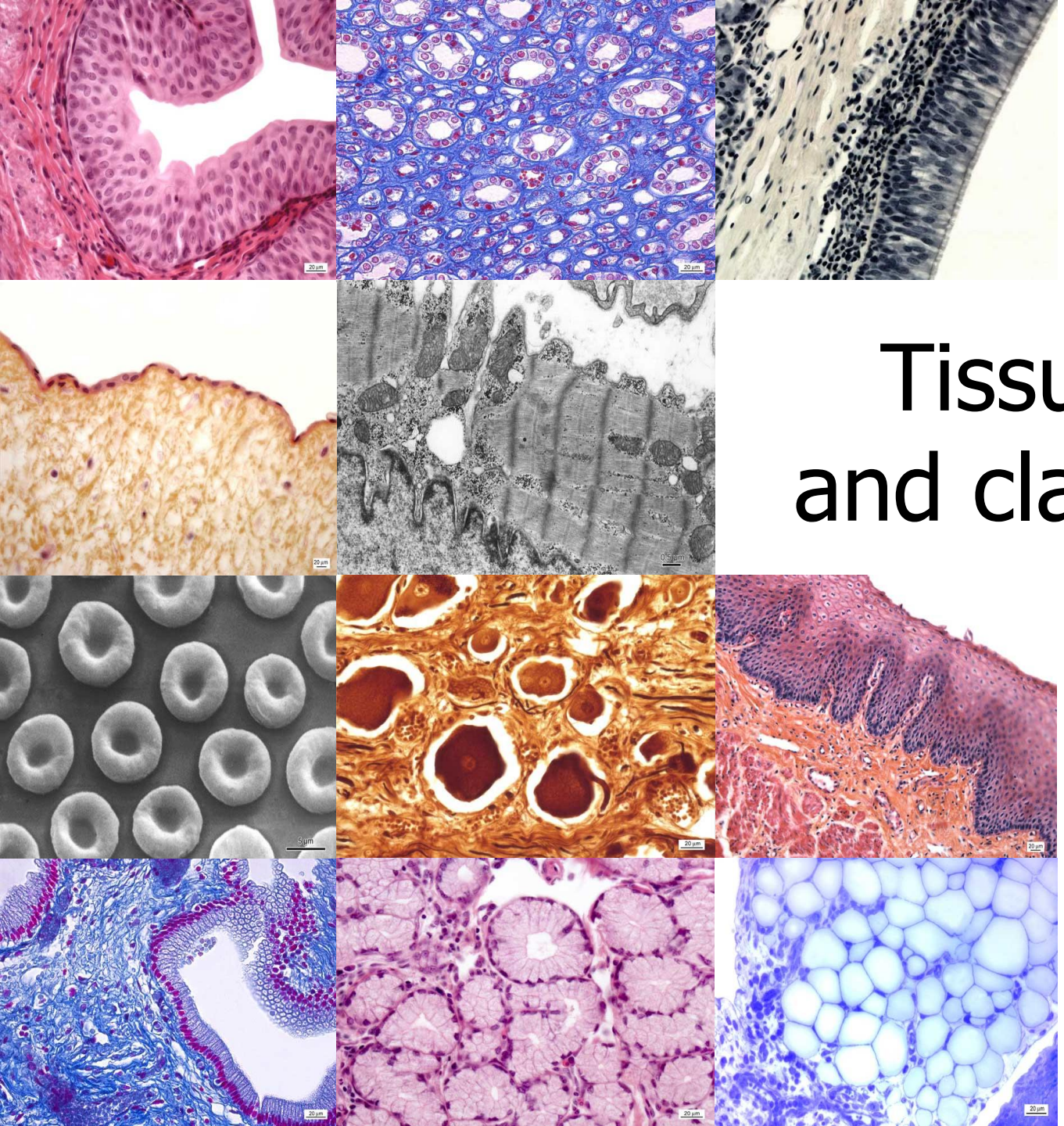


Tissue concept and classification

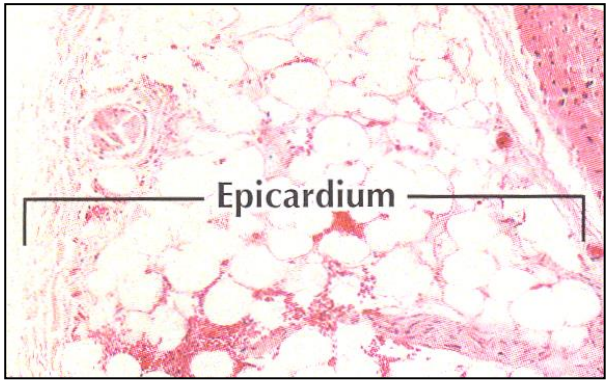
Petr Vaňhara, PhD

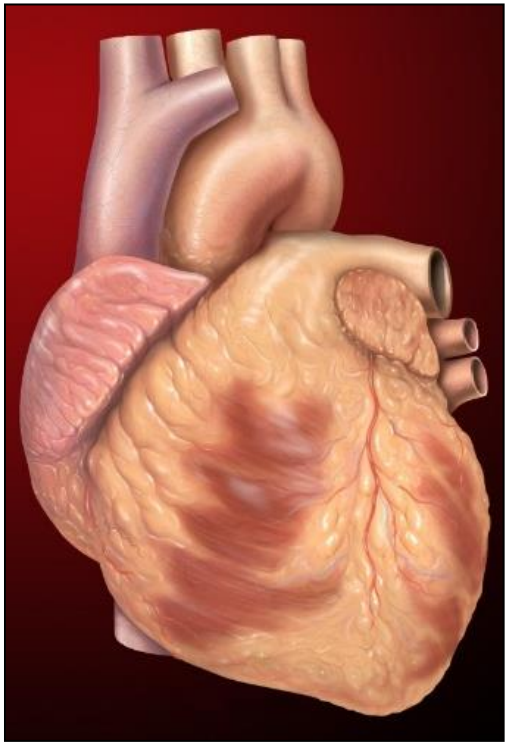
Department of Histology and Embryology,
Faculty of Medicine MU

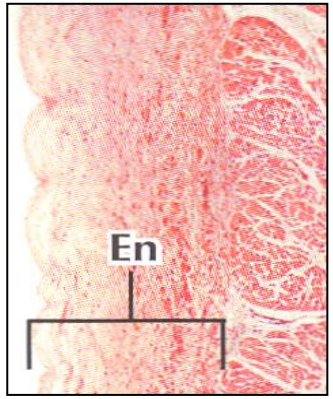
pvanhara@med.muni.cz

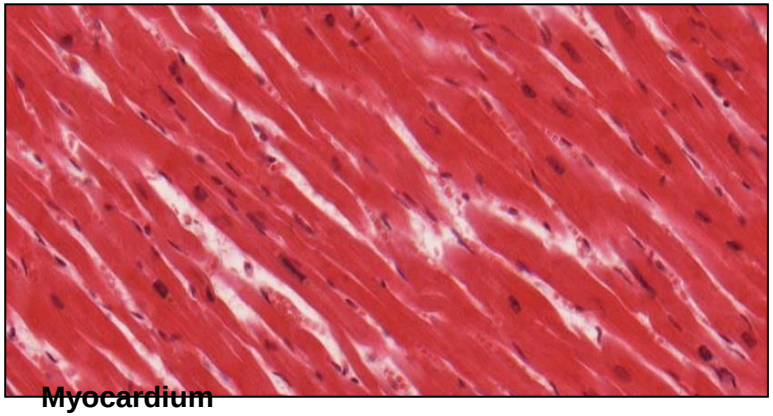
TISSUES AND ORGANS

- **6 × 10^{13} CELLS** of **200** different types
- cells form **functional**, **three-dimensional**, organized **aggregations** of morphologically similar **cells** and their **products** and derivatives - TISSUES
- tissues constitute **ORGANS** and organ systems





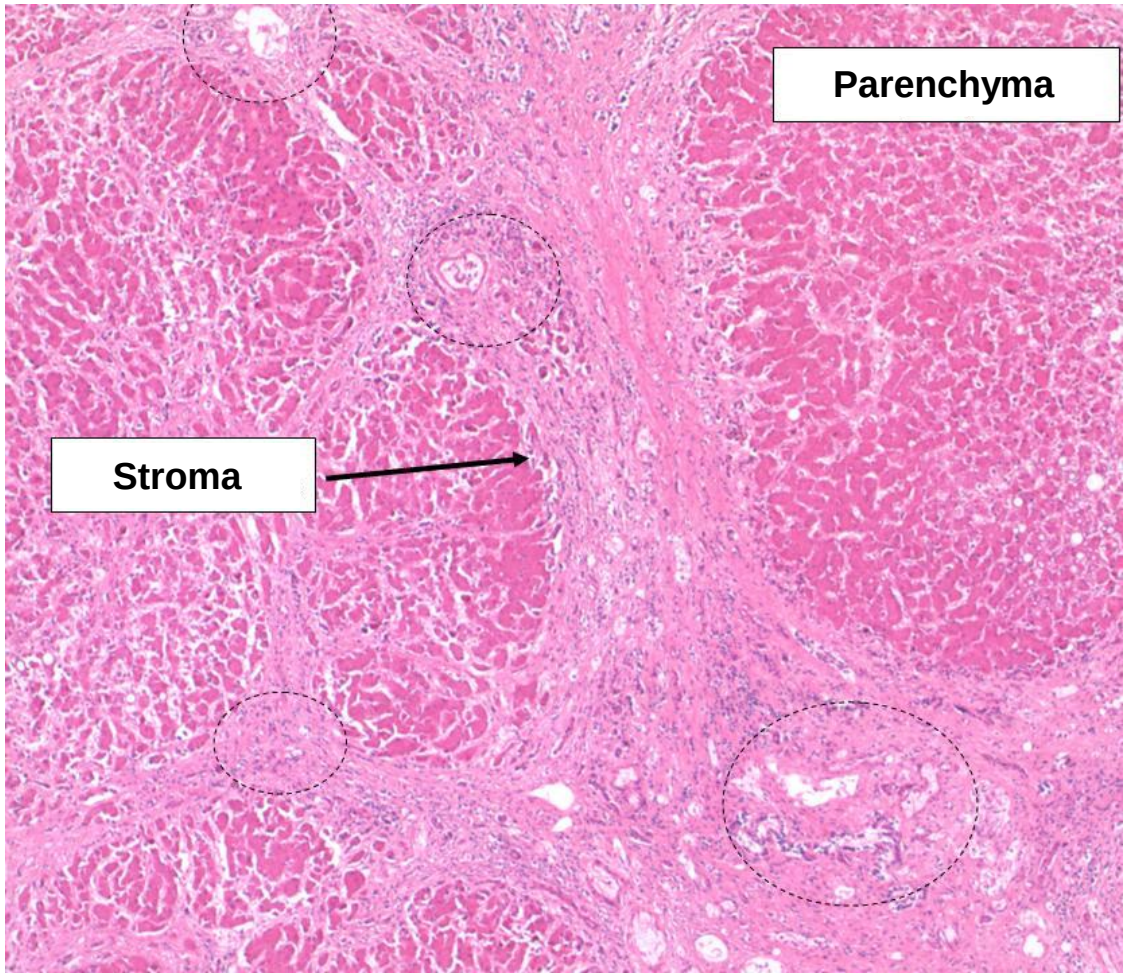




Myocardium

Parenchyma: functional component of a tissue (liver, lung, pancreatic, kidney parenchyma)

Stroma: surrounding, supportive tissue



LIVER

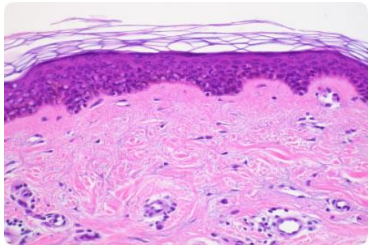
Parenchyma:
- Hepatocytes
- Sinusoids and adjacent structures

Stroma:
- Connective tissue and adjacent structures
- Vessels
- Nerves
- Bile ducts

CONTEMPORARY TISSUE CLASSIFICATION

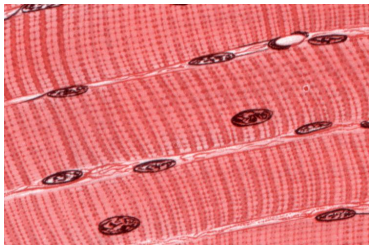
Based on **morphology** and **function**:

Epithelium



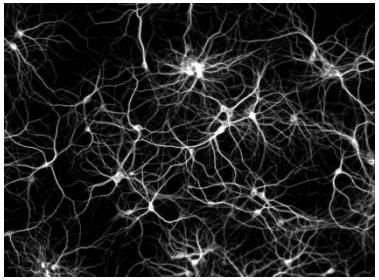
Continual, avascular layers of cells with different function, oriented to open space, with specific junctions and minimum of ECM and intercellular space.
Derivates of all three germ layers

