NERVOUS SYSTEM

Department of Histology, Cytology and Embryology
of the General Medicine Faculty
Pirogov Russian National Research Medical University

NERVOUS SYSTEM

Central

1. Brain
2. Spinal cord

Peripheral

1. Nerves
2. Nerve endings
3. Ganglia

NERVOUS SYSTEM

Somatic

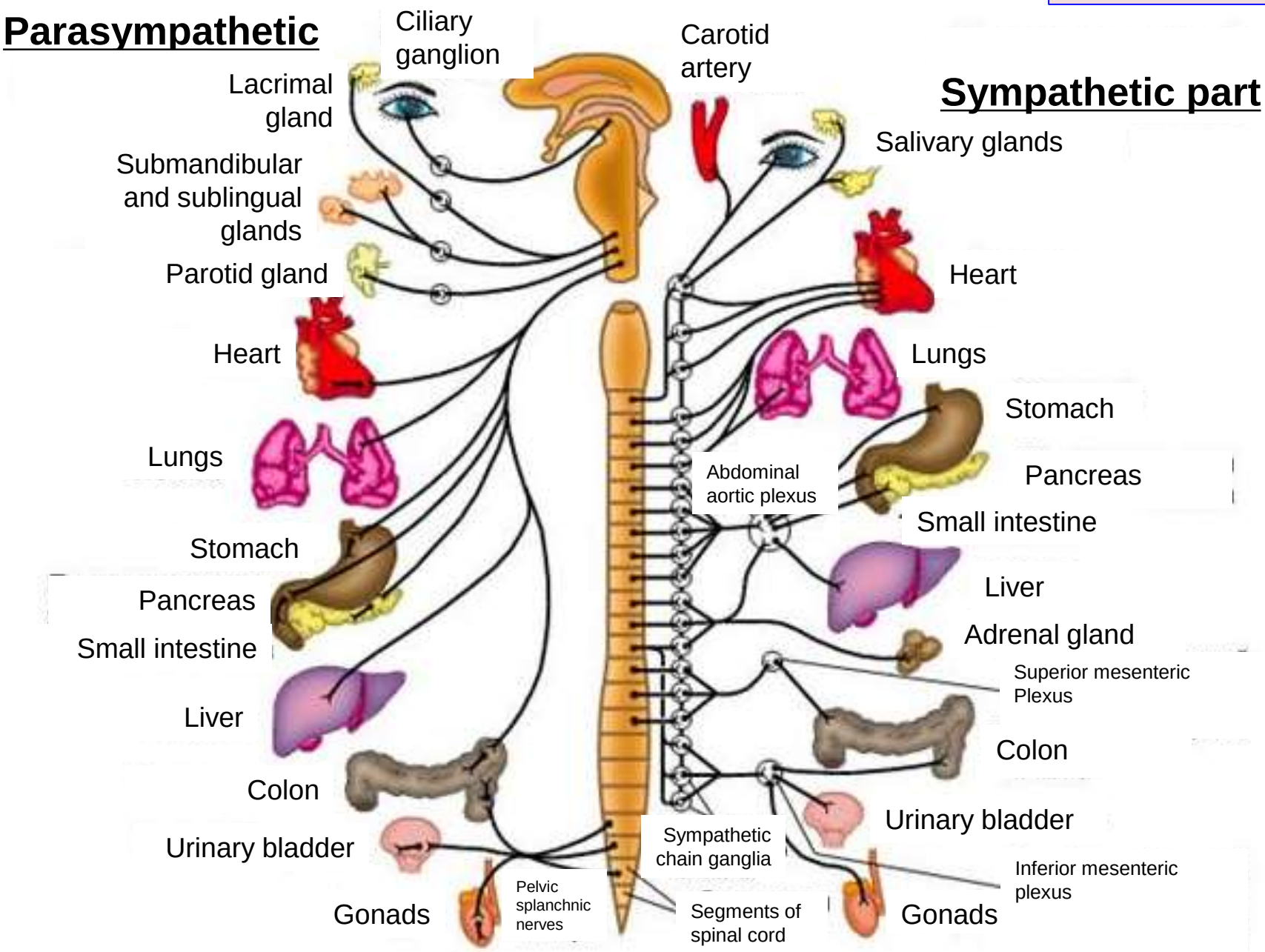
Innervates voluntary muscles

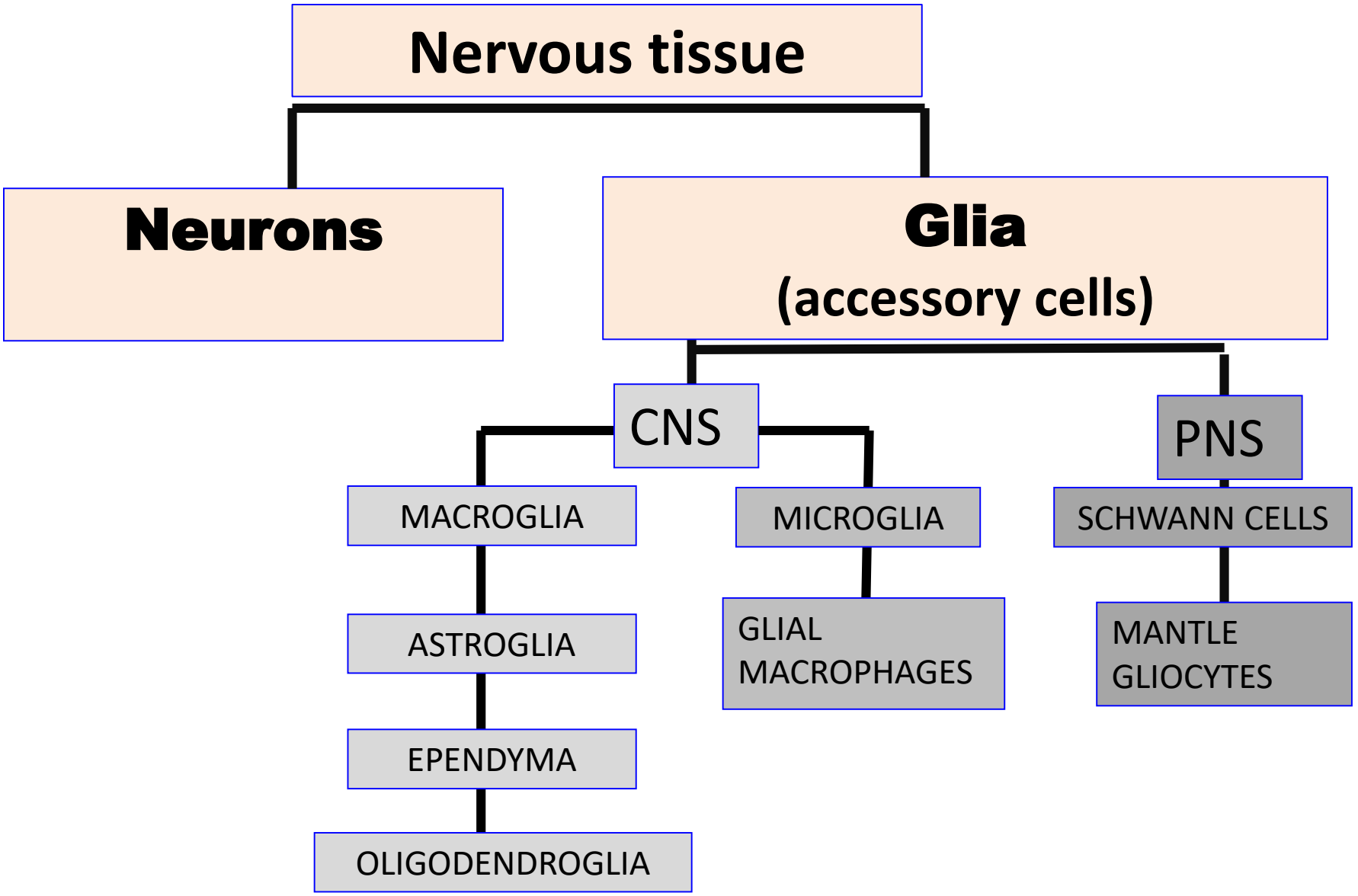
Autonomic

Innervates internal organs, blood vessels, glands

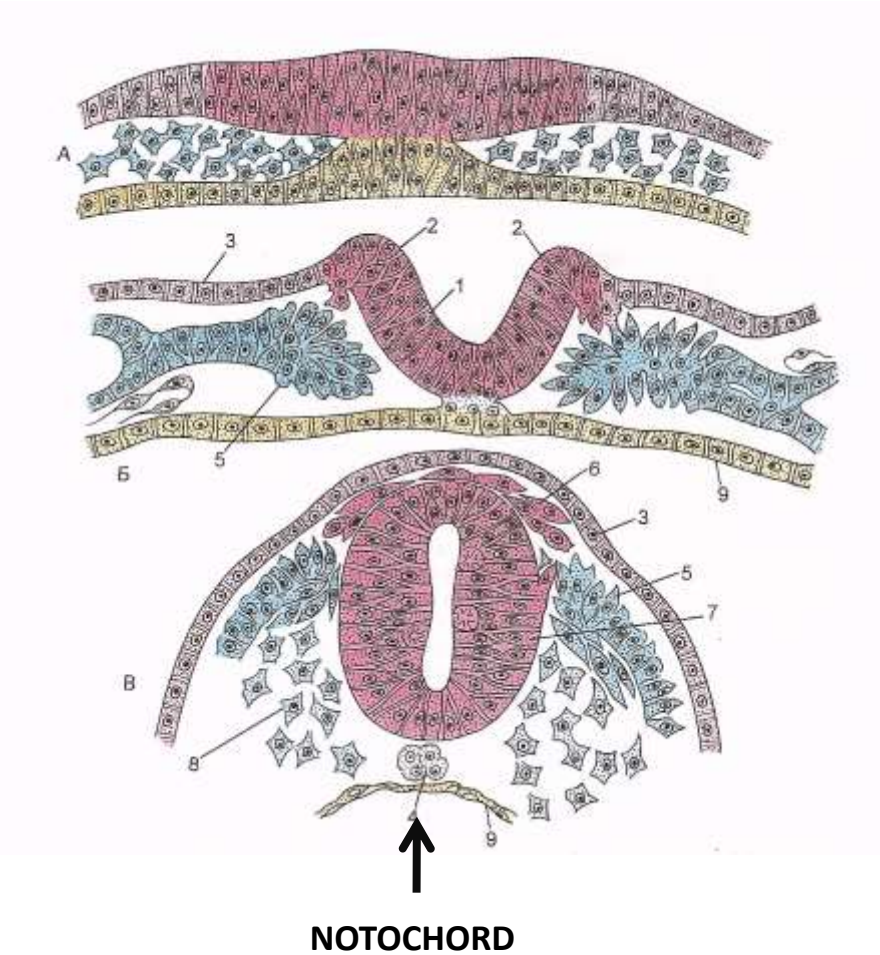
Is subdivided into

Sympathetic **Parasympathetic**


Parasympathetic
Ciliary ganglion
Lacrimal gland
Submandibular and sublingual glands
Parotid gland
Heart
Lungs
Stomach
Pancreas
Small intestine
Liver
Colon
Urinary bladder
Gonads
Pelvic splanchnic nerves
Carotid artery
Sympathetic part
Salivary glands
Heart
Lungs
Stomach
Pancreas
Small intestine
Liver
Adrenal gland
Superior mesenteric Plexus
Colon
Urinary bladder
Inferior mesenteric plexus
Gonads
Abdominal aortic plexus
Sympathetic chain ganglia
Segments of spinal cord


Nervous tissue
Neurons
Glia
(accessory cells)
CNS
PNS
MACROGLIA
MICROGLIA
SCHWANN CELLS
ASTROGLIA
GLIAL MACROPHAGES
MANTLE GLIOCYTES
EPENDYMA
OLIGODENDROGLIA

DEVELOPMENT OF NERVOUS SYSTEM



NOTOCHORD

ECTODERM
NEUROECTODERM
NEURAL PLATE

↓

NEURAL GROOVE

↓

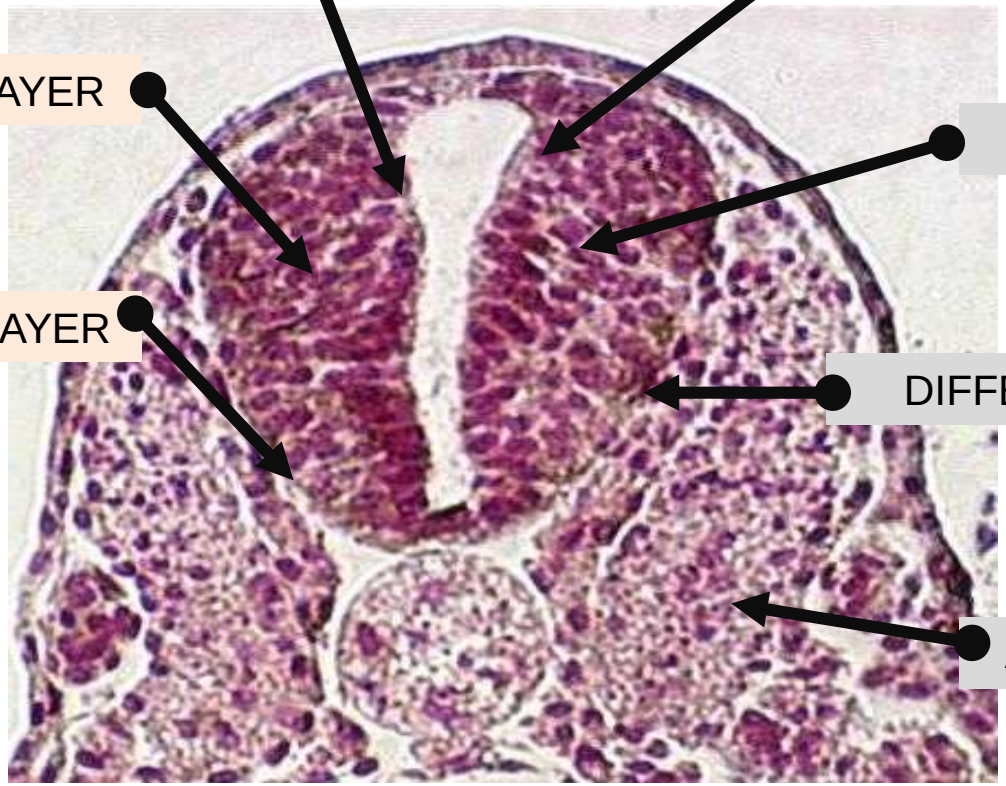
NEURAL TUBE

NEURAL CREST
(subsequently -
GANGLIONIC PLATE)

DEVELOPMENT OF NERVOUS SYSTEM

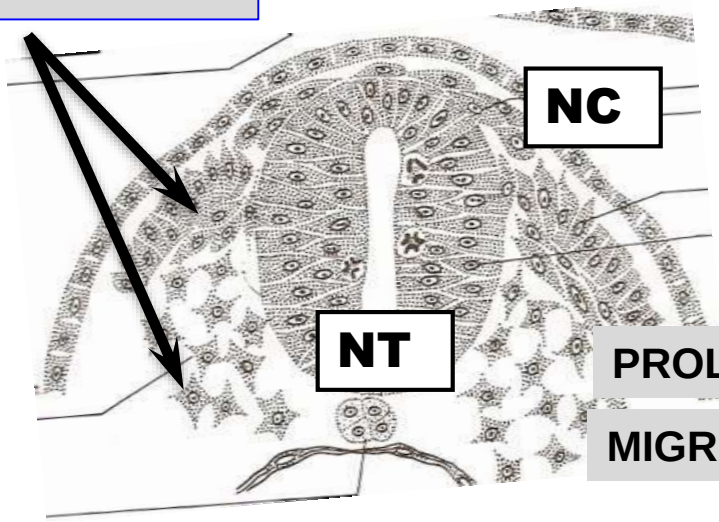
LAYERS OF THE NEURAL TUBE

CELLULAR MECHANISMS



EMBRYONIC DEVELOPMENT OF NERVOUS SYSTEM

CELLULAR MECHANISMS

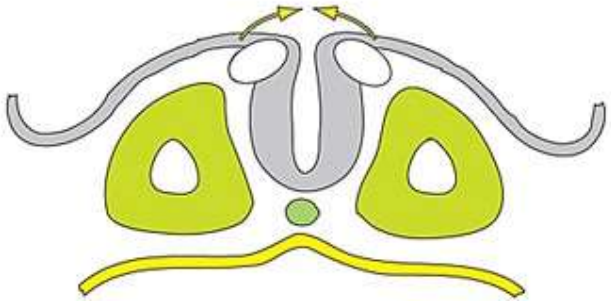


PROLIFERATION

MIGRATION

DIFFERENTIATION

APOPTOSIS

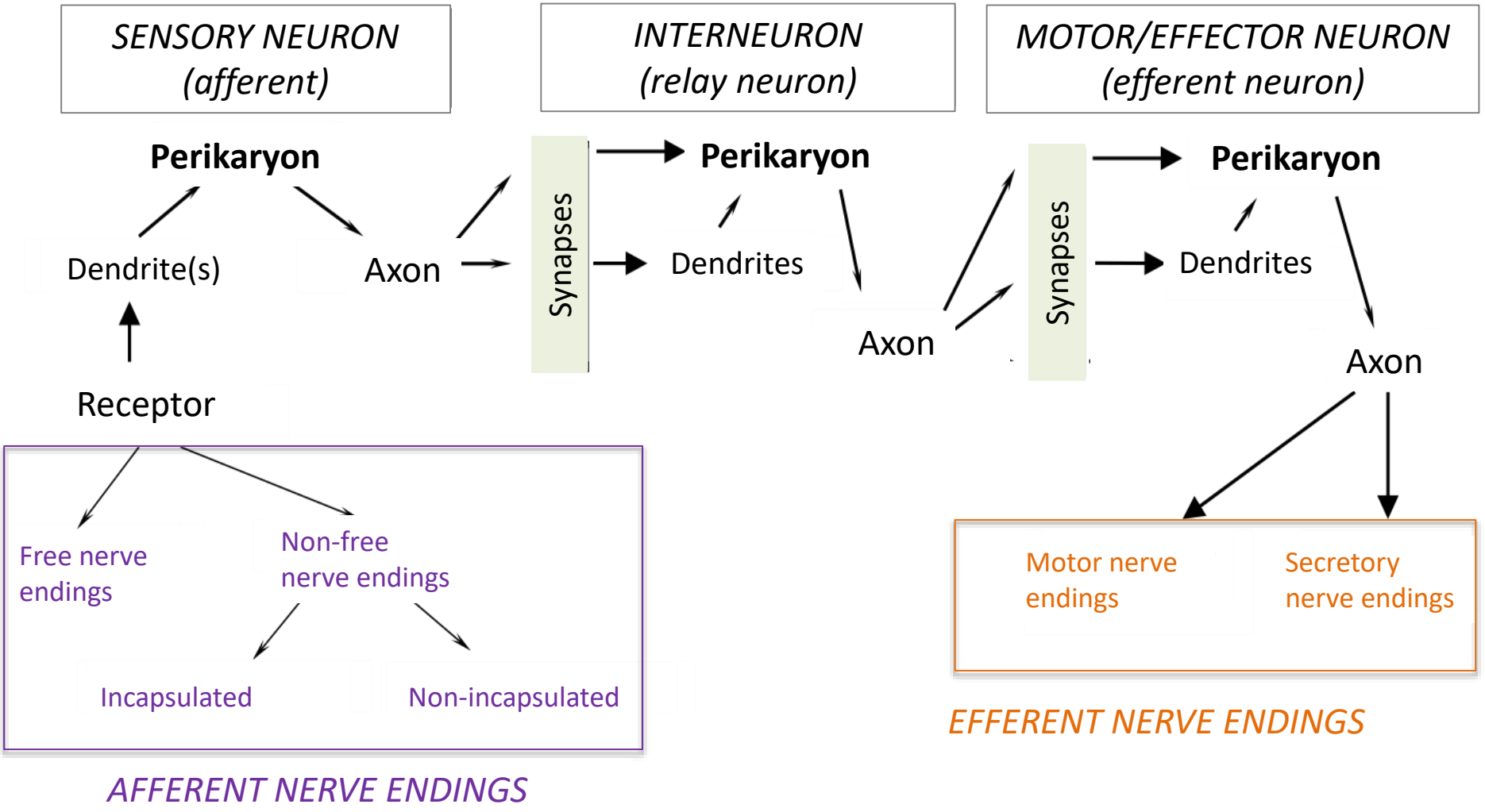


Spinal cord
Brain

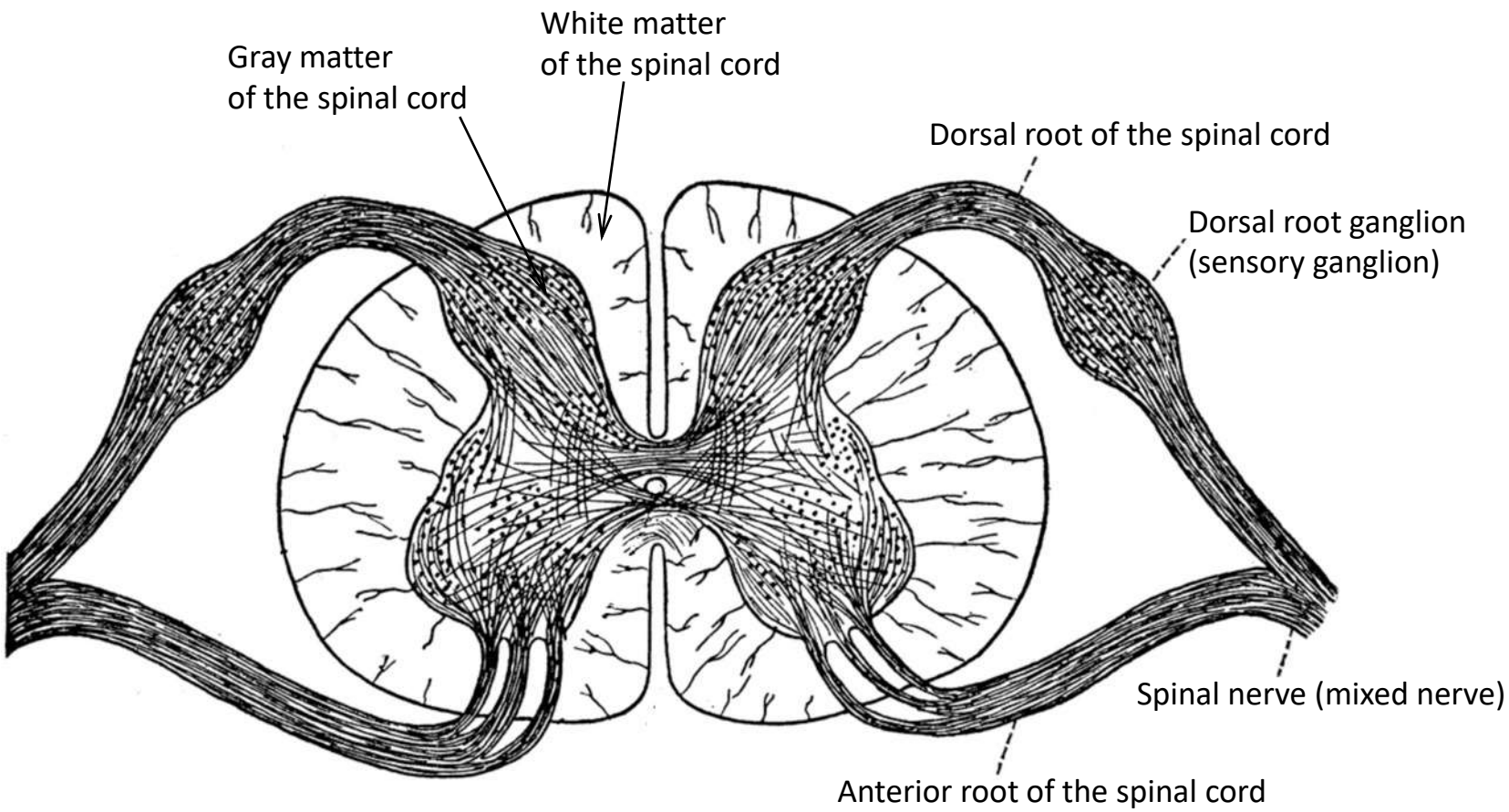
NEURAL TUBE
NEURAL CREST

Sensory ganglia
Autonomic ganglia

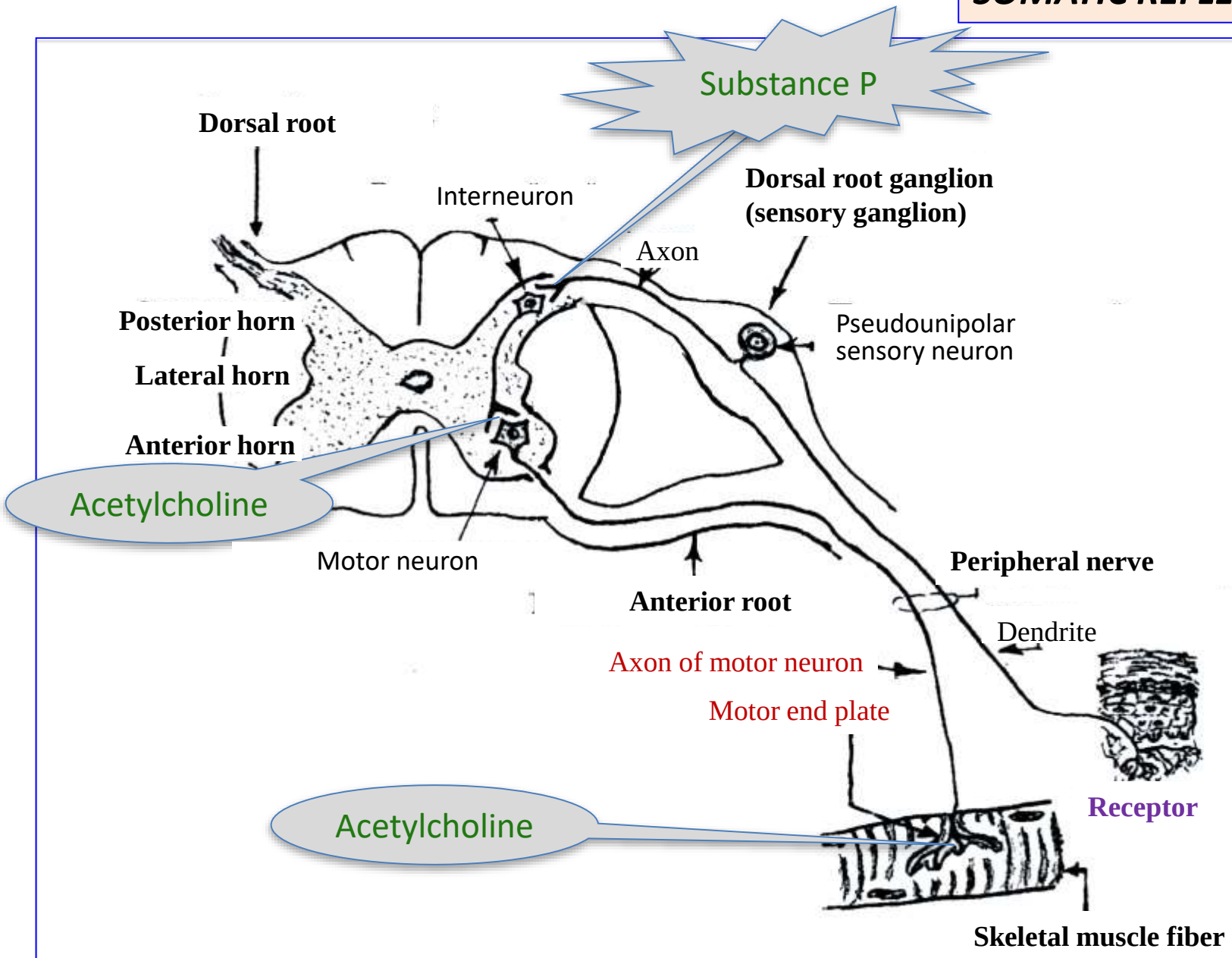
GENERAL PRINCIPLE OF THE REFLEX ARC ORGANIZATION



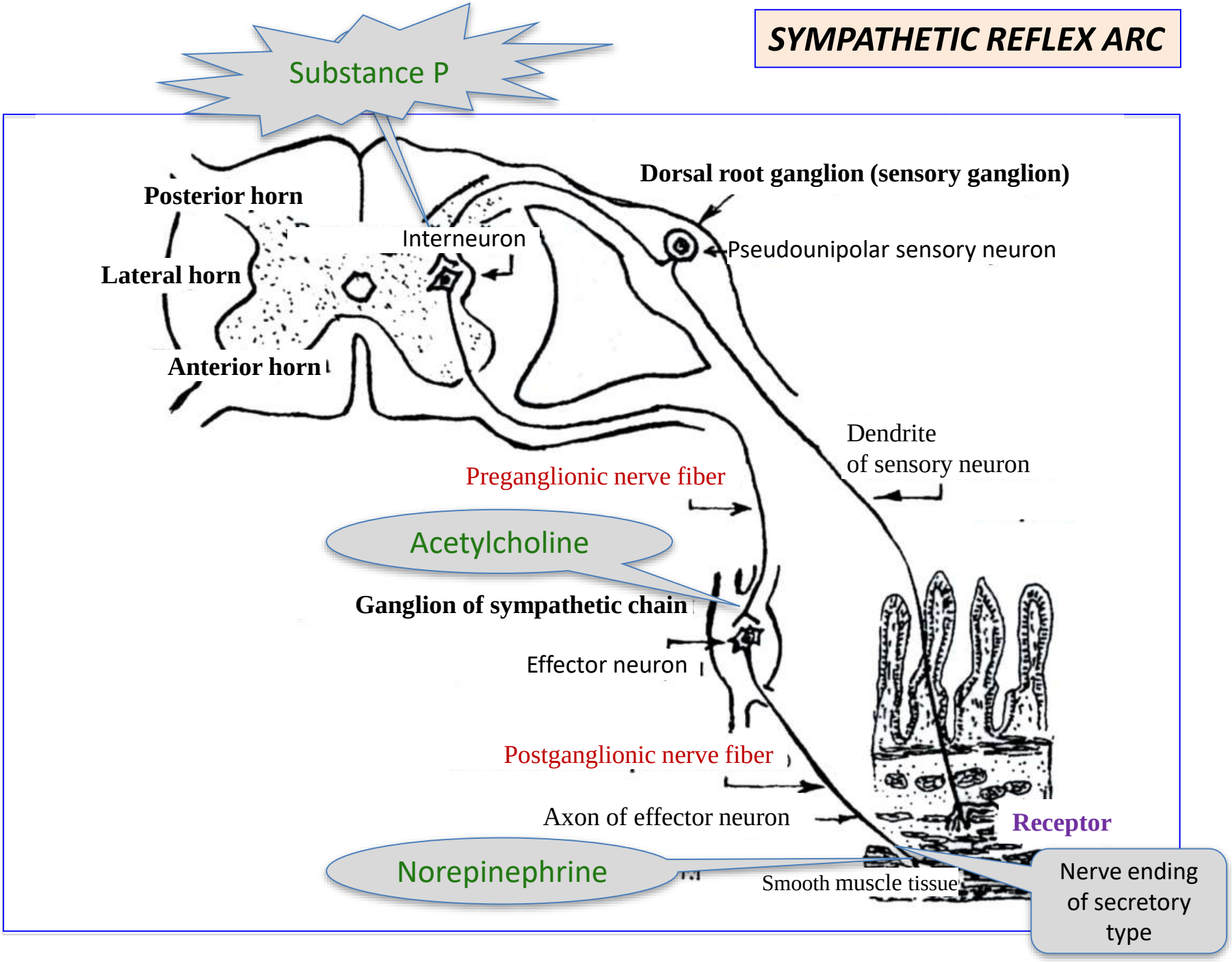
STRUCTURAL ORGANIZATION OF THE SPINAL CORD



