

Chapter 7

Nerve tissue 2

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Nerve fibers are cables in human's body to conduct nerve impulses (bioelectricity).

Cables conduct electric current from power plant to terminal user, forming a circuit loop.



4. Nerve fibers and Nerves

◆ Definition:

- Nerve fiber: axon enveloped by sheaths, conduct nerve impulse to certain direction.

◆ Classification: according to myelin-sheath

■ 4.1 myelinated nerve fiber

Thicker axons generally ensheathed by myelin sheath

- ◆ peripheral nervous system

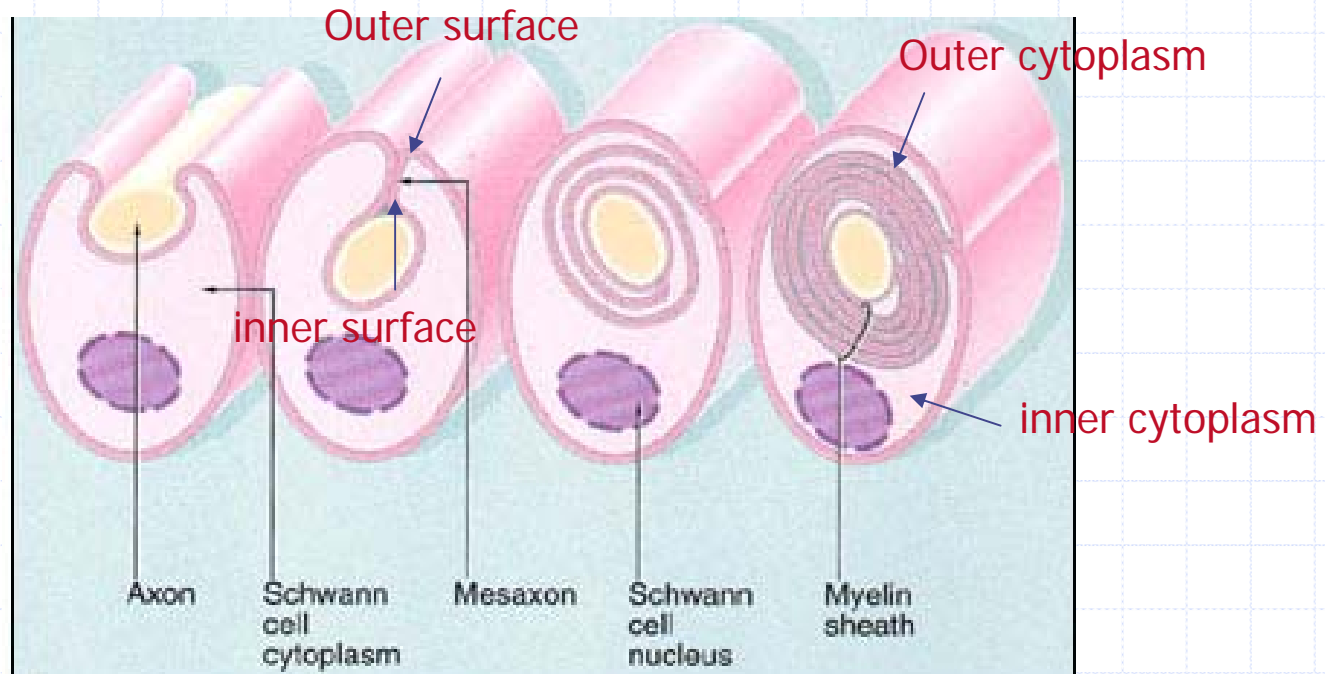
- ◆ central nervous system

■ 4.2 unmyelinated nerve fiber

Axons of small diameter

4.1.1 Myelinated fibers of the PNS

In peripheral myelinated nerve fibers, the cytoplasm of Schwann cells winds and wraps around the axon. Myelin actually consists of many layers of cell membranes.



myelin formation: Schwann cell envelop axon → the edges of the groove come together to form mesaxon → plasma membranes of the 2 edges fuse together the mesaxon wraps itself around the axon several times → become longer → to force the nucleus and cytoplasm of Schwann cells to go to two side. The inner and outer cytoplasm is called Schmidt-Lantermann clefts stained by silver in LM.

◆ Myelin-sheath:

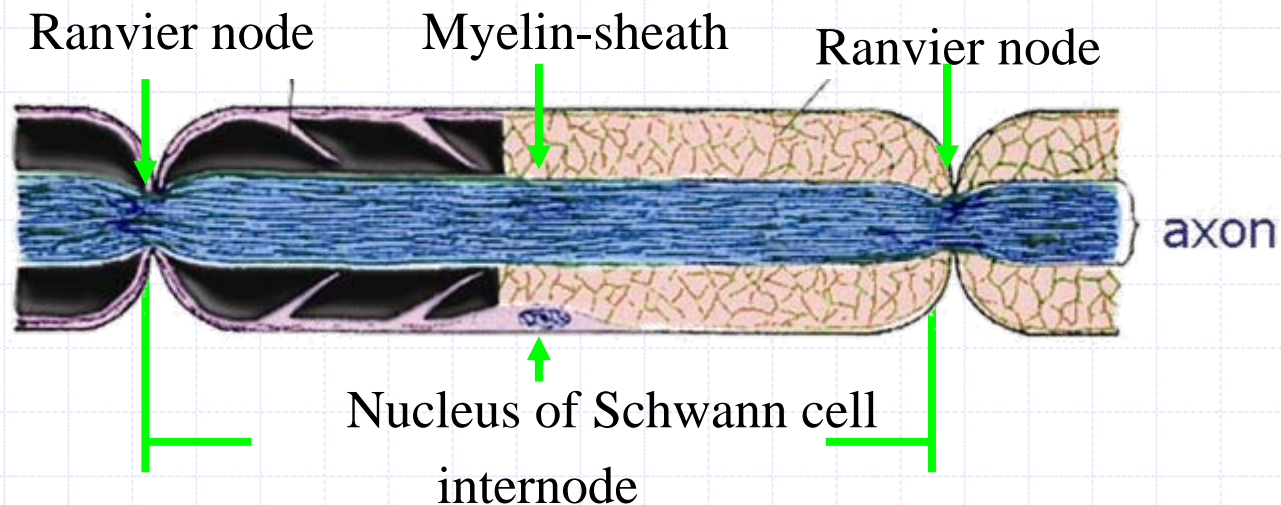
- concentric layers of membrane of Schwann cells
- Lipoprotein, floccular cotton (HE), black (osmium)

◆ Ranvier nodes:

- gaps between adjacent Schwann cells, exposed axolemma

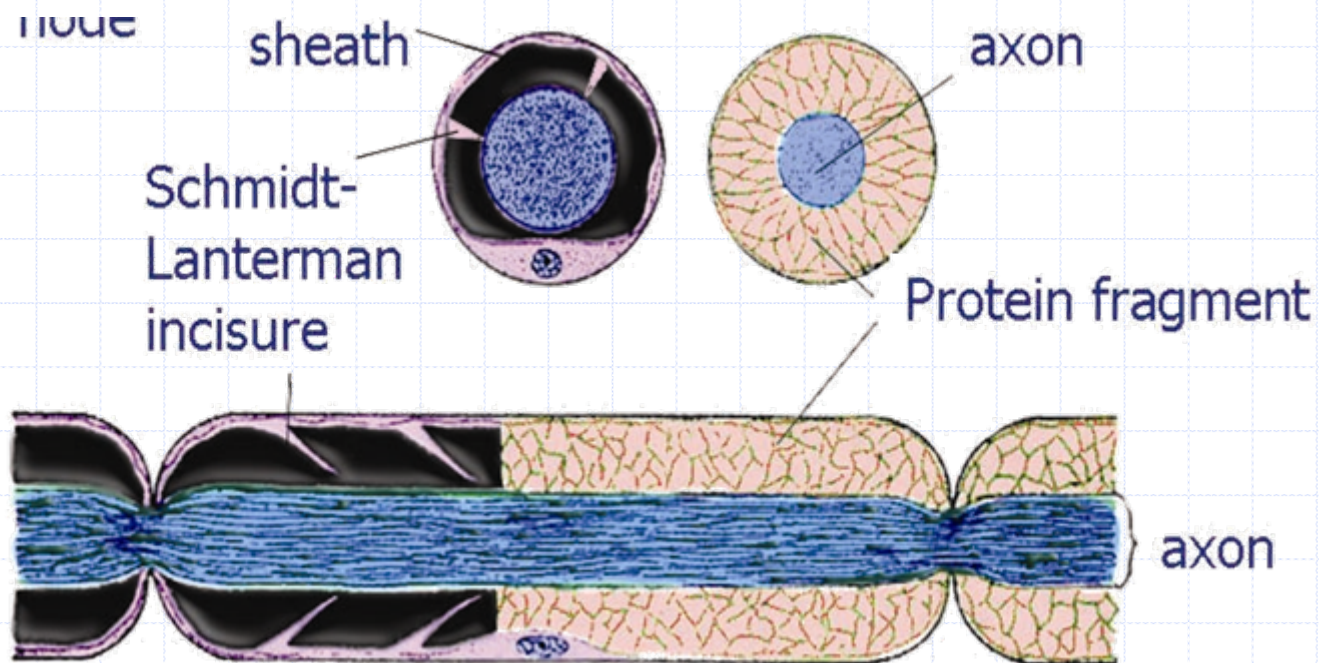
◆ internode:

- distance between 2 nodes, a Schwann cell with elongated nucleus parallel to axon and surrounded by outer cytoplasm



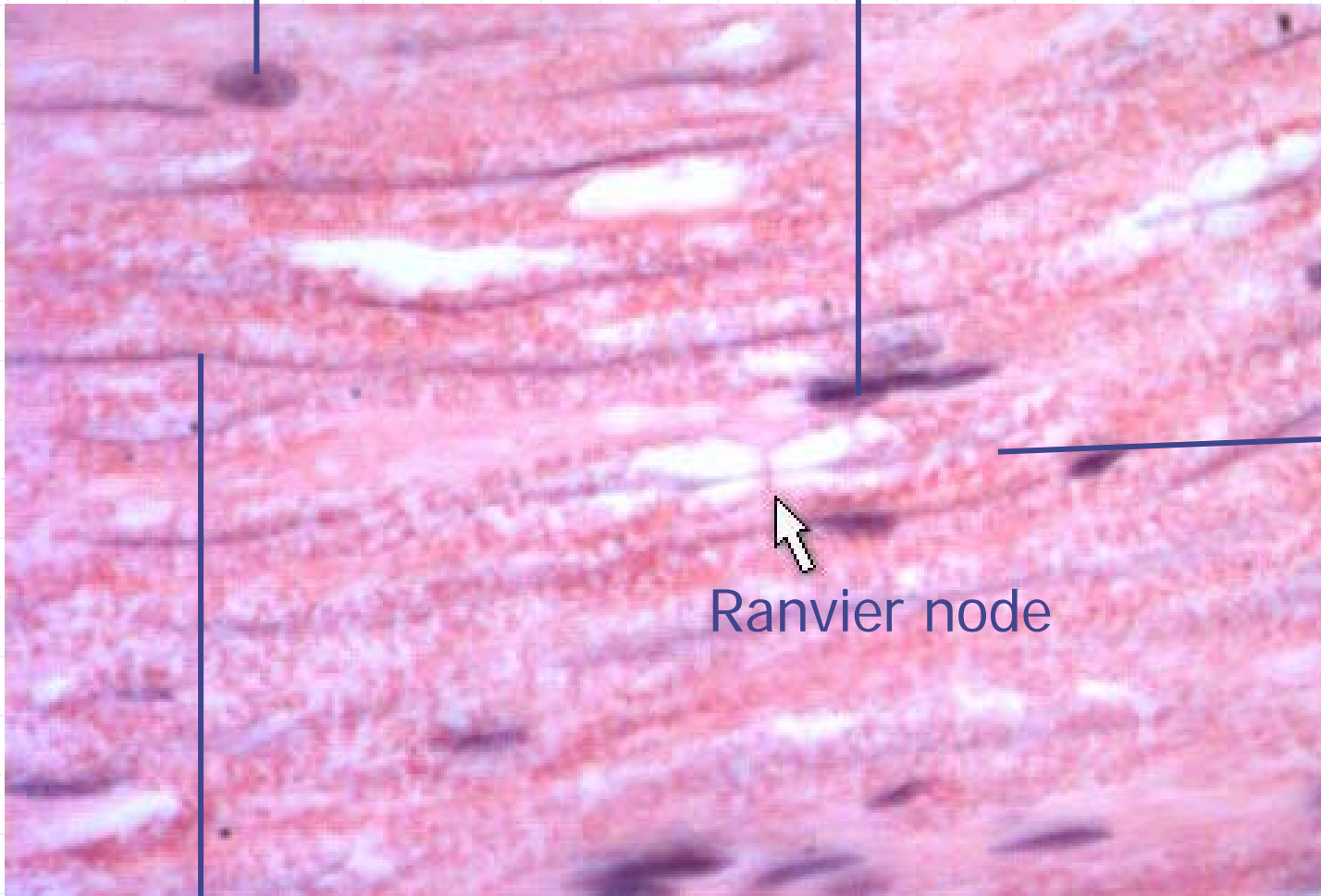
◆ Schmidt-Lantermann cleft (osmium tetroxid)

- cone-shaped clefts (cross)
- oblique bands (longitudinal)
- cytoplasm of schwann cells is present within the myelin sheath from inside of sheath to outside



