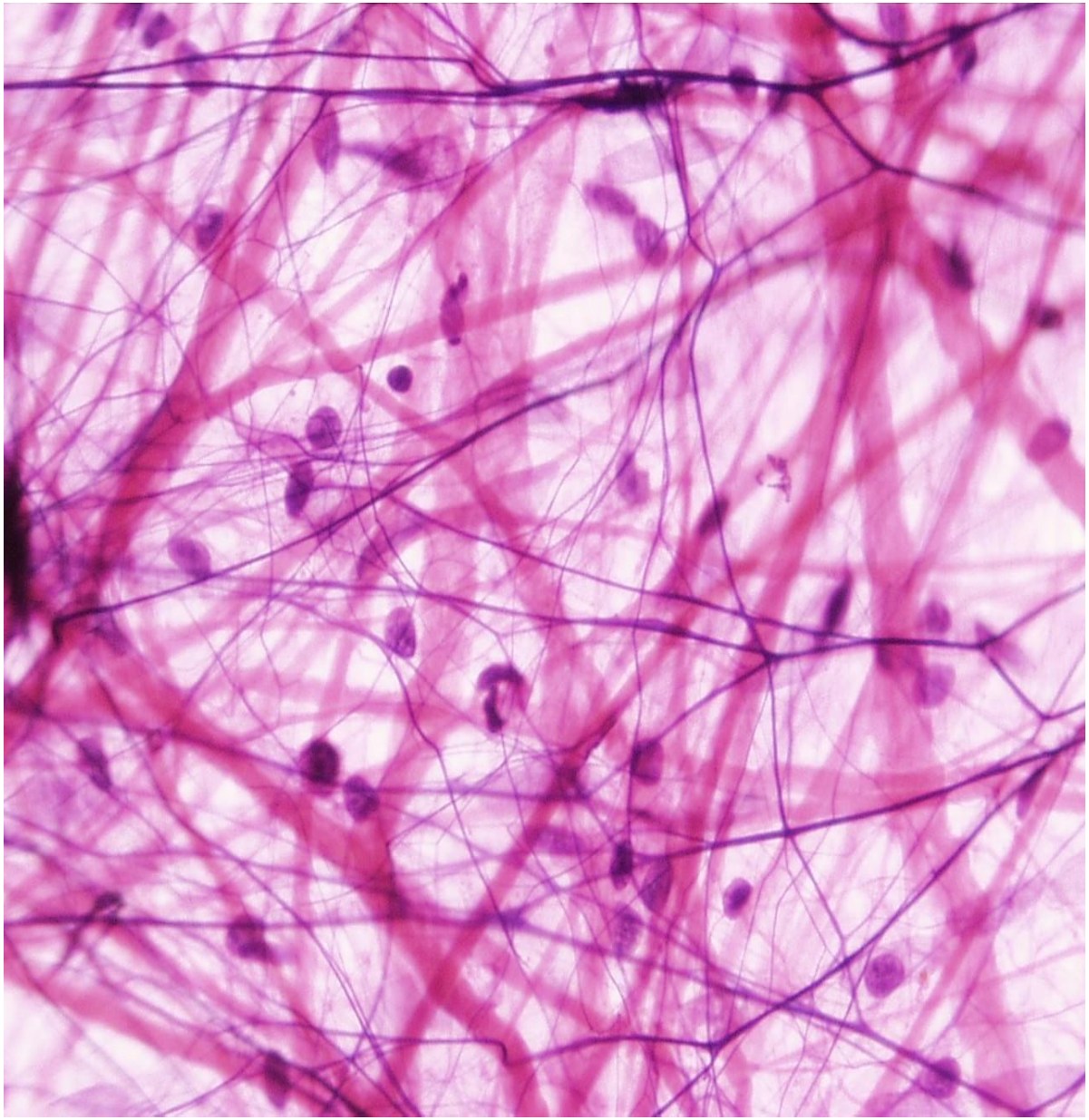


Connective tissue

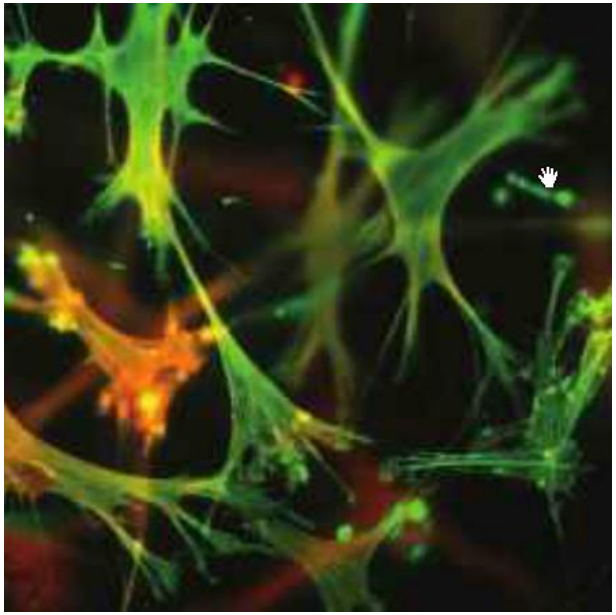
Not only a tissue glue…

General composition of connective tissue (CT)

Cells and extracellular matrix

Cells

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



Matrix – fibrous and amorphous

Fibrous component
- collagen
- reticular
- elastic

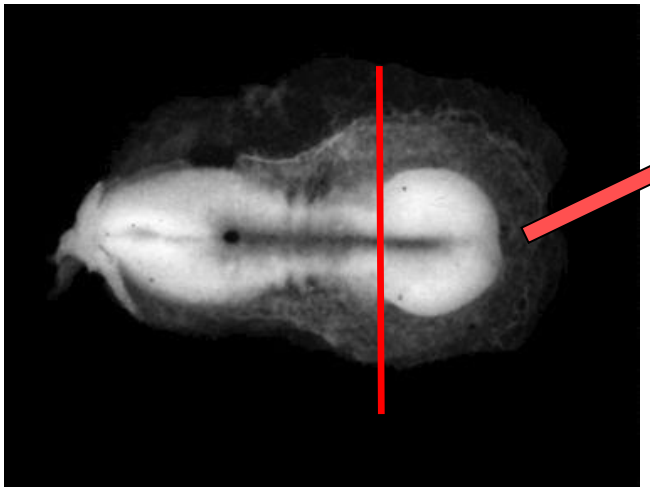
Amorphous component (amorphous ground substance)
- Complex matrix consisting of glycosaminoglycans, glycoproteins and proteoglycans,

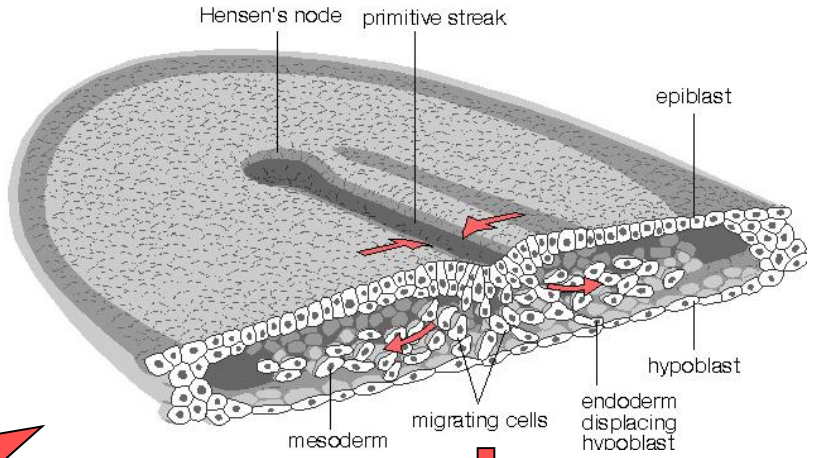
depending on tissue type (connective × ligament × cartilage × bone)

