Tissue concept and classification, connective tissue – Klára Dolinová, Yoni Solomonov

Tissue – definition, quick reminder

Tissues are three-dimensional structures of morphologically and functionally **similar cells and their products**.

And what does a cell product mean? For example, proteins or polysaccharides secreted to the cells environment to support its function and structure of the tissue.

Of course, cells of all of the body tissues have the same genetic material but keep in mind that each cell type is different in its' **gene expression** and therefore its' function.

That's why the tissue of the retina differs from skeletal muscle tissue or skin tissue.

Connective tissue

Connective tissue is made up of **cells** and **extracellular matrix**. Extracellular matrix (ECM), according to the general definition consists of **fibrous component** and **amorphous component** (that is ground substance).

Connective tissue is the most abundant tissue of the body. It has a characteristic composition – it comprises mostly matrix and only few cells (unlike muscle, epithelium or nervous tissue).

What are functions of connective tissue?

We have 4 main functions and these are:

- **Structural support** – CT provides mechanical support and shape
- **Defense** – that means mechanical protection (skin, hair, bones) and immunity (monocytes, macrophages, skin).
- **Functional environment** – CT provides environment for growth, reproduction or for storing deposits. These environments are for example reticular fibers in hematopoietic tissue.
- **Repair** – CT is very important in injury repair and in the process of scarring because it comprises the pool of fibroblasts that help to establish new connective tissues.

Ground substance

As mentioned, the ECM includes fibrillar and amorphous component.

<u>Fibrillar component</u>

We distinguish 3 main types of fibers in the ECM. These are:

- Collagen fibers.
- Reticular fibers.
- Elastin fibers.

All of these are produced by the cells of the connective tissue.

Collagen:

There are around 30 types of collagen. Each provides the tissue with different properties. Every tissue has variable composition of collagen types. I will further discuss 4 main types of collagen:

Collagen I – the most abundant in bone tissue, ligaments and tendons. This type provides strong mechanical resistance to pull.

Collagen II – very abundant in cartilage, provide strong resistance to pressure.

Collagen III (AKA *reticular fibers*) – it is high distributed in many tissues, especially in reticular tissue (also in lymphoid and hematopoietic tissue).

Collagen IV – is found in basement membrane in of epithelium.

The typical staining of collagen fibers *HE & saffron* – in which collagen appears yellow, or **AZAN** where collagen appears blue.

Elastic fibers

Are mostly found in tissues that can expand or constrict – we call them elastic connective tissues. These are for example lungs or large arteries. The elastic function of those fibers is due to their unique shape.

Amorphous component

GAG – glycosaminoglycans – are made of long linear chains of polysaccharides. They are negatively charged. The main function is to **attract water** to provide hydration of the ECM. As an example we can name hyaluronic acid, chondroitinsulfate or keratansulfate.

Proteoglycans – are core proteins of the ECM. The special importance is in cartilage where they bind hyaluronic acid which is important for the function of cartilage. Representative of this group is aggrecan or syndecan.

Multiadhesive glycoproteins – cells of connective tissue have **integrins** on the surface. Some of the multiadhesive glycoproteins can bind those integrins and by that fix cells to their ECM. Another important glycoprotein is fibronectin.

Classification of connective tissue proper

Firstly, we may classify the cells of connective tissue as **resident** cells (fibroblast, reticular cells, adipocytes, stem cells) and **wandering/transient** cells (plasma cells, mast cells = heparinocytes, macrophages = histiocytes).

Second type of classification is according to the response to deformation → **dense**, **loose** or **elastic** connective tissue.

Dense connective tissue

Dense connective tissue is the one that is abundant in collagen type I. Provides mechanical protection of organs. It is characterized by small amount of cells in contrast with high number of fibrillar component in ECM. Cells of the connective tissue are called fibroblasts (these are active) and fibrocytes (these are non-active). We distinguish 2 types of this dense CT:

Regular

Regular means that all fibers are oriented **parallel,** in the same direction. This organization provides very strong resistance to pull applied in parallel to fibers. It can be seen in **tendons** and **ligaments**.

Irregular

Here we may again see high content of fibers however, in this case the fibers are oriented in **all directions**. They provide mechanical resistance to pull in various directions. This CT can be found in the **sclera**, **fascia**, **and fibrous capsules** of internal organs.

Loose connective tissue

Loose collagen connective tissue consists of relatively low amount of fibers in contrast with high amount of cells. It has better blood supply compared to dense C.T. It also houses immune cells. Found in dermis, in lamina propria and in tunica submucosa of viscera. Fibrous component consists of collagen and elastic fibers.

Specialized connective tissue

Those connective tissues have some special features allowing the function of a specific body part or an organ.

Elastic connective tissue

High content of elastic protein (fiber). Relatively low number of cells. Characterized by the ability of the tissue to return to its original shape after deformation has been applied (= this phenomenon is called elasticity). Typically seen in the **vocal cords** or in elastic membranes of the **aorta**.

To visualize these tissues we use special staining – **orcein** – elastic fibers are in brown.

Reticular connective tissue

It comprises reticular cells that produce reticular fibers (type III collagen). This tissue is organized in a 3D network that houses blood precursor cells and lymphocytes. Therefore, this type of tissue is seen in lymphoid tissue, and in hematopoietic tissue – namely in bone marrow which is blood producing.

We stain them by silver impregnation – reticular fibers are in black.

Adipose tissue

Adipose tissue can be subdivided into white and brown adipose tissue.

White adipose tissue

It is specialized in storing triglycerides (= **fat storage**). This tissue is abundant in cells called **adipocytes.** Very important and frequently ignored function is **endocrine function** – adipose tissue is pretty active in producing hormones. The most famous is the hormone called leptin that participates in regulation of food intake.

Typical image of an adipocyte is a cell with a large droplet of fat with its nucleus and rest of organelles compressed at the periphery by this huge vacuole full of fat. However we can differ adipocytes with only one vacuole – these are univacuolar. And adipocytes with more vacuoles that are smaller – these are called multivacuolar.

Brown adipose tissue

This tissue is found mainly in newborns and small children up to first year of life. As mentioned before, the adipocytes here are multivacuolar.

Brown adipose tissue is specialized in heat production and energy production. Those cells have a lot of mitochondria which causes the brown color of this tissue.