Nucleus of Schwann cell

Nucleus of fibroblast

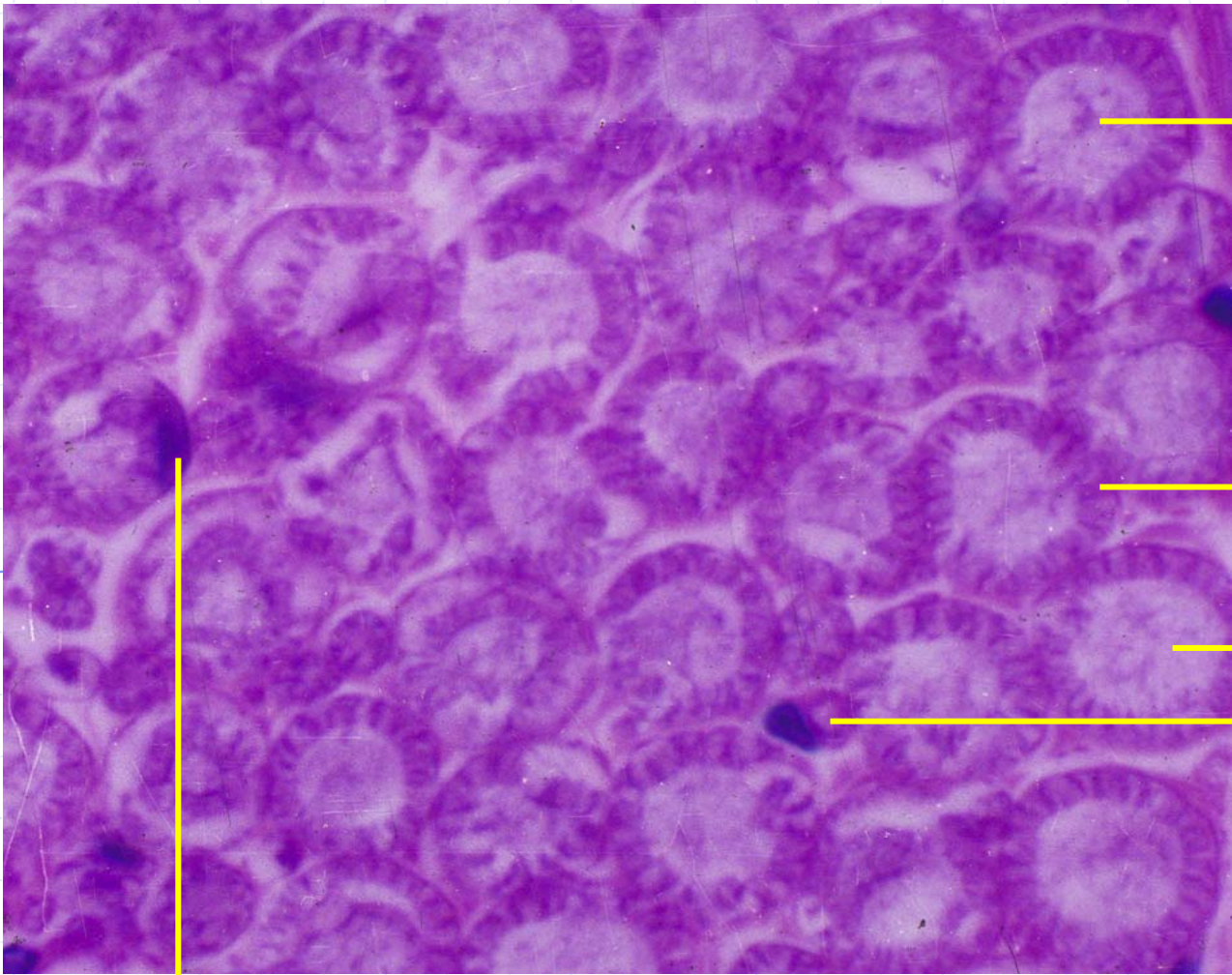


Myeline sheath

Ranvier node

axon

Longitudinal section of myelinated nerve fiber in PNS



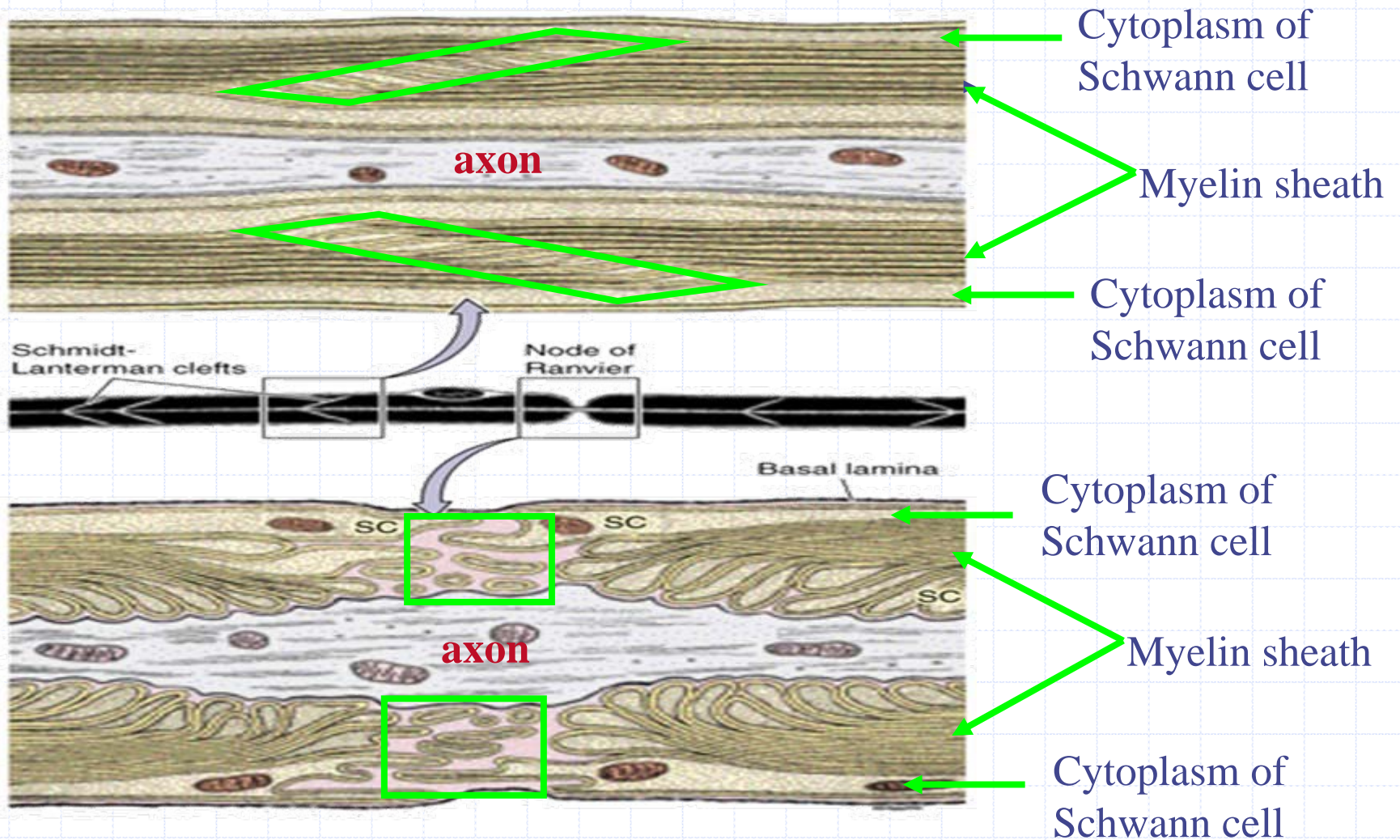
axon

cytoplasm
of Schwann cell

Myeline sheath
unmyelinated fiber

Nucleus of Schwann cell

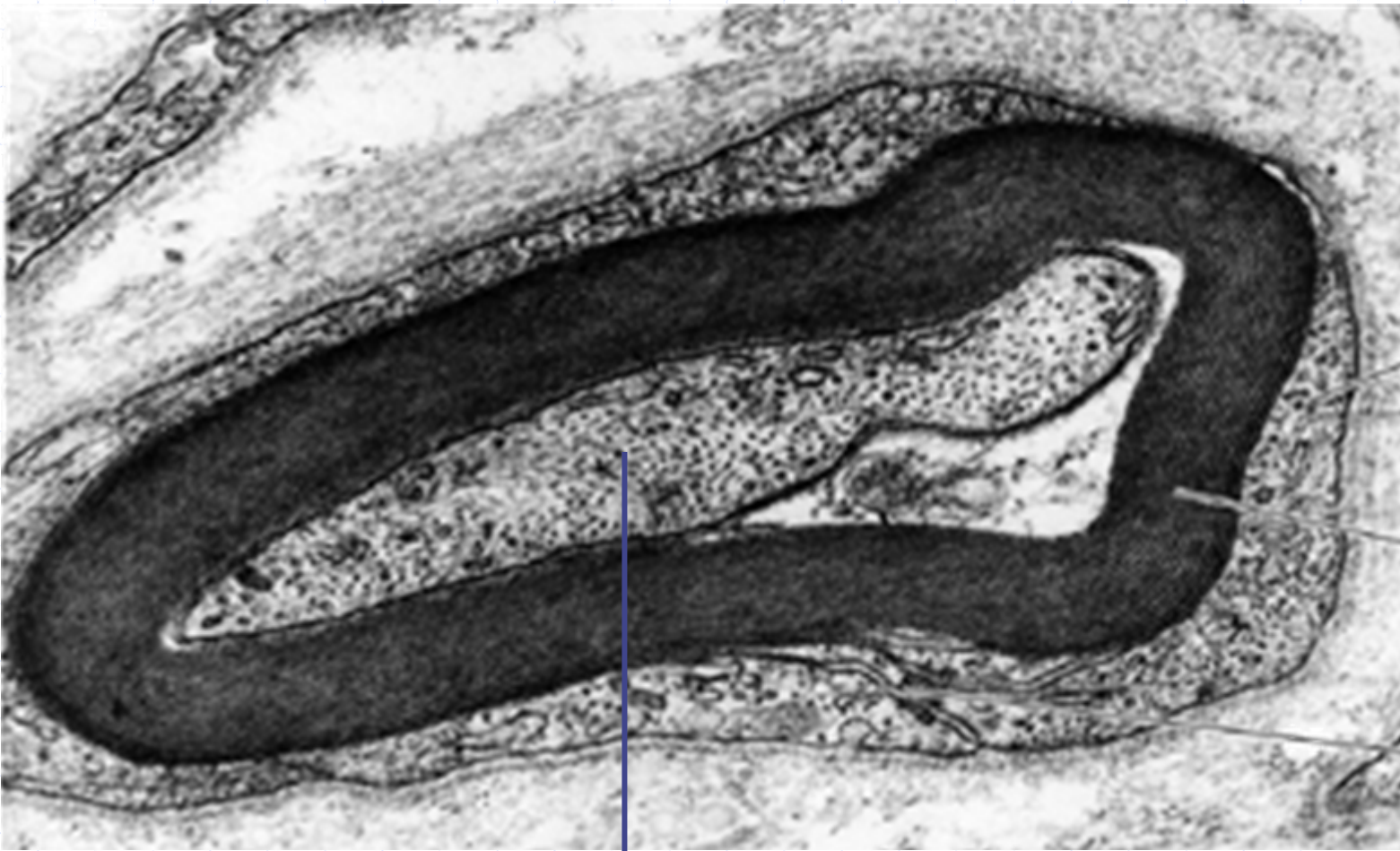
Transverse section of myelinated nerve fiber in PNS



LM (center): a myelinated peripheral nerve fiber

EM (up): Schmidt-Lantermann cleft. The cleft is formed by Schwann cell cytoplasm that is not displaced to the periphery during myelin formation.

EM (lower): Ranvier node with naked membrane.



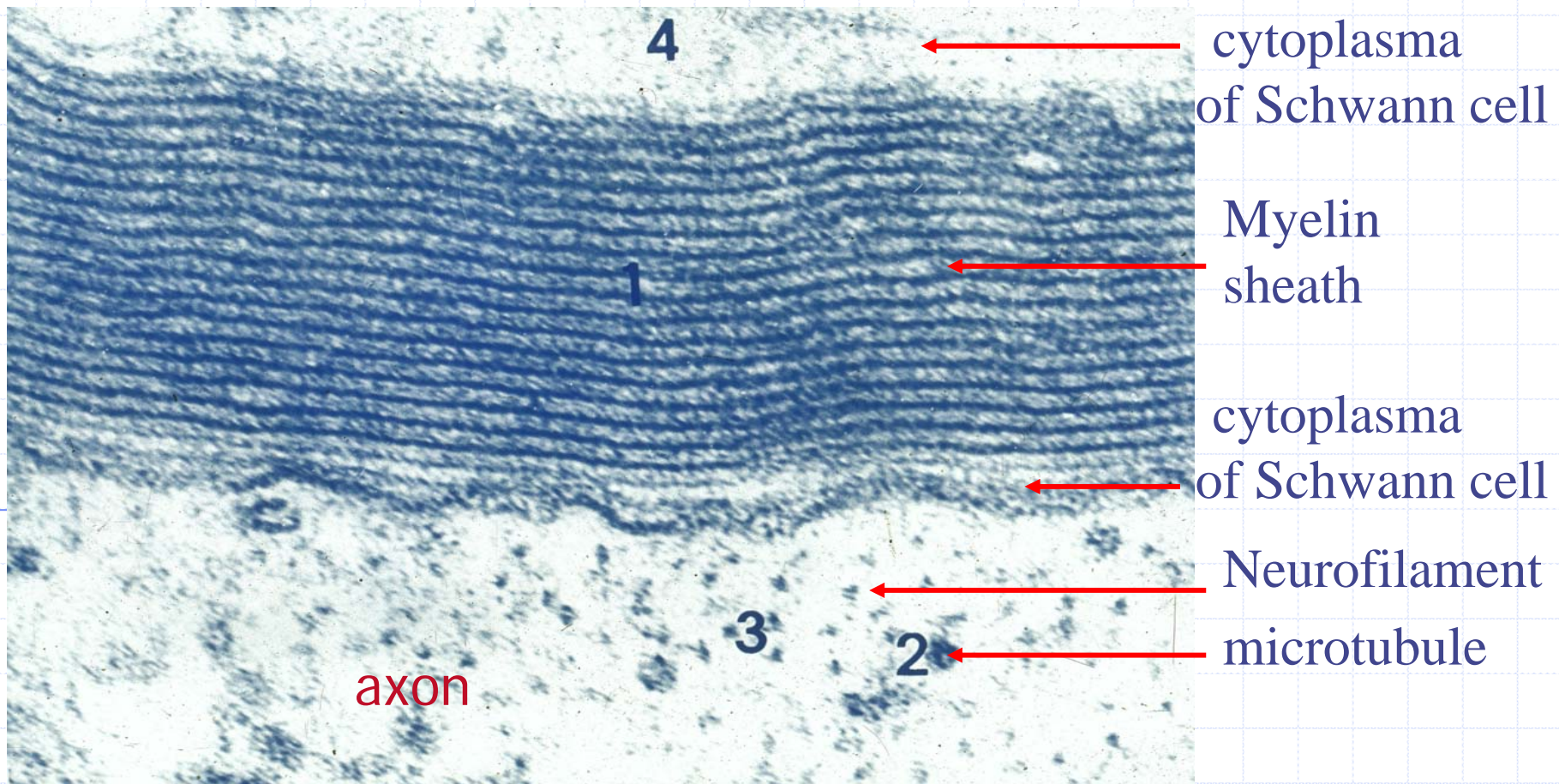
Schwann cell cytoplasm

Myelin

Mesaxon

axon

Electron micrographs of a myelinated nerve fiber. myelin sheath is seen as a series of concentrically arranged light and dark lamellae.

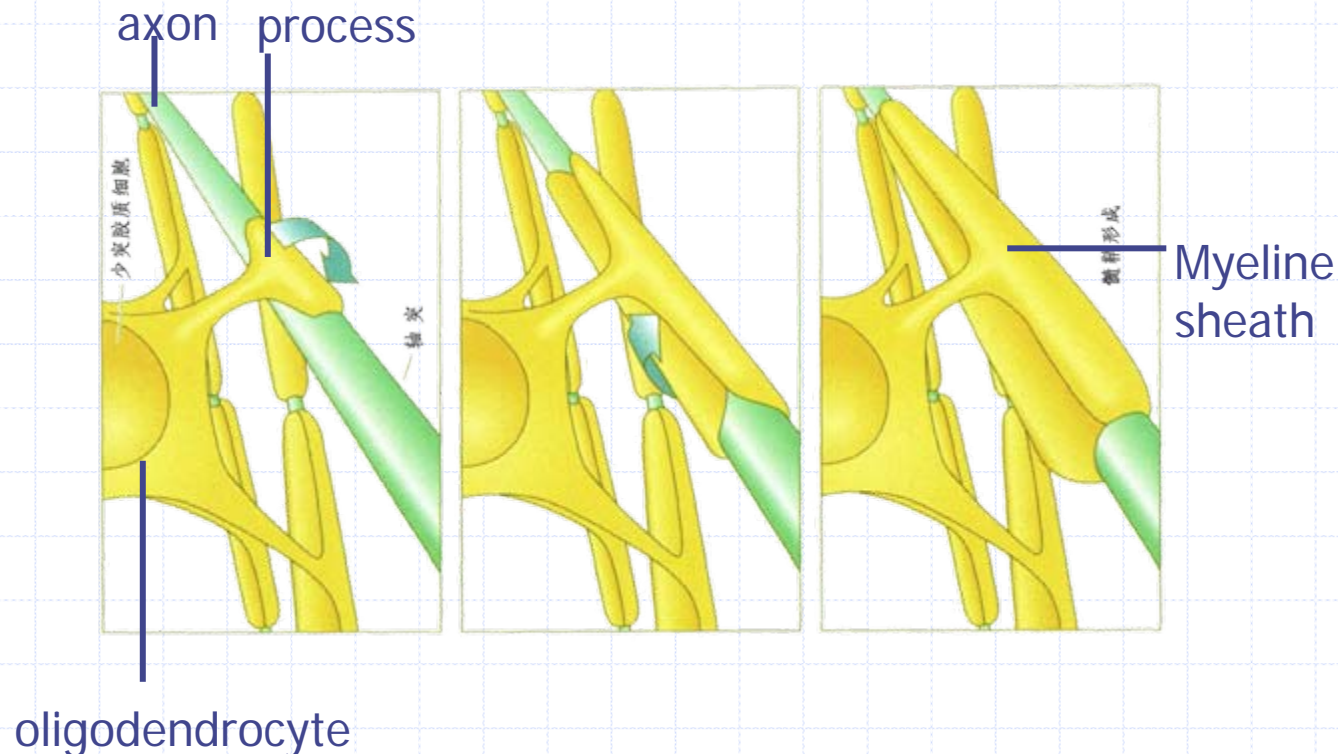


Electron micrographs of a myelinated nerve fiber.
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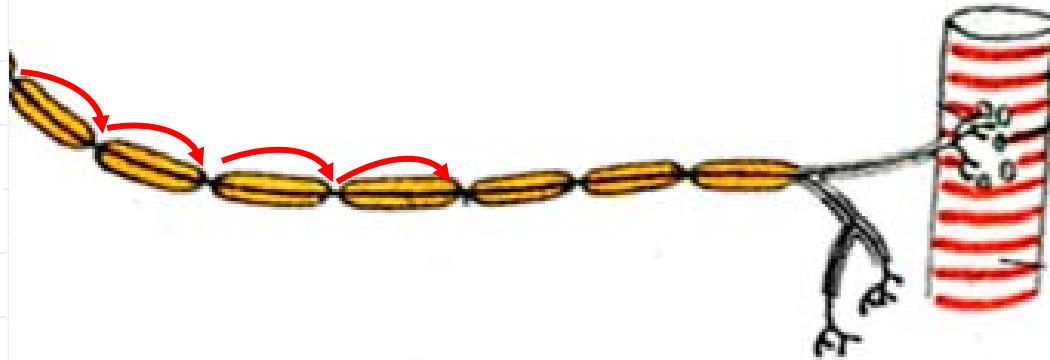
4.1.2 Myelinated fibers of the CNS

- ◆ myelin sheaths : processes of oligodendrocytes.
 - Oligodendrocytes : branches of one cell can envelop segments of several axons.
 - Schmidt-Lanterman clefts are absent.