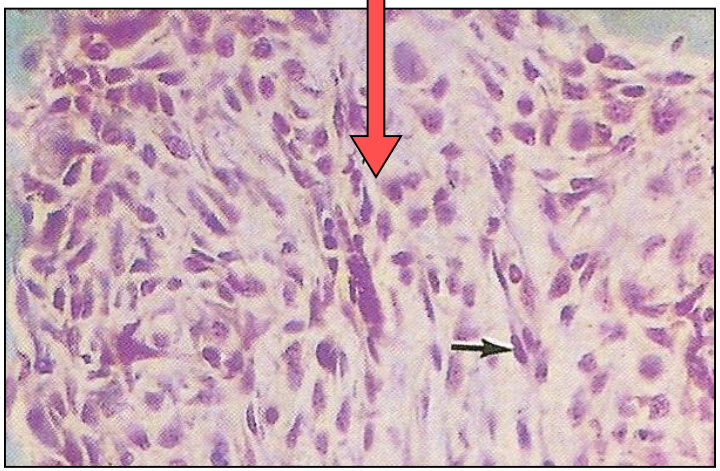
Embryonic origin of CT

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

DAY 12 of embryonic development

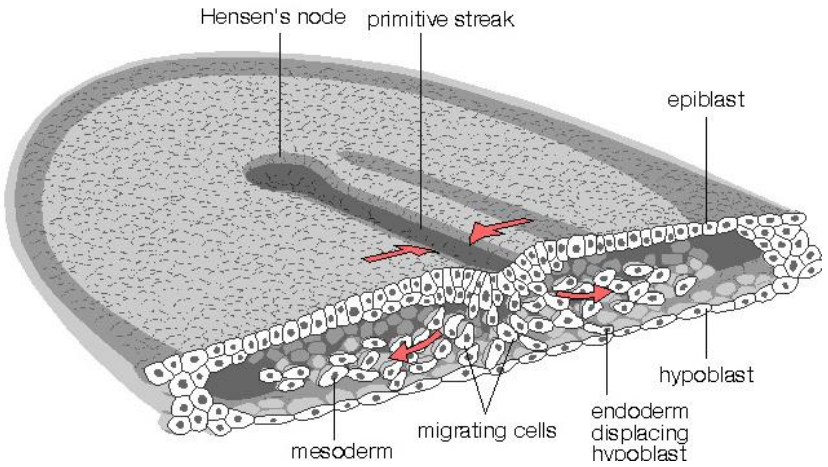


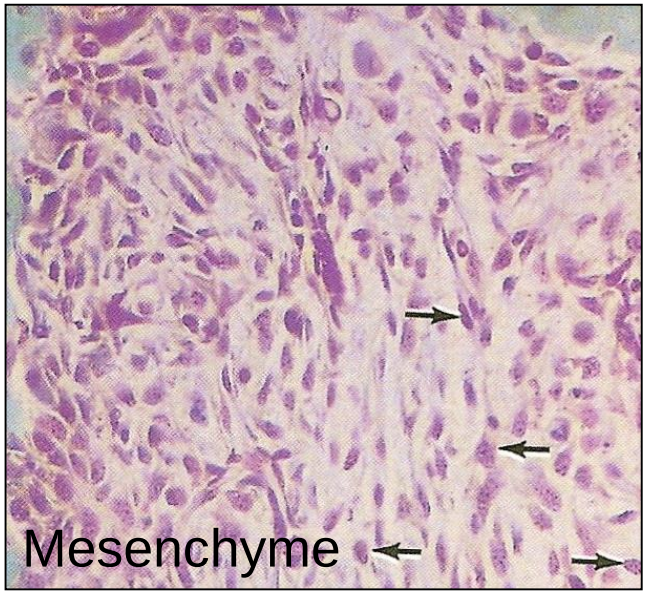


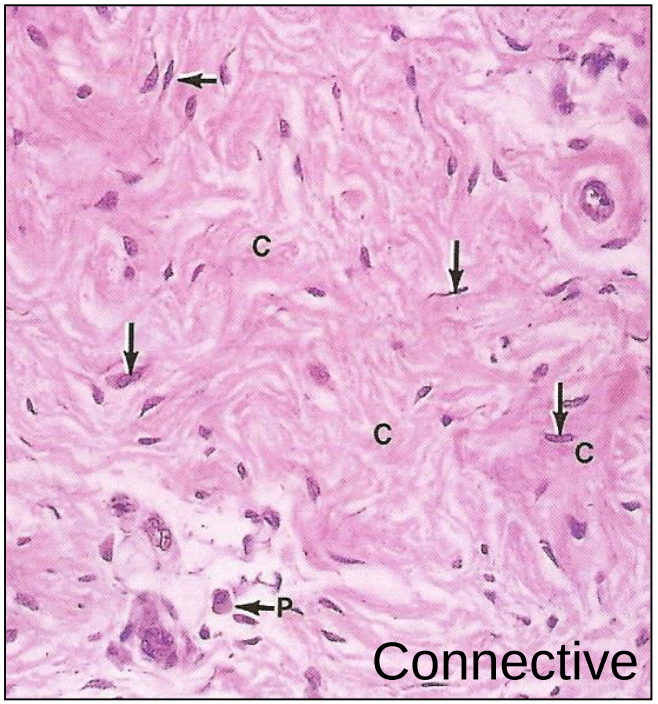


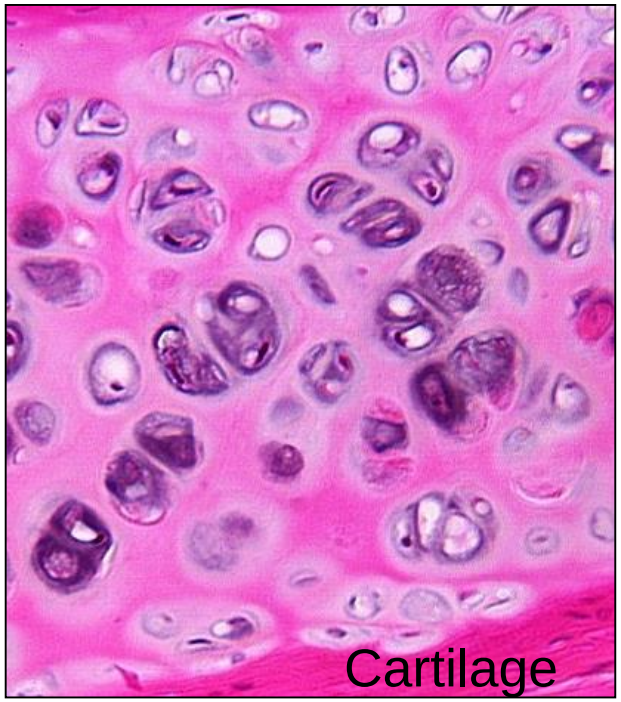
http://www.mun.ca/biology/desmid/brian/BIOL3530/DB_Ch02/DBNModel.html

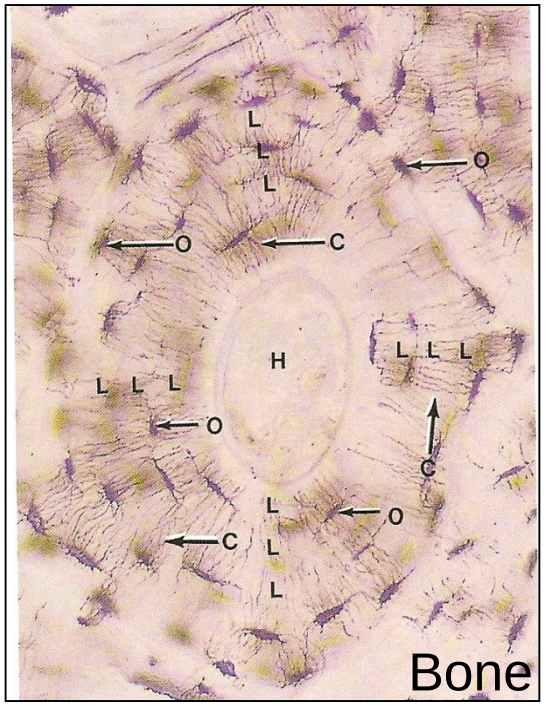
- Basic derivatives of CT











Classification of CT

Embryonic CT
- Mesenchyme
- Jelly-like CT (Wharton jelly, dental pulp, strom of iris)

Adult CT
- Areolar (loose, interstitial) CT
- Dense collagen irregular CT

} CT

- Dense collagen regular CT
- Fat (adipose tissue)
- Cartilage
- Bone

} Specialized CT

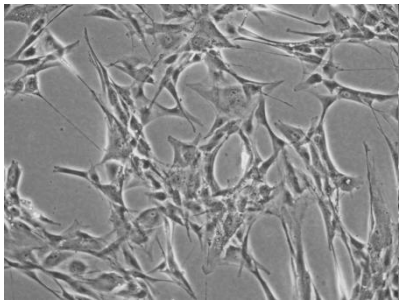
- Blood and hematopoietic tissue
- Lymphatic tissue

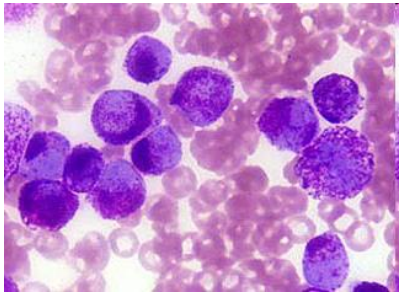
} Trophic CT (body liquids)

