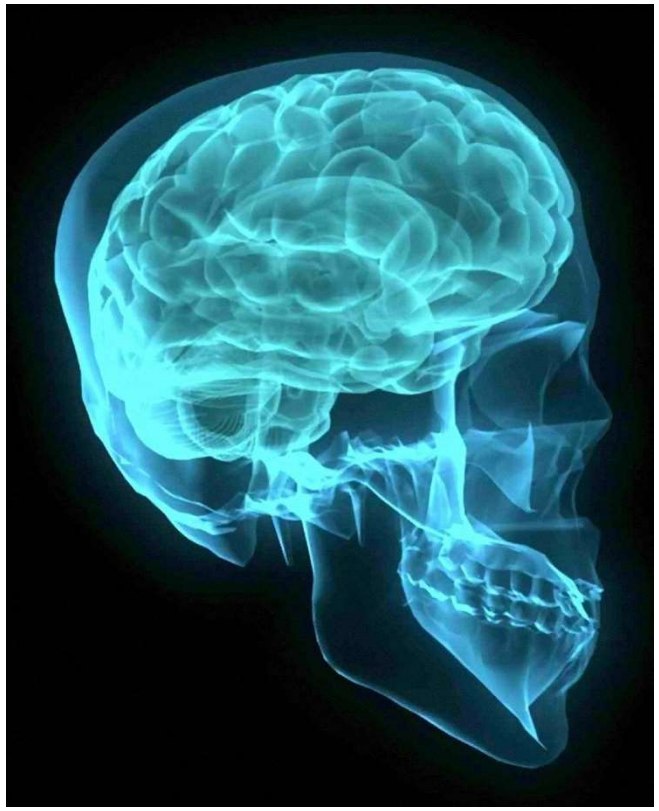
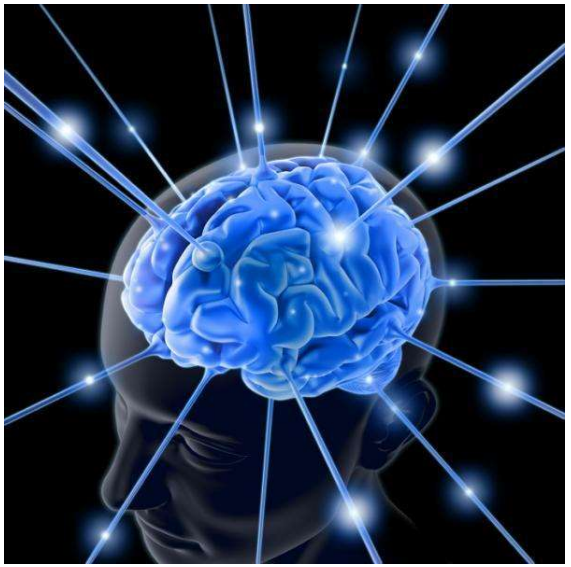


THE NERVOUS SYSTEM
(SYSTEMA NERVOSUM)

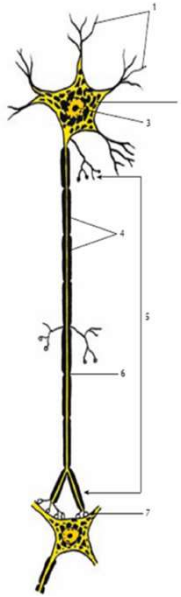
THE FUNCTIONS OF THE NERVOUS SYSTEM

control function

- The neural control of organ activity
- The basical property is the excitability and the generating of electric nerve impulses



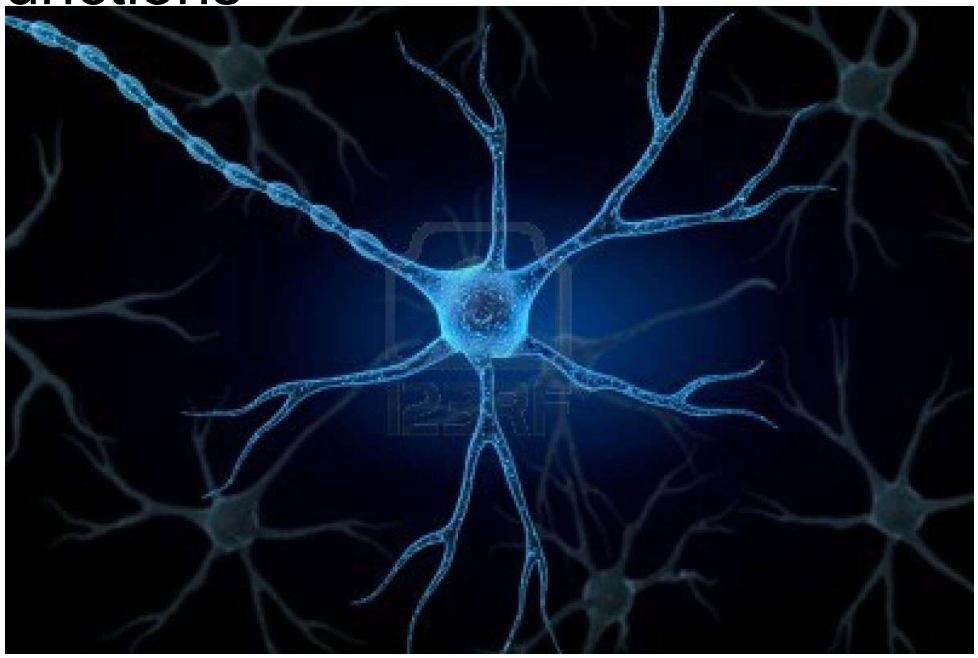
The nerve cell (neuron)

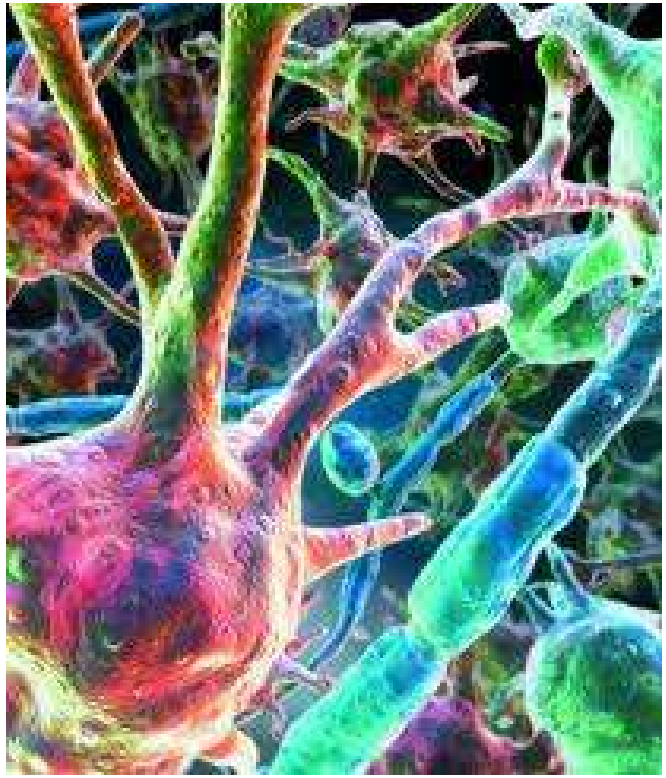


- the basic component of the nervous system
- highly specialized (excitability, conductivity)

Glial cell (neuroglia)

- supporting, nutritive, defensive and other functions

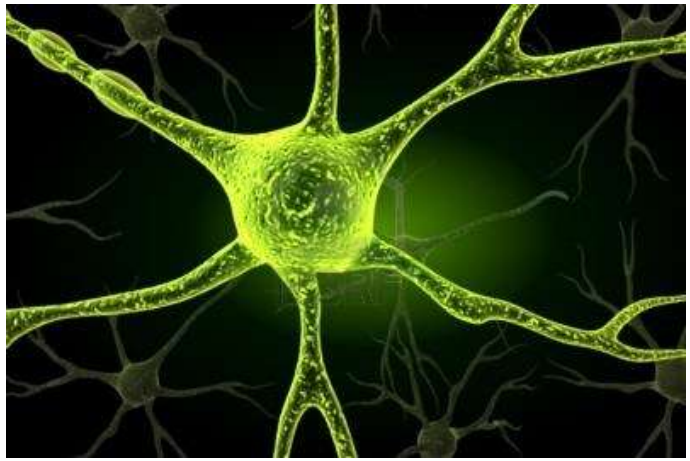




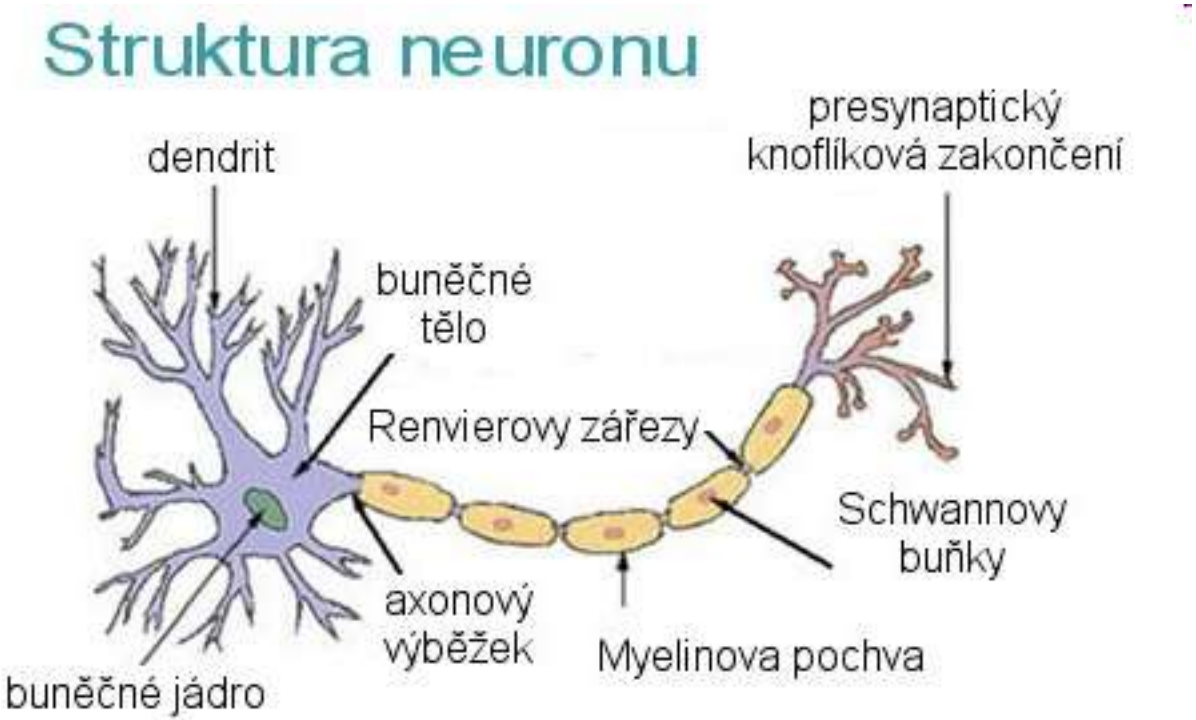
Neuron

1. **the body (perikaryon)**
2. **the projections**

- **dendrites:** receiving of stimuli

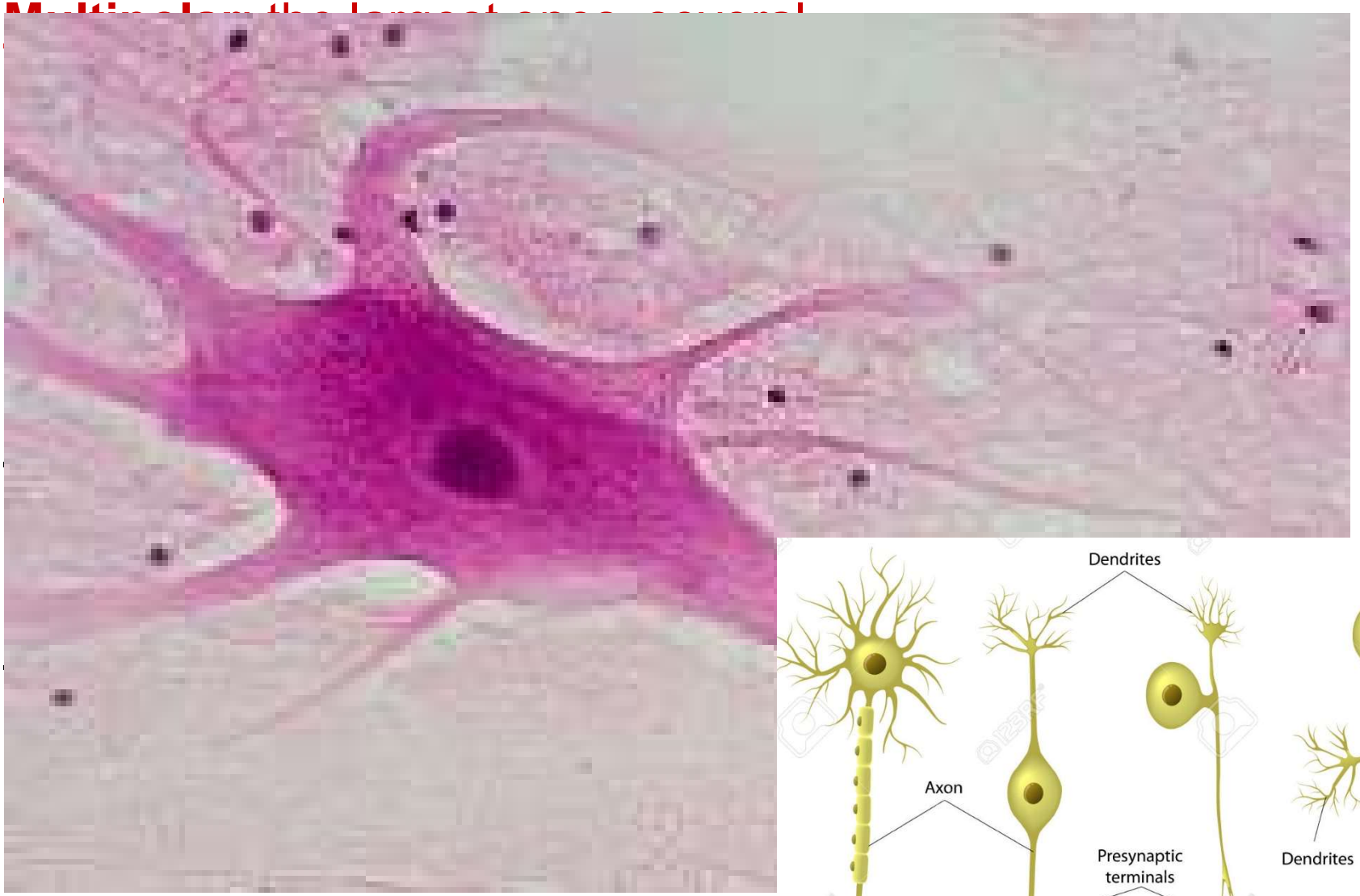


- **Axon (nerve fibre):** conducts electrical impulses away from the neuron's cell body



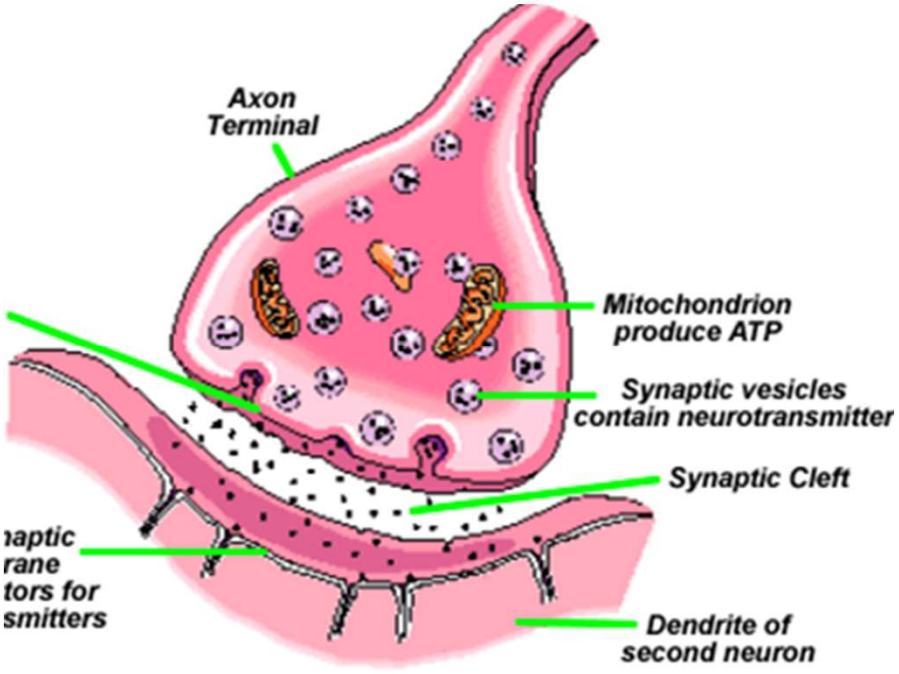
The types of the neurons

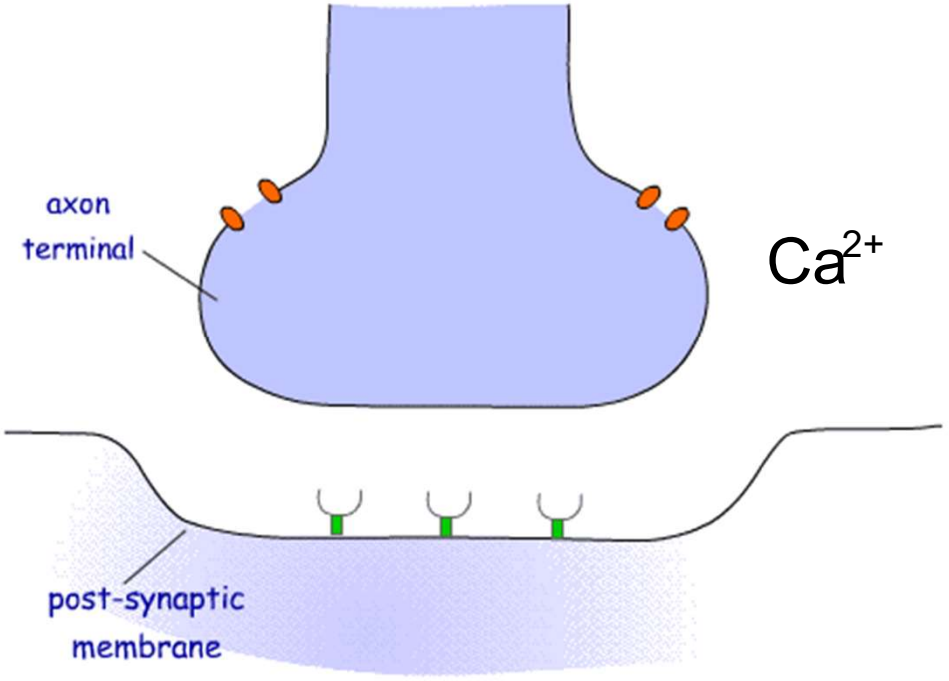
- Multipolar the largest ones, several
-
-
-

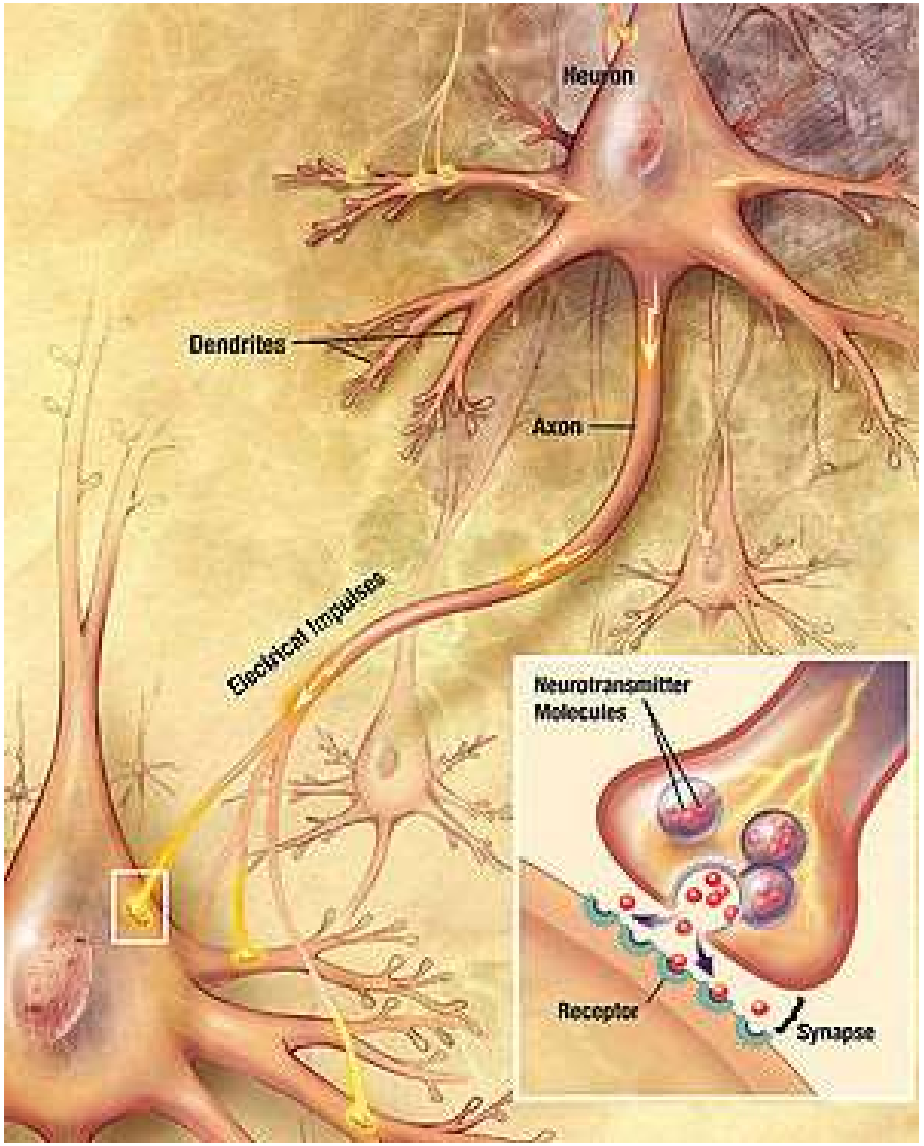


The synapse (a part of axon)

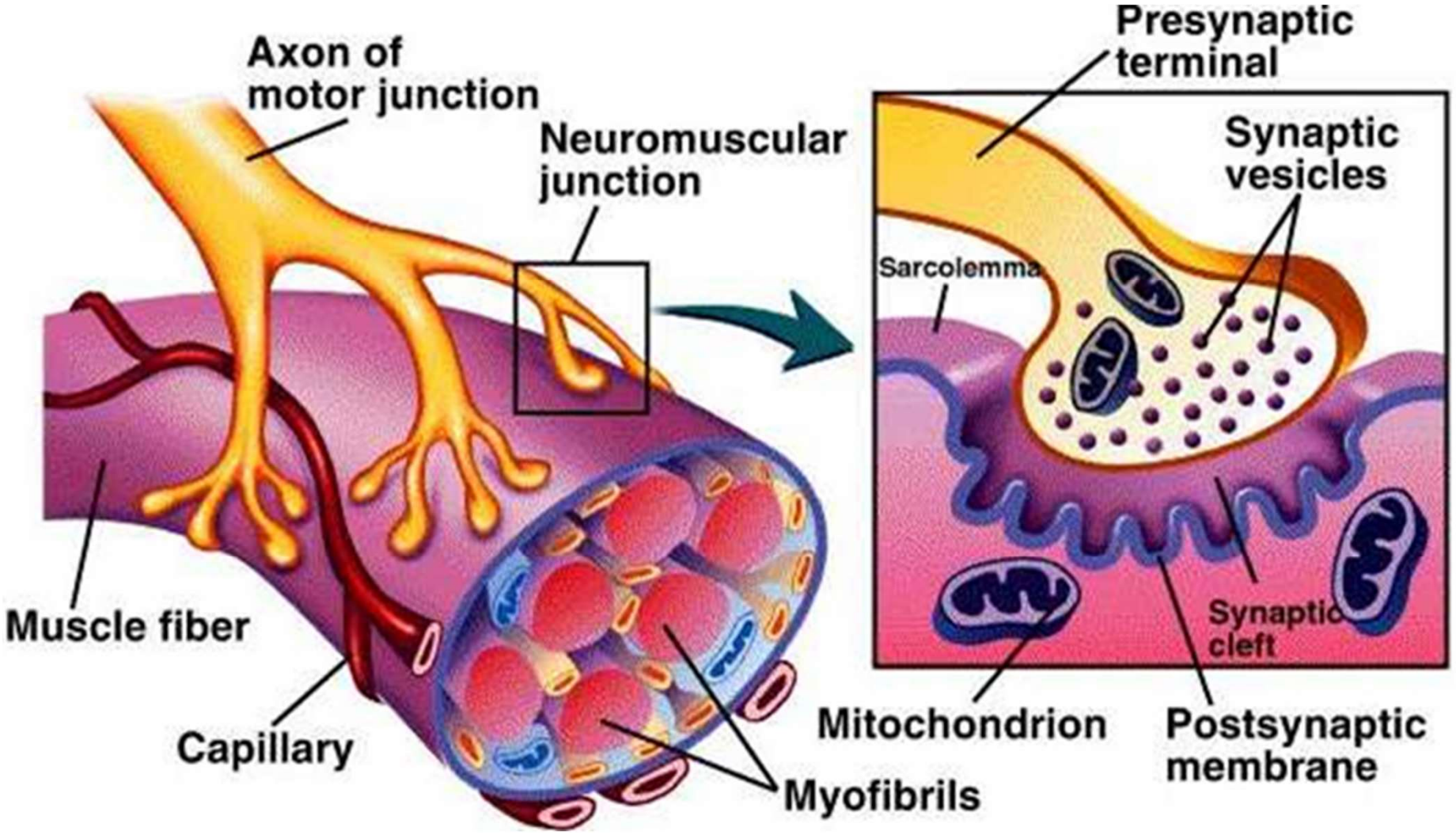
- Ended by enlargement– **terminal button** – is in contact with other neuron – the connection **synapse** (muscle – **neuromuscular junction**)
- presynaptic membrane, postsynaptic membrane
- Transfer of impulse– spread through axon centrifugally as electric signal – **action potential**
- **terminal button –** vesicles with **neurotransmitters**






Neuron
Dendrites
Axon
Electrical Impulses
Neurotransmitter Molecules
Receptor
Synapse

The neuromuscular junction



Neuroglia

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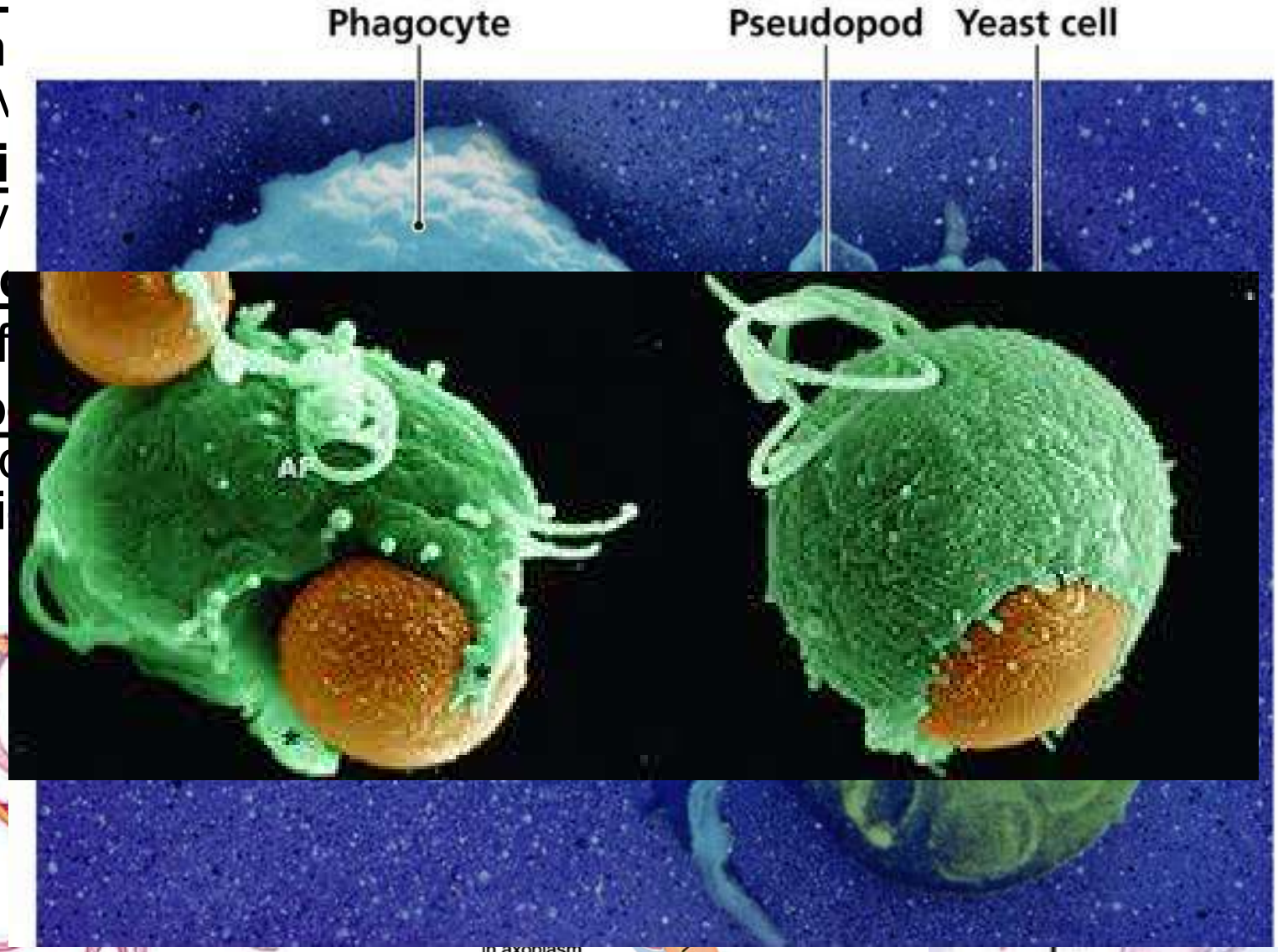
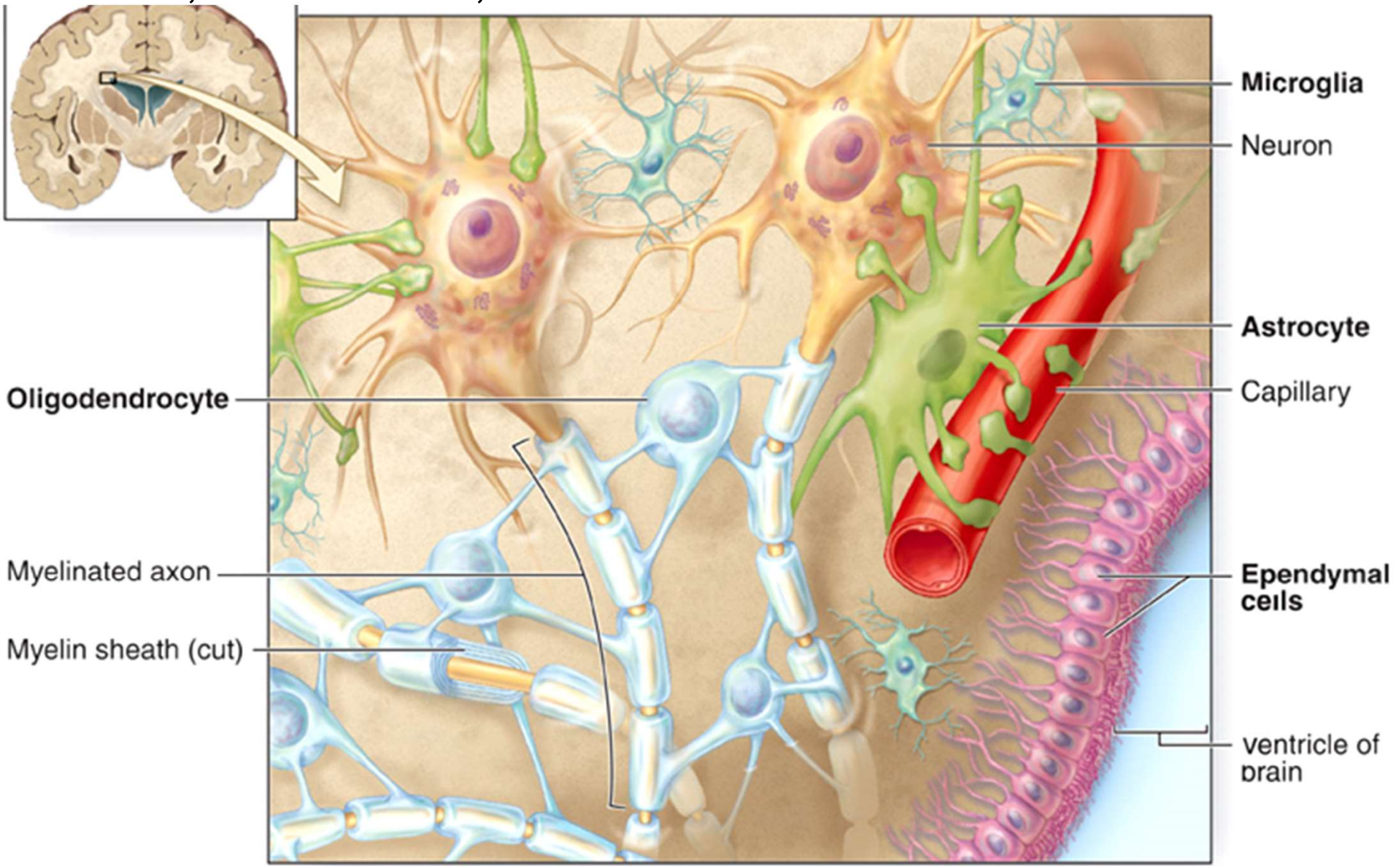
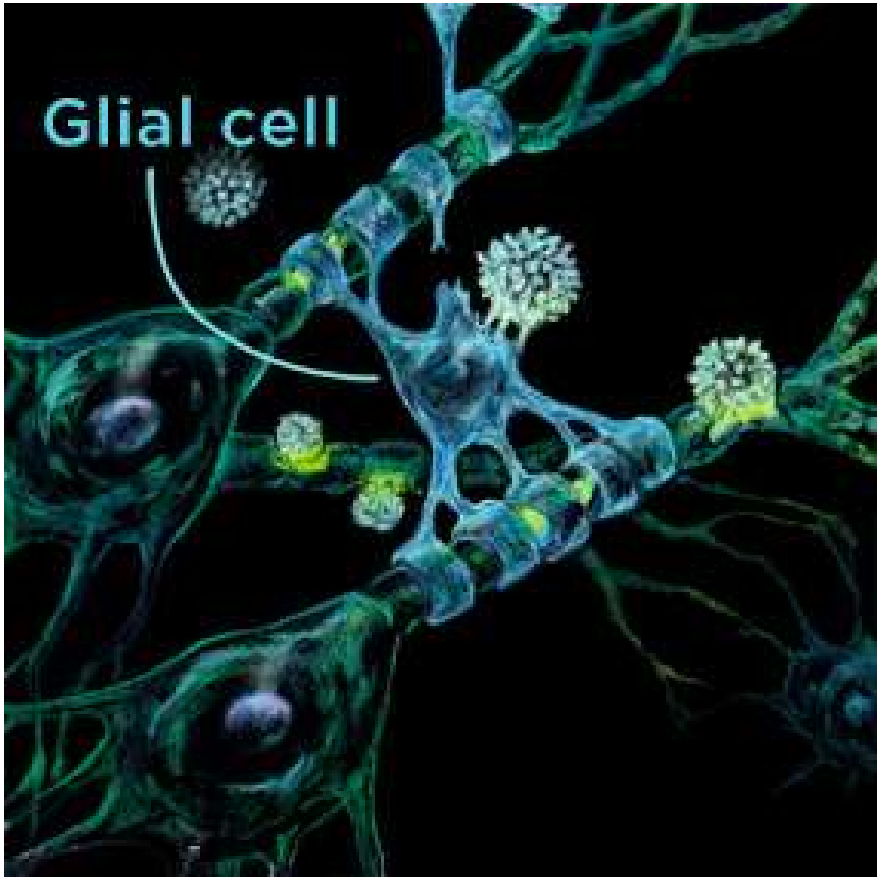


