Plan of lecture
”Functional anatomy of the vegetative nervous system”

1. **Common features and differences of the somatic and vegetative nervous systems**
2. **Common features and differences of the sympathetic and parasympathetic nervous systems**
3. **Vegetative plexuses**
4. **Dual Innervation of the organs by the ANS**
5. **Reflex types. Referred pain**

Lecturer: ***PhD, professor Tamara Hacina***

NERVOUS SYSTEM

(MORPHOLOGYCAL CLASSIFICATION)

CENTRAL

Brain

+

Spinal cord

PERIPHERAL

12 pairs of cranial nerves

+

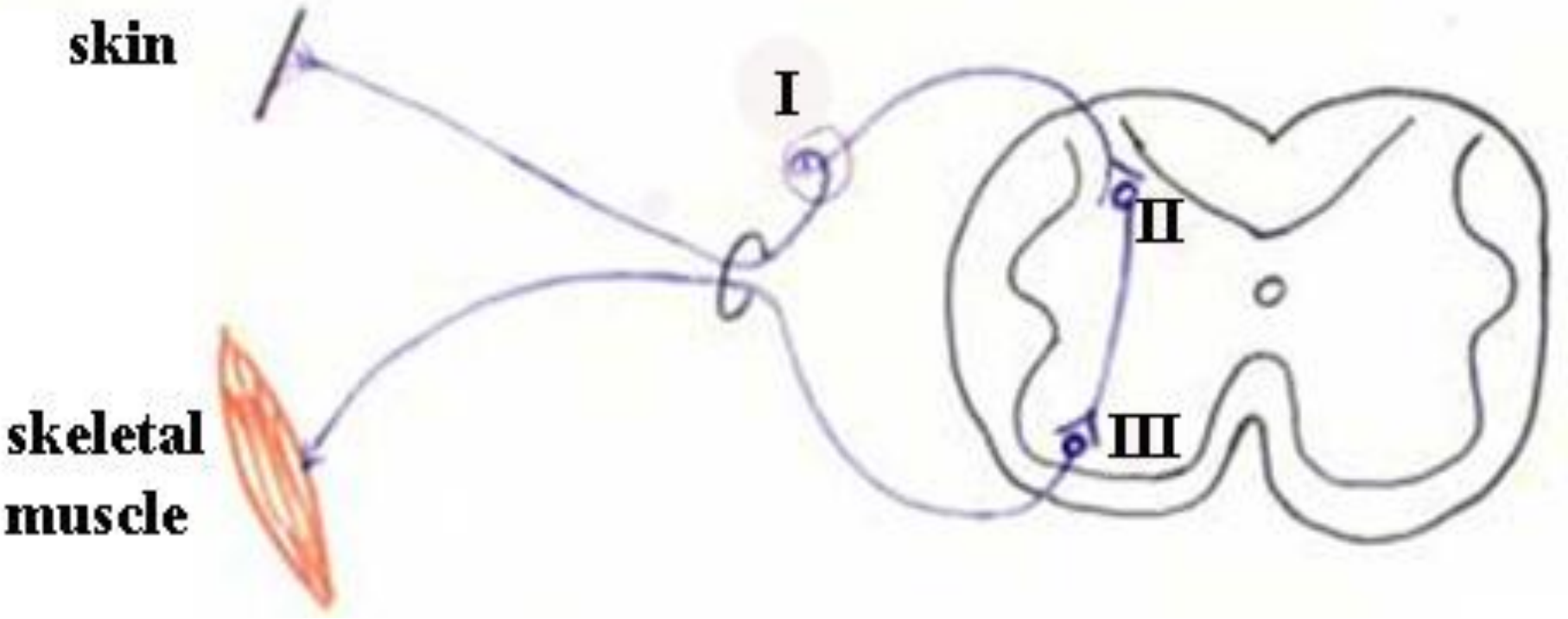
31 pairs of spinal nerve

NERVOUS SYSTEM

(MORPHOFUNCTIONAL CLASSIFICATION)

	VEGETATIVE (AUTONOMIC)	SOMATIC (ANIMAL)
	Functional differences	
Region of supply:	smooth muscles, glands	striated muscles
Action :	slow	fast
Duration:	permanent	during the action of excitant
Functions:	metabolism, growth, homeostasis	motion
	Structural differences	
	*has not segmental structure *ascending part does not form visible nerves *vegetative nerves form plexuses around blood vessels	*has segmental structure *ascending & descending fibers form visible nerves

Somatic reflex arch



5 links:

I. Receiving (receptors): *in the skin or internal organs

II. Ascending (sensory) neuron: *carries impuls to the posterior horn of the spinal cord

III central part (spinal cord or brain)

IV. Descending (motor) * carries impuls to the organ-effector.

V. organ-effector.

I neuron: *in the spinal ganglion

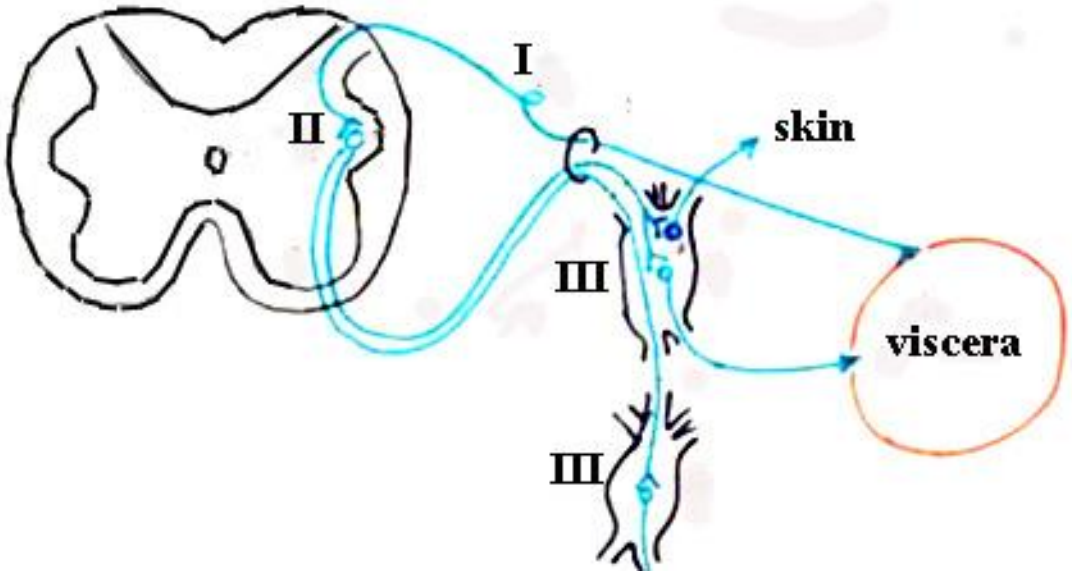
II neuron: *posterior horn of the spinal cord

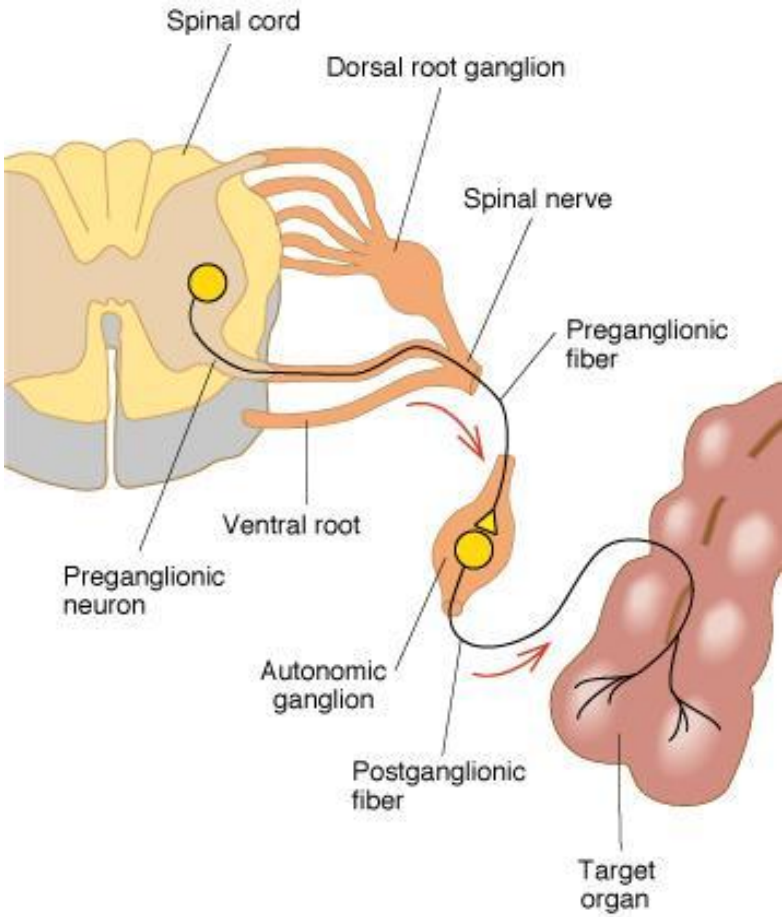
III neuron: *anterior horn

* the II neuron finishes in the spinal cord

* descending part is unineuronal

Vegetative reflex arch



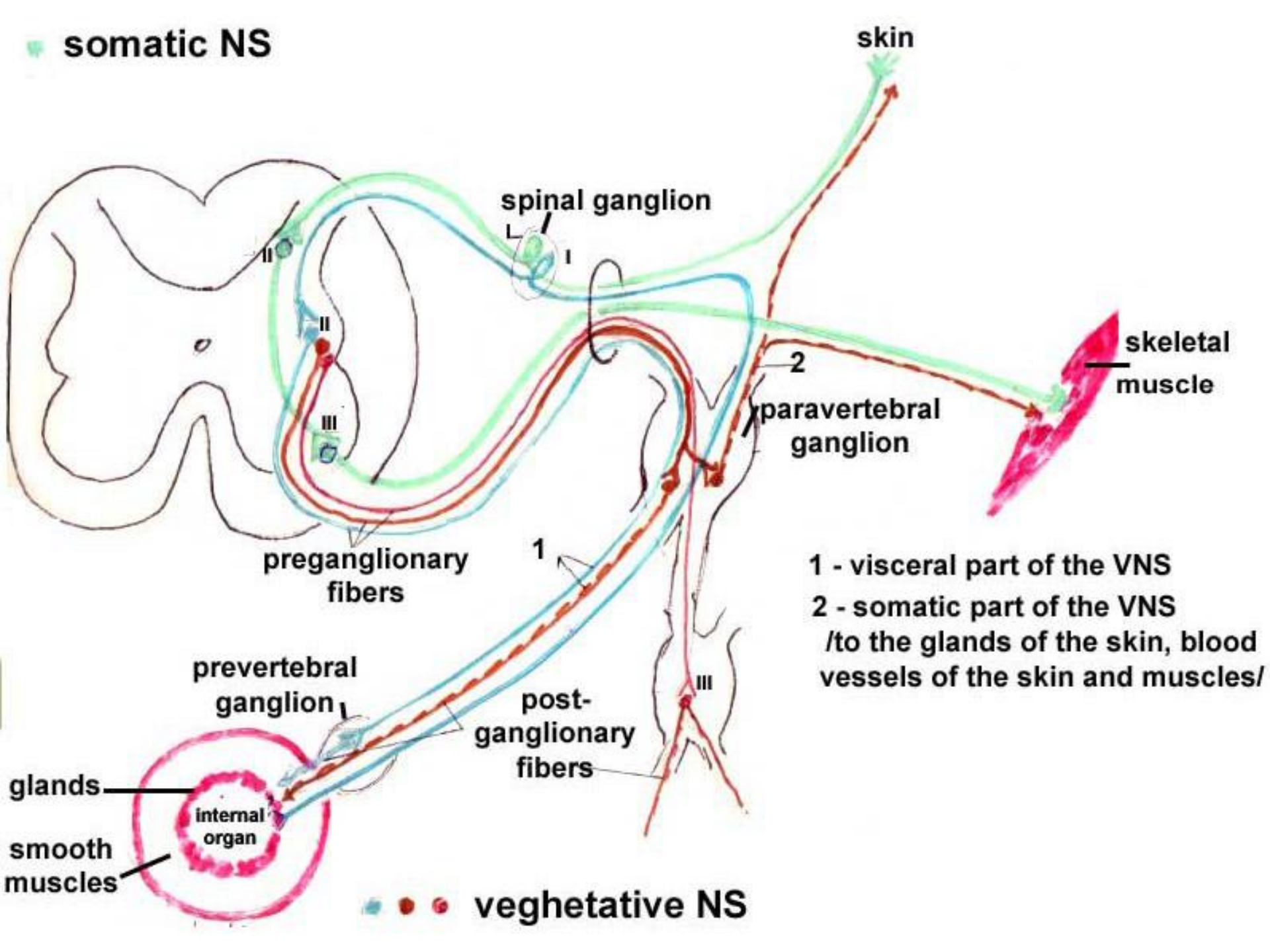


I neuron: *in the spinal ganglion

II neuron: * lateral horn of the spinal cord

III neuron: *outside of the of the spinal cord, in the vegetative ganglion

* the II neuron doesn't finish in the spinal cord
* descending part is bineuronal
* postganglionary fibers form the visceral and somatic parts
* preganglionary fibers form white communicating branch
* postganglionary fibers form gray communicating branch


somatic NS
skin
spinal ganglion
I
II
II
III
skeletal
muscle
2
paravertebral
ganglion
preganglionary
fibers
1
1 - visceral part of the VNS
2 - somatic part of the VNS
/to the glands of the skin, blood
vessels of the skin and muscles/
prevertebral
ganglion
post-
ganglionary
fibers
III
glands
internal
organ
smooth
muscles
veghetative NS

Functional differences of the sympathetic and parasympathetic nervous systems

Sympathetic nervous system:

1.All neurons forming this system originate from C8 to L2 segment of spinal cord. So it is called ***thoracolumbar*** outflow.

2.Pre-ganglionic fibers are short, relay either in paravertebral or ***prevertebral ganglia***

3.Post-ganglionic fibers are long nerve endings are adrenergic in nature except in sweat gland

4.Nerve endings are adrenergic in nature

5.Effect is widely diffused and directed towards mobilization of resources and expenditure of energy during emergency and emotional crisis

6.It supplies visceral blood vessels, skin. Afferents from viscera and specific area of skin reach the same spinal segment to go to the cerebrum. Since pain is better appreciated from the skin, it appears to be coming from skin rather than the viscera. This is the basis of referred pain.

Parasympathetic nervous system:

1. All neurons forming this system originate from brain (Ill, VII, IX, X cranial nerves) and S2—S4 segment of spinal cord. So it is called ***craniosacral*** outflow.

2. Pre-ganglionic fibers are very long reaching up to ***terminal ganglia*** mostly on viscera.

3. Postganglionic fibers are short

4. Nerve endings are cholinergic in nature

5. Effect is discrete, isolated, directed towards conservation and restoration of the resources of energy

6. It only supplies viscera. Parasympathetic system has no effect on skin

White Rami

Connecting the spinal nerves to each sympathetic trunk are rami communicantes.

Preganglionic axons are myelinated.

The white ramus has a whitish appearance

Carry preganglionic sympathetic axons from the C8–L2 spinal nerves to the sympathetic trunk.

Associated only with the C8–L2 spinal nerves.

Gray Rami

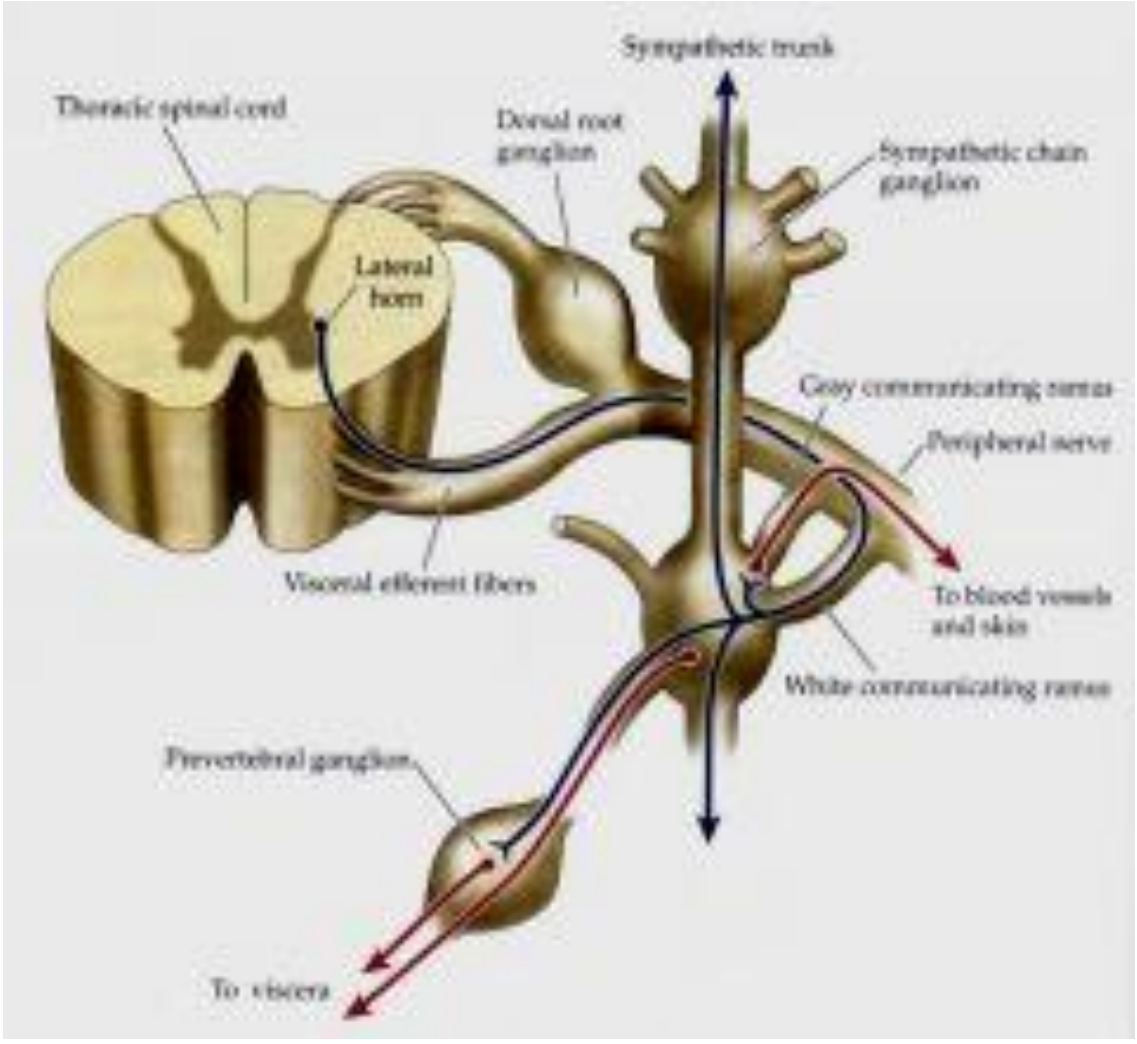
Carry postganglionic sympathetic axons from the sympathetic trunk to the spinal nerve.

Axons are unmyelinated.

