

AUTONOMIC NERVOUS SYSTEM

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Structure and functions of, autonomic nervous system (ANS)

SLO

- ☐ Functional organization of ANS
- ☐ Two branches of ANS
- ☐ Sympathetic system
- ☐ Parasympathetic system
- ☐ Adrenal medulla
- ☐ Receptors- Adrenergic and cholinergic
- ☐ Effect of the Autonomic Nervous System on the Organs
- ☐ Sympathetic and Parasympathetic Tone
- ☐ Drugs

ORGANIZATION OF THE AUTONOMIC NERVOUS SYSTEM

Innervates organs whose functions are not usually under voluntary control.

Effectors include cardiac and smooth muscles and glands.

Effectors are part of visceral organs and blood vessels

AUTONOMIC NEURONS

There are 2 neurons in the efferent pathway.

1st neuron has its cell body in gray matter of brain or spinal cord- Pre ganglionic neuron.

Synapses with 2nd neuron within an autonomic ganglion - Postganglionic neuron.

- ⦿ Autonomic ganglion has axon which extends to synapse with target tissue

Preganglionic autonomic fibers originate in midbrain, hindbrain, and upper thoracic to 4th sacral levels of the spinal cord.

Autonomic ganglia are located in the head, neck, and abdomen.

Presynaptic neuron is myelinated and postsynaptic neuron is unmyelinated.

Autonomic nerves release NT that may be stimulatory or inhibitory.

DIVISIONS OF THE ANS

Sympathetic nervous system and para-sympathetic nervous system:

Both have pre ganglionic neurons that originate in CNS.

Both have postganglionic neurons that originate outside of the CNS in ganglia.

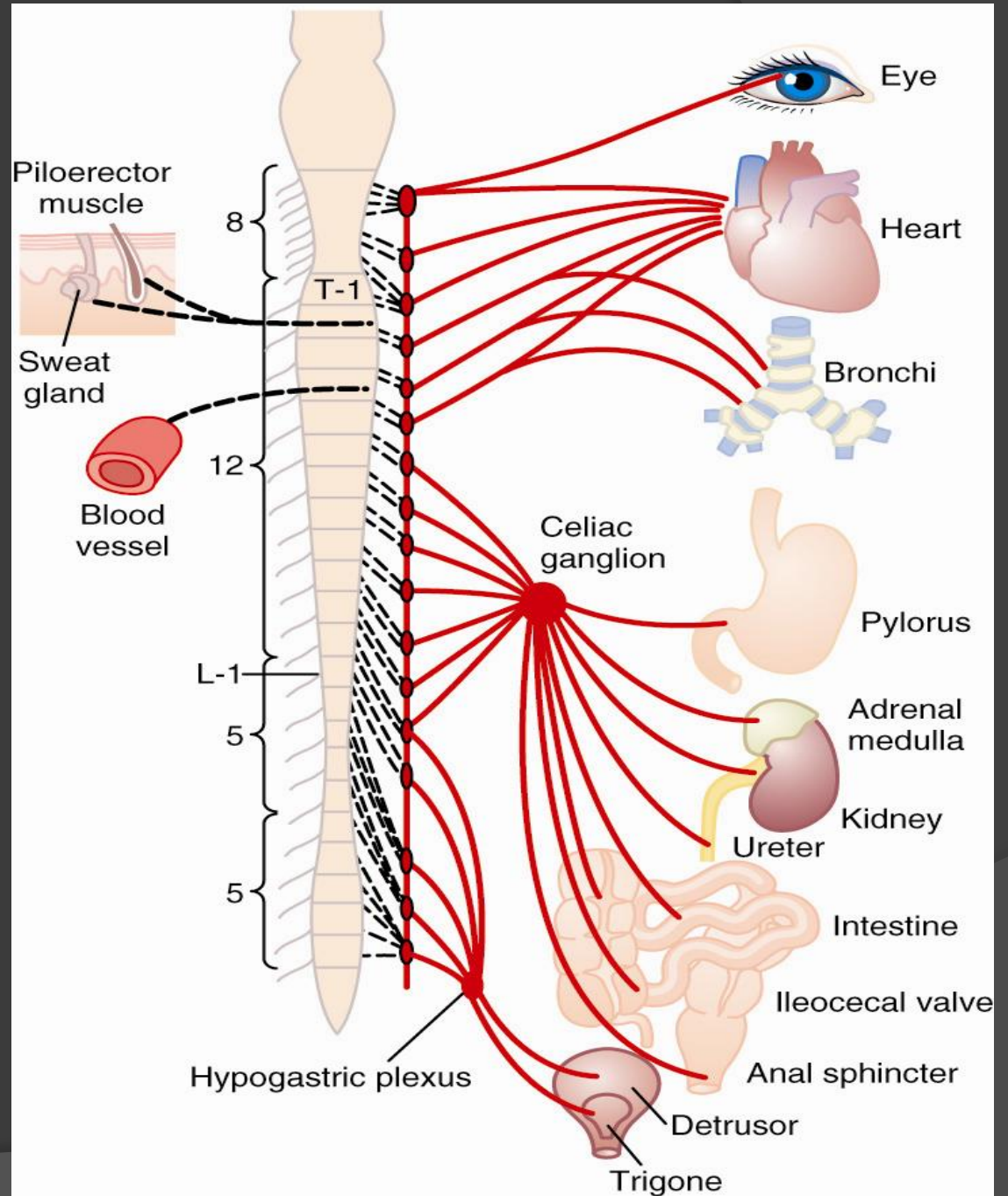
Sympathetic ganglia are located close to the spinal cord.