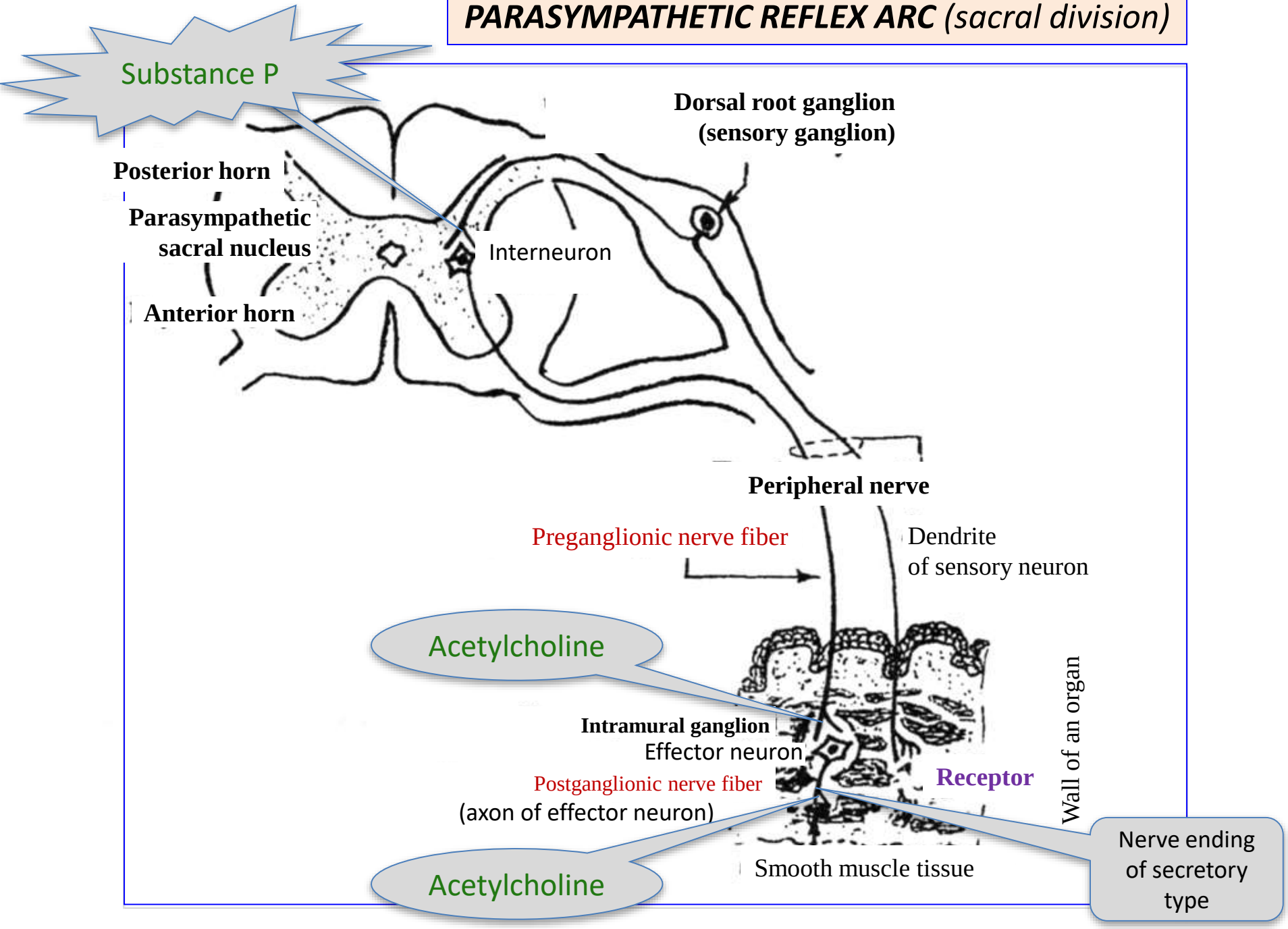
SOMATIC REFLEX ARC



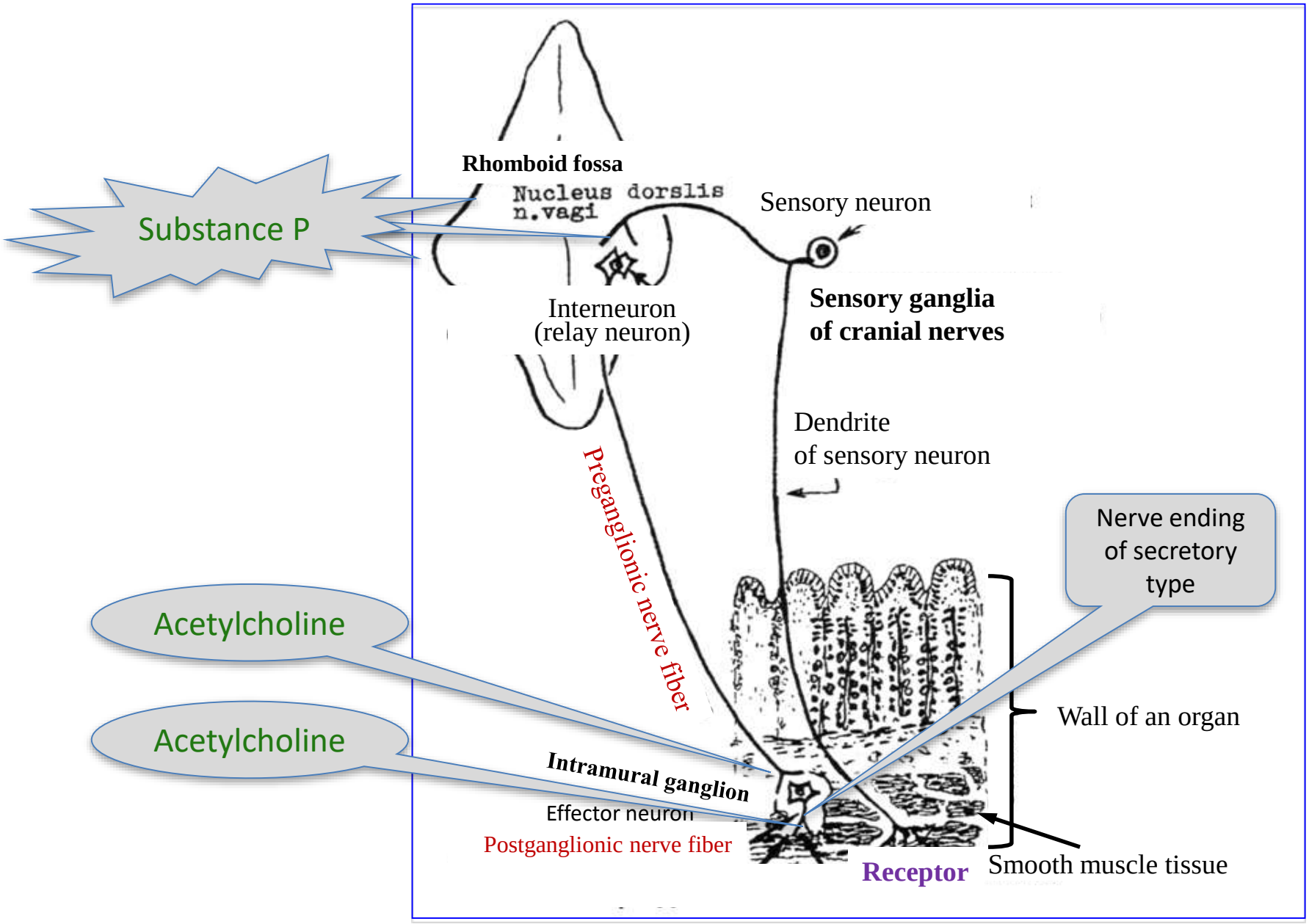
SYMPATHETIC REFLEX ARC



PARASYMPATHETIC REFLEX ARC *(sacral division)*



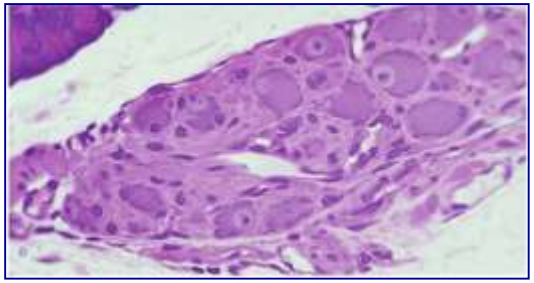
PARASYMPATHETIC REFLEX ARC *(cranial division)*



NERVOUS CENTER

Nervous center is a group of multipolar neurons that occupy *a certain site* within the nervous system, have common origin, and coordinately perform *a common function*. Nervous centers are the sites of *neuronal integration* (i.e. interaction and information transfer between the neurons), which implies the presence of *synaptic transmission*

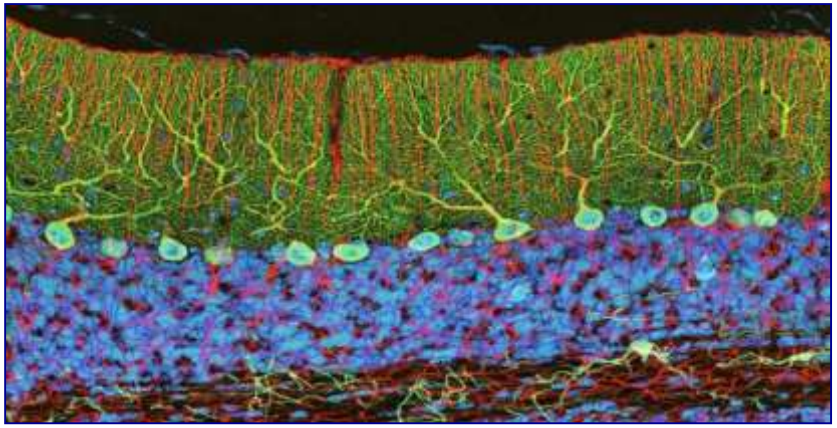
TYPES OF NERVOUS CENTERS



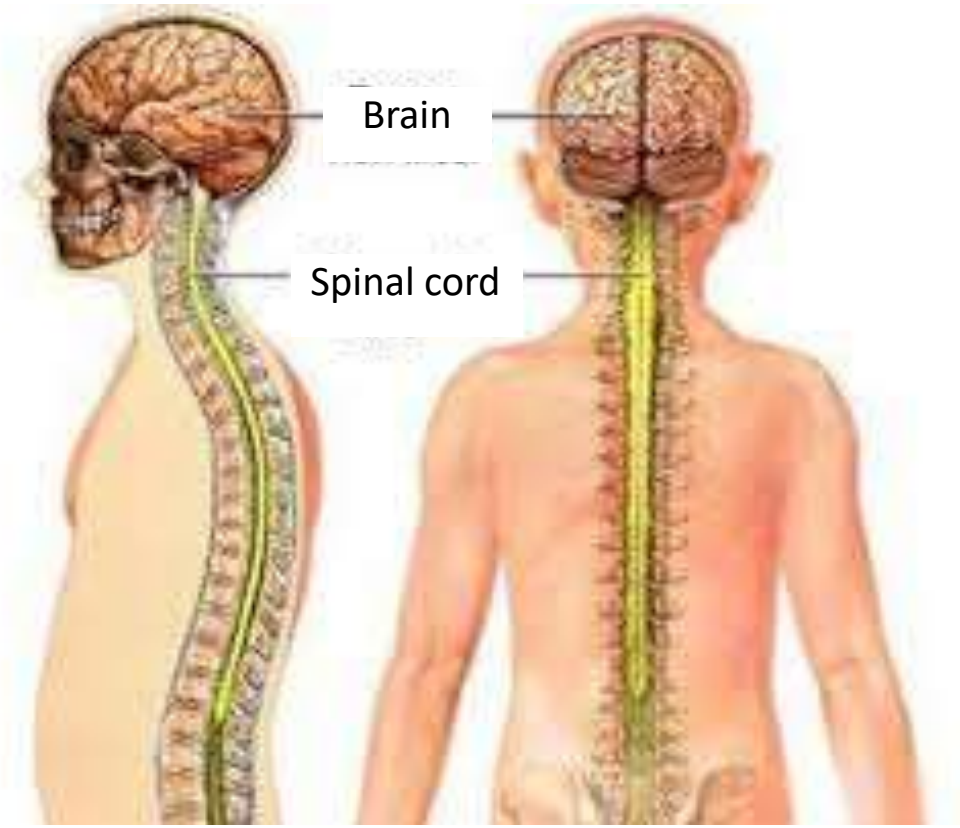
1. Ganglia – sensory and autonomic ganglia of the peripheral nervous system

2. Nuclear type – nuclei of the brain and the spinal cord

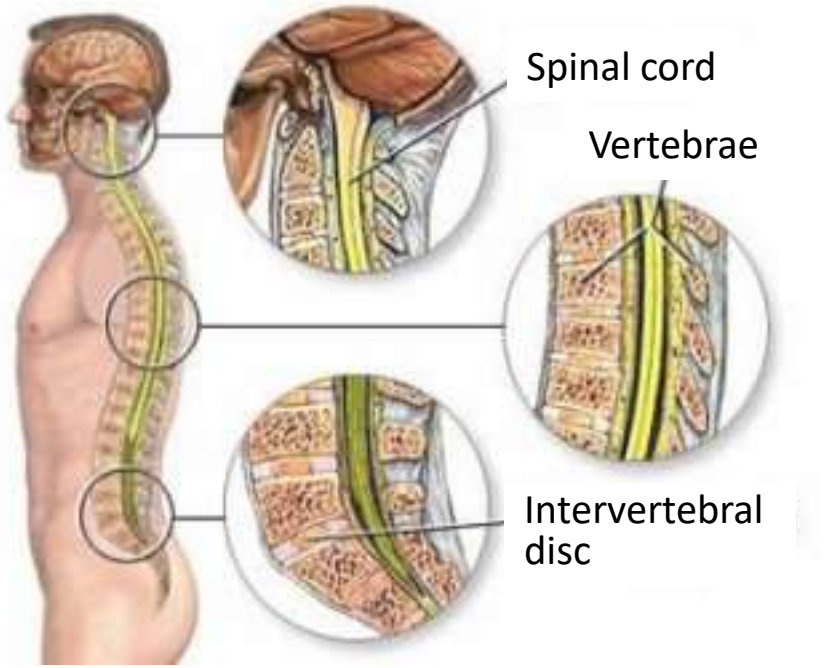
3. Plane (screen) type – cerebellar cortex, cerebral cortex



CENTRAL NERVOUS SYSTEM



Neurocranium and vertebral column protect the organs of CNS from injury



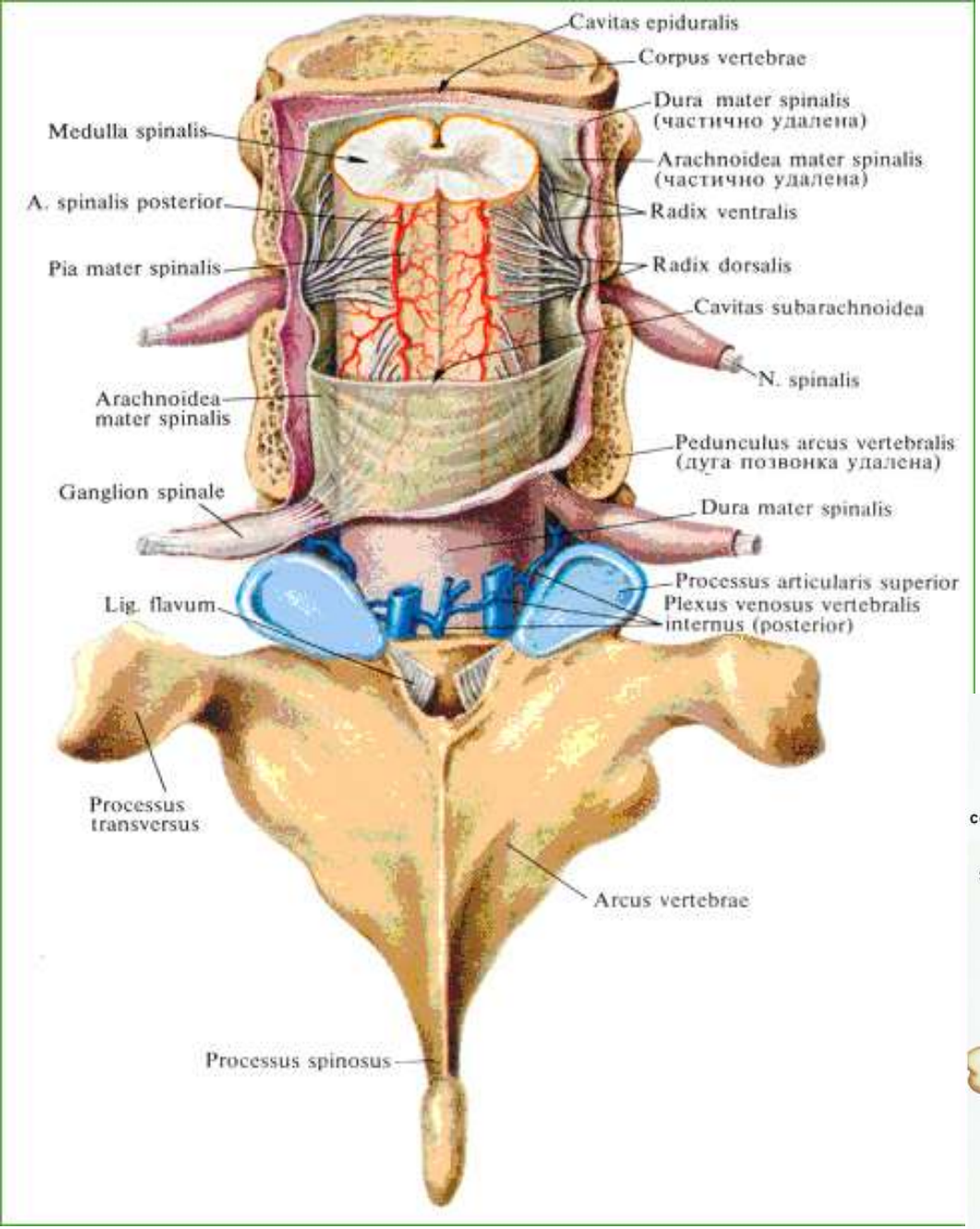
INTERVERTEBRAL DISCS are composed of fibrocartilage, which undergoes calcification as a part of aging process

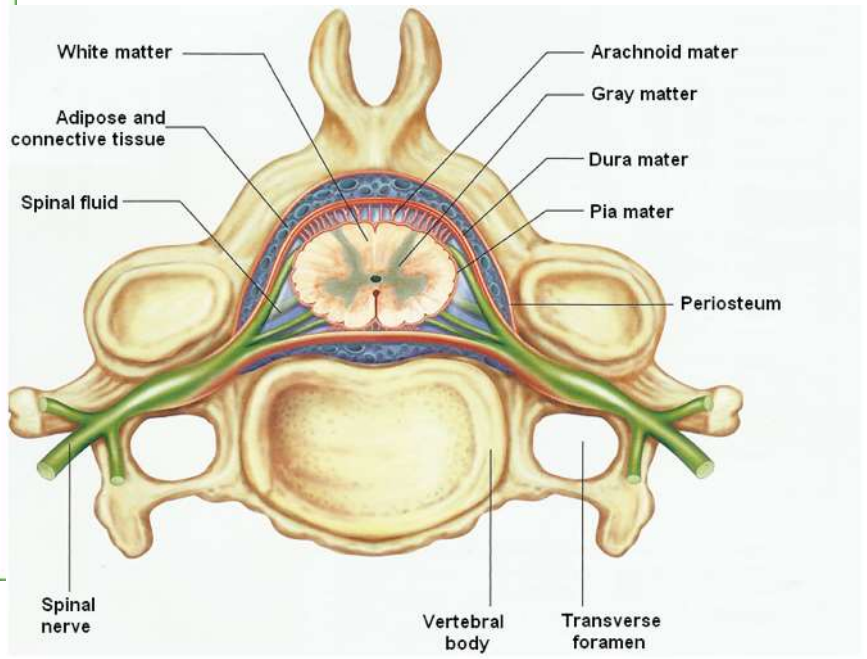
MENINGES OF THE SPINAL CORD

Dura mater
– dense irregular connective tissue + squamous cells

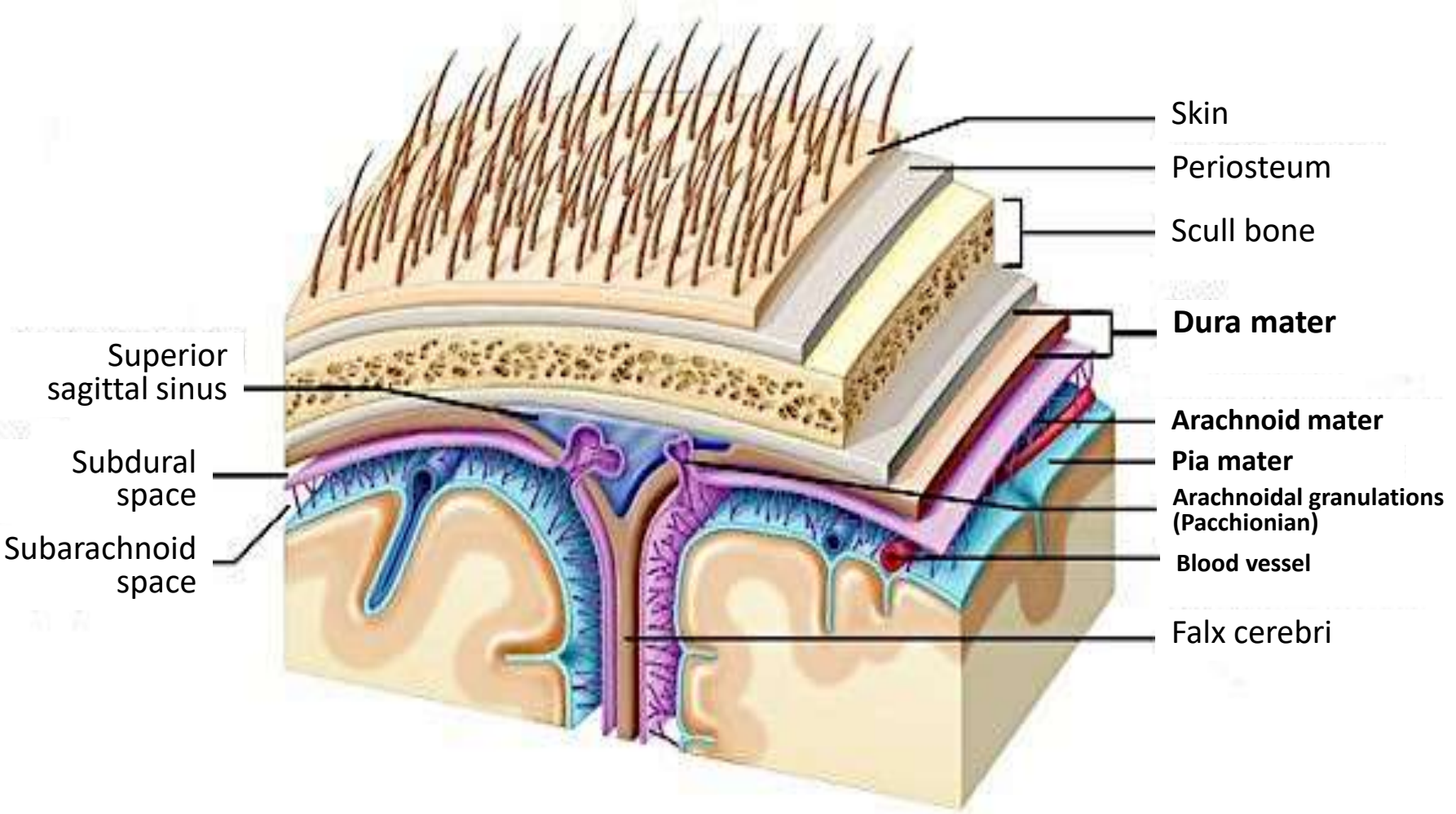
Arachnoid mater
– loose connective tissue + squamous cells

Pia mater
– loose connective tissue + squamous cells



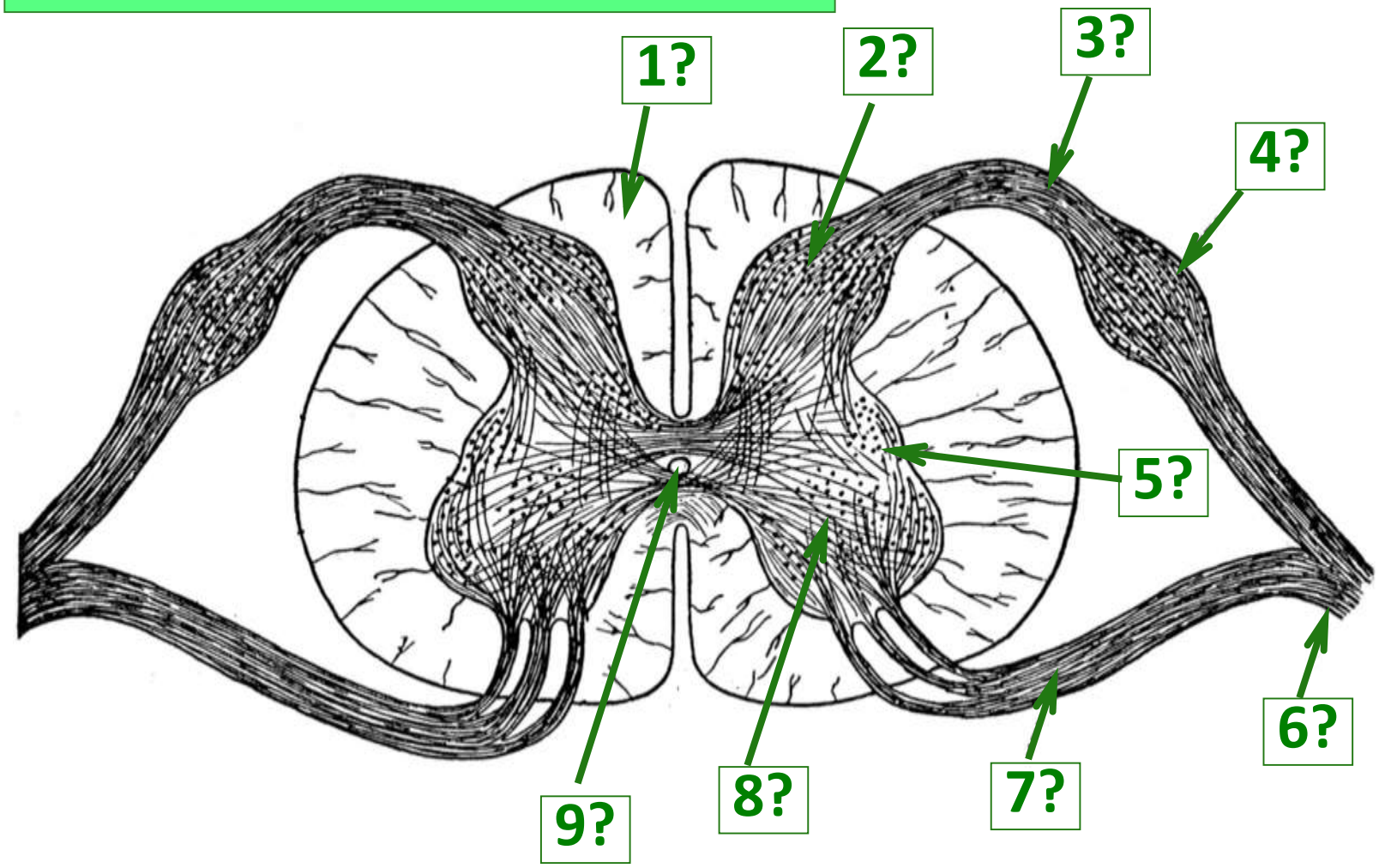


MENINGES OF THE BRAIN

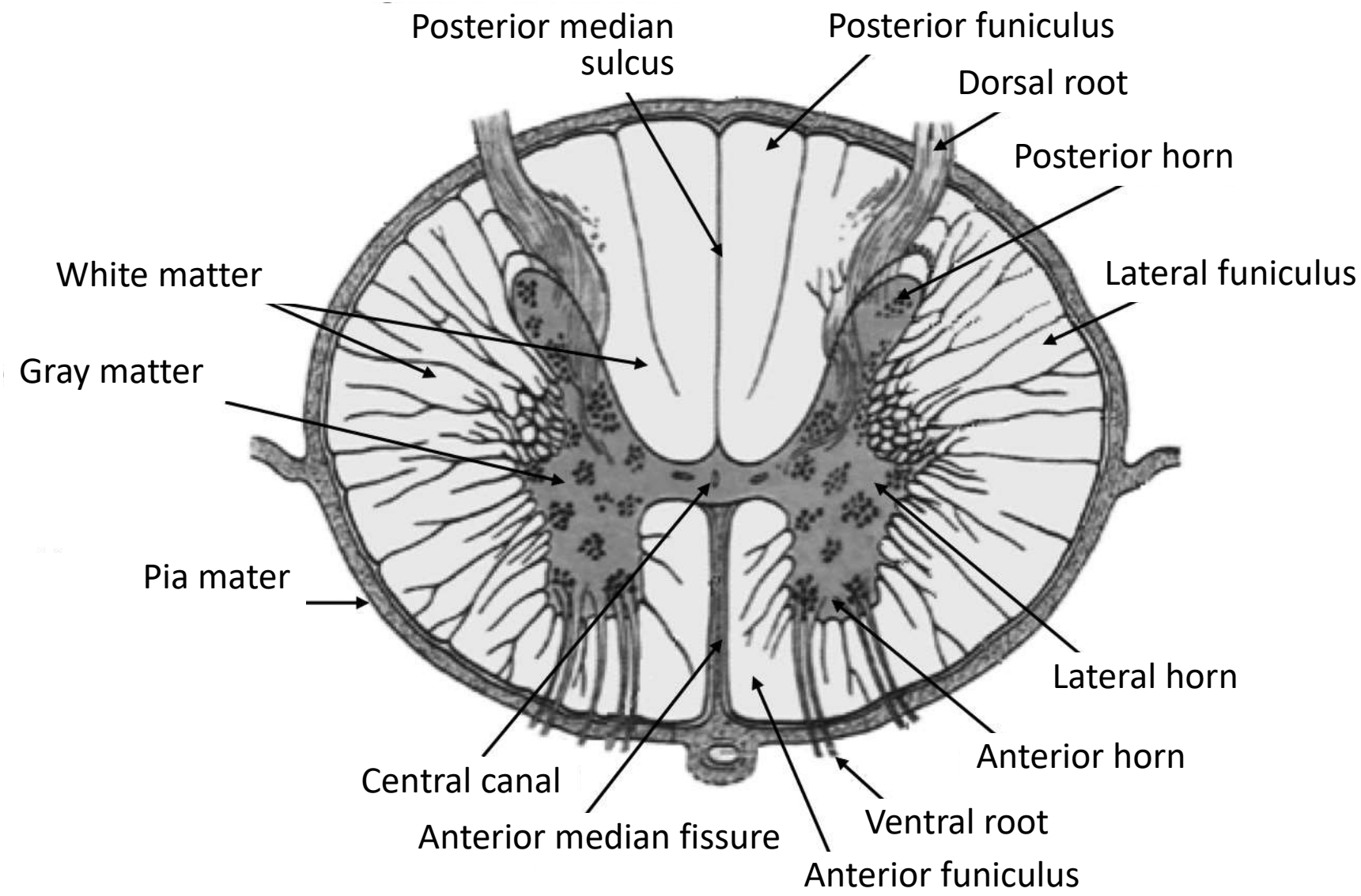


STRUCTURAL ORGANIZATION OF THE SPINAL CORD

IDENTIFY STRUCTURES AND DESCRIBE THEIR COMPOSITION



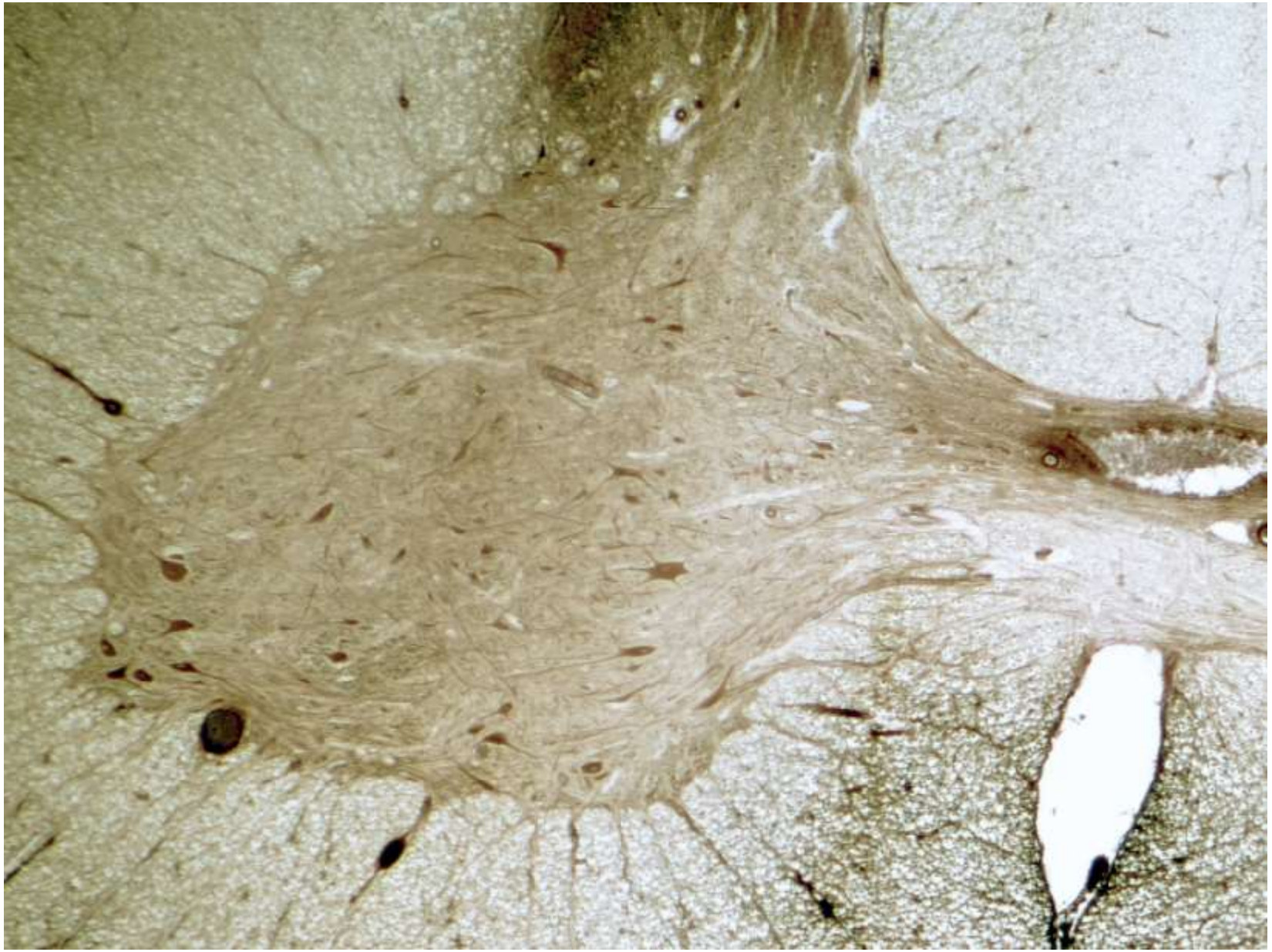

1
2
3
3
4
5
6
12
11
10
9
8
7


Posterior median sulcus
Posterior funiculus
Dorsal root
Posterior horn
White matter
Lateral funiculus
Gray matter
Pia mater
Lateral horn
Anterior horn
Central canal
Ventral root
Anterior median fissure
Anterior funiculus

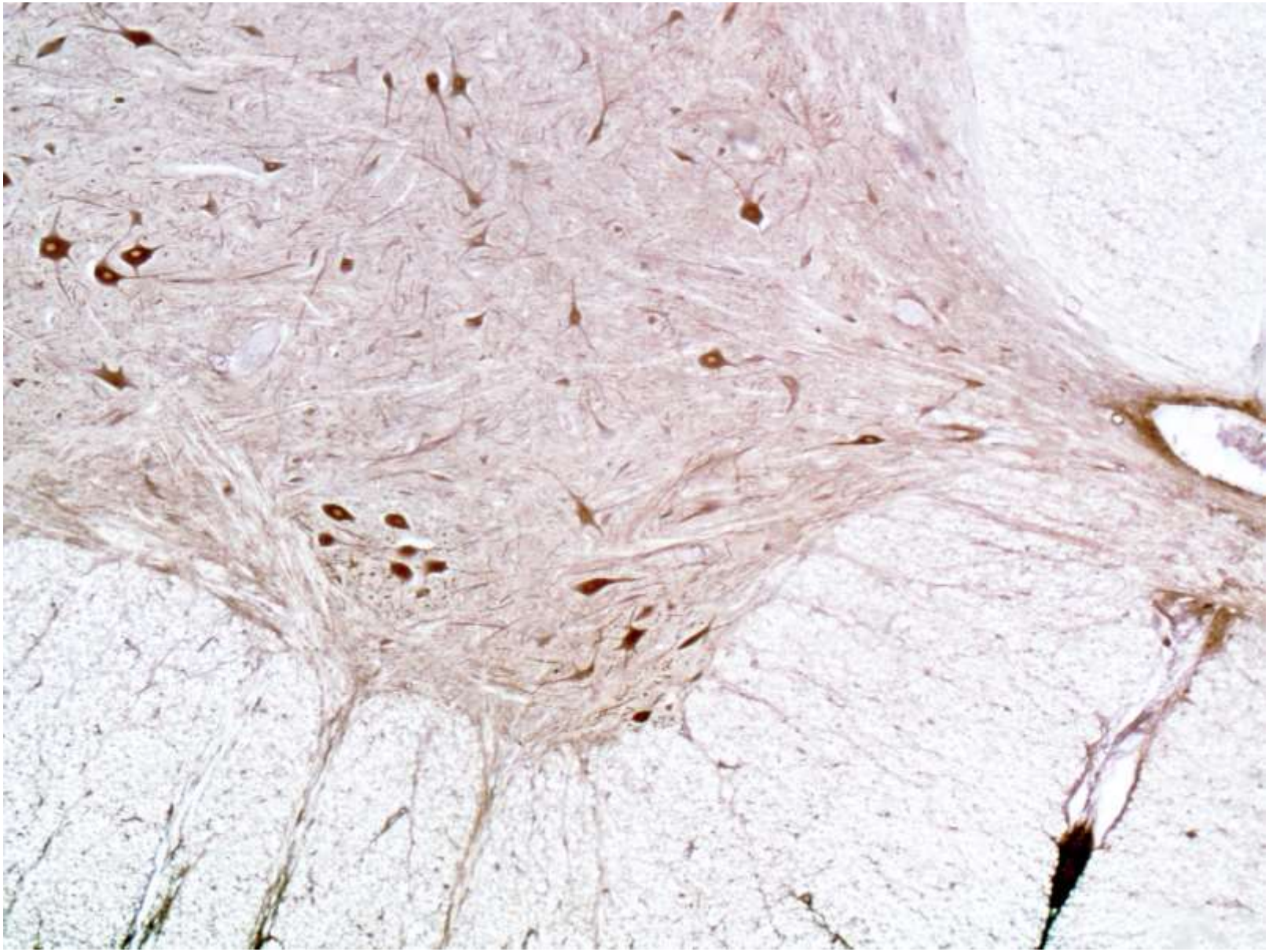
Slide №86 "Spinal cord, cross-section».
Hematoxylin-eosin staining