Gray rami have a grayish appearance

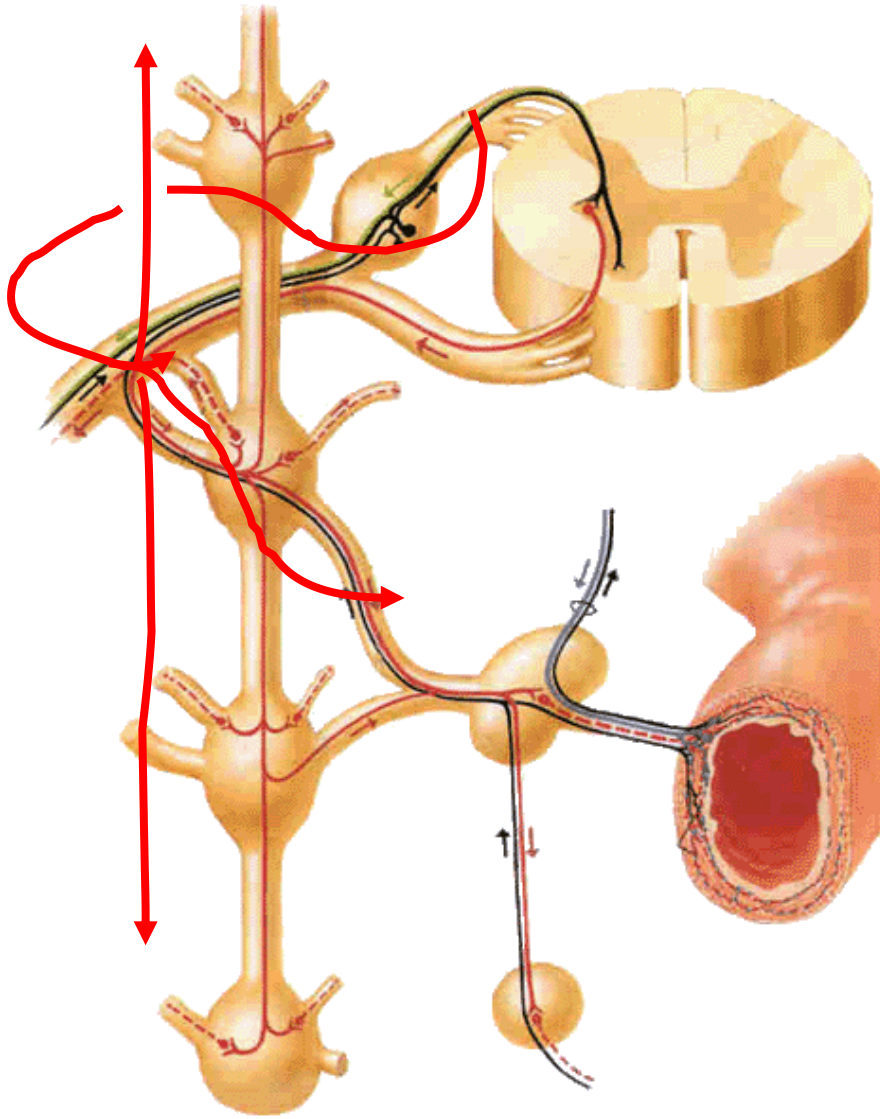
Connect to all spinal nerves.

Sympathetic information that starts in the thoracolumbar region can be dispersed to all parts of the body.



Three fates of preganglionic fibers

- **Relay in corresponding ganglion**
- **Ascend or descend in sympathetic trunk and relay in higher or lower ganglia**
- **Pass without synapse to a prevertebral ganglion for relay**

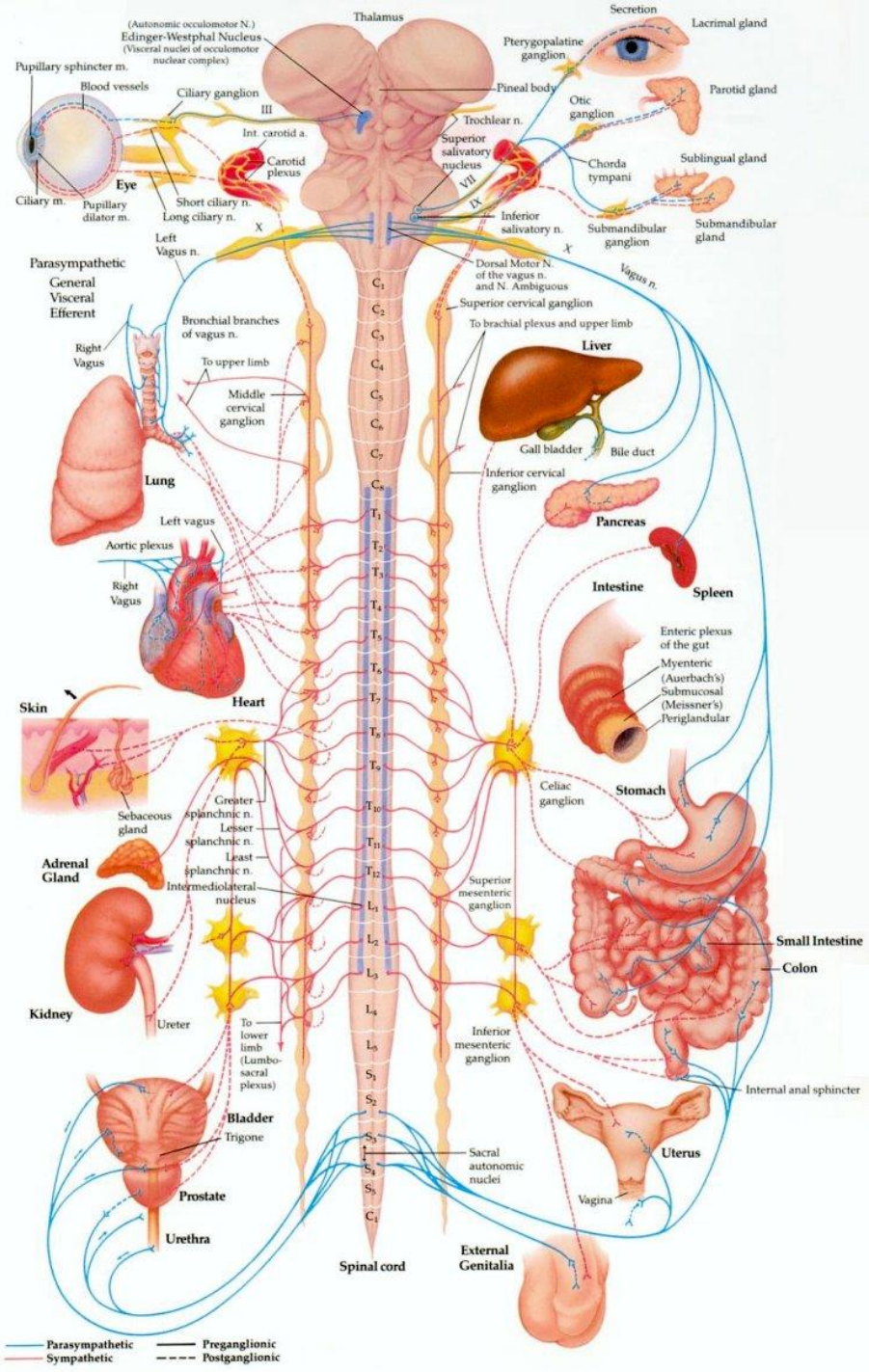


Main differences between somatic motor and visceral motor n.

	Somatic	Visceral
Effectors	Skeletal muscles	Cardiac, smooth muscles and glands
Kind of fibers	One	Two: sympathetic and parasympathetic
From lower center to effect require	Single neuron	Two neurons: preganglionic neuron (fiber) and postganglionic neuron (fiber)
Fibers	Thick myelinated	Preganglionic: thin myelinated postganglionic: unmyelinated
Distributive form	Nerve trunk	Nerve plexuses
Control	Voluntary (consciousness)	Involuntary (unconsciousness)

Divisions of the ANS

- Two divisions
  - Parasympathetic division
  - Sympathetic division
- Divisions are similar:
  - both use a preganglionic neuron (cell body in the CNS)
  - Both use a postganglionic neuron (cell body in the ganglion)
    - innervate muscles or glands.
  - Both are involuntary
  - Both are concerned with the body's internal environment (homeostasis)
- Divisions perform dramatically different functions.



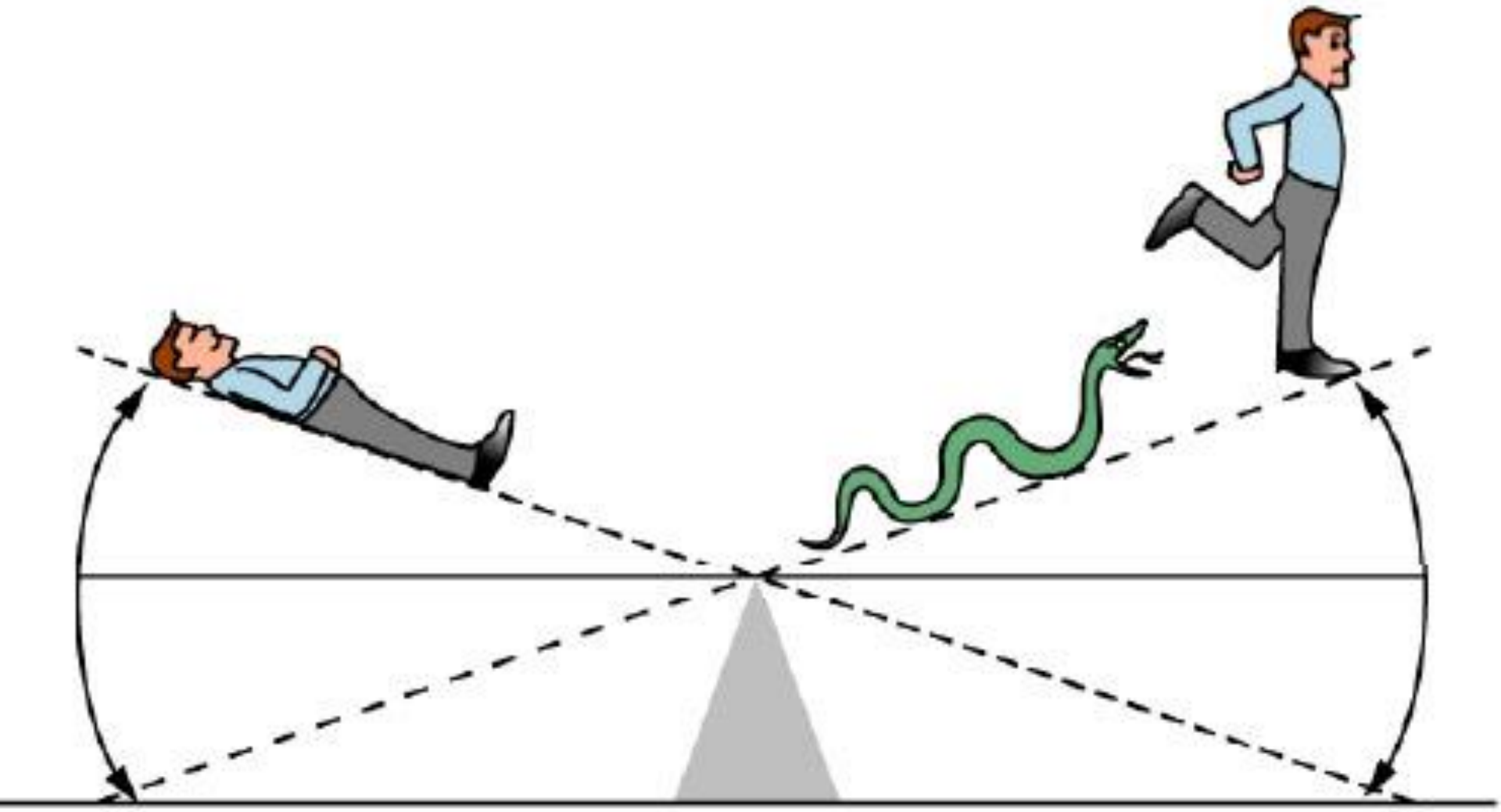
DIVISIONS OF THE VNS

Parasympathetic

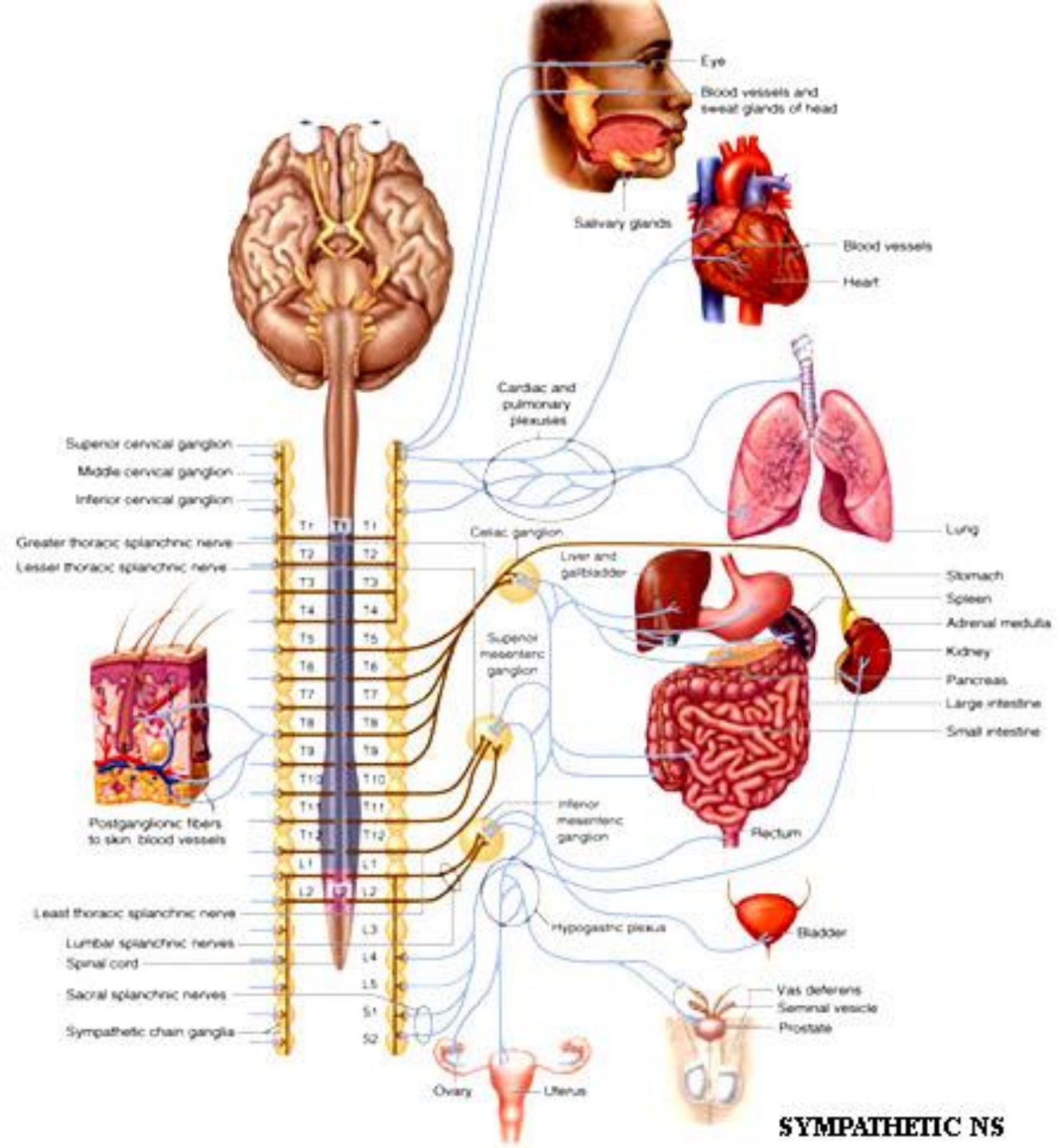
"rest-and-digest" division

Sympathetic

"fight-or-flight" division



Functions: Regulates body temperature. Coordinates CV, respiratory, excretory & reproductive activities.