Muscle



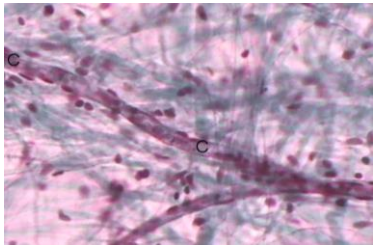
Myofibrils → contraction
Mesoderm – skeletal muscle, myocard, mesenchyme – smooth muscles
Rarely ectoderm (eg. m. sphincter a m. dilatator pupillae)

Nerve

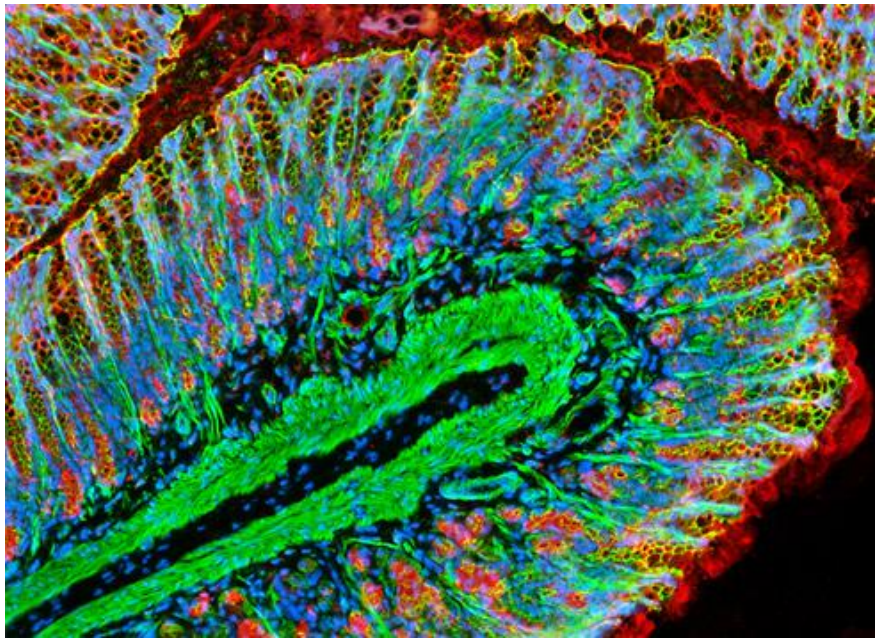


Neurons and neuroglia
Reception and transmission of electric signals
Ectoderm, rarely mesoderm (microglia)

Connective

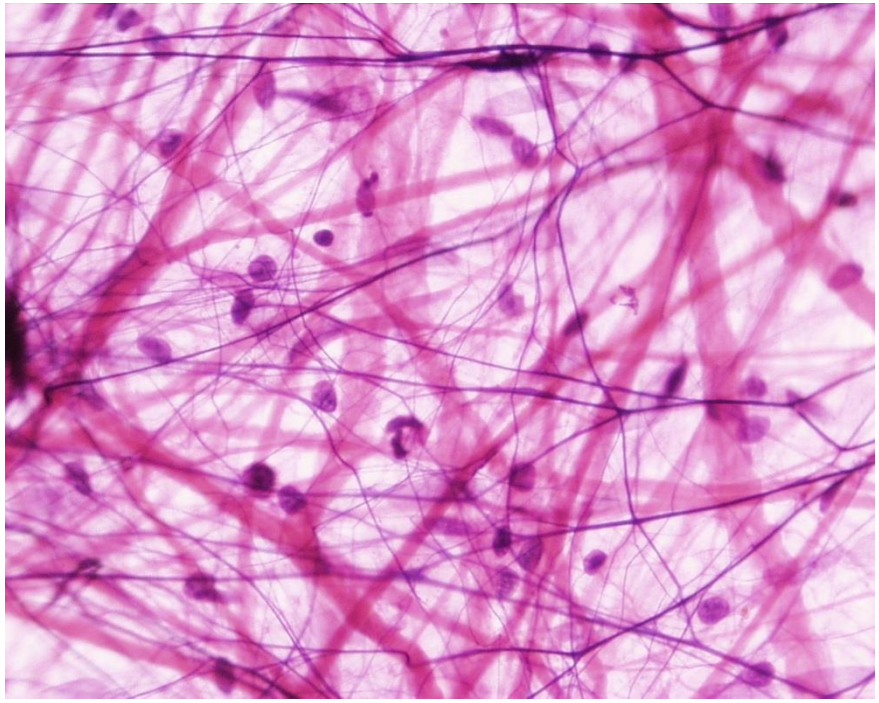


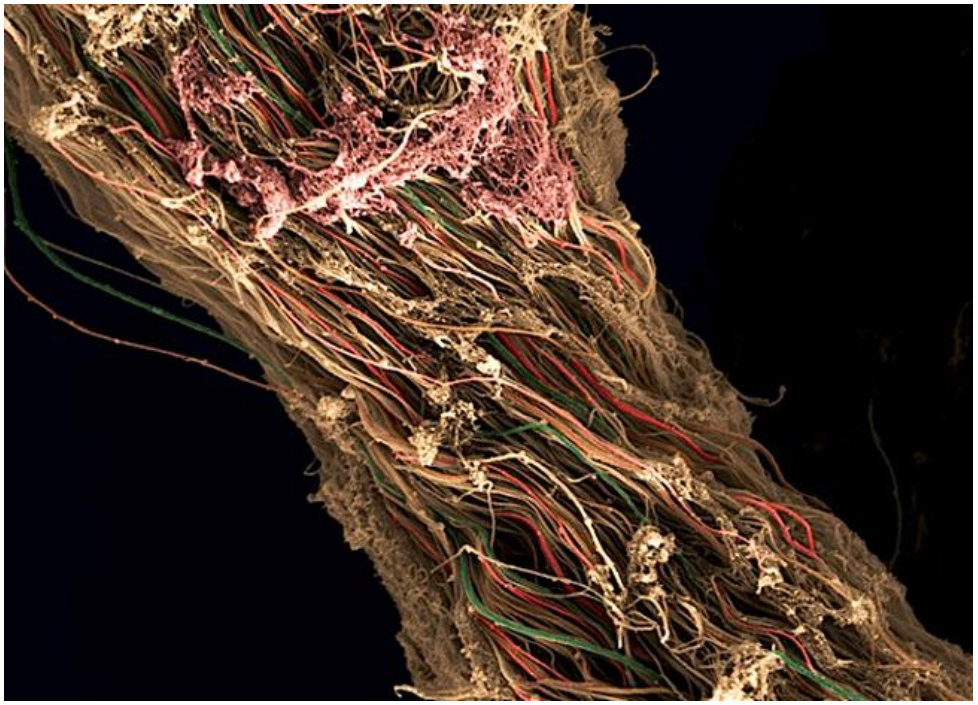
Dominant extracellular matrix
Connective tissue, cartilage, bone…
Mesenchyme



CONNECTIVE TISSUE

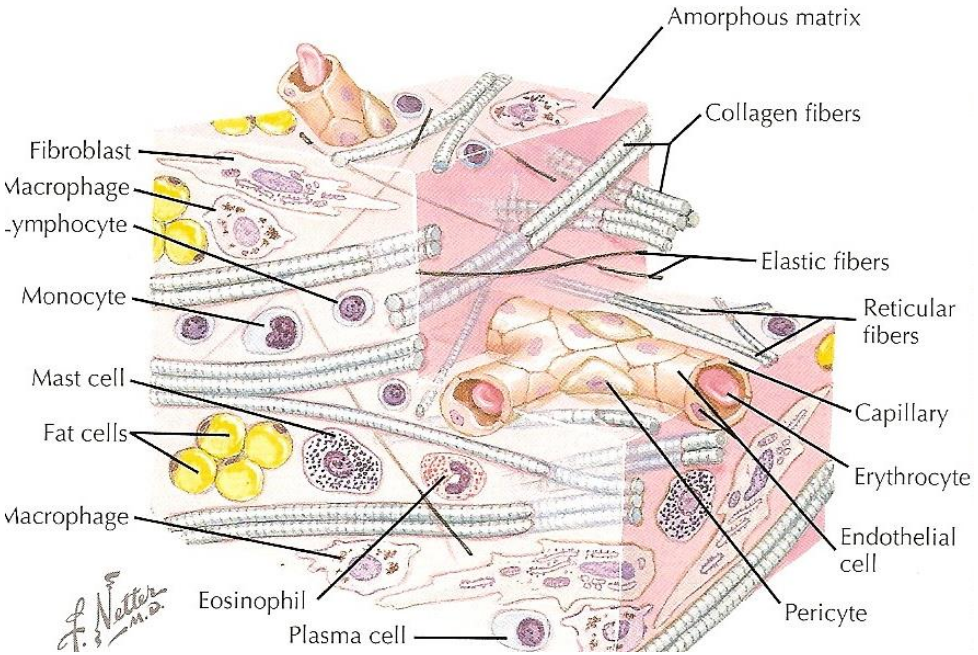
Not just a tissue glue…





Mechanical and biological properties

⟶ surrounds other tissues, allows compartmentalization, provides support, defines physico-chemical environment, brings immunological support, provides storage of energy, ...



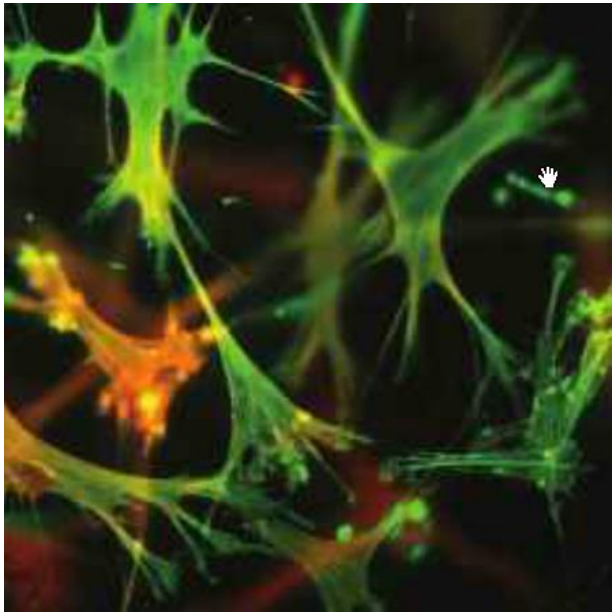
GENERAL COMPOSITION OF CONNECTIVE TISSUE

Cells and extracellular matrix (ECM)

- **Cells**

- **Connective tissue** – permanent and transient cell populations (e.g. fibroblasts/myofibroblasts, immune cells, adipocytes, adult stem cells)
- **Cartilage** – chondroblasts/chondrocytes
- **Bone** – osteoblasts/osteocytes/osteoclasts

- **Matrix** – fibrous and amorphous



- **Fibrous component**
  - collagen
  - reticular
  - elastic

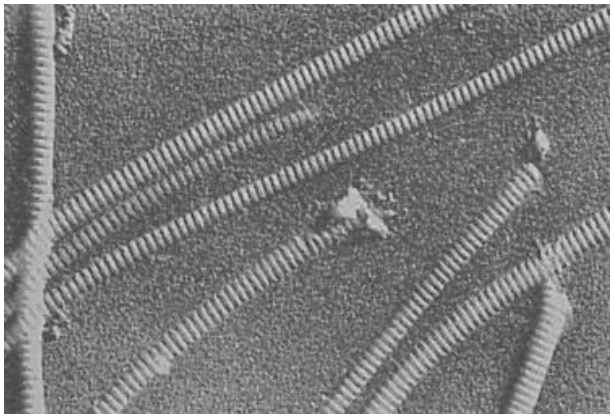
- **Amorphous component** (amorphous ground substance)

