

TISSUES: EPITHELIUM

CN: Use very light colors throughout. (1) Color the arrows pointing to the location of the epithelial tissues in the body organs.

Epithelial tissues, one of four basic tissue types, form the working surface of skin and all body cavities, including glands, ducts, and vessels. They protect, secrete, absorb, or sense (e.g., neuroepithelia). Some even contract (myoepithelia). Epithelial tissues generally exist as one layer (simple) or more (stratified). The lowest layer of epithelia is bound to the underlying connective tissue by a basement membrane (secreted basal and reticular laminae). Epithelial cells are connected together by one or more of: adhesive glycoproteins, desmosomes, gap junctions, and circumferential bands (not shown).

SIMPLE EPITHELIUM

This surface tissue functions in filtration, diffusion, secretion, and absorption.

SQUAMOUS_A

Simple squamous epithelia are thin, plate-like cells. They function in diffusion. They line the heart and all blood vessels (endothelia), air cells, body cavities (mesothelia), etc.

CUBOIDAL_B

Simple cuboidal epithelia are generally secretory cells and make up glands throughout the body, tubules of the kidney, terminal bronchioles of the lungs, and ducts of the reproductive tracts.

COLUMNAR_C

Simple columnar epithelia line the gastrointestinal tract and are concerned with secretion and absorption. Their free (apical) surface may be covered with finger-like projections of cell membrane called microvilli, increasing the cell's surface area for secretion/absorption.

PSEUDOSTRATIFIED COLUMNAR_D

Columnar cells bunched together form a single layer, appearing as if stratified. Each cell is attached to the basement membrane. These cells line reproductive and respiratory tracts. Cilia on the free surface collectively move surface material by means of undulating power strokes alternating with resting strokes.

STRATIFIED EPITHELIUM

Stratified epithelia are generally resistant to damage by wear and tear because of ready replacement of cells.

STRATIFIED SQUAMOUS_E

This tissue may be keratinized (skin) or not (oral cavity, pharynx, vocal folds, esophagus, vagina, anus). Basal cells are generally columnar and germinating.

TRANSITIONAL_F

Multiple layers of cells line the urinary tract. In the empty bladder, the fibromuscular layer is contracted because of muscle tone; the epithelia are closely concentrated. With bladder distension, cells are stretched out; the tissue is thinner than in the contracted state. The tissue is responsive to volume changes.

GLANDULAR EPITHELIUM

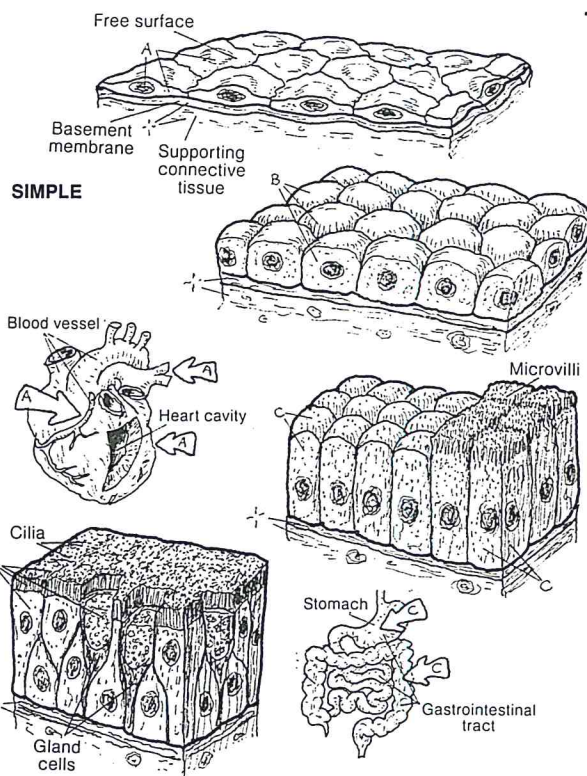
Glandular cells produce and secrete/excrete materials of varying composition—e.g., sweat, milk, sebum, cerumen, hormones, enzymes. Myoepithelial cells induce discharge of the secreted material in most cases.

