Connective tissue

The connective tissue is one of the four basic types of animal tissue, along with epithelial tissue, muscle tissue, and nervous tissue. Connective tissue is maintaining the form of the body and its organs. It differs from epithelium by the presence of large amount of extracellular matrix. The connective tissue is composed of **cells** and **extracellular matrix**, which composed of **ground substance**, **protein fibers** (collagen, elastic, and reticular fibers), and **tissue fluid**. The cells that embedded in the matrix are responsible of manufacture and maintain of fibers and ground substance. The wide variety of connective tissue types in the body reflects variations in the composition and amount of the cells, fibers, and ground substance which together are responsible for the structural and functional diversity of connective tissue. The variation in proportions of these components form the basis of classification of connective tissue.

The connective tissues develop from mesenchyme which itself derived the middle layer of the embryo, the mesoderm. The mesenchymal cells of mesenchyme being the point of origin of all types of connective tissue cells.

Functions of connective tissue

-Mechanical or support role

It provides a matrix that connects and binds cells and other tissues in organs and ultimately gives support to the body. It forms the capsules that surround the organs. Act as stroma forming the structural framework within organs of the body.

2-Defense and protection role

It has role in defense mechanism against any foreign particles due to its content of phagocytic cells which engulf inert particles and microorganisms that enter the body and destroy cellular debris. Also connective tissue have plasma cells which produce specific proteins called antibodies that combine with foreign proteins of bacteria and viruses which called antigen or with the toxins produced with bacteria and combat the biologic activity of these harmful agent. The connective tissue also protects the body, by forming physical barrier to prevent the invasion of microorganisms that pass through the epithelium.

3- Nutrition role

The connective tissue play an important role in cell nutrition. The matrix of connective tissue serves as the medium through which nutrients and oxygen and metabolites wastes are exchanges between the cells and their blood supply.

Extracellular matrix

Ground substance

The fibers and cells of connective tissue are embedded in an amorphous material called ground substance. It is an amorphous, transparent, gel-like material composed of mixture of macromolecules **glycosaminoglycans**, **proteoglycans** and **glycoproteins** that differ in amount and type in different connective tissues. The mixture of ground substance fills the space between the cells and fibers of connective tissue and, because it is viscous, acts as both a lubricant and a barrier to the penetration of any foreign particles in the

tissues. Also act as medium through which all nutrients and wastes must pass between blood vessels and cells of connective tissue.

The ground substance composed mainly of three types of macromolecules form various interactions with each other, with fibers and with the cells of connective tissue.

1-Glycosaminoglycans (GAGs)

They are linear, long, unbranched polysaccharide chains. It formed by repeating disaccharide units usually composed of a **uronic acid** and a **hexosamine**. The major glycosaminoglycans of connective tissue are **keratan sulfate**, **heparin sulfate**, **chondroition sulfate** and **hyaluronic acid**.

They have lubrication function in connective tissue in addition to structural function where binding of fibers. Also act as a medium by which nutrients, gases, and metabolites can be exchanged between blood and tissue cells.

2-Proteoglycans

They are large macromolecules composed of a **core of protein** to which **glycosaminoglycans** molecules are covalently bounded (Figure.1). They are responsible for the physical properties of ground substance, where they responsible for the gel state of the extracellular matrix. In addition, they are aid in preventing the spread of microorganisms and their toxic materials from the site of an infection.

3- Glycoproteins

They are large macromolecules composed of **polysaccharide-protein complexes**. The major types are fibronectin, laminin and chondronectin. They have binding sites for several components of the extracellular matrix. They have important roles in the adhesion of cells to the extracellular matrix.