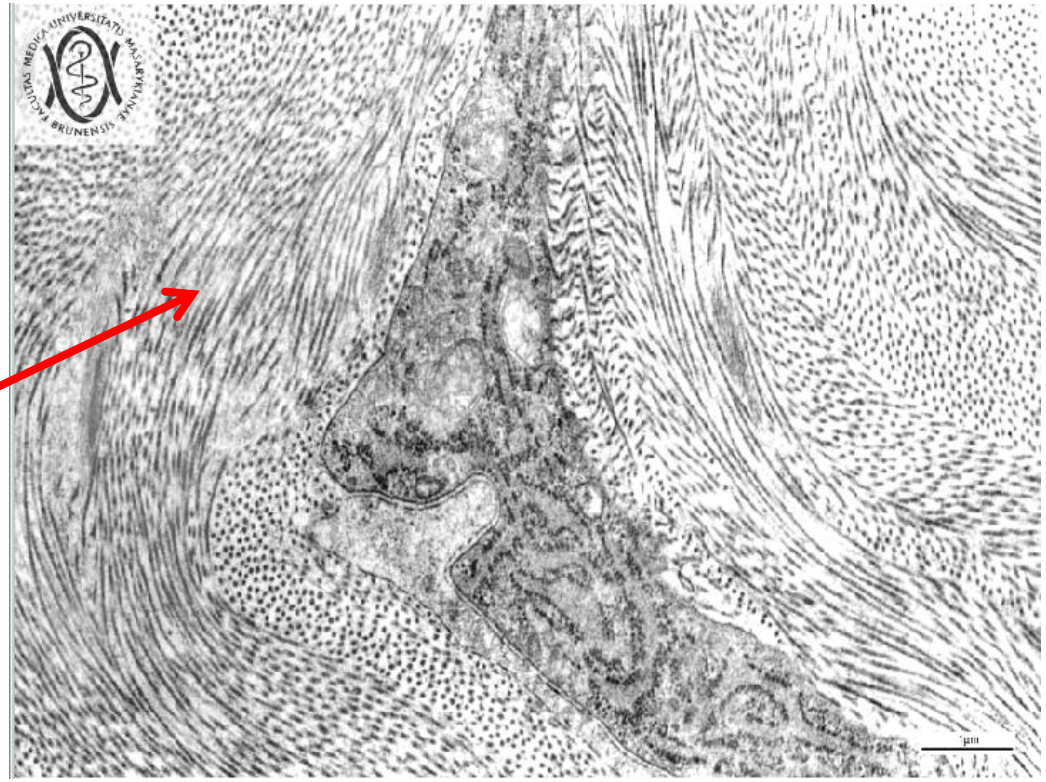
Complex matrix consisting of
- glycosaminoglycans
- glycoproteins
- proteoglycans

composition dependent on tissue type (connective × ligament × cartilage × bone)

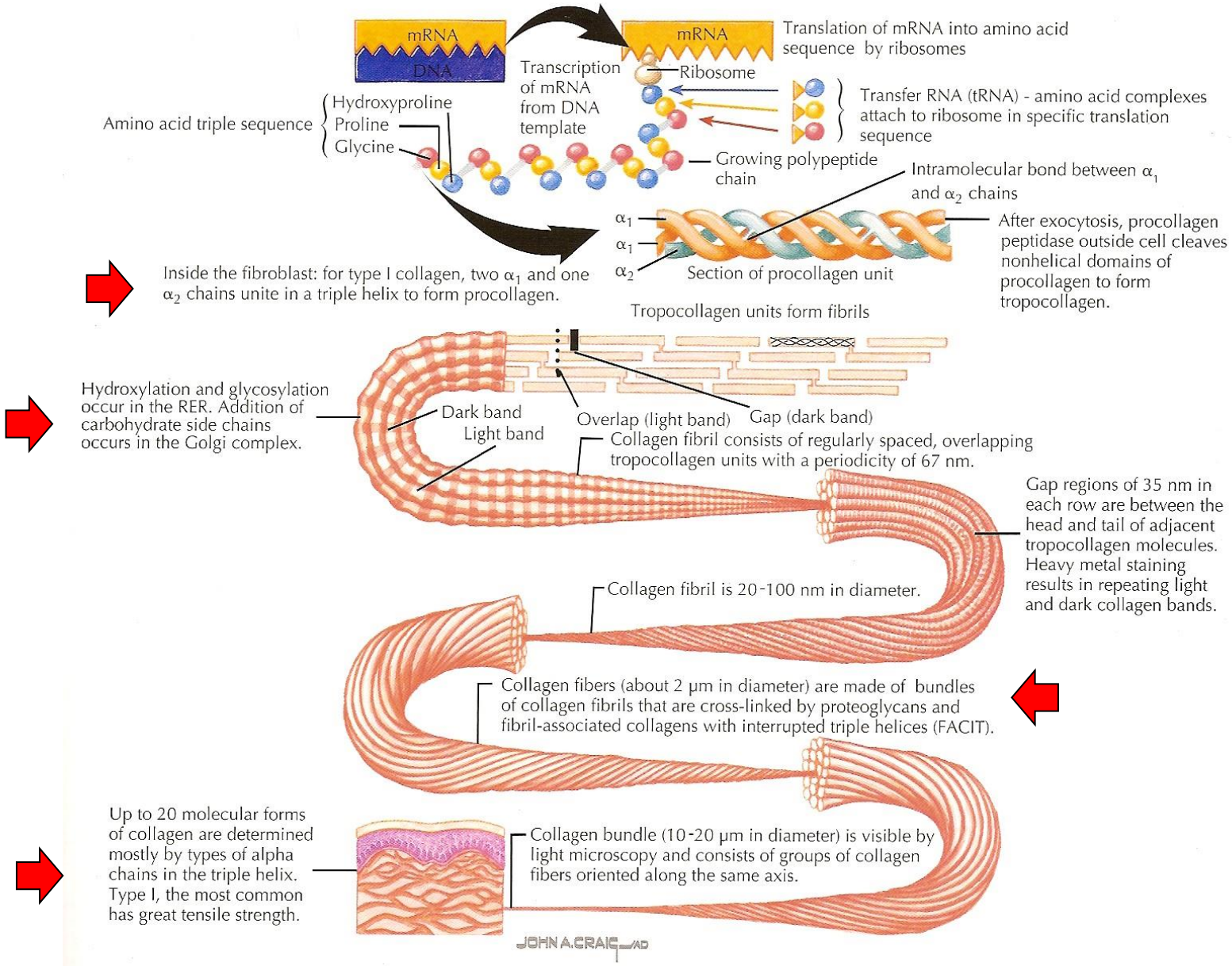
Collagen fibers

- family of fibrous proteins encoded by >35 genes (2013)
- polymer – subunit = tropocollagen; triple helix
- different structural and mechanical properties (strength, elasticity, pliability…)
- most abundant protein in human body (30% dry weight)





COLLAGEN



further study: https://www.ncbi.nlm.nih.gov/books/NBK507709/

COLLAGEN

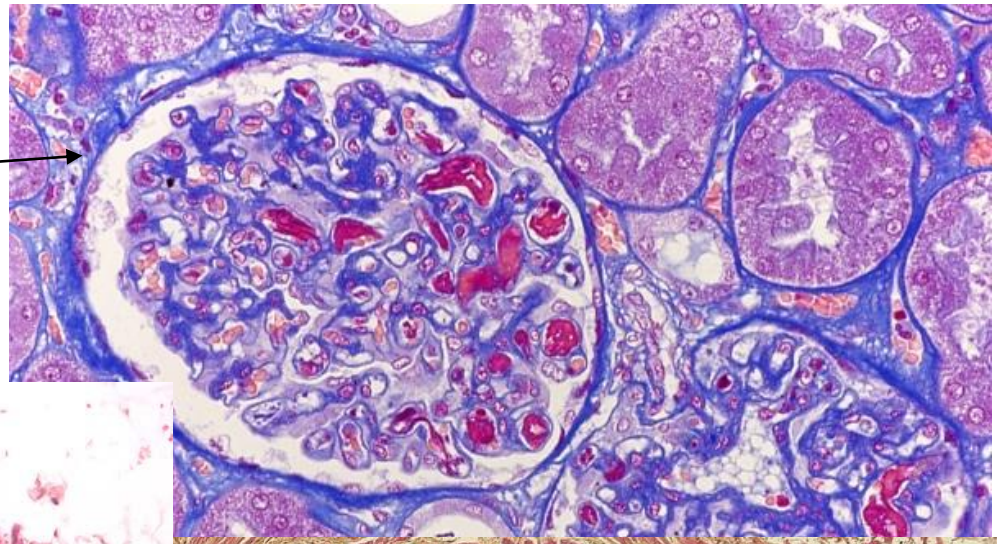
Type	Localization	Structure	Main function
I	Bone, tendons, meniscus, dentin, dermis, capsules of organs, loose CT 90% of type I	Fibrils (75nm) – fibers (1-20μm)	Resilience in pull
II	Hyaline and elastic cartilage	Fibrils (20nm)	Resilience in pressure
III	Skin, veins, smooth muscles, uterus, liver, spleen, kidney, lung	Like I, high content of proteoglycans and glycoprotiens, reticular network	Shape formation
IV	Basal lamina of epithelium and endtohelium, basal membranes	No fibrils or fibers	Mechanical support
V	Lamina of muscle cells and adipocytes, fetal membranes	Like IV	
VI	Interstitial tissue, chondrocytes – adhesion		Connecting dermis and epidermis
VII	Basal membrane of epithelium		
VIII	Some endothelia (Cornea)		
IX, X	Growth plate, hypertrophic and mineralized cartilage		Growth of bones, mineralization