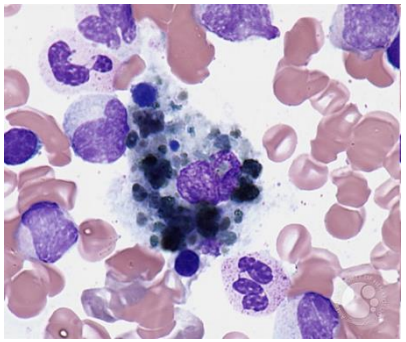
Cells of connective tissue

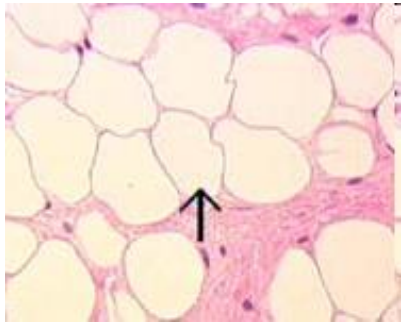
Cells

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



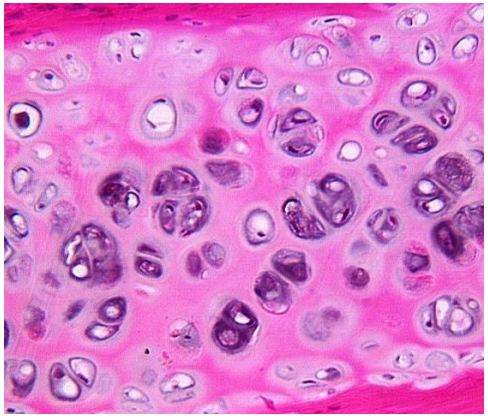


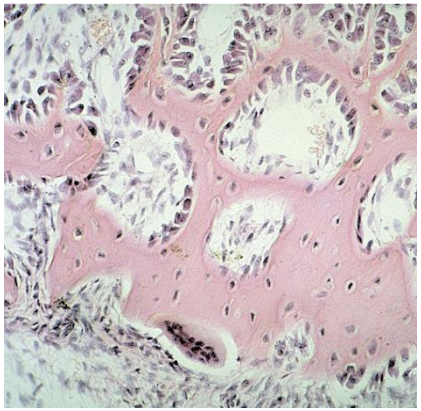


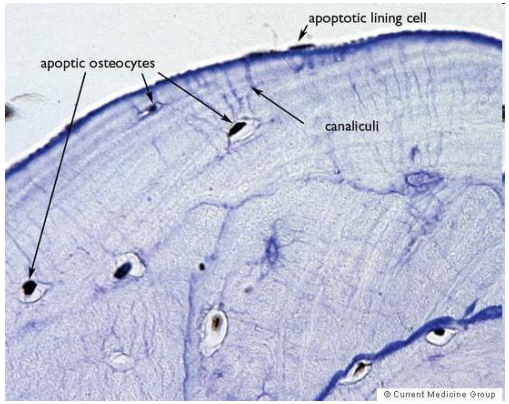


Extracellular matrix

- Fibrous compound
- Amorphous ground substance

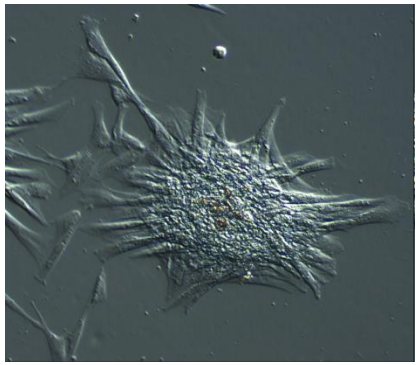


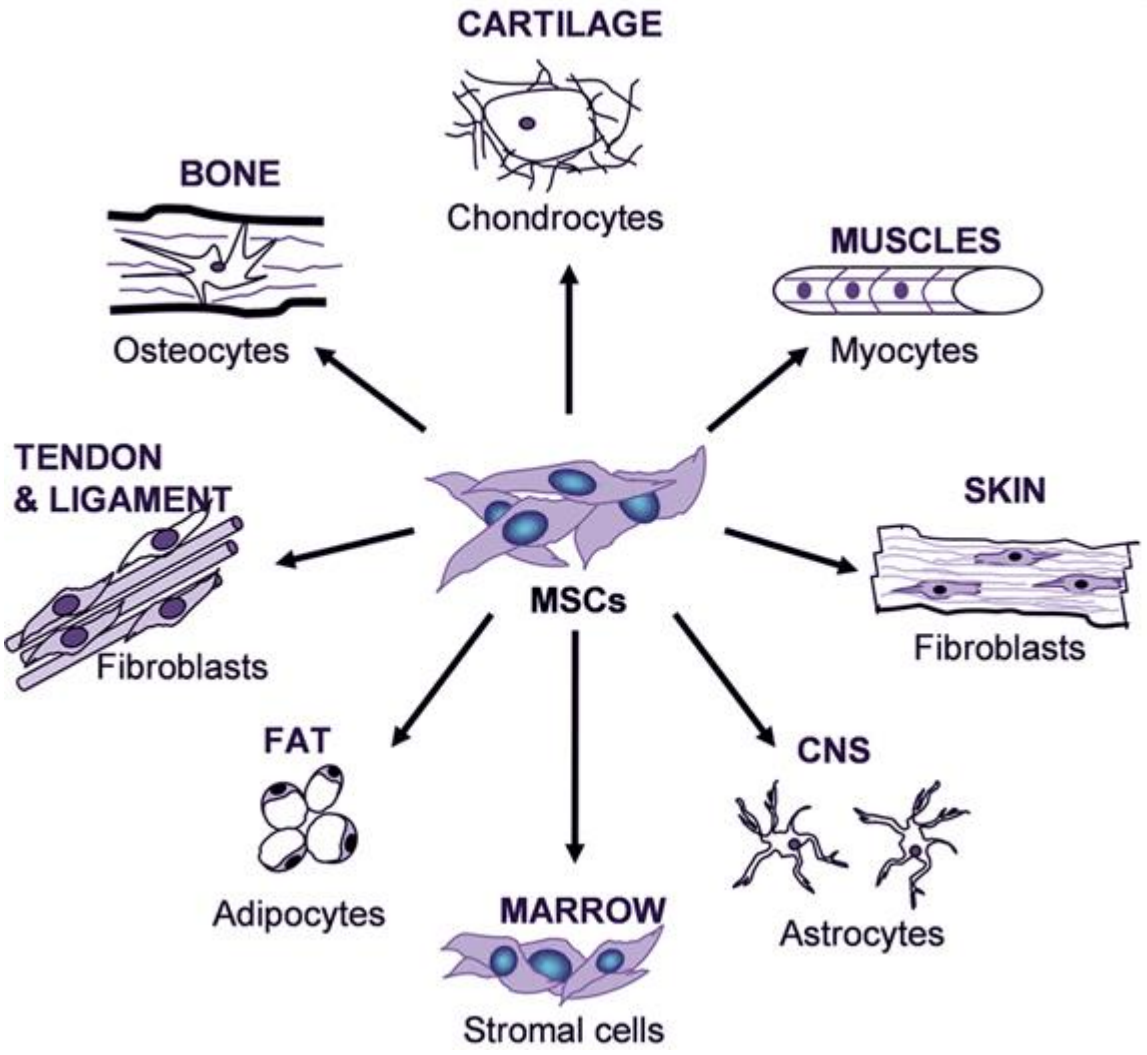




Cells of connective tissue

Mesenchymal (adult) stem cells



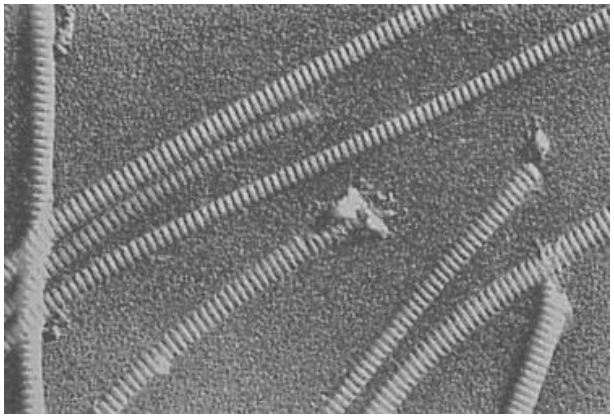


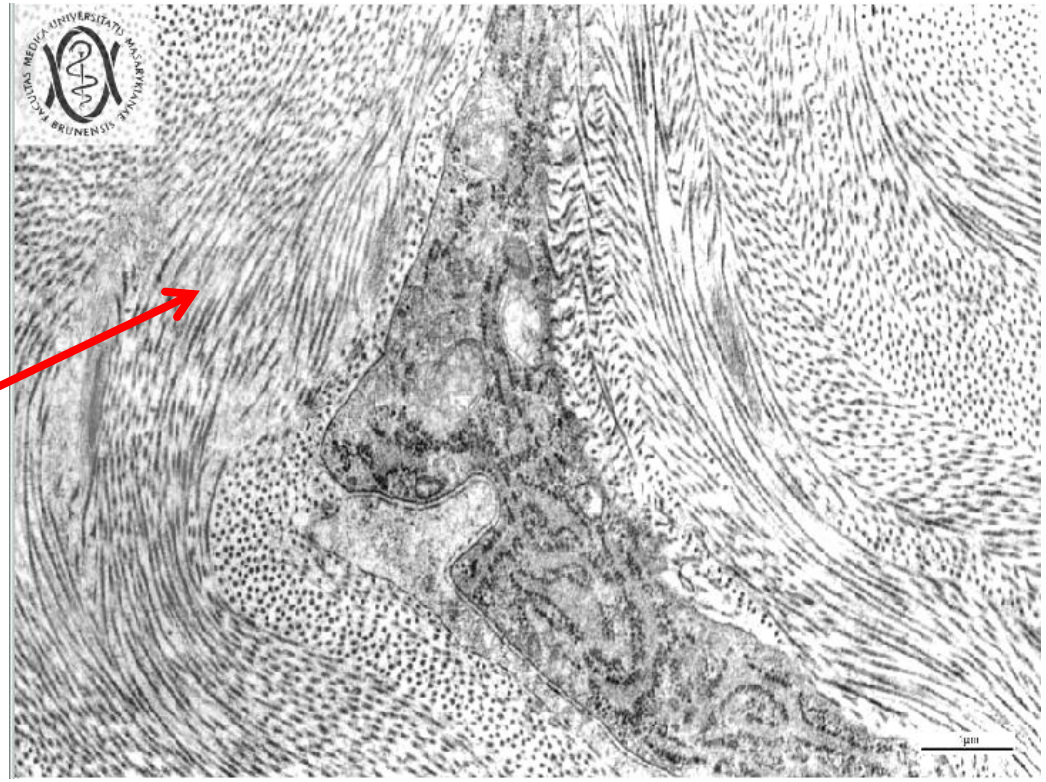
Koch *et al. BMC Biotechnology* 2007 7:26 doi:10.1186/1472-6750-7-26

Extracellular matrix – fibrous component

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)

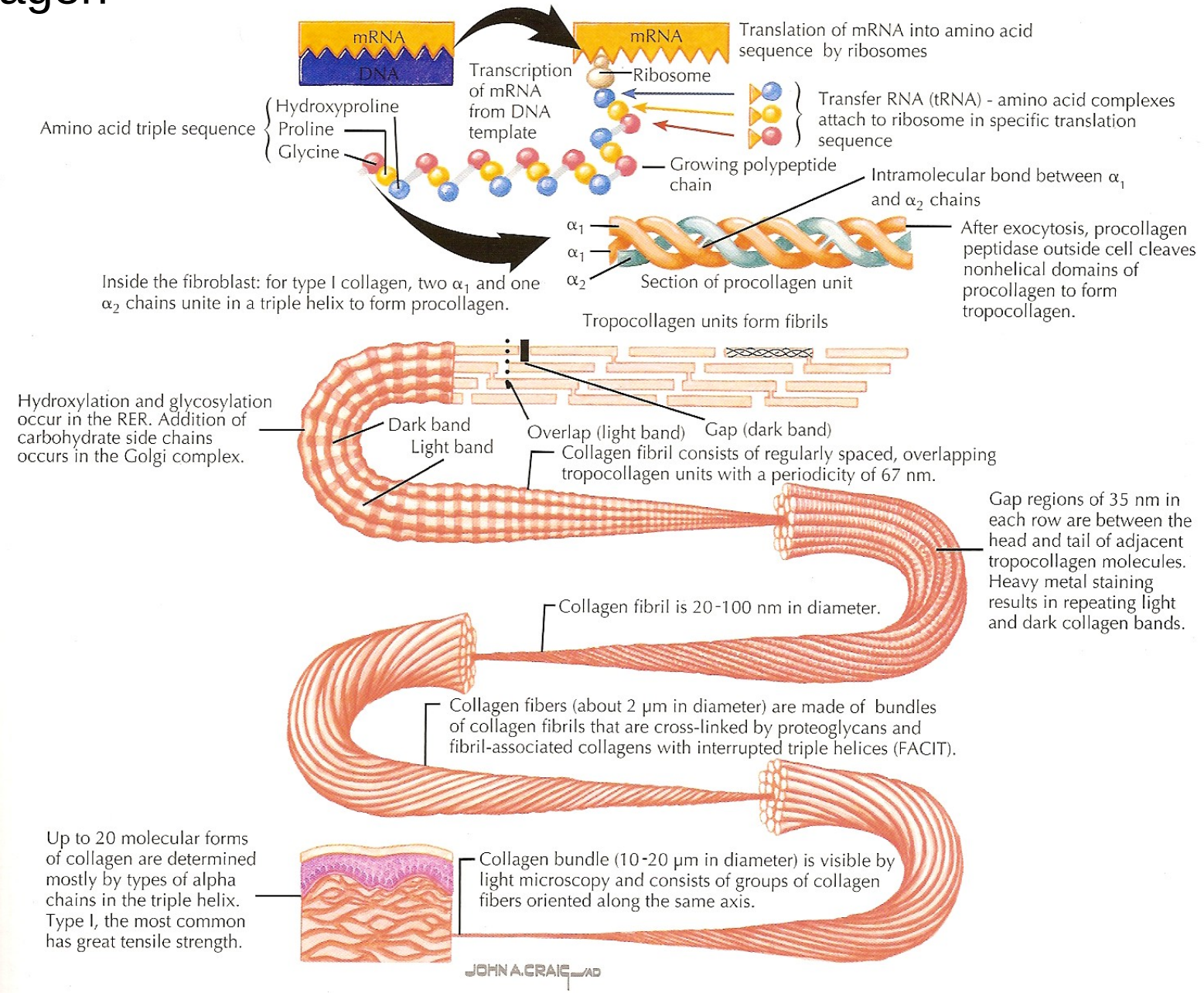




- Collagen

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)		
X	Growth plate, mineralized cartilage		Growth of bones, mineralization

