Histology

Histology, a term derived from the Greek histos, meaning tissue, and logia, meaning "the study of" or knowledge, literally, then, means the knowlege, or science, of tissues, both plant and animal. This course is restricted, in the main, to a consideration of human histology.

The Four Primary Tissues

The body is composed of three different elements:

1. Cells are the structural units of all living organisms.
2. Body fluids : include Blood and Lymph.
3. Intercellular substances are materials that are found between cells and that support and nourish them. This intercellular material gives a firmness to the tissues and is divided into two main types :-

a. The formed, or fibrous, type includes *collagen (white fibrous tissue present in meat) and *elastin, which gives the property of elasticity to tissues.

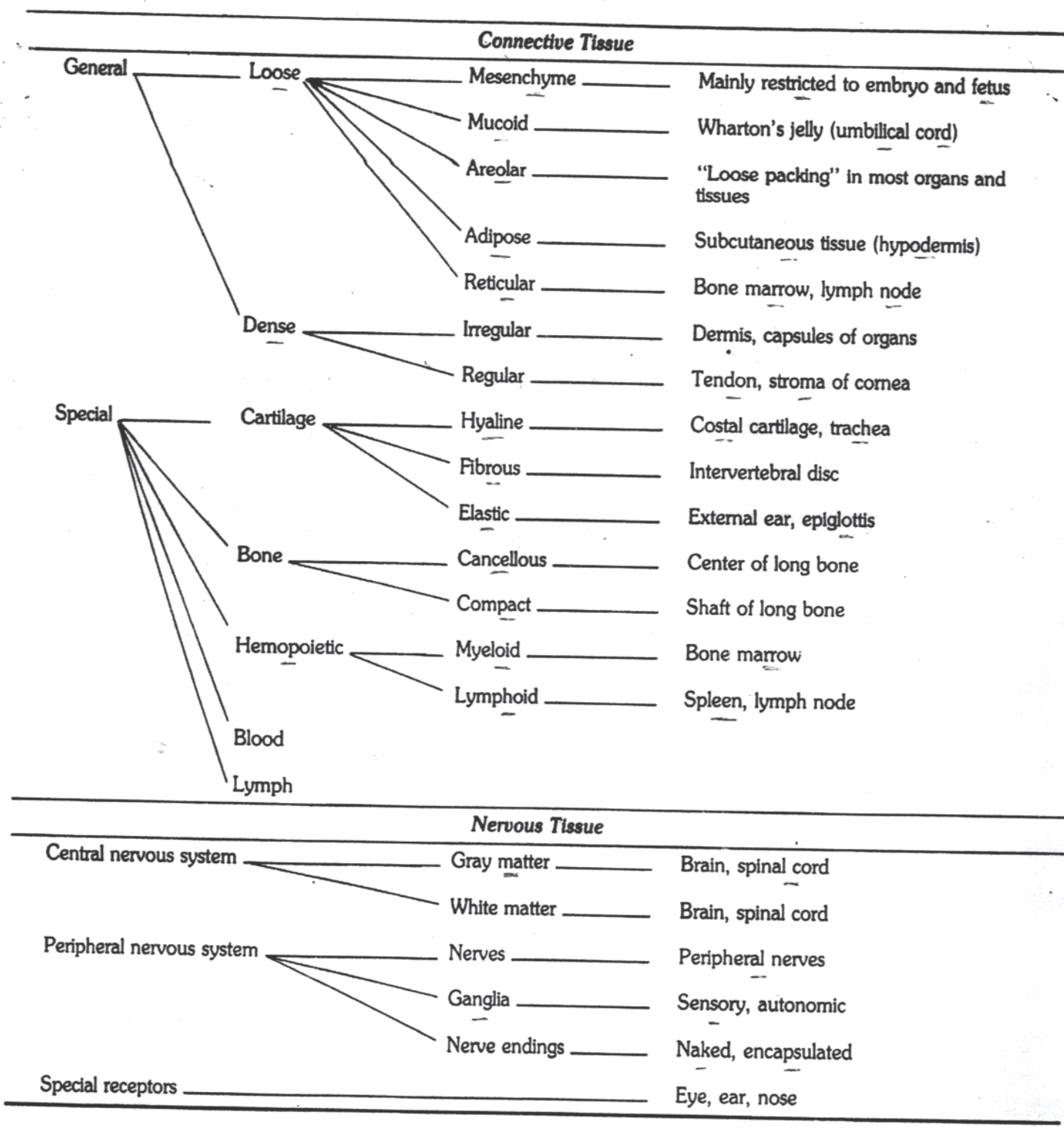
b. The amorphous type forms the ground substance. The latter contains substances called glycosaminoglycans and proteoglycans. These are carbohydrates that are bound to protein.

During development, the embryo consists of three cellular layers 1.ectoderm, 2.mesoderm, and 3.endoderm.

In all three germ layers, cells continue to divide and gradually specialize functionally and structurally. Specialized cells frequently carry out their functions as multicellular aggregates of like cell types called tissues. A primary, or basic, tissue may be defined as a collection of cells and associated intercellular materials specialized for a particular function or functions.