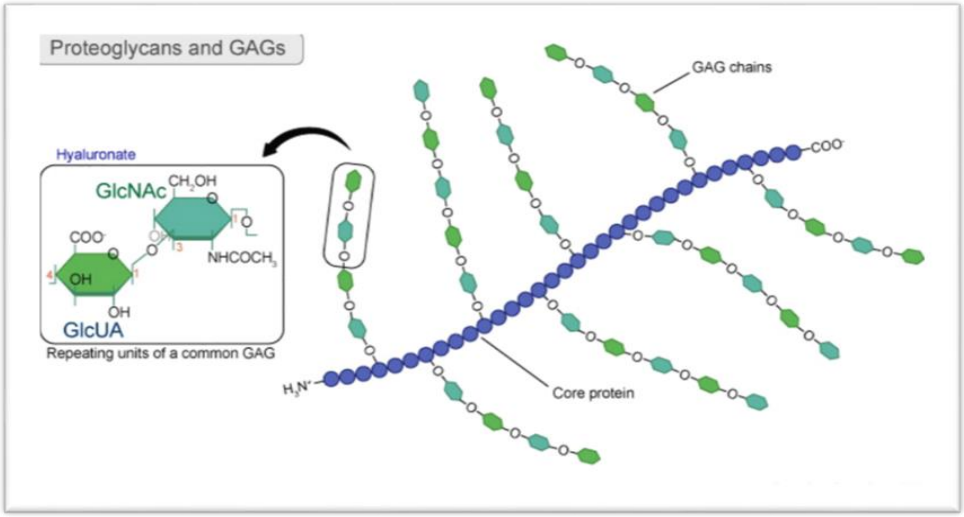

Figure (1): The molecular structures of proteoglycan and glycoprotein.

Tissue fluid

In connective tissue, in addition to the ground substance, there is a small quantity of free fluid called interstitial or tissue fluid, that is similar to blood plasma in its content of ions and diffusible substances. Tissue fluid contains a small percentage of plasma proteins of low molecular weight that pass through the capillary walls into connective tissue.

Edema

It is an abnormal accumulation of watery fluid in the intercellular spaces of connective tissue. Under normal condition, the water in the intercellular substance of connective tissue come from the blood. The water passing through blood capillary walls into the surrounding connective tissue and then returns back into the blood capillaries, where there is equilibrium exist between the water entering and water leaving the intercellular substance of connective tissue. The blood brings to connective tissue, the various nutrients and get rid metabolic waste away of tissue. Two forces act on water

contained in the capillaries: the **hydrostatic pressure** of the blood which forces water out across the capillary wall; and **osmotic pressure** of the blood plasma, which draws water back into the capillaries (Figure.2).

In several pathologic conditions, the quantity of tissue fluid increase within connective tissue causing edema. This condition is characterized by enlarged spaces between the components of the connective tissue caused by the increase in liquid (water) between the components of connective tissue.

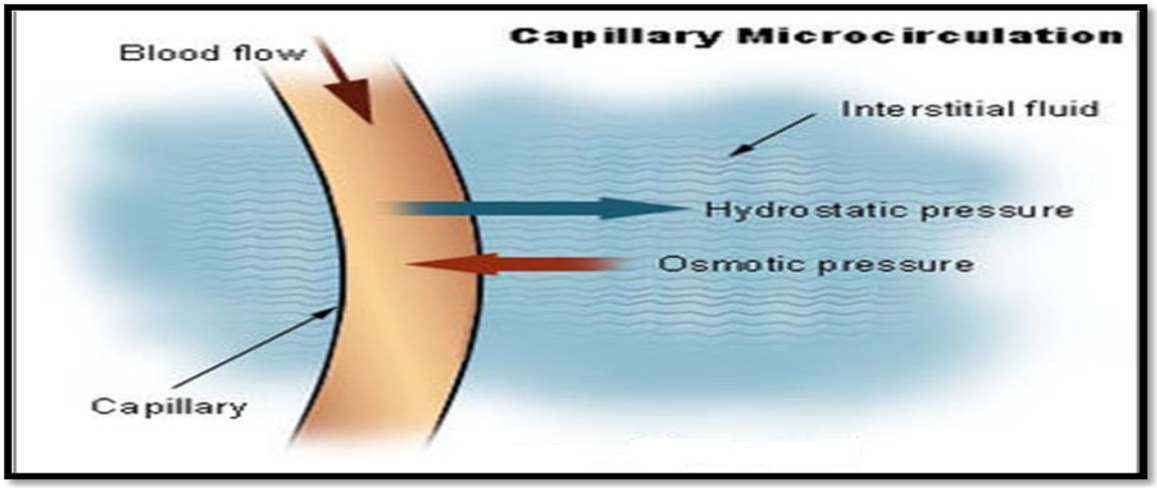

Figure (2): Movement of fluid through connective tissue.