- Collagen


mRNA
DNA
Transcription of mRNA from DNA template
mRNA
Ribosome
Translation of mRNA into amino acid sequence by ribosomes
Transfer RNA (tRNA) - amino acid complexes attach to ribosome in specific translation sequence
Amino acid triple sequence
Hydroxyproline
Proline
Glycine
Growing polypeptide chain
Intramolecular bond between α_1 and α_2 chains
α_1
α_1
α_2
Section of procollagen unit
After exocytosis, procollagen peptidase outside cell cleaves nonhelical domains of procollagen to form tropocollagen.
Inside the fibroblast: for type I collagen, two α_1 and one α_2 chains unite in a triple helix to form procollagen.
Tropocollagen units form fibrils
Hydroxylation and glycosylation occur in the RER. Addition of carbohydrate side chains occurs in the Golgi complex.
Dark band
Light band
Overlap (light band)
Gap (dark band)
Collagen fibril consists of regularly spaced, overlapping tropocollagen units with a periodicity of 67 nm.
Gap regions of 35 nm in each row are between the head and tail of adjacent tropocollagen molecules. Heavy metal staining results in repeating light and dark collagen bands.
Collagen fibril is 20-100 nm in diameter.
Collagen fibers (about 2 μm in diameter) are made of bundles of collagen fibrils that are cross-linked by proteoglycans and fibril-associated collagens with interrupted triple helices (FACIT).
Up to 20 molecular forms of collagen are determined mostly by types of alpha chains in the triple helix. Type I, the most common has great tensile strength.
Collagen bundle (10-20 μm in diameter) is visible by light microscopy and consists of groups of collagen fibers oriented along the same axis.
JOHN A. CRAIG, MD

- Collagen in LM

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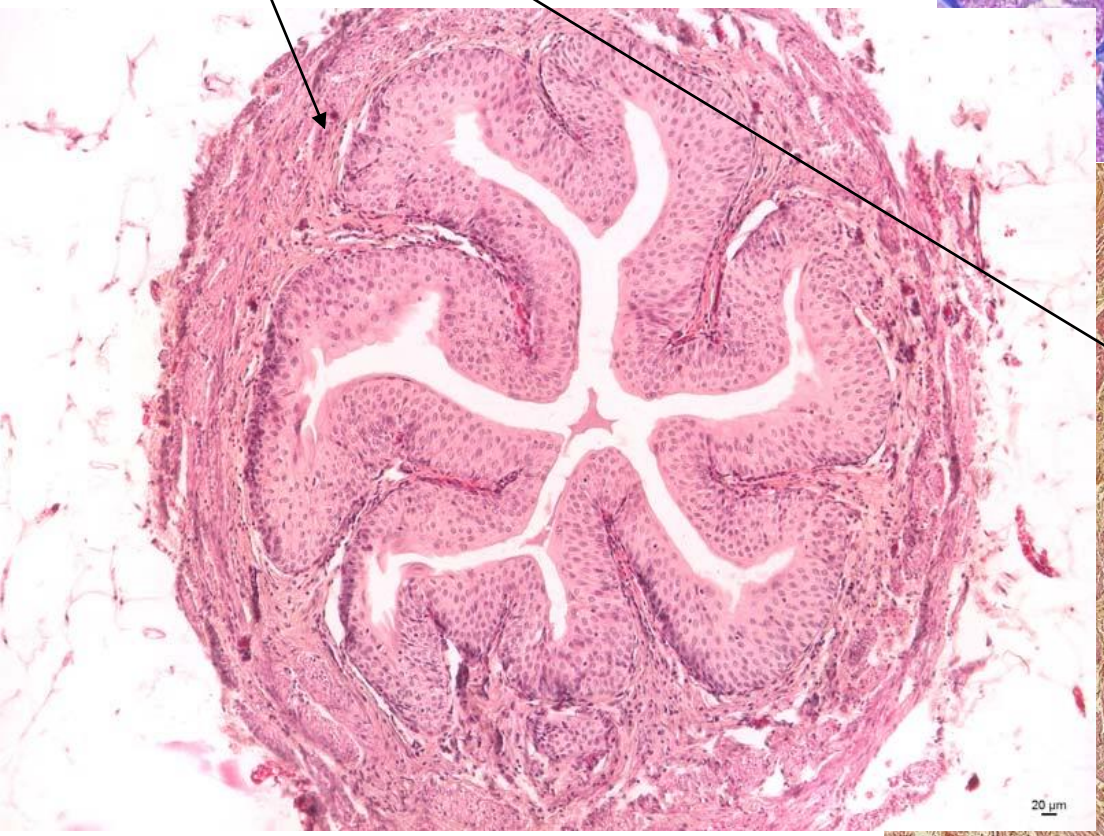
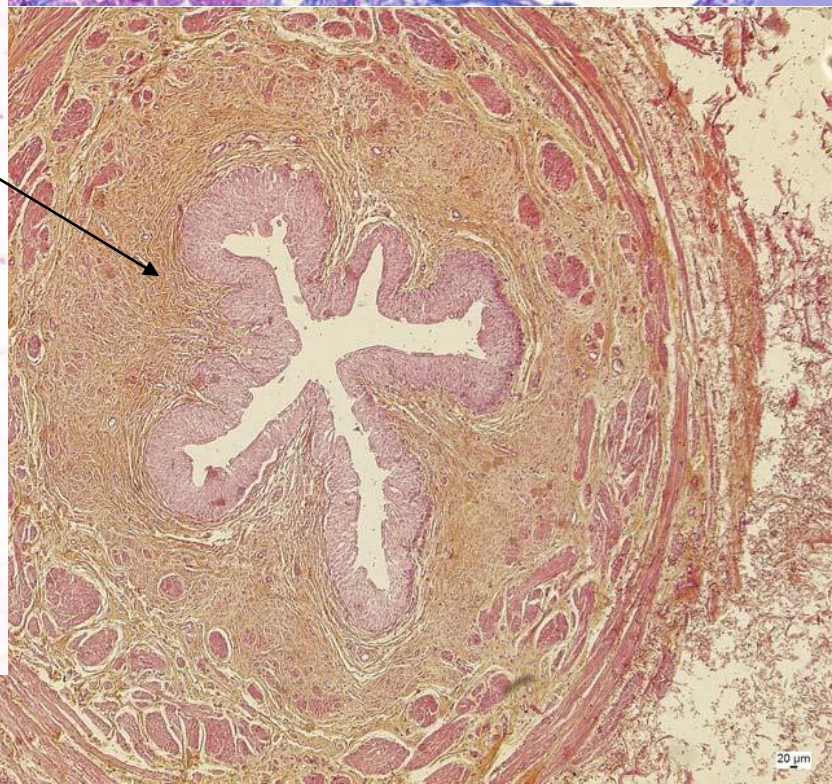




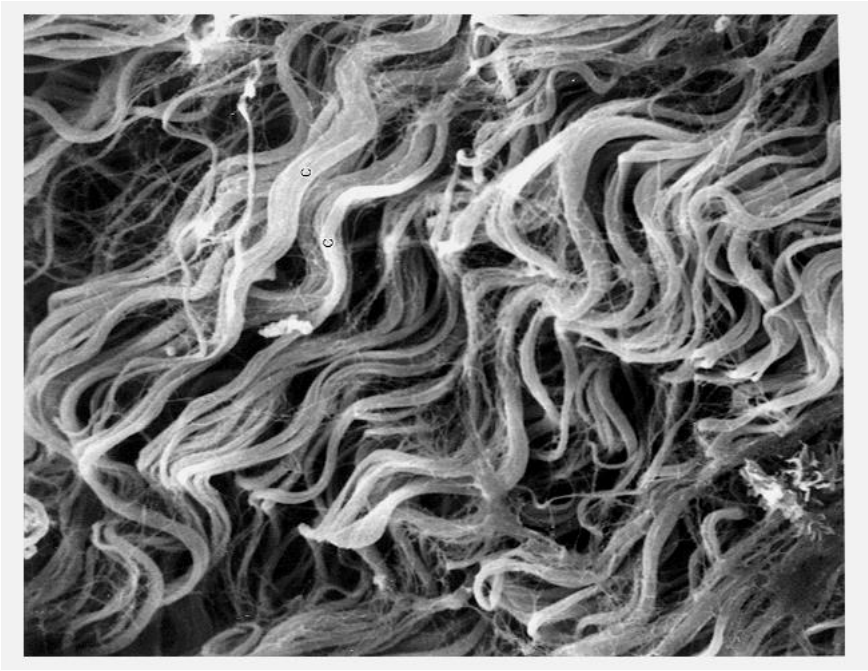
Julian Voss-Andreae "Unraveling Collagen",

