Connective Tissue

The essential components of all types of connective tissue, including bone and cartilage, are **cells, fibers, and ground substance** (the material in between the fibers and cells). In the different types of connective tissues these components vary with respect to kind, amount and arrangement to meet the functional demands of the particular site in the body. You must examine each of these three basic components when studying connective tissue, assessing them in terms of their functional significance. Note that the end of this lab includes a study of **plasma cells** and the **mononuclear phagocyte system (MPS)**. Although not strictly connective tissue cells, they are “transient cells” of connective tissue throughout the body. Fibroblasts and adipocytes (fat cells) are the principal “resident cells” in most connective tissue. The fibroblasts are responsible for manufacturing the fibers and much of the ground substance.

**EMBRYONIC CONNECTIVE TISSUE**

**Primitive Mesenchyme**

Primitive mesenchyme is the embryological tissue from which all types of supporting connective tissue, including the skeleton, are derived. It contains **fusiform** (spindle) or **stellate** (star shaped) undifferentiated cells. For the most part, these cells will differentiate into fibroblasts, though they can differentiate along other lines. They have a high ratio of nuclear to cytoplasmic volume. The intercellular material that surrounds these cells consists of sparse, delicate collagen fibrils and a viscous, amorphous ground substance, neither of which can be seen well in this routine type of preparation.

**Mucoid Connective Tissue**

**Mucoid** (aka mucous, mucin or mucinogen – the carbohydrate-rich glycoproteins found in glandular tissue in the adult) **connective tissue** can be found in the umbilical cord. It consists of a specialized extracellular matrix whose ground substance is called **Wharton’s Jelly**. This contains **Type I collagen** and a mucoid ground substance containing much chondroitin sulfate and hyaluronic acid (it appears vaguely eosinophilic, and darker near the fibroblasts).

**FIBROUS CONNECTIVE TISSUE.**

Fibrous connective tissue is usually classified into loose and dense based on the density of the fibrous component of the connective tissue. Additionally, dense connective tissue is usually subdivided into regular and irregular connective tissue based on the degree to which fibers are organized in parallel arrays. **It is important to realize that there is a continuous spectrum of degrees of density and orientation of fibers.** Some tissues, such as the mesentery and the subcutaneous connective tissue, have a very loose arrangement; others, like the lamina propria of many of the hollow organs, are intermediate; while others, such as tendons and ligaments, can be definitely classified as
dense fibrous connective tissue. Finally, some connective tissues are labeled as collagenous (fibrous), reticular or elastic based on the dominant extracellular fiber types.

**Loose CT (aka areolar CT).**
This connective tissue contains cells and fibers. The most common cell type is **fibroblasts**. These cells have oval nuclei. There may be a few macrophages, which are wandering, phagocytic cells. Often surrounding the dense, irregular nuclei of the macrophages are dark particles which the macrophages have phagocytosed and which lie in their cytoplasm. A number of **mast cells** are also present. Their cytoplasm is usually so filled with metachromatic (purplish) granules that their rather small, round nuclei are often not visible.

There are **collagen fibers** (Type I) extending throughout the tissue. **Elastic fibers** are much thinner, branching strands.

**Dense, irregular fibrous CT.**
This is a common connective tissue, most prominently located beneath the epithelium of many organs. Both collagen and elastic fibers are present in abundance, but only the former can be seen in routine H&E preparations such as this (elastic fibers don’t stain with H&E). The most prominent cell type is the fibroblast, which manufactures and maintains the fibers that comprise the bulk of the tissue.

**Dense, regular fibrous CT.**
Ligaments, tendons and aponeuroses (a sheet or band of fibrous connective tissue separating or binding together muscles) have a similar appearance. There are longitudinally-oriented bundles of acidophilic collagen fibers (which have a slightly wavy appearance). There are fibroblasts in between the collagen bundles. This type of connective tissue has a paucity of blood vessels.

**SPECIAL CONNECTIVE TISSUE**

**Elastic connective tissue.** In this connective tissue, elastic rather than collagenous fibers predominate, although some collagenous fibers are also present. It is rather restricted in its distribution, being found primarily in the walls of the large arteries and in the alveolar walls of the lung. How do these fibers differ from collagen fibers?

**Reticular connective tissue.** Reticular connective tissue is so named for the predominance of **reticular fibers** (Type III collagen) in it. Such reticular tissue is found primarily in the blood forming organs and in glands (to be studied in more detail later) where it forms a supportive framework around the gland cells and blood vessels. Silver impregnations are commonly used to demonstrate the fine reticular (argyrophilic, e.g., “silver-loving”) fibers. They are **not** visible in H&E preparations.

**Adipose (fat) tissue.** In this specialized type of connective tissue, energy-storing fat cells (adipocytes) predominate. The distribution and amount of this tissue in the human body
varies with the age, sex, and physical condition of the individual. There are two basic types of adipose tissue: white (unilocular) and brown multilocular).

White (unilocular) fat. The appearance of the fat cells forming this tissue change with the degree of their lipid storage. In the “fully loaded” cell, neutral lipid is concentrated in a large central vacuole surrounded by a thin rim of cytoplasm. Unless prepared by solvent-free histological procedures (e.g., frozen sections), all of the lipid is dissolved away in slide preparation leaving a group of empty, circular cells of the so-called “signet ring” configuration. (Diagram below). These adipose cells are held in place by collagen fibers (with a few fibroblasts), and there are numerous blood vessels.

Brown (multilocular) fat. This specialized thermogenic adipose tissue is more common in lower mammals (e.g., rodents) than in humans. (In humans, it is more evident in the newborn and infant and is more variable in adulthood) It differs considerably from white adipose tissue both in morphology and function. Review the mechanism of thermogenesis in brown adipose tissue.

PLASMA CELLS

These cells originate from white blood cells (lymphocytes) that migrate into connective tissue. (Their life history will be covered later.) Although not truly a connective tissue cell, they are common in this tissue (particularly in part of the respiratory and digestive tracts) and are often encountered at this time. It is important that you learn to identify these cells in tissue sections. Their presence in large numbers is an important diagnostic feature of chronic inflammation. What are the characteristic cytological features of the plasma cell as seen: 1) by light microscopy; 2) by electron microscopy? What is the major function of these cells?

THE MONONUCLEAR PHAGOCYTE SYSTEM (MPS)

This diffuse system of free and fixed phagocytic cells (macrophages) replaces the outdated “reticuloendothelial system” concept (a term that you will still occasionally encounter). The criteria for including a phagocytic cell in this system are: 1) origin from
bone marrow precursor cells; 2) high level of phagocytic activity mediated by immunoglobulin (antibodies) and components of the serum complement system.

**CHECK LIST**

**Remember that all connective tissue contains**

- cells
- fibers
- collagen
- elastic
- reticular
- ground substance (extracellular matrix)

**Be able to identify and know the location of all the types of connective tissue:**

- fetal mesenchyme
- mucoid connective tissue
- loose, areolar fibrous CT (e.g., mesentery)
- dense, irregular fibrous CT
- dense, regular fibrous CT
- elastic CT
- reticular CT
- adipose CT
- white (unilocular) fat
- brown (multilocular) fat

**understand the characteristics of the two major resident cells of connective tissue:**

- fibroblasts
- adipocytes

**understand the role of the transient cells of connective tissue:**

- macrophage
- mast cell
- plasma cell
- leukocytes

**Understand the terms “agyrophilia and metachromasia.”**