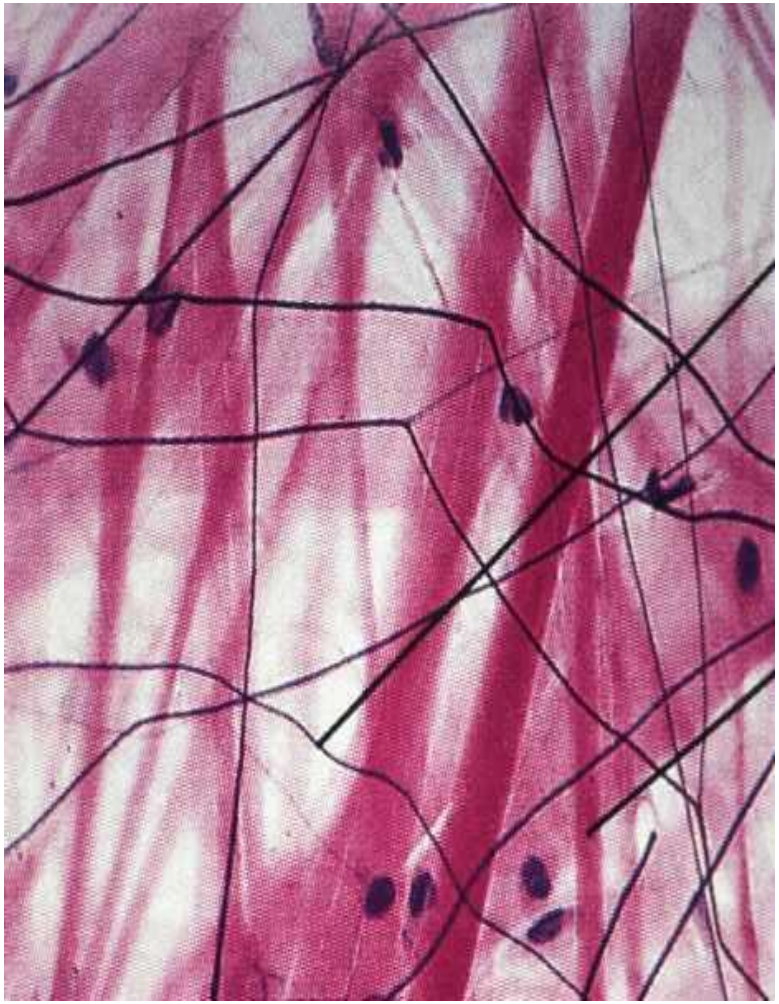
CONNECTIVE TISSUE



Common characteristics of CT:

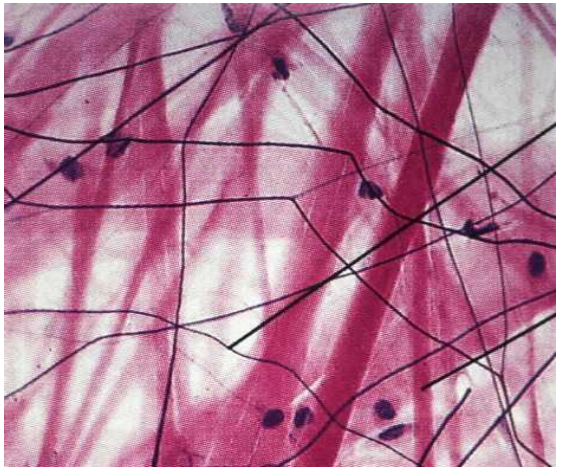
1. **Common origin**: all types of connective tissues arise from the mesenchyme (**mesoderm**).
2. **Variable degrees of vascularity**: some types of connective tissue have a rich supply of blood vessels, other is poorly-vascularized e.g. dense CT and cartilage is avascular.
3. **Several types of cells**: they are widely-separated and immersed in an abundant intercellular substance (extracellular matrix) formed by these cells.
4. **Extracellular matrix:** where as all other tissues are composed mainly of cells, connective tissue is **formed of abundant non-living extracellular matrix**, which separates the living cells of the tissue.

CONNECTIVE TISSUE

- The connective tissue (CT) is found everywhere in the body. It is the most abundant and widely-distributed tissue by its several types.
- **Structural elements of connective tissue:** it is made up of
- ➢ **cells**
- ➢ extracellular **matrix** which in turn has 2 elements the
- **ground substance**
- CT **fibers**.

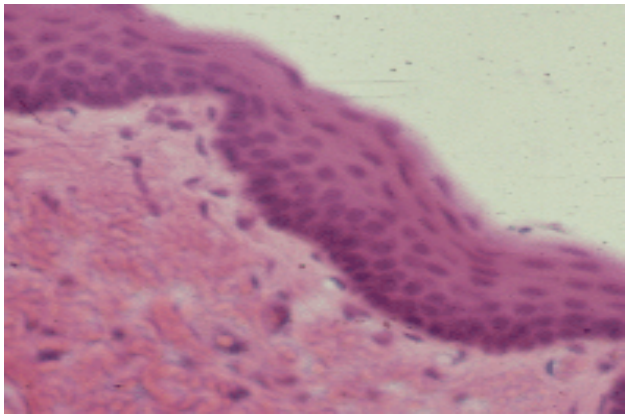
– Functions:

- Architectural **framework** of the body
- **Bind** together and provide **mechanical support** for other tissue (metabolic, defense, transport, storage)
- Nutrition
- Wound repair
- **Protection:** inflammatory response



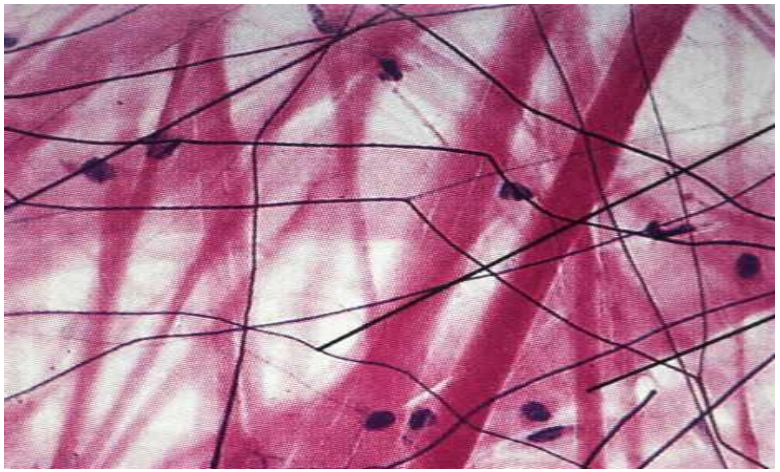
Epithelium

- **Cells:** closely aggregated, tight by junctional complexes
- **Intercellular substance:** very little
- **No fibers** in the ground substance
- **Blood vessels**: Avascular
- **Origin:** ectodermal, endodermal, mesodermal
- **Function:** covering or secretion (glands)



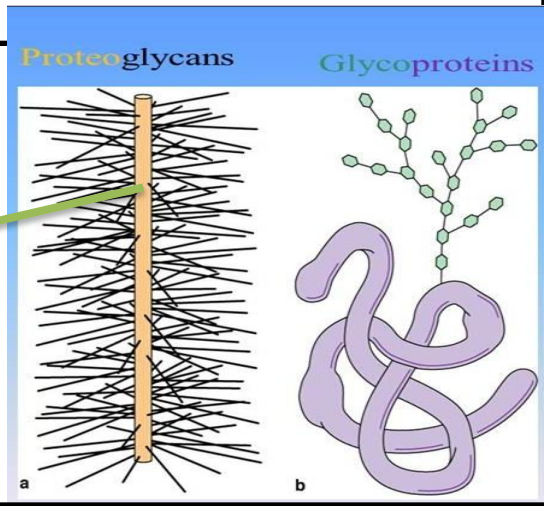
Connective T.

