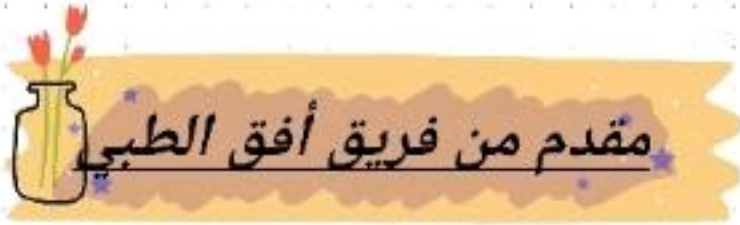

مقدم من فريق أفق الطبي


جامعة الأزهر - غزة
AL-AZHAR UNIVERSITY - GAZA
1412-1991 - ١٤١٢-١٩٩١


حركة الشبيبة الفتحاوية
الأزهر
جامعة
Fateh Youth Movement

BONE

Overview

- Specialized connective tissue with mineralized ECM
- No lymphatic vessels

Functions

Skeleton

Protection of important organs

Bone marrow

Reservoir of calcium and phosphate

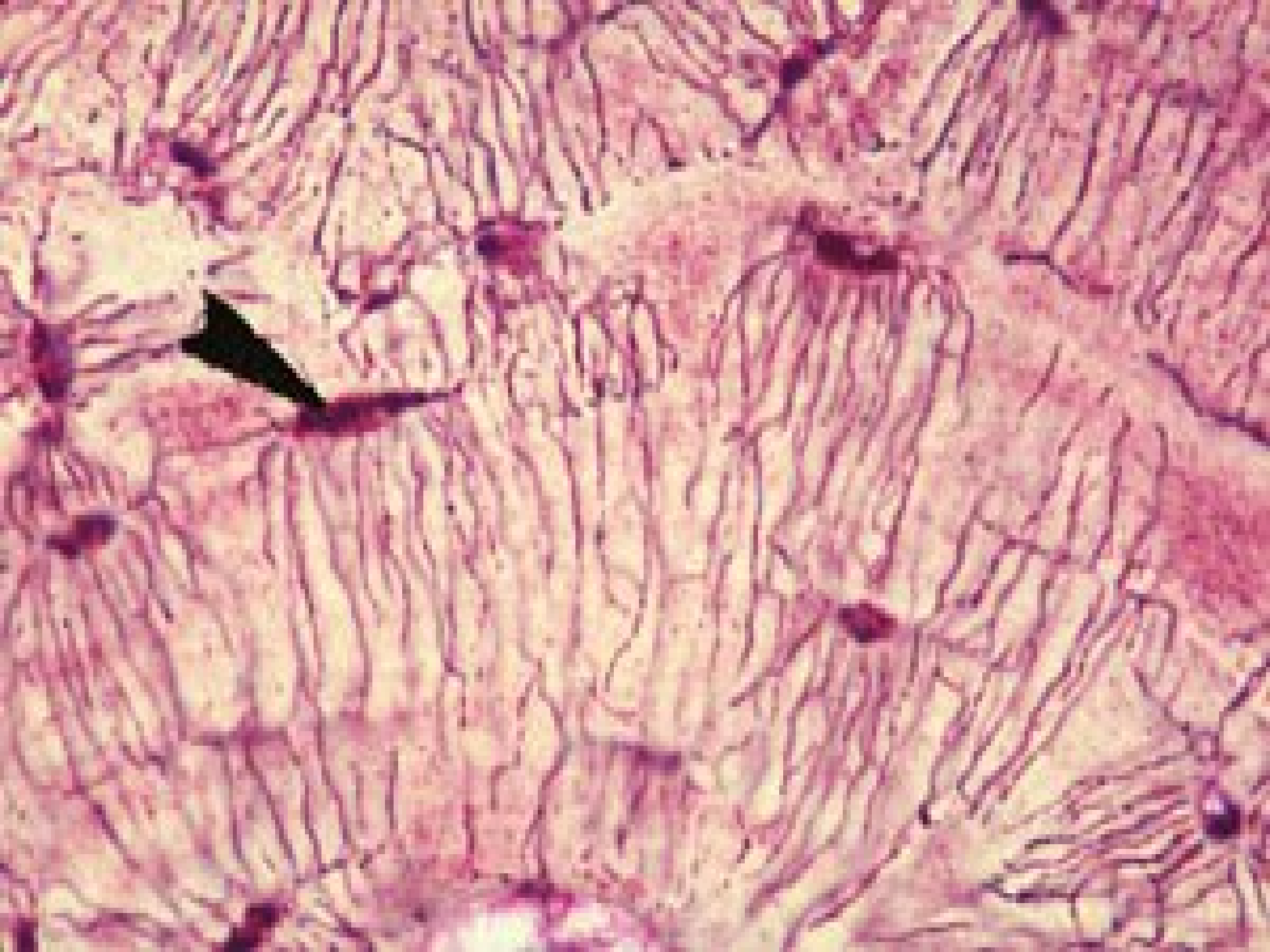
Levers for muscles

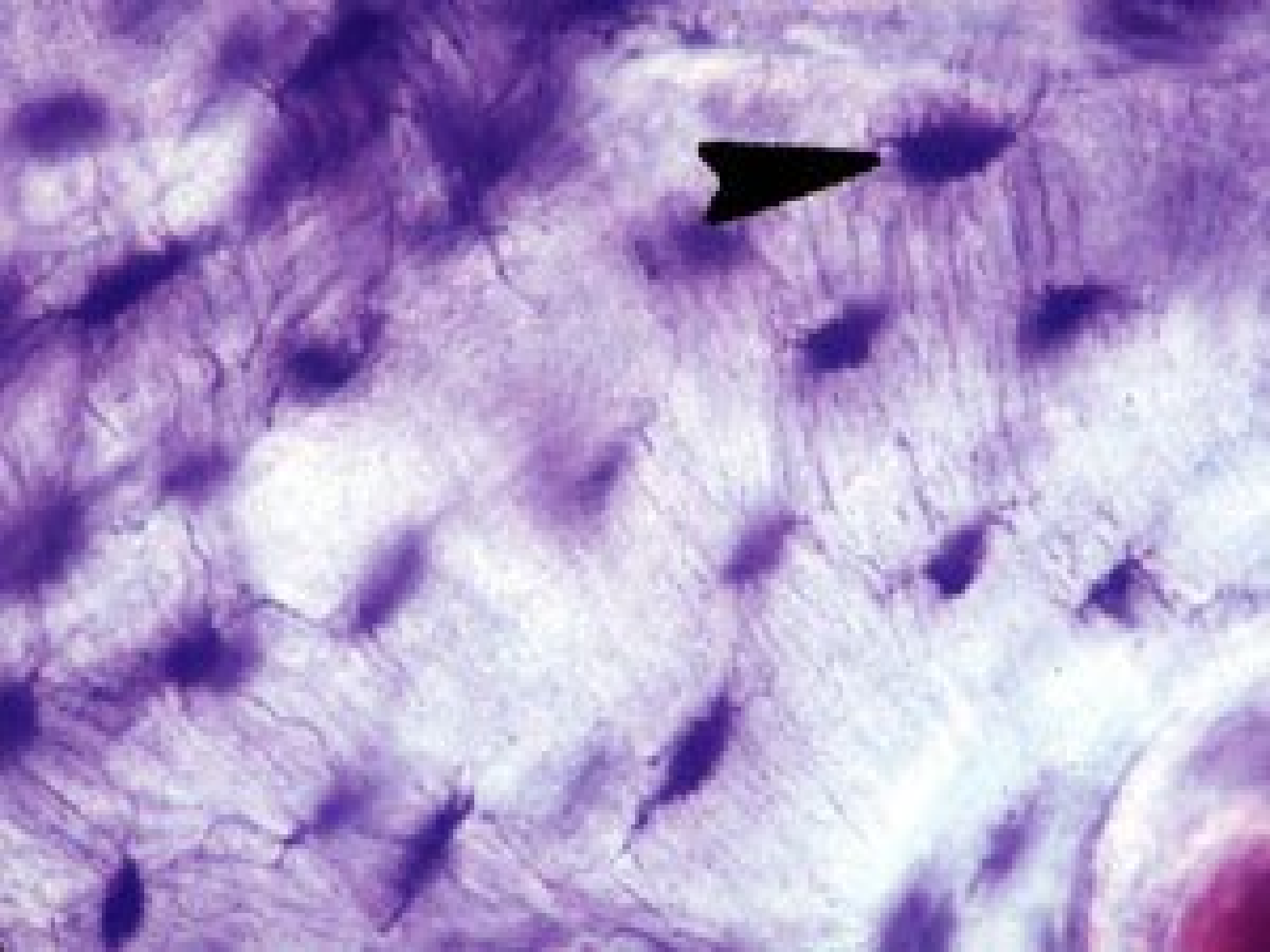
Bone matrix

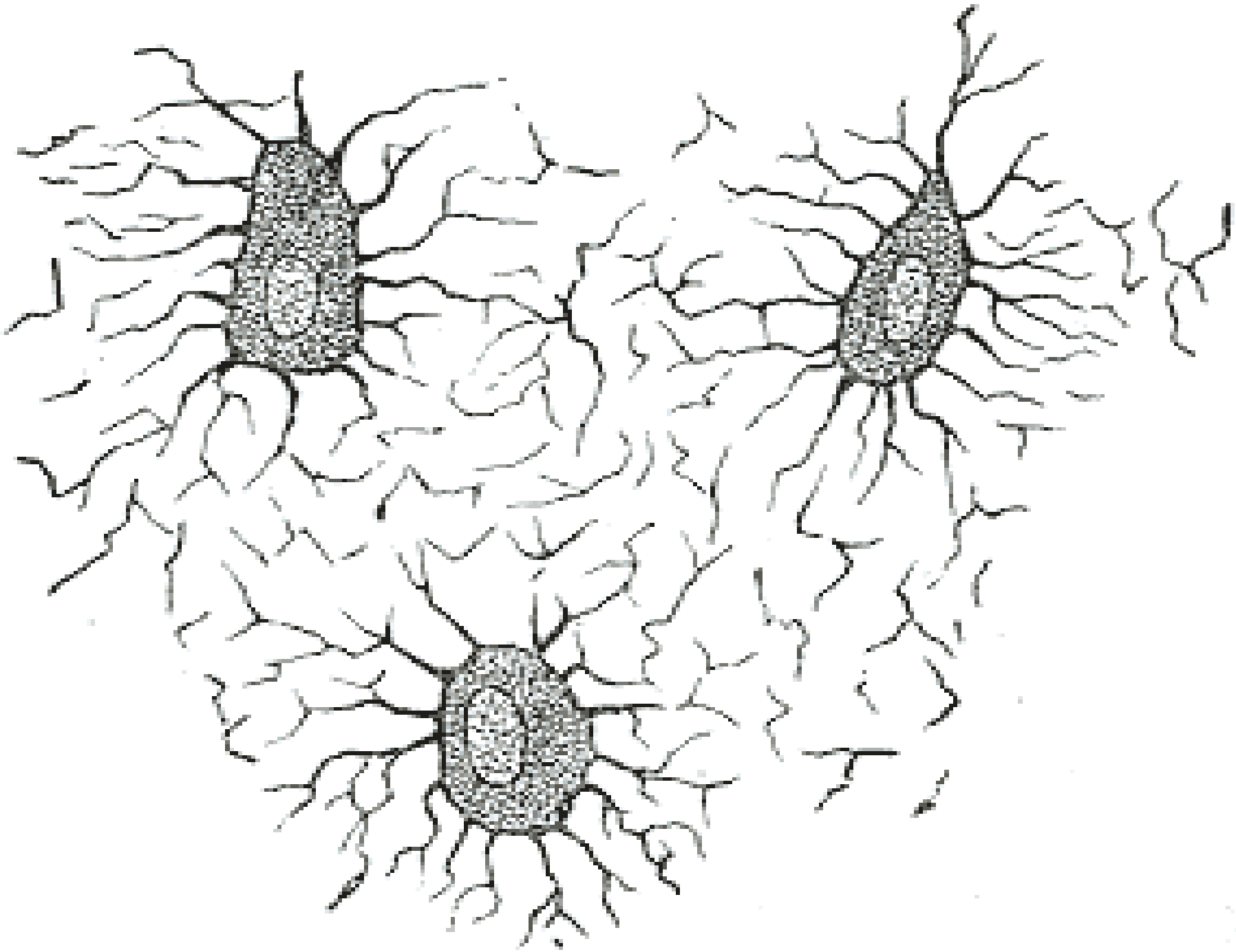
- Organic
  - Mainly collagen type I
  - Ground substance (non collagenous proteins)
    - Proteoglycan aggregates
    - Multiadhesive glycoproteins
    - Bone specific vitamin K dependent proteins
    - GFs and cytokines
- Inorganic hydroxyapatite crystals $Ca_{10}(PO_4)_6(OH)_2$ hydration shell bicarbonate, citrate, mg, k, and Na noncrystalline Ca phosphate

Cells

- Lacunae and Osteocyte
  - Processes into canaliculi
  - Interosteocytic communication by gap junctions
  - Maintains viability of the bone
- Osteoprogenitor cells
  - Give rise to osteoblasts
- Osteoblasts
  - Secrete the extracellular matrix







Cells

- Bone lining cells
  - The remaining osteoblast after bone deposition ceases
- Osteoclasts

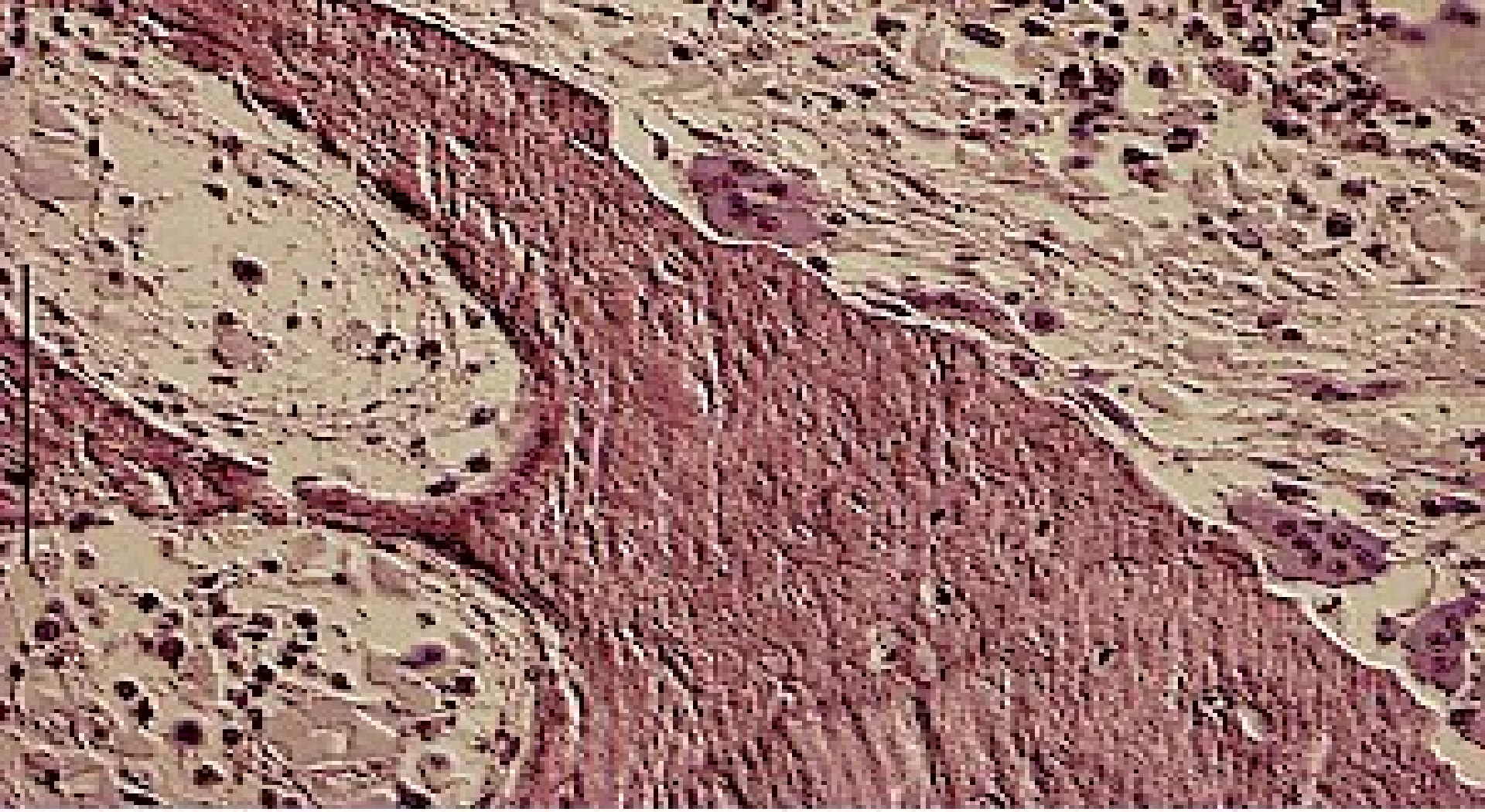
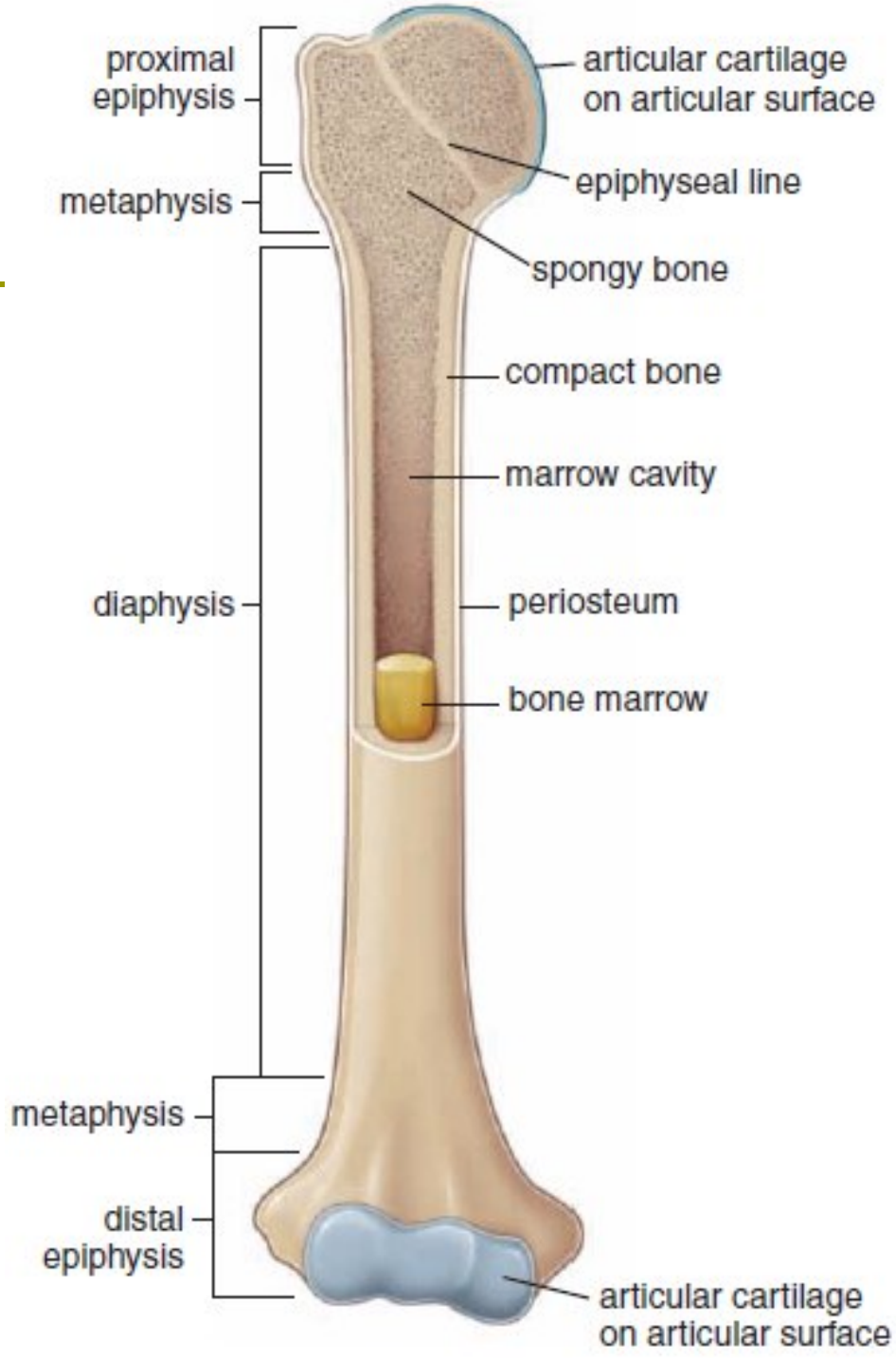
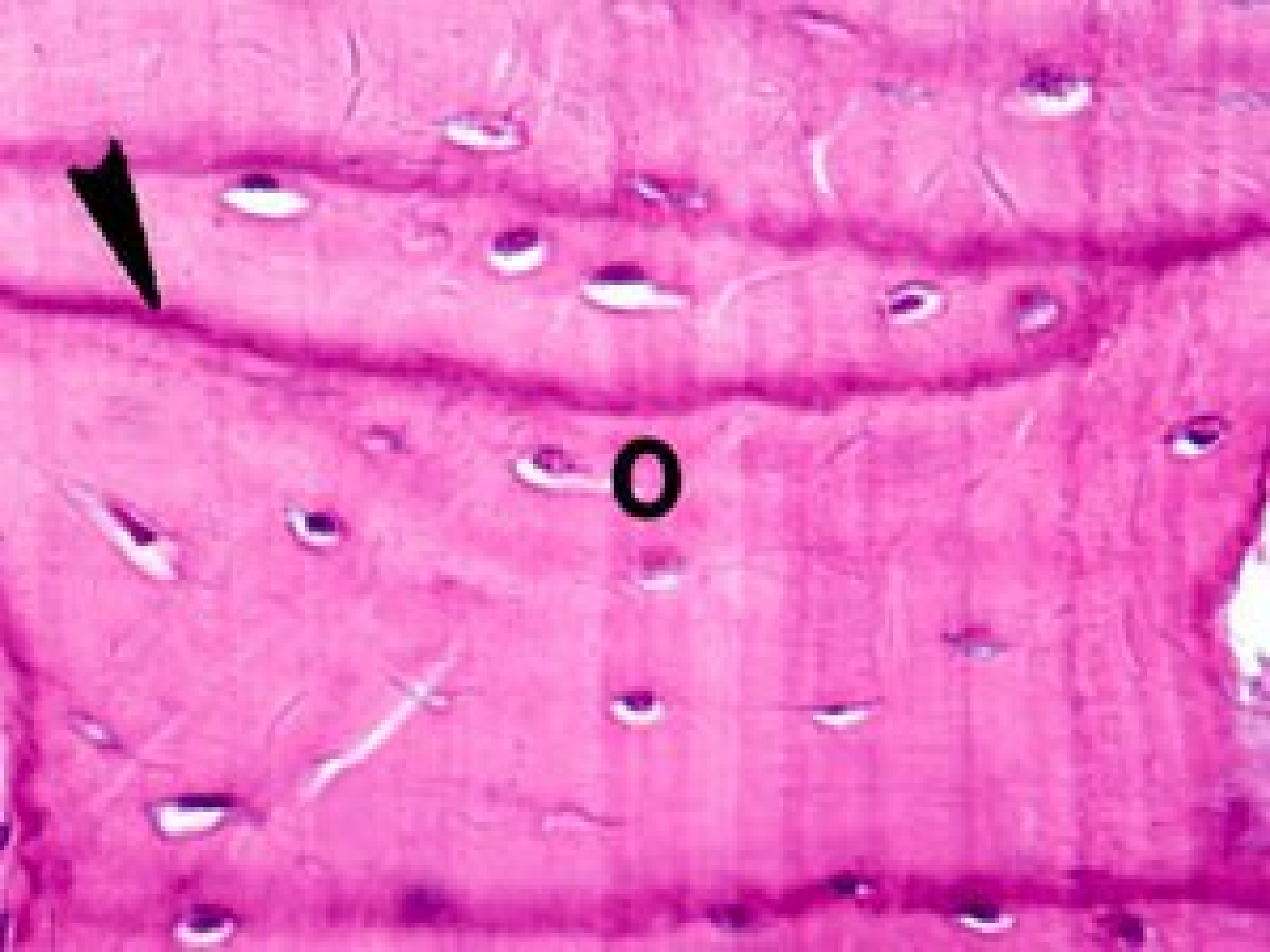


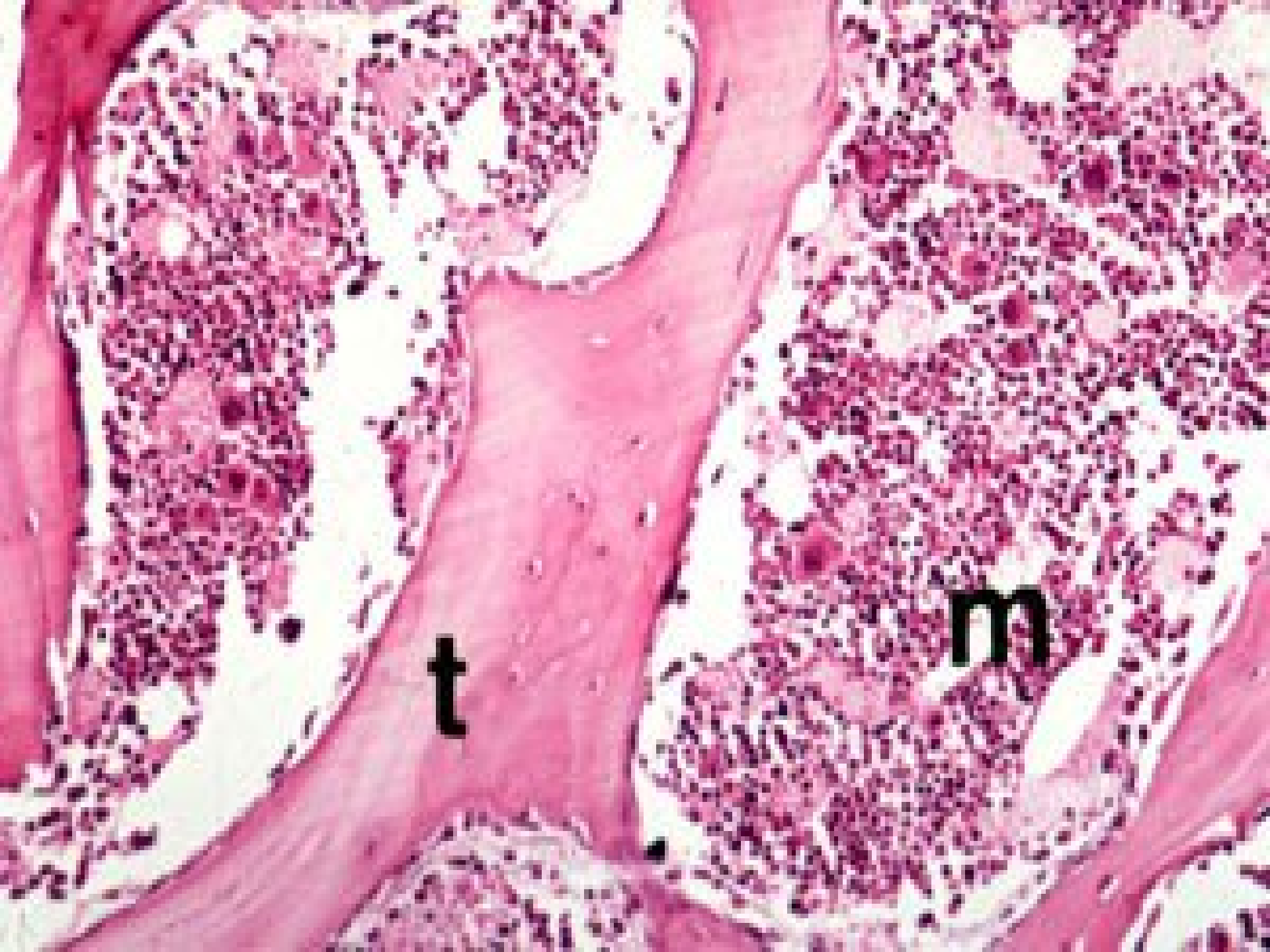
FIG. 27. A portion of a biopsy obtained from a patient with severe osteoporosis shows increased surface osteoclast activity.

General aspects

- Compact (dense) bone
- Spongy (cancellous) bone
- Classification according to shape
  - Long bones
  - Short bones
  - Flat bones
  - Irregular bone

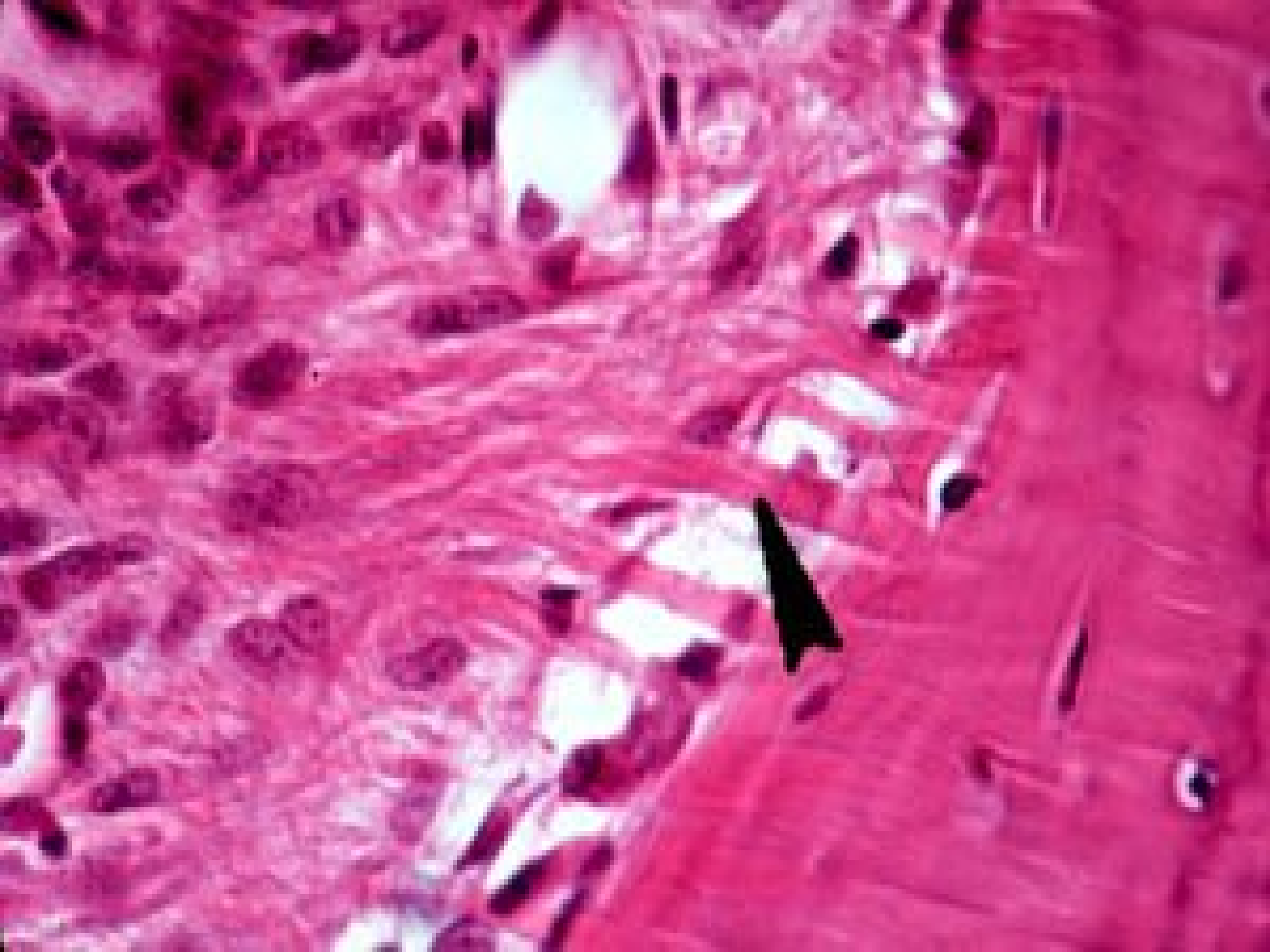

proximal epiphysis
articular cartilage on articular surface
epiphyseal line
metaphysis
spongy bone
compact bone
marrow cavity
diaphysis
periosteum
bone marrow
metaphysis
distal epiphysis
articular cartilage on articular surface