Striated (voluntary) _____ Skeletal muscle

Cardiac (striated involuntary) _____ Heart

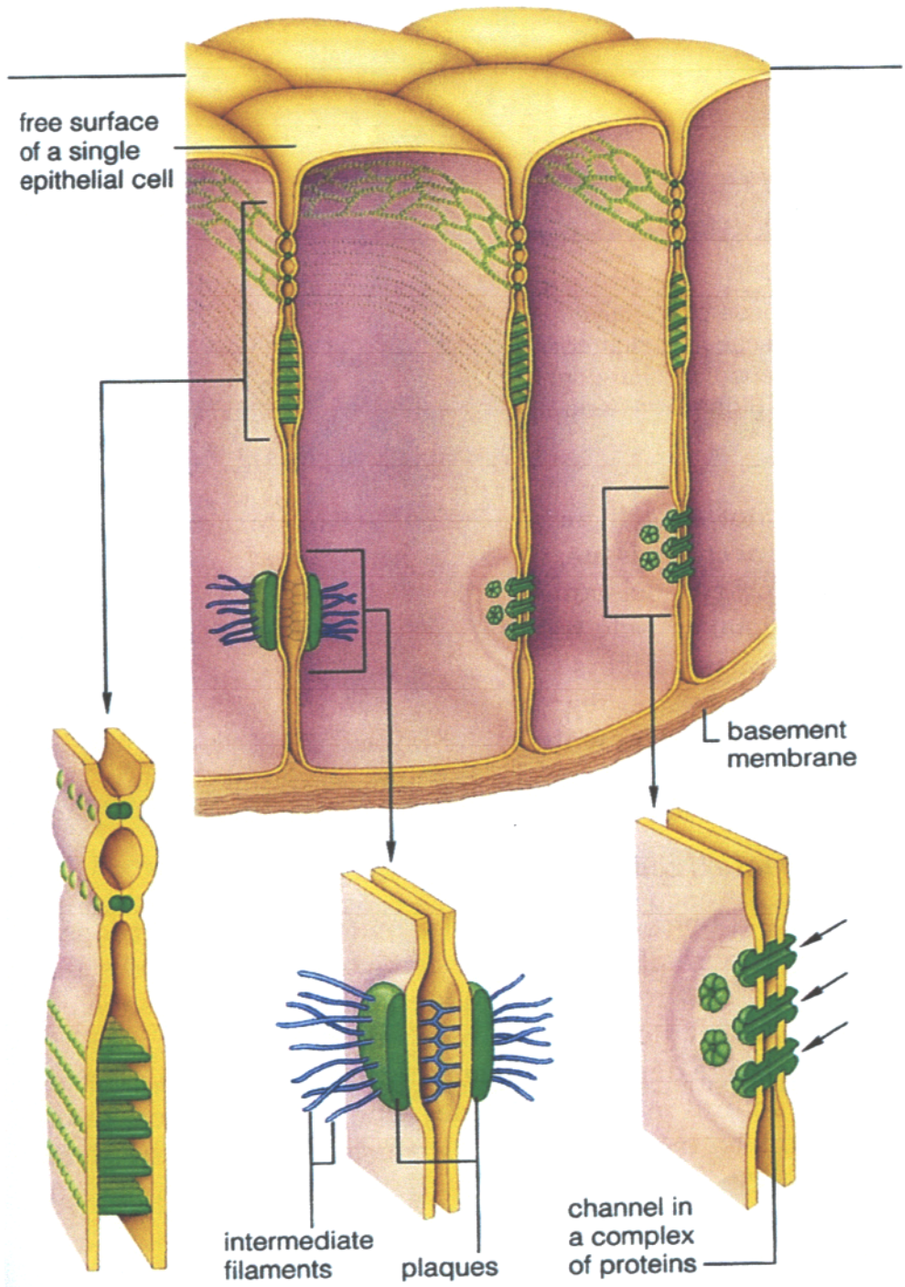


1. Epithelial tissue

Epithelial tissues are formed by closely apposed cells with little or no intercellular material and occur as membranes and as glands.

Membranes are sheets of cells that cover an external surface or line an internal surface. Glands, composed of cells mainly specialized for secretion, develop from epith

3. Gap junctions : are channels connecting the cytoplasm of abutting cells. By promoting rapid transfers of ions and small molecules, they help cells communicate with each other.



a

TIGHT JUNCTION

Strands (rows of proteins) running parallel with the free surface of the tissue; they stop leaks between adjoining cells.

b

ADHERING JUNCTION

Adjoining cells adhere at a mass of proteins (a plaque) anchored beneath their plasma membranes by many intermediate filaments of the cytoskeleton.

c

GAP JUNCTION

Cylindrical arrays of proteins that span the plasma membrane of adjoining cells pair up, forming open channels between the cytoplasm of both cells.