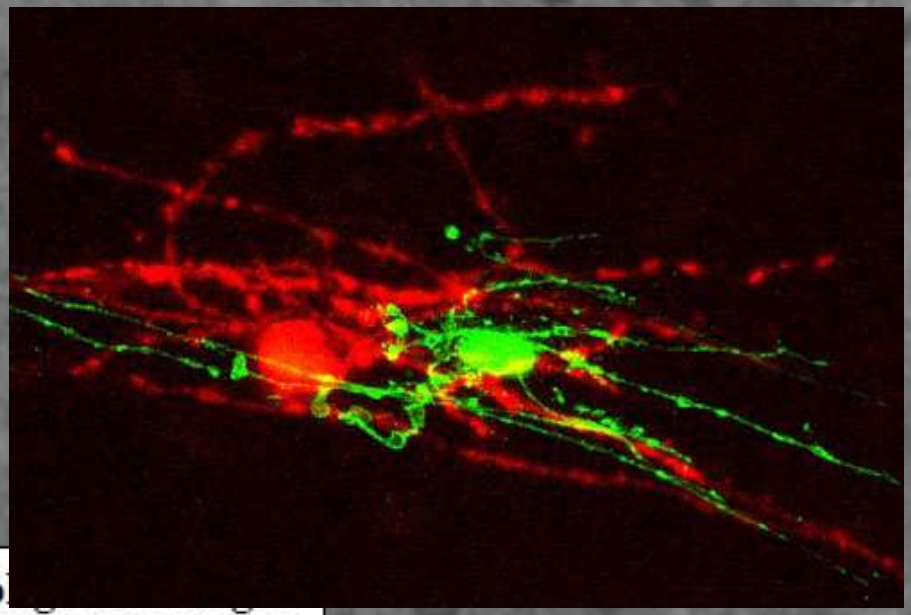
Neuroglia

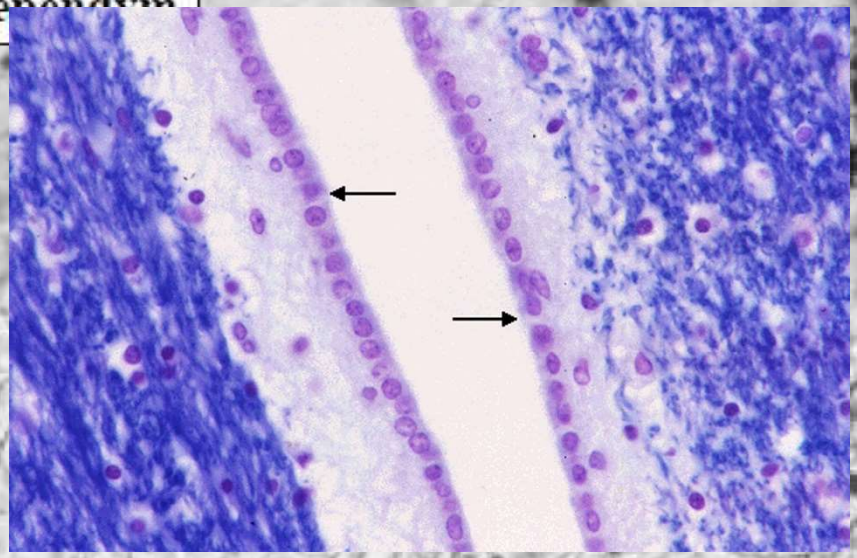
Function: they accelerate the conduction of the excitement, nutrition, homeostasis, defence function

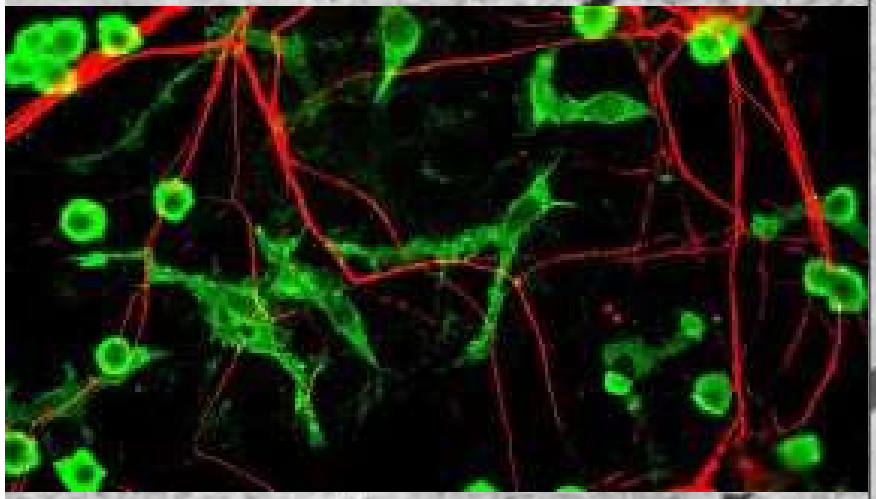


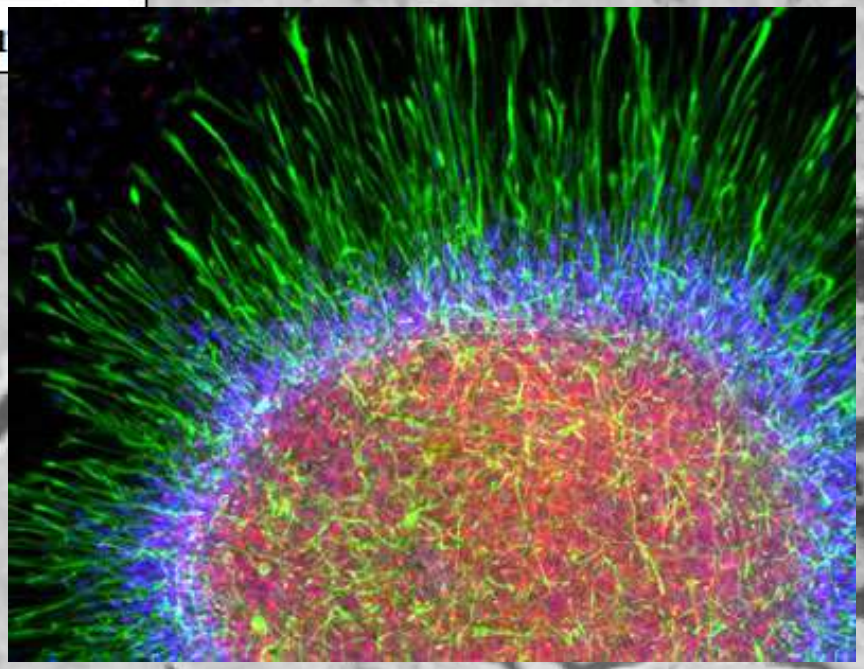

Glial cell

NEUROGLIE



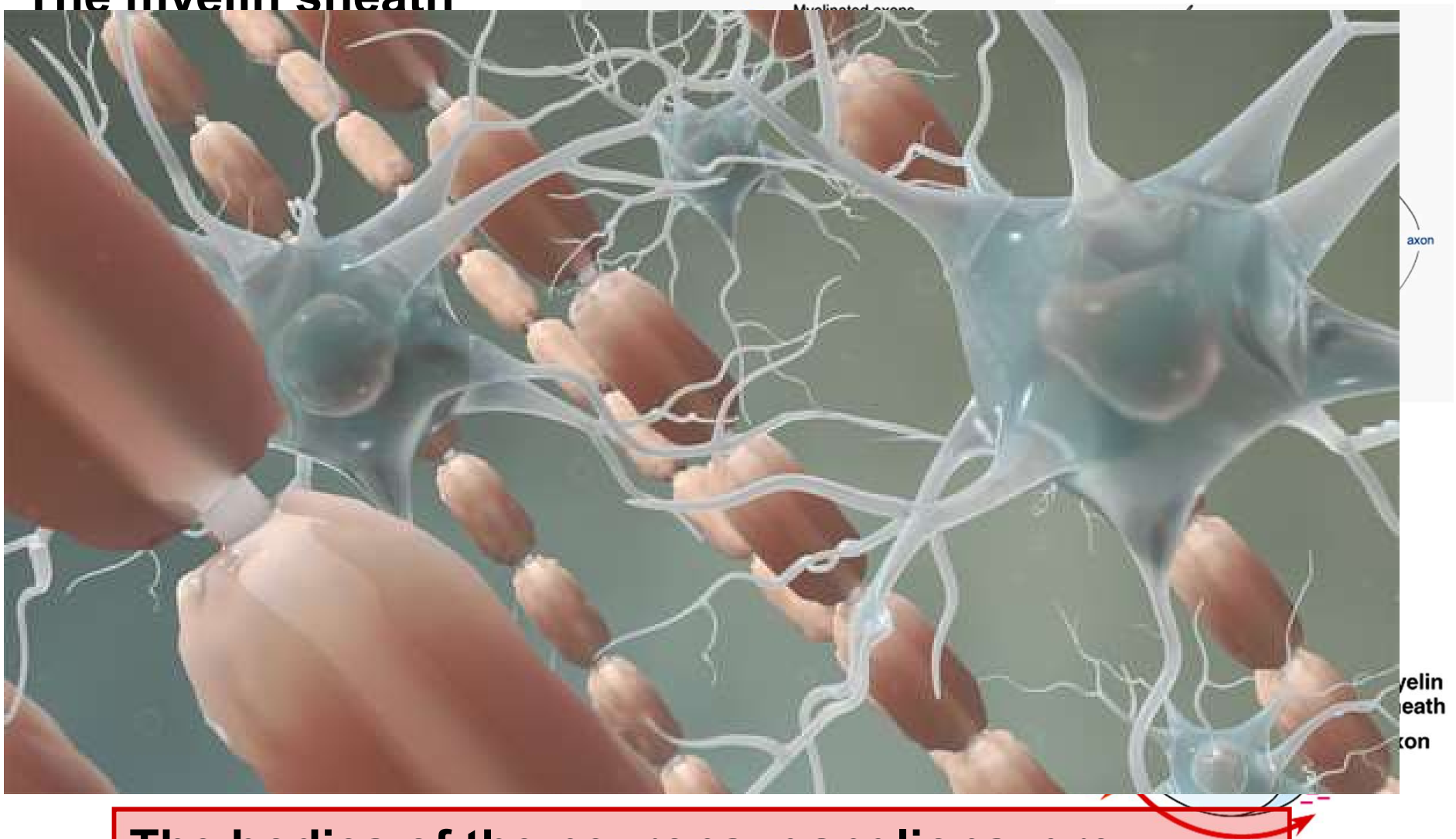






mikroglie

The myelin sheath



The bodies of the neurons: ganglions, grey matter of CNS
The projections of the neurons: white matter of CNS, nerves of PNS

THE DIVISION OF THE NERVOUS SYSTEM

1. central nervous system *(systema nervosum centrale)*

Spinal cord *(medulla spinalis)*

brain *(encephalon, cerebrum)*

- The hind-brain *(rhombencephalon)*
- The Medulla oblongata*(medulla oblongata*
- The pons *(pons Varoli)*
- The cerebellum *(cerebellum)*
- The midbrain *(mesencephalon)*
- The fore-brain *(prosencephalon)*
- The diencephalon *(diencephalon)*
- The cerebrum *(telencephalon)*

2. peripheral nervous system *(systema nervosum periphericum)*

It connects CNS with the periphery of organism (centripetally, centrifugally)

- Spinal nerves *(nervi spinales)*
- Cranial nerves *(nervi craniales)*

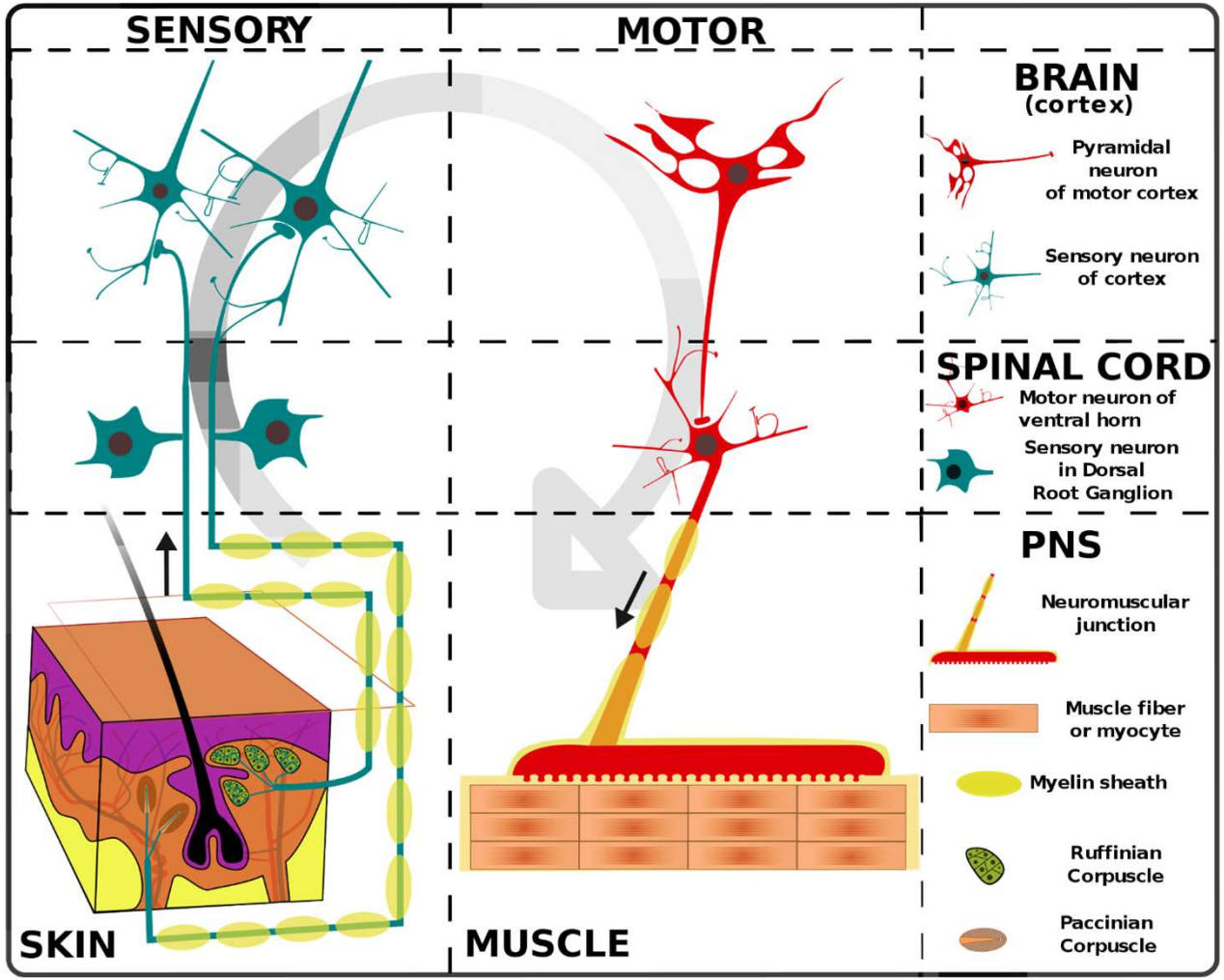
} **Cerebrospinal nerves**

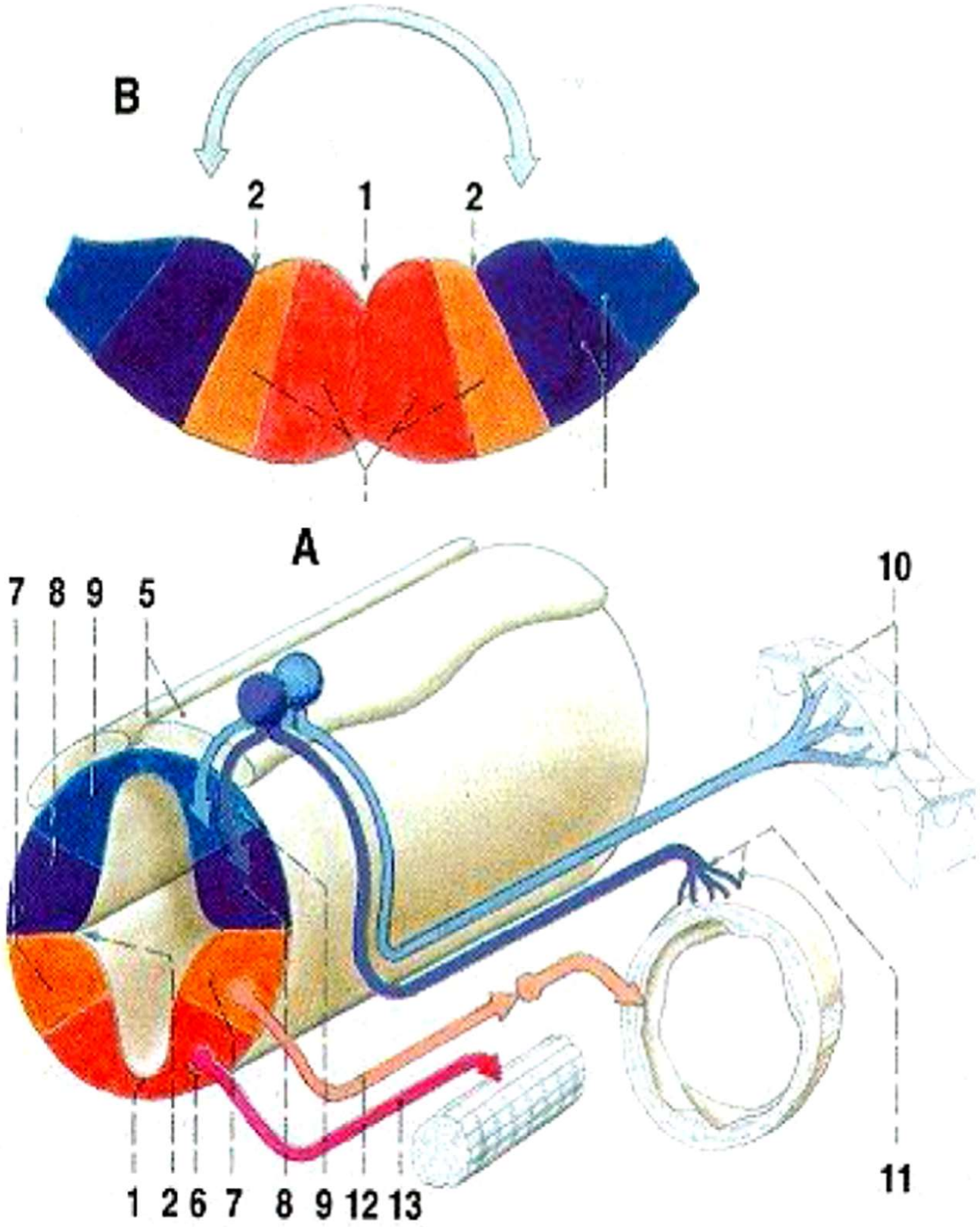
- sympathicus *(pars sympathica)*
- parasymphaticus *(pars parasympathica)*

} **Autonomic nerves**

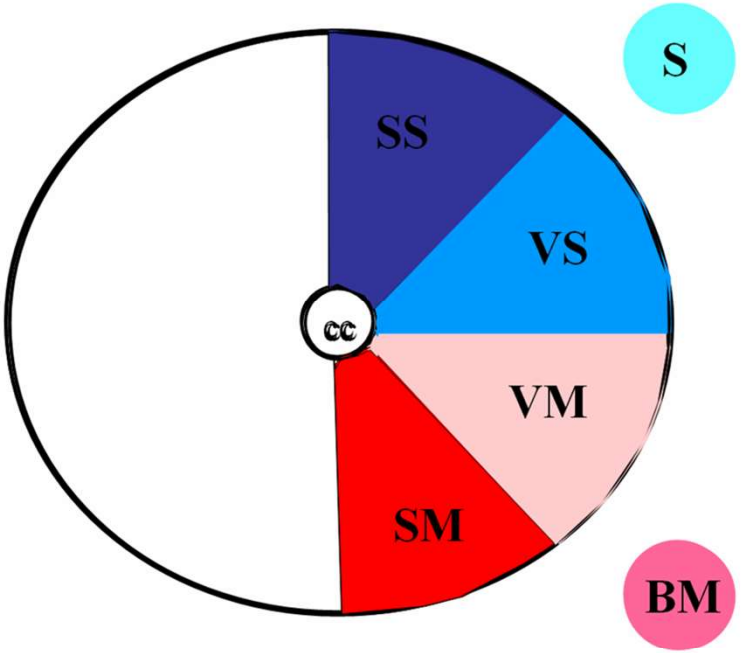
The nervous system

1) It mediates relations between external environment and organism
2) It provides body´s response to stimuli from outside
3) It mediates relations between all parts of organism
4) It provides integrality of all actions within organism

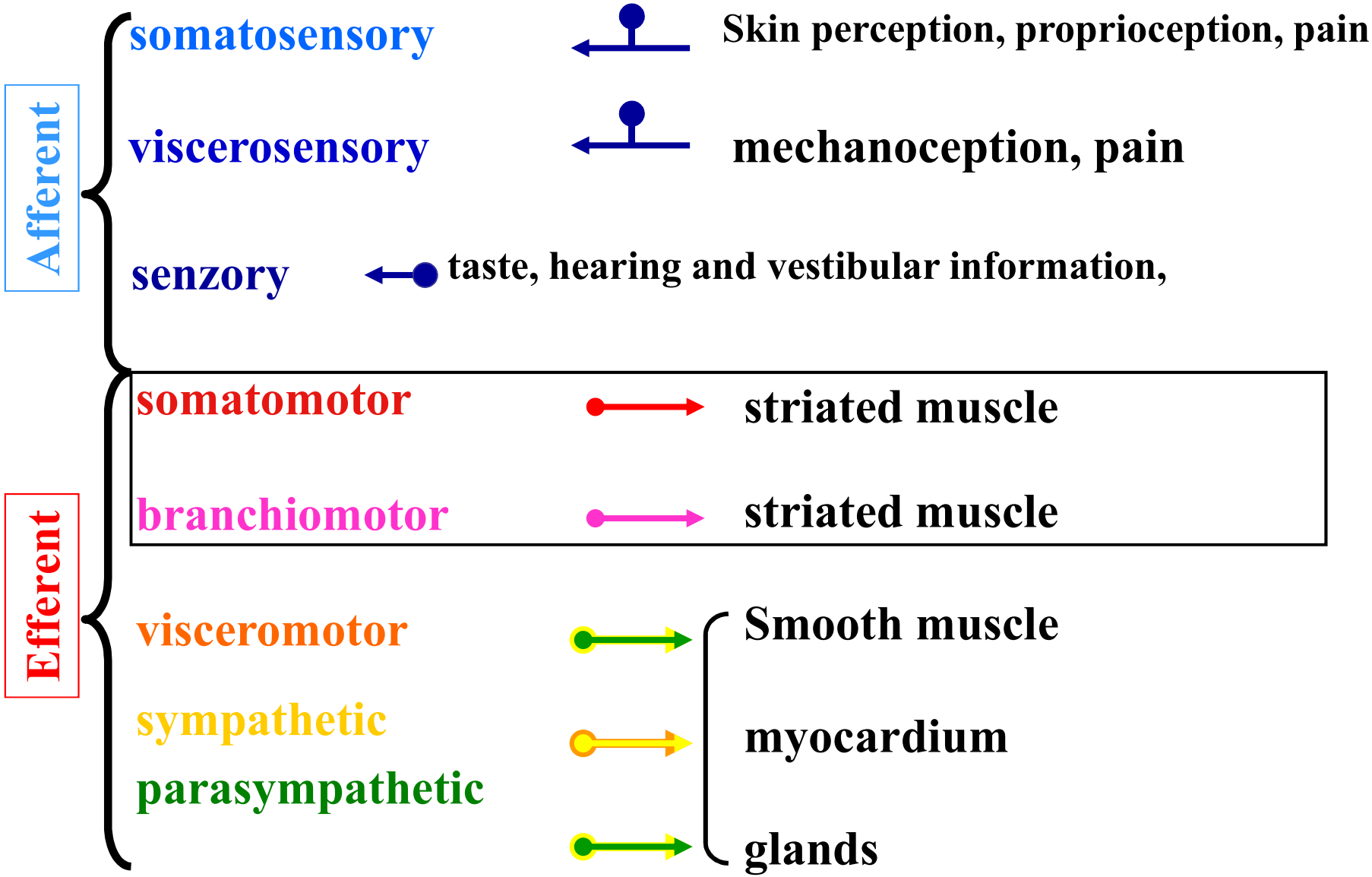




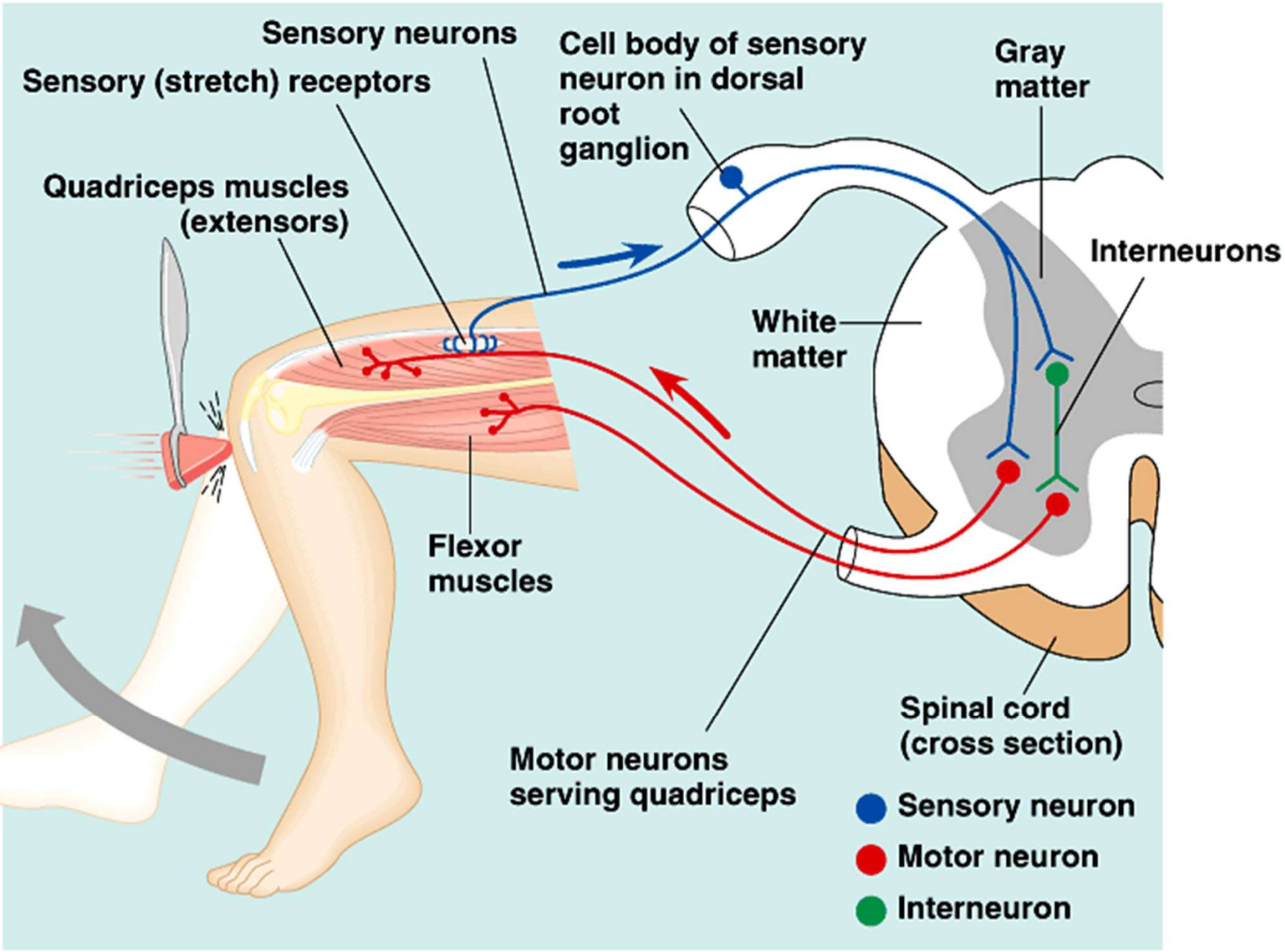
FUNKČNÍ ZÓNY NEURONŮ V CNS



FUNCTIONAL TYPES OF AXONS WITHIN PNS



THE REFLEX ARC



RECEPTORS

Receptor (sensor): react to the changes of the internal or
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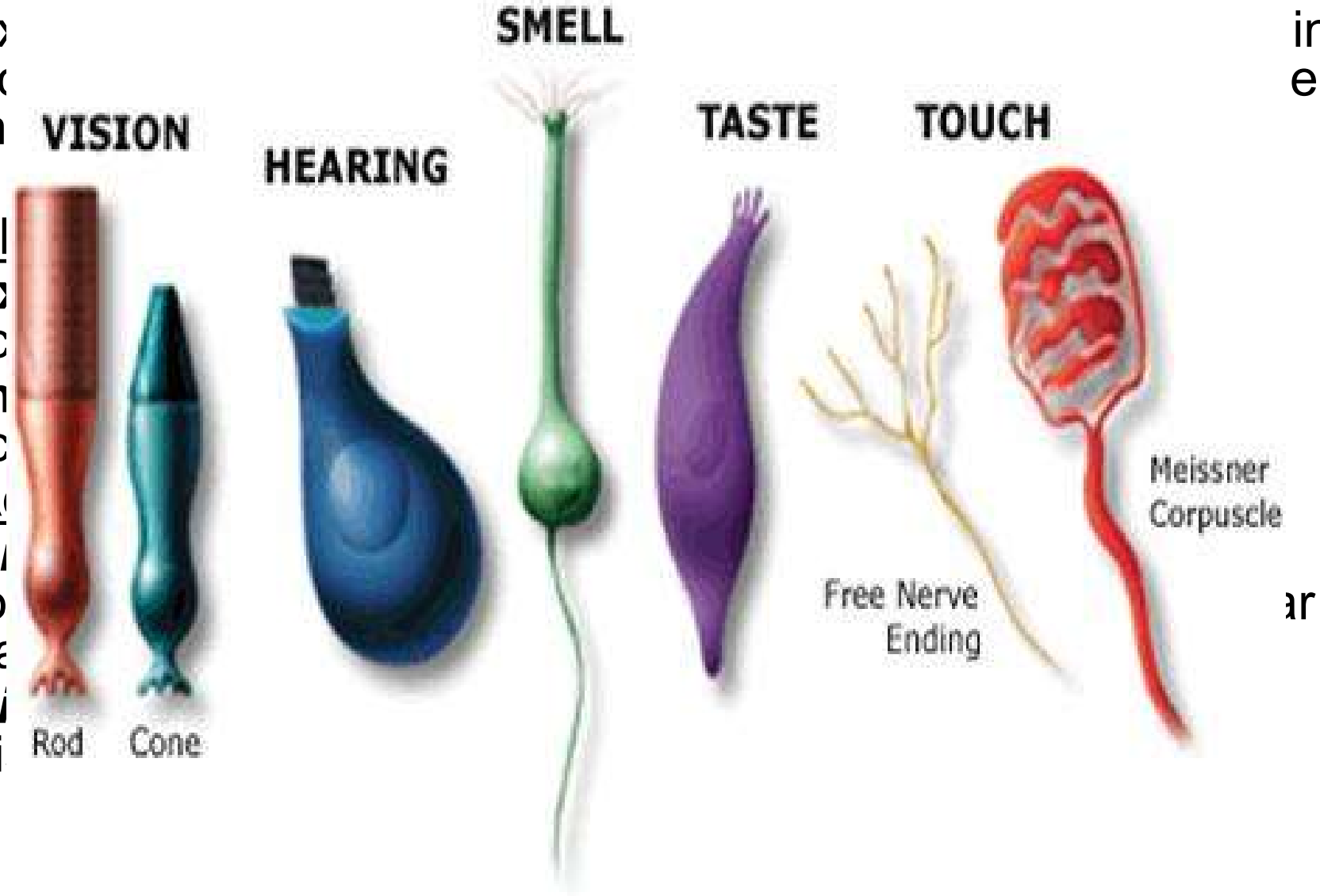

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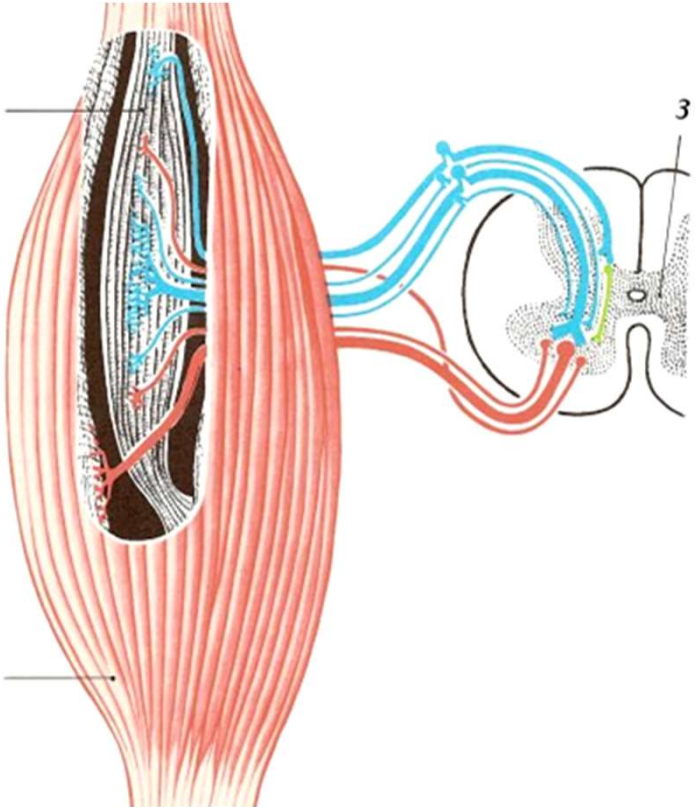
The division according to the physical character of the acting stimulus

mechanoreceptors – receptors reponding to mechanical stimuli
chemoreceptors – receptors reponding to chemical stimuli
thermoreceptors – receptors reponding to thermal stimuli
photoreceptors – receptors reponding to light stimuli

The special case present **algoreceptors** – receptors which respond to pain.

