urinary	Increased urinary output; sphincter relaxation	Decreased urinary output; sphincter contraction	tion
	Gastrointestinal	Increased motility of stomach and gastrointestinal tract; increased secretions	Decreased motility of stomach and gastrointestinal tract; decreased secretions	ionic
- Spinal -Thoraco system	Glycogen to glucose conversion	No involvement	Increased	on
Ganglionic neurons	Adrenal gland	No involvement	Release epinephrine and norepinephrine	m and
	Paravertebral			ord
- True sympathetic				l system
- Majority				ia
Prevertebral				target
- Plexus aorticus				or
Mostly diffuse effect				intramurally



ANS

Effector Response	Anatomical Pathway	Neurotransmitter	Receptor	G Protein	Enzyme or Protein	Second Messenger
Tachycardia	Sympathetic	NE	β_1 on cardiac pacemaker	G_{α_s}	\uparrow AC	\uparrow [cAMP] _i
Bradycardia	Parasympathetic	ACh	M_2 on cardiac pacemaker	Direct action of dimeric $G_{\beta\gamma}$	GIRK1 K ⁺ channels	ΔV_m
Increase cardiac contractility	Sympathetic	NE	β_1 on cardiac myocyte	G_{α_s} Direct action of G_{α_s} on Cav1.2	\uparrow AC	\uparrow [cAMP] _i
Decrease cardiac contractility	Parasympathetic	ACh	M_2 on cardiac myocyte Presynaptic M_2 receptor on noradrenergic neuron M_3 receptor on cardiac myocyte	G_{α_i} G_{α_o} G_{α_q}	\downarrow AC \downarrow AC \uparrow PLC \rightarrow \uparrow [Ca ²⁺] _i \rightarrow \uparrow NOS \rightarrow \uparrow GC	\downarrow [cAMP] \downarrow [cAMP] _i in neuron \uparrow [cGMP] _i \rightarrow \uparrow Cav1.2
Vasoconstriction in most blood vessels (e.g., skin)	Sympathetic	NE	α_1 on VSMC	G_{α_q}	\uparrow PLC	\uparrow [Ca ²⁺] _i
Vasoconstriction in some blood vessels	Sympathetic	NE	α_2 on VSMC	$G_{\alpha_{\beta\gamma}}$	\downarrow AC	\downarrow [cAMP]
Vasodilation in most blood vessels (e.g., muscle)	Adrenal medulla	Epi	β_2 on VSMC	G_{α_s}	\uparrow AC	\uparrow [cAMP]
Vasodilation in erectile blood vessels	Parasympathetic	ACh	Presynaptic M_2 receptor on noradrenergic neurons	G_{α_i}	\downarrow AC	\downarrow [cAMP] in neuron
		ACh	M_3 on endothelial cell	G_{α_q}	\uparrow PLC \rightarrow \uparrow [Ca ²⁺] _i \rightarrow \uparrow NOS	NO diffuses to VSMC
		NO	NO receptor (i.e., GC) inside VSMC	—	\uparrow GC	\uparrow [cGMP]
		VIP	VIP receptor on VSMC	G_{α_s}	\uparrow AC	\uparrow [cAMP] _i
Vasodilation in blood vessels of salivary gland	Parasympathetic	ACh	M_3 receptor on gland cell	G_{α_q}	\uparrow Kallikrein	Kinins
Vasodilation in blood vessels of muscle in fight-or-flight response	Sympathetic	ACh	Presynaptic M_2 receptor on noradrenergic neurons	G_{α_i}	\downarrow AC	\downarrow [cAMP] _i in neuron
		NANC	Receptor on VSMC			

AC, adenylyl cyclase; ACh, acetylcholine; cAMP, cyclic adenosine monophosphate; cGMP, cyclic guanosine monophosphate; Epi, Epinephrine; GC, guanylyl cyclase; GIRK1, G protein-activated/inwardly rectifying K⁺ channel (Kir3.1); NANC, nonadrenergic, noncholinergic; NE, norepinephrine; NO, nitric oxide; NOS, nitric oxide synthase; PLC, phospholipase C; VIP, vasoactive intestinal peptide; VSMC, vascular smooth muscle cell.

Brain control of ANS

Autonomic centers—brain stem and hypothalamus

1. Medulla

- Vasomotor center
- Respiratory center
- Swallowing, coughing, and vomiting centers