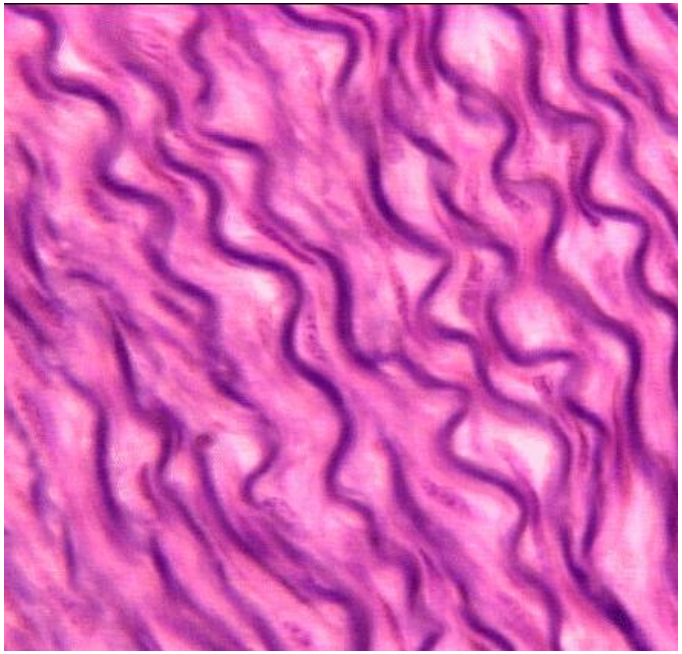
2005

Orange Memorial Park Sculpture Garden, City of South San Francisco, CA

Elastic fibers

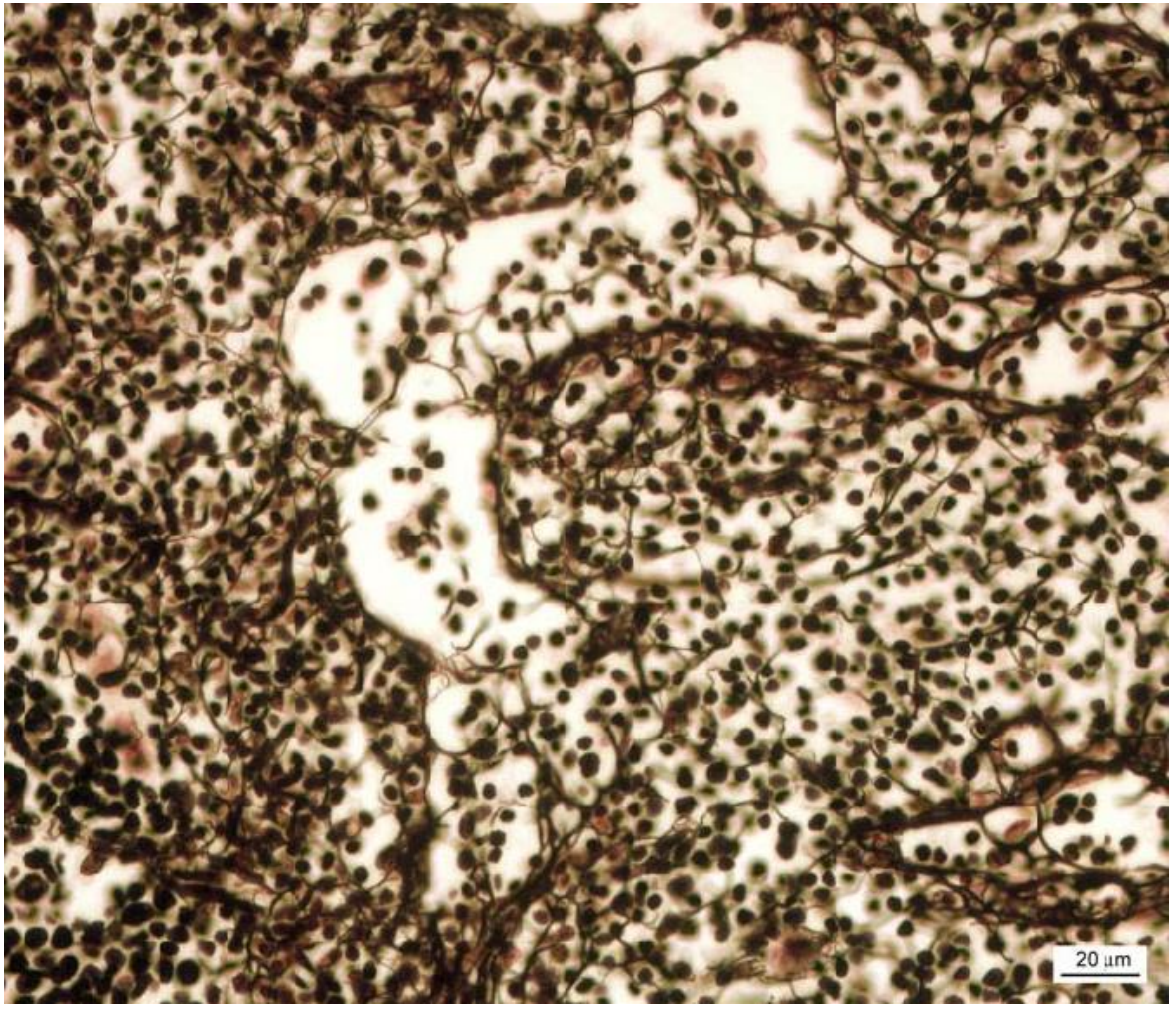
- less abundant than collagen
- polymer – tropoelastin
- minimal tensile resistance, loss of elasticity if overstretched
- reduction of hysteresis = allow return back to original state after mechanic change





Reticular fibers

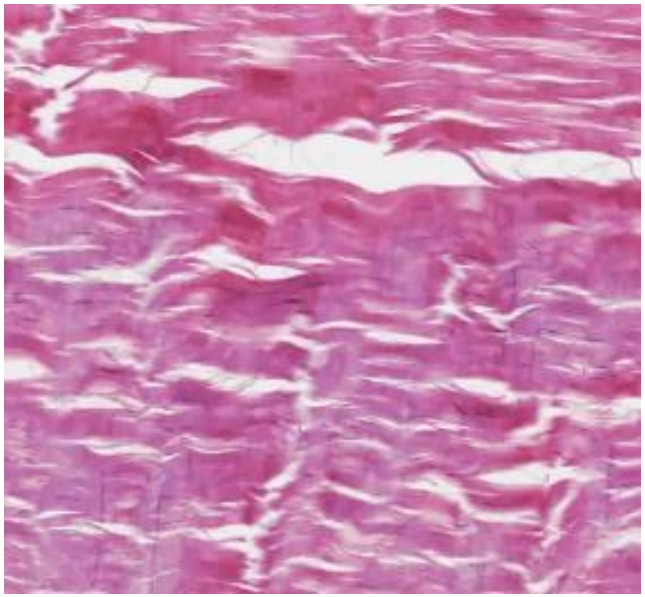
- collagen 3D meshwork
- bone marrow, spleen, lymphatic nodules
- microenvironment for e.g. hematopoietic stem cells and progenitors