EXOCRINE_G

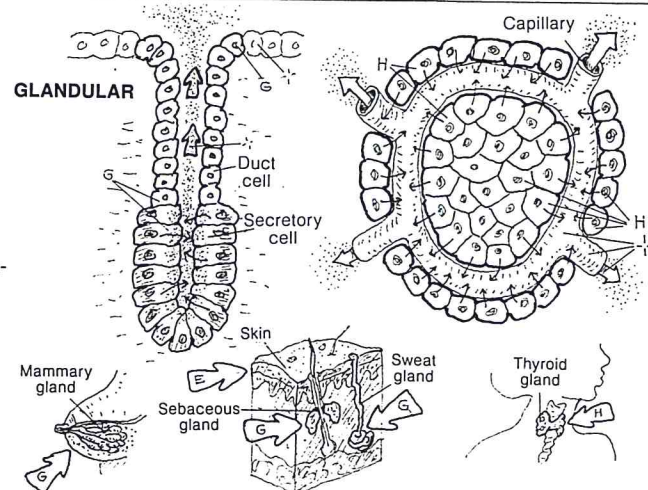
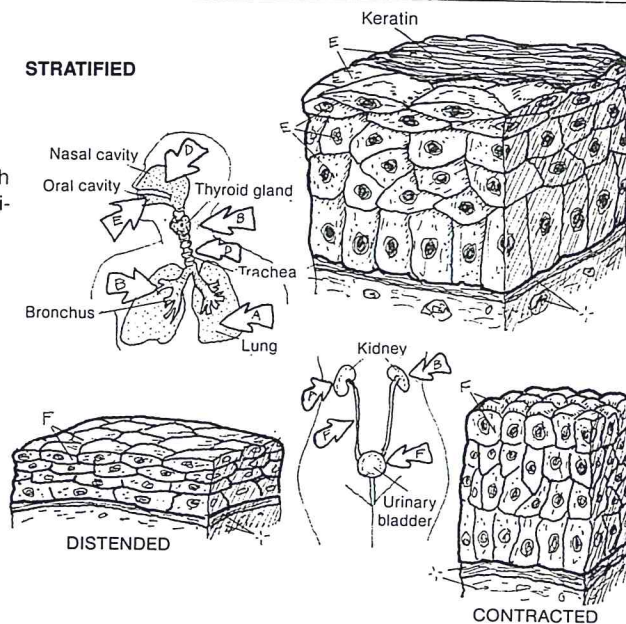
Exocrine glands (e.g., sweat, sebaceous, pancreatic, mammary) arise as outpocketings of epithelial lining tissue, retain a duct to the free surface of the cavity or skin, and excrete/secrete some substance. Secretory portions may have one of several shapes (tubular, coiled, alveolar/acinar) connected to one or more ducts.

ENDOCRINE_H

Endocrine glands arise as epithelial outgrowths but lose their connections to the surface during development. They are intimately associated with a dense capillary network and secrete their products into it.



STRATIFIED



TISSUES: FIBROUS CONNECTIVE TISSUES

CN: Use yellow for C and C¹, and red for J. (1) Begin with the illustration at middle left and the related titles (A through K). The titles and borders of the microscopic sections of dense regular/irregular c.t. (F¹, F²) receive the color of collagen (F), as that is the dominant structure in both tissues. (2) Do not color the matrix.

