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Gomel State Medical University

Department of Neurology and neurosurgery

Lecture

THEME 5. BLOOD SUPPLY OF THE BRAIN AND SPINAL CORD

THE VEGETATIVE NERVOUS SYSTEM AND ITS DISORDERS

The faculty of foreing students

Internal Carotid Artery:

1. **Begins at the bifurcation of the common carotid artery where it possesses a localized dilatation called the carotid sinus.**
2. **Ascends the neck and perforates the base of the skull by passing through the carotid canal of the temporal bone**
3. **Runs horizontally forward thru the cavernous sinus**
4. **Emerges on the anterior clinoid process by perforating the dura mater**

Internal Carotid Artery:

enters the subarachnoid space by piercing the arachnoid mater and turns posteriorly to the region of the medial end of the lateral cerebral sulcus

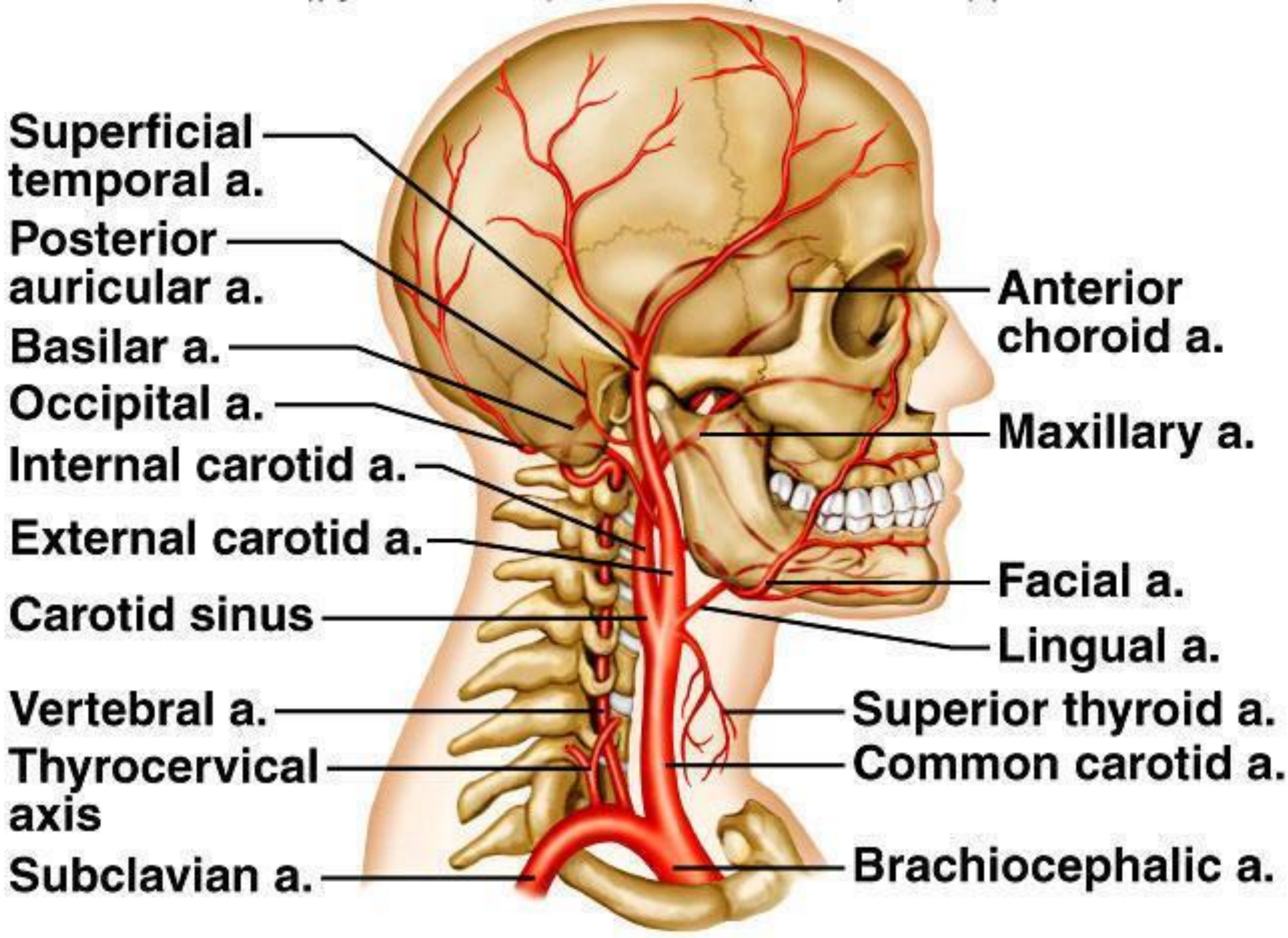
Here it divides into the anterior and middle cerebral arteries

Blood supply of the brain derives from:

1. 2 internal carotid arteries, which are the branches of the common carotid arteries.

Branches of ICA:

- **Ophthalmic artery.**
- **Anterior cerebral arteries.**
- **Middle Cerebral Arteries.**
- **Posterior communicating artery.**
- **Choroidal artery.**


Superficial temporal a.
Posterior auricular a.
Basilar a.
Occipital a.
Internal carotid a.
External carotid a.
Carotid sinus
Vertebral a.
Thyrocervical axis
Subclavian a.
Anterior choroid a.
Maxillary a.
Facial a.
Lingual a.
Superior thyroid a.
Common carotid a.
Brachiocephalic a.

Ophthalmic artery:

- **Arises as the internal carotid artery emerges from the carotid sinus**
- **Enters the orbit thru the optic canal below and lateral to the optic nerve**
- **Supplies the eye and other orbital structures**
- **Its terminal branches supply the frontal area of the scalp, the ethmoid and frontal sinuses and the dorsum of the nose**

Posterior communicating artery:

- **Runs posteriorly above the oculomotor nerve to join the posterior cerebral artery, thus forming part of the circle of Willis**

Choroidal artery:

- **Passes posteriorly close to the optic tract, enters the inferior horn of the lateral ventricle and ends in the choroid plexus**

Anterior cerebral artery:

- Curves backward over the corpus callosum and anastomoses with the posterior cerebral artery;
- Cortical branches supplies all the medial surface of the cerebral cortex as far back as the parietooccipital sulcus;
- Supplies a strip of cortex about 1 inch on the adjoining lateral surface thus supplying the “leg area” of the precentral gyrus

Middle cerebral artery:

- **Largest branch of the internal carotid, runs laterally in the lateral cerebral sulcus, the entire lateral surface of the hemisphere, except for the narrow strip supplied by the anterior cerebral artery;**
- **Supplies all the motor area except the "leg area"**
- **Central branches supply the lentiform and caudate nuclei and the internal capsule**

2. 2 vertebral arteries (branches of the 1st part of the subclavian artery).

Cranial branches of vertebral artery: meningeal arteries, anterior and posterior spinal arteries, posteroinferior cerebellar artery, medullary arteries.

At lower border of pons, vertebral arteries unite to form the basilar artery.

- **Branches of basilar artery:**

  - branches to pons, cerebellum, internal ear (artery of labyrinth);

  - posterior cerebral arteries (formed by the terminal bifurcation of the basilar artery).

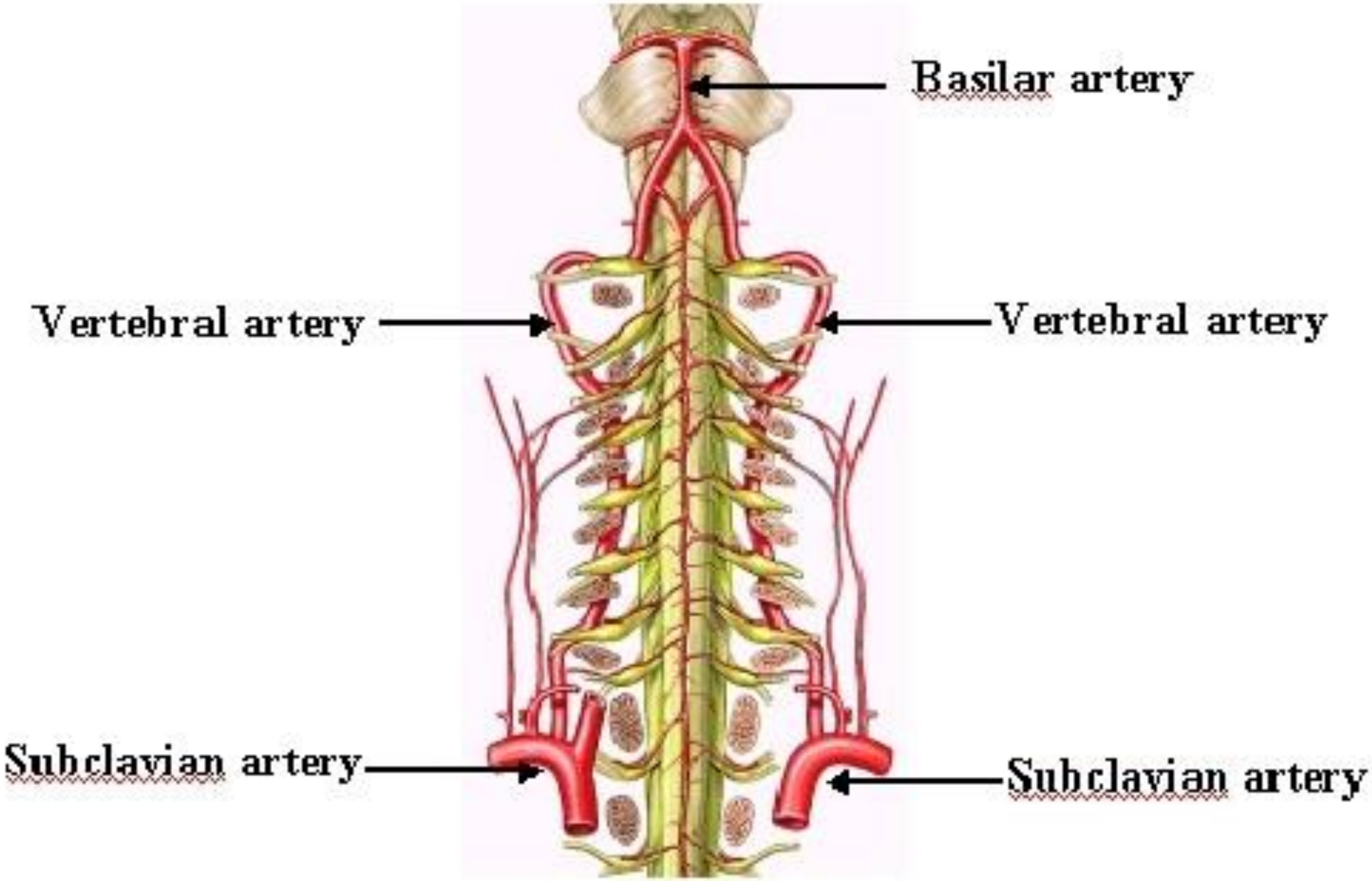
Branches of the cranial portion vertebral artery:

- **Meningeal branches are small and supply the bone and dura in the posrerior cranial fossa**
- **Posterior spinal artery may arise from the vertebral artery or the posterior inferior cerebellar artery; supplies the posterior 1/3 of the spinal cord;**
- **Anterior spinal artery formed from a contributory branch from each vertebral artery; descends as a single artery on the anterior surface of the medulla oblongata and spinal cord**

Branches of the cranial portion vertebral artery:

- **Posterior inferior cerebellar artery – largest branch supplies the:**
- **Inferior surface of the vermus;**
- **Central nuclei of the cerebellum;**
- **Undersurface of the cerebellar hemisphere;**
- **Medulla oblongata;**
- **Choroid plexus of the 4th ventricle**