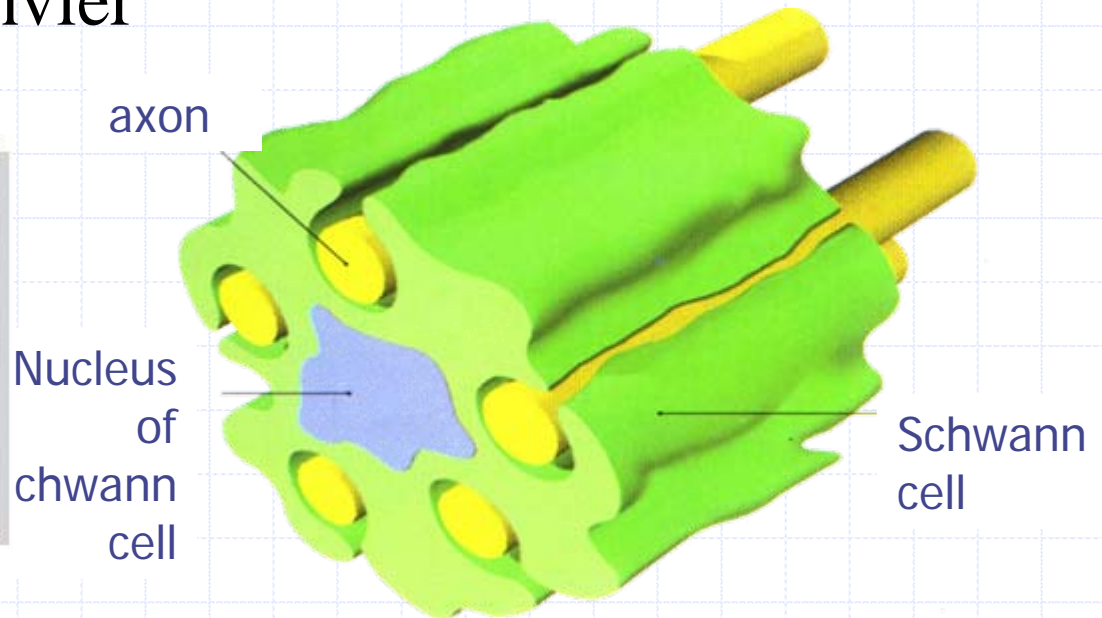
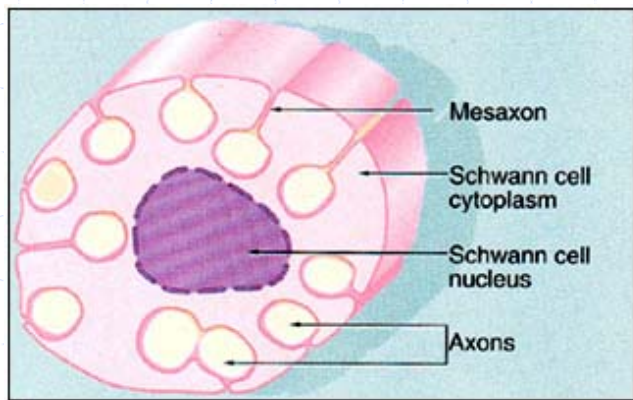
Function:

- ◆ provide an insulation layer around the axon
speed up impulse conduction
- ◆ Nerve impulses jump from node to node
across internodes of myelin sheath.

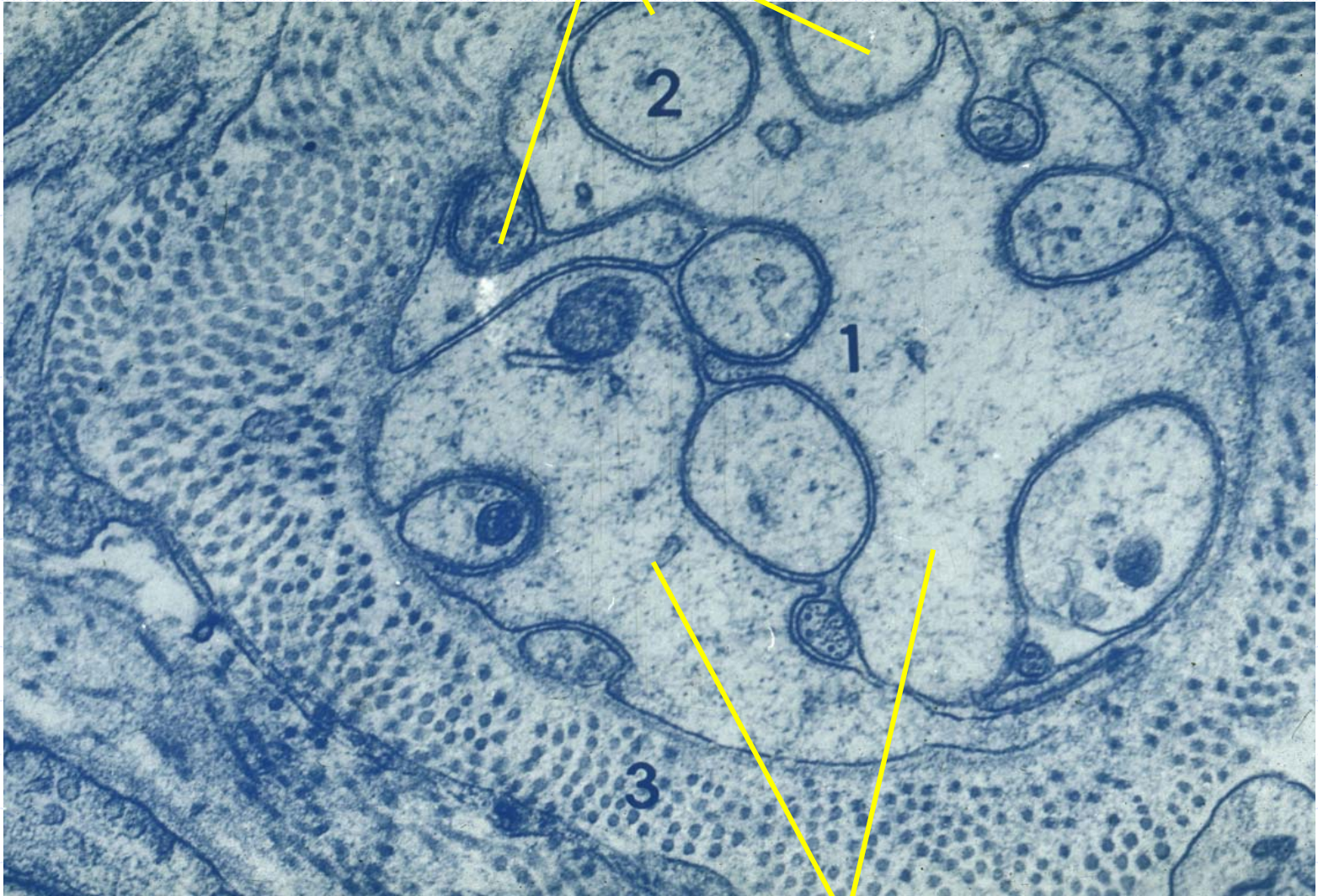


4.2 Unmyelinated fibers

- ◆ In the peripheral nervous system, Schwann cells have grooves in which axons are embedded.
- ◆ Each Schwann cell ensheath many axons.
- ◆ Adjacent Schwann cells are united to form a continuous sheath.
- ◆ without nodes of Ranvier



axons



Schwann cell

Transverse section of unmyelinated nerve fiber in PNS, EM

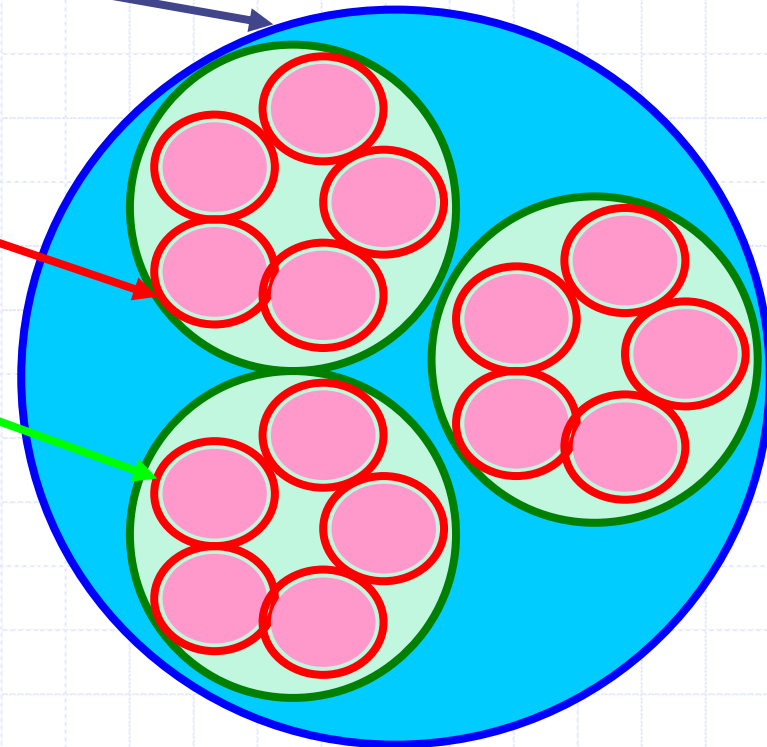
- ◆ In the central nervous system, unmyelinated nerve fibers are unsheathed and run freely among the neuronal and glial processes.
- ◆ Nerve impulse conduction occurs along axolemma in unmyelinated fibers. The impulses speed slower than that in myelinated nerve fibers.

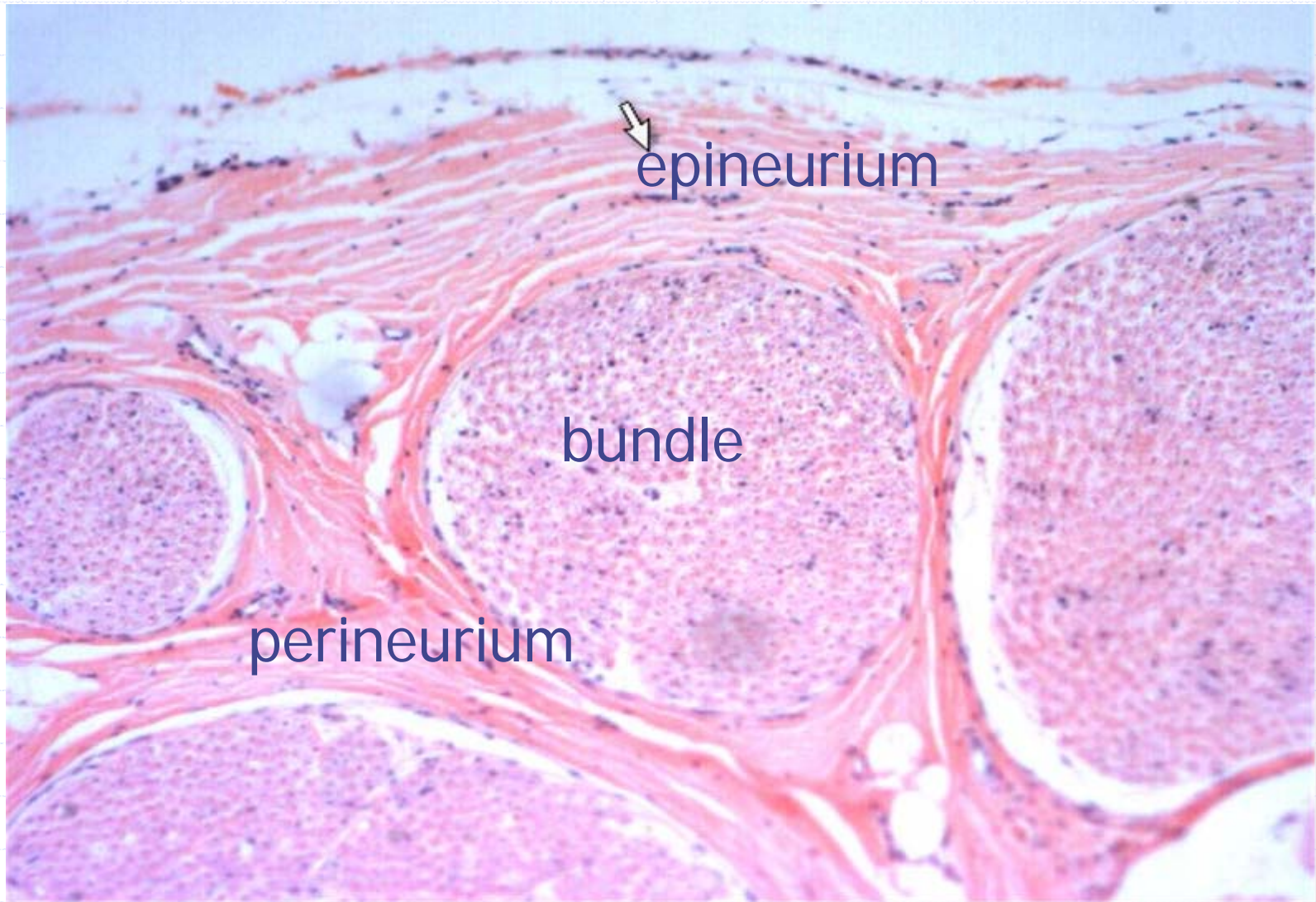
4.3 Nerves

- ◆ Nerves :
 - branching, cord-like structures
 - Many nerve fibers are grouped in bundles

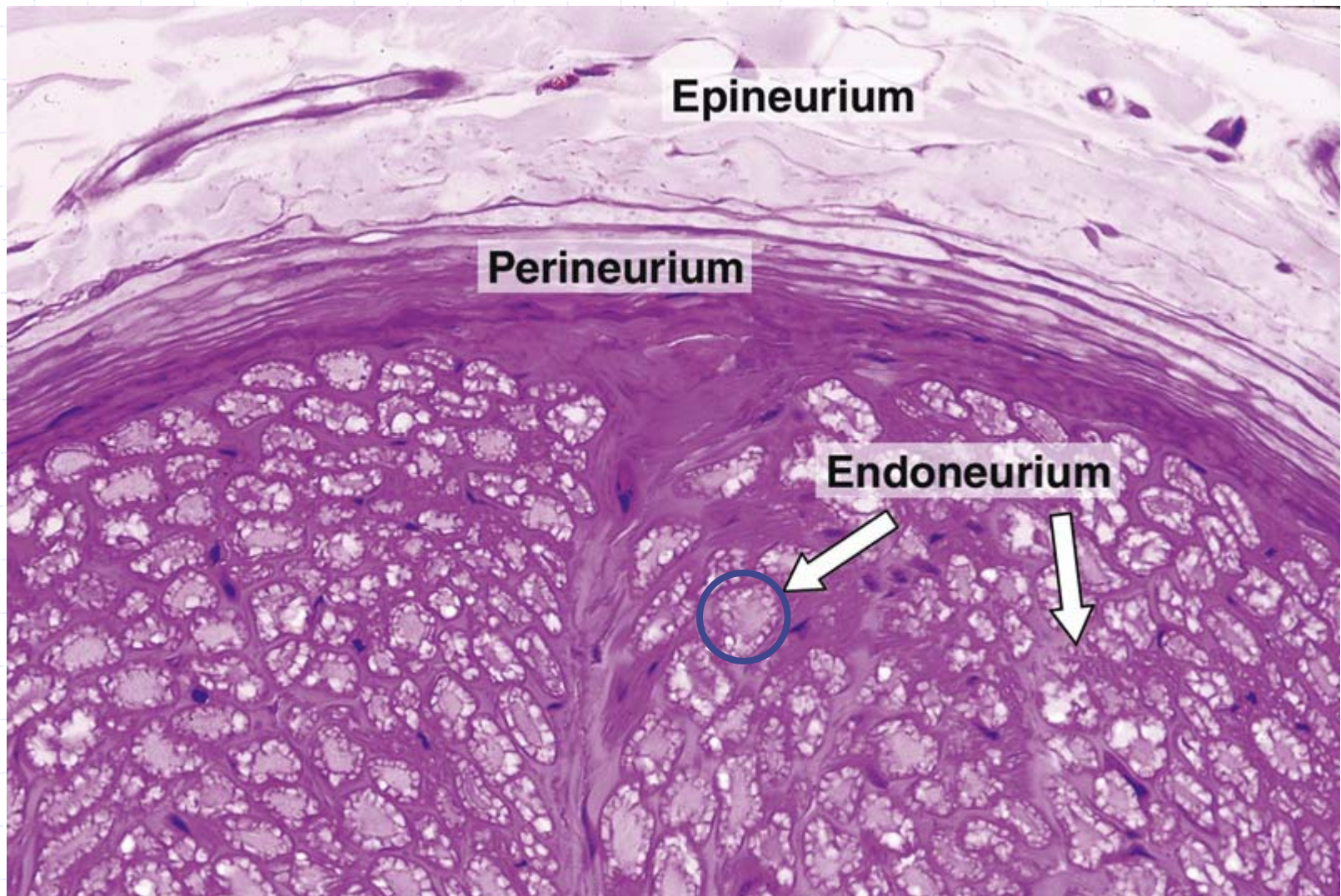
- ◆ structure:

- **epineurium**: nerve
external fibrous coat of dense connective tissue
- **perineurium**: nerve fibers bundle
made up of several layers of flat cells
tightly joined together to form a barrier
to the penetration of macromolecules
- **endoneurium**: nerve fiber
composed mainly of reticular fibers
synthesized by Schwann cells

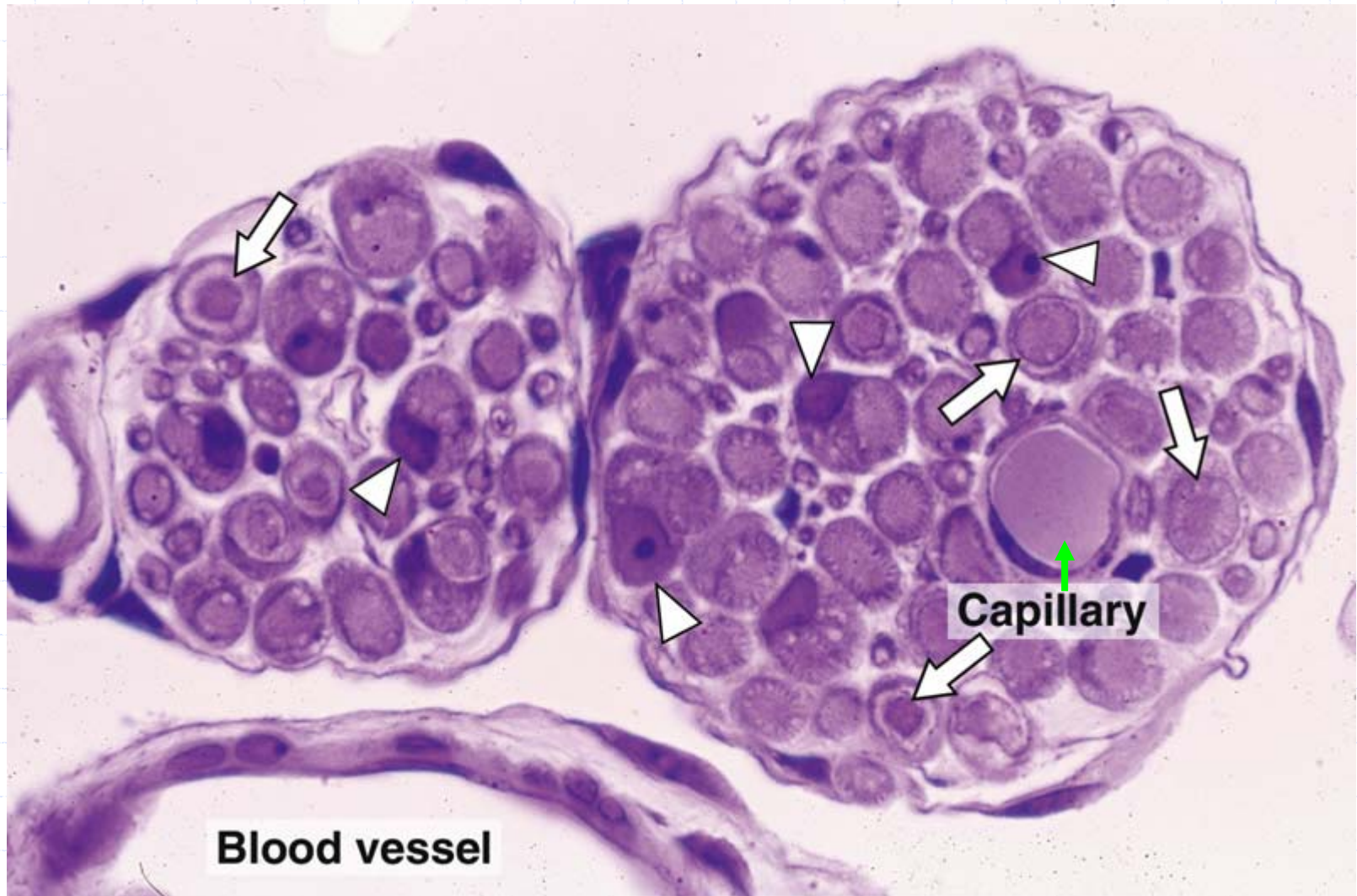




A part of nerve



Cross section of a thick nerve showing the epineurium, perineurium, and endoneurium. The myelin sheath that envelops each axon was partially removed by the histologic technique. PT stain. Medium magnification.



Cross sections of two small nerves with a thin covering layer. Note the Schwann cell nuclei (arrowheads) and the axons (arrows). PT stain. Medium magnification.

◆ Nerve:

- Afferent/sensory fiber: carry the information obtained from the interior of the body and environment to CNS
- Efferent/ motor fiber: carry impulses from CNS to the effector organs

◆ Classification:

- Sensory nerves : sensory fibers
- Motor nerves : motor fibers
- Mixed nerves :both

5 Nerve Ending

- ◆ **5.1 Sensory or Afferent nerve endings (dendrite)**
 - Receive physical and chemical stimuli,
 - generate nerve impulses responding to stimuli
 - 5.1.1 unencapsulated endings (free nerve endings)
 - 5.1.2 Encapsulated endings
- ◆ **5.2 Motor or Efferent nerve endings (motor axon)**
 - Control the activity of muscle and gland
 - 5.2.1 Somatic motor nerve endings or Motor end plate
 - 5.2.2 Visceral motor nerve endings

5.1.1 Unencapsulated endings

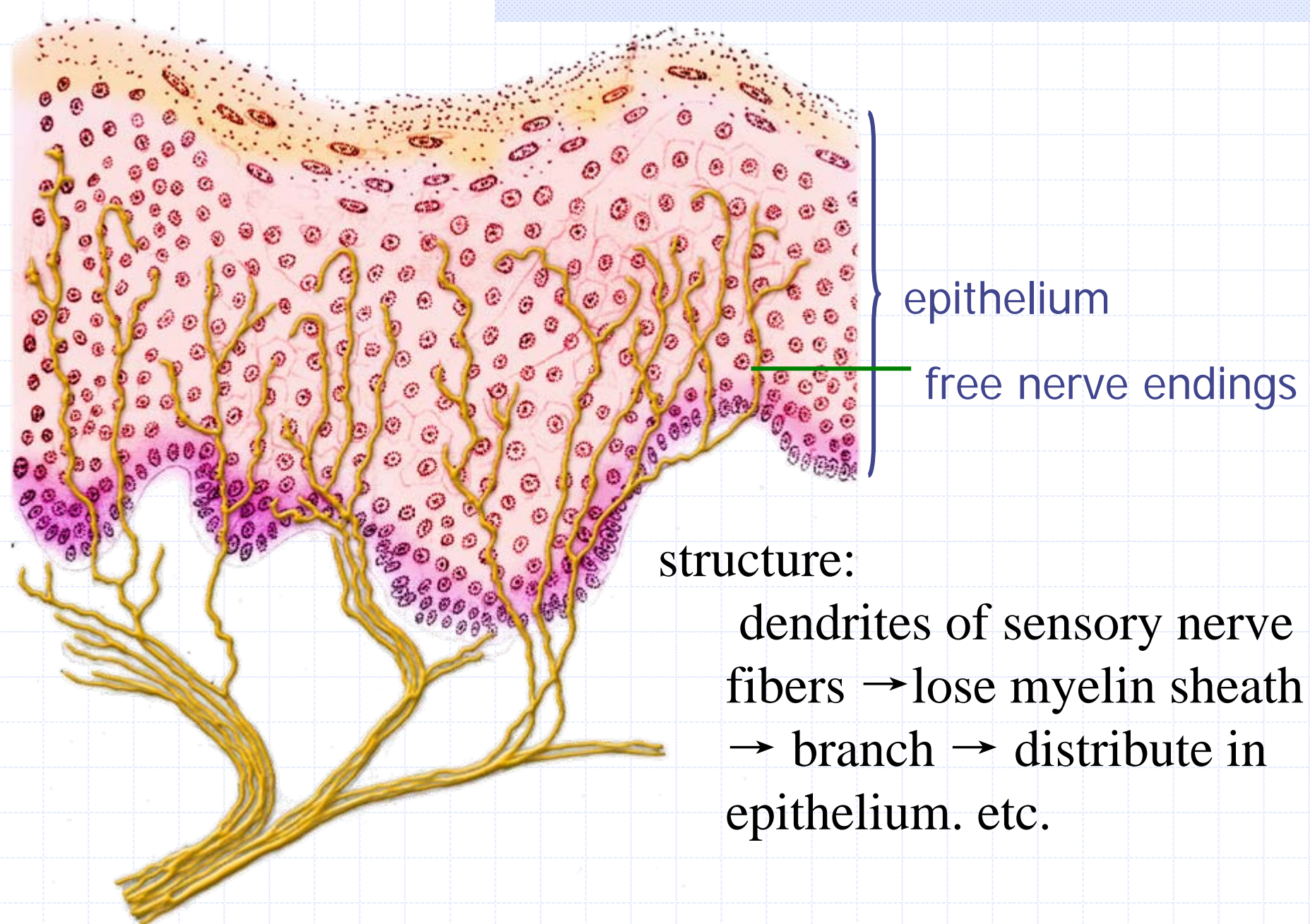
- ◆ free nerve ending

- ◆ Distribution:

- the epithelia of the cornea, oral cavity, respiratory mucosa and skin , connective tissue , hair follicles

- ◆ function:

- feel cold, hot, pain and slight touch

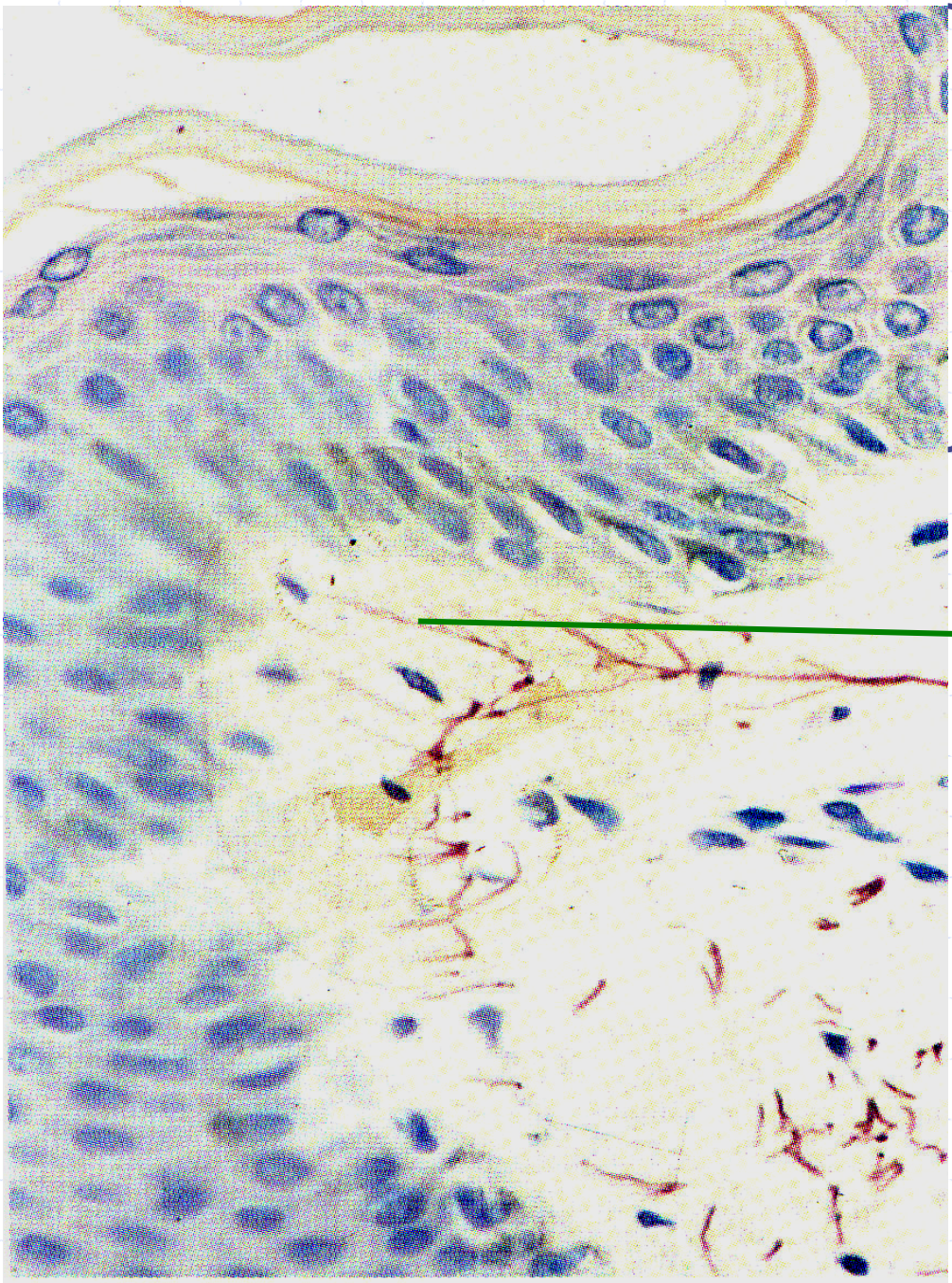


epithelium

free nerve endings

structure:

dendrites of sensory nerve
fibers → lose myelin sheath
→ branch → distribute in
epithelium. etc.



skin

free nerve endings

Silver staining



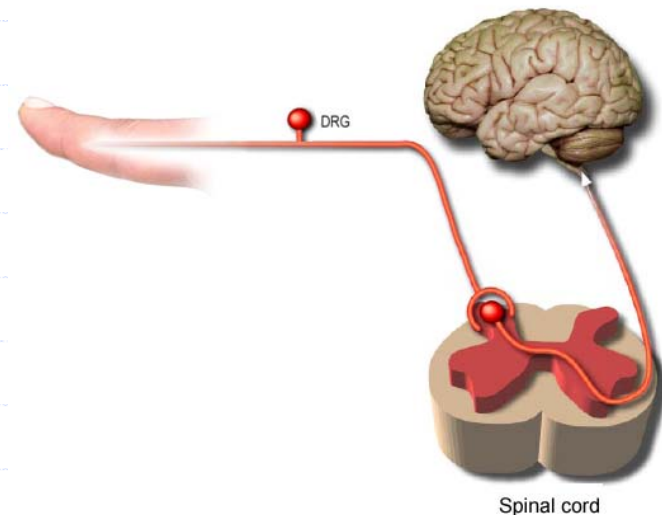
◆ 5.1.2 Encapsulated endings

- **Connective capsule surround unmyelinated sensory nerve endings.**

- ◆ 5.1.2.1 Tactile corpuscles

- ◆ 5.1.2.2 Lamellated corpuscles

- ◆ 5.1.2.3 Muscular (neuromuscular) spindles



5.1.2.1 Tactile corpuscles

◆ Meissner's corpuscles

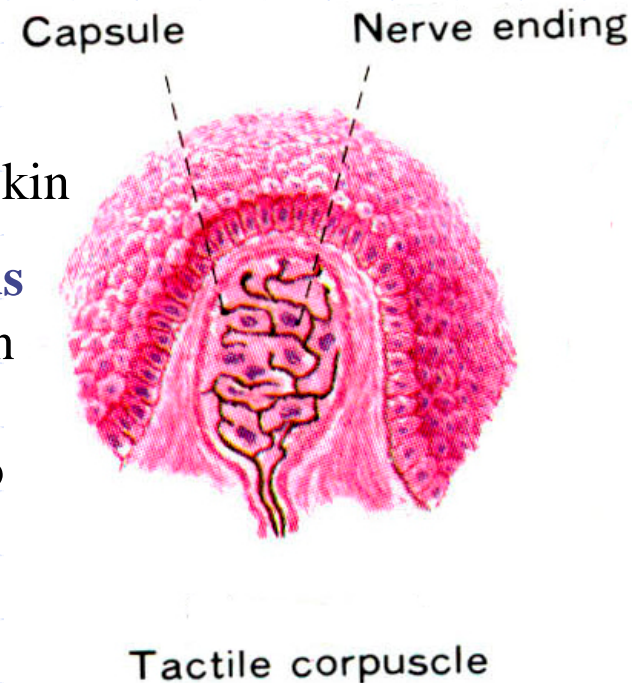
◆ dermal papillae, hairless skin (finger, toes, palms, soles)