- **Cells:** few, widely separated
- **Intercellular substance** abundant
- **fibers** are present in the ground substance
- **Blood vessels:** rich
  Origin: mesodermal
- **Function:** support, defence and nutrition



Extracellular Matrix (ECM) Ground Substance

Lamina :structure in cell
laminin :glycoprotein in ground substance



1. Glycosaminoglycans (GAG)

- linear (unbranched) polysaccharides, e.g. heparan sulfate, condroitin sulfate, keratan sulfate, hyaluronic acid
- attract sodium & **hold water**
- very hydrophilic due to abundant negative charges.
- except for hyaluronic acid, are usually bound covalently to protein core as part of **a proteoglycan**

Core of protein

2. Proteoglycans: Forms thick gel that slows the spread of pathogens

- core protein + GAG side chains (like a bottle brush)
- bind cells, other proteins, and/or ECM components

3. Multiadhesive glycoproteins

- small glycosylated proteins containing NUMEROUS binding sites to cells, signaling molecules, and other ECM components
- e.g. **fibronectin** and **laminin**: important for adhesion of epithelial cells to the basal lamina via transmembrane integrin receptors.

Tissue fluid: Similar to blood plasma

Glycoprotein: adhesion cell with ground substance.
OR: adhesion fibers with ground substance.

^Ground substance: filling spaces between connective tissue.
Interstitial fluid role is *nutrition*

The connective tissue ground substance:

- It is the material that fills the spaces between the cells and contains the fibers. It is composed of:

➢ **Interstitial tissue fluid**, formed of plasma proteins of low molecular weight that escape through the capillary wall as a result of the hydrostatic pressure.

Edema: is an increase in the quantity of the tissue fluid due to loss of the equilibrium between the tissue fluids entering and leaving the matrix of CT.

➢ **Adhesive glycoproteins** e.g. **fibronectin** and **laminin**. They serve mainly as connective tissue glue that allows connective tissue cells to bind themselves to matrix elements.

*(انه لازم يكون فيه توازن بين السائل الداخل في ،ال intracellular space and the fluid (طالع)in the lymphatic.

- **Proteoglycans**, consist of a protein core to which glycosaminoglycans (GAGs) are attached. The strand-like GAGs are large, negatively-charged polysaccharides that extend from the core protein like the fibers of a bottle brush. GAGs are like chondroitin sulfate and keratan sulfate.
- The proteoglycans tend to form huge **proteoglycan aggregates** with hyaluronic acid that trap water, forming a substance that varies from a fluid to a viscous gel
- Hyaluronic acid that trap water, forming a substance that varies from a fluid to a viscous = **Jelly like**

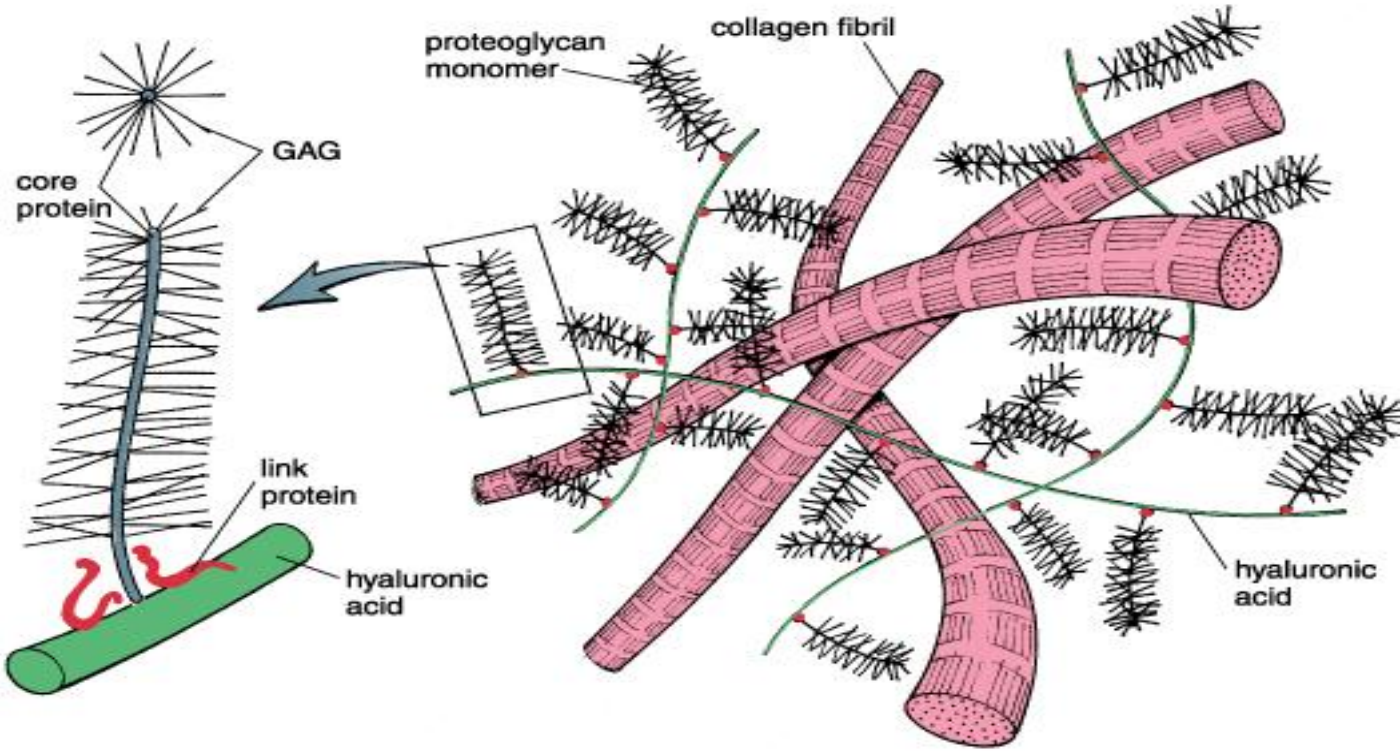
Jelly like: هاي الخاصية بتخليها تمنع انتشار العدوى
Prevent Spread of infection

Function :

Rich in protein

- 1-The ground substance **holds large amounts of fluid** and functions as a medium through which nutrients and other dissolved substances can diffuse between the blood capillaries and the cells.
- 2-Its gel state serves to **resist compression** and to act as a **lubricant**.
- 3- It also acts as a **barrier** to bacterial penetration. Some virulent bacteria can secrete the enzyme hyaluronidase that hydrolyzes the ground substance and facilitates bacterial invasion to CT.
- **4- Shock absorption. (from the record)**

That means the GAG cause trapping of water.



