Histology

lecture -1-

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Introduction to histology and epithelial tissue

Introduction

Histology(microscopic anatomy) is the study of tissue structure, extending from the level of the individual cell, through organs to organ systems. Histology is obviously related to *Cell Biology (Cytology)* and to *Anatomy*; it also forms the structural basis for understanding function (*Physiology*) and is the preparation for the study of abnormal structure and function (*Pathology*).

Whole body contains only 200 different types of cells

SPECIFIC OBJECTIVES Topics 1

- Demonstrate knowledge of the structural and functional characteristics that define a tissue.

- Demonstrate knowledge of the mechanisms of cell differentiation, aggregation, intercellular recognition and communication that lead to the formation of tissues.
- Describe the constituent elements of tissues.
- • Demonstrate knowledge of the different criteria for the classification of tissues.

Topics 2

- Demonstrate knowledge of the structural and functional characteristics of epithelial tissues that distinguish them from basic tissues.
- Demonstrate knowledge of the different types of epithelial tissue and give examples of the parts of the body in which these can be found.
- Demonstrate knowledge of the different functions of each type of epithelial tissue and relate them to the tissue structure.
- Demonstrate knowledge of the specialized functions of different types of epithelial cells and give examples of the different parts of the body in which they can be found.

§ Embryonic Tissues

1. Embryo begins as a single cell
   - divides into many cells that form layers (strata)
2. **Three primary germ layers**

A.ectoderm (outer) gives rise to: epidermis + nervous system

B.endoderm (inner): mucous membranes: GI tract and respiratory linings; digestive glands.

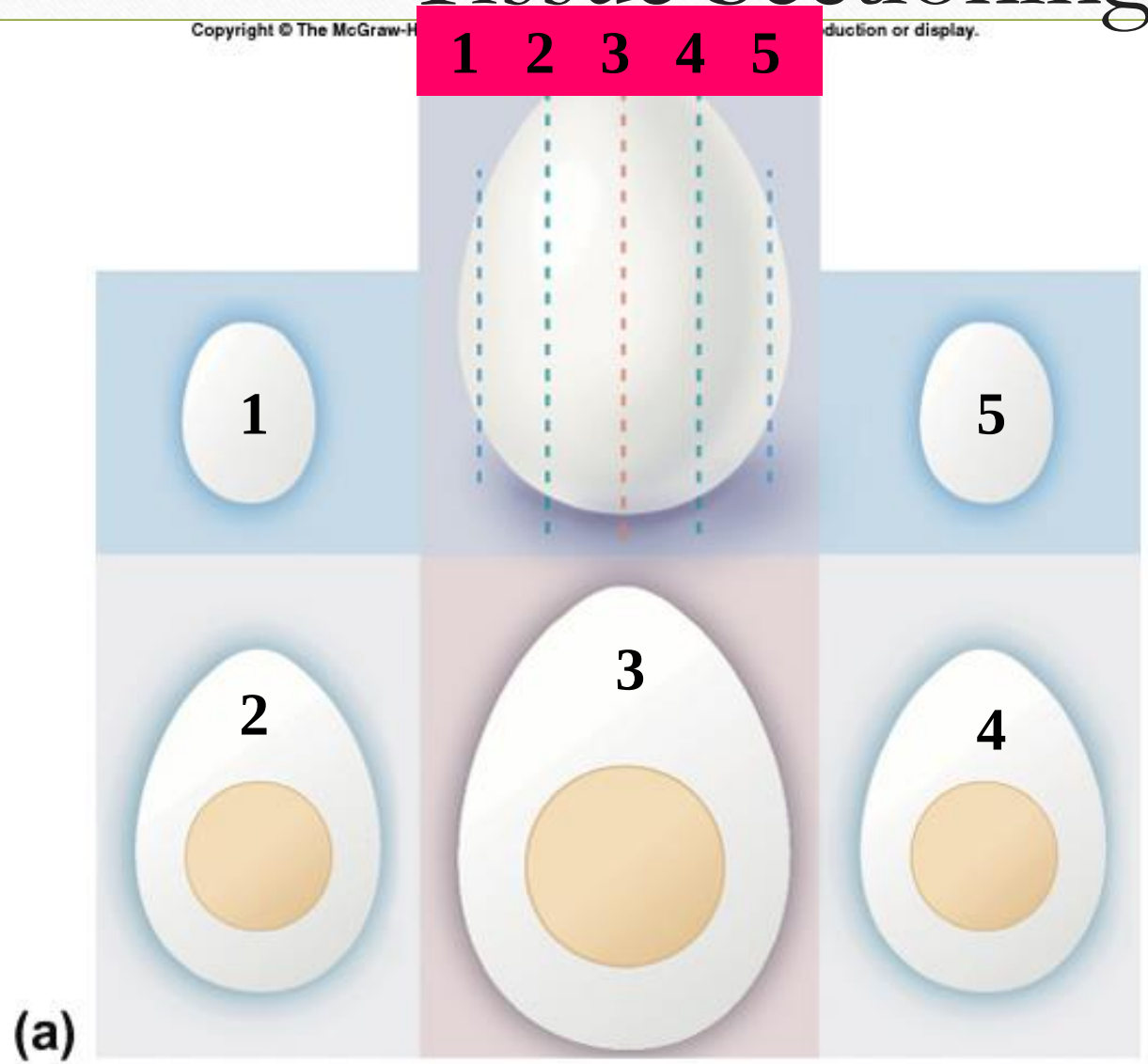
C.mesoderm (middle) forms mesenchyme (gelatinuous tissue) and then give rise to muscle, bone, and blood

§ Tissue Sectioning

1. Preparation of histological specimens
   - fixation
   - sections
   - mounted on slides & stained

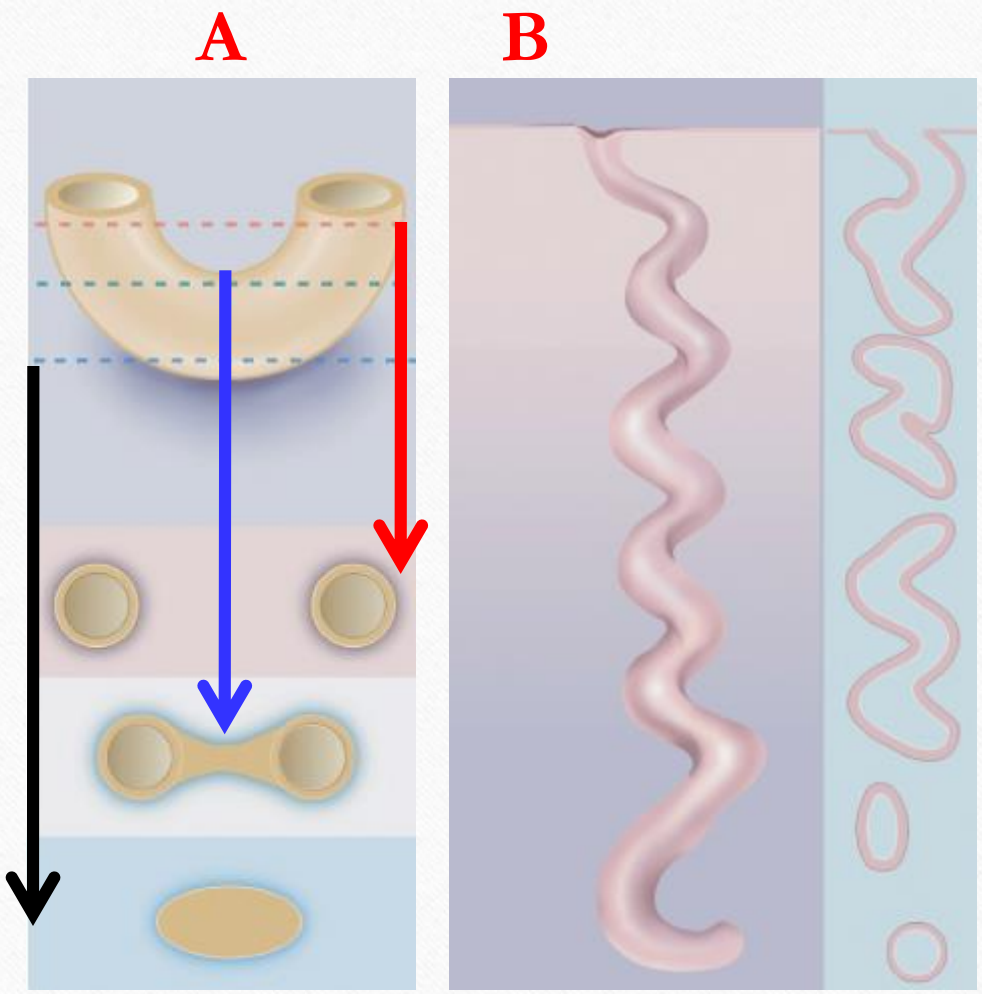
2. Sectioning (slicing) an organ or tissue reduces a 3-dimensional structure to a 2-dimensional slice (see the next 3 slides)