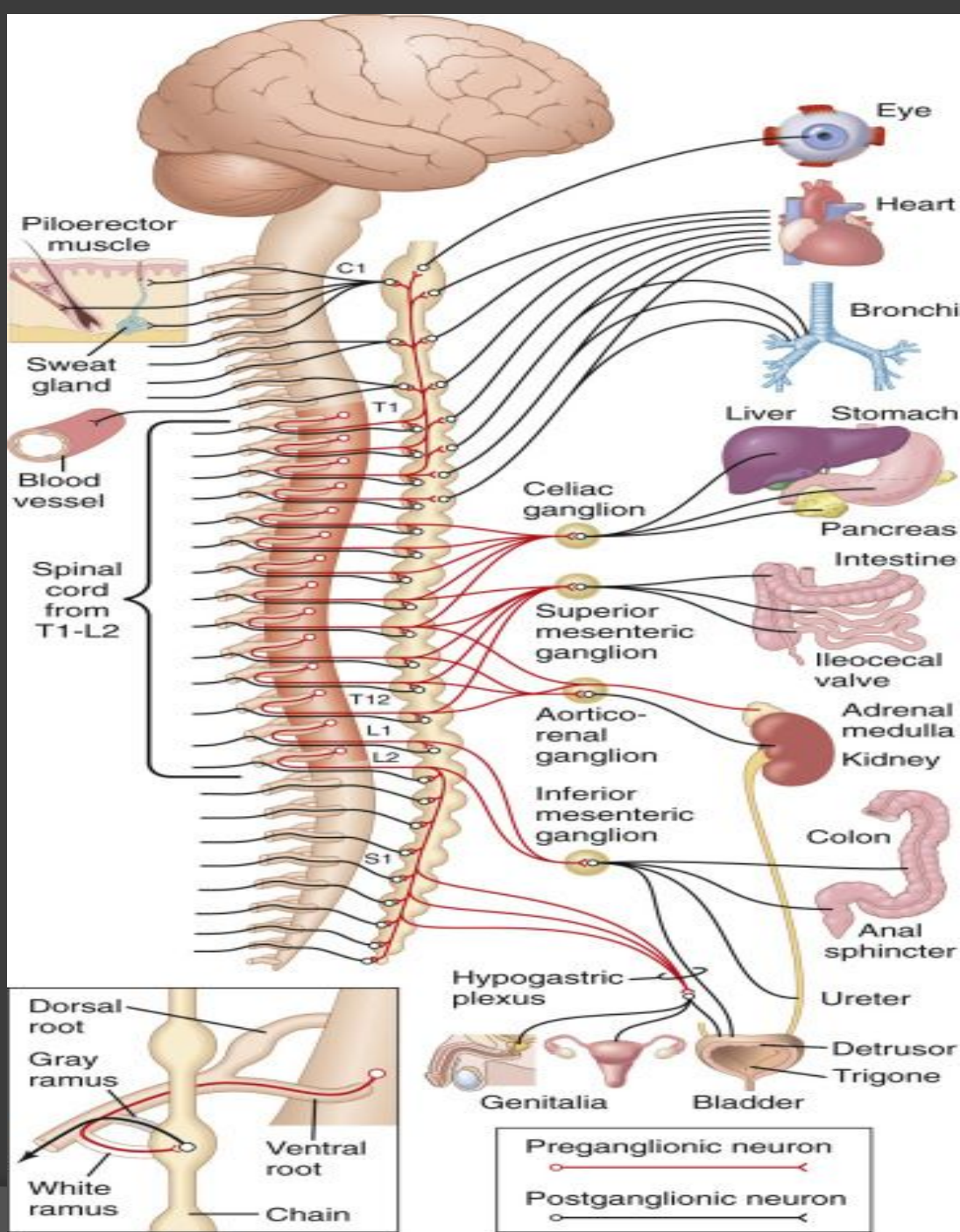
Parasympathetic ganglia are located close to the effector tissues.