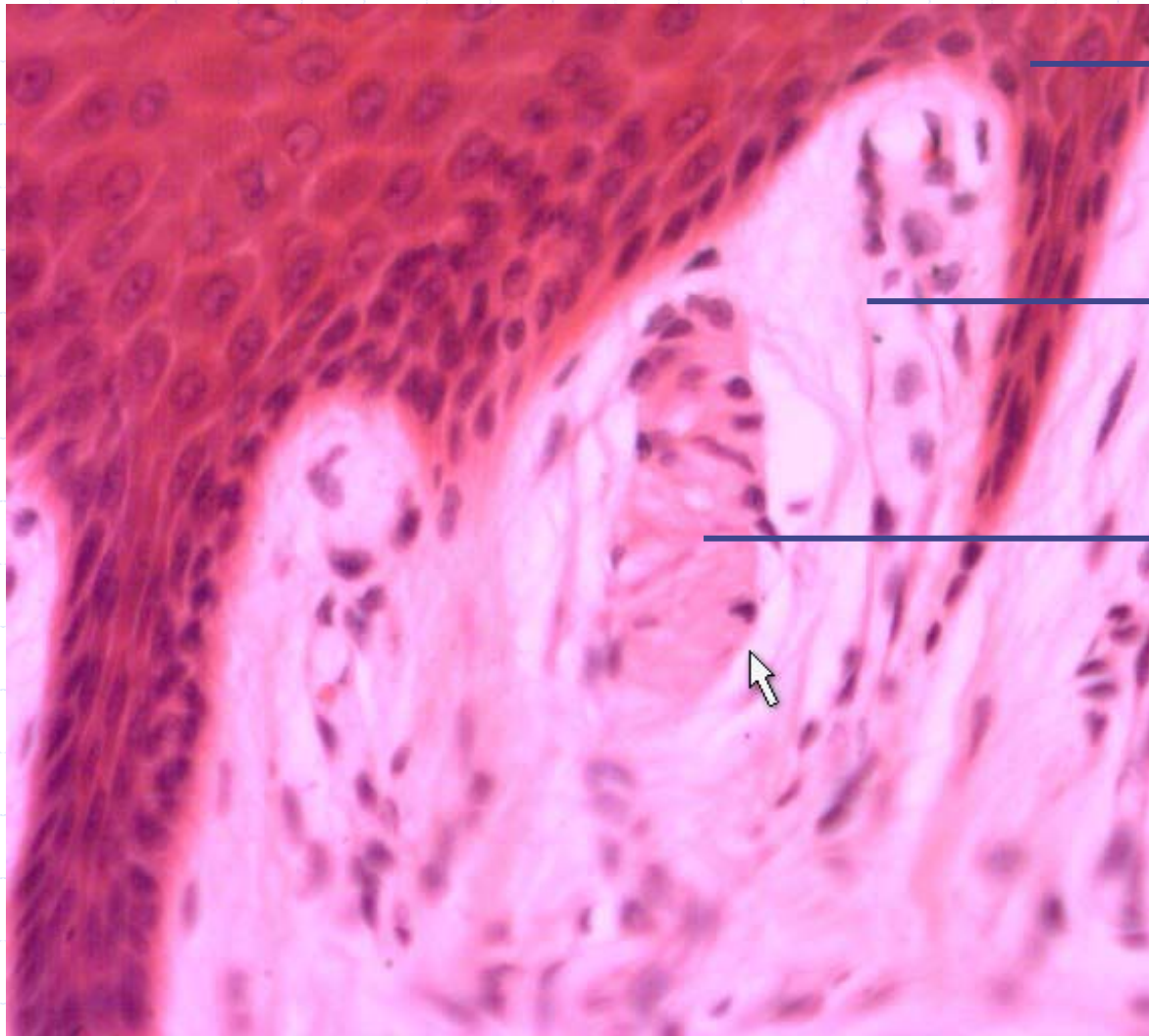
◆ function:

■ touch receptors

oval bodies with long axis vertical to the surface of the skin

These corpuscles are composed of a delicate **collagenous tissue capsule** and **flattened cells**, which are arranged in the form of multiple-stacked (horizontal) layers. One or more **unmyelinated sensory nerve terminals** enter into the corpuscle at one pole, zigzag upwards through the stacked flattened cells, and terminate at the other pole.





epidermis

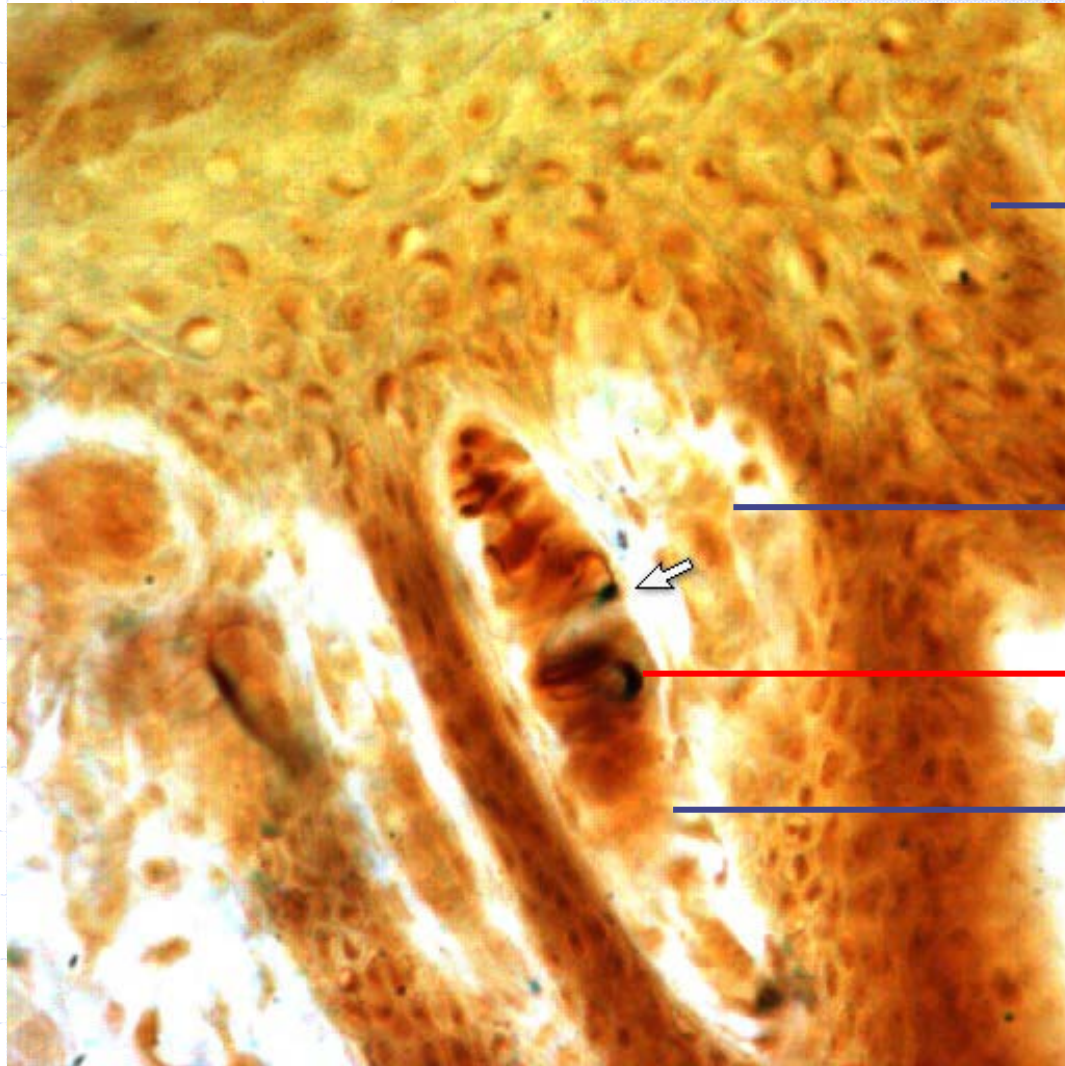
dermal papillae

Tactile corpuscles

Hairless skin

H&E stain

oval bodies with their long axis vertical to the surface of skin
Capsule+ layers of horizontal flattened cells



epidermis

dermal papillae

Nerve endings

Tactile corpuscles

Hairless skin ,Silver stain

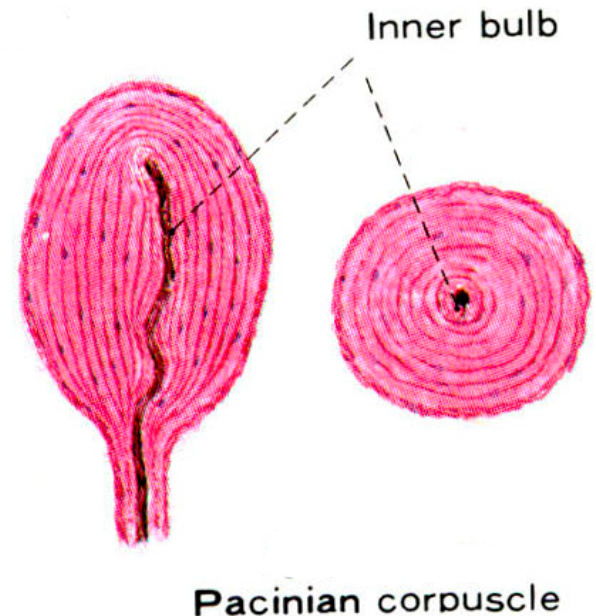
Dendrites of sensory nerve fibers → lost myelin-sheath → enter into the corpuscle at one pole → zigzags upwards through the stacked flattened cells → terminal at the other pole

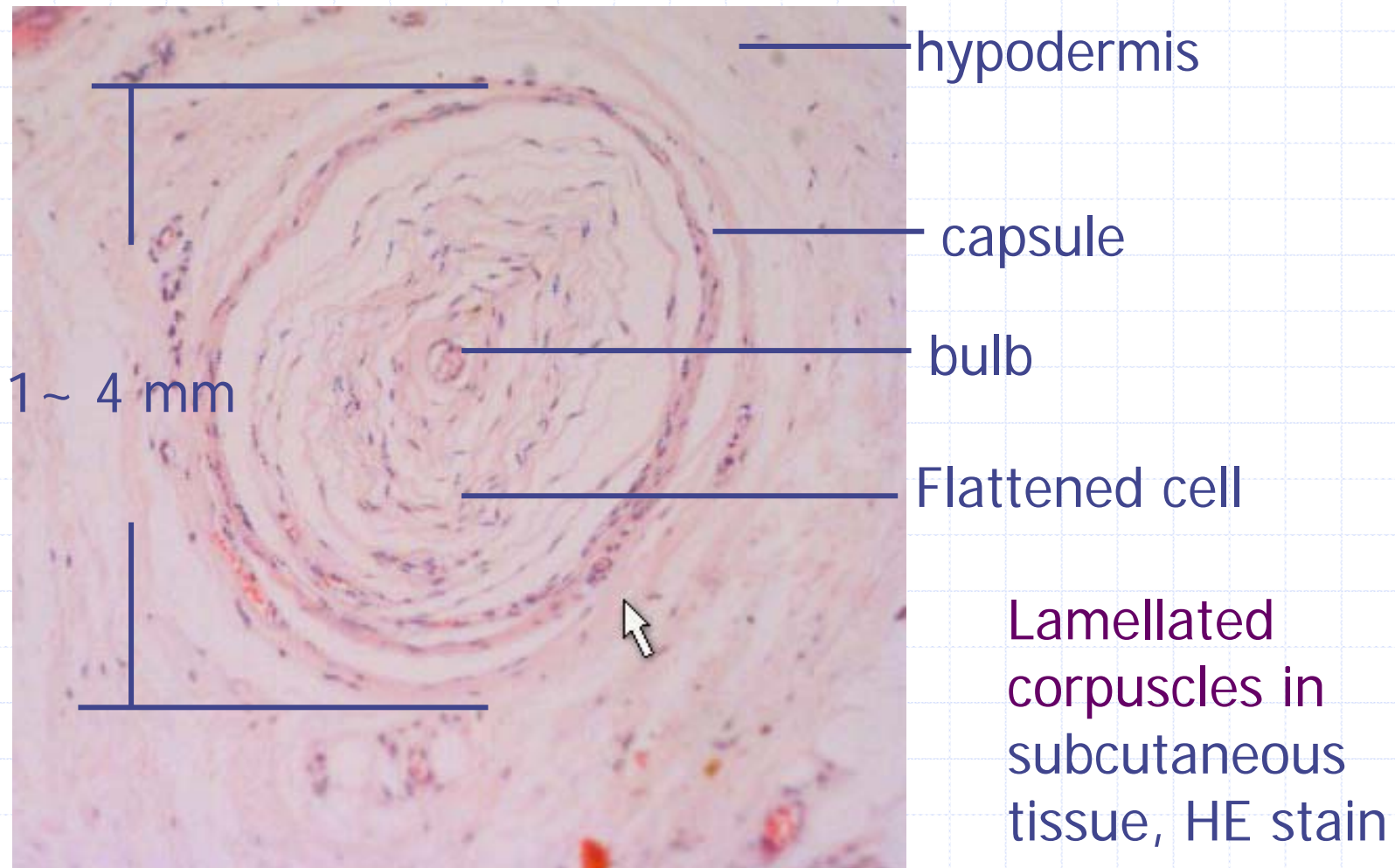


5.1.2.2 Lamellated corpuscles

- ◆ Pacini corpuscles
- ◆ hypodermis, mesentery, pancreas, loose connective tissue
- ◆ function:
 - feel deep or heavy pressure
 - Detect vibrations

The lamellated corpuscles are **large, ovoid** structures. These corpuscles consist of a **delicate capsule** enclosing many concentric **lamellae of flattened cell**. In a transverse section, the lamellated corpuscle resembles a sliced onion in a vertical section, an **unmyelinated nerve ending** enter into the corpuscle and pass through the corpuscle to end in an expanded **bulb**.