Tissue Sectioning



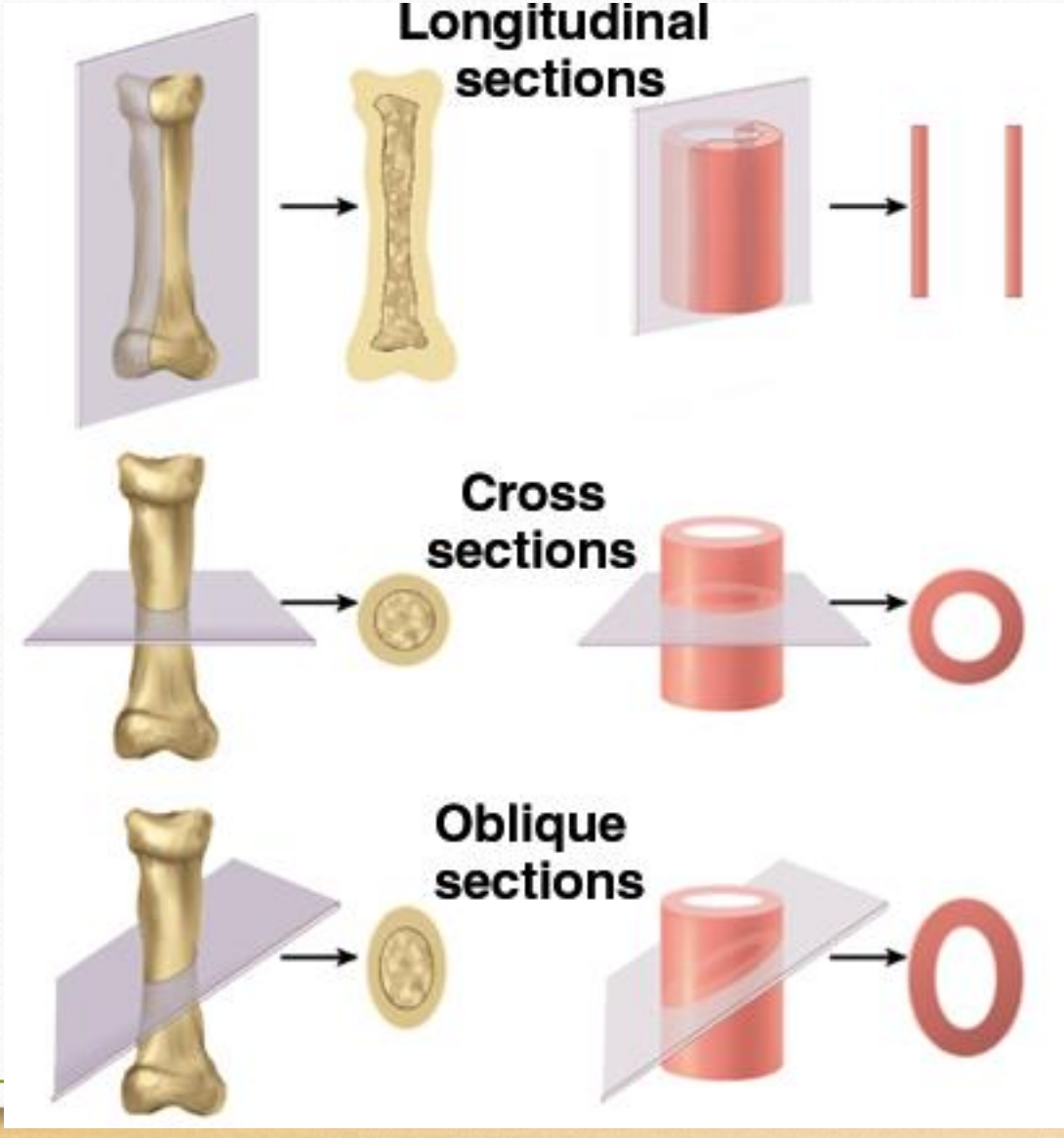
- **Slices 1 & 5** miss the yolk / cell nucleus
- Cell nucleus is smaller in **sections 2 & 4**

Tissue Sectioning



- **Image A** is a cross section of elbow macaroni, resembling a blood vessel, piece of gut, or other tubular organ.
- **Image B** is a longitudinal section of a sweat gland. Notice what a single slice could look like

§ Types of Tissue Sections



Longitudinal section

- tissue cut along the longest direction of an organ

Cross section

- tissue cut perpendicular to the length of an organ

Oblique section

- tissue cut at an angle between a cross & longitudinal section

Original 4 types of tissues:

Epithelial tissues – surface coverage

Muscular tissues – contractile property

Nervous tissues – cells forming brain, spinal cord, and nerves

Connective tissues – to link or support other specialized tissues

Epithelial tissue

A component of many organs specialized for absorption, secretion, and/or to act as a barrier.

They may cover or form a lining for body surfaces.

May form functional secretory glands.

Firmly joined together by adhesion specialization:

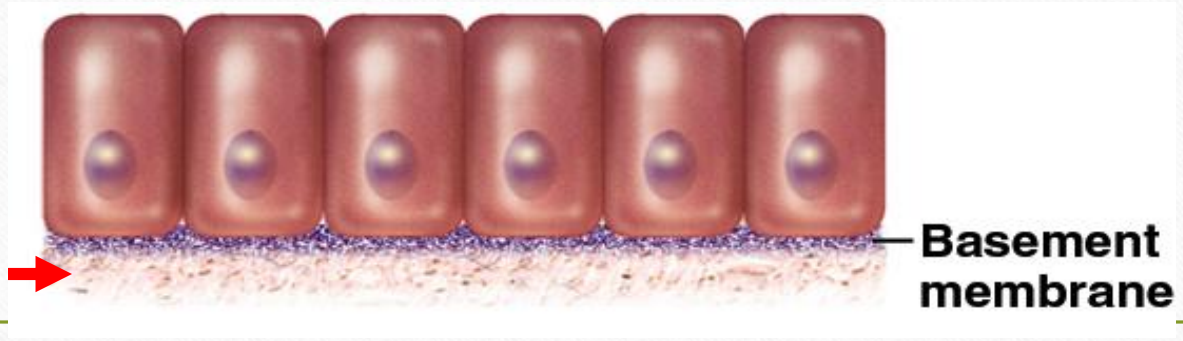
To anchor the cytoskeleton of the neighboring epithelial cells together,

To anchor the epithelial cells to the underlying/surrounding extracellular matrices.

Modified/specialized on the surface to fulfill their specific roles.