CELLS

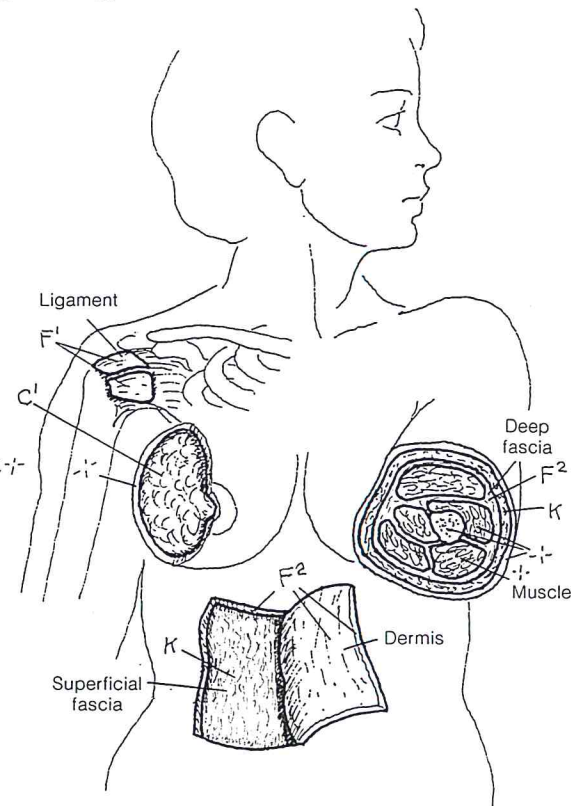
FIBROBLAST_A
MACROPHAGE_B
FAT CELL_C
PLASMA CELL_D
MAST CELL_E

FIBERS

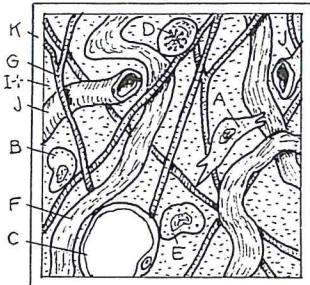
COLLAGEN_F
ELASTIC_G
RETICULAR_H

MATRIX,
GROUND SUBSTANCE_{I-J}
CAPILLARY_K

The connective tissues (c.t.) connect, bind, and support body structure. They consist of variable numbers of cells, fibers, and ground substance (fluid, viscous sol/gel, or mineralized). At the microscopic level (here illustrated at about 600× magnification), connective tissues range from blood (cells/fluid), through the fibrous tissues (cells/fibers/variable matrix) to the more stiff supporting tissues (cells/fibers/dense matrix) of cartilage and mineralized bone. Connective tissue can be seen at visible levels of body organization as well, in fascial layers of the body wall, tendons, ligaments, bone, and so on. This plate introduces the fibrous connective tissues (c.t. proper).

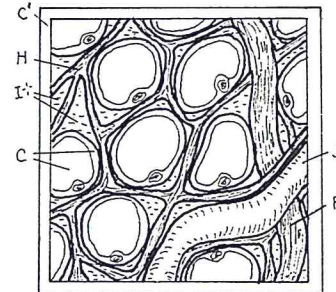


LOOSE, AREOLAR C.T. _K



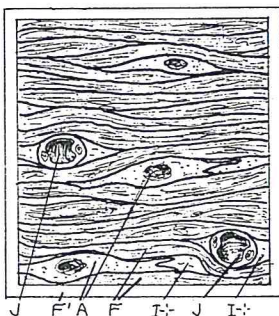
Loose, areolar connective tissue is characterized by many cells, a loose, irregular arrangement of fibers, and a moderately viscous fluid matrix. *Fibroblasts* secrete the fibers and ground substance of this tissue. Mobile *macrophages* engulf cell debris, foreign matter, and microorganisms. *Fat cells*, storing lipids, may be seen in small numbers or large (adipose tissue). *Plasma cells* secrete antibodies in response to infection. *Mast cells* contain heparin and other secretory products, some of which initiate allergic reactions when released. Numerous other cells may transit the loose fibrous tissues, including white blood cells (leukocytes). *Collagen* (linkages of protein exhibiting great tensile strength) and *elastic fibers* (made of the protein elastin) are the fibrous support elements in this tissue. *Reticular tissue* is a smaller form of collagen, forming supporting networks around cell groups of the blood-forming tissues, the lymphoid tissues, and adipose tissue. The *matrix* (consisting largely of water with glycoproteins and glycosaminoglycans in solution) is the intercellular ground substance in which all of the above function; it is fluid-like in the fibrous tissue. Numerous *capillaries* roam throughout this tissue. Loose connective tissue found deep to the skin is called superficial fascia, subcutaneous tissue, or hypodermis. It is found deep to the epithelial tissues of mucous and serous membranes of hollow organs.