Sympathetic pathways have short preganglionic fibers and long postganglionic fibers.

Parasympathetic pathways have long preganglionic and short postganglionic fibers.

SYMPATHETIC NERVOUS SYSTEM



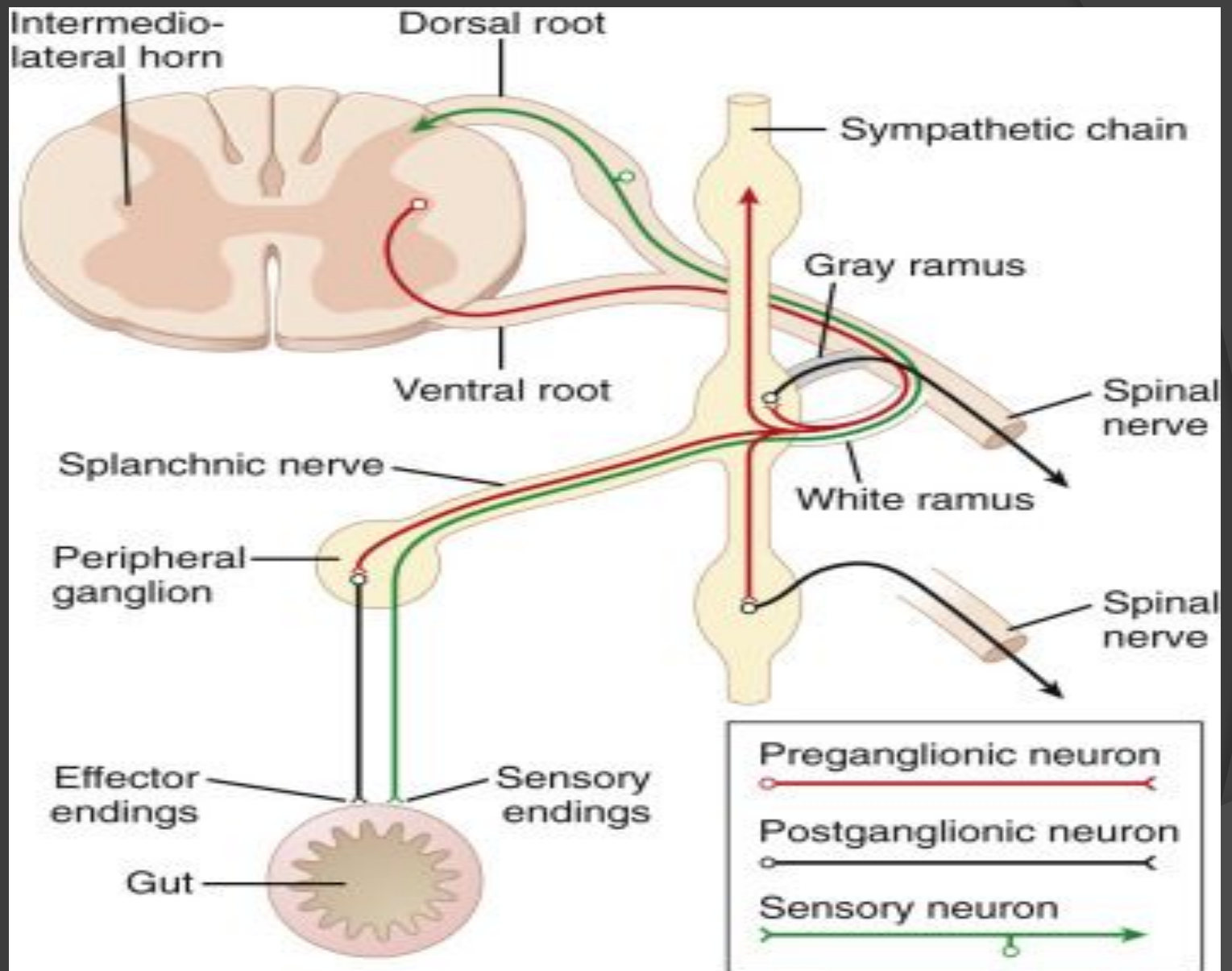


SYMPATHETIC NERVOUS SYSTEM

Myelinated preganglionic fibers exit spinal cord in ventral roots from T1 to L2 levels.

Most sympathetic nerve fibers separate from somatic motor fibers and synapse with postganglionic neurons within paravertebral ganglia.

Ganglia within each row are interconnected, forming a chain of ganglia that parallels spinal cord to synapse with postganglionic neurons.



Immediately after the spinal nerve leaves the spinal canal, the preganglionic sympathetic fibers leave the spinal nerve and pass through a white ramus into one of the ganglia of the sympathetic chain. The fibers then can take one of the following three courses: (1) they can synapse with postganglionic sympathetic neurons in the ganglion that they enter; (2) they can pass upward or downward in the chain and synapse in one of the other ganglia of the chain; or (3) they can pass for variable distances through the chain and then through one of the sympathetic nerves radiating outward from the chain, finally synapsing in a peripheral sympathetic ganglion.

ADRENAL MEDULLA

Adrenal medulla secretes epinephrine (Epi) (80%) and norepinephrine (NE) (20%) when stimulated by the sympathetic nervous system.

Modified sympathetic ganglion

Its cells are derived from the same embryonic tissue that forms postganglionic sympathetic neurons.

Sympathoadrenal system: Stimulated by mass activation of the sympathetic nervous system

Innervated by preganglionic sympathetic fibers causes prolonged activity of the substances

Stimulation of cardiovascular function and metabolic rate helps the body deal with stress

PARASYMPATHETIC NERVOUS SYSTEM

Preganglionic fibers originate in midbrain, medulla, pons; and in the 2-4 sacral levels of the spinal column.

Preganglionic fibers synapse in terminal ganglia located next to or within organs innervated.

Most parasympathetic fibers do not travel within spinal nerves.