2. Pons

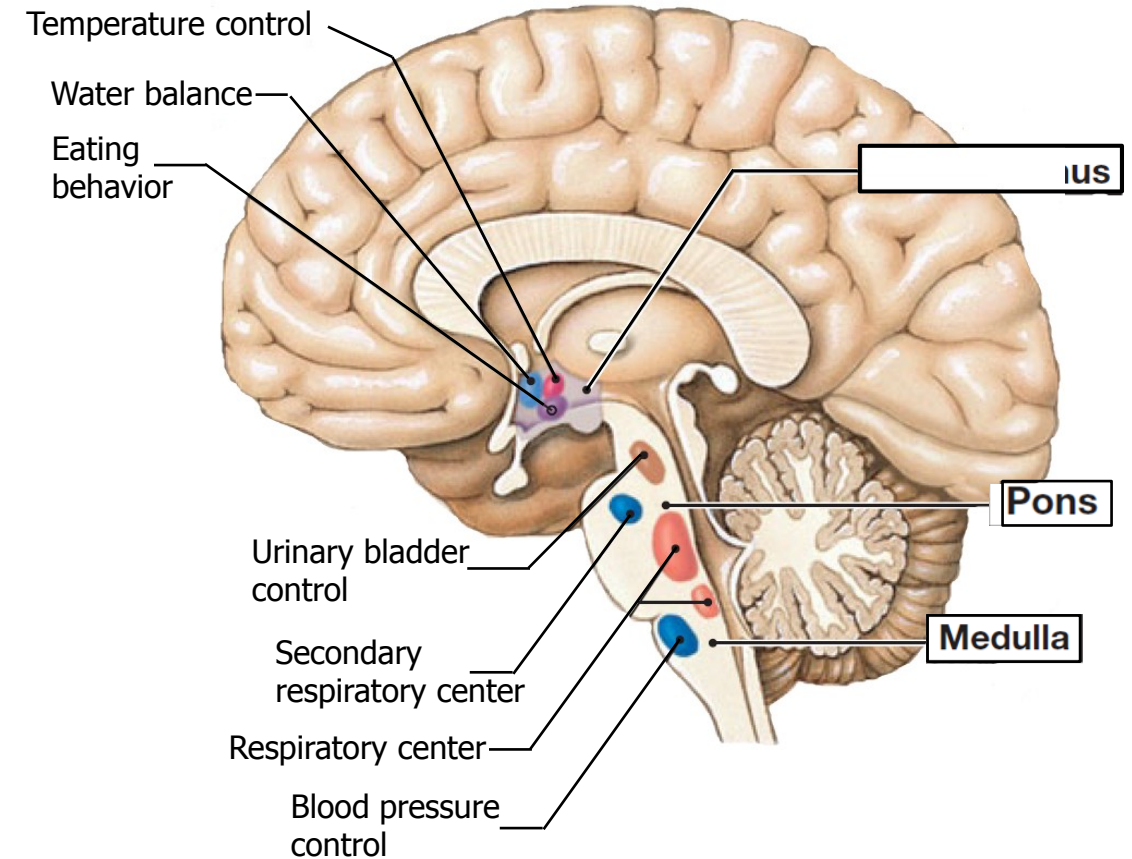
- Pneumotaxic center

3. Midbrain

- Micturition center

4. Hypothalamus

- Temperature regulation center
- Thirst and food intake regulatory centers



Hypothalamus

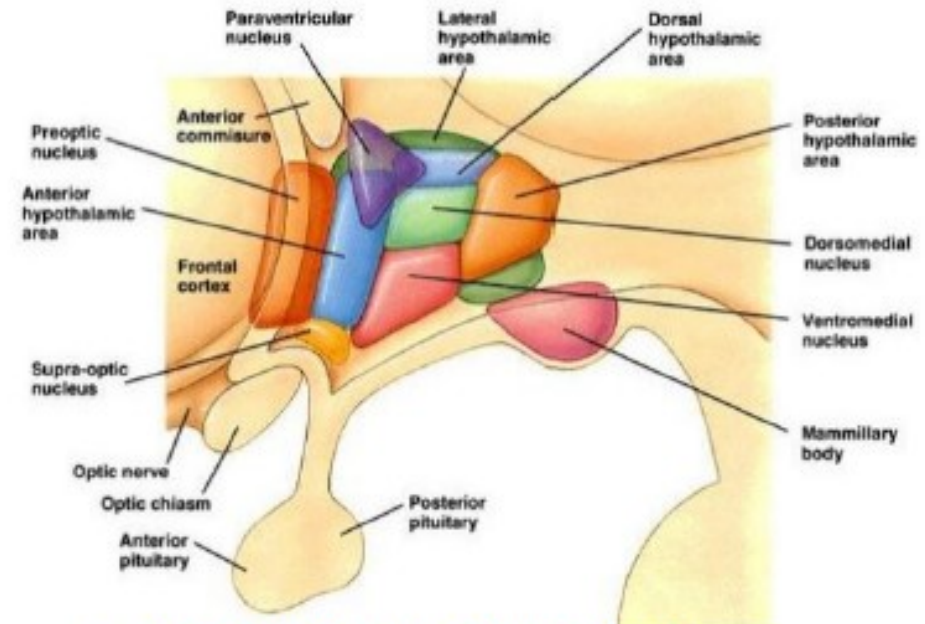
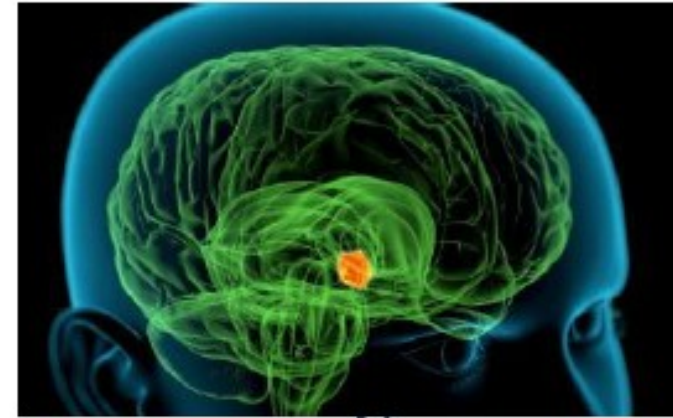
- Key center of autonomic regulations and coordination
- Integration of the information from inner and outer environment



