Connective Tissues

Connective Tissue

- **LOCATIONS**
  - Connective tissues are widely distributed tissues of the body. Examples include bones, tendons, ligaments, cartilage, blood, and the abundant loose connective tissues (such as adipose) located in and around other tissues.
- **FUNCTIONS**
  - The major functions of connective tissues include:
    (1) framework,
    (2) support,
    (3) binding,
    (4) protection,
    (5) insulation, and
    (6) transportation (specifically for blood).
- **CHARACTERISTICS**
  - Connective tissue is characterized by having extracellular material called matrix, relatively few cells, and varying degrees of vascularity. Tissue vascularity ranges from avascular (no blood vessels) such as found in cartilage, to high vascularity such as found in the loose connective tissue (such as areolar tissue and adipose).

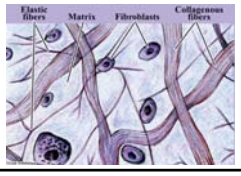
Components of Connective Tissue

The major components of connective tissue are

1. Matrix and
2. Cells.

Matrix

- Connective tissues do not form cellular membranes such as the epithelial tissues. Instead, the scattered cells are dispersed in a substance called the extracellular matrix. The matrix constitutes the nonliving extracellular material. The characteristics of the matrix are responsible for the nature of the specific connective tissue. Two materials compose the matrix:
  (1) ground substance and
  (2) fibers.

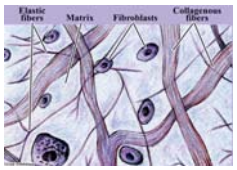


- **Ground Substance**
  Ground substance is a homogeneous material consisting largely of a complex mixture of proteins produced by connective tissue cells. It occupies the area **around** the cells and fibers
- **Fibers**
  - Fibers are distinctive protein threads embedded in the ground substance.

  Three fibers are common in connective tissues:
  - **Collagen fibers**
    Collagen fibers are the most abundant of the three fibers. Their long collagen protein structure makes them appear as fine clear threads in fresh preparations. Thus, they are often called "white fibers." They function in (1) providing a structural framework and in (2) providing strength
  - **Elastic fibers**
    Elastic fibers are made of the protein elastin and appear yellow in fresh preparations. Thus, they are often called "yellow fibers." They function in allowing the tissue to stretch and recoil
  - **Reticular fibers**
    Reticular fibers are similar in organizational structure to collagenous fibers but are thinner and more branched. Like collagen, they function in (1) providing a structural framework and in (2) providing strength.

Cells

- Each type of connective tissue will always exhibit its structural cell type (other cell types also may be present). The structural cell for the tissue is commonly named according to the tissue **type** (used as prefix) and its **activity** (used as suffix.)
  - For example the prefix applied to the type of tissue, bone tissue, is "**osteo**." The suffix for an actively dividing and/or building cell may be formed by using "**blast**." Thus, an osteoblast is a dividing and building cell of bone. The suffix for the nondividing maintenance cell of the tissue may be formed by using the suffix "**cyte**."



CLASSIFICATION

Three structural characteristics of the matrix:
(1) the types of fibers,
(2) the type of ground substance, and
(3) the structural arrangement.

Classification

- Connective tissue classification is based upon three structural characteristics of the matrix:
  - (1) the types of fibers,
  - (2) the type of ground substance, and
  - (3) the structural arrangement.
- According to these characteristics of the matrix, connective tissues are classified into four types:
  - (1) connective tissue proper,
  - (2) cartilage,
  - (3) bone, and
  - (4) blood.

Connective Tissue Proper

- The matrix of connective tissue proper is characterized
  - (1) by being flexible,
  - (2) by having a viscous ground substance, and
  - (3) by having abundant fibers.
- The structural cells are called fibroblasts. The two subclasses of connective tissue proper are
  - (1) loose connective tissue and
  - (2) dense connective tissue.

Loose Connective Tissue

- Loose connective tissue is characterized by having a loose arrangement of fibers. It includes the following three tissues:
  - (1) areolar,
  - (2) adipose, and
  - (3) reticular.