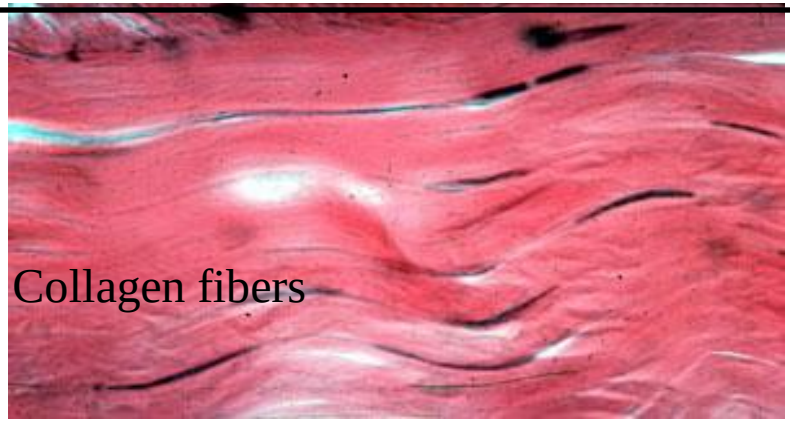
Connective tissue fibers

^Collagen: 20 type
Just 3 found in basement membrane
Type 3,4,7

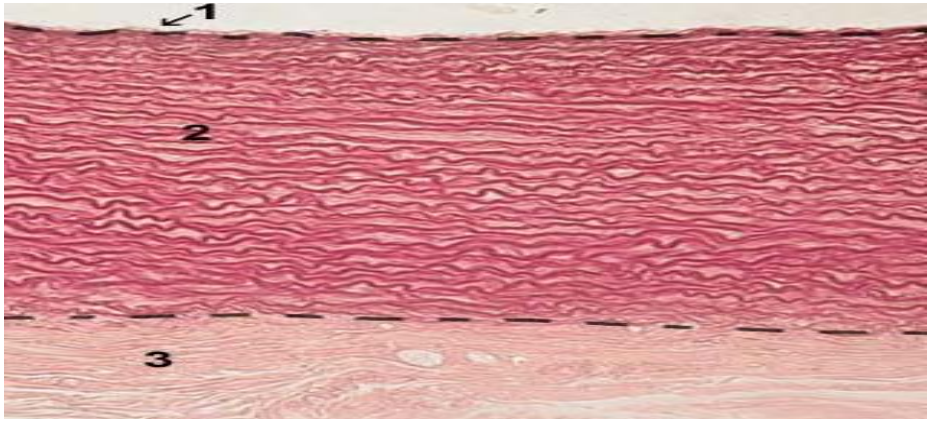
- **The fibers of connective tissue provide support. They are embedded in connective tissue matrix. There are three types of CT fibers;**
  - ❖ **collagen fibers,**
  - ❖ **elastic fibers**
  - ❖ **reticular fibers.**

في الحقيقة نوعين فقط

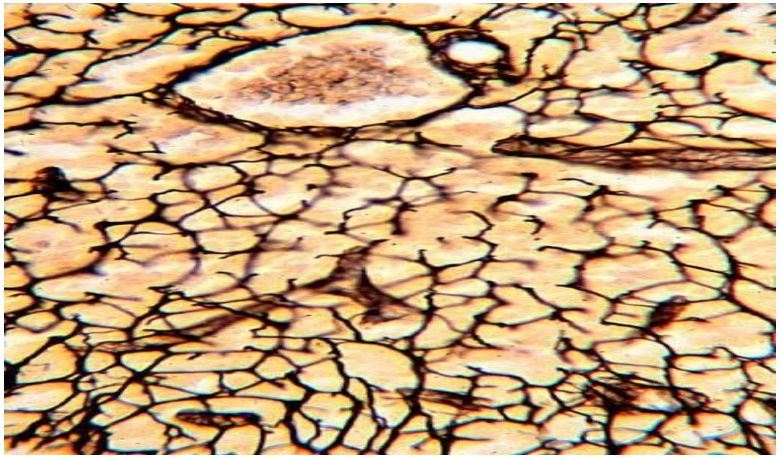
Type 3 collagen fiber



Collagen fibers



Elastic fibers



Reticular fibers

Collagen fibers= (white fibers)

Type 1 ,, site : in the eye , tendons , ligaments of muscles.


Collagen bundles stained by H&E

Characters:

–Collagen fibers are the most abundant CT fibers. → Most common in the body (عموماً)

–They are the strongest **(also flexible)** and provide **high tensile strength** (that is the ability to resist longitudinal stress). Stress test shows that collagen fibers are stronger than steel fibers of the same size.

–In fresh state, collagen fibers have a glistening white appearance; they are therefore also called **white fibers**. → لانها بتبين بالعين المجردة لهيك لونها أبيض

•Histological features:

–In longitudinal section, collagen fibers appear as cylindrical structures that run in wavy bundles

–The individual fibers do not branch while the bundles of fibers often do.

Hematoxylin = violet //Eosin = pink

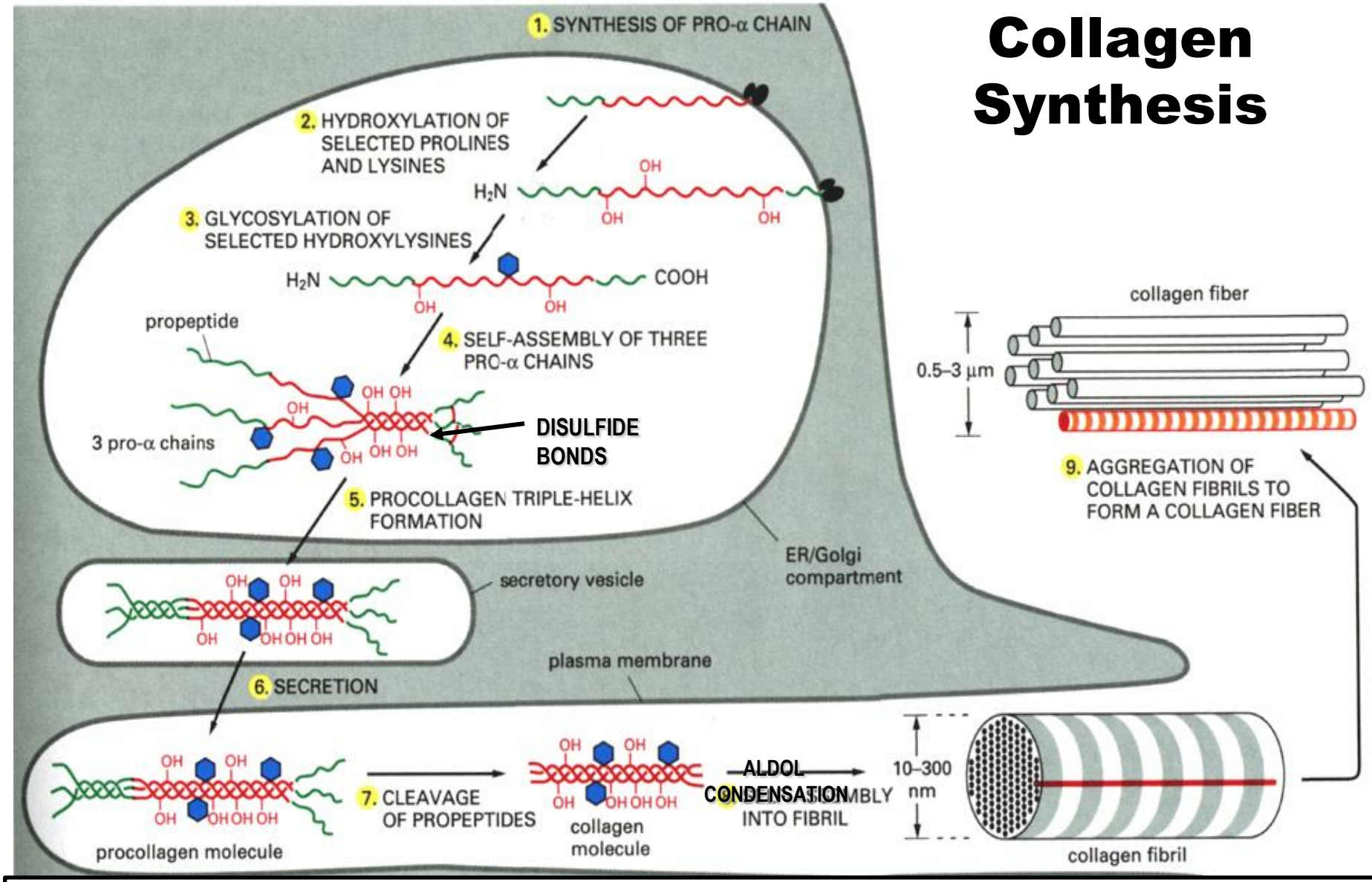
–They stain pink with H&E (eosinophilic), blue with Mallory's stain and green with Masson's trichrome stain. → Collagen protein take acidic dye = pink

