(II) Structure and Function of the Dermis

1) Components of the Dermis and Their Structure

(1) Histological Structure

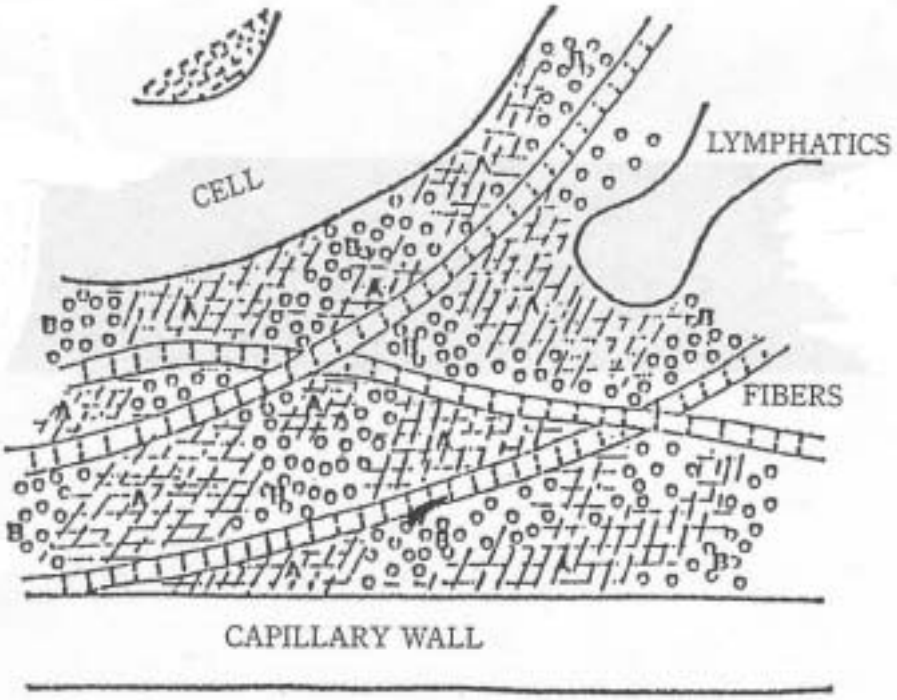
The dermis can be divided into three strata: stratum papillare, stratum subpapillare and stratum reticulare.

The most superficial of these, the stratum papillare, consists of an abundant ground substance, fine but coarse fibrous components and a dense reticulin fiber network adjacent to the basal membrane (epidermal boundary membrane). It is in this reticulin network that capillary networks reside.

In the stratum subpapillare there are arteriola, venula and nervous plexi.

The stratum reticulare, which constitutes the bulk of the dermis, consists of thick, dense fibrous components in the form of mat-like networks.

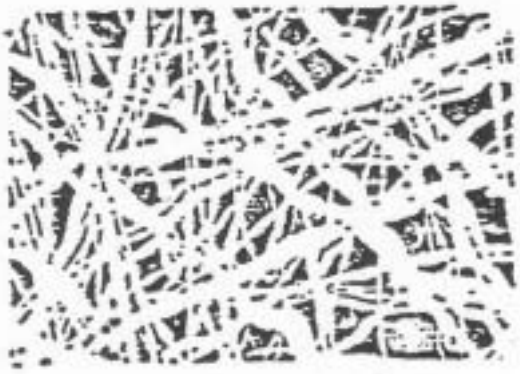
The main structural components of these three dermal strata are the fibrillar elements, the ground substance (non-fibrillar intercellular material)



A schematic drawing of hypothesized, submicroscopic organization of interstitium of connective tissue. Letter A represents fixed, colloid-rich, water-poor phase; letter B represents movable, colloid-poor, water-rich phase[1].

Figure 1[1]

and the cellular elements. Since the former fibrillar elements and ground substance are widely distributed, the dermis can be classified as a connective tissue.



Photomicrograph of collagenous fibers in the interstitial spaces of connective tissue. Note the mat-like appearance of the fiber meshwork. (Reprinted from Fawcett. Used with permission of McGraw-Hill Book Co.)