ADIPOSE C.T. _{C'}



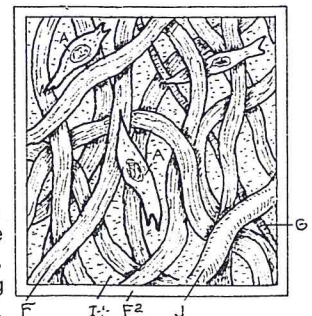
Adipose tissue is an aggregation of *fat cells*, supported by reticular and collagenous fibers and closely associated with both blood and lymph capillaries. The storage/release of fat in/from adipose tissue is regulated by hormones (including nutritional factors) and nervous stimuli. It serves as a source of fuel, an insulator, and mechanical padding and stores fat-soluble vitamins. Adipose tissue is located primarily in the superficial fasciae (largely breast, buttock, anterior abdominal wall, arm, and thigh), yellow marrow, and the surface of serous membranes.

DENSE REGULAR C.T. _{F'}



Dense, parallel-arranged, masses of collagenous/elastic fibers form ligaments and tendons that are powerfully resistant to axially loaded tension forces, yet permit some stretch. Tendons/ligaments contain few cells, largely fibroblasts. Elastic, dense regular ligaments are found in the posterior neck and between vertebrae; the tendocalcaneus is the largest elastic structure (tendon or ligament) in the body, storing energy used in gait.

DENSE IRREGULAR C.T. _{F2}



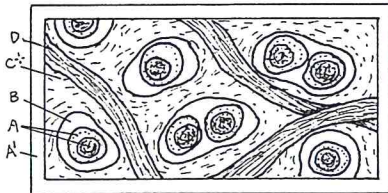
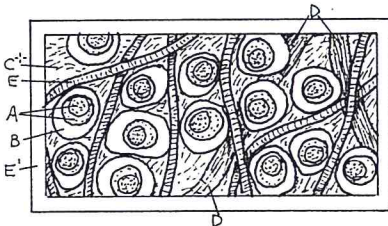
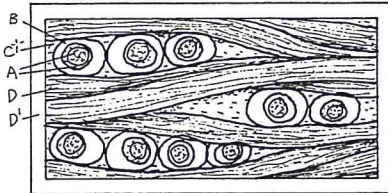
Dense, irregularly arranged masses of interwoven collagenous (and some elastic) fibers in a viscous matrix form capsules of joints, envelop muscle tissue (deep fasciae), encapsulate certain visceral organs (liver, spleen, and others), and largely make up the dermis of the skin. The tissue is impact resistant (bearing stress omnidirectionally), contains few cells, and is minimally vascularized.

TISSUES: SUPPORTING CONNECTIVE TISSUES

CN: Use the same colors as used on the previous plate for collagen (D) and elastic (E) fibers. Use a light tan or yellow for F and red for L. Use light colors for A, B, G, I, and M. Complete the upper material before coloring the bone section.

CARTILAGE

CHONDROCYTE_A
LACUNA_B
MATRIX_C
COLLAGEN FIBER_D
ELASTIC FIBER_E



Microscopic sections of cartilage tissue reveal cells (chondrocytes) in small cavities (lacunae) surrounded by a hard but flexible matrix of water bound to proteoglycans and collagen fibers. Avascular cartilage receives its nutrition by diffusion from vessels in the perichondrium. For that reason, cartilage does not repair well after injury, yet it is often a part of a temporary framework (callus) in the healing process of fractured bone. There are three types of cartilage.

Bone is unique for its mineralized matrix (65% mineral, 35% organic by weight). The skeleton is bone. Bone is a reservoir of calcium; it is an anchor for muscles, tendons, and ligaments; it harbors many viscera; it assists in the mechanism of respiration; its cavity in certain bones is a center of blood-forming activity (hematopoiesis); in other bones, its cavity is a storage site for lipid.

FIBROCARILAGE_{D'}

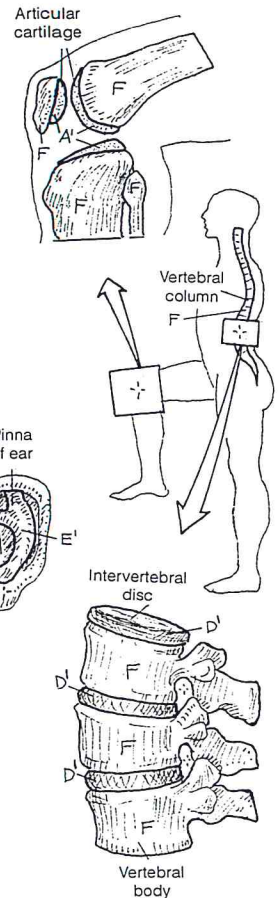
Fibrocartilage offers strength with flexibility, resisting both impact and tensile forces. The best example of this tissue is the intervertebral disc. It consists of dense fibrous tissue interspersed with cartilage cells and a relatively small amount of intercellular matrix.