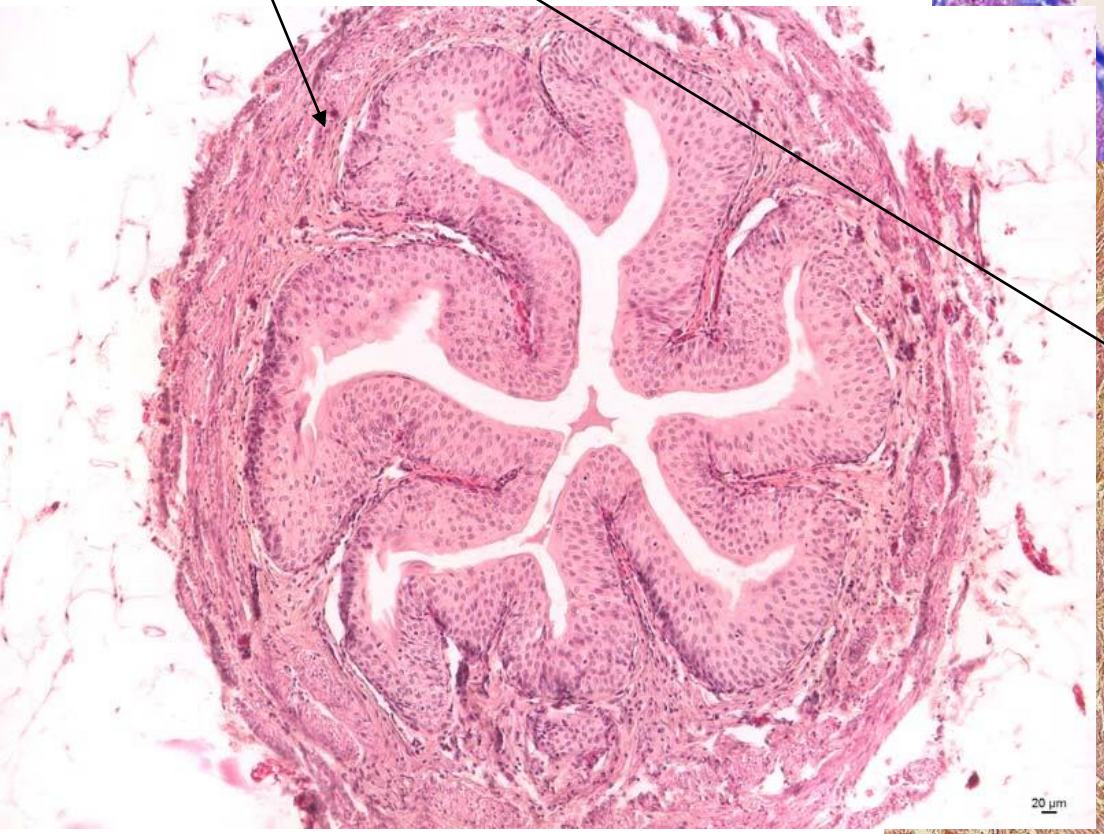
COLLAGEN IN LIGHT MICROSCOPE

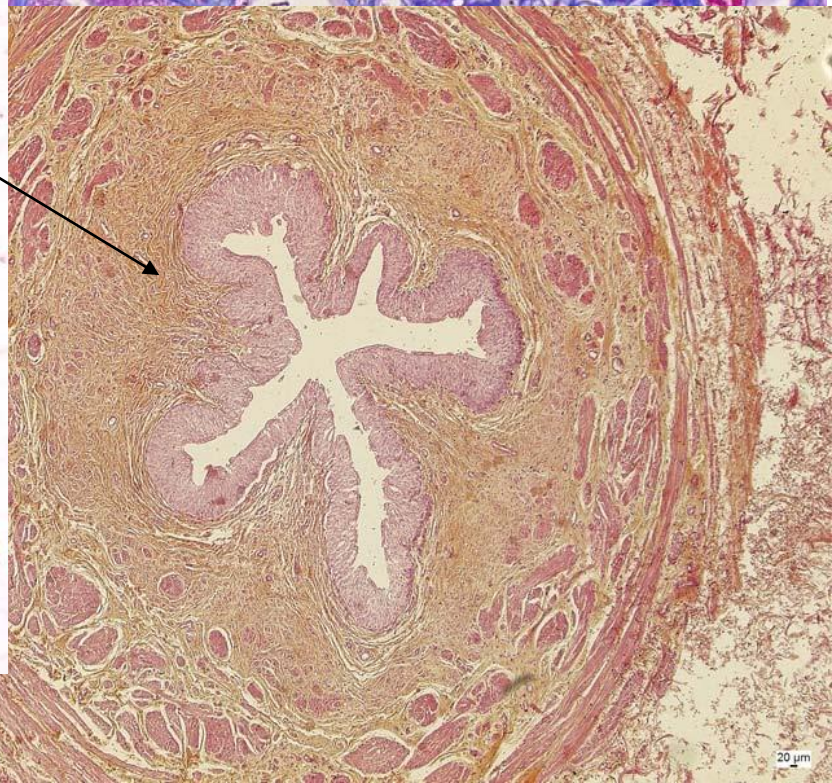
AZAN

HE

HES

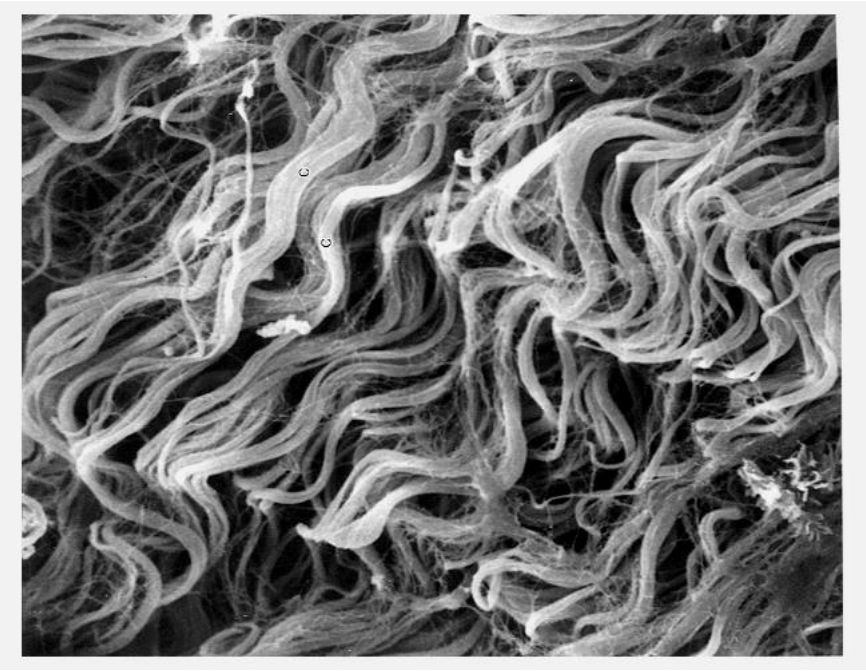


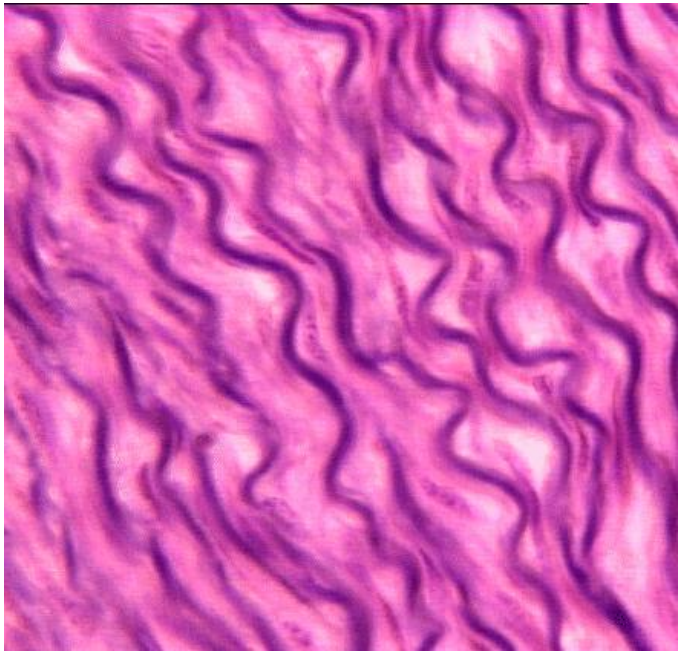




ELASTIC FIBERS

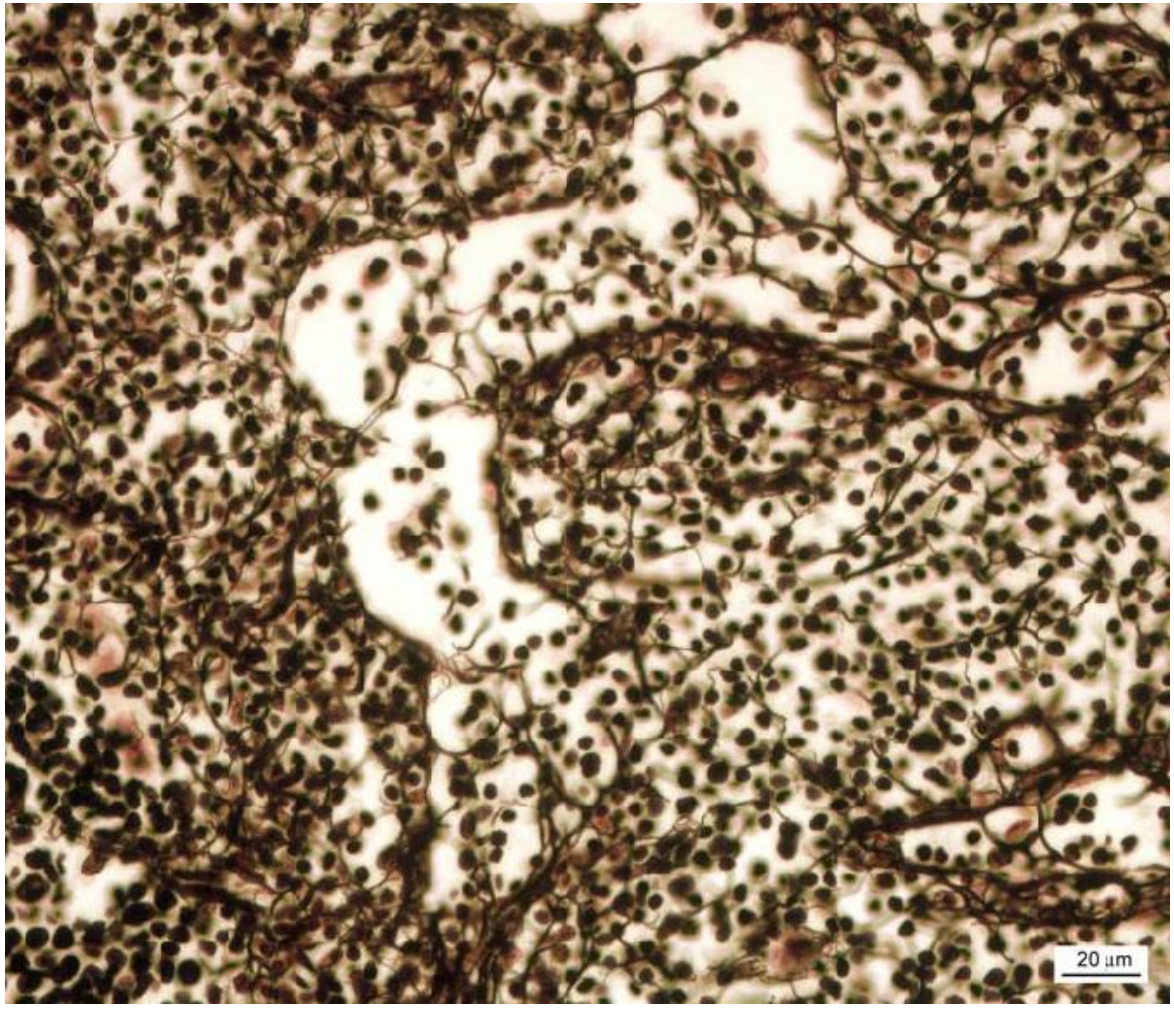
- less abundant than collagen
- polymer – tropoelastin
- minimal tensile resistance, loss of elasticity if overstretched
- reduction of hysteresis = allow return back to original state after mechanic change





RETICULAR FIBERS

- collagen 3D meshwork
- bone marrow, spleen, lymphatic nodules
- microenvironment for e.g. hematopoietic stem cells and progenitors

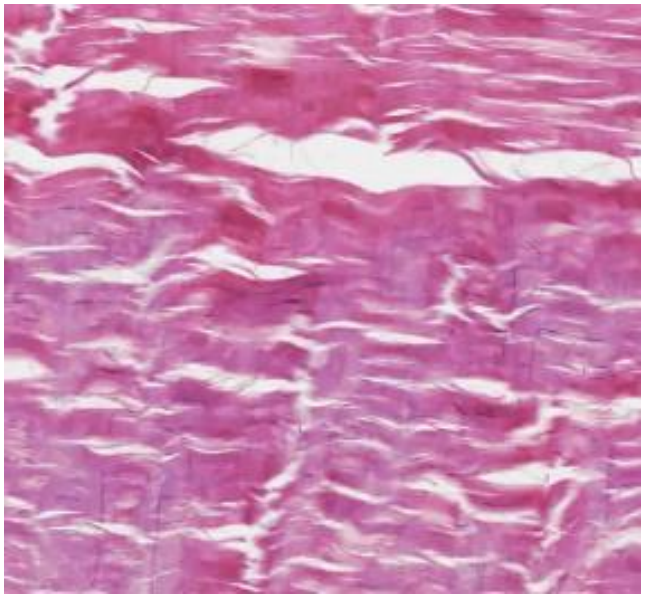


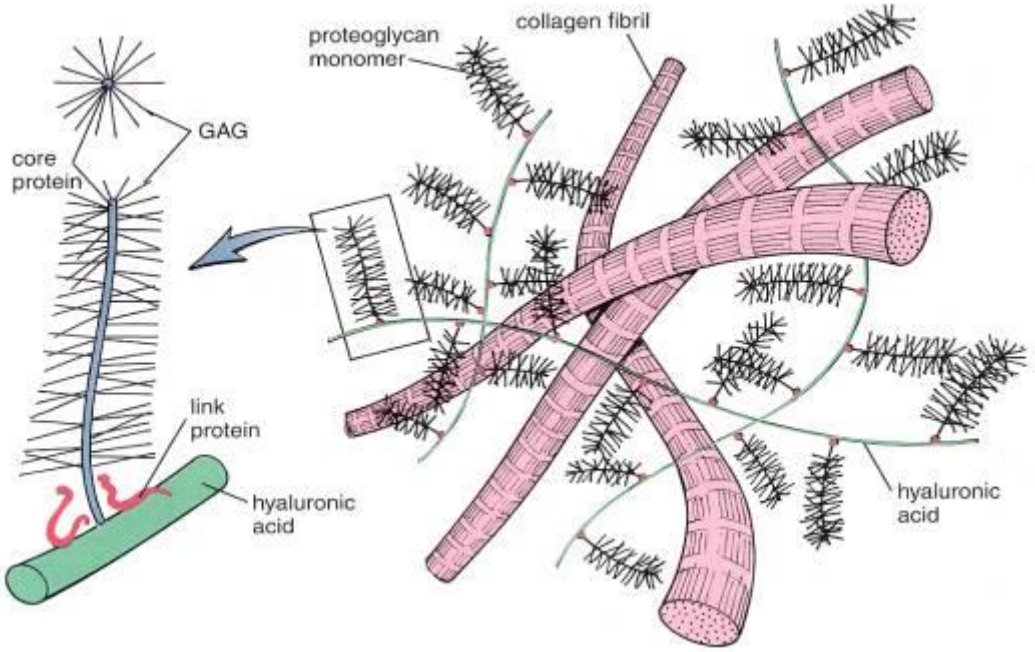
RETICULAR CONNECTIVE TISSUE

EXTRACELLULAR MATRIX – GROUND SUBSTANCE

Amorphous extracellular matrix

Colorless, transparent, homogenous substance consisting of glycosaminglycans, proteoglycans and structural glycoproteins