1
O


t
m

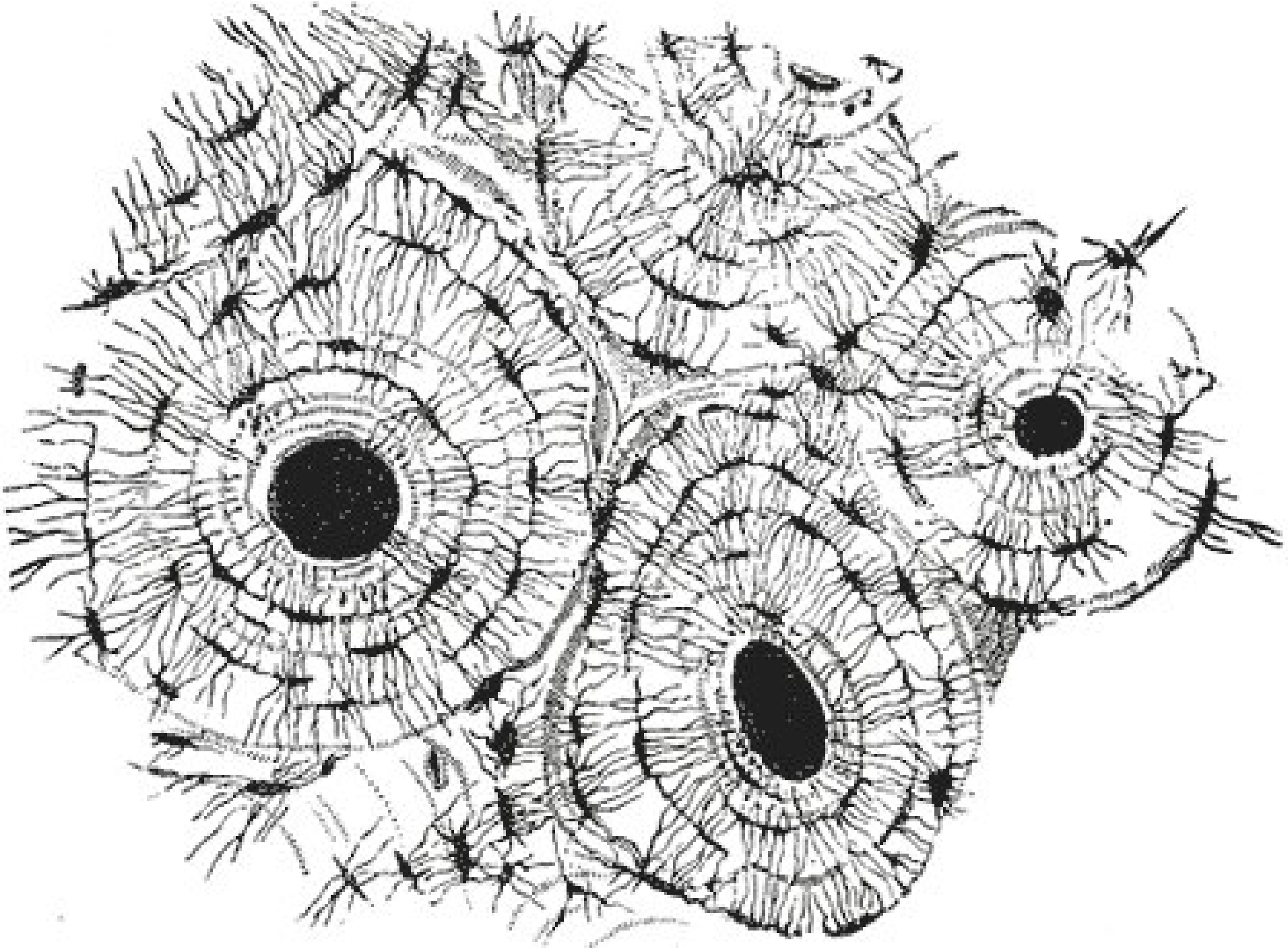
General aspects

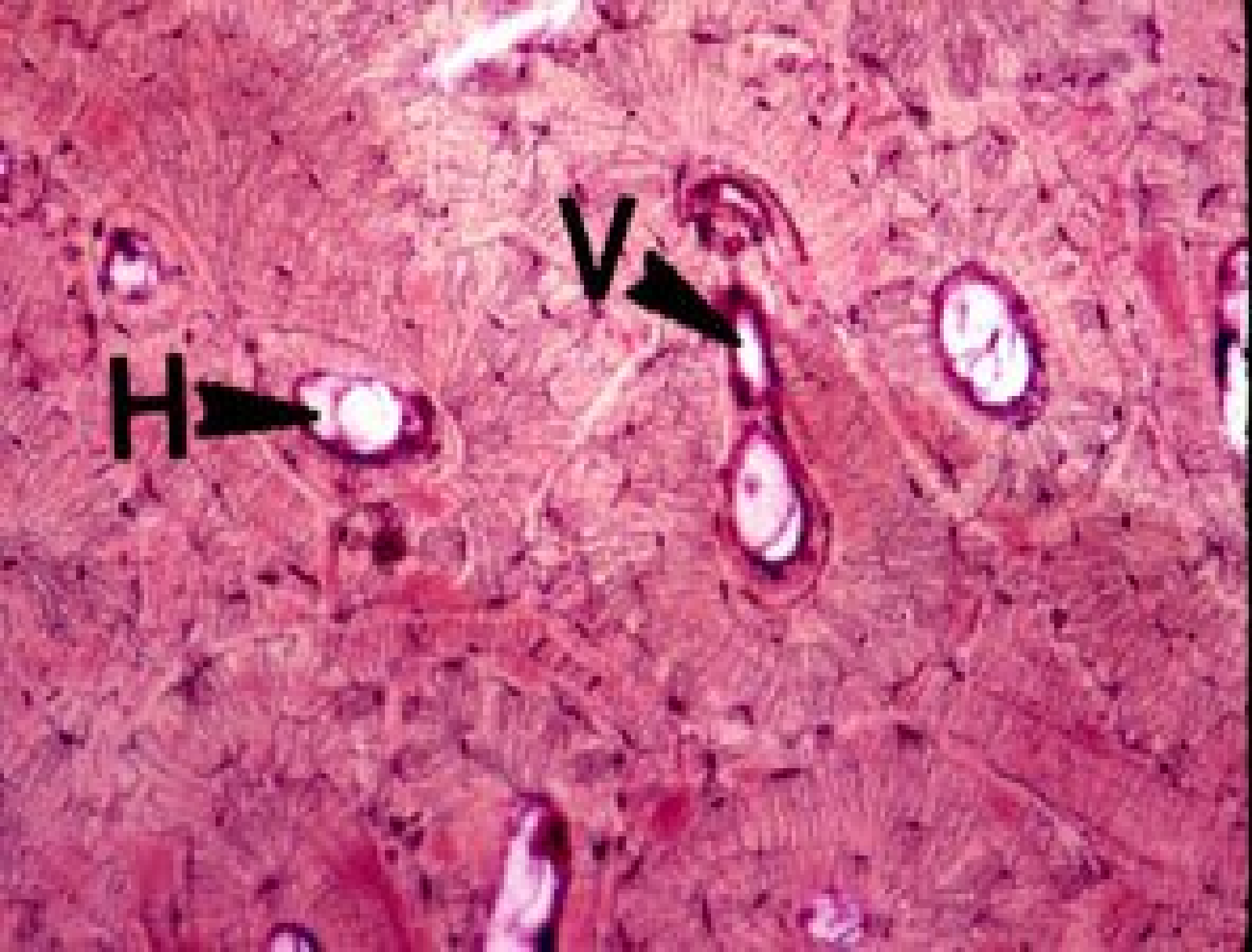
- Periosteum
  - Dense connective tissue containing osteoprogenitor cells
  - Outer fibrous layer and inner more cellular layer with osteoprogenitor cells
  - Perforating or Sharpey's fibers
- Articular surfaces covered by hyaline cartilage
- Endosteum
  - 1 cell thickness osteoprogenitor cells (endosteal cells)

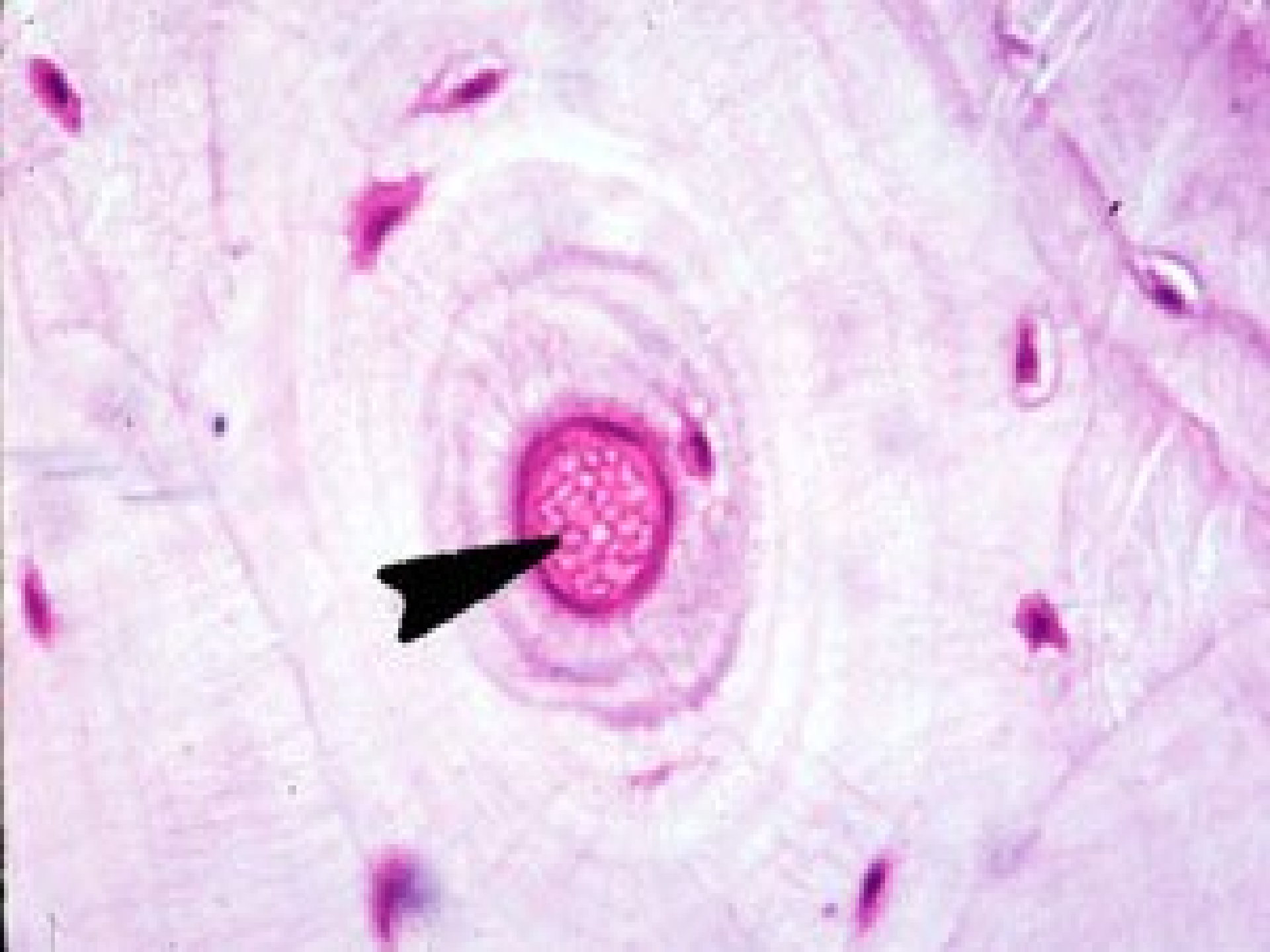


Types of bone tissue

- Mature (lamellar) bone
  - Structural units called “osteons” (Haversian system)
    - Concentric lamellae of matrix surrounding the central canal the osteonal (Haversian) canal containing vascular and nerve supply
    - The long axis is parallel to the long axis of the bone
  - Radial arrangement of the canaliculi
  - Interstitial lamellae
  - Circumferential lamellae inner and outer
  - Volkmann’s canals
  - Mature spongy bone




H
V



Types of bone tissue

- Immature (nonlamellar/woven) bone
  - No organized lamellar system
  - More cellular
  - Random cellular arrangement
  - More ground substance
  - More basophilic
  - Initially not heavily mineralized

Cartilage tissue

Overview

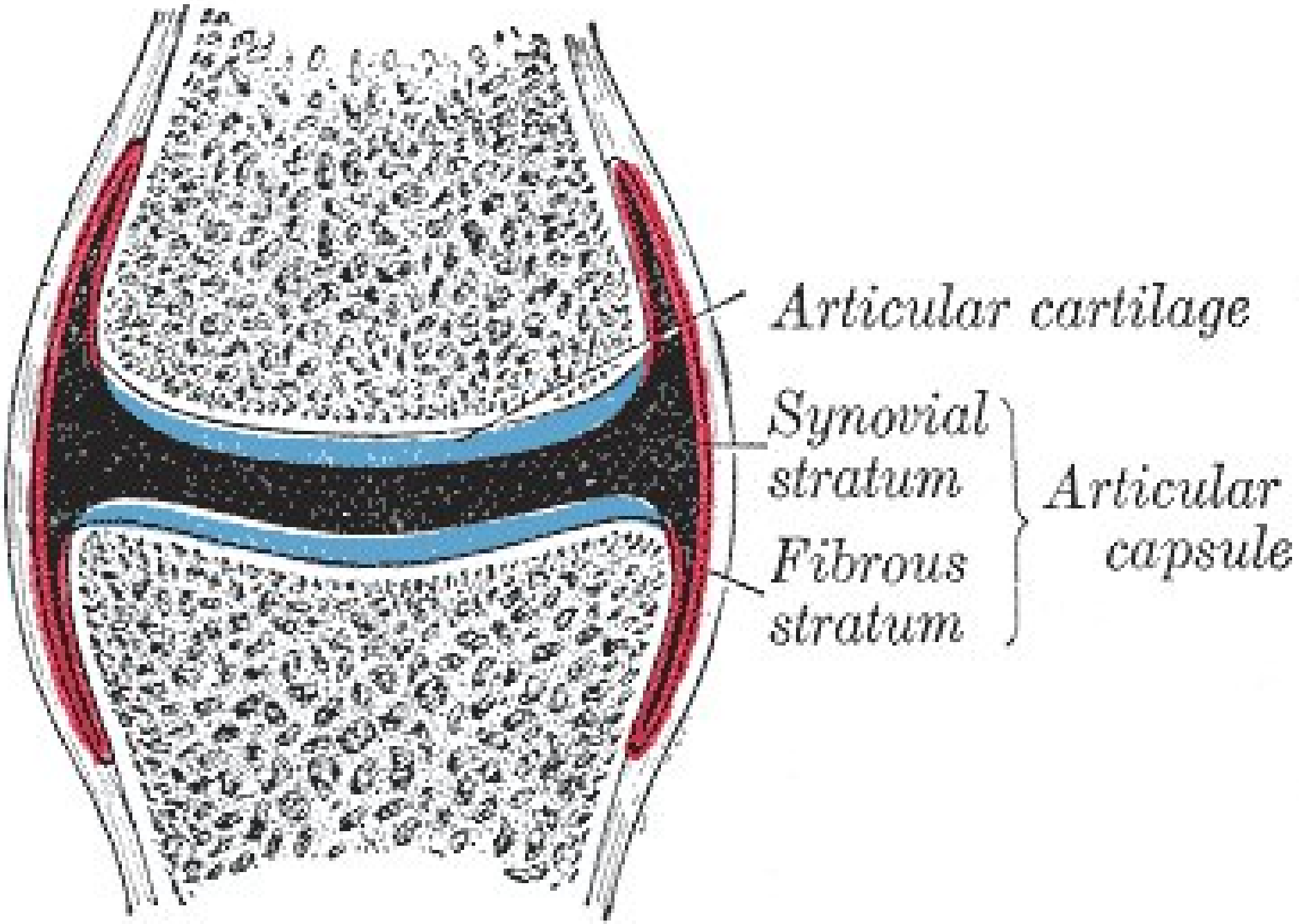
- Specialized form of connective tissue
- Avascular
- 95% ECM
  - Solid firm but pliable
  - Large ratio of GAGs to collagen II permits diffusion and maintain viability
  - Contrasting biophysical characteristics between
    - Tension resisting collagen fibrils
    - And the heavily hydrated proteoglycans
- Chondrocytes

Overview

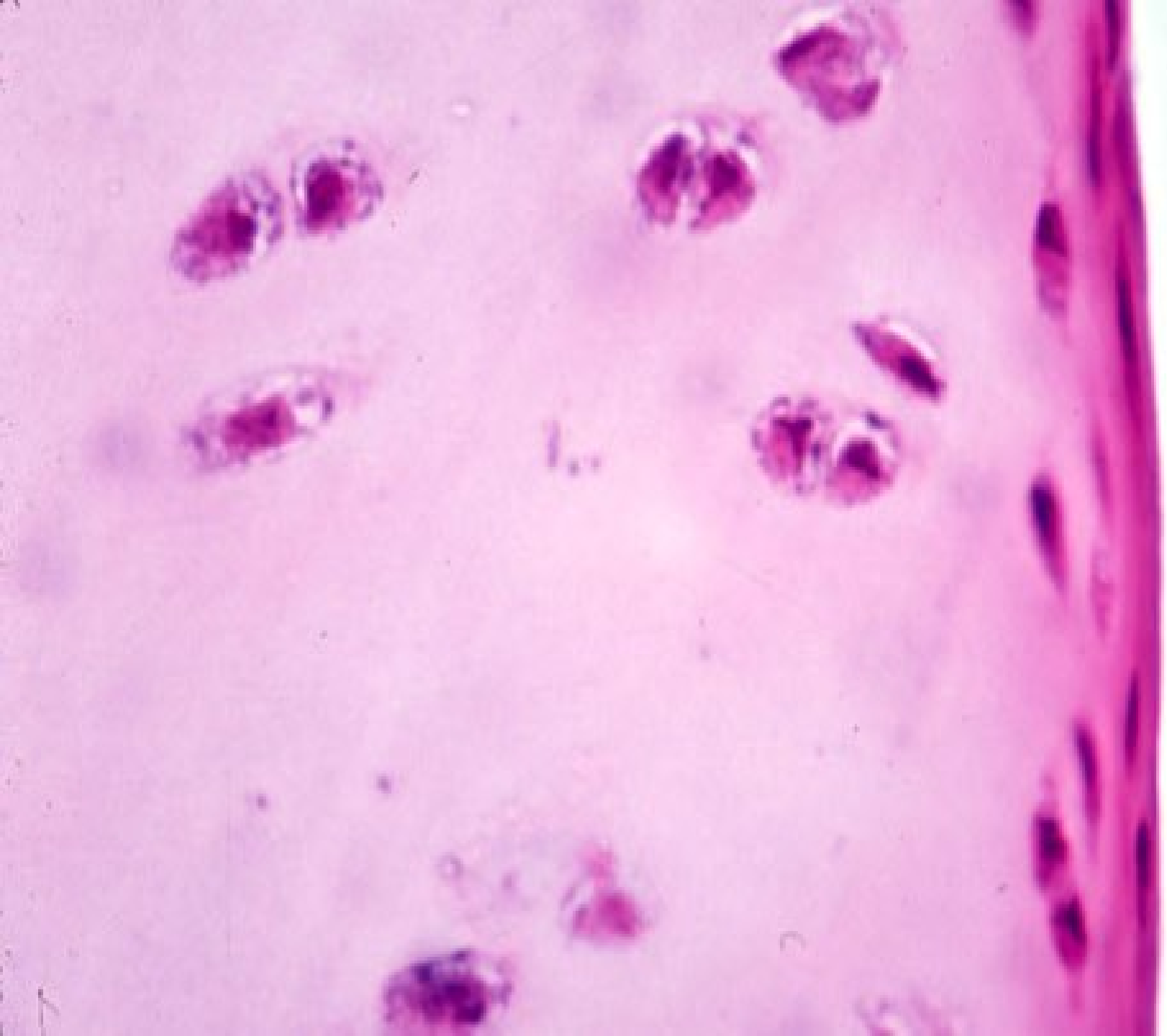
- Types in terms of morphology and biomechanical properties on the basis of ECM
  - Hyaline cartilage
    - Collagen II, GAGs/proteoglycans and multiadhesive glycoproteins
  - Elastic cartilage
    - Hyaline composition + elastic fibers and lamellae
  - Fibrocartilage
    - Hyaline composition + collagen I

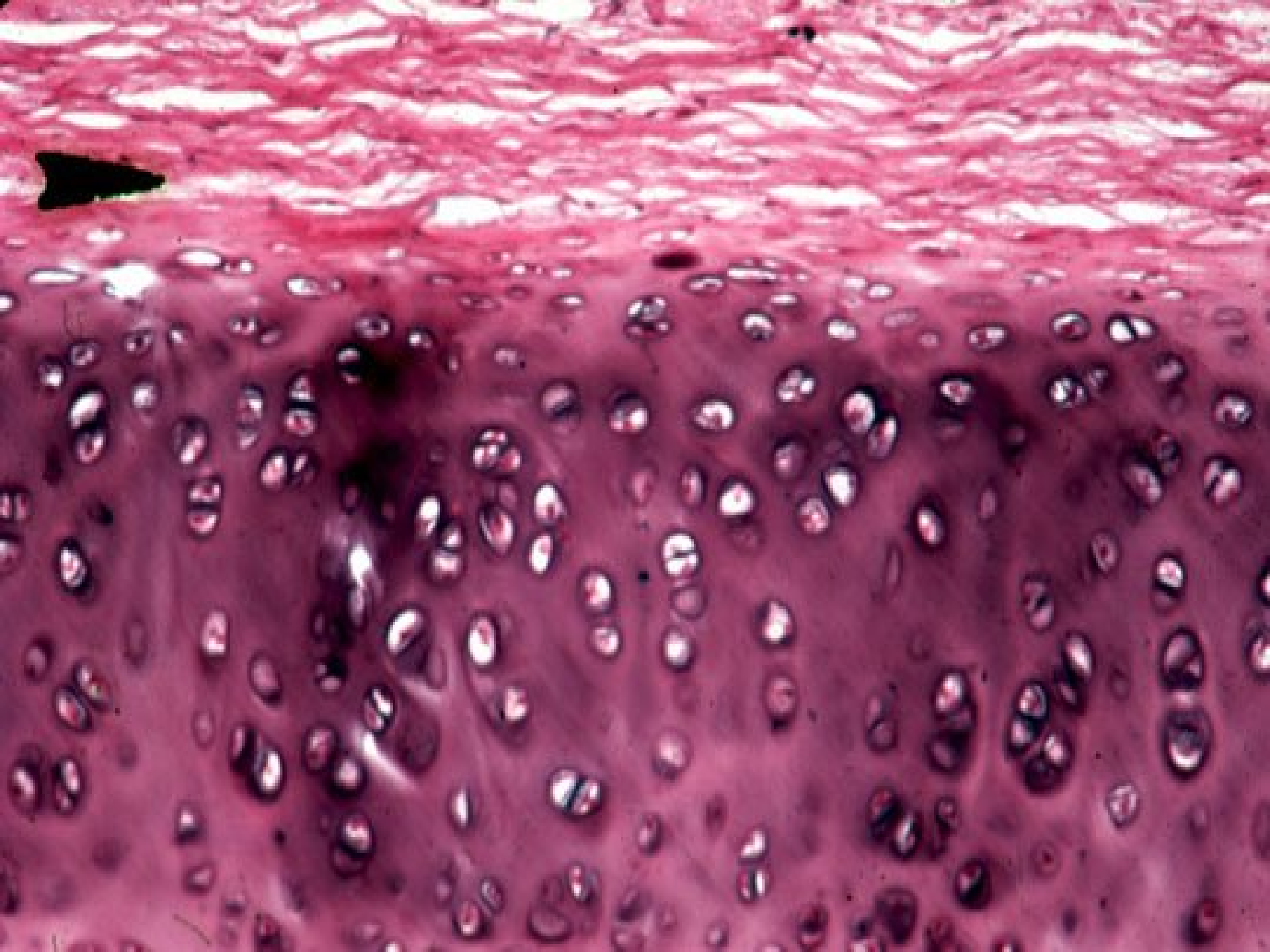
Hyaline cartilage

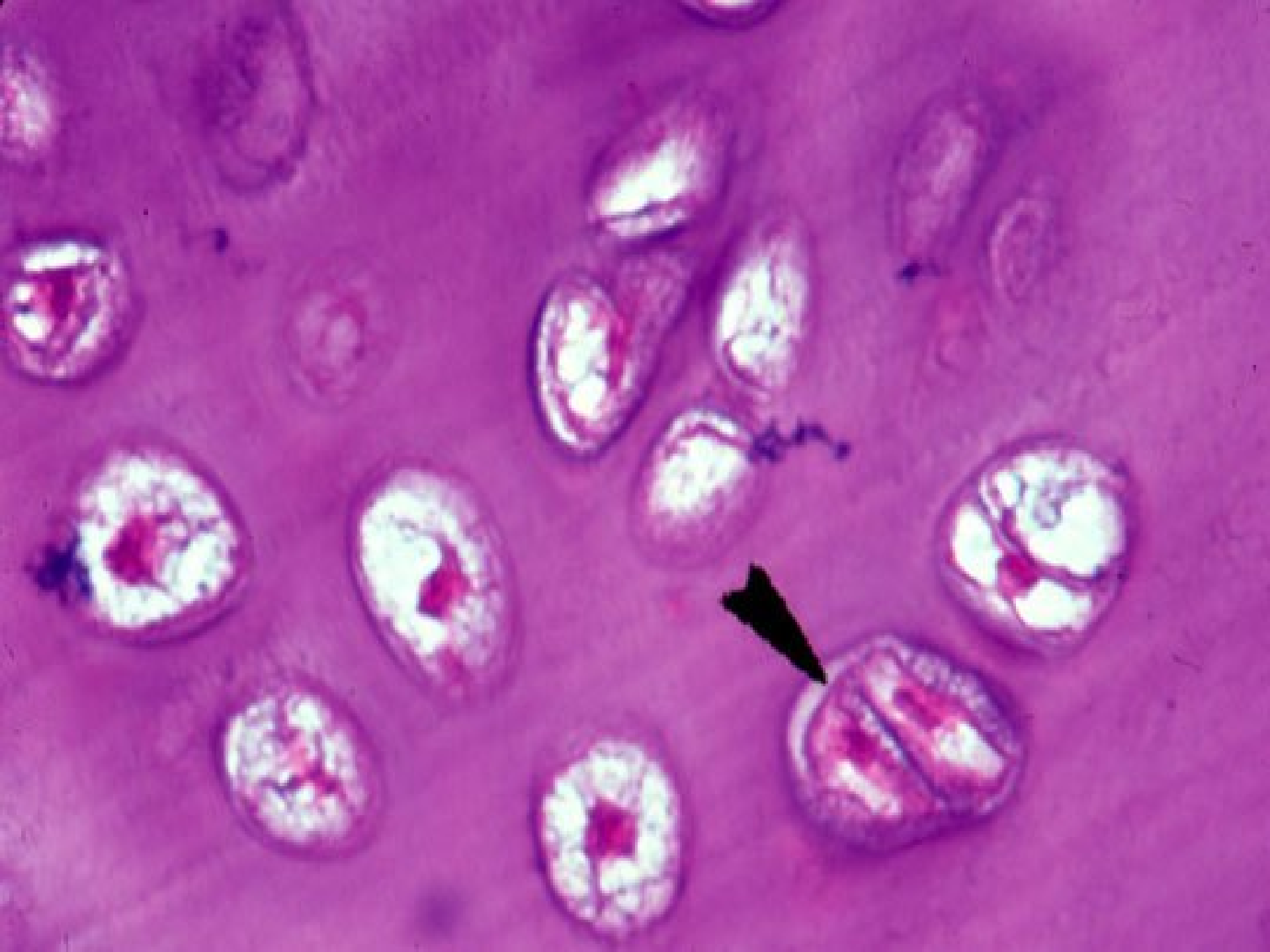
- Homogenous amorphous material
- Glassy
- Chondrocytes/lacunae
  - Produce the ECM
- Low friction surface
  - In joints
  - Lubrication
  - Distribution of forces to the underlying bone


Articular cartilage
Synovial stratum
Fibrous stratum
Articular capsule

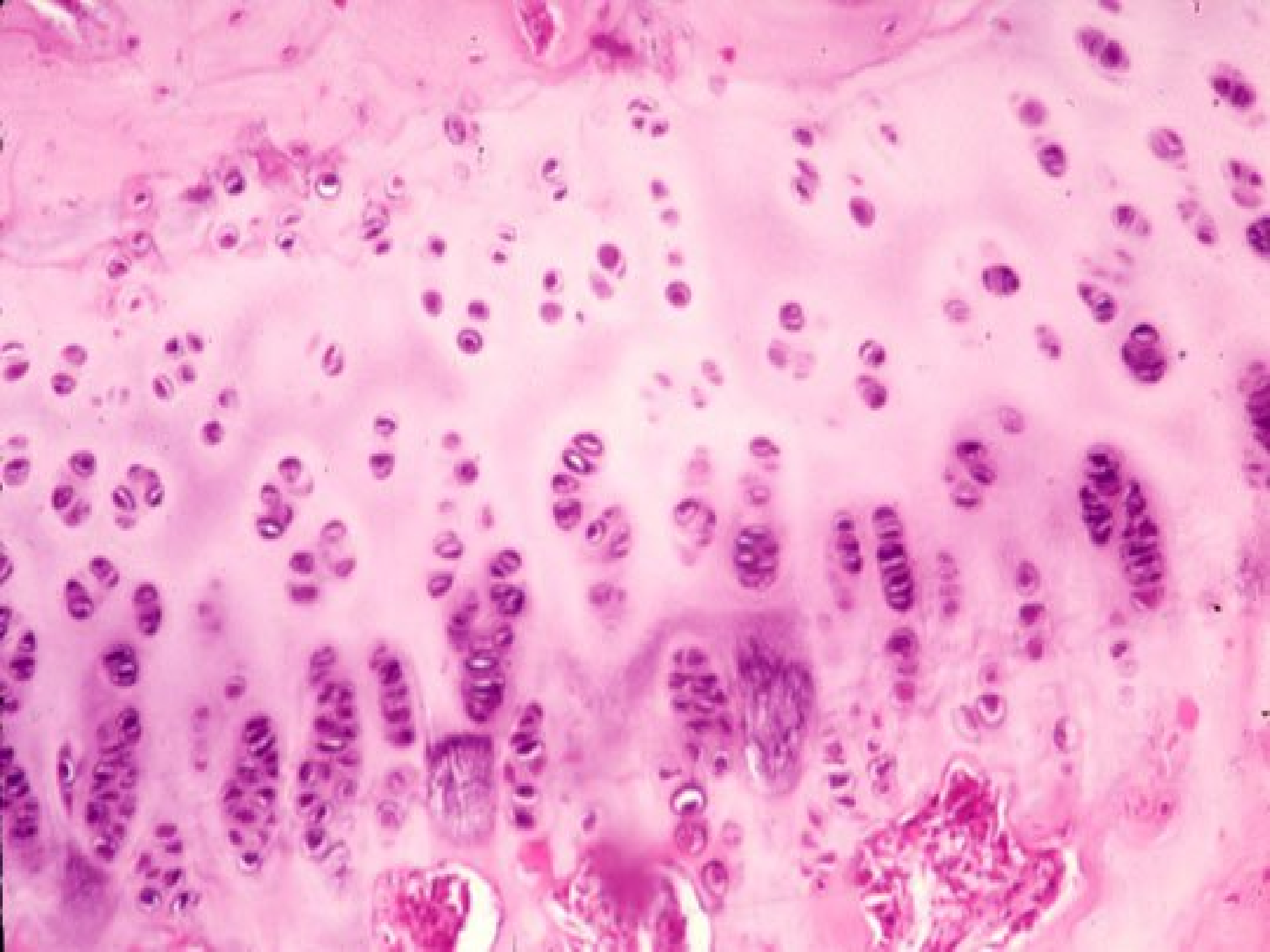

B
H
H








H
B



Hyaline cartilage; ECM

- Collagen
  - Thin and short fibrils
  - Type II (the vast majority)
  - Cartilage specific collagen molecules
    - IX, XI, X, and VI

Hyaline cartilage; ECM

- Proteoglycans
  - Aggrecan
    - Each molecule = 100 Chondroitin and 60 keratan sulfate + core protein
    - Large negative charge due to sulfate groups
    - Thus high affinity to water
  - Proteoglycan aggregates
    - 1 hyaluronan molecule bound to more than 300 aggrecan molecules by link proteins
    - Bound to the collagen fibrils by electrostatic interactions and multiadhesive glycoproteins
    - Unique biomechanical properties

Hyaline cartilage; ECM

- Multiadhesive glycoproteins
  - Influence the interaction between the chondrocytes and the matrix molecules

Hyaline cartilage; ECM

- 60-80% of the ECM is water
- Water bound tightly to the proteoglycan aggregates
- Biomechanics during movement and when subjected to pressure

Hyaline cartilage; chondrocytes

- Produce and maintain the ECM
- Single or in groups “isogenous groups”
- Morphology
  - LM
  - TEM