Dense Connective Tissue

- Dense connective tissue is characterized by having a dense arrangement of fibers. It includes the following three tissues:
  - (1) regular,
  - (2) irregular, and
  - (3) elastic.

Cartilage

- The matrix of cartilage is characterized
  - (1) by being semisolid and flexible and
  - (2) by having abundant collagenous fibers. Elastic cartilage also has elastic fibers.
- The structural cells are named according to their activity are chondroblasts or chondrocytes.
- According to the characteristics of the matrix, cartilage is divided into three types:
  - (1) hyaline,
  - (2) elastic, and
  - (3) fibrocartilage.

Bone

- The matrix of bone is characterized by being
  - (1) rigid,
  - (2) strong, and by containing
  - (3) calcium salts and
  - (4) collagen fibers.
- The structural cells are named according to their activity, osteoblasts or osteocytes.
- According to the characteristics of the matrix, bone is divided into two types:
  - (1) compact and
  - (2) spongy (cancellous).

Blood

- The matrix of blood is characterized by being a
  - (1) viscous fluid with
  - (2) no formed fibers.
- In bone marrow the formative ancestral cells are named hemocytoblasts; in blood the mature cells are named leukocytes (white blood cells) and erythrocytes (red blood cells).

THE LOOSE CONNECTIVE TISSUES

Areolar Tissue

Structure

- The matrix of areolar tissue consists of abundant collagenous, elastic, and reticular fibers. The fibers are dispersed in an abundant viscous ground substance.
- The ground substance is viscous because it contains abundant glycoproteins and mucopolysaccharides (proteoglycans) such as hyaluronic acid.
- The structural cells of areolar tissue are fibroblasts. Other cell types include mast cells (produce histamine) and macrophages (leukocytes which function in phagocytosis).

Areolar Tissue

- **Locations**
  - Areolar is widely distributed throughout the body. It is found attaching and supporting many tissues and organs. For example, it attaches the skin to underlying tissues, surrounds and supports many organs, such as blood vessels and glands.
- **Functions**
  - The tissue functions in (1) attaching, and (2) supporting tissues and organs.

Lab Activity 7- Areolar Tissue

- Observe a tissue preparation labeled "Areolar Tissue."

  Identify, the
  - (1) collagenous fibers (wavy, usually pink to red stained),
  - (2) elastic fibers (small, usually blue stained), and
  - (3) open "spaces" (where the semifluid ground substance was located prior to tissue processing).

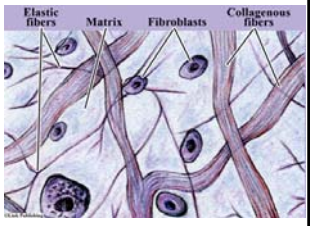


Fig. 8.38

Areolar Tissue

- Areolar tissue (100x) has scattered fibroblasts and a loose arrangement of fibers. The structural cells of the tissue are fibroblasts. Mast cells are commonly associated with this tissue.

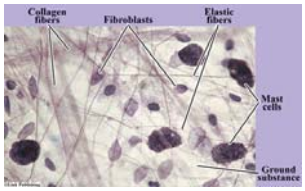


Fig. 8.39

Adipose Tissue

- **Structure**
  - The matrix of mature adipose tissue is small in quantity and is usually not observed in mature tissue preparations. The fibers of the matrix are collagenous and elastic fibers. The fibers form a network between adipocytes giving the tissue strength and flexibility. Fibroblasts are associated with the fibers. Adipocytes are the dominate cells and store neutral fats (triglycerides) in a lipid droplet. As the lipid droplet enlarges, the cytoplasm and nucleus are forced to the periphery of the cell.

Adipose Tissue

- **Locations**
  - Adipose is widely distributed in the body, especially subcutaneously and around internal organs.
- **Functions**
  - Adipose tissue functions (1) as a reserve energy source, (2) as an insulator from heat loss, and (3) structurally supports and (4) cushions organs.