- **Synthesis of collagen:**

the fibroblasts (بتصنع كل أنواع)Fibers and ground substance

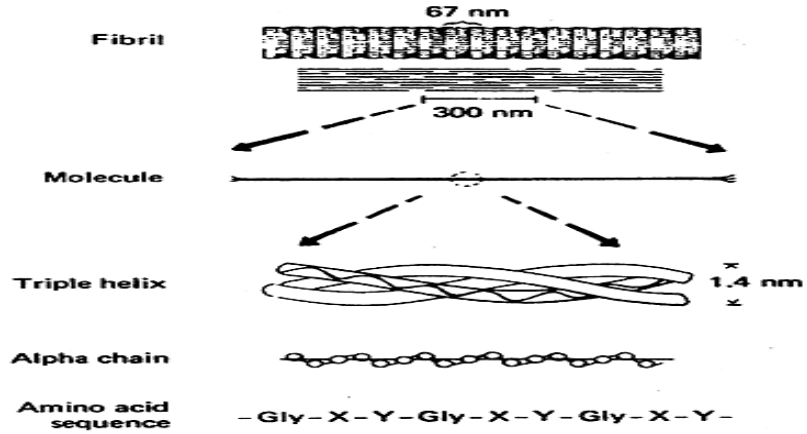
- Procollagen, a precursor of collagen protein is formed inside the fibroblasts then it is released by exocytosis into the extracellular space.
- Procollagen is cleaved to form collagen molecules which assemble spontaneously into collagen fibrils.
- Collagen fibrils in turn are further assembled into collagen fibers which may be bundled together into the thick collagen bundles.
-
- **Types of collagen:**
- More than **20 different types of collagen** fibers are known. They differ by their molecular composition, morphologic features, distribution in tissues and functions.
- The major types of collagen are:
- Type I collagen fibers in connective tissue proper, and in fibrocartilage and bone matrix.
- Type II collagen fibrils in cartilage matrix (hyaline and elastic).
- Type III collagen fibers form the reticular fibers.
- Type IV in basement membrane.