The muscles

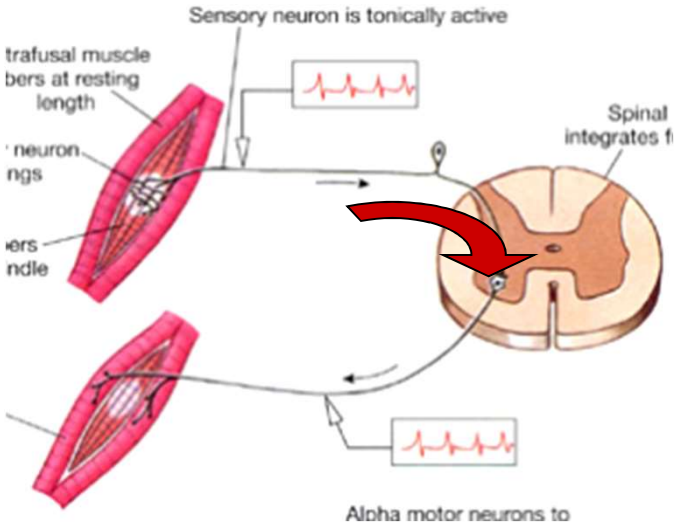
- Muscle and tendon spindles (intrafusal fibres) – **degree of contraction and tension of the muscle fibers**
- Free nerve ending around the muscle fibers - pain

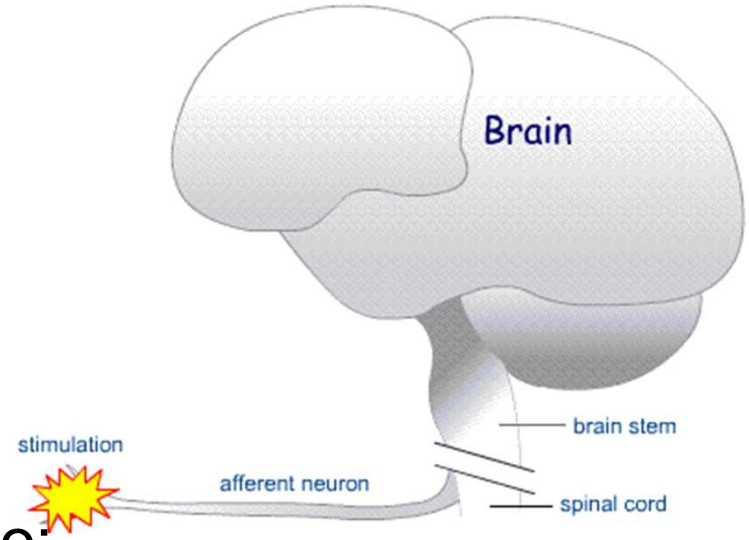


The afferent nerve pathways

The afferent (centripetal, sensory) pathways conduct the neural impulses from the receptors into CNS.

They are formed by the projections of **sensory neurons**, whose bodies are located out of CNS within **sensory ganglions**.





The afferent pathways are divided into:

Somatosensory pathways – bring information from receptors within skin and locomotor system

Viscerosensory pathways – bring information from visceroreceptors (from visceral organs)

Sensory pathways – bring information from sensors – specialized sensory organs (visual, auditory, vestibular, olfactory and gustatory systems)

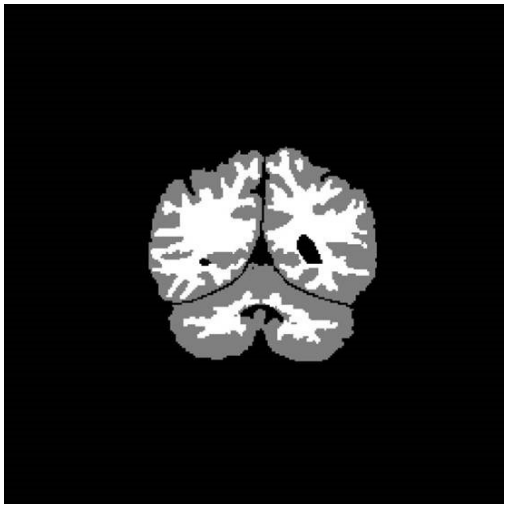
THE CENTRAL NERVOUS SYSTEM

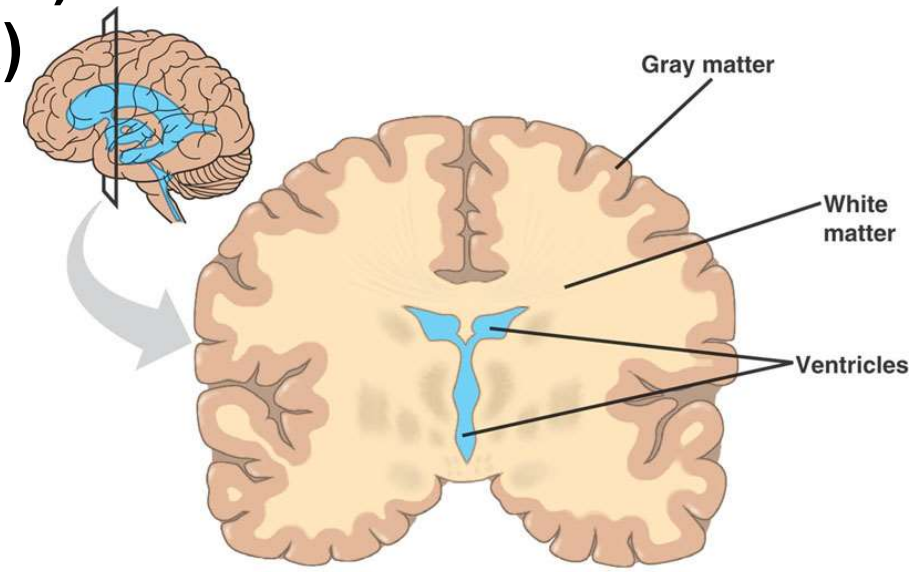
- **The central nervous system (CNS) is the directing centre of the nervous system. It receives the informations from the receptors using the afferent nerve pathways. It processes and evaluates these information and provides the responses of the organism using the efferent nerve pathways and effectors.**

The nervous tissue of CNS is formed by two types of the matter:

The grey matter (substantia grisea)

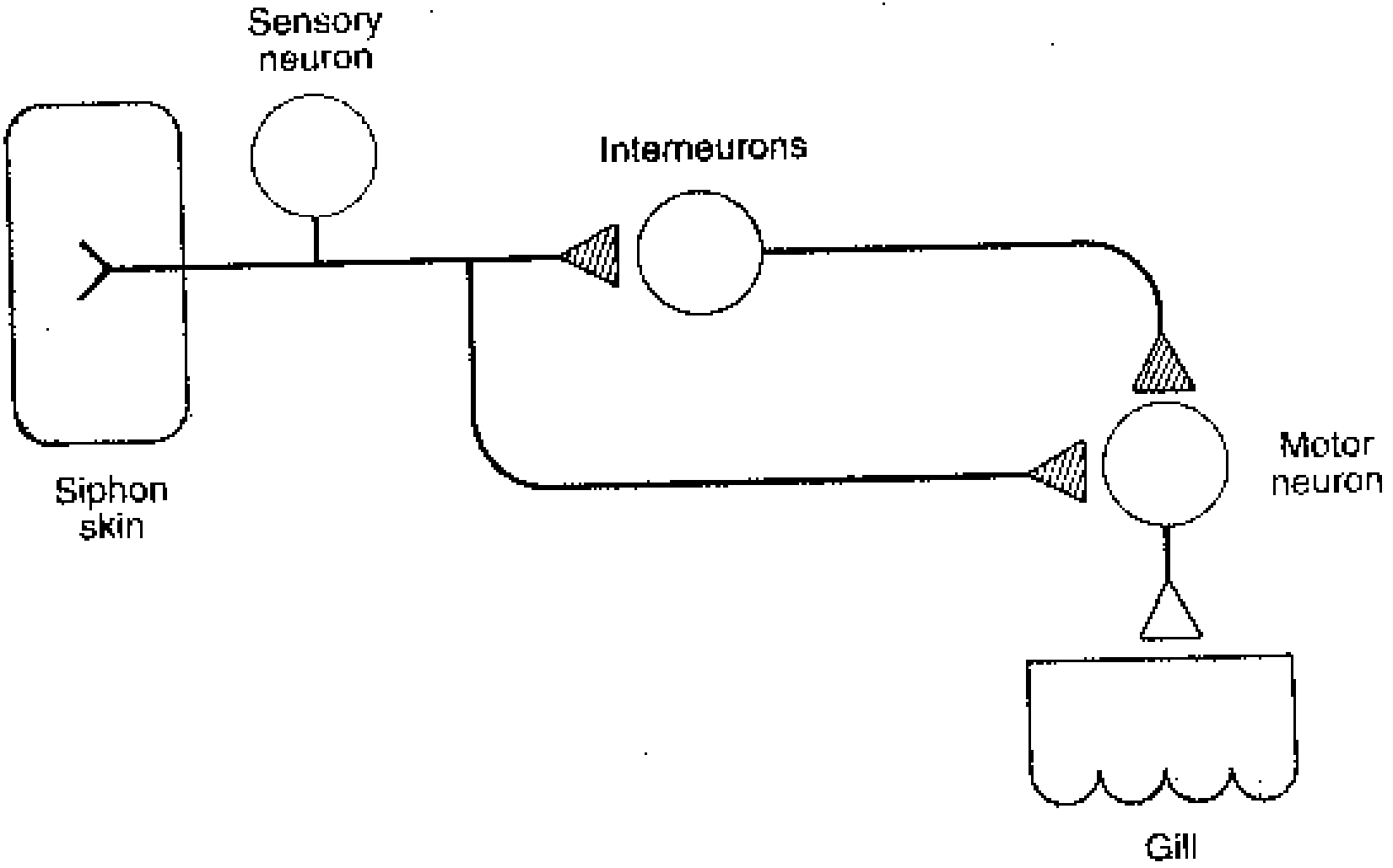
The white matter(substantia alba)





The grey matter *(substantia grisea):*

- is formed by the bodies and dendrites of the neurons + glial cells
- T… s
- o… tl…
- C… n… r… n…



The white matter *(substantia alba):*

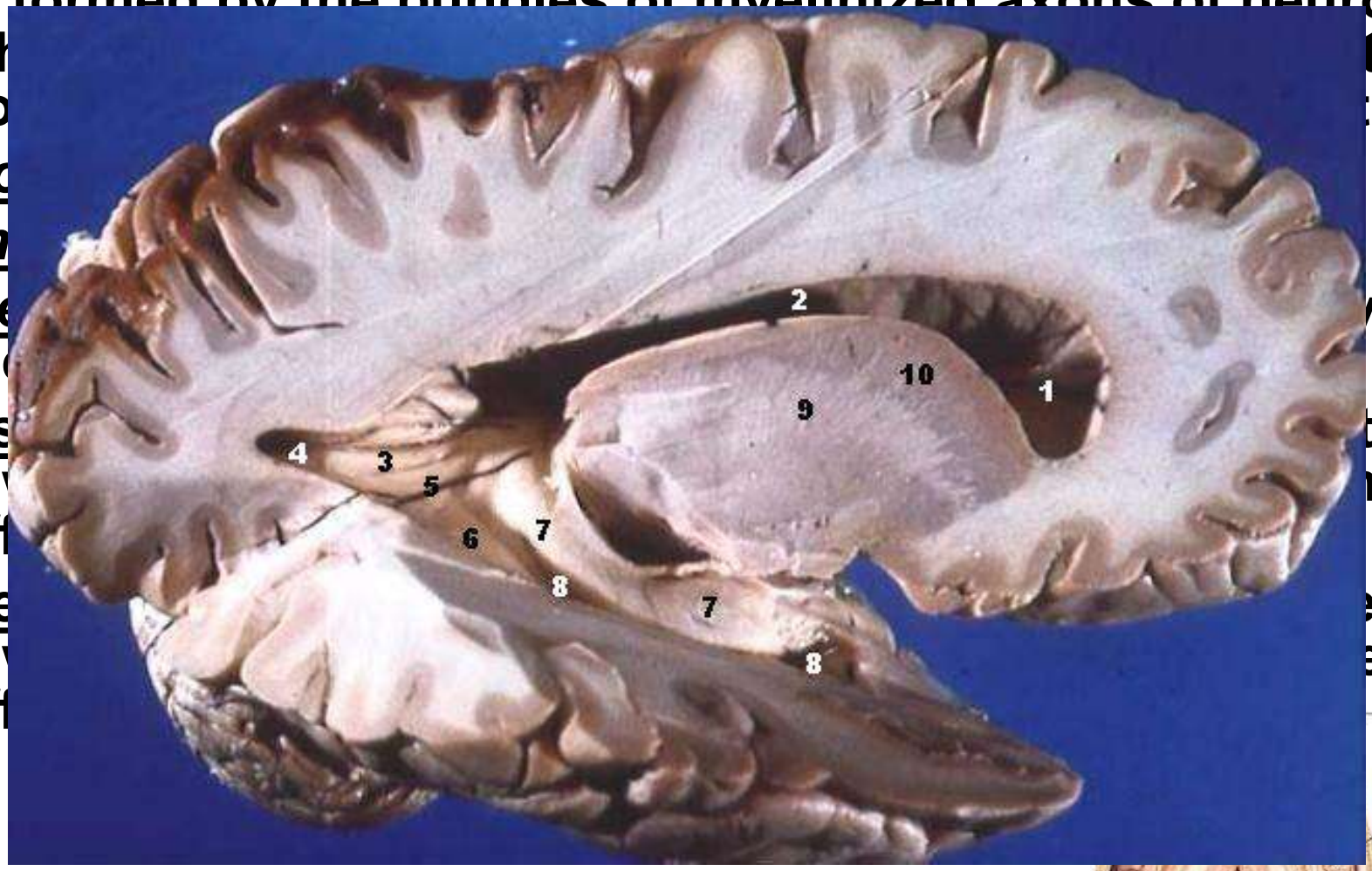
- Is formed by the bundles of myelinized axons of neurons, wh… …the co… …ter

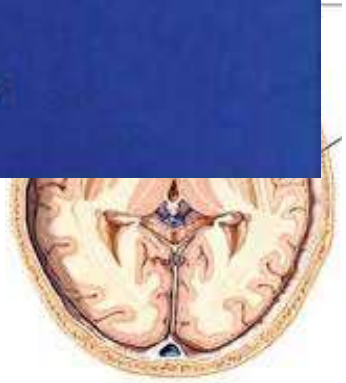
Asso…

Com…

Proje… …vide th…

- As… …tre to… …he aff…
- De… …entre to… …e eff…





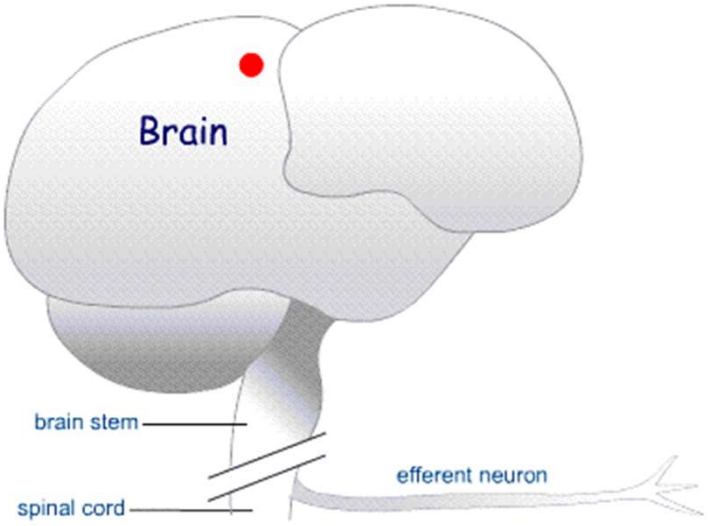
The efferent nerve pathways

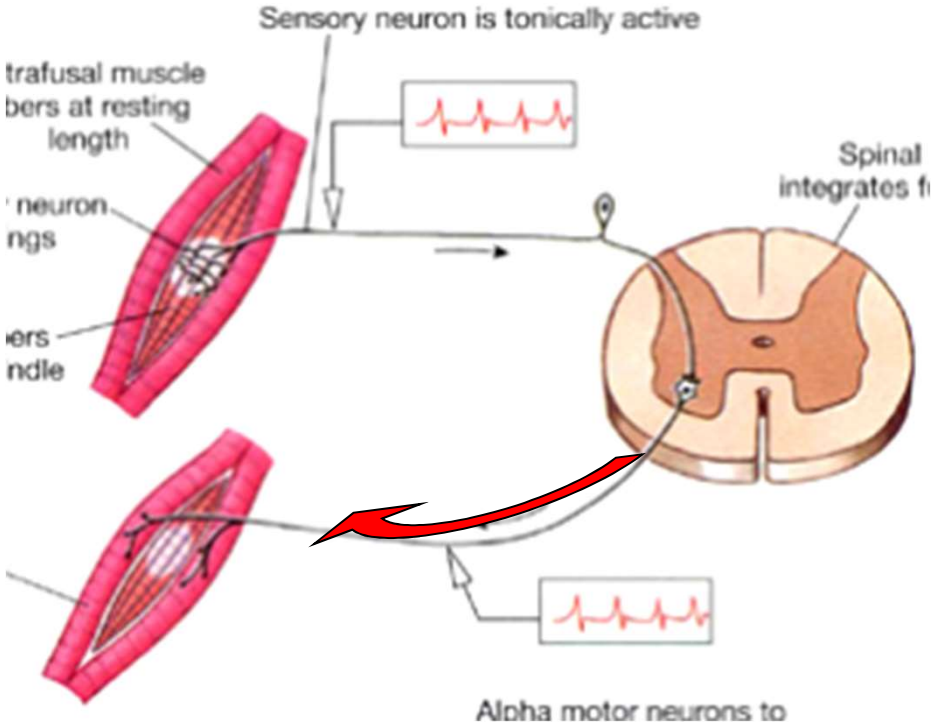
The efferent, centrifugal, motor) nerve pathways:

- They lead the nervous impulses from CNS into effectors (executive organs)
- They begin with the **motor neuron** within CNS, axon of this neuron leaves CNS and presents the proper efferent (motor) pathway

Somatomotor pathways

Visceromotor pathways



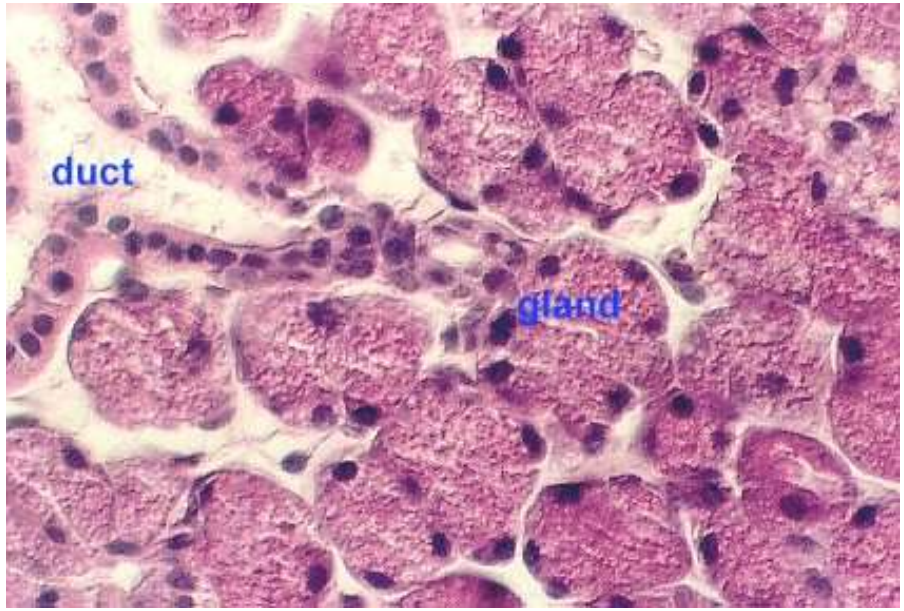


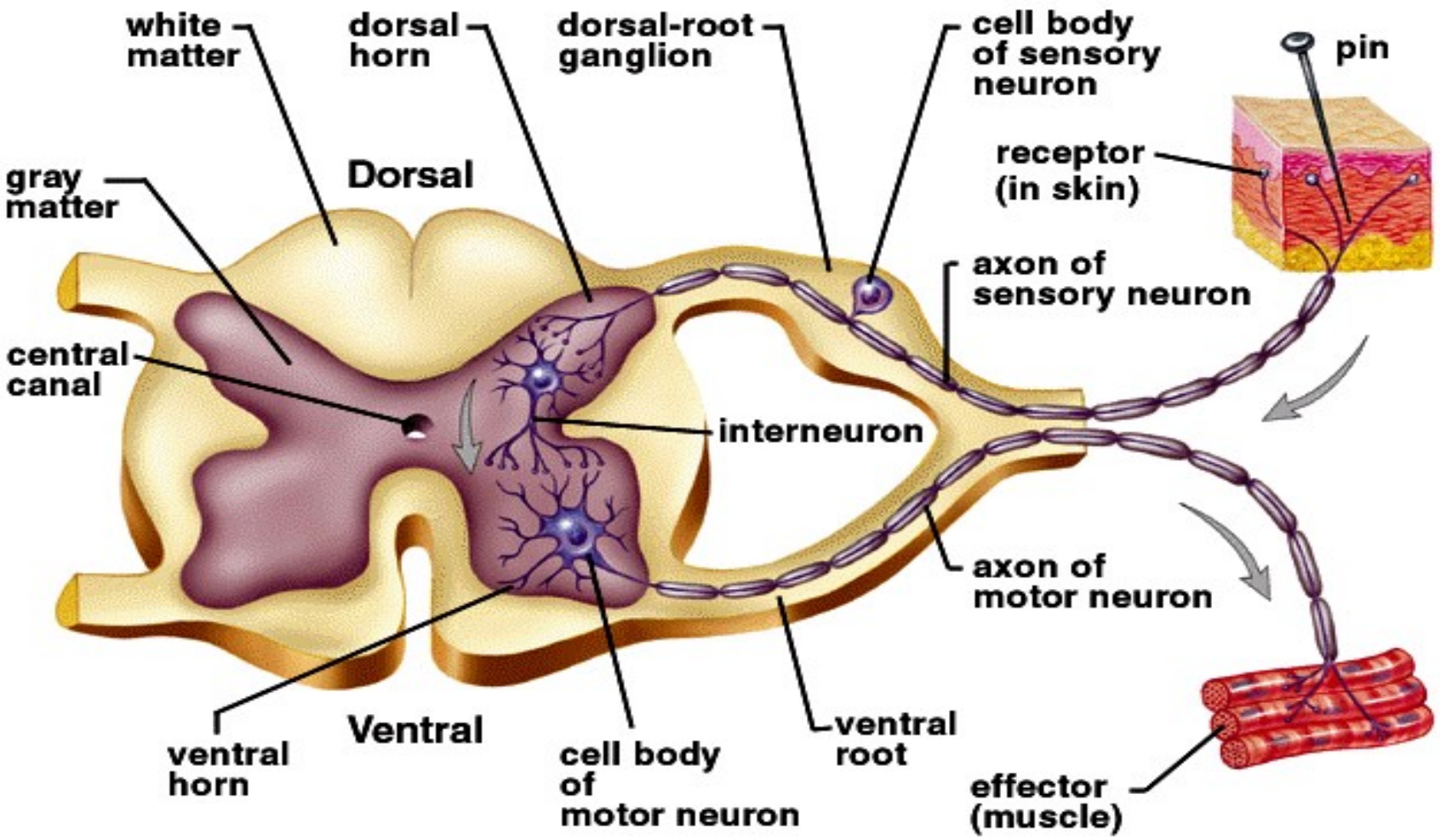
EFFECTORS

Effectors are the executive organs or tissues, which provide the proper response of the organism to the irritation. They can be:

Muscle cells– the result of the reflex is the motion

Glandular cells– the result of the reflex is the secretion

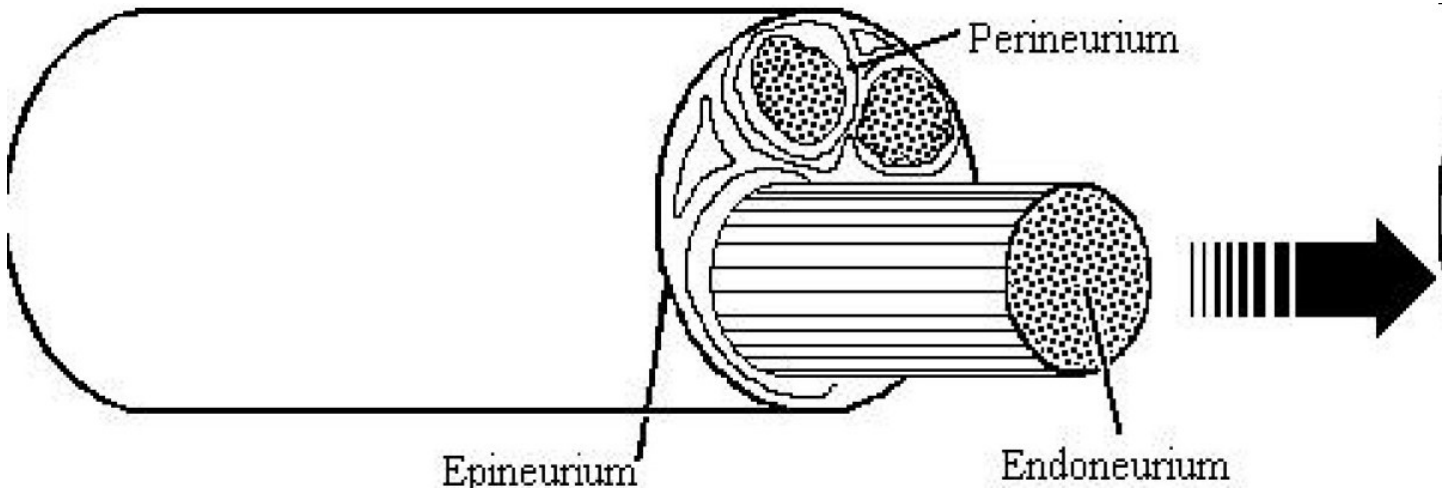


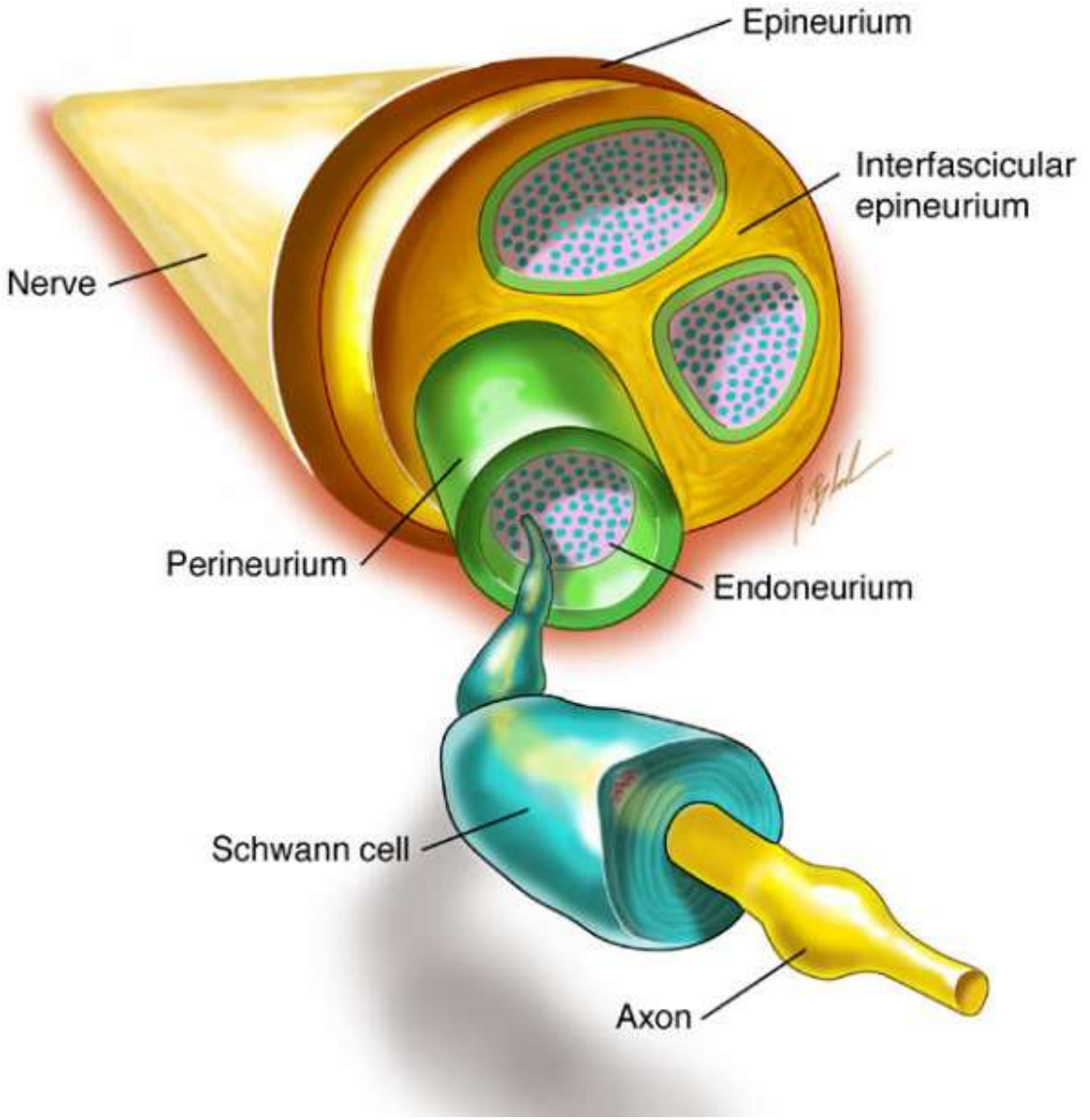

white matter
dorsal horn
dorsal-root ganglion
cell body of sensory neuron
pin
receptor (in skin)
Dorsal
gray matter
axon of sensory neuron
central canal
interneuron
axon of motor neuron
Ventral
ventral horn
cell body of motor neuron
ventral root
effector (muscle)

THE PERIPHERAL NERVOUS SYSTEM

(systema nervosum peripheric um)

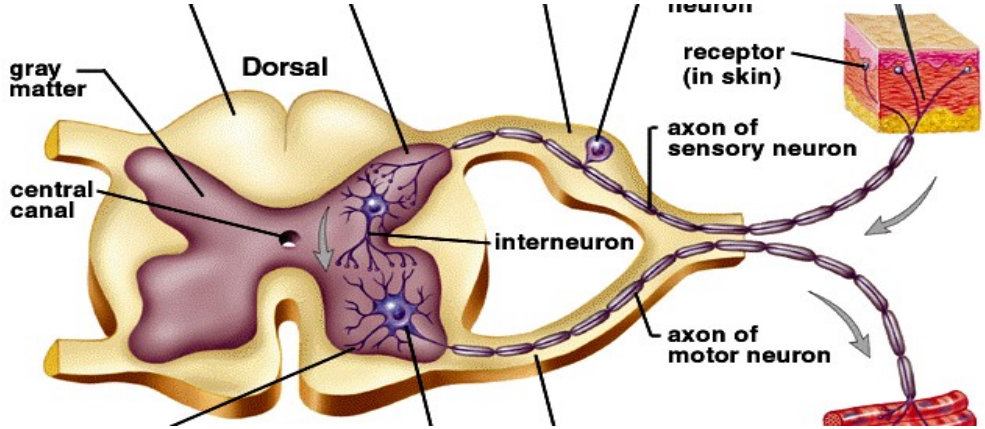
- The peripheral nervous system is formed by a system of nerves and ganglions, which convey reversible transfer of the information between CNS and the periphery (skin, locomotor system and visceral organs)
- Nerve is consist of nerve fibres and fibrous connective tissue
- Nerve fibres are myelinated (white) or unmyelinated (grey) projections of the neurons
- Nerve fibres create fascicles, a few fascicle create nerve,
- Particular nerve fibres are interconnected using the fibrous connective tissue – ***endoneurium***, within the nerve
- the fascicles of the fibres are interconnecte using ***perineurium***
- The surface of the nerve is covered by fibrous layer– ***epineurium***




Epineurium
Interfascicular epineurium
Nerve
Perineurium
Endoneurium
Schwann cell
Axon

Sensory nerves

- They contain the afferent fibres, which lead the information from the receptors toward CNS
- Within theirs course, there are sensory ganglions inserted with the bodies of **pseudounipolar neurons**
- **Peripheral branch** leads the impulses from receptors within the periphery into the ganglion, the bundles of these peripheral branches form the nerve
- **Central branch** leads the impulses from the ganglion toward the grey matter of CNS



somatosensory – lead the information from the receptors within the skin and the locomotor system (muscles, tendons, periosteum, articular capsules)

viscerosensory –lead the information from receptors within the organs

sensory – lead the information from sensors

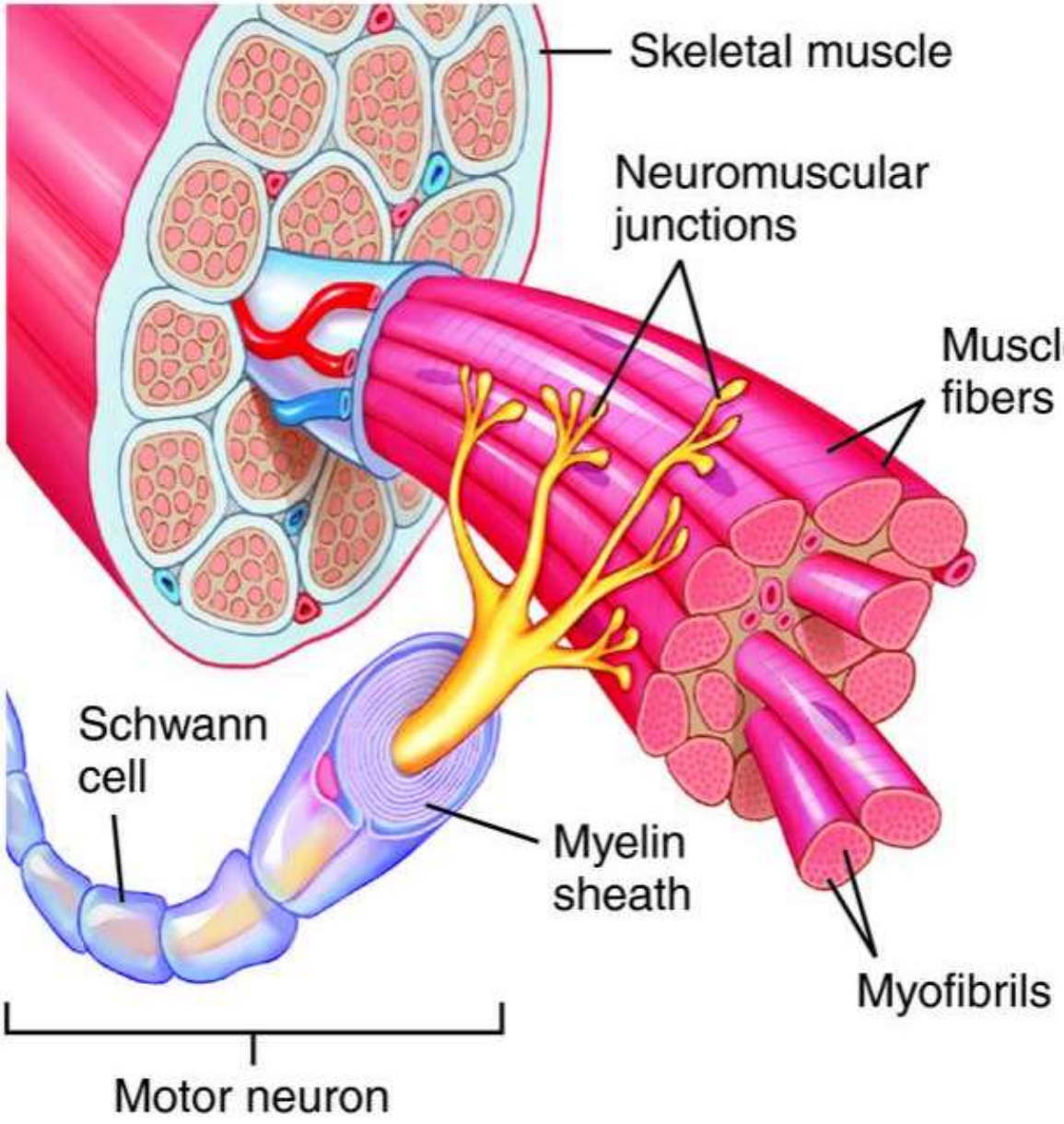
motor nerves

- They cor S into effectors ity
- They oric the spinal cord or th

somatom he nerve fibers (ax tch-over

viscerom nd **glandula** ter at least one switc

- They cor **ost of the nerves a** or or clearly sensory



The peripheral system

1. According to from which part of CNS the nerves arise, we can divide them into:

The cranial nerves (pass through the base skull)