Epithelia are derived from all three embryonic germ layers, although most of the epithelia are derived from ectoderm and endoderm.

The ectoderm gives rise to the oral and nasal mucosae, cornea, the epidermis of skin, and glands of the skin and the mammary glands.

The liver, pancreas, and lining of the respiratory and gastrointestinal tract are derived from the endoderm.

The uriniferous tubules of the kidney, the lining of the male and female reproductive system, the *endothelial lining of the circulatory system, and *mesothelium of body cavities develop from the mesodermal germ layer.

*. Epithelial tissues have numerous functions:

1. Protection of underlying tissues of the body from abrasion and injury.
2. Transcellular transport of molecules across epithelial layers.
3. Secretion of mucus, hormones, enzymes, and so forth from various glands.
4. Absorption of material from a lumen (e.g., intestinal tract or certain kidney tubules).
5. Control of movement of materials between body compart-ments via selective permeability of intercellular junction-s between epithelial cells.
6. Detection of sensations via taste buds, retina of the eye, and specialized hair cells in the ear.

*. Basal laminae:

Basal laminae are sheets of extracellular material present under the basal surface of epithelial cells, around muscles, nerves, capillaries, and fat cells, and situated between these elements and the underlying or surrounding conn-ective tissue. Thus, they are distributed widely, and, in many orga-ns, the connective tissue elements virtually are limited by basal lamina

*. Classification of Epithelial membranes

Classification depends upon two factors : the shape of the cells and their arrangement into layers. Only three cell shapes are used in the classification :-

1. Squamous.
2. Cuboidal.
3. Columnar.

In all, nuclear shape conforms to that of the cell and thus is flattened in squamous cells, spheroidal in cuboidal cells, and ovoid in columnar cells.

In membranes, cells are arranged in one or more layers. *Simple epithelia show cells in a single layer, whereas *stratified epithelia show cells in two or more layers, only the cells of the deepest or basal layer contacting the basal lamina.

Pseudostratified epithelia are those in which all cells con-tact the basal lamina but not all reach the surface. Thus, it really is a simple epithelium, with several cell types present in a single layer but with nuclei at different levels, giving the false appearance of several layers.

By combining the two factors of shape and layering, thus we classify simple squamous, simple cuboidal, and simple columnar epithelia. In stratified epithelia, only the surface layer of cells is utilized to determine the classification of stratified squamous, stratified cuboidal, and stratified columnar. A special type of stratified epithelium is called transitional. This lines the urinary tract and can accommodate to distention, the surface layer varying from squamous to cuboidal with the degree of distention.

Additionally, specific names are applied to certain epithelia. *Endothelium lines the vascular system, and *mesothe-lium lines the body cavities.

Note :
* Pseudostratified columnar epithelia may be ciliated or nonciliated.

Type	Shape of surface cells	Sample locations	Functions
*Simple			
1. Simple squamous	Flattened	Lining: pulmonary alveo-li, loop of Henle, parietal layer of Bowman capsule, inner and middle ear	Limiting membran-e, fluid transport, gaseous exchange, lubrication.
2. Simple cuboidal	Cuboidal	Ducts of many glands, covering ovary.	Secretion, protect-ion, absorption.
3. Simple columnar	Columnar	Lining: oviducts, uterus	Transportation
4. Pseudostratified	Surface cells are columnar	Lining: most of trachea.	Absorption.
*Stratified			
1. Stratified squa-mous (nonker-atinized).	Flattened (with nuclei)	Lining: mouth, vagina.	Protection, secretion.
2. Stratified squa-mous (keratin-ized).	Flattened (without nuclei)	Epidermis of skin	Protection.
3. Stratified cubo-idal.	Cuboidal	Lining: ducts of sweat glands.	Absorption.
4. Stratified colu-mnar.	Columnar.	Conjunctive of eye.	Secretion, absorpti-on, protection.
5. Transitional	Dome-shaped (relaxed), Flattened (distended)	Lining: urinary tract from renal calyces to urethra.	Protection, distensible.