Lab Activity 8- Adipose Tissue

- Observe a tissue preparation labeled "Adipose Tissue." The lipid droplets were removed during processing and their locations are seen as large clear areas. The pattern of these large clear areas often gives the tissue a net-like appearance.
- Identify the location of the lipid droplets and cytoplasm. As the lipid droplet increases in size, the cytoplasm becomes more peripherally located (between the lipid droplet and the plasma membrane.)

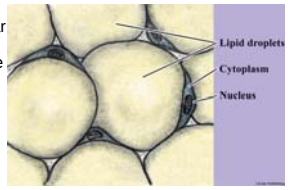


Fig. 8.40

Adipose Tissue

- Adipocytes are the dominate cells of mature adipose tissue (100x). The small quantity of matrix is compressed between the large adipocytes, which show large cleared areas. These areas contained droplets of triglycerides prior to tissue processing.

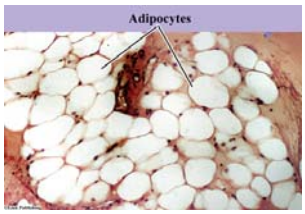


Fig. 8.41

Developing Adipose Tissue

- A whole mount (wm) of developing adipose tissue shows small adipocytes surrounded by matrix. The matrix contains a viscous ground substance, collagen fibers, and reticular fibers.

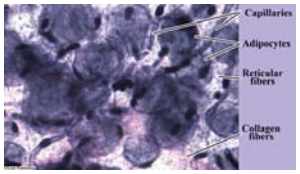


Fig. 8.42

Reticular Connective Tissue

- **Structure**
  - The matrix of reticular connective tissue consists of a network of thin, delicate, highly branched reticular fibers with a small quantity of ground substance. The structural cells are fibroblasts that are called reticular cells.

Reticular Connective Tissue

- **Location**
  - Reticular tissue is located in the liver, lymph nodes, spleen, and the bone marrow.
- **Functions**
  - Reticular tissue functions in forming the supporting framework of soft organs (the liver, lymph nodes, and spleen) and is found in bone marrow. Because the reticular cells (fibroblasts) are distributed among the functional cells of the organ, they are difficult to differentiate.

Lab Activity 9- Reticular Tissue

- Observe a tissue preparation labeled "Reticular Tissue," or "Lymph node." Identify the short, highly branched reticular fibers which are usually stained dark blue.

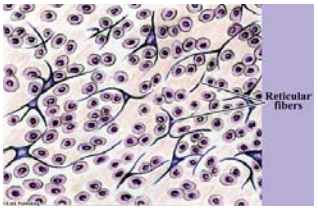


Fig. 8.44

Reticular Tissue

- Reticular connective tissue from a lymph node. Reticular fibers are seen as short branching fibers.

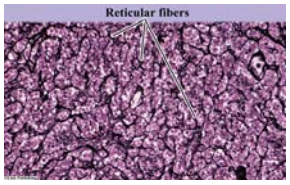


Fig. 8.45

THE DENSE CONNECTIVE TISSUES

Dense Regular Connective Tissue

- **Structure**
  - The matrix of dense regular connective tissue consists of dense bundles of parallel (regular arrangement) collagenous fibers. The bundles of collagenous fibers are surrounded by a small quantity of ground substance. The structural cells are called fibroblasts and are found in rows between bundles of collagenous fibers.

- **Locations**
  - Dense regular connective tissue is mostly found forming (1) tendons and (2) ligaments.
- **Functions**
  - The tissue functions in providing for (1) attachments and (2) great tensile strength. Tendons attach muscle to bone, and ligaments attach bone to bone. The collagen fibers of tendons and ligaments provide great tensile strength and resist stretching when tension is applied end-to-end.

Lab Activity 10 – Tendon (Dense Regular)

- Observe a tissue preparation labeled "Tendon," (or "White Fibrous Connective Tissue"). Identify the lightly stained parallel collagenous fibers. The collagen fibers may appear wavy. Identify the rows of fibroblasts located between bundles of collagen fibers

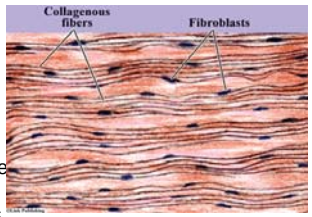


Fig. 8.46

Tendon (Dense Regular)

- Dense regular connective tissue, a tendon (100x), consists of abundant collagenous fibers and rows of fibroblasts.