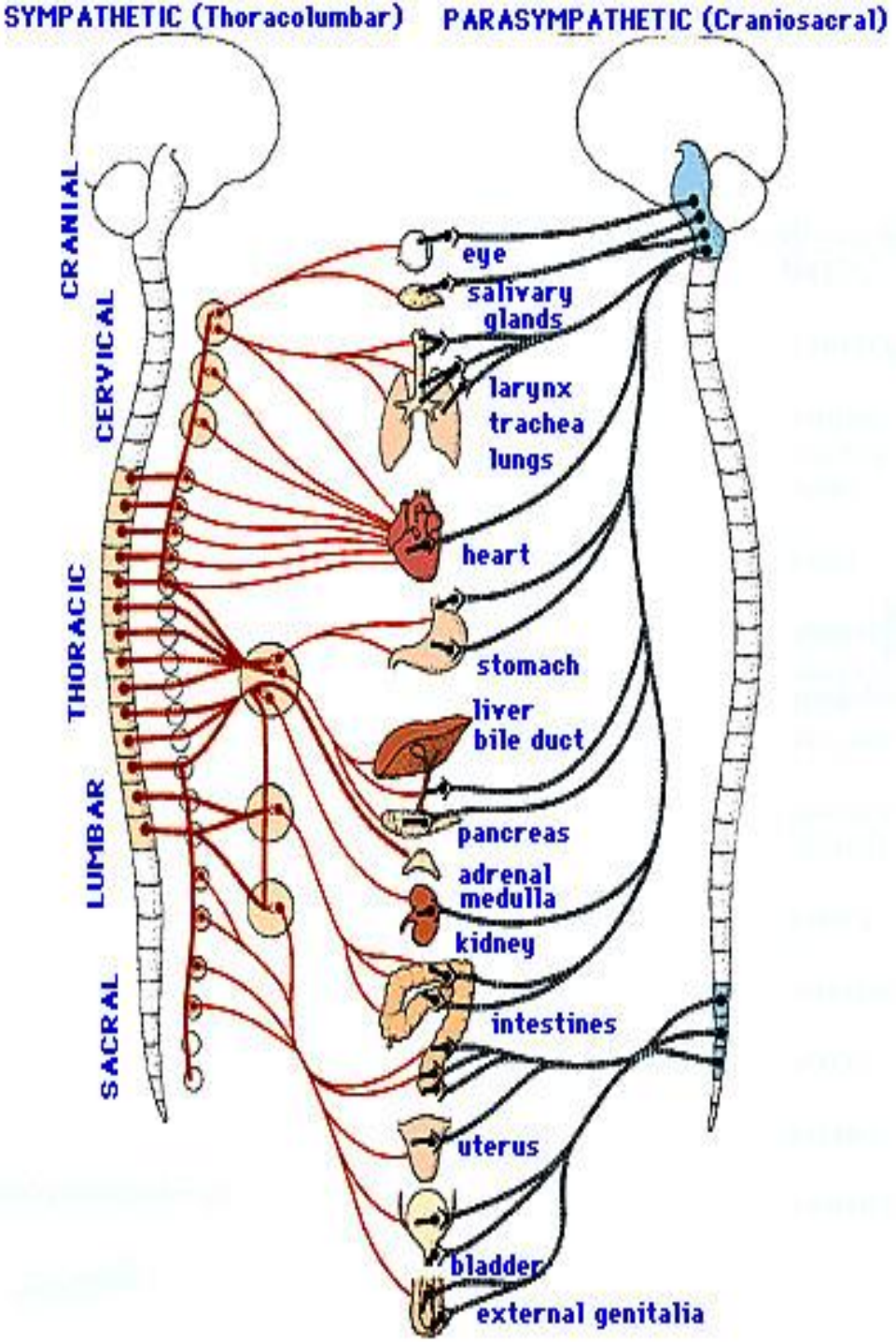
Sympathetic division

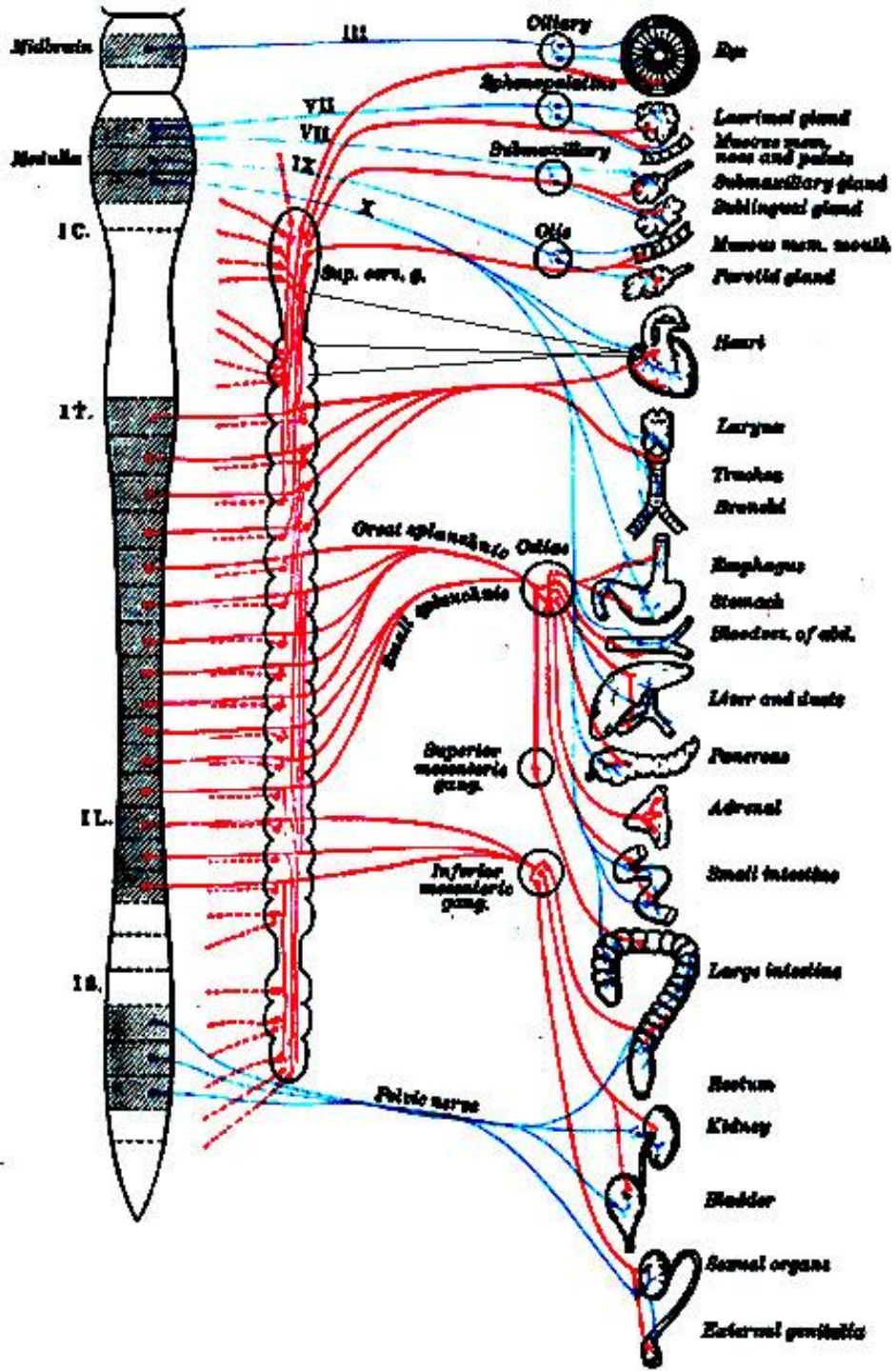
Preganglionic neurons

- **located within the lateral horn of the C8-L2 spinal segments**
- **their axons enter ventral roots of the C8-L2 spinal nerves**
- **axons synapse in sympathetic ganglia /para- or prevertebral/**
- **all preganglionic fibers are stimulatory**
- **fibers are divergent**
- **1 preganglionic fiber can synapse with 1 of ganglionic neurons**
- **Some of them are finished in sympathetic trunk (it consists of 20 – 23 ganglia) – 3 cervical, 10 – 12 thoracic, 3 – 4 lumbar, 4 pelvic.**
- **The rest fibers are going to the prevertebral ganglia or plexuses**

Sympathetic Nervous System

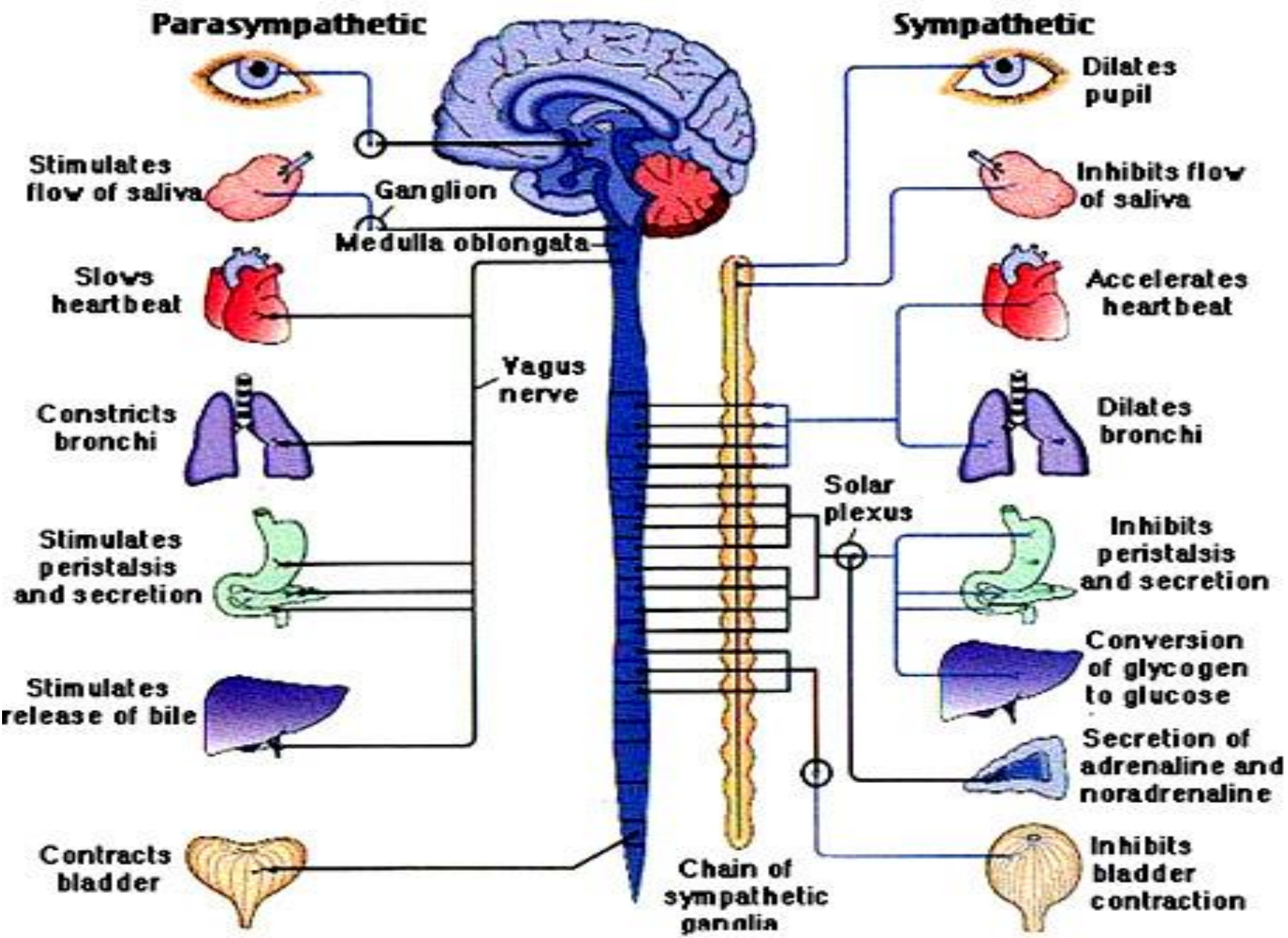
- Also called thoracolumbar system (T1-L2)
- Preganglionic cell bodies in lateral horn
- Preganglionic fibers leave spinal cord with ventral roots
- Leave spinal nerve via white rami communicans
- Postganglionic cell bodies are located in ganglia
  - Sympathetic chain (paravertebral)
  - Collateral (prevertebral)



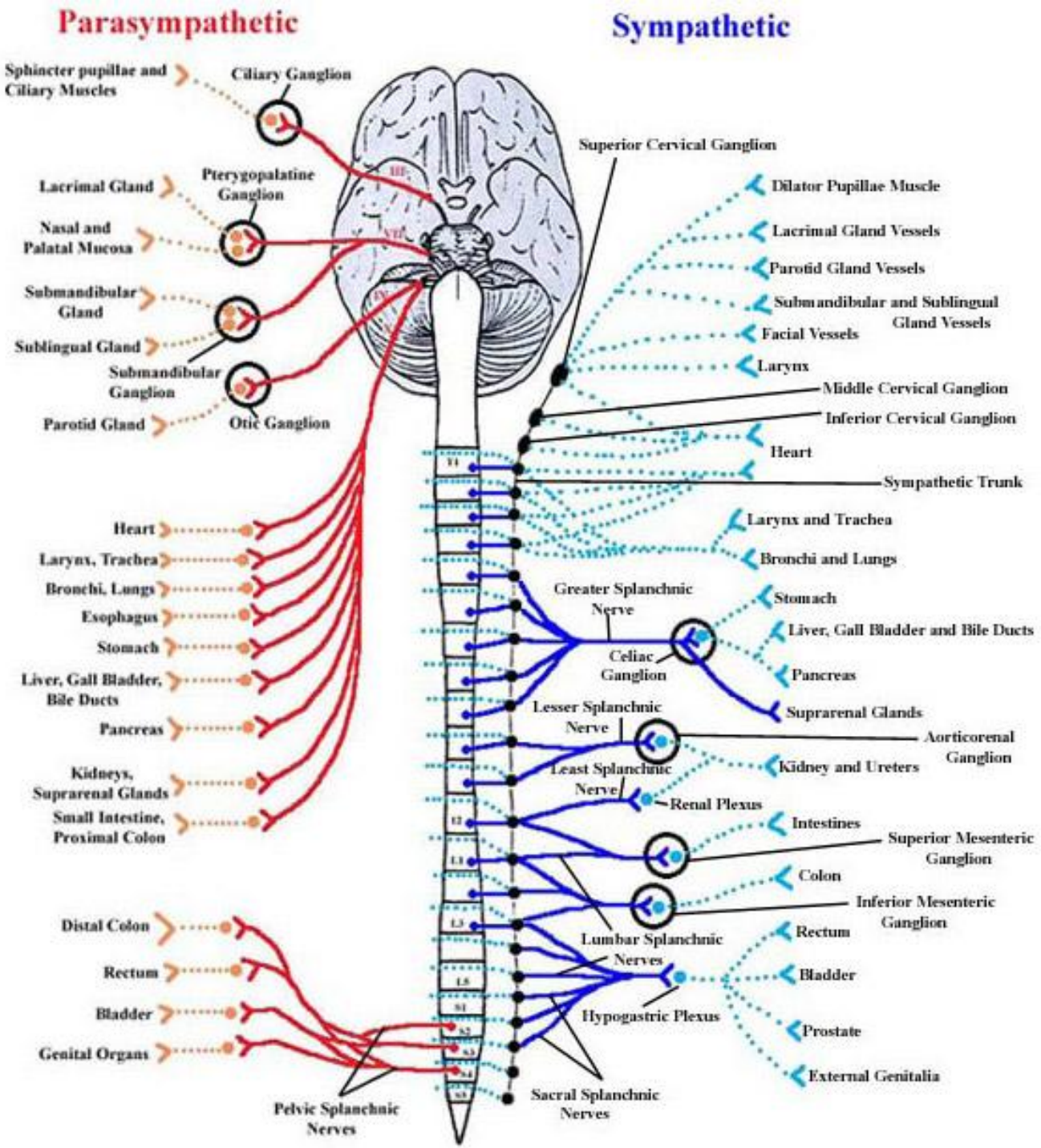


BRANCHES OF THE SYMPATHETIC CHAIN

- C1 g. — carotid nerves (ext., int)
  - jugular nerve
  - the larynx and pharynx
  - superior cervical nerve of the heart
- C2 g. — middle cervical nerve of the heart
  - subclavian branches
- C3 g. — branches to the vagus
  - and phrenicus nerves
  - inferior cervical nerve of the heart
- C3 +Th1= g. stelatum
  - rr. bronchiales - plexus pulmonaris
  - rr.esophagei
- Th1-Th4-5 — plexus aorticus thoracicus
  - nervi cardiaci thoracici
- Th5-9 — n. splanchnicus major
- Th10-12 — n.splanchnicus minor
- L1-5 — plexus aorticus abdominalis
  - rectalis
  - vesicalis
- S1-Co — plexus cavernosus penis
  - ductus deferentis
  - prostaticus
  - uterovaginalis



Actions of the VNS


Parasympathetic
Sympathetic
Sphincter pupillae and Ciliary Muscles
Ciliary Ganglion
Lacrimal Gland
Pterygopalatine Ganglion
Nasal and Palatal Mucosa
Submandibular Gland
Sublingual Gland
Submandibular Ganglion
Parotid Gland
Otic Ganglion
Heart
Larynx, Trachea
Bronchi, Lungs
Esophagus
Stomach
Liver, Gall Bladder, Bile Ducts
Pancreas
Kidneys, Suprarenal Glands
Small Intestine, Proximal Colon
Distal Colon
Rectum
Bladder
Genital Organs
Pelvic Splanchnic Nerves
Superior Cervical Ganglion
Dilator Pupillae Muscle
Lacrimal Gland Vessels
Parotid Gland Vessels
Submandibular and Sublingual Gland Vessels
Facial Vessels
Larynx
Middle Cervical Ganglion
Inferior Cervical Ganglion
Heart
Sympathetic Trunk
Larynx and Trachea
Bronchi and Lungs
Greater Splanchnic Nerve
Celiac Ganglion
Stomach
Liver, Gall Bladder and Bile Ducts
Pancreas
Suprarenal Glands
Lesser Splanchnic Nerve
Aorticorenal Ganglion
Kidney and Ureters
Least Splanchnic Nerve
Renal Plexus
Intestines
Superior Mesenteric Ganglion
Colon
Inferior Mesenteric Ganglion
Lumbar Splanchnic Nerves
Rectum
Bladder
Hypogastric Plexus
Prostate
External Genitalia
Sacral Splanchnic Nerves

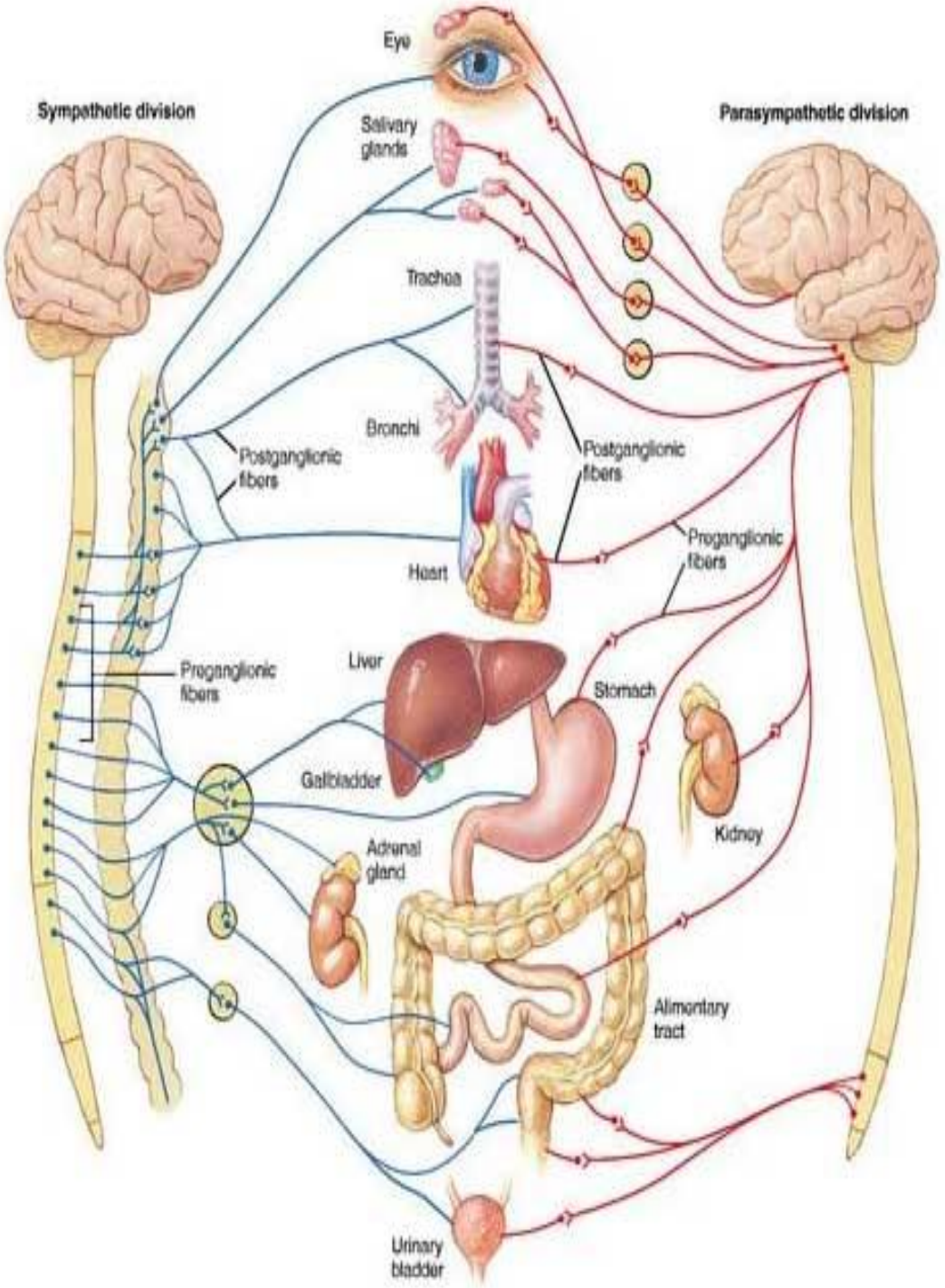
Structural differences of the sympathetic and parasympathetic nervous systems

SNS

- **central**
  - C8-L2
- **peripheral**
  - fibers
    - preganglionic
    - postganglionic
  - ganglia
    - paravertebral
    - prevertebral

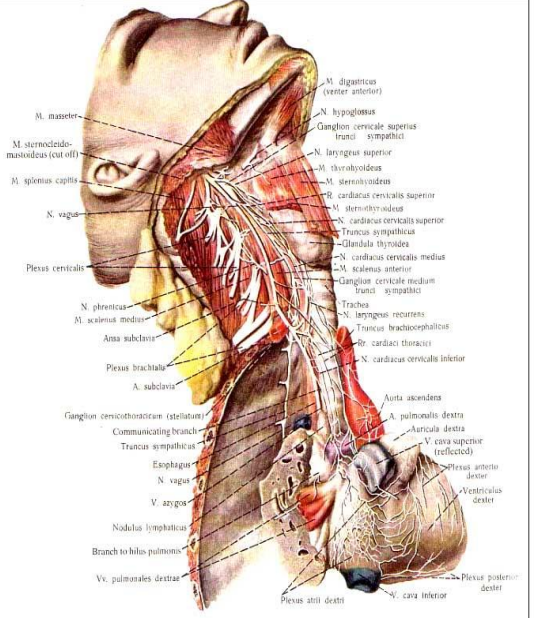
PSNS

- **central**
  - Brain stem
  - S2-S4
- **peripheral**
  - fibers
    - preganglionic
    - postganglionic
  - ganglia
    - terminal
    - intramural

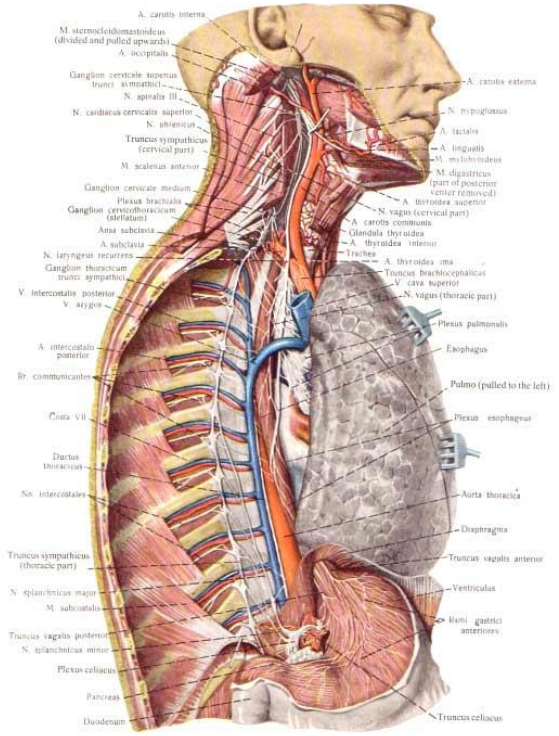


Left and Right Sympathetic Trunks

- Immediately anterior to the paired spinal nerves are the left and right sympathetic trunks.
- Each is located immediately lateral to the vertebral column.
- A sympathetic trunk is like a pearl necklace:
  - the "string" of the "necklace" is composed of bundles of axons
  - the "pearls" are the sympathetic trunk (or paravertebral) ganglia
    - house sympathetic ganglionic neuron cell bodies
- One sympathetic trunk ganglion is approximately associated with each spinal nerve.
- Cervical portions
  - three sympathetic trunk ganglia
    - superior, middle, and inferior cervical ganglia
    - opposed to the eight cervical spinal nerves.