The spinal nerves (pass through foramina intervertebralia)

2. According to the innervated parts of the body:

somatic nervous system

• It is controlled by our consciousness

• It is consist of **somatosensory** (or sensory) and **somatomotor** nerve fibers (tracts)

• It does the sensory innervation of the skin and the locomotor system (muscles, tendons, bones, articular capsules) and the motor innervation of the striated muscle

autonomic nervous system

• It works independently on our consciousness

• sympathicus, parasympathicus

THE SPINAL NERVES *(nervi spinales)*

- The spinal nerves rise from the spinal cord in the number of 31 pairs

The cervical nerves *(nervi cervicales)* – **8** pairs

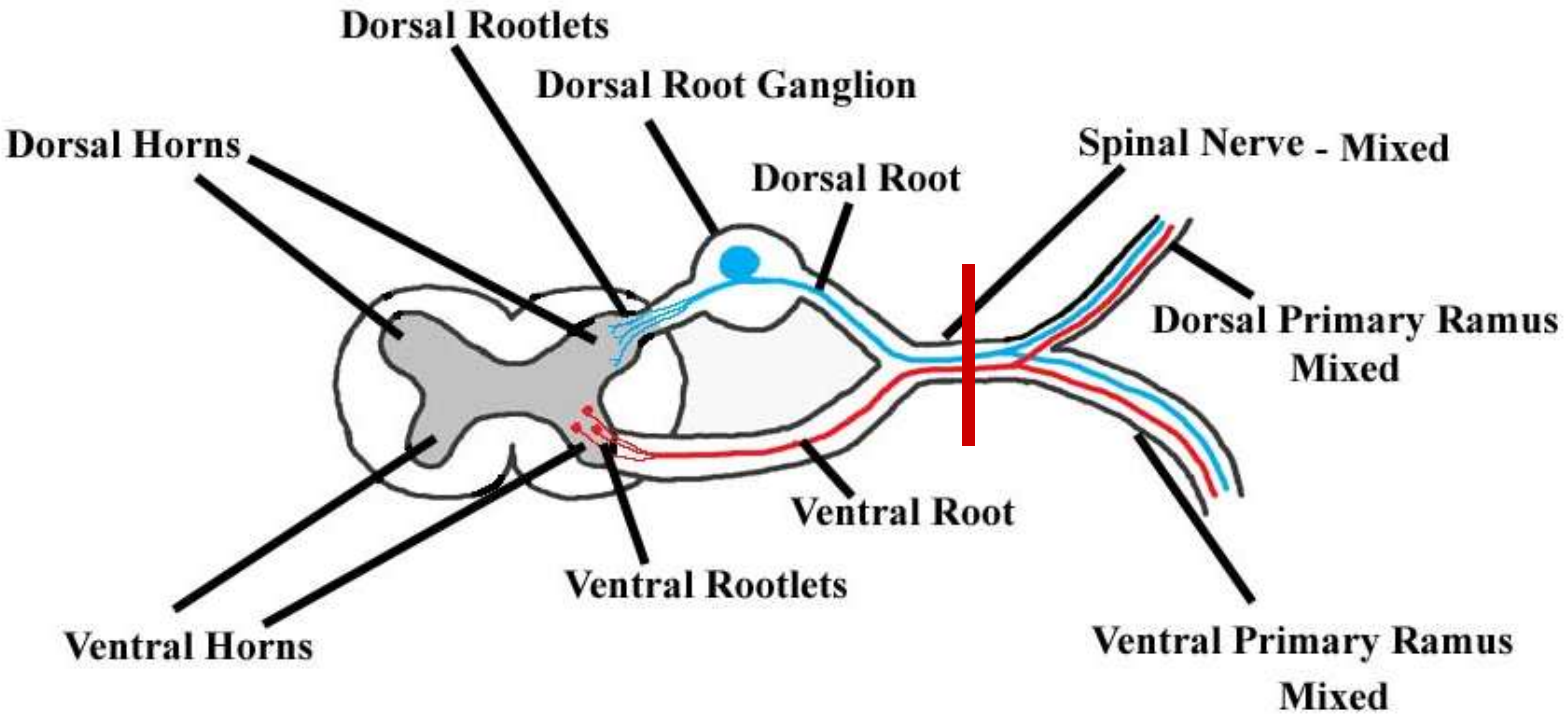
The thoracic nerves *(nervi thoracici)* – **12** pairs

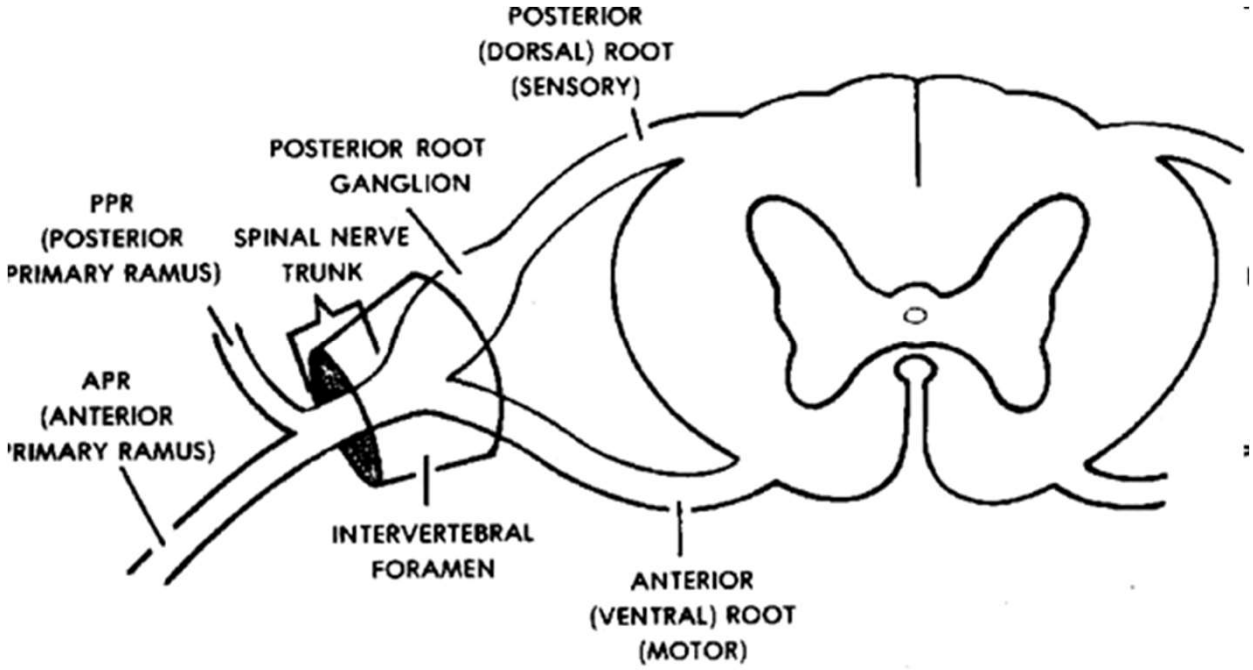
The lumbar nerves *(nervi lumbales)* – **5** pairs

The sacral nerves *(nervi sacrales)* – **5** pairs

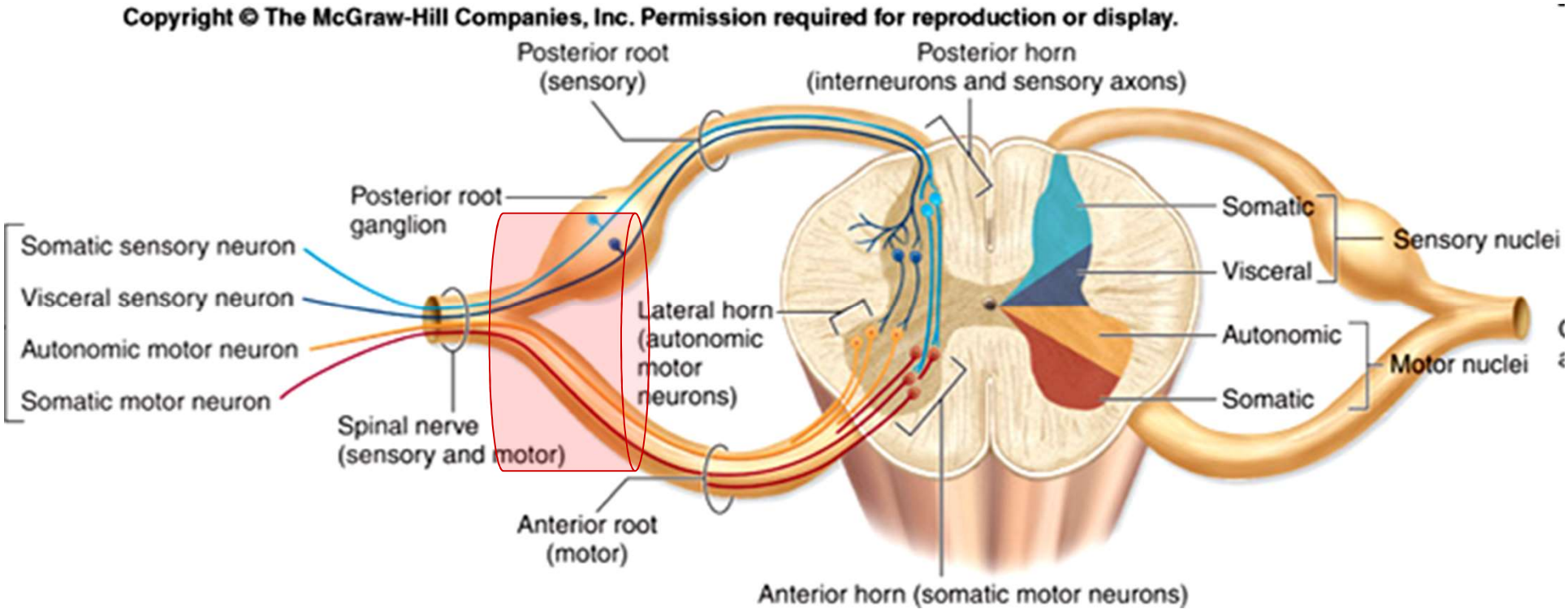
The coccygeal nerve *(nervus coccygeus)* – **1** pair

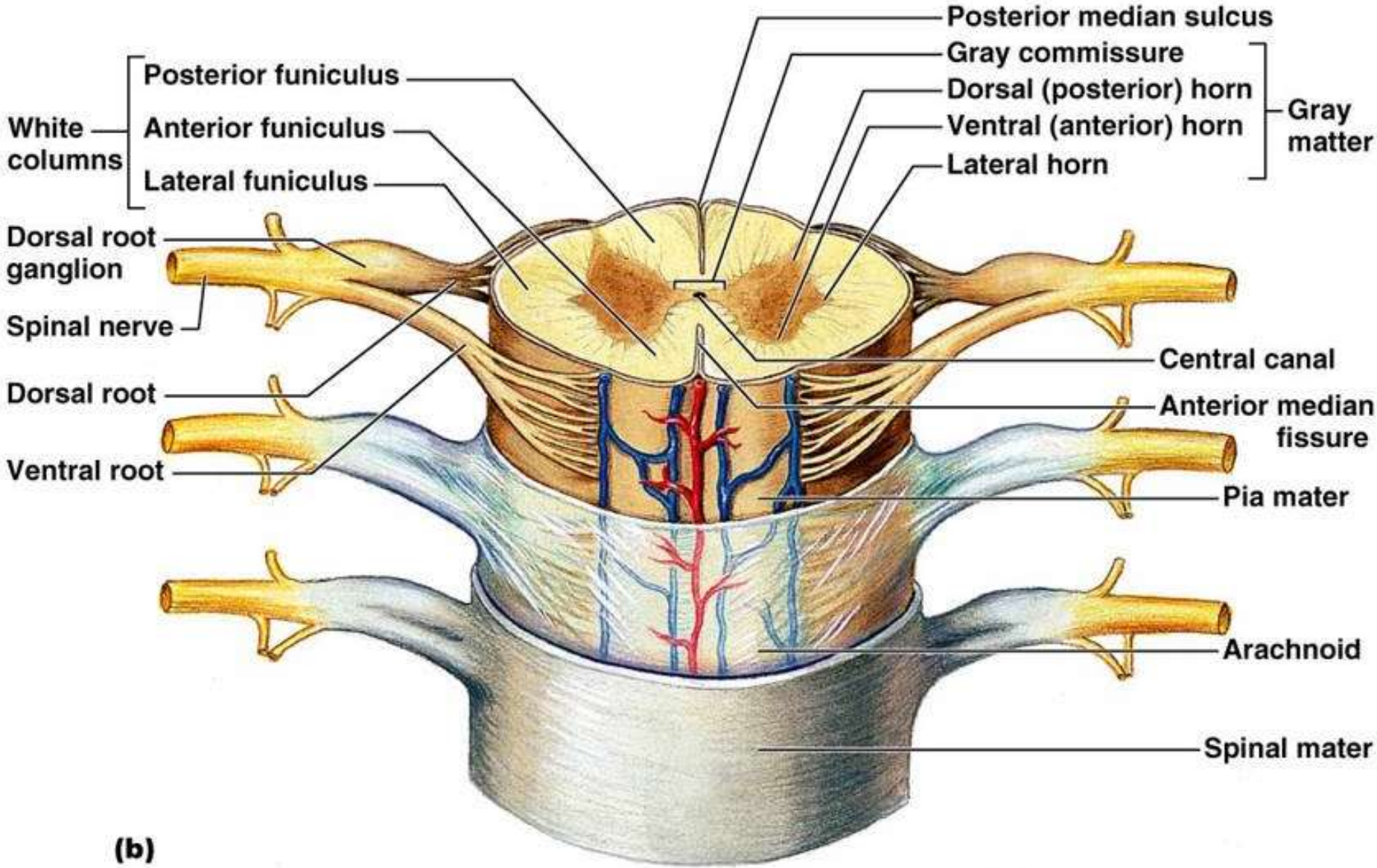
- Each spinal nerve rises from the spinal cord through two roots, the anterior one ***(radix ventralis)*** and the posterior one ***(radix dorsalis)***
- The anterior roots contain only efferent fibres (motor), the posterior roots only afferent fibres (sensory)
- Within the course of the posterior root, there is the spinal ganglion ***(ganglion spinale)*** inserted

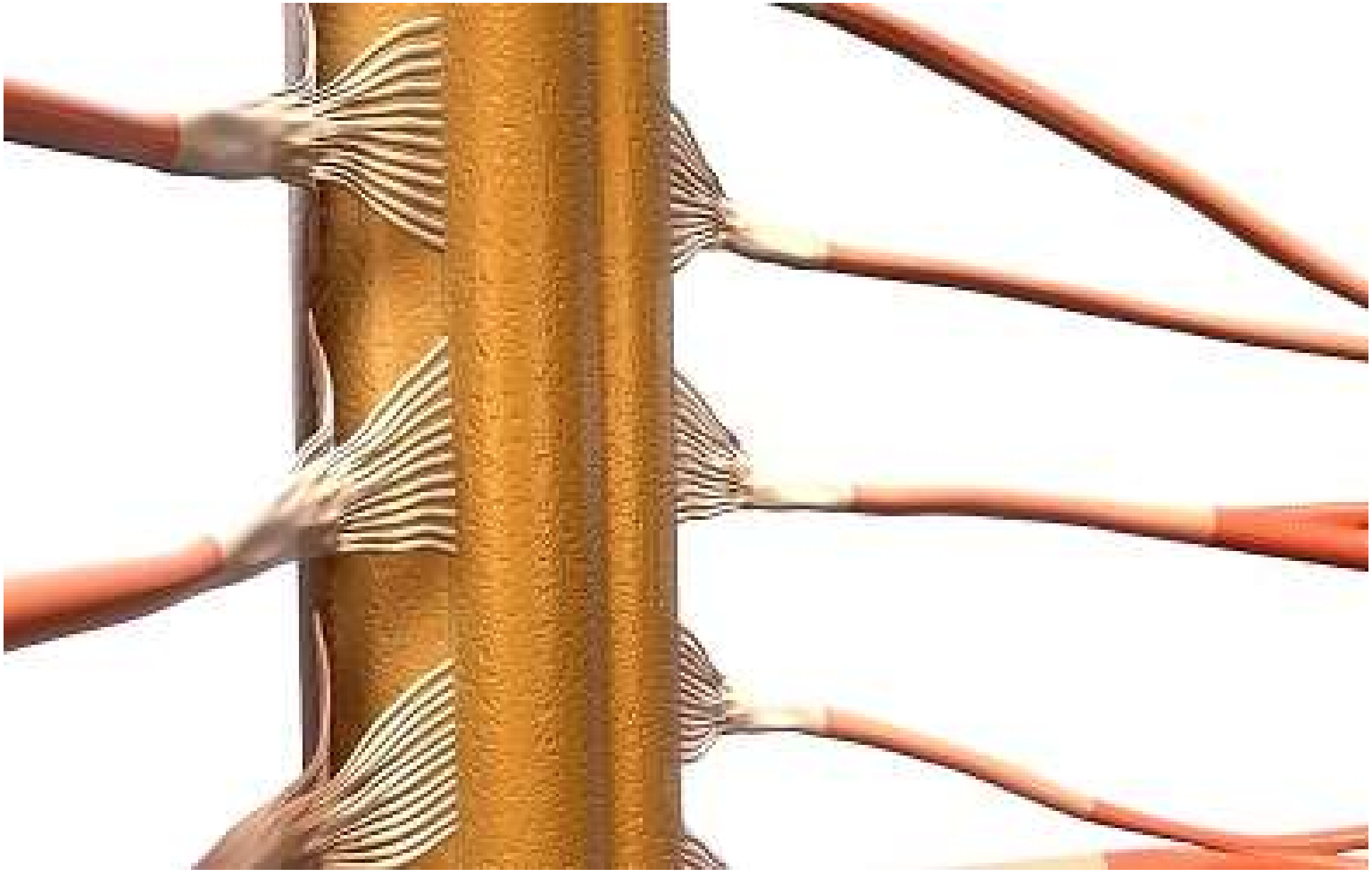

Dorsal Rootlets
Dorsal Root Ganglion
Dorsal Horns
Dorsal Root
Spinal Nerve - Mixed
Dorsal Primary Ramus
Mixed
Ventral Root
Ventral Rootlets
Ventral Horns
Ventral Primary Ramus
Mixed

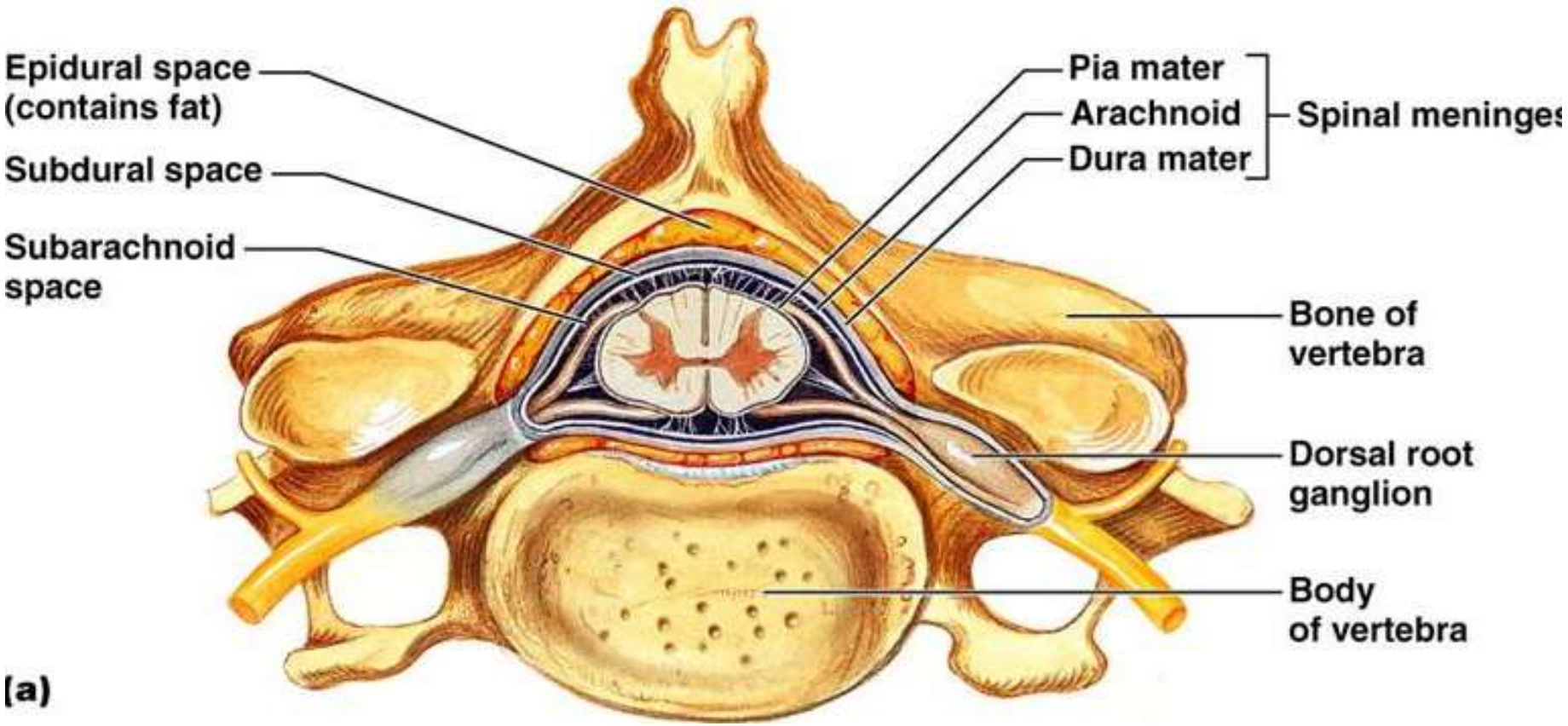

POSTERIOR
(DORSAL) ROOT
(SENSORY)
POSTERIOR ROOT
GANGLION
PPR
(POSTERIOR
PRIMARY RAMUS)
SPINAL NERVE
TRUNK
APR
(ANTERIOR
PRIMARY RAMUS)
INTERVERTEBRAL
FORAMEN
ANTERIOR
(VENTRAL) ROOT
(MOTOR)

<u>The posterior root (radix dorsalis)</u> contains afferent fibres, which serve to superficial and deep perception, leading of pain, warmth and cold. On each posterior root, there is **ganglion spinale** located, which consists pseudounipolar neurons
<u>The anterior root (radix ventralis)</u> contains efferent somatomotor fibres (for striated muscle) and visceromotor fibres (for smooth muscle cells within the walls of organs and vessels, the skin etc.).

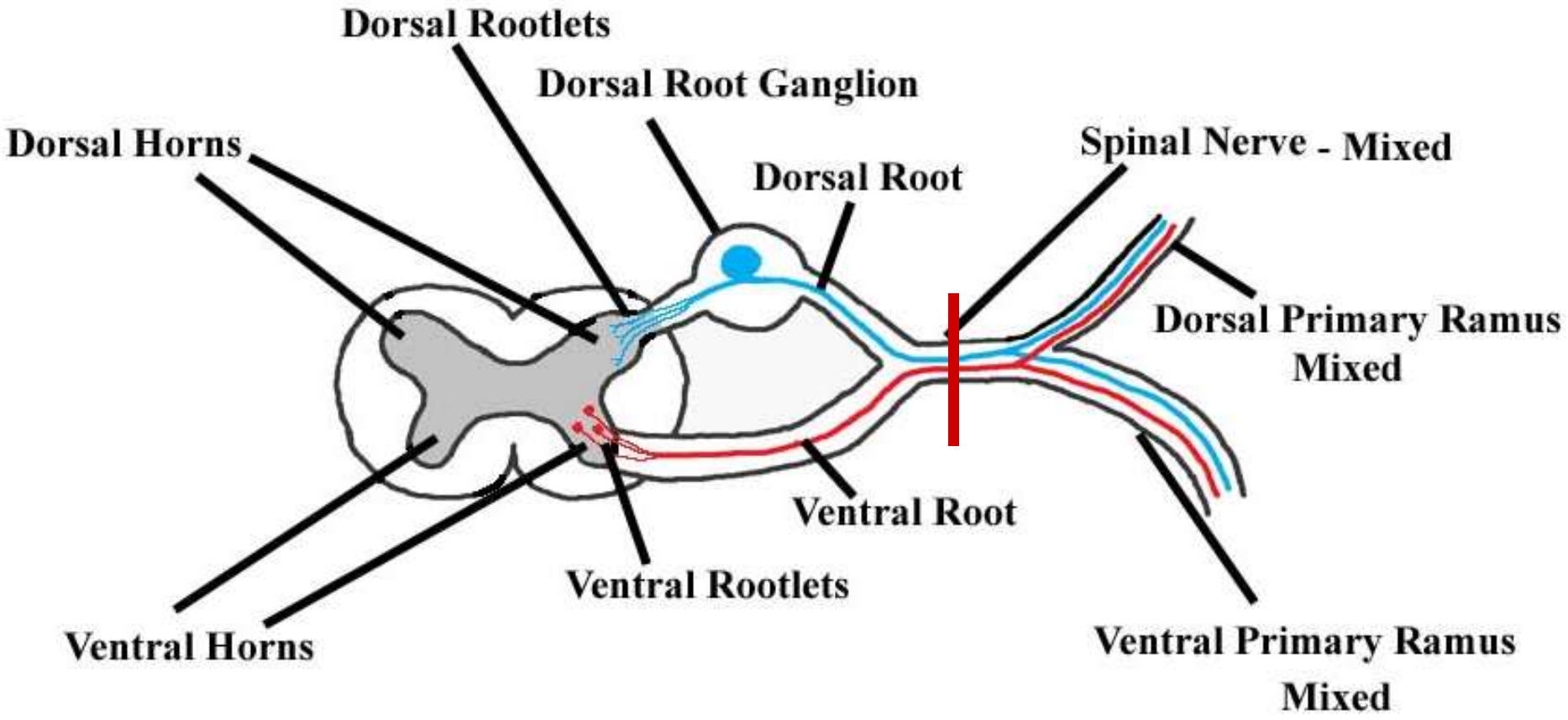


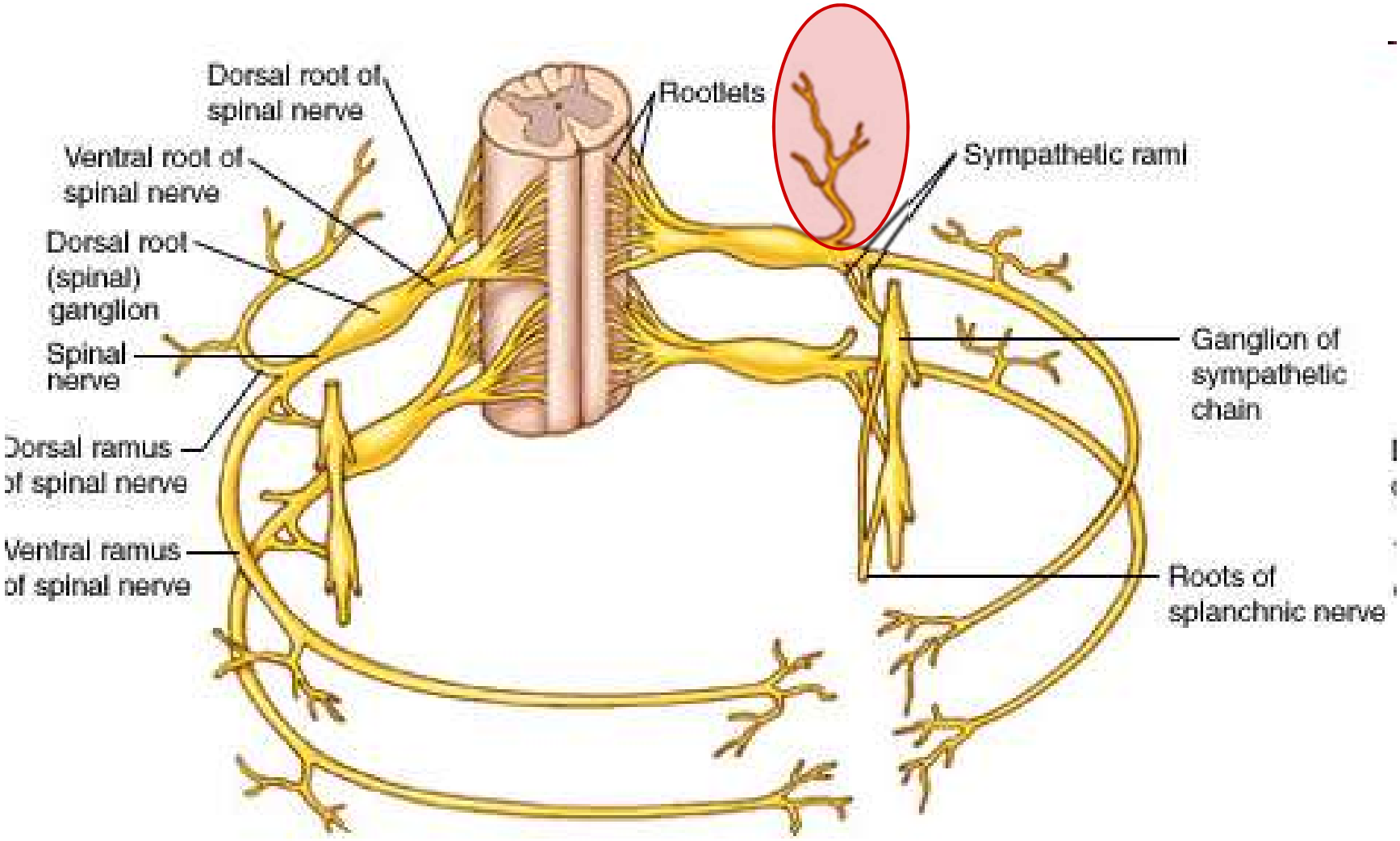

Posterior median sulcus
Gray commissure
Dorsal (posterior) horn
Ventral (anterior) horn
Lateral horn
Gray matter
White columns
Posterior funiculus
Anterior funiculus
Lateral funiculus
Dorsal root ganglion
Spinal nerve
Dorsal root
Ventral root
Central canal
Anterior median fissure
Pia mater
Arachnoid
Spinal mater
(b)





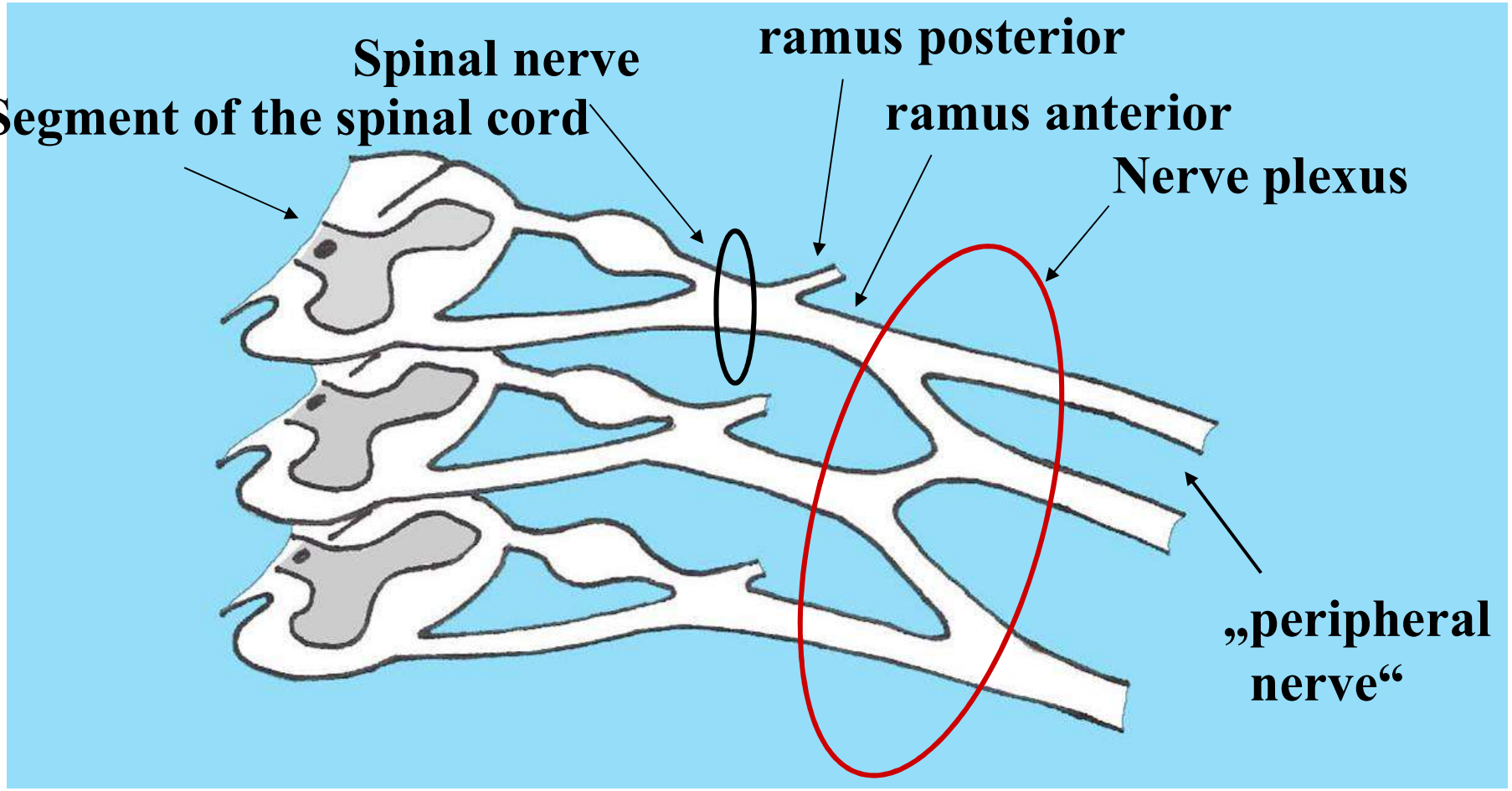
- The proper spinal nerv is formed by connection of the anterior and posterior root and it arises from the spinal canal through **foramen intervertebrale**
- After the leaving of the spinal canal, the spinal nerve divides into 2 branches – the posterior branch ***(ramus dorsalis)*** and the anterior branch ***(ramus ventralis)***, both branches contain the afferent and efferent tracts.