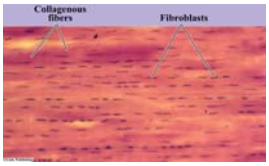


Fig. 8.47

Dense Irregular Connective Tissue

- **Structure**
  - The matrix of dense irregular connective tissue consists mostly of irregularly arranged collagenous fiber bundles with a small quantity of ground substance. An irregular arrangement means that the bundles (groups of collagenous fibers) are interwoven in many directions.

Dense Irregular Connective Tissue

- **Location**
  Tissue locations include
  - (1) the dermis (skin) and
  - (2) connective tissue sheets surrounding muscles (fasciae) and some
  - (3) organs such as the liver and lymph nodes.
- **Functions**
  - The irregular arrangement of collagenous fibers provides
  - (1) structural support
  - (2) organization and
  - (3) great tensile strength in many directions.

  Fibroblasts are dispersed among the bundles of collagenous fibers.

Lab Activity 11 - Dense Irregular Connective Tissue

- Observe a tissue preparation labeled "Dense Irregular Connective Tissue," or "Skin." If observing the skin, the thick layer of dense irregular connective tissue is the layer underlying the epidermis, the surface layer of stratified squamous epithelium.

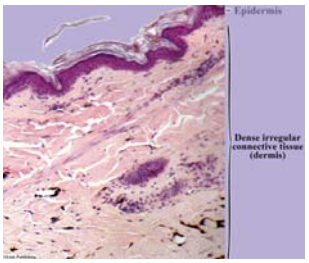


Fig. 8.48

Dense Irregular Connective Tissue Dermis of Skin

- Dense irregular connective tissue located in the dermis of the skin.

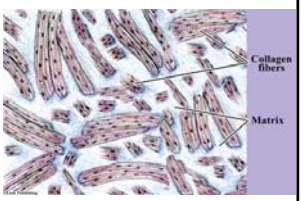


Fig. 8.49

Dense Irregular Connective Tissue Dermis of Skin

- Dense irregular connective tissue located in the dermis of the skin.

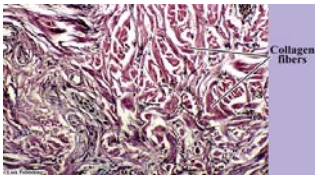


Fig. 8.50

Elastic Connective Tissue

- **Structure**

  Elastic connective tissue may be considered a special type of dense regular connective tissue. This is because its matrix consists mostly of densely arranged elastic fibers, not collagenous fibers. Scattered collagenous fibers are located in small spaces among the elastic fibers. Fibroblasts are found throughout the tissue.

Elastic Connective Tissue

- **Locations**

  Elastic connective tissue locations include the
  - (1) vocal cords,
  - (2) walls of large arteries,
  - (3) walls of respiratory airways such as the trachea and bronchi, and
  - (4) the ligamentum nuchae (a flat ribbon-like elastic ligament that connects the vertebrae of the neck of the back of the skull).
- **Functions**

  Elastic connective tissue functions in providing considerable
  - (1) strength,
  - (2) stretch, and
  - (3) recoil.

Lab Activity 12 – Elastic Connective Tissue

- Observe either the tissue preparation of an "Artery, Vein, and Nerve," or a preparation labeled "Elastic Connective Tissue."
- **Artery (elastic)**

  Elastic connective tissue is found in the walls of elastic arteries. In this location the elastic tissue is found situated among smooth muscle fibers.

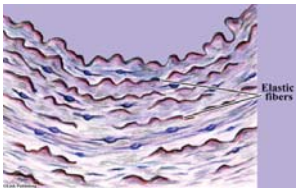


Fig. 8.51

Elastic Connective Tissue

- The wall of an elastic artery consists of abundant elastic tissue. The elastic tissue consists of abundant elastic fibers and fibroblasts. The elastic tissue is mostly located in layers between the fibers of smooth muscle.