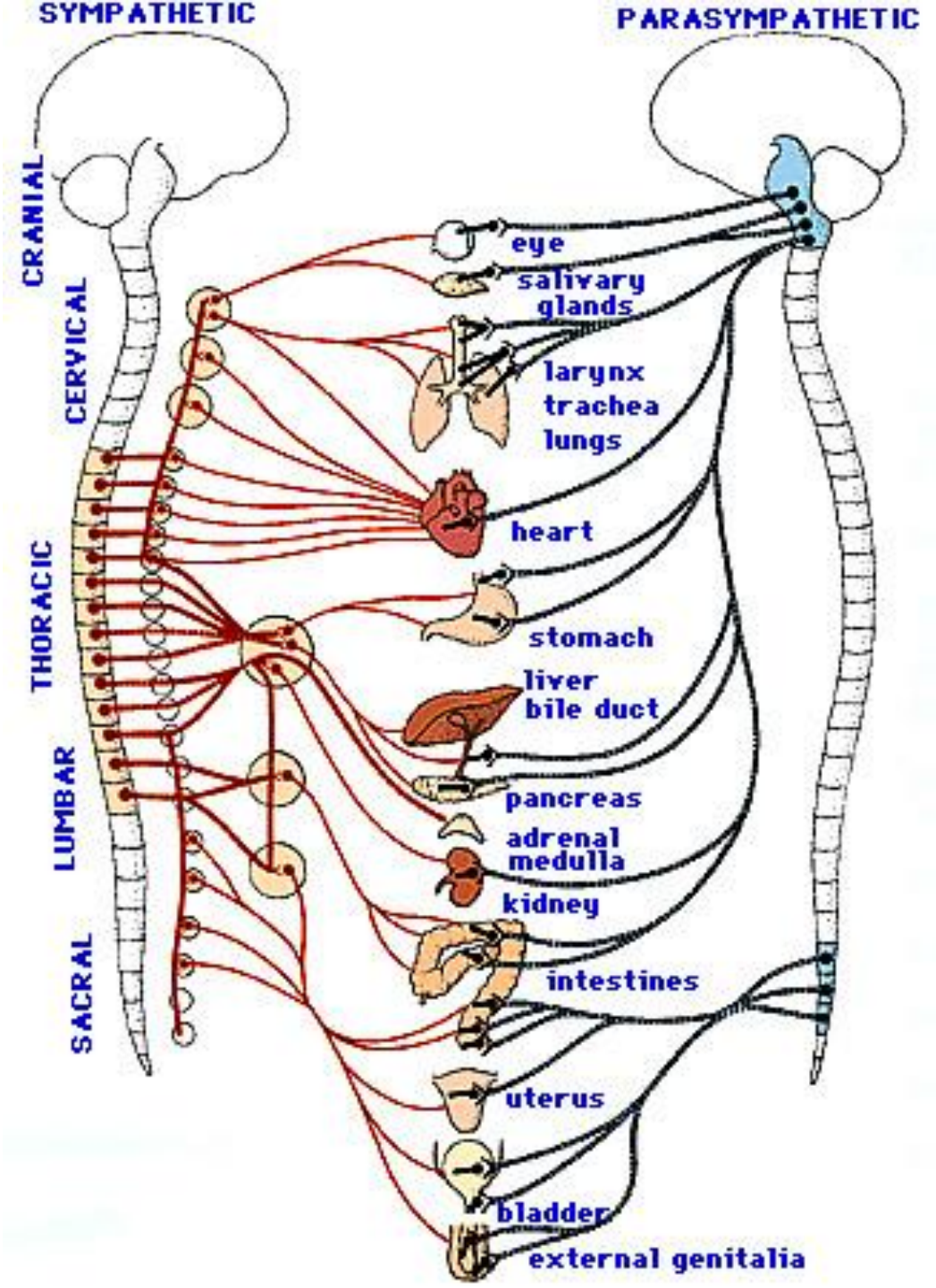
Cervical ganglia, nerves of the heart

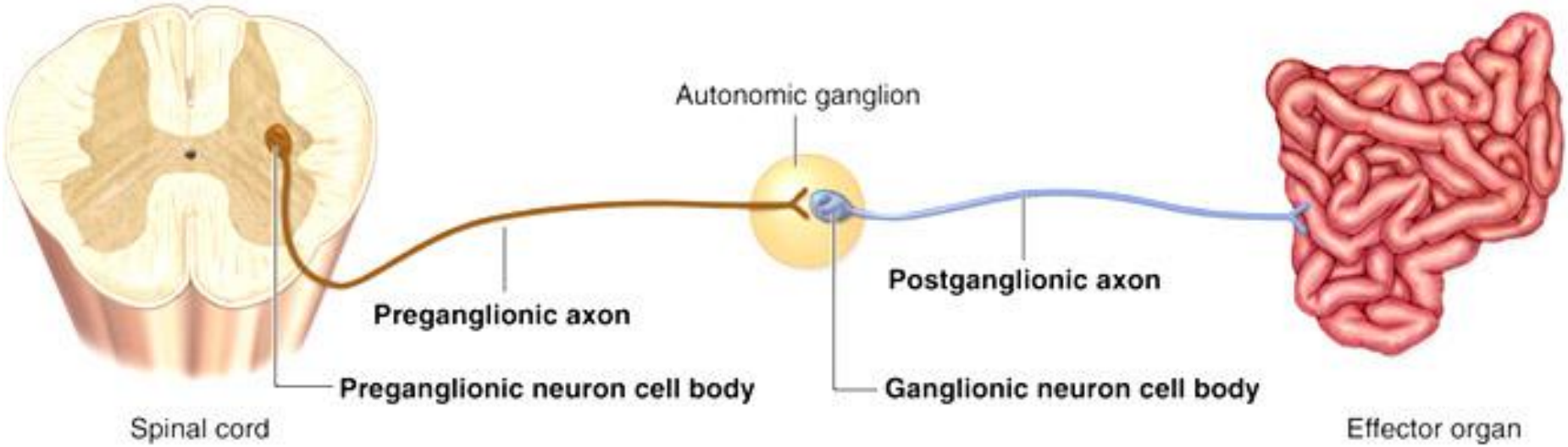


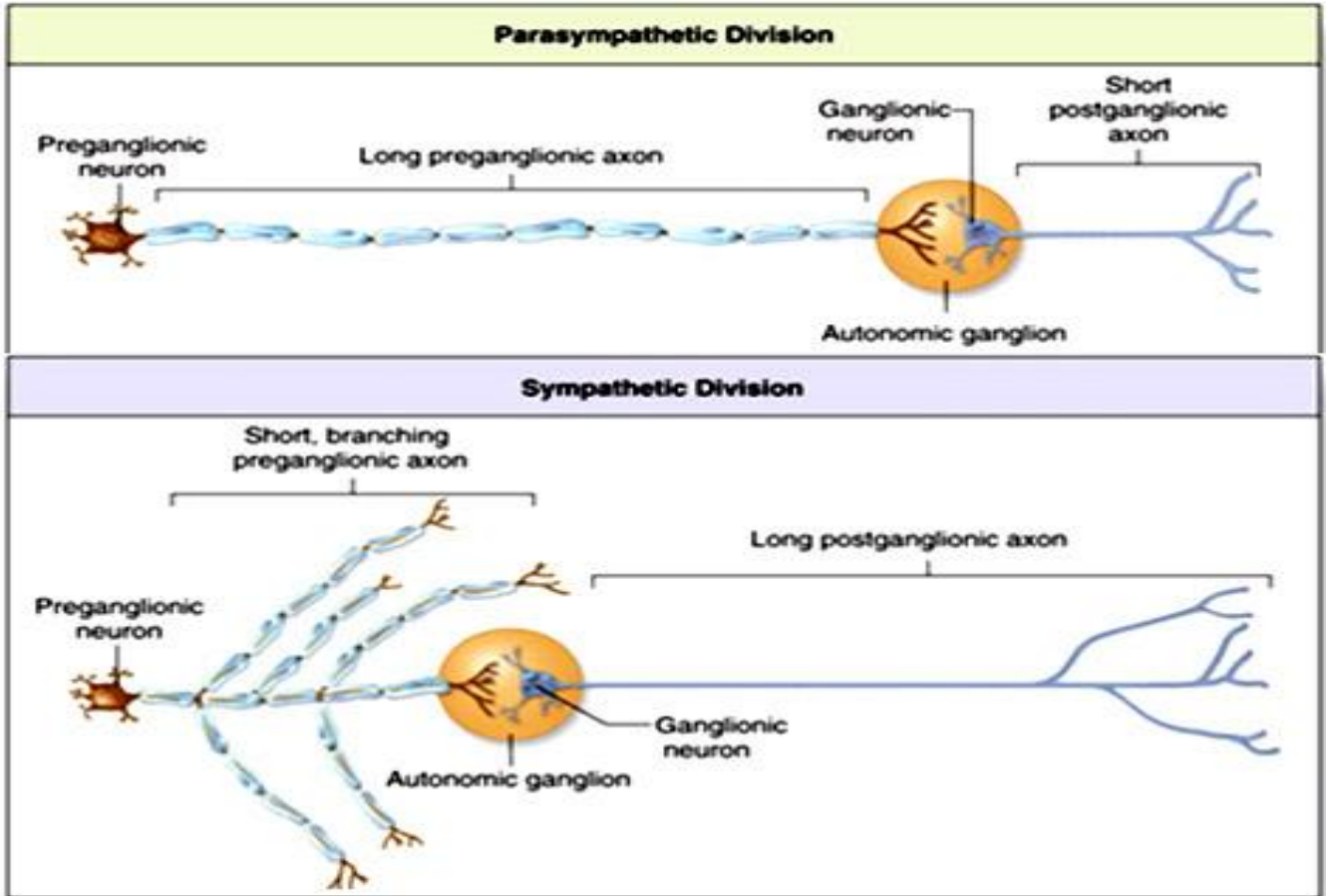
Nerves and plexuses of thoracic organs; right aspect (¾).

SPLANCHNIC NERVES

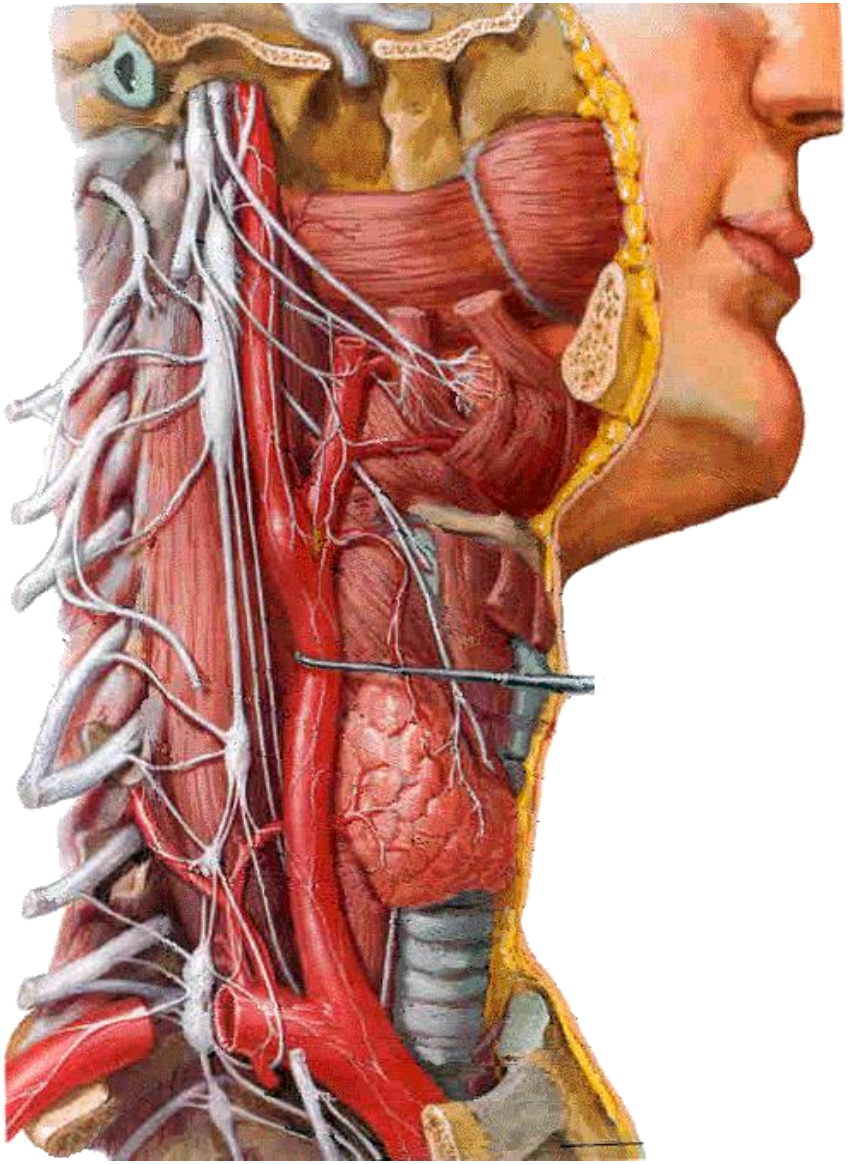
- **Composed of preganglionic sympathetic axons.**
- **Run anteriorly from the sympathetic trunk to most of the viscera.**
- **Should not be confused with the pelvic splanchnic nerves associated with the parasympathetic division.**
- **Larger splanchnic nerves have specific names:**
  - ***greater thoracic splanchnic nerves***
  - ***lesser thoracic splanchnic nerves***
  - ***least thoracic splanchnic nerves***
  - ***lumbar splanchnic nerves***
  - ***sacral splanchnic nerves***
- **Terminate in prevertebral (or collateral) ganglia called "prevertebral" because they are immediately anterior to the vertebral column.**
- **Prevertebral ganglia typically cluster around the major abdominal arteries and are named for these arteries.**