§ Epithelial Tissue Introduction

1. One or more layers of closely adhering cells
2. (Top) Forms a flat sheet with the upper (_____) surface exposed to the environment or an internal body cavity
3. (Bottom) Sits on **basement membrane** (basal surface of cells)
   - anchors epithelium to underlying connective tissue
4. **(Nourishment) No room for blood vessels; . . .**



Classification of Epithelial cells: by their shape and their stacking pattern

By shape (morphology):

- Squamous (flat, plate-like)
- Cuboidal (height and width similar)
- Columnar (height = 2x – 5x greater than width)

- **Covering** of external surfaces
- **Lining** of cavities
- Limiting structure

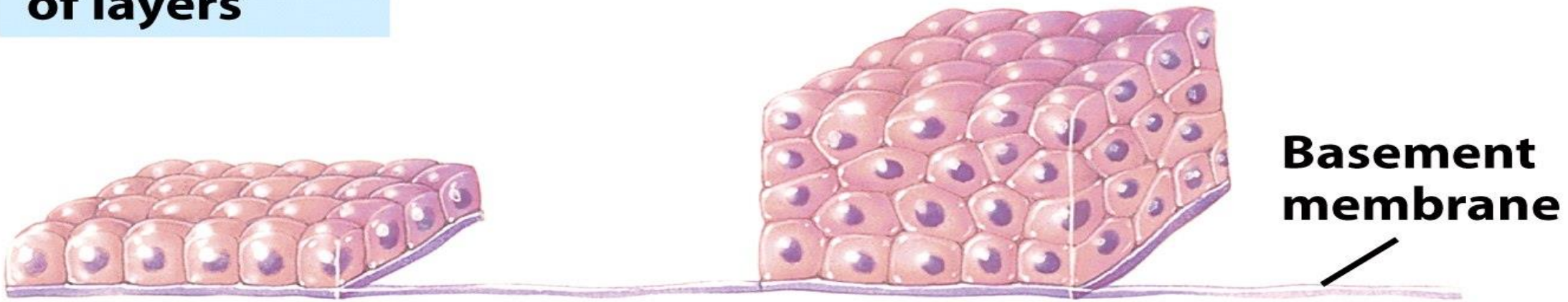
- **Control passage of substances**
- Variety of **other functions**
- **Compact sheets** of cells
- Very little intercellular substance
- Basement membrane
- **Avascularity**… ***supporting tissue required.***

By stacking:

- Simple: forming a single layer, all the cells contact the underlying extracellular matrix.

- Stratified: multiple layer of cell stacking, where only the bottom layer is in contact with the extracellular matrix.
- Pseudostratified: cells appear arranged in layers, but all in contact with the extracellular matrix.
- Transitional: specialized epithelium only in the urinary tract, varies between cuboidal and squamous, depending on the degree of stretching.

Arrangement of layers



Cell shape

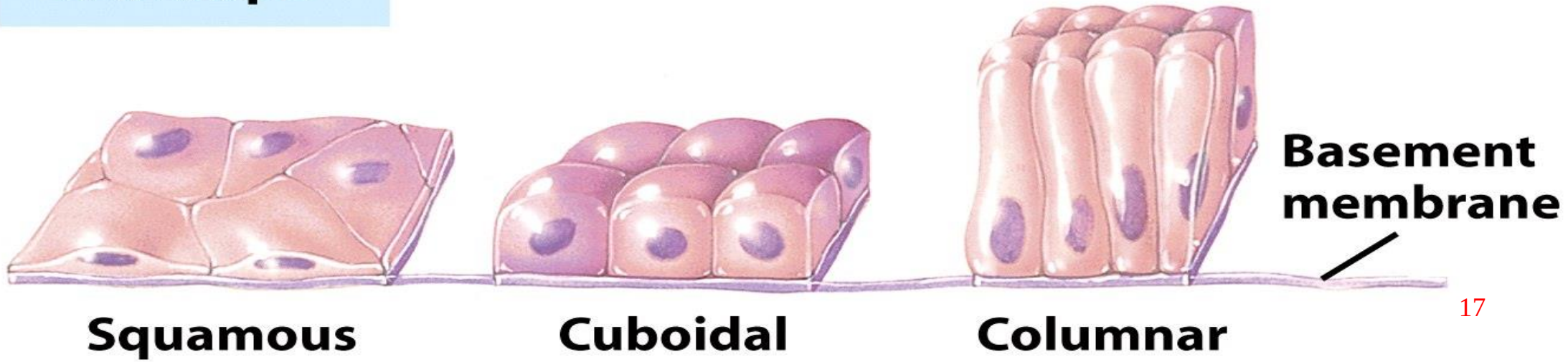
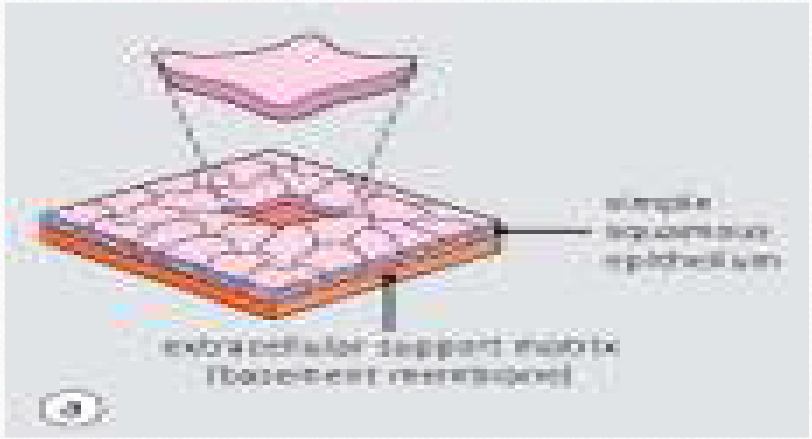
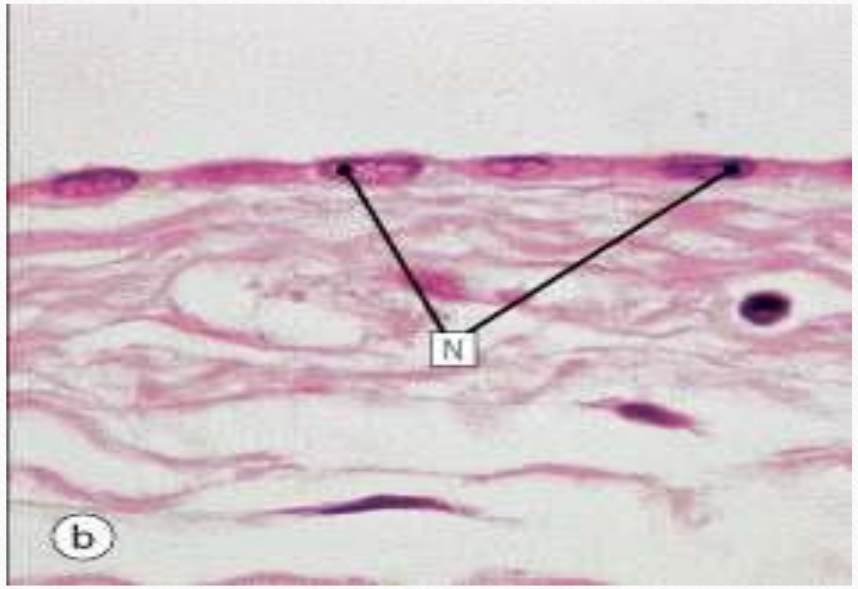


Figure 4-3 Principles of Anatomy and Physiology, 11/e

Simple squamous epithelium:

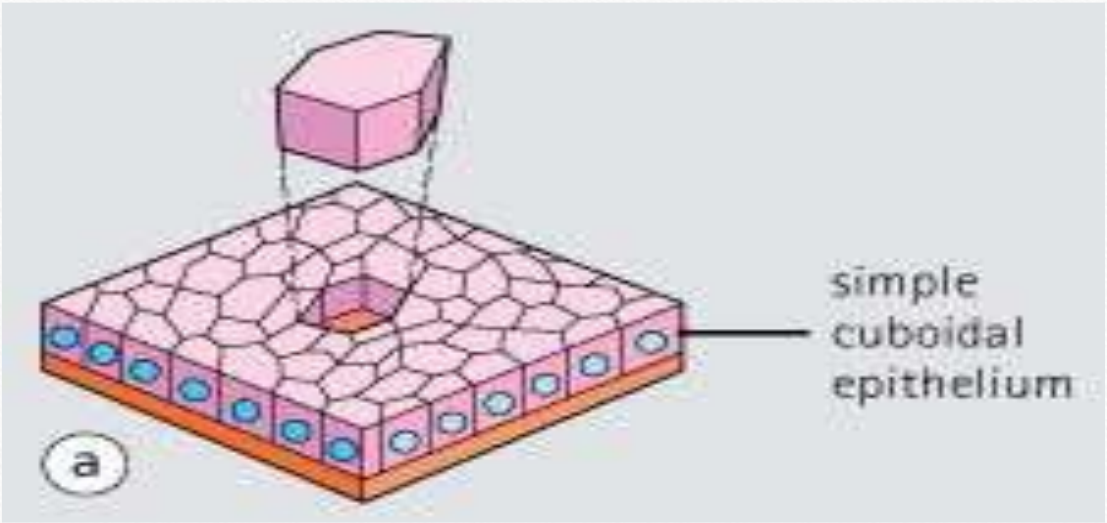
- Consisted of a single layer of cells that are flat and plate like. Many having such characteristics have specialized name, such as endothelium.