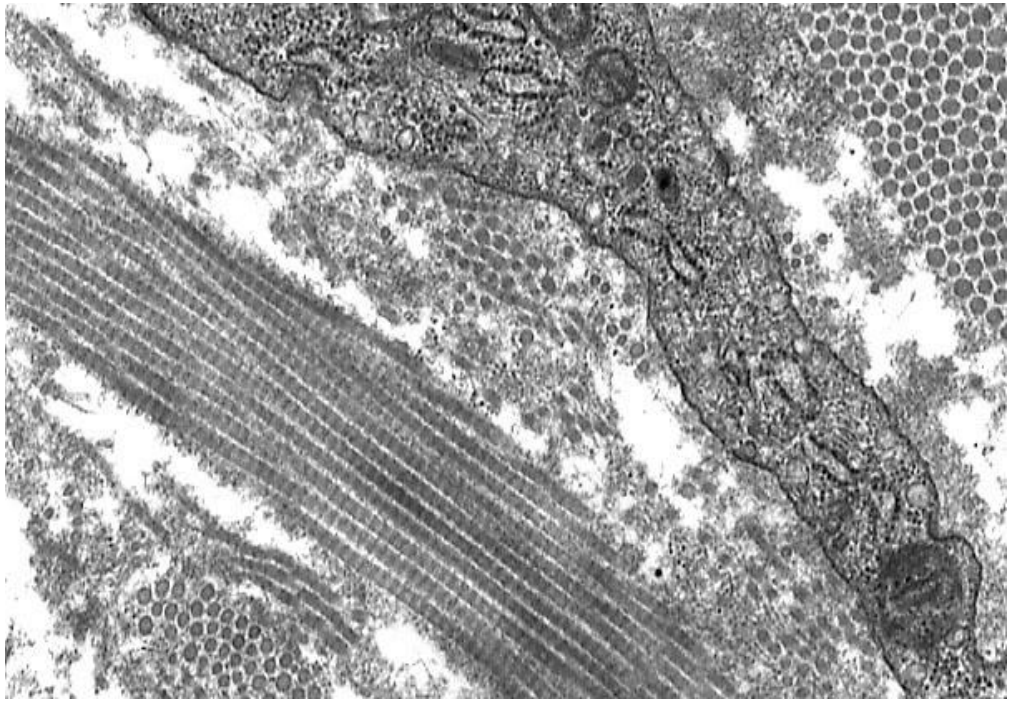
Collagen Synthesis

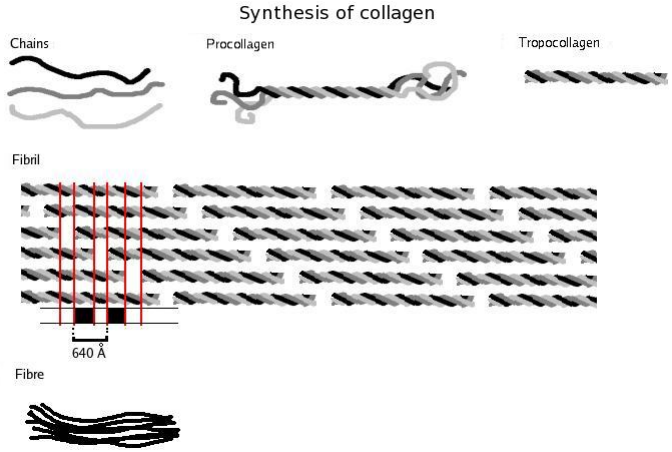


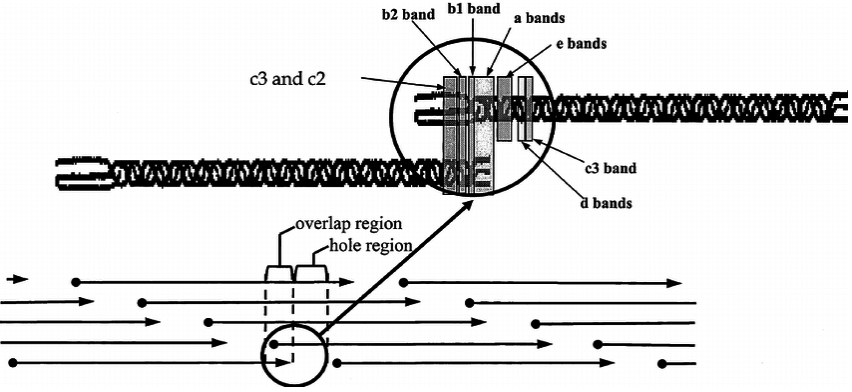
تبدا الخلية تصنع collagen ... الفا هيلكس بتاخد 3 منهم وبتلزقهم وبتعملTriple-helix والاشياء الزيادة بصيرلهم Cleavage وبطلع Collagen fibril بصيرله Overlap وبعمل Collagen fiber ← no overlap فيها جزء فاتح

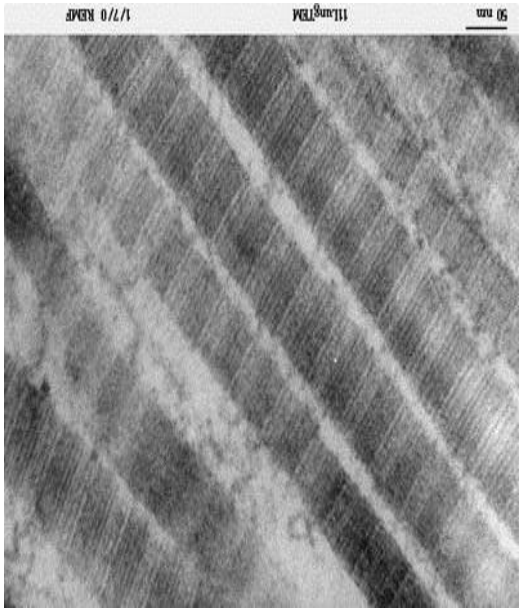
← over lap جزء غامق

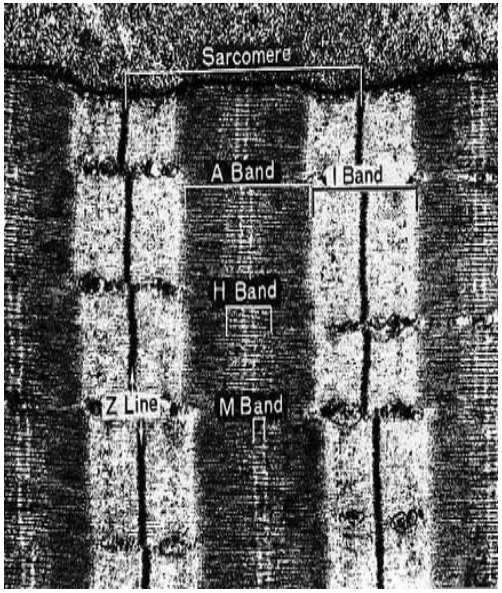

67 nm
Fibril
300 nm
Molecule
Triple helix
1.4 nm
Alpha chain
Amino acid sequence
– Gly – X – Y – Gly – X – Y – Gly – X – Y –



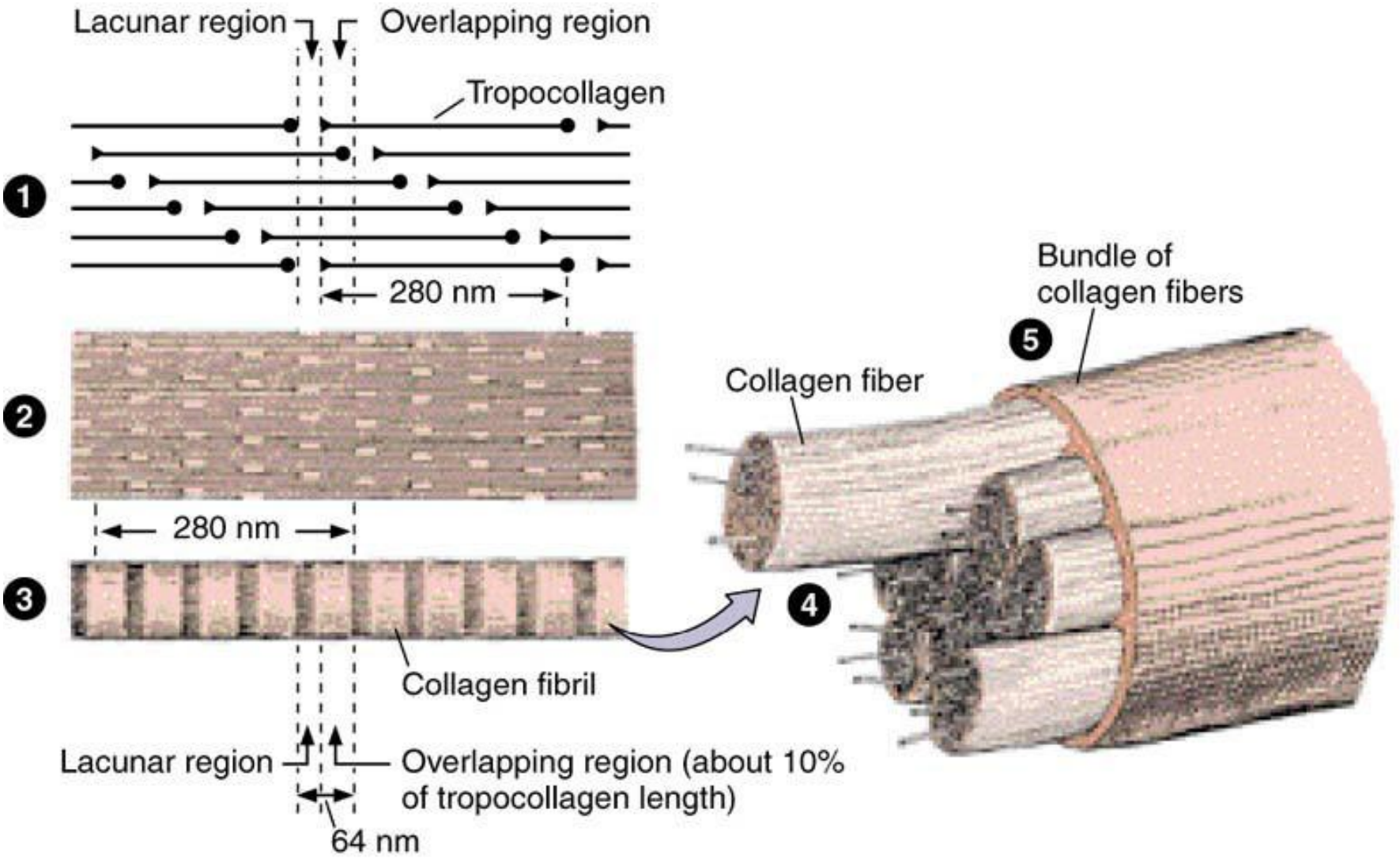

Synthesis of collagen
Chains
Procollagen
Tropocollagen
Fibril
640 Å
Fibre


b2 band
b1 band
a bands
e bands
c3 and c2
c3 band
d bands
overlap region
hole region