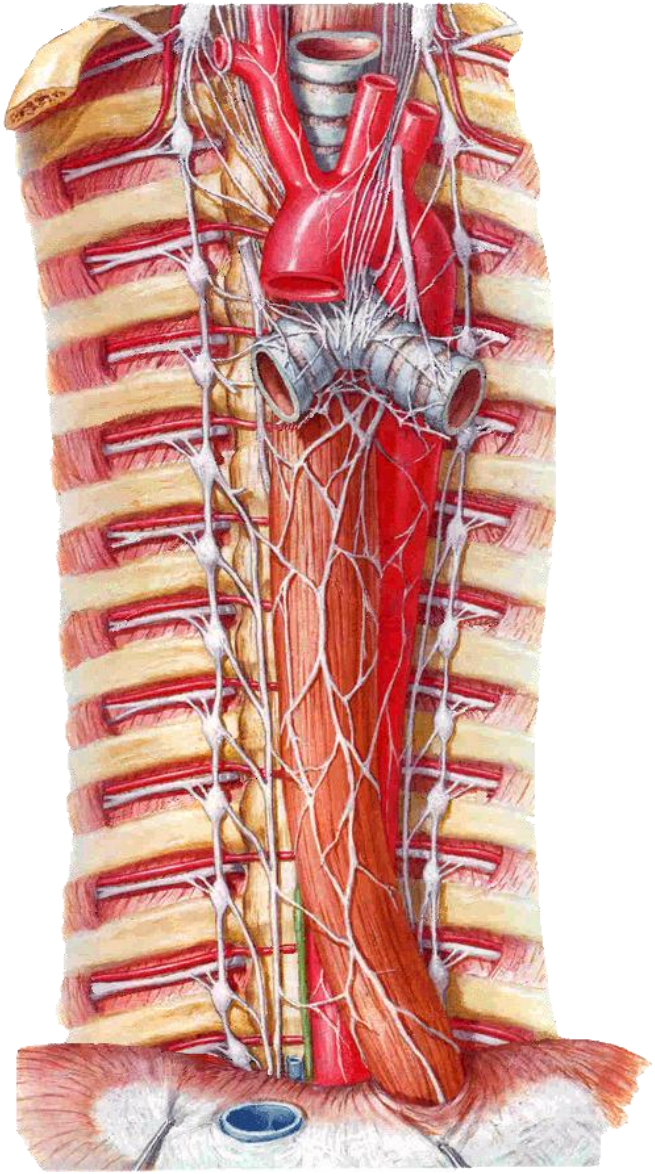


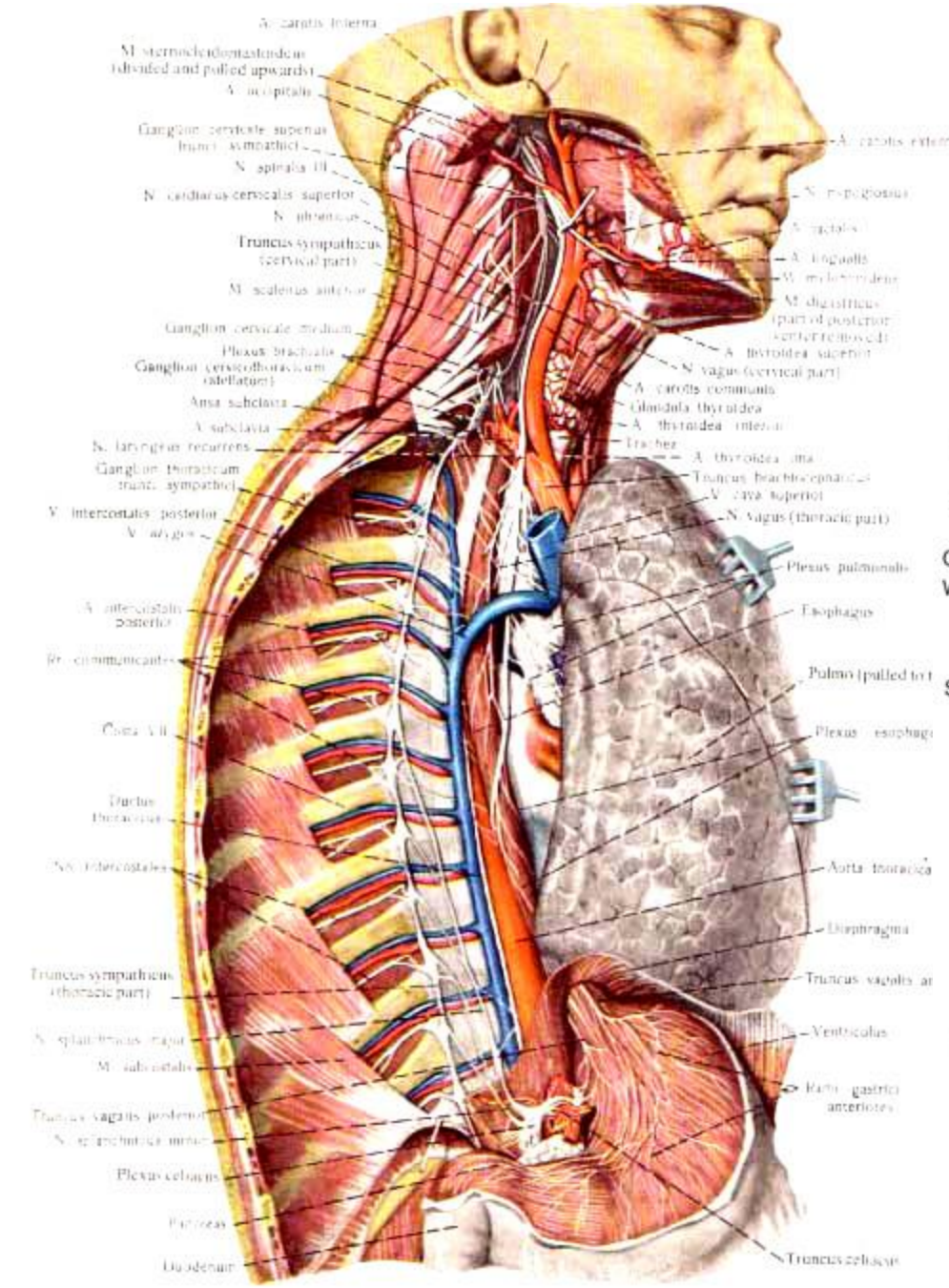

Autonomic ganglion
Postganglionic axon
Preganglionic axon
Preganglionic neuron cell body
Ganglionic neuron cell body
Spinal cord
Effector organ

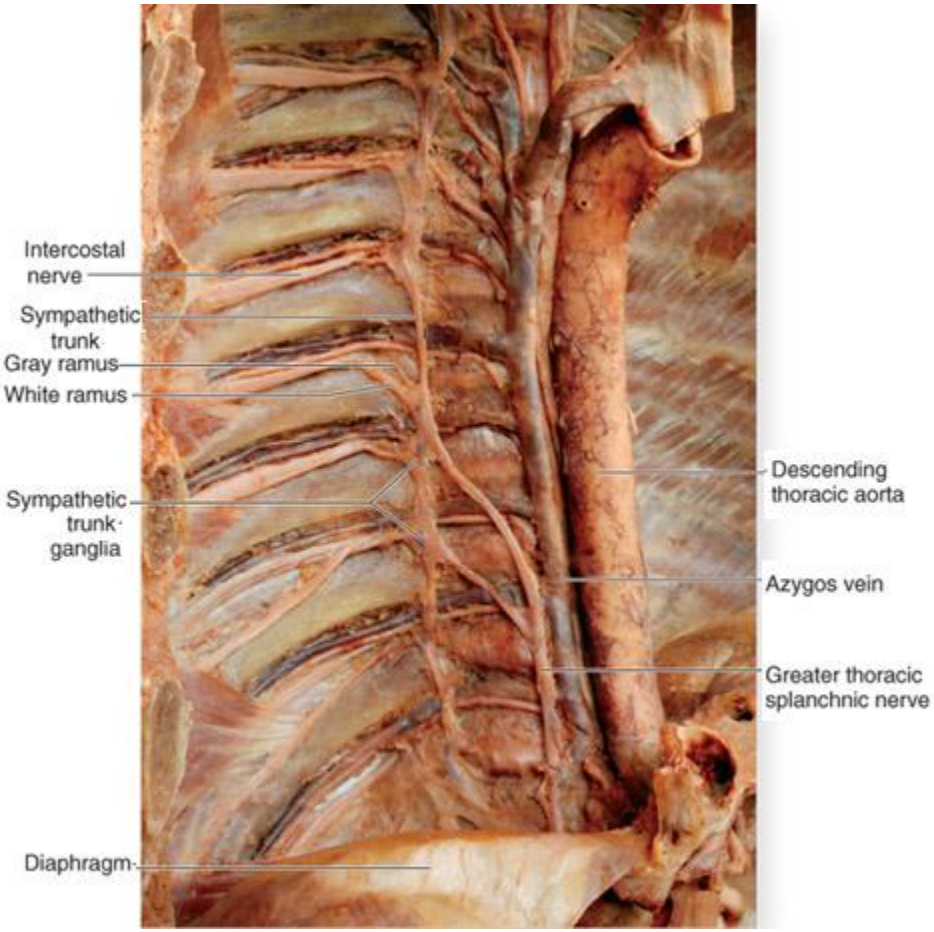

Parasympathetic Division
Preganglionic neuron
Long preganglionic axon
Ganglionic neuron
Short postganglionic axon
Autonomic ganglion
Sympathetic Division
Short, branching preganglionic axon
Long postganglionic axon
Preganglionic neuron
Ganglionic neuron
Autonomic ganglion

Cervical and thoracic divisions of the sympathetic trunk









Nerves and plexuses of thoracic organs; right aspect (¼).

TYPES OF PREVERTEBRAL GANGLIA

Differ from the sympathetic trunk ganglia.

Are single structures, rather than paired.

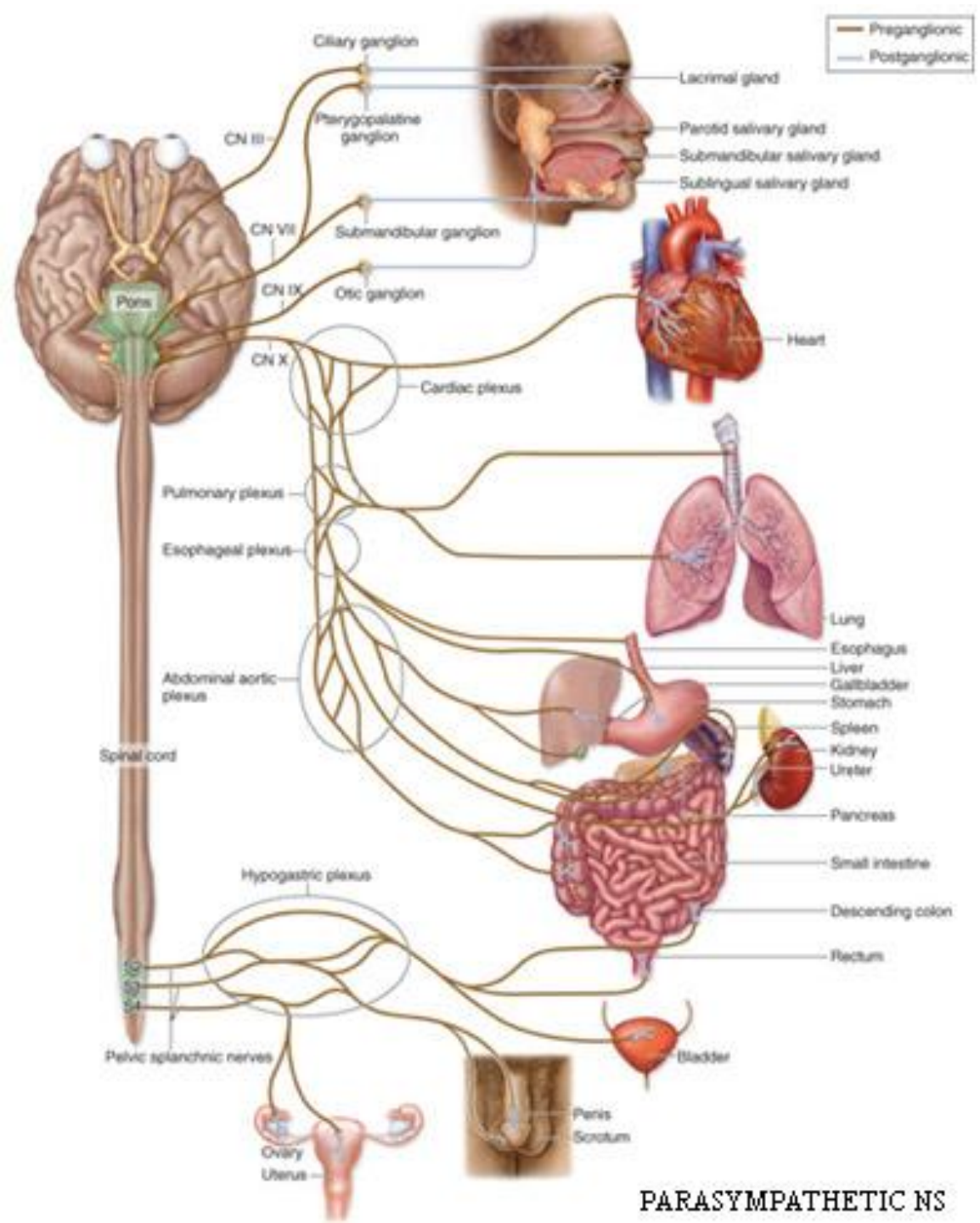
Are anterior to the vertebral column, on the

anterior surface of the aorta.

Located only in the abdominopelvic cavity.

Prevertebral ganglia include:

- **the celiac ganglion**
- **superior mesenteric ganglion**
- **interior mesenteric ganglion.**

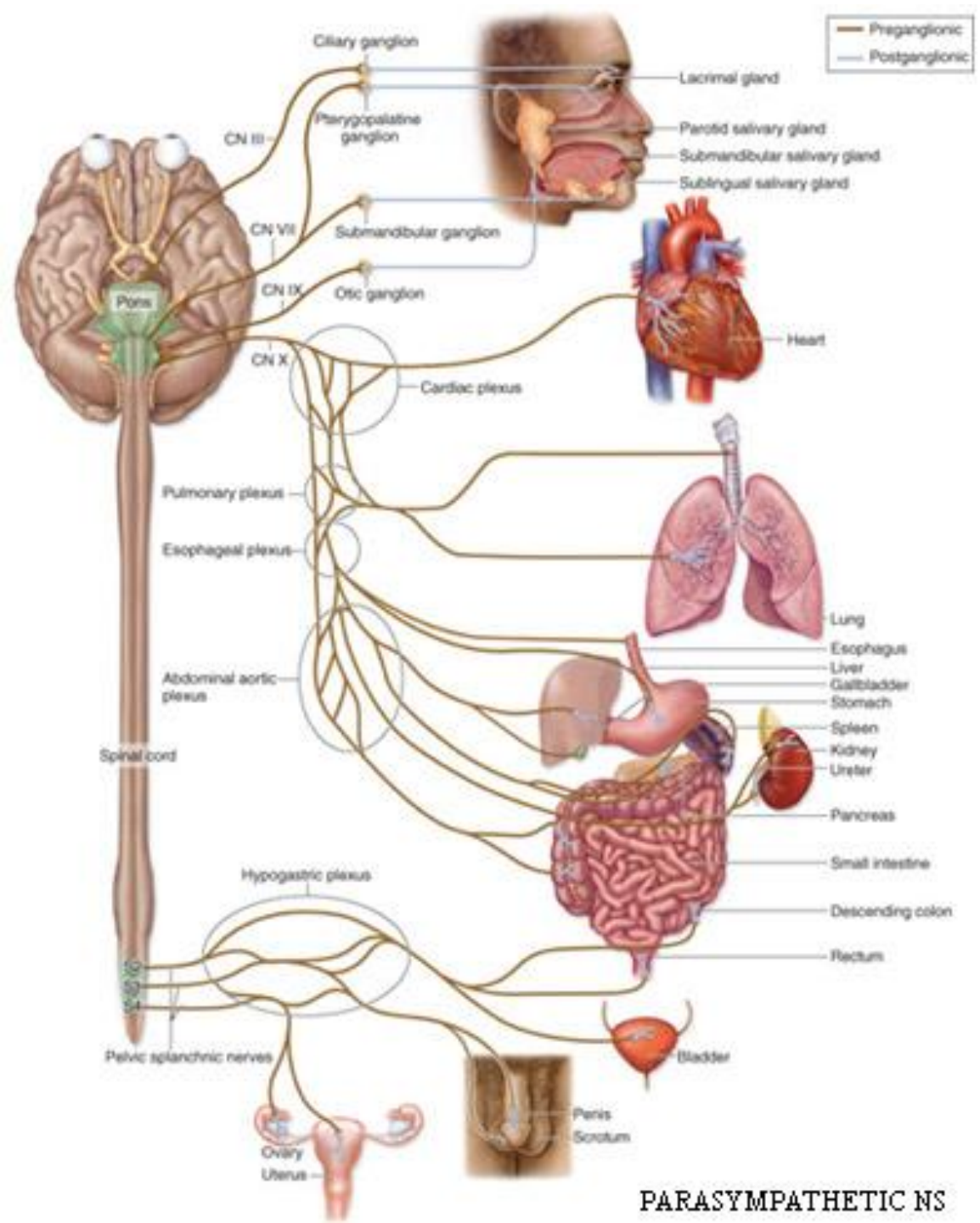


Parasympathetic division

is also termed the *craniosacral division* because its preganglionic neurons are:

- **housed within nuclei in the brainstem, within the lateral gray regions of the S2–S4 spinal cord segments.**

Postganglionic neurons in the parasympathetic division are found in *terminal ganglia:* are located close to the target organ & *intramural ganglia:* located within the wall of the target organ.



Two sources of parasympathetic preganglionic fibers

1) the brain stem via cranial nerves III, VII, IX, X
2) sacral part of spinal cord visa spinal nerves S2 through S4

parasympathetic ganglia lie in body close to organ or body part innervated, thus preganglionic parasympathetic fibers tend to be long.

Preganglionic fibers remain in cranial or sacral nerve in which they exited CNS until they reach target.

All organs of body except liver receive parasympathetic input, but skin and blood vessels generally not innervated.

Function:

When stimulated, heart rate decreases, blood pressure falls, blood is directed away from skeletal muscles to viscera

Generally relaxes body, although increases activity in digestive system and a few other organs

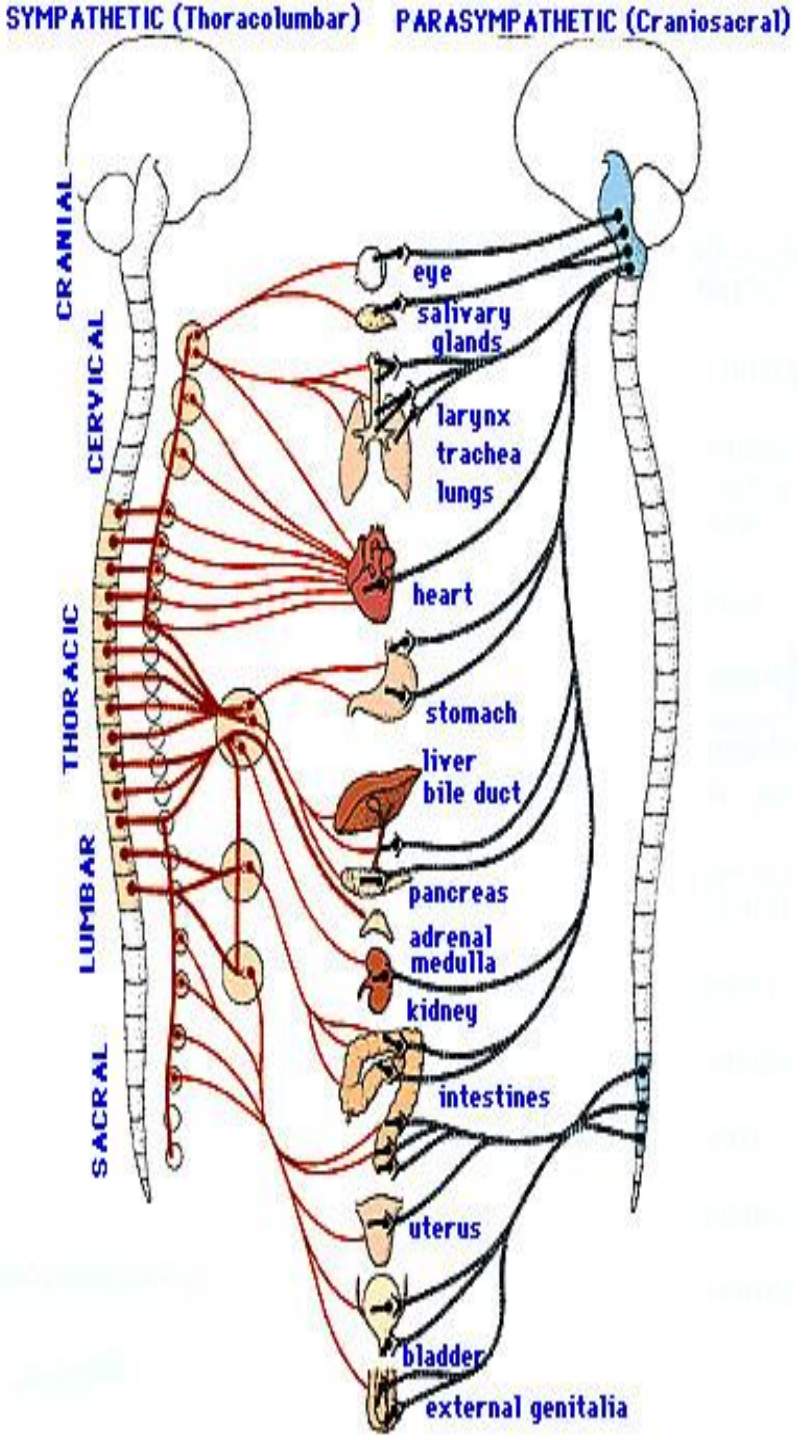
Parasympathetic nervous system

- Mesencephalic level (nuclei of Perlea and Yakubovich), the fibers are going within the III CN and provide innervating of m. Sphincter pupillae, m. Ciliaris

- Pontine level (n.salivatorius superior)

- Bulbar (n.salivatorius inferior et n. dorsalis nervi Vagi) within VII, IX, X CN's innervate parotid, sublingual, submandibular glands and internal organs (except the pelvic organs)

- Sacral part – the cells of lateral horn S2 – S4 – innervating of pelvic organs



Vegetative component of the cranial nerves

Nerves associated with the parasympathetic division:

the oculomotor (CN III)

facial (CN VII)

glossopharyngeal (CN IX)

vagus (CN X)

First three **of these nerves convey parasympathetic innervation to the head.**

Vagus nerve **is the source of parasympathetic stimulation for:**

organs of the neck,

thoracic organs,

most abdominal organs.