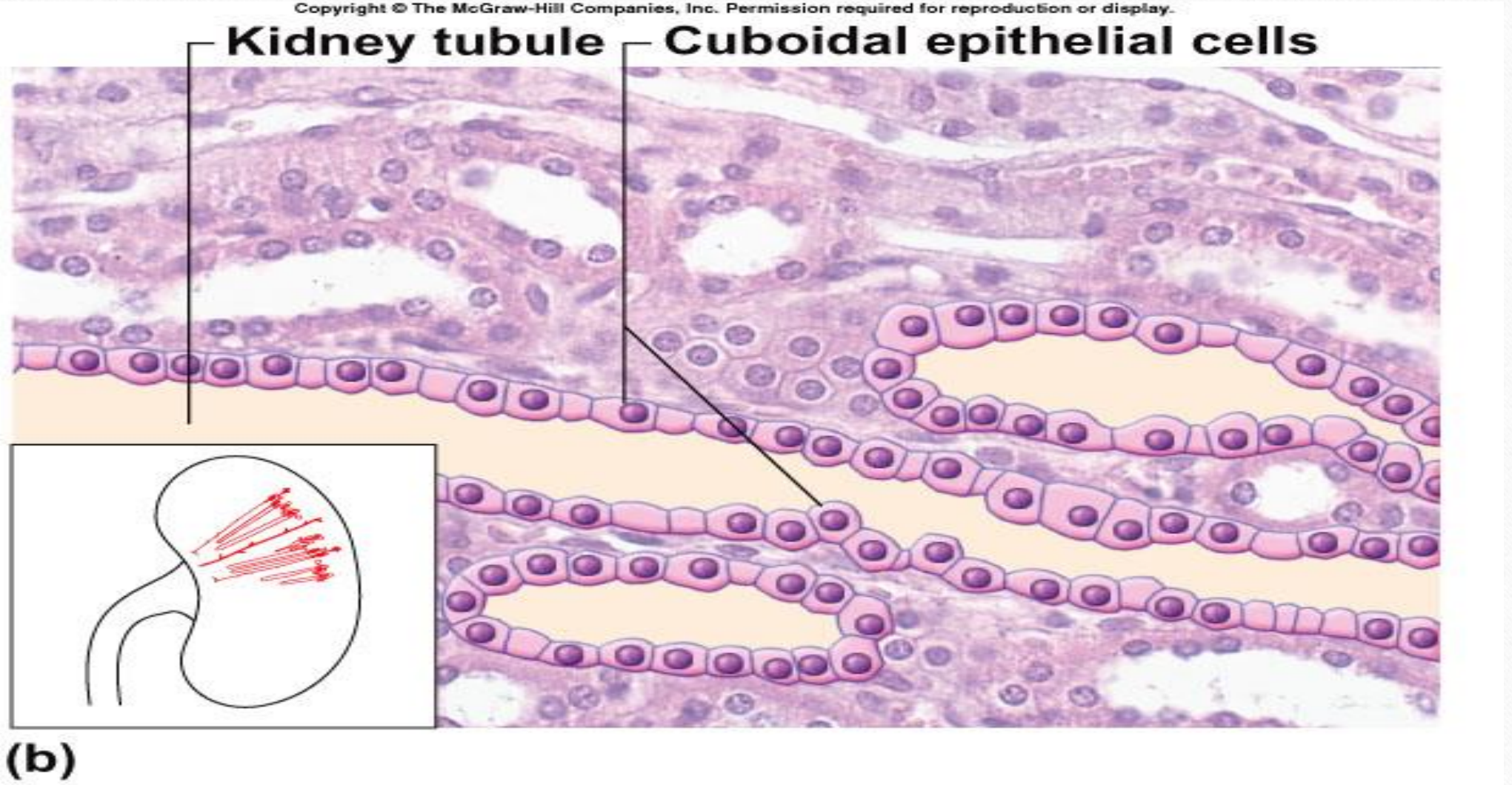




Simple cuboidal epithelium

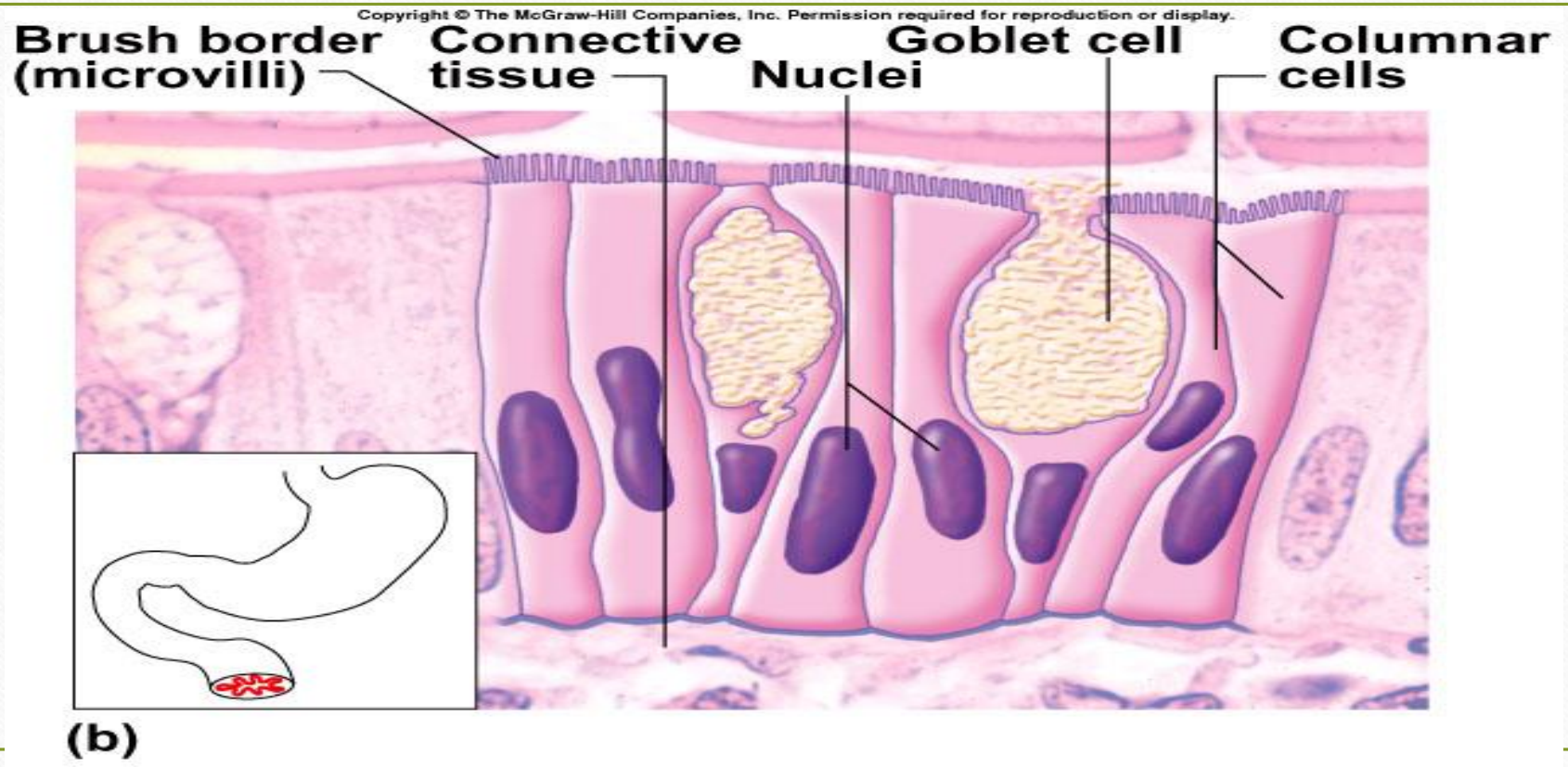
- A single layer of cells whose height, width, and depth are almost the same, cells that have a basic cube shape.