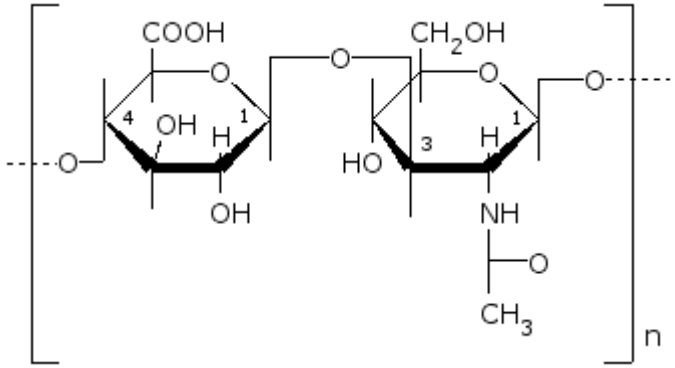


GLYCOSAMINOGLYCANS

linear polysaccharides composed of two disaccharide subunits
– uronic acid and hexosamine

polysaccharides rich in hexosamines = acid mukopolysaccharides

glucuronic or iduronic acid



glucosamin or galactosamin

GLYCOSAMINOGLYCANS

They bind to protein structures (except for hyaluronic acid)

Glycosaminoglycan	Localization
Hyaluronic acid	Umbilical cord, synovial fluid, fluid of corpus vitreum, cartilage
Chondroitinsulphate	Cartilage, bone, cornea, skin, notochord, aorta
Dermatansulphate	Skin, ligaments, adventitia of aorta
Heparansulphate	Aorta, lungs, liver, basal membranes
Keratansulphate	Iris, cartilage, nucleus pulposus, anulus fibrosus

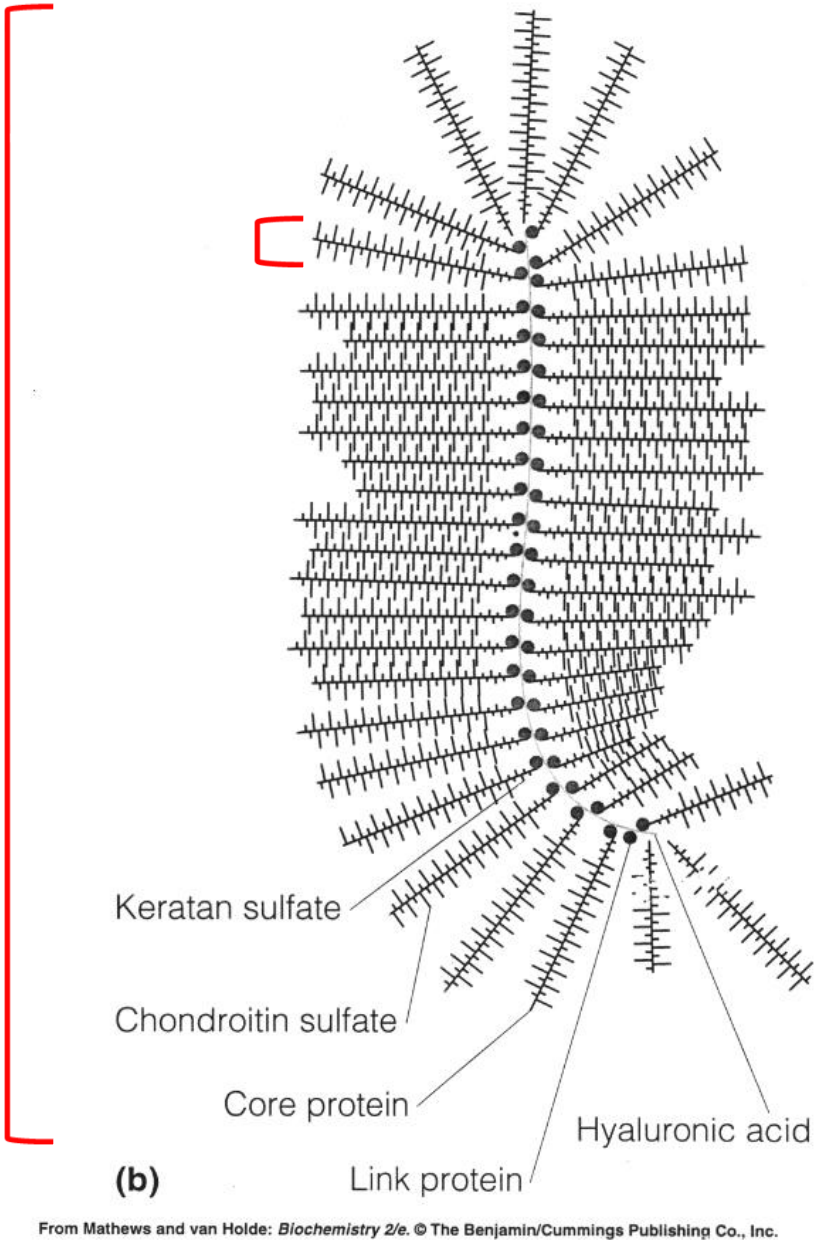
PROTEOGLYCANS

— protein + dominant linear saccharide component

— proteoglycan aggregates

— water-binding, volume dependent of hydratation

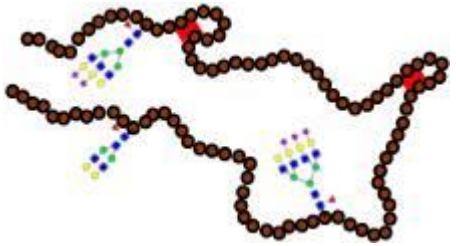
— aggrecan (cartilage)
— syndecan
— fibroglycan



From Mathews and van Holde: *Biochemistry 2/e.* © The Benjamin/Cummings Publishing Co., Inc.

STRUCTURAL GLYCOPROTEINS

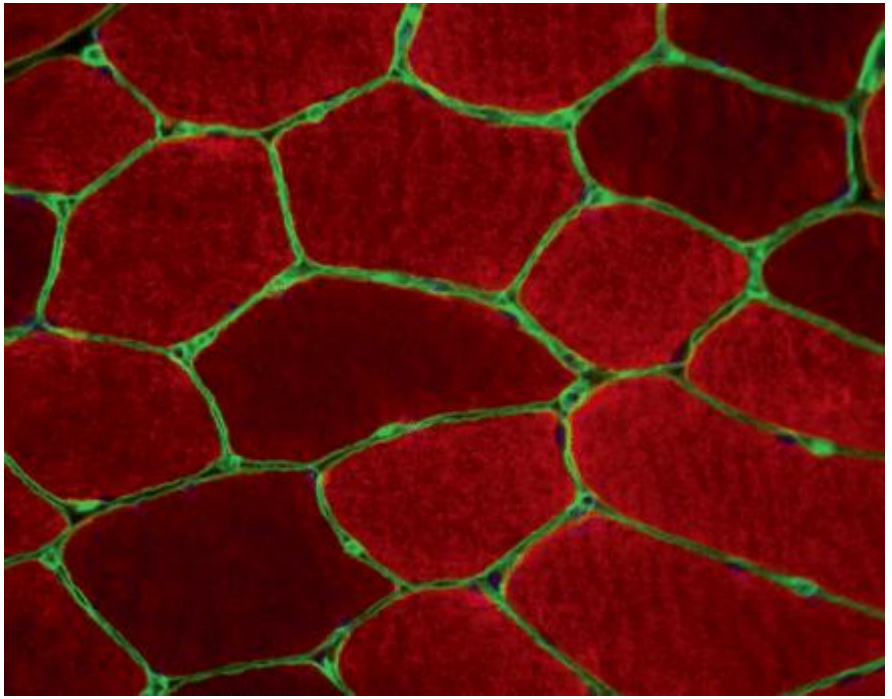
- dominant protein + branched saccharide component
- interaction between cells and ECM



— **fibronectin** – connects collagen fibers and glykosaminoglycans, cell adhesion and migration

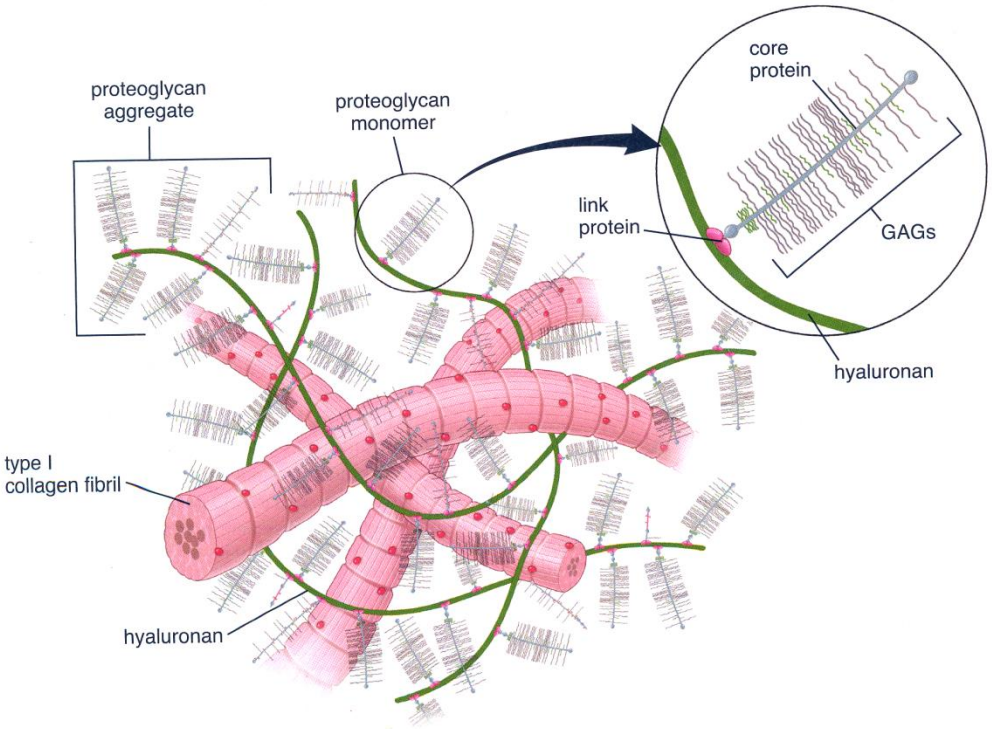
— **laminin** – basal lamina – epithelial integrity

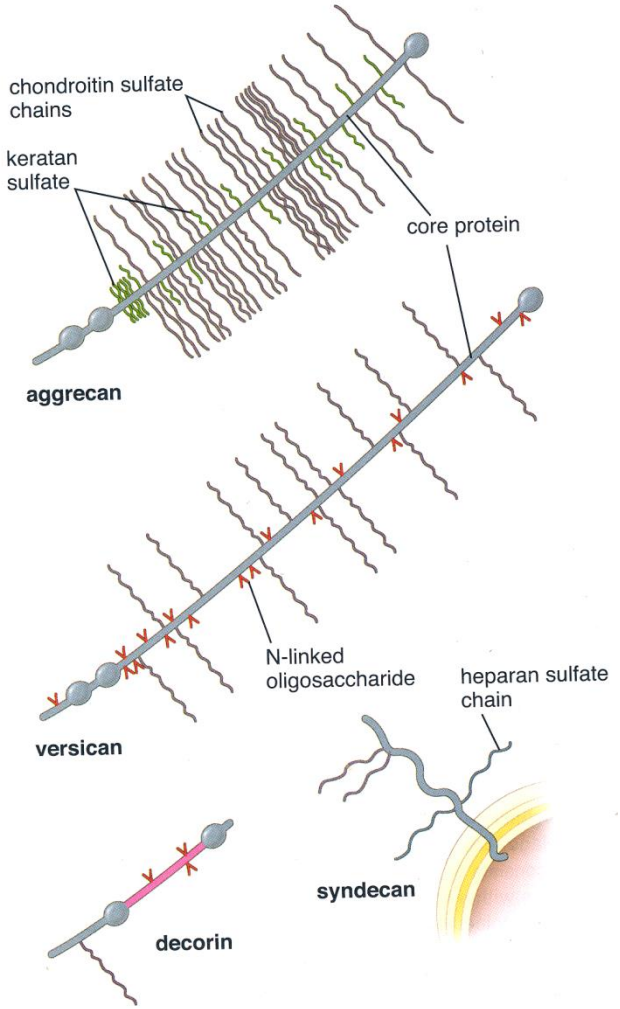
— **chondronectin** – cartilage – adhesion of chondrocytes to collagen



(J. Nutr. 136:2123-2126, 2006)