*. Classification of Epithelial membranes

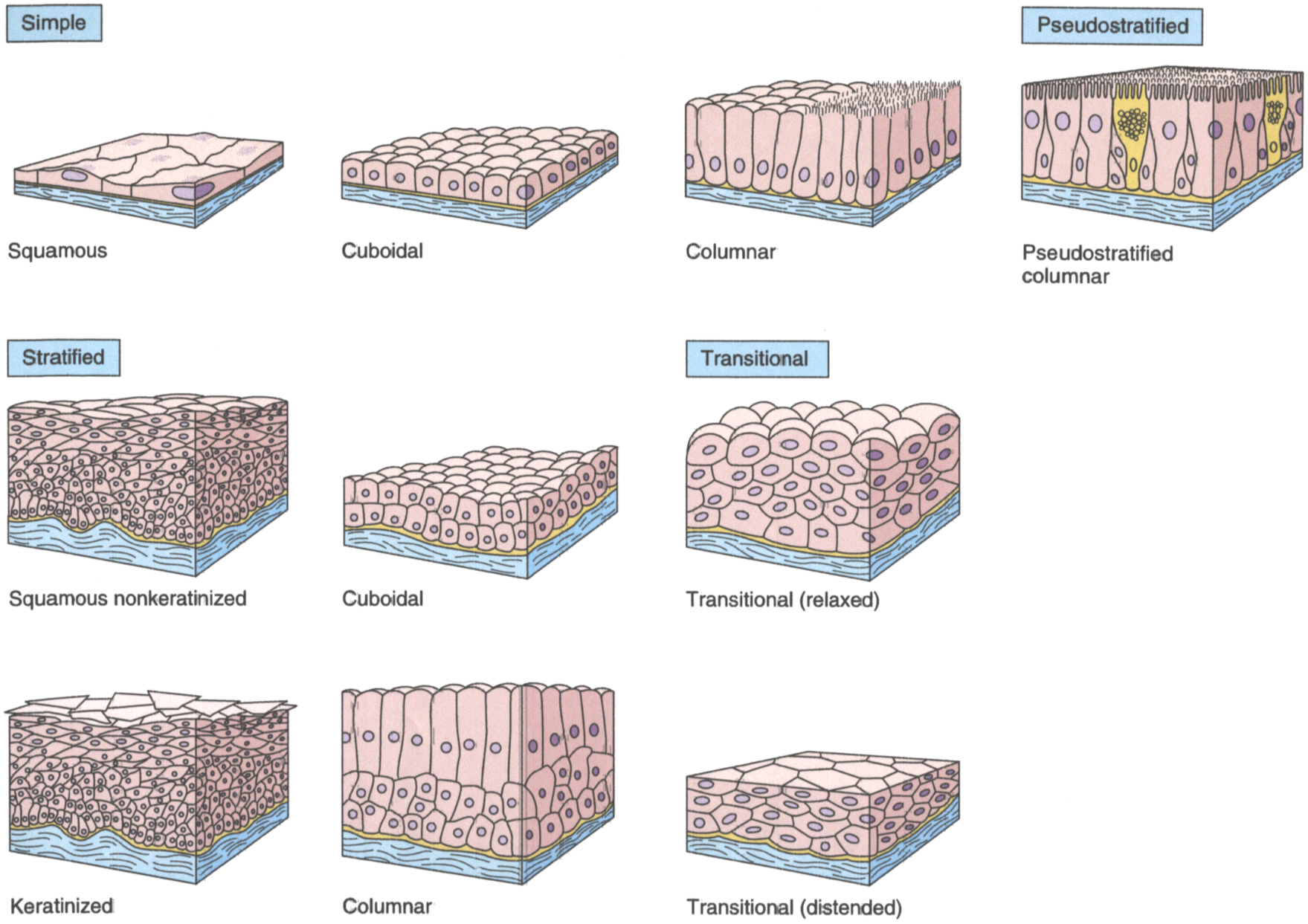


Figure 5–1 Types of epithelia.

♦.*Glands*

Glands originate from epithelial cells that leave the surface where they developed and penetrate into the underlying connective tissue, manufacturing a basal lamina around themselves.

The secretory units, along with their ducts, are the *parenchyma of the gland, whereas the *stroma of the gland represents the elements of the connective tissue that invade and support the parenchyma.

Glandular epithelia manufacture their product intracellularly by synthesis of macromolecules that are usually packaged and stored in vesicles called *secretory granules.

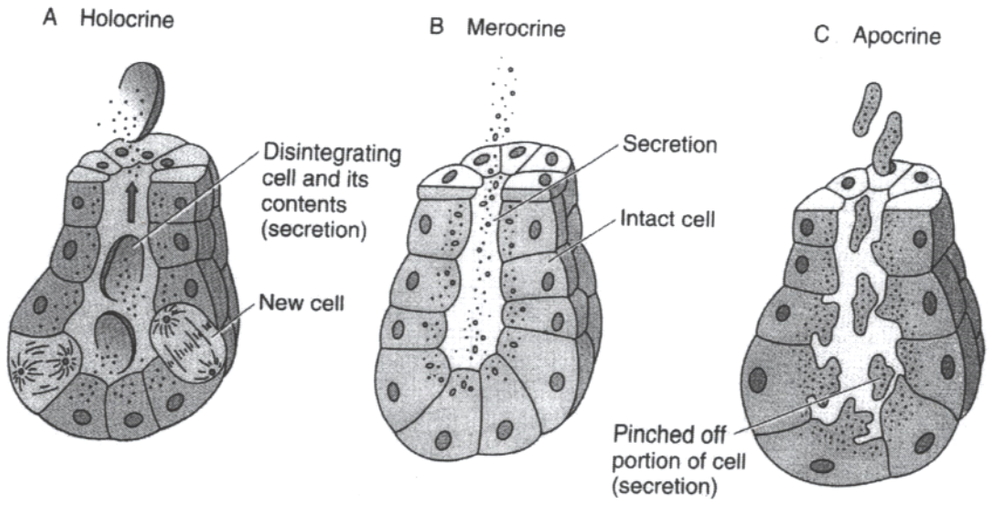
Glands are classified into two major groups on the basis of the method of distribution of their secretory products :-

1. Exocrine glands — secrete their products via ducts onto the external or internal epithelial surface from which they originated.