Slide №86a. «Spinal cord, cross-section»
Silver impregnation

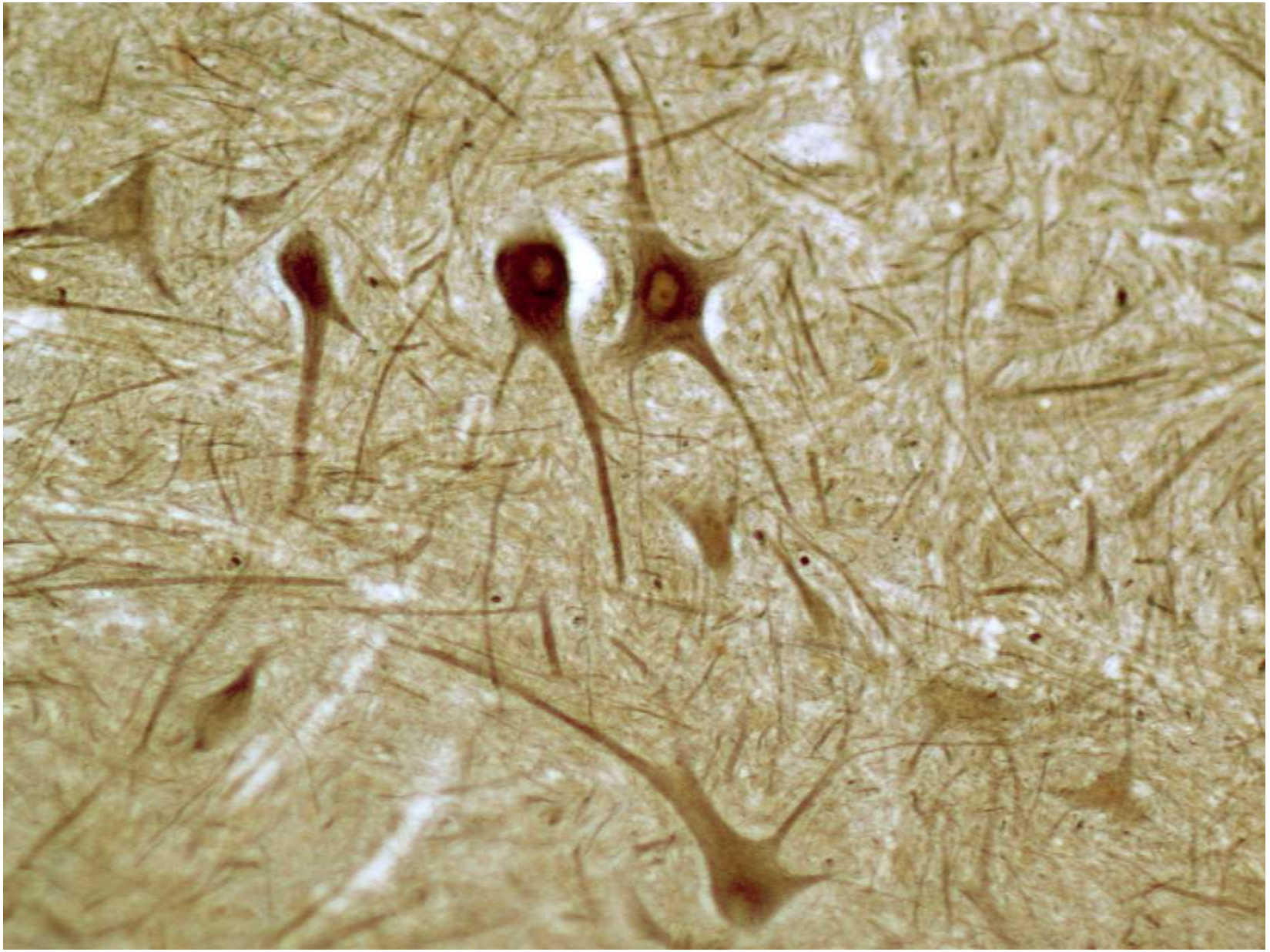
Slide №86a. «Spinal cord, cross-section»
Silver impregnation

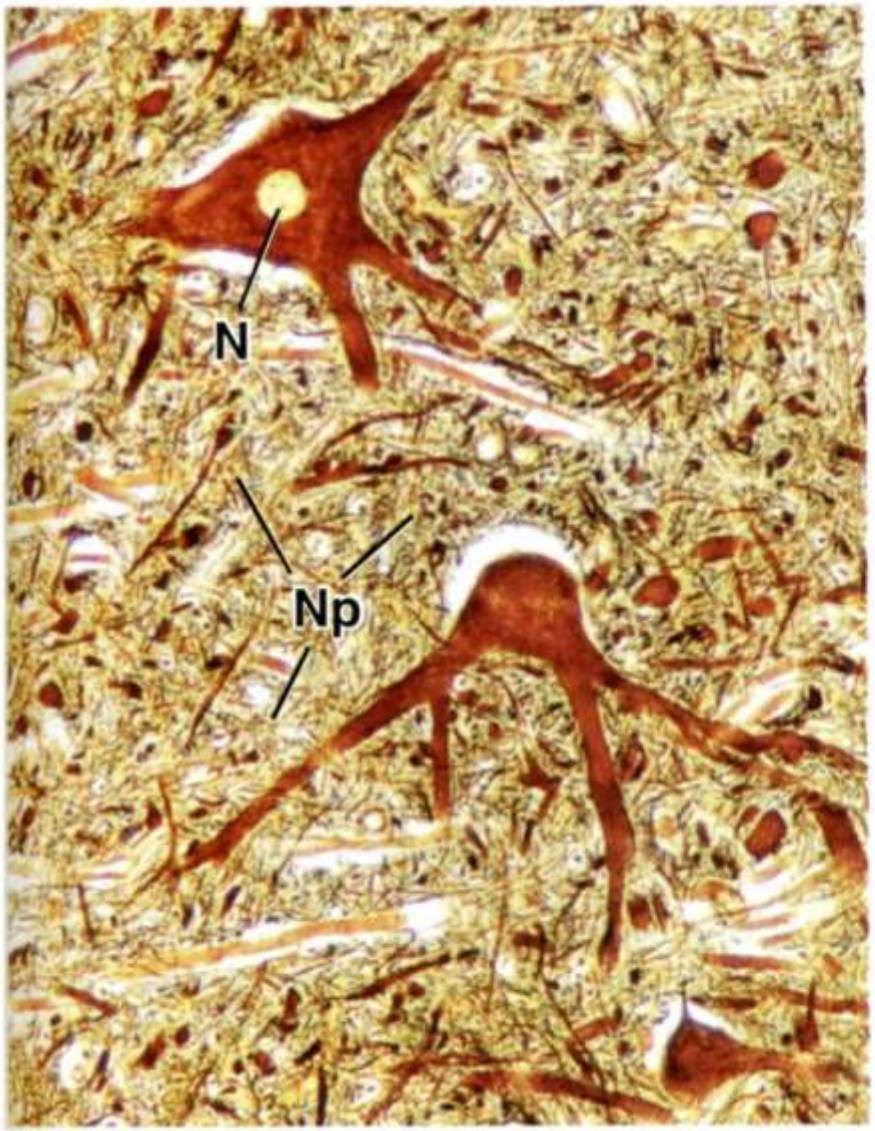


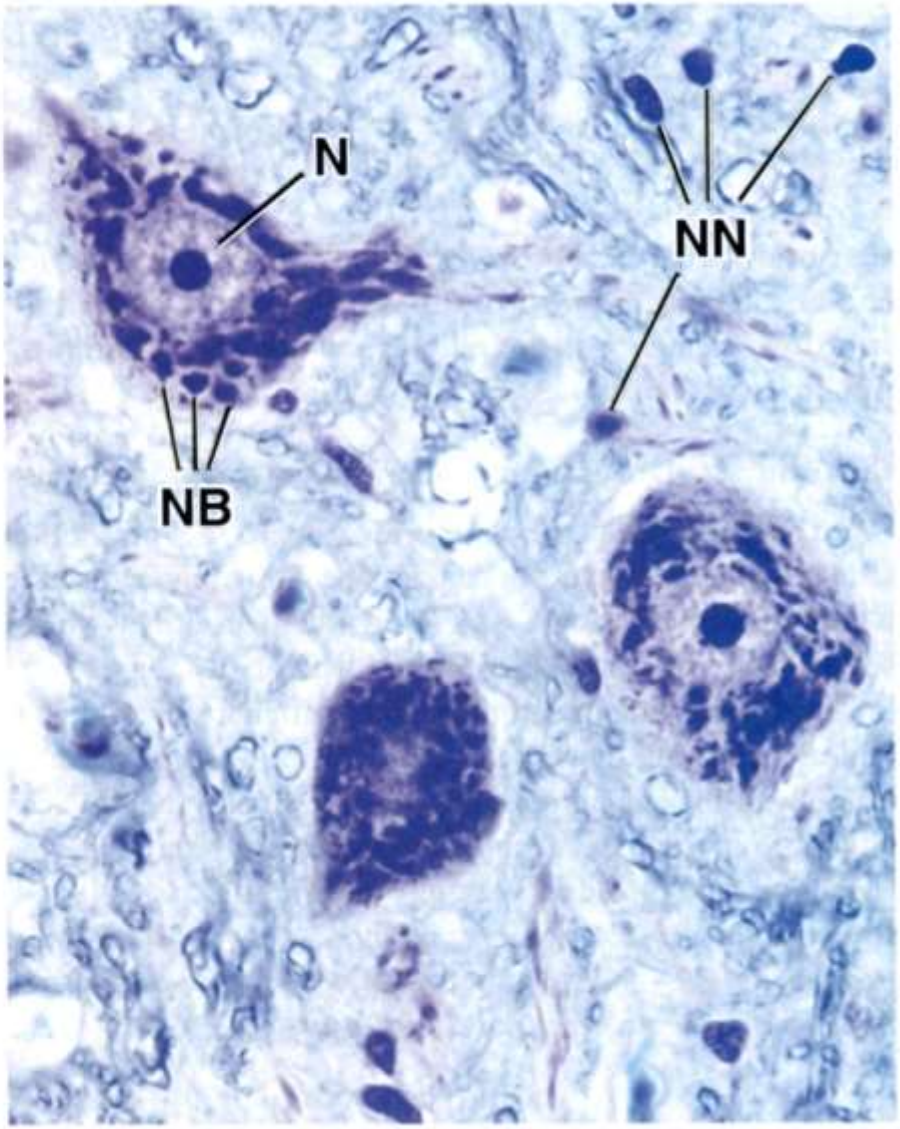
Slide №86a. «Spinal cord, cross-section»
Silver impregnation



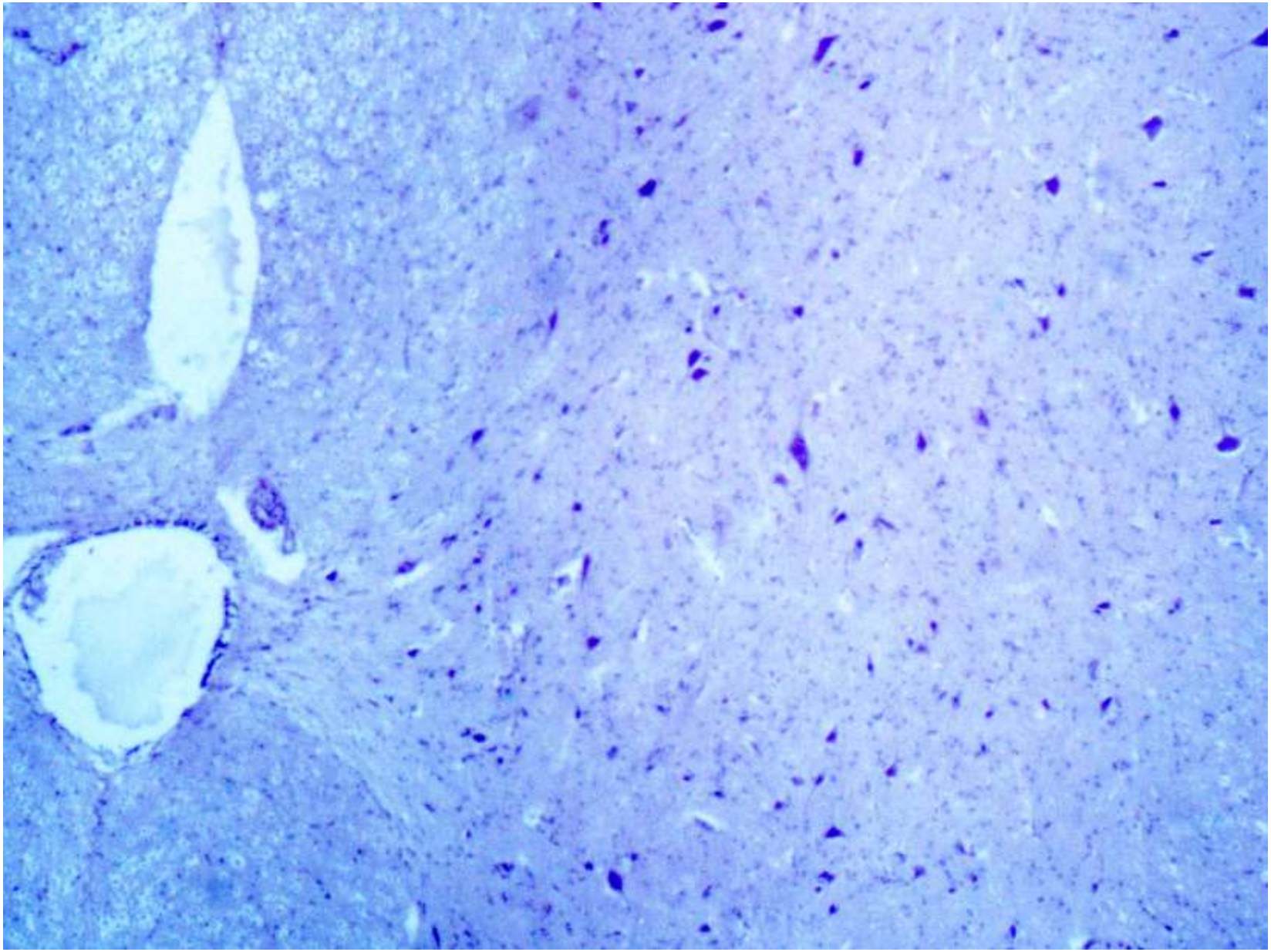
Slide №86a. «Spinal cord, cross-section»
Silver impregnation



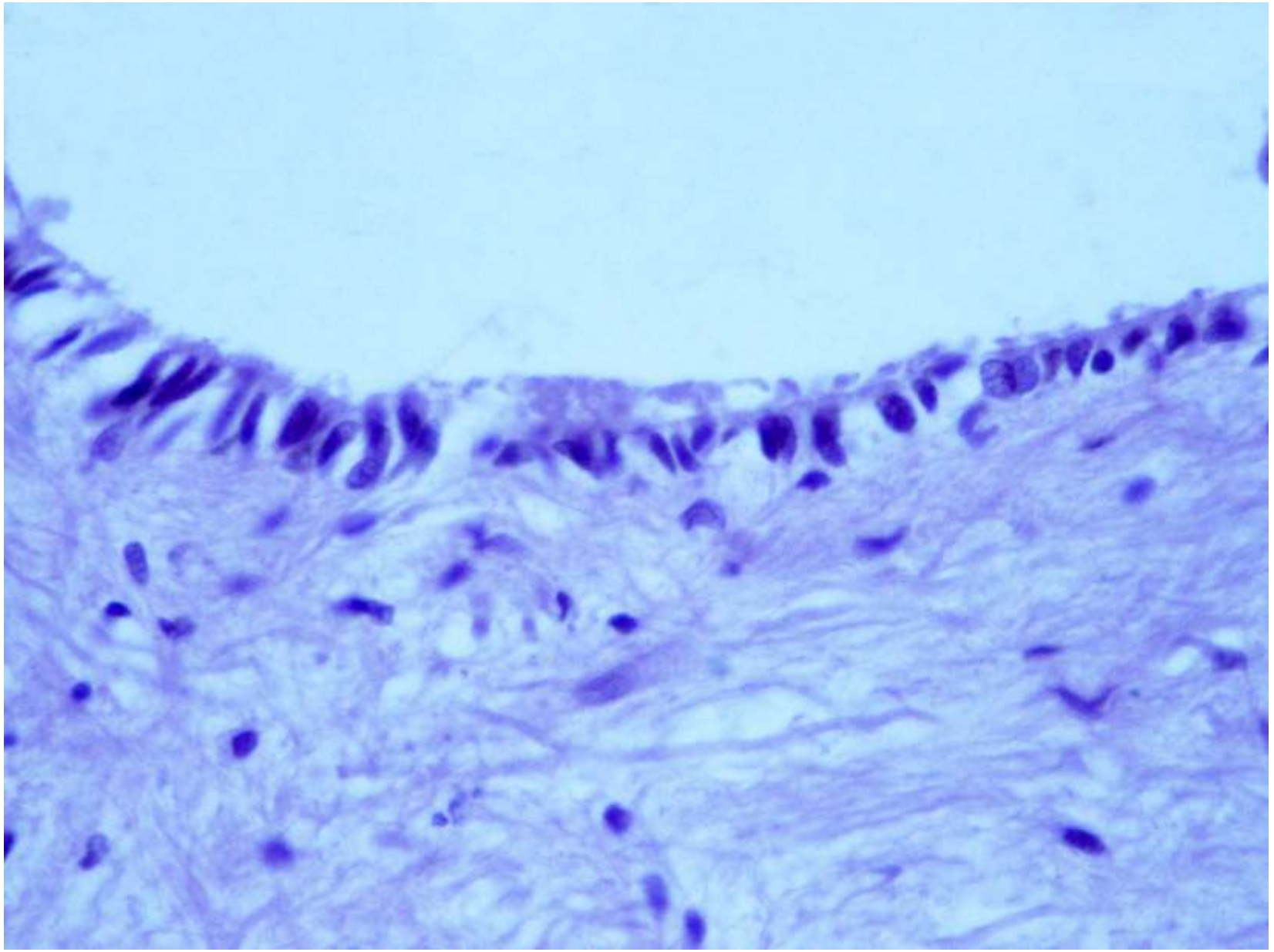

N
Np


N
NN
NB

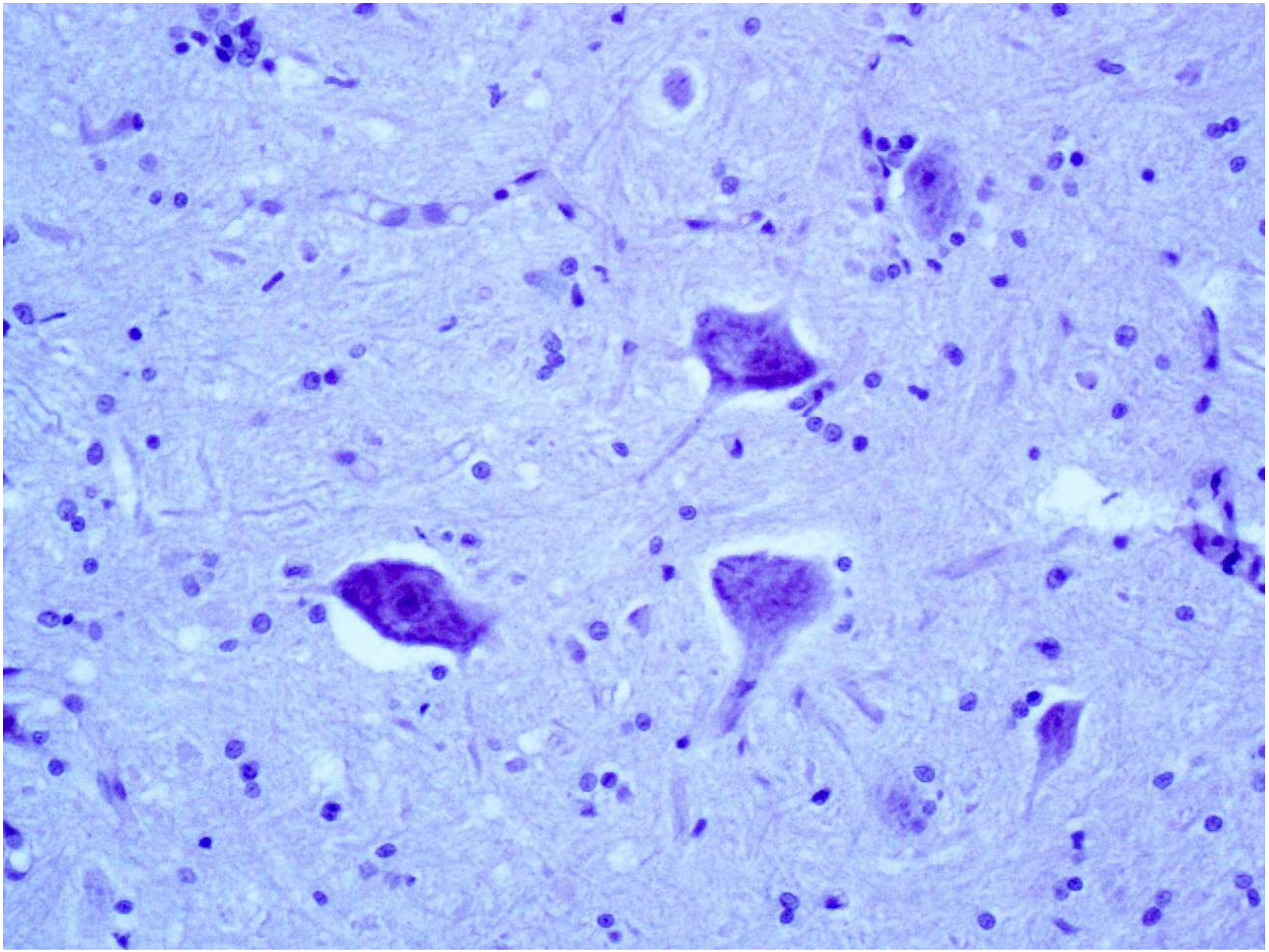
Slide №86a. «Spinal cord, cross-section»
Methylene blue staining



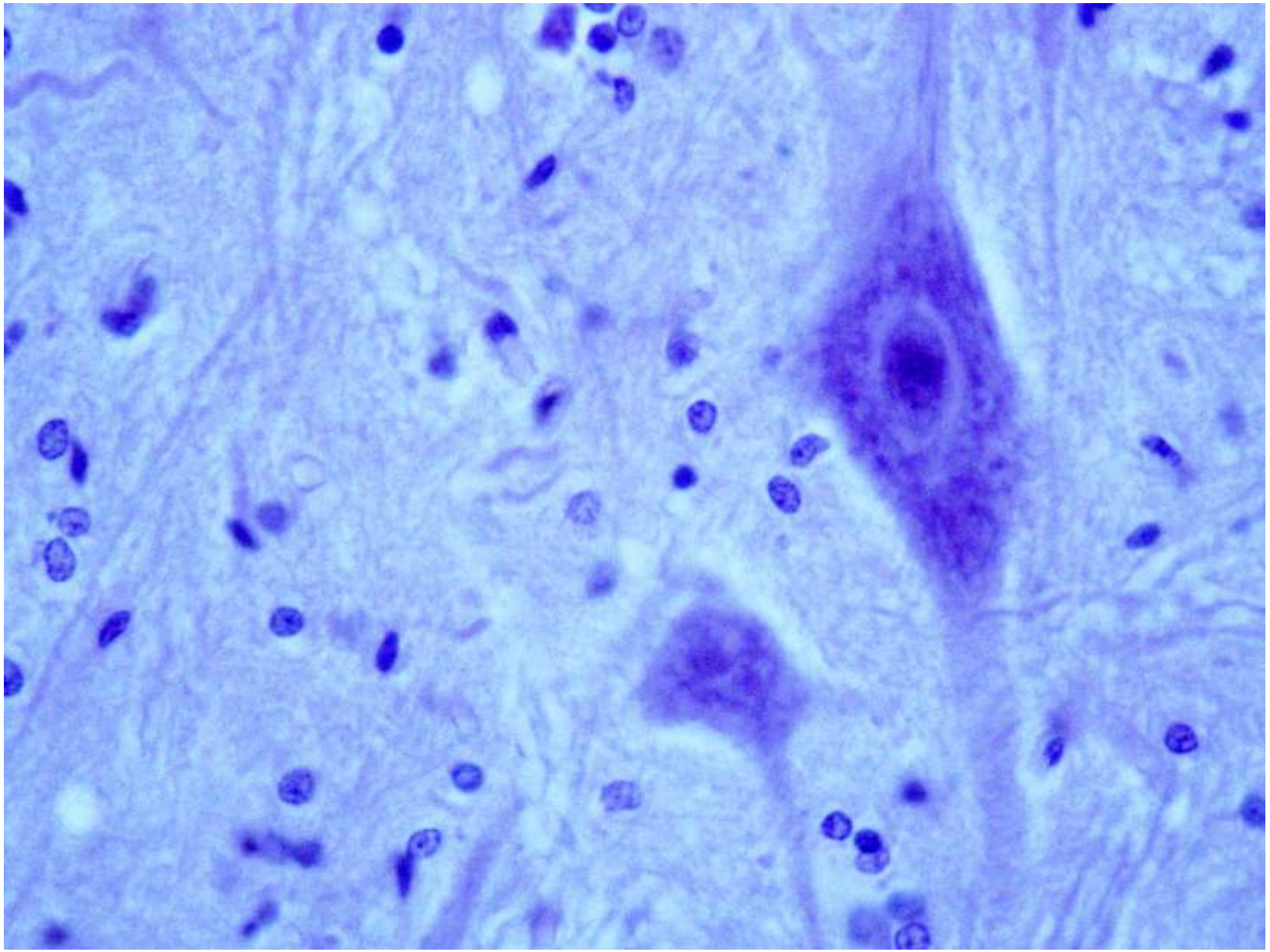
Slide №86a. «Spinal cord, cross-section»
Methylene blue staining



Slide №86a. «Spinal cord, cross-section»
Methylene blue staining



Slide №86a. «Spinal cord, cross-section»
Methylene blue staining

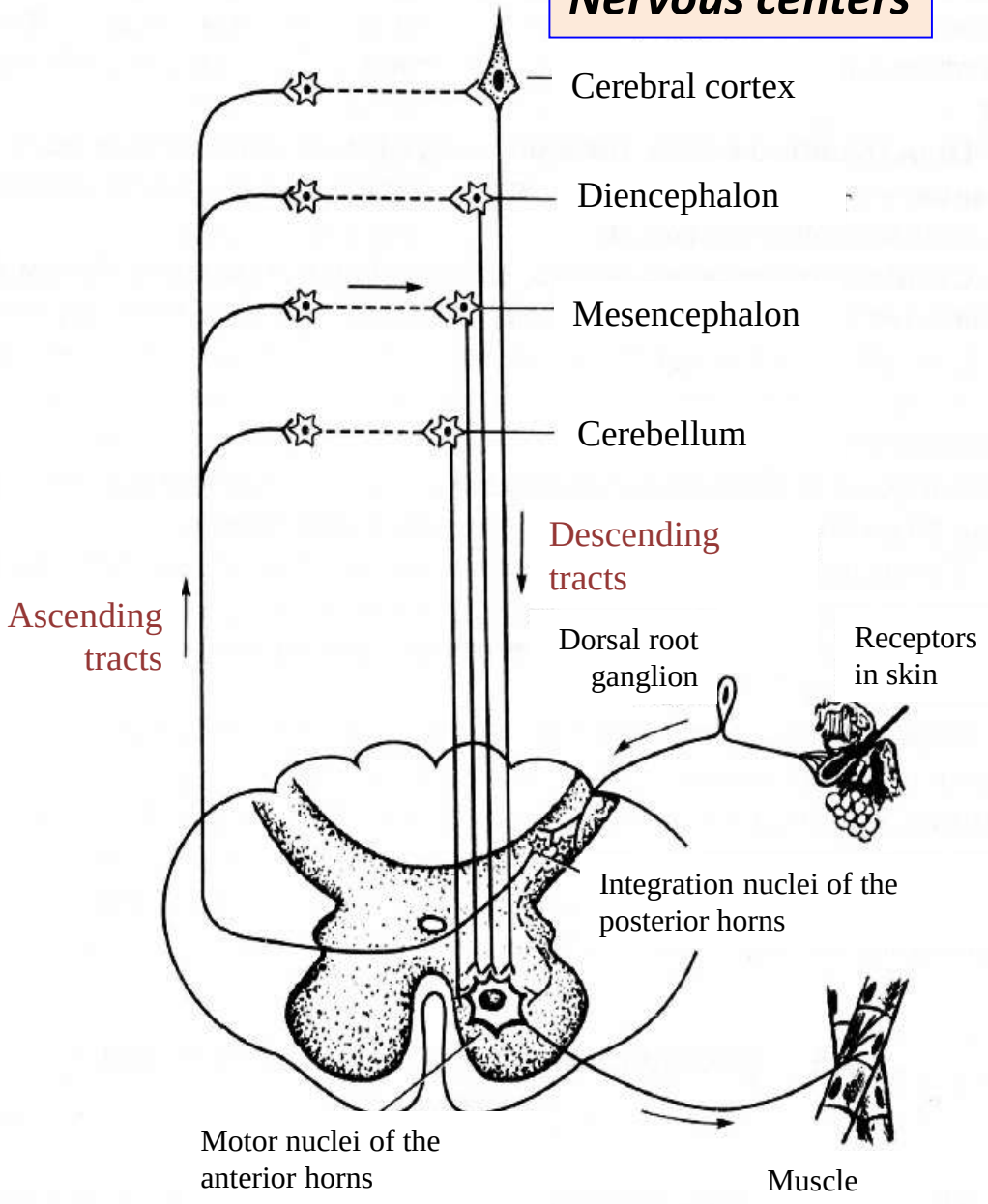


CONDUCTING TRACTS

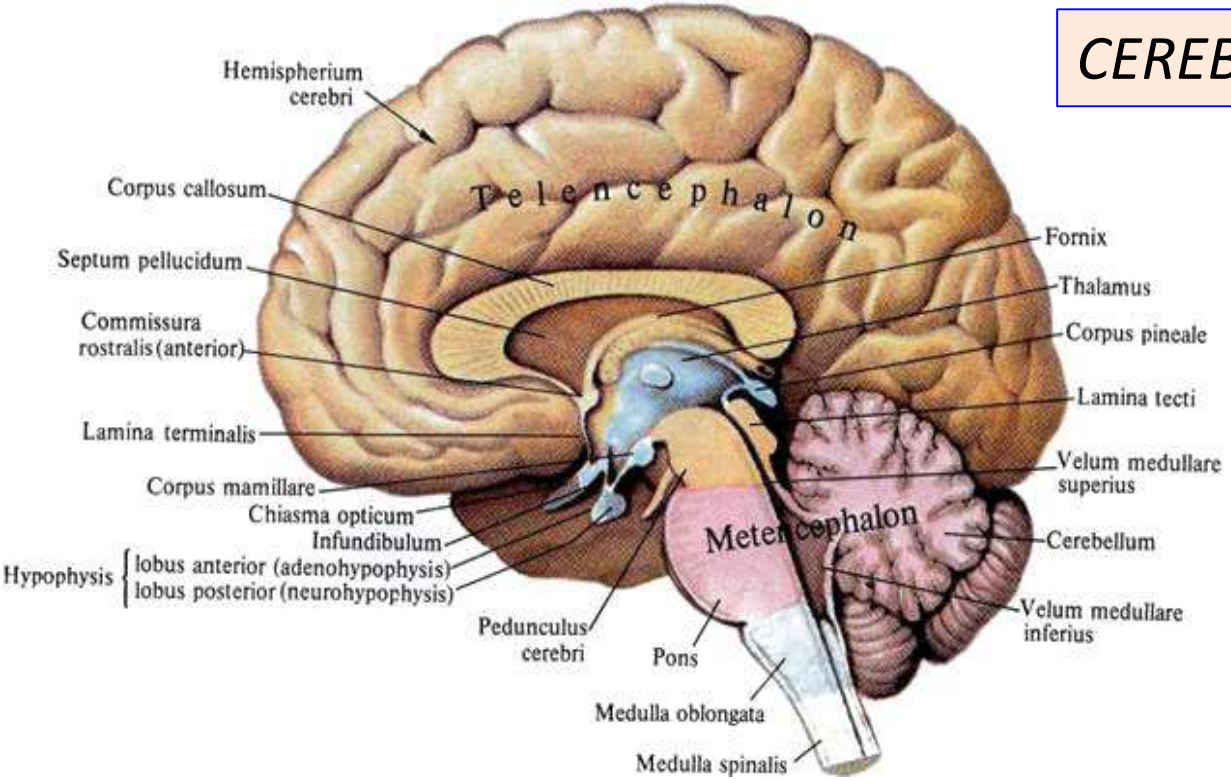
In a broader sense, the *conducting tracts* represent chains of anatomically and functionally linked neurons, that ensure conduction of functionally identical nerve impulses in a strictly defined direction.