Dorsal Rootlets
Dorsal Root Ganglion
Dorsal Horns
Dorsal Root
Spinal Nerve - Mixed
Dorsal Primary Ramus
Mixed
Ventral Root
Ventral Rootlets
Ventral Horns
Ventral Primary Ramus
Mixed

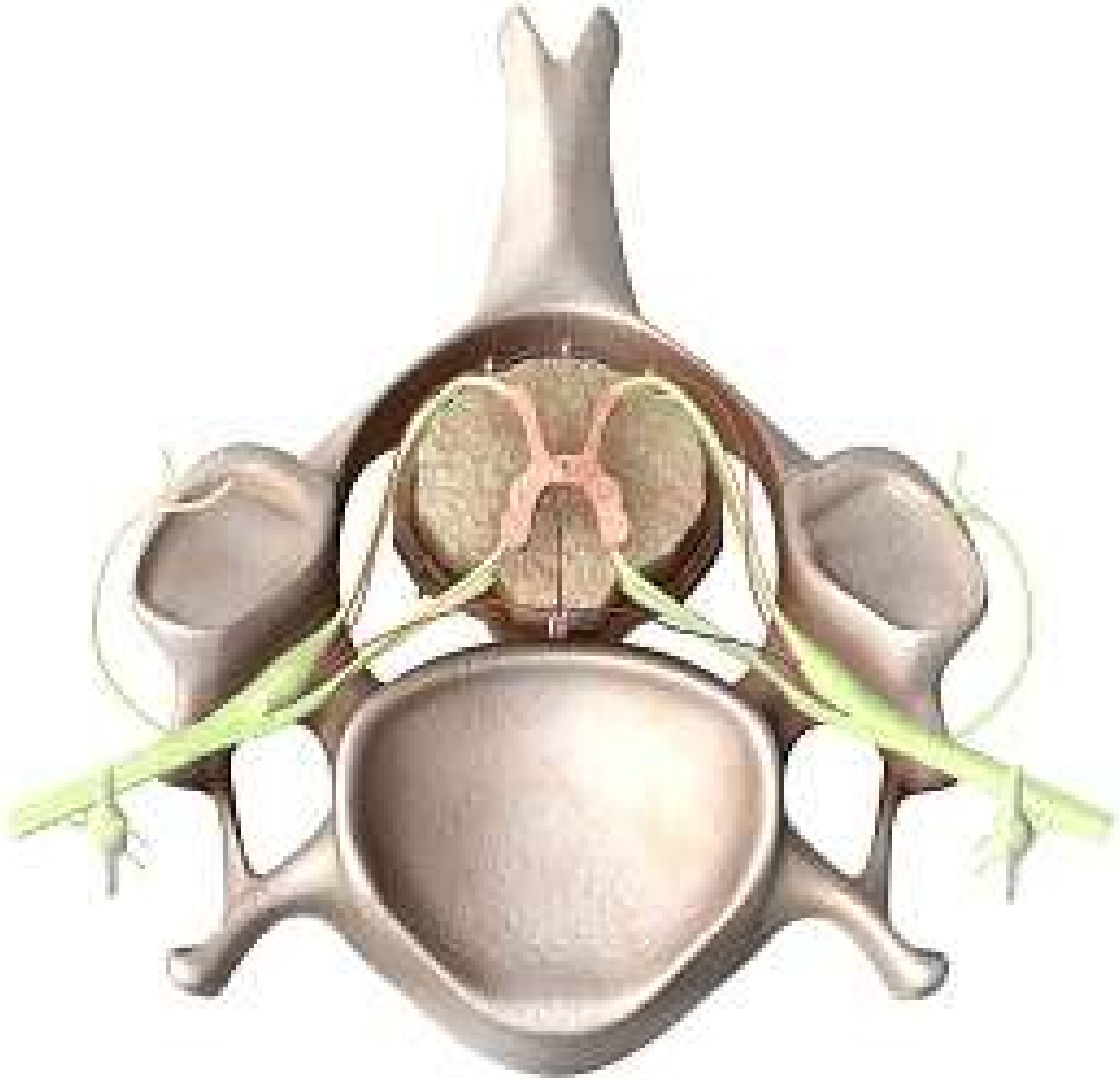

Dorsal root of spinal nerve
Rootlets
Ventral root of spinal nerve
Sympathetic rami
Dorsal root (spinal) ganglion
Spinal nerve
Ganglion of sympathetic chain
Dorsal ramus of spinal nerve
Ventral ramus of spinal nerve
Roots of splanchnic nerve

Ramus dorsalis: doesn´t form plexuses

Ramus ventralis: forms plexuses



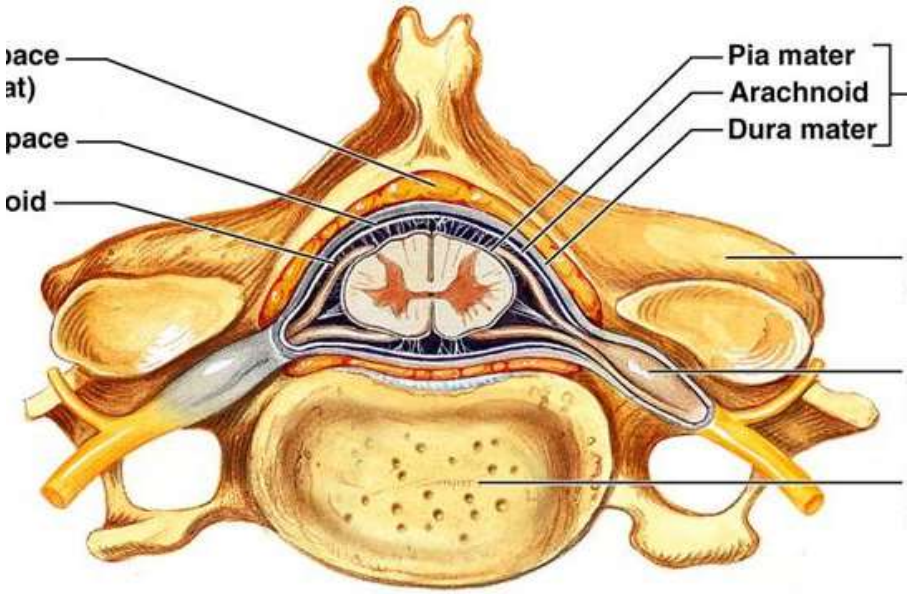
The nerve plexuses are allways formed only by the anterior branches of the appropriate spinal nerves!

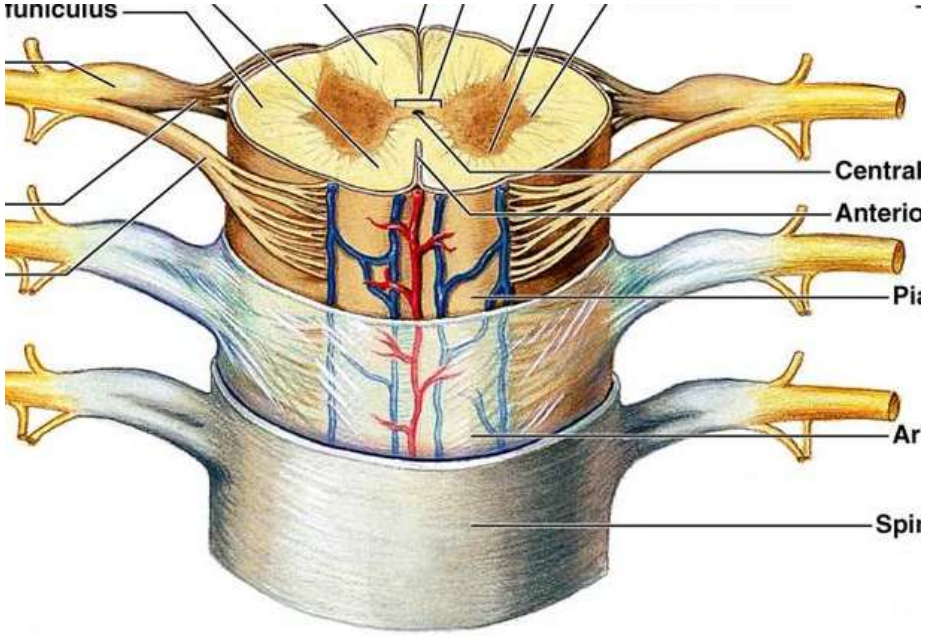


The posterior branches (rami dorsales) –

don´t form the plexuses

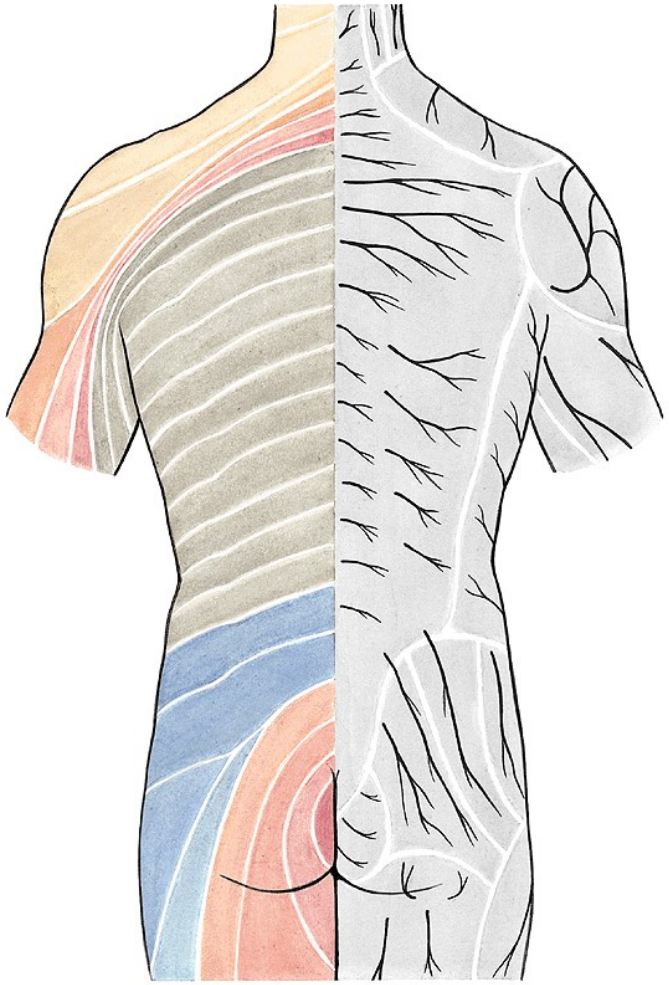
- They are short and thin branches of the spinal nerve
- **function:** motor and sensory innervation of the back part of the trunk (mixed nerves)
- They do the motor innervation of autochtone (deep) back muscles and sensory innervation of the skin in adjacent area
- During their course, they keep simple segmental arrangement
- Only the posterior branches of **C1 – C3**, **L1 – L3** a **S1 – S3** have more complicated arrangement

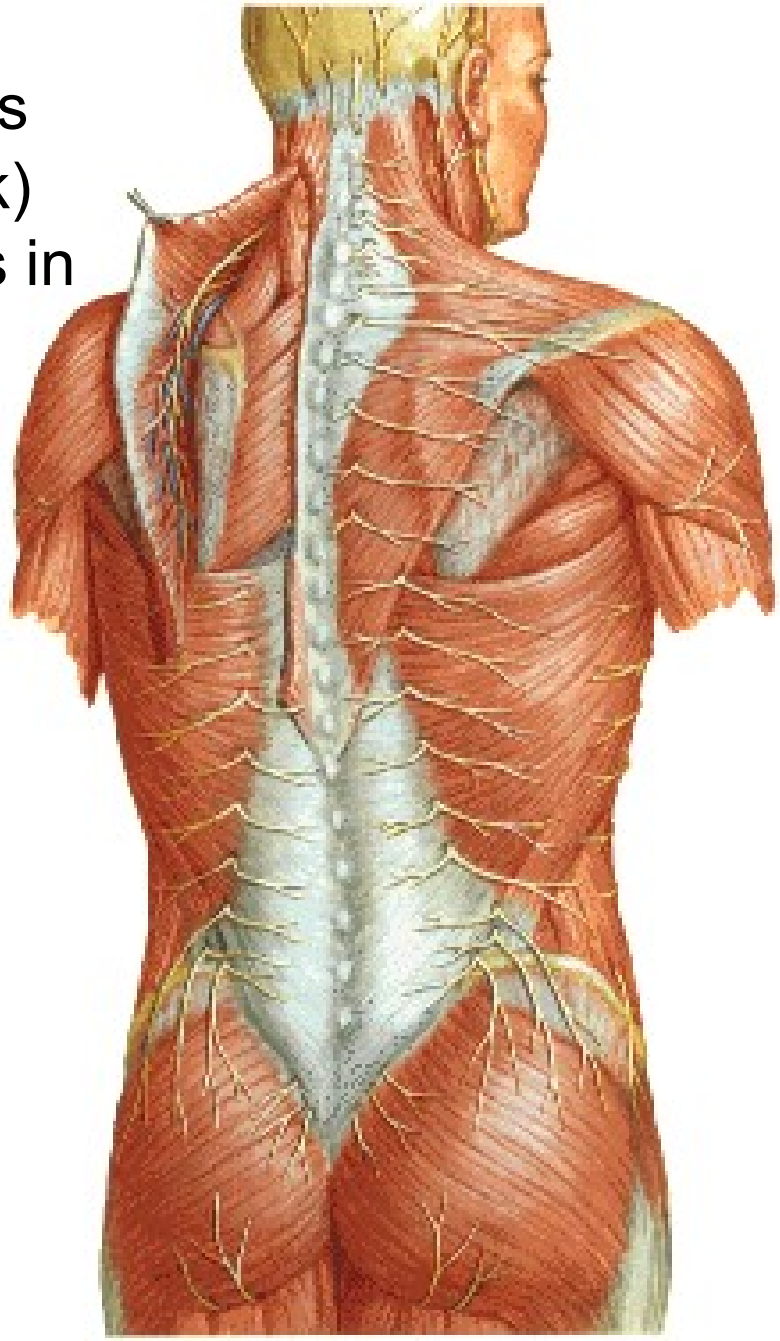




Ramus dorsalis:

- **ramus medialis** (deep back muscles and the skin of medial part of the back)
- **ramus lateralis** (deep back muscles in the lateral part of the back)





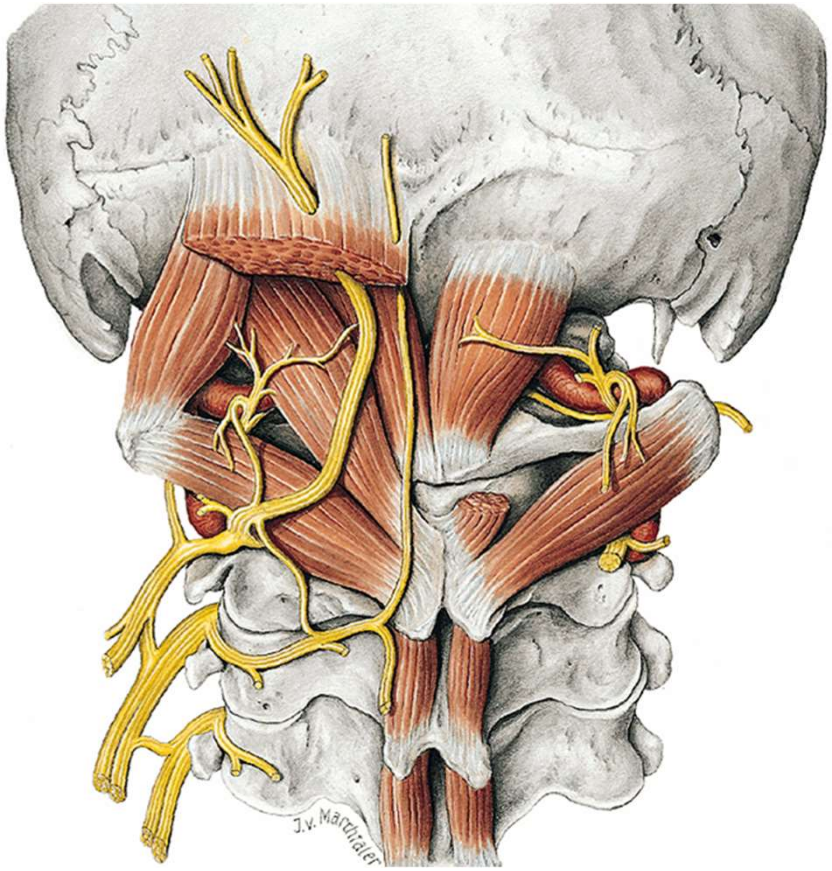
C1 – C3

n. suboccipitalis

n. occipitalis major

n. occipitalis tertius

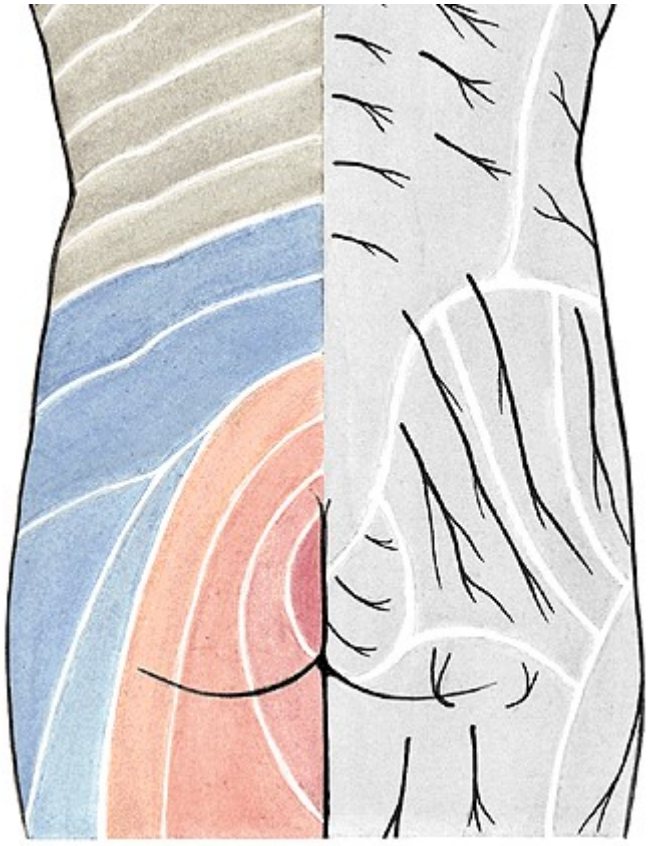
• suboccipital muscles + skin

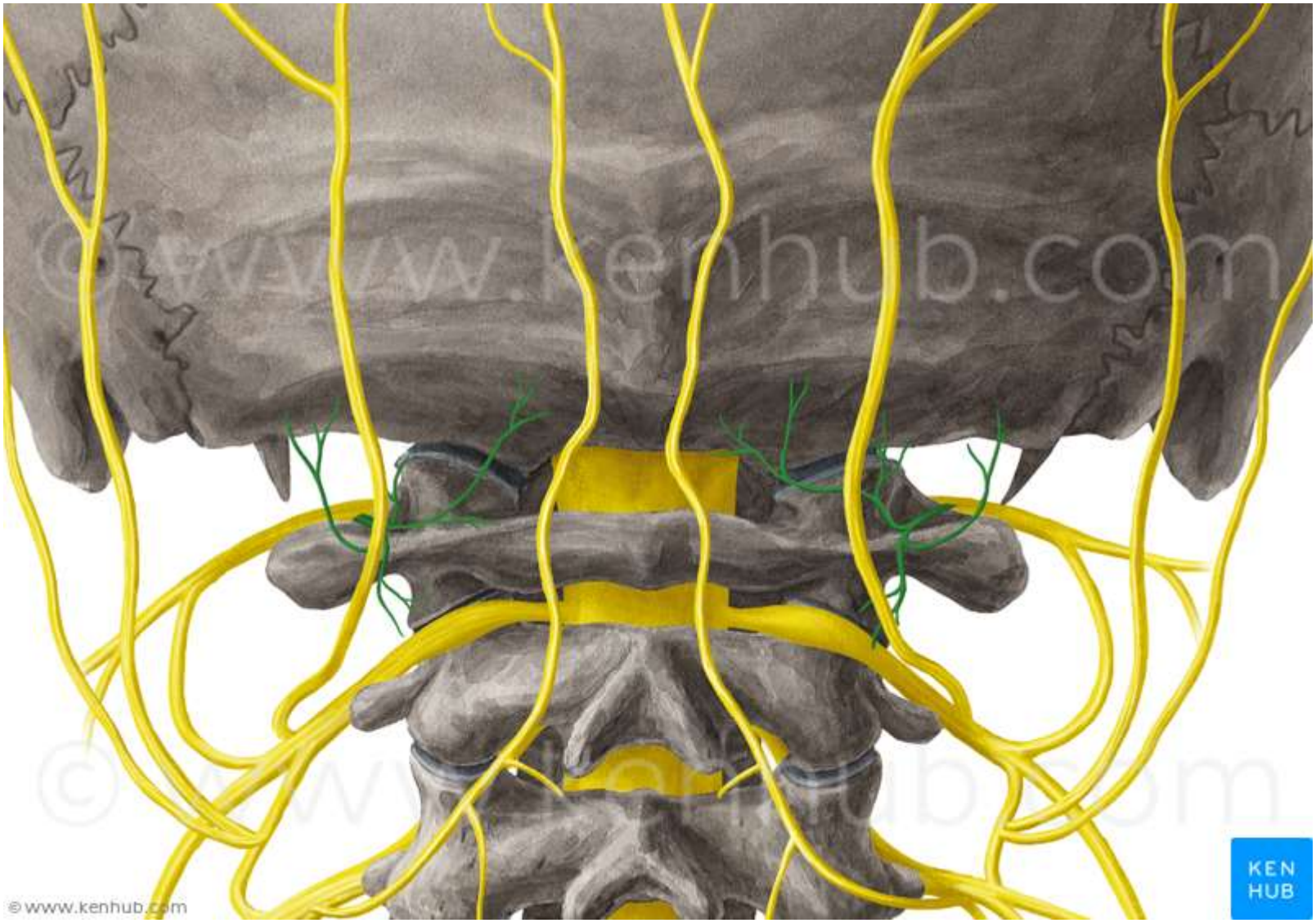


L1 – L3 a S1 – S3

nn. clunium superiores
nn. clunium medii

• skin of the gluteal region

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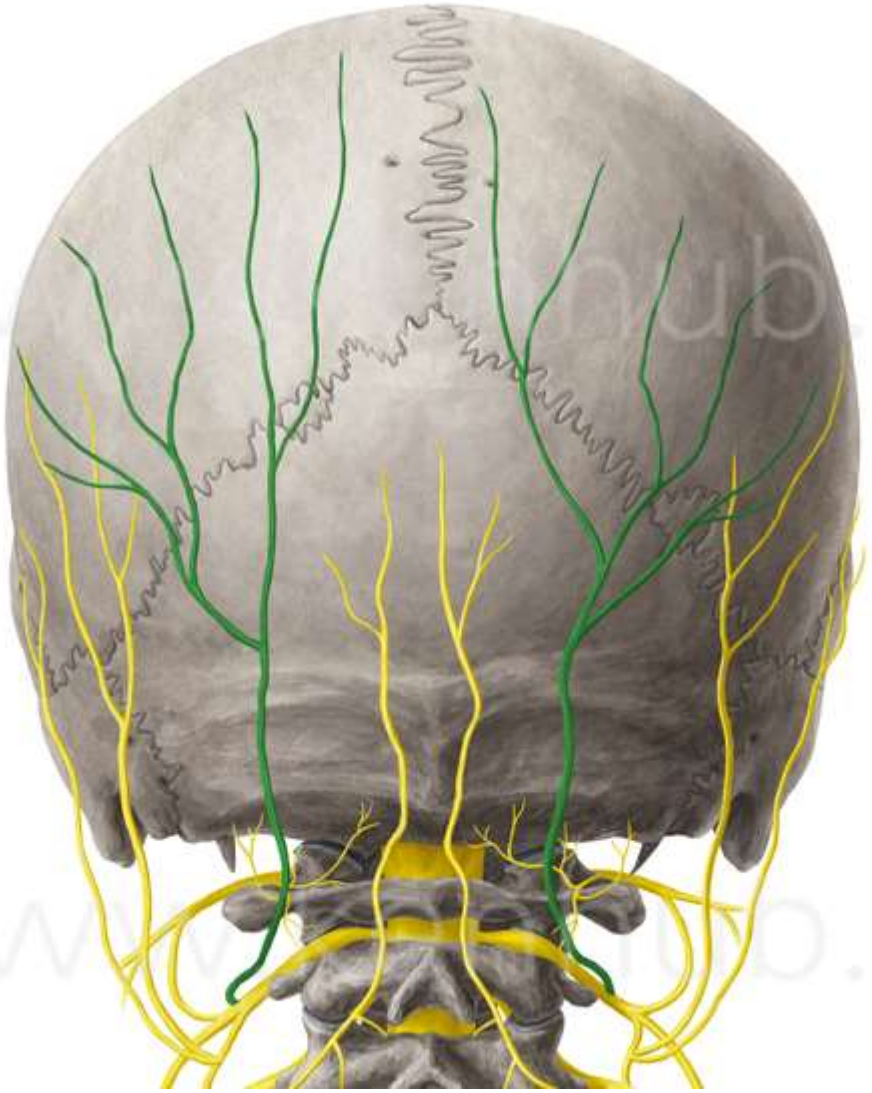

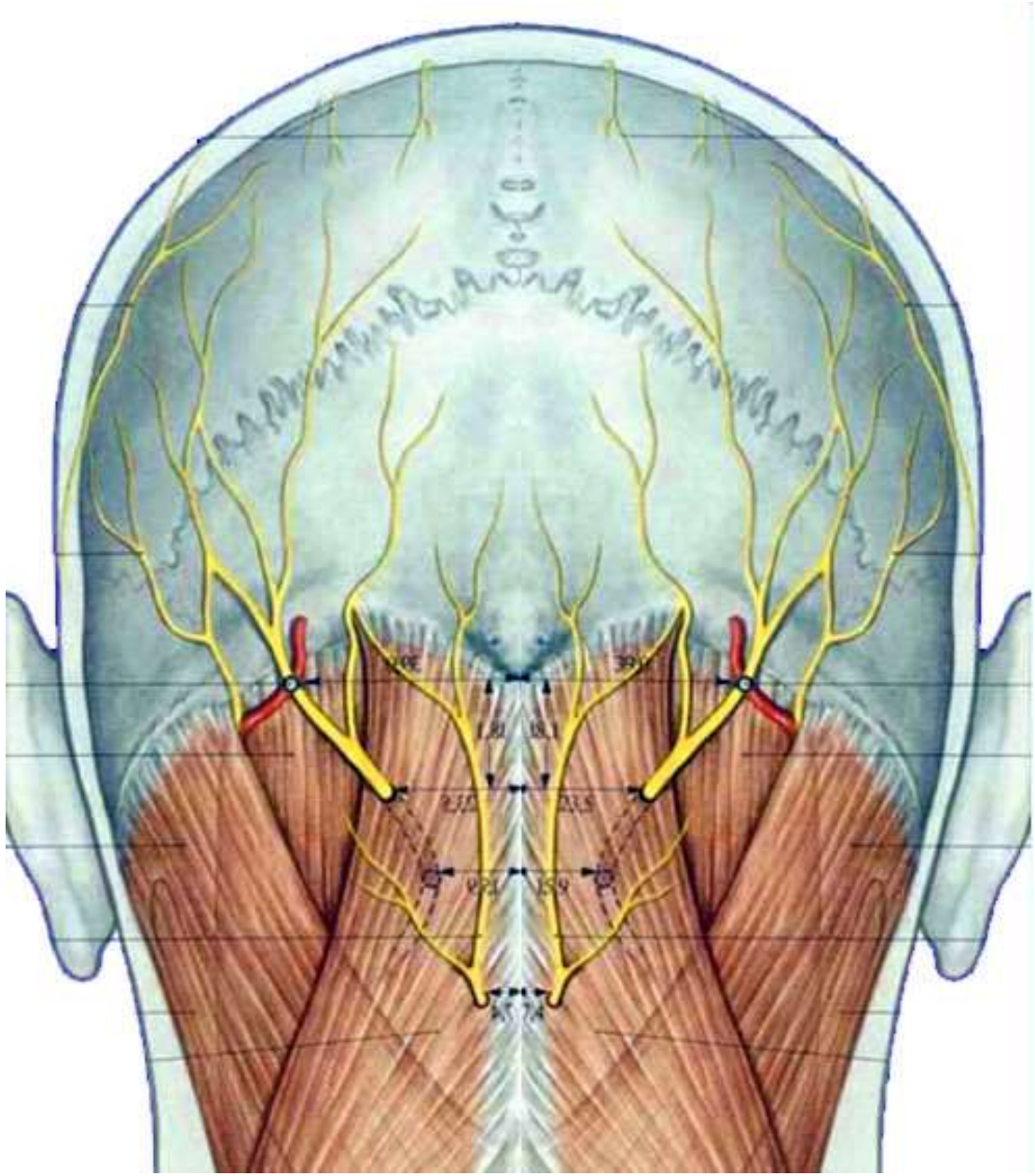

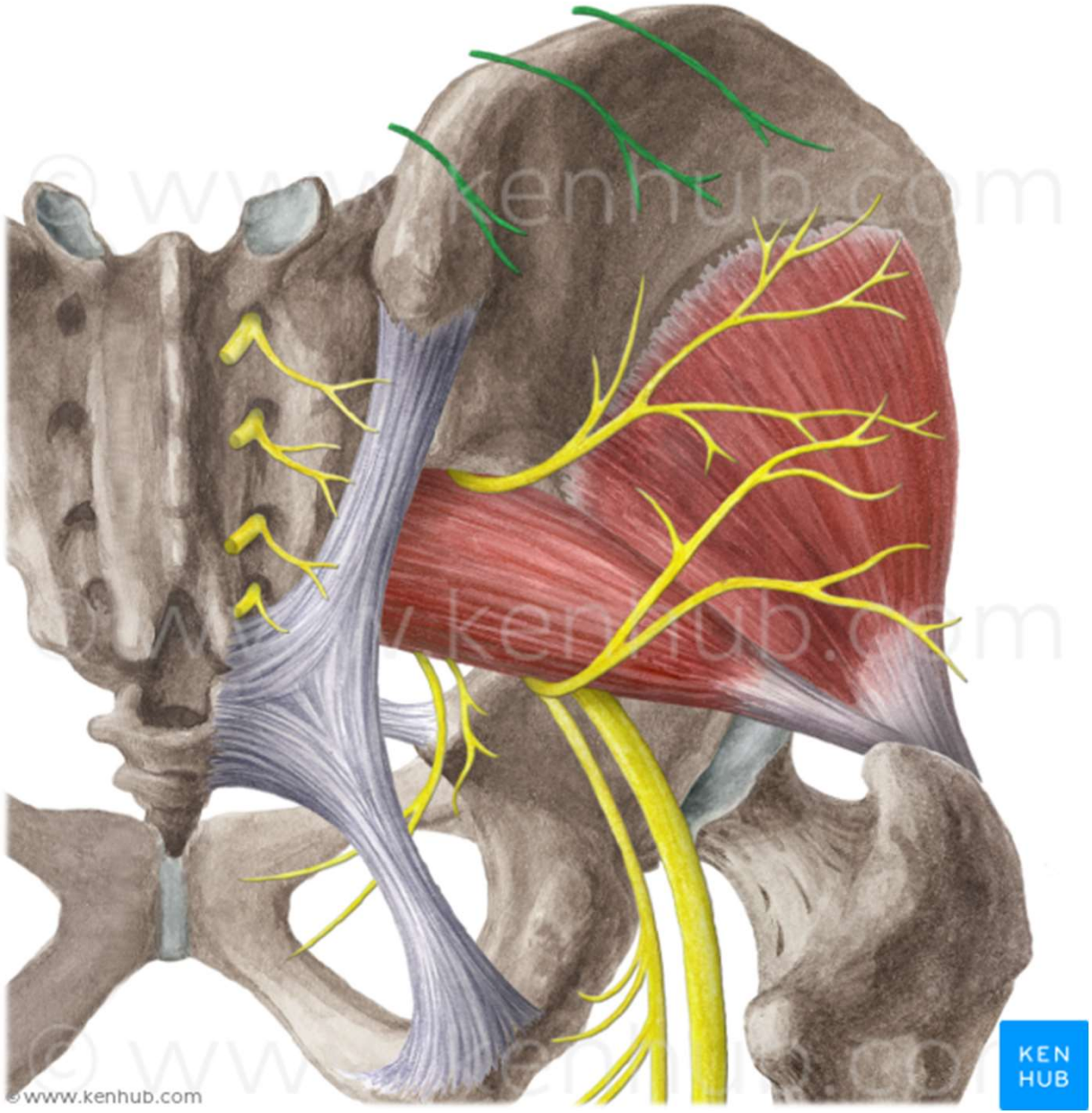
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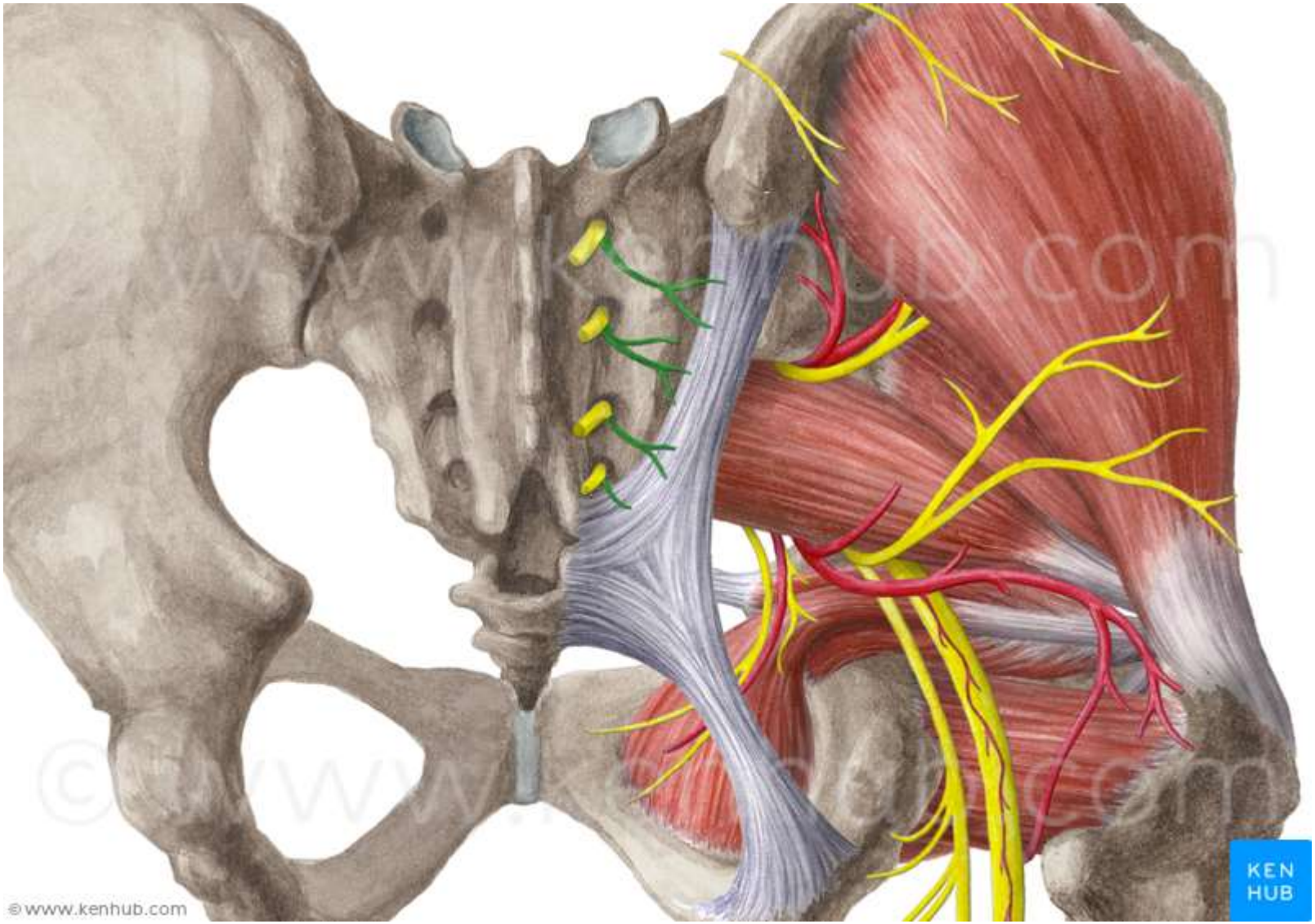
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The anterior branches (rami ventrales)