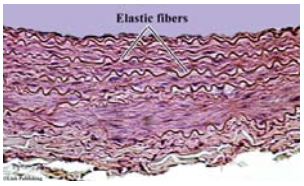


Fig. 8.52

Elastic Connective Tissue (ligamentum nuchae)

- Observe a tissue preparation labeled "Elastic Connective Tissue." Preparations of "elastic connective tissue" are usually from the ligamentum nuchae, the flat ribbon-like strong elastic ligament that connects the vertebrae of the neck to the back of the skull.

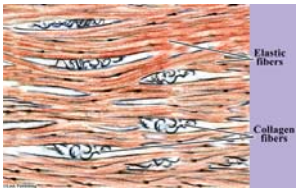


Fig. 8.53

Elastic Connective Tissue (ligamentum nuchae)

- Elastic connective tissue from the ligamentum nuchae consists predominately of large elastic fibers. Collagen fibers are found situated in areas around the elastic fibers.

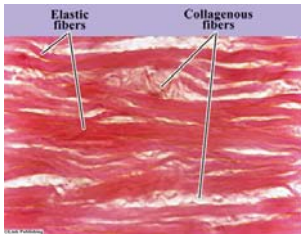


Fig. 8.54

CARTILAGE

Cartilage functions as a
(1) supportive and
(2) structural connective tissue.

Cartilage

- Its thickness is limited because it is **avascular**.
- The matrix is semisolid and slightly flexible and consists mostly of **collagen fibers** embedded in a protein ground substance.
- The structural cells of mature cartilage are **chondroblasts**.
- A membrane of dense irregular connective tissue, called the **perichondrium**, forms the surface of most cartilage.

Hyaline Cartilage

- **Structure**
- The matrix of hyaline cartilage is firm and resilient. It consists of abundant collagenous fibers embedded in ground substance and appears amorphous (with no definite form). The structural cells are called chondroblasts. A small cavity called a lacuna surrounds each cell. A connective tissue layer called the perichondrium surrounds all hyaline cartilage except the cartilage's articular surfaces. The perichondrium helps to support and protect the hyaline cartilage. Hyaline cartilage is avascular and without nerves.

Hyaline Cartilage

- **Locations**
- Hyaline cartilage is widely distributed throughout the body. Its locations include (1) where the ribs connect to the sternum (called costal cartilage), (2) the ends of long bones (called articular cartilage), (3) the tip of the nose, and (4) the framework of larger respiratory airways.
- **Functions**
- Hyaline cartilage functions in providing (1) support, (2) a structural framework, and (3) cushioning.

Lab Activity 13 – Hyaline Cartilage

- Observe a tissue preparation labeled "Hyaline Cartilage." Hyaline cartilage preparations usually show the tissue as part of an organ, like the trachea. Locate the perichondrium, the supportive layer of dense irregular connective tissue (abundant collagen fibers) at the surface of the cartilage.

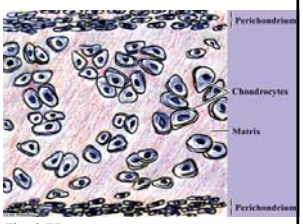


Fig. 8.55

Hyaline Cartilage

- Hyaline cartilage consists of collagenous fibers embedded in a firm amorphous ground substance. The structural cells of developing cartilage are chondroblasts.

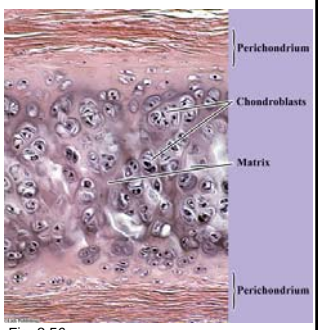


Fig. 8.56

Fibrocartilage

- **Structure**
  - The matrix of fibrocartilage consists of dense, compact, collagenous fiber bundles with little ground substance. The fiber bundles usually appear wavy and are nearly parallel with chondroblasts located along their surface.