Hyaline cartilage

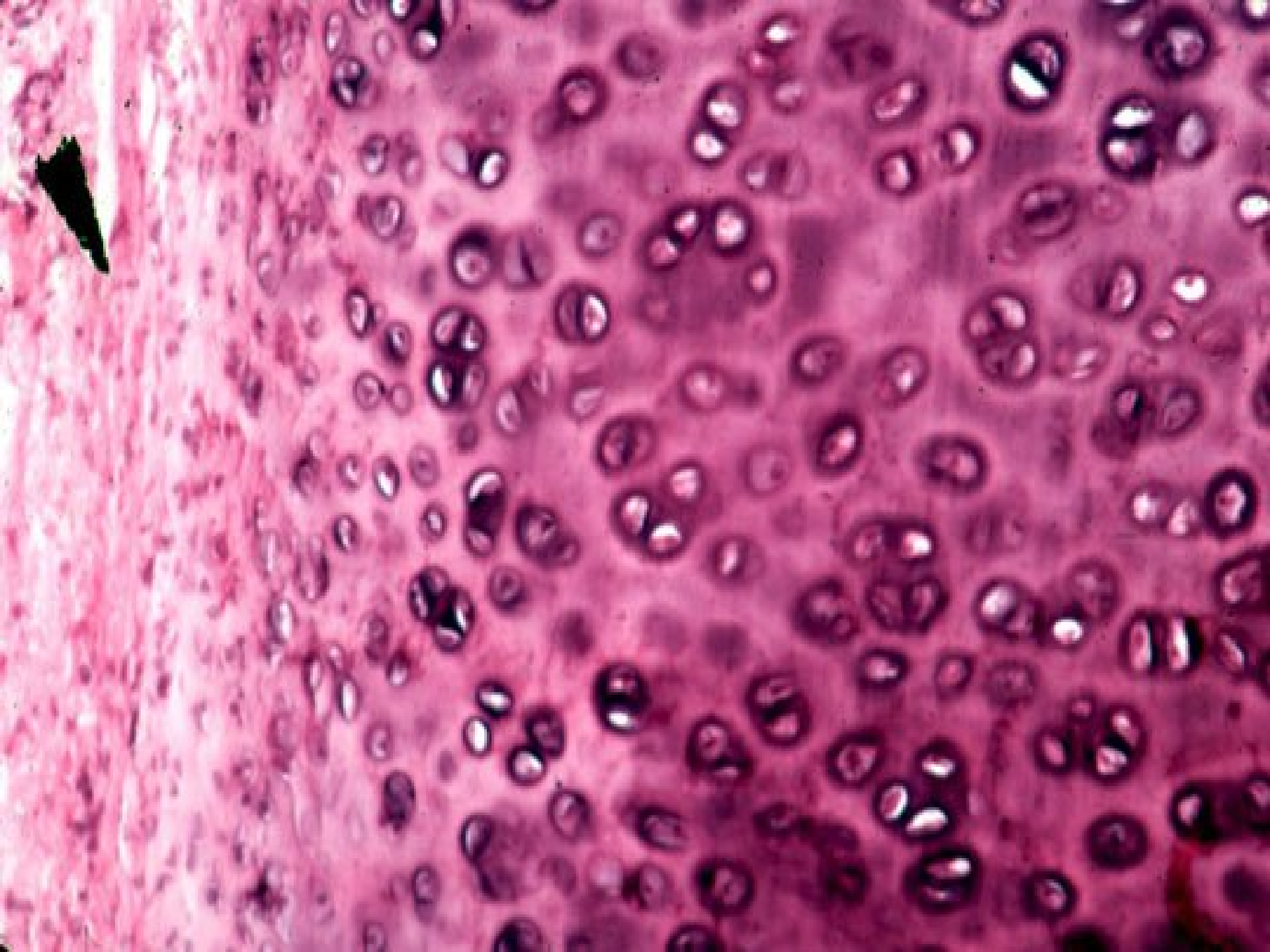
- Types of matrix in terms of staining properties and composition
  - Capsular (pericellular) matrix
  - Territorial matrix
  - Interterritorial matrix
- Decreased proteoglycans with aging
- A model for the developing fetal skeleton
- Epiphyseal growth plate

Hyaline cartilage

- Localization in adults
  - Joint surfaces
  - Costal cartilage
  - Larynx nose and tracheobronchial tree

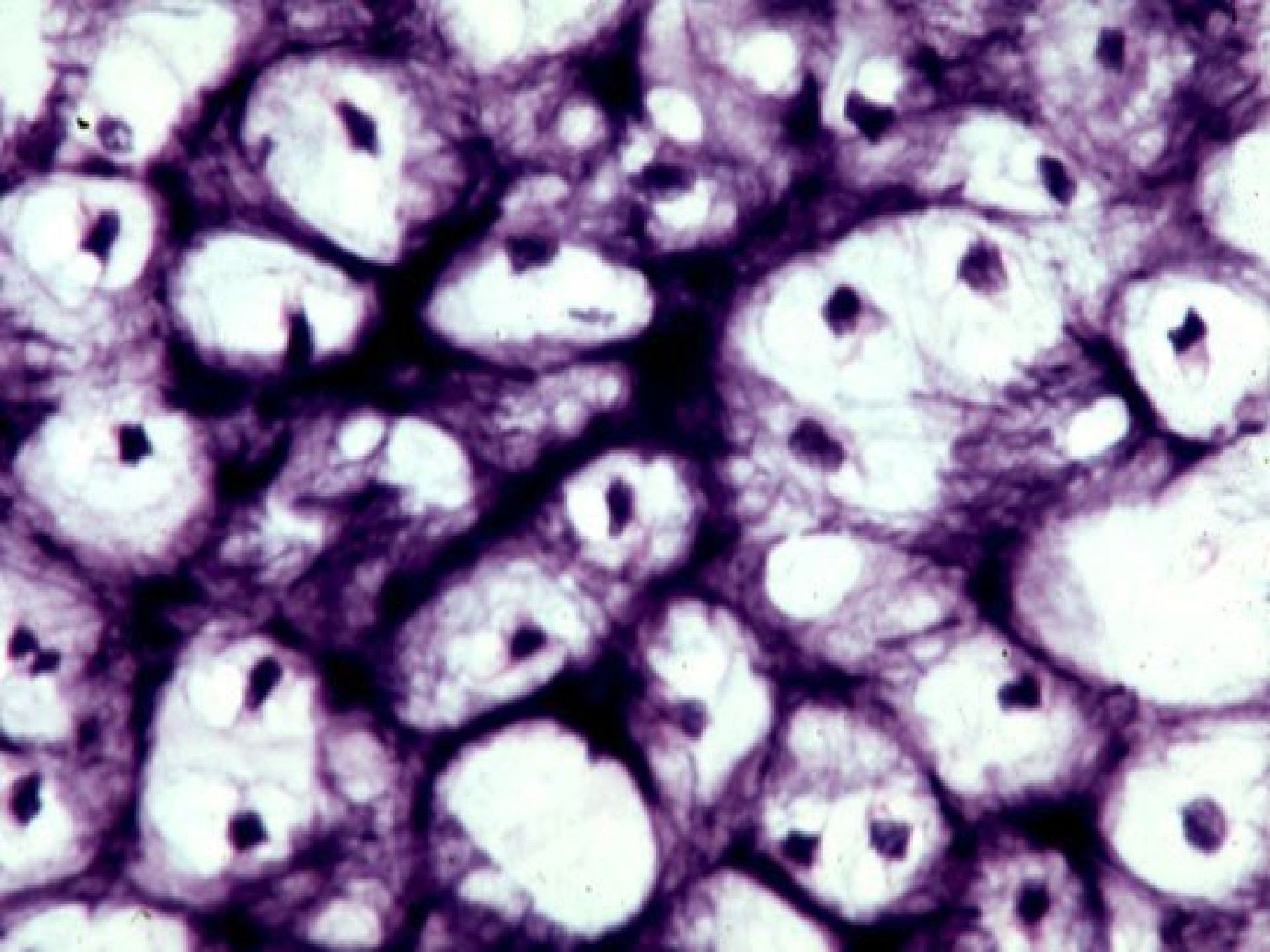
The perichondrium

- Dense irregular connective tissue
- Outer fibrous layer
- Inner cellular layer, the source of new cartilage cells
- Hyaline articular cartilage (2-5 mm thickness) has no perichondrium



Elastic cartilage

- Dense network of branching anastomosing elastic fibers and interconnecting lamellae
- Pliability and resilience
- Locations
  - External ear and meatus, Eustachian tube and the epiglottis
- Does not calcify during aging (in contrast to hyaline type)
- Surrounded by perichondrium

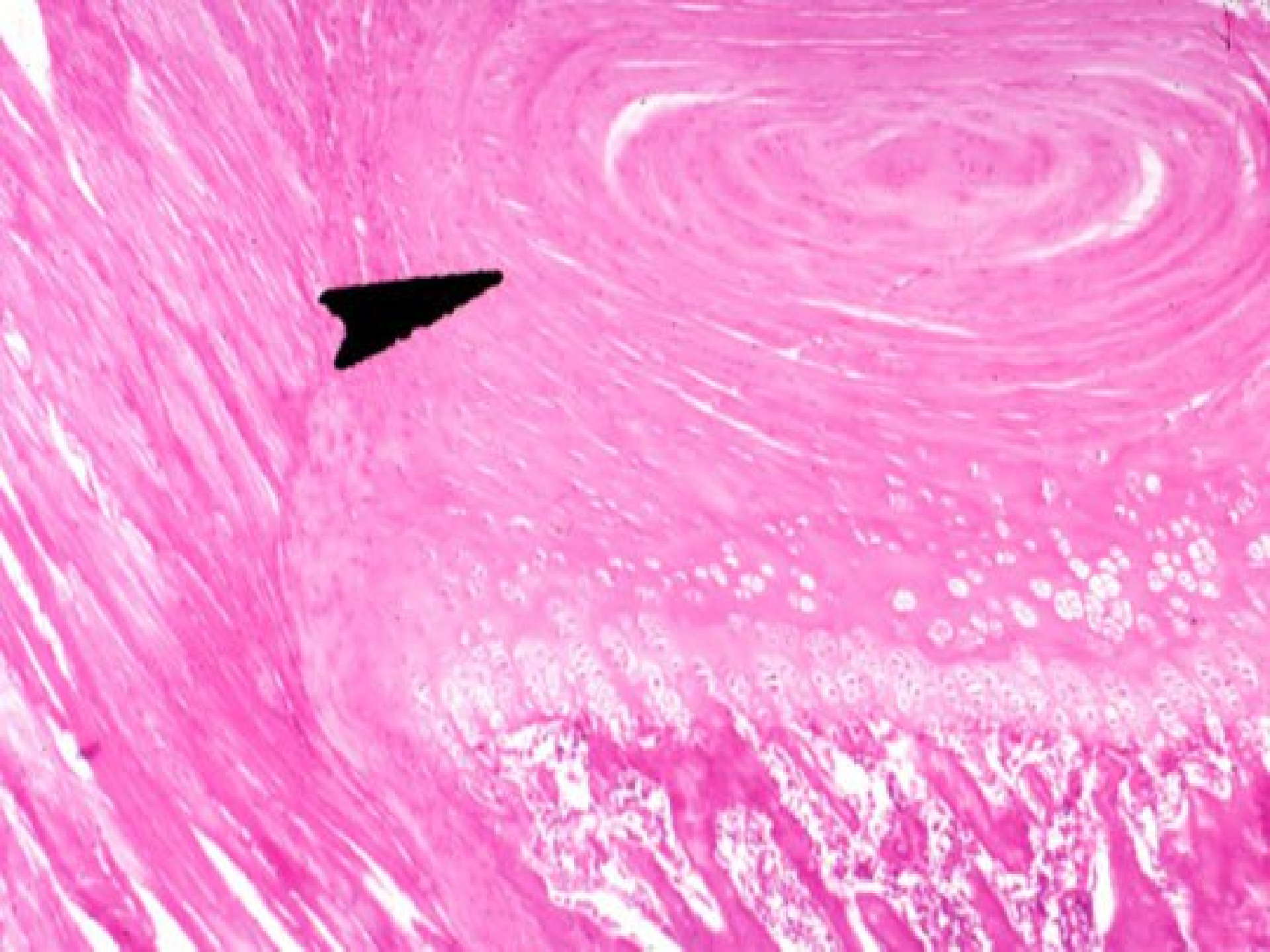


Fibrocartilage

- Combined dense regular CT and hyaline cartilage
- Chondrocytes, single, in rows and as isogenous groups
- No perichondrium
- Less cartilage matrix
- Both chondrocyte and fibroblast

Fibrocartilage

- Localization
  - Intervertebral discs
  - Pubic symphysis
  - Articular discs of sternoclavicular and temporomandibular joints
  - Menisci of the knee joint
  - Triangular fibrocartilage complex of the wrist
  - Where tendons attached to the bone
- Both collagen I and II



Growth

Interstitial growth early stages of formation epiphyseal plates articular cartilage in other regions less important

Apposition growth starting from perichondrium

Muscle tissue

Muscle tissue

Skeletal

Cardiac

Smooth

Different terminology

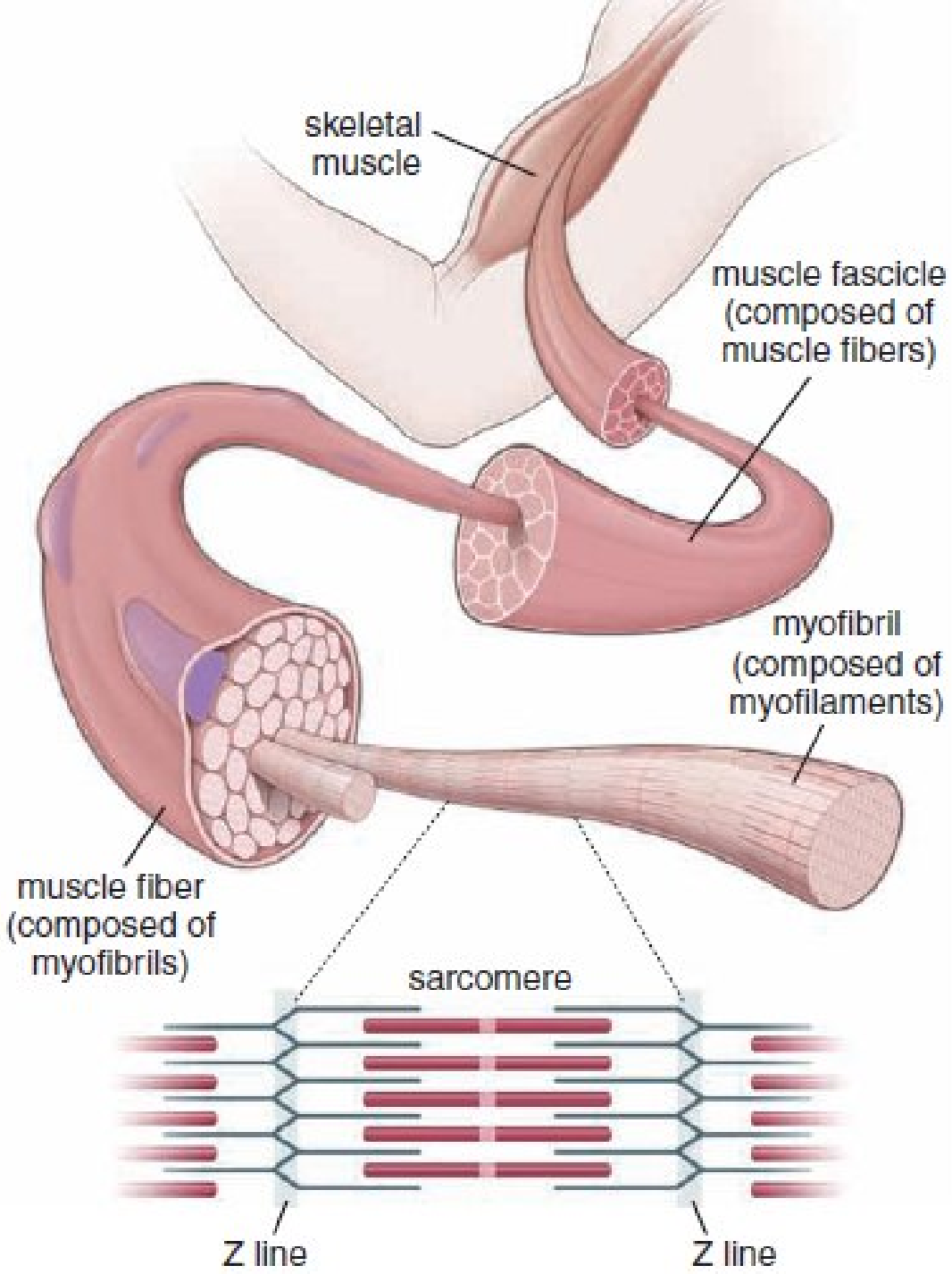
Skeletal muscle

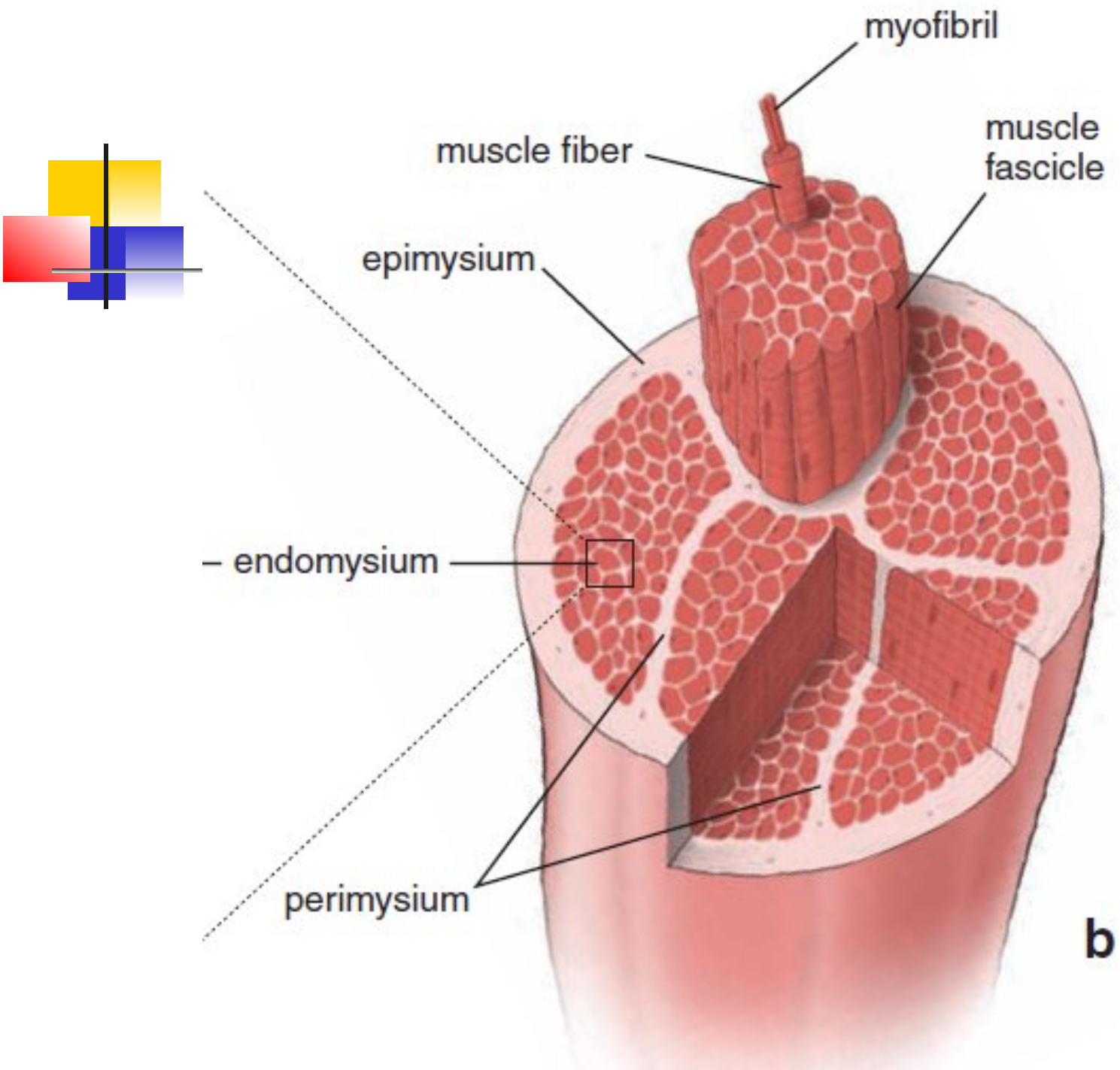
Characteristics of muscle fiber

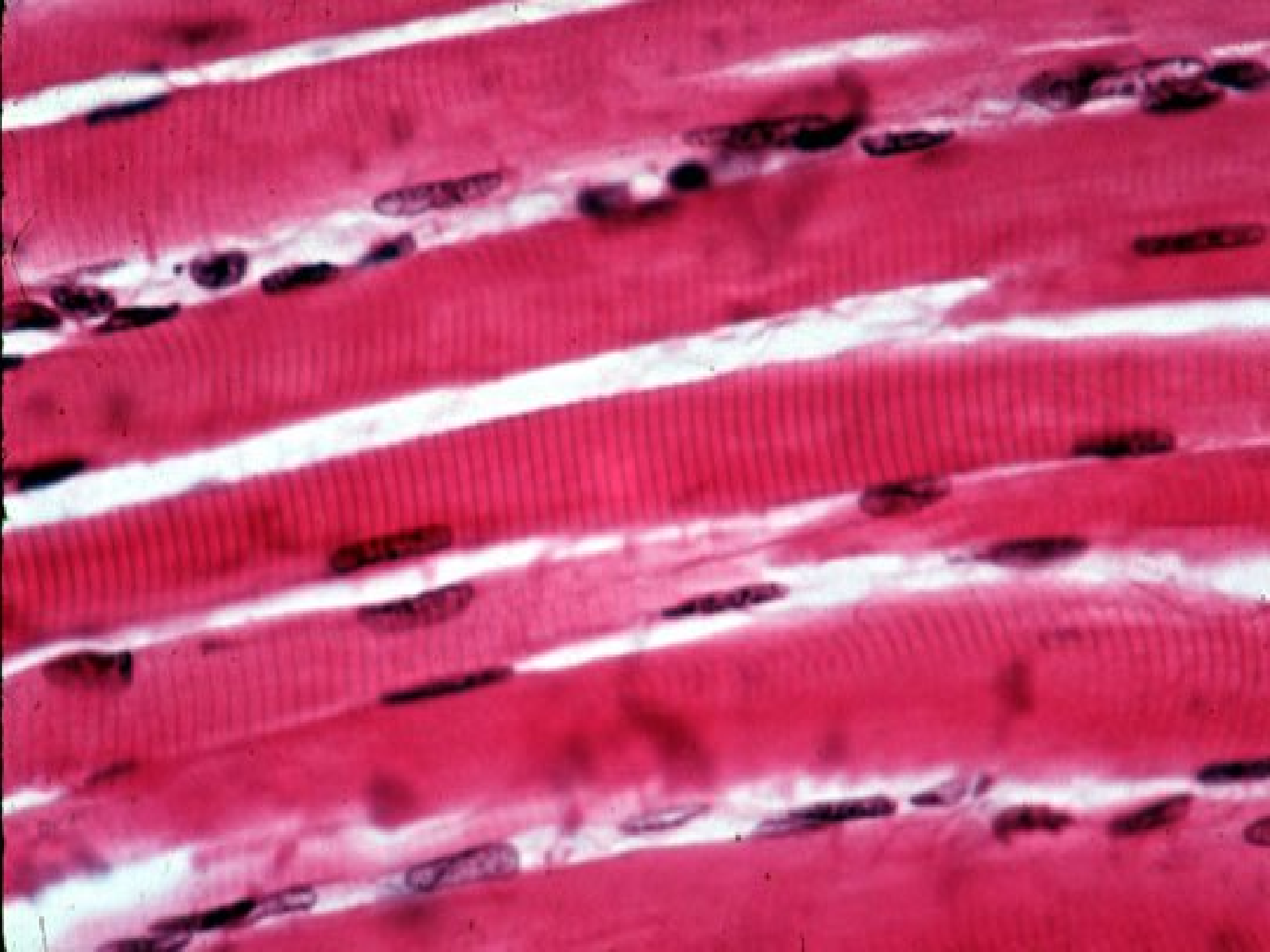
Hypertrophy & hyperplasia

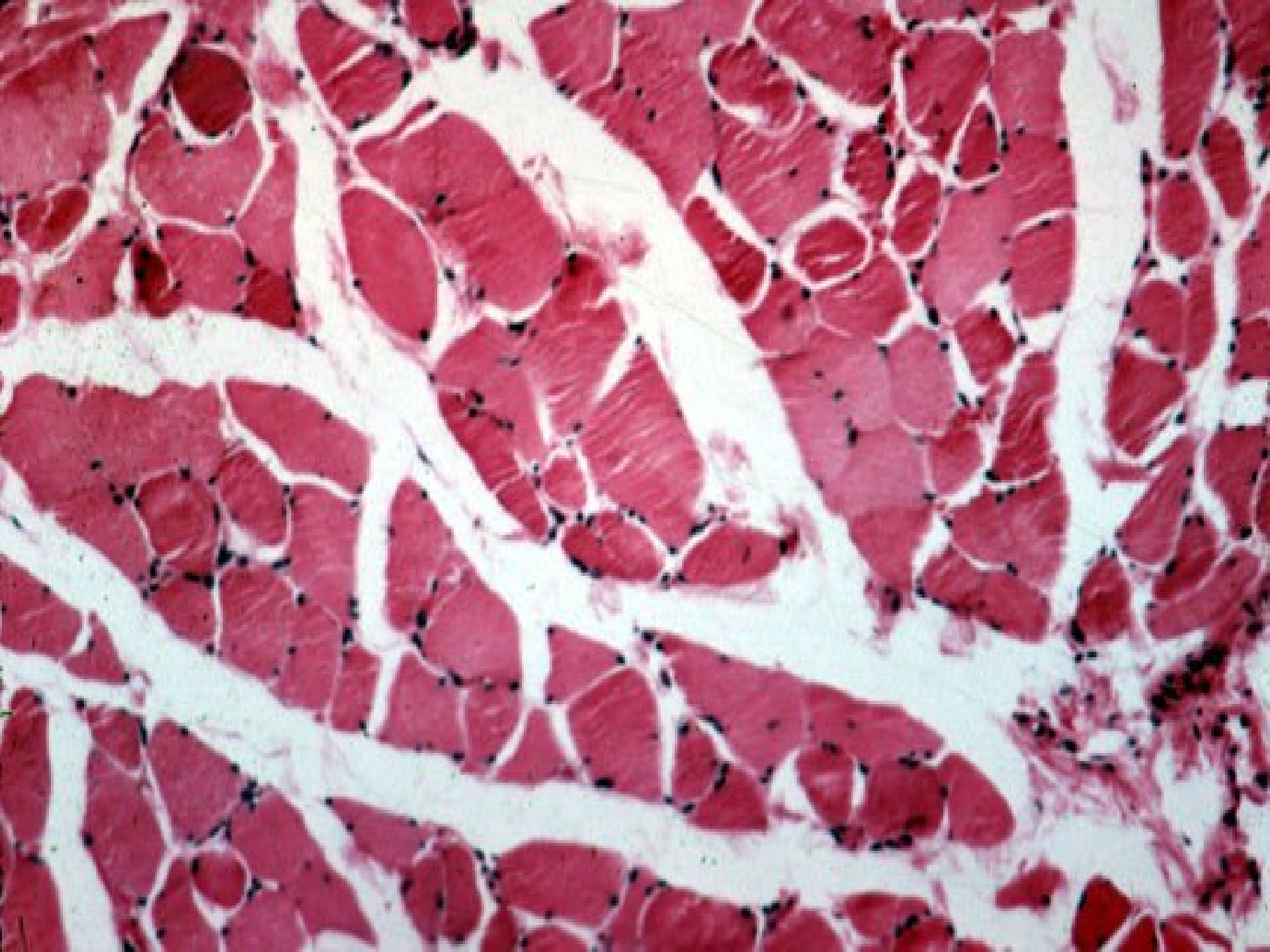
Organization: epimysium
perimysium endomysium

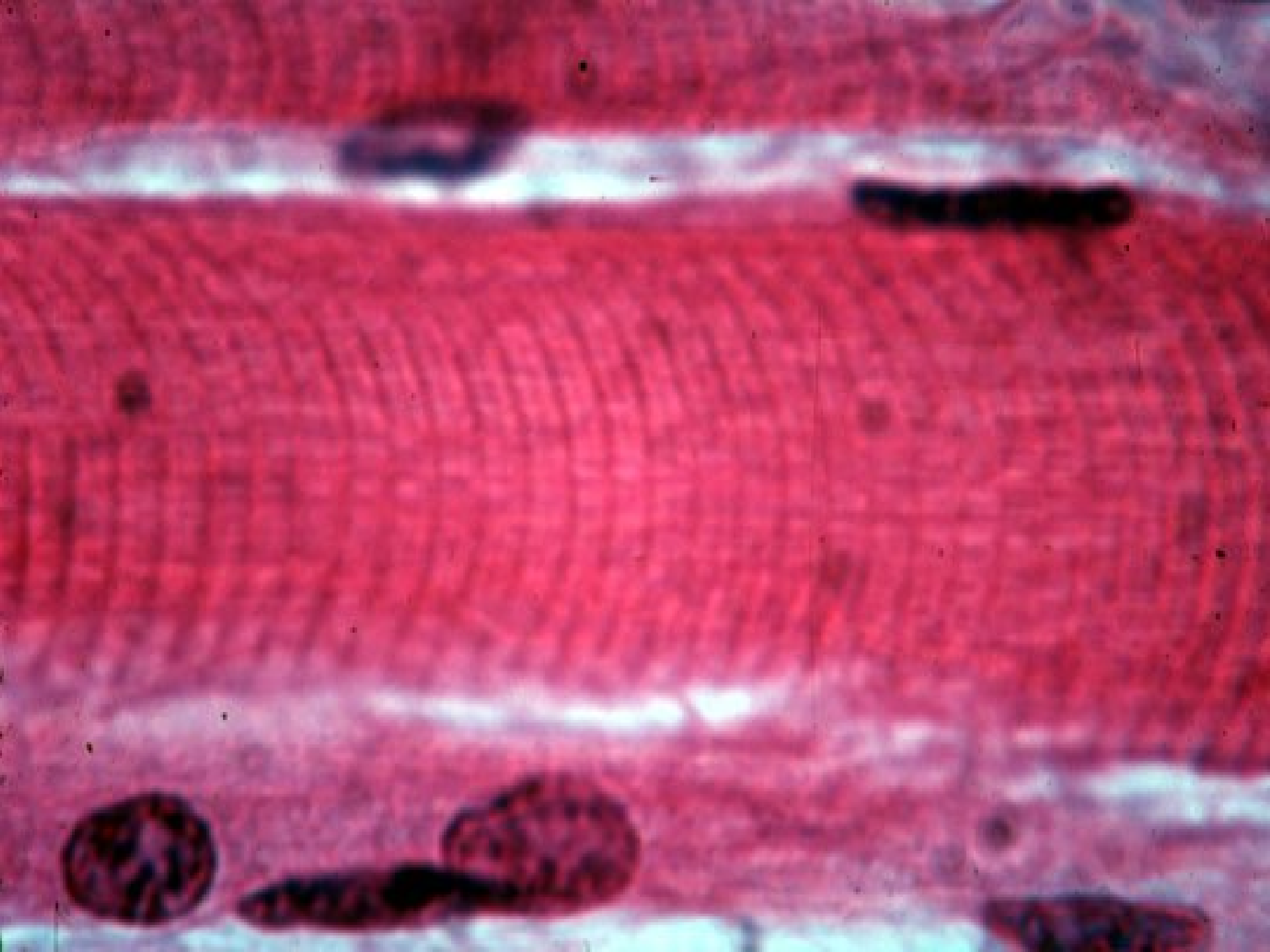
Myotendinous junction

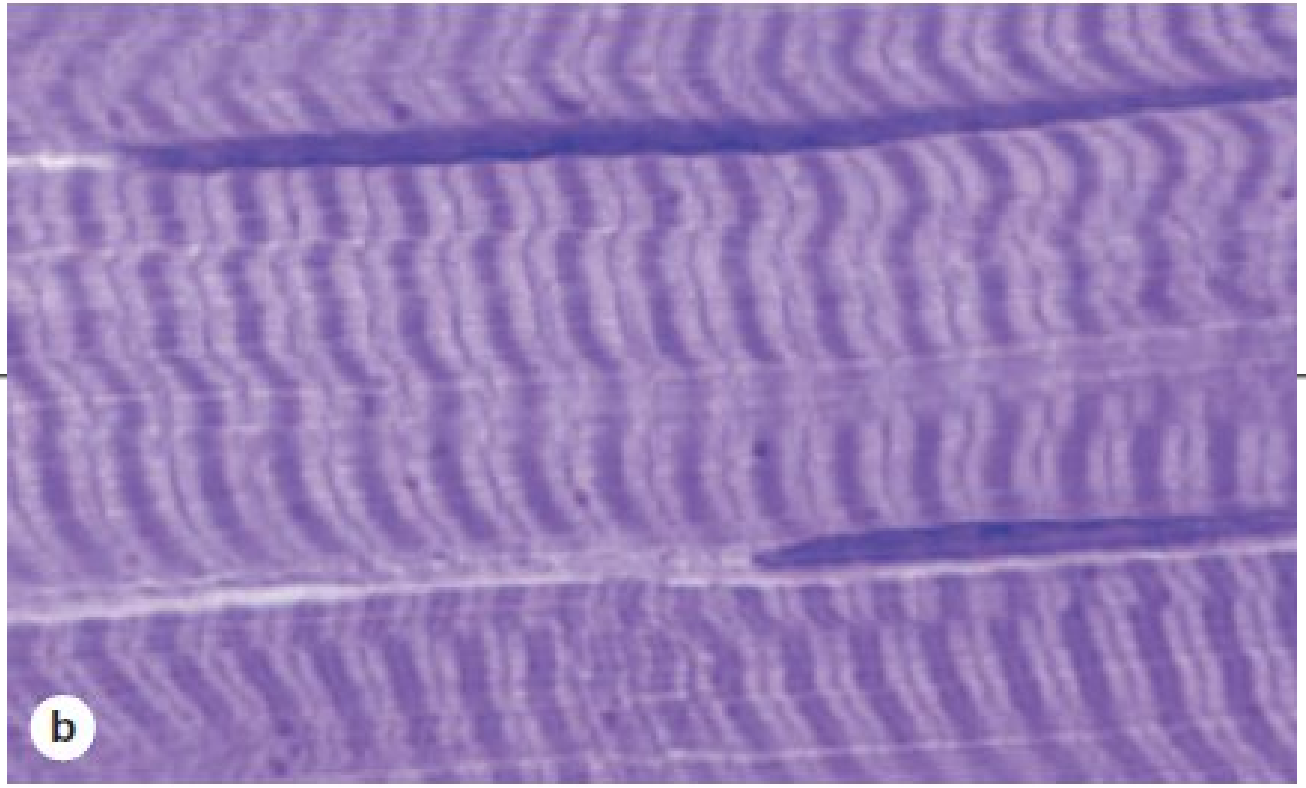

skeletal muscle
muscle fascicle (composed of muscle fibers)
myofibril (composed of myofilaments)
muscle fiber (composed of myofibrils)
sarcomere
Z line
Z line