- Behavioral modulation
- Regulation of autonomic nervous system

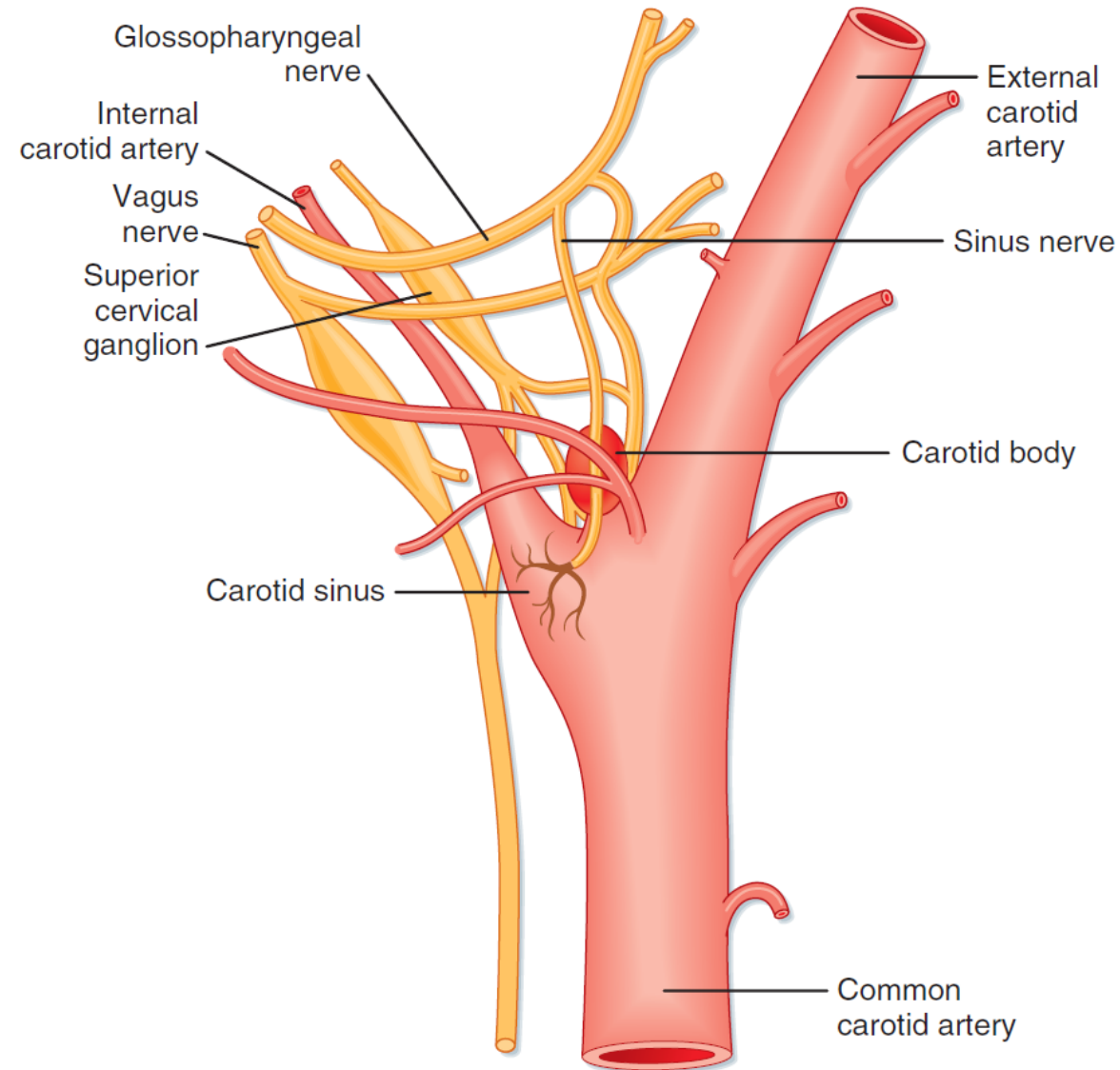


- **Maintenance of homeostasis**



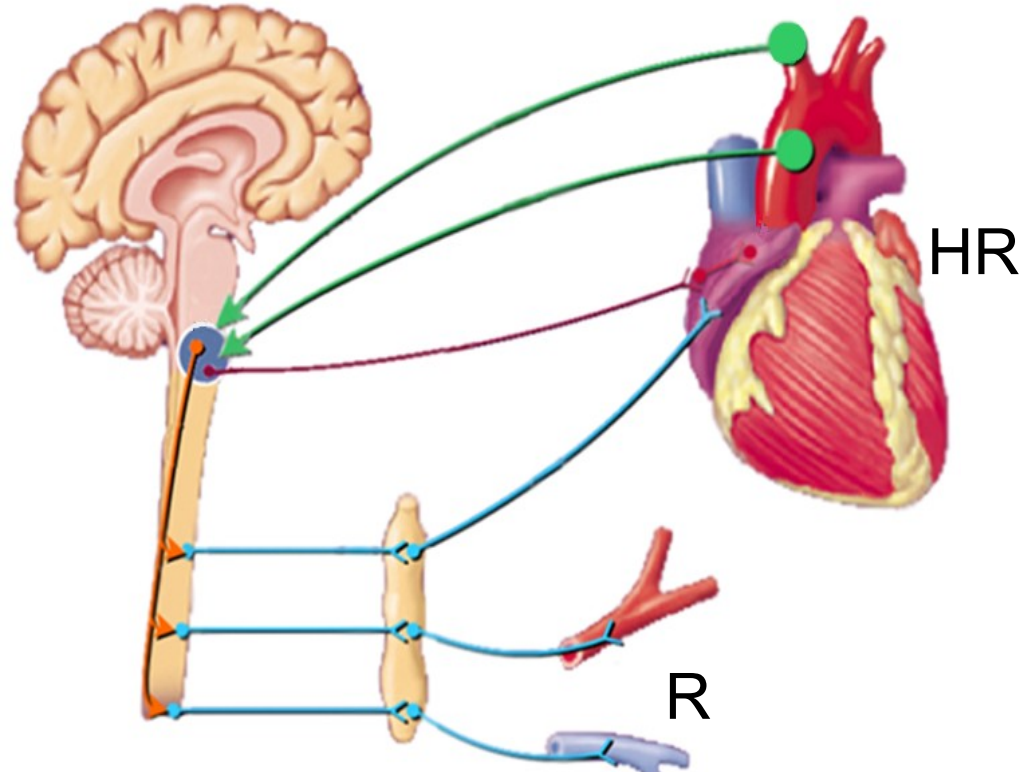
<http://www.slideshare.net/physiology/mci/hypothalamus-13-apr-2016>

Baroreceptor vs. Chemoreceptor

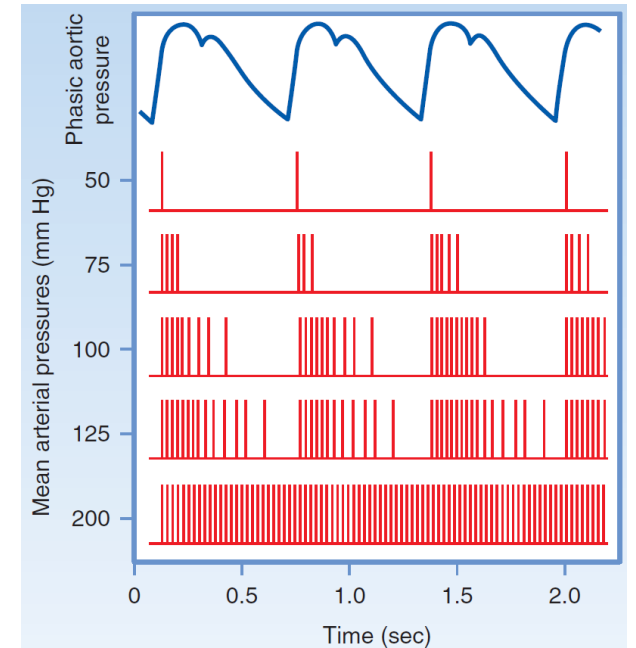


Baroreflex I

- Aferent pathway
- Parasympathetic pathway
- Sympathetic pathway



- Inotropic
 - Chronotropic
 - Dromotropic
 - Batmotropic
- } effect



$$BP = HR \times SV \times R$$

Something more...

Oculocardial reflex

- Pressure on the eyebulbes decreases heart rate (activation of the vagus)
- It is used to suppress or stop atrial tachycardia

Low pressure baroreflex

- greater expansion of the left ventricle stimulates baroreceptors –vagus→medulla - inhibition of SNS – vasodilation, bradycardia – decrease of BP

Diving reflex

- Cold water on the face causes respiratory arrest, peripheral vasoconstriction and bradycardia

Coronary chemoreflex (Bezoldov-Hirtov-Jarisch reflex)

- Substances applied to the left coronary artery (veratridine, capsaicin, some contrast agents, substances produced by ischemic tissue) induce apnea and then hyperpnea, hypotension, bradycardia (vagal afferentation)

Testing of autonomic nervous system

Tilt table test

- Neurocardiogene syncope (cardioinhibitory – vasodepresory-both)
- Cerebral vasoconstriction with syncope