2. Endocrine glands — are ductless, having lost their connections to the originating epithelium, and thus secrete their products into the blood or lymphatic vessels for distribution.

In general, exocrine glands can be classified by the manner in which their secretory product is elaborated.

1. Holocrine – the entire cell breaks down (e.g., sebaceous glands).
2. Apocrine – release of secretory product involves loss of apical cytoplasm (e.g., mammary glands).
3. Merocrine – Most glands (e.g, salivary glands and the pancreas) are merocrine, that is, the secretory product is formed in and discharged from the cell by exocytosis without the loss of any cytoplasm.



Exocrine glands

Exocrine glands are classified according to the nature of their secretion, their mode of secretion, and the number of cells (unicellular or multicellular).

According to the nature of the secretion, exocrine glands are classified into :~

1. Mucous glands : examples of mucous glands include goblet cells and the minor salivary gland of the tongue.
2. Serous glands : such as the pancreas, secrete an enzyme-rich watery fluid.
3. Mixed glands : contain acini (secretory units) that produce mucous secretions as well as acini that produce serous secretion; in addition, some of their mucous acini possess serous demilu-nes, a group of cells that secrete a serous fluid. The sublingual and submandibular glands are examples of mixed glands.

Exocrine glands may be also classified according to the number of cells as follows :~

a. Unicellular exocrine glands

Unicellular exocrine glands, represented by isolated secre-tory cells in an epithelium (Single cells lying in a columnar

or pseudostratified columnar epithelium), are the simplest form of exocrine gland. The primary example is *goblet cells, which are dispersed individually in the epithelia lining the digestive tract and portions of the respiratory tract. The secretions released by these mucous glands protect the lining of these tract (Goblet cells produce mucous).

Note:-

Goblet cells derive their name from their shape, that of a goblet.

b. Multicellular exocrine glands

Because of their structural arrangement, multicellular glands are subclassified according to the organization of their secretory and duct components as well as according to the shape of their secretory units.

Multicellular glands are classified as *simple if their ducts do not branch and *compound if their ducts branch. They are further categorized according to the morphology of their secretory units as *tubular, *acinar (also referred to as *alveolar, resembling a grape), or *tubuloalveolar.

Summary Table 2–2 Epithelial Glands

Type of Gland	Classification	Duct System	Secretory Unit	Example
Unicellular	Exocrine	—	—	Goblet cell
	Endocrine	—	—	Enteroendocrine
Multicellular	Exocrine	Simple (unbranched)	Tubular	Intestinal glands (crypts of Lieberkühn)
			Tubular, coiled	Sweat glands
		Simple (branched)	Tubular	Fundic (stomach) glands, glands of Bowman
			Acinar (saccular)	Meibomian glands
		Compound	Tubular	Gastric cardia, labial glands
			Tubuloalveolar, serous	Pancreas, parotid, lacrimal
			Tubuloalveolar, mucous	Bulbourethral, labial
			Tubuloalveolar, mixed	Submandibular
			Acinar (saccular)	Prostate, mammar
	Endocrine	—	Cord and clump	Adrenal medulla, pars distalis (hypophysis)
			Follicular	Thyroid

Manner of secretion:
- Holocrine—the entire cell breaks down (e.g., sebaceous glands)
- Apocrine—release of secretory product involves loss of apical cytoplasm (e.g., mammary gland)
- Merocrine—secretory product discharged by exocytosis, no loss of cytoplasm (most glands)