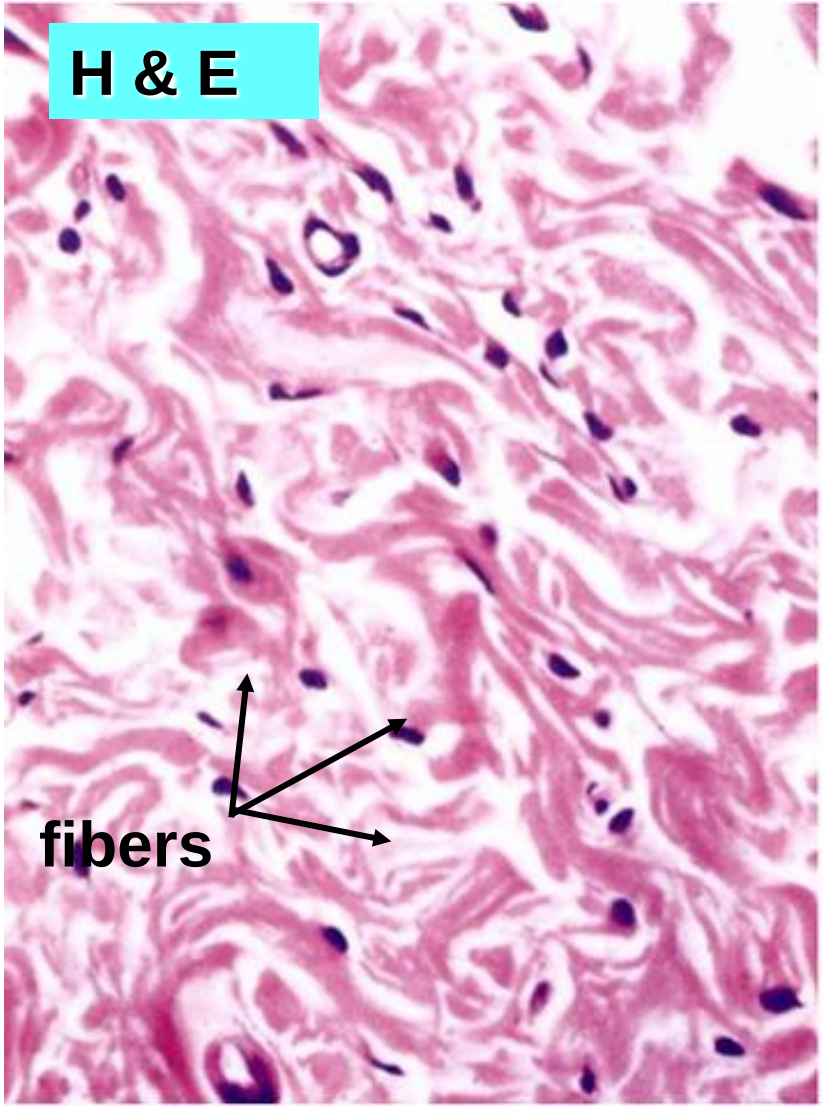

Sarcomere
A Band
I Band
H Band
Z Line
M Band

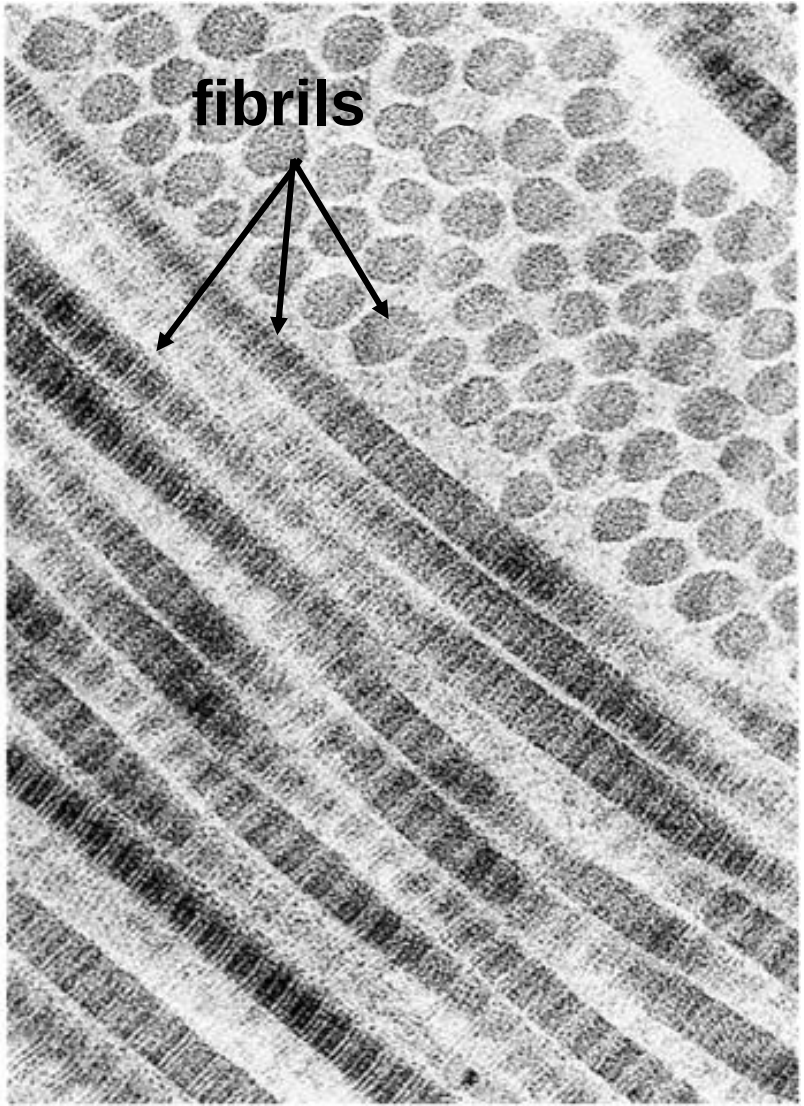
Assembly of collagen fiber bundles



Collagen Fibers

Irregular type (بوجود) capsule of Organs.
Regular (white color) collagen type >> which is regularly arranged.