4 of the 12 pairs of cranial nerves (III, VII, X, XI) contain preganglionic parasympathetic fibers.

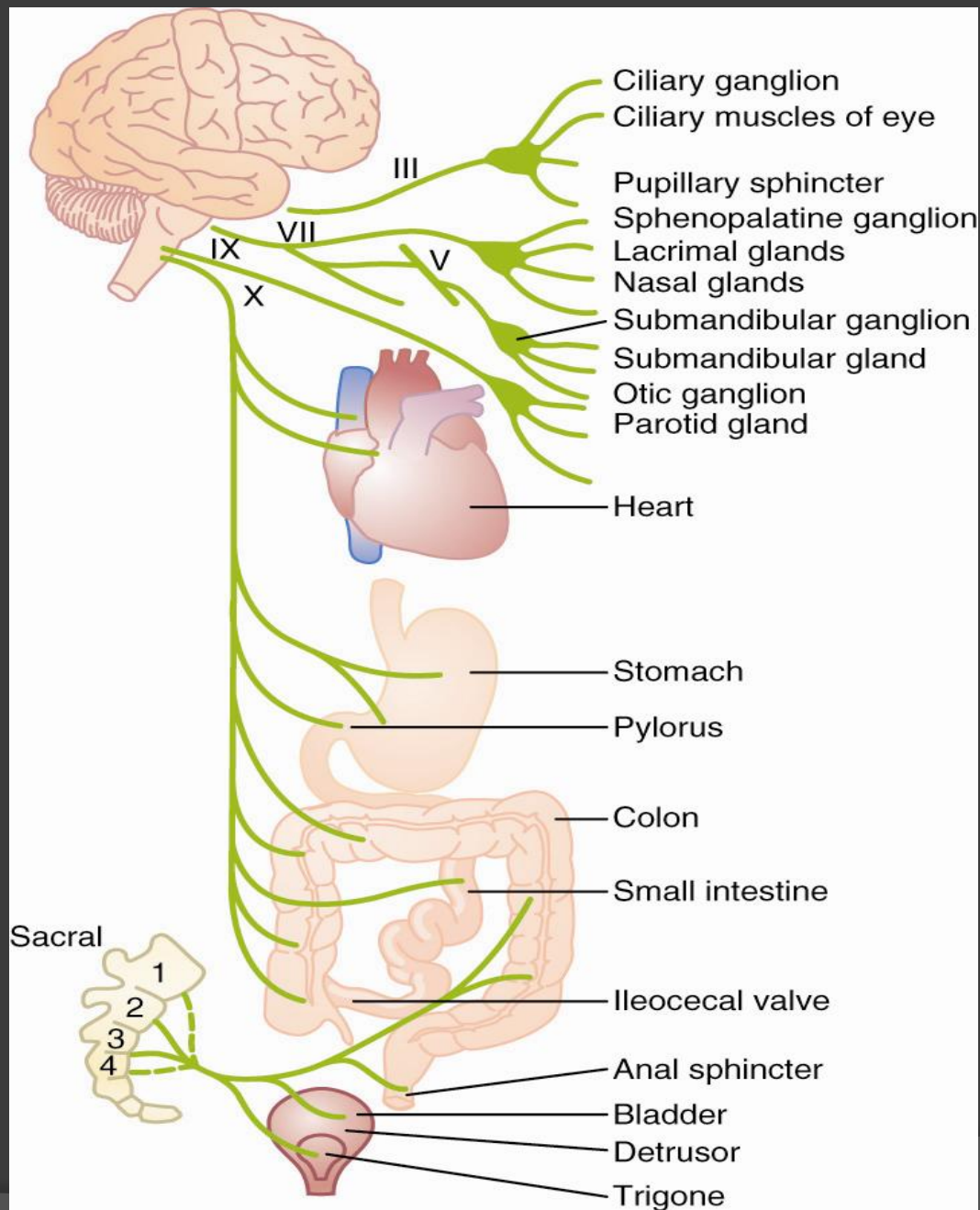
- III, VII, XI synapse in ganglia located in the head.
- **oculomotor nerve** - fibers to the pupillary sphincters and ciliary muscle
- **facial nerve** - fibers to nasal, lacrimal and submandibular gland
- **glossopharyngeal nerve** - fibers to parotid gland

X synapses in terminal ganglia located in widespread regions of the body.