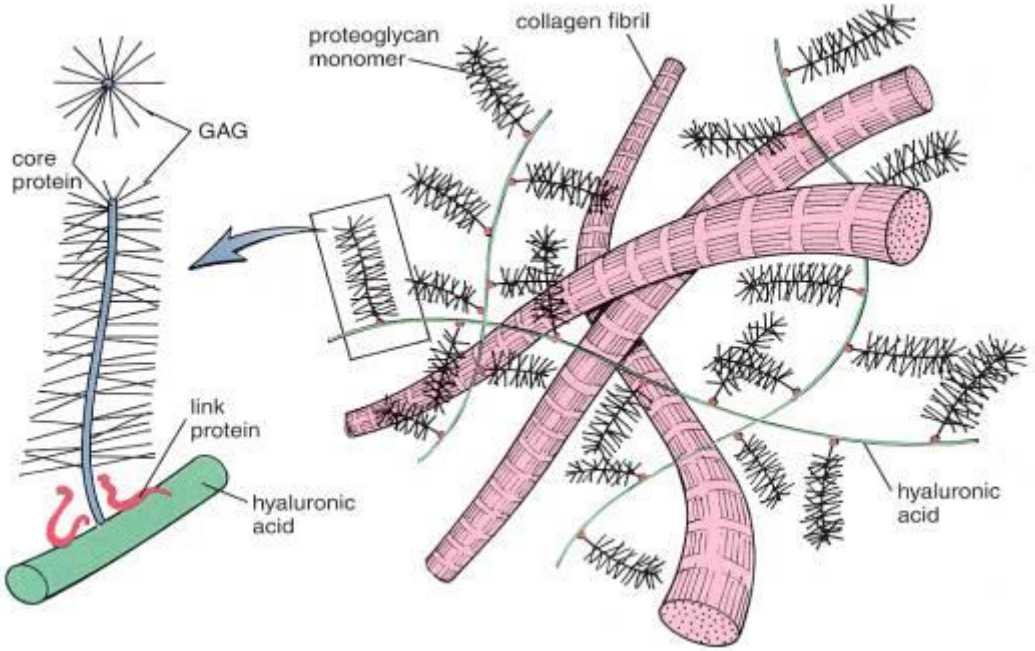


Extracellular matrix – ground matrix

Amorphous extracellular matrix

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



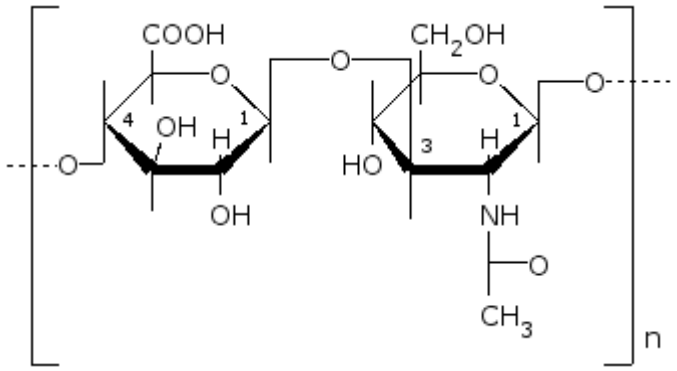


Glycosaminoglycans

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

polysaccharides rich in hexosamines = acid mukopolysaccharides

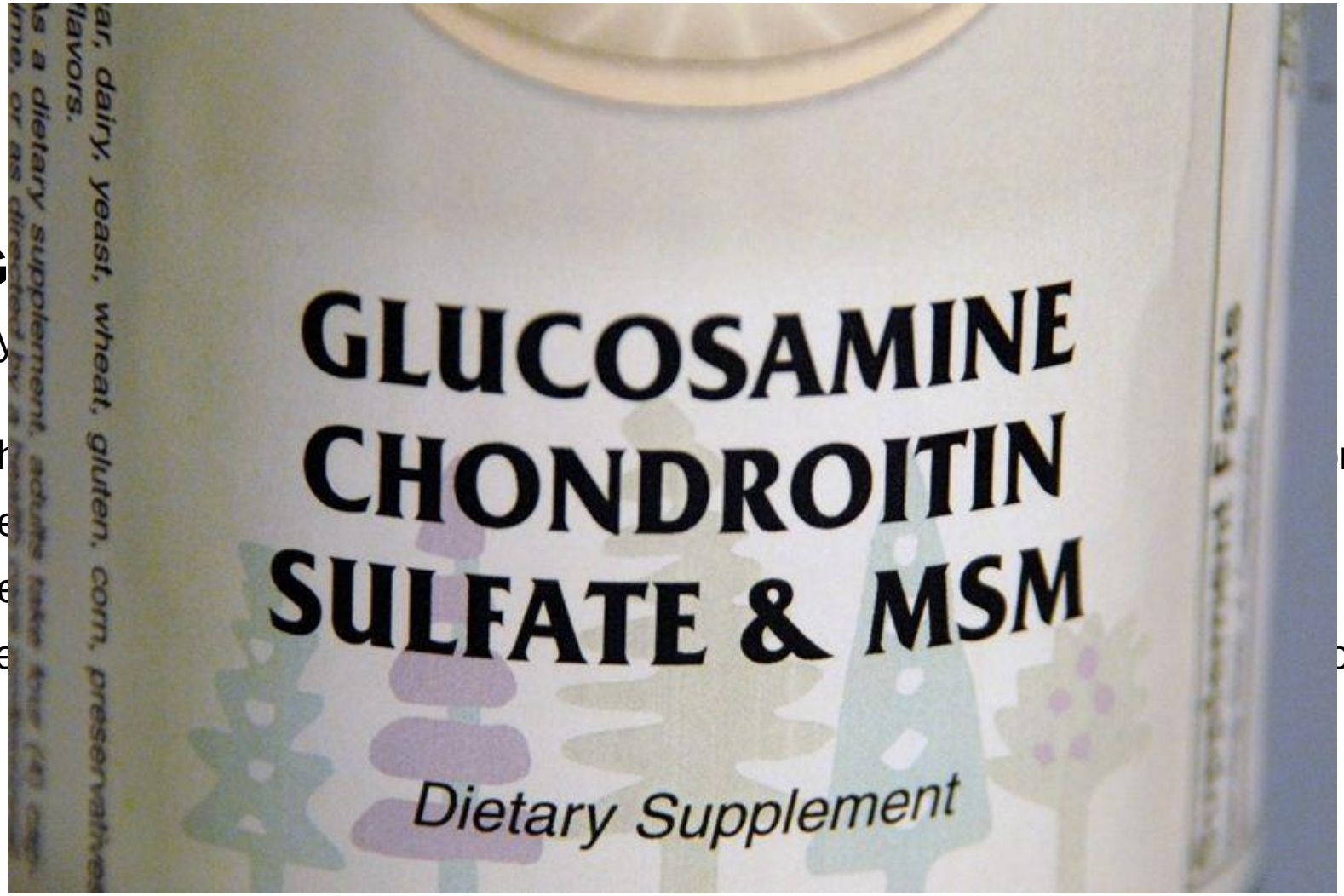
glucuronic or iduronic acid



glucosamin or galactosamin

- Glycosaminoglycans

They bind to protein structures (except for hyaluronic acid)



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Proteoglycans

— protein + dominant linear saccharide component

— proteoglycan aggregates

— water-binding, volume dependent of hydratation

— aggrecan (cartilage)
— syndecan
— fibroglycan

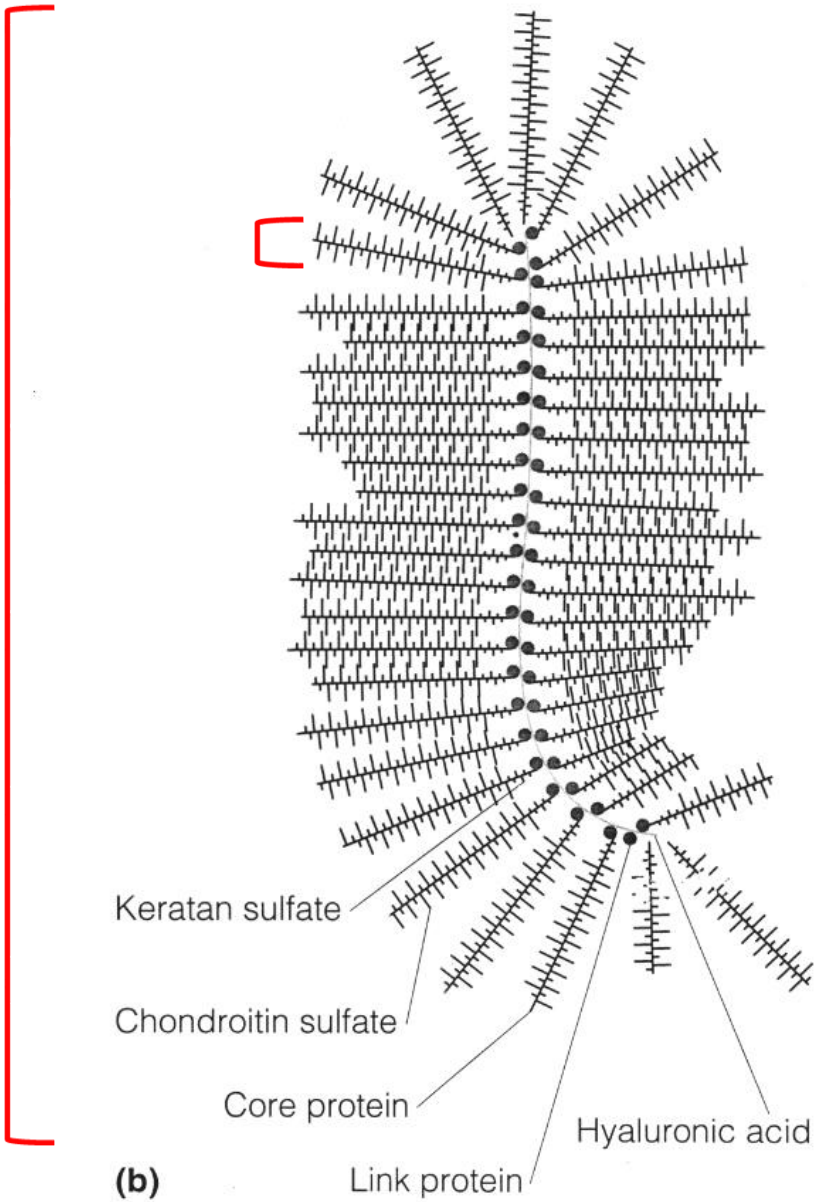
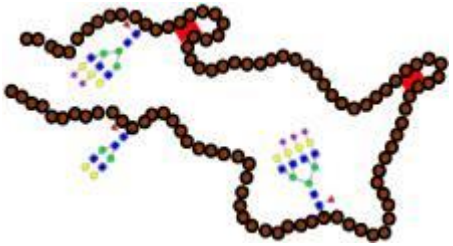


Figure 9.25b Proteoglycan structure in bovine cartilage

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

Structural glycoproteins

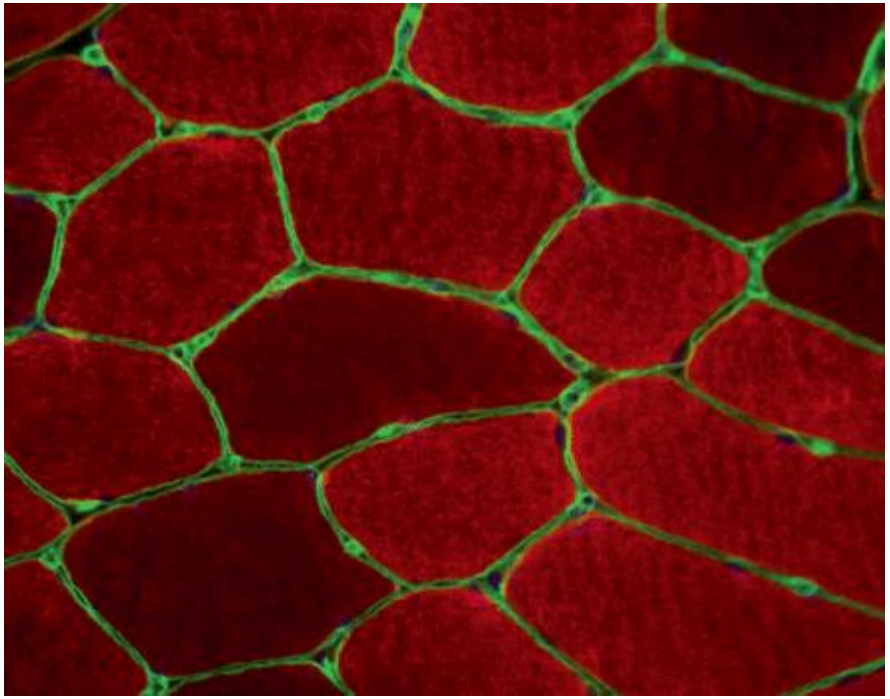


• dominant protein + branched saccharide component
• interaction between cells and ECM

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

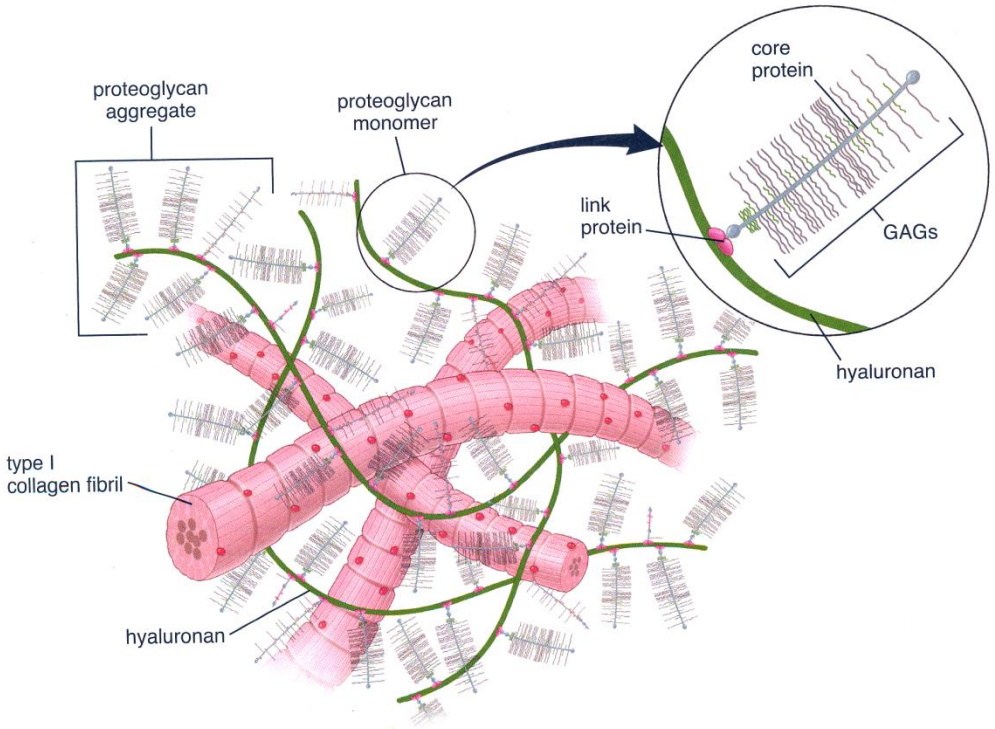
— **laminin** – basal lamina – epithelial integrity