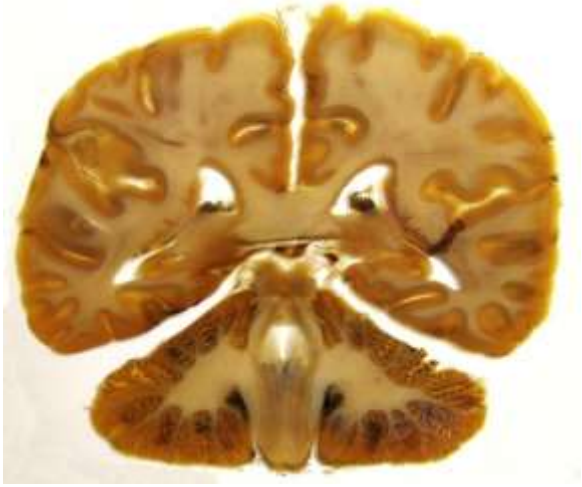
- *Afferent (ascending) tracts* ensure conduction from receptors found throughout the body to the higher sites of neuronal integration (nervous centers) in the brain up to the neocortex.
- *Accociative tracts* provide links that coordinate the teamwork of the integration centers inside the brain, e.g. between the cerebellum and the neocortex, or between the hemispheres of the brain.
- *Efferent (descending) tracts* ensure conduction of the nerve impulses from the higher integration centers to the effector organs of the body.

Nervous centers

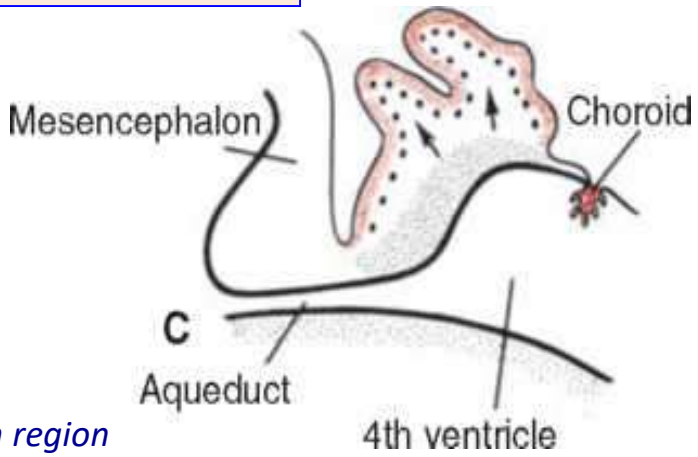


CEREBELLUM

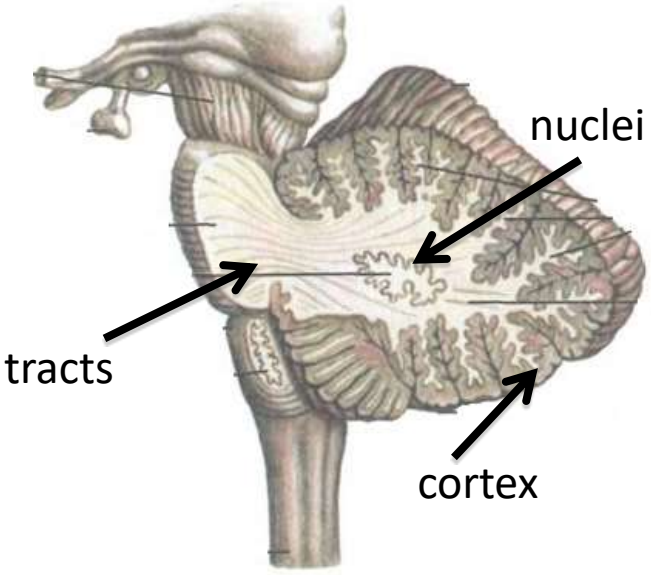




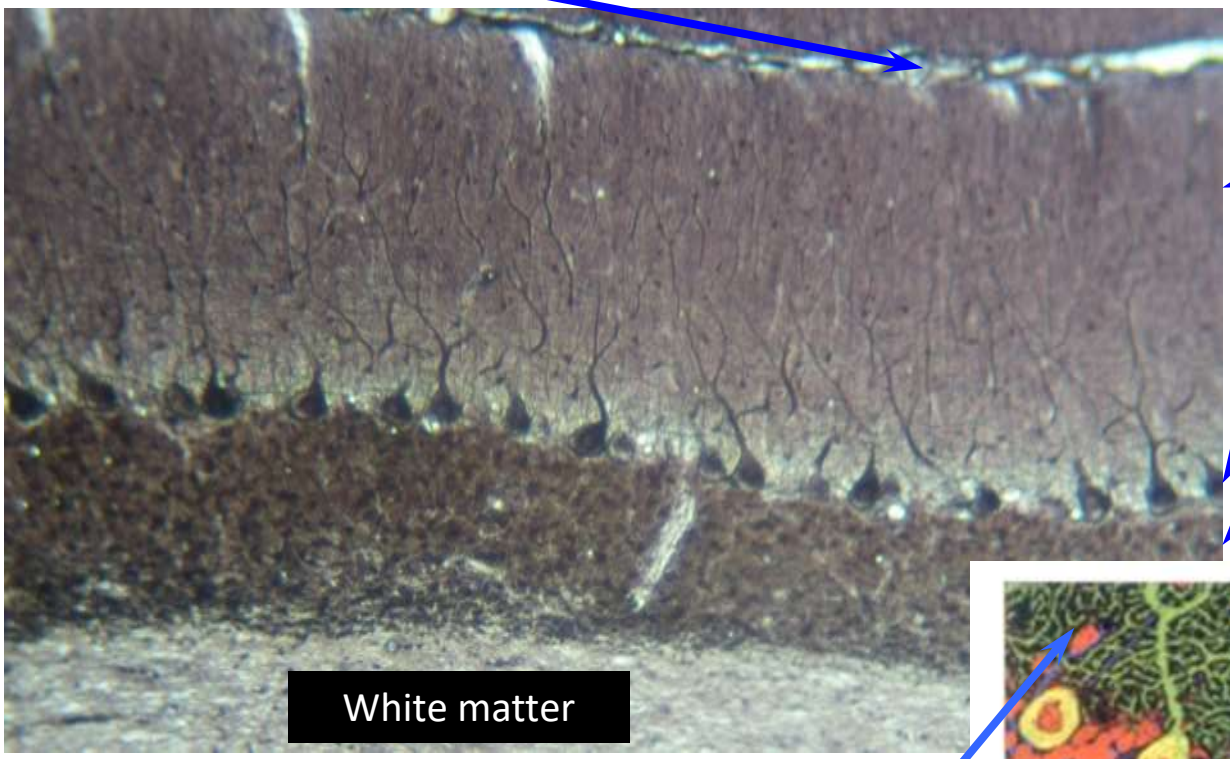
DEVELOPMENT OF THE CEREBELLUM

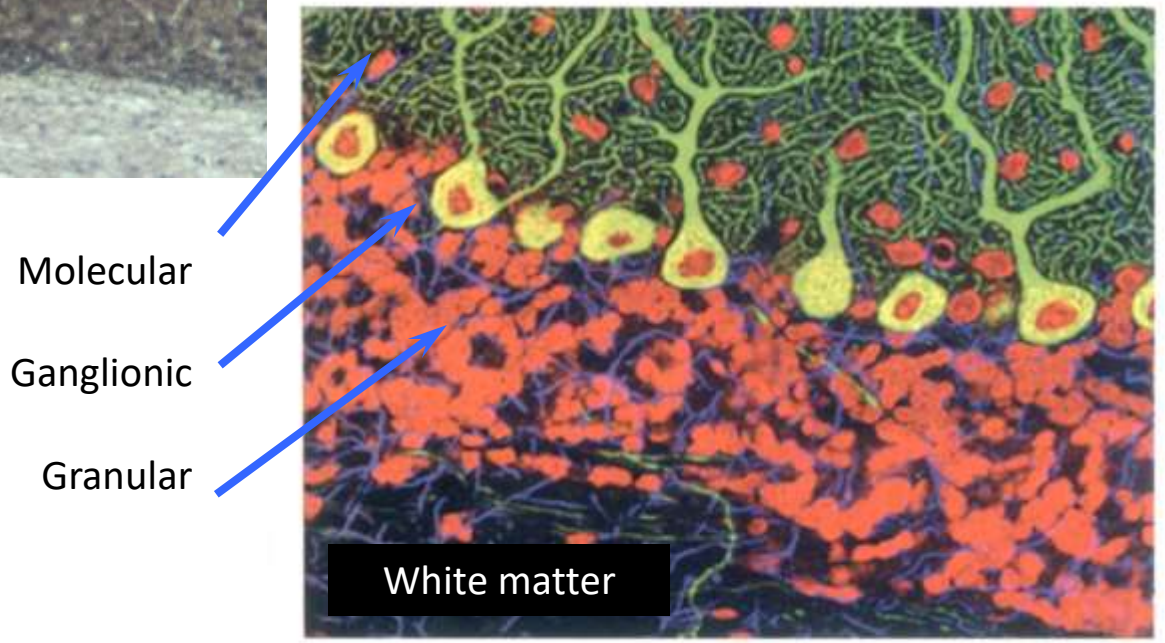


from the hindbrain region

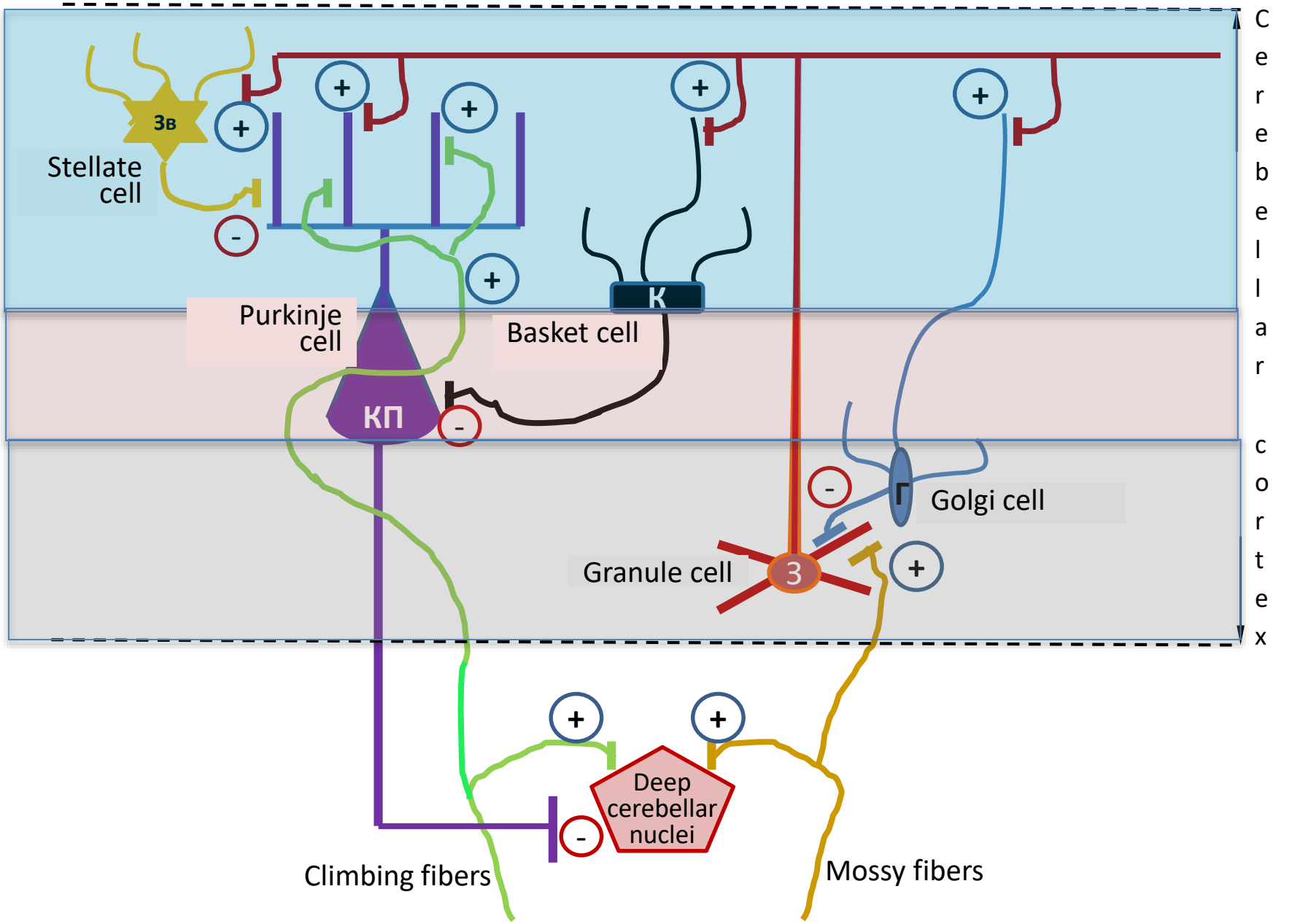


STRUCTURAL ORGANIZATION OF THE CEREBELLAR CORTEX

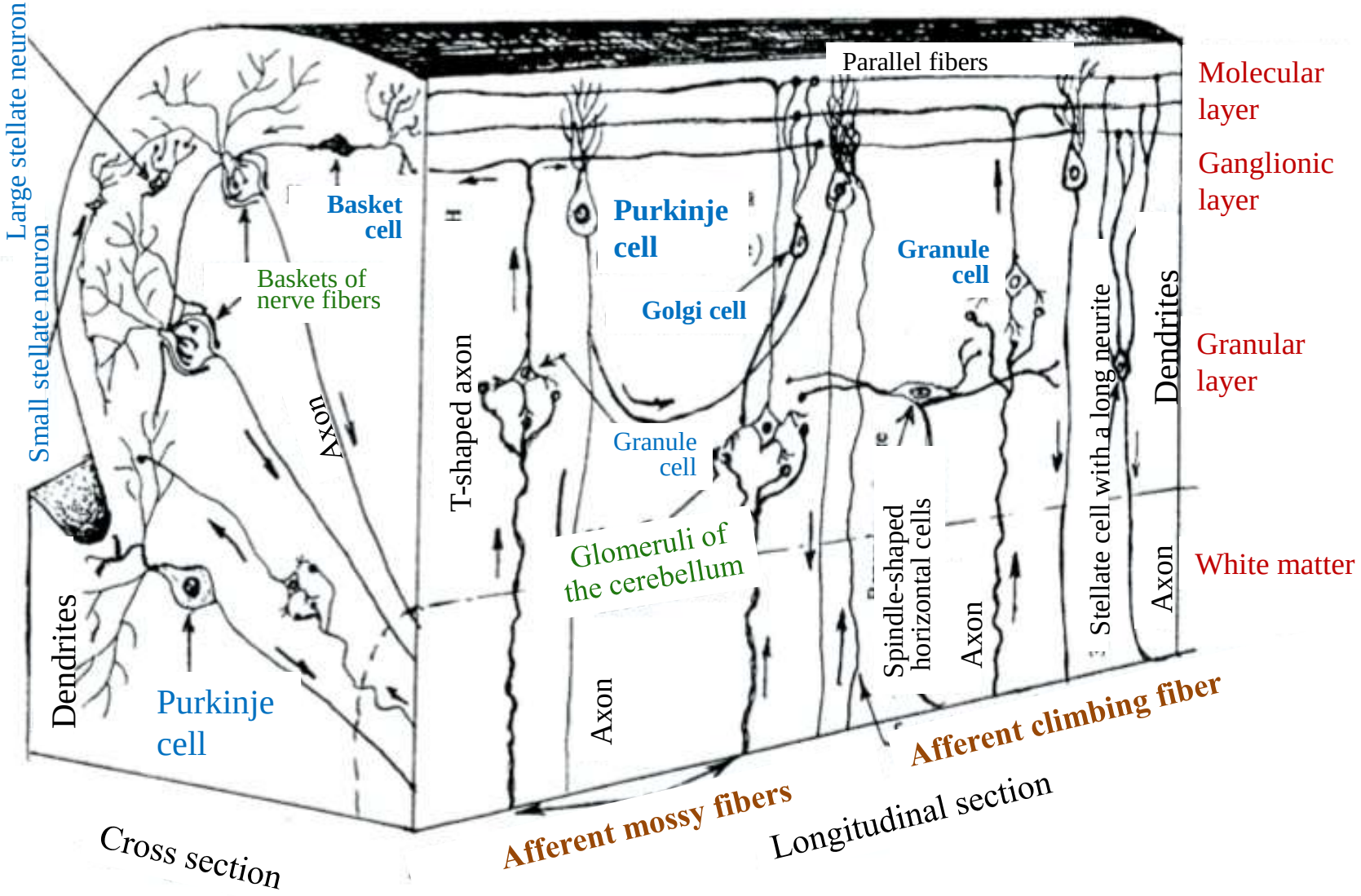




CONNECTIONS OF THE CEREBELLAR CORTEX

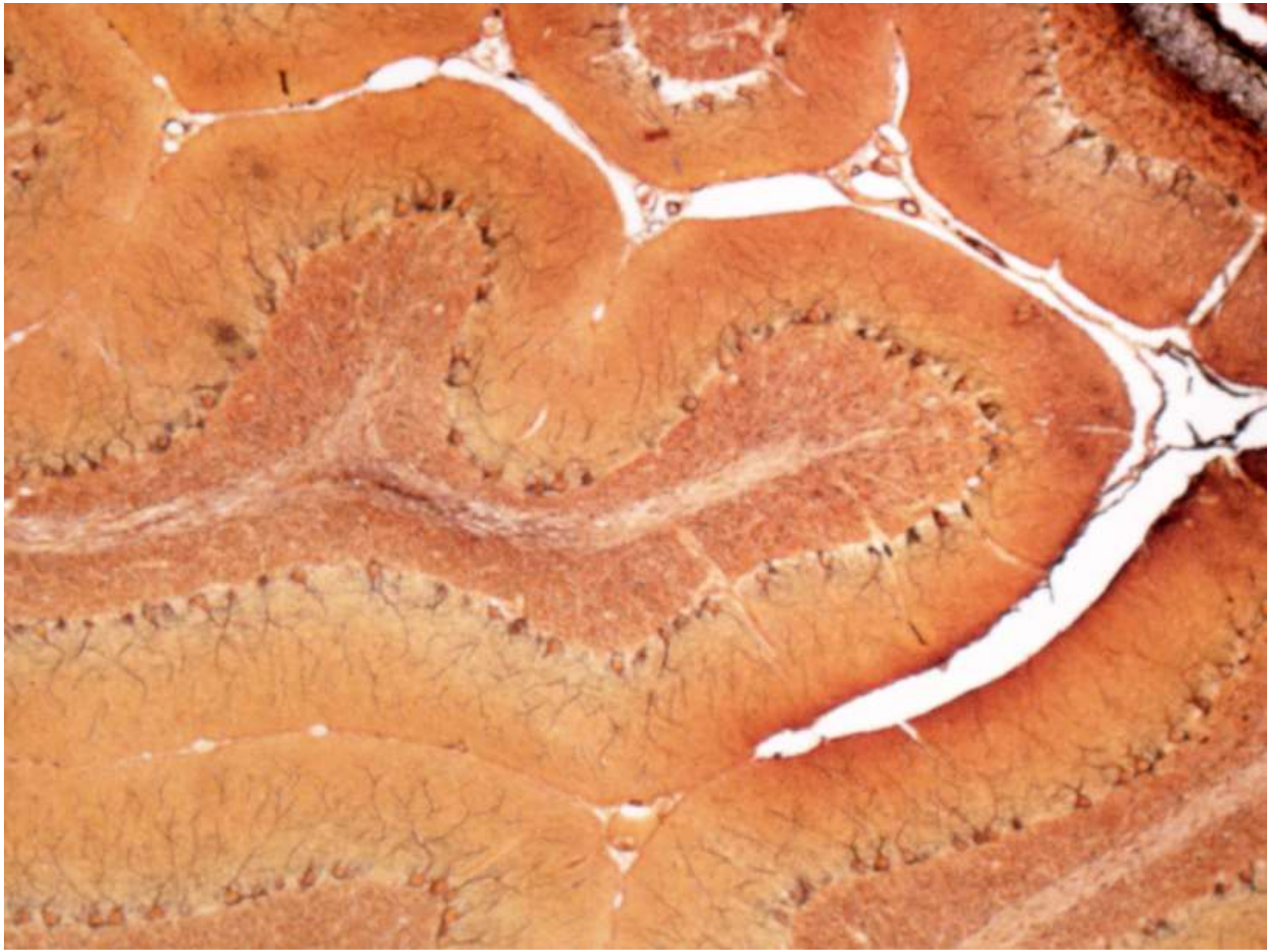


INTERNEURONAL CONNECTIONS IN THE CEREBELLAR CORTEX



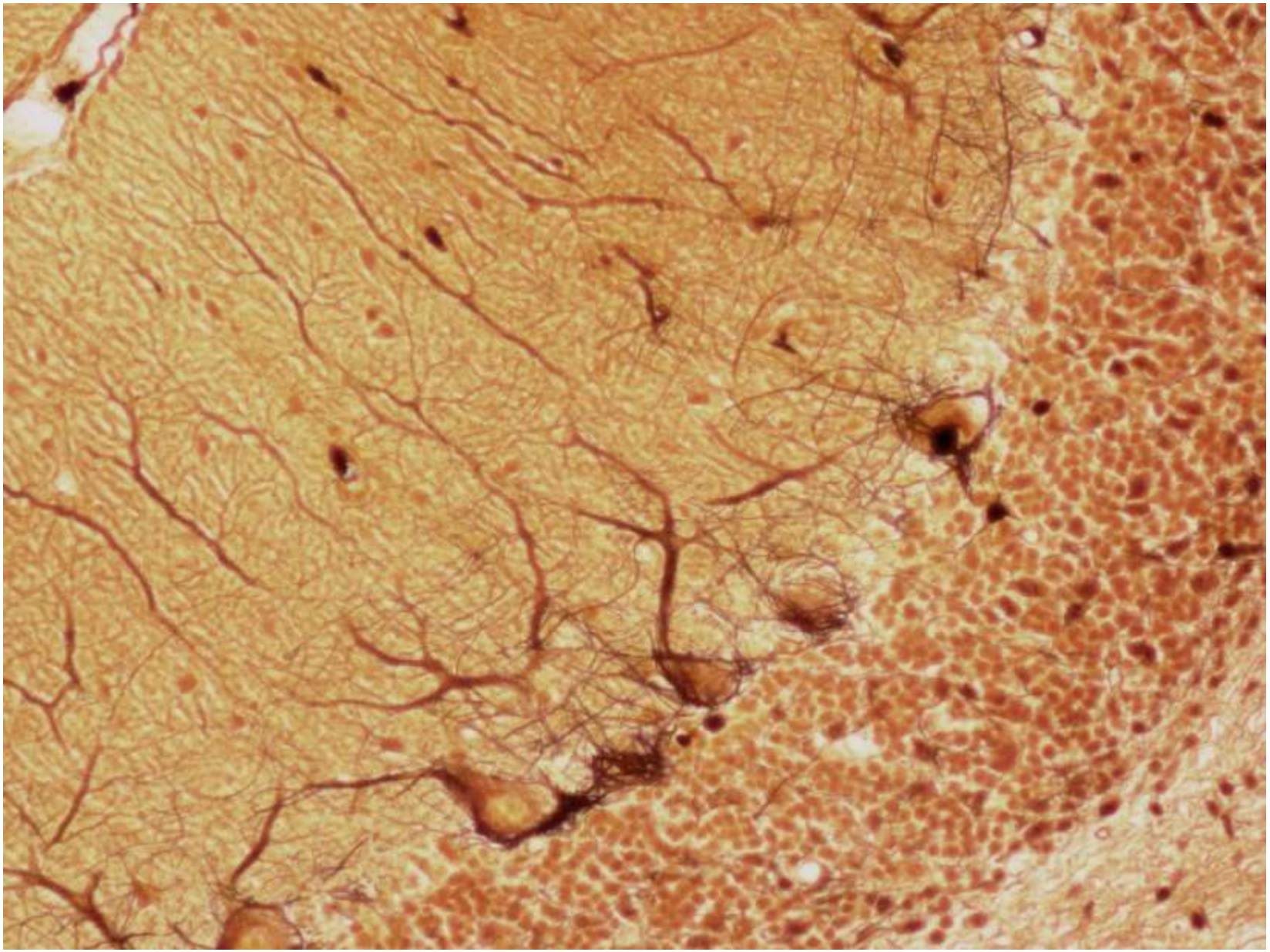
Slide №91 «Cerebellum»

Silver impregnation



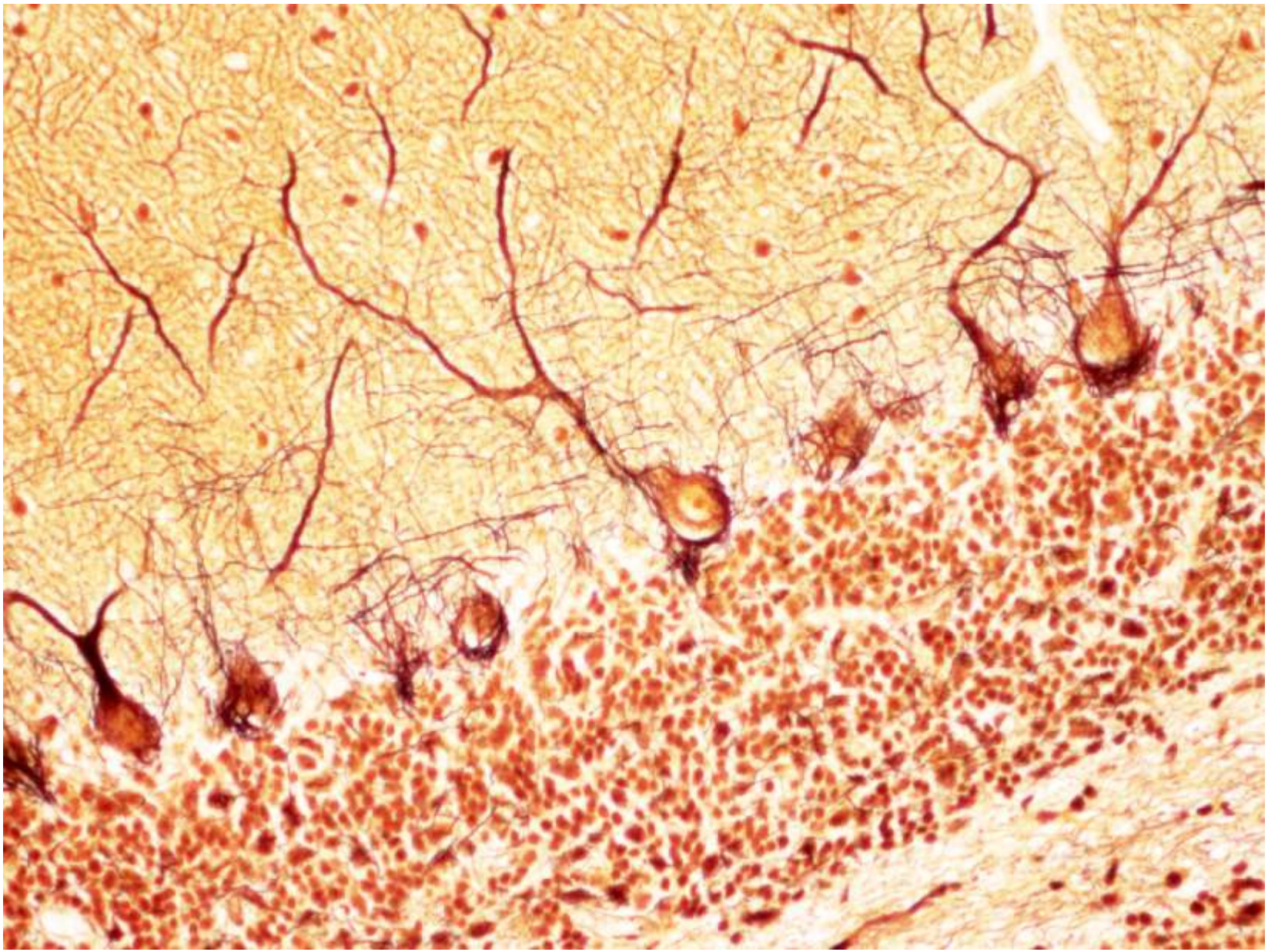
Slide №91 «Cerebellum»

Silver impregnation



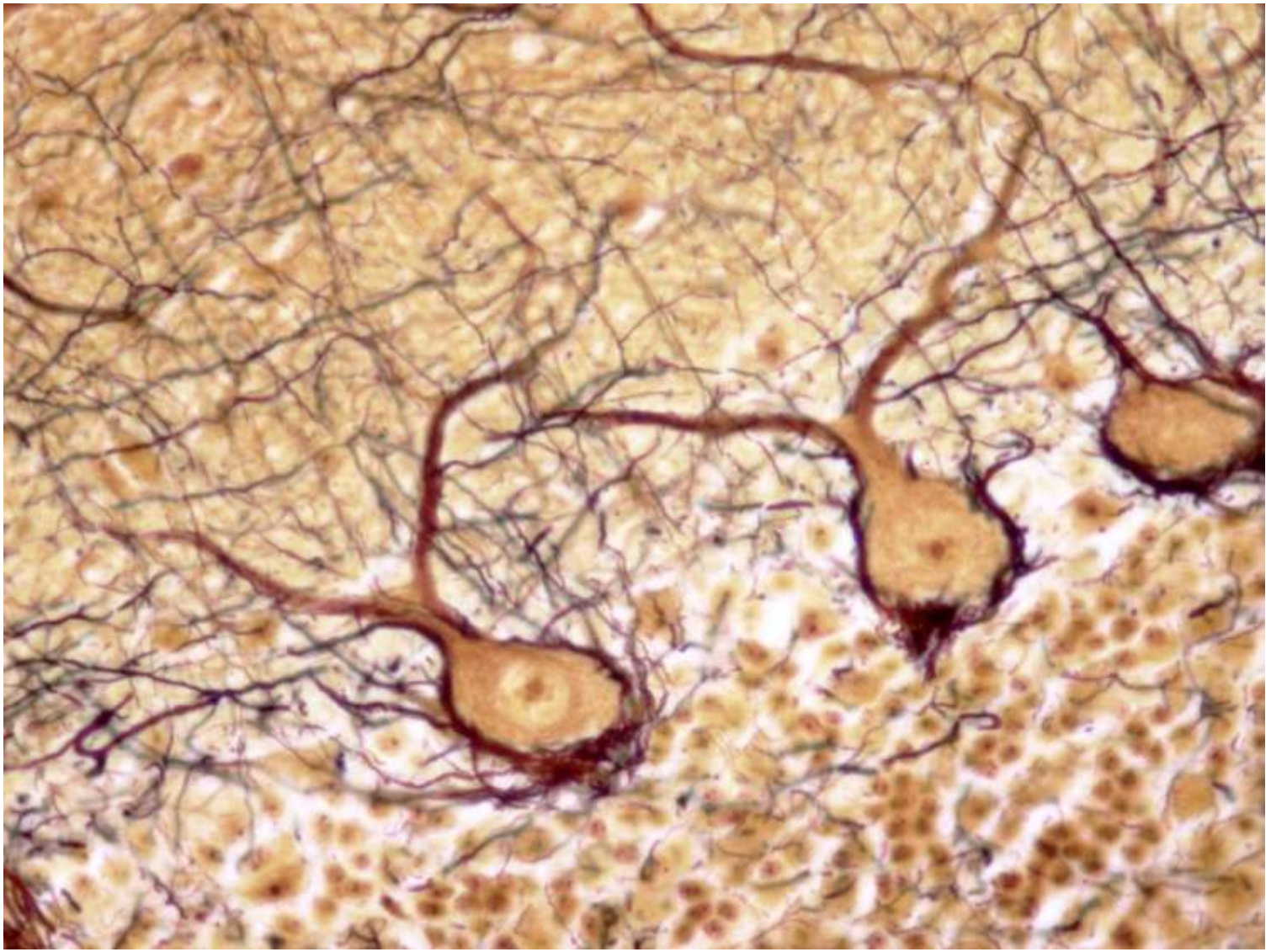
Slide №91 «Cerebellum»

Silver impregnation

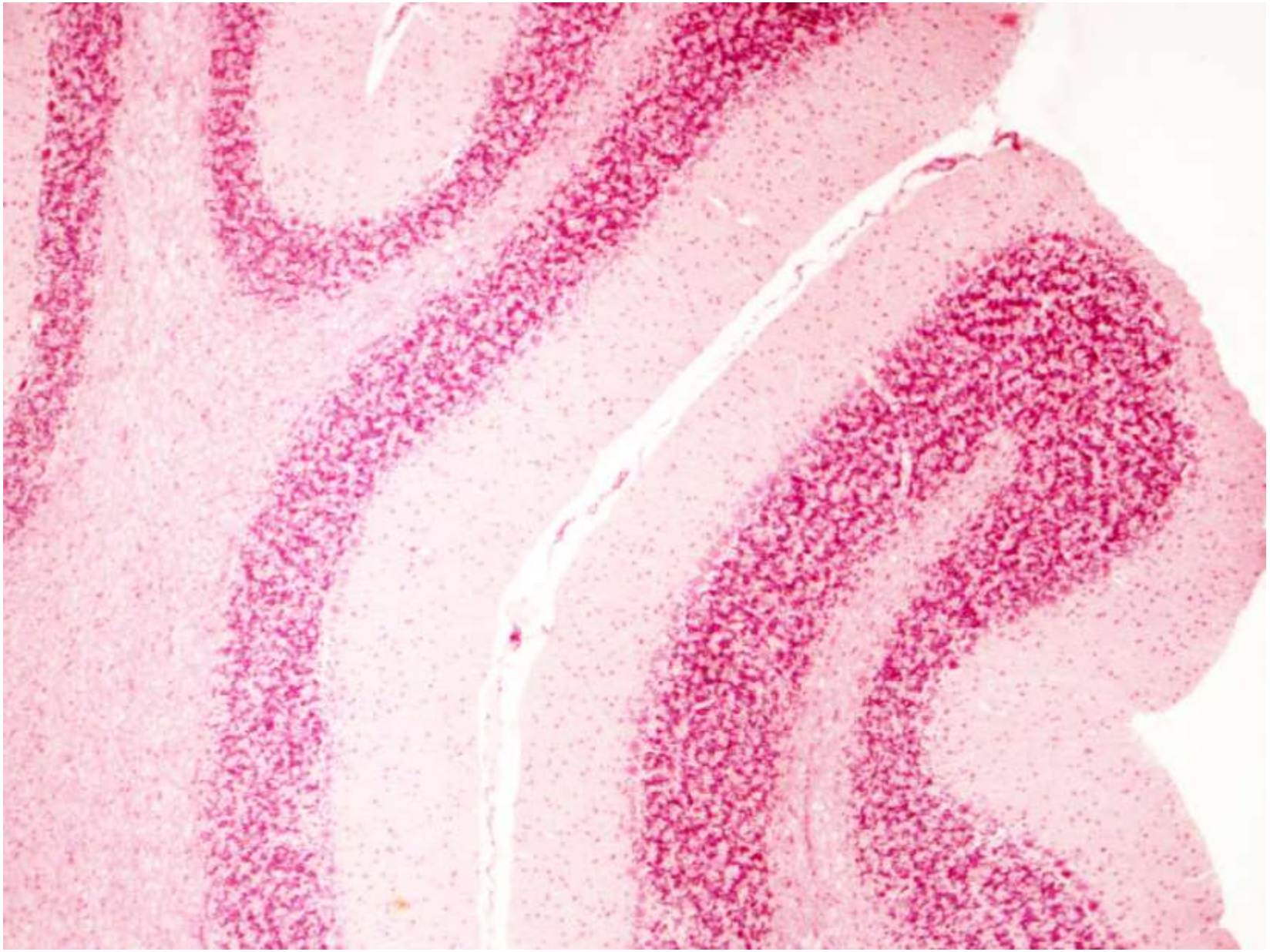


Slide №91 «Cerebellum»