Connective tissue fibers

Connective tissue fibers are formed by proteins that polymerize into elongated structure. There are three main types of fibers are collagen, elastic, and reticular fibers. Collagen and reticular fibers are both formed by the protein collagen, and elastic fibers are composed mainly of protein elastin. They are distinguished by their appearance, biochemical and mechanical properties. These fibers distributed in variable proportions among different types of connective tissue. The predominant fiber type is responsible for conferring specific properties on the tissue.

1- Collagen fibers (white fibers)

They consist of **collagen protein**, in fresh state, they appear colorless or white and therefore called white fibers. The fibers in connective tissue are usually less than (10 µm) in diameter. The collagen fibers are the most widely distributed fibers of the connective tissue and are present in all types of connective tissue but vary greatly in their abundance.

Histologically, these fibers appear as straight or slightly wavy structures, not branched and run in bundle (Figure.3) and (Figure.4).

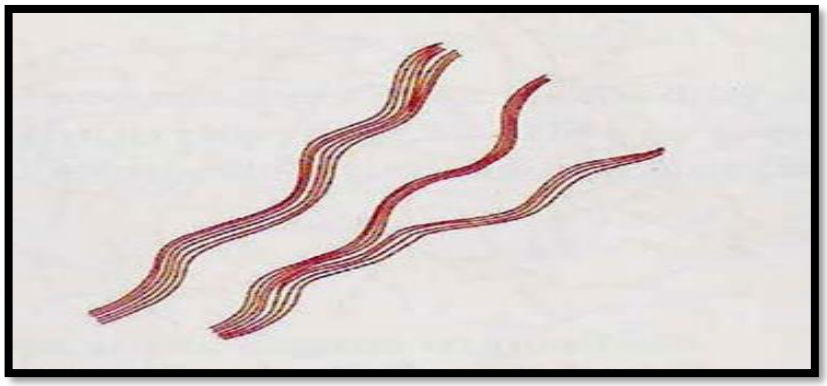

Figure (3): The characteristic features of collagen fibers

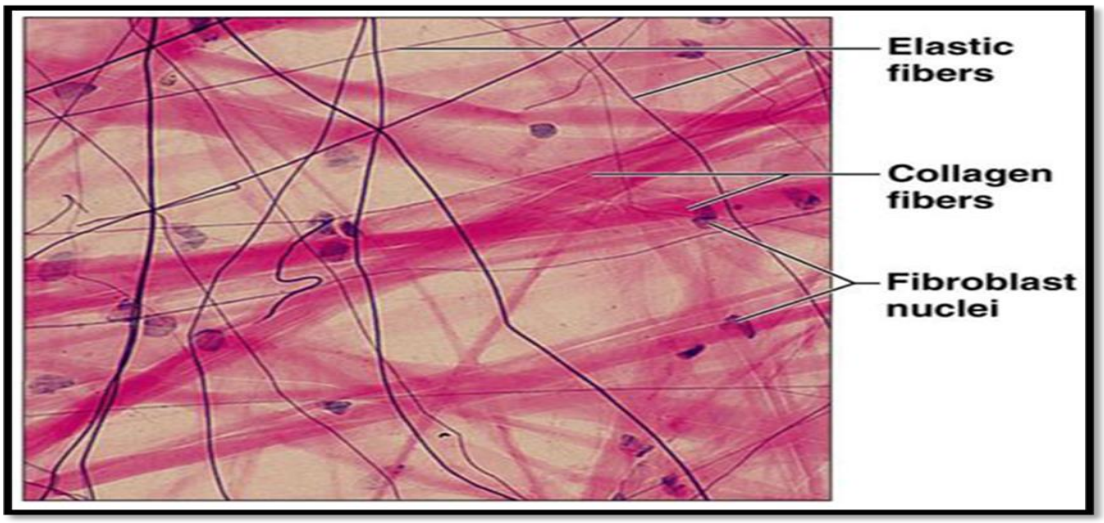

Figure (4): The distribution of collagen fibers in connective tissue.

Within **bundle**, the **collagen fibers** are hold together by a small amount of mucoprotein, each fiber consists of parallel aggregation of thinner fibrils. Each **fibril** is composed of microfibrilis, and the microfibrilis made of smaller units called **tropocollagen** molecules. Each molecule composed of three polypeptide chains called α-chain arranged in triple helix (Figure.5). The collagen fibers are flexible, inelastic and have high tensile strength. These fibers confer both flexibility and strength to the tissue.