Simple columnar epithelium

- A single layer of cells whose height is two to five times greater than its width.



Special features of epithelium

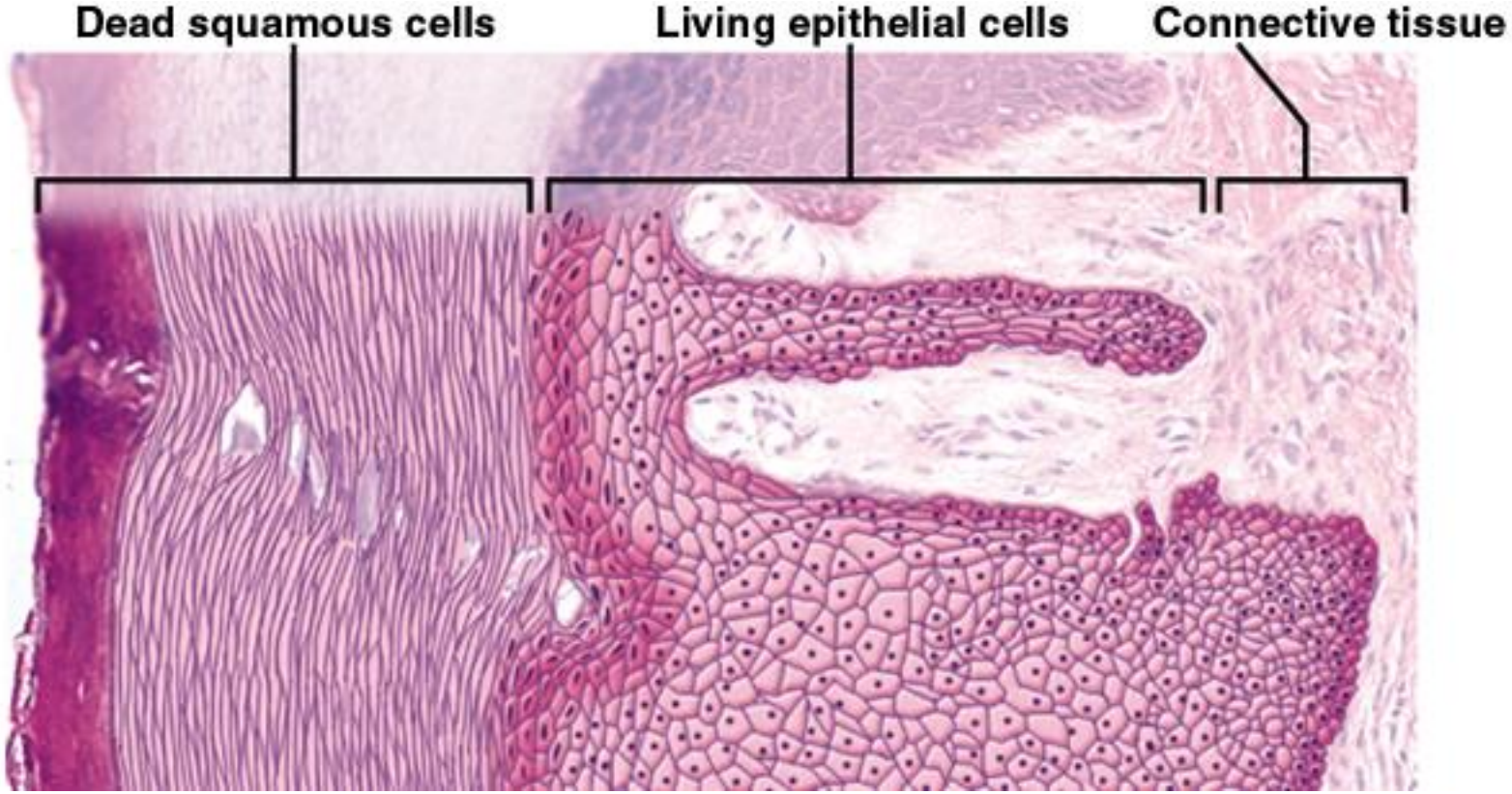
- **Cilia**- (singular= cilium, Latin= eyelash)- hair-like appendages attached to the apical surface of cells that act as sensory structures or to produce movement.
- **Goblet cells**- specialized cells that produce mucus to lubricate and protect the surface of an organ
- **Villi**- (singular= **villus**, Latin= shaggy hair)- finger-like projections that arise from the epithelial layer in some organs. They help to increase surface area allowing for faster and more efficient adsorption.
- **Microvilli**- smaller projections that arise from the cell's surface that also increase surface area. Due to the bushy appearance that they sometimes produce, they are sometimes referred to as the **brush border** of an organ.

Stratified squamous epithelium

- Multiple layers of stacked cells.
- Upper layer: squamous (flattened) shape.
- Middle and basal (bottom) layer: pyramidal or polygonal shape.

Keratinized Stratified Squamous

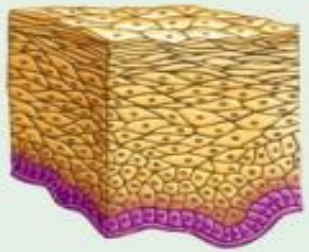
Fig. 5.8 Skin from the sole of the foot



- Layers of epithelium covered with compact, _____ squamous cells (no nuclei) packed with protein keratin
- Retards water loss, prevents entrance of organisms
- Forms epidermal layer of skin (**esp.** soles and palms)

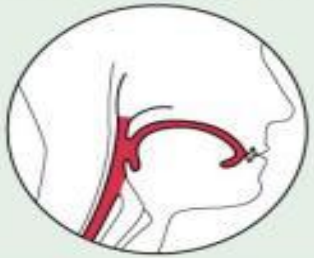
(e) Stratified squamous epithelium

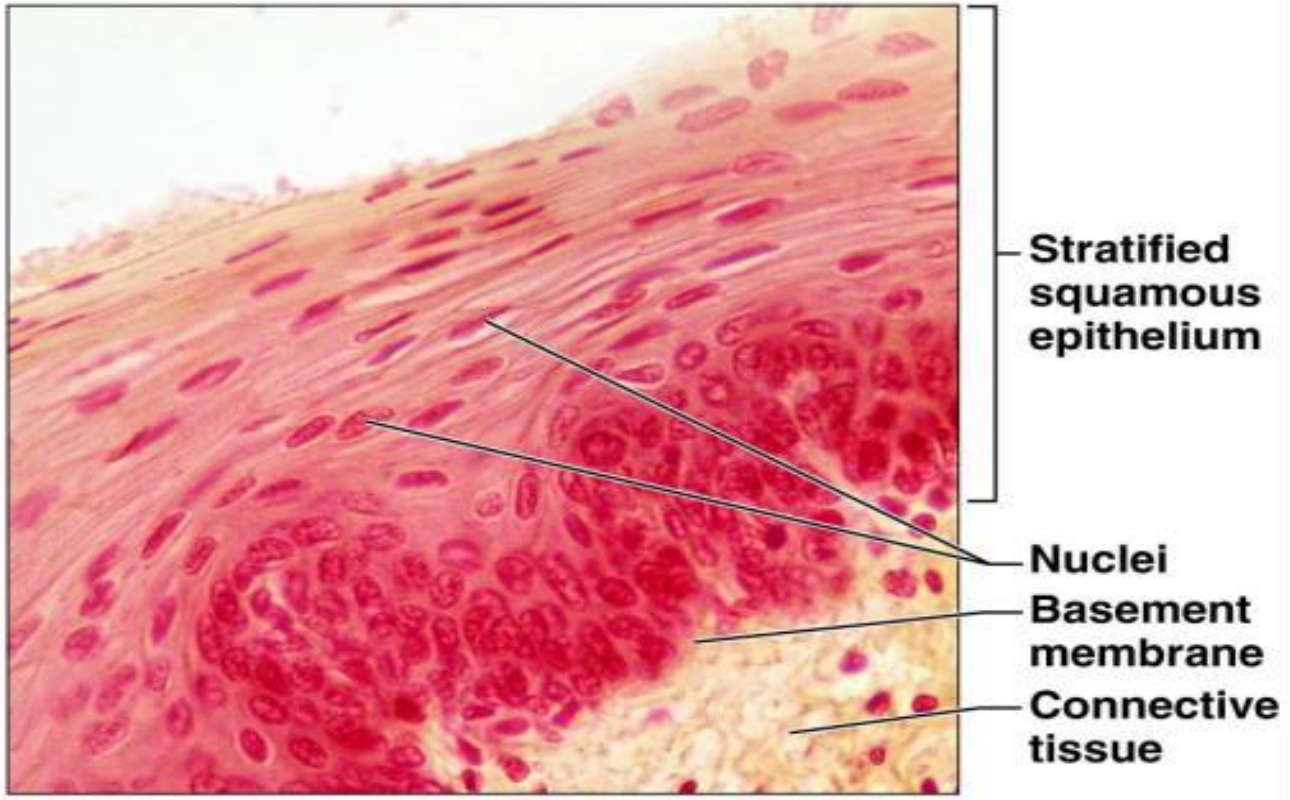
Description: Thick membrane composed of several cell layers; basal cells are cuboidal or columnar and metabolically active; surface cells are flattened (squamous); in the keratinized type, the surface cells are full of keratin and dead; basal cells are active in mitosis and produce the cells of the moresuperficial layers.