VERTEBRAL ARTERIES

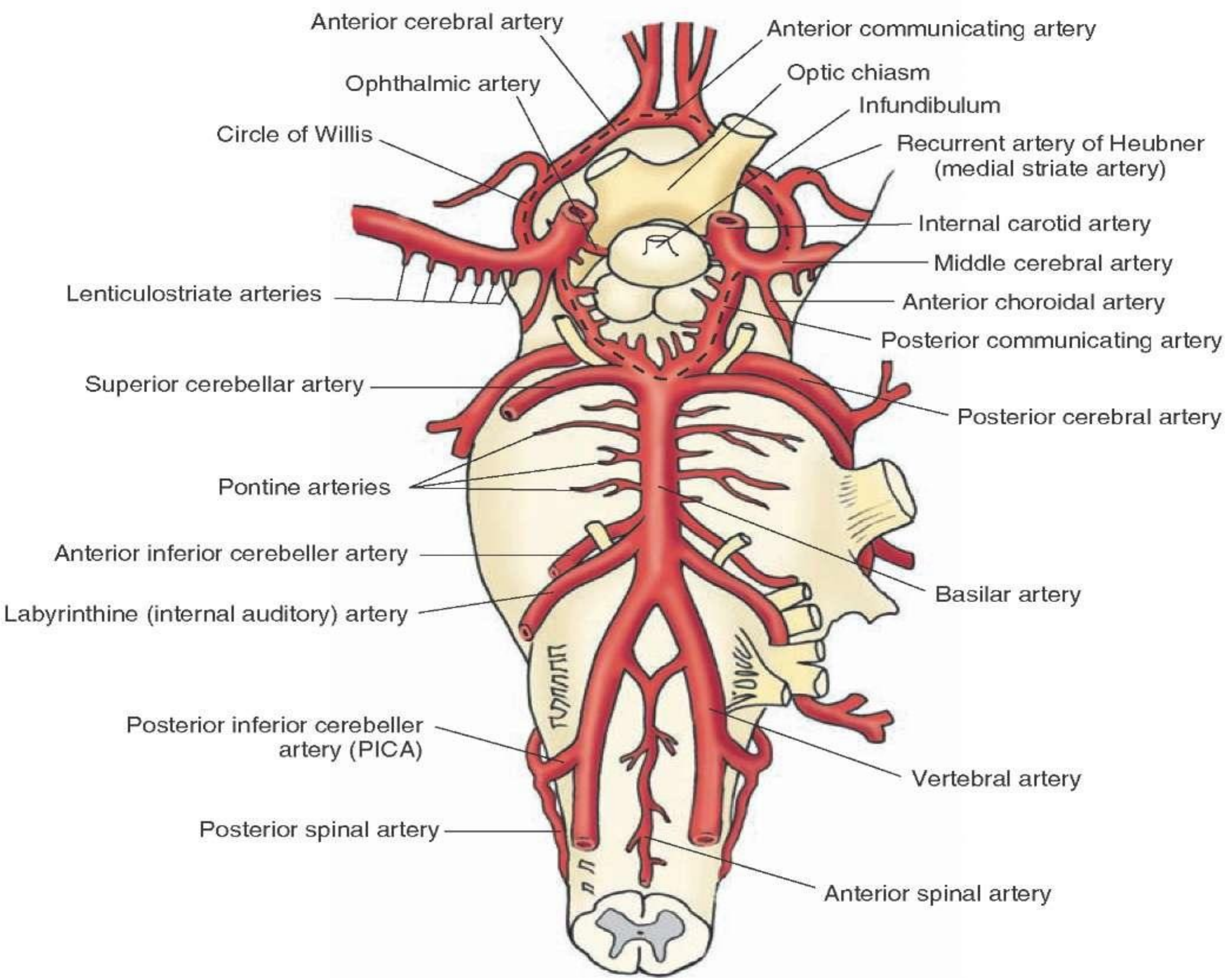


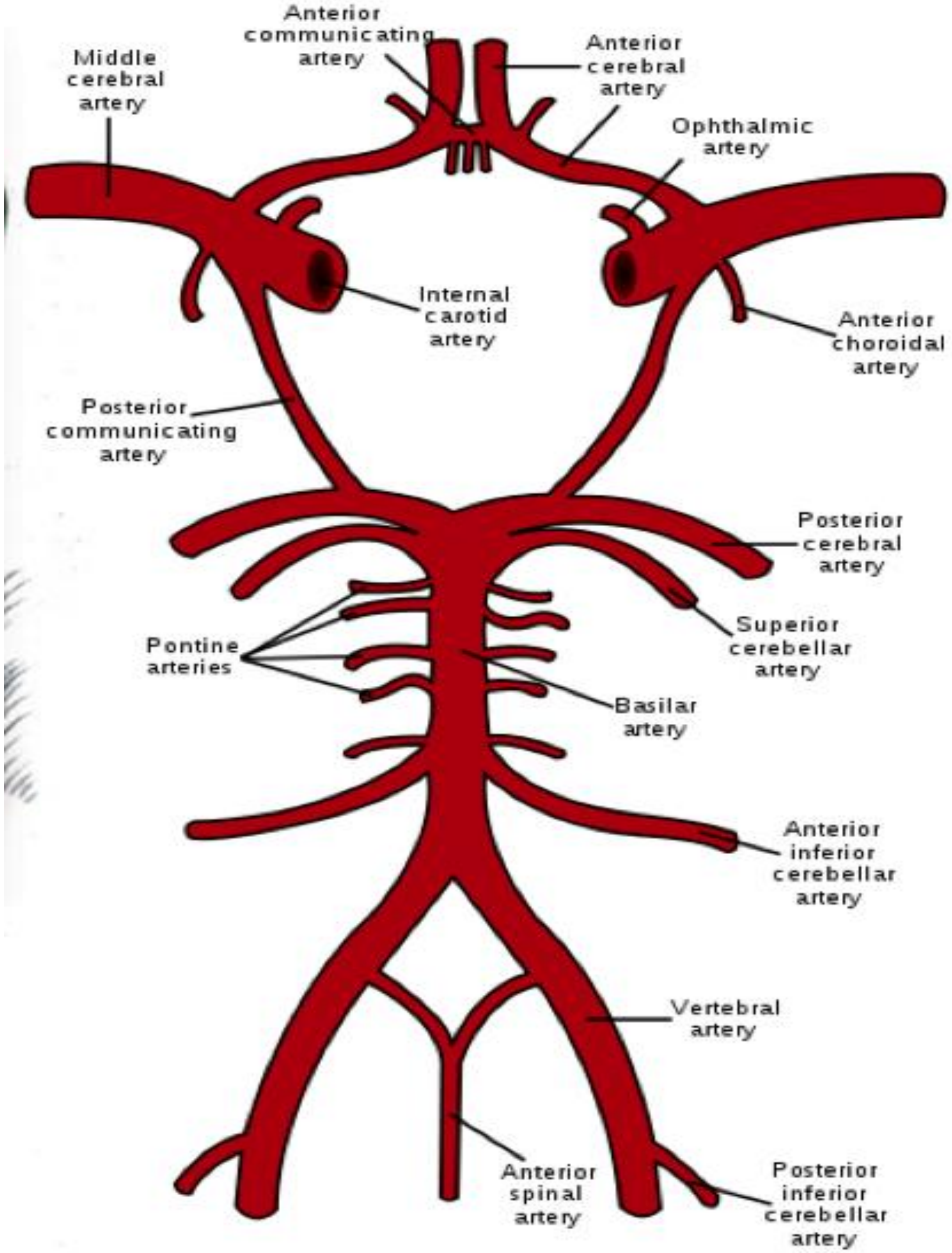
CIRCLE OF WILLIS

- **located at base of brain;**
- **anterior part lies in front of optic chiasm;**
- **posterior part situated just below the mamillary bodies;**
- **allows for excellent collateral circulation.**

Circle of Willis is formed by:

- **terminal part of the ICA;**
- **proximal parts of the anterior, middle and posterior cerebral arteries;**
- **anterior and posterior communicating arteries;**

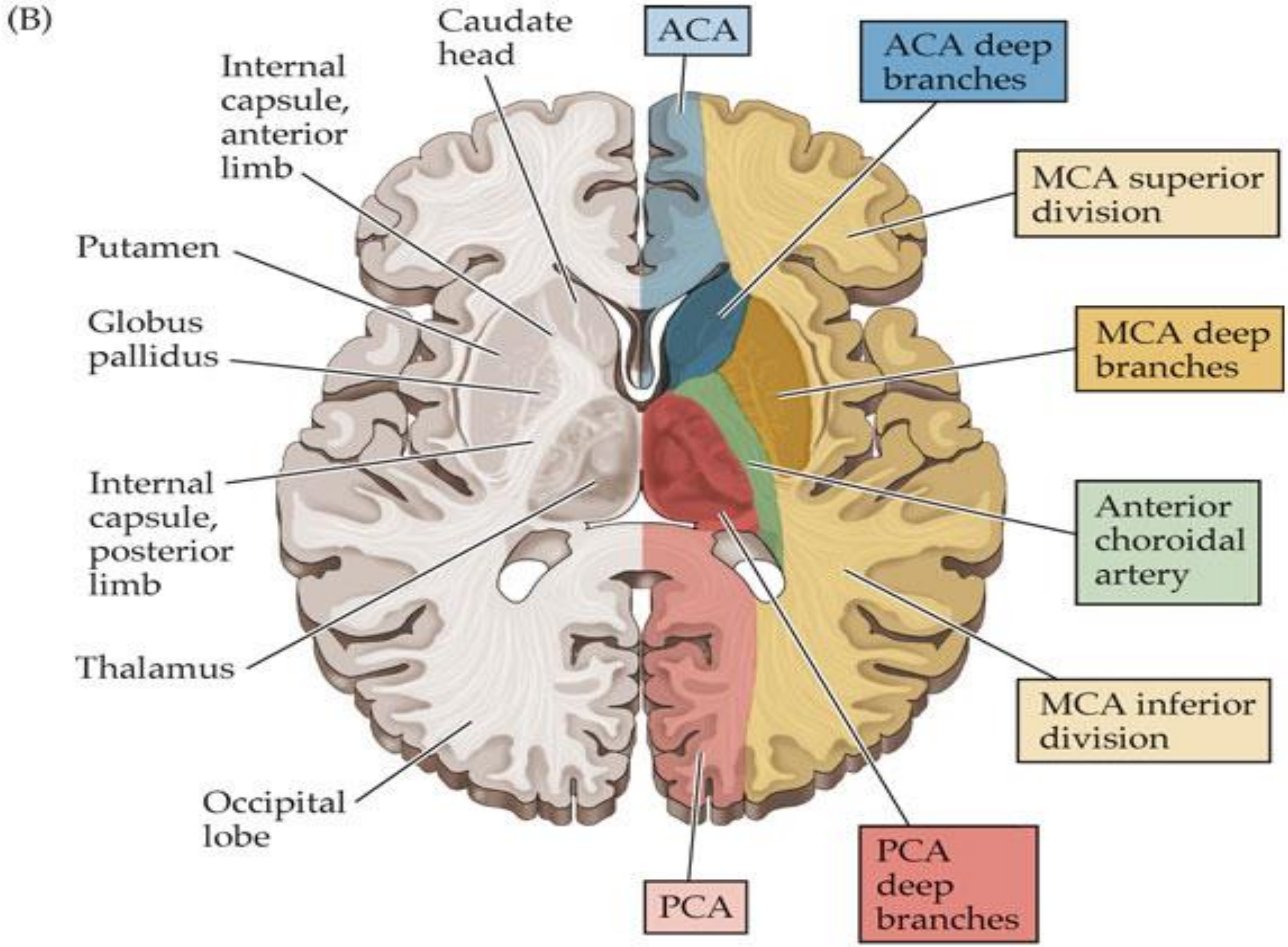

Anterior cerebral artery
Anterior communicating artery
Optic chiasm
Ophthalmic artery
Infundibulum
Circle of Willis
Recurrent artery of Heubner
(medial striate artery)
Internal carotid artery
Middle cerebral artery
Lenticulostriate arteries
Anterior choroidal artery
Posterior communicating artery
Superior cerebellar artery
Posterior cerebral artery
Pontine arteries
Anterior inferior cerebeller artery
Basilar artery
Labyrinthine (internal auditory) artery
Posterior inferior cerebeller
artery (PICA)
Vertebral artery
Posterior spinal artery
Anterior spinal artery


Anterior communicating artery
Middle cerebral artery
Anterior cerebral artery
Ophthalmic artery
Internal carotid artery
Anterior choroidal artery
Posterior communicating artery
Posterior cerebral artery
Superior cerebellar artery
Pontine arteries
Basilar artery
Anterior inferior cerebellar artery
Vertebral artery
Anterior spinal artery
Posterior inferior cerebellar artery

Anterior cerebral arteries

Supply:

- **cortical branches supply all medial surface of cerebral cortex up to parieto-occipital sulcus;**
- **corpus callosum, pellucid septum, anterior commissure;**
- **approximately 1 inch of the frontal and parietal cortex on the superior aspect of their lateral surface (this include the leg area of the precentral gyrus);**
- **anterior portions of the basal ganglia and internal capsule;**
- **central branches supply deep masses of gray matter in the cerebral hemisphere.**

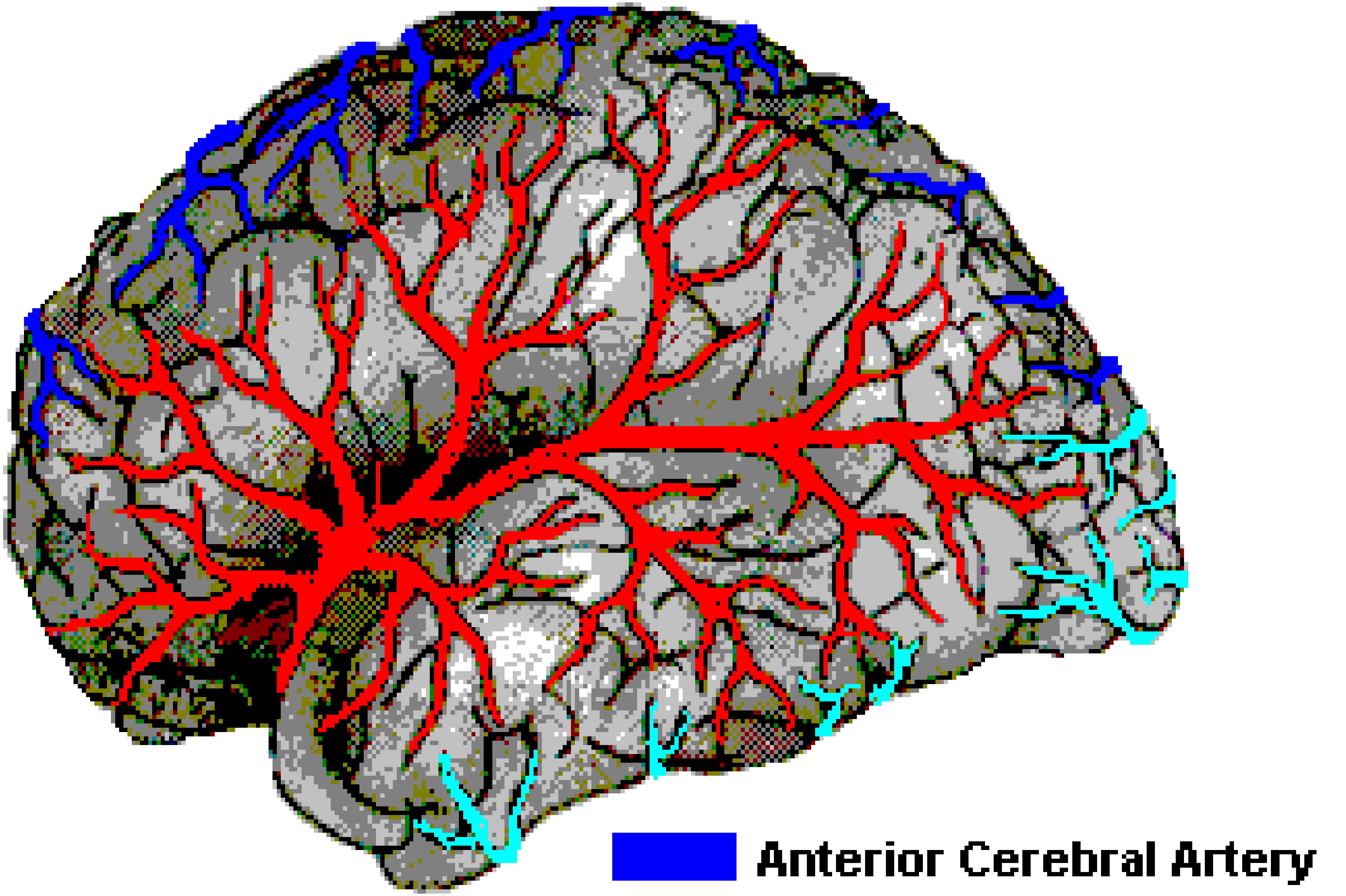

(B)
Caudate head
ACA
ACA deep branches
Internal capsule, anterior limb
MCA superior division
Putamen
Globus pallidus
MCA deep branches
Internal capsule, posterior limb
Anterior choroidal artery
Thalamus
MCA inferior division
Occipital lobe
PCA
PCA deep branches