Fibrocartilage

- **Locations**
  Fibrocartilage locations include
  - (1) the intervertebral discs (fibrocartilage discs) that separate the vertebrae,
  - (2) part of the knee joint and
  - (3) the symphysis pubis (connects the two pubic bones).
- **Functions**
  Fibrocartilage functions include
  - (1) providing strength and
  - (2) resisting compression

Lab Activity 14
Fibrocartilage

- Observe a tissue preparation labeled "Fibrocartilage." Preparations are usually made from the internal structure of the tissue; thus, the external tissue, the perichondrium, is usually not shown.

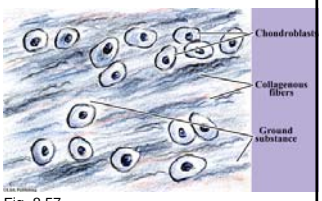


Fig. 8.57

Fibrocartilage

- Fibrocartilage (100x) consists of bundles of collagenous fibers embedded in a small quantity of ground substance. The structural cells are chondroblasts.

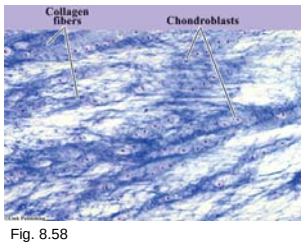


Fig. 8.58

Elastic Cartilage

- **Structure**
  - The matrix of elastic cartilage consists of abundant collagenous and elastic fibers embedded in a small quantity of ground substance. The matrix, like hyaline cartilage would be amorphous if not for the presence of the distinctive elastic fibers.
  - The matrix provides structure and resists compression.
  - The structural cells, the chondroblasts, are distributed among the fibers.
  - Small cavities, the lacunae, surround the chondroblasts.

Elastic Cartilage

- **Locations**
  The locations of elastic cartilage include the
  - (1) external ear and the
  - (2) epiglottis (cartilage structure that closes the opening to the airway when swallowing food).
- **Functions**
  Elastic cartilage functions include providing
  - (1) support,
  - (2) framework, and
  - (3) flexibility.

Lab Activity 15 – Elastic Cartilage

- Observe a tissue preparation labeled "Elastic Cartilage." Preparations of elastic cartilage will either be of the complete tissue located within an organ (like the epiglottis), or a tissue section that shows only the internal structure.

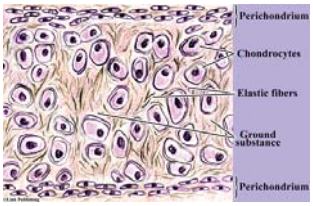


Fig. 8.59

Elastic Cartilage

- The matrix of elastic cartilage (100x) consists of elastic and collagenous fibers embedded in ground substance. The primary cells of the tissue are chondroblasts.

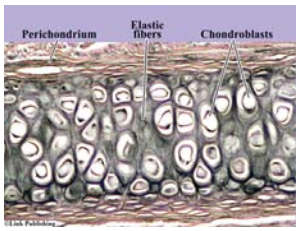


Fig. 8.60

BONE (OSSEOUS TISSUE)

The matrix of bone consists of about one-third collagenous fibers and two-thirds calcium salts.

BONE

- **Structure**
- The **matrix** of bone consists of about one-third collagenous fibers and two-thirds calcium salts. The calcium salts make bone tissue hard, and the collagenous fibers give it strength. The mature cells of bone embedded in the matrix are called **osteocytes**. Bone-forming cells (osteogenic cells) are called **osteoblasts**, and bone destroying cells are called **osteoclasts**. Osteoblasts and osteoclasts are located in areas where bone is being modified by building and/or destruction.
- The two structural types of bone tissue are
  - (1) compact and
  - (2) spongy.
- The **central (Haversian) canal** contains blood vessels and occasionally a nerve. Each Haversian canal is surrounded by **lamellae** (concentric rings of matrix) separated by rows of osteocytes. Small canals called **canaliculi** pierce the matrix. Canaliculi are pathways for branches of the osteocytes. By the interconnection of their branches, the osteocytes maintain a connection with the blood vessels located in the Haversian (central) canal. Spongy bone is organized into plates called **trabeculae**.