Parasympathetic nervous system

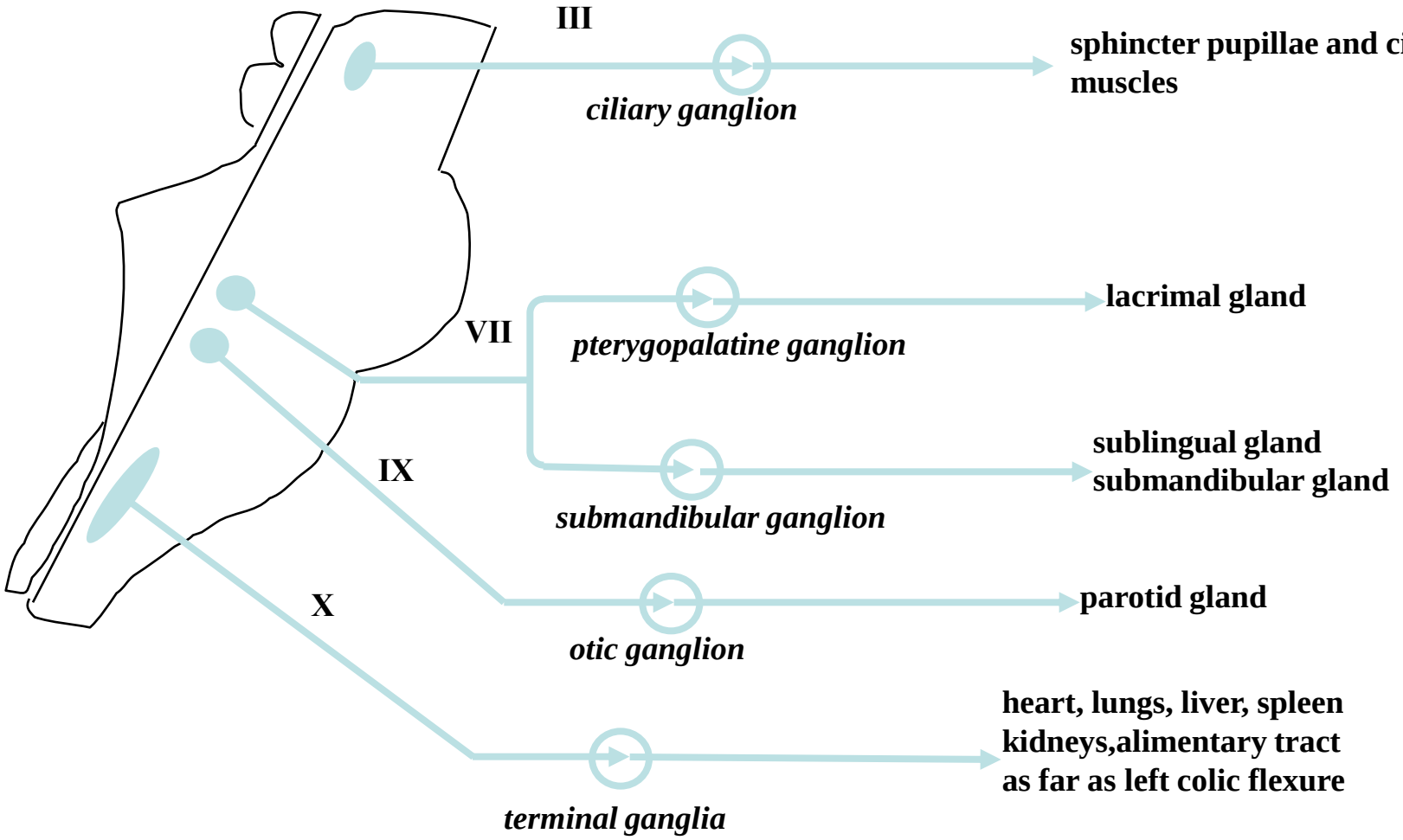
Cerebral part

nuclei	nerve	Neuron-effector	Region of the supply
n.Iacubovich n.Perl	III */oculomotorius/*	g.ciliare /in the orbit/	m.constrictor pupilae m.ciliaris
n.salivatorius superior	VII */facial/*	g.sphenopalatinum /fossa pterygopalatina/ g.submandibulare /fossa glandlae submandibularis/	gl. lacrimalis +glandulae mucosae /nose+mouth/ gl.submandibularis gl.sublingualis
n.salivatorius inferior	IX */glossopharyngeus/*	g.oticum /foramen ovale/	gl.parotidea
n.dorsalis	X */vagus/*	gg. terminales gg. intramurales	Internal organs of the neck, thorax, abdominal cavity /to the level of the descendens colon/

Sacral part:

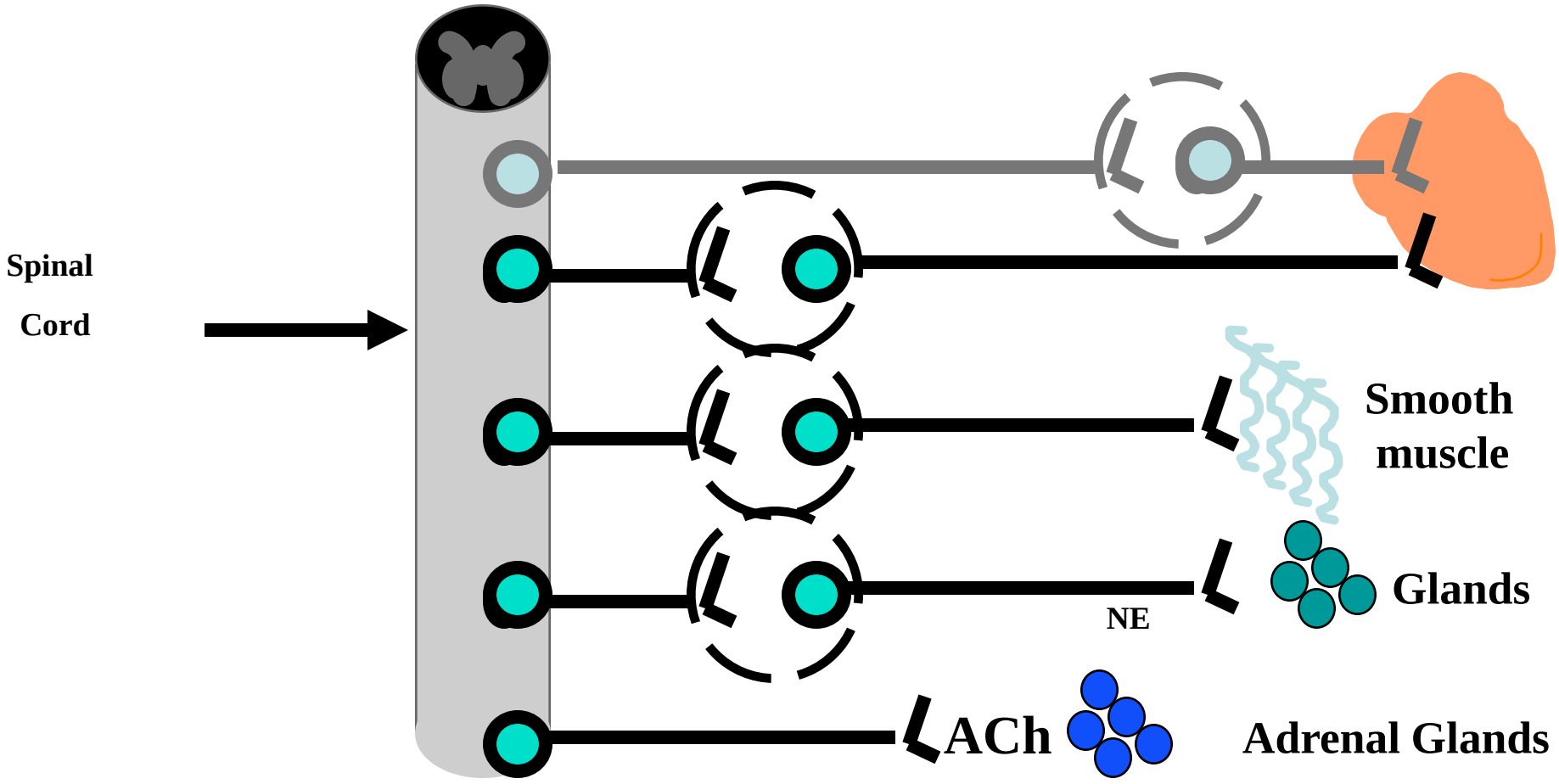
* supplies the descendens colon, sigmoid colon, organs of the pelvis

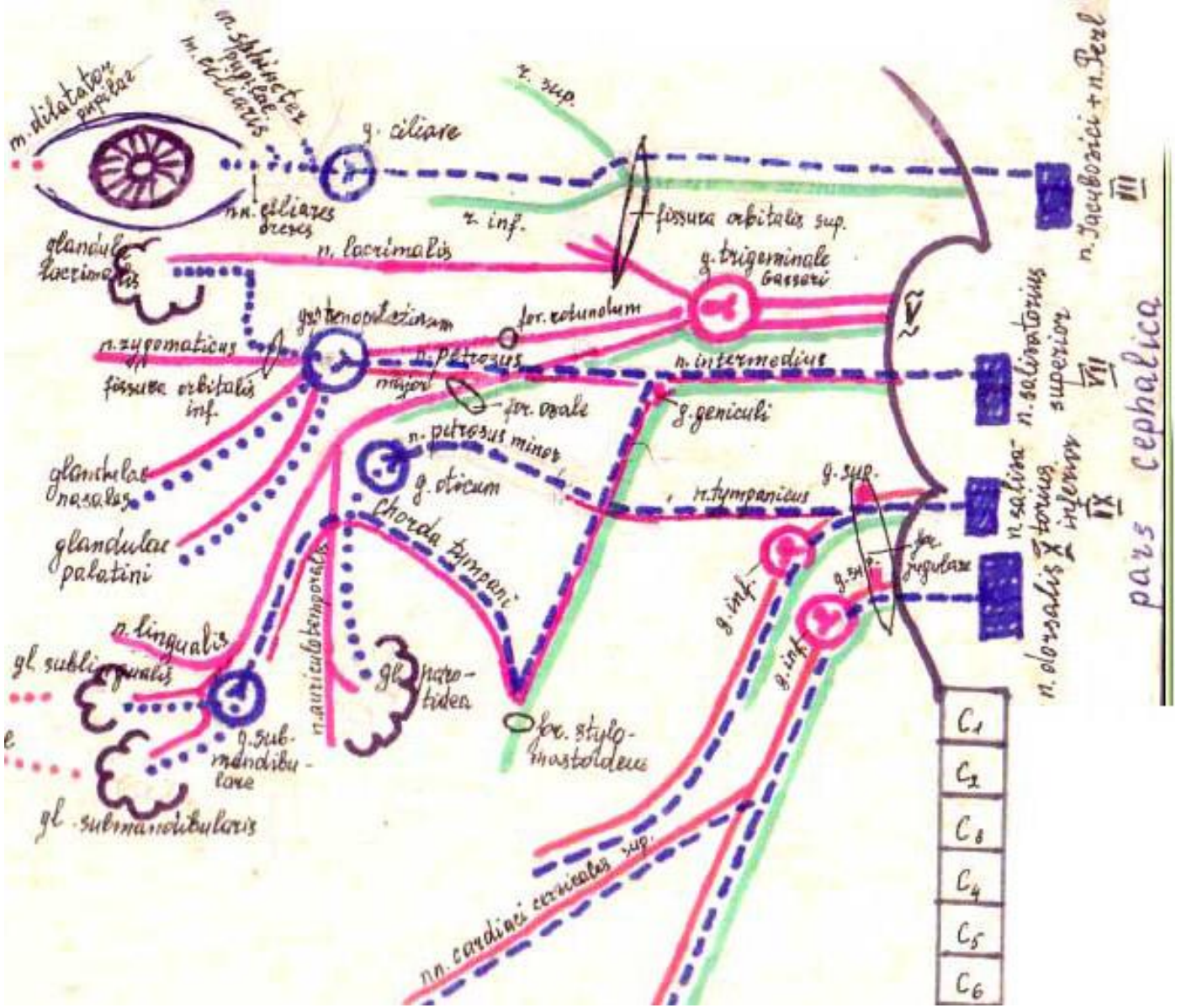
Cranial portion



Parasympathetic

Sympathetic





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Dual Innervation of the organs by the ANS

Many viscera are innervated by postganglionic axons from both ANS divisions.

Both types of autonomic fibers form autonomic plexuses around each organ.

Nerve impulses are transmitted by chemical messengers, called *neurotransmitters,* specific in each division of the autonomic nervous system

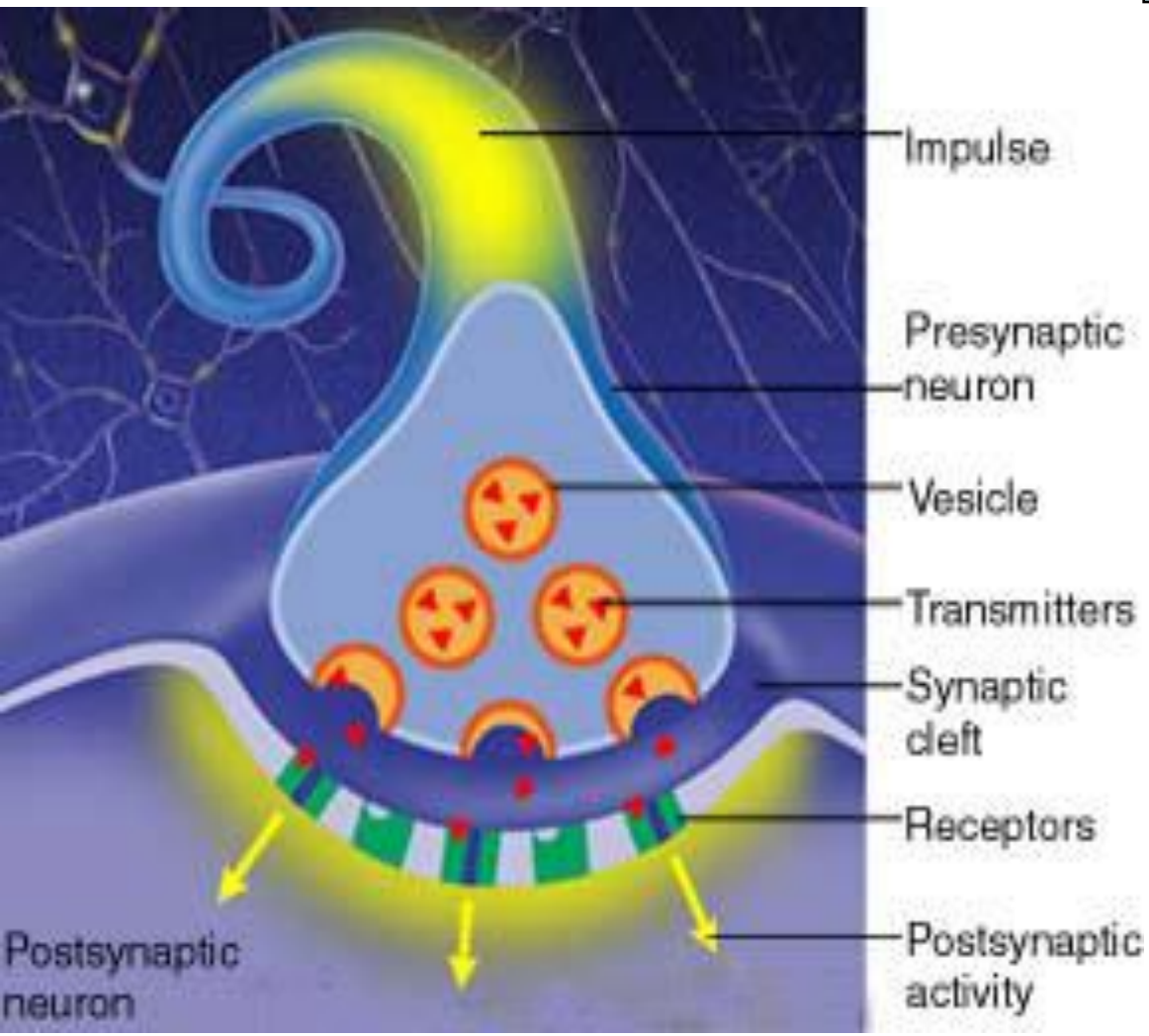
Maintains homeostasis through autonomic reflexes that occur in the innervated organs.

Actions of the divisions usually oppose each other.

Divisions of ANS exert antagonistic effects on the same organ

opposing effects are also achieved by increasing or decreasing activity in one division.

Neurotransmitters and Receptors



Two neurotransmitters are used in the ANS: acetylcholine (ACh)

norepinephrine (NE)

Neurotransmitters are released by the presynaptic cell.

Bind to specific receptors in the postsynaptic cell membrane.

Binding has either an excitatory or an inhibitory effect on the effector, depending on the specific receptor.

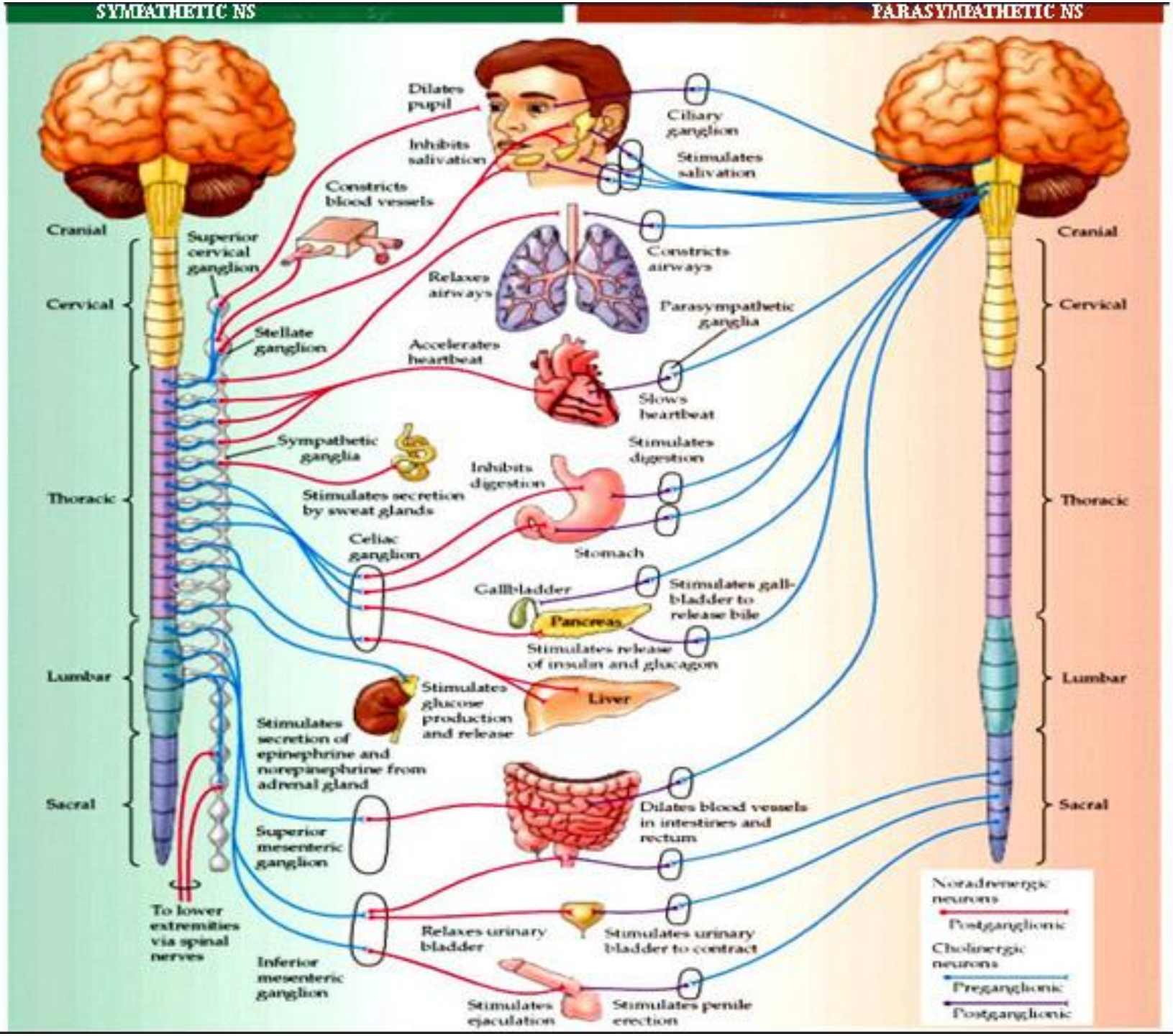
Both the preganglionic and postganglionic axons in the parasympathetic division release acetylcholine and thus are called *cholinergic*.