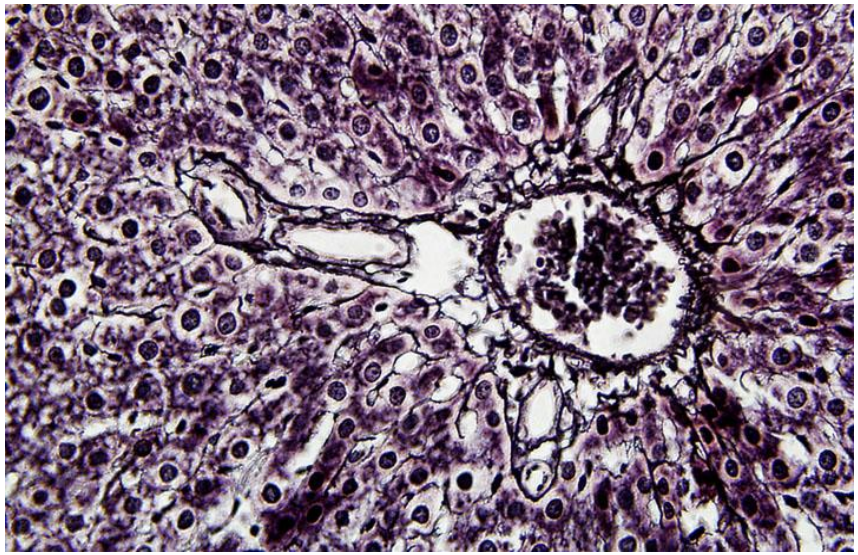
Major Collagen Fiber Types (out of at least 20)

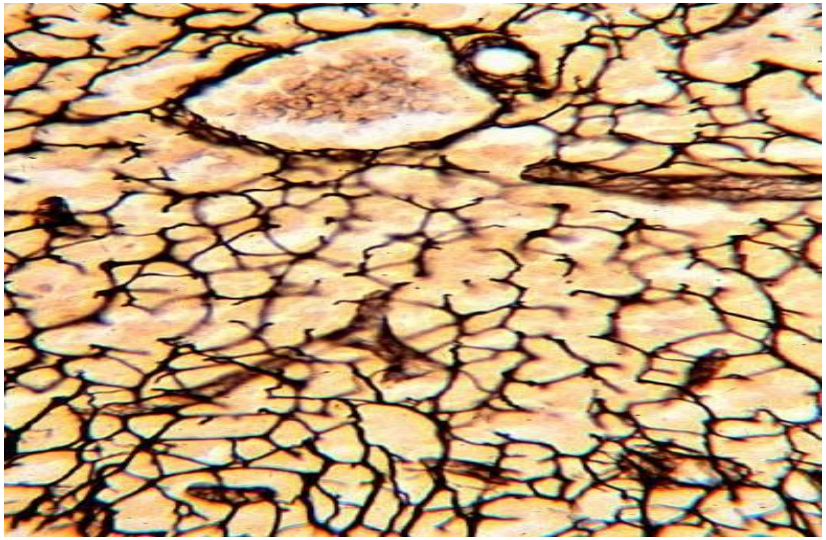
According to the chemical composition of collagen molecules

Collagen Type	Tissues	Function
Fibril-forming collagens (these are visible)		
I (most abundant)	Skin, tendon, bone, dentin	Resistance to tension
II	Cartilage, vitreous of eye	Resistance to pressure
III (reticulin)	Skin, muscle, blood vessels, liver, etc.	Structural framework and stability
Network-forming collagens		
IV	All basement membranes	Support and filtration
Fibril-associated collagens with interrupted triple helices (FACIT)		
VI, IX	Assoc. w/ type I and II fibrils	Fibril-fibril / fibril-ECM binding
Anchoring filament collagens		
VII	Epithelia	Epidermis to basal lamina

Network Type 3

Reticular (Reticulin) Fibers





Not stain with H&E

- **Form a delicate supporting framework** for highly cellular tissues (endocrine glands, lymph nodes, liver, bone marrow, spleen, smooth muscle).
- **Composed mainly of Type III collagen,** with a carbohydrate moiety that reduces Ag+ to metallic sliver **= argyrophilic. (gives brown network)** بتحب ال silver
- **Special stain**: silver impregnation to visualize.
- **Thinner than type I collagen** (Type III fibrils are 30-40 nm diameter; type I fibrils are ~200 nm diameter) الارقام مش مطلوبة
- made by **reticular cells** (specialized modified fibroblasts) and vascular smooth muscle cells

Elastic fibers

Characters:

•These fibers contain protein, elastin that allows them to stretch and recoil like rubber bands. Because the fresh elastic fibers appear yellow, they are called **the yellow fibers**.

•**Histological features:**

•Elastic fibers may exist in two different forms:

•Individual long and thin fibers that branch in the extracellular matrix.

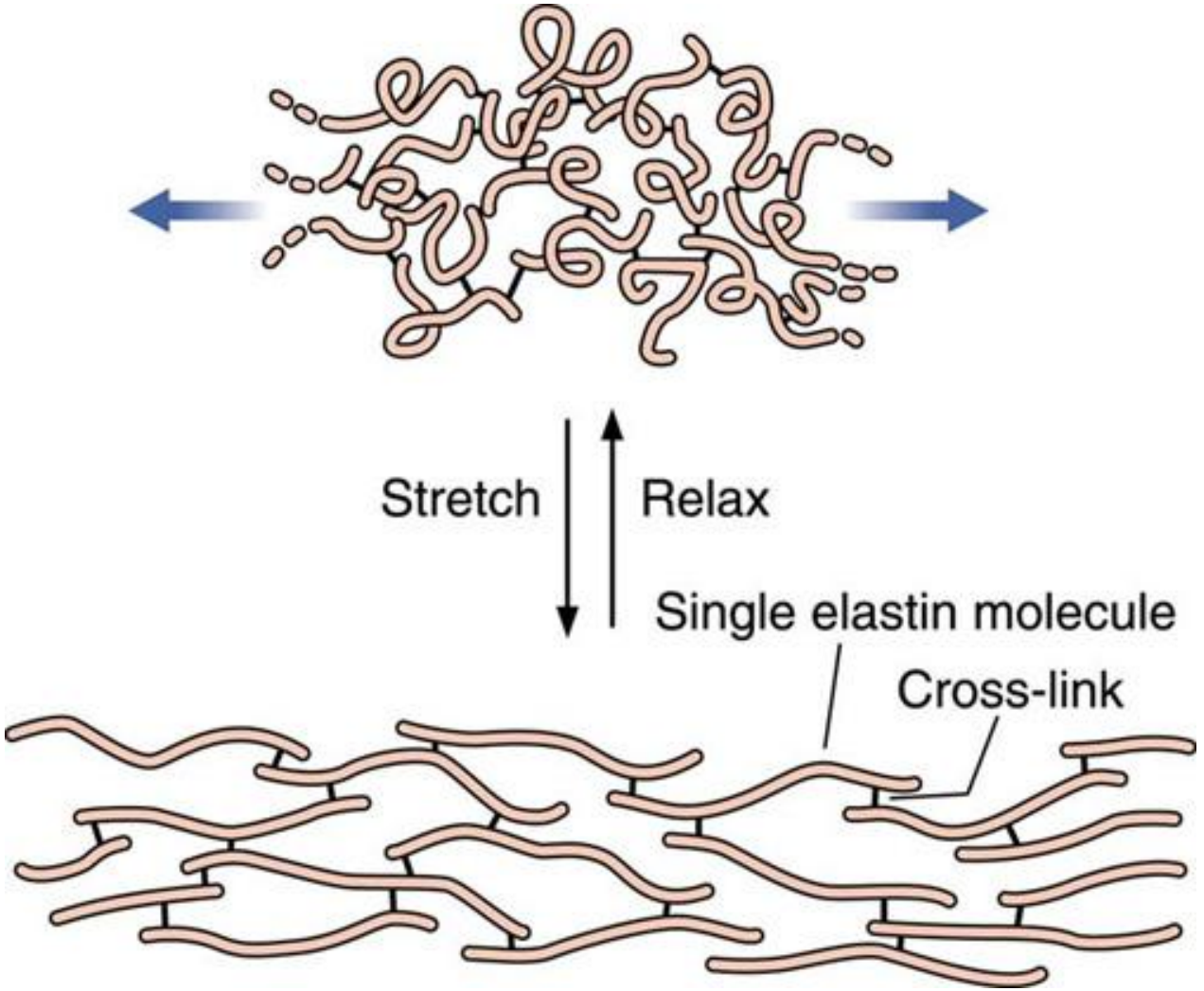
•In the wall of large blood vessels they form fenestrated parallel sheets

•They stain weakly with H&E.