- They are longer and thicker branches of the spinal nerve
- **Function:** motor and sensory innervation of the anterior part of the trunk
- They do the motor innervation of the muscles of the anterior part of the trunk (neck except infrahyoid muscles, thorax, abdomen and pelvis) and the muscles of the limbs and the sensory innervation of the skin of the anterior part of the trunk and the limbs
- They have more complicated arrangement than the posterior branches of the spinal nerves, they lost the segmentation and created **nerve plexuses**):
- **Plexus cervicalis C1-C4**
- **Plexus brachialis C4-Th1**
- **Nervi thoracici Th1-Th12** (they keep segmental arrangement)
- **Plexus lumbalis Th12-L4**
- **Plexus sacralis L4-5,S1-5,Co**

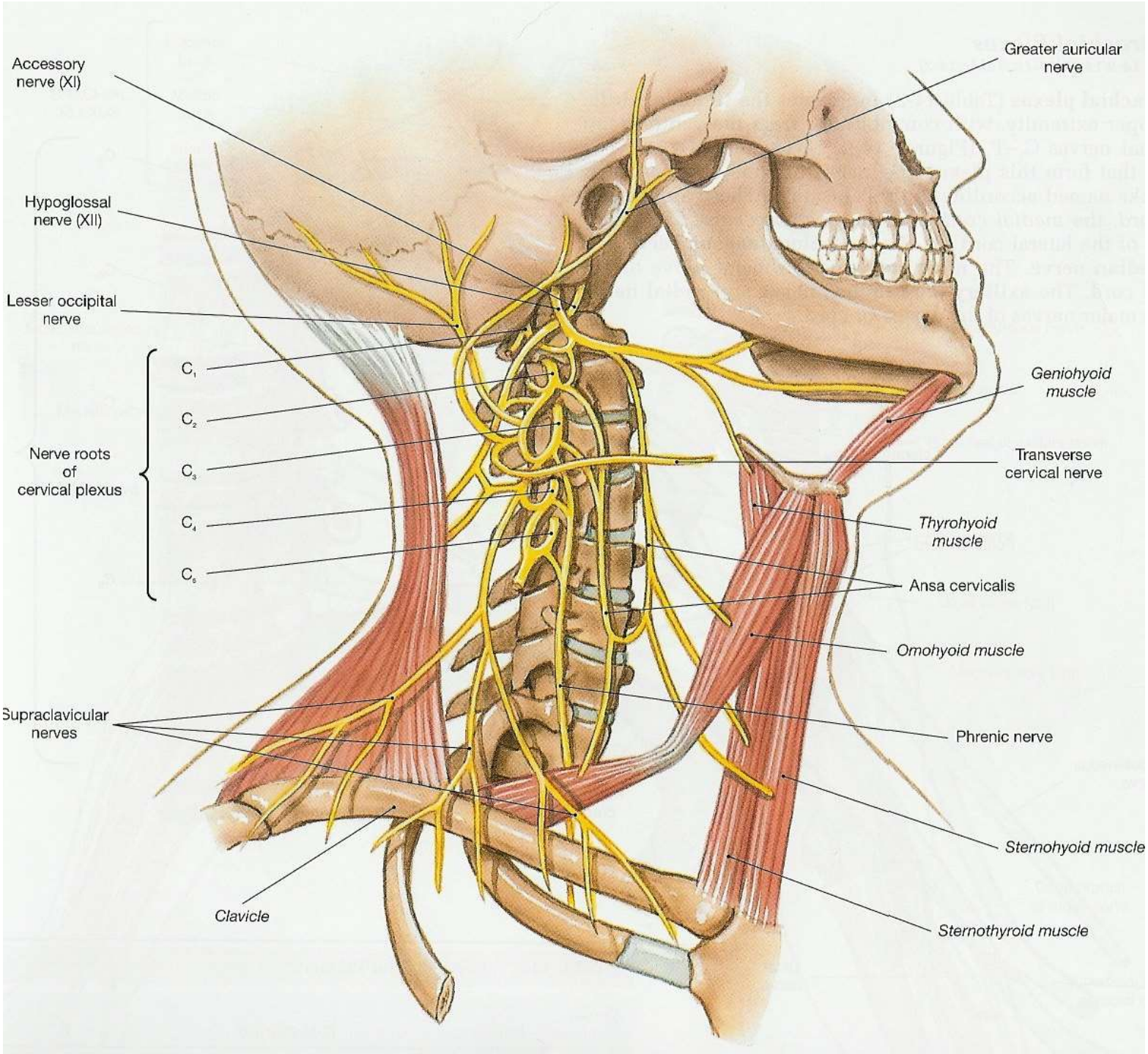
THE CERVICAL PLEXUS *(plexus cervicalis)*

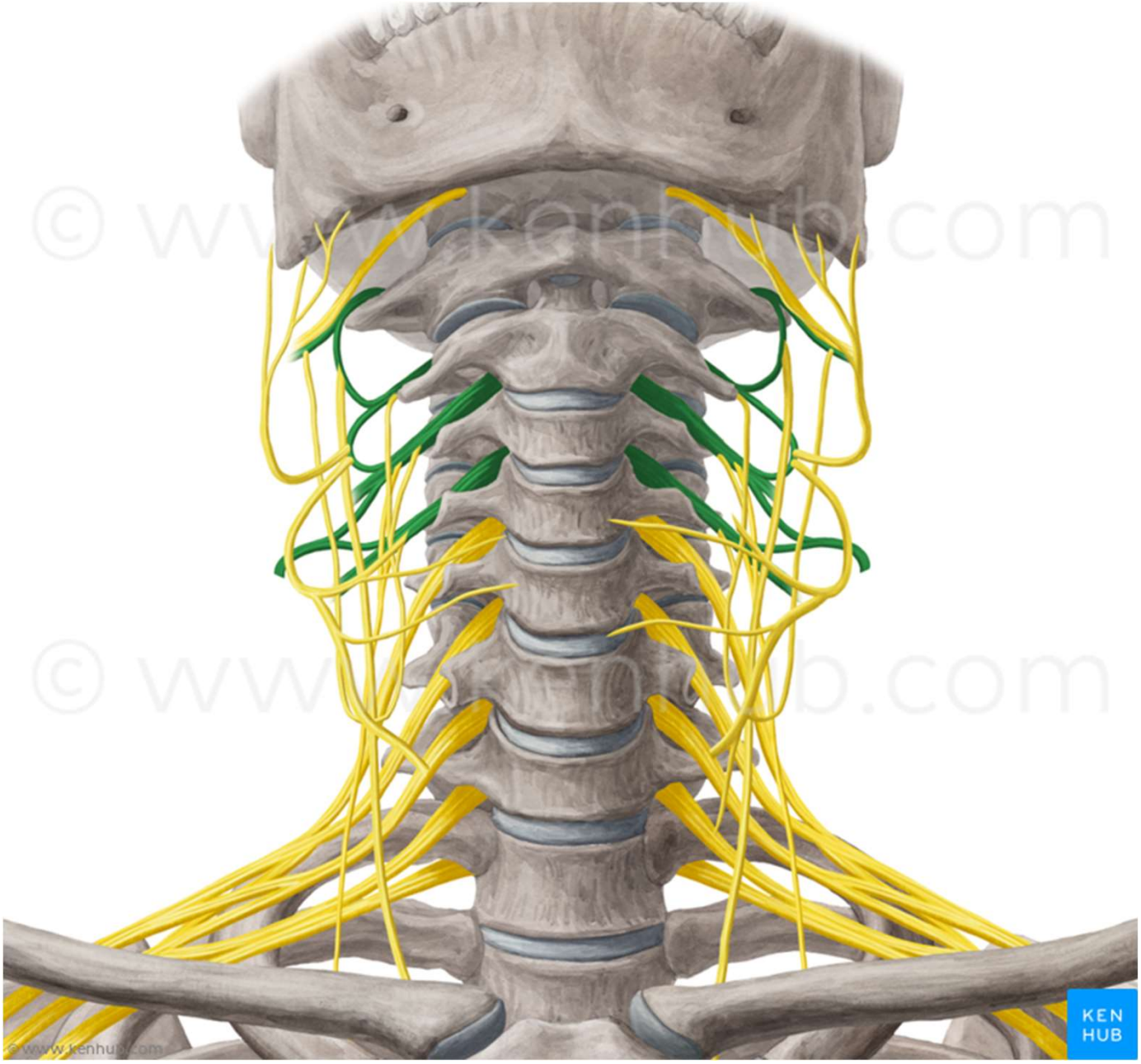
- It is created by the anterior branches of first four cervical nerves (C1 – C4)
- It is located sides the cervical vertabral column and several sensory, motor and mixed nerve rise from it. The particular nerves of the cervical plexus innervate:

Sensory innervation: the skin in the neck area, a part of the head and a part of upper extremity girdle

Motor innervation: neck muscles (**infrahyoid muscles**, **musculi scaleni** and **deep neck muscles** and **diaphragm**, which originates in the neck area during embryonic development)

- *suprahyoid muscles + m. sternocleidomastoideus + m. platysma are of gill origin an they are innervated by some cranial nerves, not cervical nerves*


Accessory nerve (XI)
Hypoglossal nerve (XII)
Lesser occipital nerve
Nerve roots of cervical plexus
C1
C2
C3
C4
C5
Supraclavicular nerves
Clavicle
Greater auricular nerve
Geniohyoid muscle
Transverse cervical nerve
Thyrohyoid muscle
Ansa cervicalis
Omohyoid muscle
Phrenic nerve
Sternohyoid muscle
Sternothyroid muscle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The cervical plexus

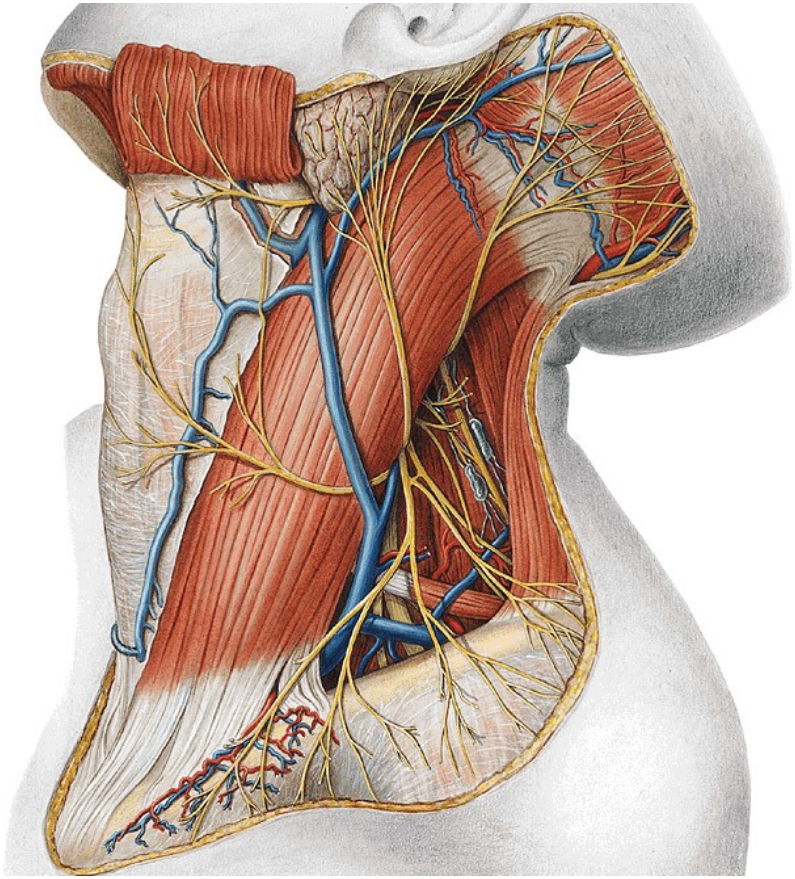
The sensory branches – they rise together by the posterior margin of m. sternocleidomastoideus – ***punctum nervosum sensitivum***:

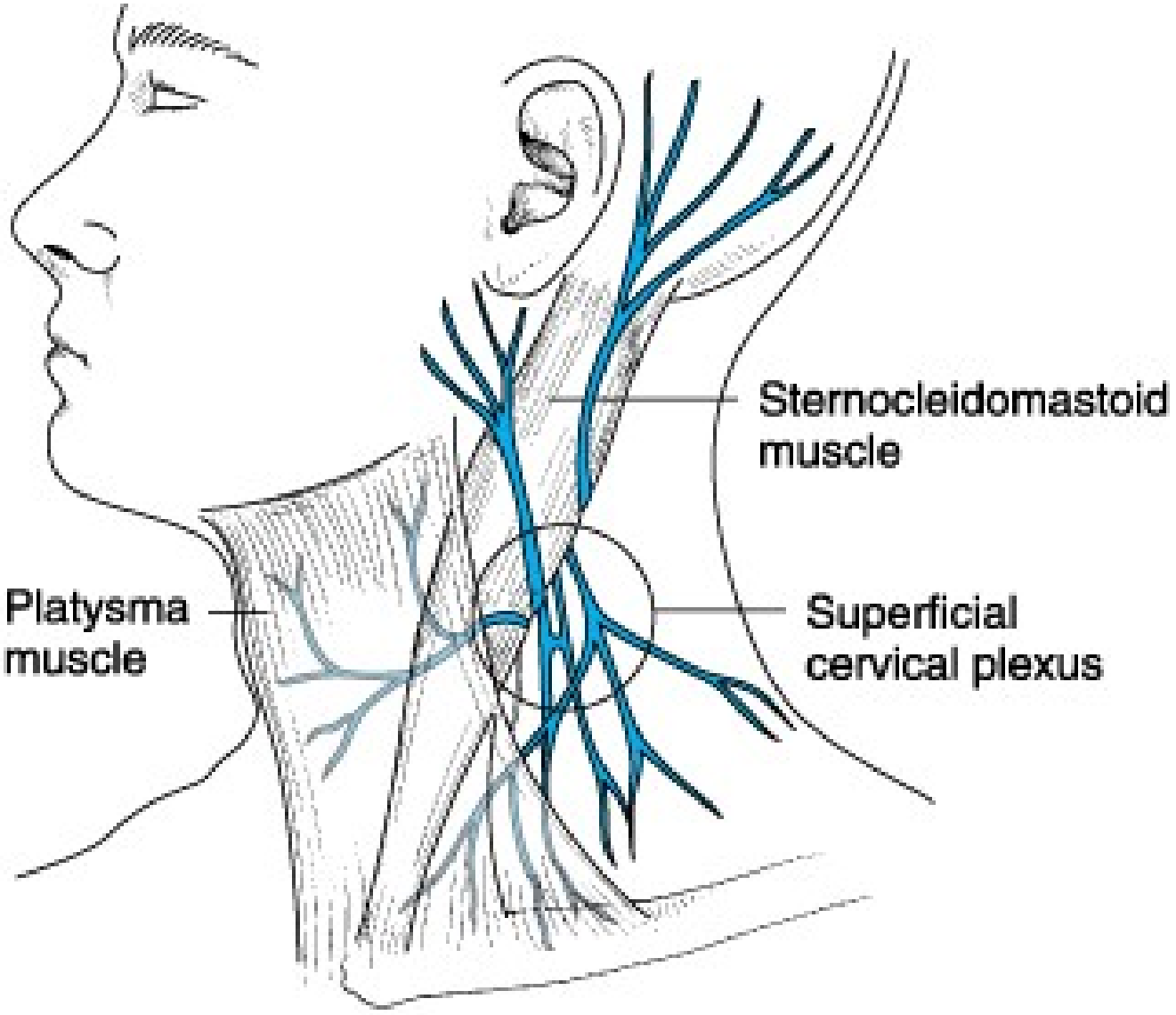
- **n. occipitalis minor (C2–3)**
- **n. auricularis magnus (C2-C3) ramus anterior et posterior**
- **n. transversus colli (C3)- rr. superiores et inferiores- ansa cervicalis superficialis**
- **nn. supraclaviculares (C3-4)**

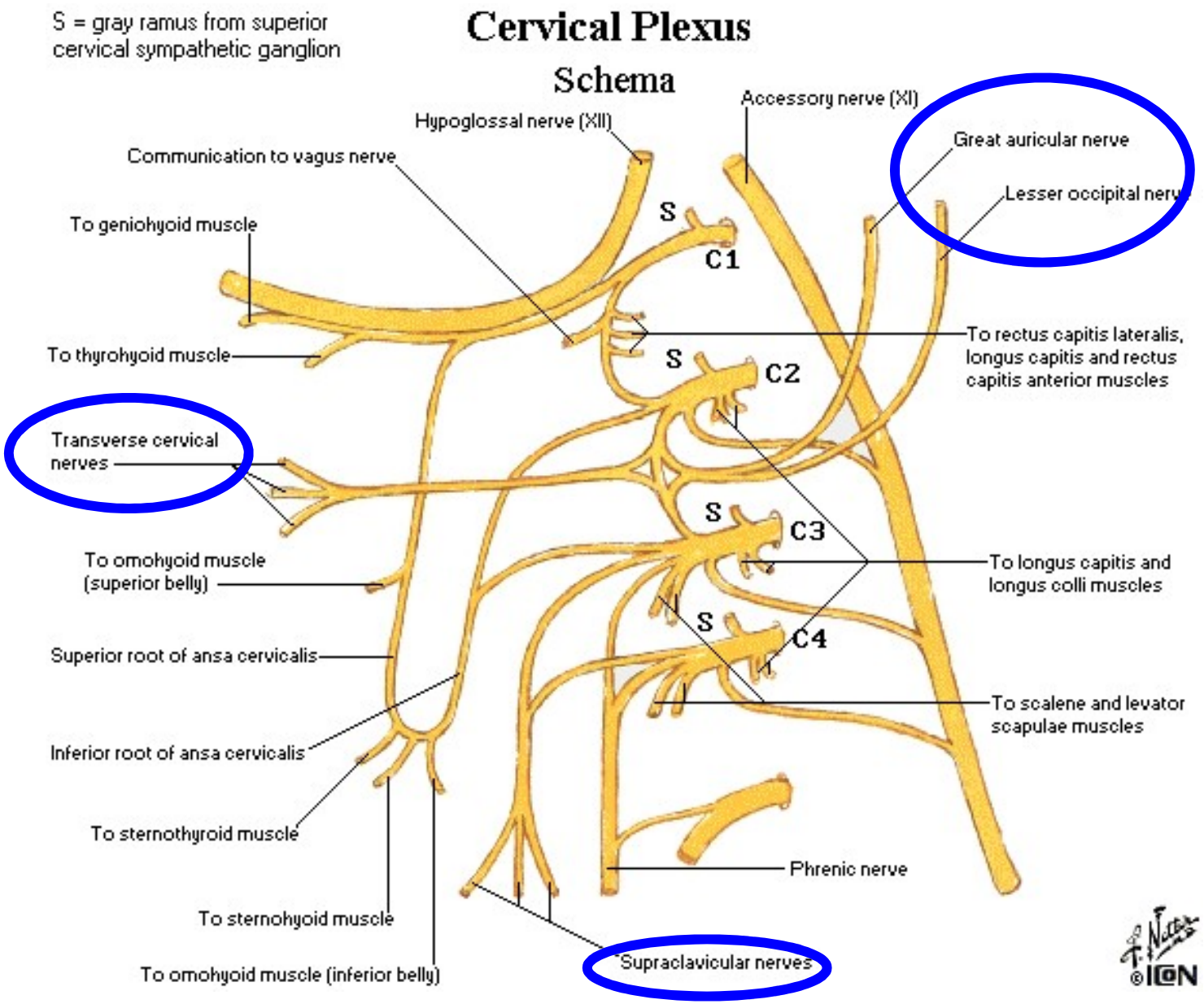
  mediales

  intermedii

  laterales






S = gray ramus from superior cervical sympathetic ganglion
Cervical Plexus
Schema
Accessory nerve (XI)
Hypoglossal nerve (XII)
Great auricular nerve
Communication to vagus nerve
Lesser occipital nerve
To geniohyoid muscle
S
C1
To rectus capitis lateralis, longus capitis and rectus capitis anterior muscles
To thyrohyoid muscle
S
C2
Transverse cervical nerves
S
C3
To omohyoid muscle (superior belly)
To longus capitis and longus colli muscles
S
C4
Superior root of ansa cervicalis
To scalene and levator scapulae muscles
Inferior root of ansa cervicalis
To sternothyroid muscle
Phrenic nerve
To sternohyoid muscle
Supraclavicular nerves
To omohyoid muscle (inferior belly)
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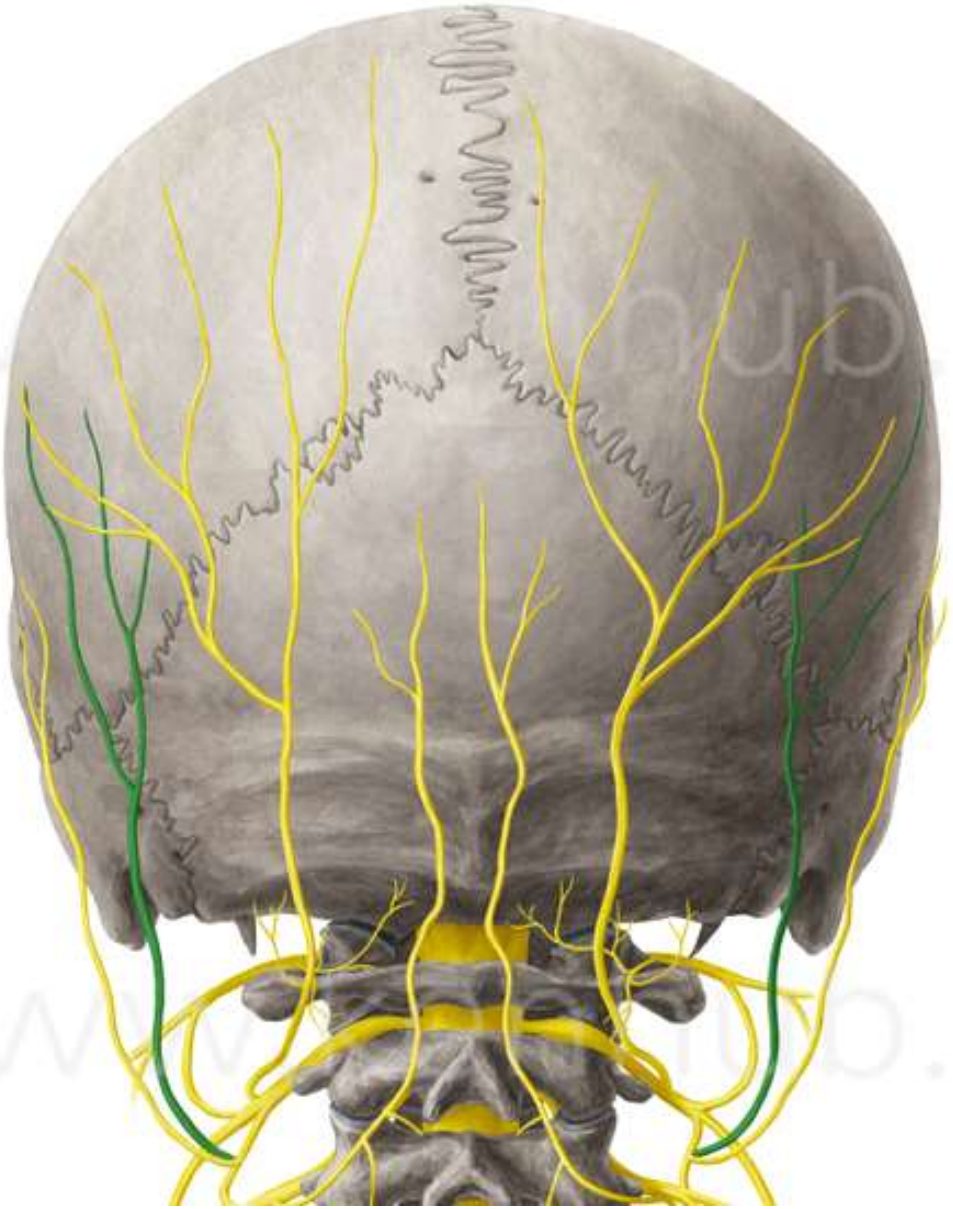

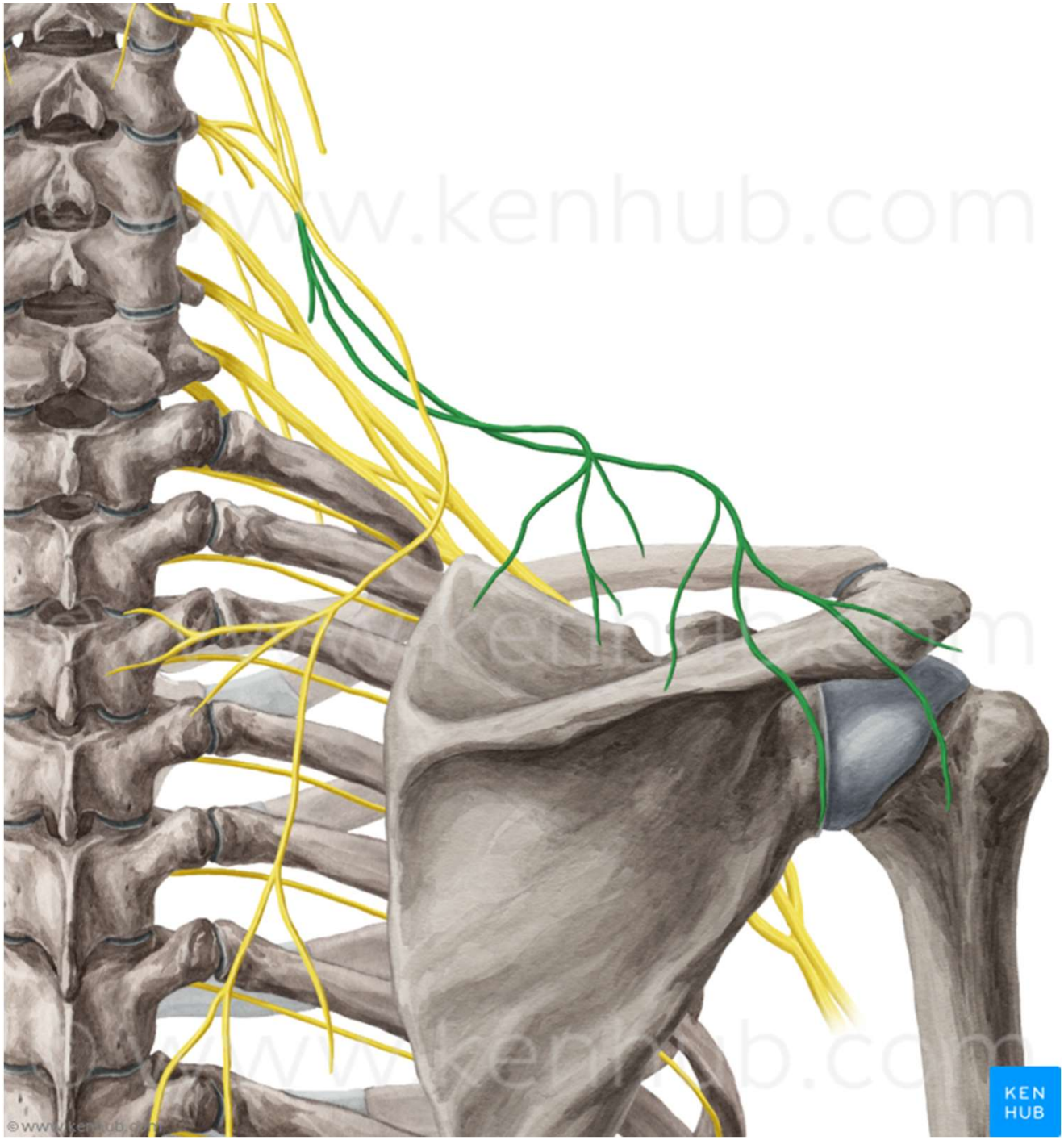

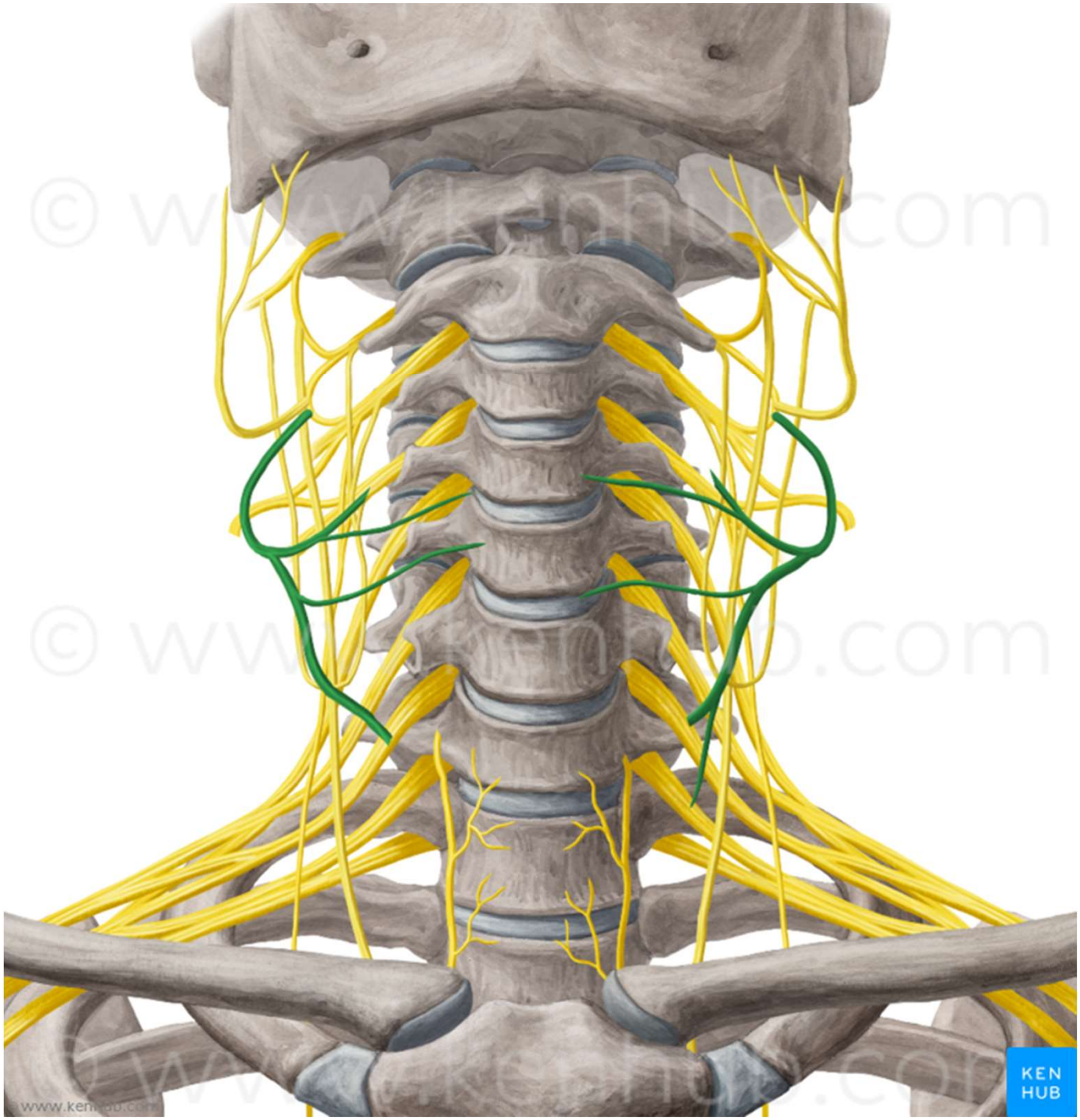
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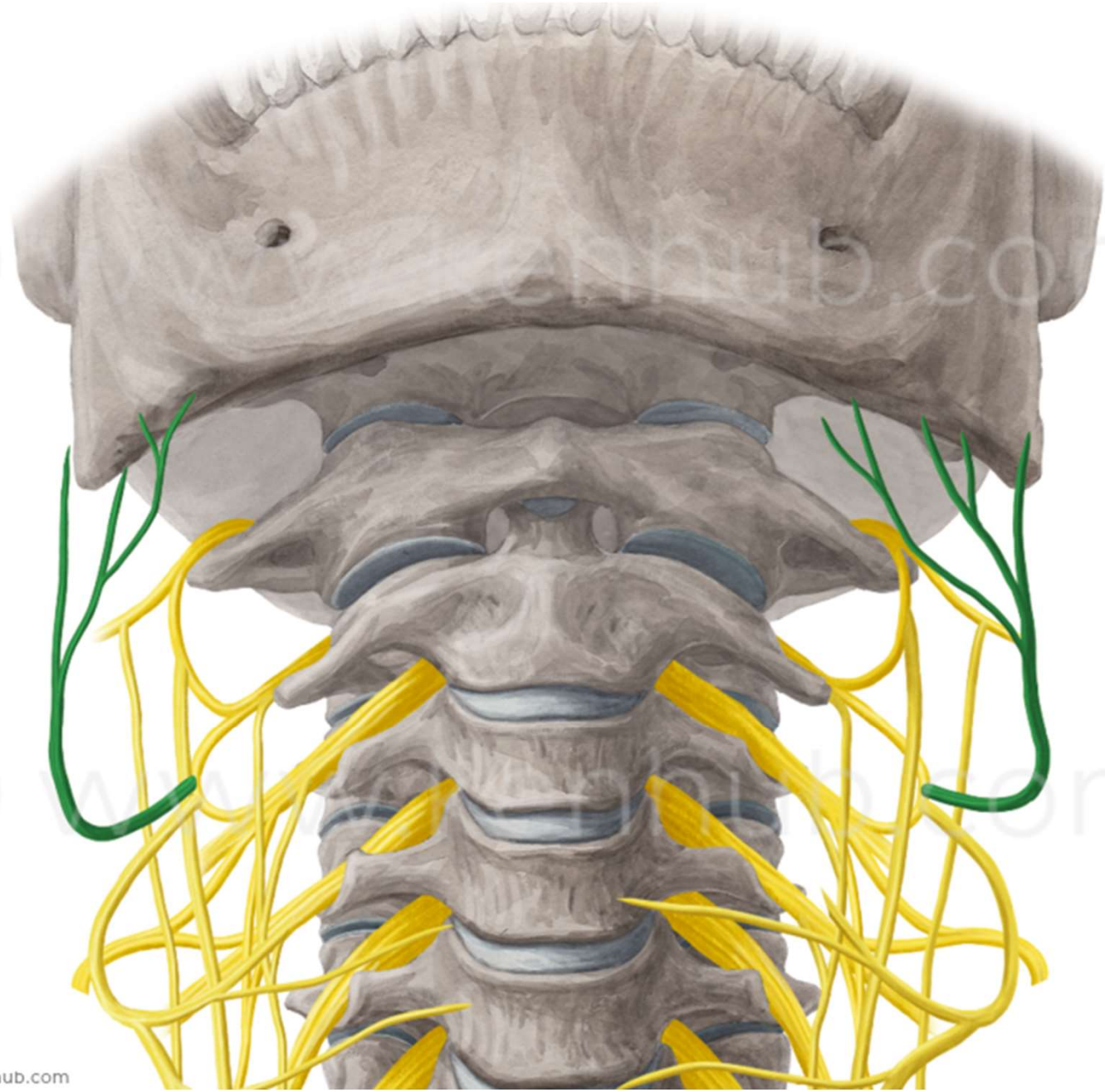
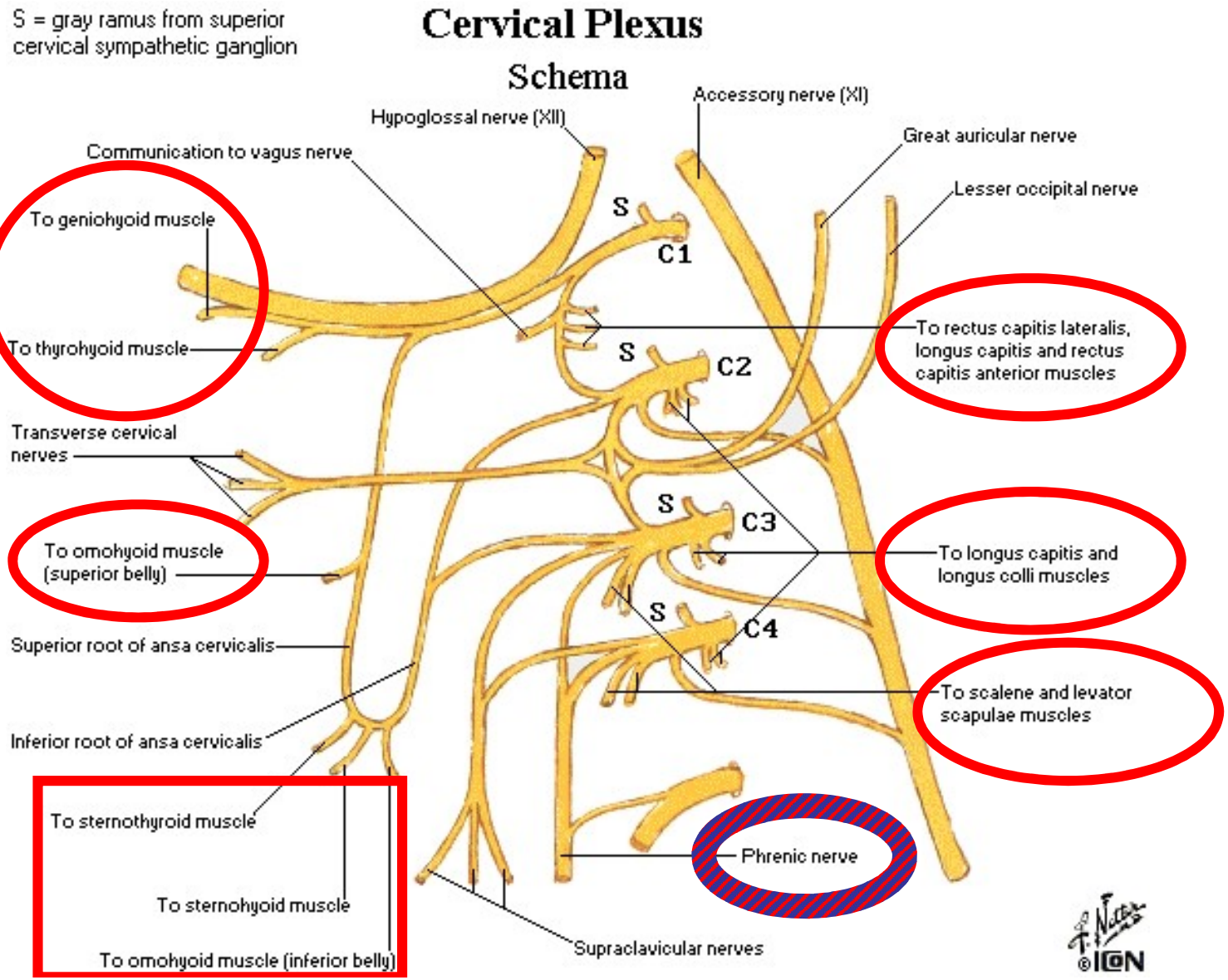
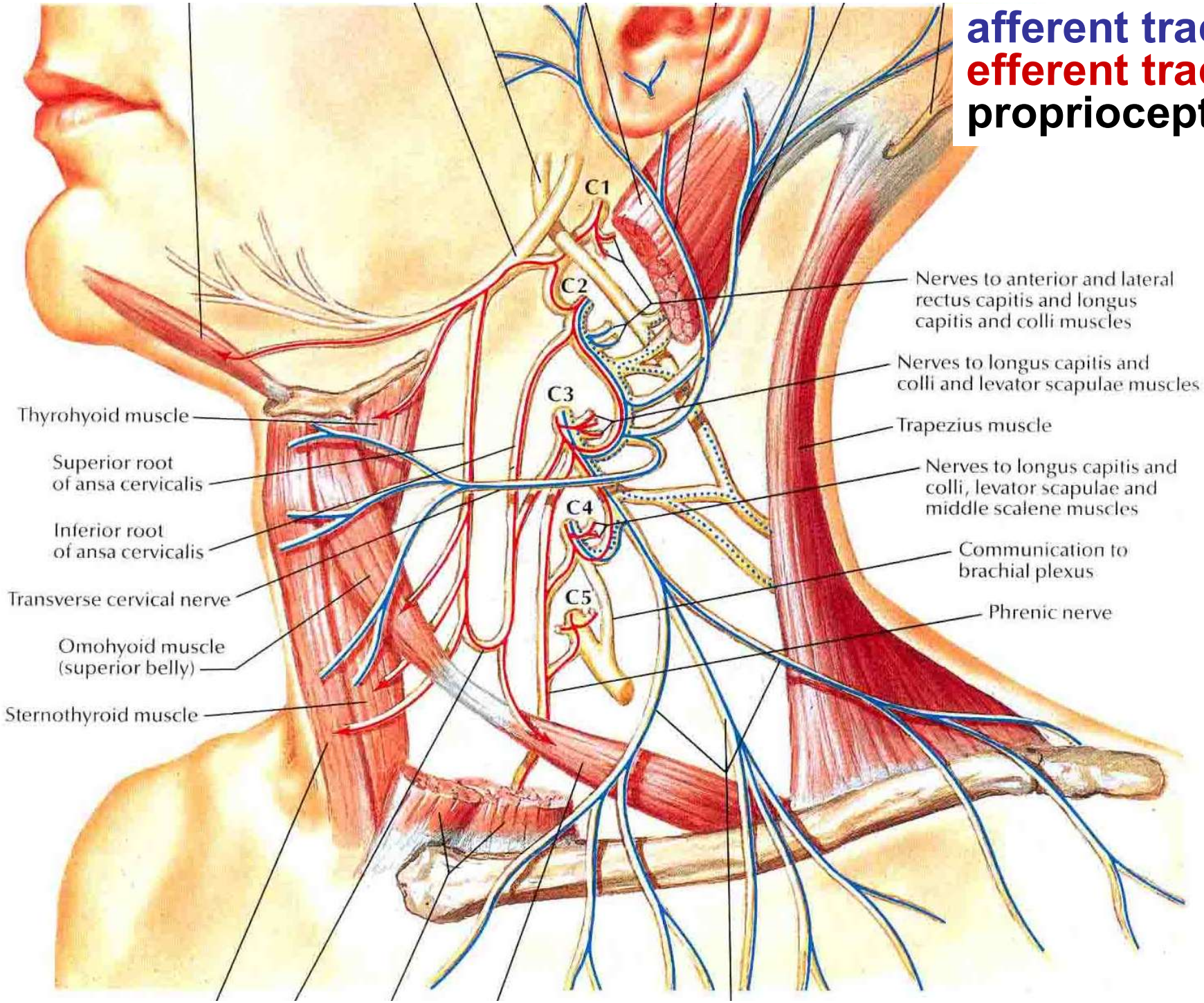