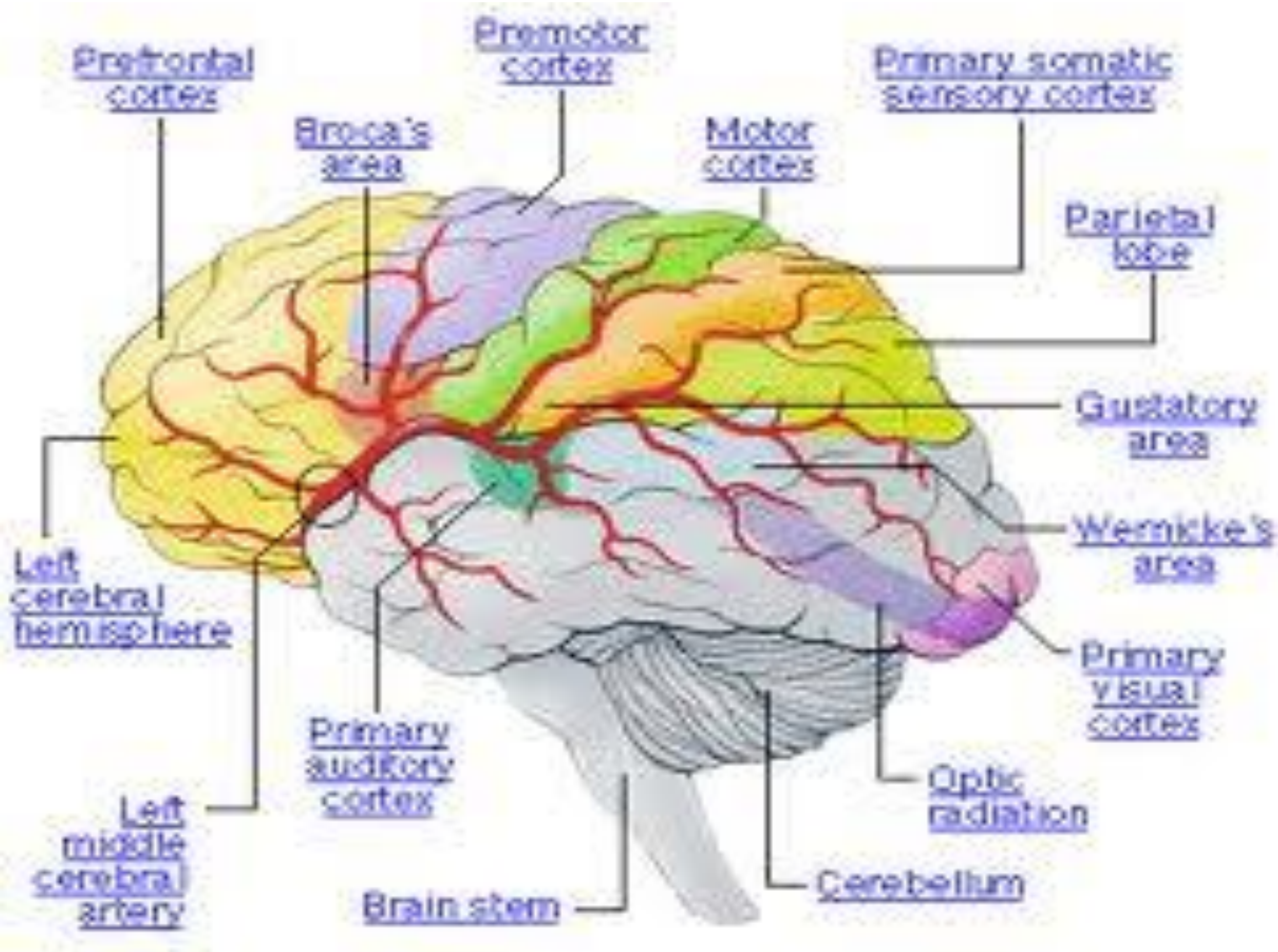
Symptoms of Anterior cerebral artery occlusion are the following:

- contralateral spastic hemiplegia;
- contralateral hemyanesthesia;
- emotional and behavioral disorders;
- memory disorders.

Supply:

- **4/5 of the convexital surface of the cerebral hemispheres;**
- **basal parts of the frontal lobes (premotor cortex, posterior parts of the inferior and middle frontal convolutions, Broca's center), parietal lobe (lower 2/3 of postcentral gyrus, supramarginal gyrus, angular gyrus- praxis center), temporal pole, posterior parts of the superior temporal Wernicke's gyrus, transverse temporal (Heschl's) gyri;**
- **motor area except for "leg area";**
- **parts of the internal capsule and basal ganglia;**
- **central branches supply deep masses of gray matter within the cerebral hemisphere.**


Anterior Cerebral Artery
Middle Cerebral Artery
Posterior Cerebral Artery

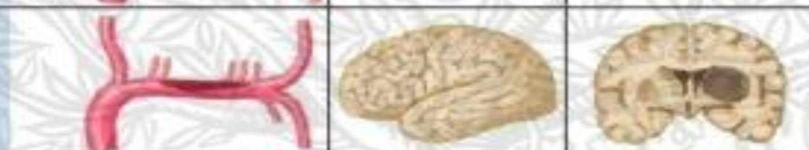
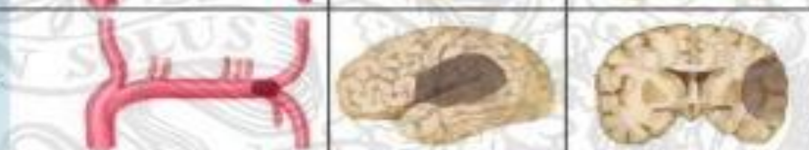
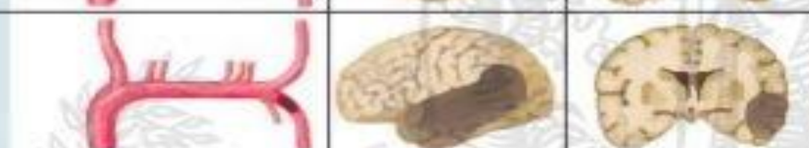


Prefrontal cortex
Premotor cortex
Primary somatic sensory cortex
Broca's area
Motor cortex
Parietal lobe
Gustatory area
Left cerebral hemisphere
Wernicke's area
Primary visual cortex
Primary auditory cortex
Optic radiation
Left middle cerebral artery
Brain stem
Cerebellum

Symptoms of Middle cerebral artery occlusion:

- **Central gaze paralysis;**
- **Motor, sensory, amnestic, semantic aphasia;**
- **apraxia;**
- **alexia;**
- **agraphia;**
- **acalculia;**
- **astereognosis and autotopagnosia;**
- **anosognosia and autotopagnosia in case of subdominant hemisphere lesion;**
- **contralateral spastic hemiplegia;**
- **contralateral hemyanesthesia.**

Occlusion of Middle and Anterior Cerebral Arteries

Lesion		Artery occluded / Infarct, surface / Infarct, coronal section	Clinical manifestations
Middle cerebral artery	Entire territory		Contralateral gaze palsy, hemiplegia, hemisensory loss, spatial neglect, hemianopsia Global aphasia (if on left side) May lead to coma secondary to edema
	Deep		Contralateral hemiplegia, hemisensory loss Transcortical motor and/or sensory aphasia (if on left side)
	Parasylvian		Contralateral weakness and sensory loss of face and hand Conduction aphasia, apraxia, and Gerstmann syndrome (if on left side) Constructional dyspraxia (if on right side)
	Superior division		Contralateral hemiplegia, hemisensory loss, gaze palsy, spatial neglect Broca aphasia (if on left side)
	Inferior division		Contralateral hemianopsia or upper quadrant anopsia Wernicke aphasia (if on left side) Constructional dyspraxia (if on right side)
Anterior cerebral artery	Entire territory		Incontinence Contralateral hemiplegia Abulia Transcortical motor aphasia or motor and sensory aphasia Left limb dyspraxia
	Distal		Contralateral weakness of leg, hip, foot, and shoulder Sensory loss in foot Transcortical motor aphasia or motor and sensory aphasia Left limb dyspraxia

F. Netter

Posterior cerebral arteries

Supply:

- **Posterior parts of the thalamus and hypothalamus;**
- **vascular plexus of third and lateral ventricles of cerebrum;**
- **lateral and medial parts of the mesencephalic tegmentum and base of cerebral peduncles;**
- **lateral surface of the hemisphere — occipital pole and inferior temporal lobe;**
- **medial surface of the hemisphere — occipital lobe and posterior 2/3 of temporal lobe.**

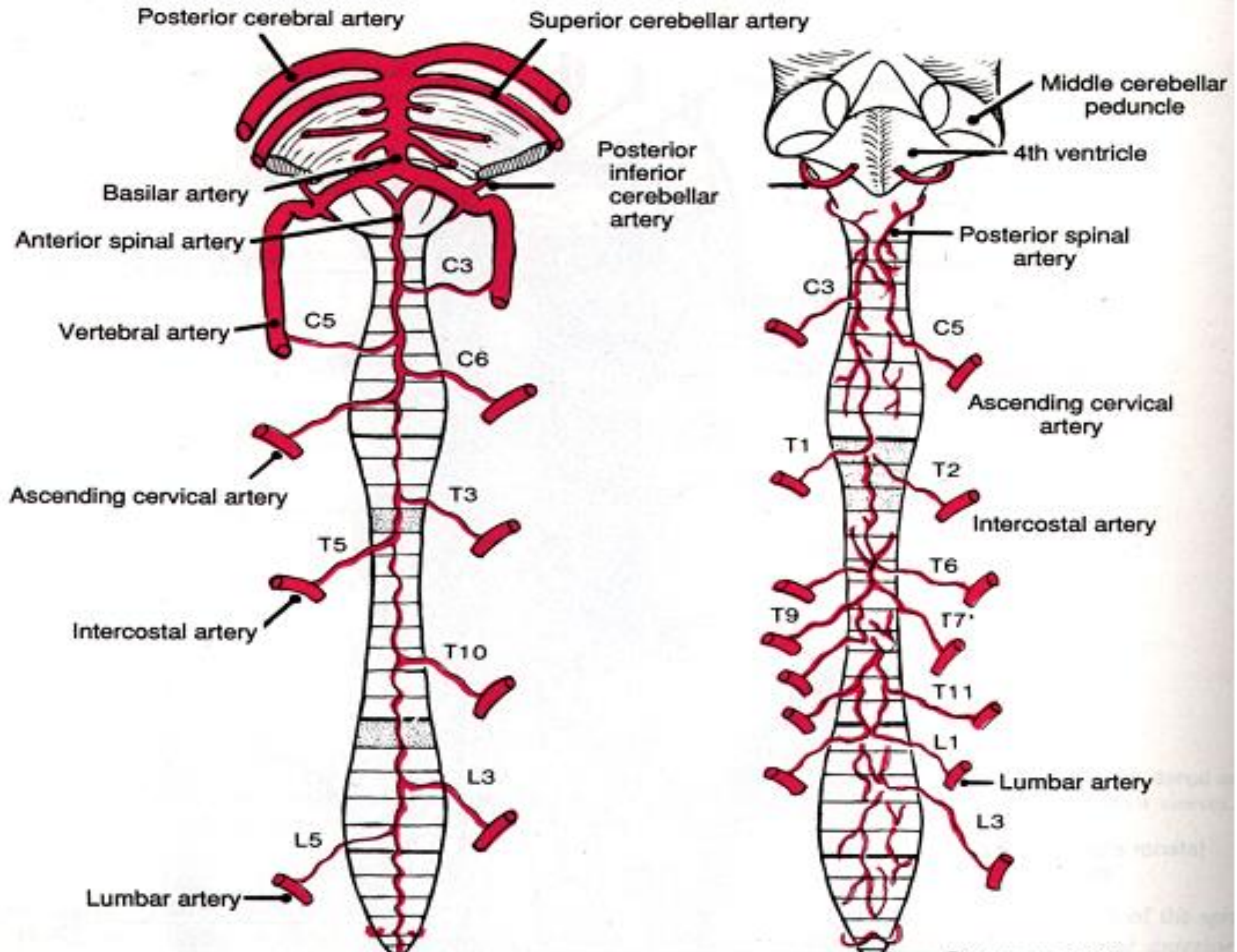
Symptoms of posterior cerebral artery occlusion are the following:

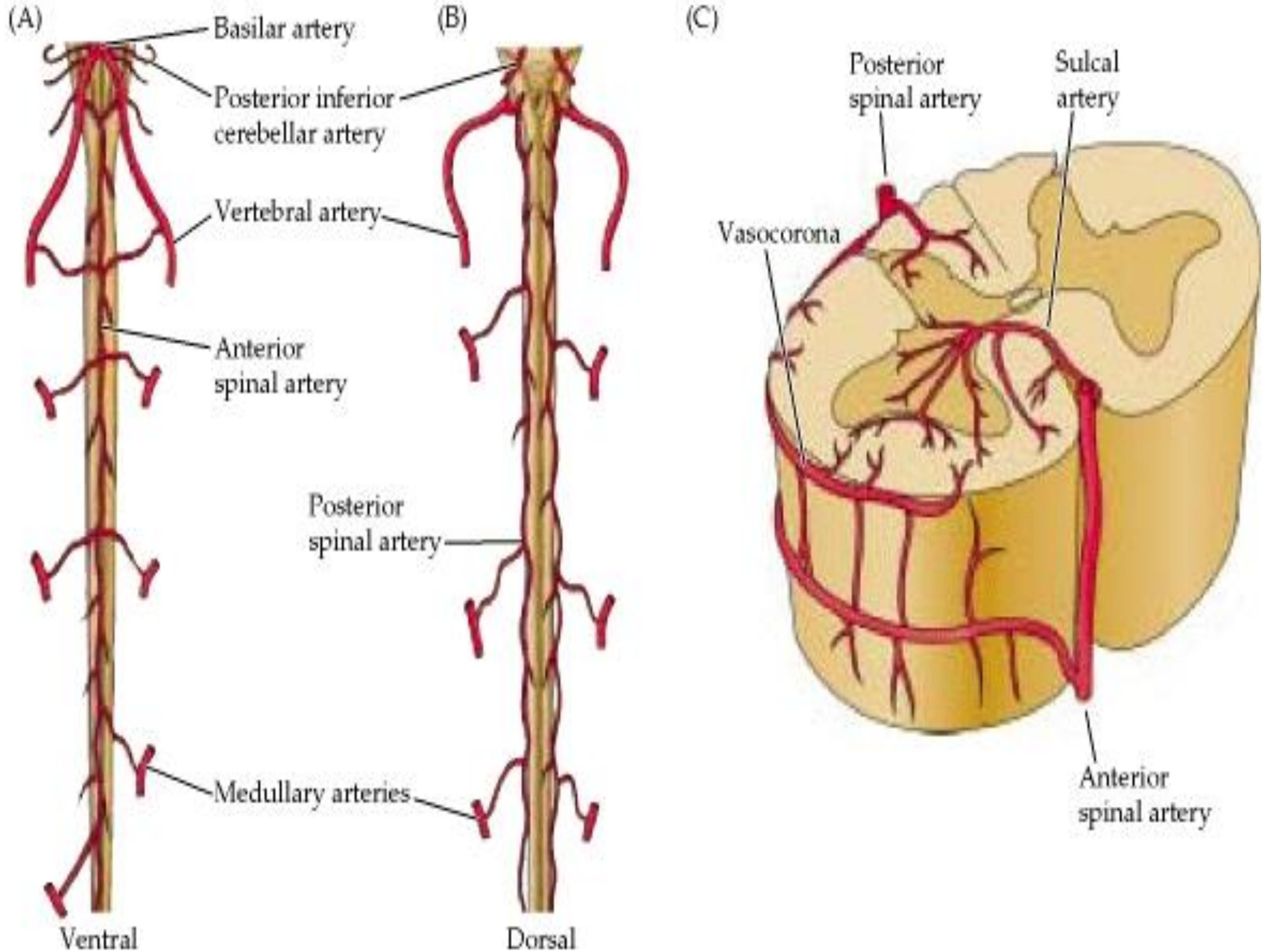
- **Transient global amnesia (occlusion of both sides of posterior cerebral artery);**
- **all types of memory disorders;**
- **vision disorders: quadrantanopsia, contralateral hemianopsia;**
- **behavioral disorders;**
- **memory disorders.**

The spinal cord is supplied with blood by the anterior spinal artery and a pair of posterior spinal arteries.

Anterior spinal artery arises from branches of vertebral arteries and descends till the length of the spinal cord in the anterior median fissure. Anterior spinal artery supplies the anterior surface of the medulla oblongata and anterior 2/3 of the spinal cord.

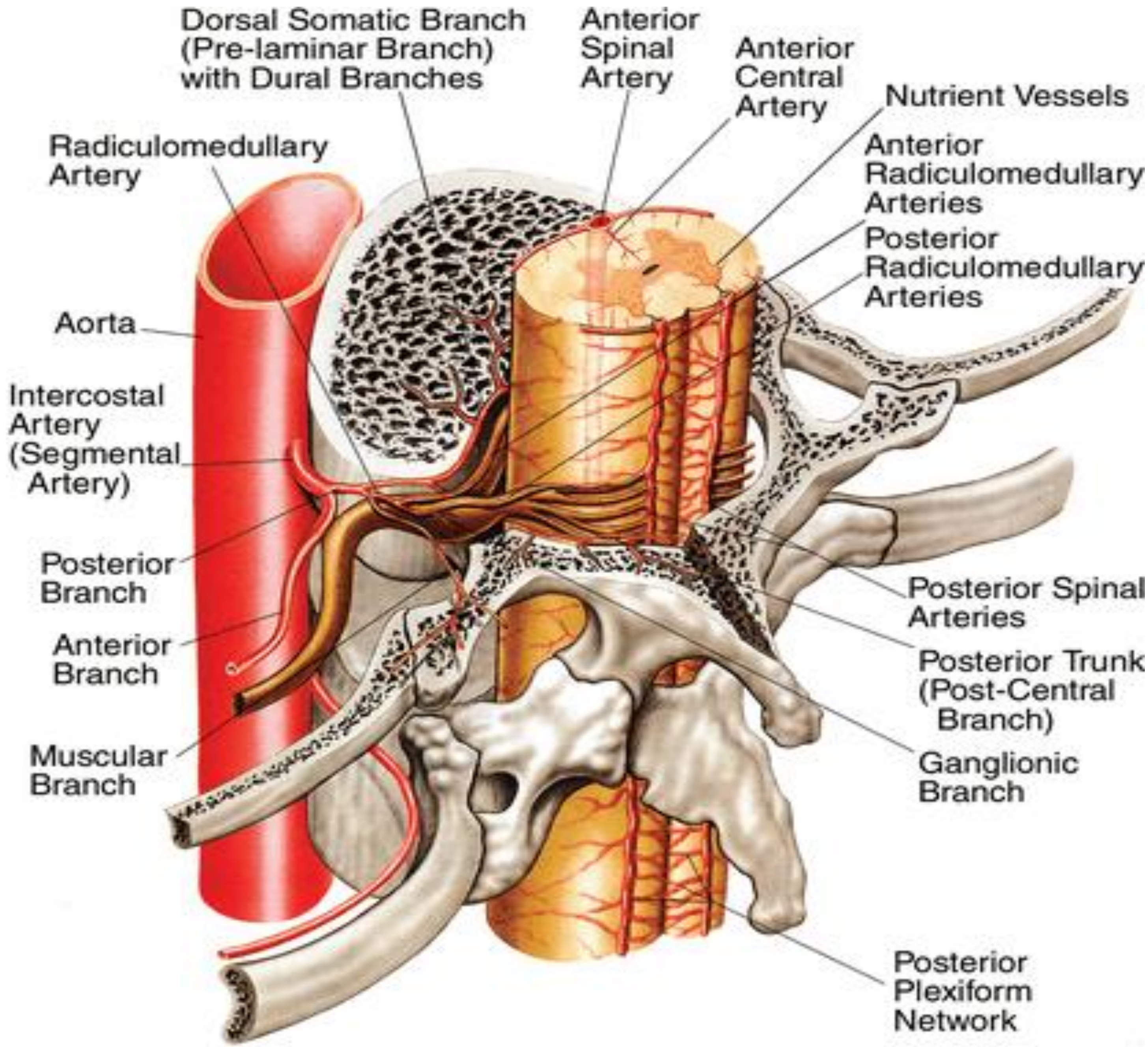
Paired posterior spinal arteries derive from the vertebral arteries and supply posterior 1/3 of the spinal cord.


Posterior cerebral artery
Superior cerebellar artery
Basilar artery
Anterior spinal artery
Posterior inferior cerebellar artery
Vertebral artery
C3
C5
C6
Ascending cervical artery
T3
T5
Intercostal artery
T10
L3
L5
Lumbar artery
Middle cerebellar peduncle
4th ventricle
Posterior spinal artery
C3
C5
Ascending cervical artery
T1
T2
Intercostal artery
T6
T9
T7'
T11
L1
Lumbar artery
L3

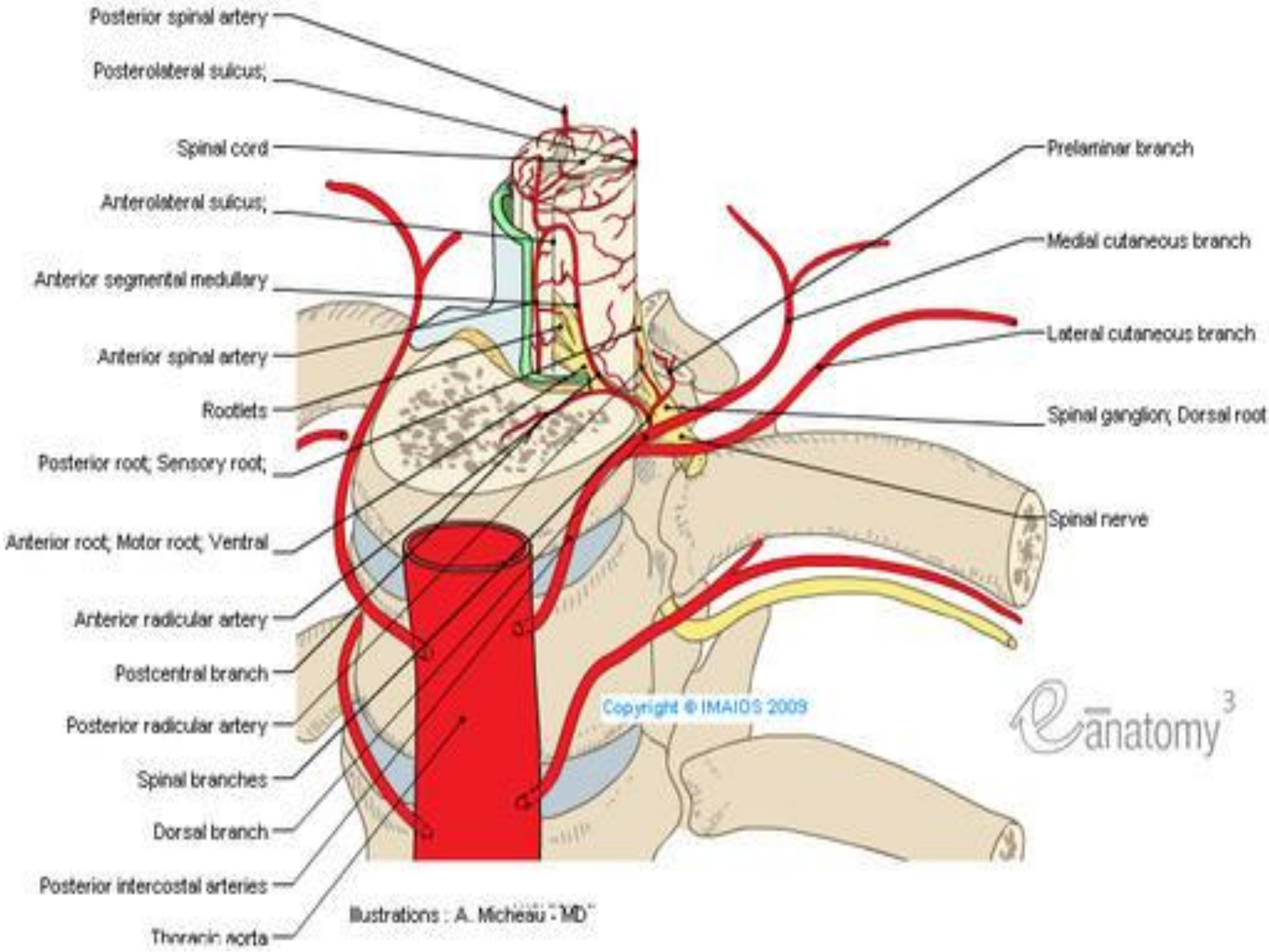


(A)
Basilar artery
Posterior inferior
cerebellar artery
Vertebral artery
Anterior
spinal artery
Medullary arteries
Ventral
(B)
Posterior
spinal artery
Dorsal
(C)
Posterior
spinal artery
Sulcal
artery
Vasocorona
Anterior
spinal artery

The spinal cord is also supplied by radicular arteries that arise from various vessels: vertebral artery, costocervical trunk, subclavian artery, segmental intercostal and lumbar arteries.



Dorsal Somatic Branch
(Pre-laminar Branch)
with Dural Branches
Anterior
Spinal
Artery
Anterior
Central
Artery
Nutrient Vessels
Radiculomedullary
Artery
Anterior
Radiculomedullary
Arteries
Posterior
Radiculomedullary
Arteries
Aorta
Intercostal
Artery
(Segmental
Artery)
Posterior
Branch
Anterior
Branch
Muscular
Branch
Posterior Spinal
Arteries
Posterior Trunk
(Post-Central
Branch)
Ganglionic
Branch
Posterior
Plexiform
Network


Posterior spinal artery
Posterolateral sulcus;
Spinal cord
Anterolateral sulcus;
Anterior segmental medullary
Anterior spinal artery
Rootlets
Posterior root; Sensory root;
Anterior root; Motor root; Ventral
Anterior radicular artery
Postcentral branch
Posterior radicular artery
Spinal branches
Dorsal branch
Posterior intercostal arteries
Thoracic aorta
Prelaminar branch
Medial cutaneous branch
Lateral cutaneous branch
Spinal ganglion; Dorsal root
Spinal nerve
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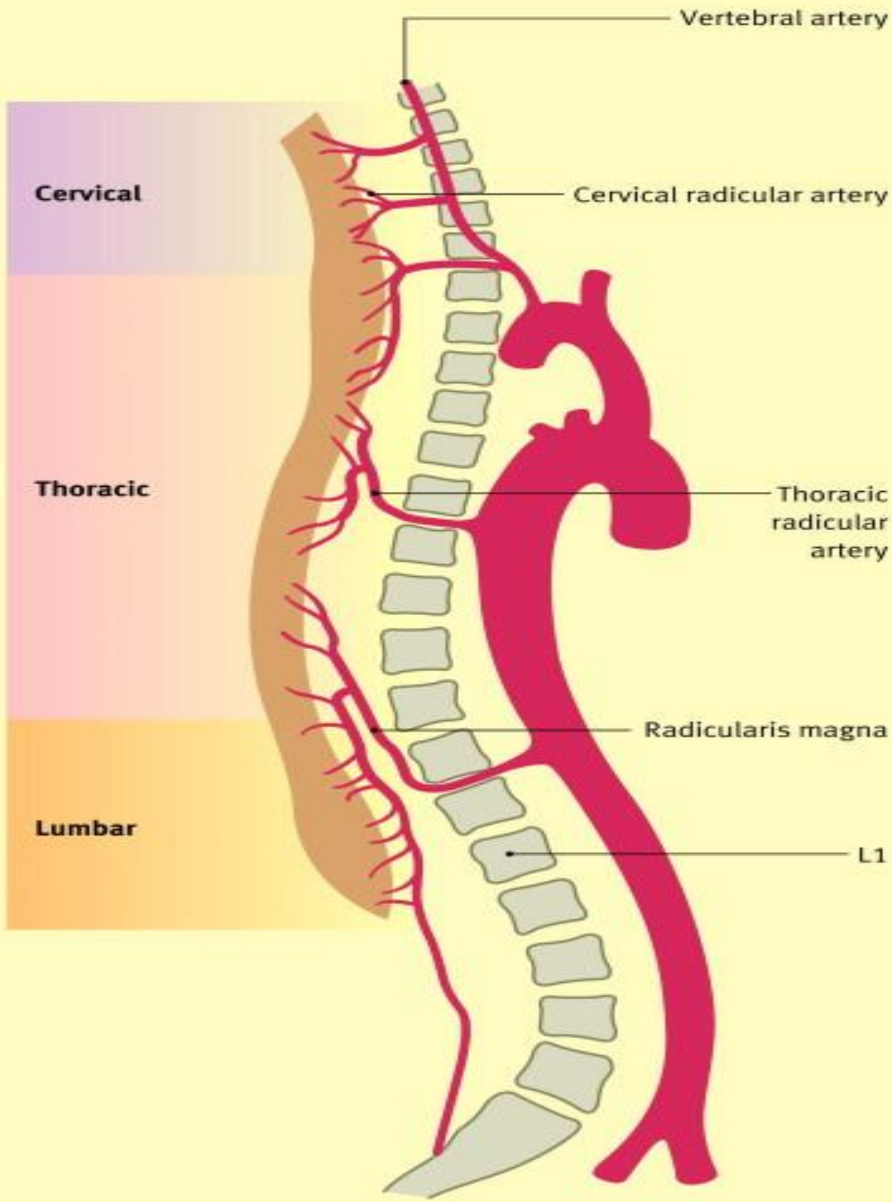
anatomy 3
Illustrations : A. Micheau - MD