Vagus(X):

Innervates heart, lungs esophagus, stomach, pancreas, liver, small intestine and upper half of the large intestine.

Preganglionic fibers from the sacral level innervate the lower half of large intestine, the rectum, urinary and reproductive organs.



PARASYMPATHETIC
NERVOUS SYSTEM

CHARACTERISTICS OF SYMPATHETIC AND PARASYMPATHETIC FUNCTION-CHOLINERGIC AND ADRENERGIC FIBERS

sympathetic nerves release norepinephrine at their
nerve endings

- these nerves are called *adrenergic nerves*

parasympathetic nerves release acetylcholine at their
nerve endings

- these nerves are called *cholinergic nerves*

almost all postganglionic sympathetic nerves release
norepinephrine

- except for sweat glands, piloerector muscles and
select blood vessels

All postganglionic parasympathetic nerves release acetylcholine.

All preganglionic sympathetic and parasympathetic nerves release acetylcholine.

Norepinephrine and epinephrine are synthesized from the amino acid tyrosine.

Acetylcholine is a combination of acetyl CoA and choline.

Receptors on the Effector Organs

- ◎ **Adrenergic Receptors—Alpha and Beta Receptors**
- ◎ Sympathetic nerves release *norepinephrine*.
 - Norepinephrine stimulates *alpha* and *beta* adrenergic receptors.
 - Alpha receptors are located on blood vessels where they cause vasoconstriction.
 - Beta receptors are further divided into *beta₁* and *beta₂*.
 - activation of *beta₁* - causes an increase in heart rate and contractility
 - activation of *beta₂* - causes bronchial dilation, dilation of blood vessels in skeletal muscles, calorogenesis, and glycogenolysis

Adrenergic Receptors and Function

Alpha Receptor	Beta Receptor
Vasoconstriction	Vasodilation (β_2)
Iris dilation	Cardioacceleration (β_1)
Intestinal relaxation	Increased myocardial strength (β_1)
Intestinal sphincter contraction	Intestinal relaxation (β_2) Uterus relaxation (β_2)
Pilomotor contraction	Bronchodilation (β_2)
Bladder sphincter contraction	Calorigenesis (β_2)
Inhibits neurotransmitter release (α_2)	Glycogenolysis (β_2) Lipolysis (β_1) Bladder wall relaxation (β_2) Thermogenesis (β_3)

- ◎ **Acetylcholine Receptors—Muscarinic and Nicotinic Receptors**
- ◎ Parasympathetic nerves release *acetylcholine*.
 - Acetylcholine excites two types of receptors *nicotinic* and *muscarinic*.
 - Nicotinic receptors are found in synapses between the pre- and post- ganglionic neurons.
 - Muscarinic receptors are found on all effector cells stimulated by postganglionic parasympathetic fibers.

EFFECT OF THE AUTONOMIC NERVOUS SYSTEM ON THE ORGANS

◎ **eye**

- sympathetic --pupillary dilation
- parasympathetic--pupillary constriction and accommodation (focusing) of the lens

◎ **glands of the body**

- parasympathetic stimulate the nasal, lacrimal, salivary, and G.I. glands
- sympathetic stimulates the sweat glands

◎ **G.I. tract**

- parasympathetic stimulates overall activity including G.I. smooth muscle
- sympathetic has very little effect

◎ **heart**

- sympathetic increases the rate and contractility
- parasympathetic decreases heart rate