COMPOSITION OF ECM





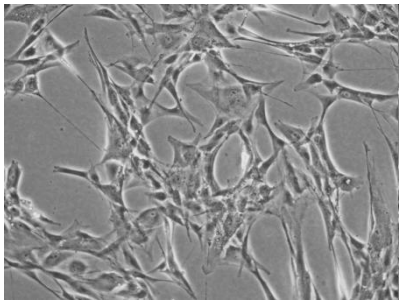
CLASSSIFICATION OF CONNECTIVE TISSUE

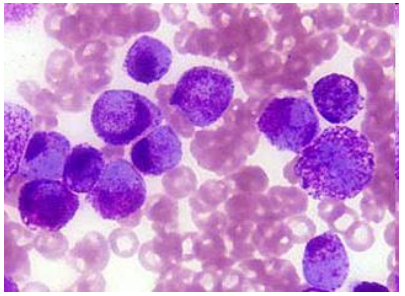
Collagen	**Structure**	**Function and distribution**
Loose collagen CT	Abundant ground substance, few collagen fibers with random arrangement	Microvascularisation Innervation
Irregular dense collagen CT	Few ground substance, few cells, many collagen fibers, random arrangement	Mechanically resistant organ capsules
Regular dense collagen CT	Tightly arranged collagen fibers with fibroblasts intercalated between them	Part of musculoskeletal system. Tendons, ligaments
Embryonic		
Mesenchyme	Undifferentiated cells uniformly dispersed in the ground substance, few collagen fibers	Undifferentiated progenitors
Wharton's jelly	Viscous amorphous matrix with collagen fibers. Fibroblasts.	Matrix of umbilical cord
Special		
Reticular CT	Network of collagen III fibers and reticular cells	Support of hematopoietic and lymphatic cells
Elastic	Rich in elastic fibers	Flexible support to the elastic arteries and aorta
Adipose	Adipocytes	Energy storage (white fat), heat production (brown fat)
Cartilage	Chondroblasts, chondrocytes	Mechanical support
Bone	Osteoblasts, ostecoytes, osteoclasts	Mechanical support, calcium and phospate metabolism
Blood	See lecture on blood & hematopoiesis this semester	

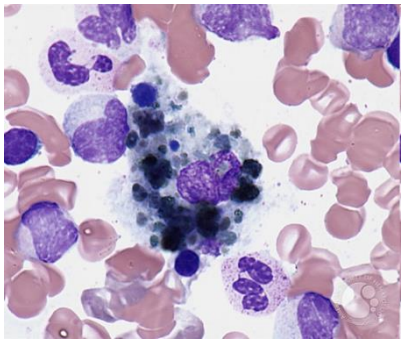
LOOSE COLLAGEN CONNECTIVE TISSUE

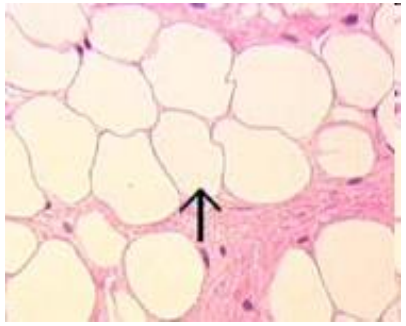
Cells

- Fibroblasts/fibrocytes/myofibroblasts
- Heparinocytes
- Macrophages of CT = histiocytes
- Plasma cells
- Lymphocytes
- Adipocytes
- Adult stem cells



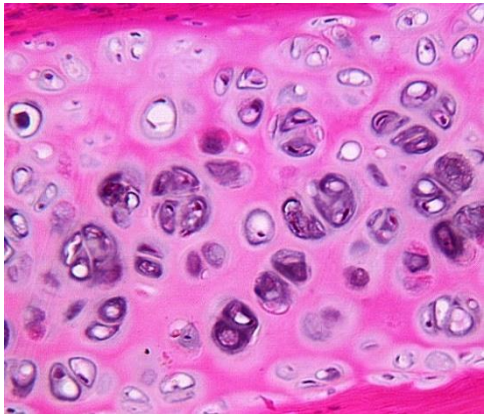


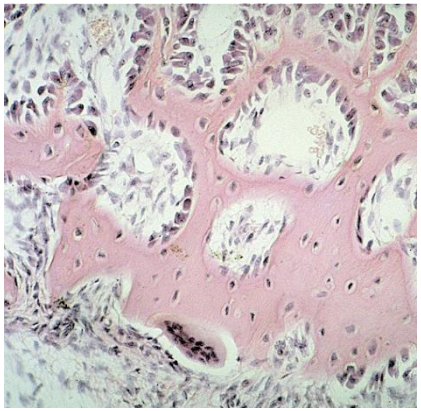


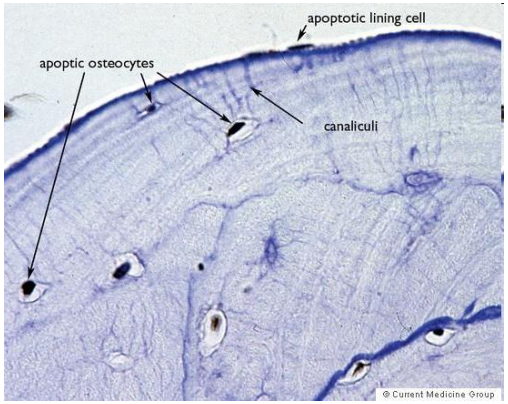


Extracellular matrix

- Fibrous compound
- Amorphous ground substance

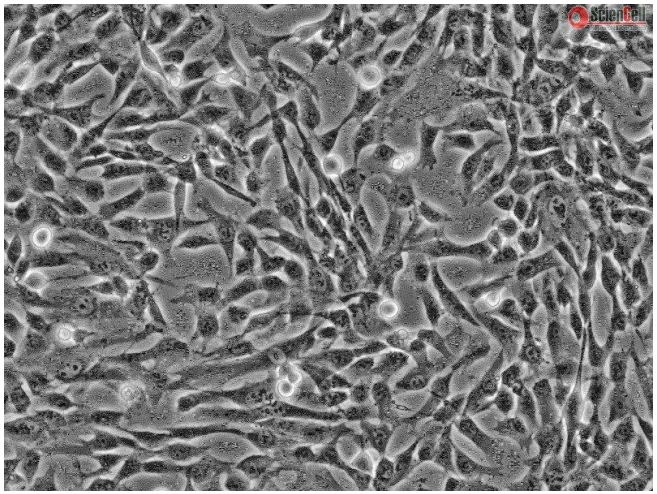


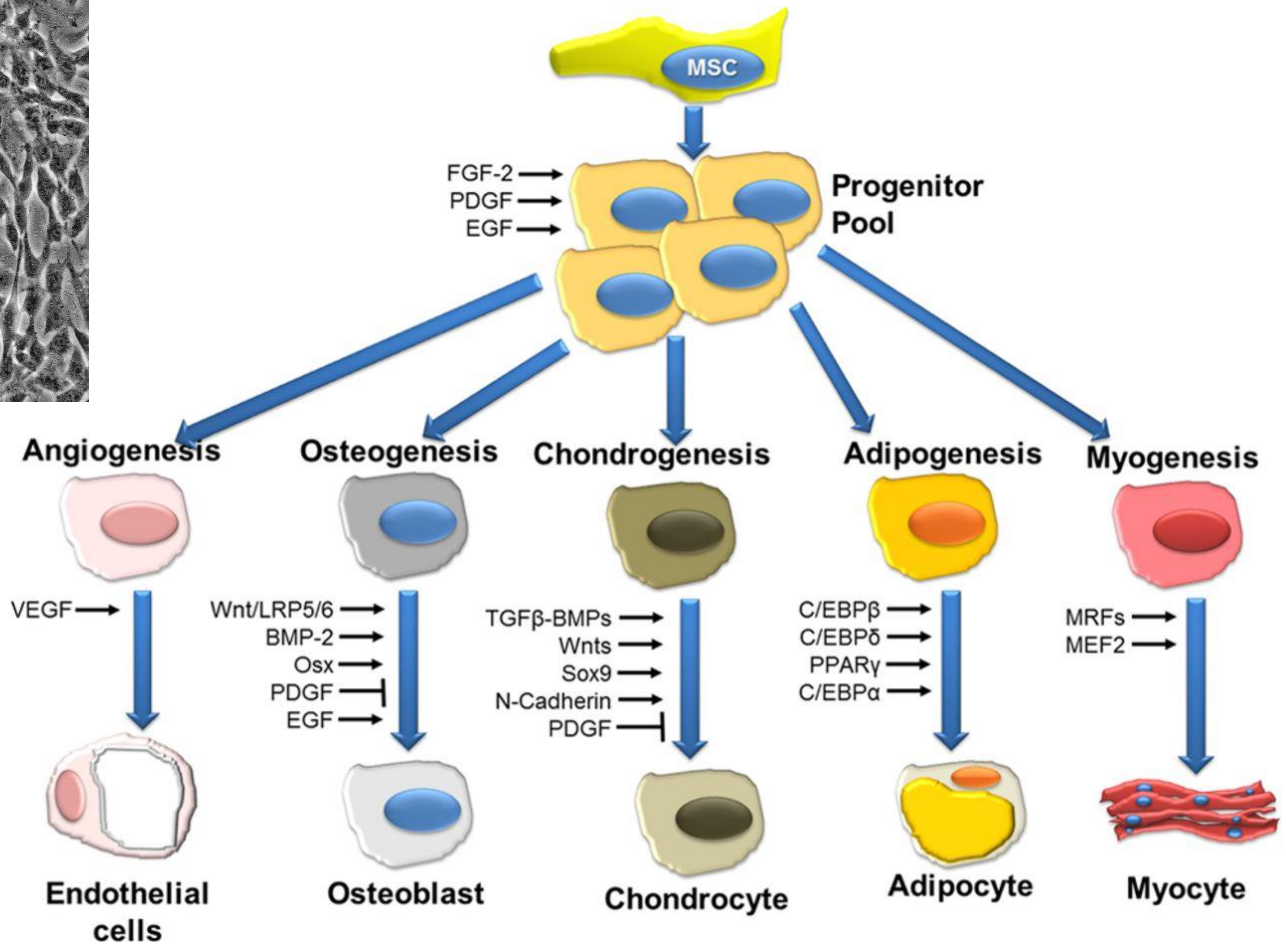




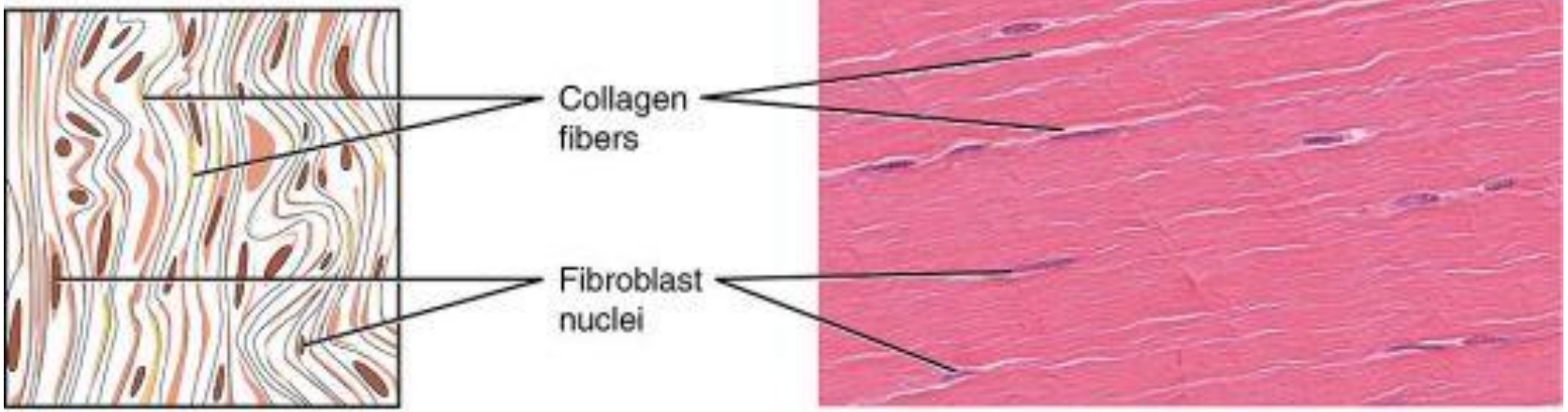
CELLS OF LOOSE COLLAGEN CONNECTIVE TISSUE