Figure 2-1[2]

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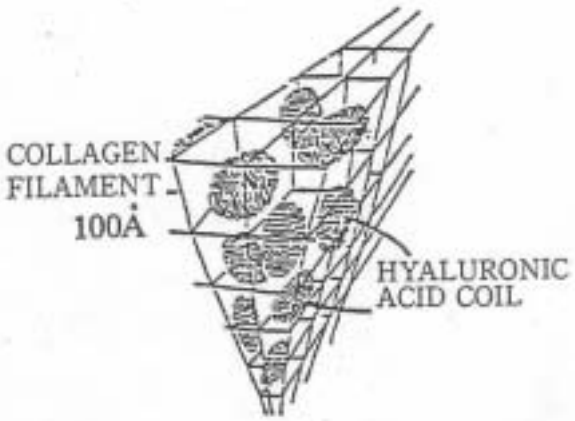

Diagram of the fibrous network of collagen fibrils reinforced with hyaluronic acid molecules, as a model of the macromolecular structure of the interstitial spaces of connective tissue. (Reproduced from Balazs, 1961, with permission of the Academic Press Inc., New York.)

Figure 2-2[3]

(2) Three Structural Elements of the Dermal Connective Tissue

① Cellular Elements

Fibroblasts are the main cells of the dermis and produce collagen and mucopolysaccharides.

Histocytes are cells that are found in small numbers around the capillaries and are capable of digesting bacteria, cellular debris, metabolic products and other materials by the process of phagocytosis (cellular engulfing).

Mast cells are found in abundance along the blood vessels and include heparin and histamine. They play a major role in the I-type allergic reaction including the receptor of IgE type antibodies in their surfaces.

② Fibrillar Proteins

The three main types of fibers embedded between the cells of the dermal connective tissue are white collagenous fibers (90% of total bulk), elastic fibers (elastin), and reticular fibers (reticulin).

③ Ground Substance

This is the extravascular, extracellular, extrafibrillar material which fills the space between the fibers and cells of connective tissue. By nature it is an amorphous (formless) material which consists of non-fibrillar colloidal matter,

plasma proteins, electrolytes and water.

Early views considered the whole interstitial space in a deliberately simplified manner as a homogeneous and inactive space. However, recent histological and physiological evidence suggests that the interstitial space is a highly functional and organized structure and that two separate phases may be distinguished within the ground substance. Thus there appears to be a water-poor, colloid-rich phase which is more in contact with the structural components of the connective tissue (various fibers and membranes) and a water-rich, colloid-poor phase which includes water-soluble, mobile components. This two phase organization of the interstitial (intercellular) tissue is illustrated in Figure 1.

It seems that the BP current flows in this water-rich, colloid-poor phase of the ground substance.

The non-fibrillar colloidal matter of the ground substance consists of soluble collagen and other proteins, acid and neutral mucopolysaccharides and their protein complexes. In human dermis, the main acid mucopolysaccharide constituents are hyaluronic acid and dermatan sulfate (chondroitin sulfate B). These two main acid mucopolysaccharides differ not only in their chemical structure and physical parameters, but also in their localization; whereas hyaluronic acid seems to exist as a coil-like structure within the interfibrous spaces of the collagen network (see Figure 2-1, 2-2), dermatan sulfate seems to be firmly associated with the collagen fibers of the native tissue.

Due to difficulty in the analytical separation of the neutral polysaccharides from plasma-related materials, the role of these polysaccharides is poorly understood at present.

In the living dermis these three elements (cells, fibers, and ground substance) comprising the dermal connective tissue are in a continual state of turnover; the fibrous protein and ground substance are perpetually undergoing degradation and resynthesis.

Furthermore, it is known that the acid mucopolysaccharides, particularly hyaluronic acid, reinforcing the collagenous fiber network, have a profound influence on water and electrolyte count and movement in the ground substance.

Because it seems certain that the nature of the collagen-hyaluronic acid network of the ground substance will exert a strong influence on the magnitude of the BP current, we will now go on to consider this network in more detail.[3]