◎ **blood vessels**

- sympathetic causes vasoconstriction
- parasympathetic causes some vasodilation

SYMPATHETIC AND PARASYMPATHETIC “TONE”

- ⊙ the basal rate of activity of each system
- ⊙ this background activity allows for an increase or decrease in activity by a single system
- sympathetic tone normally causes about a 50 % vasoconstriction
 - increasing or decreasing “tone” can change vessel diameter
- parasympathetic tone provides background G.I. activity

Tone Caused by Basal Secretion of Epinephrine and Norepinephrine by the Adrenal Medullae

- The normal resting rate of secretion by the adrenal medullae is about 0.2 $\mu\text{g/kg/min}$ of epinephrine and about 0.05 $\mu\text{g/kg/min}$ of norepinephrine.
- These quantities are -enough to maintain the blood pressure almost normal - all direct sympathetic pathways to the cardiovascular system are removed.
- Therefore, it is obvious that much of the overall tone of the sympathetic nervous system results from basal secretion of epinephrine and norepinephrine in addition to the tone resulting from direct sympathetic stimulation.

Autonomic Reflexes

- Many visceral functions of the body are regulated by autonomic reflexes.
- Cardiovascular Autonomic Reflexes.-baroreceptor reflex
- Gastrointestinal Autonomic Reflexes-defecation reflex
- Micturition reflex

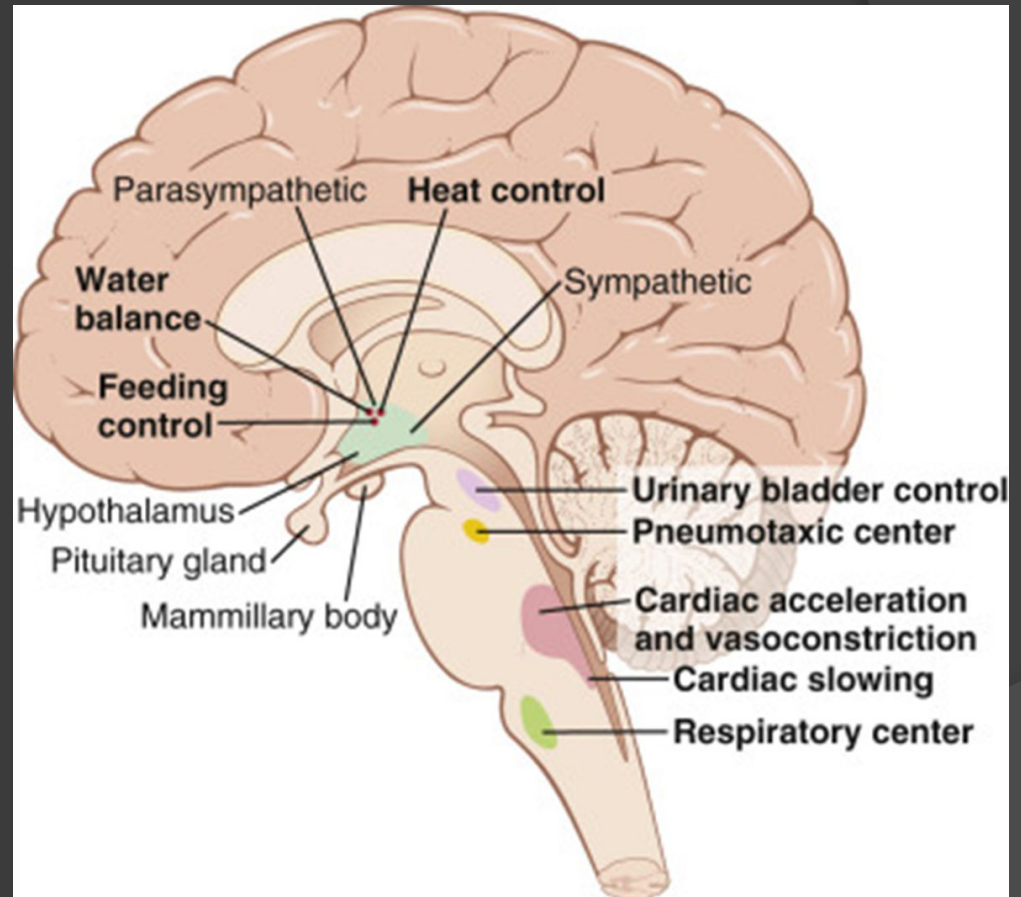
Mass Discharge-“Alarm” or “Stress” Response of the Sympathetic Nervous System