The preganglionic axon and a few postganglionic axons in the sympathetic division are also *cholinergic*.

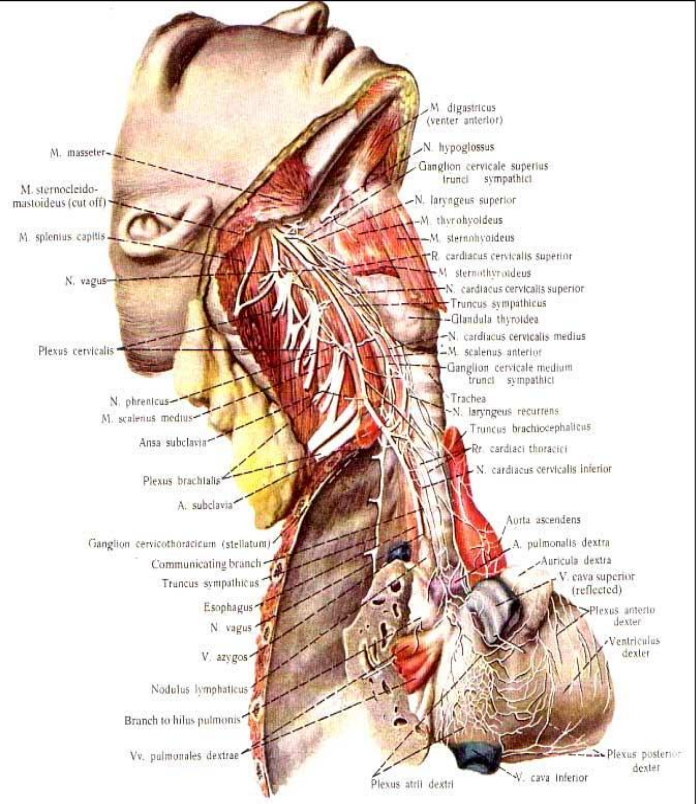
Most of the postganglionic axons of the sympathetic division release norepinephrine and are called *adrenergic*.

adrenergic neurons

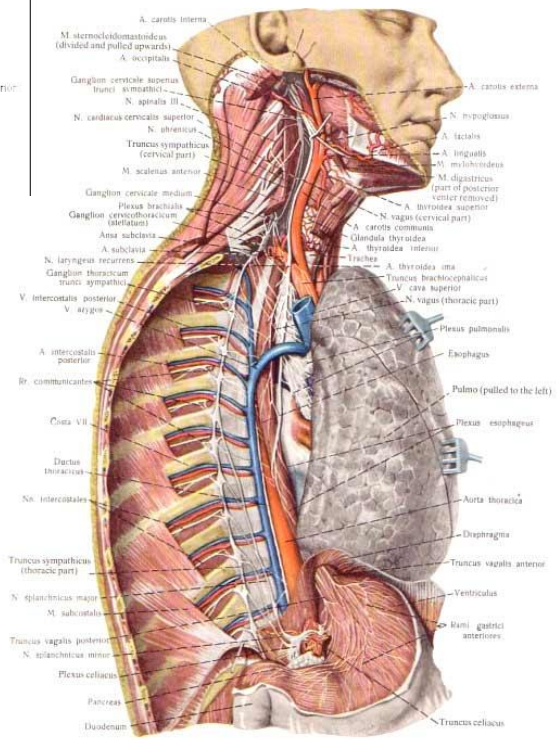
cholinergic neurons



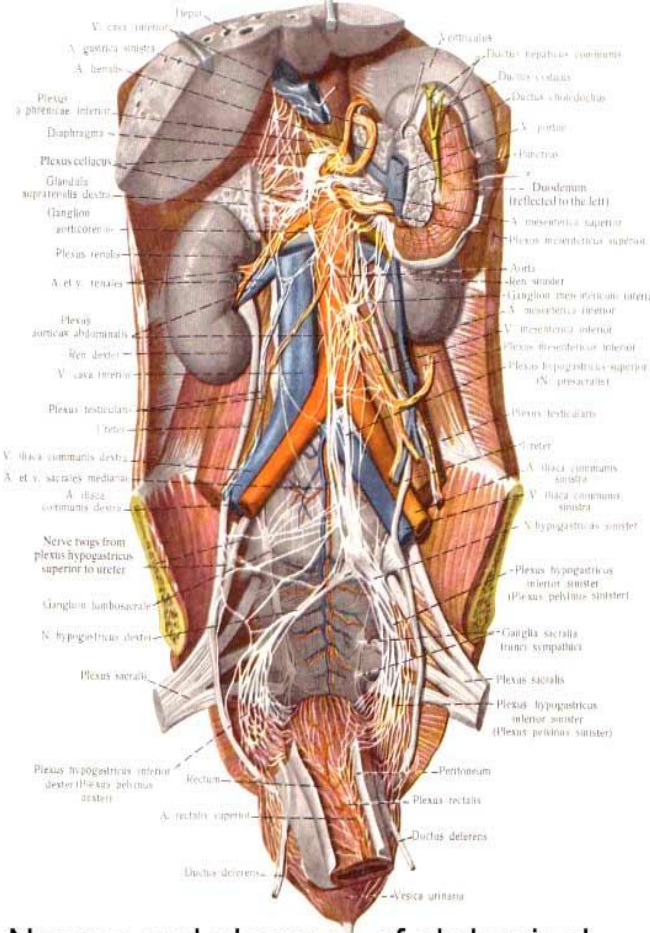
Vegetative plexuses



Cervical ganglia, nerves of the heart

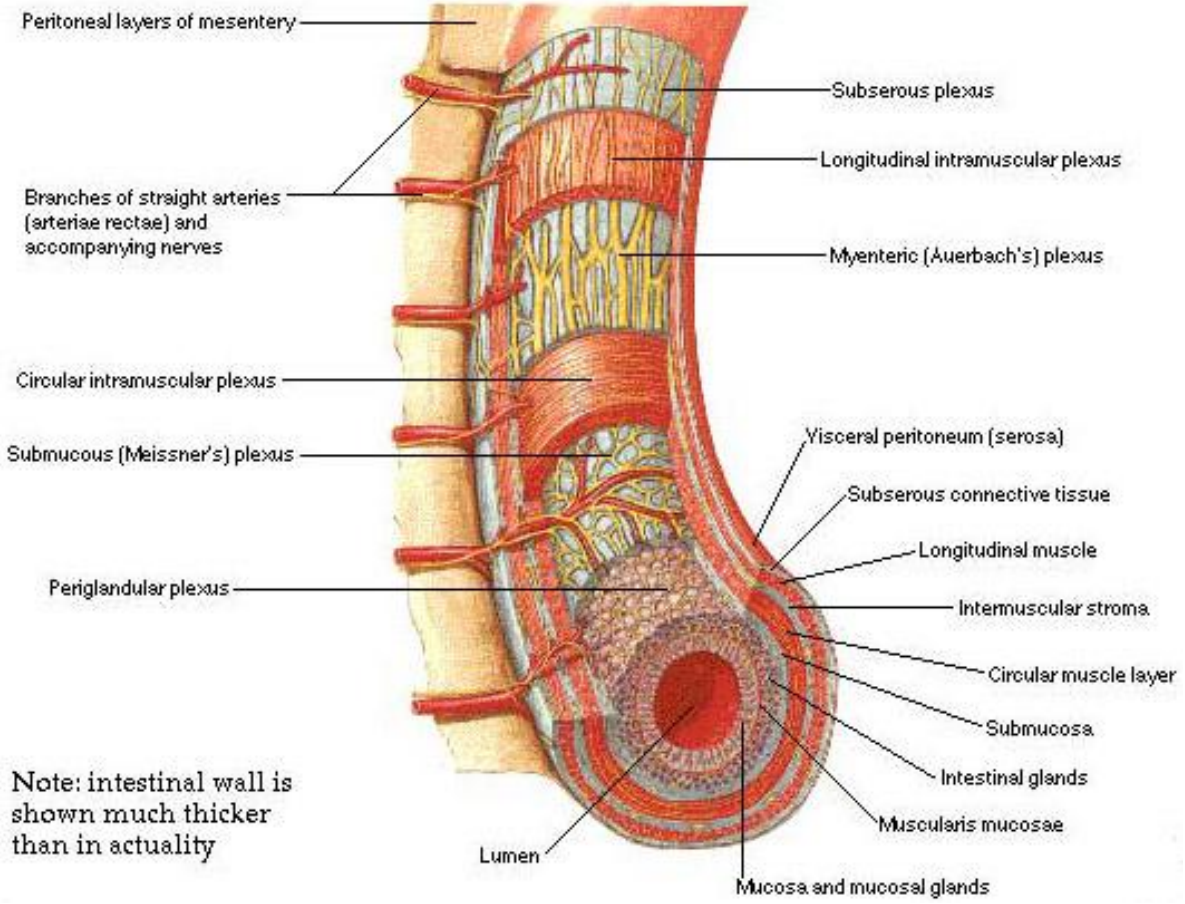


Nerves and plexuses of thoracic organs; right aspect (¼).



Nerves and plexuses of abdominal and pelvic cavities

Intrinsic Autonomic Plexuses of Intestine



Enteric nervous system

Two arrays of ganglia and nerves distributed along the gut

Myenteric plexus

Ganglia and nerves located between the longitudinal and circular muscles of the intestines

Submucosal plexus

Ganglia and nerves within the submucosa (layer of fibrous connective tissue that attaches a mucus membrane to its subadjacent parts)

Enteric ganglia receive input from both sympathetic and parasympathetic systems

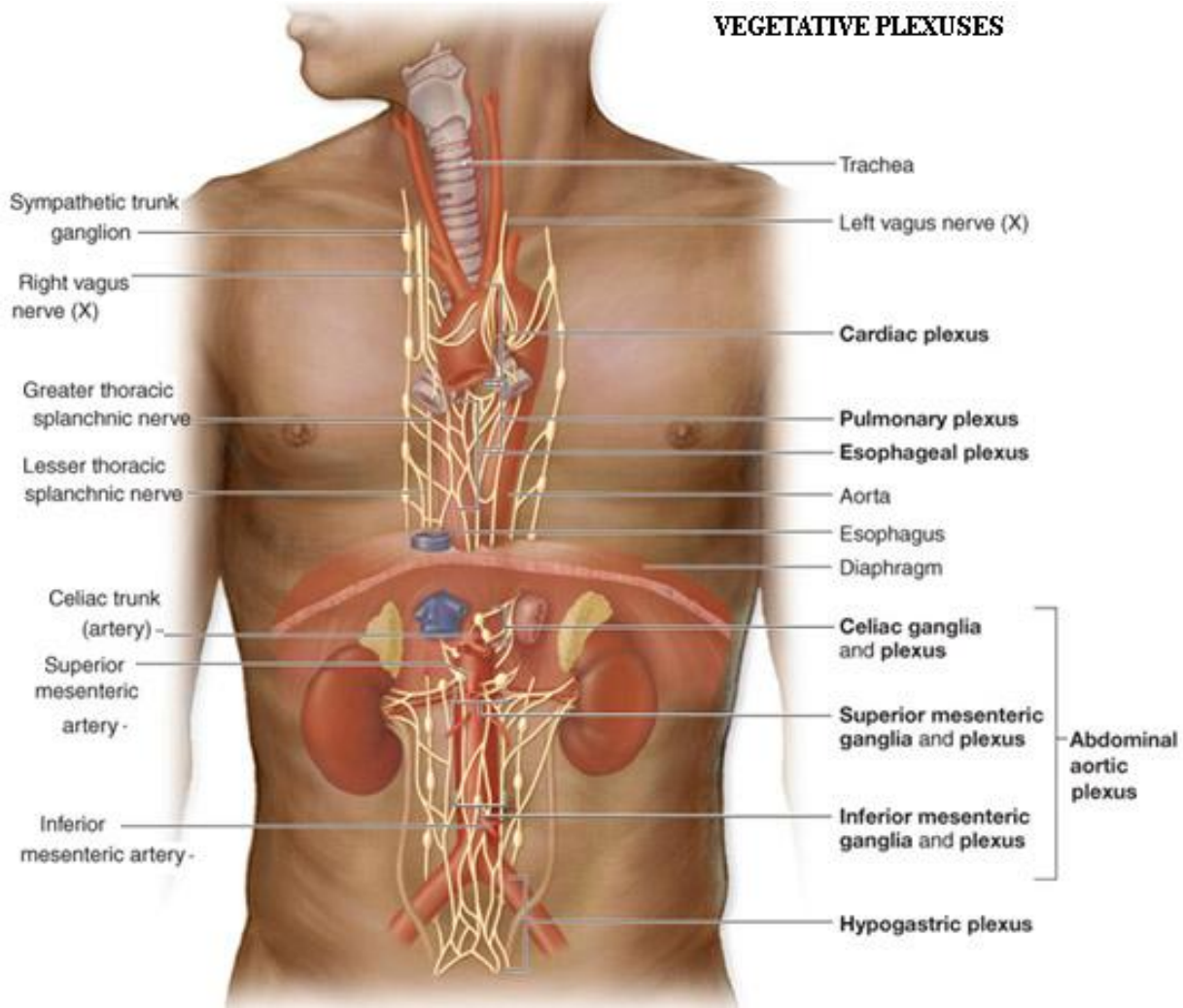
Ganglia contain many local neurons that allow enteric system to function semiautonomously

VEGETATIVE PLEXUSES

Collections of sympathetic postganglionic axons **and** ***parasympathetic preganglionic axons*****, as well as some visceral sensory axons are called the vegetative plexuses.**

Close to one another, but they do not interact or synapse with one another.

Provide a complex innervation pattern to their target organs.



Cardiac plexus

increased sympathetic activity increases heart rate and blood pressure, while increased parasympathetic activity decreases heart rate

Pulmonary Plexus

parasympathetic pathway causes bronchoconstriction and increased secretion from mucous glands of the bronchial tree

sympathetic innervation causes bronchodilation

Esophageal Plexus

parasympathetic axons control the swallowing reflex

Abdominal aortic plexus

consists of the celiac plexus, superior mesenteric plexus, and inferior mesenteric plexus

Hypogastric plexuses

Autonomic plexuses of the abdomen

The celiac plexus: - It lies around the celiac trunk

*it has 5 sympathetic nodules /2 coeliac, 2 aortorenal, 1 superior mesenteric ganglion/

***Formation*:**

a) sympathetic postganglionary fibers

b)parasympathetic preganglionary fibers from nn.vagi /mainly the right/

Branches:

around the celiac trunk and its branches /gastric, splenic, hepatic/

---- the superior mesenteric artery, the renal and gonadal arteries

4)to the suprarenal gland

the intermesenteric plexus **– it** lies between the superior and inferior mesenteric arteries

***Formation*:**

a) sympathetic fibers - from the celiac plexus as well as the first and second lumbar splanchnic nerves /of both sides/

b) parasympathetic fibers – from the pelvic splanchnic nerves of both sides

Branches:

around the inferior mesenteric artery, gonadal artery, iliac arteries

branches to ***the superior hypogastric plexus*** - lies just below aortic bifurcation /in front of L5/

divides below into R and L divisions which join the R and L inferior hypogastric plexuses

***Formation*:**

a) sympathetic fibers – from the aortic plexus, the third and fourt lumbar splanchnic nerves of both sides

b) parasympathetic fibers from the pelvic splanchnic nerves of both sides /S2,3,4/

Branches:

a) It divides inferiorly to the R and L hypogastric nerves which descend into the pelvis to form the R and L inferior hypogastric plexuses

b) it also gives branches to the ureteric, gonadal and common iliac plexuses

Inferior hypogastric plexuses

* lying in the extraperitoneal tissue of the pelvis on each side of the rectum and base of the urinary bladder /or cervix of the uterus/

***Formation*:**

a) sympathetic fibers – from the superior hypogastric plexus

the upper 2 sacral sympathetic ganglia

parasympathetic fibers - from the pelvic splanchnic nerves of both sides /S2,3,4/

Branches:

middle rectal plexus to the rectum

vesical plexus: to the urinary bladder, seminal vesicles and vas deferens

prostatic: to the prostate and penis

uterovaginal : to the uterus and vagina

Vegetative plexuses:

of the neck and head

common carotid — internal carotid
external carotid

of the thorax

cardiac
bronchial – pulmonary
oesophageal
aortic

of the abdomen

coeliac - lienal
- gastric
- hepatic
- pancreatic

upper mesenteric
lower mesenteric
Intermesenteric
renalis – uretericus

of the pelvis

upper hypogastric
2 lower hypogastric
- rectal
- prostatic
- urovaginal

Summary of reflex types

There are a number of ways of classifying reflexes.

One is in terms of the systems that receive the stimulus and give the response.

There are *somato-somatic reflexes*, like the knee jerk that follows tapping the patellar tendon;

***Somato-visceral reflexes*, such as the vasoconstriction that results from cooling the skin;**

***Viscero-visceral reflexes*, for example the decrease in heart rate that follows distention of the carotid sinus;**

and *viscero-somatic reflexes*, like the abdominal cramping that accompanies rupture of the appendix.

*Regulation of the VNS depends on *the highest vegetative centers*:

* thalamus
* hypothalamus
* cerebellum
* basal nuclei of the brain
* reticular formation
* cortex of the brain
* grey matter surounding the aqueduct of the midbraih

The relevance of the ANS

The autonomic nervous system is so important in regulation of a vast number of body processes that one could say "it's relevant in almost every disease state"!