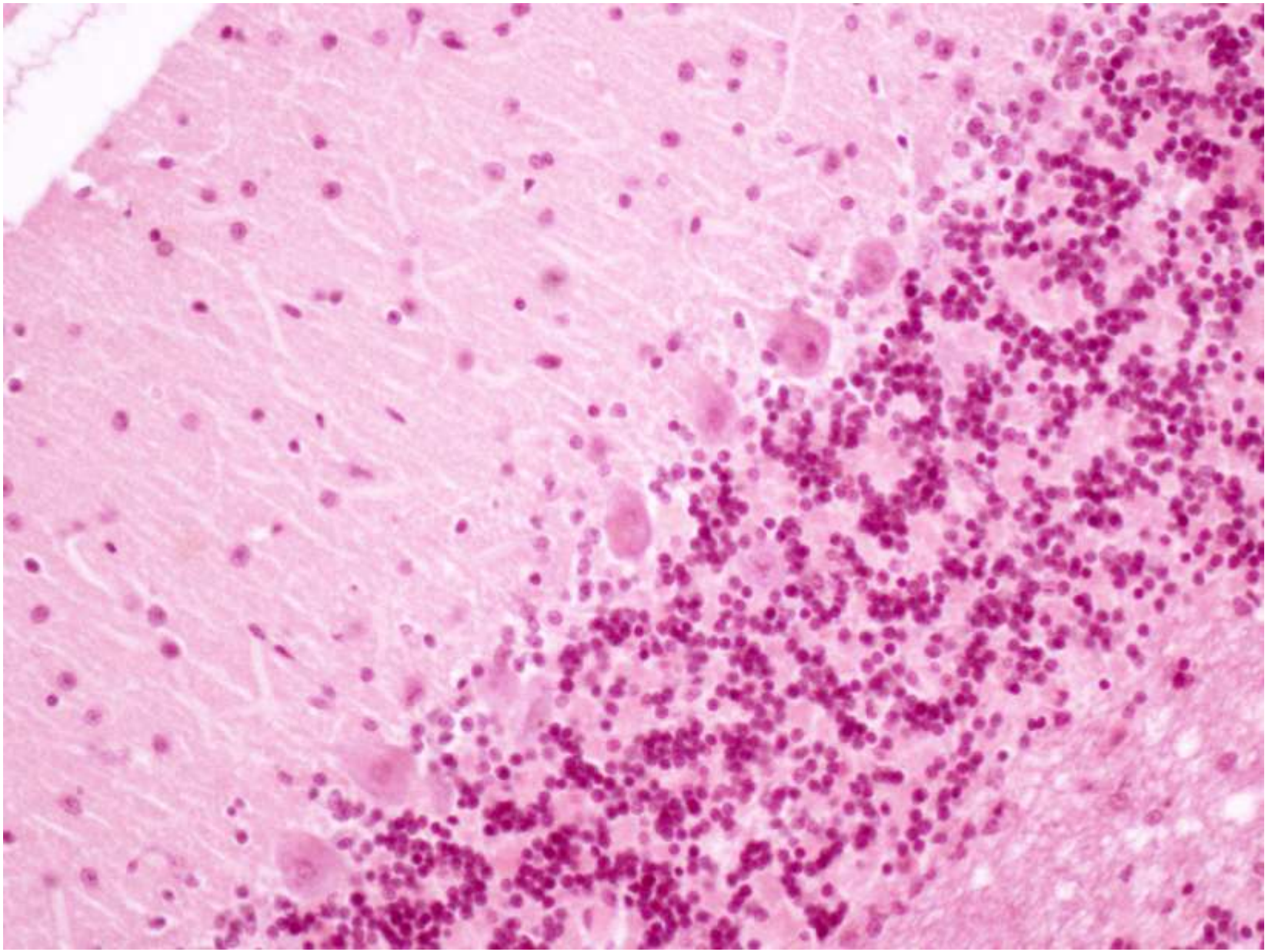
Silver impregnation



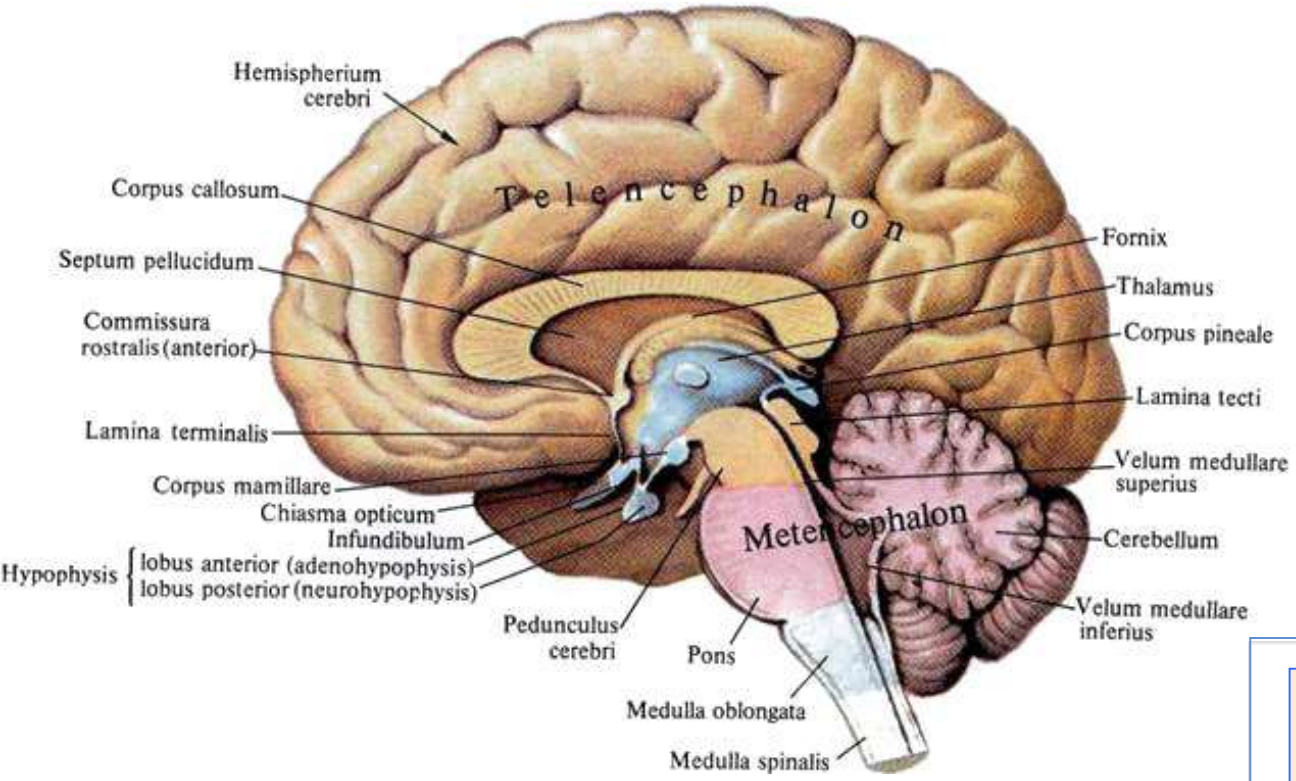
Slide №90 «Cerebellum»
Hematoxylin-eosin staining



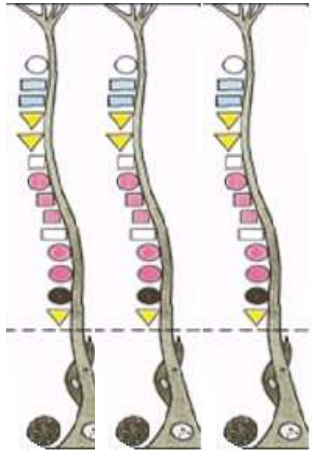
Slide №90 «Cerebellum»
Hematoxylin-eosin staining



CEREBRAL CORTEX

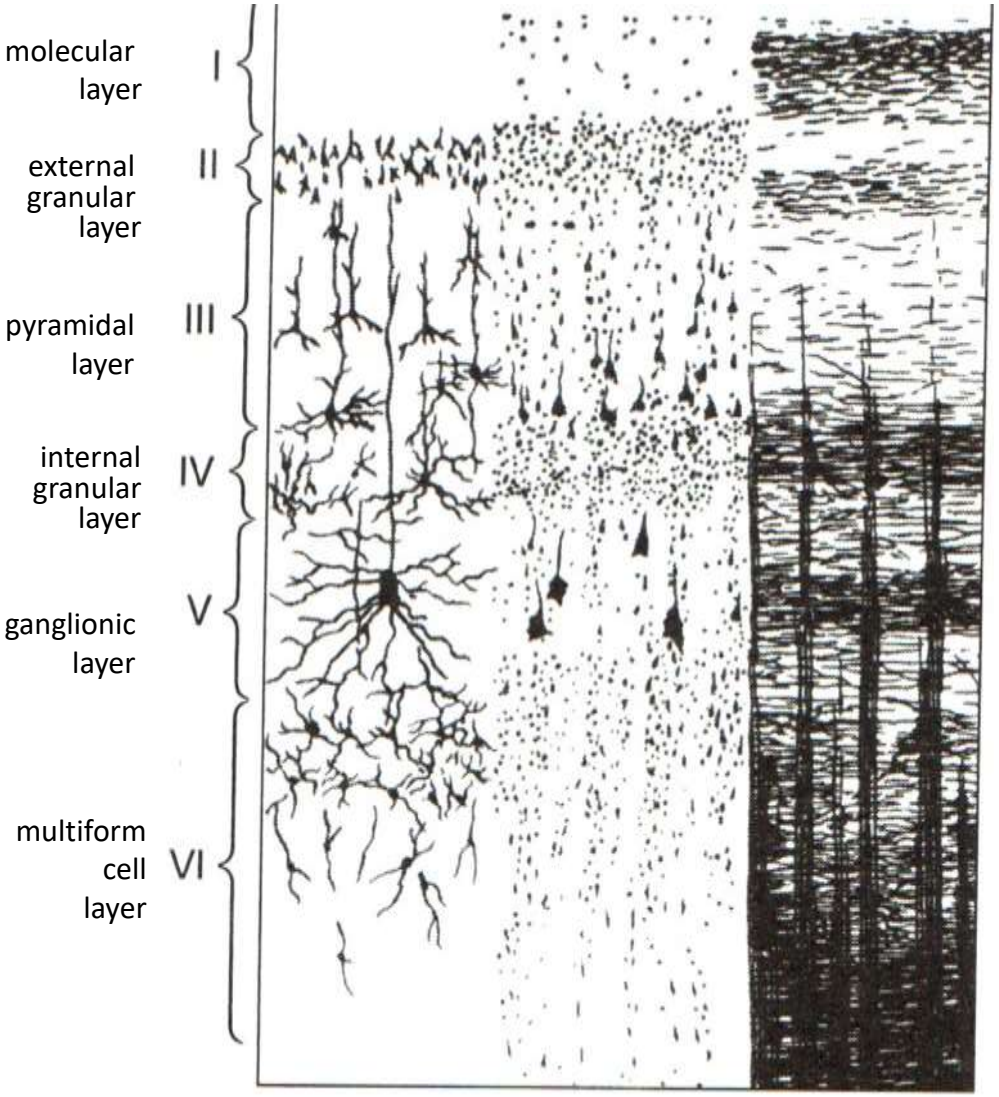


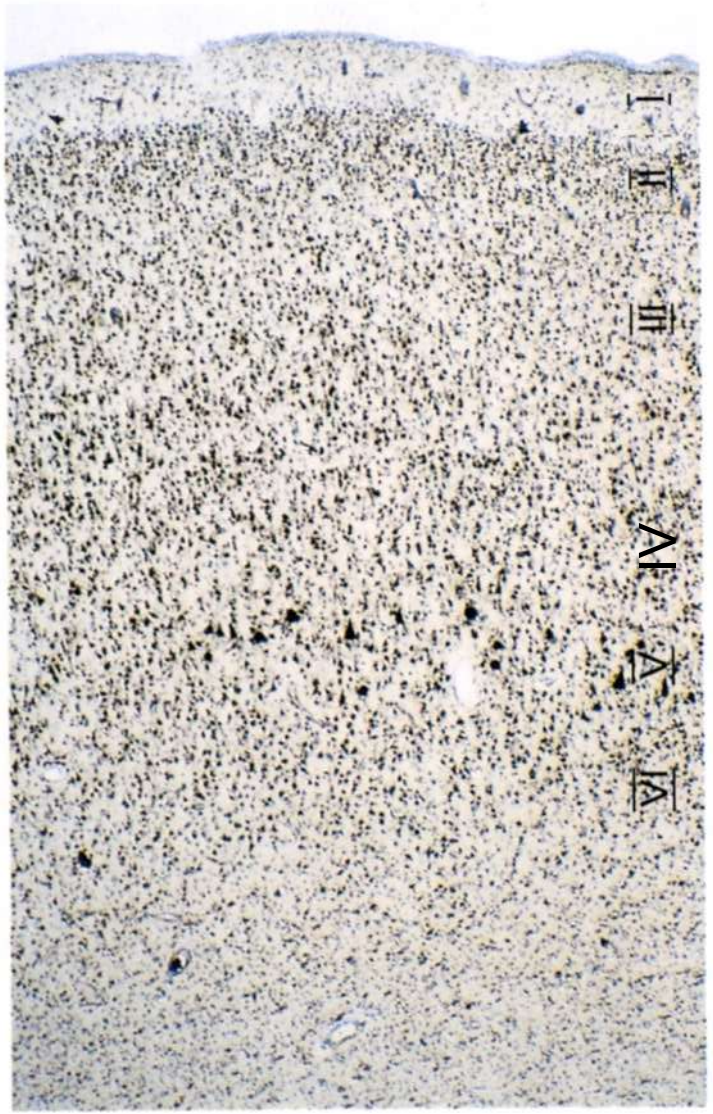
DEVELOPMENT OF CEREBRAL CORTEX



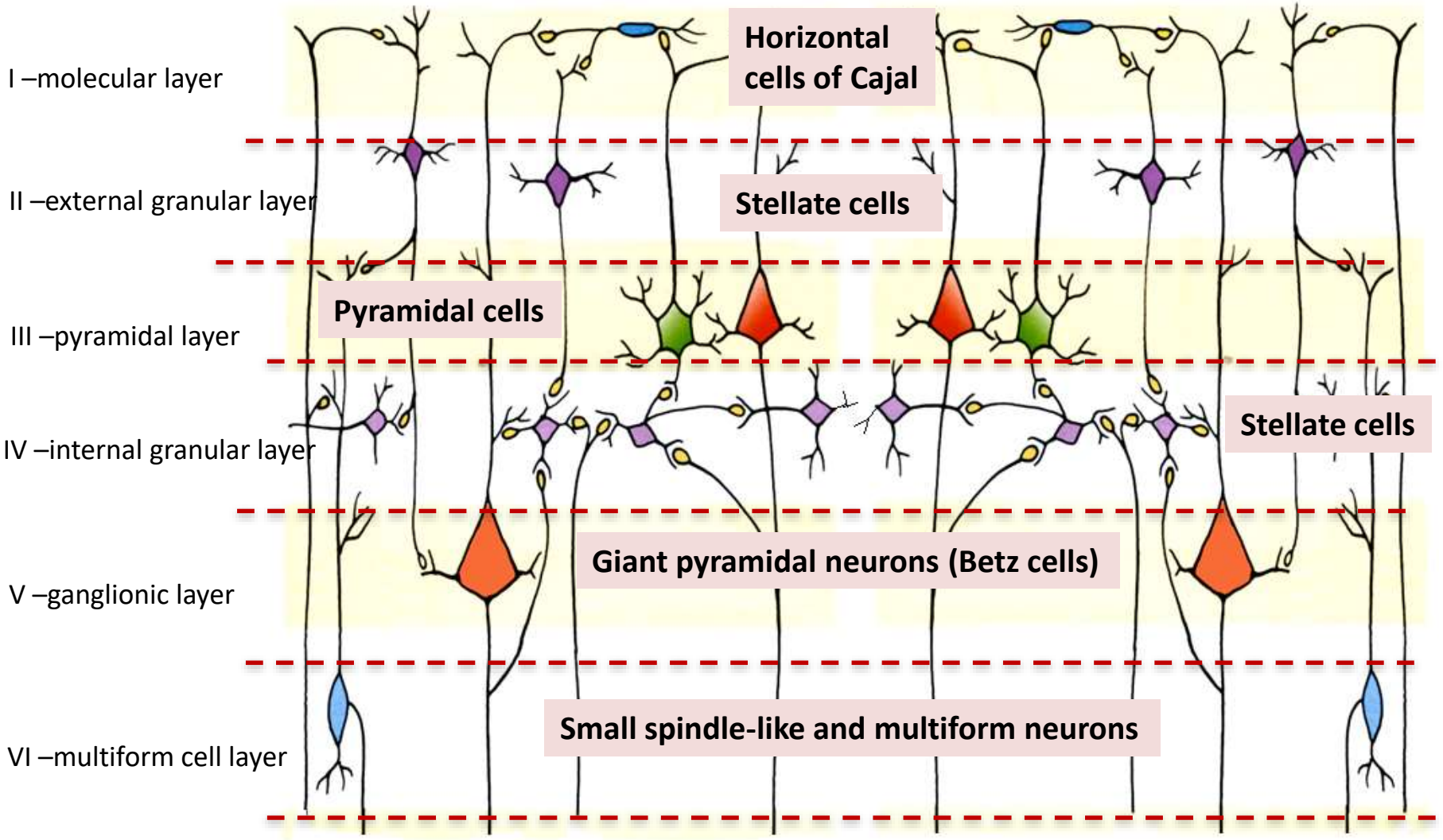
from cortical plate

STRUCTURAL ORGANIZATION OF THE CEREBRAL CORTEX





LAYERS AND NEURONS OF THE CEREBRAL CORTEX



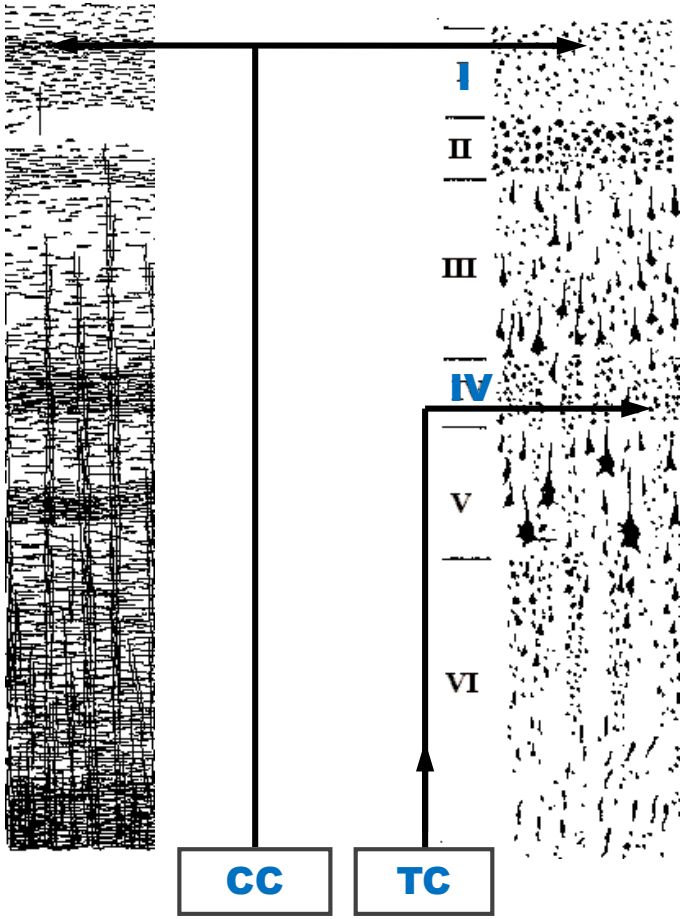
CORTICAL CONNECTIONS

AFFERENT

EFFERENT

CC: CORTICO-CORTICAL

TC: THALAMO-CORTICAL



II ASSOCIATION fibers

III COMMISSURAL fibers

V PROJECTION fibers

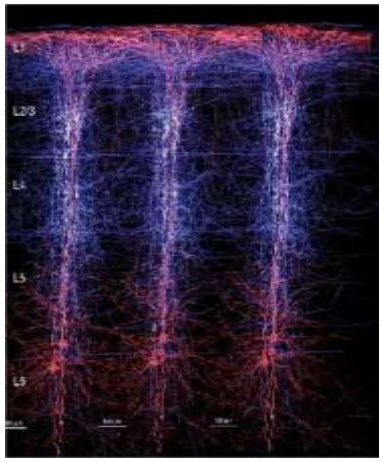
VI CORTICO-THALAMIC fibers

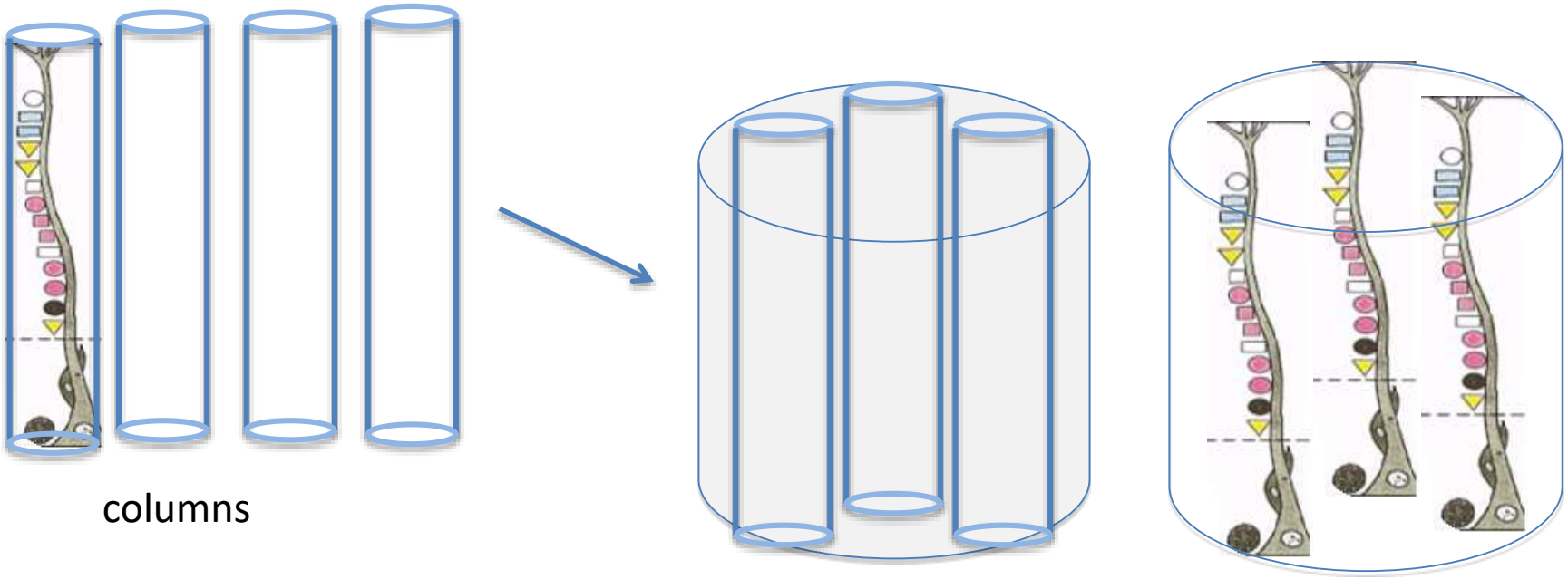
CEREBRAL CORTEX IS ORGANIZED IN MODULES

COLUMN – a vertical column through the cortical layers – represents an elementary functional unit of the cerebral cortex that contains neurons responsive to only a single modality

CORTICAL MODULE **(composed of columns) represents the structural and functional unit of the cortex**

The modules implement summation and comparison processes (integrative processing)





columns

The module has three basic compartments:

- *Afferent pathways*
- *Integration circuits*
- *Efferent pathways*

Layers

I. Molecular

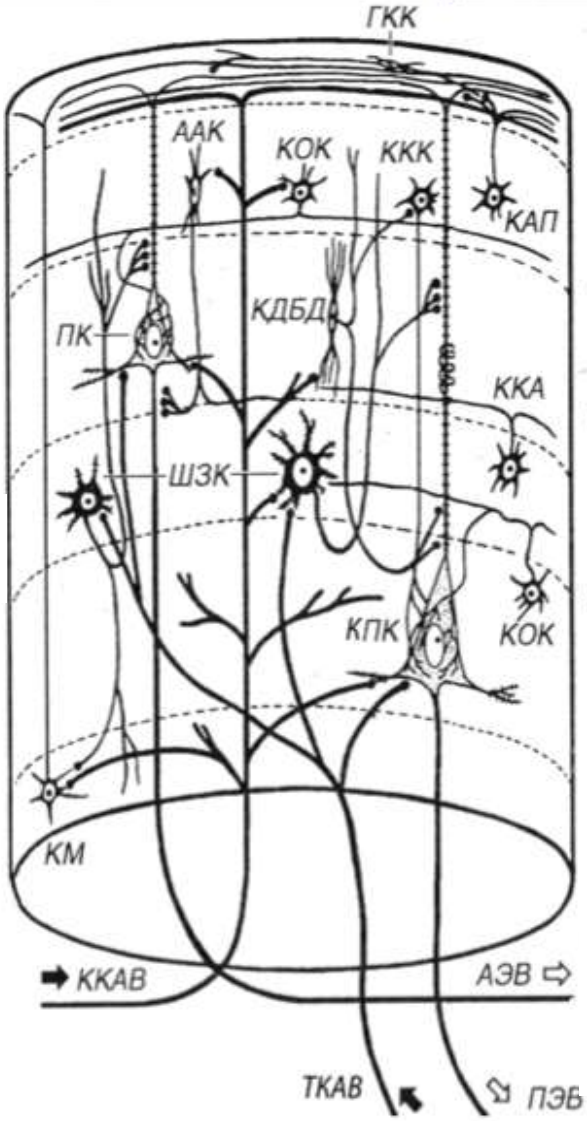
II. External granular

III Pyramidal

IV Internal granular

V. Ganglionic

VI. Multiform cell layer



ААК- Axoaxonic cell
КОК- Basket cell
КДБД- Bitufted cell
ККА- Chandelier cell

inhibitory neurons of the module

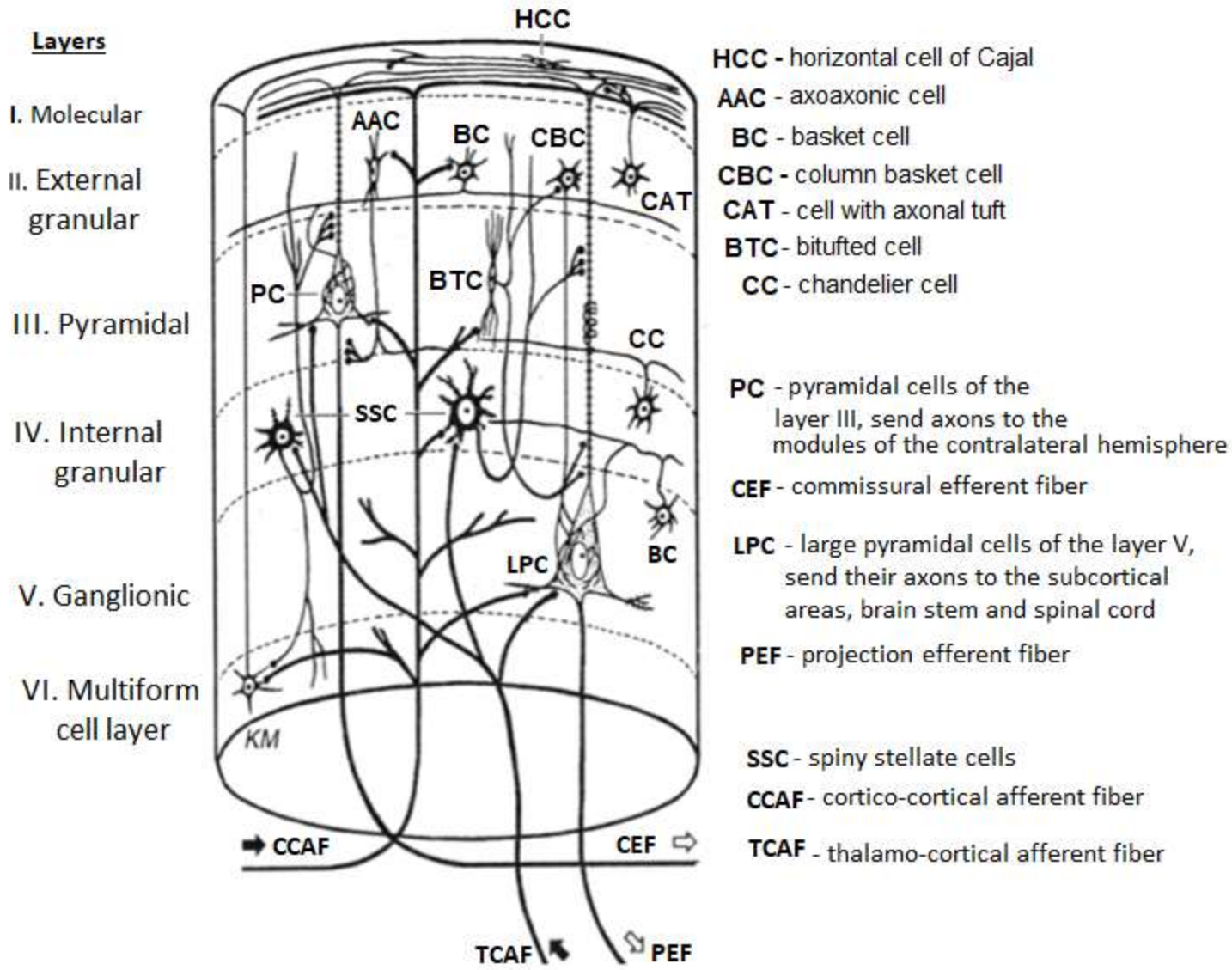
ПК- Pyramidal cells of the layer III, send axons to the columns of the neighboring hemisphere;
АЭВ – commissural fibers

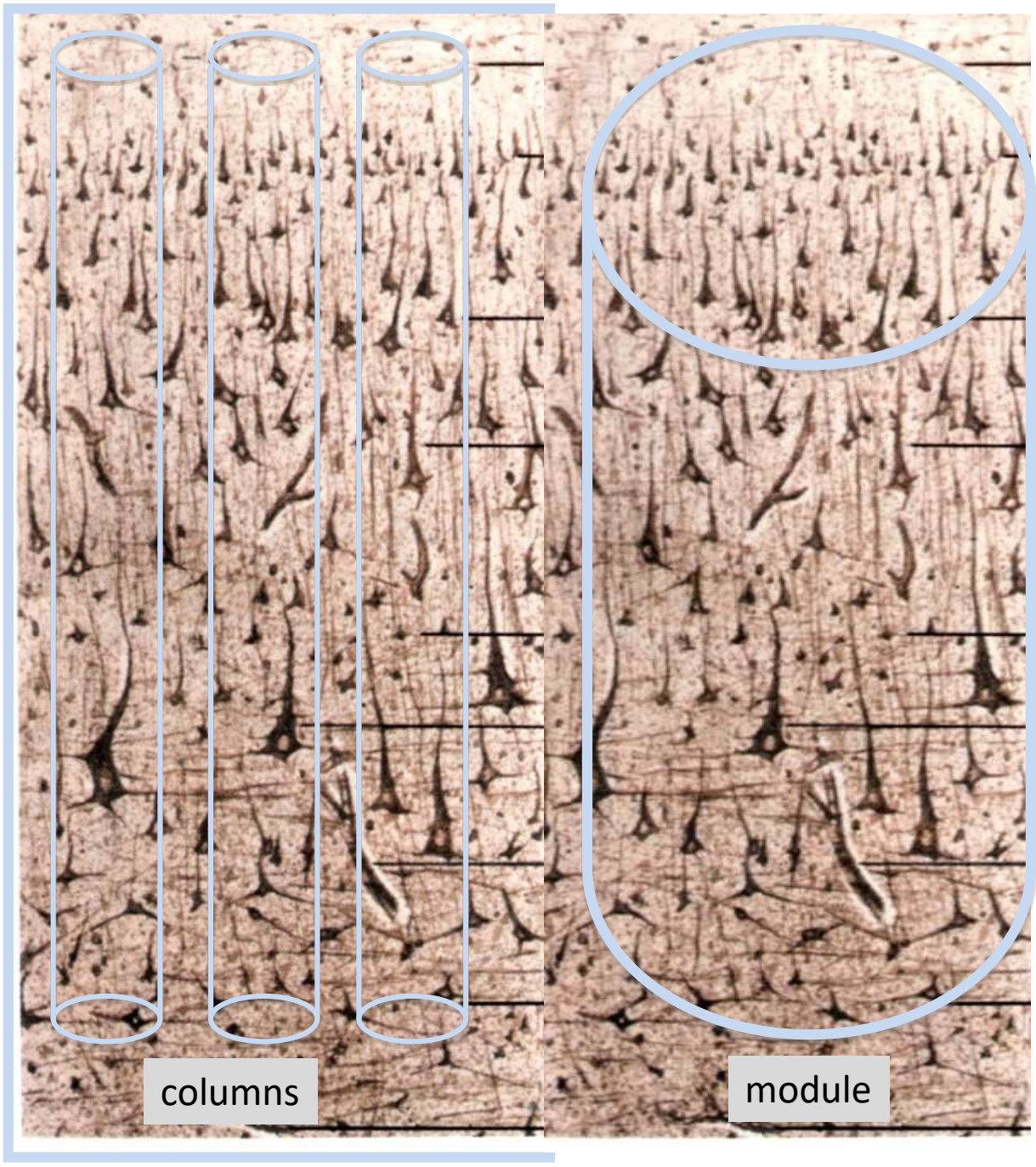
КПК- Large pyramidal cells of the layer V, send axons to the subcortical centers;
ПЭВ – projection fibers

efferent pathways

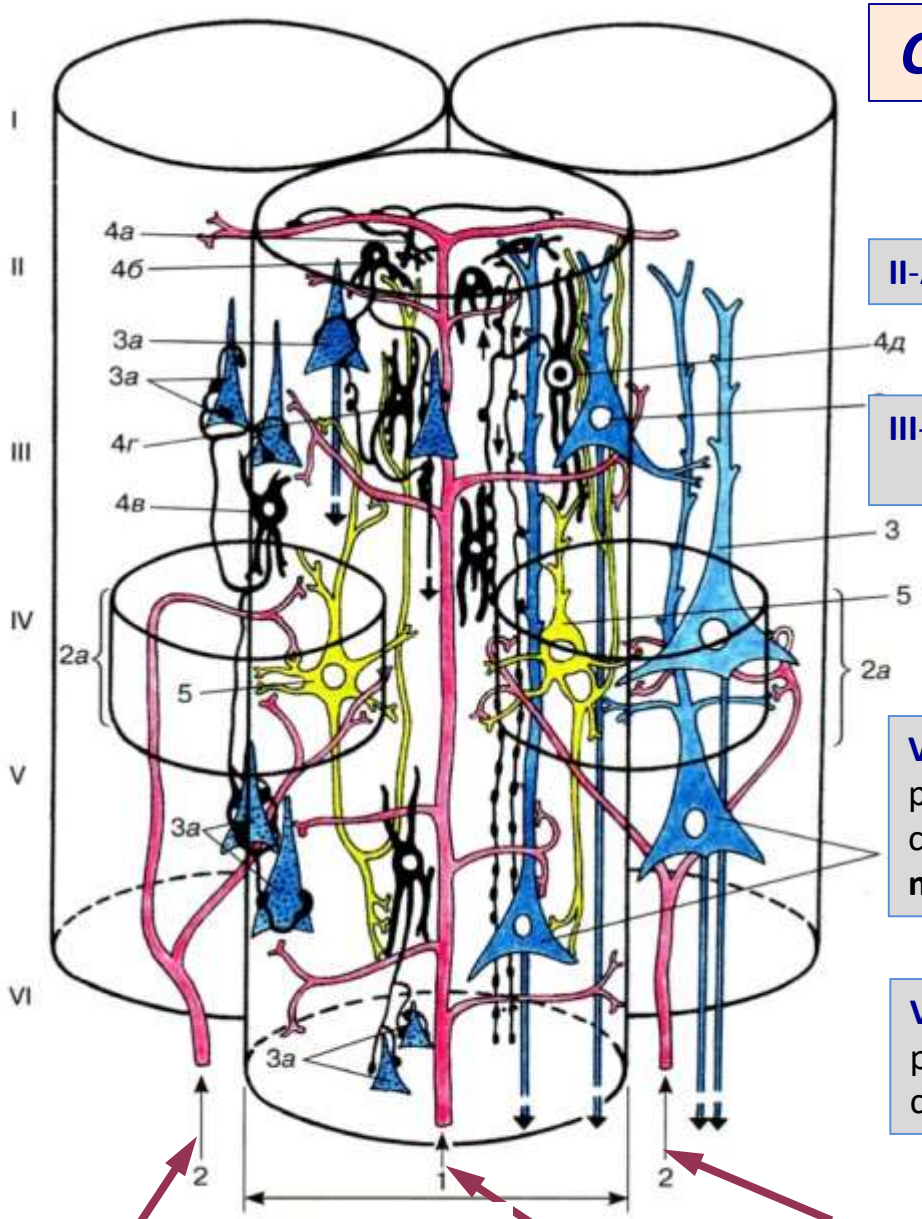
ККАВ- cortico-cortical afferent fibers (from neighboring columns)
ТКАВ-thalamo-cortical afferent fibers

afferent pathways


Layers
I. Molecular
II. External granular
III. Pyramidal
IV. Internal granular
V. Ganglionic
VI. Multiform cell layer
HCC
AAC
BC
CBC
CAT
BTC
PC
CC
SSC
LPC
BC
KM
CCAF
CEF
TCAF
PEF
HCC - horizontal cell of Cajal
AAC - axoaxonic cell
BC - basket cell
CBC - column basket cell
CAT - cell with axonal tuft
BTC - bitufted cell
CC - chandelier cell
PC - pyramidal cells of the layer III, send axons to the modules of the contralateral hemisphere
CEF - commissural efferent fiber
LPC - large pyramidal cells of the layer V, send their axons to the subcortical areas, brain stem and spinal cord
PEF - projection efferent fiber
SSC - spiny stellate cells
CCAF - cortico-cortical afferent fiber
TCAF - thalamo-cortical afferent fiber


columns
module

CONNECTIONS OF THE MODULE



II-ASSOCIATION – to 3 modules on its side

III-COMMISSURAL – to 2 modules on the opposite side

V-PROJECTION – principal cortical efferent projections to basal ganglia, brain stem and spinal cord, terminate on motoneurons, **ensure the motor response of the cortex**