Mesenchymal (adult) stem cells

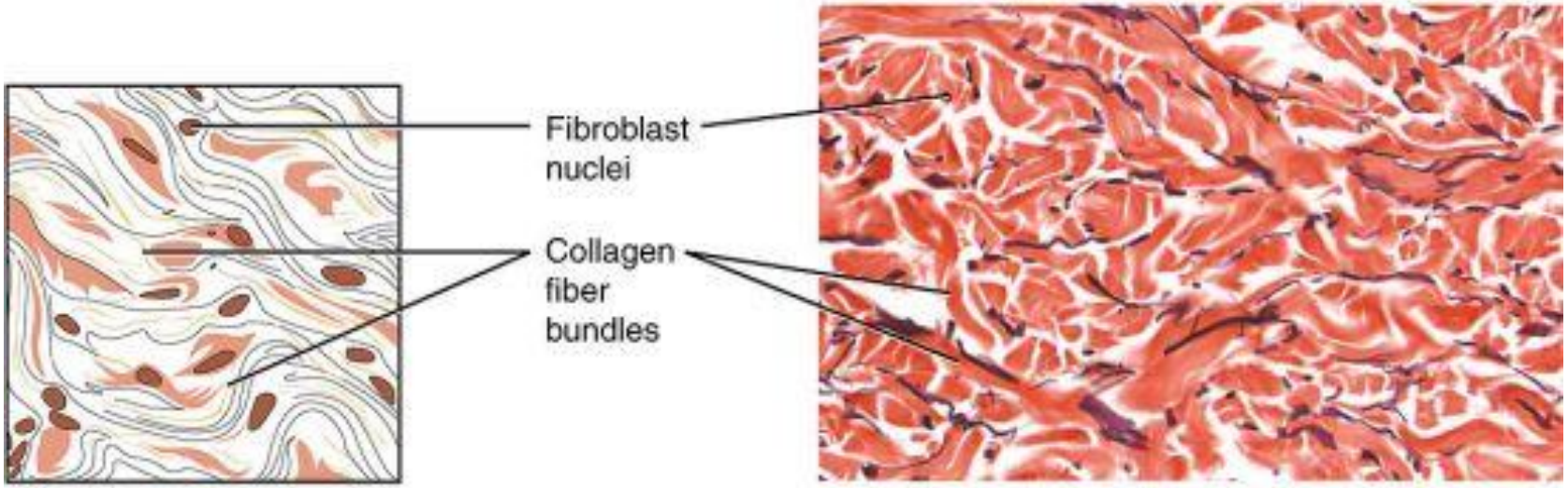




DENSE COLLAGEN CONNECTIVE TISSUE



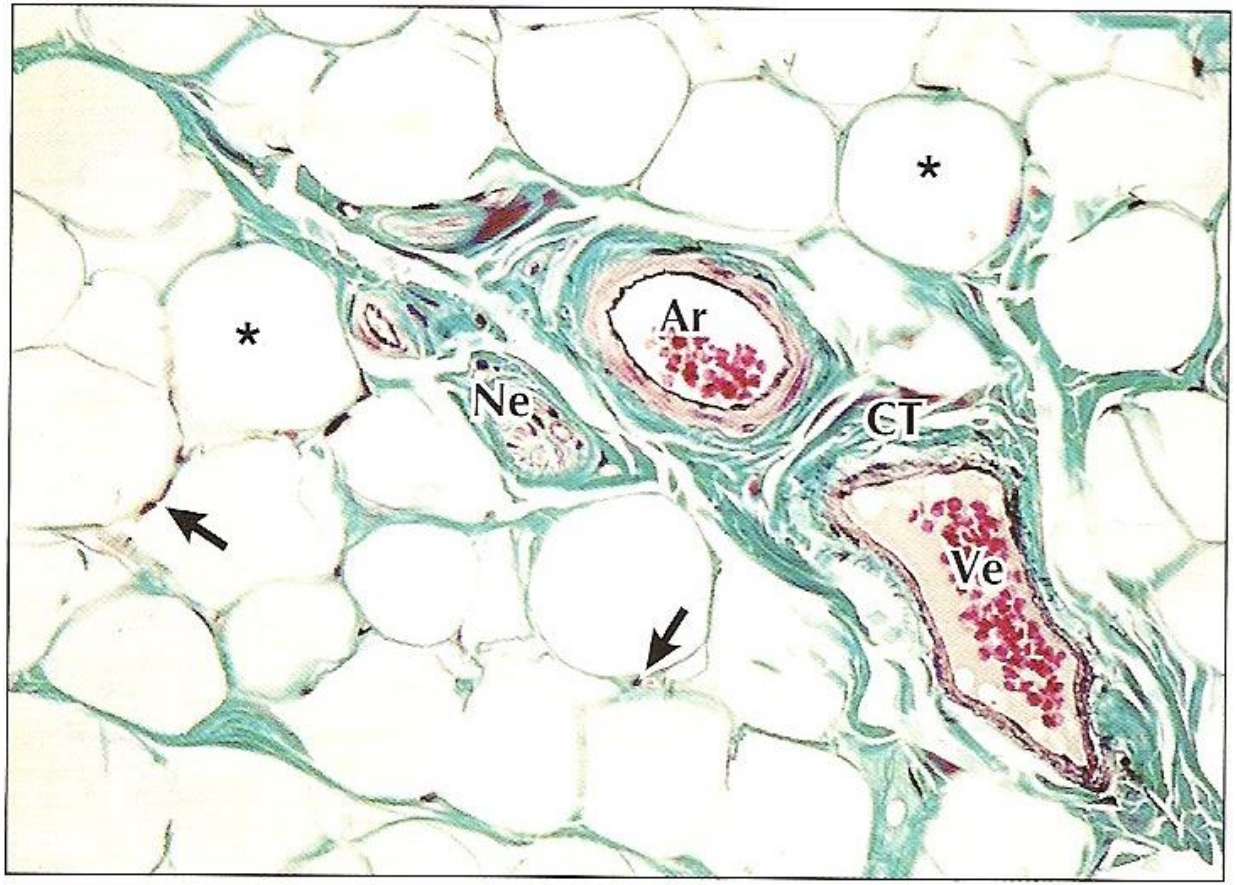
(a) Regular dense



(b) Irregular dense

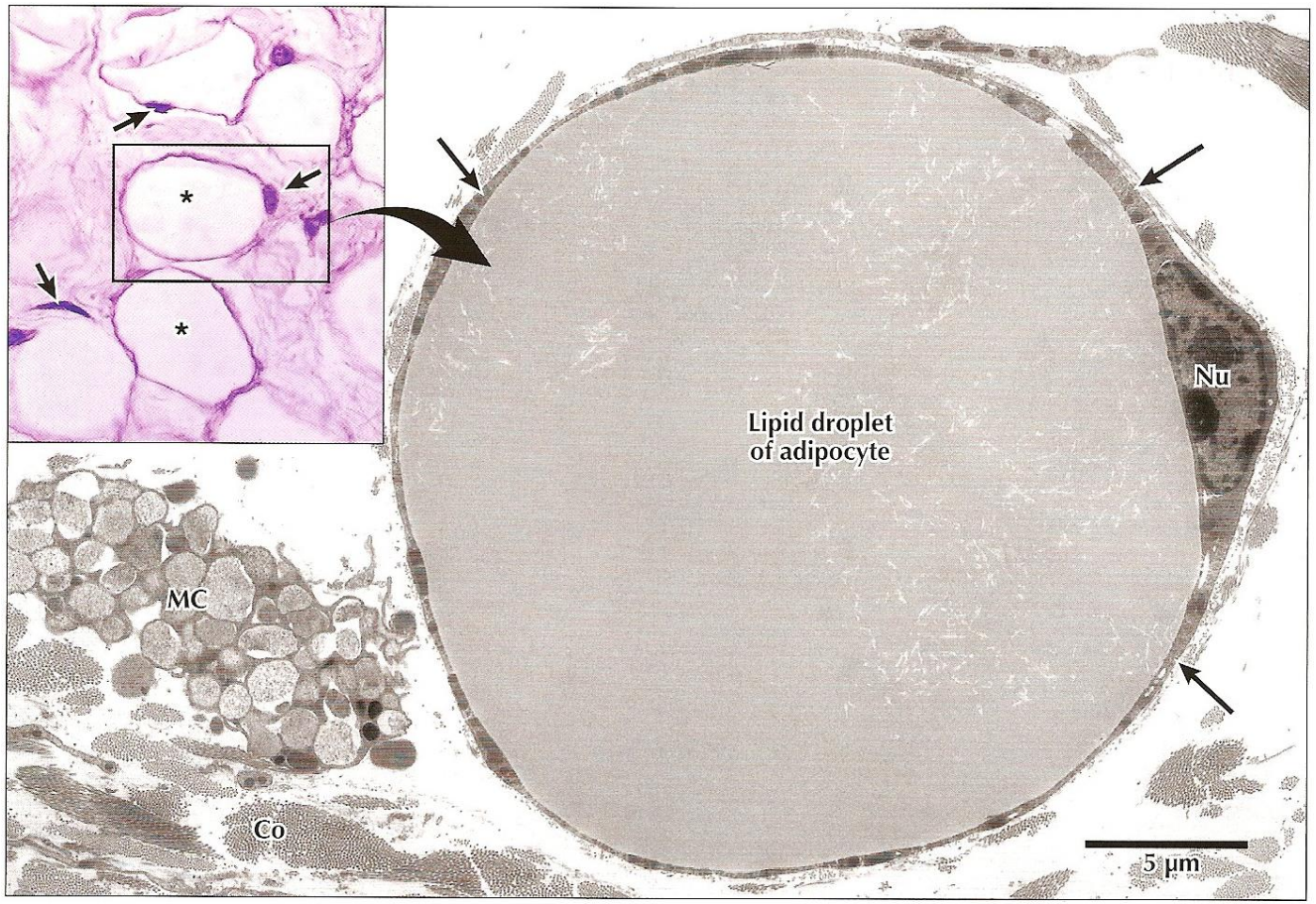
ADIPOSE TISSUE

- Adipocytes, fibroblasts, reticular, collagen and elastic fibers, capillaries
- White and brown adipose tissue

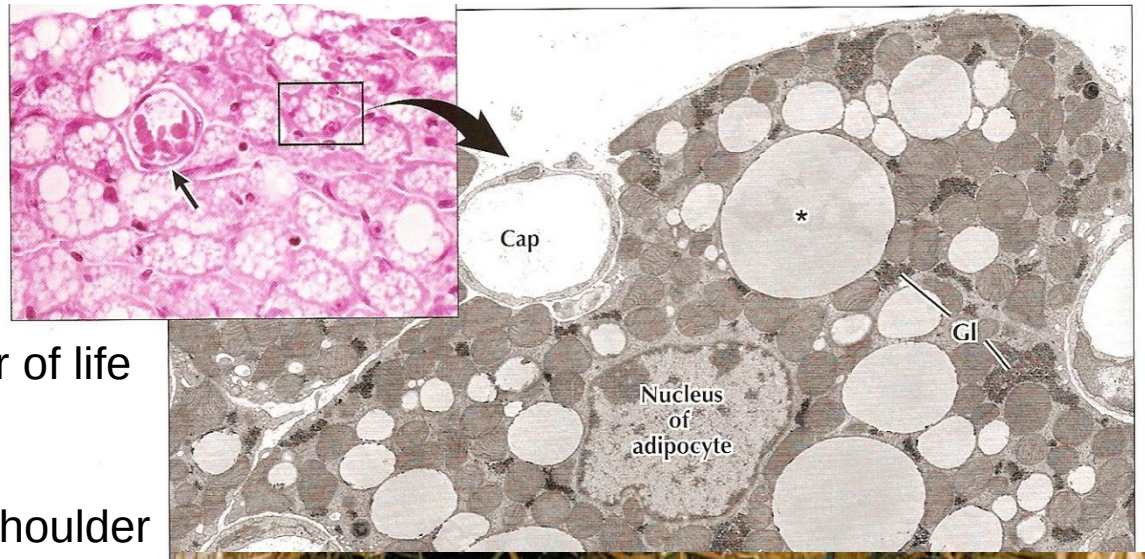


WHITE ADIPOSE TISSUE

- adipocytes are actively formed until 2nd year of life
- no innervations, but rich vascularisation
- adipocytes with only one lipid droplet
- leptin (adipokinins)