Function: Protects underlying tissues in areas subjected to abrasion.

Location: Nonkeratinized type forms the moist linings of the esophagus, mouth, and vagina; keratinized variety forms the epidermis of the skin, a dry membrane.



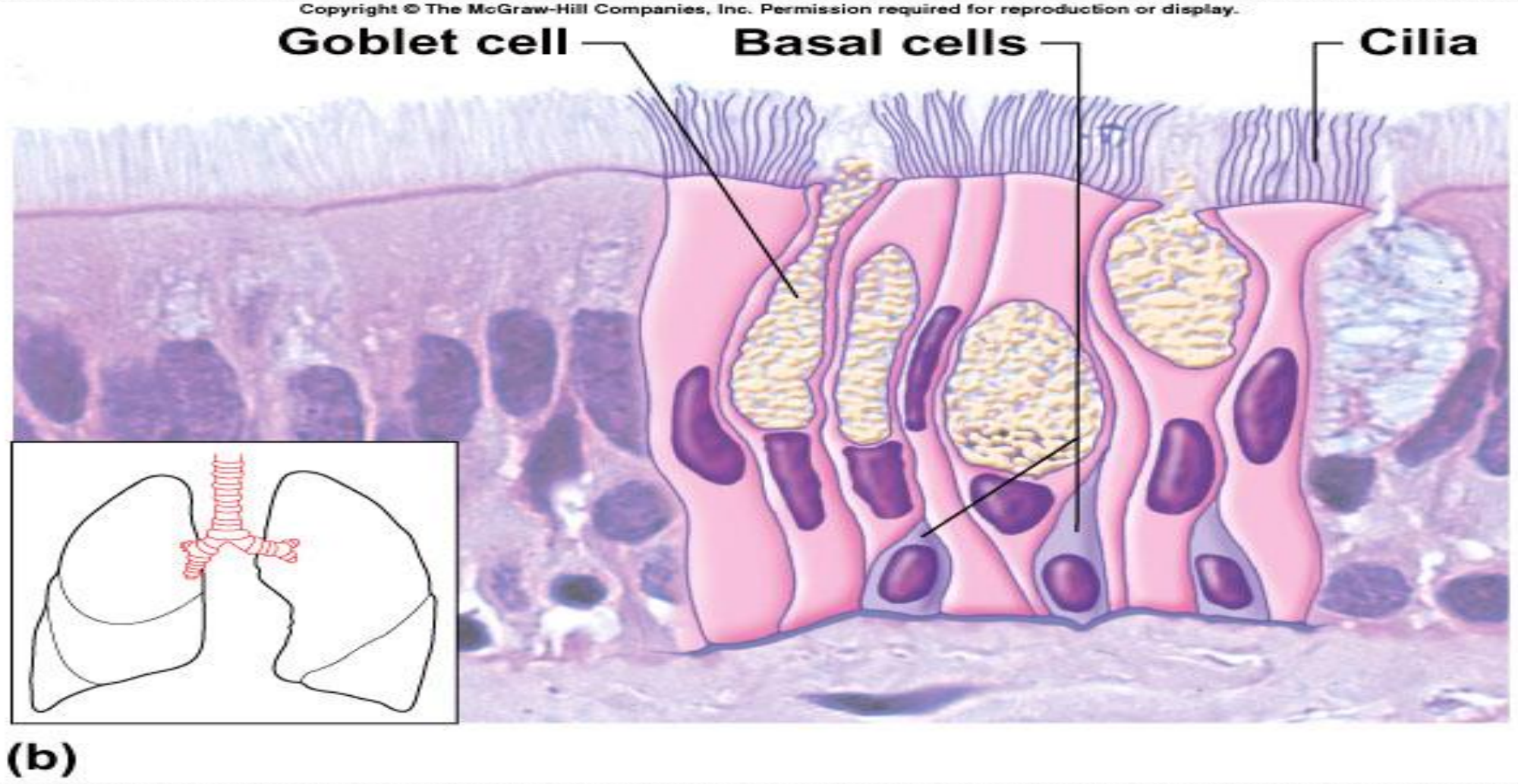


Photomicrograph: Stratified squamous epithelium lining the esophagus (425×).

Pseudostratified columnar epithelium:

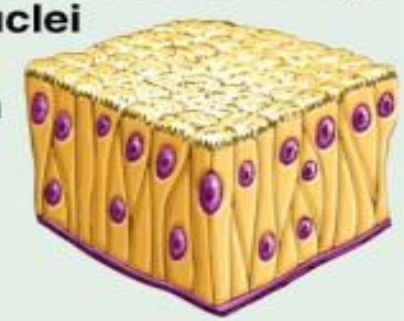
Multiple layers of nuclei, suggesting multiple layer of cells

But all the cells are in contact with the underlying extracellular matrix (basal membrane).



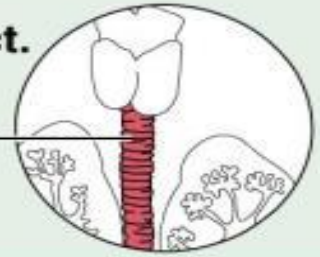
(d) Pseudostratified columnar epithelium

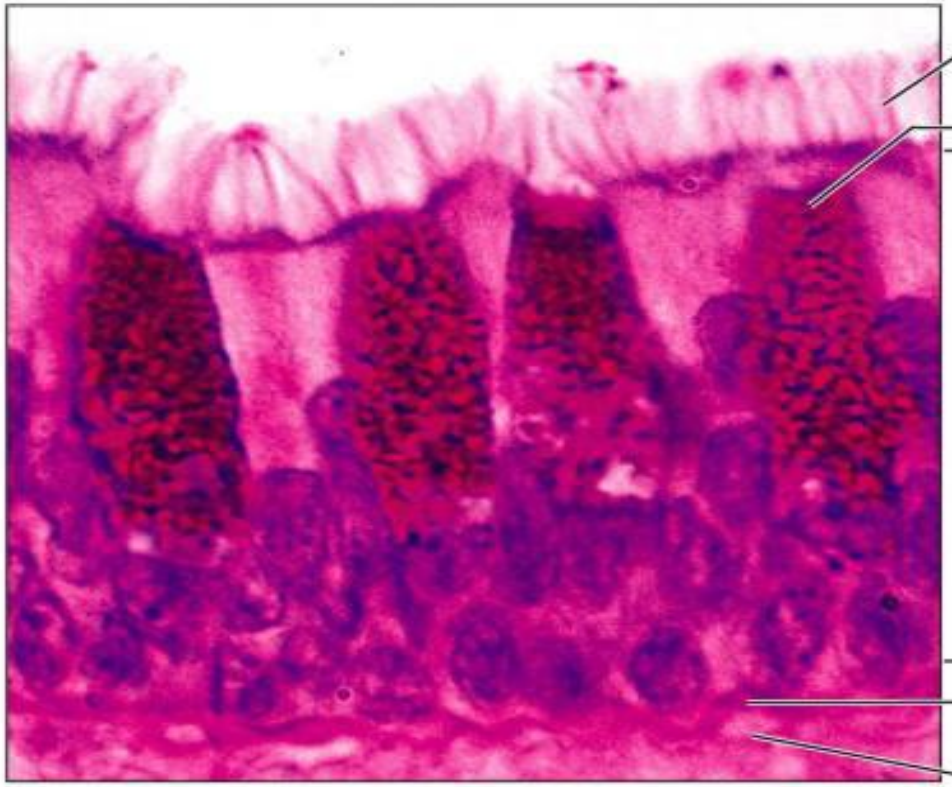
Description: Single layer of cells of differing heights, some not reaching the free surface; nuclei seen at different levels; may contain goblet cells and bear cilia.