There are 3 vascular basins in the spinal cord:

- **superior (cervicothoracic);**
- **middle (thoracic);**
- **inferior (thoracolumbar).**

Arterial supply of the spinal cord: schematic lateral view



Superior basin
(up to third thoracic vertebra)

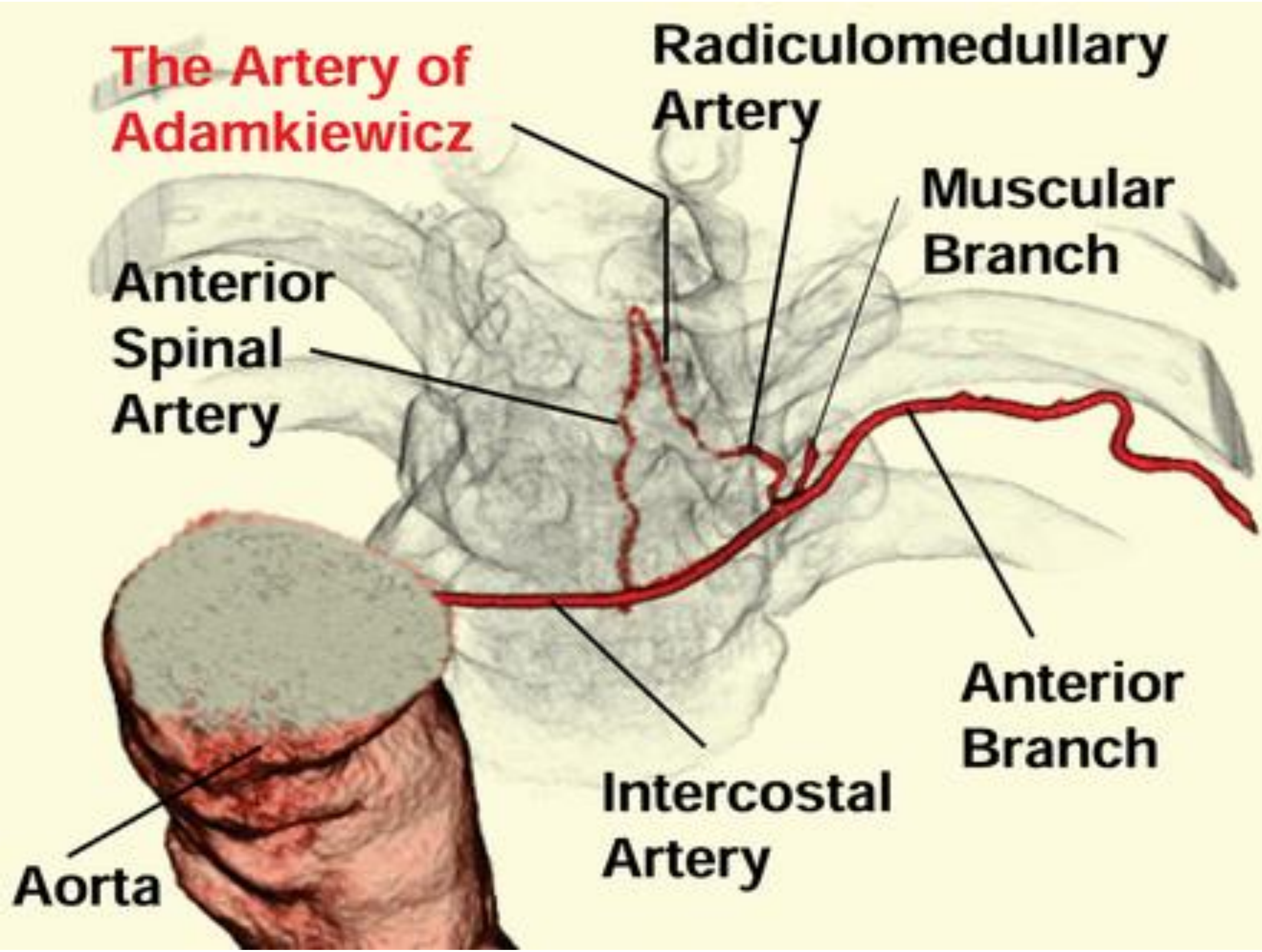
Blood supply of the uppermost segments of a spinal cord (CI-CIII) is carried out by the anterior and a pair of posterior spinal arteries, which derive from the vertebral arteries in the cranial cavity.

All downstream spinal segments are supplied by the segmental radiculo-spinal arteries. In the cervical part of the spinal cord there are 3 radiculo-spinal arteries.

Middle vascular basin
(From 3rd to 8th thoracic vertebra)

From an intercostal artery derives dorsal branch. It passes through the intervertebral foramina and divides into posterior and anterior radiculo-spinal arteries, which follow the posterior and anterior roots respectively. The anterior radicular arteries contribute to the anterior spinal artery, and the posterior radicular arteries contribute to the posterior spinal arteries. In the superior and middle parts of the spinal cord there are 2-3 radiculo-spinal arteries.

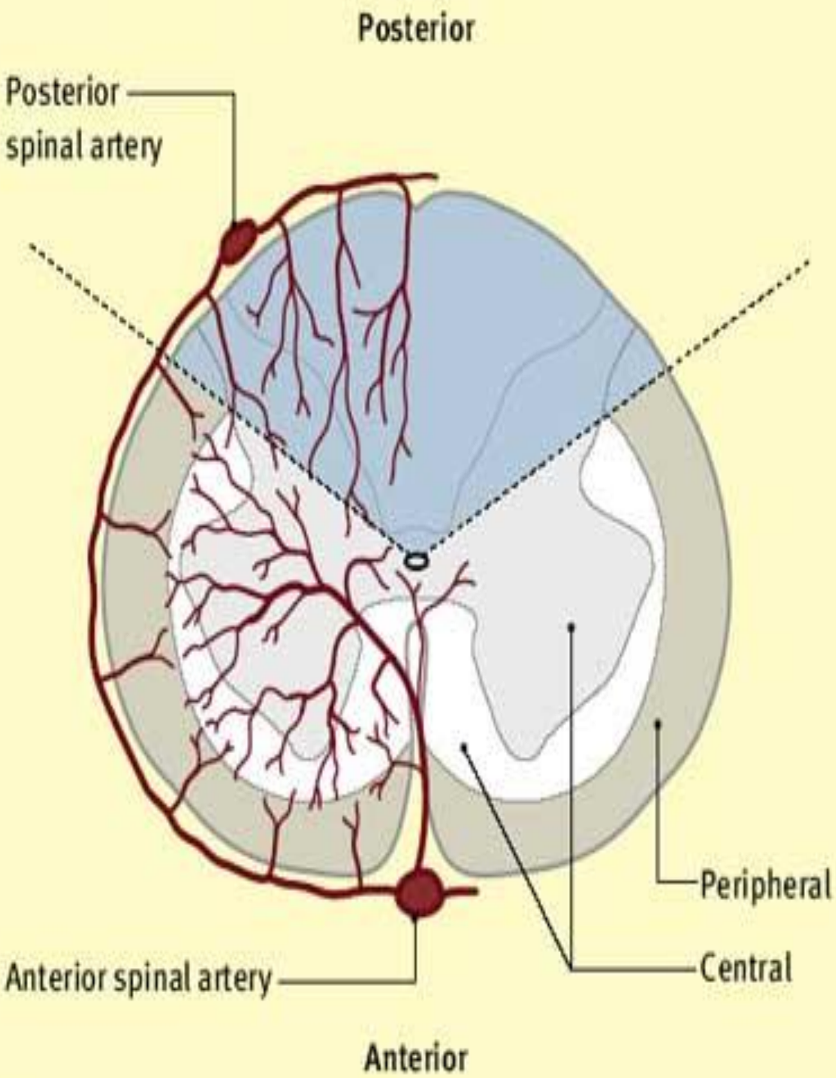
In the inferior thoracic, lumbar and sacral parts of the spinal cord there are from 1 to 3 radiculo-spinal arteries. In the lumbar region, one anterior radicular artery is quite large (up to 2 mm in diameter) and is known as the lumbar enlargement artery (artery of Adamkiewicz). 25% of people have supplemental artery of Deproges Gotteron.


The Artery of Adamkiewicz
Radiculomedullary Artery
Muscular Branch
Anterior Spinal Artery
Anterior Branch
Intercostal Artery
Aorta

Anterior radiculo-spinal arteries are larger than posterior. The largest anterior radicular artery is known as the artery of Adamkiewicz. This artery is usually found on the left and enters the vertebral canal by following an anterior root from Th_1 to L_2 level.

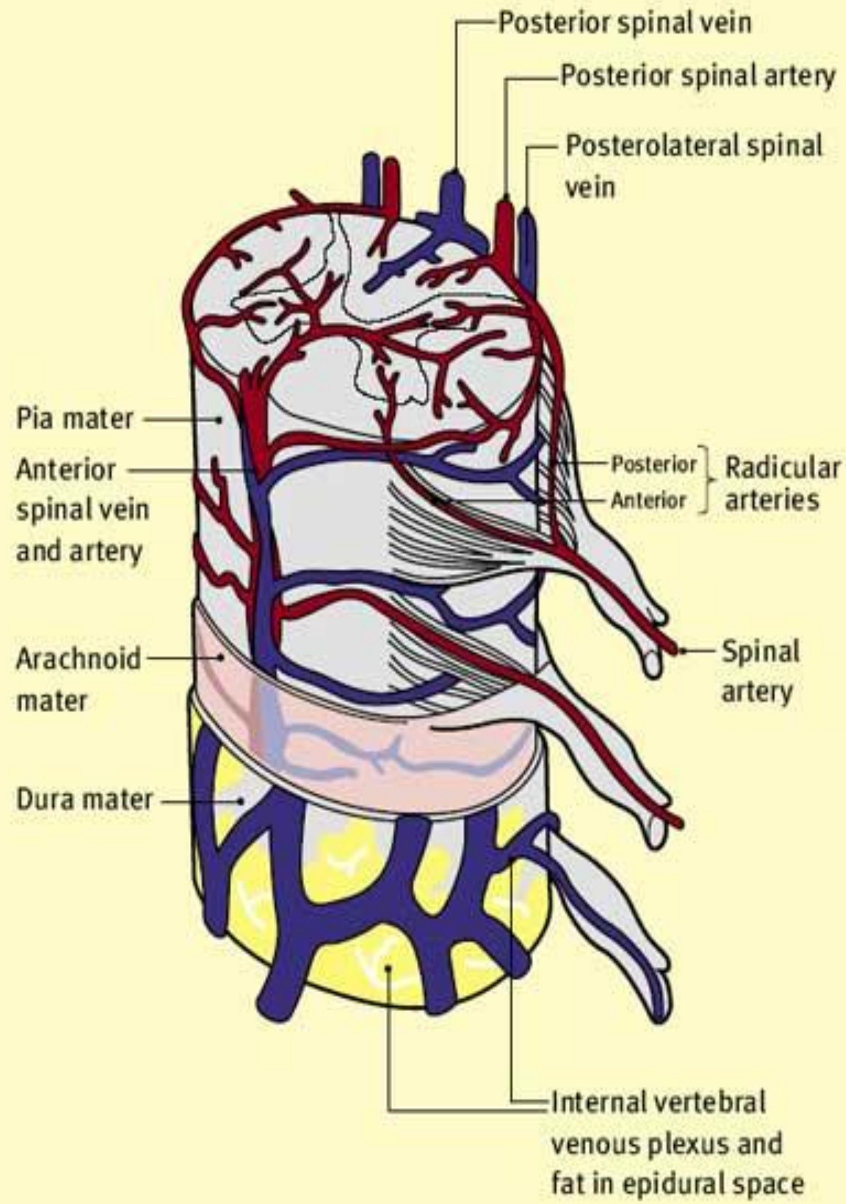
In case of the artery of Adamkiewicz occlusion the syndrome of the myelogenic or neurogenic intermittent claudication occurs.

Blood supply to the spinal cord: horizontal distribution



The central area supplied only by the anterior spinal artery is predominantly a motor area

Arterial supply and venous drainage of the spinal cord



The greatest distance between radicular arteries that contribute significantly to the anterior and posterior spinal arteries is found at the thoracic level of the spinal cord. At this level, occlusion of just one radicular artery could lead to significant infarct of spinal tissue. The T_1–T_4 levels of the thoracic cord are particularly vulnerable to infarct following occlusion of a radicular artery. Spinal cord segment L_1 is another vulnerable region.