VI-CORTICO-THALAMIC – influence sensory processing in the thalamus, ensure the thalamo-cortical feedback

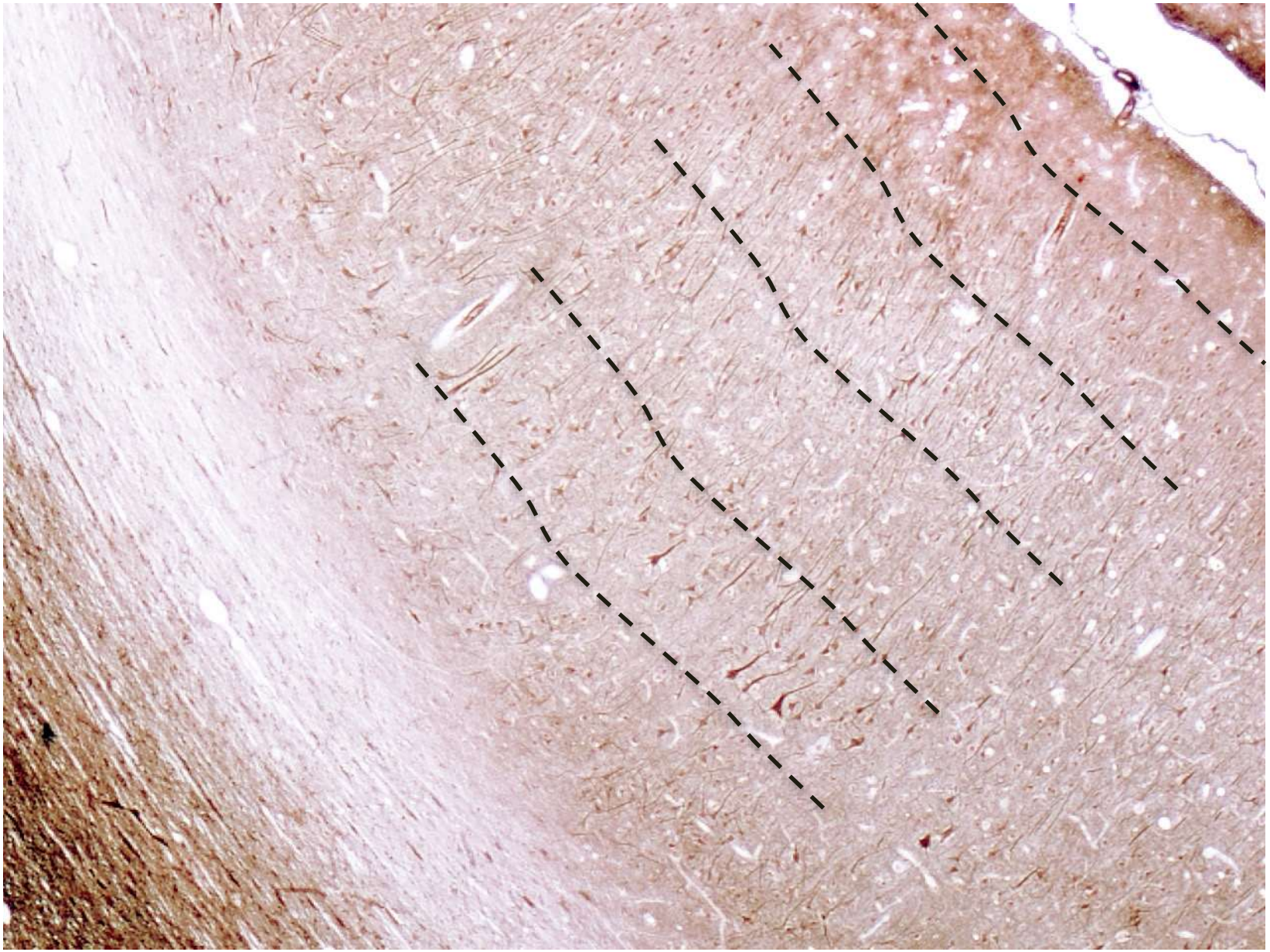
THALAMO-CORTICAL

30 um minicolumn

THALAMO-CORTICAL

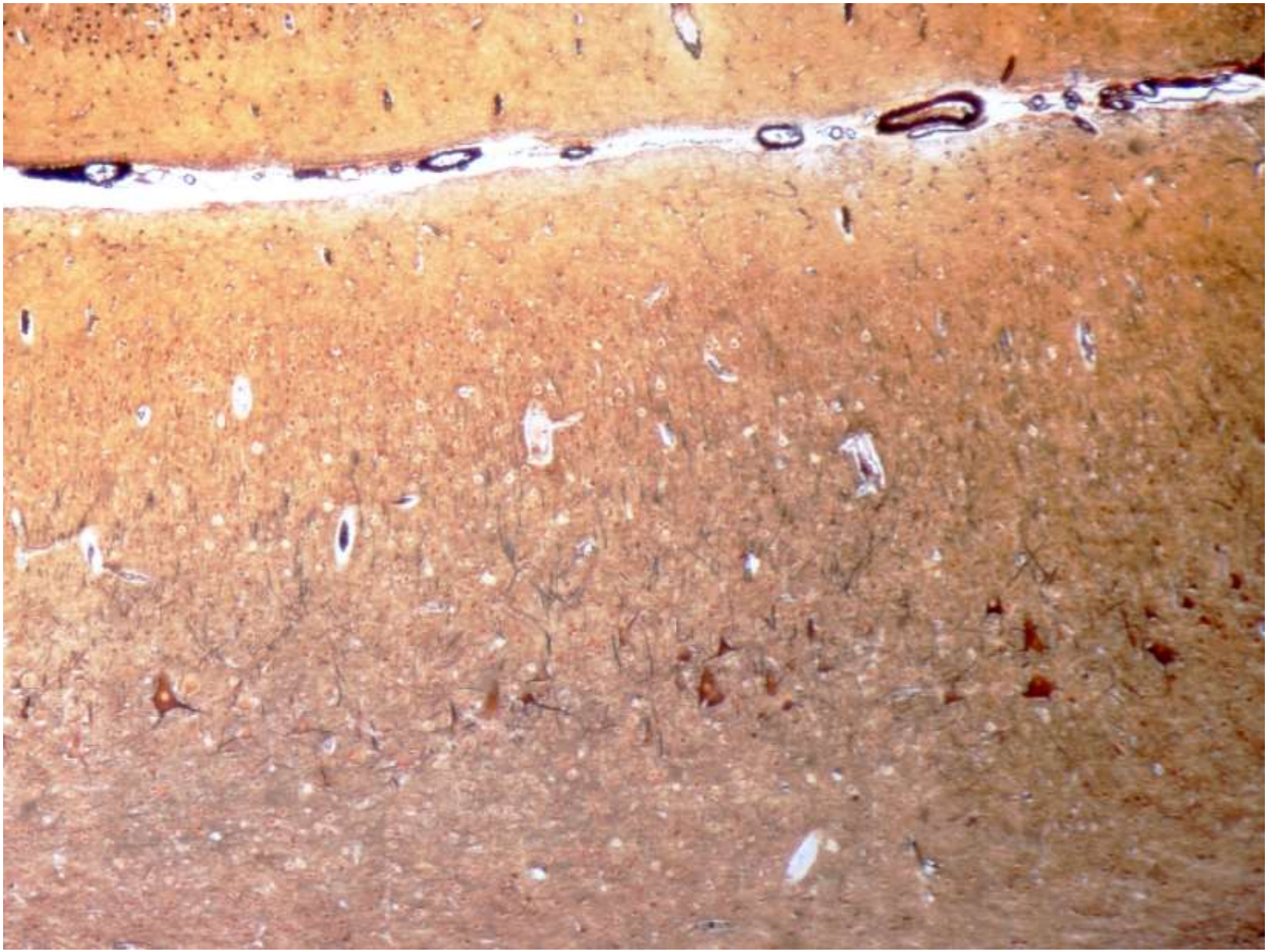
CORTICO-CORTICAL

Slide №92a. «Cerebral cortex (neocortex)»
Silver impregnation

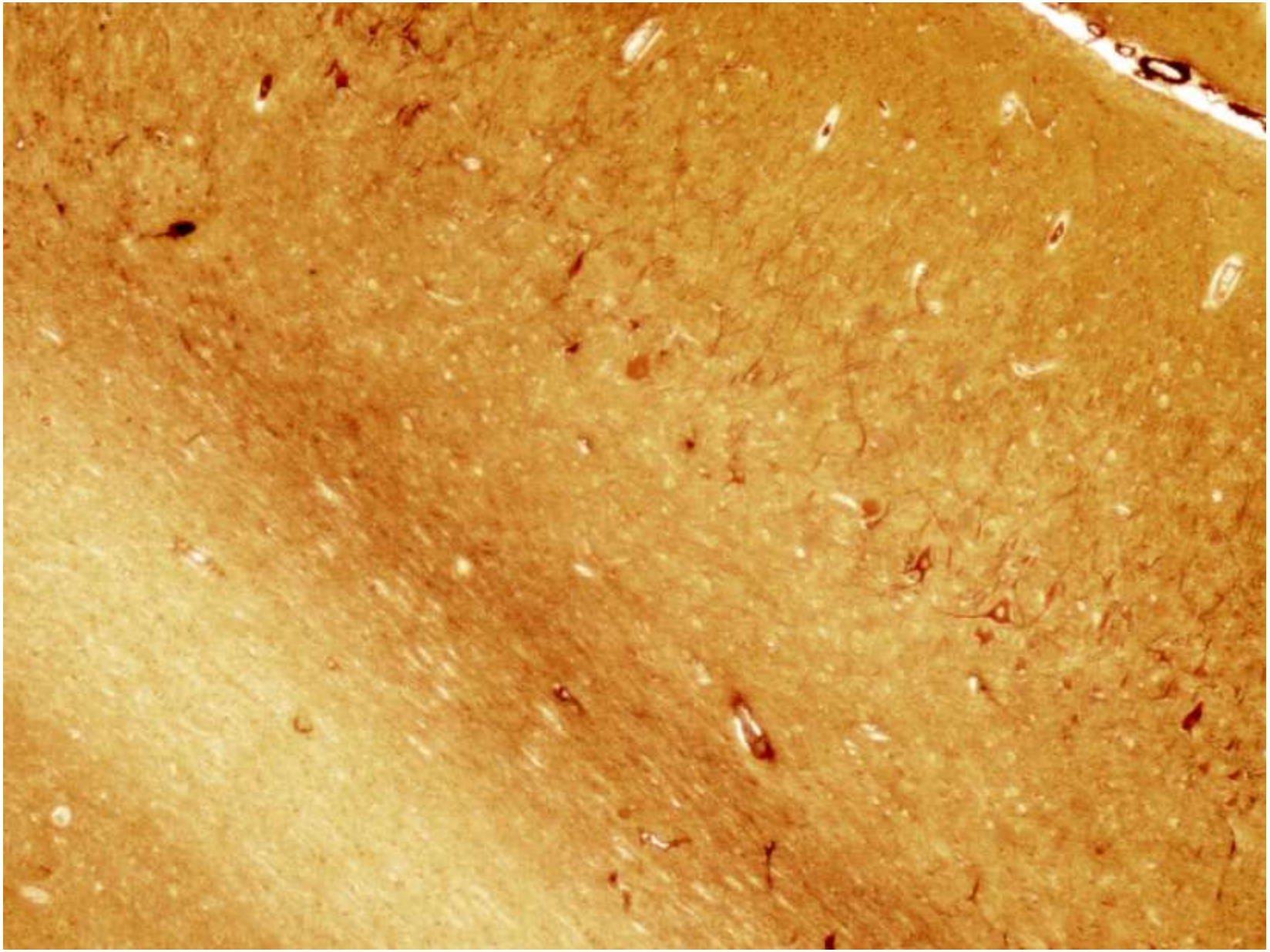


Slide №92a. «Cerebral cortex (neocortex)»
Silver impregnation

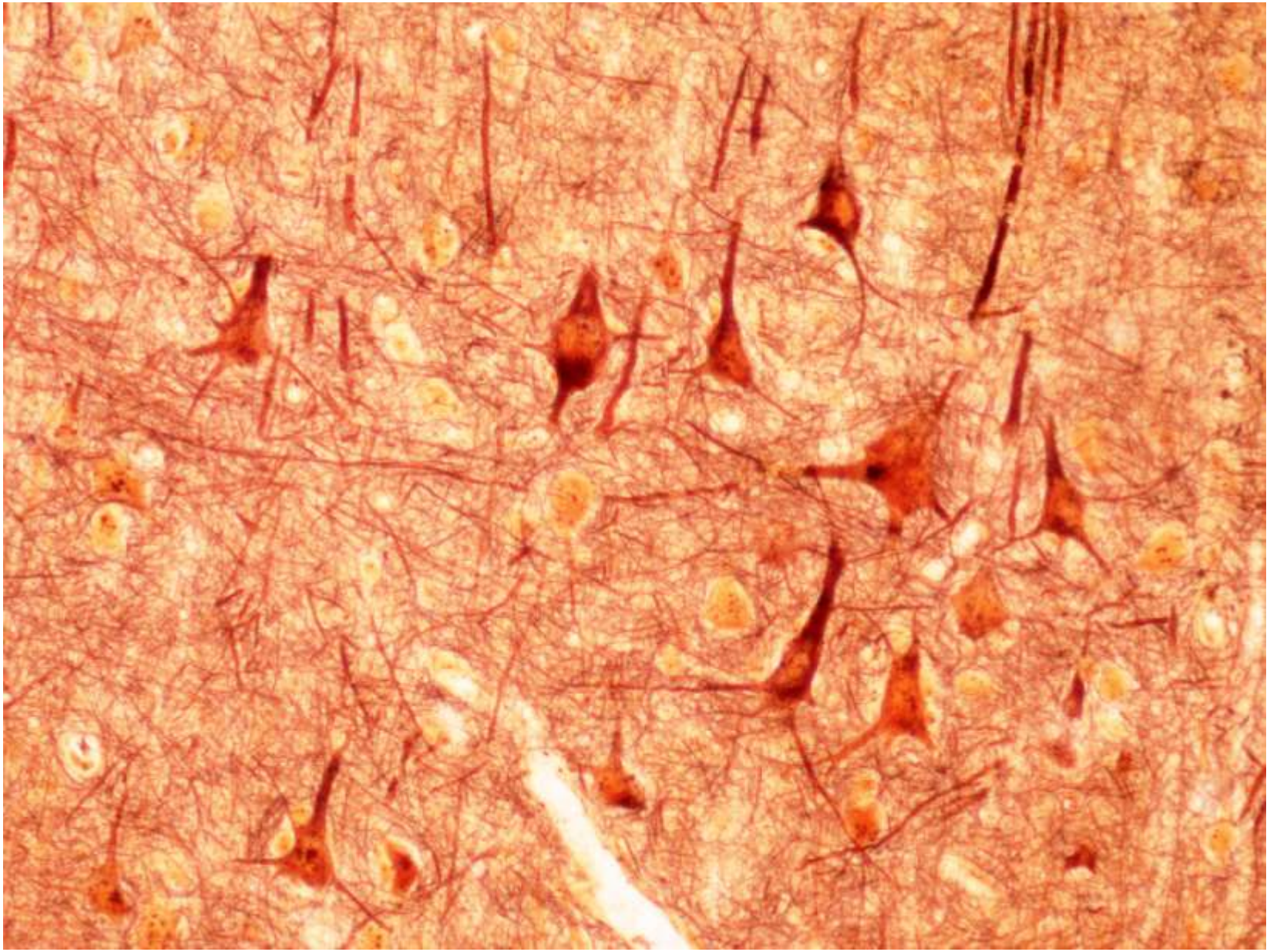
Slide №92a. «Cerebral cortex (neocortex)»
Silver impregnation



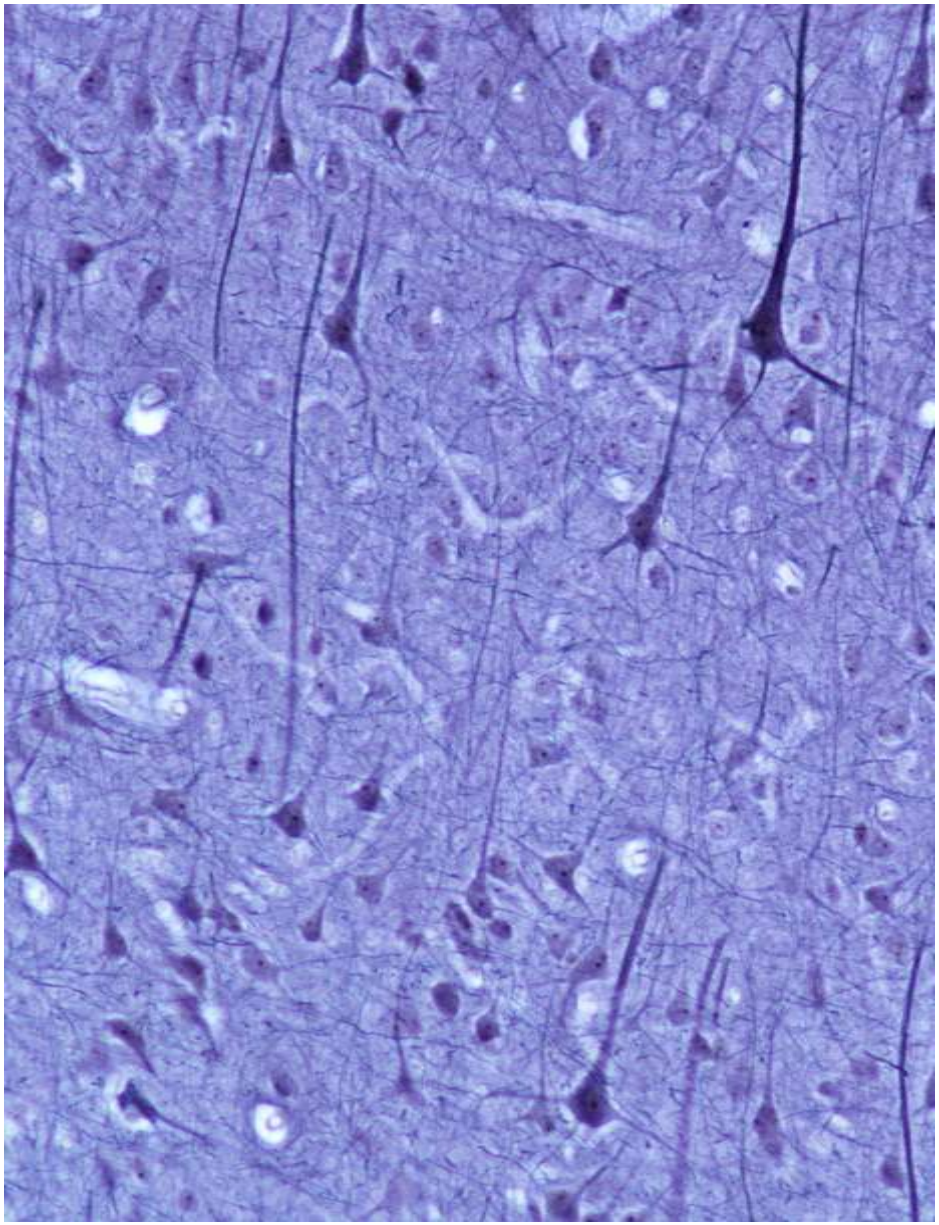
Slide №92a. «Cerebral cortex (neocortex)»
Silver impregnation



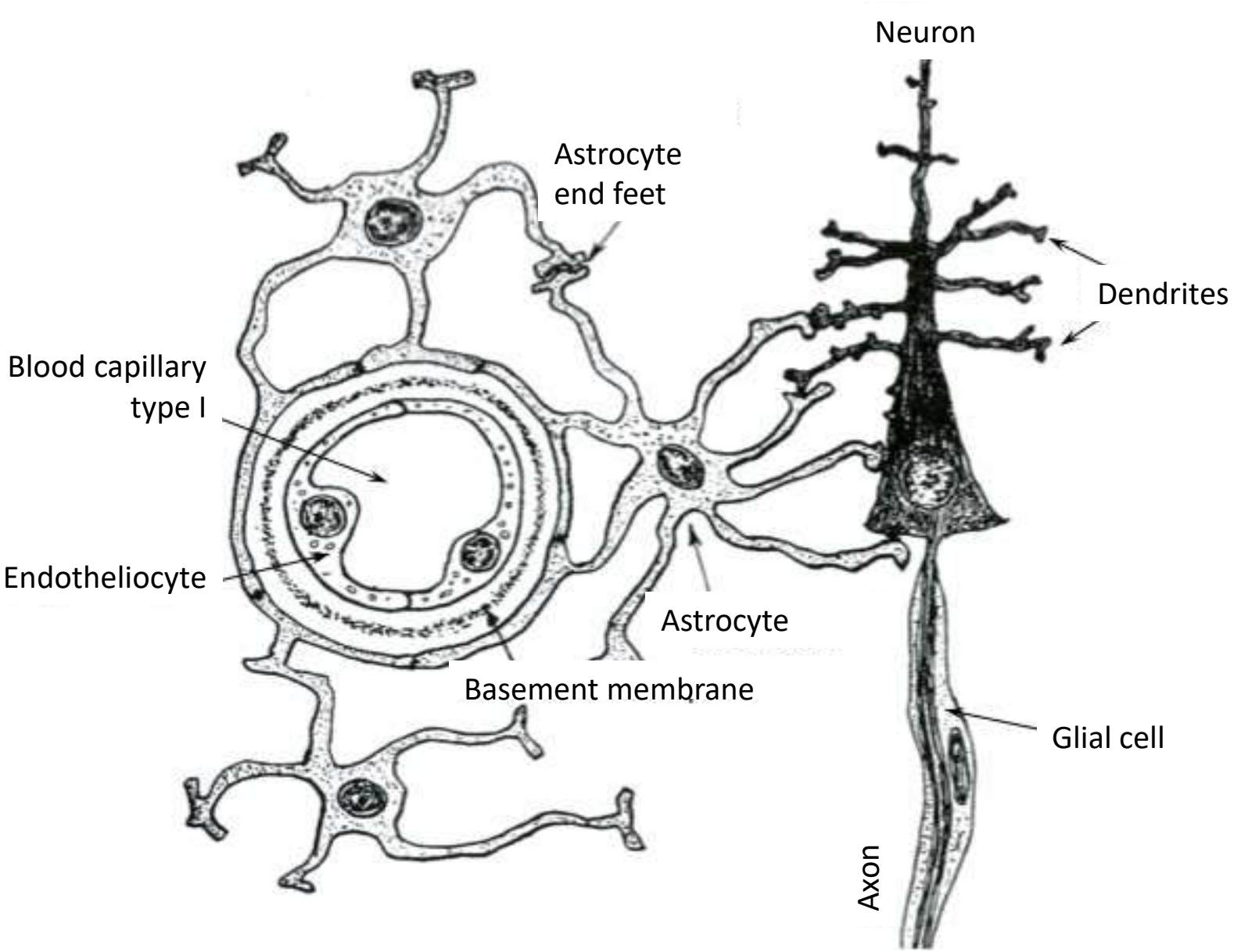
Slide №92a. «Cerebral cortex (neocortex)»
Silver impregnation



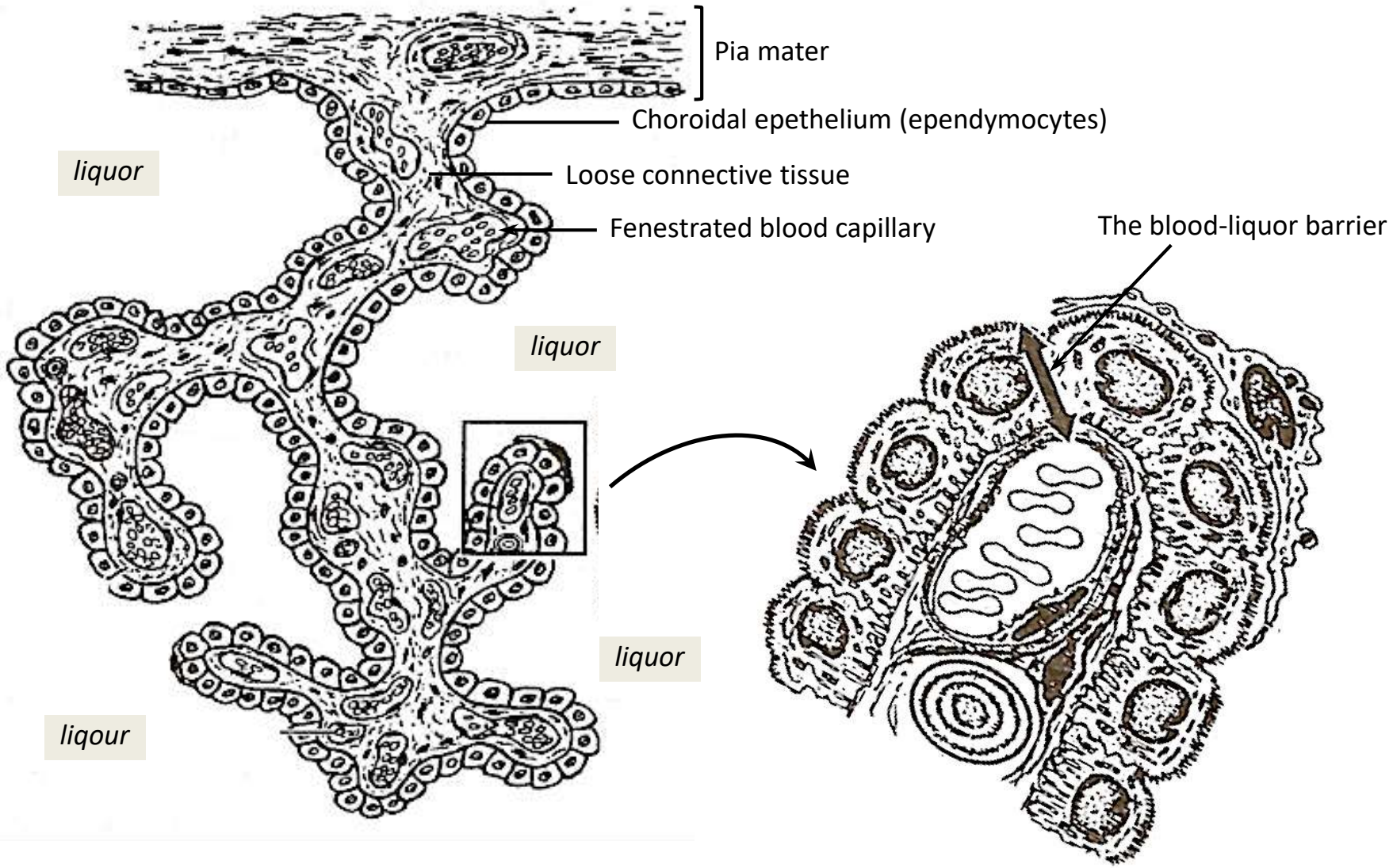
Slide №92a. «Cerebral cortex (neocortex)»
Silver impregnation