ELASTIC CARTILAGE_{E'}

This tissue is essentially hyaline cartilage with elastic fibers and some collagen. It supports the external ear and the epiglottis of the larynx. Feel its unique flexibility in your own external ear.

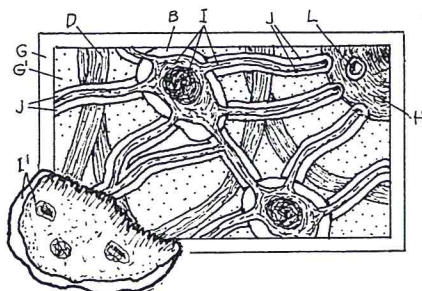
HYALINE CARTILAGE_{A'}

Well known as the covering at bone ends (articular cartilage), hyaline cartilage is avascular, insensitive, and compressible. It is porous, enhancing absorption of nutrients and oxygen. It supports the external nose (feel and compare with the elastic cartilage of the ear). It is the main structural support of the larynx and much of the lower respiratory tract. It forms the model for most early developing bone (Plate 168).

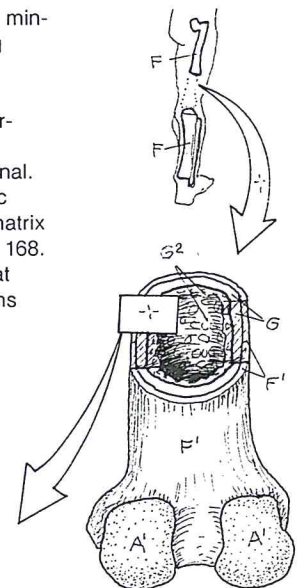
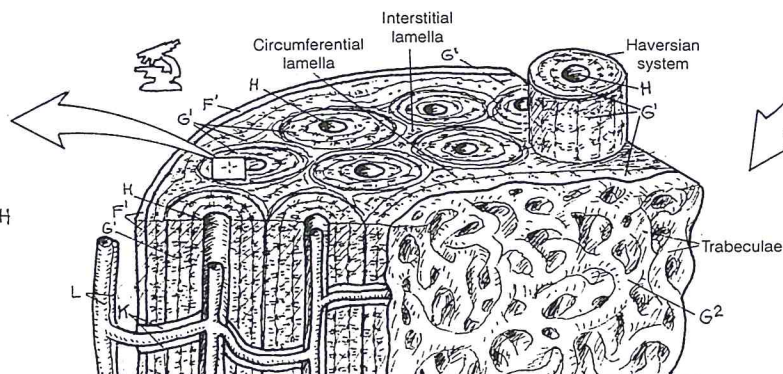


BONE_F

PERIOSTEUM_{F'}
COMPACT BONE_G
HAVERSIAN SYS_{O*}
HAV. CANAL_H
LAMELLAE_{G'}
OSTEOCYTE_I
OSTEOCLAST_{I'}
LACUNA_B
CANALICULI_J
VOLKMANN CANAL_K
BLOOD VESSEL_L
SPONGY BONE_{G²}



As you read, check Plate 20. Bone has compact and cancellous forms. Compact bone is the impact-resistant, weight-bearing shell of bone lined by a sheath of life-supporting fibrous periosteum. Compact bone consists of columns called haversian systems or osteons: concentric layers (lamellae) of mineralized, collagenous matrix around a central (haversian) canal containing blood vessels. Volkmann's canals interconnect the haversian canals. Note the interstitial lamellae between columns and the circumferential lamellae enclosing the columns. Between lamellae are small cavities (lacunae) interconnected by little canals (canaliculi). Bone cells (osteocytes) and their multiple extensions fill these spaces, which connect with the haversian canal. In areas of resorbing bone matrix, large, multinucleated, avidly phagocytic osteoclasts can be seen with multiple cytoplasmic projections facing the matrix they are destroying. Bone-forming cells (osteoblasts) can be seen in Plate 168. Cancellous bone is internal to compact bone and is especially well seen at the ends of long bones. It consists of irregularly-shaped, interwoven beams (trabeculae) of bone, lacking haversian systems.