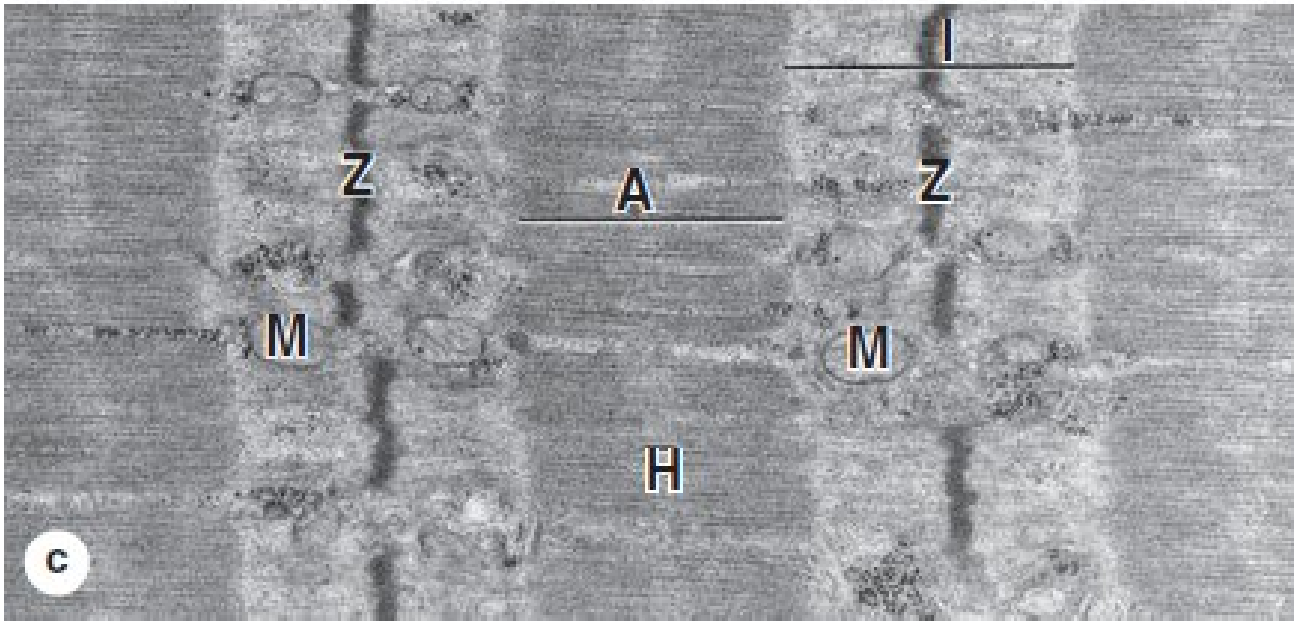

myofibril
muscle fiber
muscle fascicle
epimysium
endomysium
perimysium
b








b


I
Z
A
Z
M
M
H
c

Microstructure

A band (anisotropic, birefringent)

I band (isotropic)

Z line

Sarcomere (2.5 μm)

Myofibrils thick filament (1.6 μm x 15 nm) thin filament (1 μm x 8 nm)

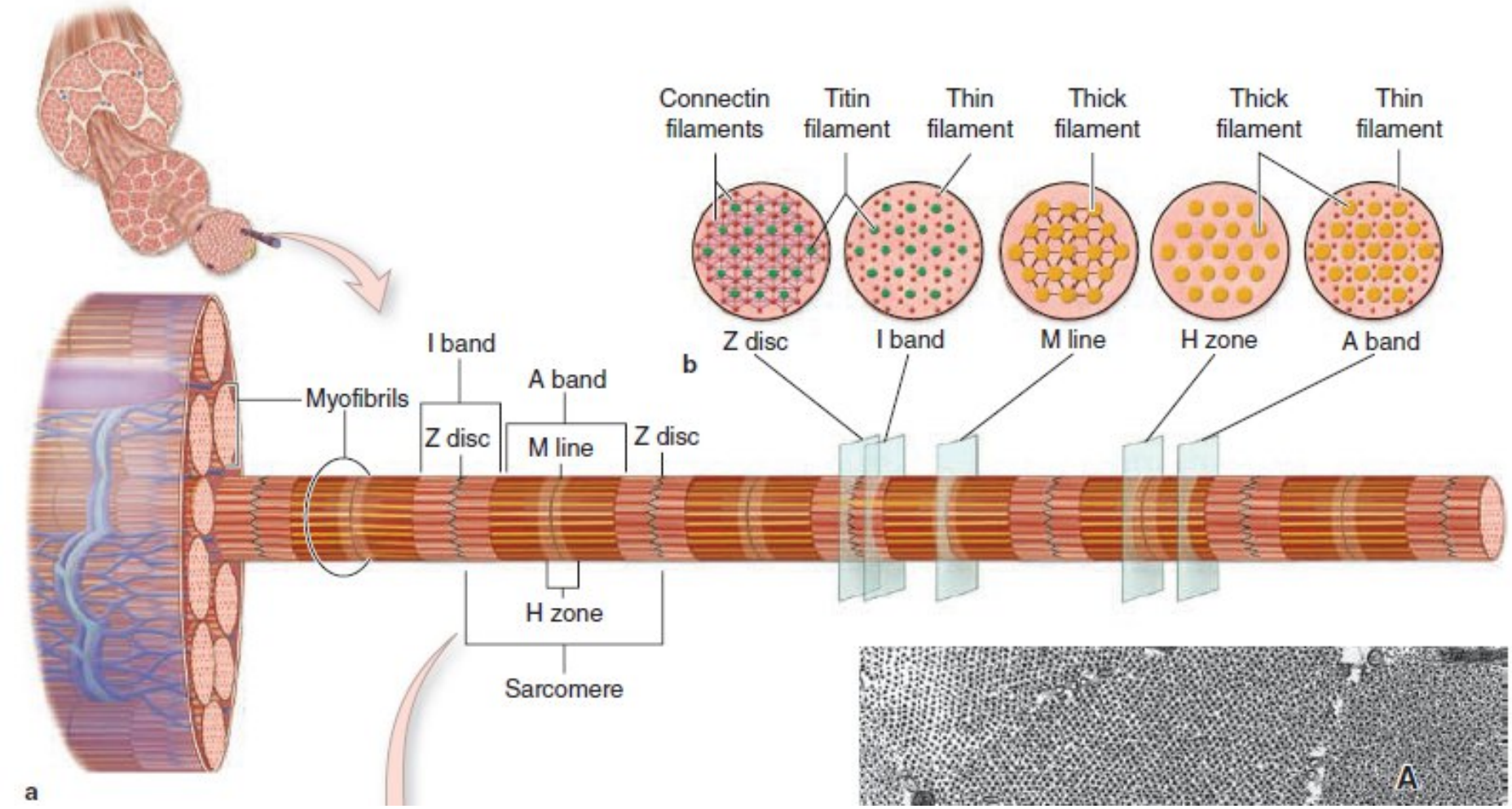
Microstructure

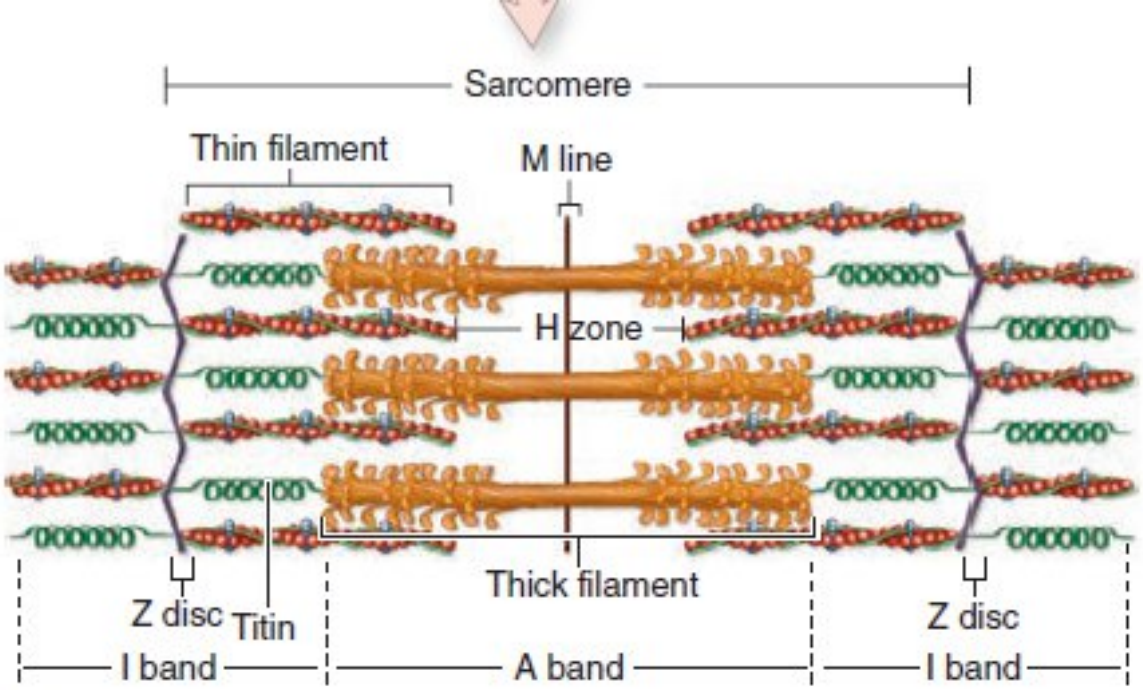
H band

m line (creatine kinase)
phosphocreatin+ADP= creatin+ ATP

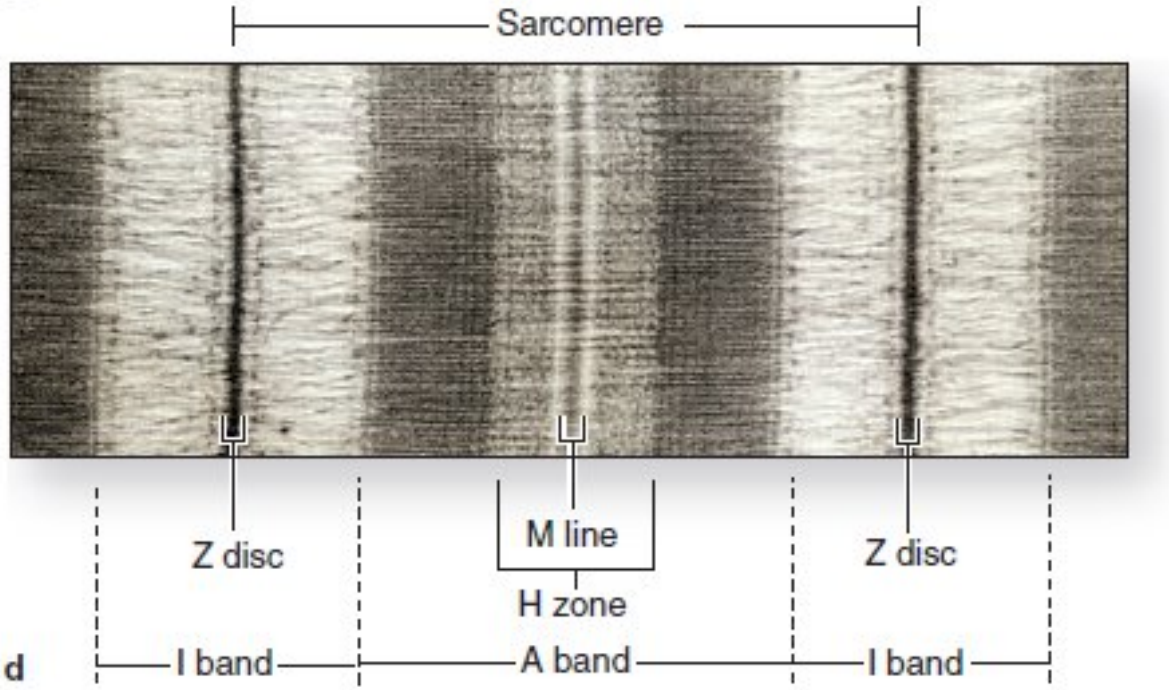
Cross section in overlapping region

Main proteins -thin filament: actin, tropomyosin, & troponin -thick filament: myosin

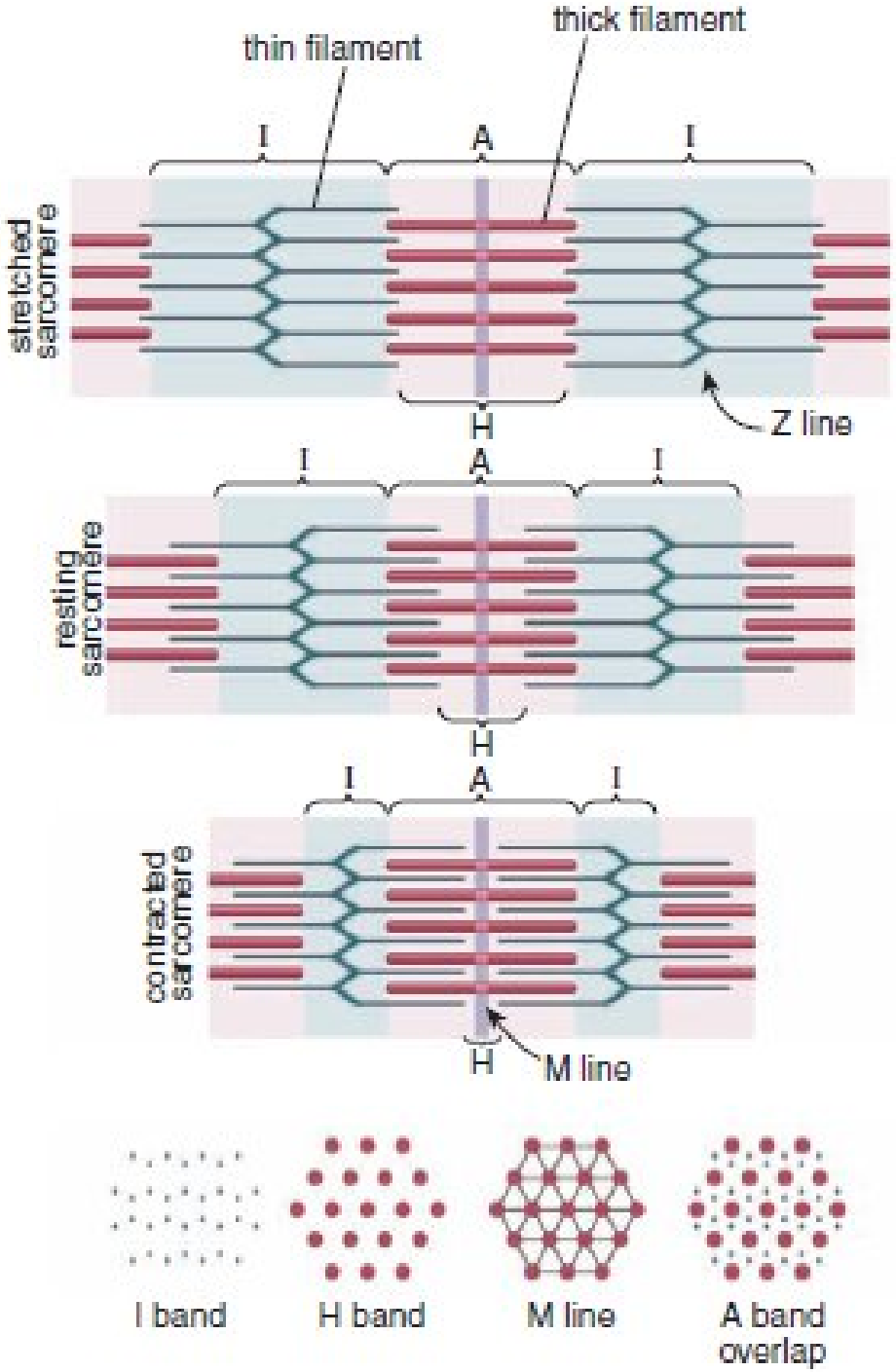

Connectin filaments
Titin filament
Thin filament
Thick filament
Thick filament
Thin filament
Z disc
I band
M line
H zone
A band
b
I band
A band
Myofibrils
Z disc
M line
Z disc
H zone
Sarcomere
a
A


Sarcomere
Thin filament
M line
H zone
Thick filament
Z disc
Titin
Z disc
I band
A band
I band

c


Sarcomere
Z disc
M line
H zone
Z disc
I band
A band
I band

d


thin filament
thick filament
I
A
I
stretched sarcomere
H
Z line
resting sarcomere
contracted sarcomere
M line
I band
H band
M line
A band
overlap

Actin

F-actin (filamentous): -2 strands of G-actin (globular) monomers -double helix

G-actin: -asymetric -binding site for myosin

Opposite polarity of actin fil. On each side of Z line

α actinin (Z line) & desmin tie adjacent sarcomeres together

Tropomyosin

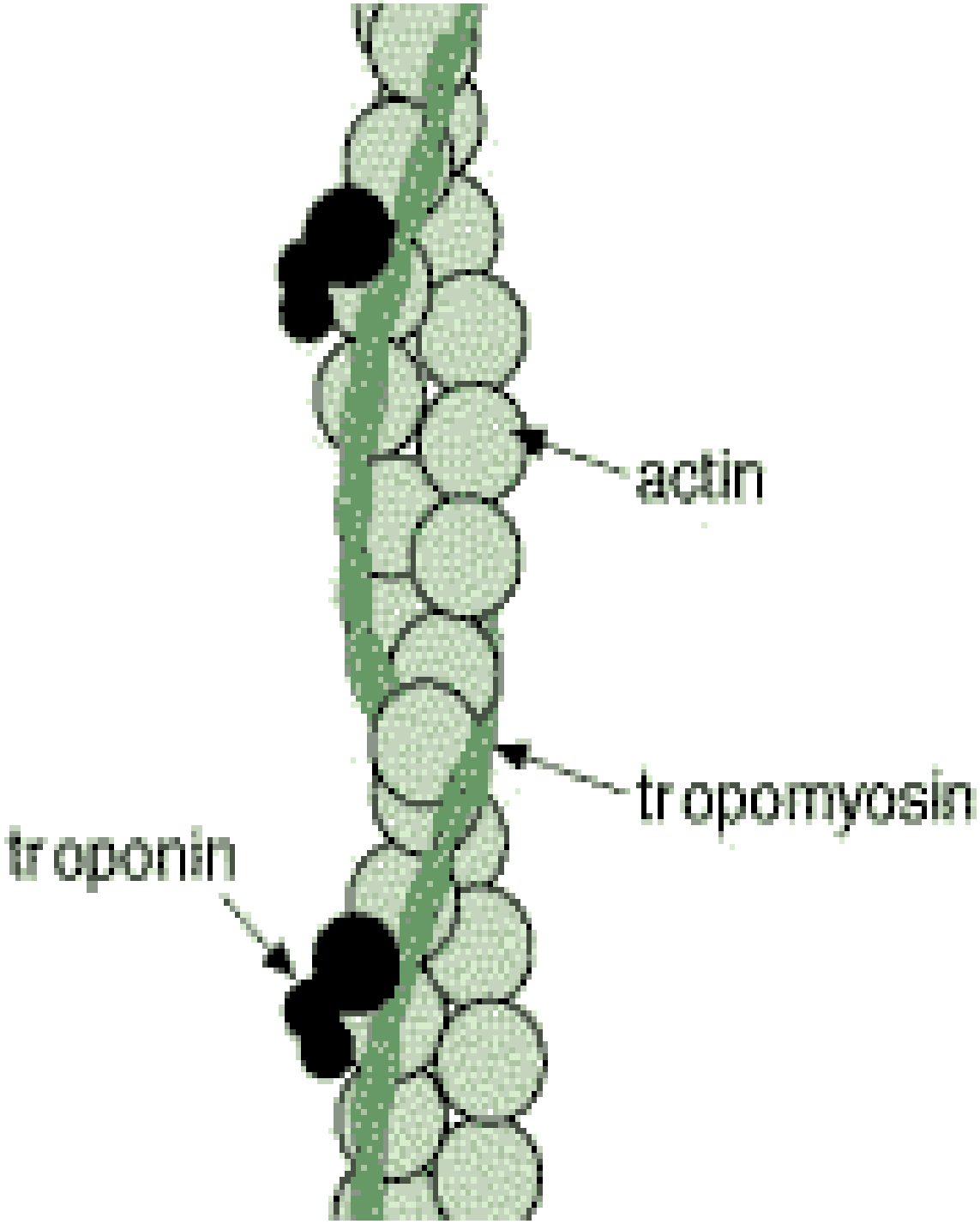
2 polypeptide chains

Alongside the outer edge of the groove

Troponin

A complex of 3 subunuits TnT TnC TnI

Trpomyosin spans G-actins and has one troponin complex

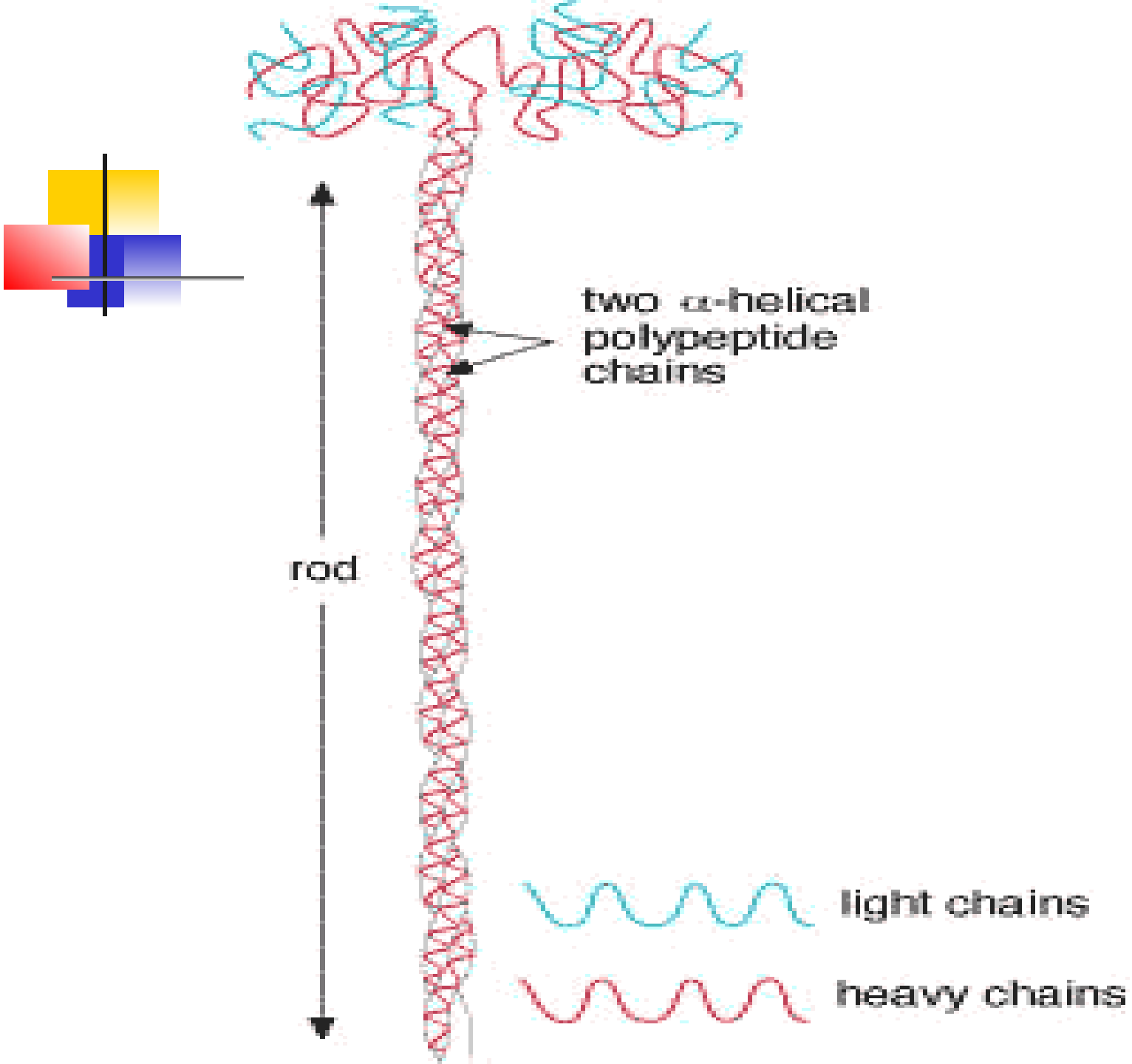

actin
tropomyosin
troponin

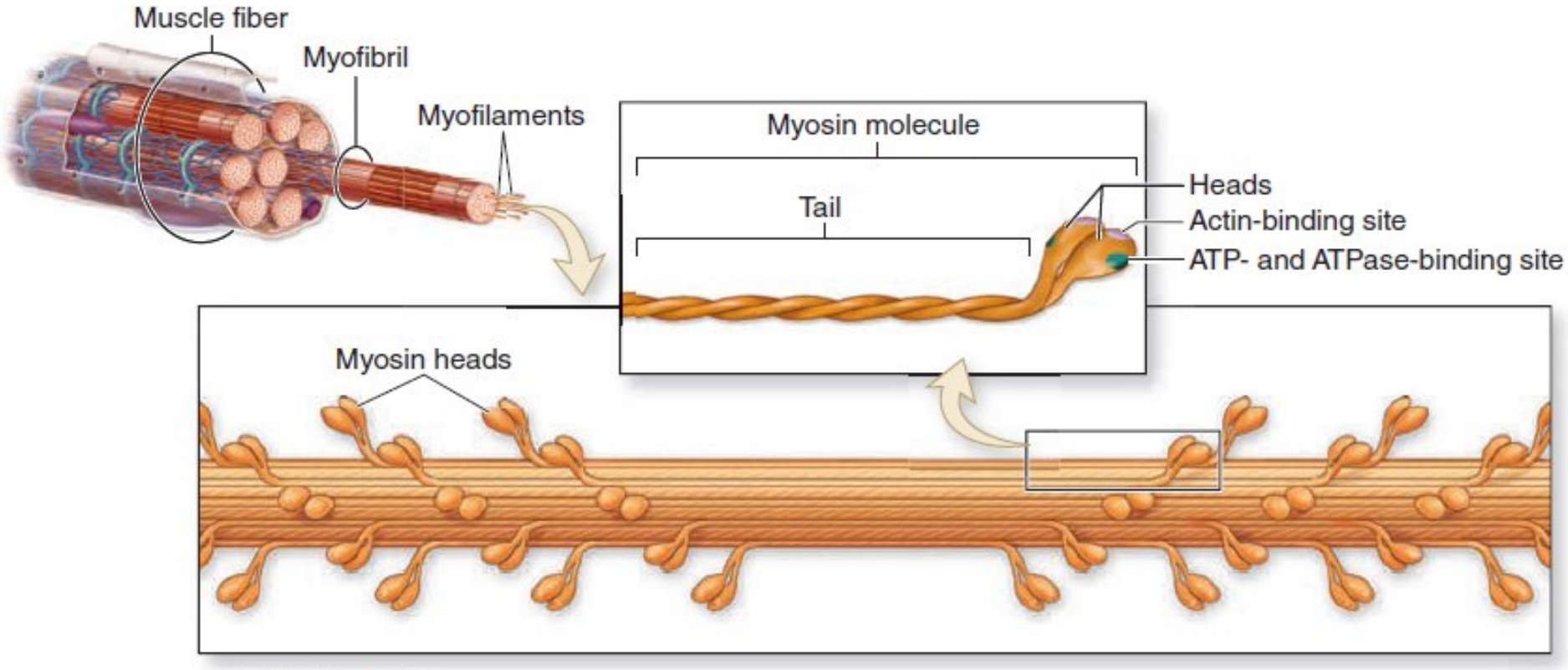
Myosin

2 identical heavy chains, twisted together

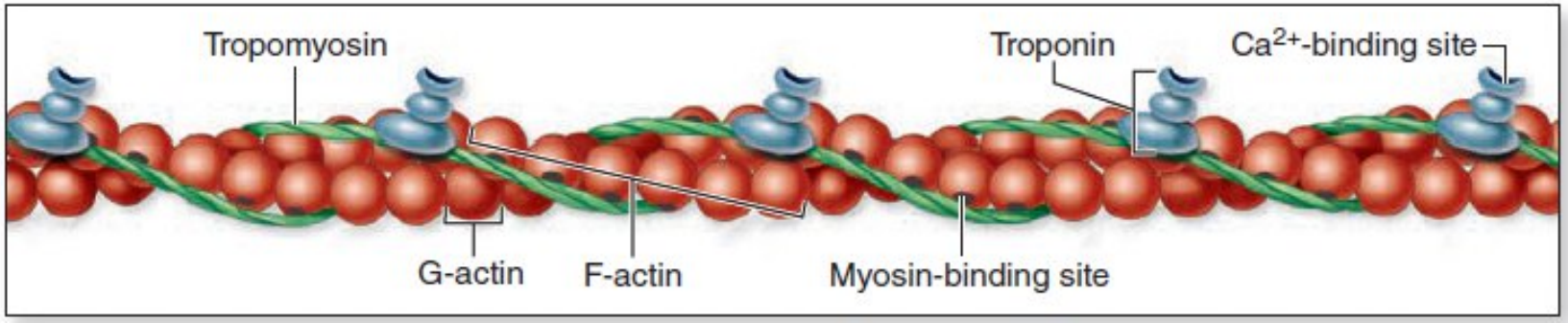
Heads of heavy chains: -globular projections -ATP binding sites -ATPase activity -binds actin

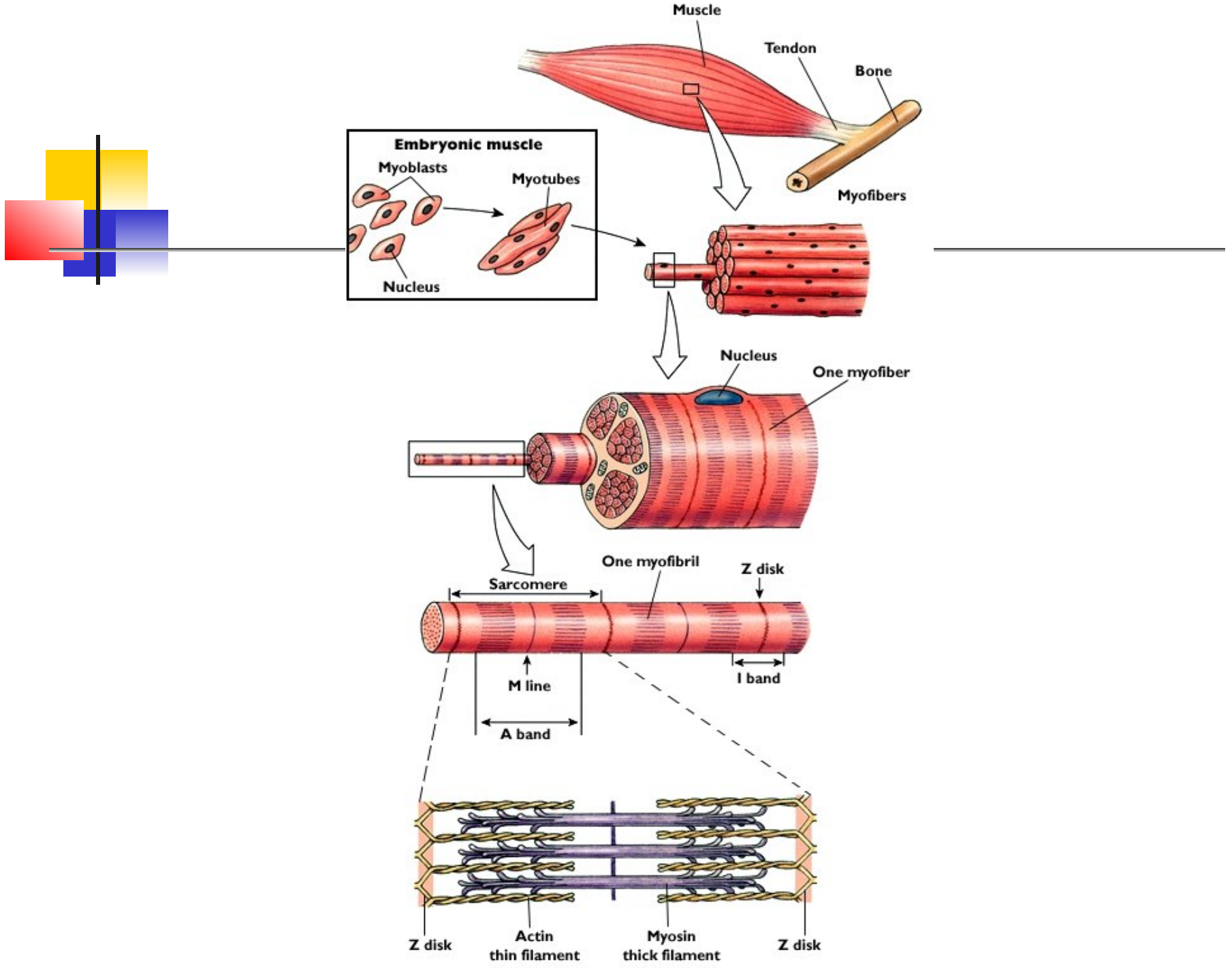
2 pairs of light chains, associated with the head