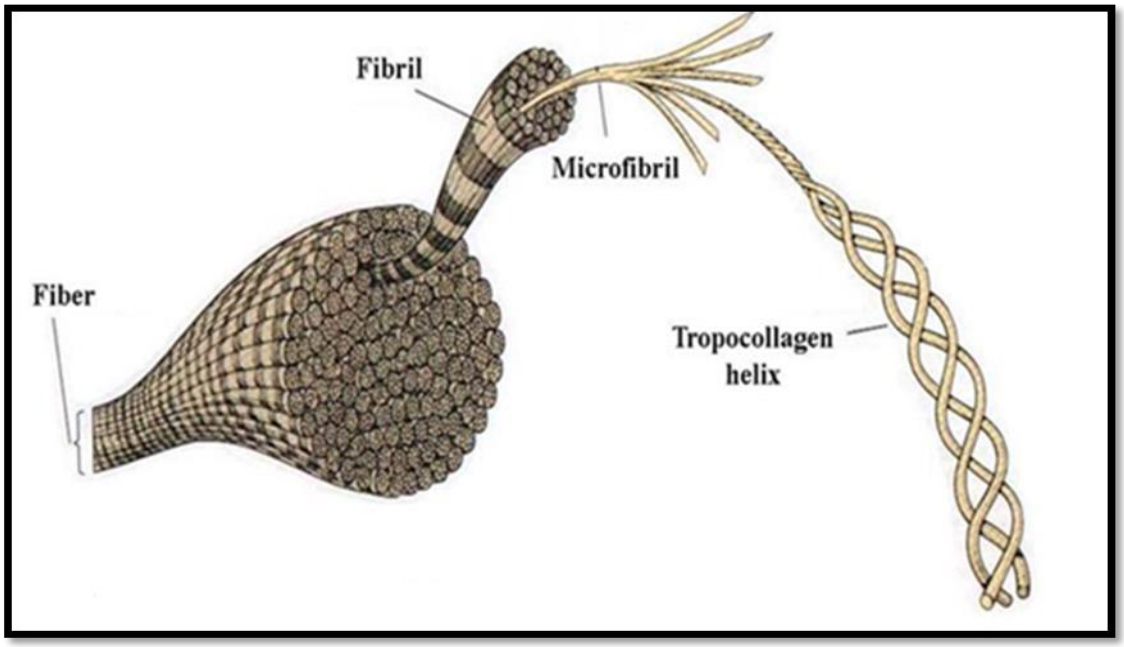

Figure (5): The structure of collagen from the tropocollagen to the fiber.

There are different types of collagen, more than20 different types have been identified that distinguished by their composition, morphologic characteristics, distribution and function.

1-Type I collagen (1): Is the most common type and has widespread distribution, forms **thick fibers** that organized into thick bundle. It occurs in tendon, dermis of skin, bone and organ capsule.

2-Type II collagen (2): It occurs as **fine fibrils** and not form fibers. It presents in hyaline cartilage and elastic cartilage.

3- Type III collagen (3): It occurs as thin fibers arranged in **loose networks**. It found in reticular connective tissue, smooth muscle, liver, spleen and blood vessels.

4-Type IV collagen (4): not form fibers. It forms **meshwork of procollagen molecules**. It is found in basement membrane that constitute the structural components of basal lamina.

5- Type V collagen (5): Forms **very thin fibrils** and is found in association with type I collagen and in placenta.

6- Type VI collagen (6): Forms small aggregation known as **anchoring fibrils** that bind the basal lamina to the underlying connective tissue.

The collagen is synthesis by cells called **fibroblasts**, also other cells form it as **chondroblasts** and **osteoblasts**. These cells synthesis **tropocollagen molecules** which consists of three polypeptide chains intertwined in triple helix. Differences in the chemical structure of these polypeptide chain are responsible for the various types of collagen. The **tropocollagen** molecules aggregate into **microfibrillar** subunits that are packed together to form **fibrils**. The collagen fibrils are thin elongated structures that are aggregate to form **fiber**. The collagen fibers arranged into **bundle**.