<u>The motor branches</u> – for pre- and intervertebral muscles, m. scalenus medius, m. sternocleidomastoideus, m. trapezius a m. levator scapulae



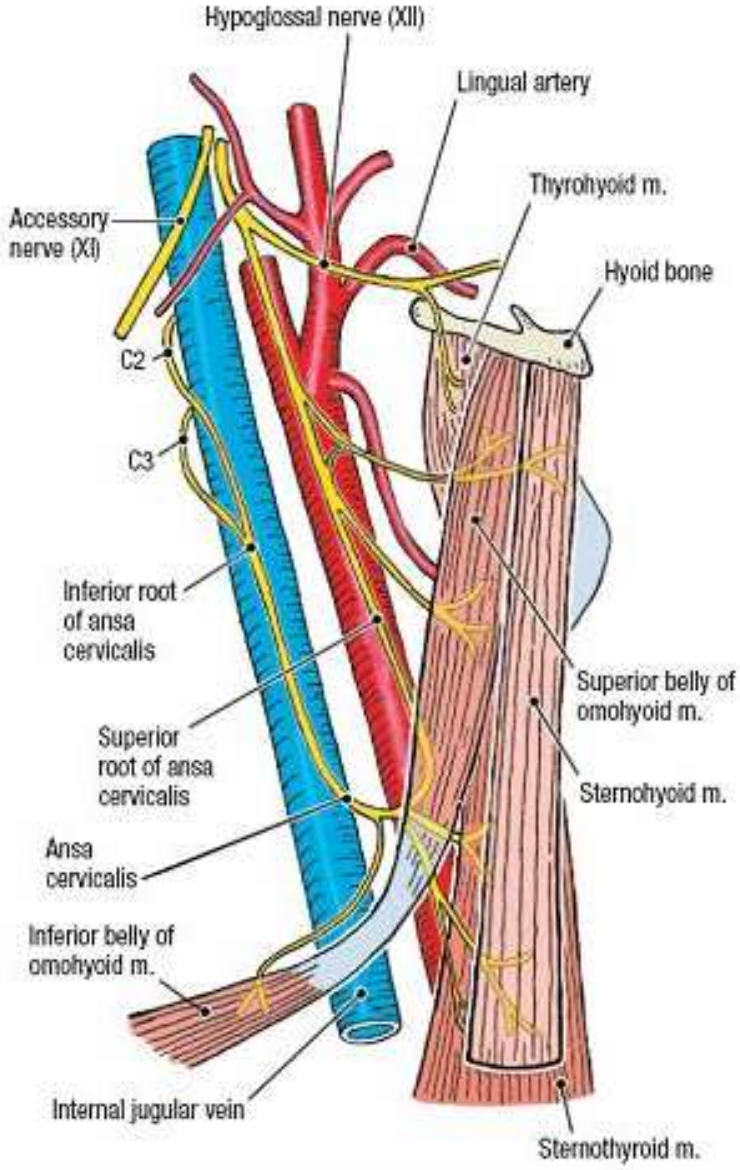
afferent tracts
efferent tracts
proprioception



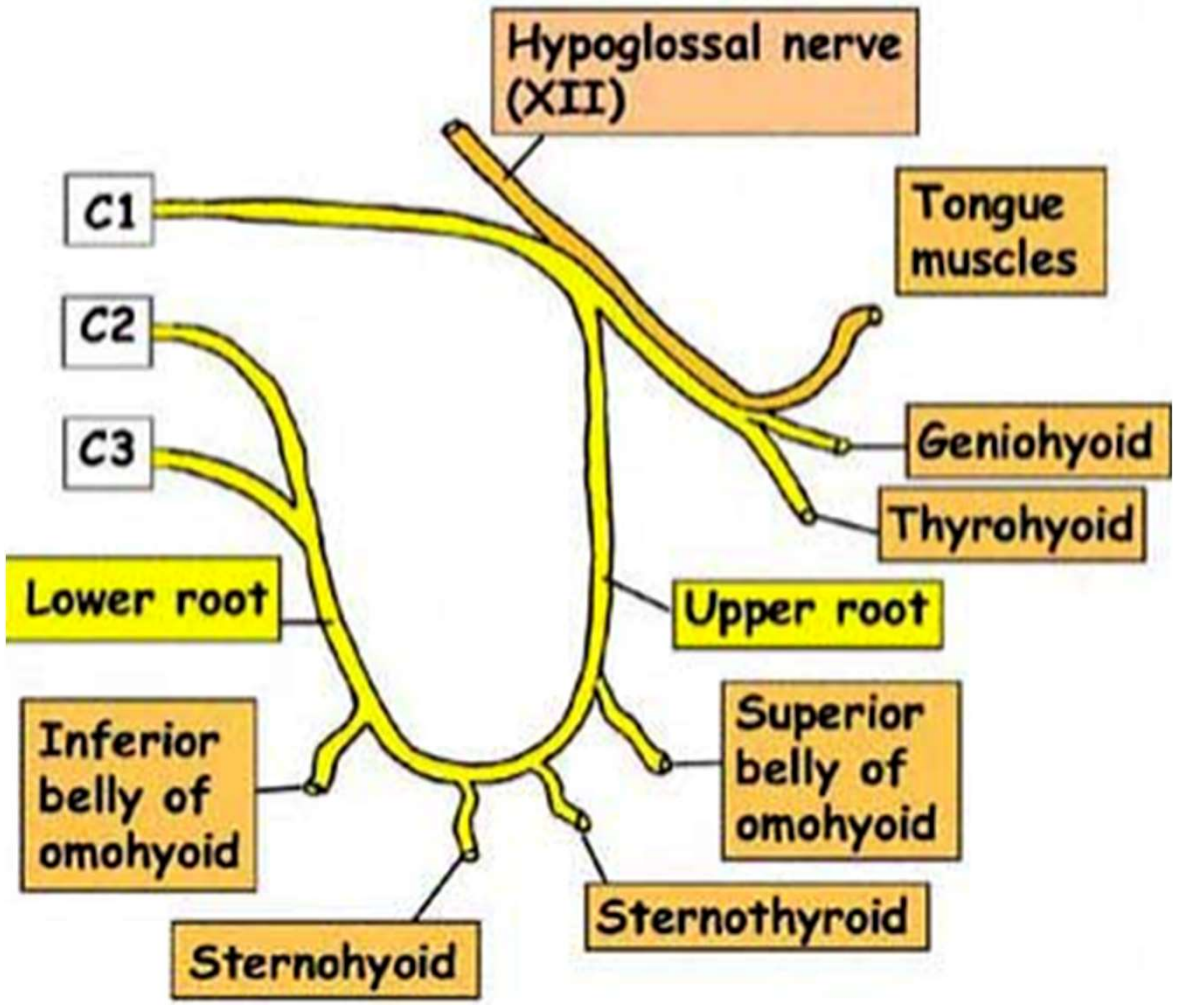
Ansa cervicalis (profunda) (C1–3) – (*ansa n. hypoglossi*) motor fibres for **infrahyoid muscles**, except *m. thyrohyoideus* (separate branch of n. thyrohyoideus)

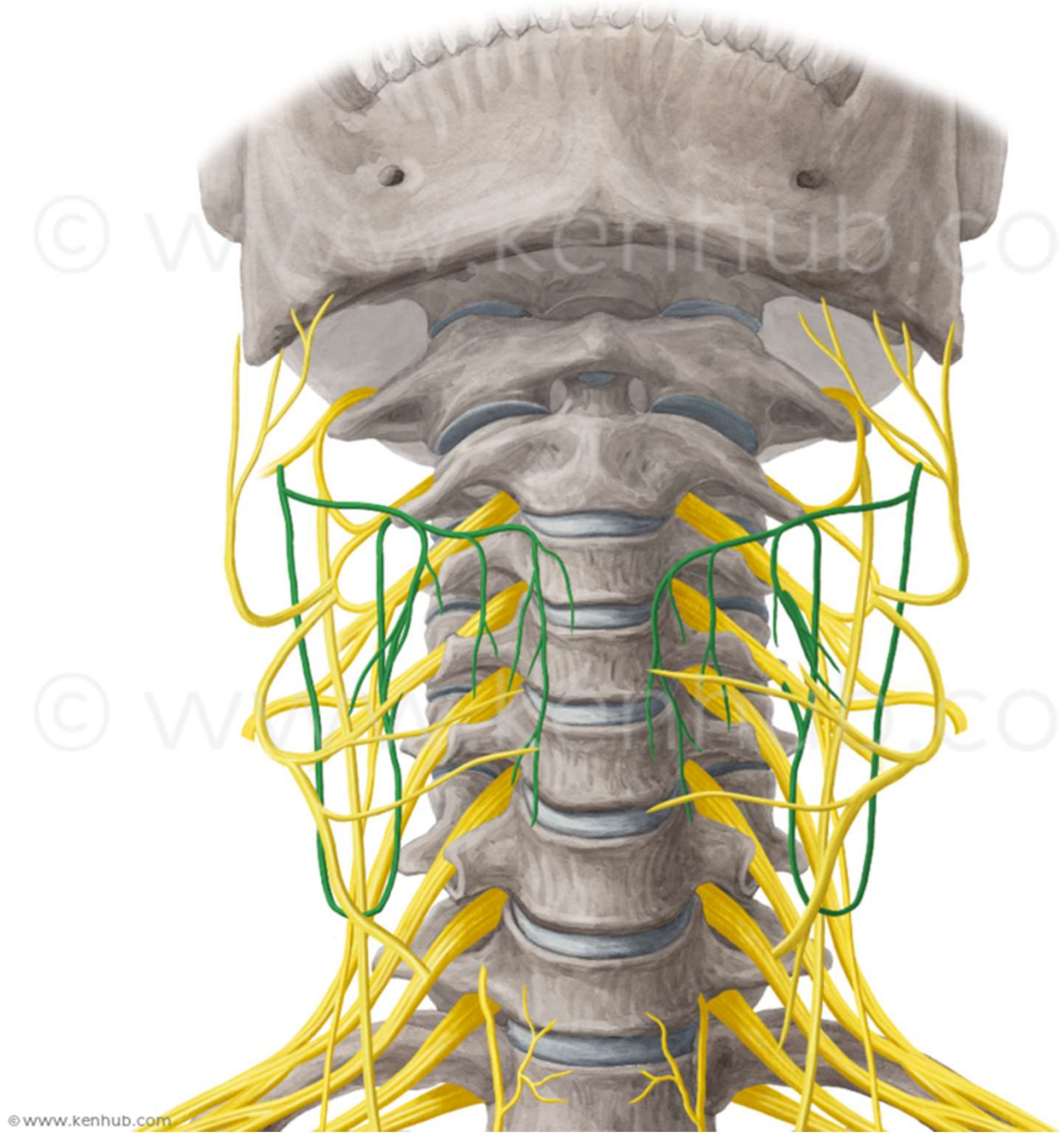
- ***radix sup.*** **(C1)** – joins n. hypoglossus and passes between a. carotis comm. and v. jugularis int.

- ***radix inf.*** **(C2–3)** - along v. jugularis int., above tendon of m. omohyoideus both roots connect and ansa (loop) is created



ANSA CERVICALIS





The mixed branches

n. phrenicus (C3–5)

- It divides on the inferior surface of the diaphragm – **rr. phrenicoabdominales** – motor innervation of the diaphragm, sensory innervation of the peritoneum, gall bladder, pancreas; **r. pericardiacus** – sensory innervation of the pericardium and adjacent part of pleura

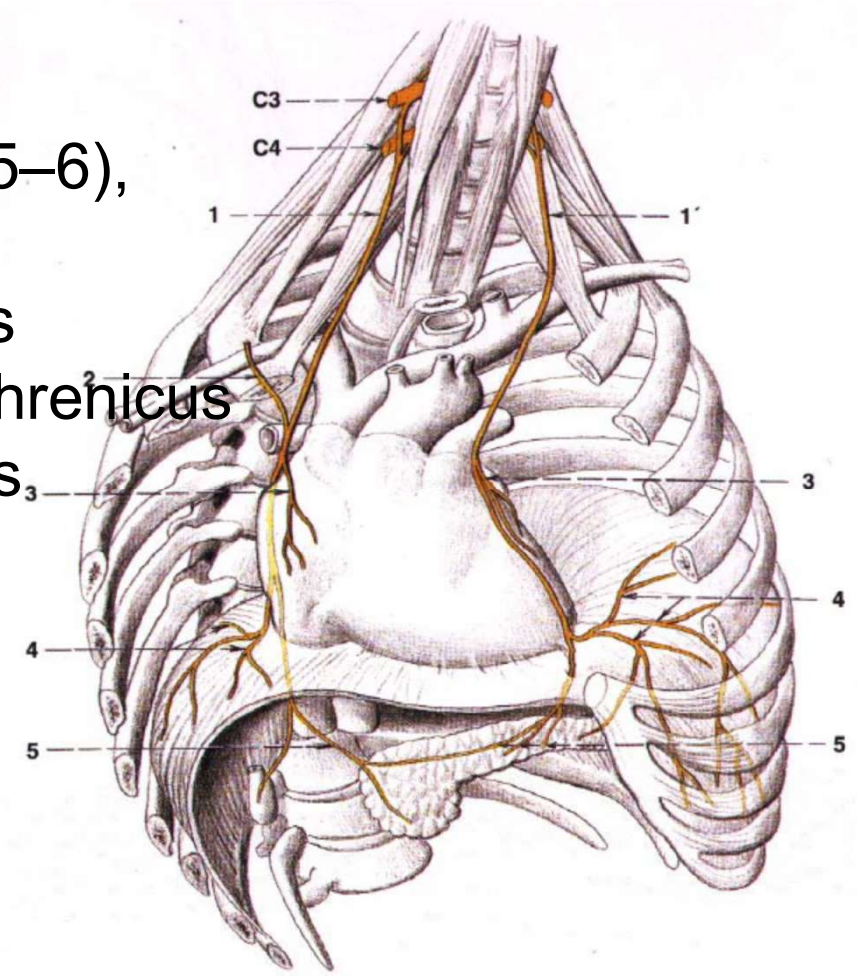
nn. phrenici acc. – accessory fibres

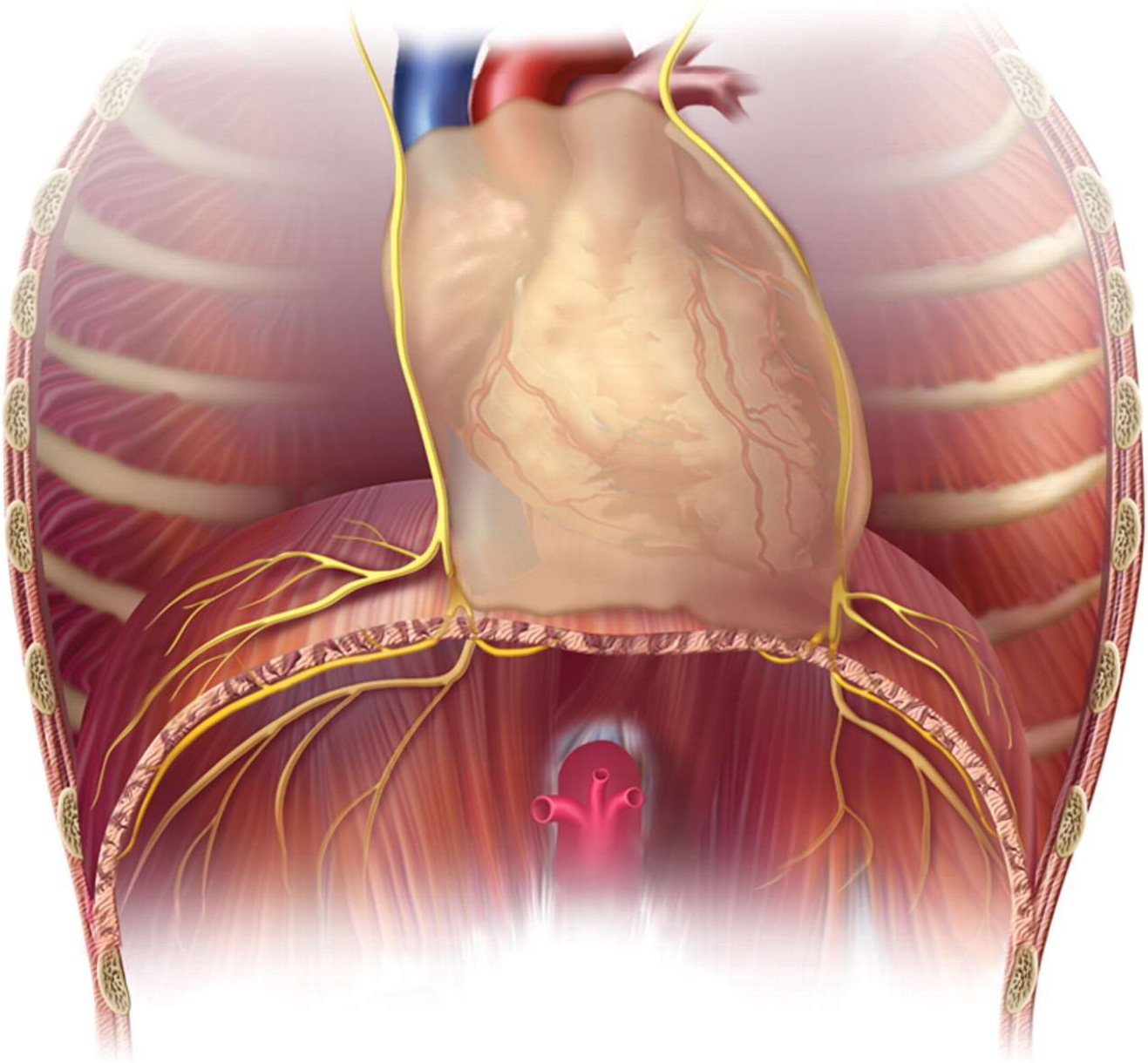
a) directly from plx. brachialis (C5–6),

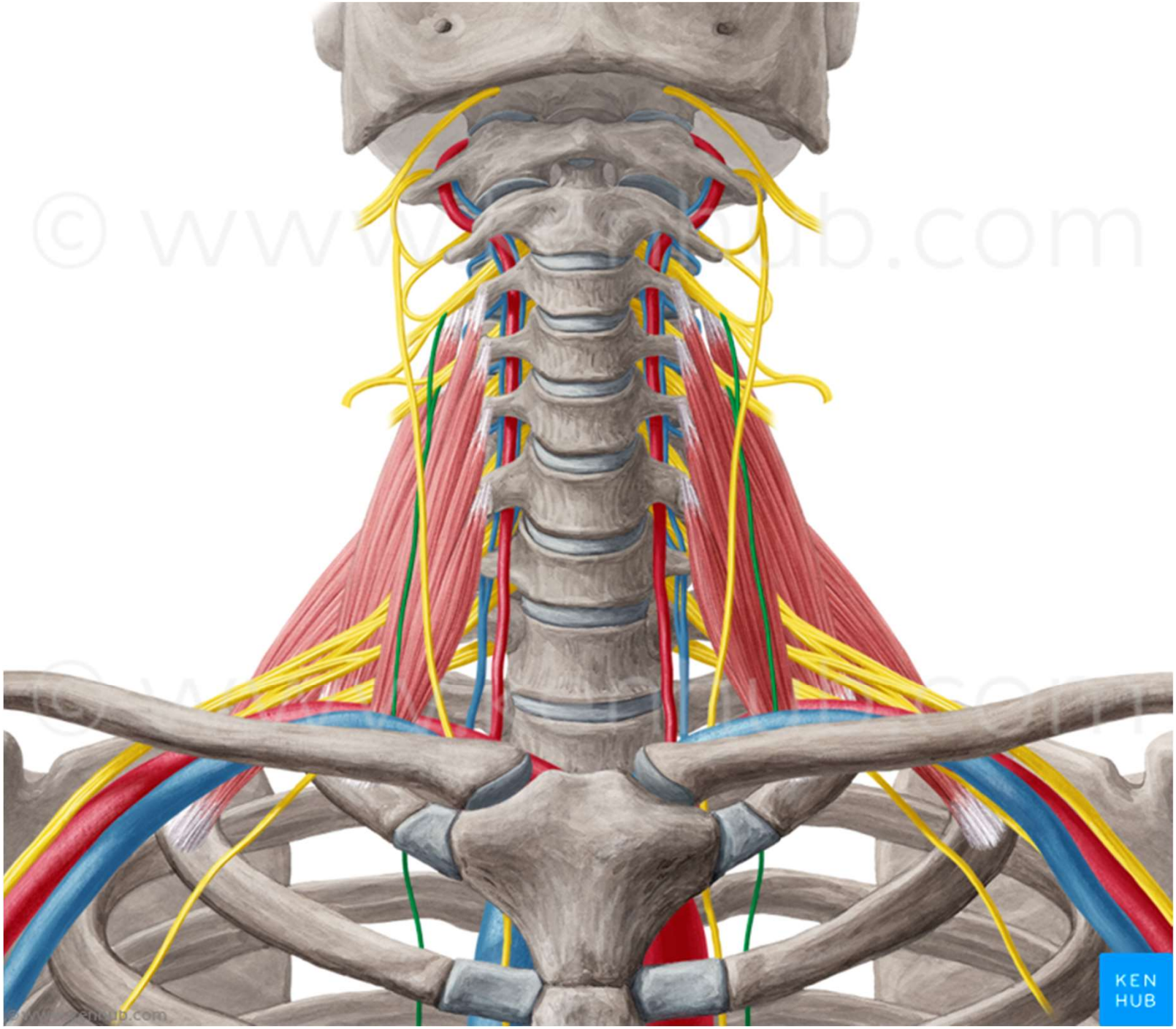
b) through n. subclavius

c) friom radix inf. ansae cervicalis

- They can substitute typical n. phrenicus
- Irritation of the nerve – singultus (hiccup)



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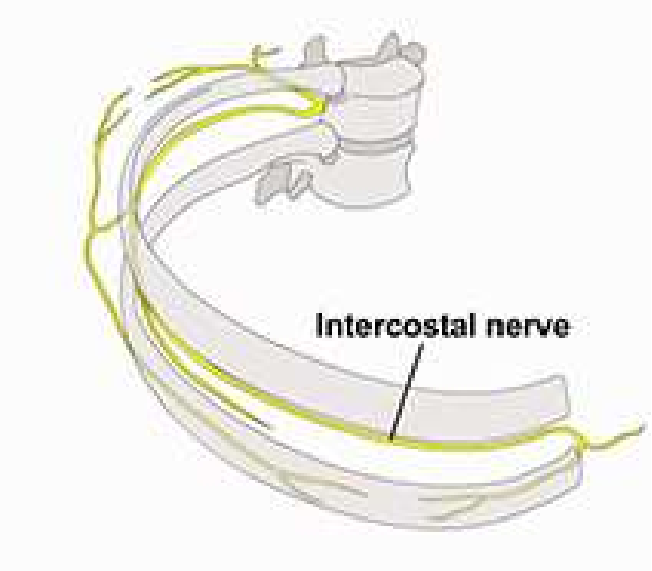
THE THORACIC NERVES *(nervi intercostales)*

- They keep segmental arrangement, don´t form plexuses, pass within intercostal spaces from behinf forward together with the intercostal vessels (within sulcus costae on the inferior margin of the rib)
- 1. – 6. toward the sternum, 7. – 12. toward the anterior abdominal wall

  they innervate:
- ***Sensory i.:*** skin of thorax and abdomen and parietal sheet of pleura and peritoneum
- ***Motor i.:*** proper thoracic (intercostal) muscles and anterior and lateral group of abdominal muscles



Nn. thoracici Th1-12

- **Don´t form plexuses**

  nn. intercostales

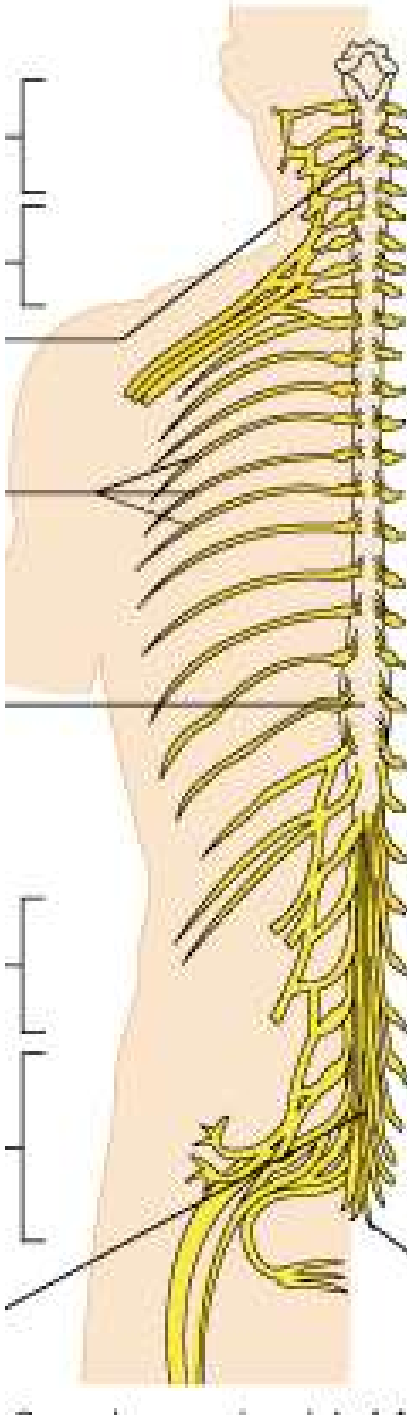
  n. subcostalis

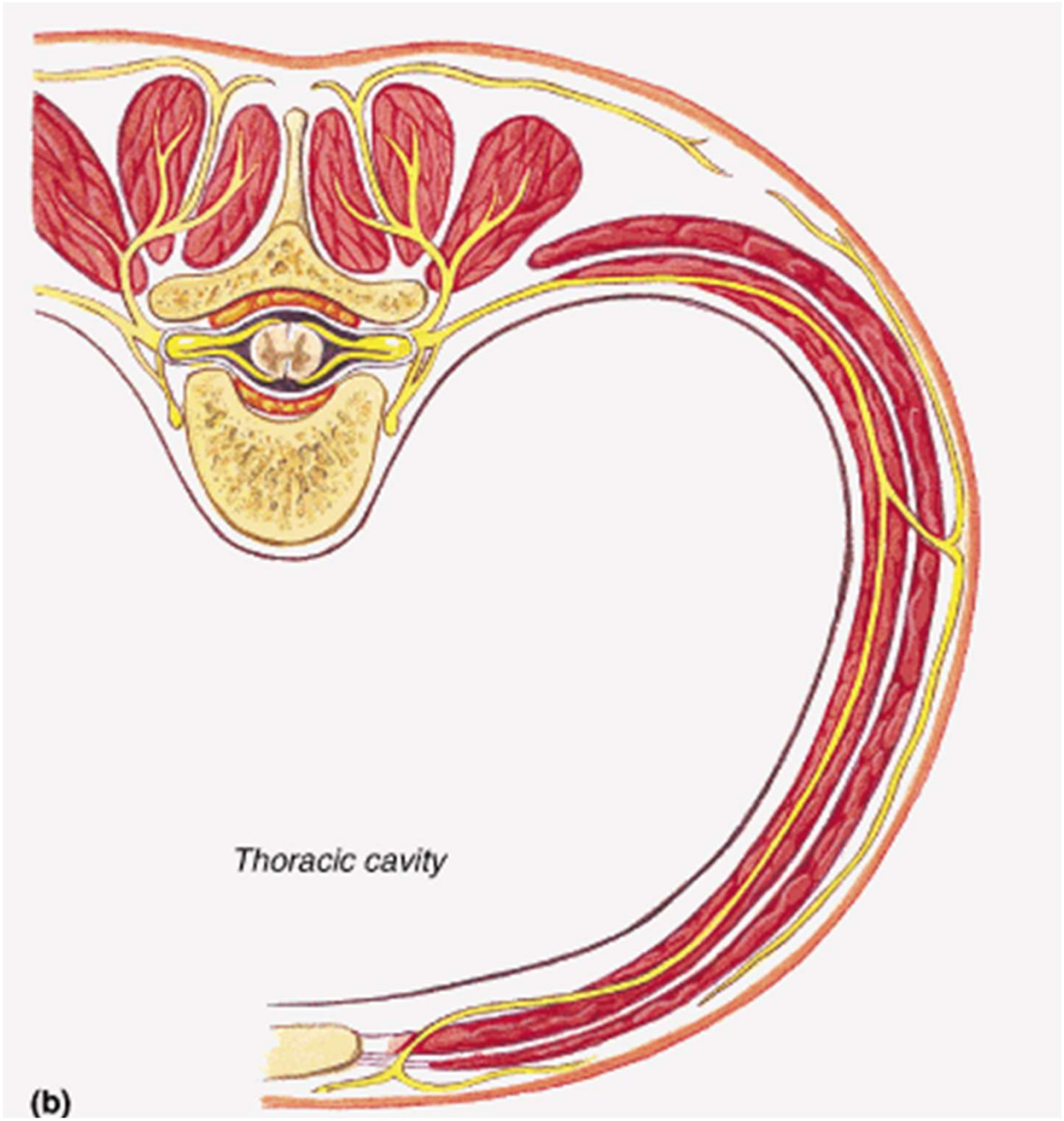
- **rr. musculares** (autochtone muscles of thorax)
- **rr. cutanei- laterales- nn. intercostobrachiales**