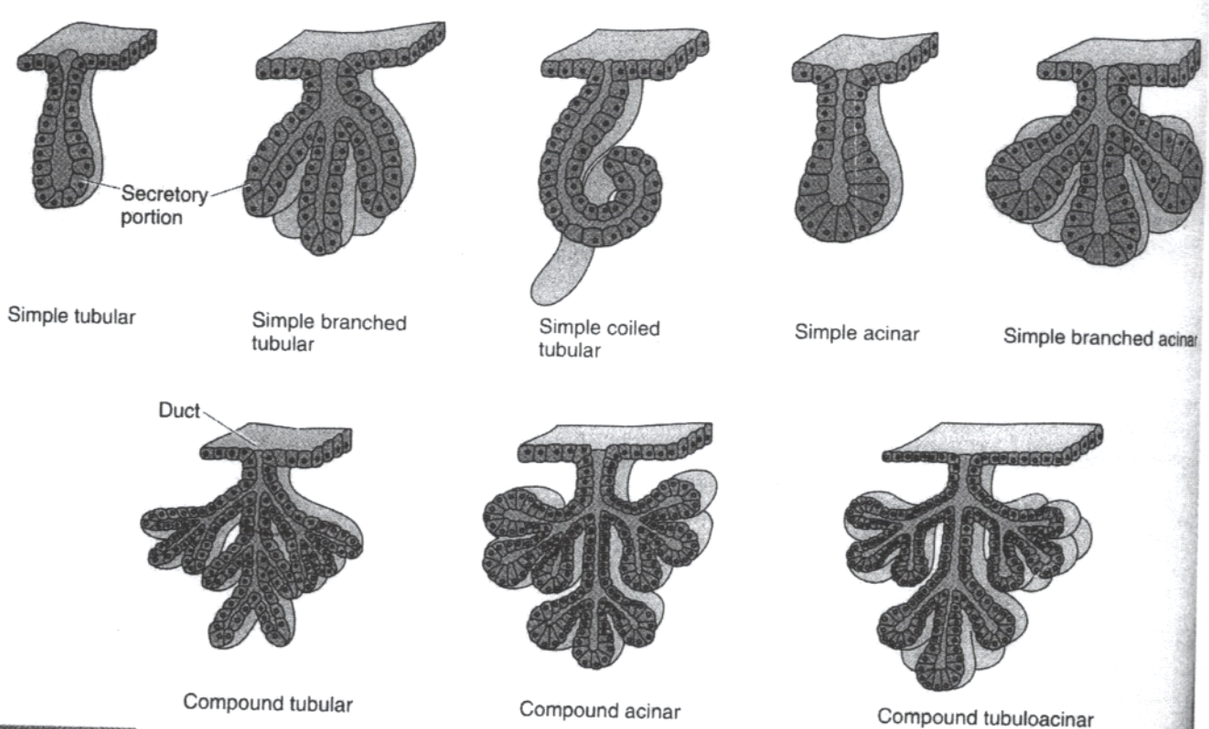


Figure 5–23 Schematic diagram of the classification of multicellular exocrine glands. Green represents secretory portion; lavender represents the duct portion of the gland.

*Endocrine glands

Endocrine glands release their secretions, hormones, into blood or lymphatic vessels for distribution to target organs. The major endocrine glands of the body include the suprarenal (adre-nal), pituitary, thyroid, parathyroid, and pineal glands as well as the ovaries, placenta, and testes.

The secretory cells of endocrine glands are organized either in *cords of cells or in a *follicular arrangement.

In the cord type, the most common arrangement, cells form anastomosing cords around capillaries or blood sinusoids. Examples of the cord type of endocrine gland include the suprarenal gland, anterior lobe of the pituitary gland, and para-thyroid gland.

In the follicle type of endocrine gland, secretory cells (follic-ular cells) form follicles that surround a cavity that receives and stores the secreted hormone. An example of a follicle type of endocrine gland is the thyroid gland.

Some glands of the body are mixed, having both exocrine and endocrine functions. In these mixed glands (e.g., pancreas, ovary, and testes), the exocrine portion of the gland secretes its product into a duct, whereas the endocrine portion of the gland secretes its product into the bloodstream.

*Myoepithelial Cells

Certain cells associated with glandular secretory units possess contractile capabilities. These myoepithelial cells are modified to assist in the delivery of the secretory products into the ducts of the gland. Myoepithelial cells are flattened and possess long processes that wrap around the glandular units. Myoepithelial cells contain both actin and myosin.

In lactating mammary glands, myoepithelial cells contract upon the release of *oxytocin; in the lacrimal gland, they contract because of the action of *acetylcholine.

2. Connective tissue

During embryological development, the ectoderm and endoderm become separated by the third germ layer, the mesoderm. The embryonic tissue formed by cells of the mesoderm is termed *mesenchyme (mesos; middle ; enchyma : infusion), and it is from mesenchyme that the connective tissues of the body develop.

Mesenchymal cells are multipotent and are able to differentiate along several different lines to produce many different kinds of connective tissue cells. Thus, the tissues that have a common origin from mesenchyme are known as mesenchymal tissues, or connective tissues.

Mesenchymal cells migrate throughout the body, giving rise to the connective tissues and their cells, including those of bone, cartilage, tendons, capsules, blood and hemopoie -tic cells, and lymphoid cells.

Mature connective tissue is classified as *Connective tissue proper and *specialized connective tissue (i.e., carti -lage, bone, and blood).

Connective tissue is composed of *cells and *extracellul -ar matrix consisting of ground substance and fibers.

* Functions of connective tissue

1. Providing structural support

Bones, cartilage, and ligaments holding the bones together, as well as the tendons attaching muscles to bone, act as support. Similarly, the connective tissue that forms the capsules encasing organs and the stroma forming the structural framework within organs has support functions.

2. Forming a site for storage of fat.

3. Serving as a medium for exchange

Connective tissue functions as a medium for exchange of metabolic waste, nutrients, and oxygen between the blood and many of the cells of the body.

4. Aiding in the defense and protection of the body.

The functions of *defense and *protection are carried out by :-

a. The body's phagocytic cells, which engulf and destroy cellular debris, foreign particles, and microorganisms.

b. The body's immunocompetent cells, which produce antibodies against antigens.

c. Certain cells that produce pharmacological substances that help in controlling inflammation.