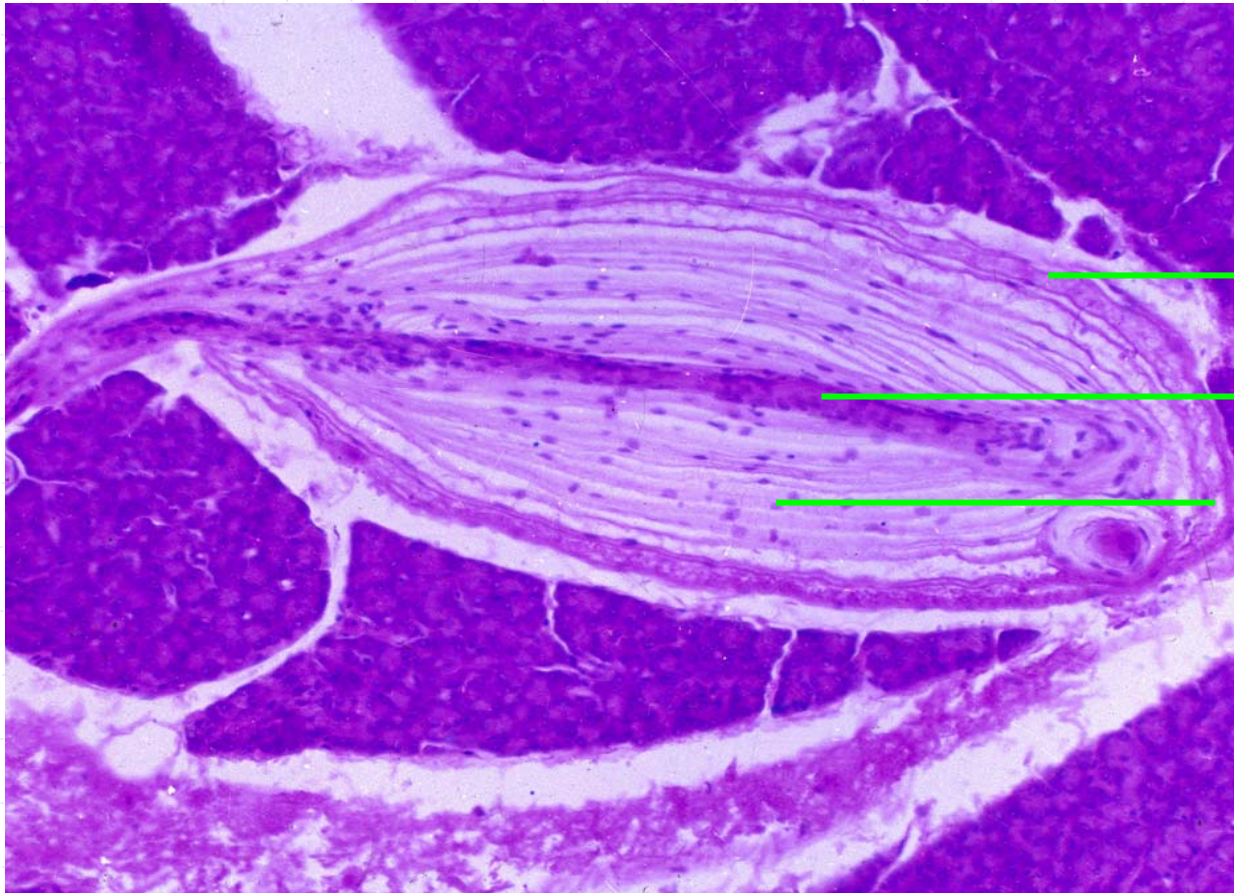




large , oval or spherical;

Capsule + layers of concentric flattened cells

In transverse section, lamellated corpuscle resembles a sliced onion.



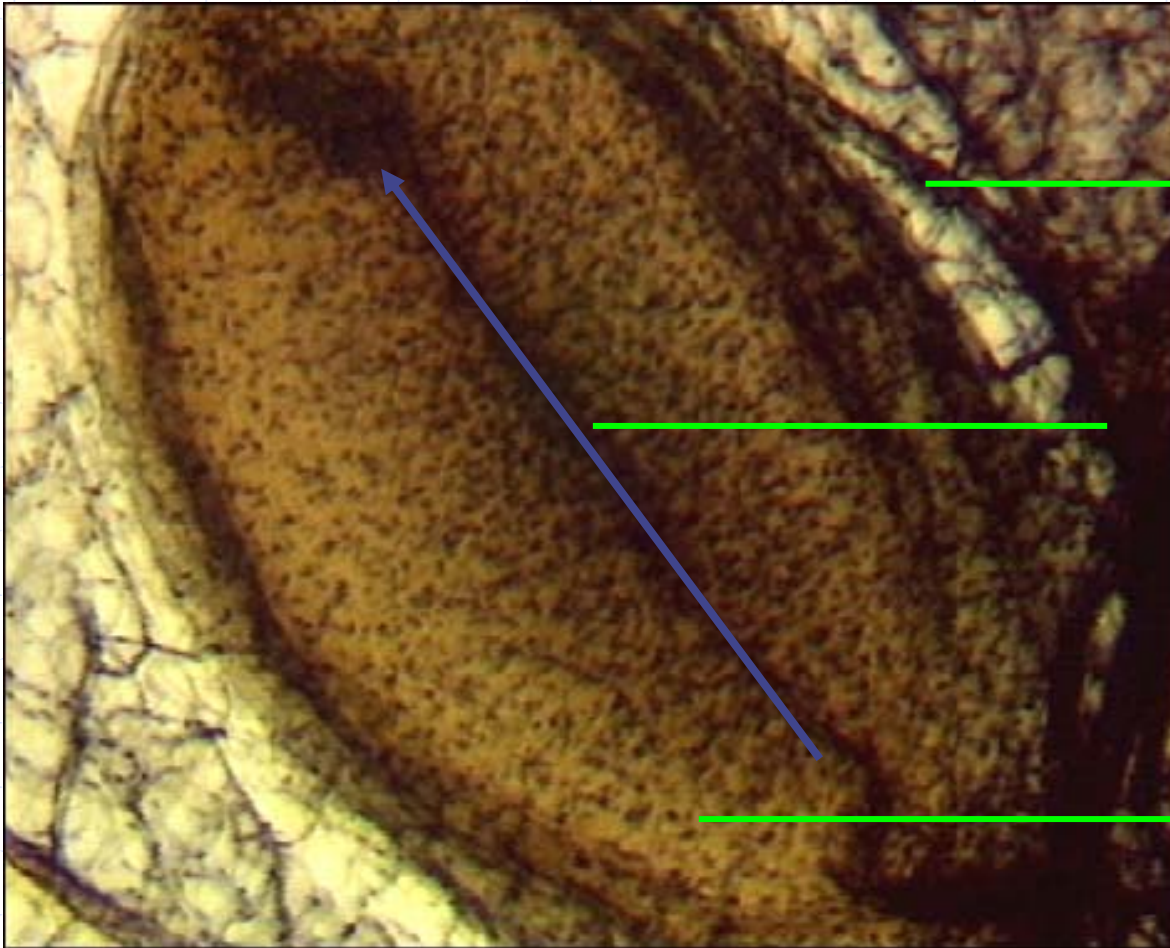
capsule

bulb

Flattened cells

Lamellated
corpuscles in
pancreas, HE stain

Dendrites of sensory nerve fibers → lost myelin sheath → enter into the corpuscle → bulb



capsule

Nerve ending in
the bulb

Flattened cells

Longitudinal section of Lamellated corpuscles in
hypodermis, silver stain



5.1.2.3 Muscular spindles

- ◆ skeletal muscle, often near a tendon ,a mechanoreceptor
 - detect changes in muscle length
 - important in the reflex regulation of muscle tension.
- ◆ Capsule+ intrafusal muscle fibers+sensory nerve endings
 - nuclear chain fibers: nuclei are aligned along the length of the muscle fiber
 - nuclear bag fibers: nuclei are clustered in bag-like dilation in middle of muscle fiber.

sensory nerve endings

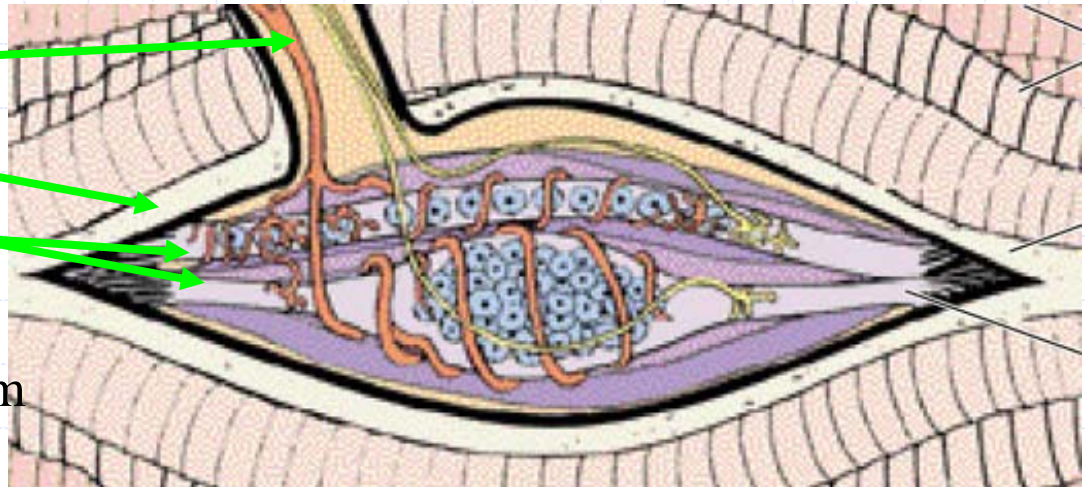
Capsule

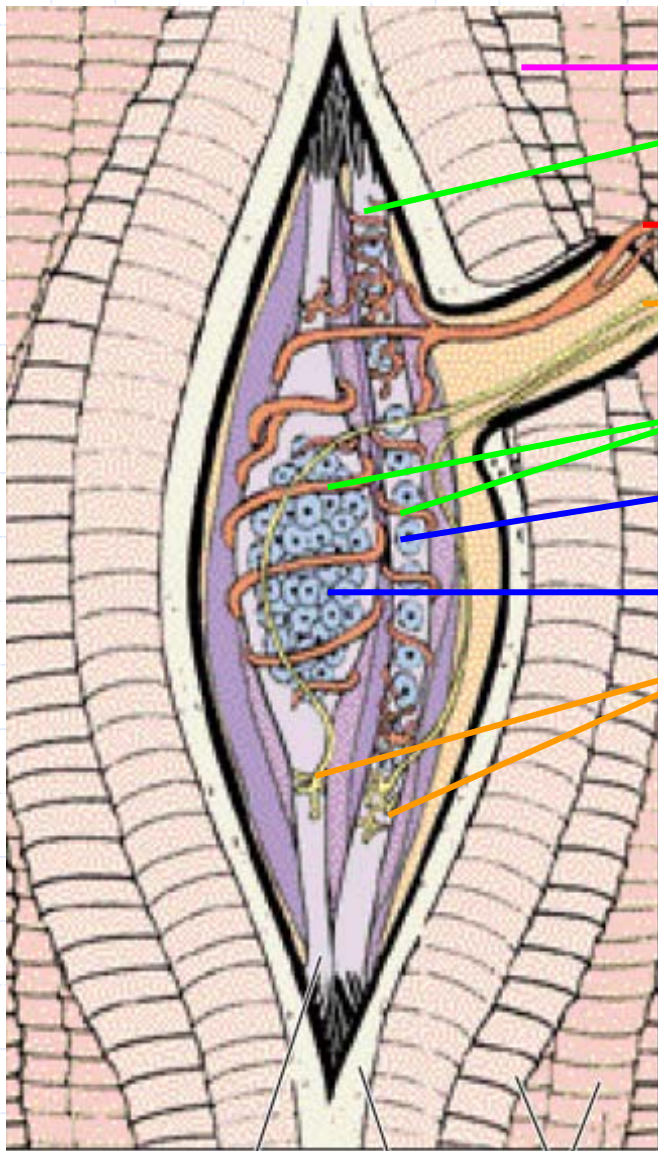
intrafusal muscle fibers

smaller

thinner and richer in sarcoplasm

central non-striated area

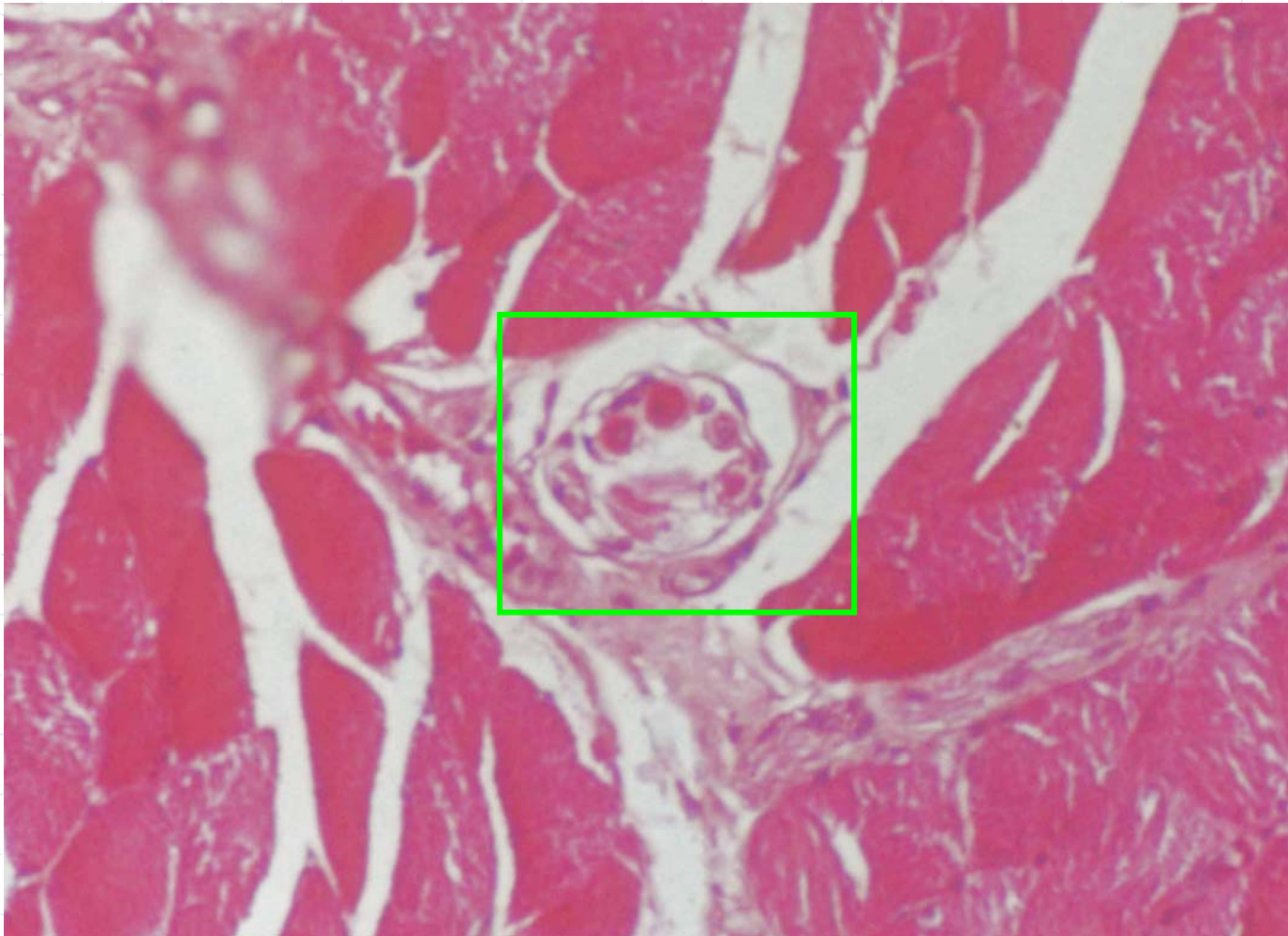




Intrafusal fibers External capsule Striated muscle

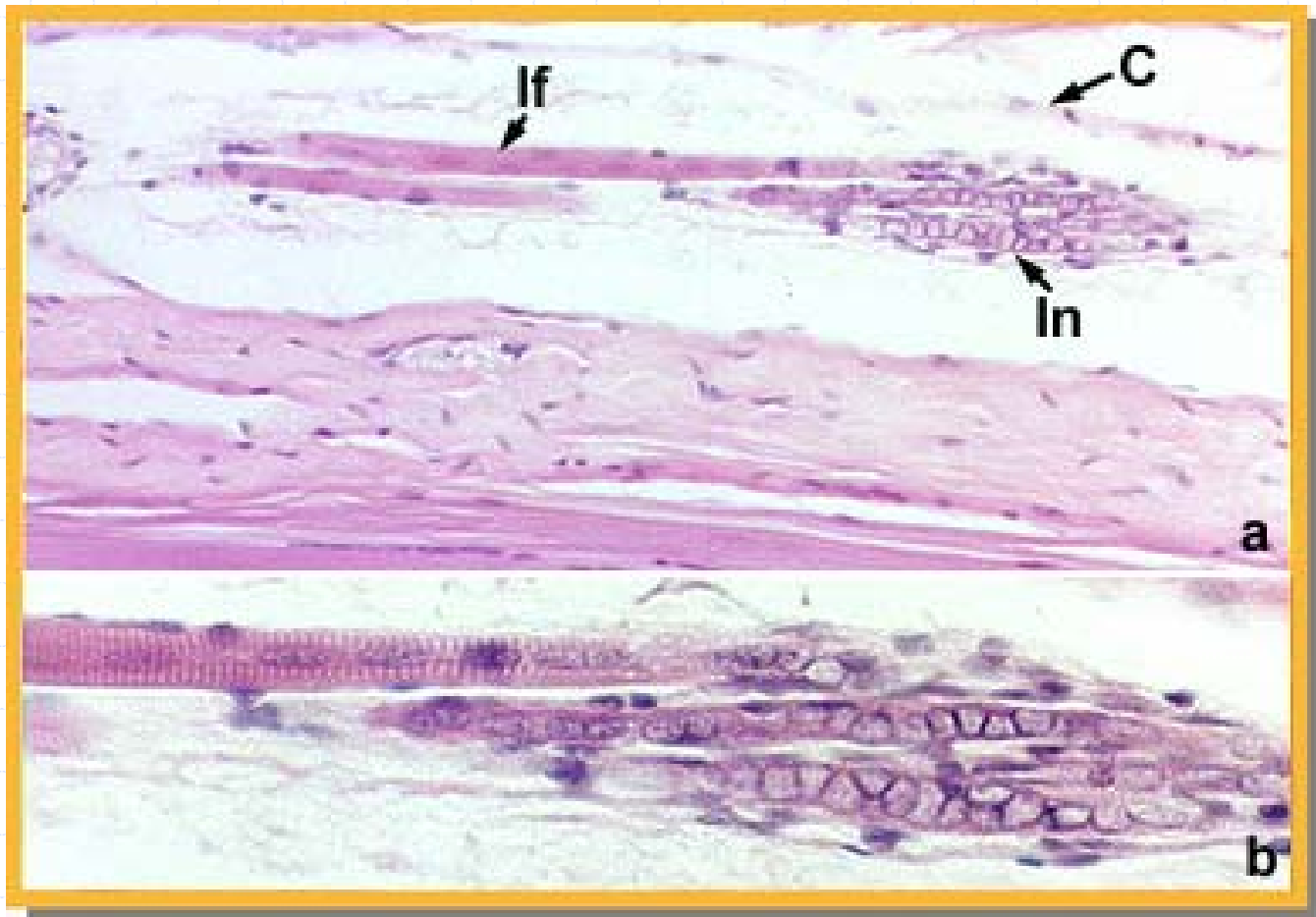
- extrafusal muscle fibers
- Secondary Flower spray endings
- Sensory nerve fiber ending
- motor nerve fiber ending
- Primary Spire-like sheath endings
- Nucleus chain fiber
- Nucleus bag fiber
- Motor end plate

sensory fibers → lose myeline sheath → encounter the intrafusal fibers → primary nerve fiber endings enwrap the central region → spire-like sheath → secondary nerve fibers ending branch in clusters → flower spray endings.