- ⦿ When large portions of the sympathetic nervous system discharge at the same time—that is, a mass discharge—this action increases the ability of the body to perform vigorous muscle activity in many ways
 - ▢ Increased arterial pressure
 - ▢ Increased blood flow to active muscles concurrent with decreased blood flow to organs such as the gastrointestinal tract and the kidneys that are not needed for rapid motor activity
 - ▢ Increased rates of cellular metabolism throughout the body
 - ▢ Increased blood glucose concentration

- Increased glycolysis in the liver and in muscle
- Increased muscle strength
- Increased mental activity
- Increased rate of blood coagulation
- ❖ The sum of these effects permits a person to perform far more strenuous physical activity than would otherwise be possible.
- ❖ Mental or physical stress - excite the sympathetic system-sympathetic stress response.
- ❖ sympathetic system is strongly activated in many emotional states-Rage- alarm reaction-fight-or-flight reaction

Control of Brain Stem Autonomic Centers by Higher Areas

- Many neuronal areas in the brain stem reticular substance, medulla, pons, and mesencephalon, special nuclei –control different autonomic functions of systems –regulatory centers



- Signals from the hypothalamus and even from the cerebrum can affect the activities of almost all the brain stem autonomic control centers.

Eg: stimulation in appropriate areas—posterior hypothalamus—can activate the medullary cardiovascular control centers strongly enough to increase arterial pressure to more than twice normal

- Therefore, the autonomic centers in the brain stem act as relay stations for control activities initiated at higher levels of the brain, especially in the hypothalamus.

Pharmacology of the Autonomic Nervous System

● Sympathomimetic Drugs-Adrenergic drugs

- same effects as sympathetic stimulation

- 1.Epinephrine and methoxamine
- 2.Stimulate adrenergic receptor-phenylephrine (alpha receptors), isoproterenol (beta receptors), albuterol (only beta 2 receptors).
- 3.Cause release of norepinephrine from sympathetic nerve endings-ephedrine, tyramine, and amphetamine.

◎ **Adrenergic Blockers**

1. The synthesis and storage –prevented- Reserpine.
2. Release of norepinephrine –blocked- Guanethidine.
3. The sympathetic alpha receptors can be blocked.

Block both alpha 1 and alpha 2 adrenergic receptors - phenoxybenzamine and phentolamine.

Selective alpha 1 adrenergic blockers - prazosin and terazosin,

alpha 2 blockers-yohimbine

4. The sympathetic beta receptors can be blocked.
beta 1 and beta 2 receptors blocker- propranolol.
beta 1 blocker- atenolol , nebivolol , and metoprolol.
5. Sympathetic activity can be blocked by drugs that block transmission of nerve impulses through the autonomic ganglia.

◎ **Parasympathomimetic drugs-Cholinergic Drugs**-same effects as sympathetic stimulation

- 1.pilocarpine and methacholine
- 2.Anticholinesterase Drugs-neostigmine, pyridostigmine, and ambenonium.

Antimuscarinic Drugs-Atropine and similar drugs, such as homatropine and scopolamine

Nicotinic drugs-Nicotine

Ganglionic Blocking Drugs-Drugs that block impulse transmission from the autonomic preganglionic neurons to the postganglionic neurons - tetraethyl ammonium ion, hexamethonium