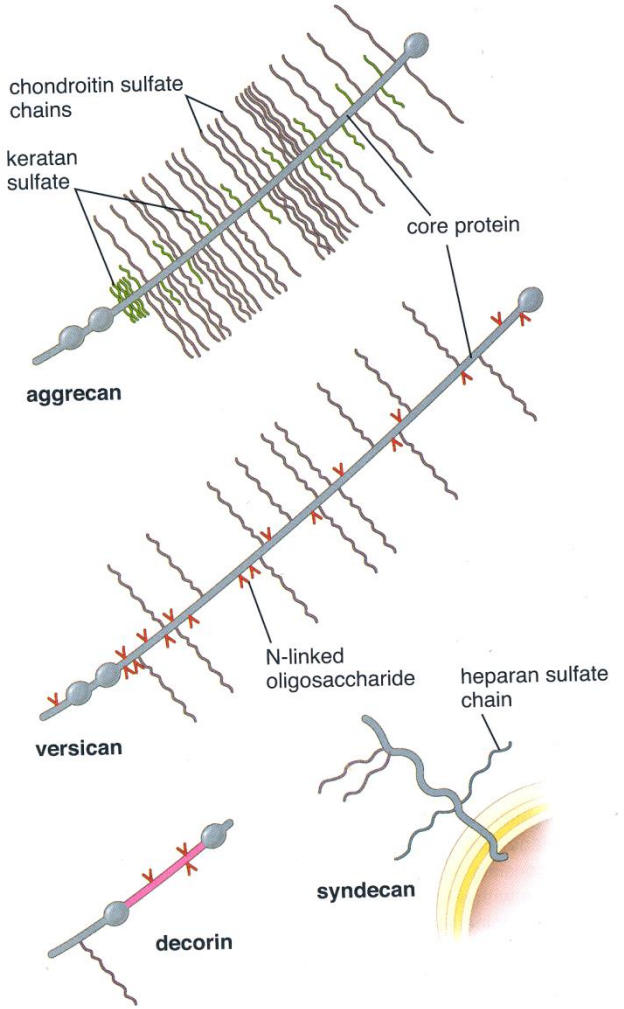
— **chondronectin** – cartilage – adhesion of chondrocytes to collagen



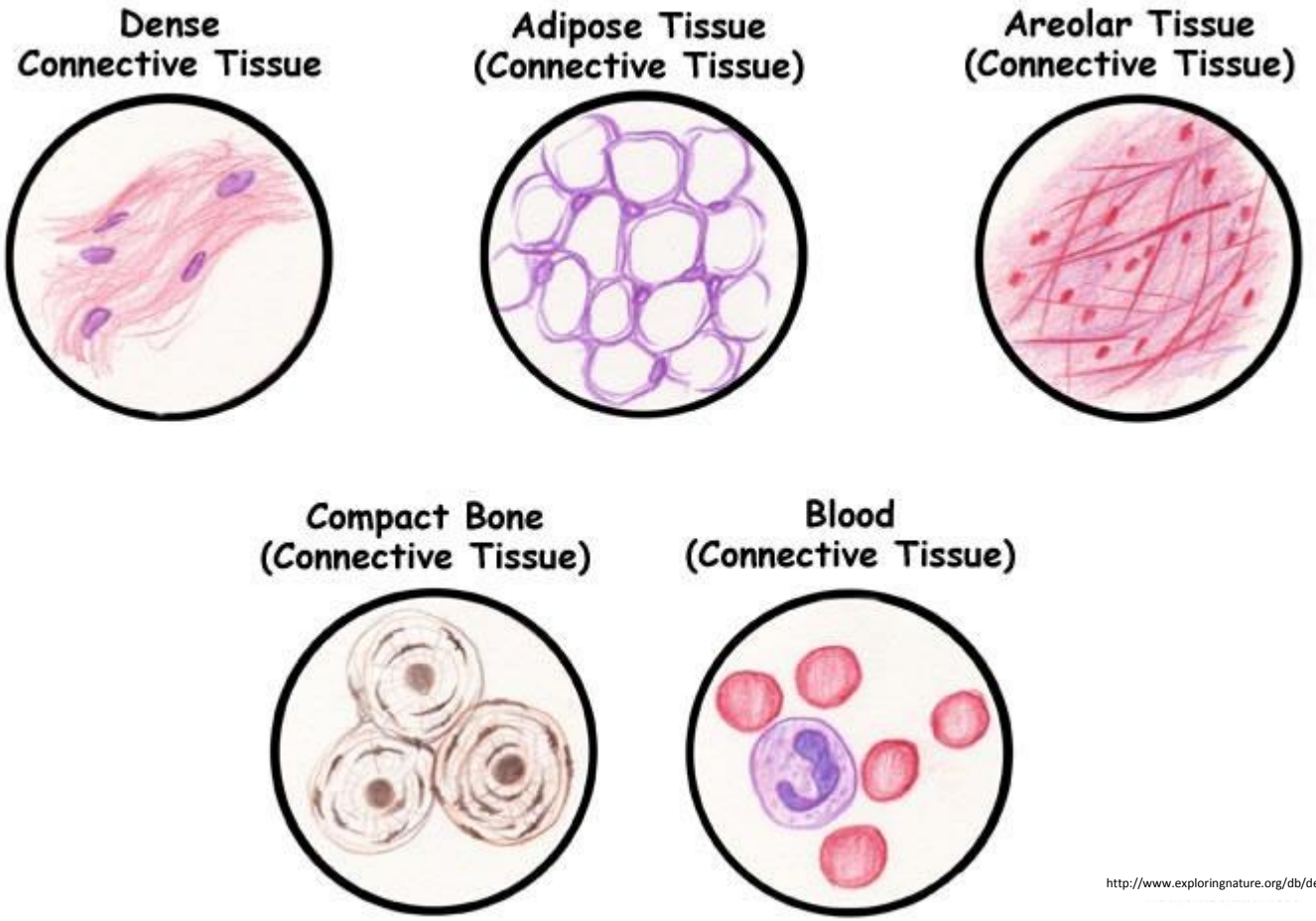
(J. Nutr. 136:2123-2126, 2006)

- Composition of amorphous ground matrix





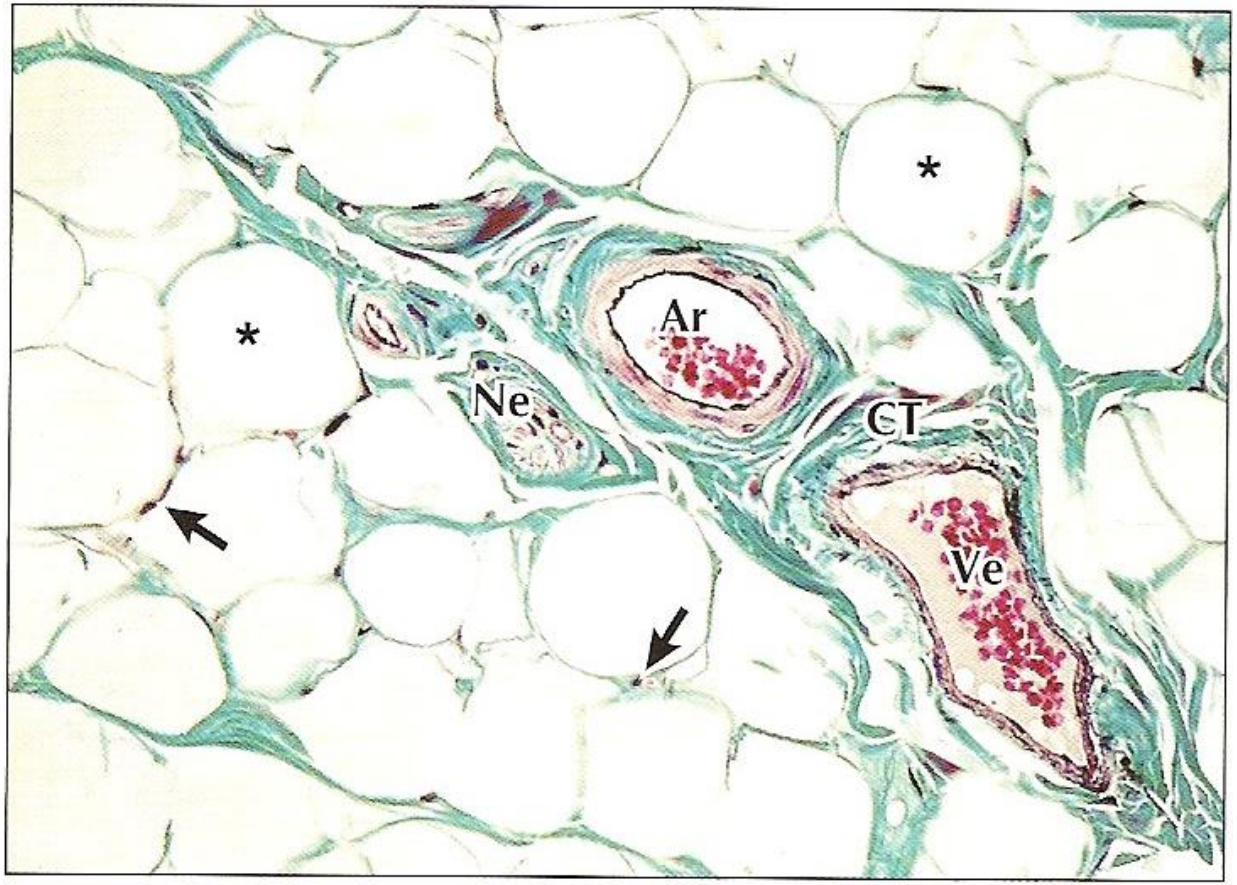
- Classification of specialized connective tissue