Unterharnscheidt's syncopal vertebral syndrome: **quick turn of a head leads to the upper and lower extremities paralysis, loss of consciousness for 2-3 mines; in 3-10 mines all symptoms regress.**

Syndrome of superior cervical segments CI-CIV lesion:

- spastic tetraplegia;
- loss of all types of sensation below the uppermost level of the lesion;
- root CI-CIV lesion symptoms;
- in case of the posterior horns CI-CIII lesion- dissociative anesthesia in the posterior parts of the face (tr. spinalis n. trigemini);
- bladder and rectal dysfunction;
- diaphragm paralysis-respiratory impairment, singultus (n. phrenicus).

Syndrome of the cervical intumescence C_V-Th_{II} lesion:

- **spastic paresis of the lower extremities;**
- **flaccid paresis of the upper extremities;**
- **sensory loss below the lesion;**
- **upper neuron type of bladder and rectal dysfunction;**
- **Horner's syndrome: ptosis, miosis, enophthalmos.**

Symptoms of the Th_3-Th_{12} segments lesion:

- spastic palsy of legs;
- sensory loss below the lesion;
- upper neuron type of bladder dysfunction;
- loss of the abdominal reflexes;
- trophic changes in lower part of the body and legs.

Anterior spinal artery syndrome (Preobrazhensky syndrome) **— quadriparesis (depending on the level of the injury) and impaired pain and temperature sensation, normal tactile and proprioception.**

Stanilovsky-Tanon syndrome (stroke in the ventral part of the spinal cord): **spastic paraplegia in lower extremities, dissociative paraanesthesia, urinary and defecation retention.**

Occlusion of posterior spinal arteries (Williamson‘s syndrome) **causes loss of tendon reflexes and loss of joint position sense.**

Deproges Gotteron's artery occlusion syndrome: **feet paresis and myelogenic intermittent claudication.**

Syndrome of lumbar enlargement L_1-S_2 lesion:

- flaccid palsy of legs;
- sensory loss in legs and saddle (paranesthesia);
- upper neuron type of bladder dysfunction.

Syndrome of the epiconus L_4-S_2 lesion:

- **flaccid palsy of posterior group of muscles of the leg, absent Achilles reflex;**
- **sensory loss in shin, foot, buttocks and saddle (paranesthesia);**
- **upper neuron type of bladder dysfunction, impotence.**

Cone S_{III}–S_{V} syndrome:

- sensory loss in saddle region;
- lower neuron type of bladder dysfunction;
- trophic changes in sacral region;
- anal reflex absence, impotence.

Syndrome of the conus medullaris and epiconus L_4-S_5 lesion:

- **flaccid palsy of distal parts of the legs, pathological foot signs;**
- **sensory loss in shin, foot, buttocks and saddle (paranesthesia);**
- **upper neuron type of bladder and bowel dysfunction;**
- **trophic changes in sacral region, feet.**

Cauda equina L_2-S_5 lesion:

- **flaccid palsy in legs;**
- **sensory loss in legs, buttocks and saddle;**
- **lancinating pain;**
- **tension symptoms;**
- **lower neuron bladder dysfunction.**

Veins of the brain:

- **Have no muscular tissue in their very thin walls**
- **Possess no valves**
- **Emerge from the brain and lie in the subarachnoid space**
- **Pierce the arachnoid mater and meningeal layer of the dura and drain into the cranial venous sinuses**

External Cerebral Veins:

- **Superior cerebral veins – pass upward over the lateral surface of the cerebral hemisphere and empty into the superior sagittal sinus**
- **Superficial middle cerebral vein drains the lateral surface of the cerebral hemisphere and empties into the cavernous sinus**
- **Deep middle cerebral vein drains the insula and is joined by the anterior cerebral and striate veins to form the basal vein**

Internal Cerebral Veins:

- **2 internal cerebral veins formed by the union of thalamostriate vein and the choroid vein**
- **Both run posteriorly in the tela choroidea of the 3th ventricle and unite beneath the corpus callosum form the great cerebral vein**
- **Great cerebral vein then empties into the straight sinus**

Vegetative nervous system

is a multifaceted neural network that controls visceral functions and metabolism.

The vegetative nervous system, also known as the autonomic nervous system, cannot be voluntarily controlled.

The main functions of VNS are:

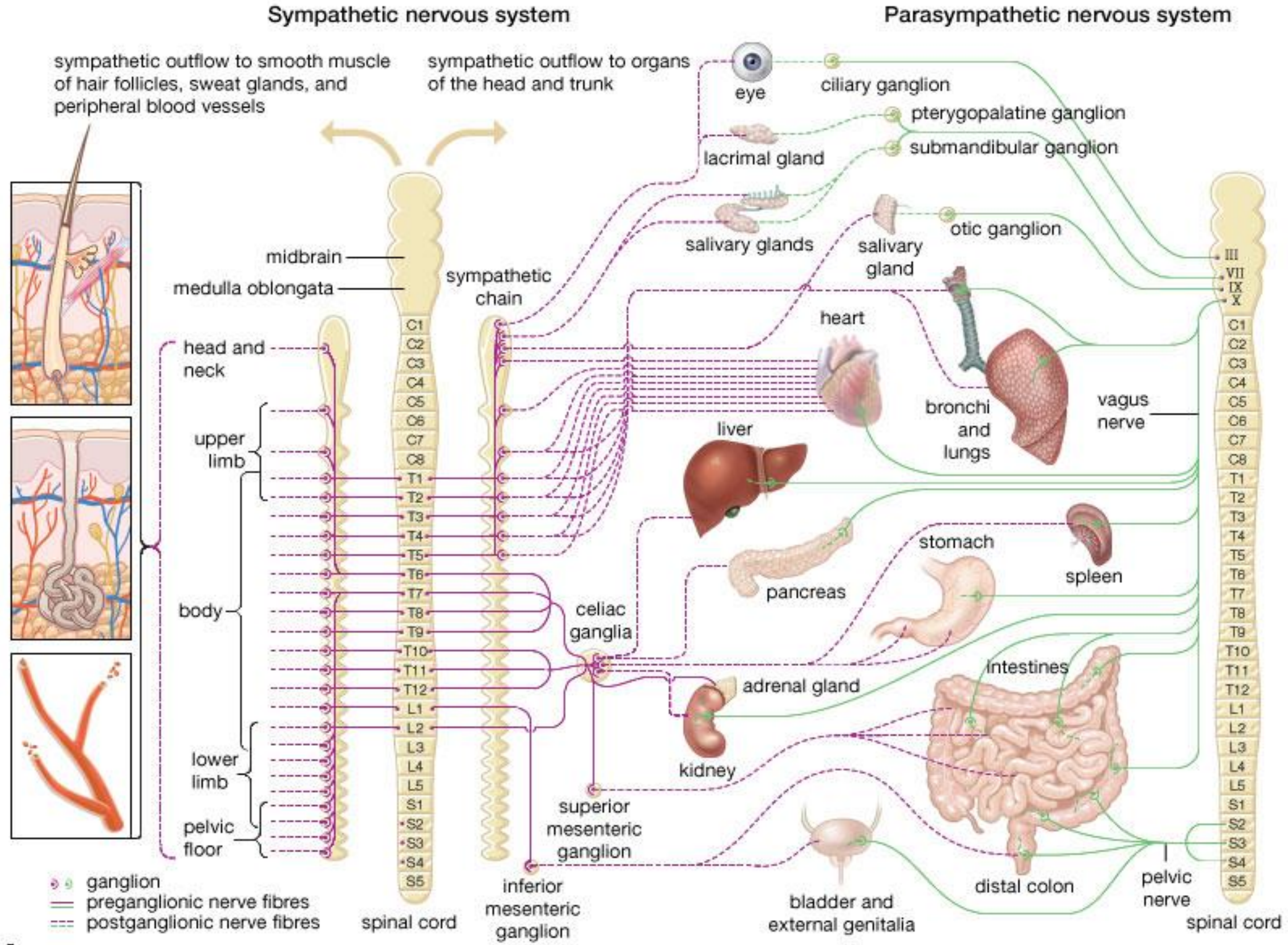
1. Maintenance of the homeostasis.

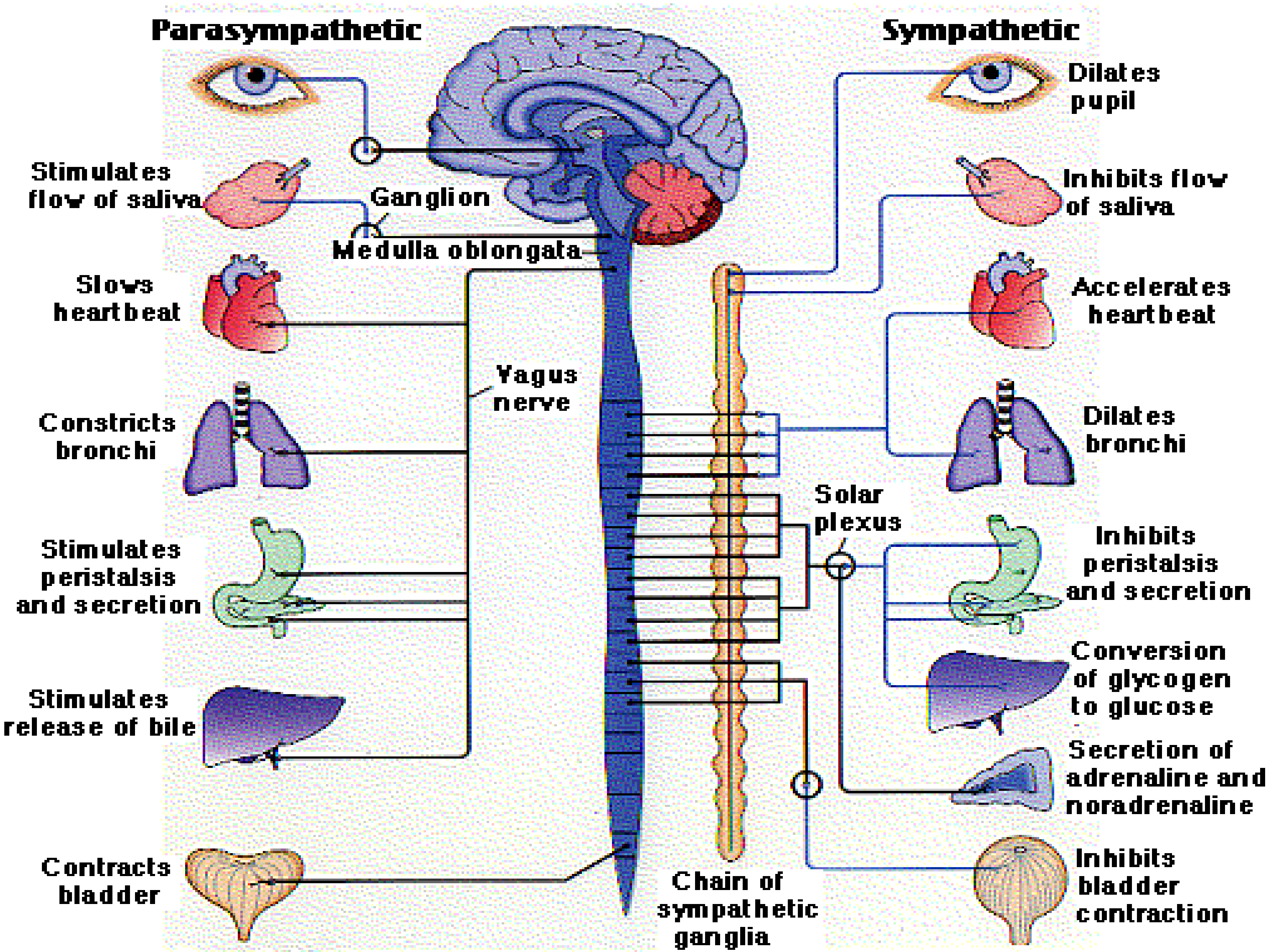
2. Vegetative maintenance of various forms of activity and adaptation to changing conditions of environment.

In CNS vegetative cells are located in:

- **brainstem and spinal cord;**
- **hypothalamus nuclei, limbic system and reticular formation;**
- **association cortex.**

The VNS is divided into sympathetic nervous system and parasympathetic nervous system.


Sympathetic nervous system
Parasympathetic nervous system
sympathetic outflow to smooth muscle of hair follicles, sweat glands, and peripheral blood vessels
sympathetic outflow to organs of the head and trunk
eye
ciliary ganglion
pterygopalatine ganglion
submandibular ganglion
lacrimal gland
salivary glands
salivary gland
otic ganglion
midbrain
medulla oblongata
sympathetic chain
heart
bronchi and lungs
vagus nerve
liver
head and neck
upper limb
body
lower limb
pelvic floor
celiac ganglia
pancreas
stomach
spleen
intestines
adrenal gland
kidney
superior mesenteric ganglion
inferior mesenteric ganglion
distal colon
bladder and external genitalia
pelvic nerve
spinal cord
spinal cord
III
VII
IX
X
C1
C2
C3
C4
C5
C6
C7
C8
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
L1
L2
L3
L4
L5
S1
S2
S3
S4
S5
ganglion
preganglionic nerve fibres
postganglionic nerve fibres



Parasympathetic
Sympathetic
Dilates pupil
Stimulates flow of saliva
Ganglion
Inhibits flow of saliva
Medulla oblongata
Slows heartbeat
Accelerates heartbeat
Vagus nerve
Constricts bronchi
Dilates bronchi
Solar plexus
Stimulates peristalsis and secretion
Inhibits peristalsis and secretion
Conversion of glycogen to glucose
Stimulates release of bile
Secretion of adrenaline and noradrenaline
Contracts bladder
Inhibits bladder contraction
Chain of sympathetic ganglia