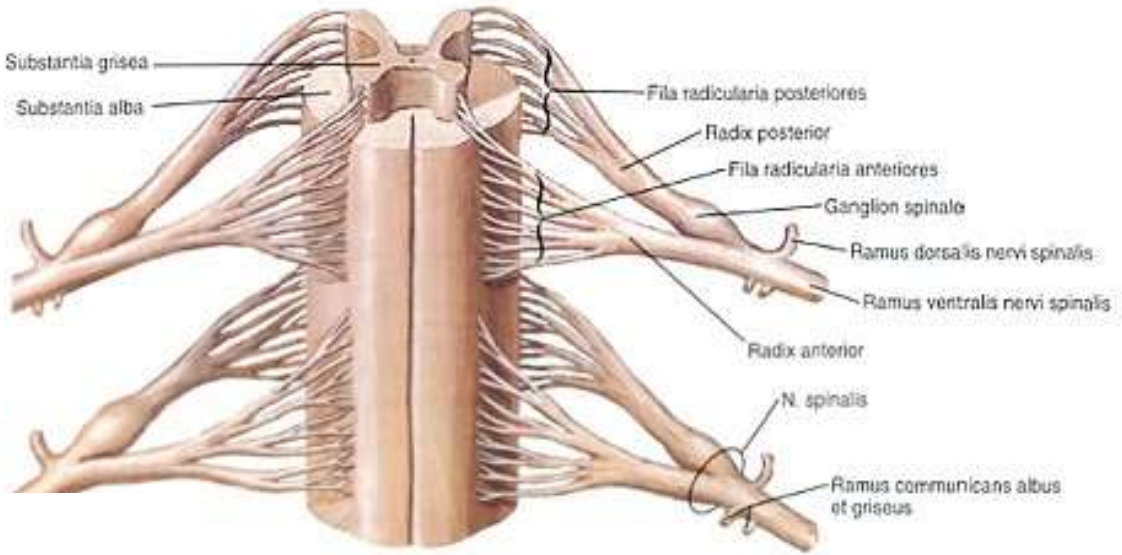
THE BLOOD-BRAIN BARRIER

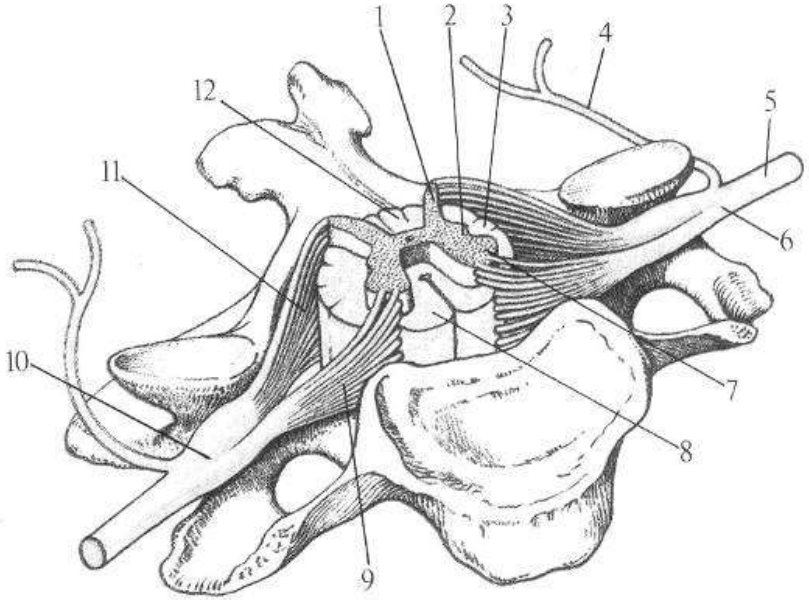


THE BLOOD-LIQUOR BARRIER

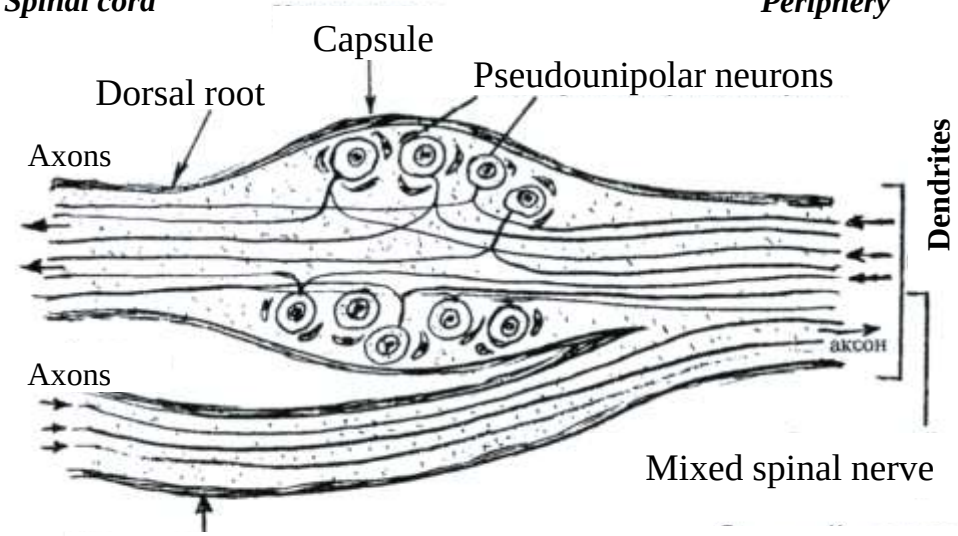


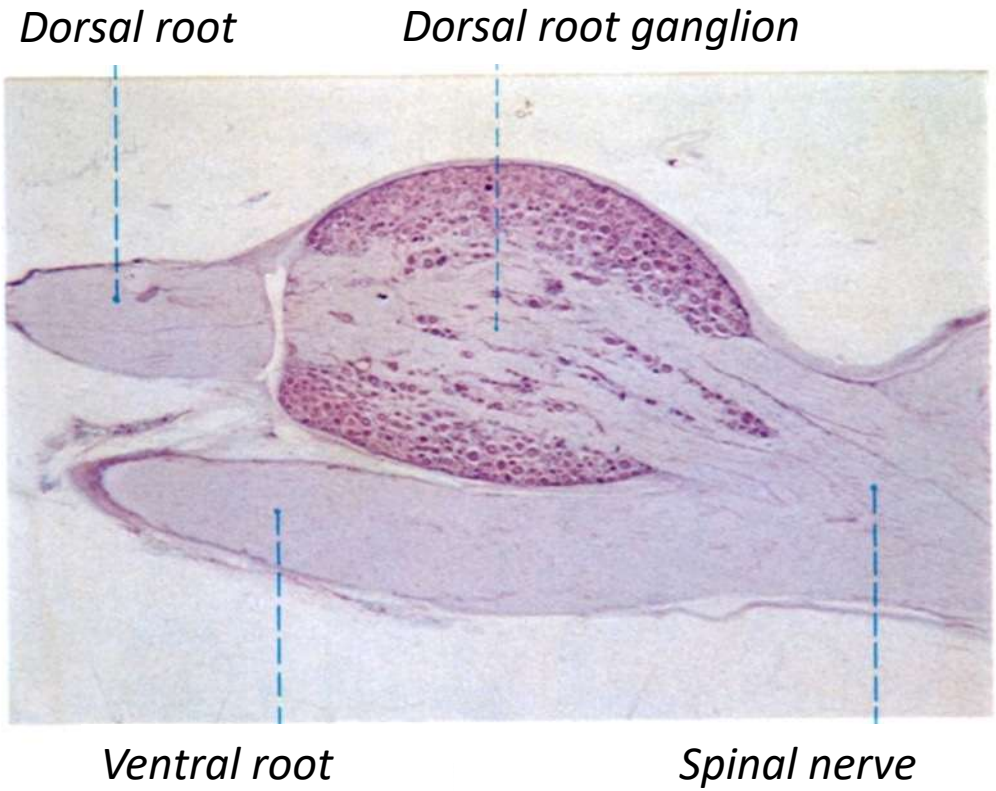
SPINAL CORD ANATOMY



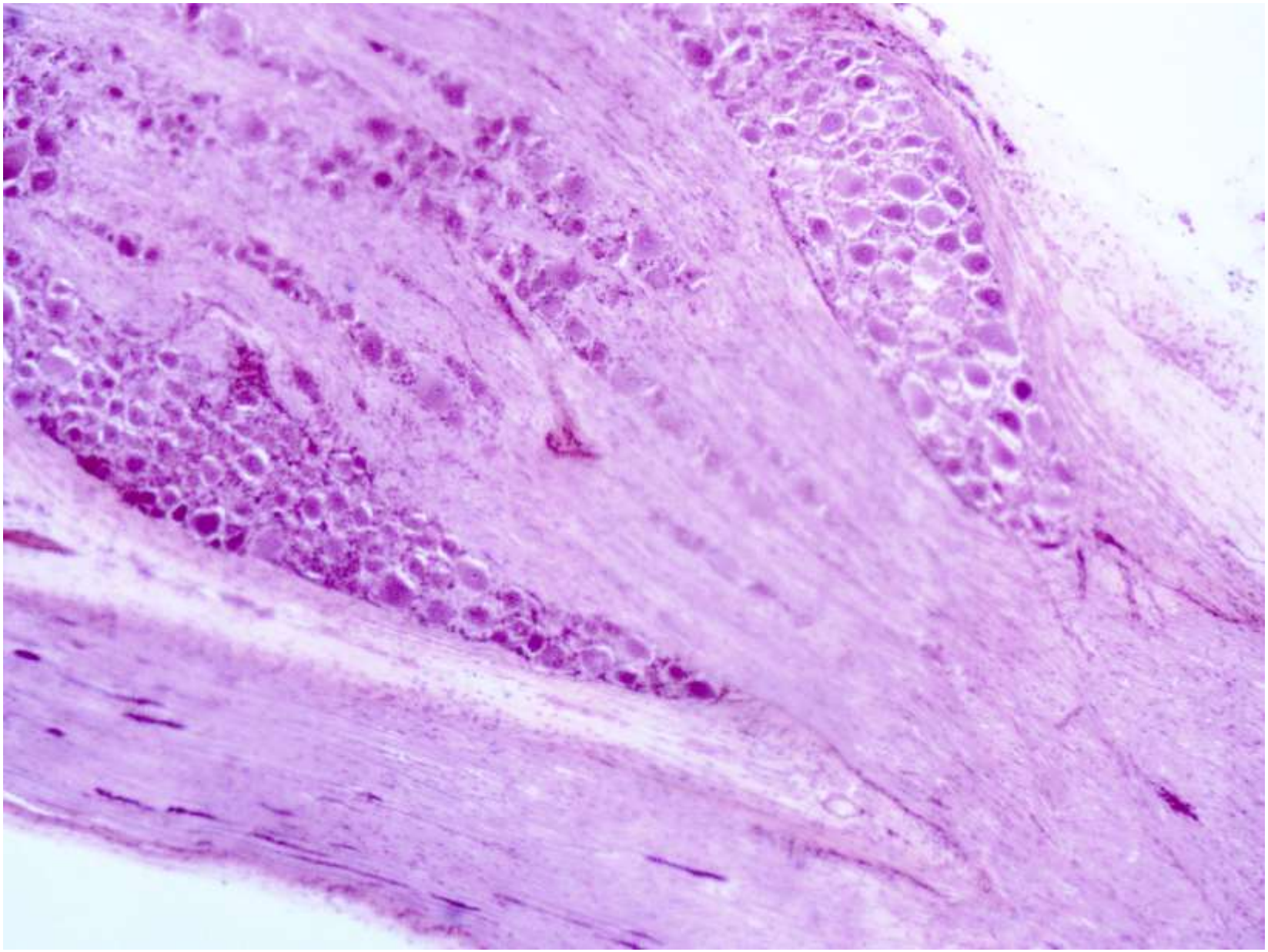


DORSAL ROOT GANGLION



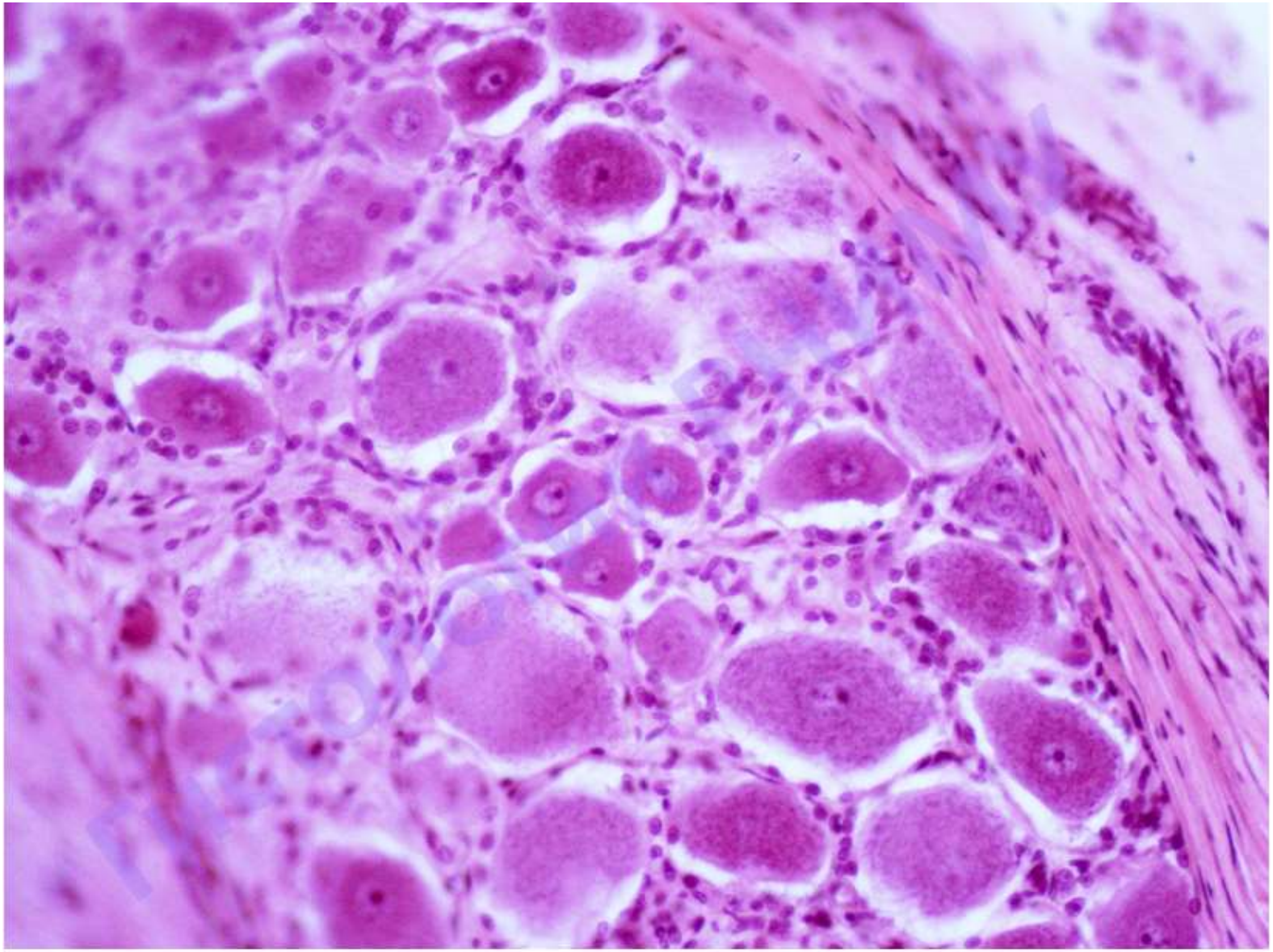


Slide №85 "Dorsal root ganglion»
Hematoxylin-eosin staining

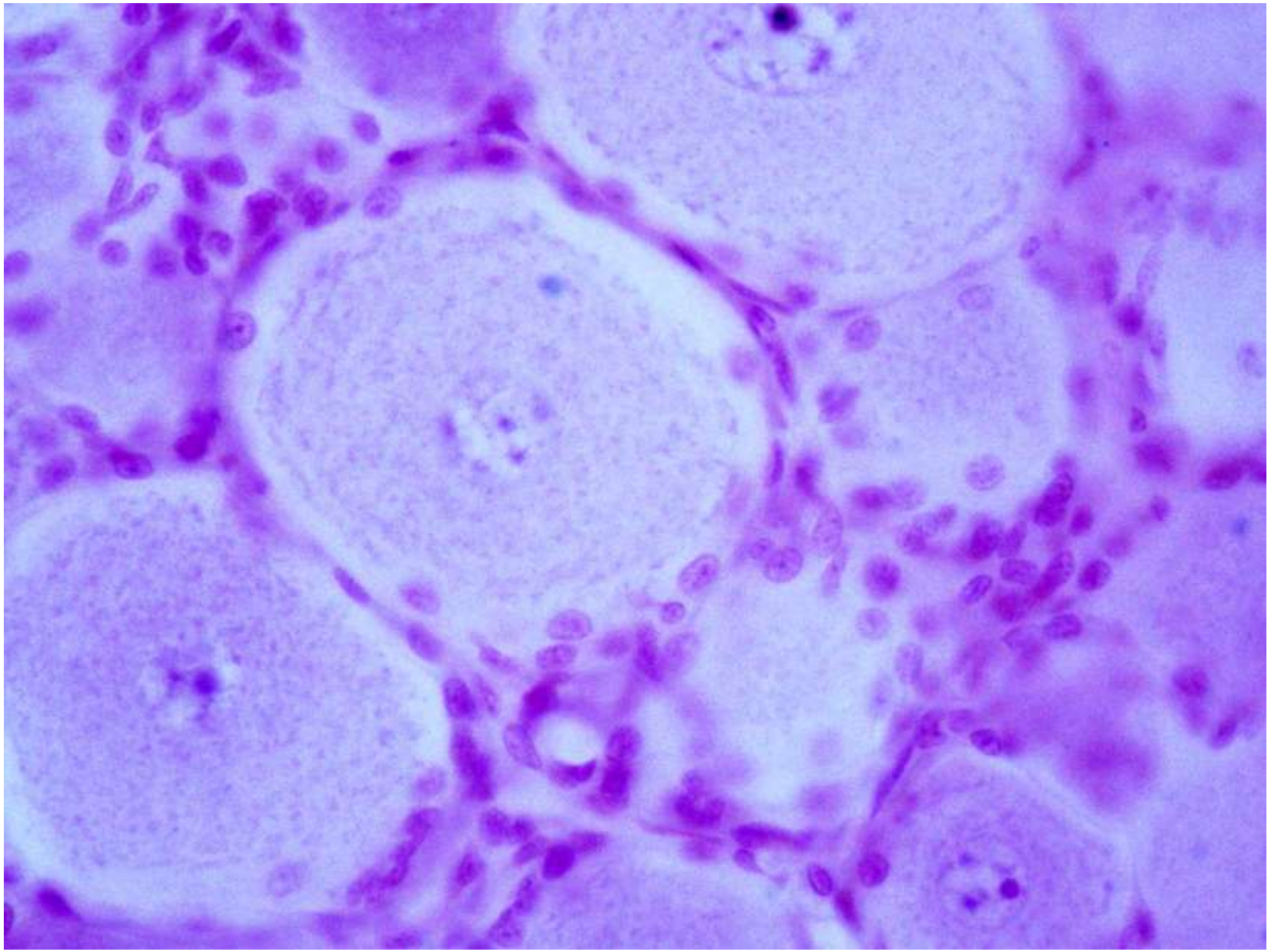


Slide №85 "Dorsal root ganglion»

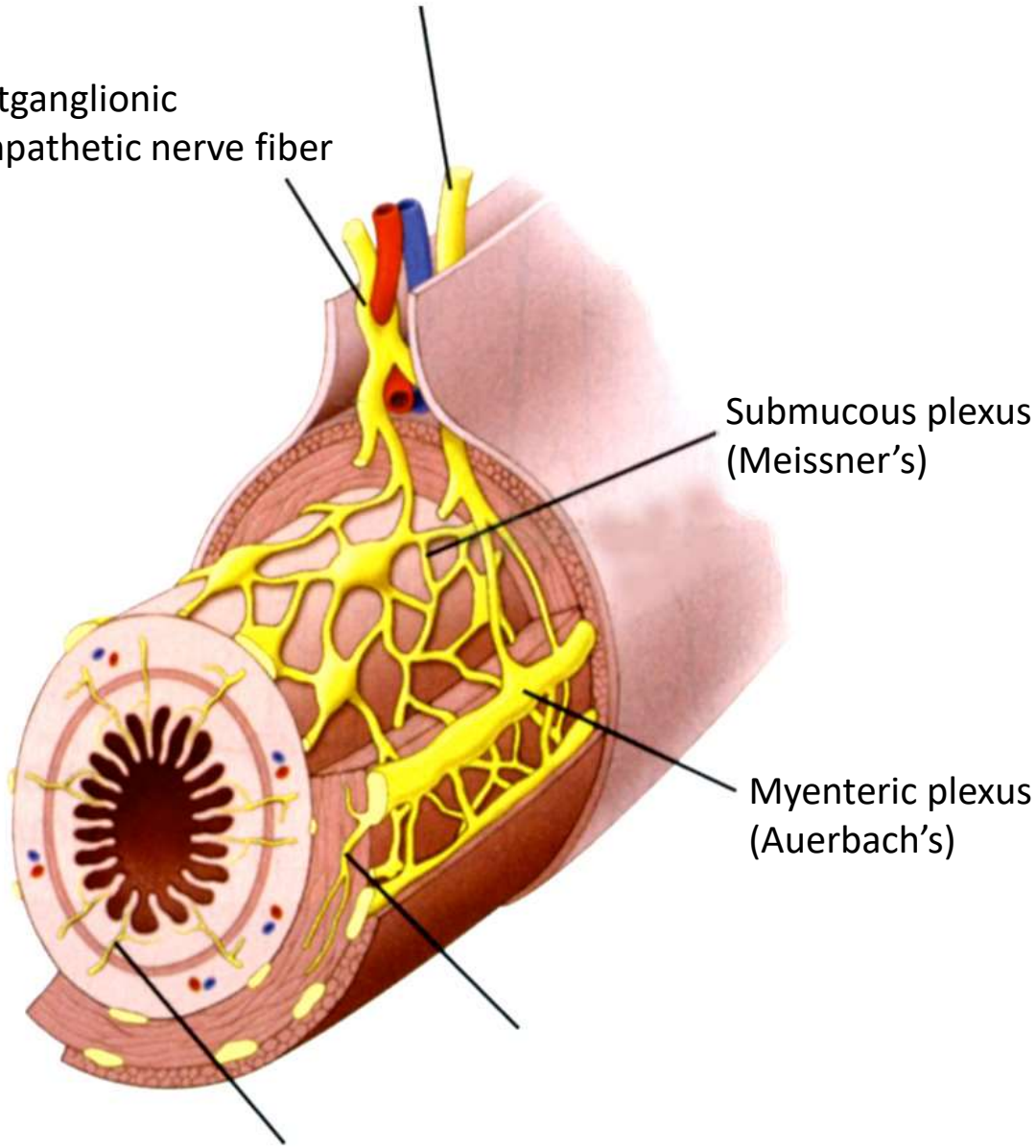
Hematoxylin-eosin staining

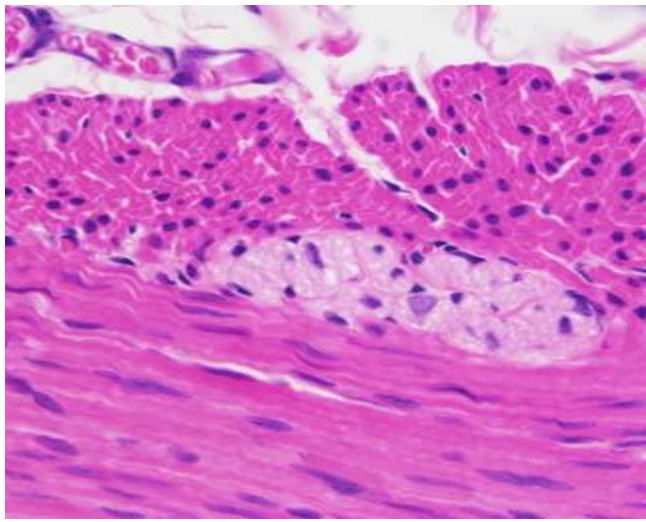


Slide №85 "Dorsal root ganglion»
Hematoxylin-eosin staining

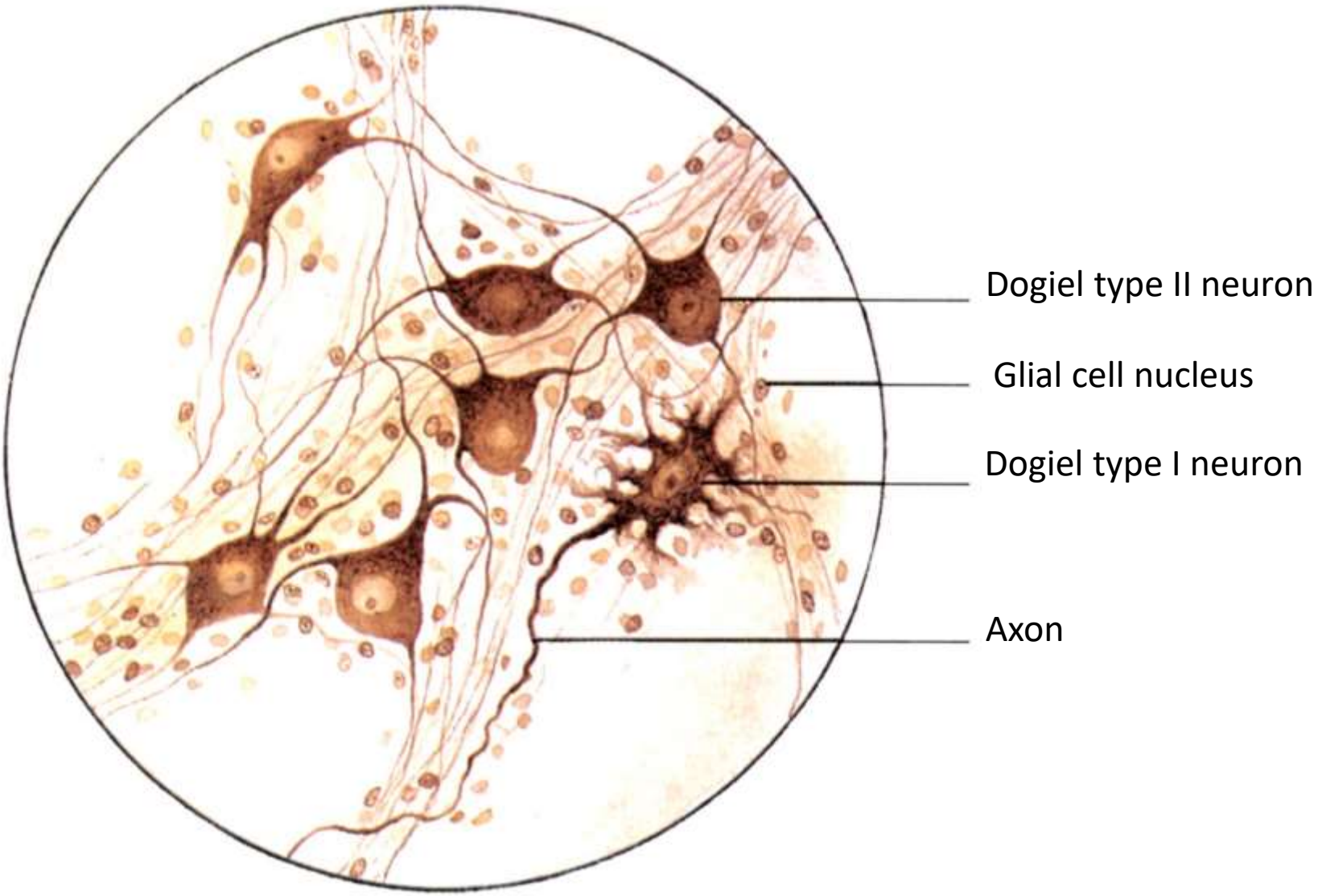


INTRAMURAL AUTONOMIC GANGLION

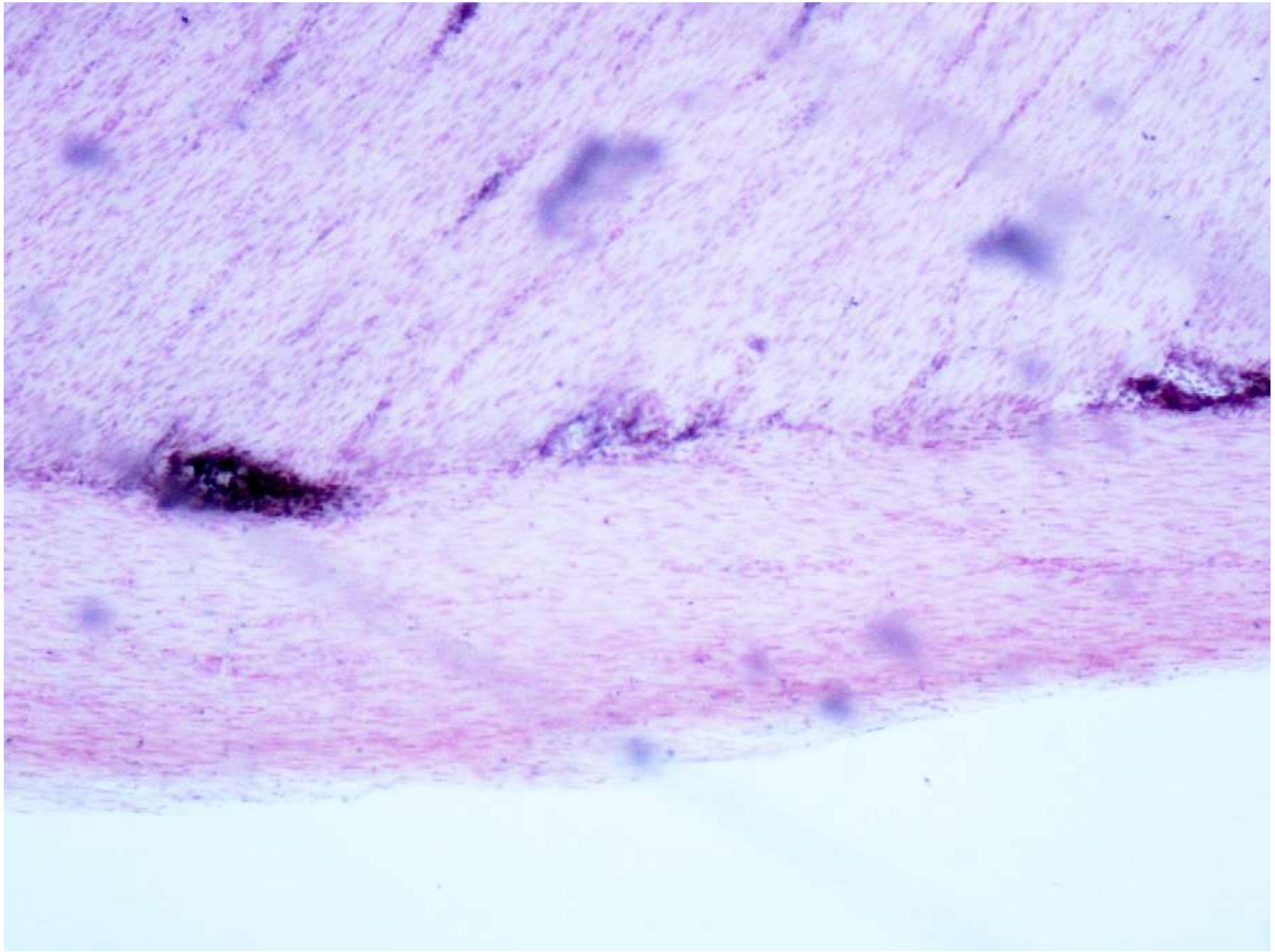




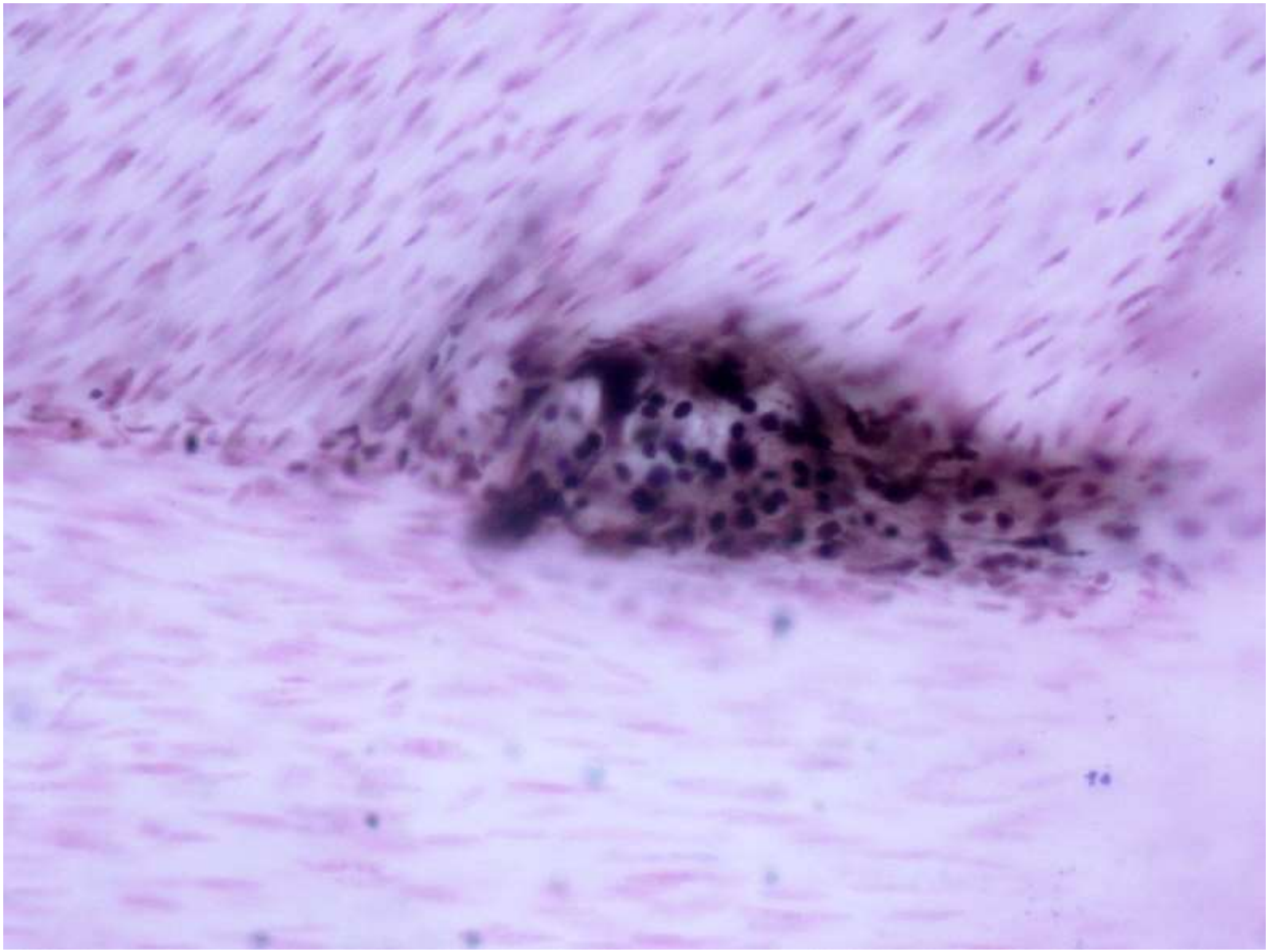
INTRAMURAL AUTONOMIC GANGLION



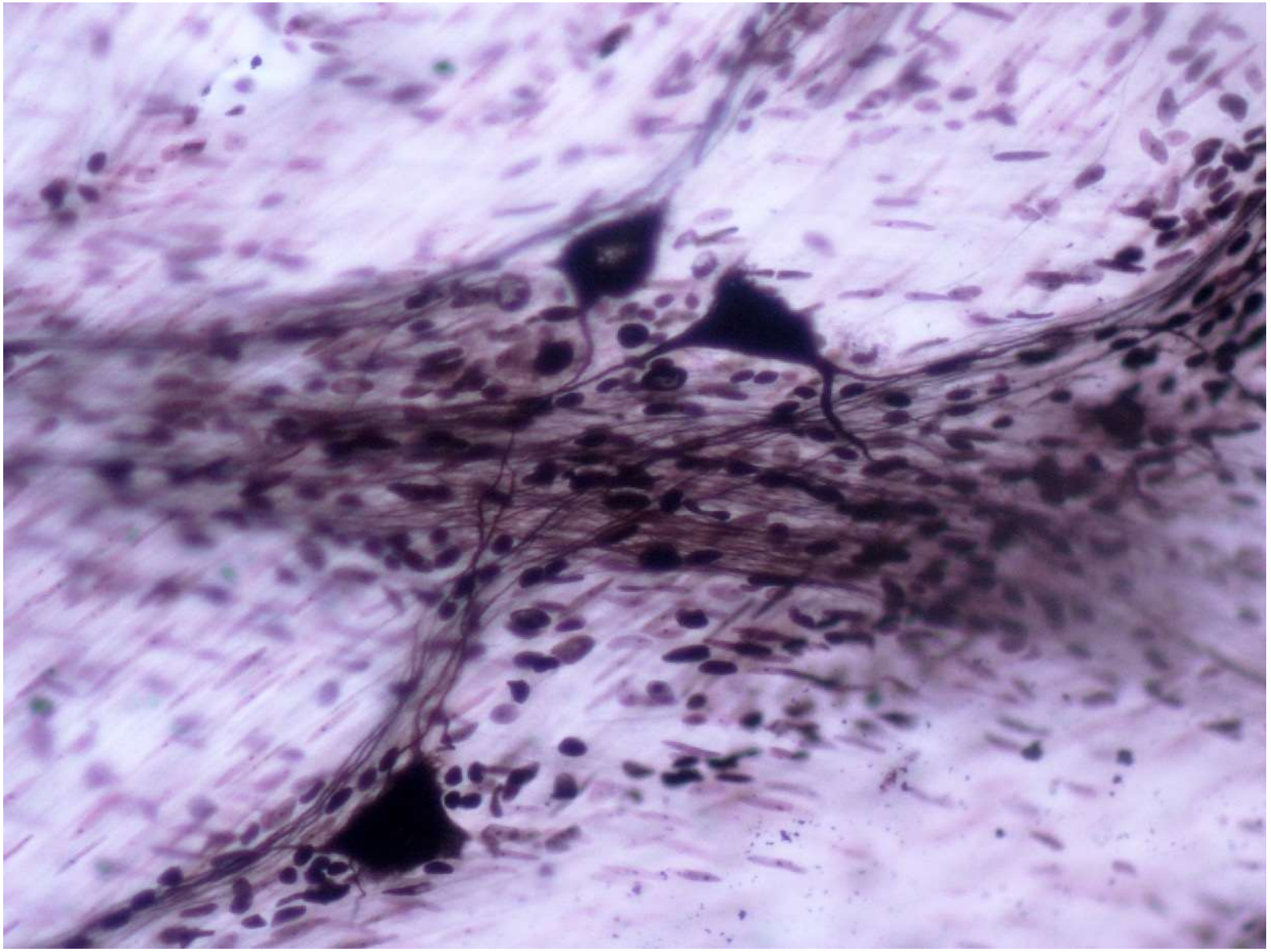
Slide №87a «Intramural autonomic parasympathetic ganglion. Muscular layer of the stomach»
Silver impregnation