BROWN ADIPOSE TISSUE

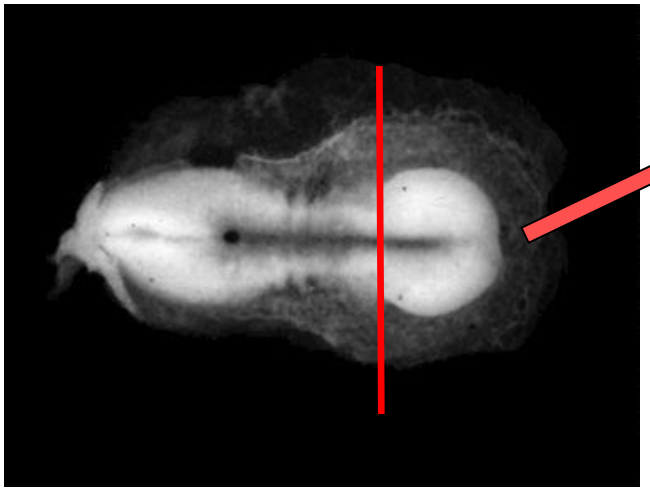


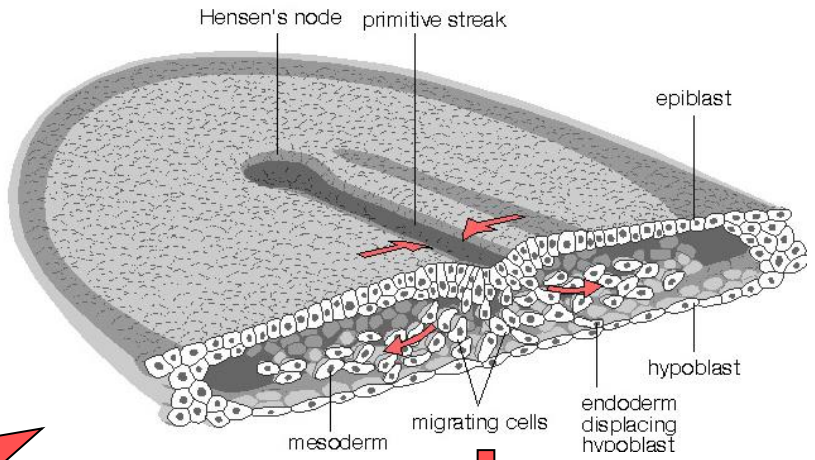
- fetus and children up to 1st year of life
- fast source of energy
- typical localization – between shoulder blades, axilla, mediastinum, around kidneys, pancreas, small intestine
- small cells with numerous fat droplets

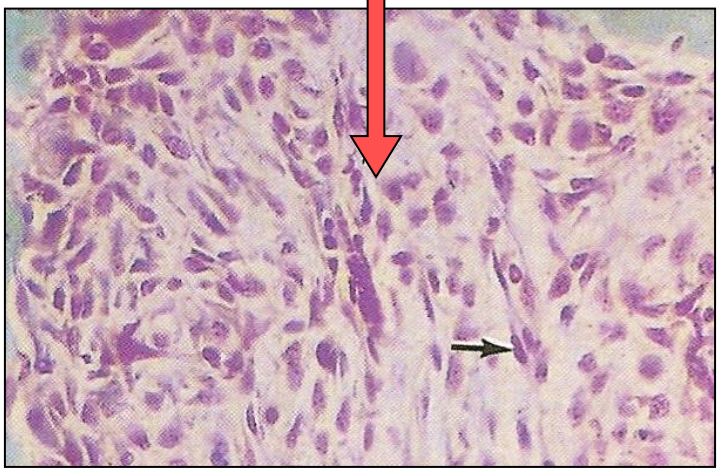
EMBRYONIC ORIGIN OF CONNECTIVE TISSUE

- Mesenchyme = loose tissue between germ layers
- Complex network of star- or spindle-shaped cells
- Jelly-like amorphous ground substance

DAY 12 of embryonic development

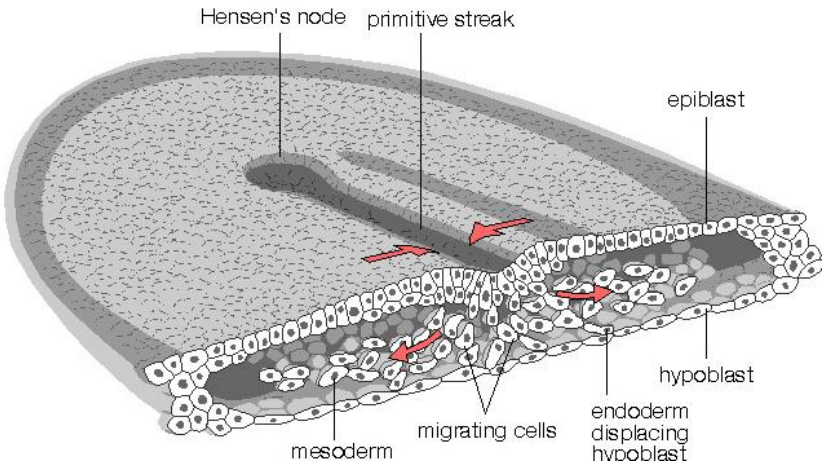


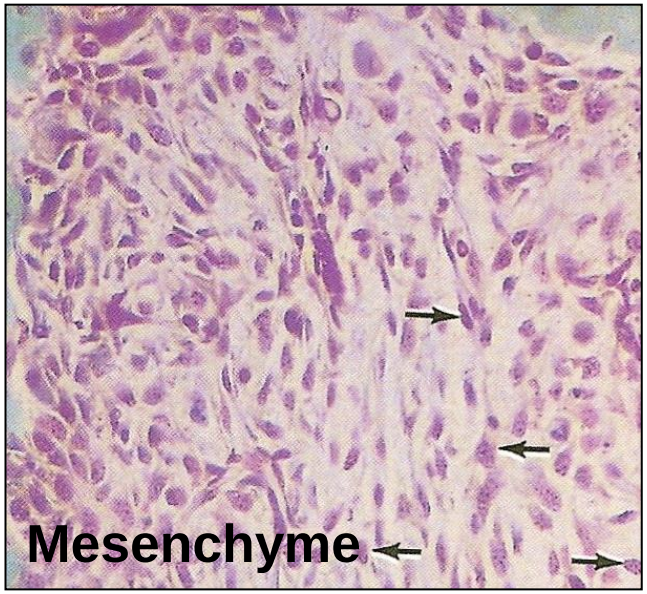


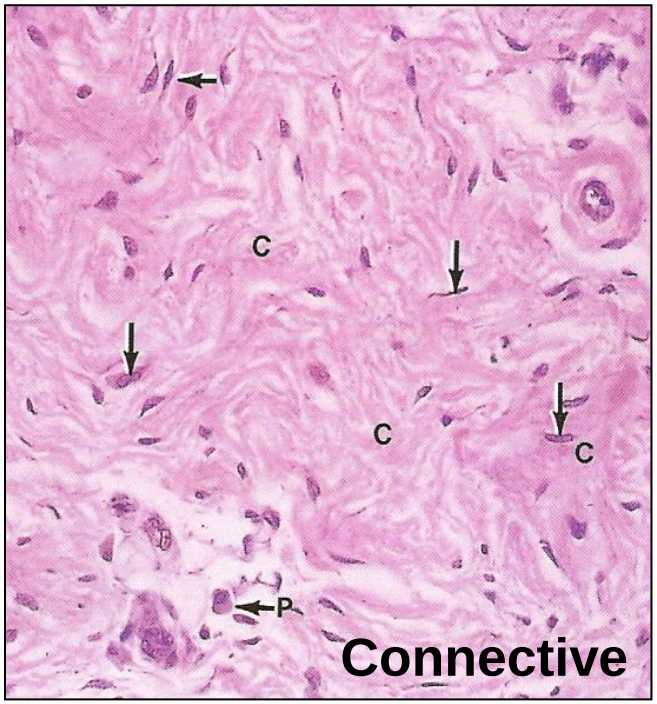


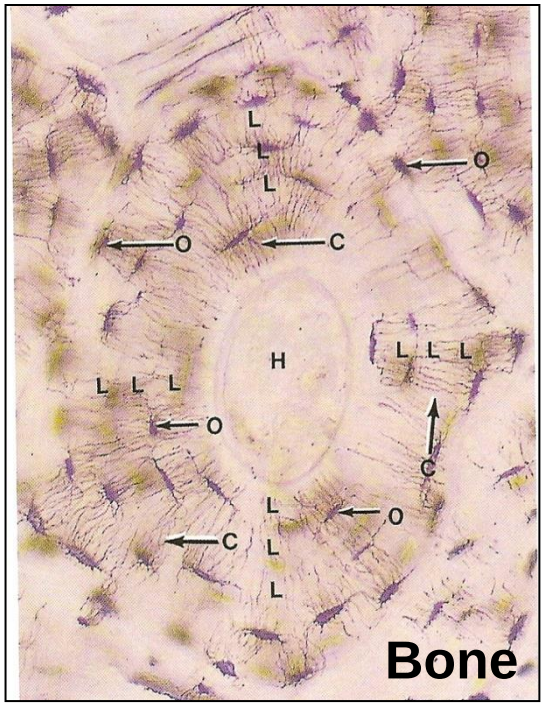
http://www.mun.ca/biology/desmid/brian/BIOL3530/DB_Ch02/DBNModel.html

DEVELOPMENT OF CONNECTIVE TISSUES

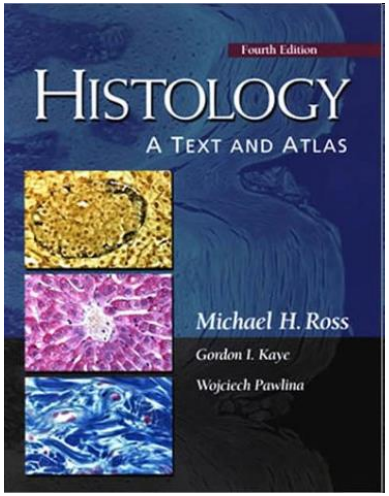


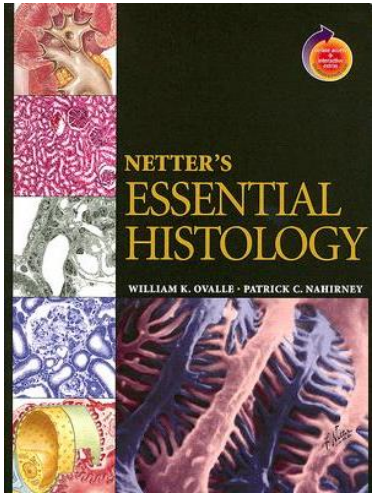


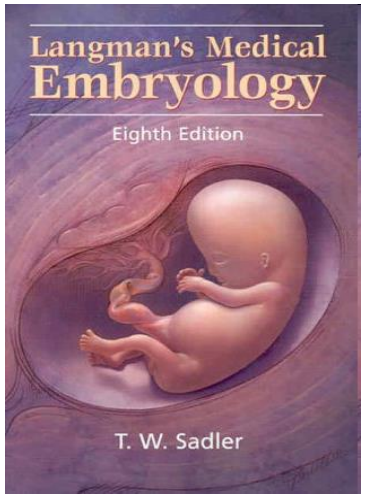


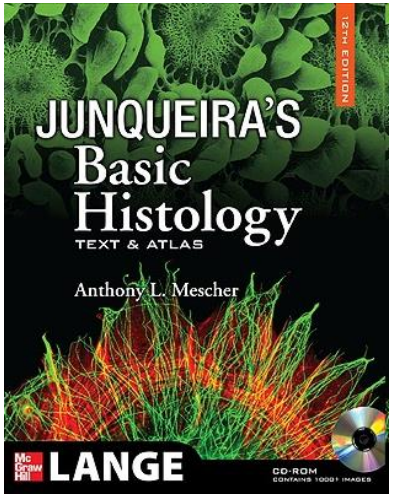


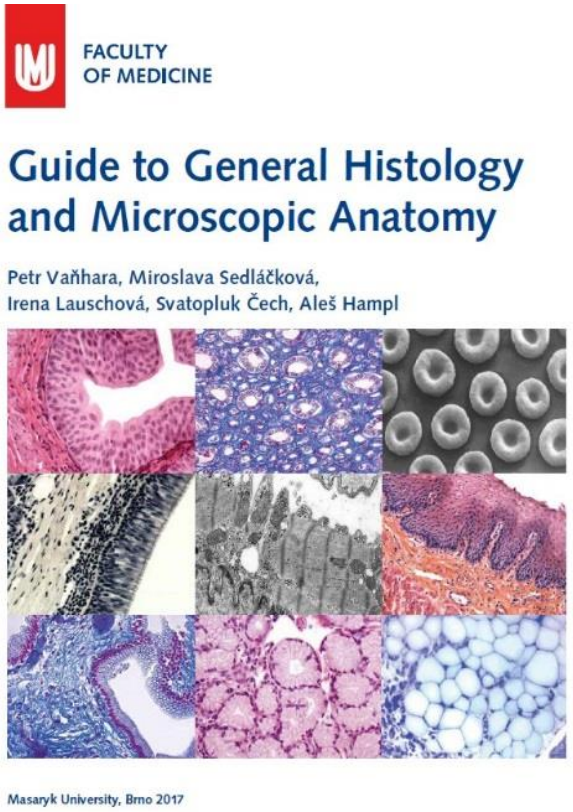
FURTHER STUDY











http://www.histology.med.muni.cz

pvanhara@med.muni.cz

Thank you for attention