Function: Secretion, particularly of mucus; propulsion of mucus by ciliary action.

Location: Nonciliated type in male's sperm-carrying ducts and ducts of large glands; ciliated variety lines the trachea, most of the upper respiratory tract.

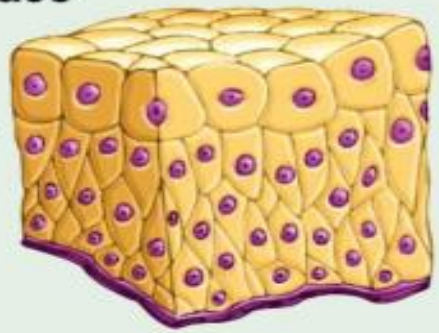




Photomicrograph: Pseudostratified ciliated columnar epithelium lining the human trachea (400×).

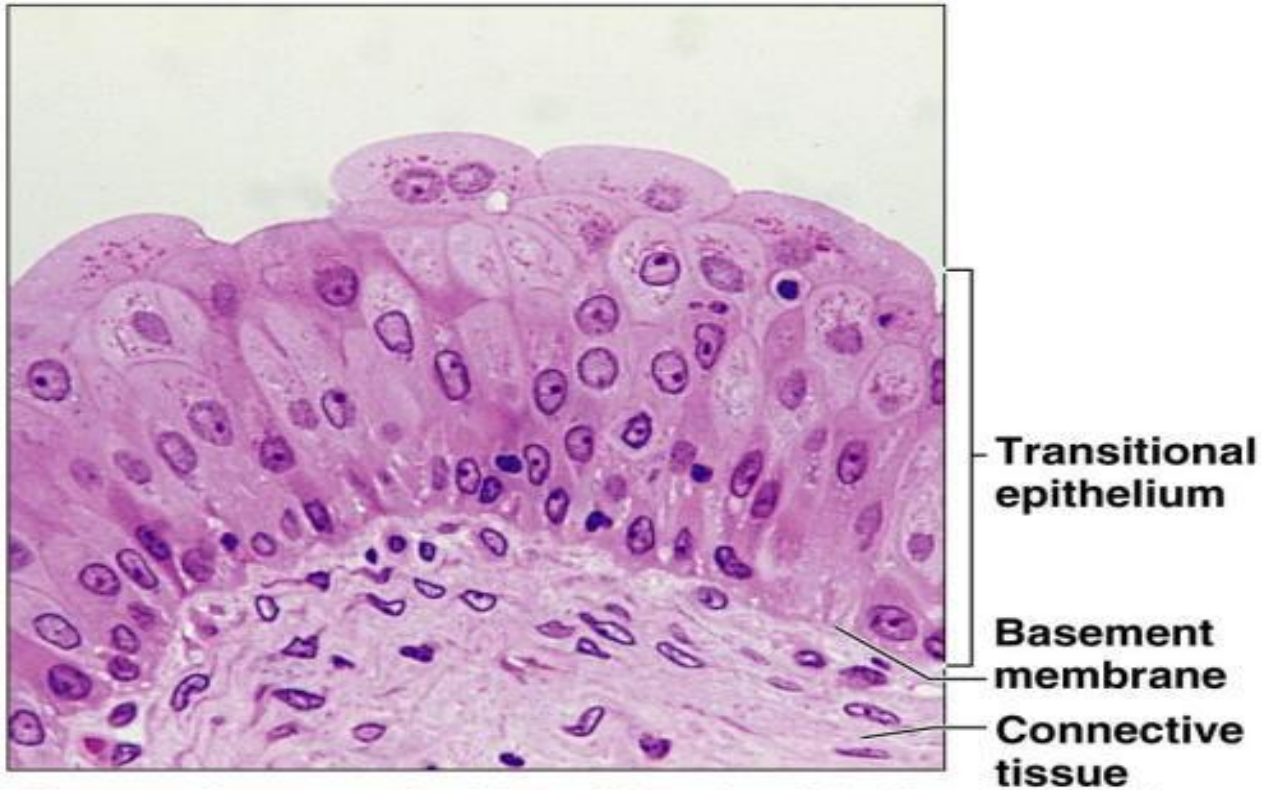
(f) Transitional epithelium

Description: Resembles both stratified squamous and stratified cuboidal; basal cells cuboidal or columnar; surface cells dome shaped or squamouslike, depending on degree of organ stretch.



Function: Stretches readily and permits distension of urinary organ by contained urine.

Location: Lines the ureters, bladder, and part of the urethra.



Photomicrograph: Transitional epithelium lining the bladder, relaxed state (500×); note the bulbous, or rounded, appearance of the cells at the surface; these cells flatten and become elongated when the bladder is filled with urine.

Epithelial Cell Junctions:

- Junction: specialized structures in the epithelia that link (adhere) individual cells together to form a functional unit.
- Two main systems involved in the cell adhesion:

1. Cell membrane proteins function as specialized cell adhesion molecules.
2. Specialized areas of cell membrane incorporated into cell junctions.

- Three types of cell junctions:

1. Occluding junctions: Link cells to form impermeable barrier.
2. Anchoring junctions: Link cells to provide mechanical strength.
3. Communicating junctions: Allow movement of molecules between cells.

Occluding junctions

Function:

- Prevention of diffusion of molecules between adjacent cells.
- Prevention of lateral migration of specialized cell membrane proteins.
- Delineating and maintaining specialized cell membrane domains.
- Also known as tight junction ultrastructurally.
- Well developed in the intestinal epithelia:
- Prevent digested macromolecules from passing between the cells.
- Confine specialized area of cell membrane involved in absorption or
- secretion to the luminal side of the cell.

Occluding Junction: Also found in cells actively transport substances.

Prevent the back-diffusion of the transported substance.

Occludin and claudin are involved in the formation of occluding junctions.

Anchoring Junction

- Provide mechanical stability to groups of epithelial cells.
- Extracellular interaction may be mediated by additional extracellular proteins or ions(such as cadherins).

Actin network interact with two types of junctions:

- Adherent junctions link the actin filament network between adjacent cells.
- Focal contacts link the actin filament network of a cells to the extracellular matrix.

Adherent Junctions

- Most common toward the apex of adjacent columnar and cuboidal epithelial cells. Forms adhesion belt by linking the submembranous actin bundles.
- Prominent in the cells lining the small intestine, forming an eosinophilic band
- Transmit motile forces generated by the acting filaments across the whole sheets ofcells.
- Essential in mediating folding of epithelial sheet to form early organs in the embryo.

Intermediate filament network interact with two different types of junctions:

- Desmosomes that connect the intermediate filament networks of adjacent cells.
- Hemidesmosomes connect the intermediate filament network of cells to

  extracellular matrix.

Desmosomes

- Very good characteristics of epithelial cells.
- Provide mechanical stability in epithelial cells subject to tensile and shearing
- stresses.
- Well developed in stratified squamous epithelium covering the skin.
- A biomarker in differentiating the origin of the invasion in the malignant tumors of uncertain nature.

Junctional complex

- The close association of several types of junction between adjacent epithelial cells.
- A manifestation of the requirement for several types of attachment between epithelial cells to maintain structural and functional integrity.