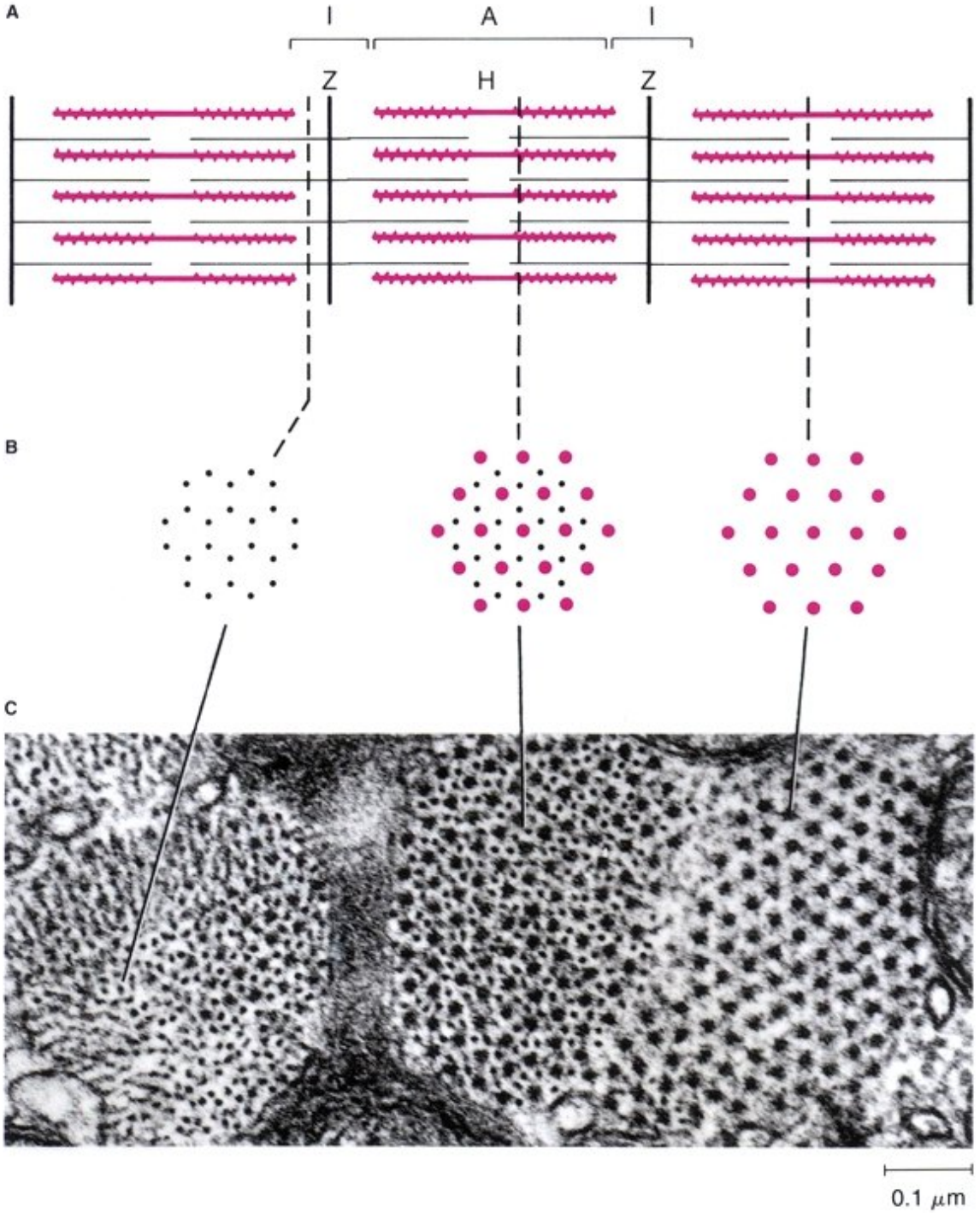

two α-helical
polypeptide
chains
rod
light chains
heavy chains

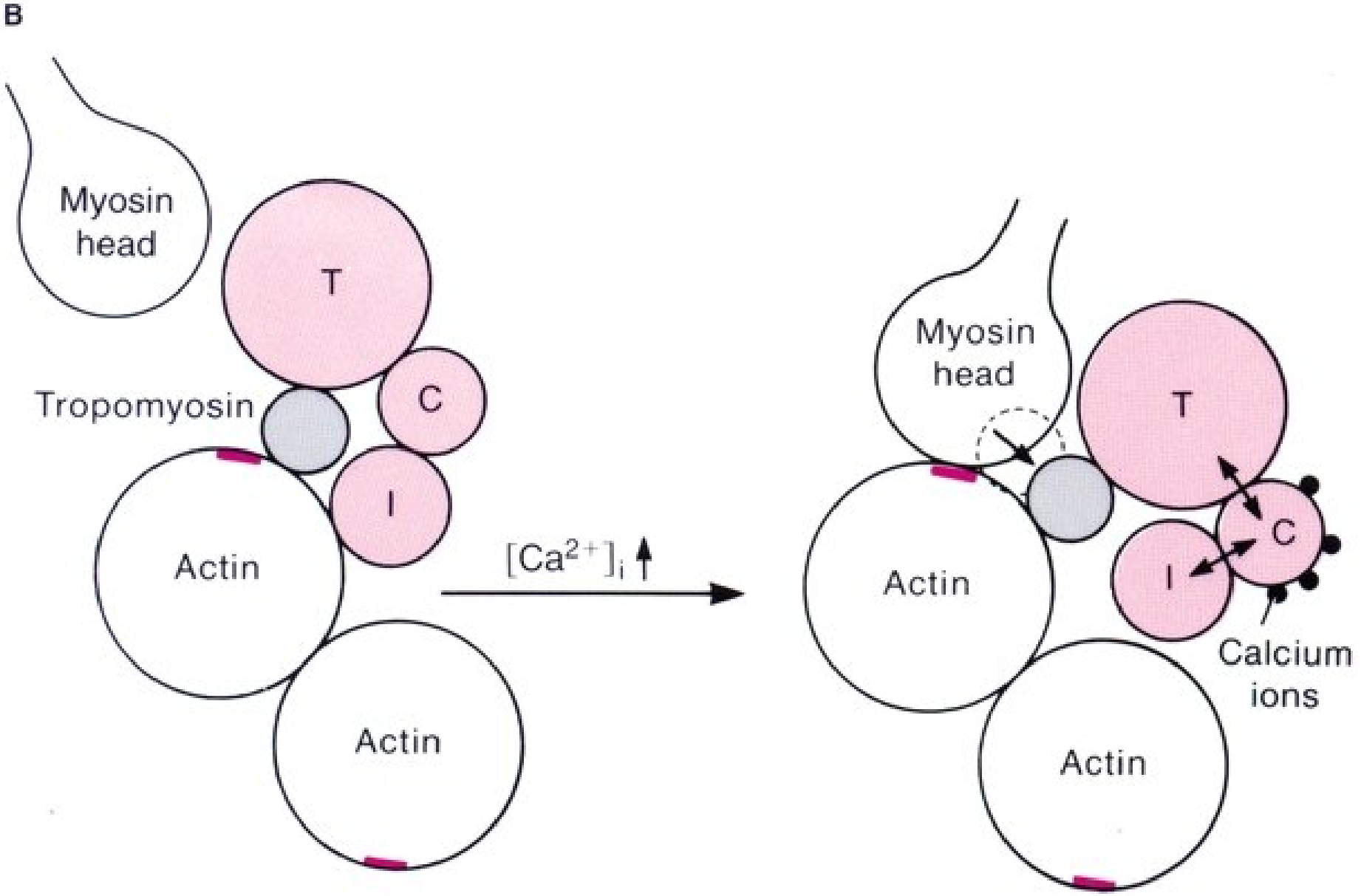


a Thick filament




Muscle
Tendon
Bone
Myofibers
Embryonic muscle
Myoblasts
Myotubes
Nucleus
Nucleus
One myofiber
One myofibril
Z disk
Sarcomere
M line
I band
A band
Z disk
Actin
thin filament
Myosin
thick filament
Z disk


A
I
A
I
Z
H
Z
B
C
0.1 μm


B
Myosin head
T
Tropomyosin
C
I
Actin
Actin
$[Ca^{2+}]_i$
Myosin head
T
C
I
Actin
Actin
Calcium ions

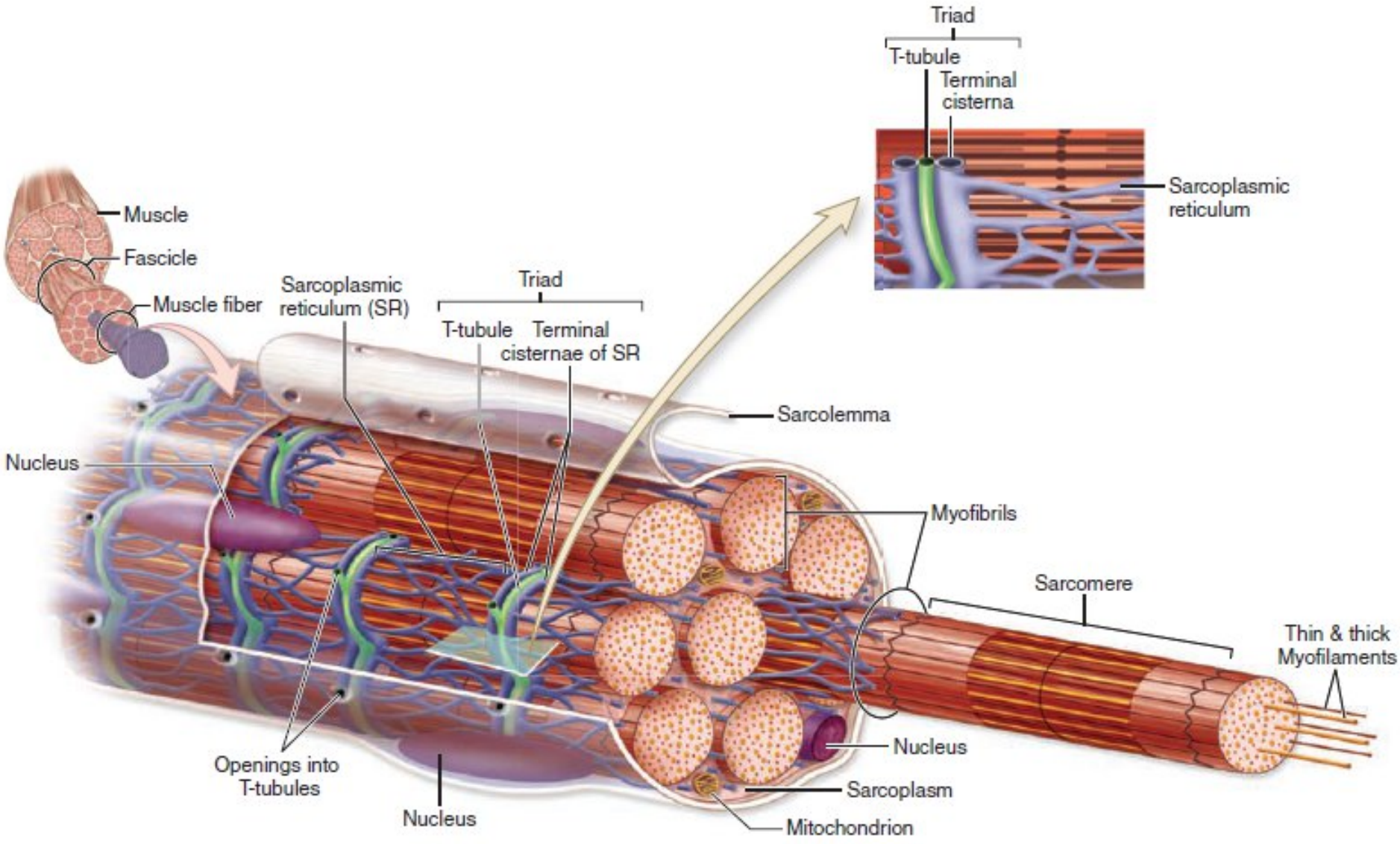
Microstructure

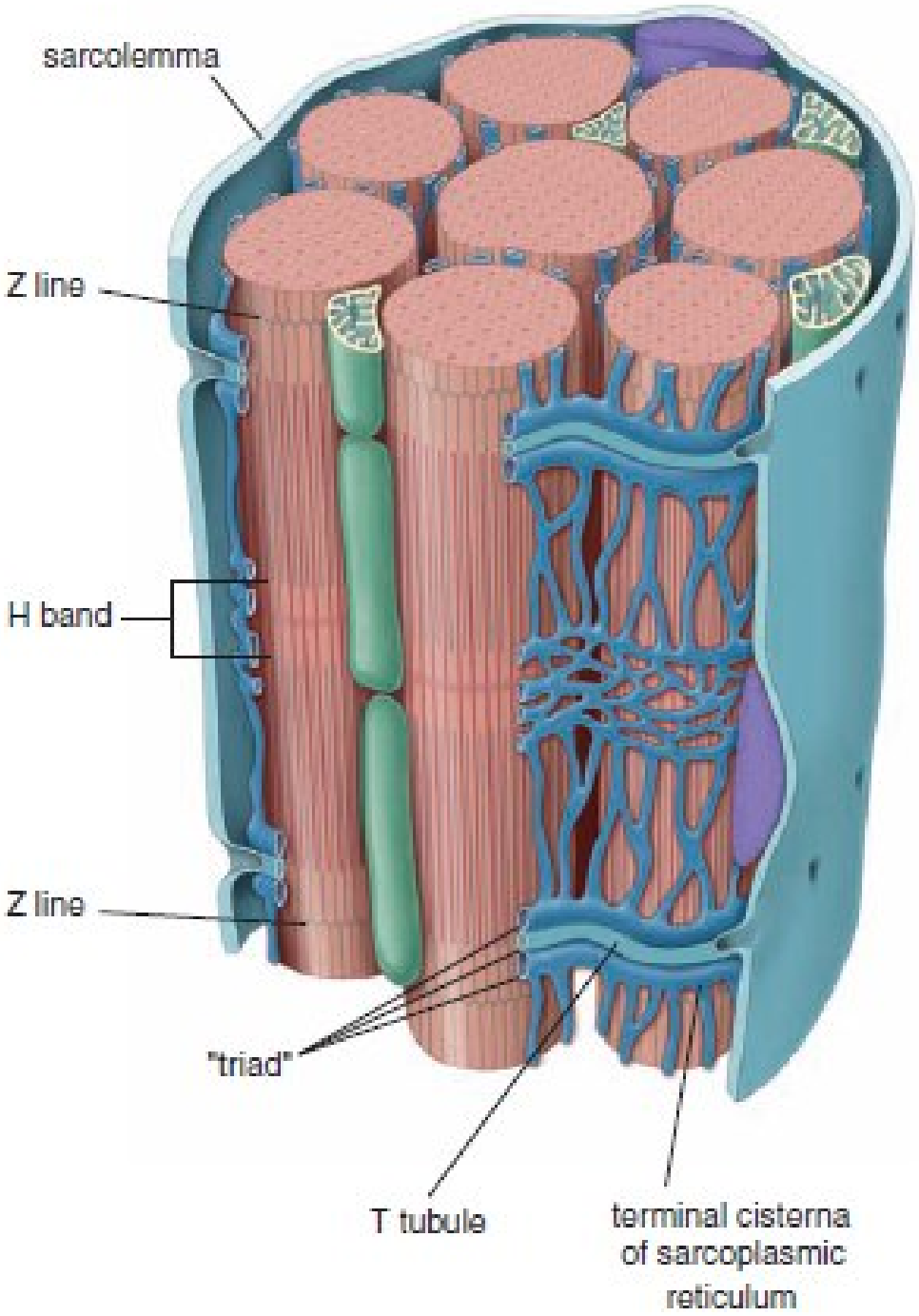
Transverse (T) tubules 2 for each sarcomere at A & I junction

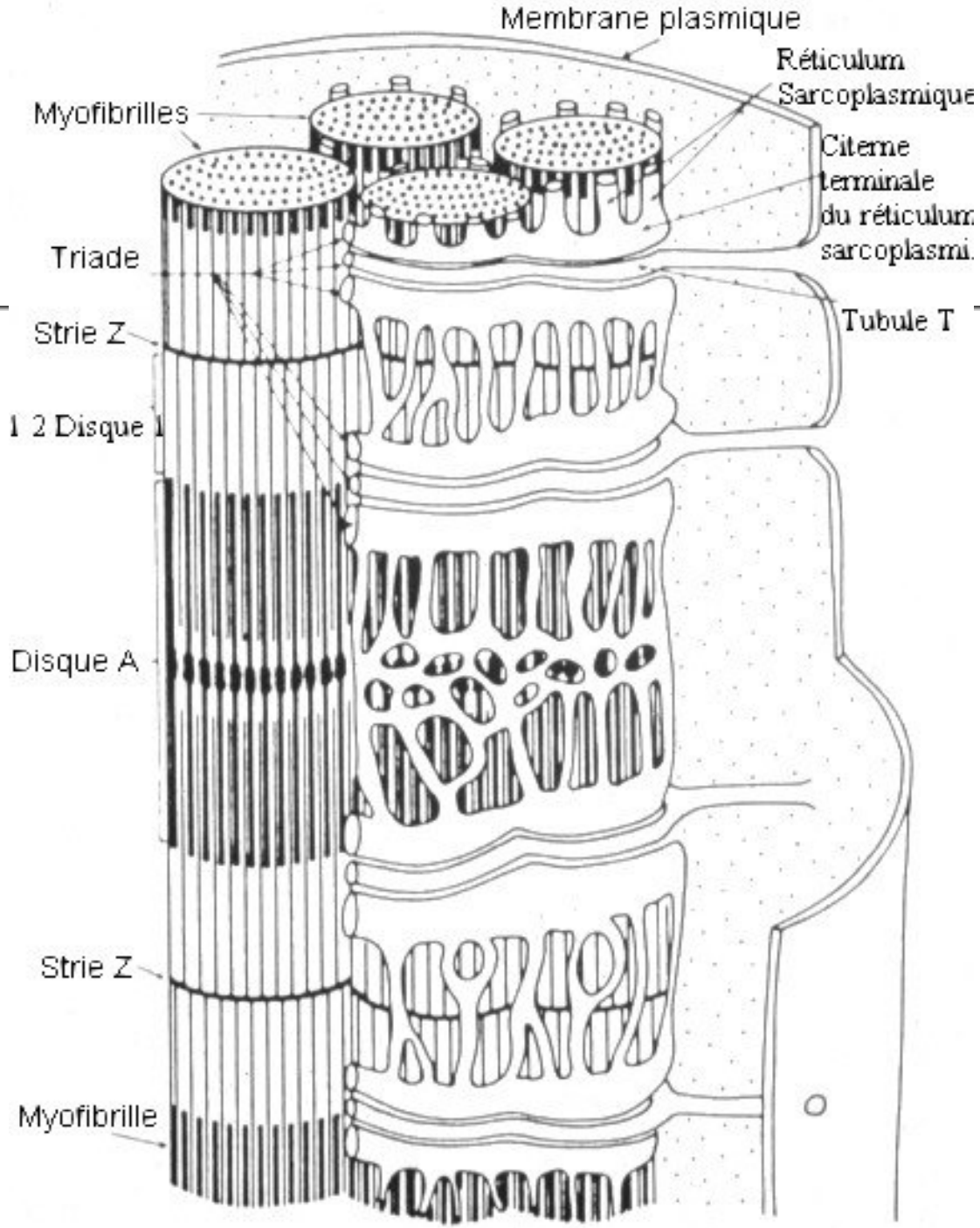
Terminal cisternae

The triad

Role of Ca++


Triad
T-tubule
Terminal cisterna
Sarcoplasmic reticulum
Muscle
Fascicle
Muscle fiber
Sarcoplasmic reticulum (SR)
Triad
T-tubule
Terminal cisternae of SR
Sarcolemma
Nucleus
Myofibrils
Sarcomere
Thin & thick Myofilaments
Openings into T-tubules
Nucleus
Nucleus
Sarcoplasm
Mitochondrion


sarcolemma
Z line
H band
Z line
"triad"
T tubule
terminal cisterna
of sarcoplasmic
reticulum


Membrane plasmique
Réticulum
Sarcoplasmique
Myofibrilles
Citerne
terminale
du réticulum
sarcoplasmi
Triade
Tubule T
Strie Z
1 2 Disque I
Disque A
Strie Z
Myofibrille

Physiology of contraction

Sliding hypothesis

Ca^{++} binding to TnC

Change of configuration

Tropomyosin deeper into the groove of actin helix

Exposure of myosin binding site

Interaction with the myosin head

Physiology of contraction

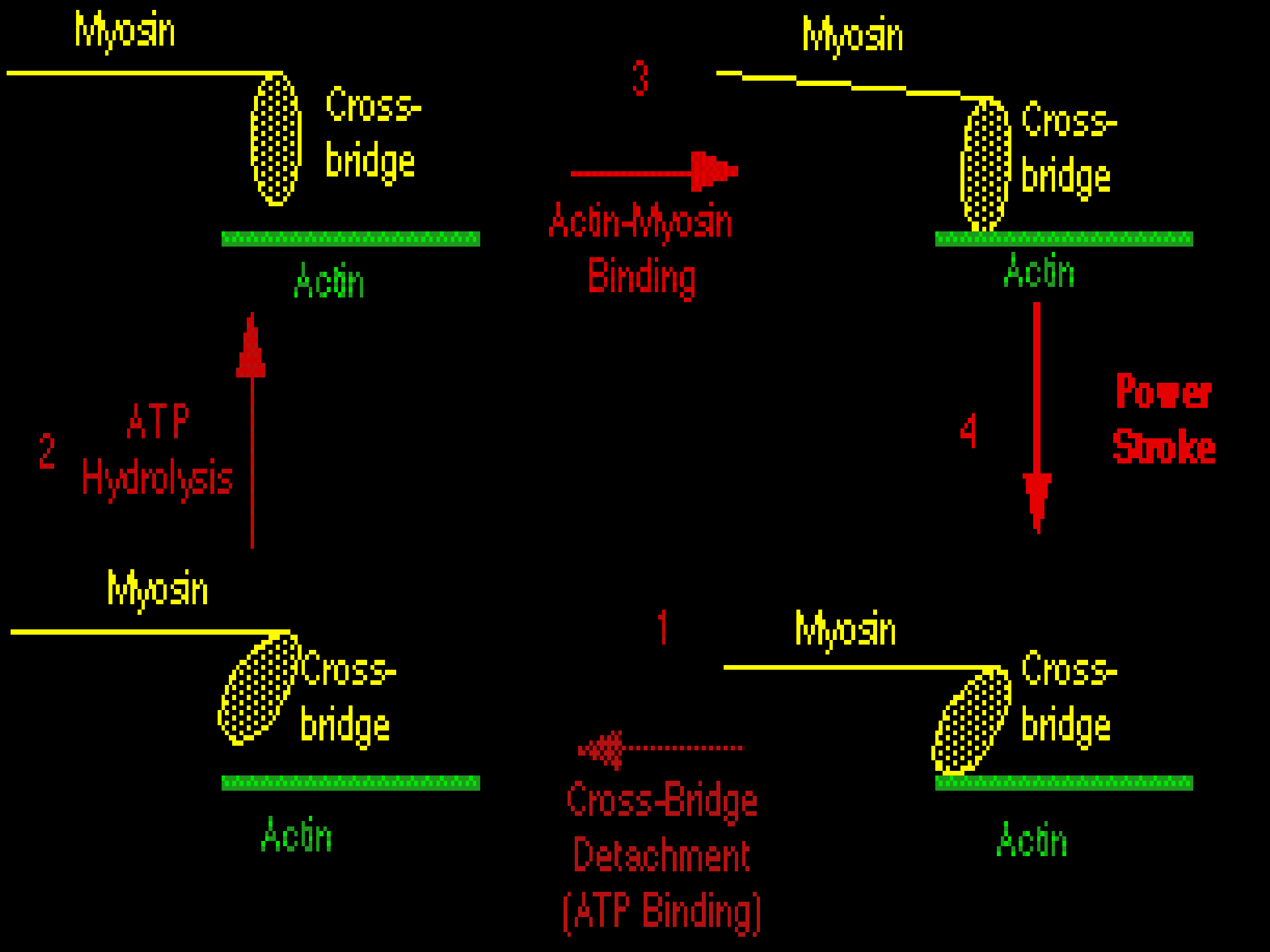
Acceleration of ATP hydrolysis on the myosin head

Energy release

Bending of the myosin head

Sliding of actin into A band

Energy dependent detachment (rigor mortis)


Myosin
Cross-bridge
Actin
3
Actin-Myosin Binding
Myosin
Cross-bridge
Actin
2
ATP Hydrolysis
4
Power Stroke
Myosin
Cross-bridge
Actin
1
Cross-Bridge Detachment (ATP Binding)
Myosin
Cross-bridge
Actin

Innervation

Branching at perimysium

Myoneural junction (motor end-plate)

Acetylcholine

Synaptic cleft

Junctional folds

Depolarization & ca^{++} release

Myasthenia graves

Physiology

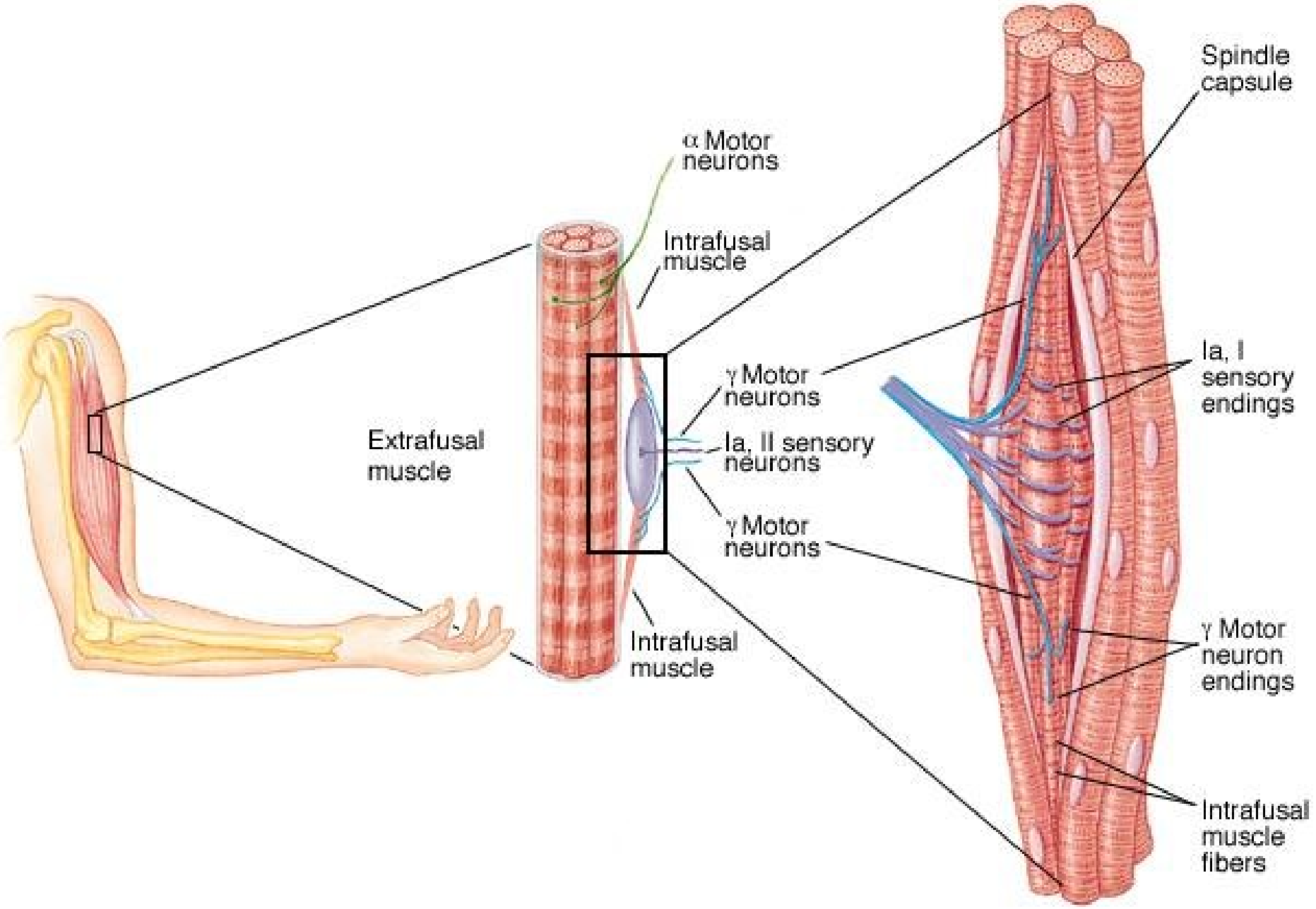
Motor unit (1-160 fibers/axon)

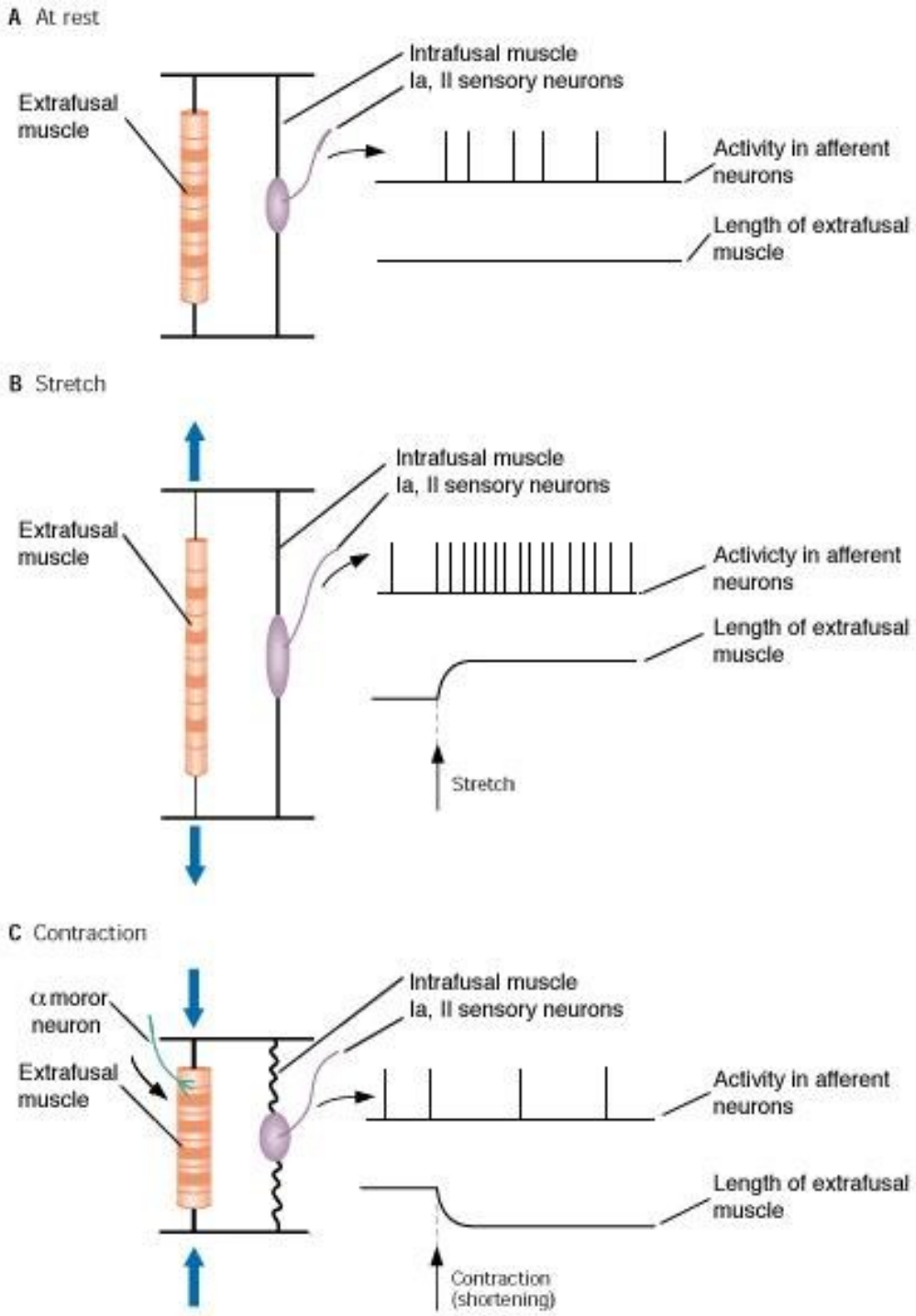
Delicate & coarse movement

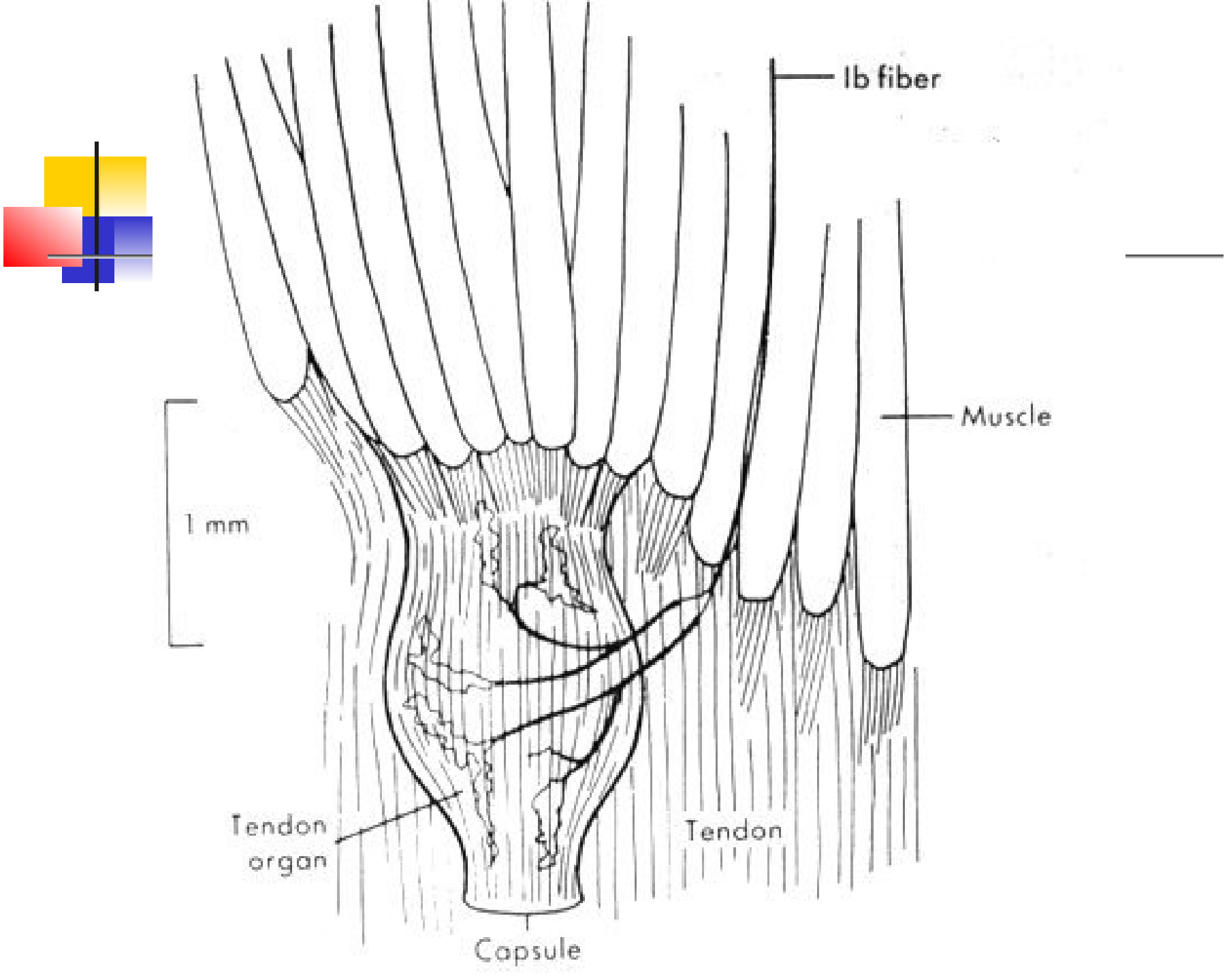
Muscle spindles
Golgi tendon organ

Structure

function


α Motor neurons
Intrafusal muscle
Spindle capsule
γ Motor neurons
Ia, II sensory neurons
Ia, I sensory endings
Extrafusal muscle
γ Motor neurons
γ Motor neuron endings
Intrafusal muscle
Intrafusal muscle fibers