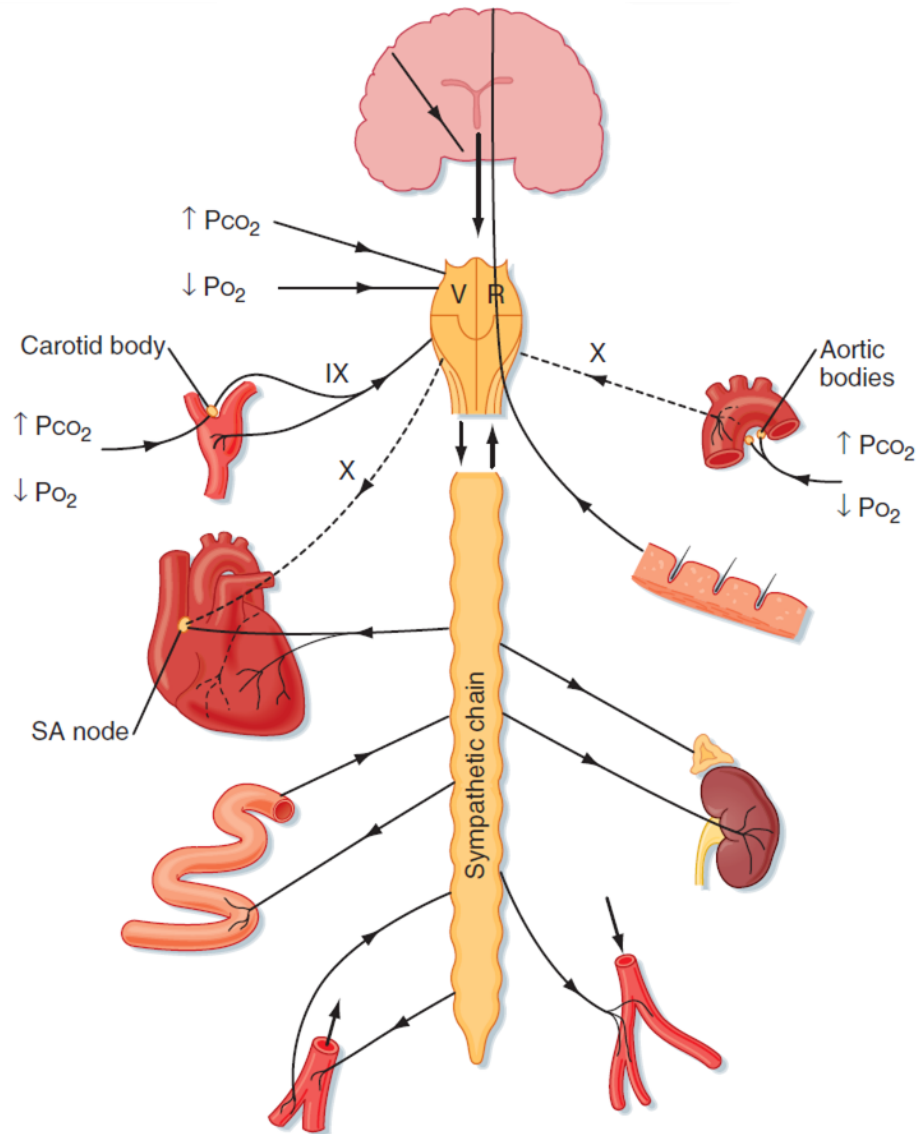
Pressure of the eyebulbes or sinus caroticus

- Cardioinhibitory-vasodepresory-both answer (hypersensitivity of sinus caroticus)

Farmacological tests

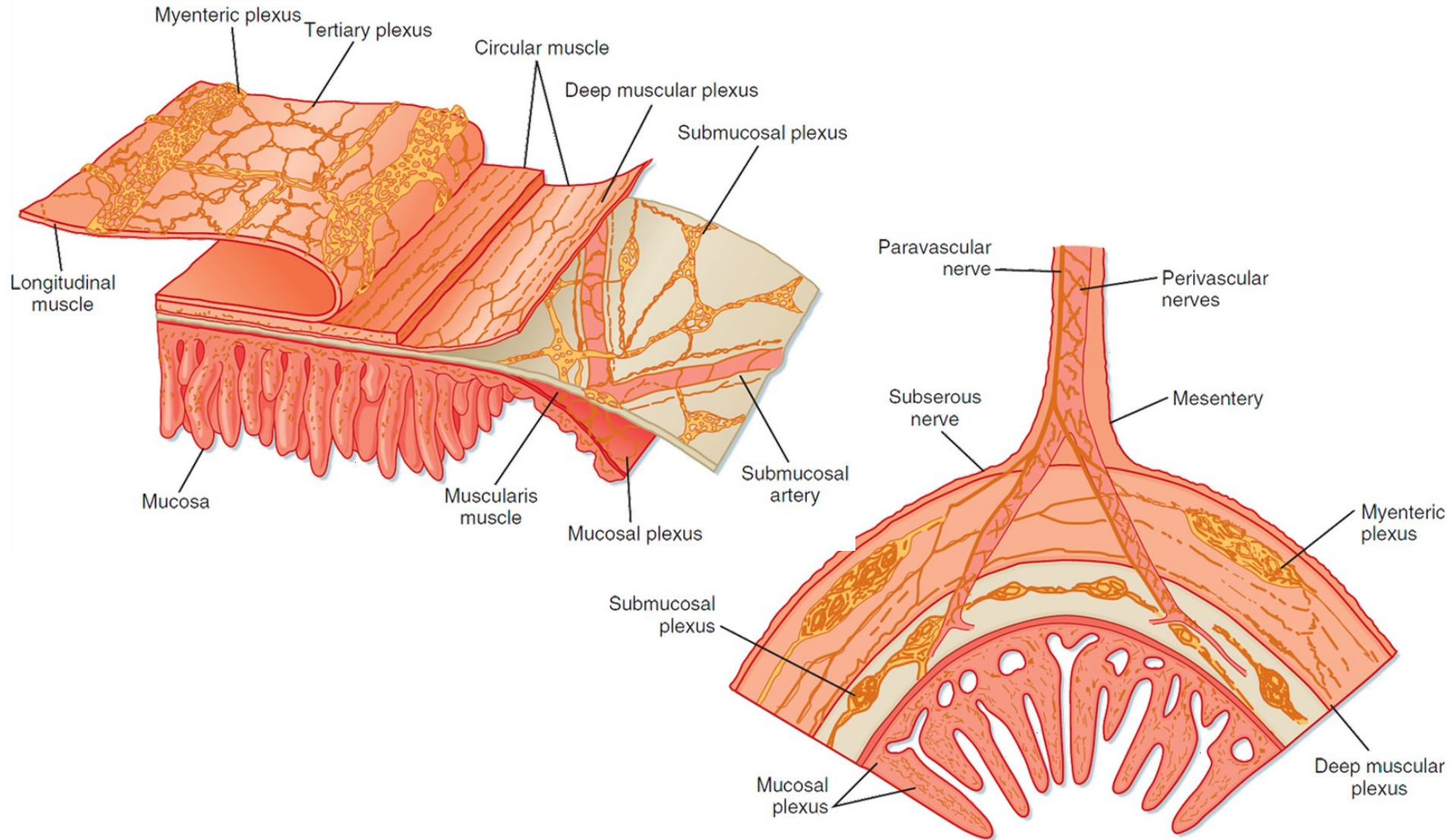
- With norepinephrine, isoprenaline, atropine