Muscle spindle, cross section, HE

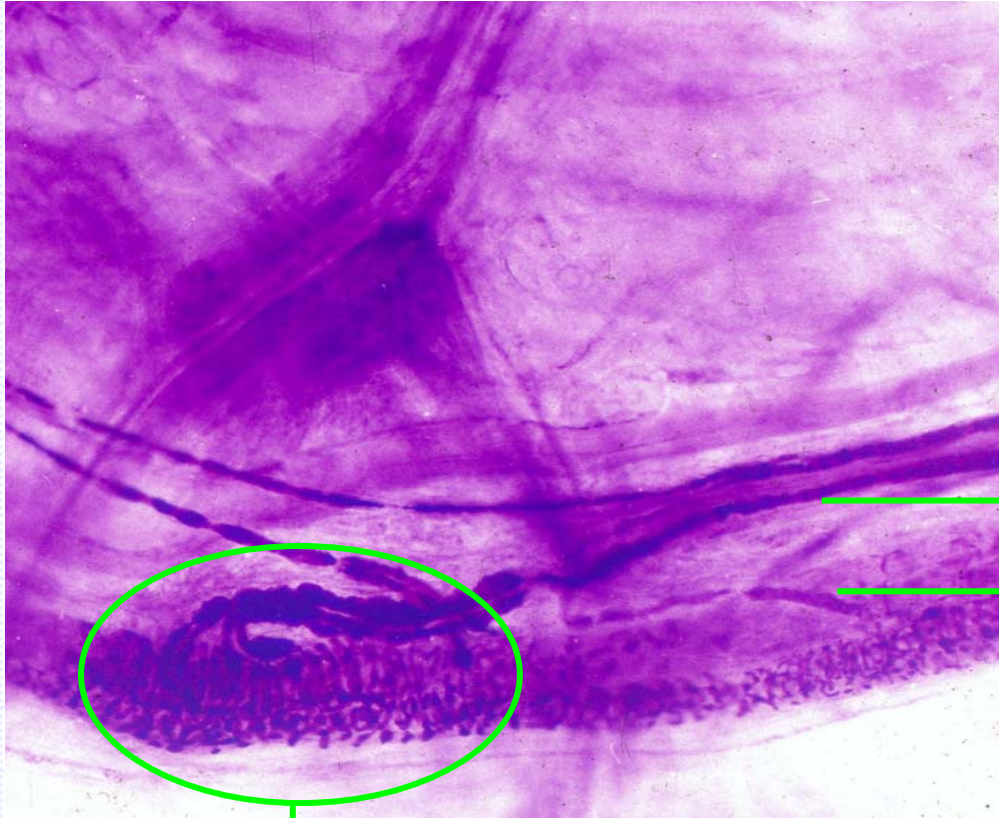
Intrafusal muscle fibers are much thinner than extrafusal muscle fibers and embed in endomysium.



Muscle spindle, longitudinal section, HE

Intrafusal muscle fibers with numerous nuclei in the center are much thinner than extrafusal muscle fibers. Fig.a low mag. Fig. b high mag.

If: intrafusal muscle fiber; In: nucleus; C: capsule



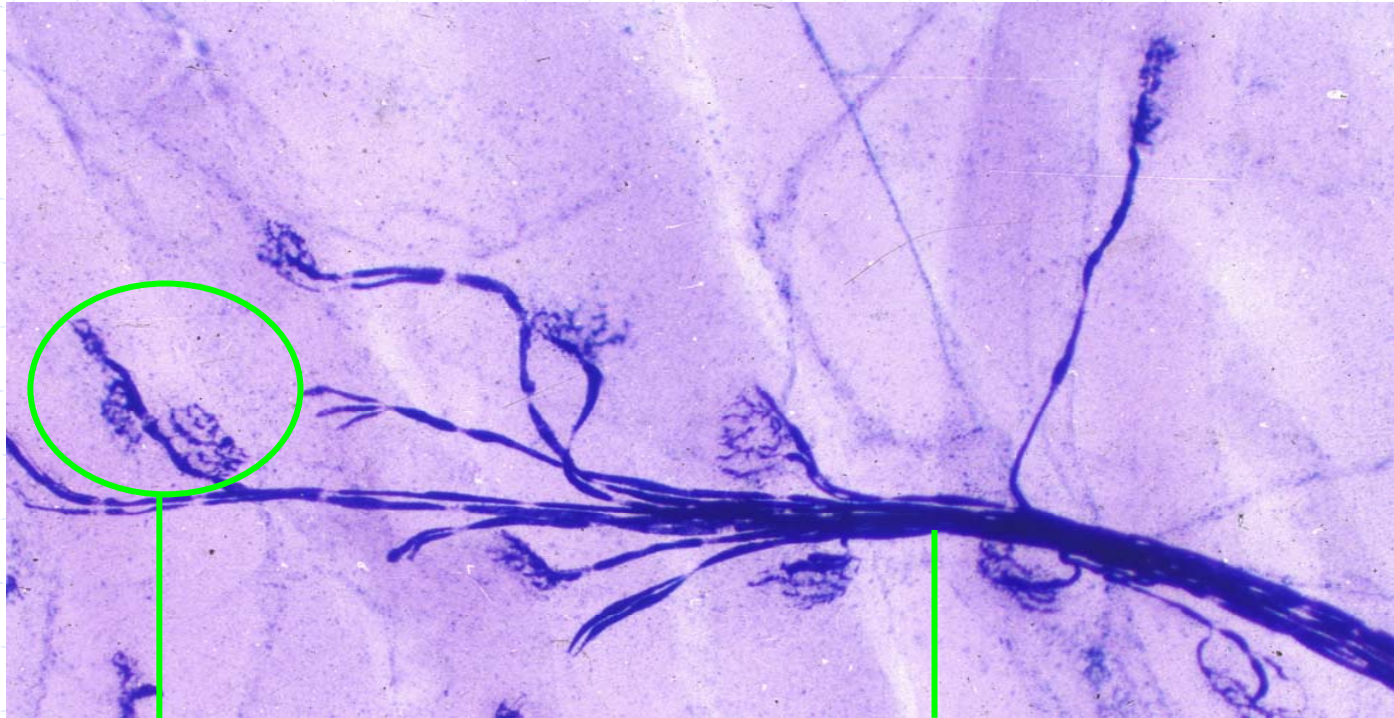
Muscular spinal

Sensory nerve fiber ending
intrafusal muscle fibers

Muscular spinal,
gold stain



5.2.1 Motor end plate



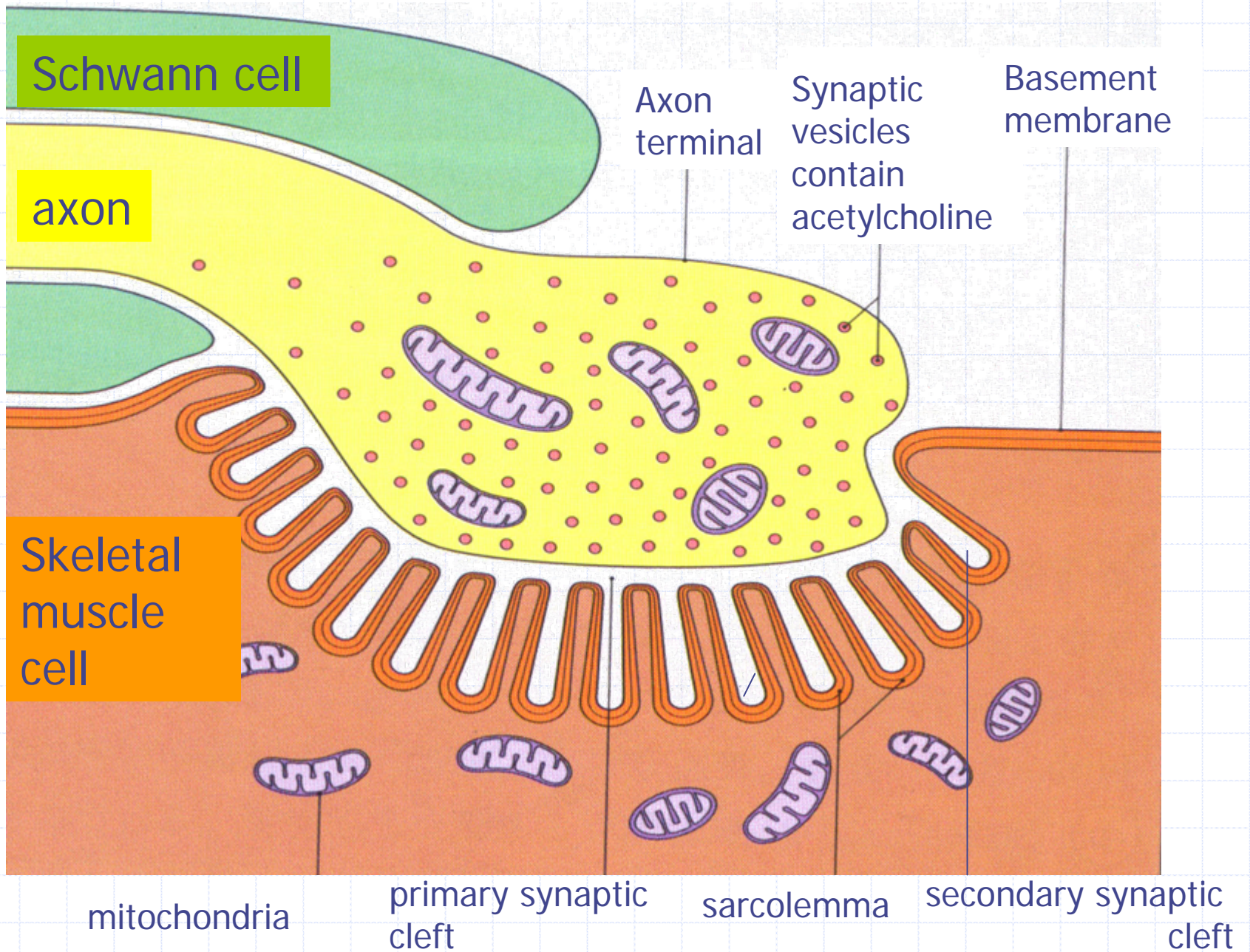
motor end plate

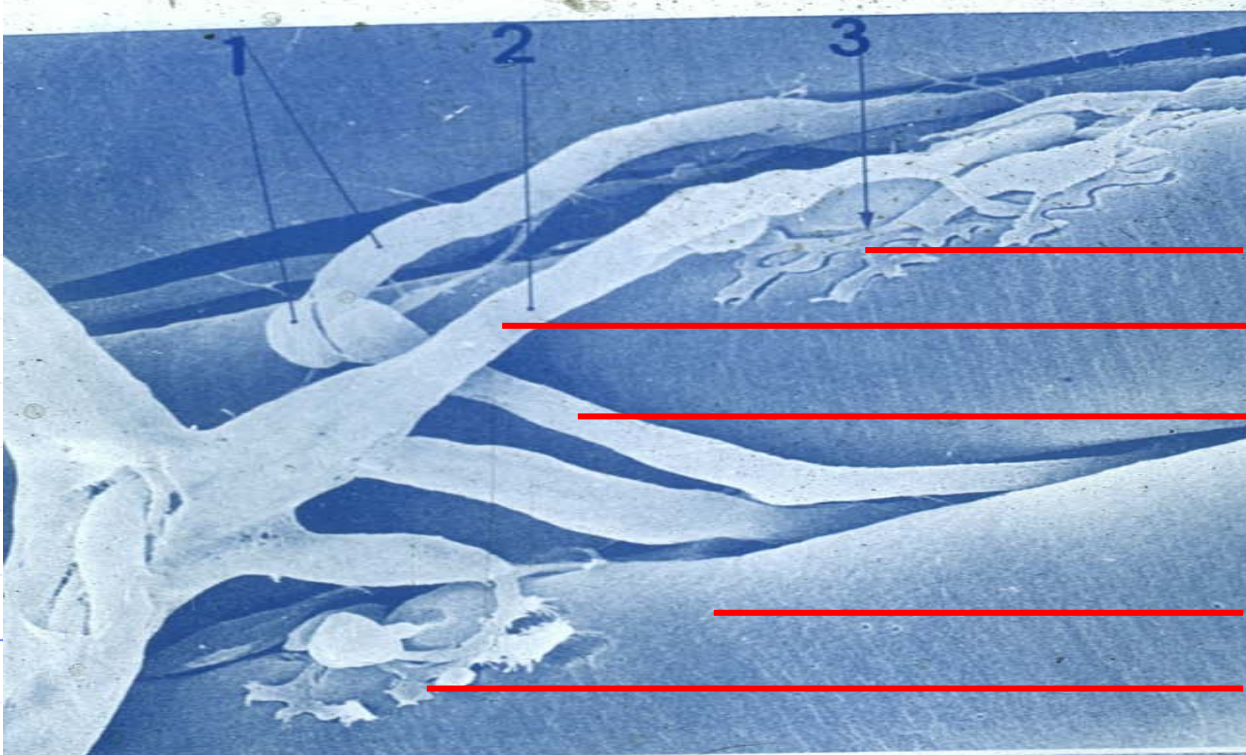
motor nerve fiber ending

- ◆ Between terminal of motor nerve fiber and skeletal muscle,
- ◆ myoneural junction (motor end plate) , synapse
- ◆ Motor nerve fiber end → lose myelin sheath → covered by Schwann cell cytoplasm → terminal button → on muscle cell surface

◆ Structure

- Presynaptic element: axon terminal
 - ◆ Presynaptic membrane
 - ◆ synaptic vesicles : **acetylcholine**
- Synaptic cleft
 - ◆ **primary synaptic cleft**
 - ◆ **secondary synaptic cleft**
- Postsynaptic element:
 - ◆ Postsynaptic membrane: sarcolemma
 - ◆ **acetylcholine receptor**