A At rest
Extrafusal muscle
Intrafusal muscle Ia, II sensory neurons
Activity in afferent neurons
Length of extrafusal muscle
B Stretch
Extrafusal muscle
Intrafusal muscle Ia, II sensory neurons
Activicty in afferent neurons
Length of extrafusal muscle
Stretch
C Contraction
α moror neuron
Extrafusal muscle
Intrafusal muscle Ia, II sensory neurons
Activity in afferent neurons
Length of extrafusal muscle
Contraction (shortening)


Ib fiber
Muscle
1 mm
Tendon
organ
Tendon
Capsule

Energy

ATP & phosphocreatine

Sources: glycogen, fatty acids

Anaerobic condition

Denervation & atrophy

Sarcoplasm

Glycogen

Myoglobin

Low amount of RER

Types of muscle fibers

Type I:

Slow

Red

Myoglobin

Continuous contraction

Ox.phos. Of fatty acids

Low glycogen,
high lipid

Type II:

Rapid

white

Less myoglobin

Discontinuous contraction

Glycolysis

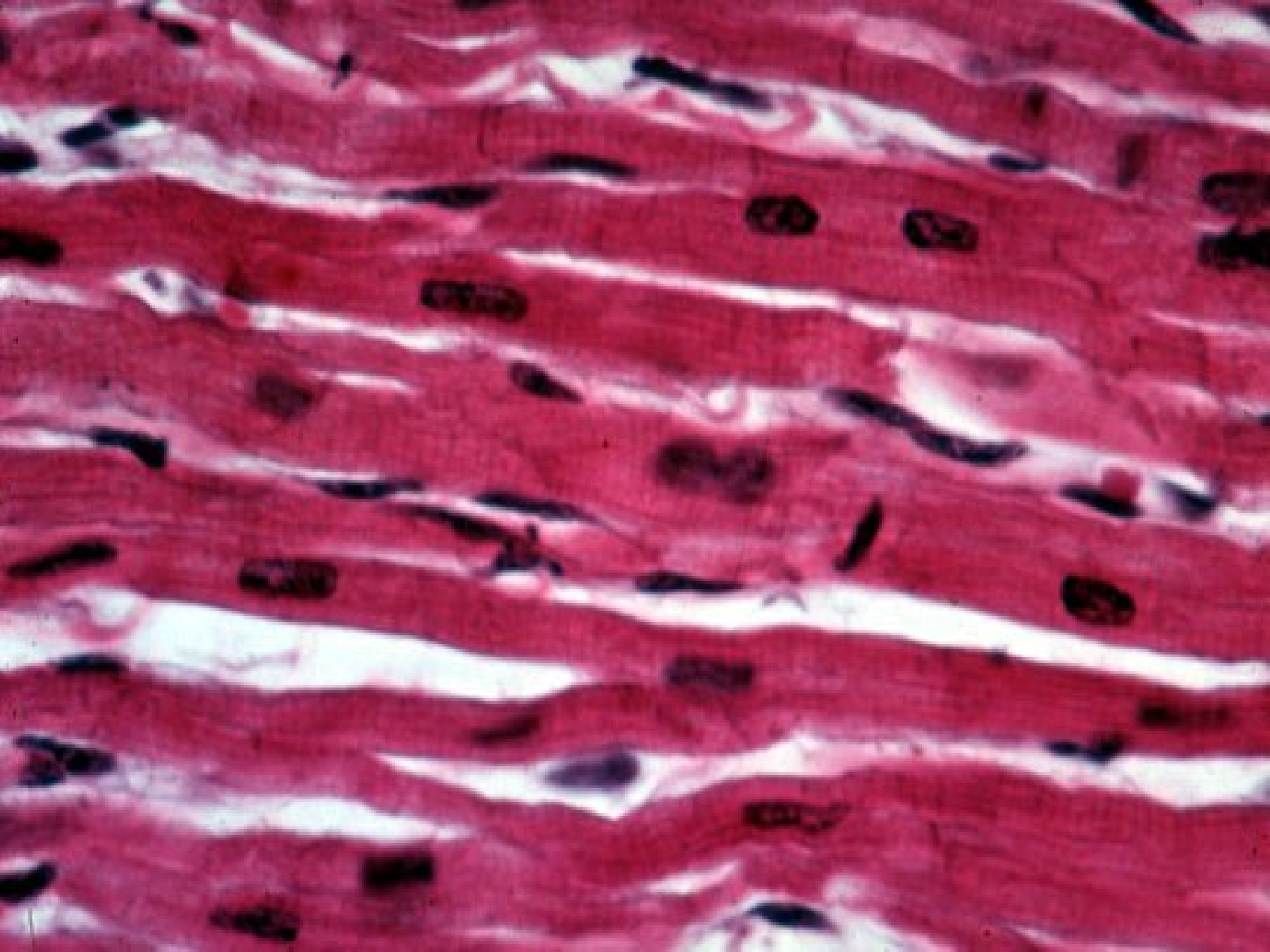
Subtypes IIA, IIB & IIC

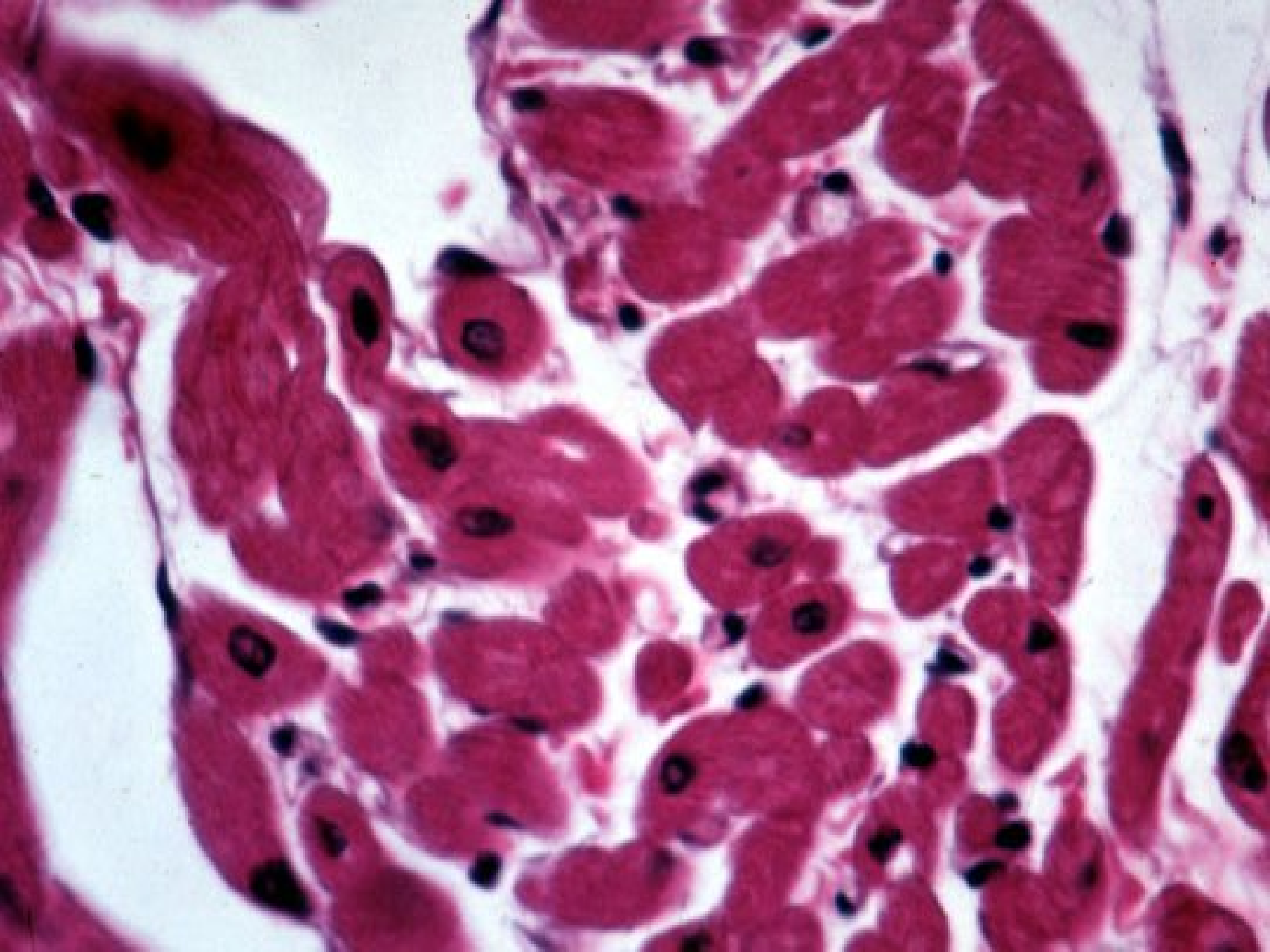
Cardiac muscle

Cross striation

Branching and communicating cells

One/two centrally located nuclei





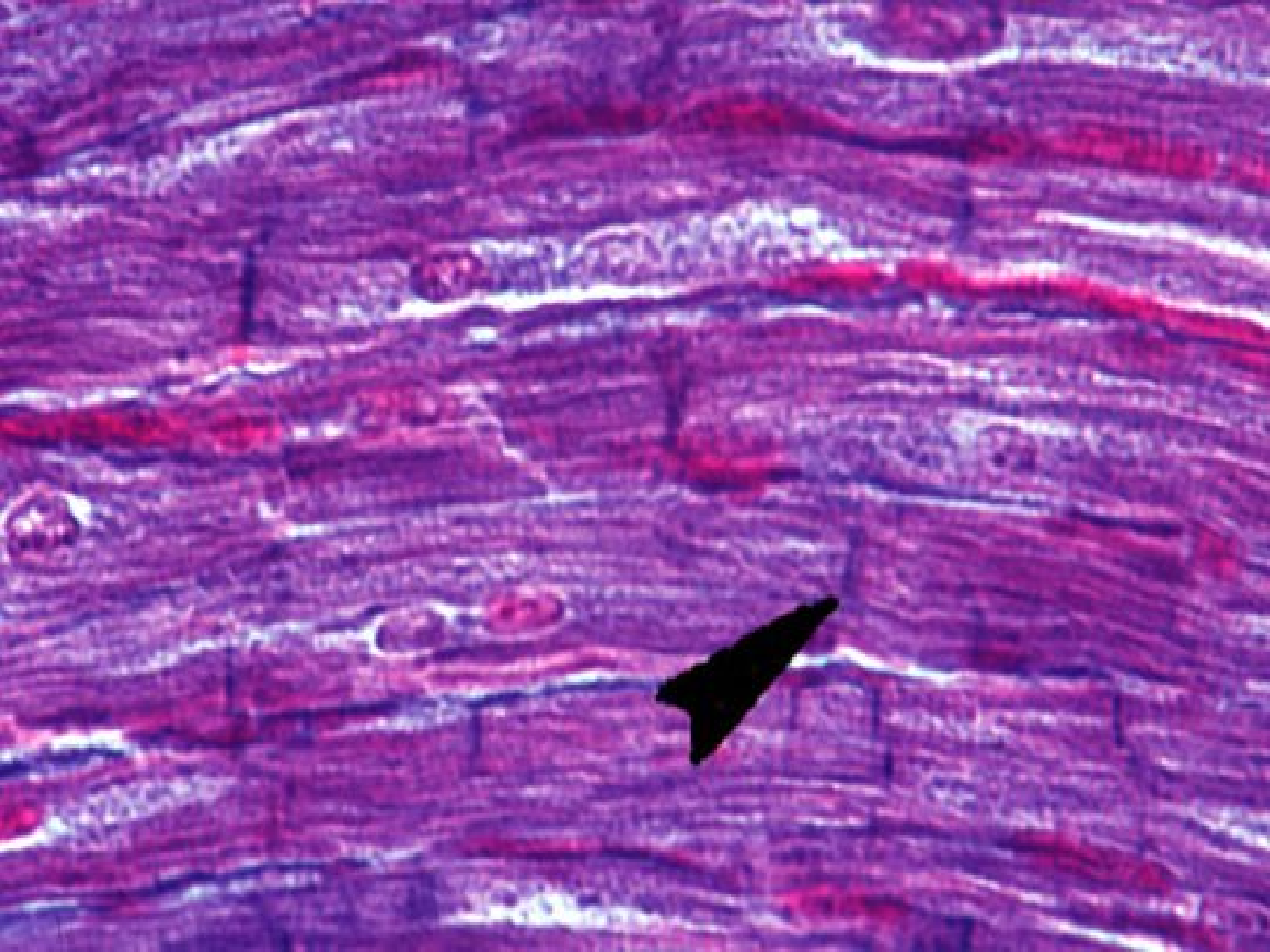
Intercalated disks

Straight or step-like pattern

Composed of 3 specialization

transverse portion 1) fasciae (zonula) adherentes: anchoring site for actin; hemi-Z bands 2) desmosome

lateral portion 3) gap junction



Cardiac muscle

T-tubules less regular, no discrete
myofibrils larger & more numerous in the ventricles At the level of Z-band diads

Mitochondria 40%

Major source: Fatty acids

Limited glycogen

Cardiac muscle

Lipofuscin

Atrial muscles smaller cells
fewer T-tubules

Atrial natriuretic factor particularly
right atrium natriuresis & diuresis

Smooth muscle

Non-striated

Fusiform

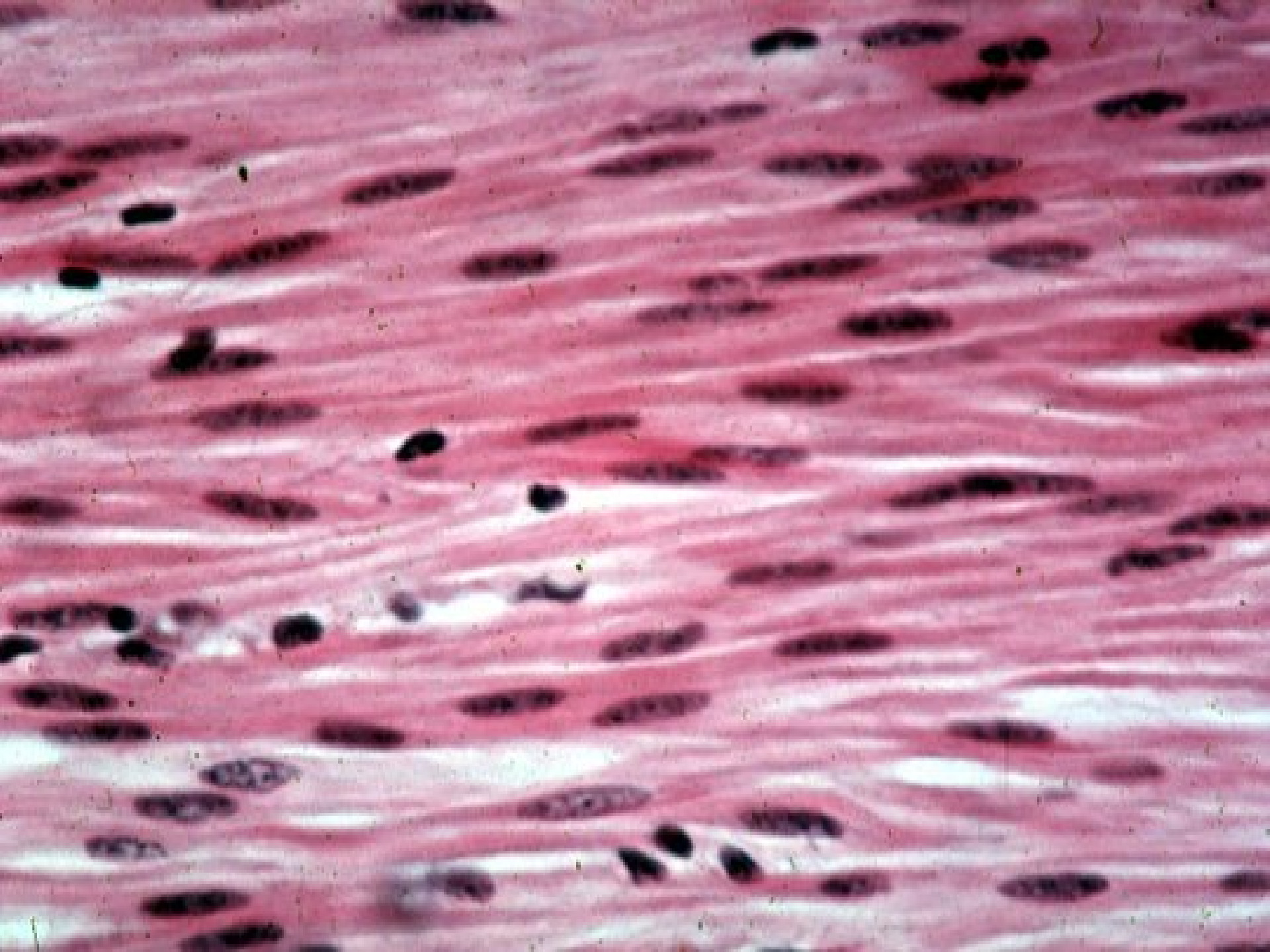
Central single nucleus

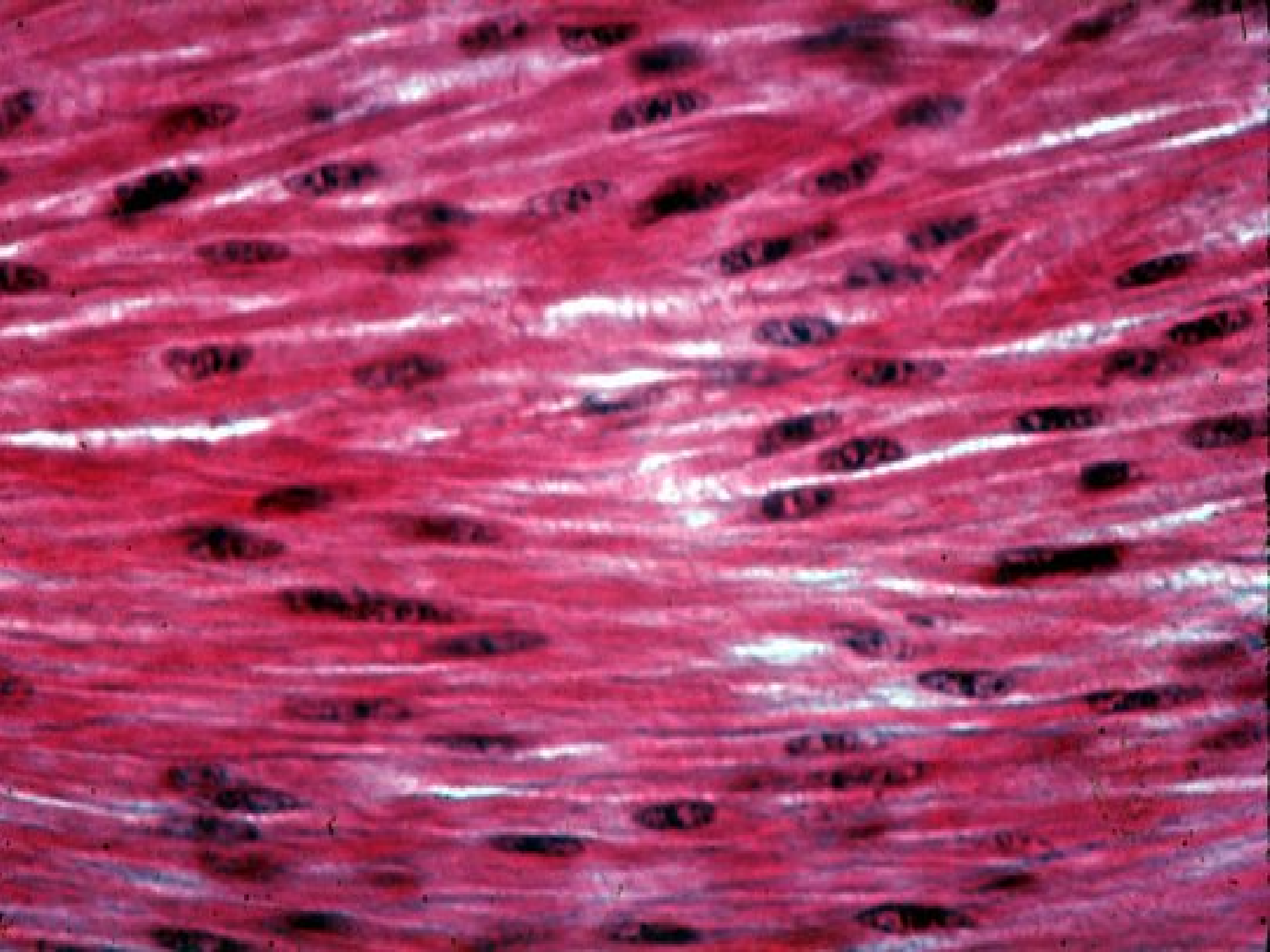
scalloped borders when contracts

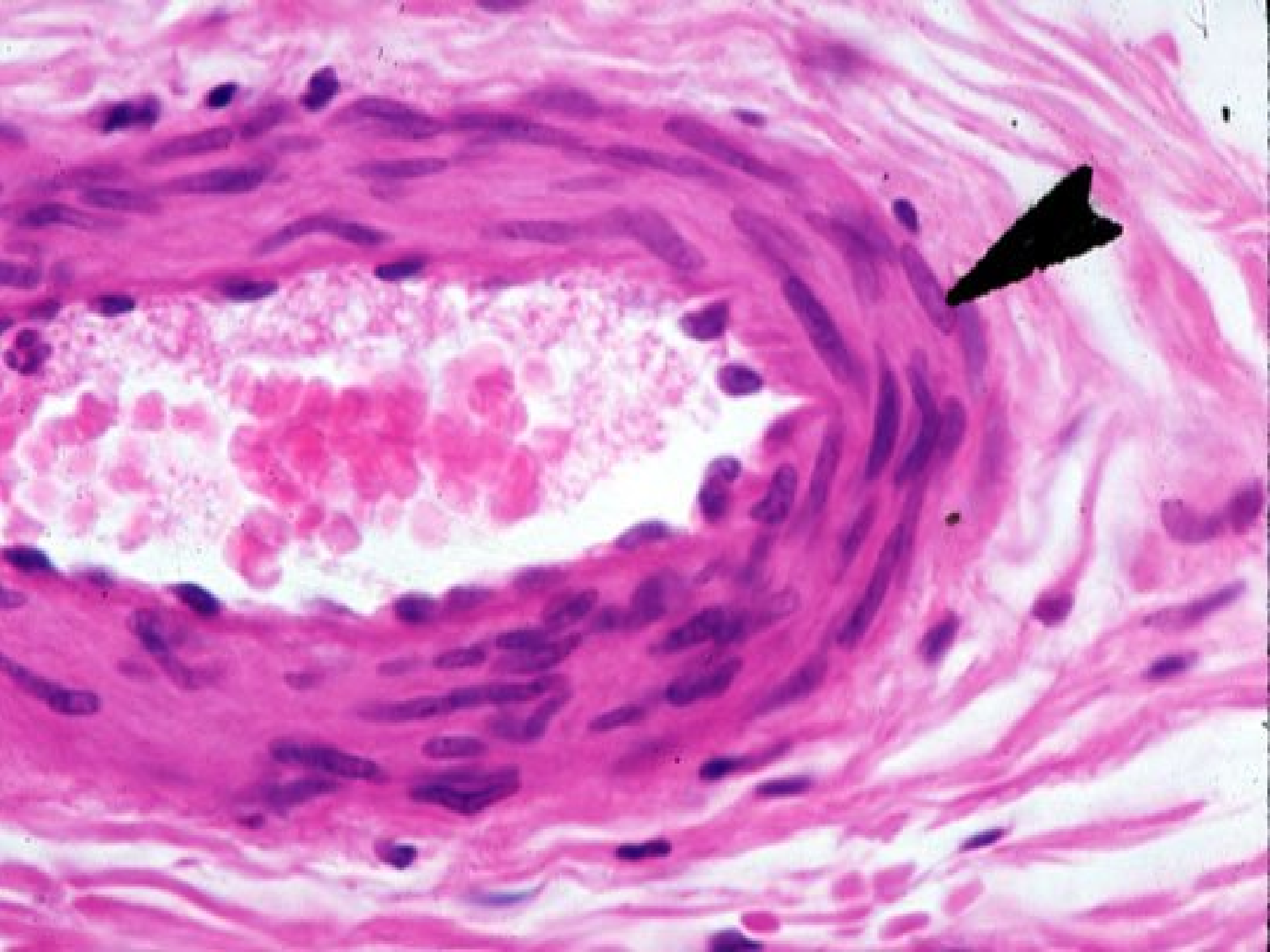
Organelles are perinuclear

No T-tubules

Rudimentary sarc.ret.







Smooth muscle

Latticelike network

Similar sliding mechanism

Ca^{++} initiate contraction

Ca^{++}/calmodulin complex activates myosin light chain kinase

Interaction of actin/myosin

ES/PR…..cAMP…kinase

Smooth muscle

Membrane associated & cytoplasmic dense bodies contains α-actinin similar to Z lines

Innervation relatively poor abundant
Gap junctions autonomic no
neuromuscular junctions 1) syncytial fashion (visceral) 2) multiunit (iris)

Smooth muscle

Innervation modify basal activity rather than initiating

Synthesis activity collagen, elastin & proteoglycans

Regeneration activity division of muscle cells and pericytes

skin

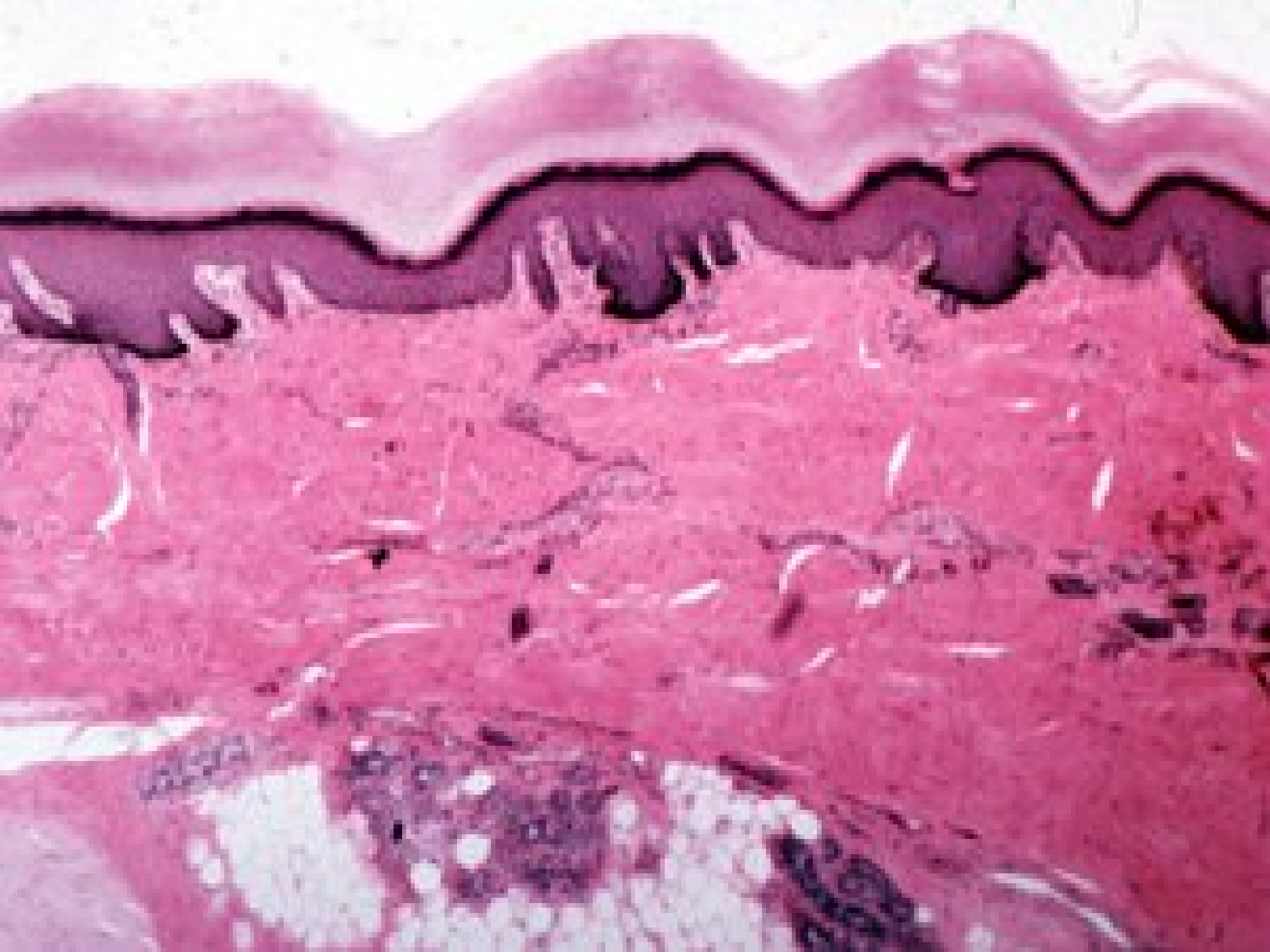
Skin

- The integumentary system
  - The skin (cutis, integument)
    - Epidermis
    - Dermis
    - Subcutaneous tissue (hypodermis, panniculus adiposus, superficial fascia)
- The largest organ (15-20% of body mass)

Skin

Skin appendages (epidermal derivatives of the skin)

- Hair follicles
- Sebaceous glands
- Sweat glands
- Nails
- Mammary glands



Skin

- Prevents water loss
- Protection (impact, friction, & UV)
- Receptor organ
- Thermoregulation
- Cytokines, GFs, Metabolism (D vitamin)
- Excretion of substances
- Dermatoglyphics (fingerprints)
  - Dermal ridges

Skin

- Thick skin
  - Palms and soles
  - Hairless
- Thin skin
  - The rest of skin
  - Hair with few exceptions
  - Upper back versus eyelid

Epidermis

Malpighian layer

Stratum basale (stratum germinativum)

- Stem cells
- Morphology
- Low power basophilia
- Melanin and melanocytes
- Desmosomes and hemidesmosomes
- Interdigitations of the basal surface with the BM
- Upward migration

Epidermis

- Malpighian layer
  - Stratum spinosum
    - Spinous layer/prickle cell layer
    - Morphology of cells
    - Squamous morphology toward the surface