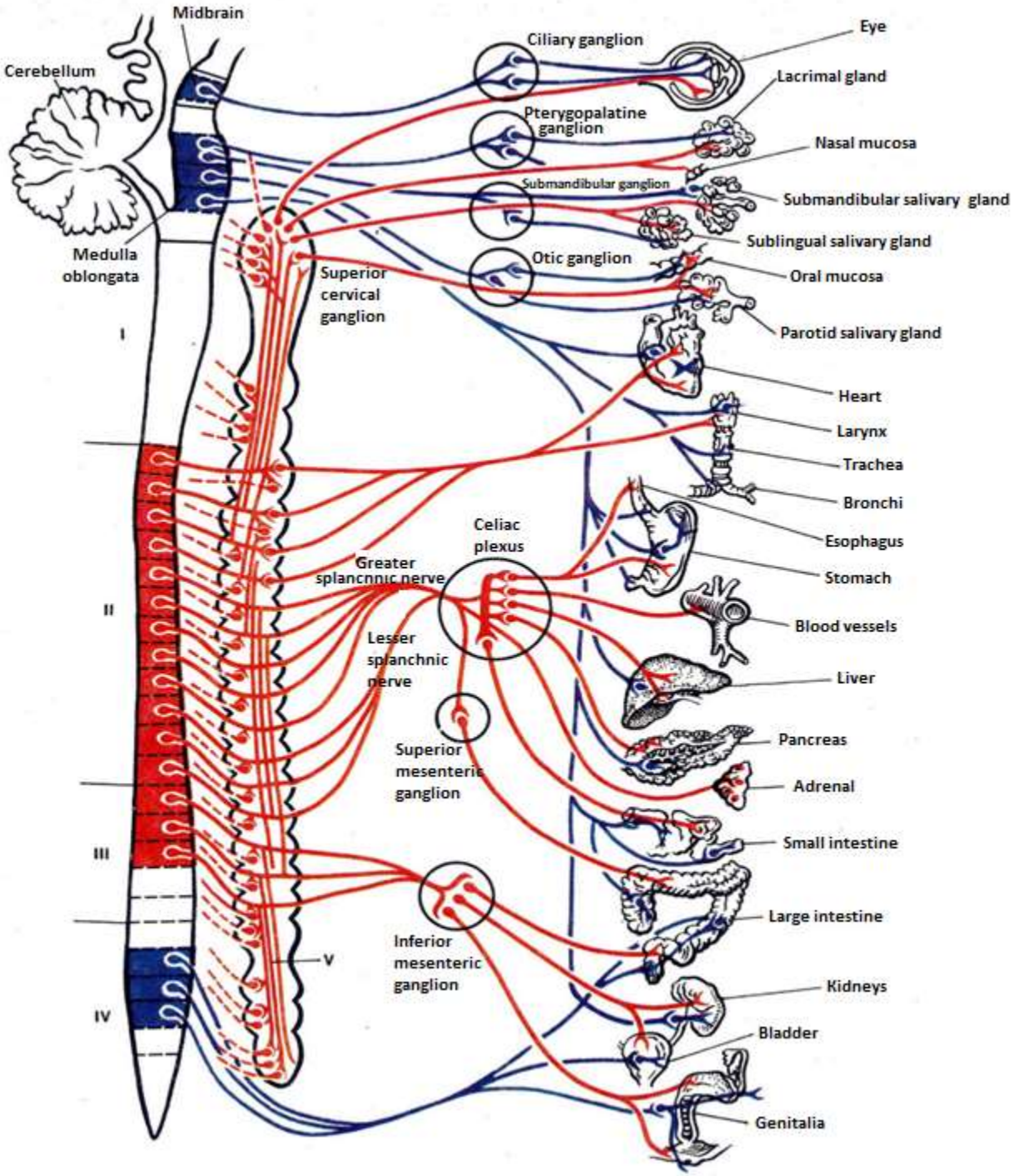
Slide №87a «Intramural autonomic parasympathetic ganglion. Muscular layer of the stomach»
Silver impregnation



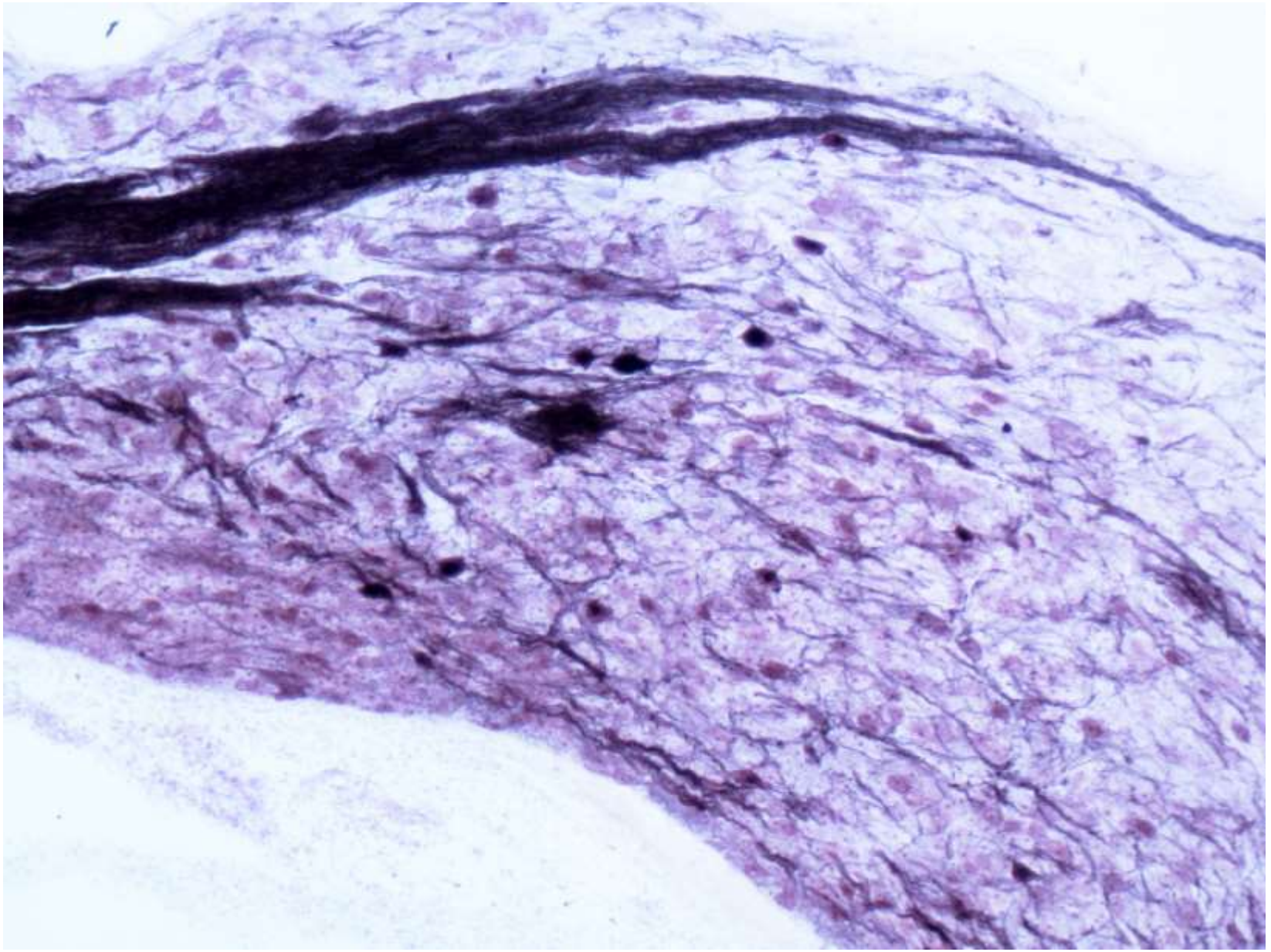
Slide №87a «Intramural autonomic parasympathetic ganglion. Muscular layer of the stomach»
Silver impregnation



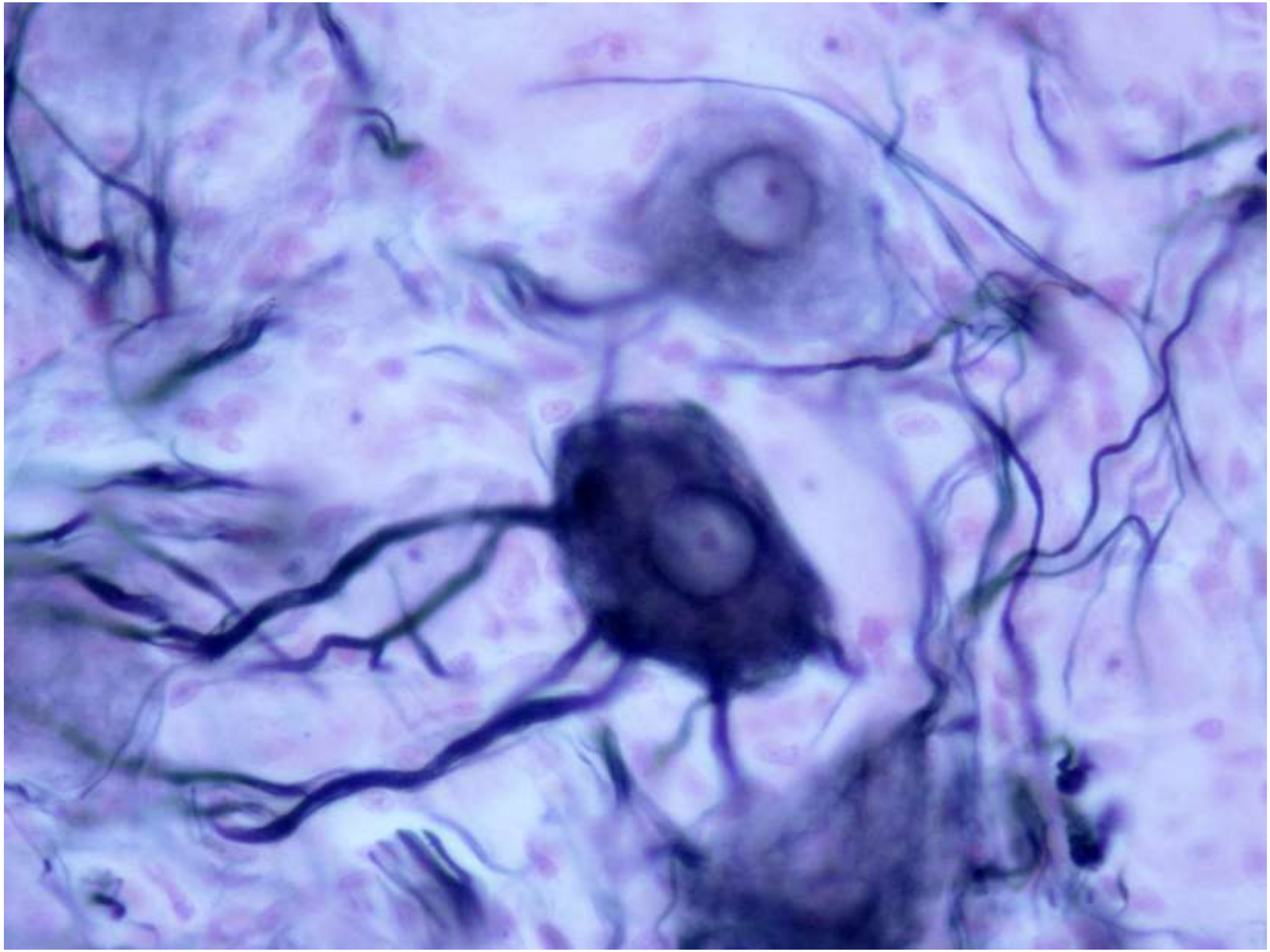
AUTONOMIC GANGLIA
(extraorgan position)



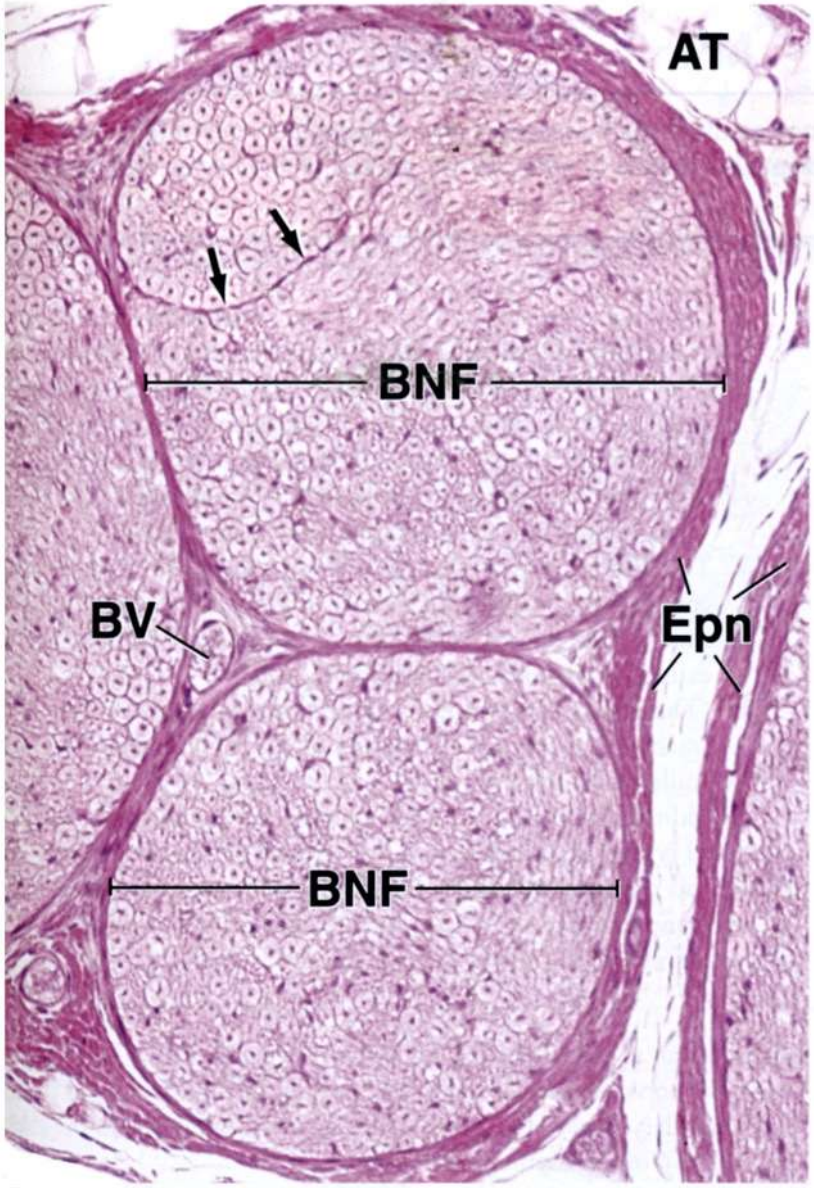
Slide №87 «Autonomic sympathetic ganglion, coeliac plexus» *Silver impregnation*

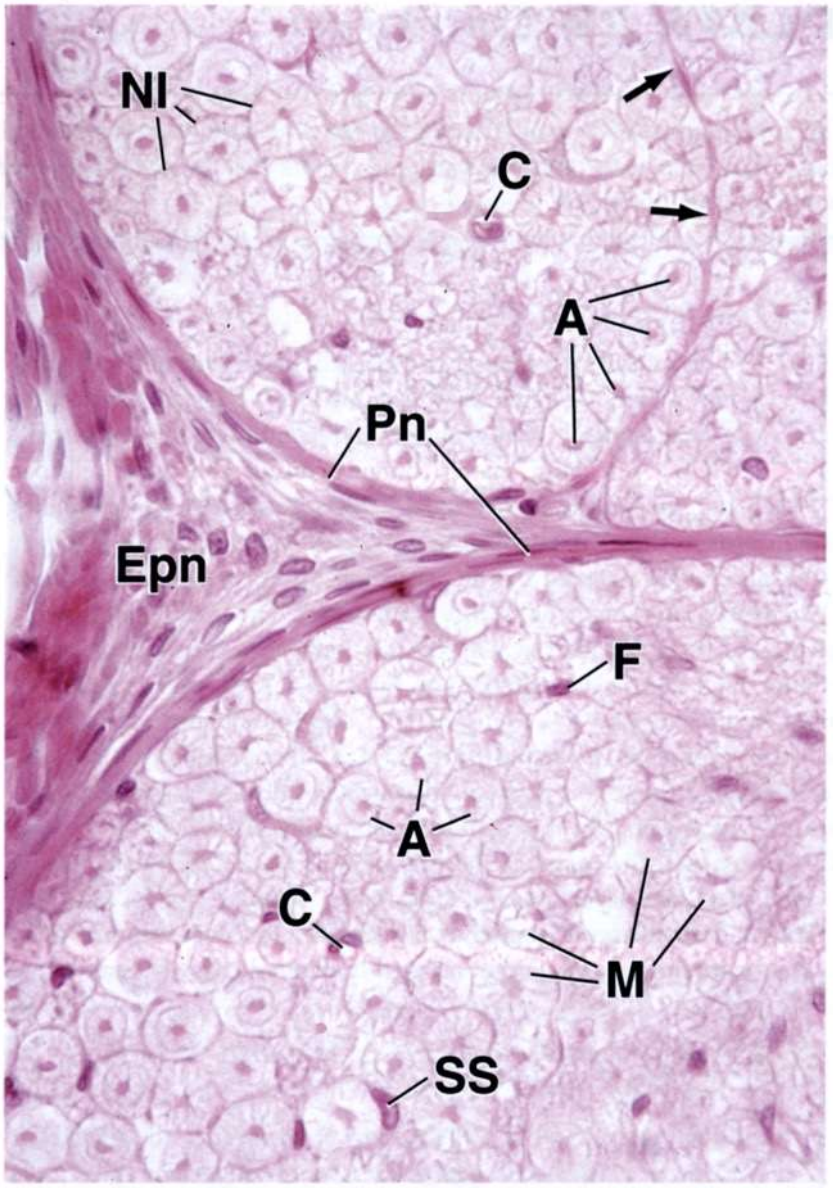


Slide №87 «Autonomic sympathetic ganglion, coeliac plexus» *Silver impregnation*

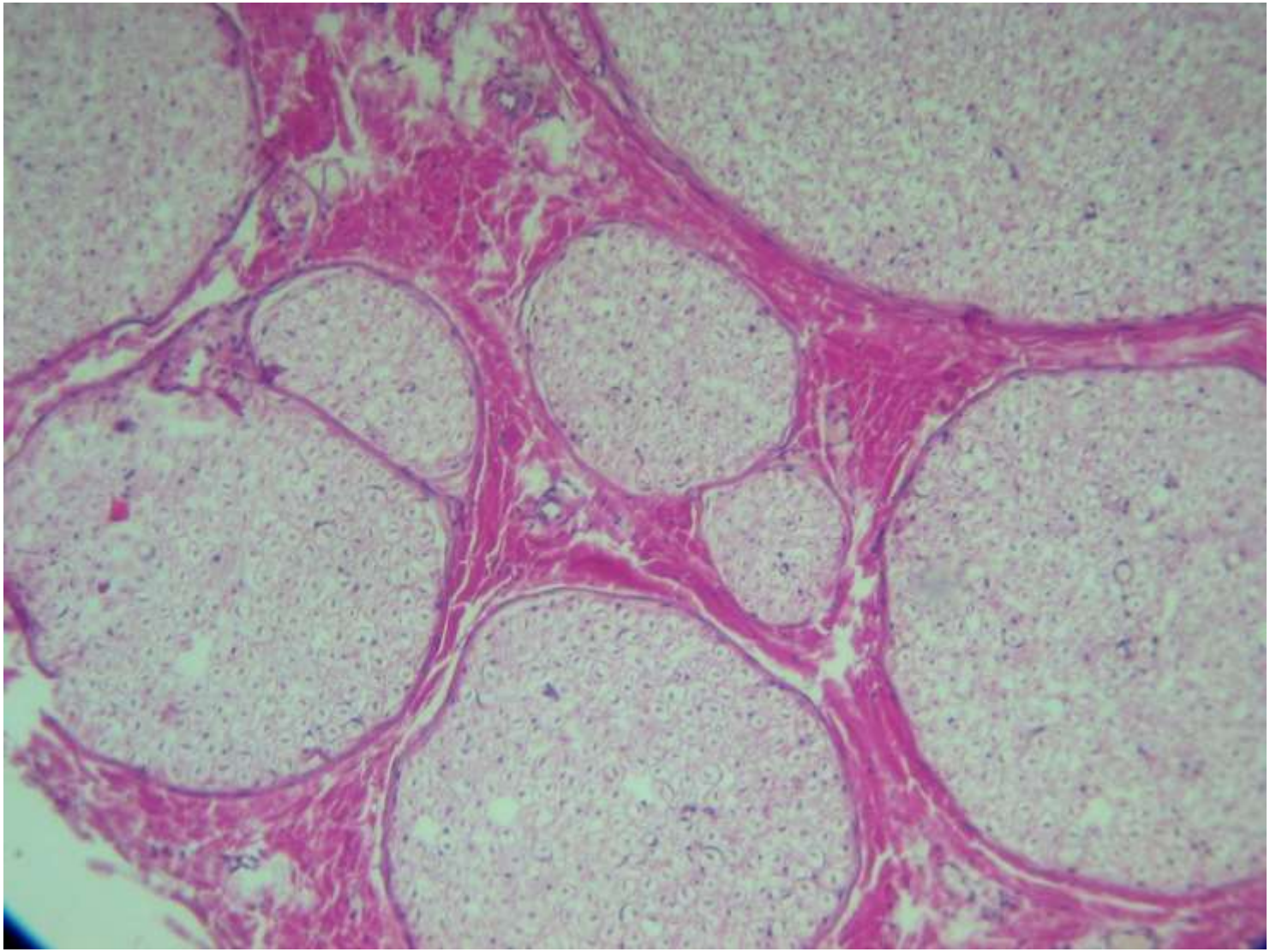


PERIPHERAL NERVE
(cross section)

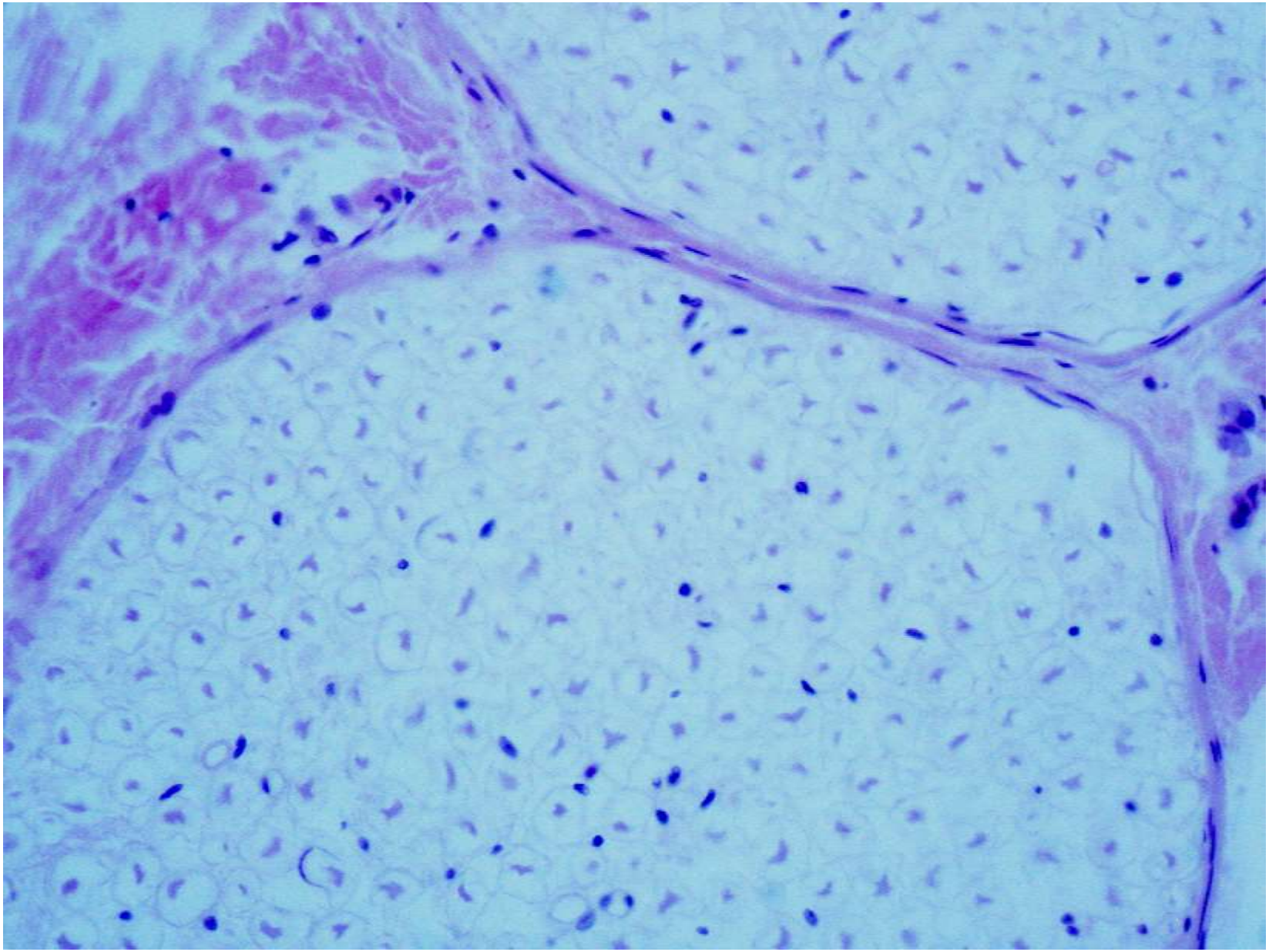




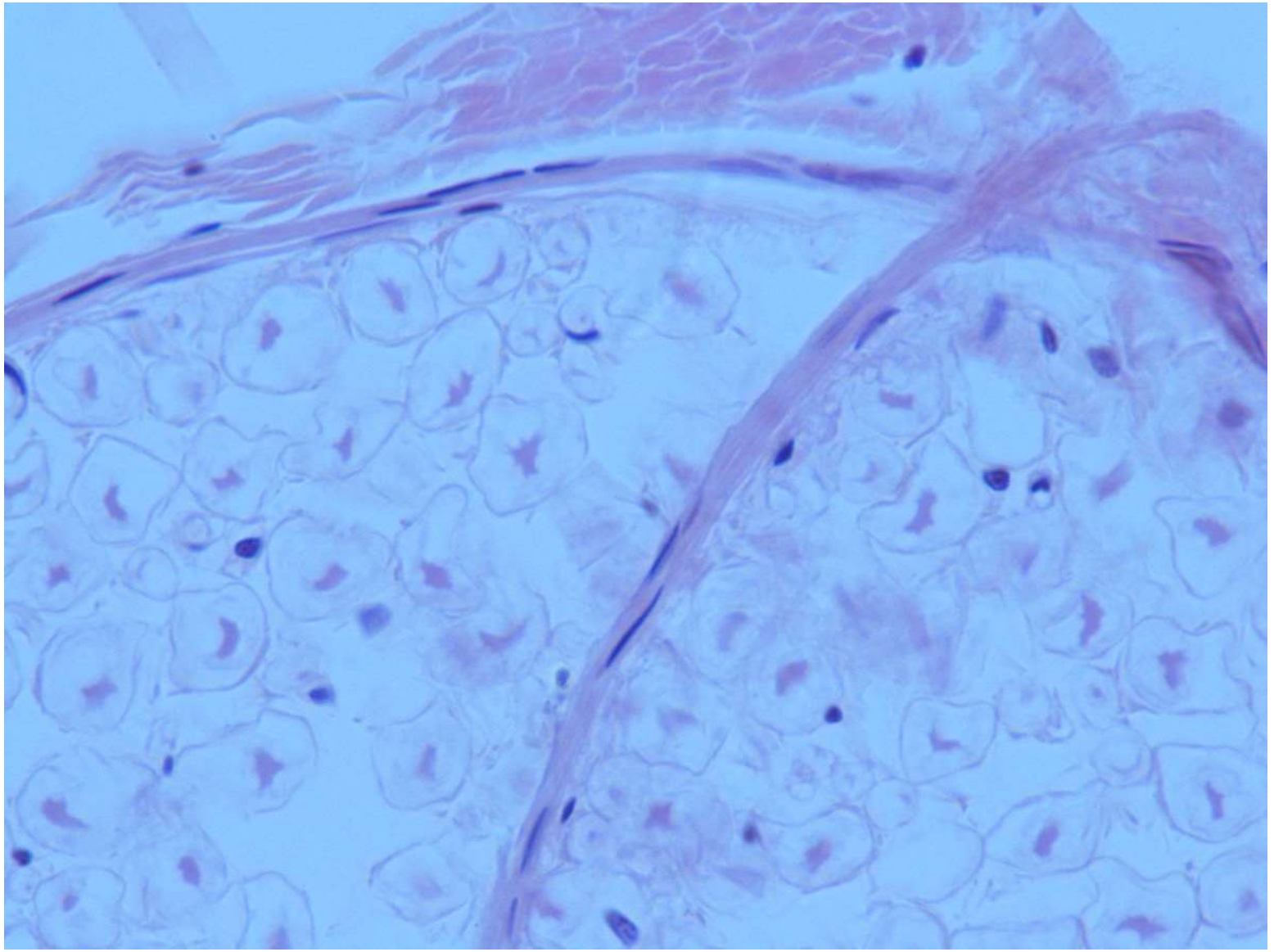
Slide №89. Periferal nerves, cross-section, H&E



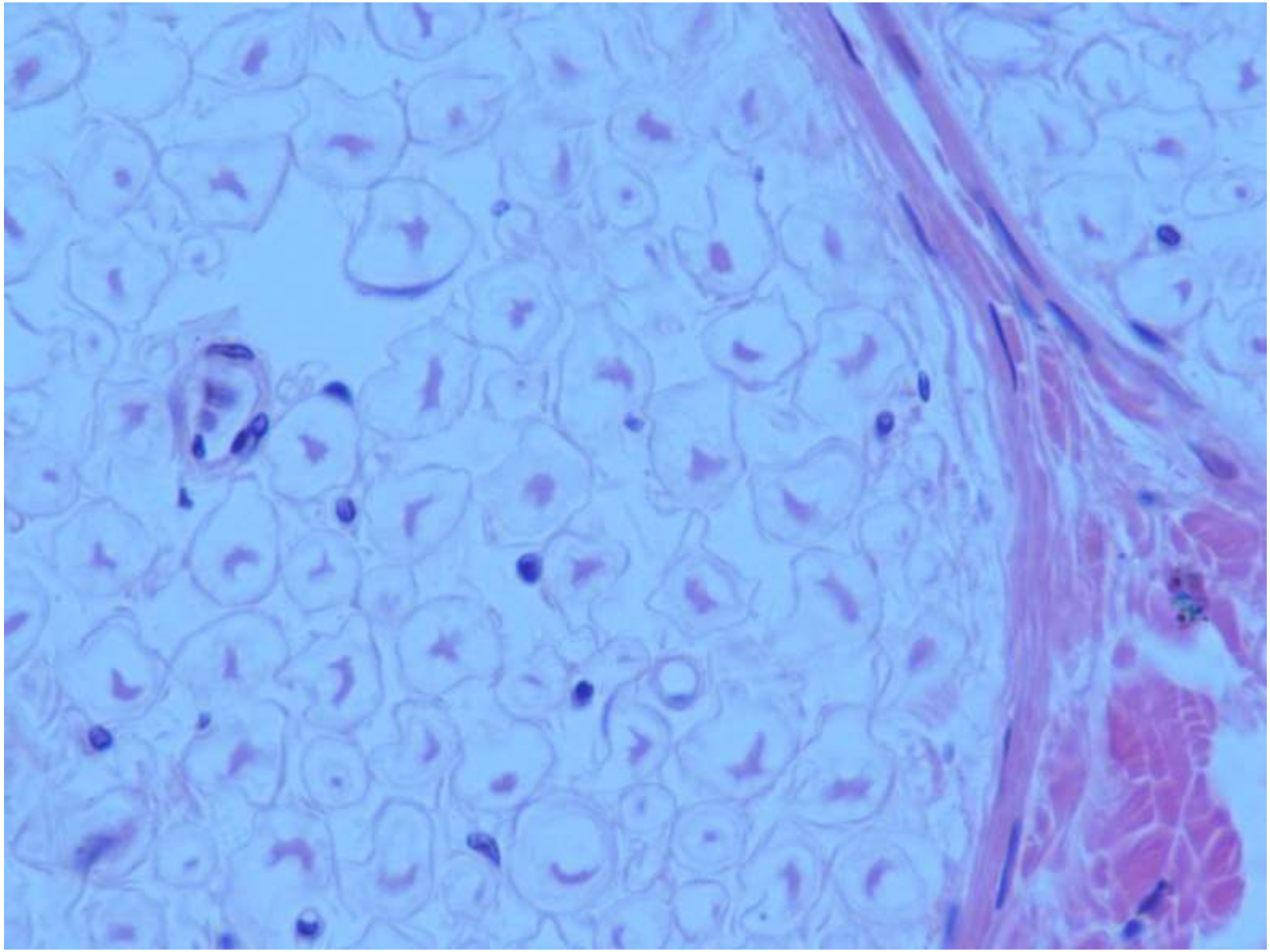
Slide №89 «Periferal nerve, cross-section»
Hematoxylin-eosin staining



Slide №89 «Periferal nerve, cross-section»
Hematoxylin-eosin staining



Slide №89 «Periferal nerve, cross-section»
Hematoxylin-eosin staining



MENINGITES an acute inflammation of the meninges, most commonly of the pia mater and arachnoid mater

ENCEPHALITIS an acute infection and inflammation of the brain itself

- *Polioencephalitis* affects the gray matter
- *Leukoencephalitis* affects the white matter

MYELITIS an acute inflammation of the spinal cord

POLIOMYELITIS a disease of the anterior horn motor neurons of the spinal cord and brain stem nuclei, caused by the poliovirus. Mainly affects children under 5 years old, is preventable with the polio vaccine.

RADICULITIS a condition caused by inflammation or compression of a spinal nerve at its root