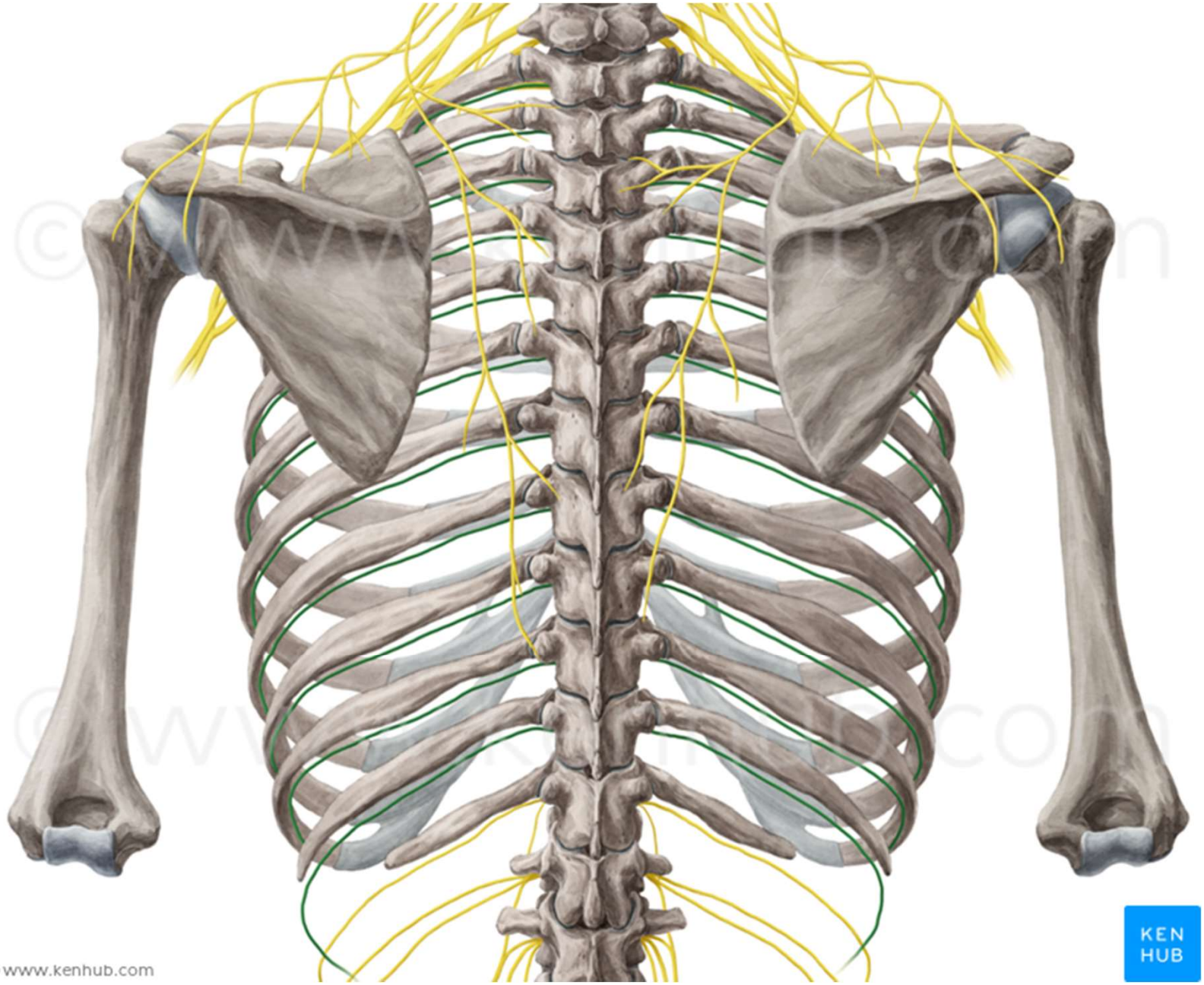
  - anteriores (by the sternal margin)

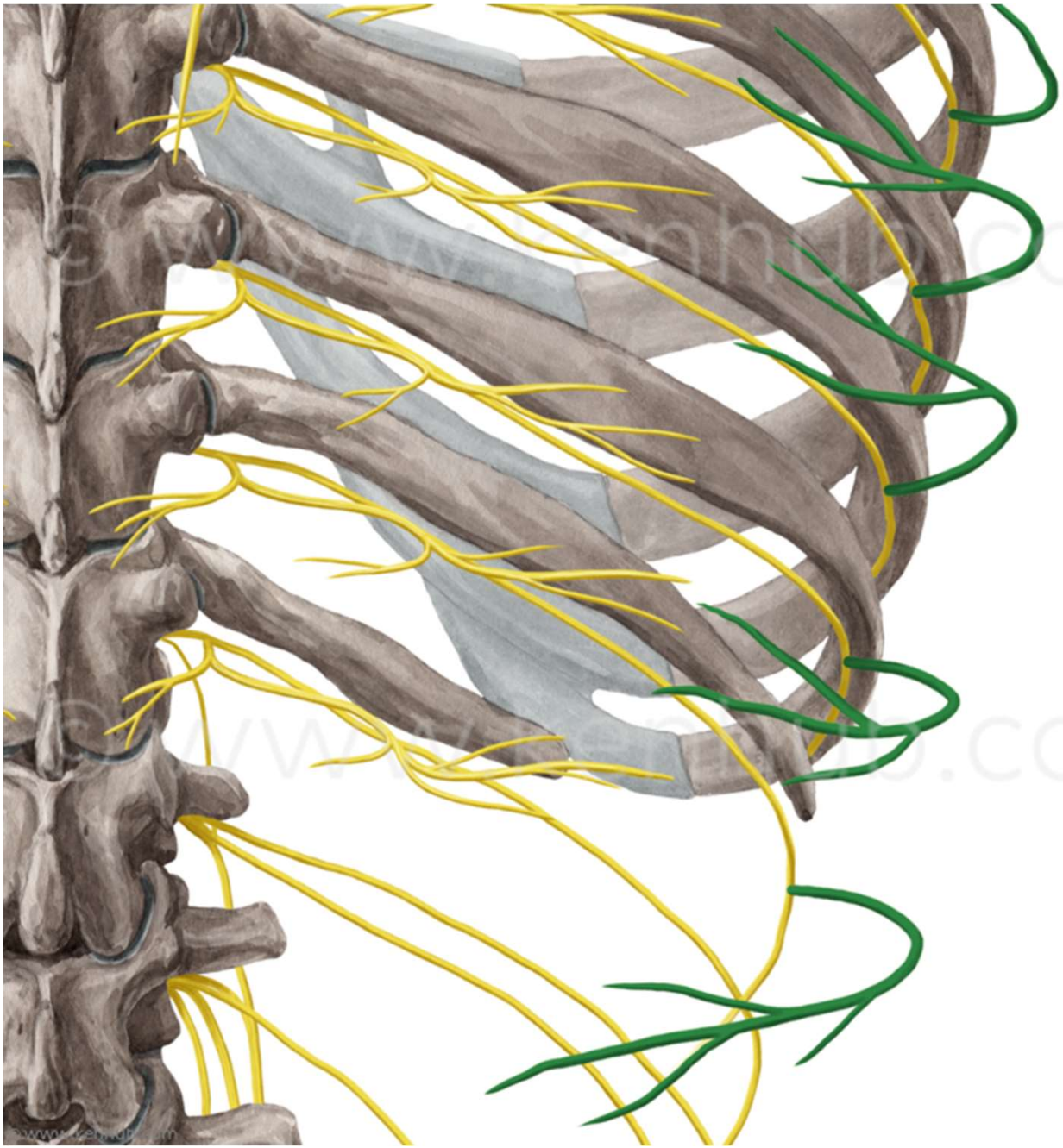
  Skin of thorax and abdomen
- **rr. pleurales**

from Th1- strong connection into plexus brachialis (nervus intercostobrachialis)



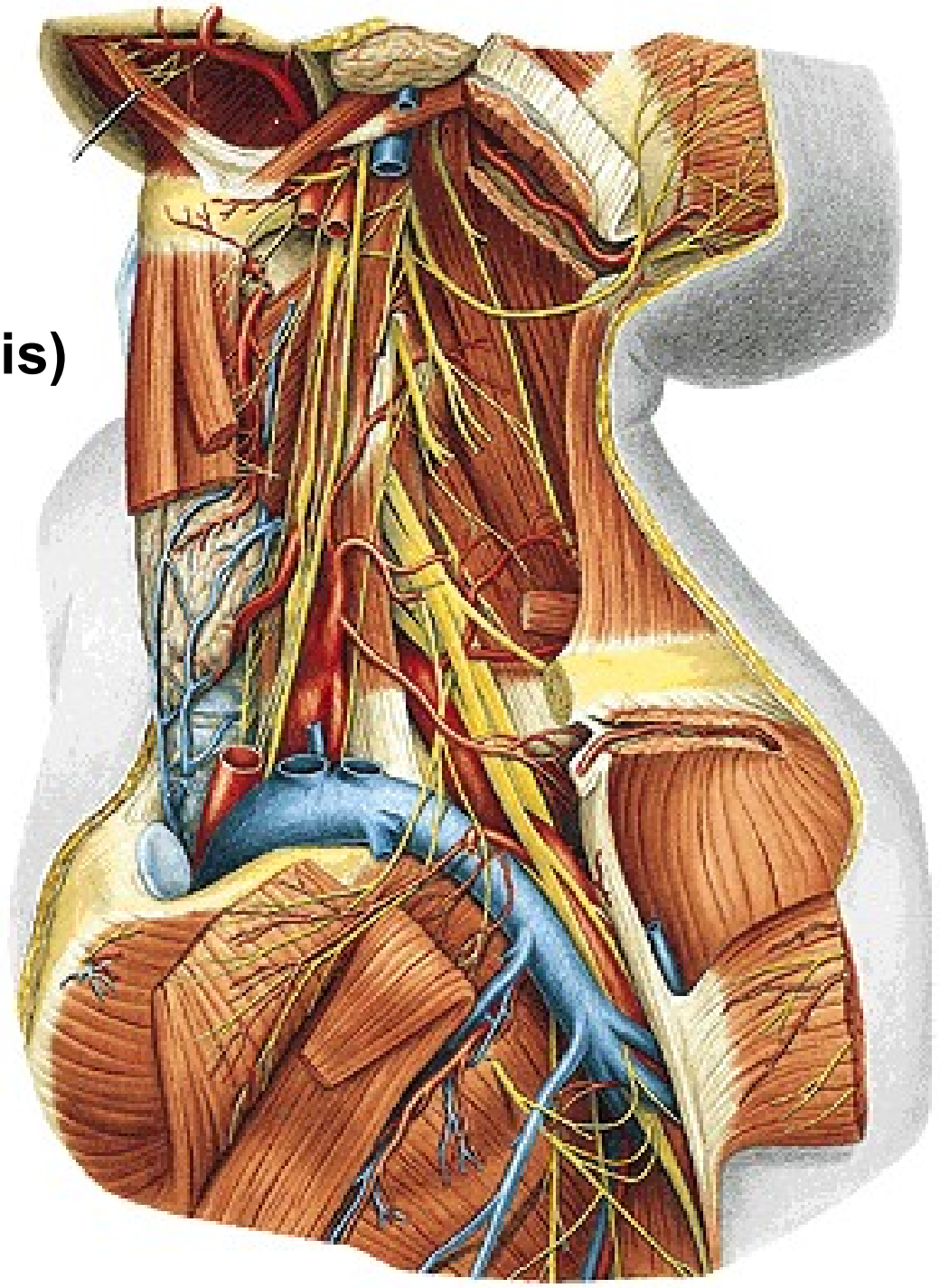

Thoracic cavity
(b)

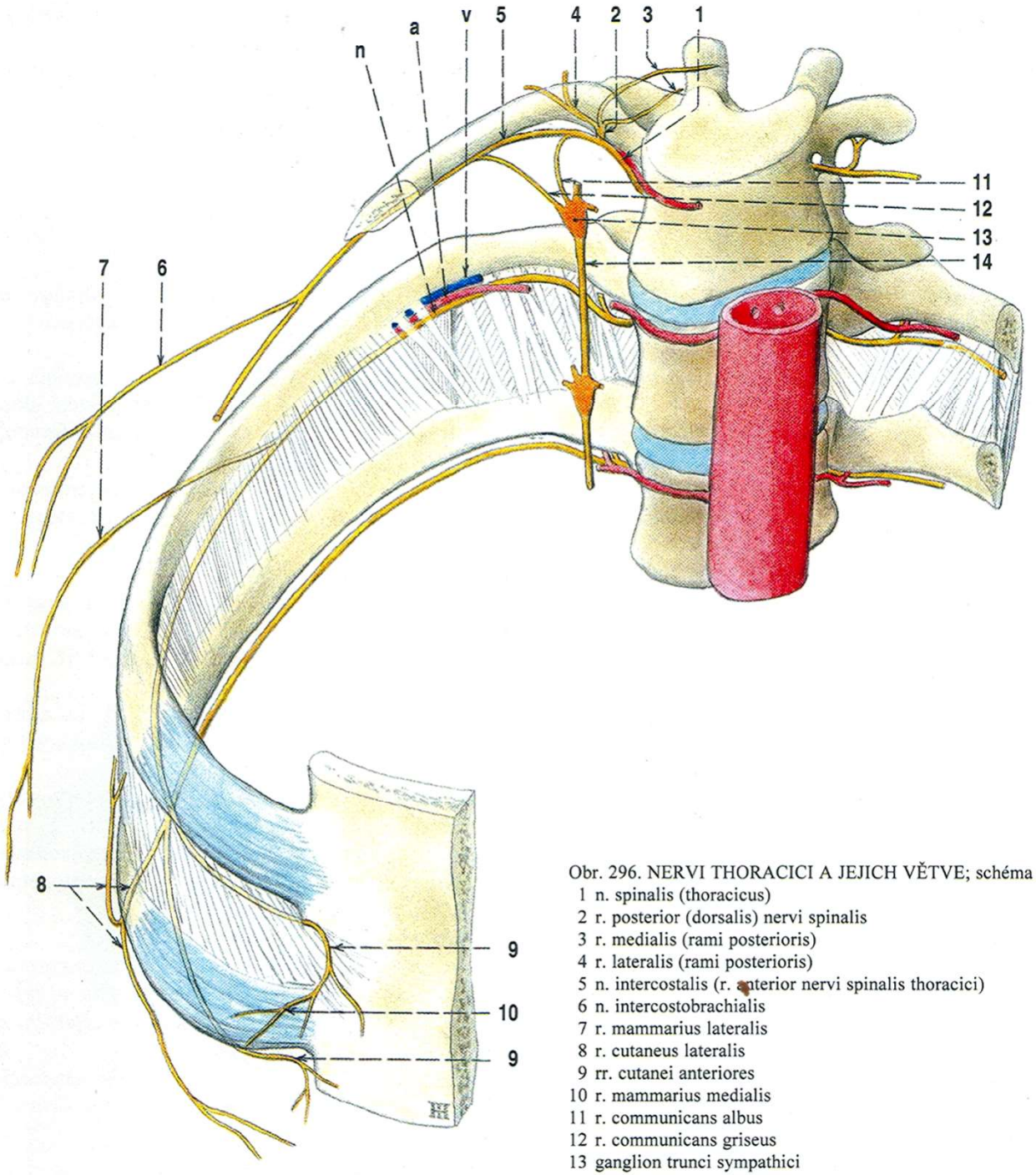




Nn. intercostobrachiales

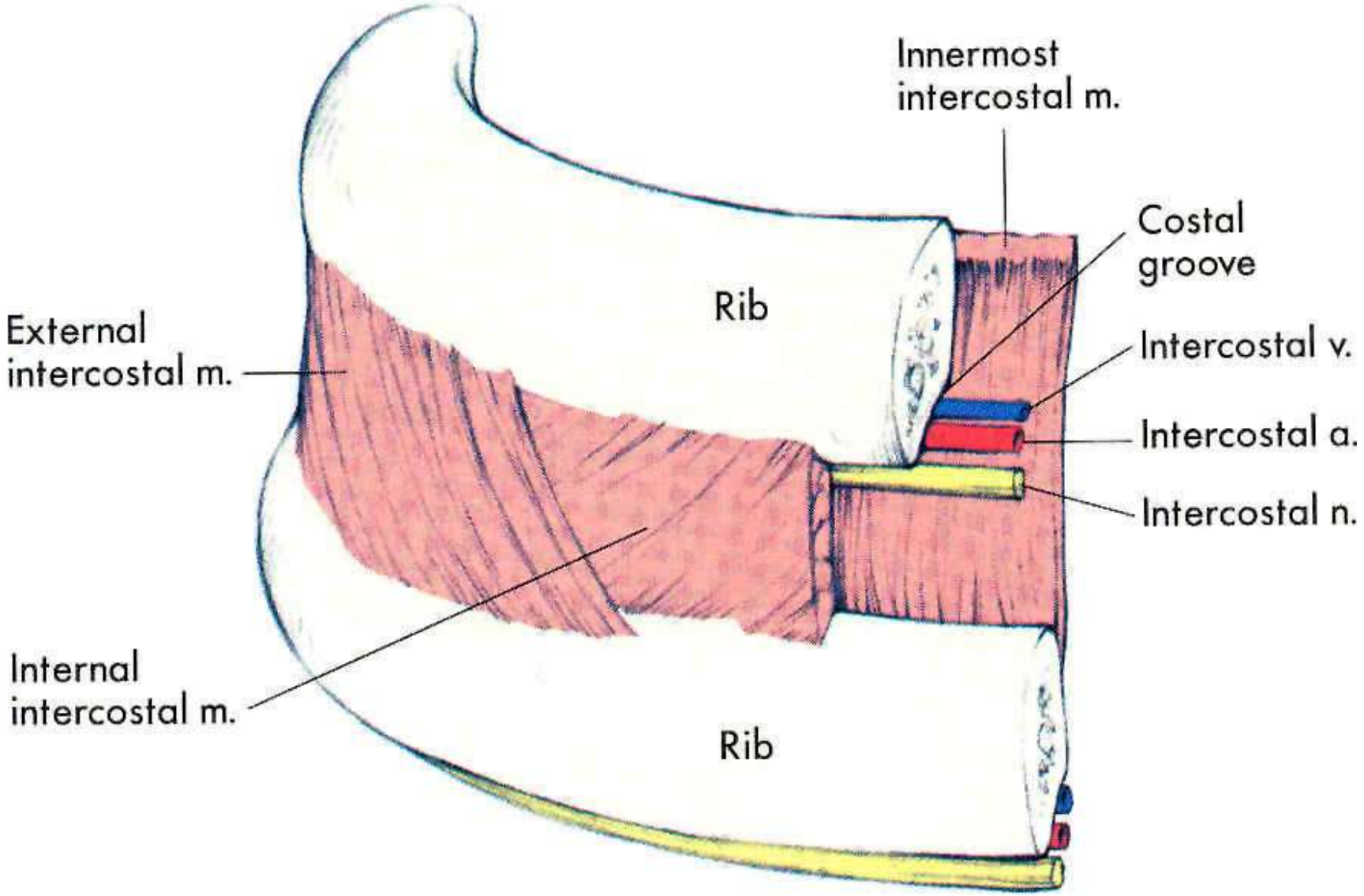
(n. cutaneus brachii medialis)

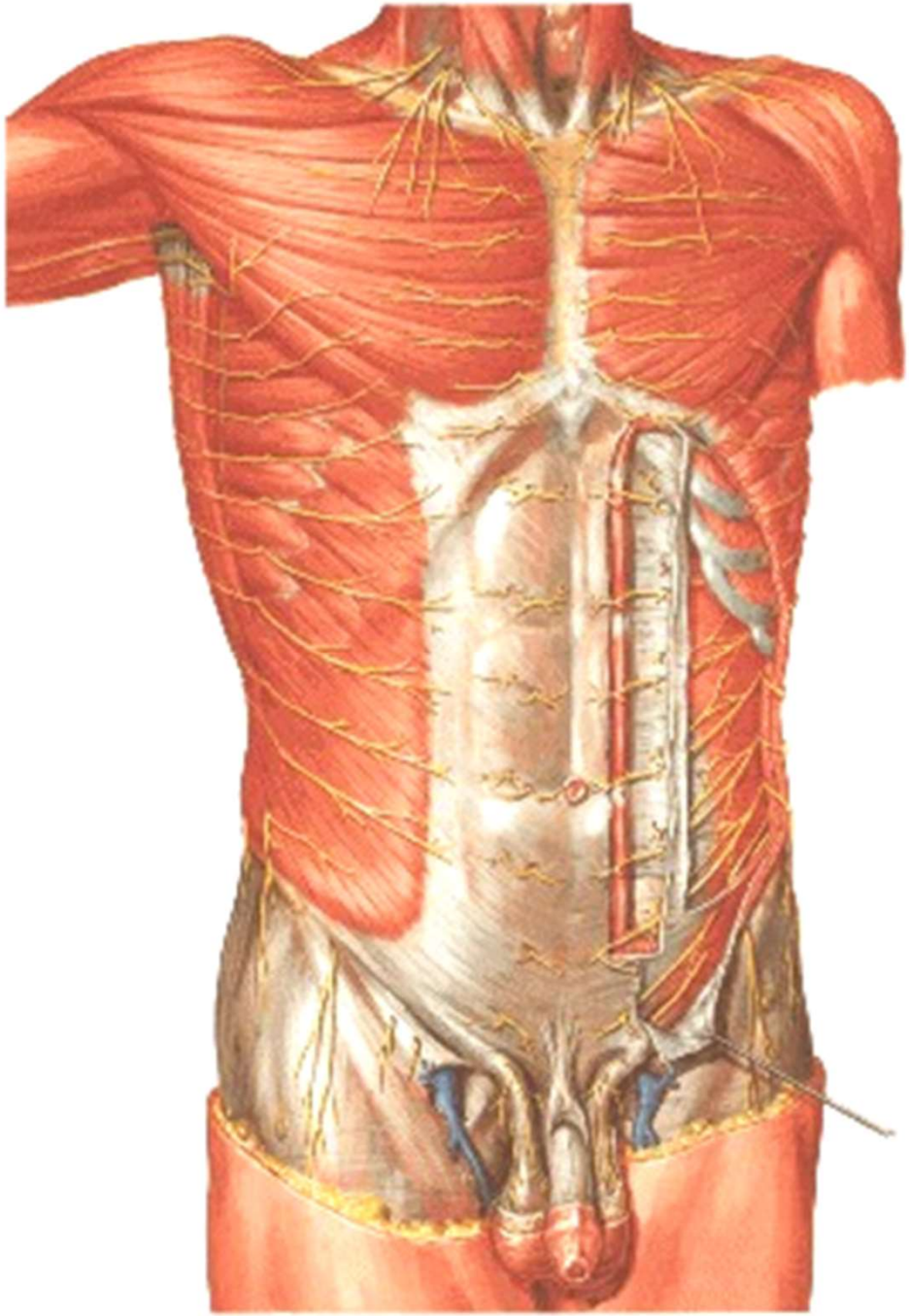


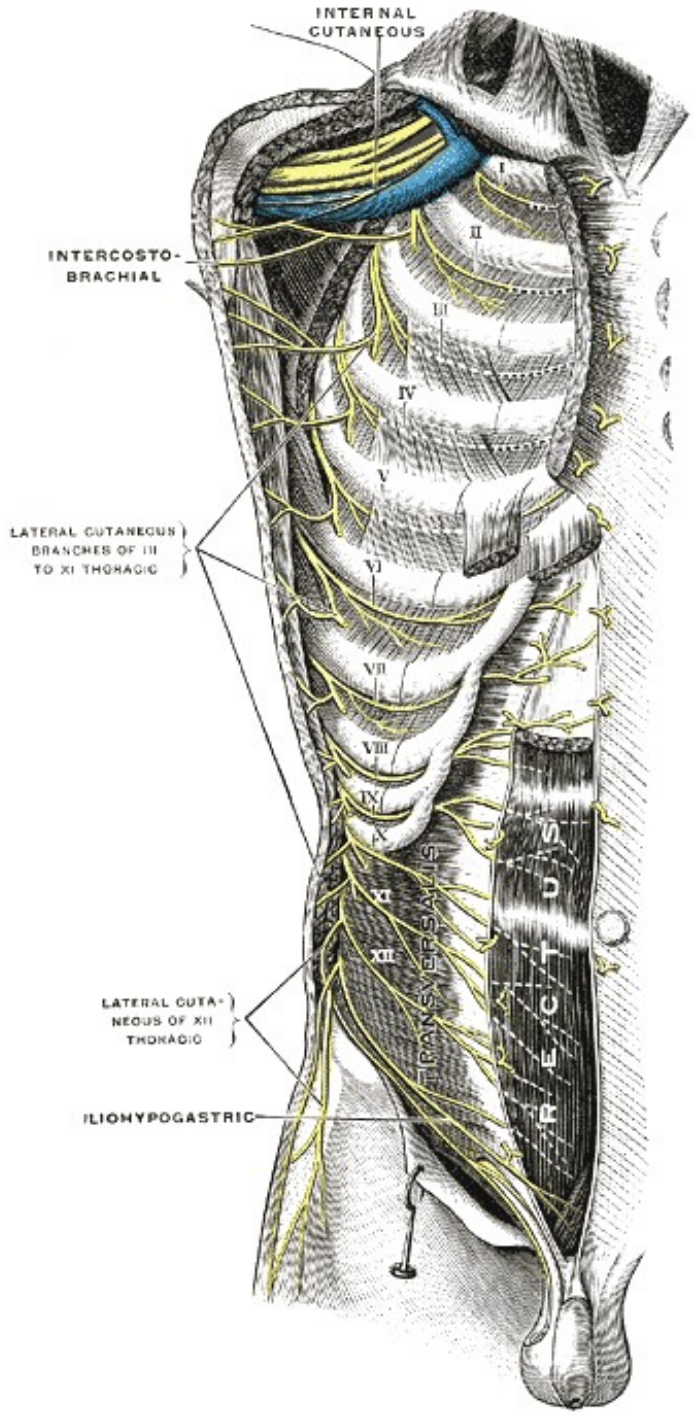


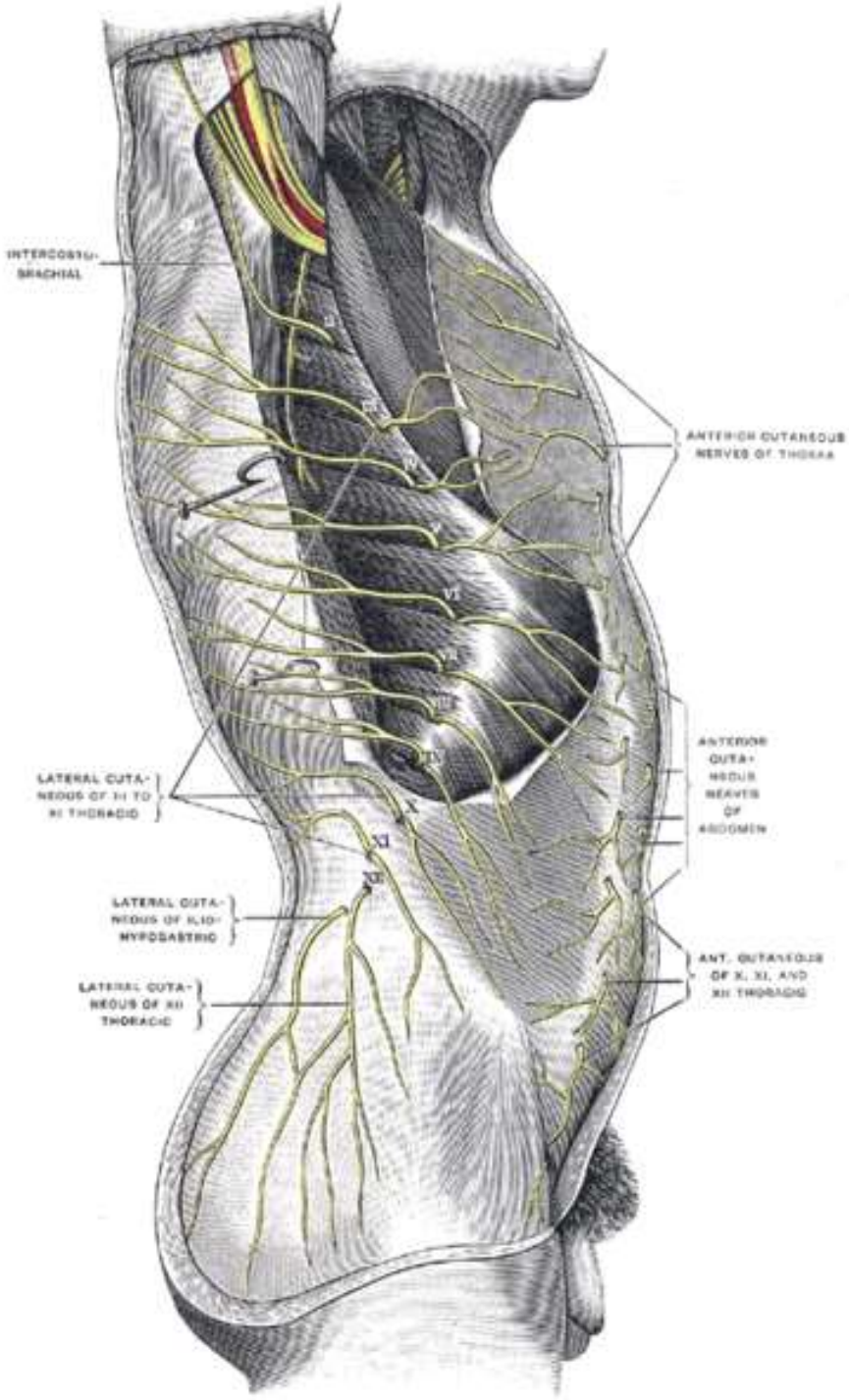
Obr. 296. NERVI THORACICI A JEJICH VĚTVE; schéma

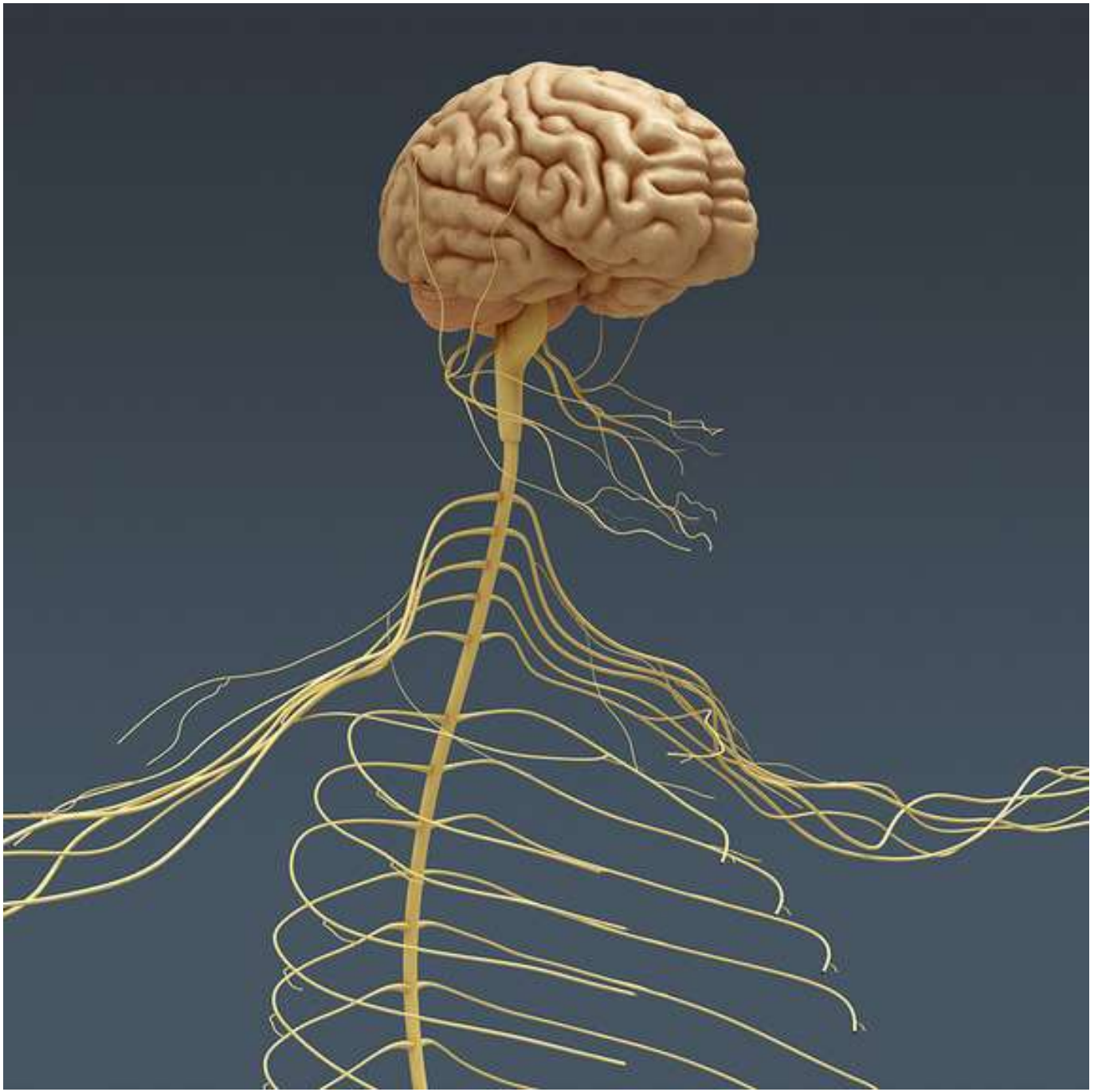
1 n. spinalis (thoracicus)
2 r. posterior (dorsalis) nervi spinalis
3 r. medialis (rami posterioris)
4 r. lateralis (rami posterioris)
5 n. intercostalis (r. anterior nervi spinalis thoracici)
6 n. intercostobrachialis
7 r. mammarius lateralis
8 r. cutaneus lateralis
9 rr. cutanei anteriores
10 r. mammarius medialis
11 r. communicans albus
12 r. communicans griseus
13 ganglion trunci sympathici
14 truncus sympathicus


Innermost
intercostal m.
Costal
groove
Rib
External
intercostal m.
Intercostal v.
Intercostal a.
Intercostal n.
Internal
intercostal m.
Rib




INTERNAL CUTANEOUS
INTERCOSTO-BRACHIAL
LATERAL CUTANEOUS BRANCHES OF III TO XI THORACIC
LATERAL CUTANEOUS OF XII THORACIC
ILIOHYPOGASTRIC
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
TRANSVERSALIS
RECTUS


INTERCOSTO-BRACHIAL
ANTERIOR CUTANEOUS NERVES OF THORAX
LATERAL CUTANEOUS OF III TO XI THORACIC
ANTERIOR CUTANEOUS NERVES OF ABDOMEN
LATERAL CUTANEOUS OF ILIO-HYPOGASTRIC
ANT. CUTANEOUS OF X, XI, AND XII THORACIC
LATERAL CUTANEOUS OF XII THORACIC



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