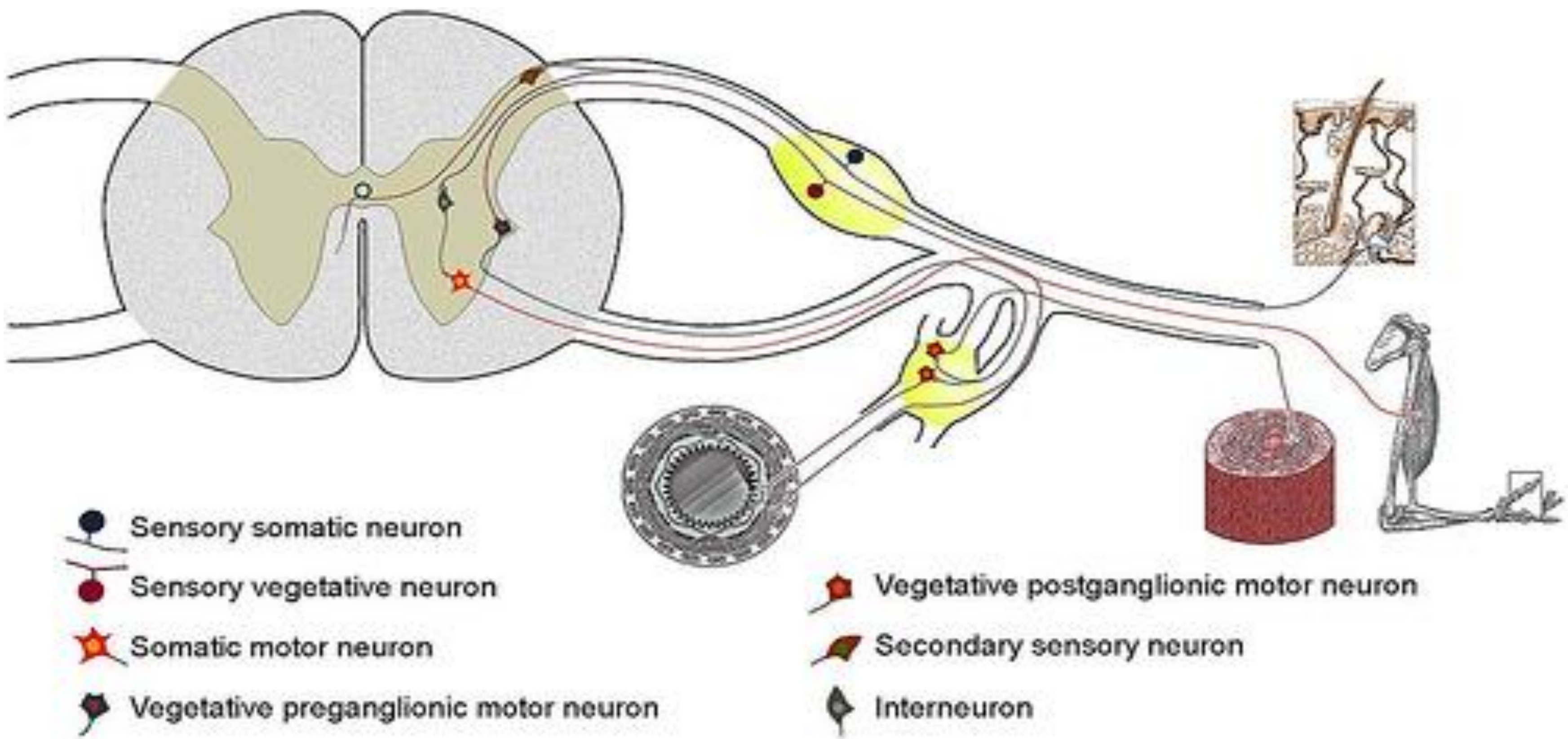
Sympathetic nervous system is represented by:

1. **Spinal sympathetic centers.**
2. **Sympathetic trunks.**
3. **Sympathetic nerves and ganglions.**
4. **Prevertebral sympathetic ganglion.**
5. **Sympathetic plexuses around blood vessels.**
6. **Sympathetic fibers in somatic nerves.**

1. Spinal sympathetic centers are located in the lateral horns of spinal cord (intermediolateral cell columns) from C_8 to L_3.

Sympathetic cells of the spinal cord have afferent and efferent fibers. Afferent fibers originate *from* spinal ganglion cells. Peripheral process of ganglion cell goes to the internal organ. Central nerve-cell process goes to the spinal cord and synapses with back horn neurons, and then with the sympathetic centers of lateral horns.

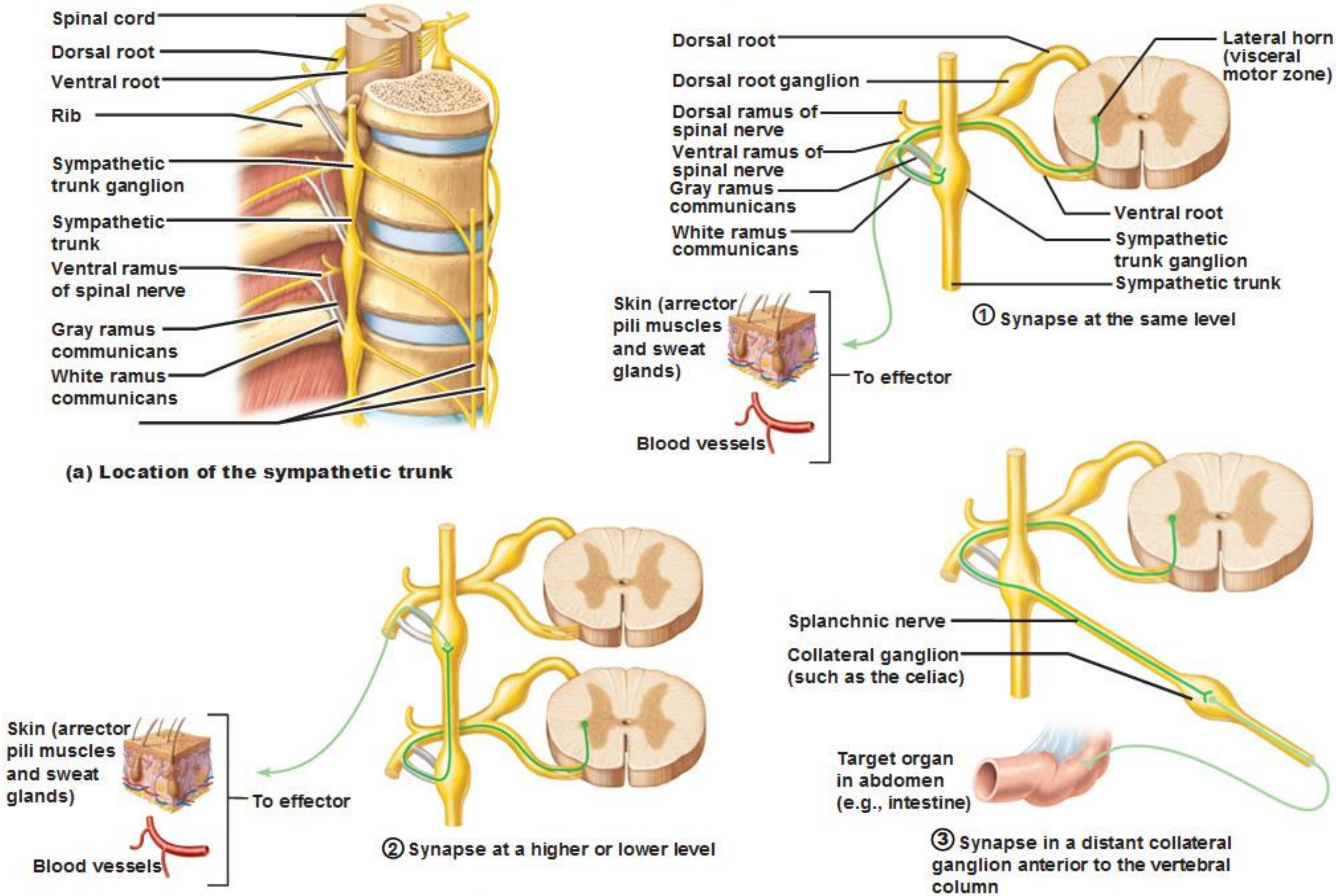
Efferent fibers of sympathetic cells leave the spinal cord together with the ventral roots, then separate from them (rami communicants albi) and enter the truncus sympathicus.



2. Sympathetic *trunk* is formed by the sympathetic ganglions connected between themselves by longitudinal bunches of fibers. There are 20-22 paravertebral ganglions *from each side*:

- **3 cervical ganglions (superior, middle and inferior). Inferior cervical ganglion usually conjugates with superior thoracic ganglion and they form cervicothoracic stellate ganglion;**
- **10-12 thoracic ganglions;**
- **3-4 abdominal ganglions;**
- **4 pelvic ganglions.**

Sympathetic Chain



(a) Location of the sympathetic trunk

(b) Three pathways of sympathetic innervation

Parasympathetic nervous system is divided into:

1. Hypothalamic division.

2. Mesencephalic division.

3. Bulbar division.

4. Sacral division.

- **Hypothalamic division is *presented by* the supraoptical nucleus**
- **Mesencephalic division is formed *by* vegetative neurons of oculomotor nerve.**

3. Bulbar division is presented by neurons of CN VII, IX, X nuclei and by this nerve-cells processes. Parasympathetic fibers of an facial nerve innervate lacrimal gland, mandibular and sublingual glands. Parasympathetic fibers of the CN IX innervate parotid gland. The vagus nerve provides parasympathetic innervation.

4. Sacral division is formed by the neurons of SII-SIV segments of spinal cord.

Double innervation

The majority of internals and tissues are innervated by sympathetic and parasympathetic nerves simultaneously.

The autonomic innervation of the eye

Parasympathetic efferent fibers of the oculomotor nerve probably arise from cells of the accessory nucleus. These preganglionic ***fibers run with*** **the third nerve into the orbit and pass to the ciliary ganglion. Postganglionic fibers proceed as the short ciliary nerves to the sphincter pupillæ muscle. Thus, in case of parasympathetic cells and fibers lesion, the pupil becomes mydriatic, due to the m.dilatator pupillae constriction (sympathetic innervation).**

The dorsal nucleus of oculomotor nerve innervates a ciliary muscle. Accommodation disorders are the result of lesion of the ciliary muscle innervation.

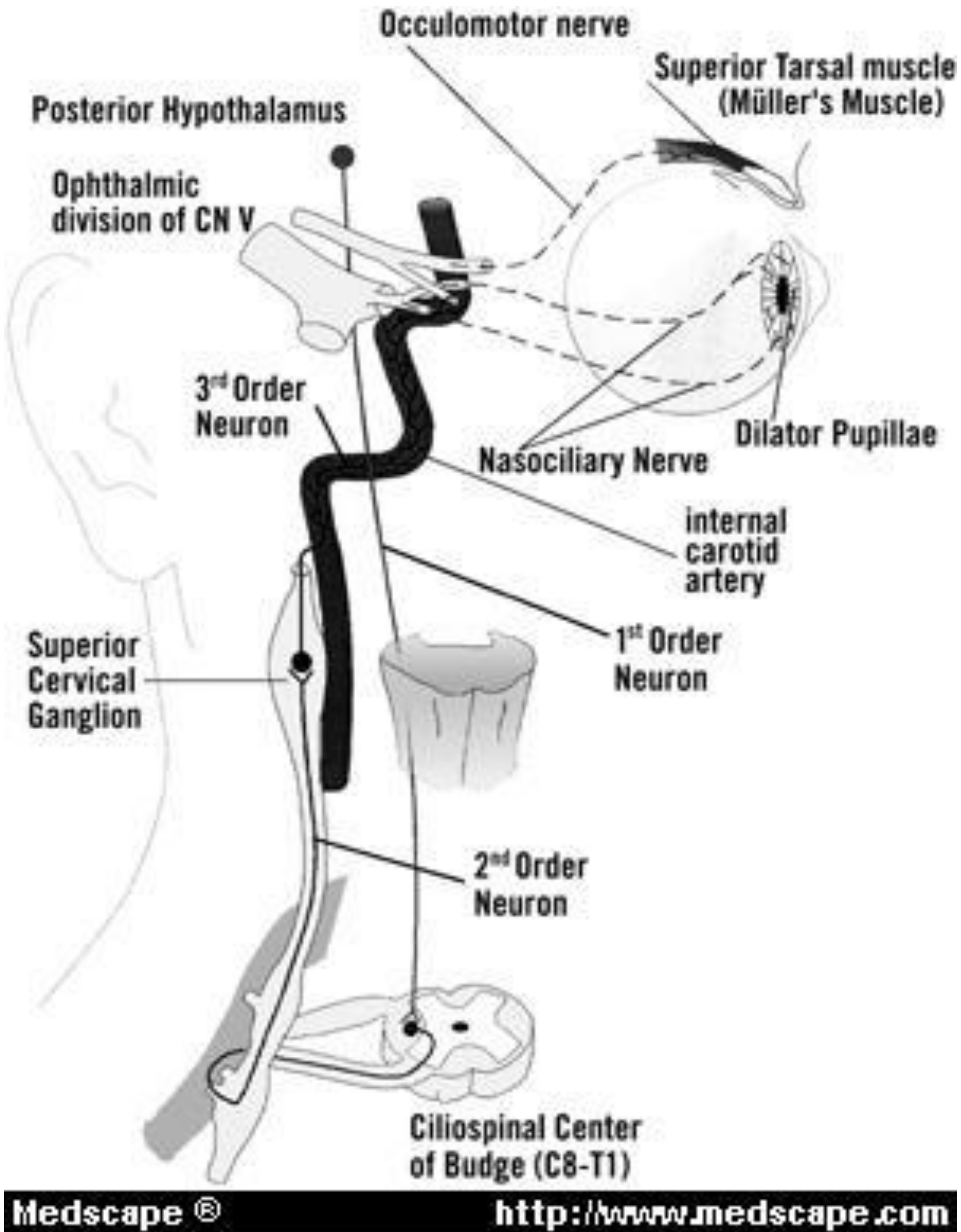
Preganglionic sympathetic **fibers** ***originate from*** **neurons located in lateral horns of C_8-Th_1 spinal segments.**