http://www.exploringnature.org/db/detail.php?dbID=21&detID=691

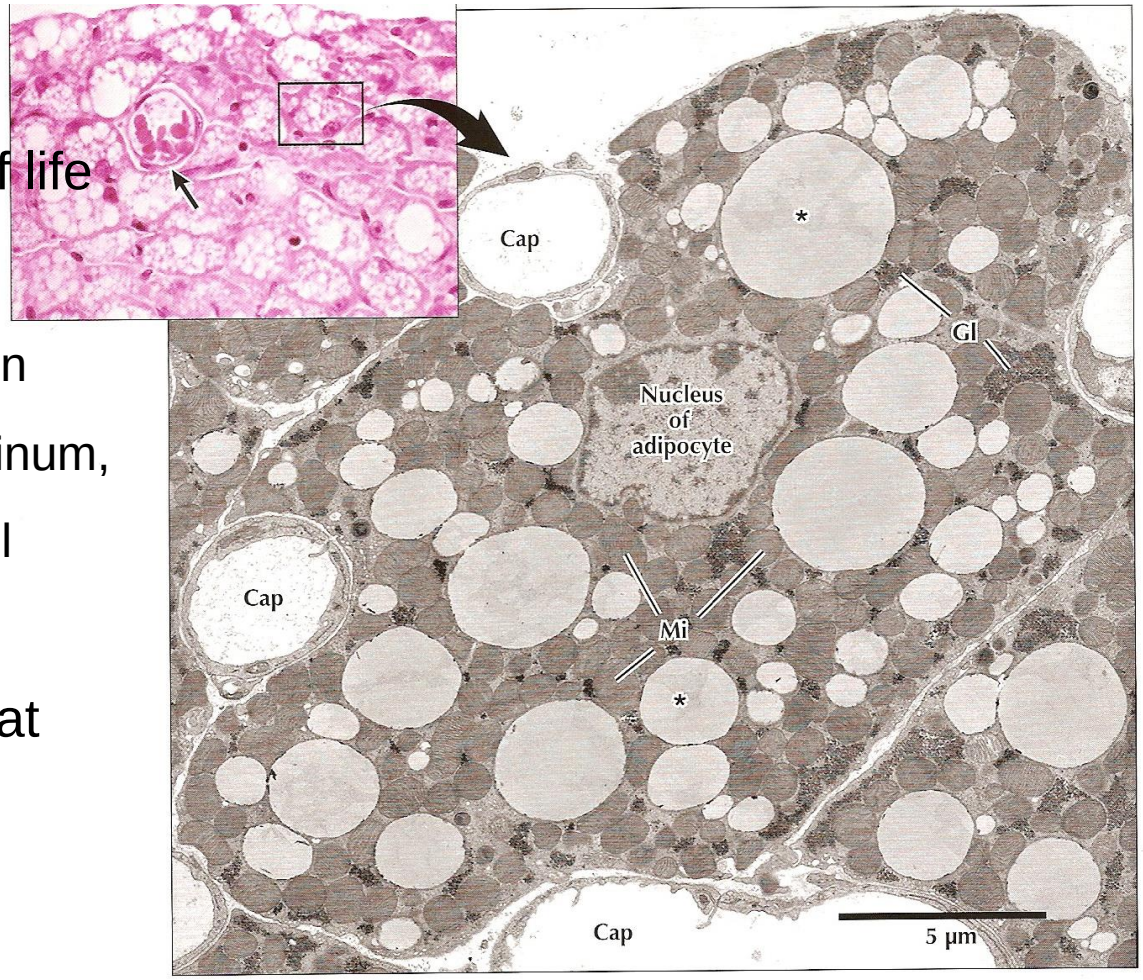
Adipose tissue

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



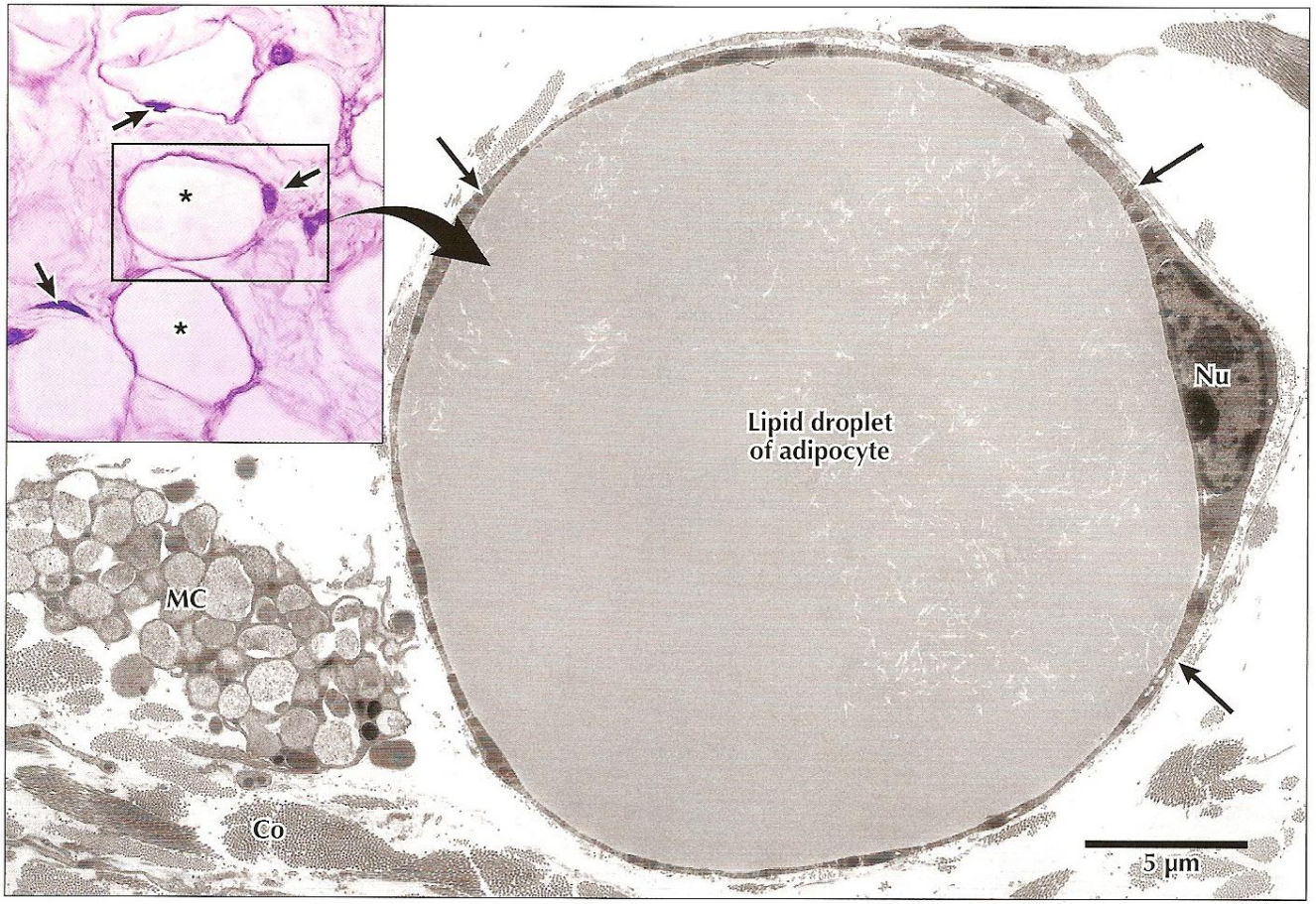
Brown adipose tissue

- fetus and child 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

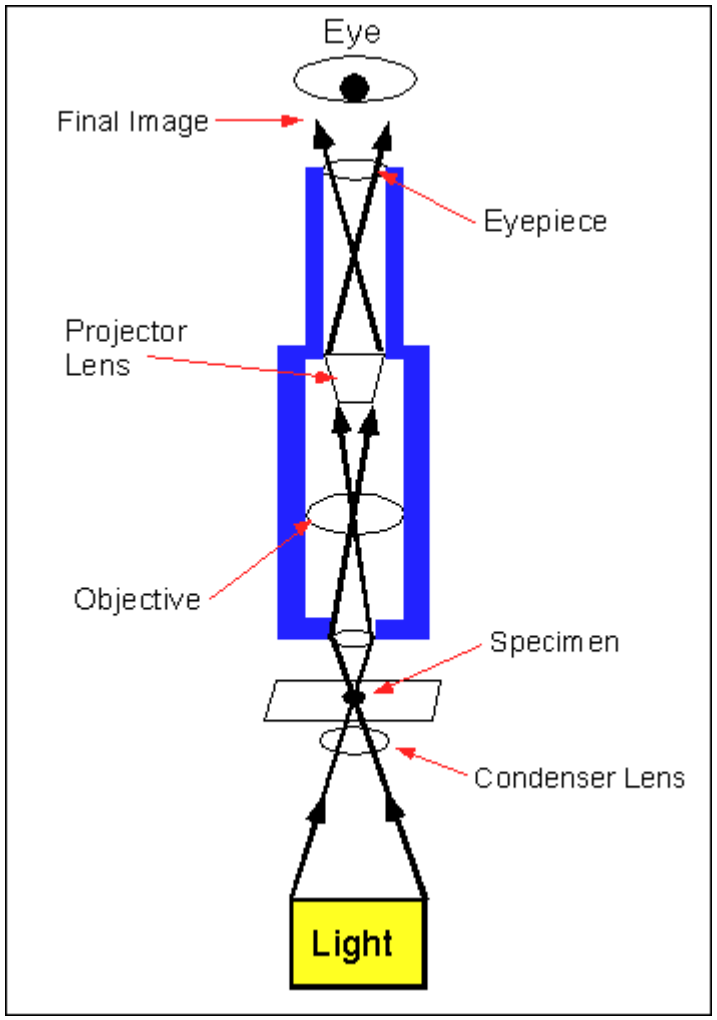


White adipose tissue

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




Nikon


Eye
Final Image
Eyepiece
Projector Lens
Objective
Specimen
Condenser Lens
Light

Instructions

1. Turn on the light source
2. Start with the lowest magnification (usually red, 5x)
3. Insert the slide with cover glass facing up
4. Focus on the sample using the rough focusing screw (big knob)
5. Then the adjust focusing using microscrew (small knob on the big one)
6. If the sample is not focused properly, use the optical correction
7. Make a general scheme of the tissue
8. Use higher magnification to observe details (10, 20x)
9. NEVER USE THE HIGHEST LENS (BLACK) = IMMERSION USE ONLY

10. When you finish, remove the slide, put the red lens to the position, switch off the light, cover the microscope

11. Enjoy the trip to the world of microscopic structures