BONE

- **Location**
  Bone tissue forms bones, the framework of the skeleton.
- **Function**
  Bones function in
  - (1) providing protection,
  - (2) serving as attachment sites for muscles and connective tissues,
  - (3) providing reserves for minerals,
  - (4) blood cell production (marrow), and
  - (5) providing a site for fat deposit (yellow marrow).

Lab Activity 16
Ground Compact Bone

- Observe a tissue preparation of compact bone labeled "Bone, ground." The preparations are thick; DO NOT USE HIGH POWER OR OIL IMMERSION for observations. The term "ground" means that the bone was prepared by polishing (grinding) to give it a smooth surface for observation. Identify the **Haversian systems**, each with its centrally located Haversian (central) canal.

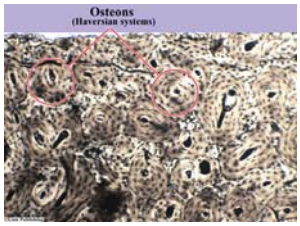


Fig. 8.61

Ground Compact Bone

- Each Haversian system contains a centrally located Haversian (central) canal. In the matrix are concentric rows o osteocytes. Small canals, the canaliculi, contain branches of the osteocytes.

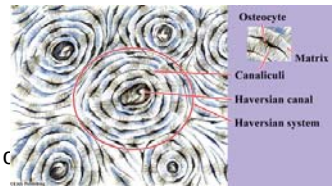


Fig. 8.62

Compact Bone - Demineralized

- Demineralized bone tissue (100x) shows numerous osteocytes surrounded by collagen fibers.

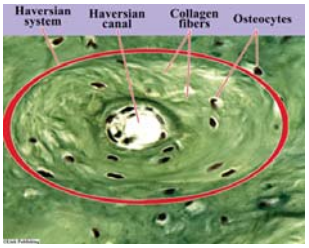


Fig. 8.63

BLOOD

The matrix of blood is the fluid component called plasma.

BLOOD

- **Structure**
  - The matrix of blood is the fluid component called **plasma**. The plasma, consisting mostly of water, transports dissolved substances such as nutrients, wastes, hormones, etc. Also, plasma transports the formed elements.
  - The formed elements consist of cells called erythrocytes (red blood cells) and leukocytes (white blood cells), and cell fragments called platelets.

Blood

- **Locations**

  Blood is located within the **cardiovascular system** (heart and the blood vessels). Blood circulates through a system of blood vessels (vascular system). Arteries are vessels that carry blood away from the heart, and veins carry blood toward the heart. The smallest blood vessels are the capillaries that serve as sites of exchange between the blood and the interstitial fluid.

Blood

Functions

Blood functions include

- (1) transportation of substances such as respiratory gases (oxygen and carbon dioxide), nutrients, wastes, hormones, antibodies, etc. and
- (2) provides protection against disease (immunity) and
- (3) protects from blood loss by its clotting mechanism.

- Erythrocytes function mostly in the transport of oxygen. Erythrocytes also transport some carbon dioxide, however, most carbon dioxide is transported in ionic form in the plasma.
- Leukocytes are involved in protection of the body from disease (phagocytosis, antibody production, cell-to-cell interactions, etc.).
- Platelets function in stopping blood loss (clotting) by forming a plug at the site of vascular injury.

Lab Activity 17
Blood

- A human blood smear shows the formed elements, the erythrocytes (RBCs), leukocytes (WBCs), and platelets. Erythrocytes do not have nuclei. A leukocyte has a single nucleus and its cytoplasm may contain granules.

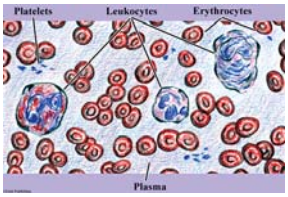


Fig. 8.64

Blood

- Blood (430x) consists of a matrix called plasma and the formed elements. The formed elements include two major groups of cells, the erythrocytes (RBCs) and the leukocytes (WBCs) and cell fragments called platelets.

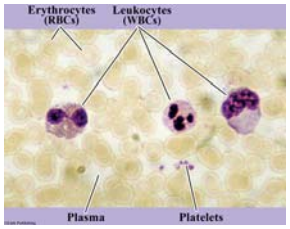


Fig. 8.65