Connective tissues also help protect the body by forming a physical barrier to invasion and dissemination of microorganisms.

*. Extracellular matrix

The extracellular matrix, composed of ground substance and fibers, resists compressive and stretching forces.

(a). Ground substance.

(b). Fibers

Fibers of the extracellular matrix are *collagen (and *reticular) and *elastic fibers.

Collagen fibers are inelastic and possess great tensile strength. The six major collagen types, are summarized here:

*. Type I : in connective tissue proper, bone, dentin and cementum
*. Type II : in hyaline and elastic cartilages.
*. Type III : reticular fibers.
*. Type IV: lamina densa of the basal lamina.
*. Type V : associated with type I collagen and in the placenta.
*. Type VII : attaching the basal lamina to the lamina reticularis.

Elastic fibers are composed of elastin and microfibrils. These fibers are highly elastic and may be stretched to 150% of their resting length without breaking.

*. Cellular components

The cells in connective tissues are grouped into two categories, *fixed cells and *transient cells.

Fixed cells are a resident population of cells that have developed and remain in place within the connective tissue, where they perform their functions.

The fixed cells are a stable and long-lived population that include:

1. Fibroblasts

Fibroblasts, the most abundant cell type in the connective tissue, are responsible for the synthesis of almost all of the extracellular matrix.

2. Myofibroblasts

Myofibroblasts are modified fibroblasts that demonstrate characteristics similar to those of both fibroblasts and smooth muscle cells. Myofibroblasts are abundant in areas undergoing wound healing; they also are found in the

periodontal ligament, where they probably assist in tooth eruption.

3. Pericytes

Pericytes surround endothelial cells of capillaries and small venules and technically reside outside the connective tissue compartment because they possess their own basal lamina.

4. Adipose cells

Adipose cells are fully differentiated cells that function in the synthesis, storage, and release of fat.

5. Mast cells

Mast cells arise from bone marrow stem cells and function in mediating the inflammatory process and immediate hypersensitivity reactions.

The presence of numerous granules in the cytoplasm is the identifying characteristic of mast cells.

6. Macrophages

Monocytes develop in the bone marrow and circulate in the blood. At the proper signal, they leave the bloodstream by migrating through the endothelium of capillaries or venules. In the connective tissue compartment, they mature into macrophages, which normally have a life span of about 2 months.

Macrophages belong to the mononuclear phagocytic system and are subdivided into two groups of cells, phagocytes and antigen-presenting cells.

Macrophages phagocytose foreign substances and damaged and senescent cells as well as cellular debris, they also assist in the initiation of the immune response.

Transient cells (free or wandering cells) originate mainly in the bone marrow and circulate in the bloodstream. Upon receiving the proper stimulus or signal, these cells leave the bloodstream and migrate into the connective tissue to perform their specific functions. Because most of these motile cells are usually short-lived, they must be replaced continually from a large population of stem cells. Transient cells include:

*. Plasma cells.
*. Lymphocytes.
*. Neutrophils.
*. Eosinophils.
*. Basophils.
*. Monocytes.
*. Macrophages.

*. Plasma cells

Plasma cells are derived from B lymphocytes and manu-facture antibodies.

*. Leukocytes

Leukocytes are white blood cells that circulate in the bloodstream. However, they frequently migrate through the capillary walls to enter the connective tissues, especially during inflammation, when they carry out various functions.

*. Monocytes have been discussed under "Macrophages".

*. Neutrophils phagocytose and digest bacteria in areas of acute inflammation, resulting in formation of *pus, an accumulation of dead neutrophils and debris.

*. Eosinophils, like neutrophils, are attracted to areas of infla-mmation by leukocyte chemotactic factors. Eosinoph-ils combat parasites by releasing cytotoxins. They also are attracted to sites of allergic inflammation where they moderate the allergic reaction and phagocytose antibody-antigen complexes.

*. Basophils (similar to mast cells) release preformed and newly synthesized pharmacological agents that initiate, maintain, and control the inflammatory process.

*. Lymphocytes are present only in small numbers in most connective tissue, except at sites of chronic inflammation, where they are abundant.

*. Macrophages: some macrophages behave as fixed cells and some as transient cells. Because mac-rophages are active phagocytes, they fun-ction in removing cellular debris and in protecting the body against foreign invade-rs.

Note

All the transient connective tissue cells are derived from precursors in the bone marrow.