INTEGRATION OF TISSUES

This plate has one goal: to aid you in visually integrating the four basic tissues into somatic (body wall) and visceral (cavity-containing organs) structure. Concentrate on how the four tissues are arranged in each example of body structure. Consider the general function of each tissue in the overall function of the part/organ. There are an infinite number of functionally related variations in the way these four tissues form a discrete construction of the soma and viscera of the body.

SOMATIC STRUCTURE*

EPITHELIAL TISSUE

SKIN (OUTER LAYER)_A

CONNECTIVE TISSUE

SKIN (DEEP LAYER)_B

SUPERFICIAL FASCIA_{B¹}

DEEP FASCIA_{B²}

LIGAMENT_{B³}

BONE_{B⁴}

PERIOSTEUM_{B⁵}

MUSCLE TISSUE

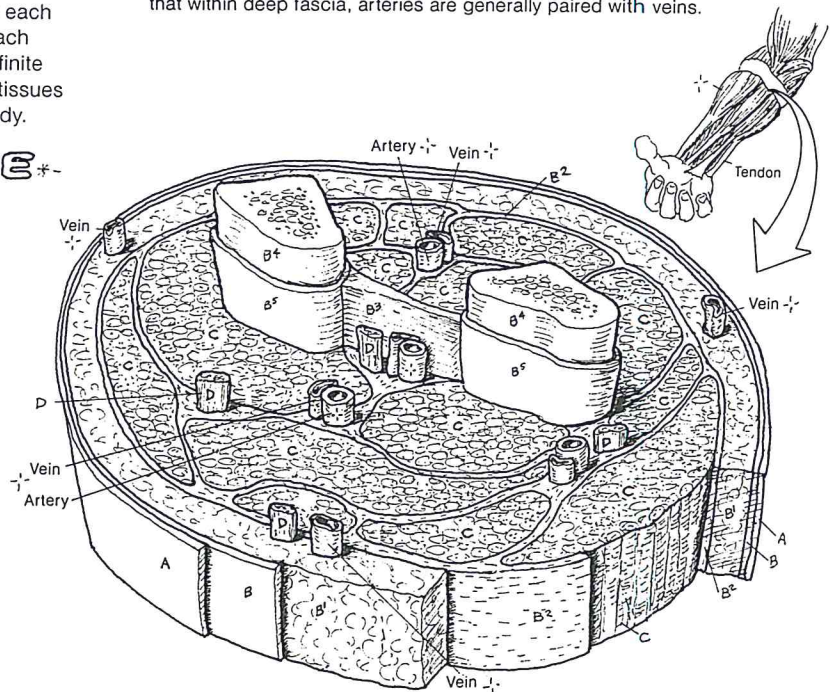
SKELETAL MUSCLE

NERVOUS TISSUE

NERVE

Somatic structure, making up the skin-covered musculoskeletal frame of the body, is concerned with stability, movement, and protection. Its construction reflects these functions. The outermost covering of the body wall everywhere is a protective keratinized *stratified squamous epithelial tissue*, constituting the *outer layer of skin* (epidermis). Other epithelial tissues in somatic structure are the inner layers of blood vessels, and the glands (not shown). Connective tissue layers of the body wall include the *deep layer of skin* (dermis), consisting of dense, irregular fibrous *connective tissue*; and the sub-adjacent, variously mobile, subcutaneous *superficial fascia*

CN: Use yellow for D and light, contrasting colors for A and B, and a medium brown for C. The various vessels that are shown in these tissues—arteries and veins above, and arterioles, venules, capillaries, and lymph vessels below—are not to be colored, as they are made up of more than one basic tissue. Note that within deep fascia, arteries are generally paired with veins.