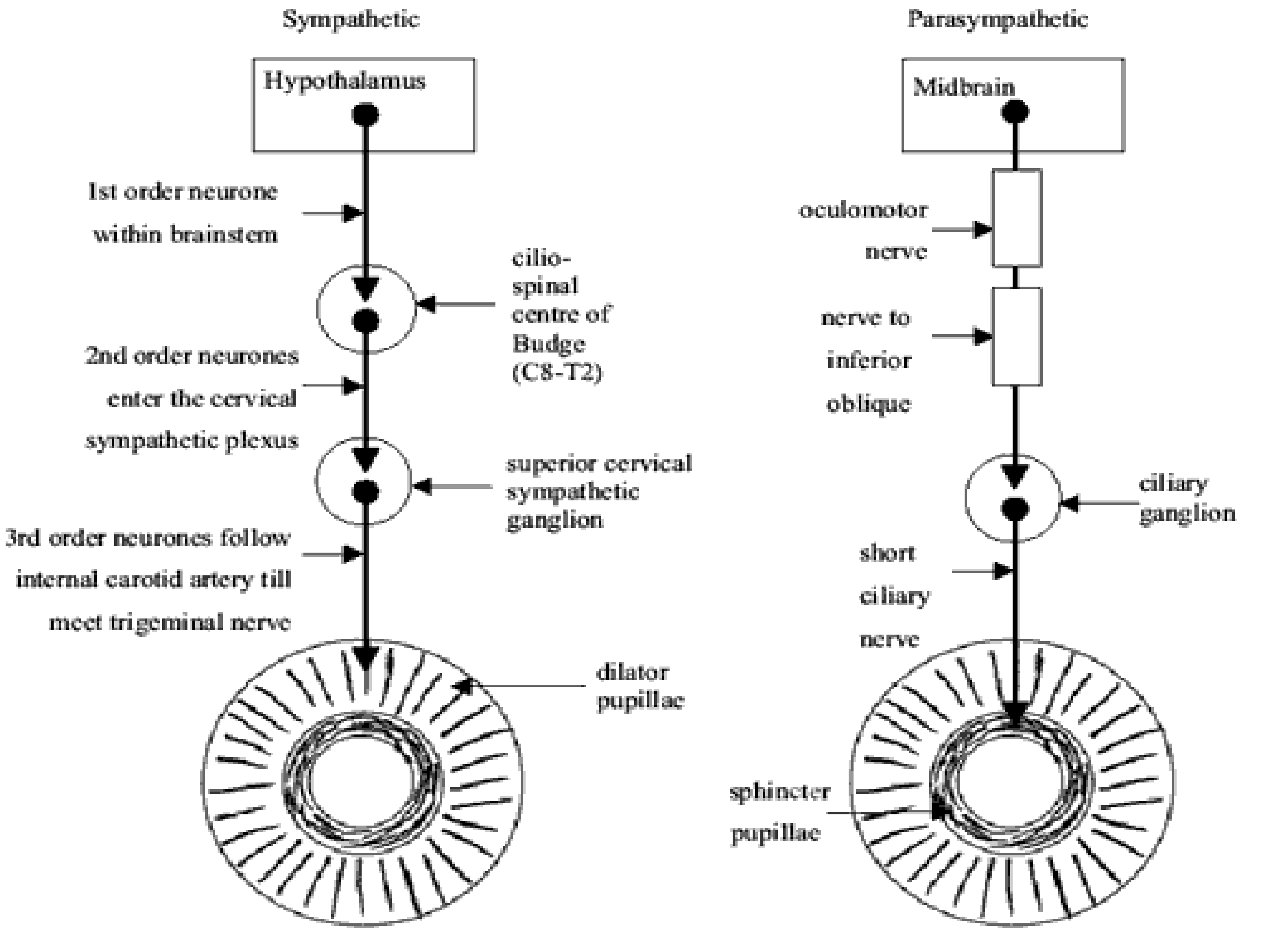
Efferent fibers of sympathetic cells leave the spinal cord together with the ventral roots, separate from them and enter the stellate ganglion.

Fibres pass through stellate ganglion, the middle cervical ganglion and form synapses in superior cervical ganglion.

Postganglionic sympathetic fibers ascend with the internal carotid artery as a plexus of nerves *to the braincase*. Sympathetic fibers innervating the eye separate from the carotid plexus within the cavernous sinus. They run forward through the superior orbital fissure and innervate the dilator pupillae.

Besides, sympathetic fibers touch with muscle dilator palpebral fissure and unstriped muscle of orbit cellular tissue.


Occulomotor nerve
Superior Tarsal muscle (Müller's Muscle)
Posterior Hypothalamus
Ophthalmic division of CN V
3rd Order Neuron
Dilator Pupillae
Nasociliary Nerve
internal carotid artery
1st Order Neuron
Superior Cervical Ganglion
2nd Order Neuron
Ciliospinal Center of Budge (C8-T1)
Medscape ®
http://www.medscape.com



Sympathetic
Hypothalamus
1st order neurone within brainstem
cilio-spinal centre of Budge (C8-T2)
2nd order neurones enter the cervical sympathetic plexus
superior cervical sympathetic ganglion
3rd order neurones follow internal carotid artery till meet trigeminal nerve
dilator pupillae
Parasympathetic
Midbrain
oculomotor nerve
nerve to inferior oblique
ciliary ganglion
short ciliary nerve
sphincter pupillae

Claude Bernard-Horner syndrome can be caused by the lesion of the sympathetic neurons and fibers. This syndrome is the combination of the eyelid drooping(ptosis), enophthalmos and constriction of the pupil (miosis).

The most common causes are following:

- **lateral horns C8-Th1 lesion;**
- **Pancoast tumor (tumor in the apex of the lung);**
- **internal carotid and ophthalmic arteries lesions.**

Pourfour du Petit syndrome is a rare dysautonomic disorder characterized by mydriasis, eyelid retraction, and hyperhidrosis and is caused by irritative stimulation of the sympathetic cervical chain.

The bladder has double vegetative (sympathetic and parasympathetic) innervation. The parasympathetic control of the bladder unstriped musculature (mainly detrusor), the contraction of which causes bladder emptying, originates with neurons in the sacral spinal cord segments (S_2–S_4).

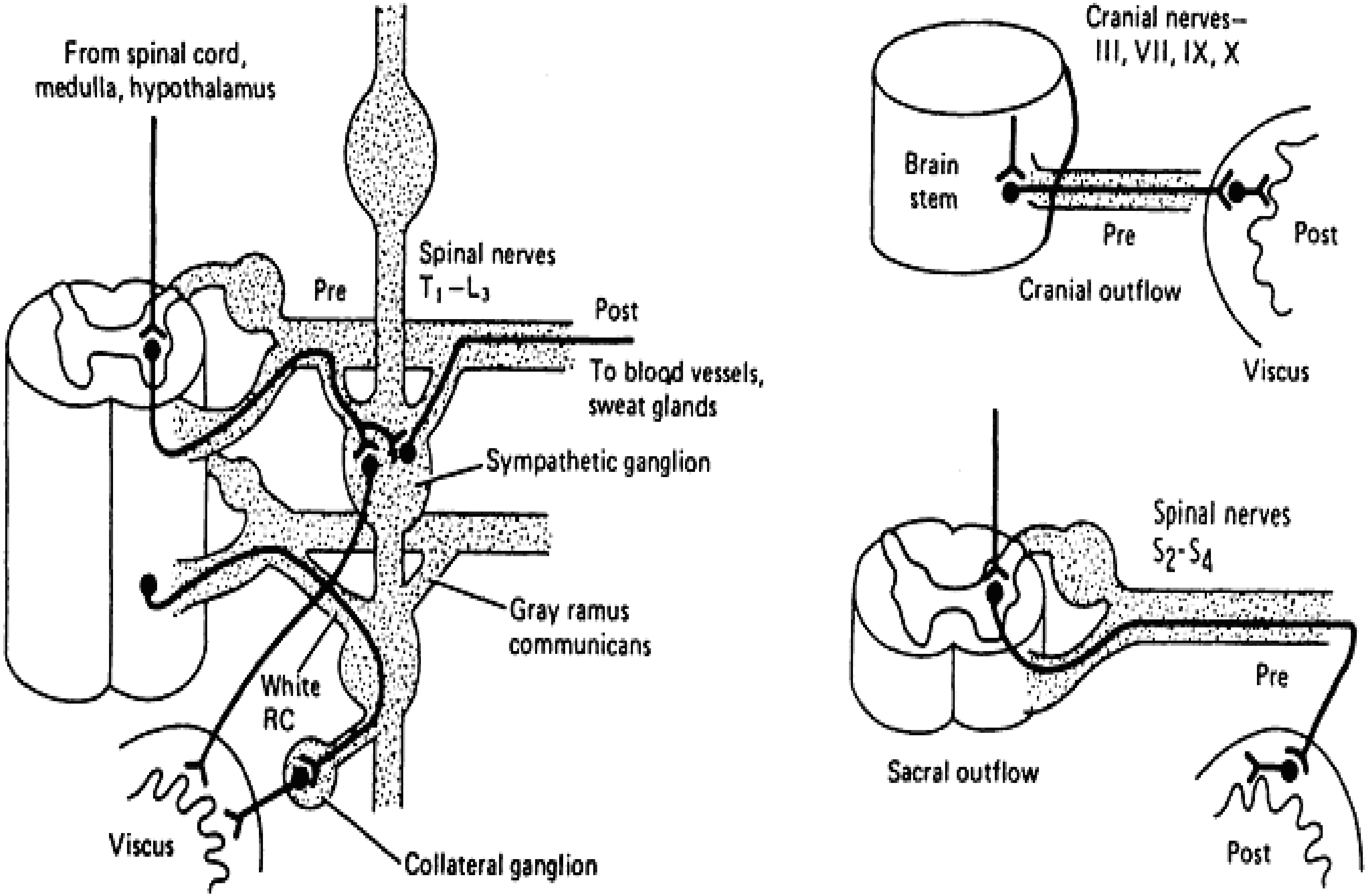
Parasympathetic system provides contraction of detrusor and bladder sphincter relaxation.

The sympathetic innervation of the bladder originates in the lower thoracic and upper lumbar spinal cord segments (T_{10}-L_2), the preganglionic axons running to sympathetic neurons in the inferior mesenteric ganglion and the ganglia of the pelvic plexus. The postganglionic fibers from these ganglia travel in the hypogastric and pelvic nerves to the bladder, where sympathetic activity causes the internal urethral sphincter contraction, and detrusor relaxation.

Bladder functioning is performed due to *spinal reflex*: sphincter contraction leads to detrusor muscle relaxation — a bladder filled with urine. When the bladder is full, the internal sphincter muscle relaxes and the bladder contracts. In this circumstance, the urine is held in check by the voluntary (somatic) motor innervation of the external urethral sphincter muscle.

The afferent part of this reflex originates with receptors in the internal sphincter. Nerve impulses enter the spinal ganglions, dorsal roots, dorsal columns, medulla, pons, midbrain and reache girus fornicatus. From there nerve impulses arrive in lobulus paracentralis (motor urination center).

The efferent part of a reflex as a part of a corticospinal tract passes in lateral and dorsal columns of the spinal cord and comes to an end in the spinal urination centers (S2-S4 segments). *Then* fibers go in the ventral roots, plexus pudendus, n. pudendus and reach the external bladder sphincter.



SYMPATHETIC DIVISION

PARASYMPATHETIC DIVISION

TYPES OF BLADDER DYSFUNCTION

Upper motor neuron lesion

Acute transverse lesions rostral to the sacral segments:

- **flaccid and hypotonic bladder during the stage of spinal shock.**

Chronic lesion:

- **the bladder ultimately becomes spastic and «hyperreflexic» (usual effects of upper motor neuron lesions on motor function);**
- **the bladder empties automatically in response to minimal distention by urine;**
- **since the bladder never distends to its full capacity, it ultimately contracts;**
- **the patient urinates frequently and involuntarily and voids only small quantities of urine.**

When the voluntary sphincter is very spastic, the bladder may become huge and distended.

Lower motor neurons lesion:

- **hypotonic bladder;**
- **contracts sluggishly, or it may be paralytic — incontinence;**
- **sensation may be preserved;**
- **the bladder wall distends and becomes very thin;**
- **residual urine and bladder capacity are huge.**

Deafferentiation of the bladder:

- **huge, distended bladder (up to 1,000 to 1,500 ml of urine);**
- **the bladder wall becomes hypertrophic;**
- **the patient has no sensation of fullness;**
- **the absence of afferent impulses makes urination difficult or impossible to initiate;**
- **the patient has overflow incontinence and huge quantities of residual urine.**

TYPES OF BLADDER DYSFUNCTION DEPENDING ON LESION LOCATION

- **lobulus paracentralis: upper motor neuron lesion; involuntary urination;**
- **complete cord transection: upper motor neuron lesion; urine retention; automatical emtying of the bladder (*incontinentia urinae intermittens*);**
- **sacral segments of the cord: lower motor neuron lesion; involuntary urination without retention (*incontinentia urinae vera*);**
- **incomplete lesion of the sacral segments of the cord: lower motor neuron lesion; excretion of small quantities of urine as the bladder distents (*ishuria paradoxa*).**

Diagnosing of the autonomic nervous system disorders

Patients examination:

- **pupils condition;**
- **exophthalmus;**
- **xerodermia or hyperhidrosis;**
- **skin color and pigmentation;**
- **trembling;**
- **palpation: pulse rate, temperature, hyperhidrosis.**

Functional methods of examination

Cardiac reflexes:

- **Hering reflex, or so-called respiratory arrhythmia: pulse depression at a deep breath and its elevation at an exhalation;**
- **The oculocardiac reflex, also known as Aschner-Dagnini reflex, is a decrease in pulse rate associated with compression of the eyeball;**
- **Czermak-Hering test: pulse depression caused by the external digital pressure applied to the carotid sinus.**

Symptoms of VNS disorders:

1. Hyperexcitability of the sympathetic system(sympathicotonia):

- **midriasis, widening of the palpebral fissure;**
- **xerodermia, paleness;**
- **tachycardia, blood pressure increase;**
- **tachypnea;**
- **dry mouth, decrease of the gastric and intestinal motor and secretory abilities;**
- **bent to a weight loss owing to the raised metabolism.**

Sympathicotonia often accompanies fever, manic state, Basedow's disease, etc.

2. Hyperexcitability of the parasympathetic system(parasympathicotonia or vagotonia) is represented by the following symptoms:

- **miosis, contraction of the palpebral fissure;**
- **cold, cyanotic discoloring skin, hypergidrosis;**
- **bradicardia, respiratory arrhythmia, extrasystole, blood pressure reduction;**
- **hypersalivation, increase of the gastric and intestinal motor and secretory abilities;**
- **increase of weight due to the *reduced metabolism.***

Parasympathicotonia *occurs due to* depression, shock, bronchial asthma.

***3. Hyperexcitability of the sympathetic and parasympathetic systems* – characterised by instability of a vegetative nervous tone and excessive reaction to irritations from various organs and systems.**

4. Hypoexcitability of the sympathetic and parasympathetic systems **is characterised by decreased reactions to irritations. In some cases of this syndrome the following symptoms are observed: pulse and breath increase, cold sweat, body temperature fall, singultus, nausea, vomiting, blood pressure falling, i.e. a shock picture.**