ANS and blood vessels



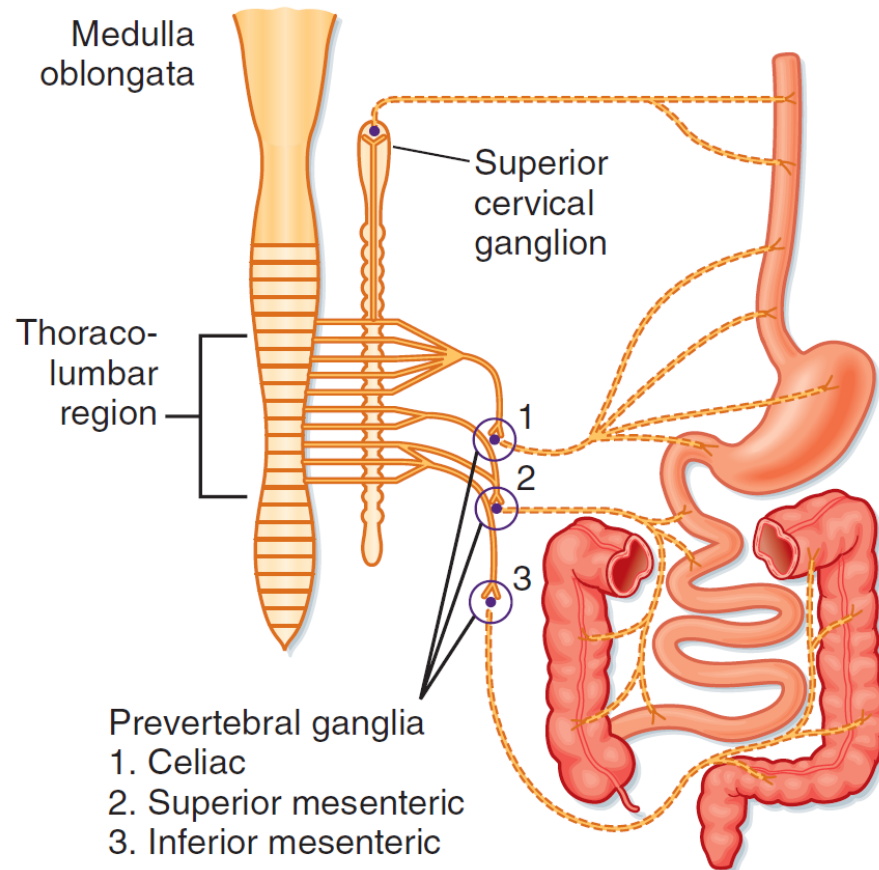
EFFECTORS	RECEPTORS	ADRENERGIC REACTION
CORONARY A.	α, β_2	C, D
SKIN A.	α	C
SKELETAL MUSCLE	α, β_2	C, D
BRAIN A.	α	C
LUNGS A.	α, β_2	C, D
ABDOMINAL A.	α, β_2	C, D
VEINS	α, β_2	C, D