Epidermis

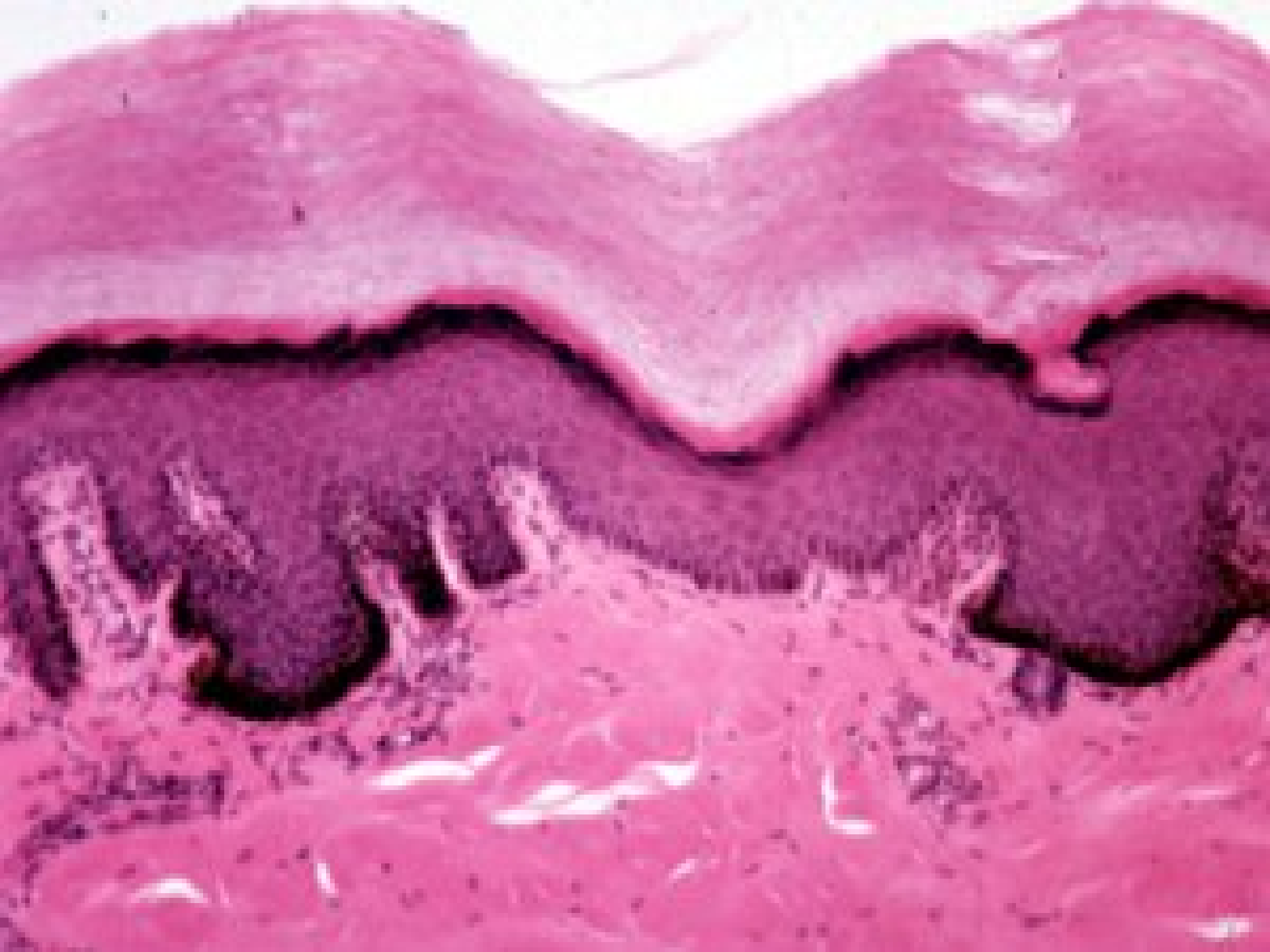
- Stratum granulosum
  - Keratohyalin granules (phosphorylated histidine-rich protein & cystine containing proteins) membrane-coated lamellar granule
  - Precursor for the protein “filaggrin”
  - Which aggregates the keratin filaments
  - 1-3 cell thickness

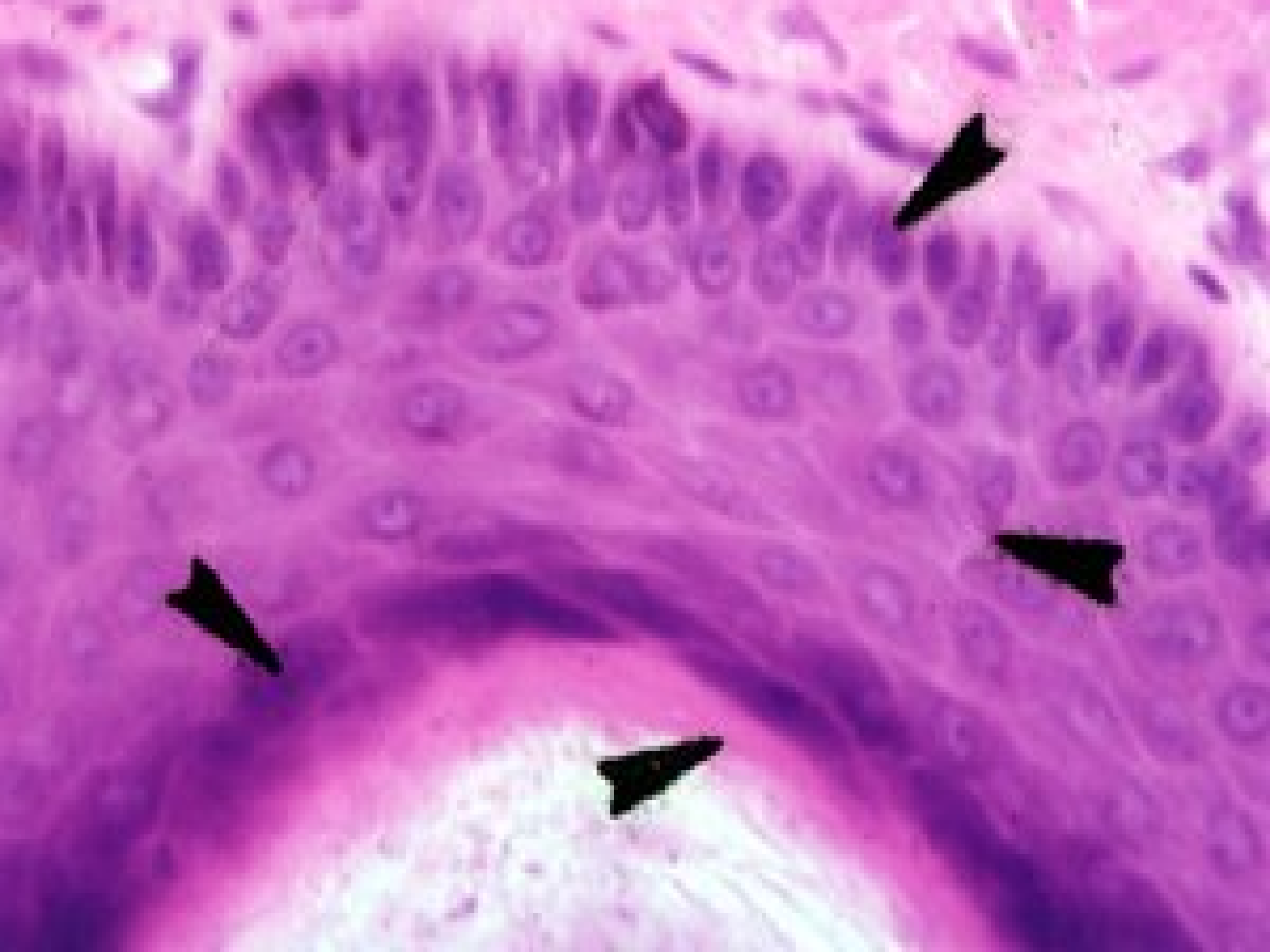
Epidermis

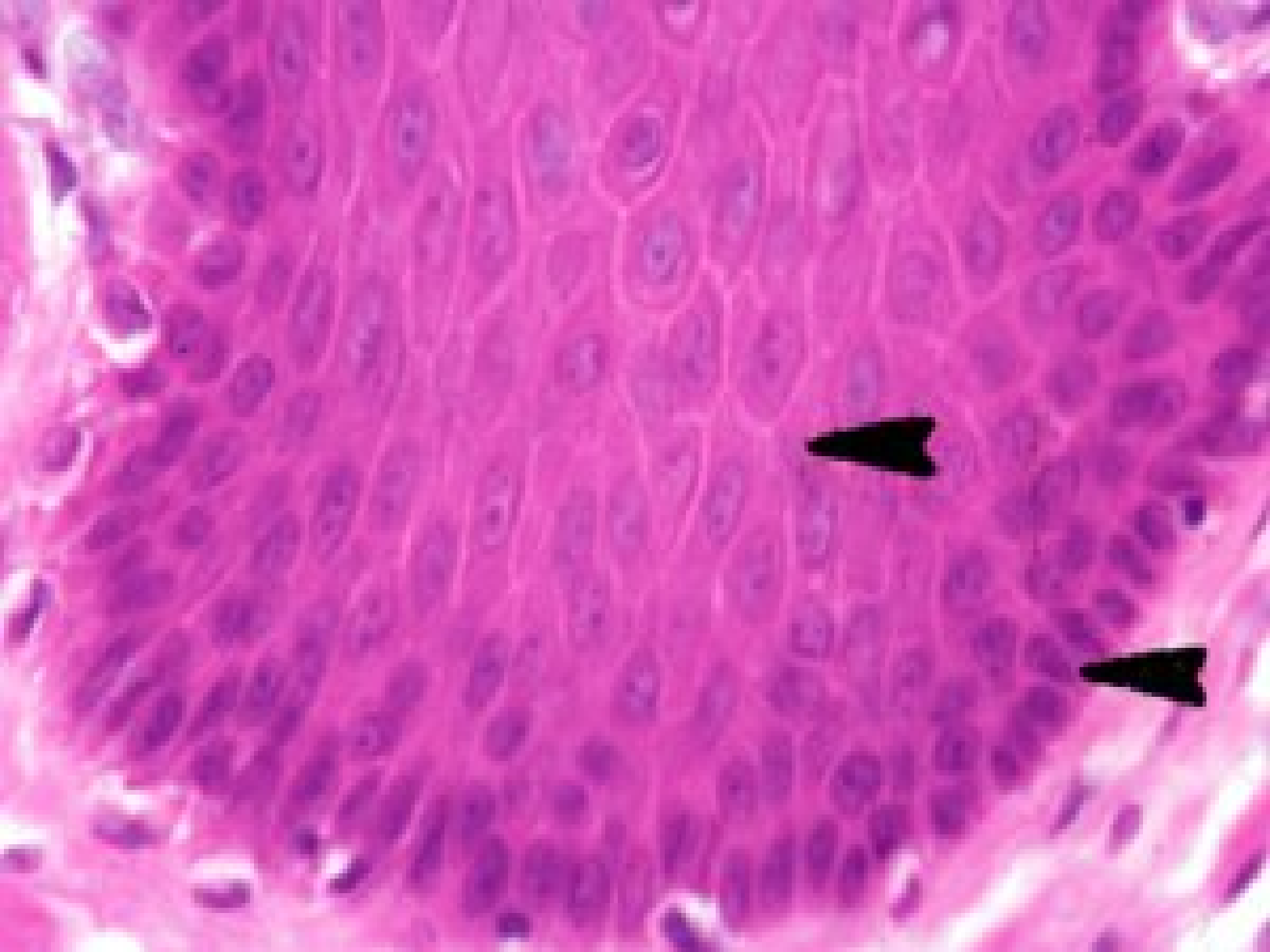
- Stratum lucidum
  - Limited to thick (acral) skin
  - Refractile layer
  - Eosinophilic cells with advanced keratinization

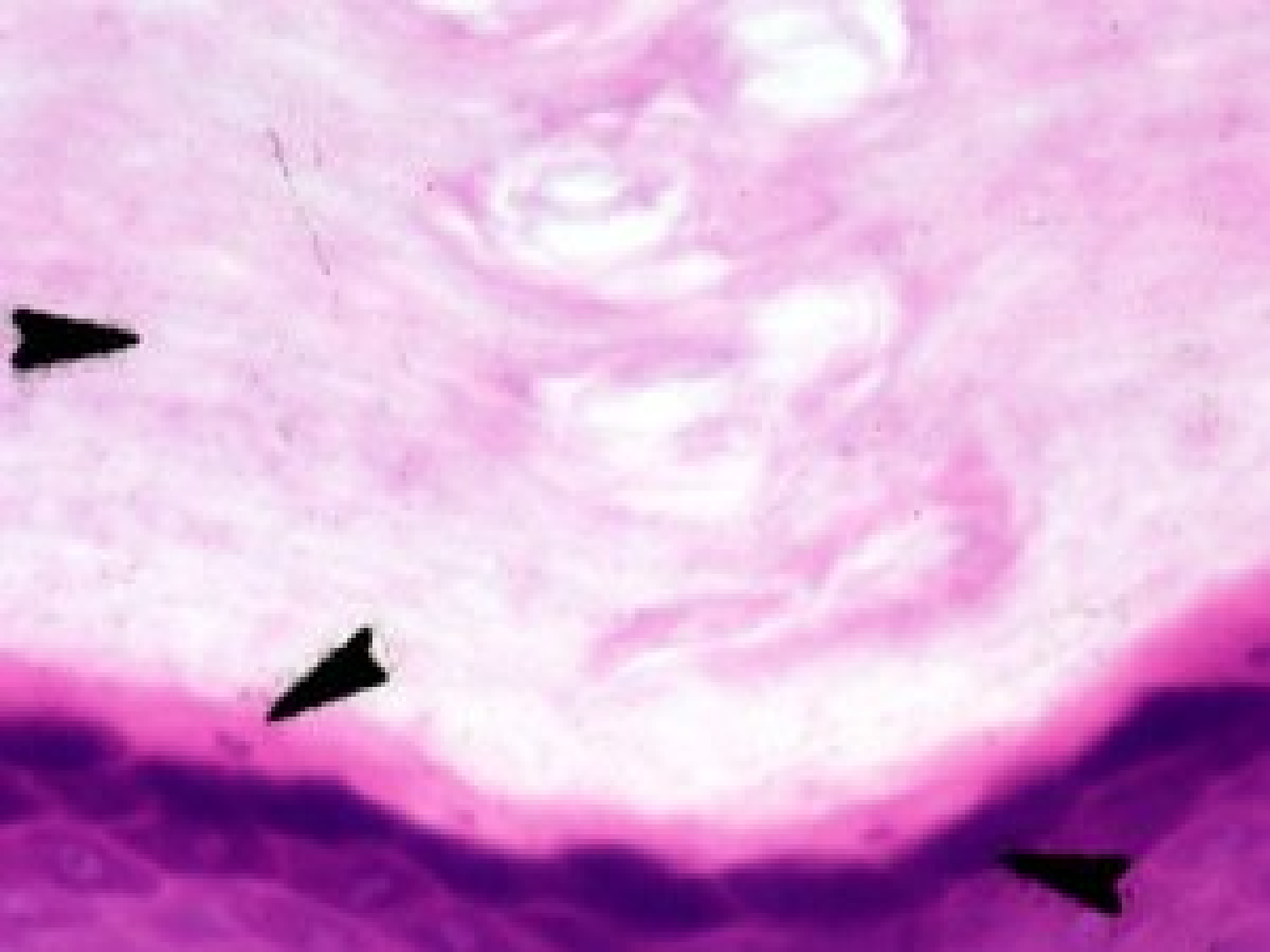
Epidermis

- Stratum corneum
  - Abrupt transition
  - Keratinized cells
  - Special form of apoptosis
  - Layer of lipids (water barrier)
  - Make the principal difference between thick and thin skin









Melanocytes

Melanocytes: position, origin, & morphology.

Eumelanin & pheomelanin

Tyrosine…dopa…dopaquinone …melanin

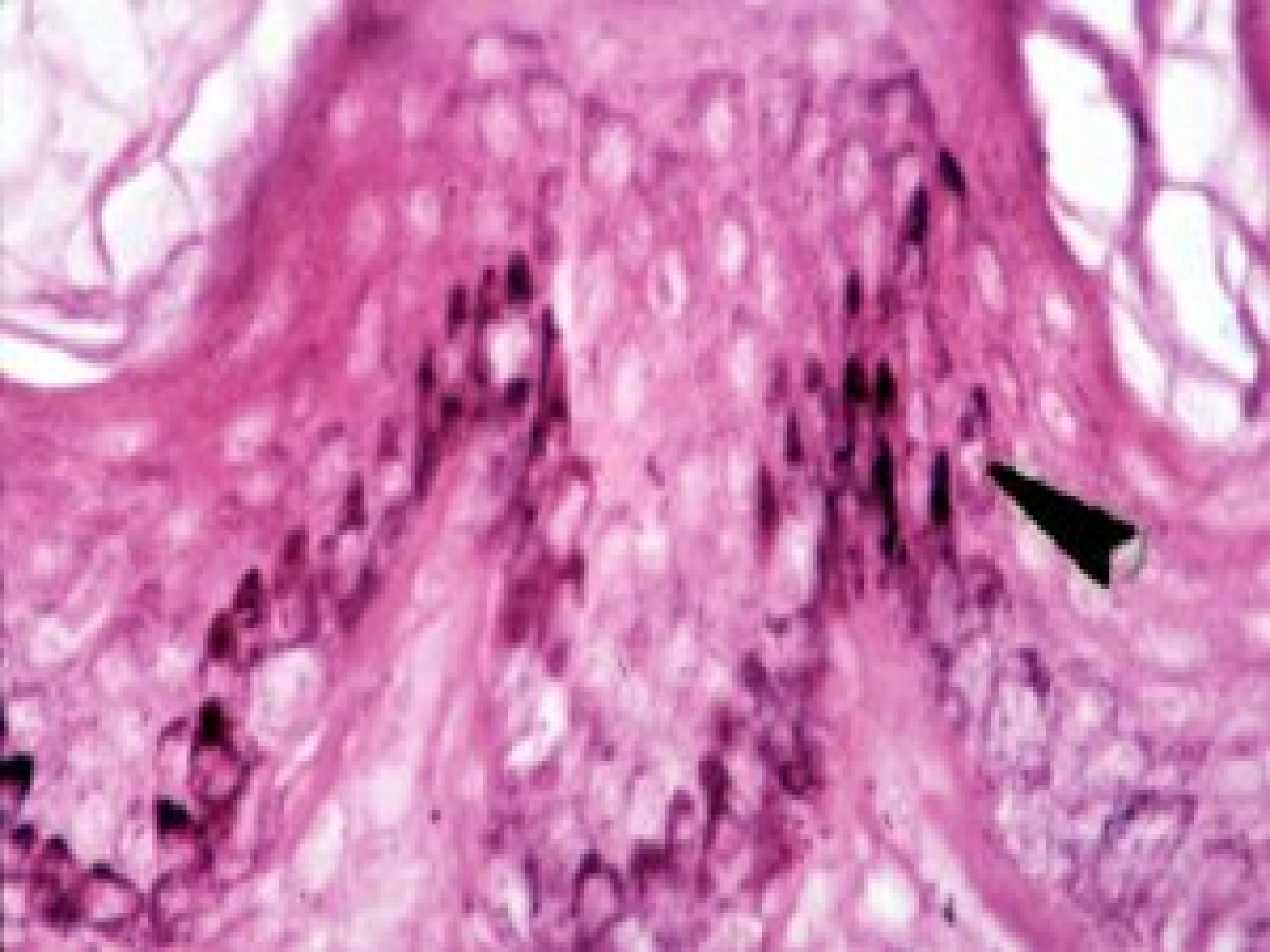
Formation of melanin granules

Injection of melanin into keratinocytes

Constant epidermal-melanin units

Darkening of skin after exposure to solar radiation

Addison disease. Albinism. Vitiligo



Langerhans cells

Bone marrow derived

In stratum spinosum

Function

Role of skin in immunology

Merkel’s cells

Presence in palms and soles

Dense granules

Sensory mechanoreceptors ??

Diffuse neuroendocrine system ??

Dermis

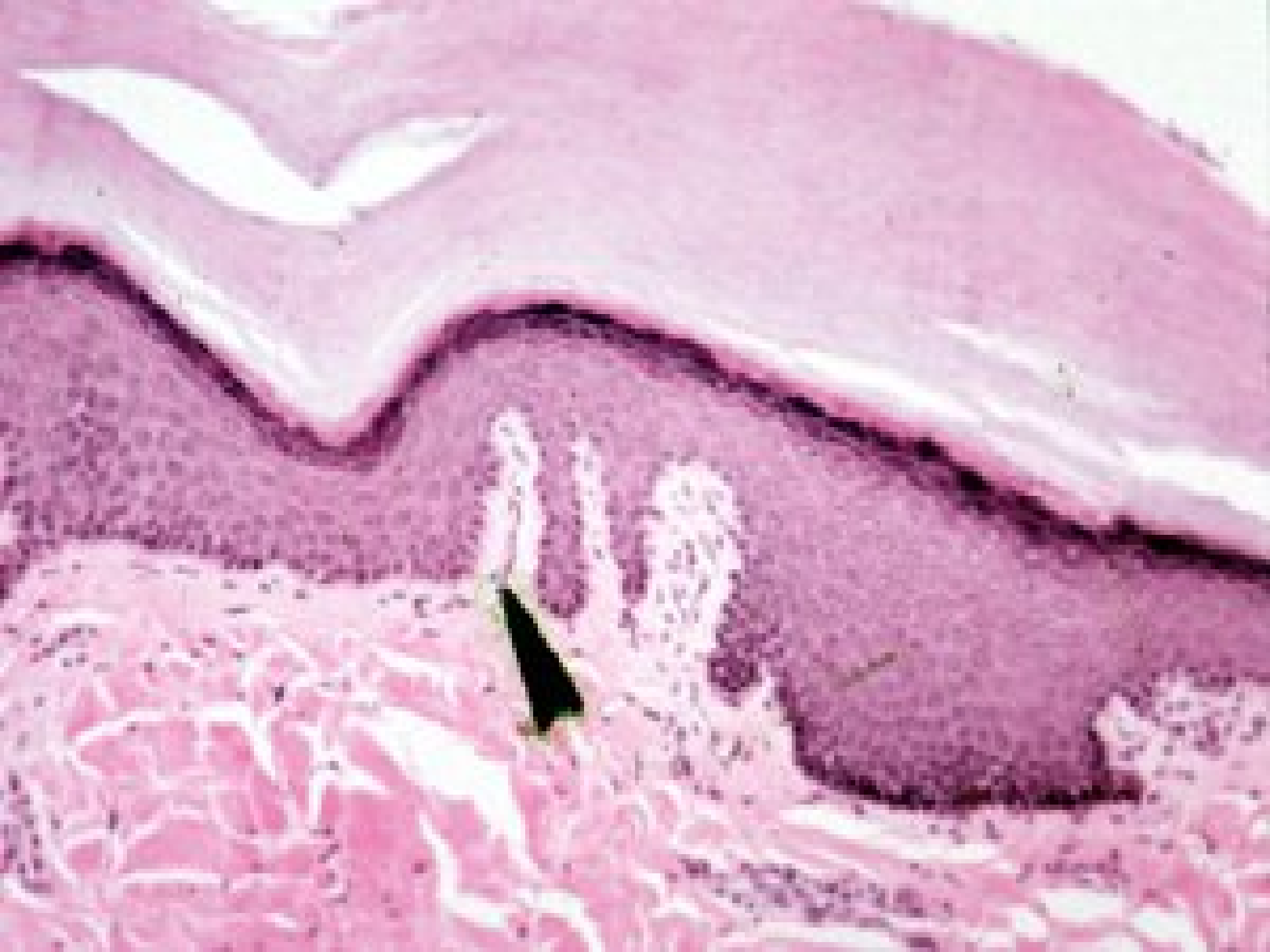
- Dermo-epidermal junction
  - Dermal papillae and rete ridges
- Role in determining epidermal characteristics

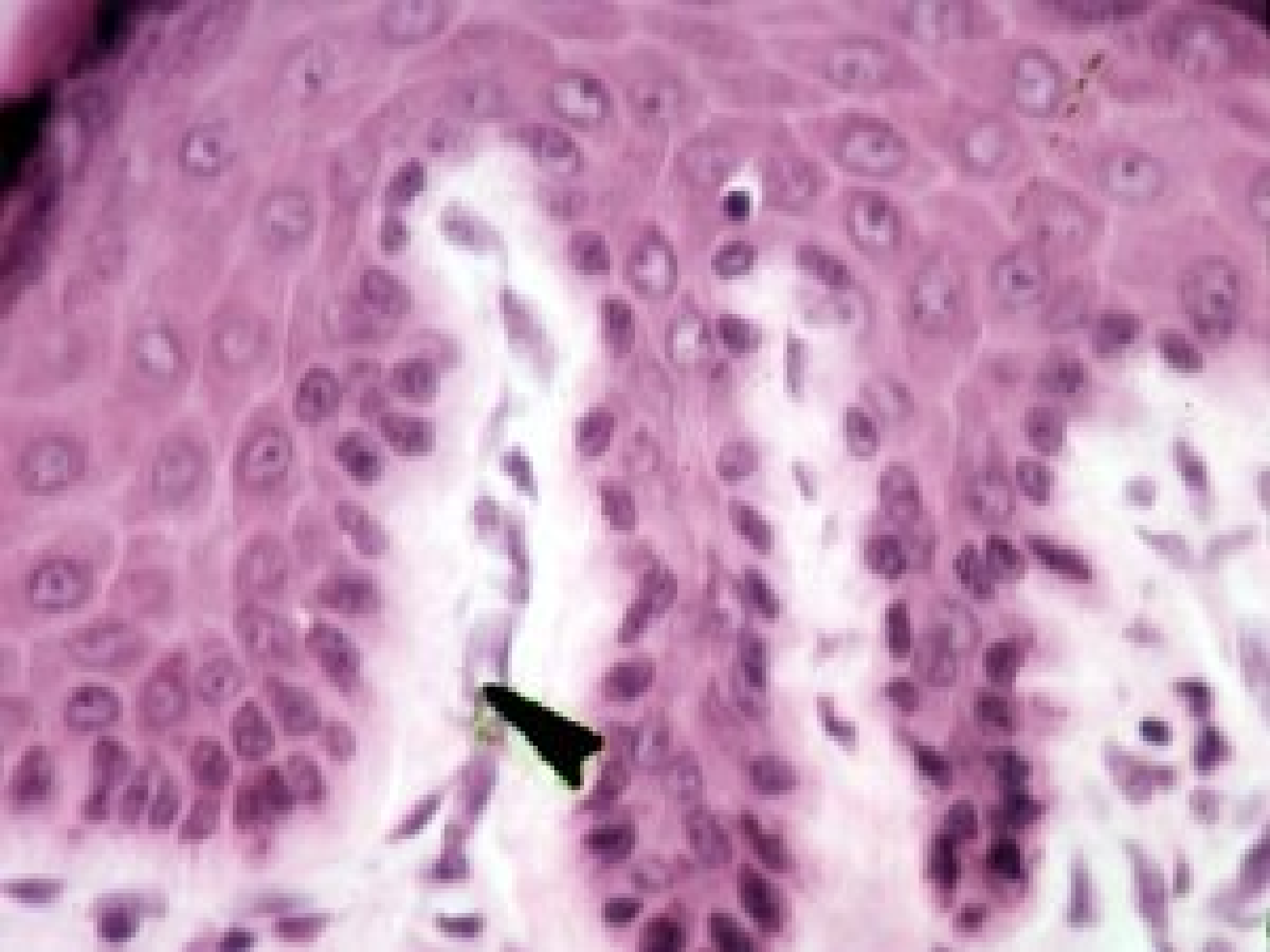
Dermis

- Papillary layer
  - Loose connective tissue
  - Delicate type I and III collagen
  - Elastic fibers
  - Blood vessels and nerve endings
- Reticular layer
  - Thicker and less cellular
  - Collagen type I
  - Coarser elastic fibers
  - Deep smooth muscle plexus of the areola, penis, scrotum and perineum
  - Arrector pili muscle
  - A-V shunts, role in thermoregulation
  - No parasympathetic

Dermis

- Subcutaneous tissue
- Panniculus carnosus
  - Deep to subcutaneous fascia of face and neck





Vessels

Superficial & deep arterial plexuses

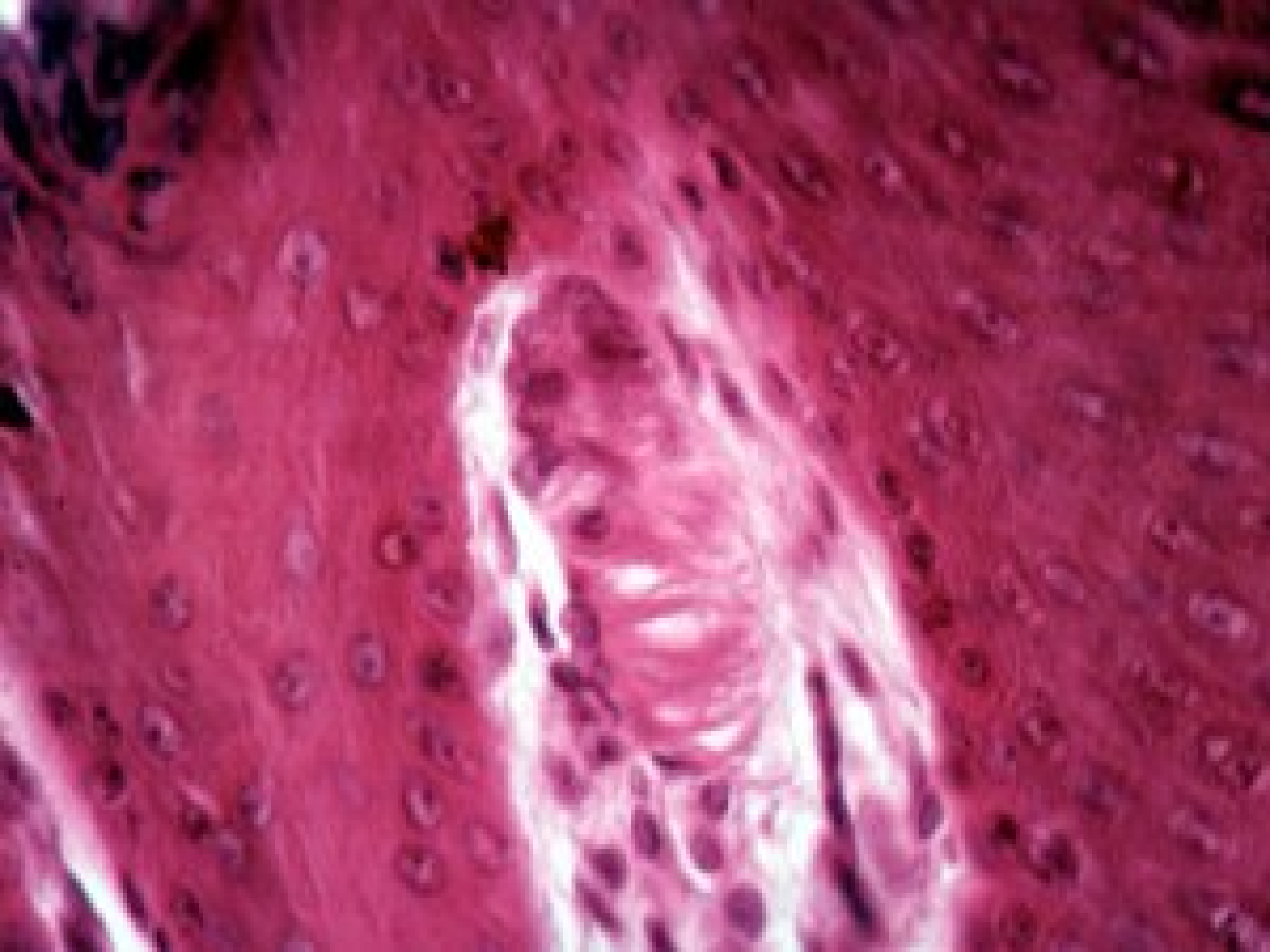
3 venous plexuses

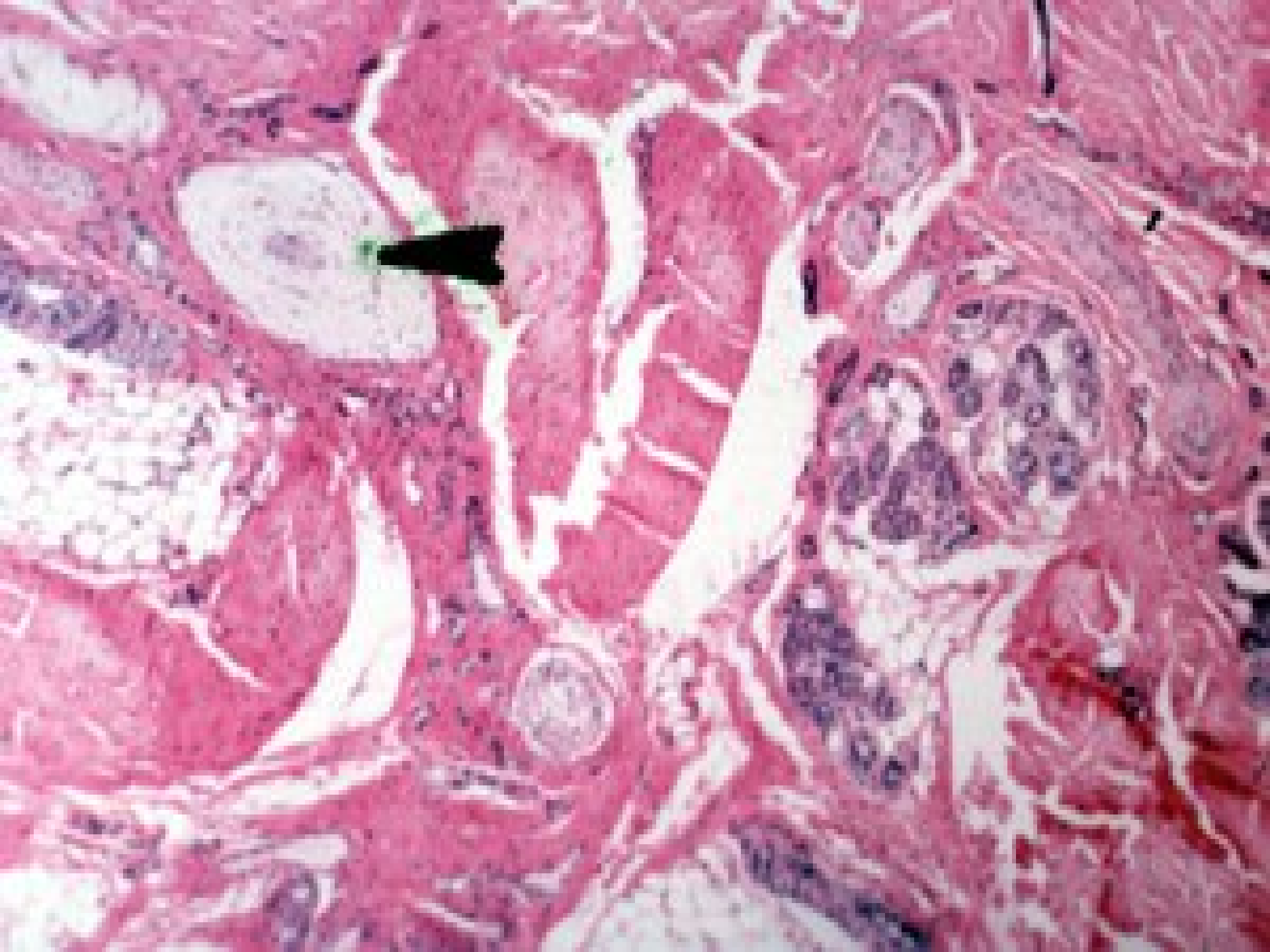
A-V anastomosis

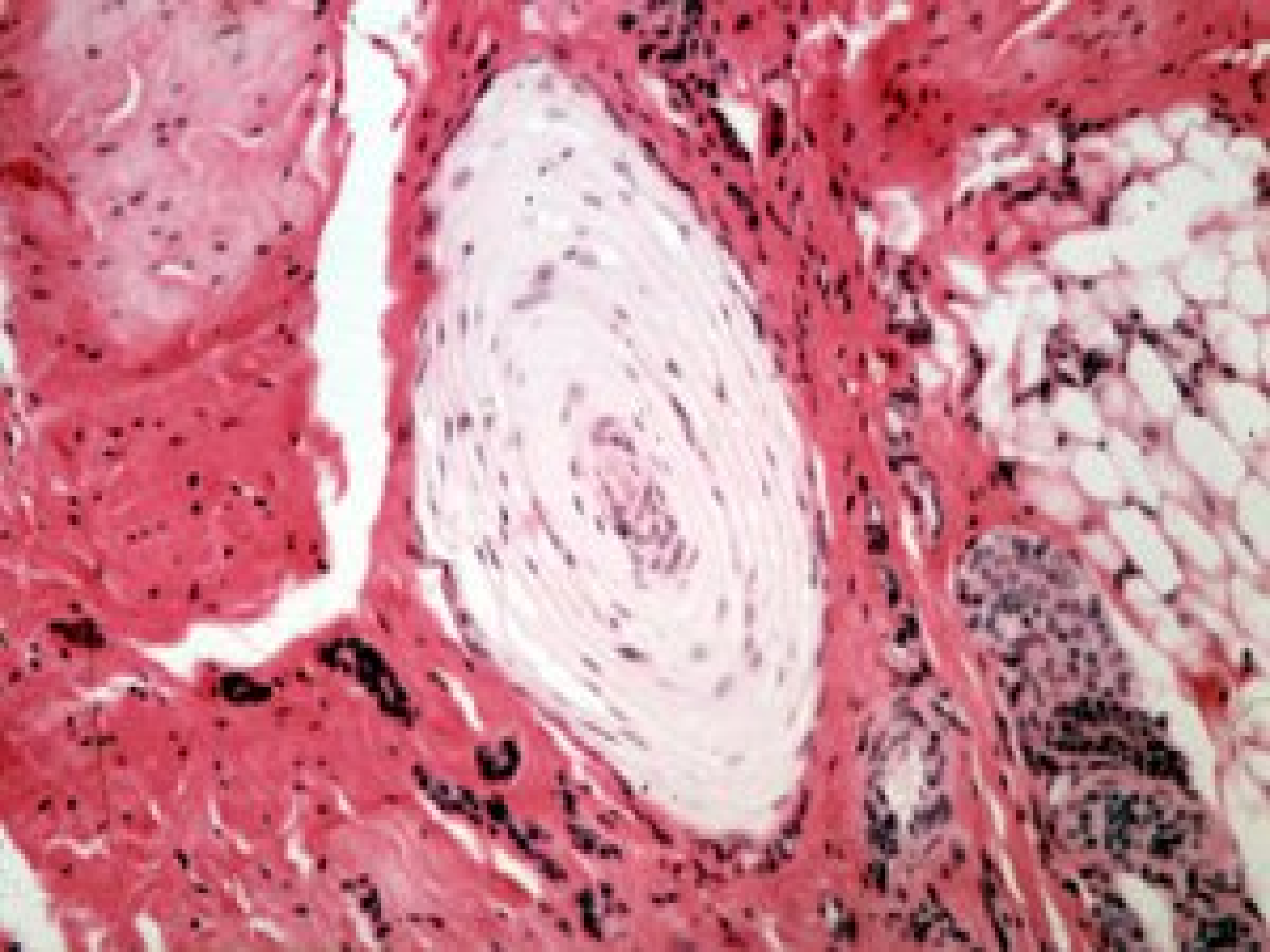
Lymphatics

Sensory function

- Free nerve endings
  - The most numerous
- Encapsulated endings (corpuscles)
  - Pacinian corpuscle
  - Meissner’s corpuscles
  - Ruffini’s corpuscles