(loose connective and adipose tissues), containing cutaneous nerves, small vessels, and occasional large veins. *Deep fascia*, a more vascular, sensitive, dense, irregular fibrous tissue, ensheathes skeletal muscle (myofascial tissue) as well as the supporting nerves and vessels. *Ligaments* (dense regular connective tissue) bind *bone* to *bone* by way of *periosteum* (vascular, cellular, dense, irregular, fibrous tissue). *Skeletal muscles* and their *nerves* are packaged in groups, separated by slippery septa of deep fascia securing neurovascular structure. The fibrous investments of skeletal muscle converge to form tendons of the muscle.

VISCERAL STRUCTURE*

EPITHELIAL TISSUE

MUCOSAL LINING_{A¹}

GLAND_{A²}

SEROSA (OUTER LAYER)_{A³}

CONNECTIVE TISSUE

LAMINA PROPRIA_{B⁶}

SUBMUCOSA_{B⁷}

SEROSA (INNER LAYER)_{B⁸}

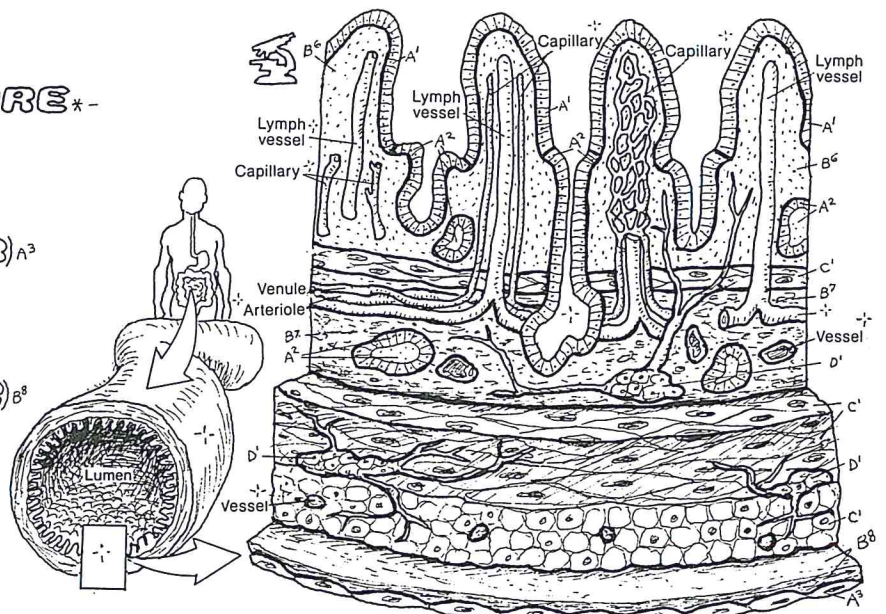
MUSCLE TISSUE

SMOOTH MUSCLE_{C¹}

NERVOUS TISSUE

NERVE CELLS_{D¹}

Visceral structure is generally concerned with absorbing, secreting, trapping, and/or moving food, air, secretions, and/or waste in its cavities. *Epithelial tissue* is the innermost layer (*mucosal lining*) of the thin and pliable visceral wall. It faces the lumen (cavity of the viscus); it is often a single layer of cells (esophagus, urinary tract, and reproductive tract excepted) and deals with the contents of the visceral cavity. *Glands*, unicellular or larger in the mucosa or submucosa, are epithelial, as are the inner layers of blood and lymph vessels. The mucosa includes a sub-epithelial layer of loose fibrous tissue (*lamina propria*), supporting mobile



cells, glands, vessels, and *nerves*. The deepest layer of the mucosa (when present) is a thin *smooth muscle* layer moving finger-like projections (villi) of the mucosal surface. Deep to the mucosa is a dense fibrous tissue (*submucosa*), replete with large vessels and small nerves/nerve cells (intramural ganglia) supplying the mucosa. Deeper yet, two or three layers of smooth muscle (*tunica muscularis*), innervated by local nerve cells, move the visceral wall in peristaltic contractions. The outermost layer of the gastrointestinal tract is the slippery serosa: an *outer* secretory simple squamous epithelial layer and an *inner* supporting layer of light fibrous tissue.