GIT - Enteric Nervous System

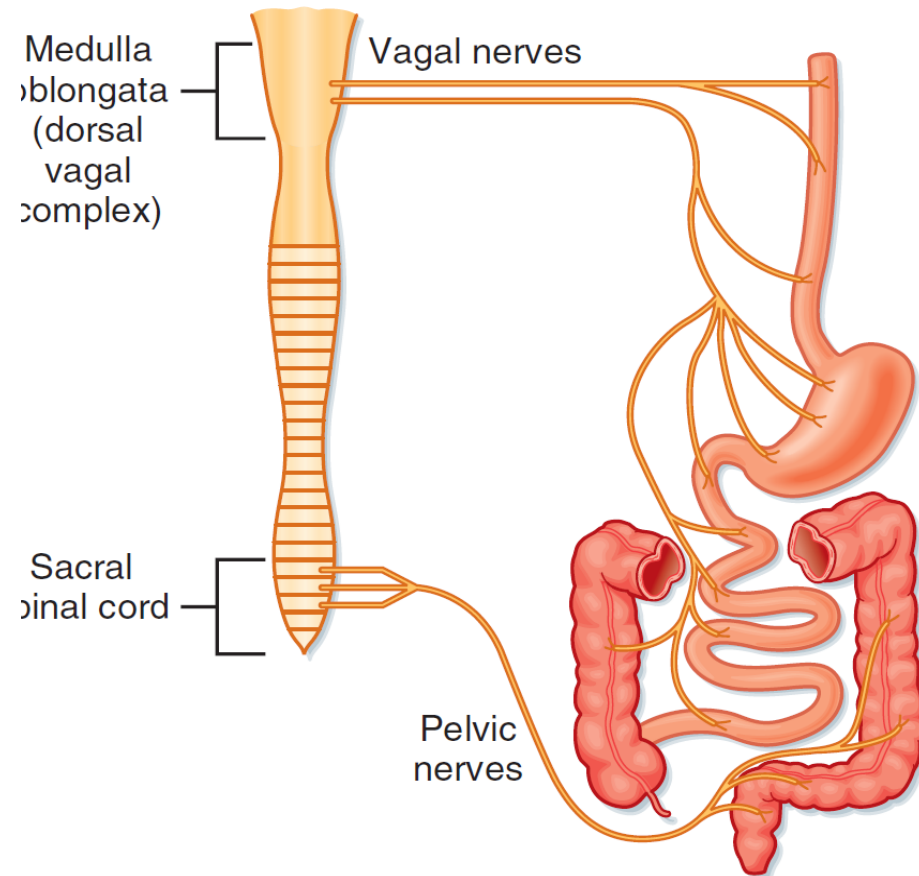


GIT and ANS

SNS



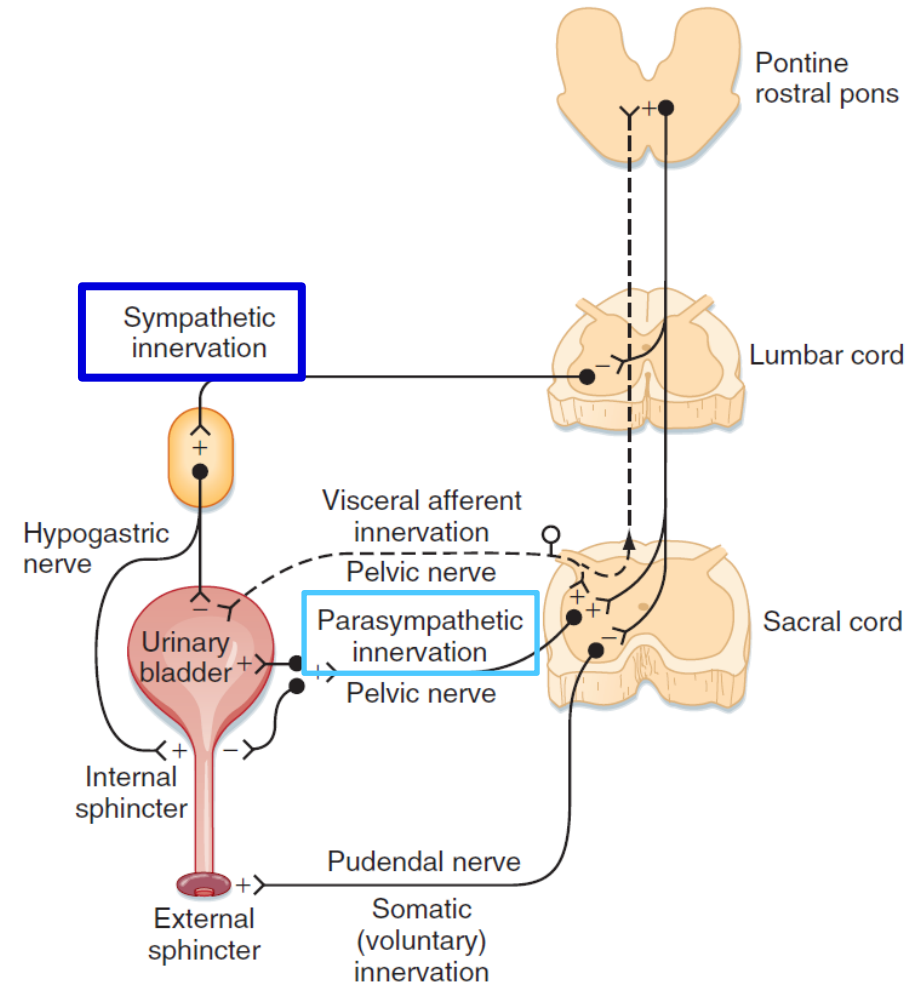
PNS



ANS and urinary bladder

SNS	
DETRUSOR	RELAXATION
SPHINCTER	CONTRACTION

PSN	
DETRUSOR	CONTRACTION
SPHINCTER	RELAXATION



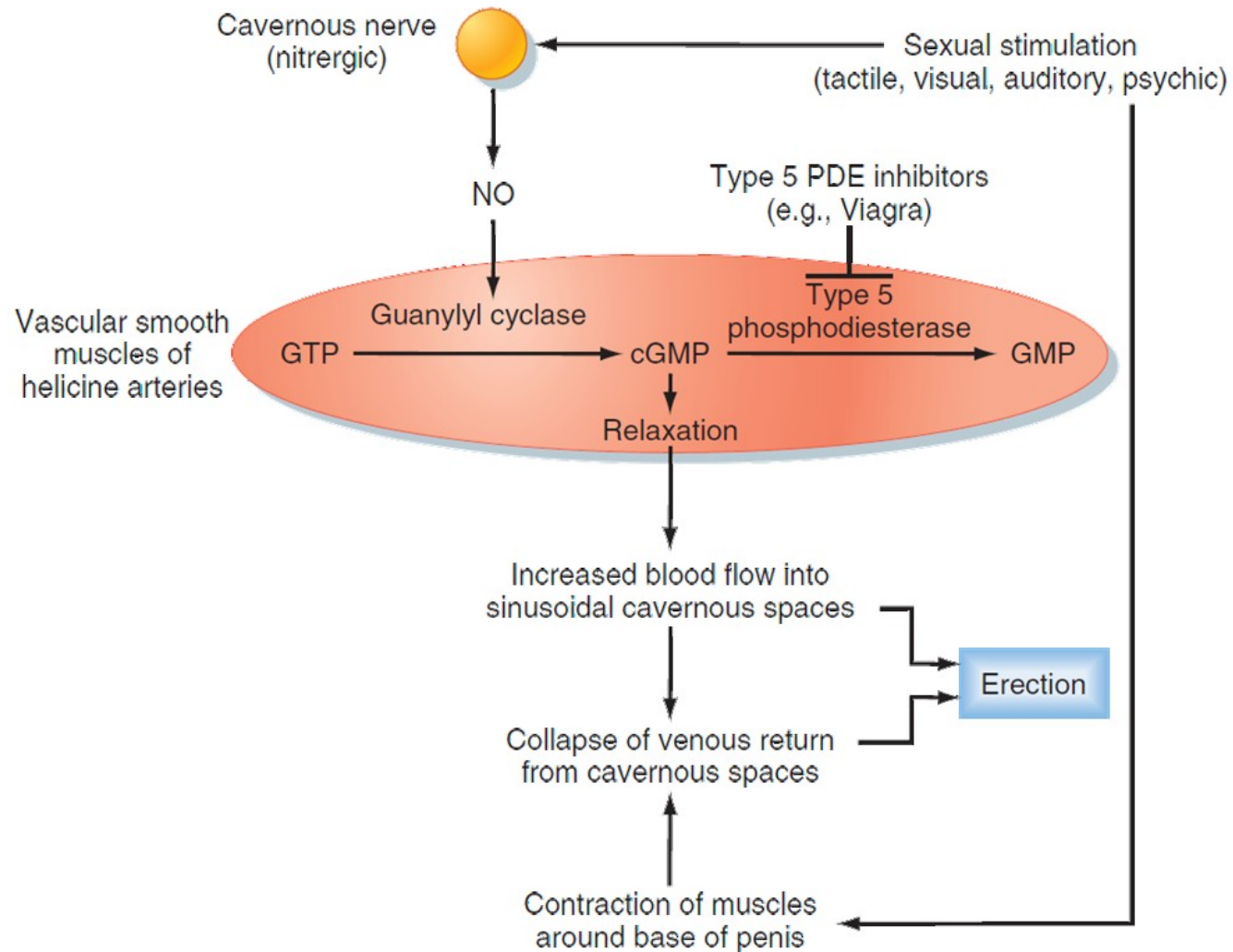
Thank you for your attention

Extra information

Neurogenic bladder

NAME	COMMENTS
Uninhibited bladder	Lesion: above the pontine micturition center Signs: reduced awareness of bladder fullness, incontinence may occur
Upper motor neuron bladder (Detrusor-sphincter dyssynergia)	Lesion: between the pontine micturition center and sacral cord Signs: detrusor is usually spastic, simultaneous detrusor and urinary sphincter contractions increase pressures in the bladder, can lead to vesicoureteral reflux that and renal damage
Mixed type A bladder	Lesion: sacral cord lesion at the detrusor nucleus with sparing of the pudendal nucleus Signs: the detrusor muscle is flaccid, bladder is large, external urinary sphincter is spastic, incontinence uncommon
Mixed type B bladder	Lesion: sacral cord lesion at the pudendal nucleus with sparing of the detrusor nucleus Signs: the bladder is spastic and the external urinary sphincter is flaccid, incontinence is common
Lower motor neuron bladder	Lesion: sacral cord or sacral root while the thoracic sympathetic outflow to the lower urinary tract is preserved Signs: bladder is large and hypotonic, incontinence uncommon

ANS and sexual function



ANS and sexual function