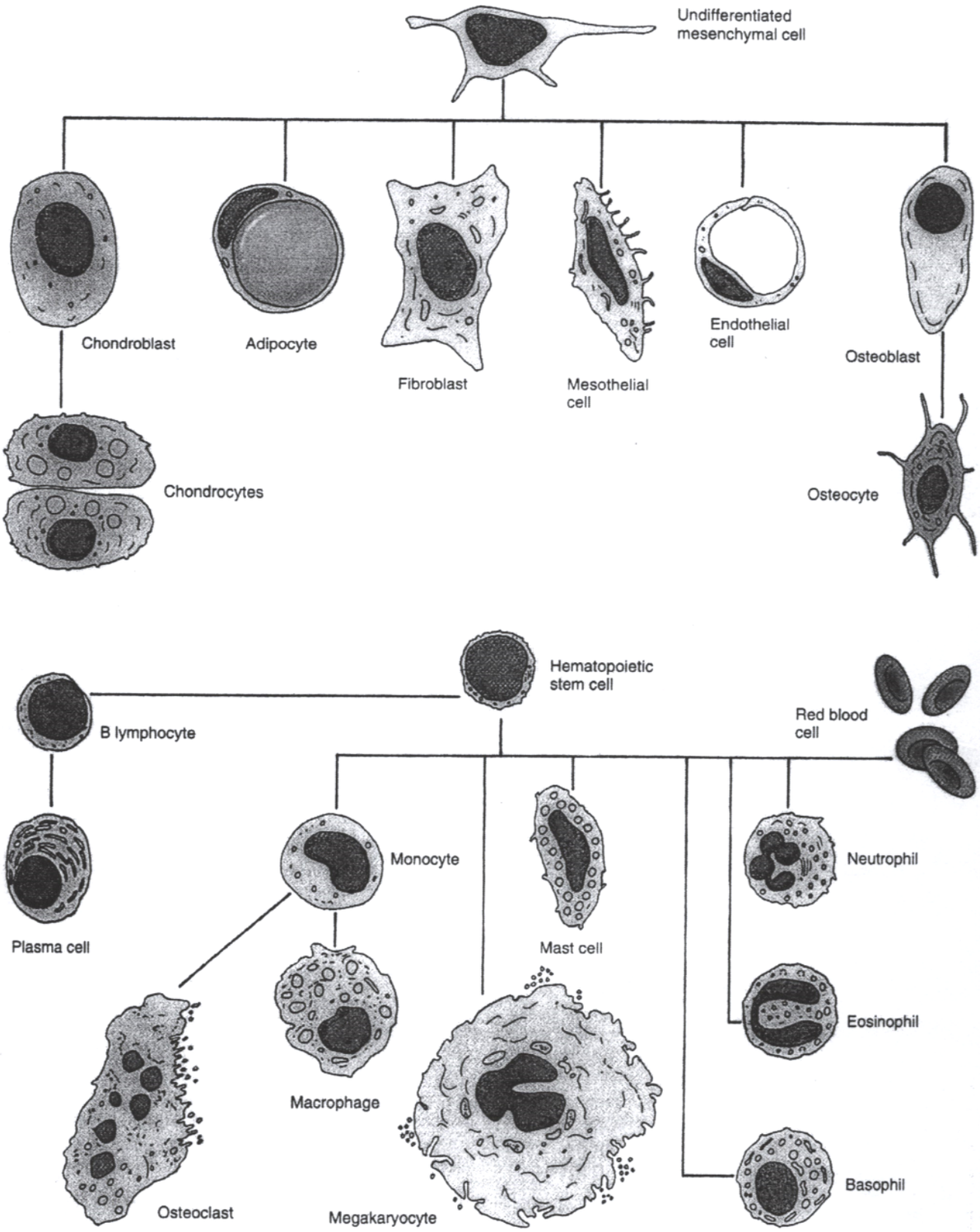


Figure 6–1 Schematic diagram of the origins of the cells of connective tissue. Cells not drawn to scale.

*Classification of connective tissue

Connective tissue is classified into *connective tissue proper and *specialized connective tissue, embracing cartil-age, bone and blood.

*Connective tissue proper

Summary Table 3–2. Types of Connective Tissue Proper

Type	Location	Principal Components
LOOSE CONNECTIVE TISSUES		
Mesenchyme	Primarily in embryo	Mesenchymal cells, ground substance, and scattered reticular fibers
Mucous connective tissue	Umbilical cord	Stellate fibroblasts, abundant ground substance, fine collagenous fibers
Loose (areolar) connective tissue	Widespread as packing and anchoring material	All connective tissue cells, but principally fibroblasts and macrophages, ground substance, and collagenous, elastic and reticular fibers
White adipose tissue	Subcutaneous tissues, omenta	Unilocular fat cells, fine reticular fibers; arranged in lobules
Brown adipose tissue	Embryo, neck, abdomen	Multilocular fat cells; richly vascularized
Reticular tissue	Lymphoid organs, bone marrow	Reticular cells, reticular fibers
DENSE CONNECTIVE TISSUES		
Irregularly arranged	Dermis, fascias, capsules of organs, periosteum, perichondrium	Fibroblasts, collagenous fibers
Regularly arranged	Tendons, ligaments, aponeuroses	Collagenous fibers (primary tendon bundles), fibroblasts (tendon cells)
Elastic tissue	Yellow elastic ligaments: ligamentum nuchae, ligamenta flava	Elastic fibers, fibroblasts