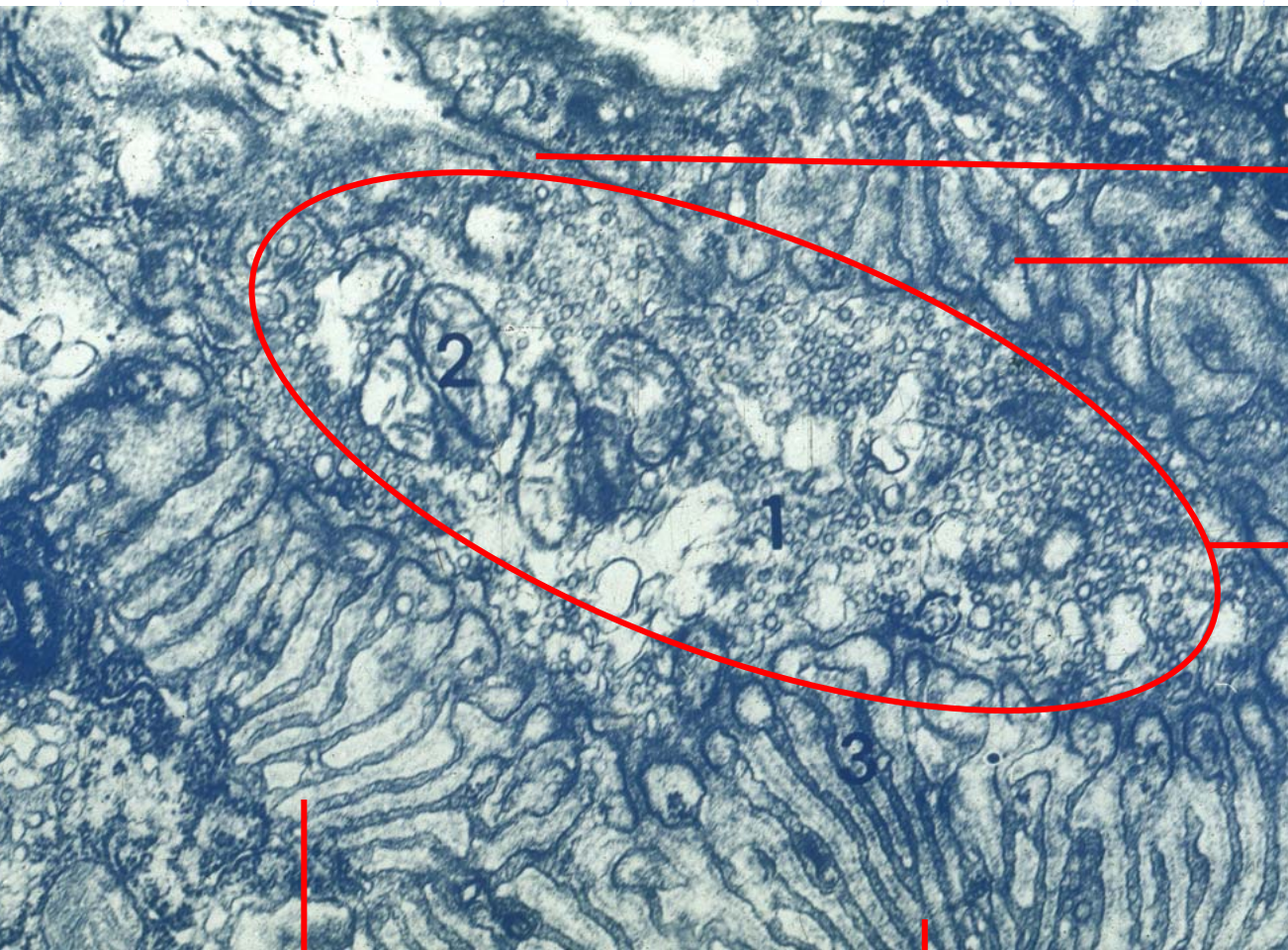
Motor end plate
Motor nerve ending
capillary



Skeletal muscle
Motor end plate
Skeletal muscle

Primary
synaptic cleft

motor end plate



primary synaptic cleft

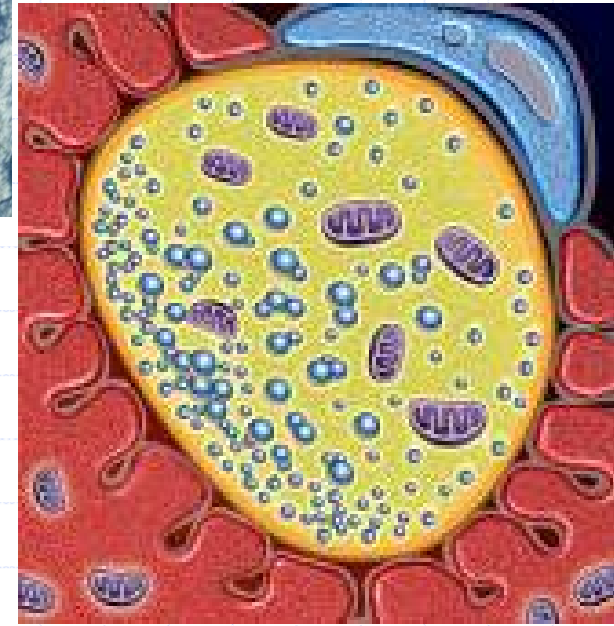
sarcolemma

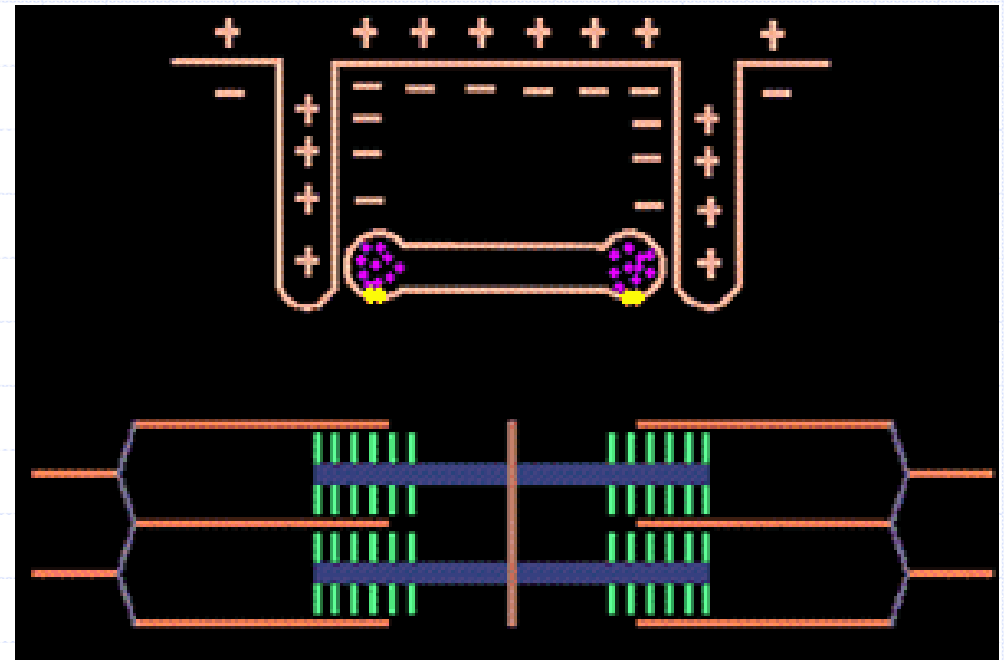
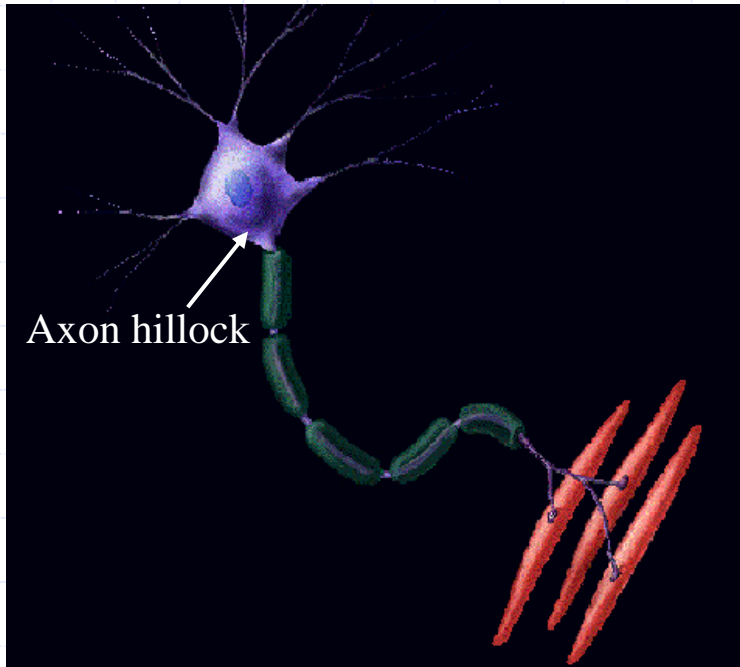
Axon terminal with synaptic vesicles

sarcolemma

Secondary synaptic cleft

motor end plate





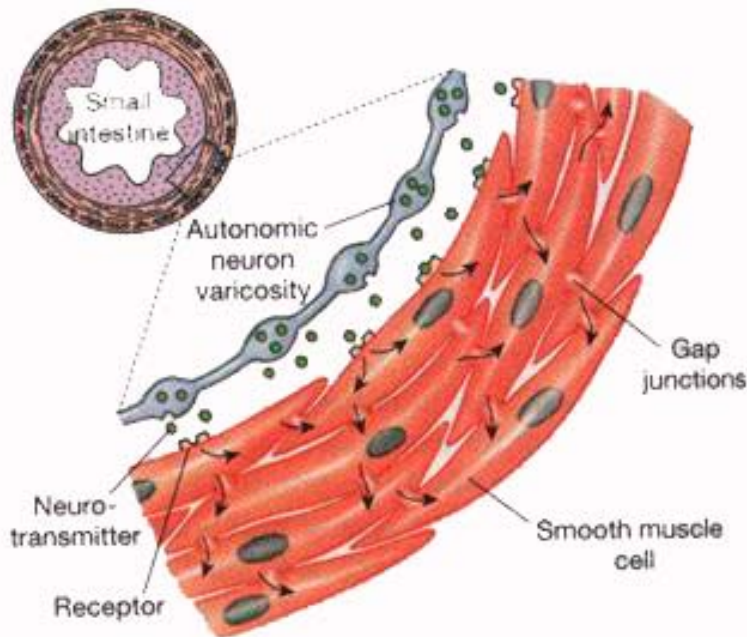
impulses → terminal axon release acetylcholine → bind to receptor
 → an action potential passes over sarcolemma → T-tubules →
 liberate calcium ions from terminal cisternae → sliding filament
 mechanism of muscle contraction → Acetylcholinesterase → relaxation



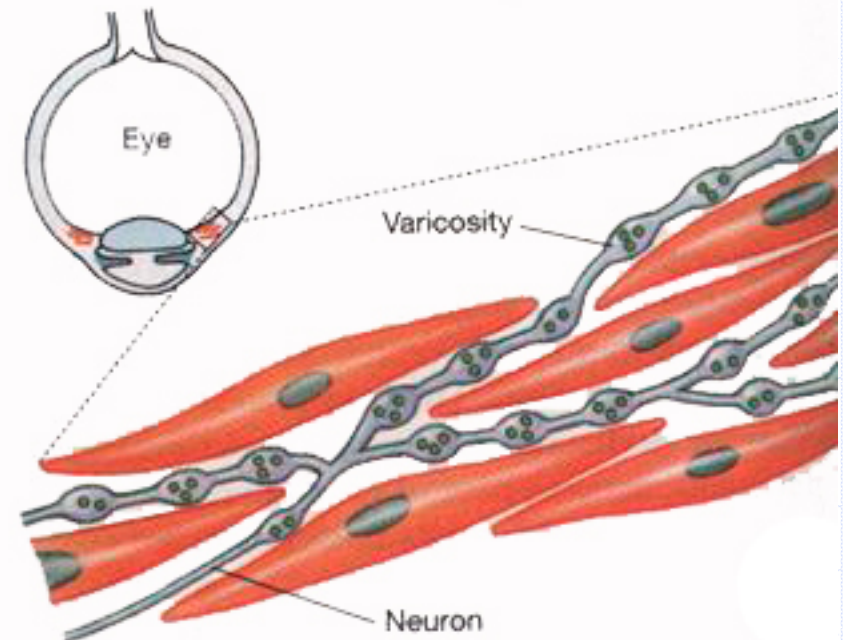
5.2.2 Visceral motor nerve endings

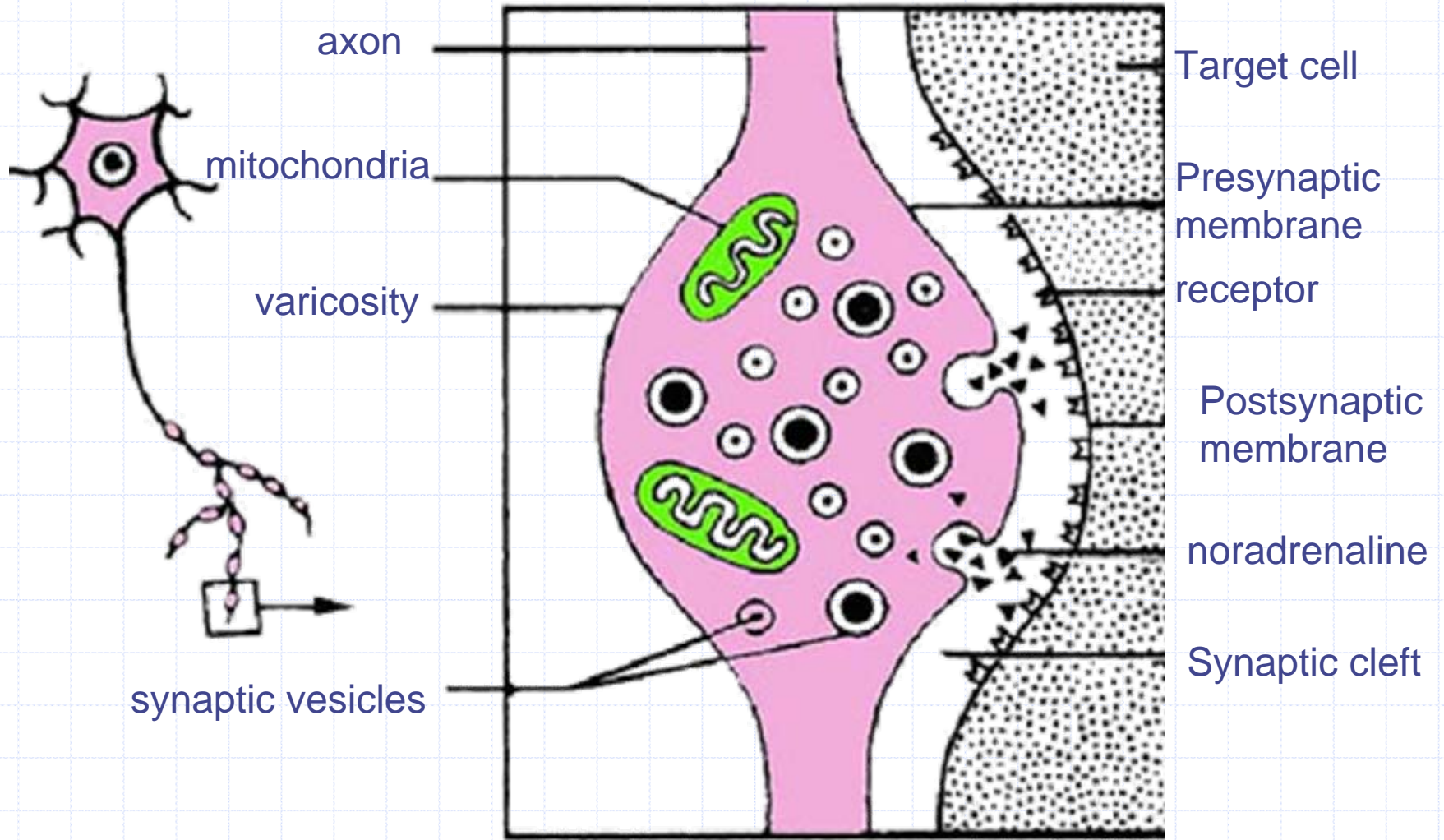
- ◆ heart, smooth muscle, gland epithelial cells.
- ◆ Formation
 - unmyelinated postganglionic visceral motor nerve fiber endings → varicosities with synaptic vesicles (noradrenaline) → target organs

(a) Single-unit smooth muscle



(b) Multi-unit smooth muscle





focal points

- ◆ The structure of myelinated fibers in PNS & CNS
- ◆ Terms: Ranvier node, internode, clefts of Schmidt-Lanterman
- ◆ The define and structure of nerves
- ◆ The structures and functions of 4 types of sensory endings
- ◆ The structures and functions of motor end plate