However, autonomic dysfunction plays a particularly prominent role in certain diseases, including:

diabetes mellitus

other conditions where there is autonomic neuropathy

heart failure

tetanus

Guillain-Barré syndrome

porphyria

organophosphate poisoning

ischaemic heart disease and arrhythmias

The Roles of Reflexes

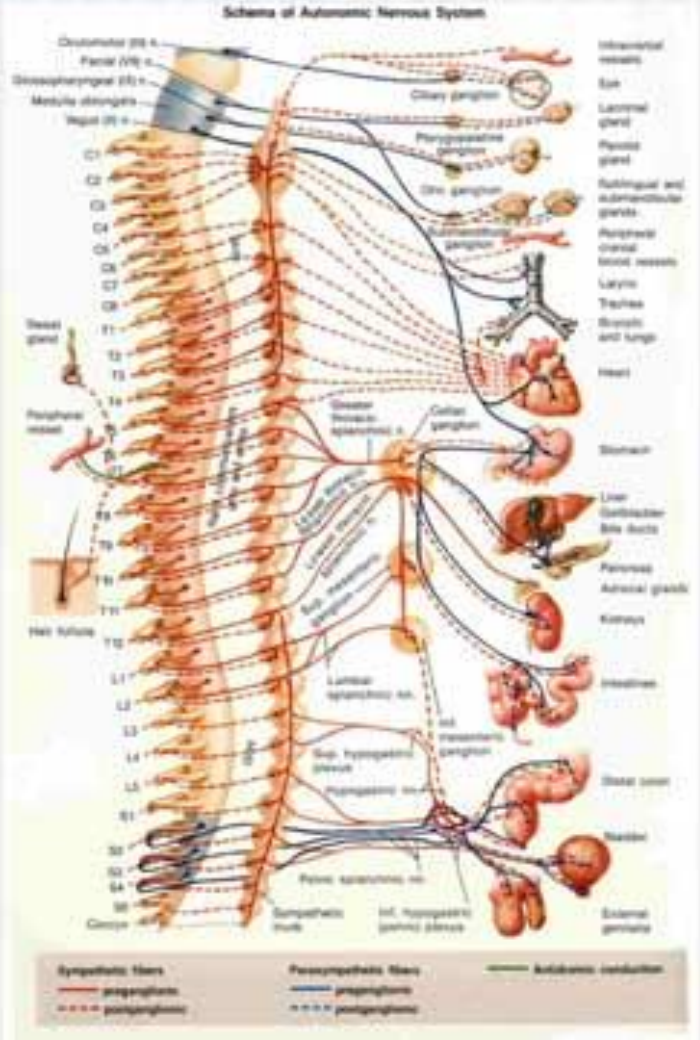
- Communication, Integration, Homeostasis
  - Senses
  - Proprioception
  - Positive & Negative Feedback

Viscero-Visceral Reflexes

- Found in all of the body's systems and may be local (influencing the structure which generated the impulses) or systemic (influencing other structures in response to a given stimuli)

Somato-Visceral & Viscero-Somatic Reflexes

- Somato-Visceral influences via the nervous (central, peripheral, and autonomic) systems
- Viscero-Somatic influences via the nervous (central, peripheral, and autonomic) systems



Psycho-Somato-Visceral Reflexes

- The mind influences the body and vice versa via complex interconnections and interactions

Referred pain:

- **The pain is reffered to a cutaneous site remote from the site of the lesion.**
- **The referred cutaneous site may be tender and painfull to touch.**
- **Examples:**

1) pain in the right shoulder region in cholecystitis;

2) pain caused by the stretching and irritation of the liver capsule may be referred to the right side of the neck, shoulder or scapula;

3) compression of the lower end of the spine causes pain to the pelvic region or upper leg;

4) pain in the left shoulder region or arm in heart diseases

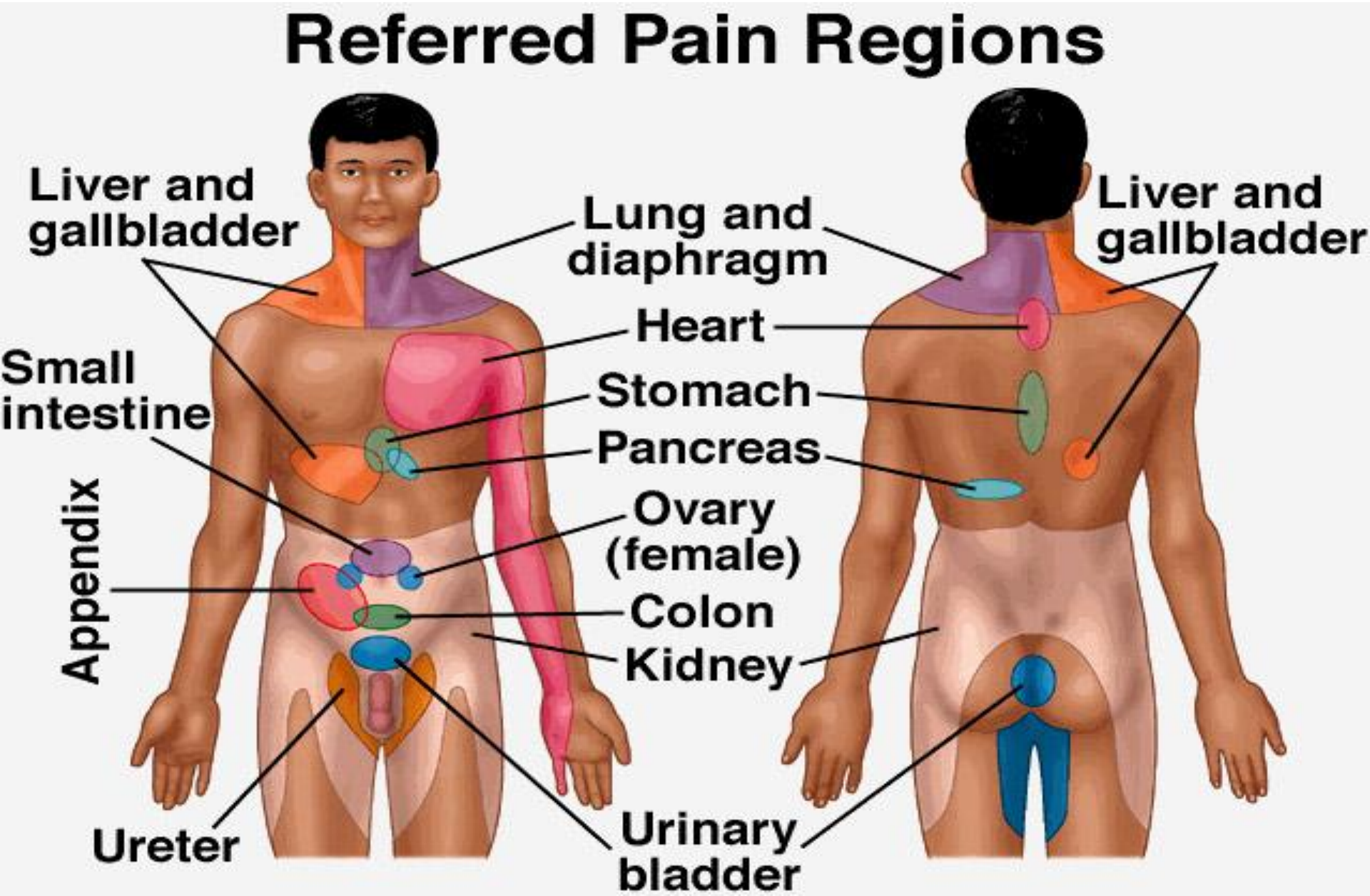
What Is Referred Pain?

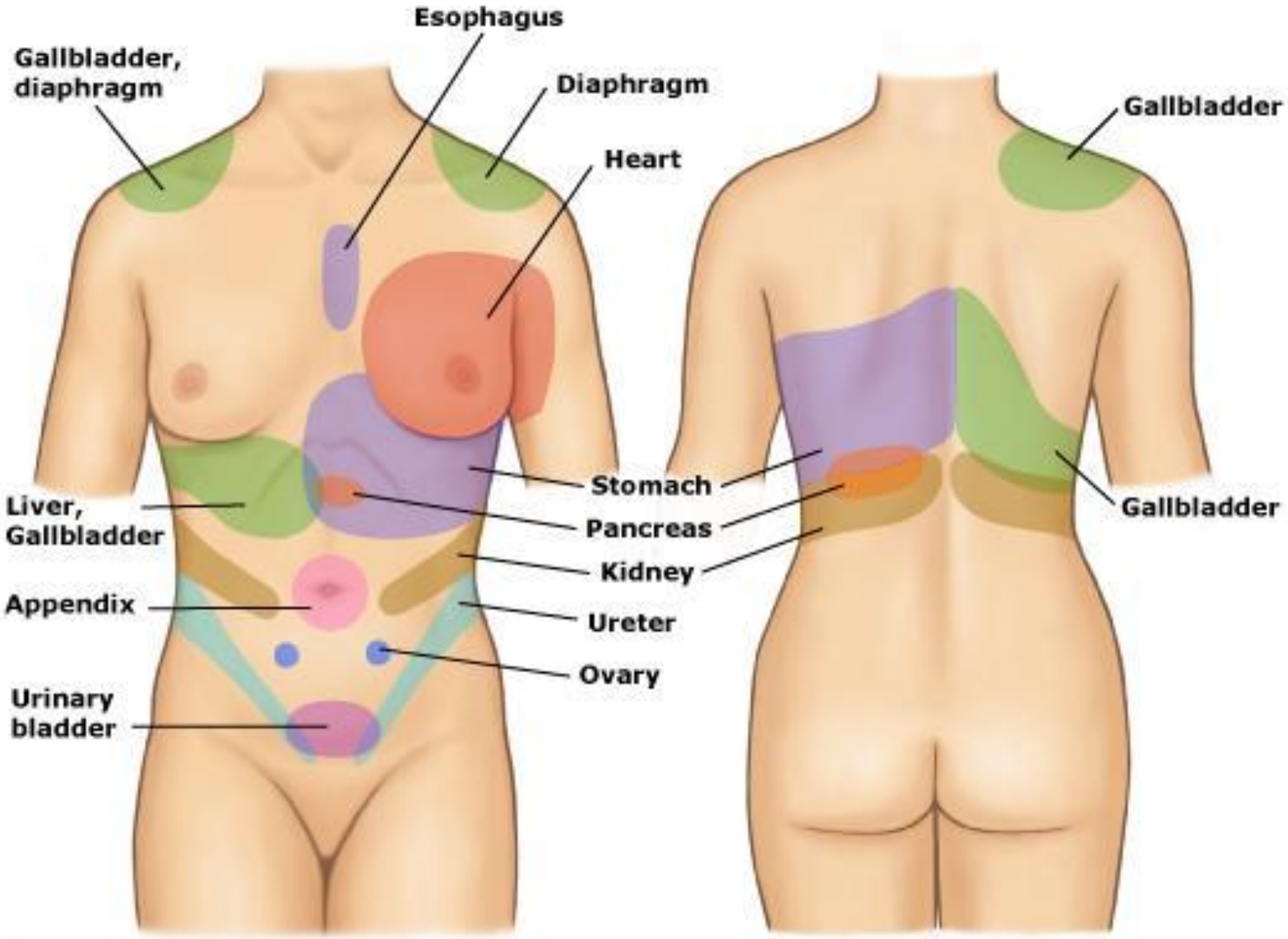
Referred pain has its source in one place but is felt in another.

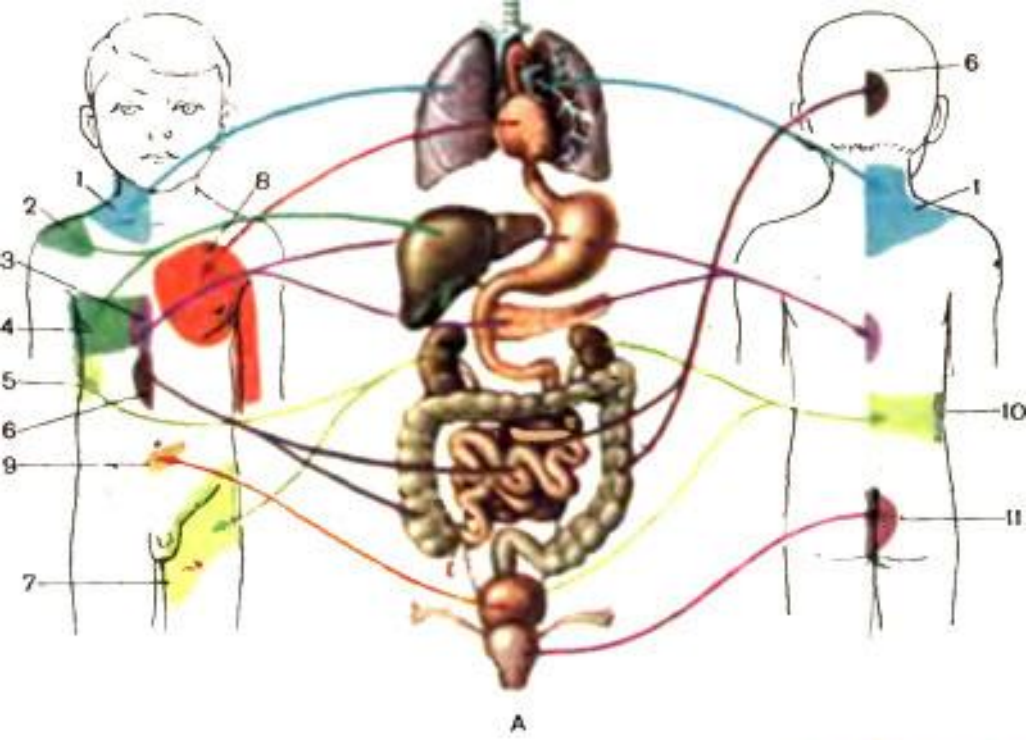
For example, pain behind the eyes may actually be caused by tense muscles in the neck and shoulders.

This means that the place that hurts may not be the part of the head that needs treatment.

When a person has a heart attack where do they have pain?
The pain usually manifests in the left arm, chest, neck -Zakharyin-Head's areas




Esophagus
Gallbladder, diaphragm
Diaphragm
Heart
Gallbladder
Stomach
Liver, Gallbladder
Pancreas
Gallbladder
Kidney
Appendix
Ureter
Ovary
Urinary bladder



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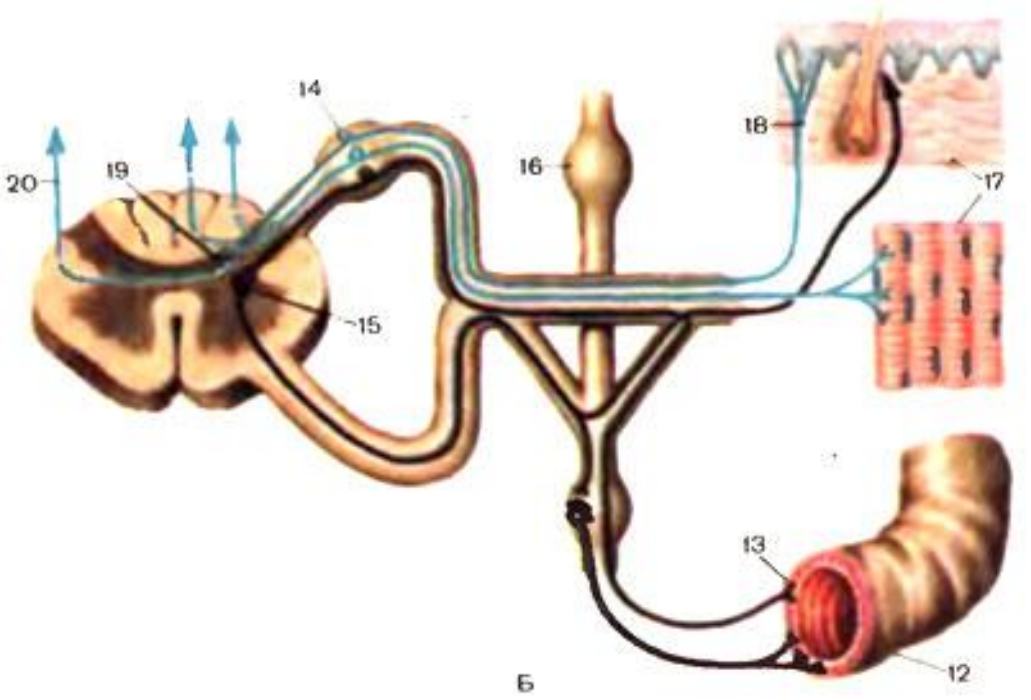


Б

А. Zakharyin-Head's areas regions :

1 — lungs; 2 — capsule of the liver; 3 — stomac; pancreas; 4 — liver; 5 — kidney; 6 — intestine; 7 — ureter; 8 — heart; 9 — urinary bladder; 10 — urogenital organs; 11 — uterus.

Б. Scheme of the viscero-cutaneus reflex : **12 —** affected internal organ**; 13 — interoreceptor; 14 — spinal ganglion; 15 — vegetative cell of the lateral horn; 16 — sympathetic chain; 17 — Zaharin-head region (**hyperesthesia and muscle tension**); 18 — exteroreceptor; 19 — sensory neuron of the posterior horn; 20 — lateral spino-thalamic pathway.**

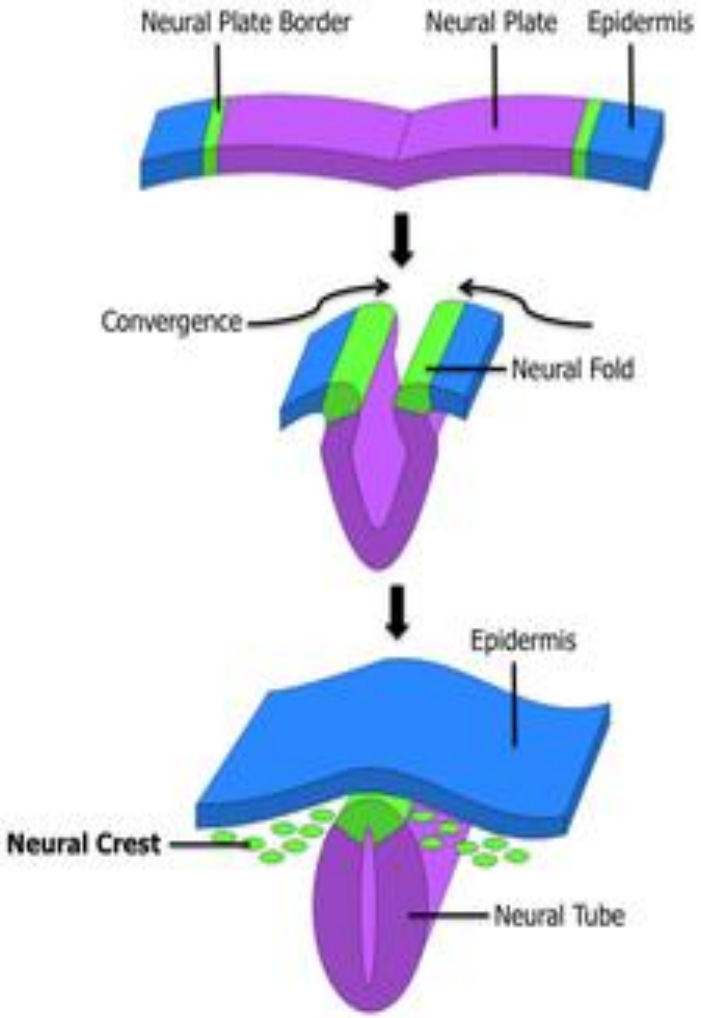
Development of the vegetative ganglia

The ganglion cells of the sympathetic system are *derived* from the cells of the neural crests.

As these crests move forward along the sides of the neural tube and become segmented off to form the spinal ganglia,
certain cells detach themselves from the ventral margins of the crests and migrate toward the sides of the aorta, where some of them are grouped to form the ganglia of the sympathetic trunks, while others undergo a further migration and form the ganglia of the prevertebral and visceral plexuses.

The ciliary, sphenopalatine, otic, and submaxillary ganglia which are found on the branches of the trigeminal nerve are formed by groups of cells which have migrated from the part of the neural crest which gives rise to the semilunar or Gasser's ganglion.

Some of the cells of the ciliary ganglion are said to migrate from the neural tube along the oculomotor nerve.



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