•Special staining with **orcein stain** gives a brick-red color to elastic fibers, while staining with **V.VG stain** gives them a dark violet color.

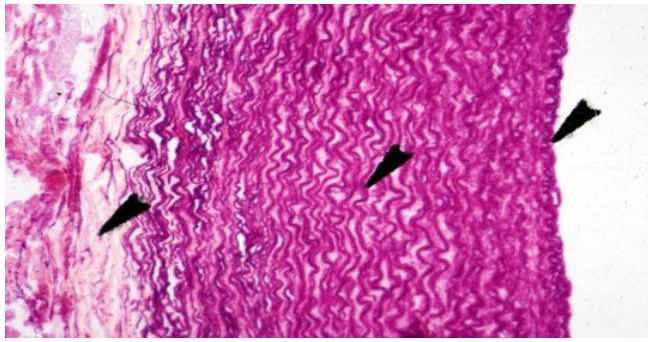
As aorta

Network of elastin molecules can stretch and recoil like a rubber band



Elastic Fibers

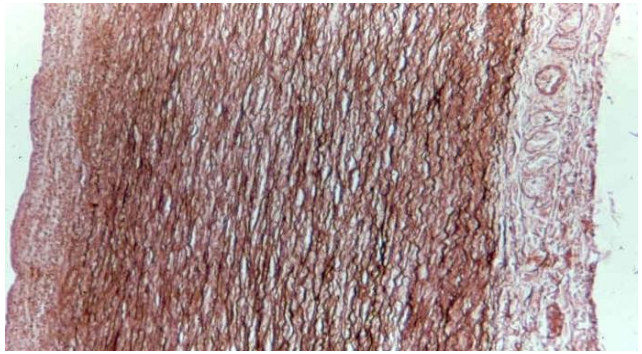
Elastic fibers are found in : Vocal cord / large blood vessel / lung Which these need recoil & elasticity



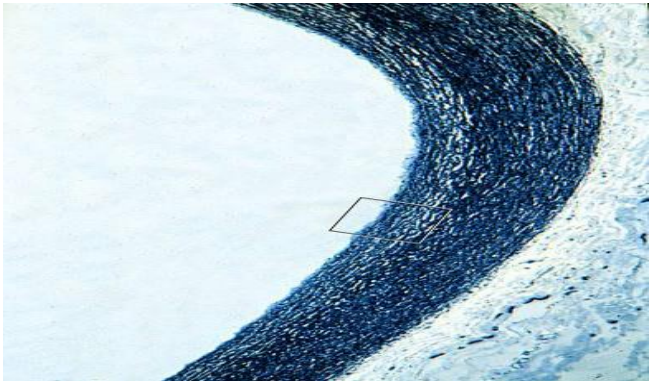
Elastic fibers (yellow fibers): can be stretched to one and one-half times their length, but recoil to their initial length when released.

Fresh elastic fibers appear yellow and are also called **yellow fibers.**

Stain : H&E , Orcein(brick red) ,VVG(dark violet or black)

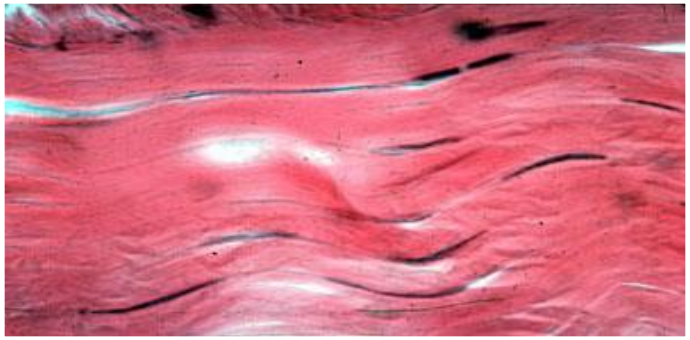


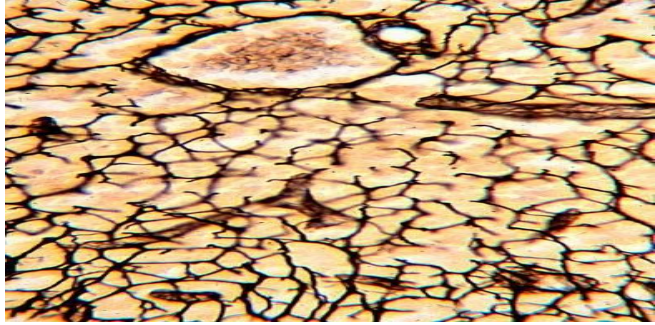
Elastin: is rich in glycine and proline, but it contains little or no hydroxyproline and hydroxylysine . uniquely contains **desmosine** and **isodesmosine**, which are thought to cross-link the molecules into a network of randomly coiled chains. This cross-linking is responsible for its rubber-like properties.



They are found where greater elasticity is needed **present in large amounts in ligaments, lung, skin, bladder, and walls of blood vessels.**

Fibers



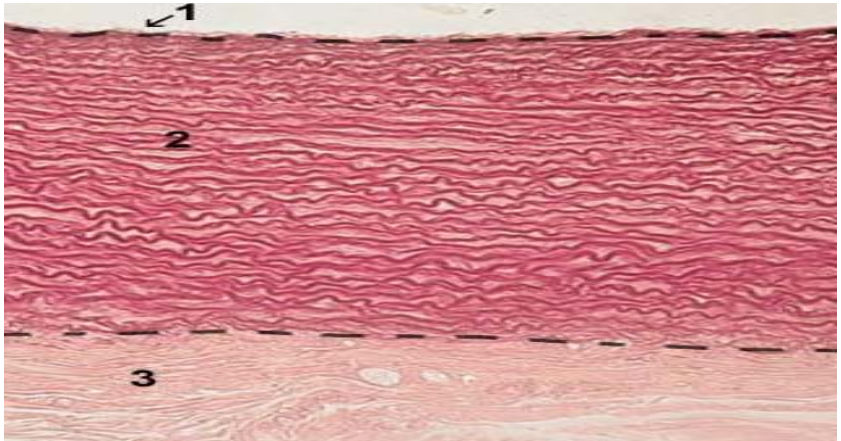


- The most **numerous**
- White if in great number **(white fibers)**
- **Strong and flexible**
- Fibers do not branch but bundles can do
- Formed of **collagen protein**
- Stain pink with eosin
- Types of Collagen Fibres

- **Thin branching**
- **Not** stained by H&E
- Stained dark brown with **silver stain**
- Consist of type **III collagen**
- Supportive function

Highly cellular Organ = support
Sites : liver , bone marrow , lymphatic organ (spleen)

- Yellow if in great number (**Yellow fibers)**
- Elastic and **stretchable**
- Fibers can **branch** and unit
- Formed of **elastin** protein
- Stained weakly by H&E
- Stain brick red by **orcein**
- Stain dark violet with **V.V.G** stain.



Thank You