Hairs

Non-hairy regions: palms, soles, lips, glans penis, clitoris, and labia minora

Hair follicle

Hair bulb, dermal papilla

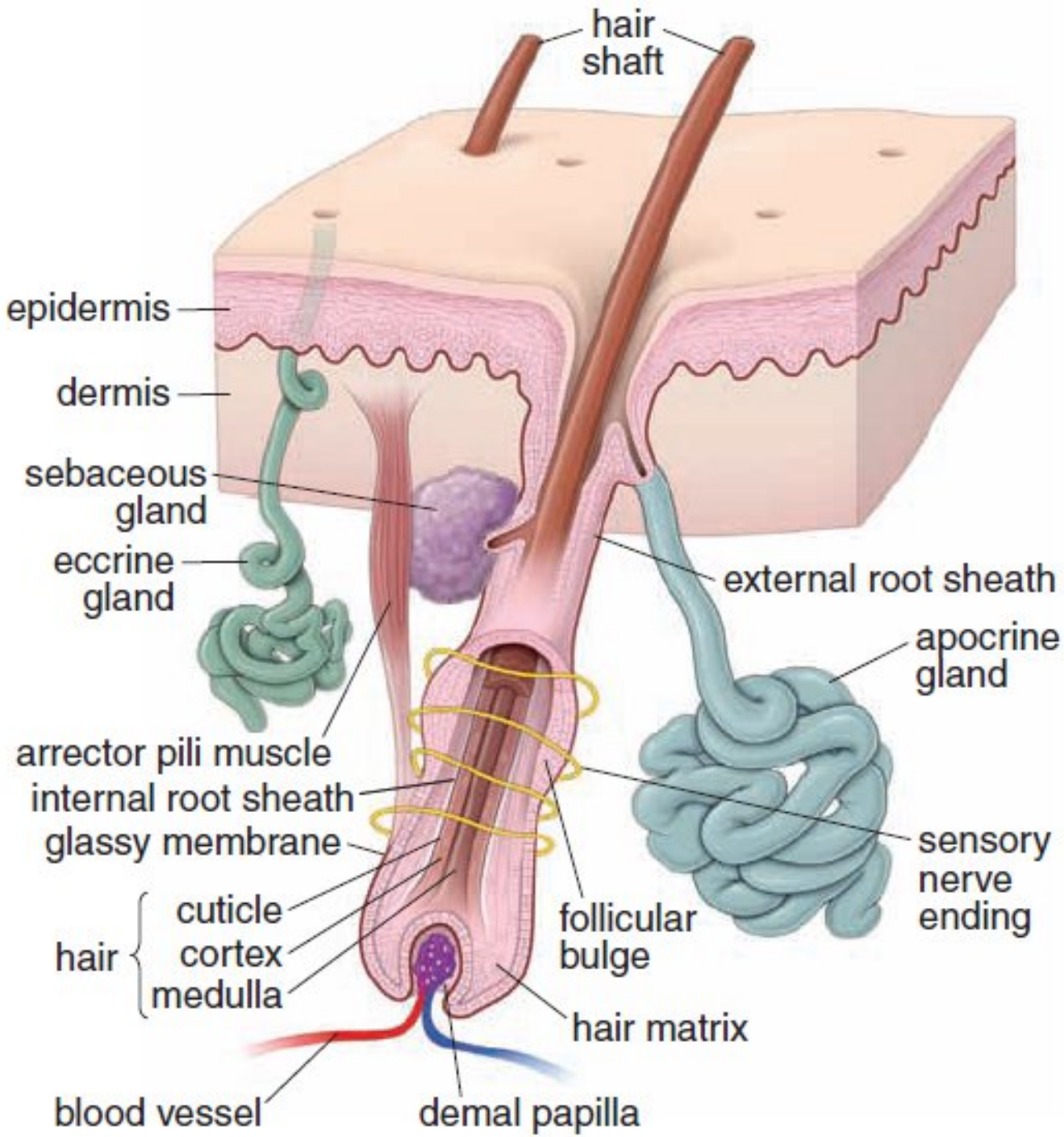
Root & shaft

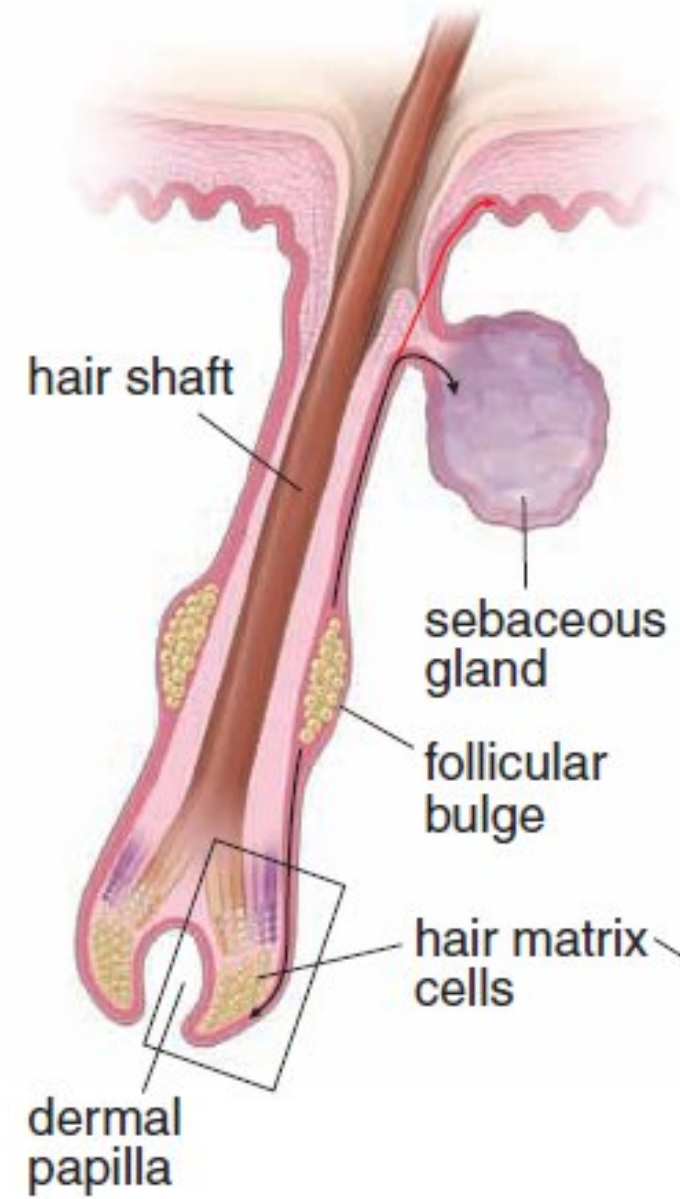
Medulla, cortex, cuticle

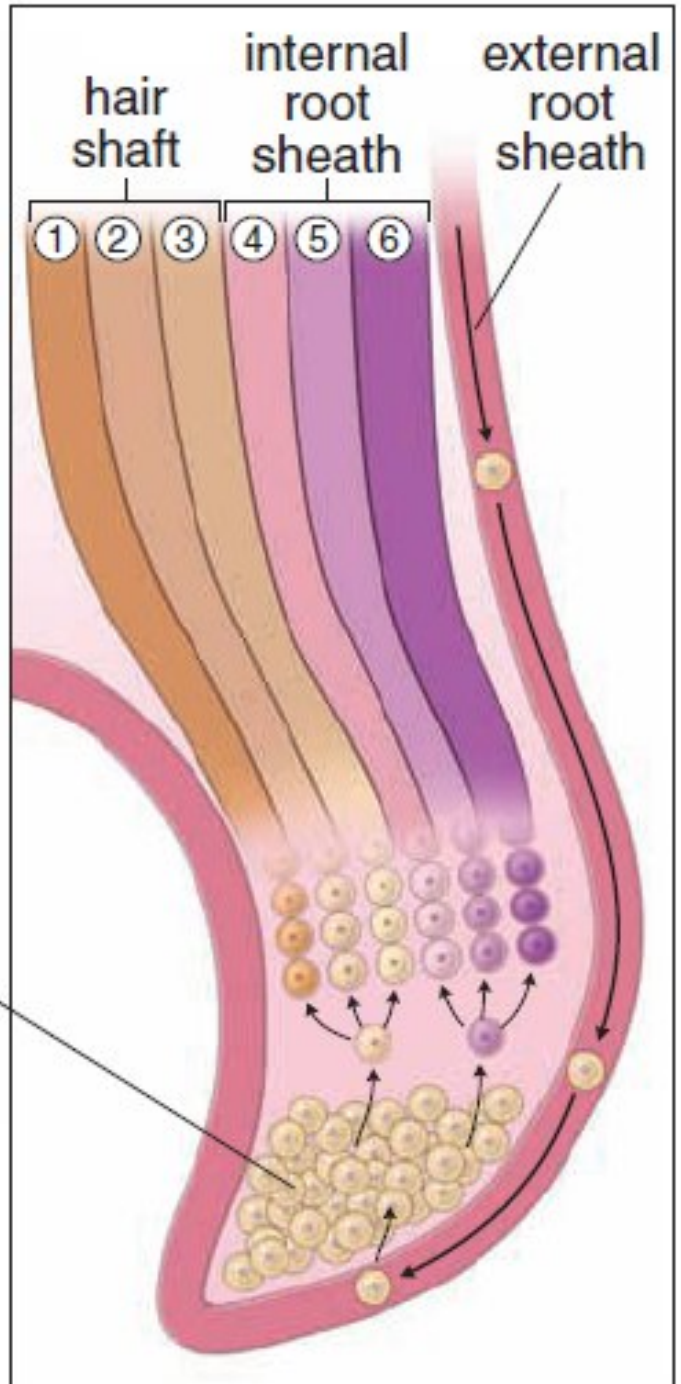
Internal & external root sheath

Glassy membrane

Connective tissue sheath & arrector pili


hair shaft
epidermis
dermis
sebaceous gland
eccrine gland
external root sheath
apocrine gland
arrector pili muscle
internal root sheath
glassy membrane
sensory nerve ending
hair
cuticle
cortex
medulla
follicular bulge
hair matrix
blood vessel
demal papilla


hair shaft
sebaceous gland
follicular bulge
hair matrix cells
dermal papilla


hair shaft
internal root sheath
external root sheath
1
2
3
4
5
6

Nails

Nail root

Nail plate

Cuticle

Nail bed

Nail matrix

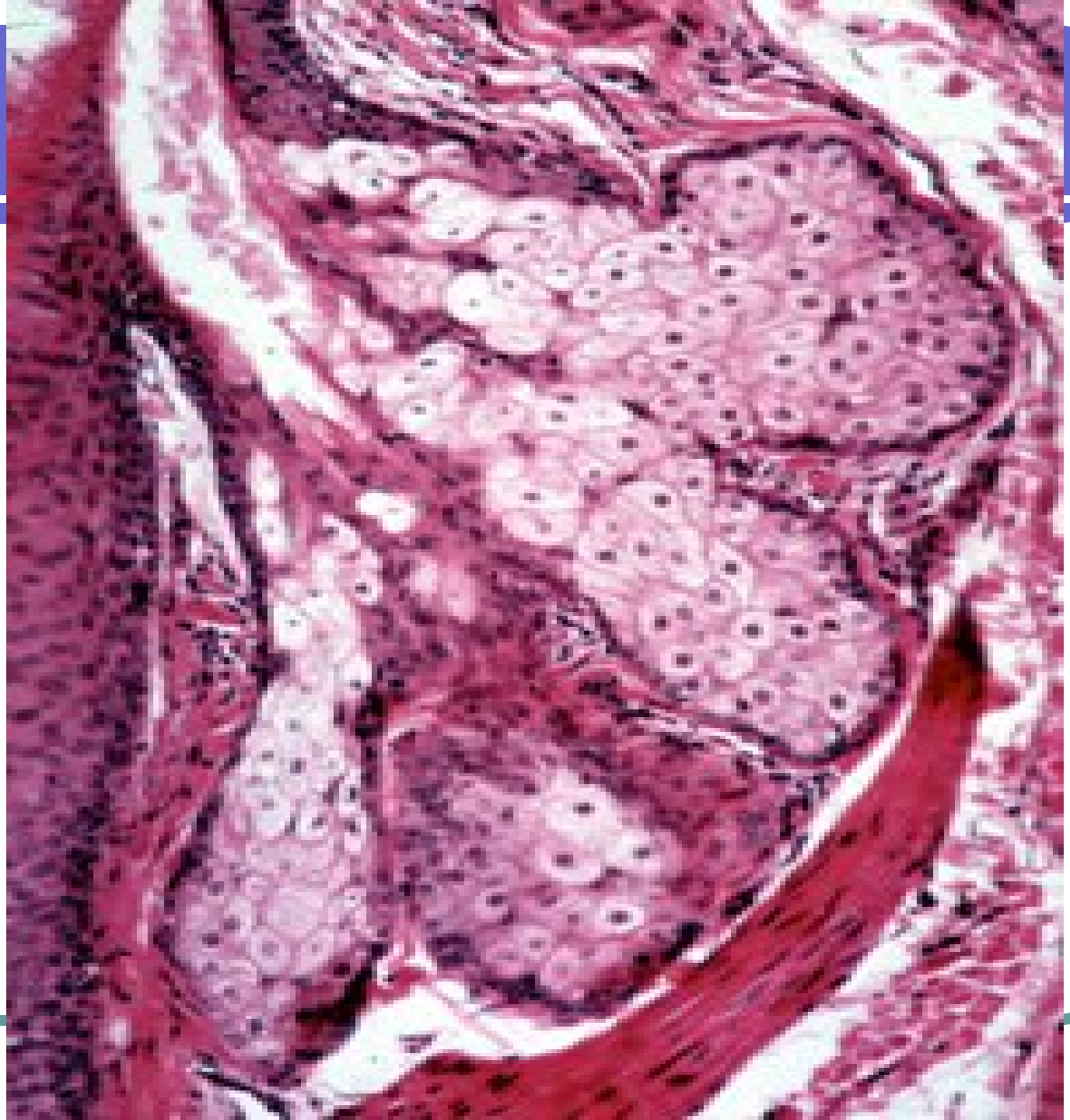
Sebaceous glands

Exceptions: palms & soles

Structure & physiology (Holocrine)

Acne

Antibacterial & antifungal properties



Sweat glands

Exception: glans penis

Simple coiled tubular

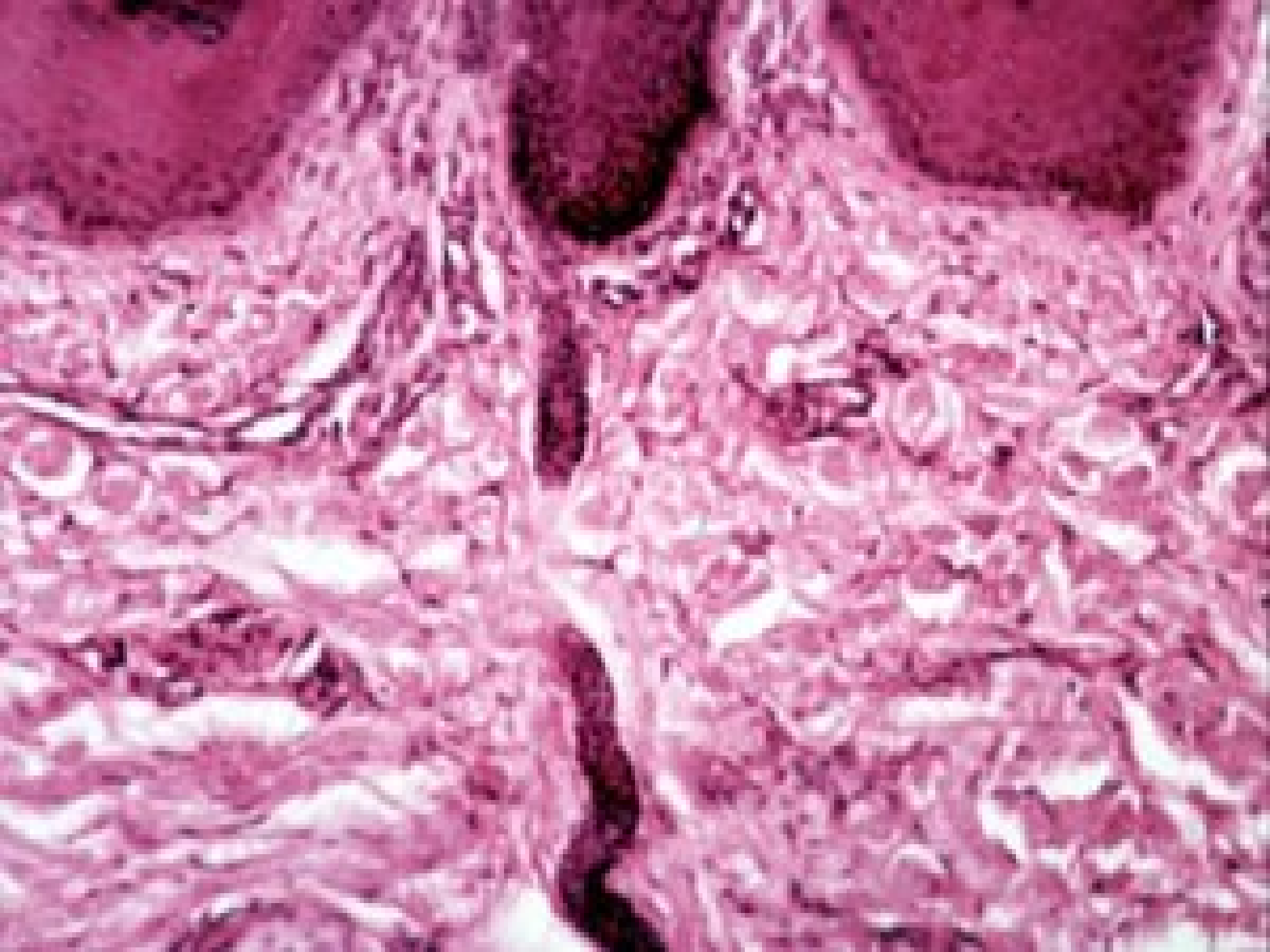
Duct: stratified cuboidal epithelium

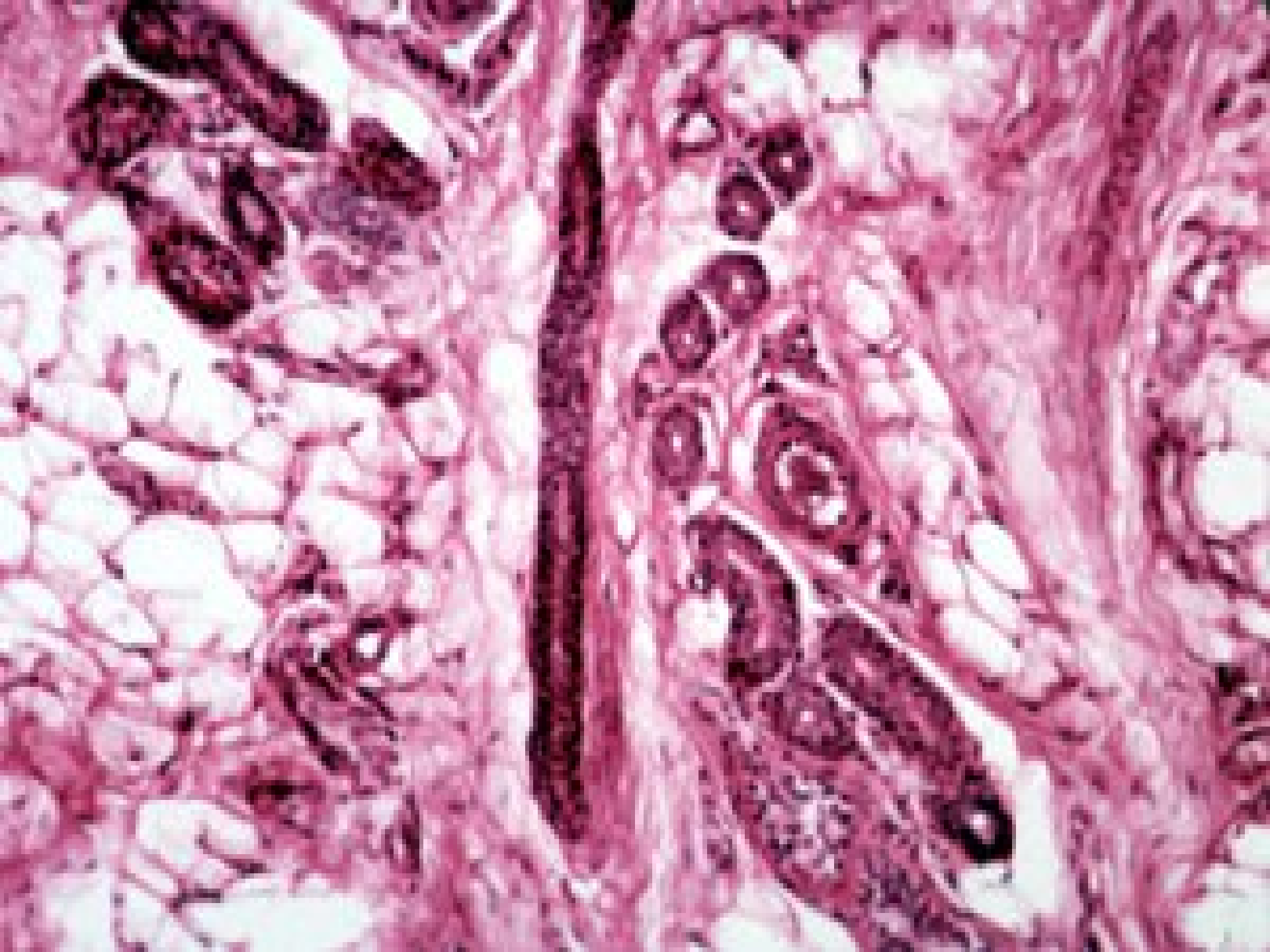
Secretory portion:

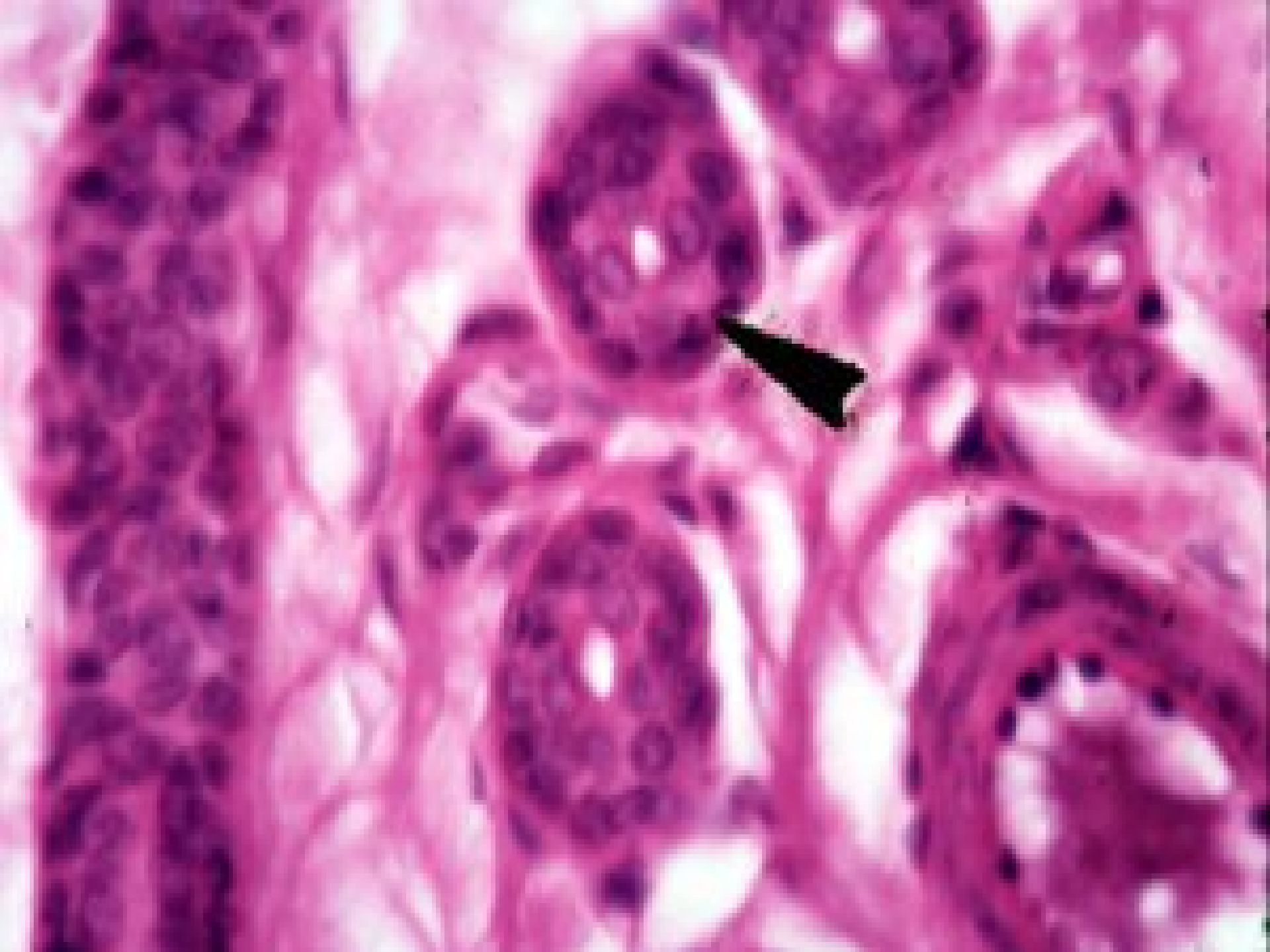
Dark cells: pyramidal, does not touch the basal lamina, glycoprotein secretory granules

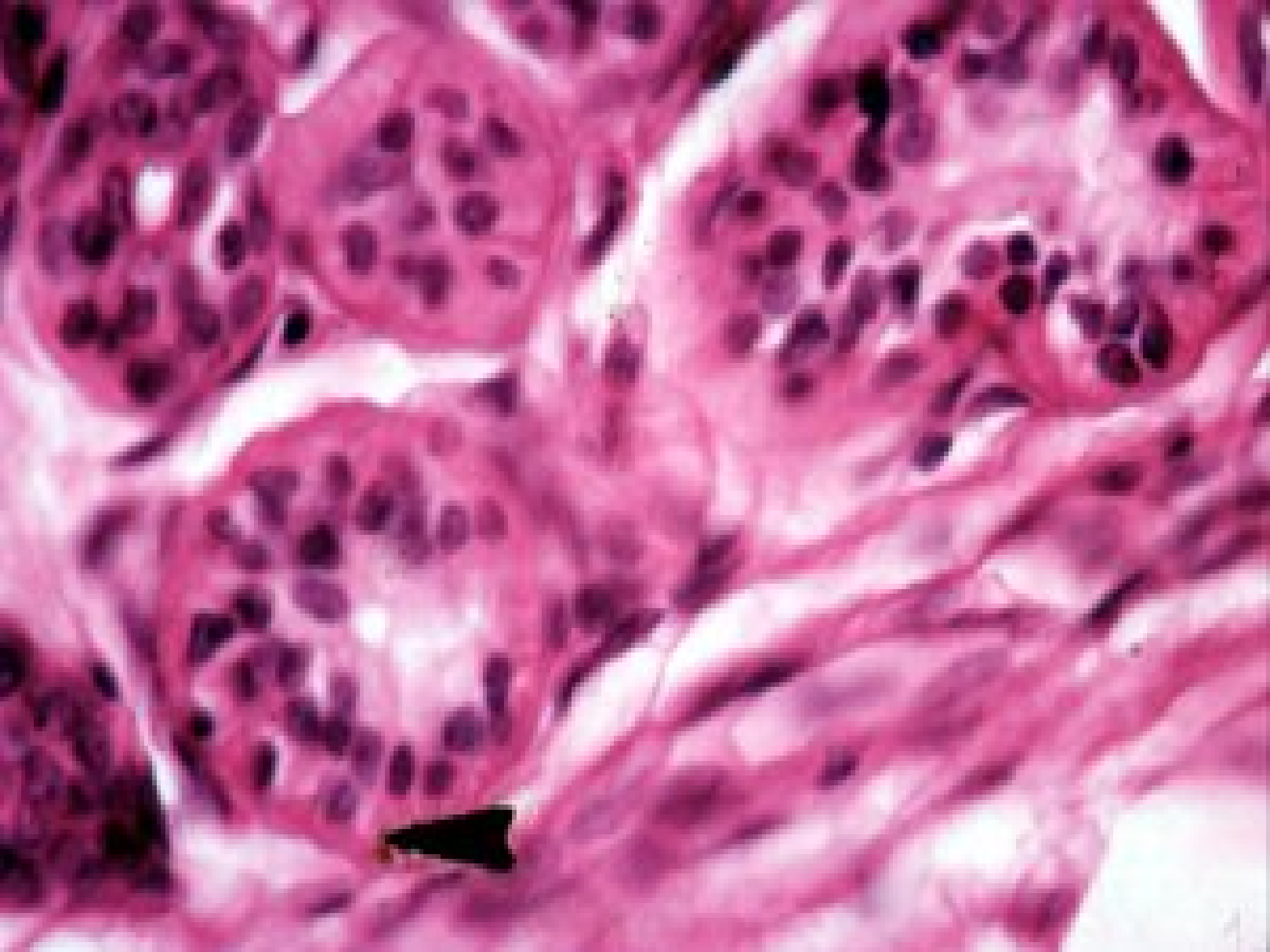
Clear cells: transepithelial salt and fluid transport

Cooling and elimination function









Apocrine glands

Localization

Open into hair follicles

Odor

Innervation