Communication Junction (Gap Junction)

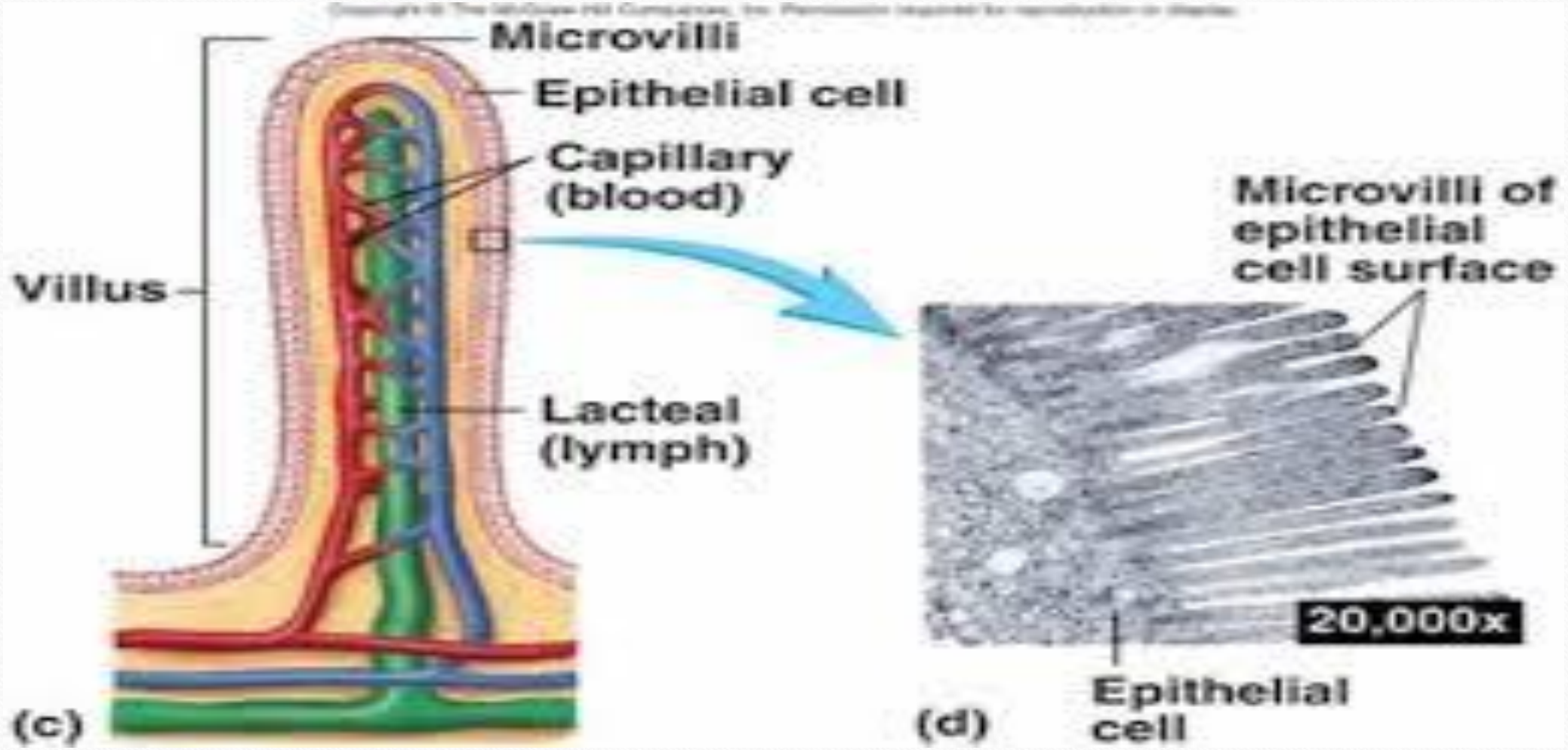
- Allow selective diffusion of molecules between adhacent cells and facilitate cell-cell direct communication.
- Found mostly in embryogenesis.
- In cardiac and smooth muscle: signal passage between cells.
- In some cerebellar synapses: direct synapses.

Basement Membrane

- Anchors epithelial cells to the underlying tissues.
- Contains Type IV collagen synthesized by the epithelial cells.
- Appears as a linear structure at the base of epithelia, can be stained with PAS stain.

Microvilli

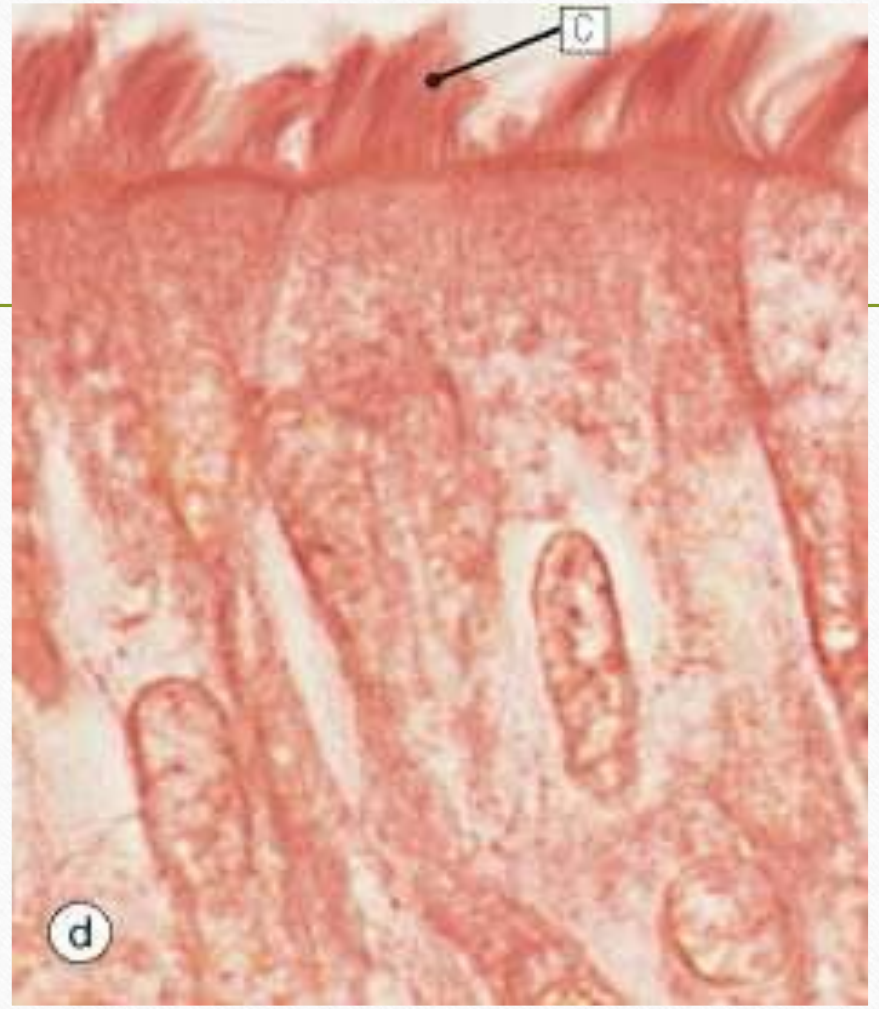
- Finger-like projections of the apical cells surface.
- Most developed in absorptive cells like kidney tubule cells and epithelia of small intestine.
- Morphology: maintained by bundle of actin filaments that anchored to the actin cortex.
- Surface of microvilli: specific cell surface glycoprotein and enzymes related to absorption process.


Microvilli
Epithelial cell
Capillary (blood)
Villus
Lacteal (lymph)
(c)
Microvilli of epithelial cell surface
20,000x
Epithelial cell
(d)

Cilia

- Hair-like projections, ~ 0.2 =m in diameter, arise from the surface of certain specialized cells.
- Involved in moving fluid over the surface of the cell or to give cells motility.
- Highly specialized extension of cytoskeleton (microtubules).
- Microtubules bound with other proteins to produce energy-dependent movement causing side-to-side beating.
- Evident in respiratory tract epithelium (moving mucus), epithelium of fallopian tube

(moving ova to the uterus)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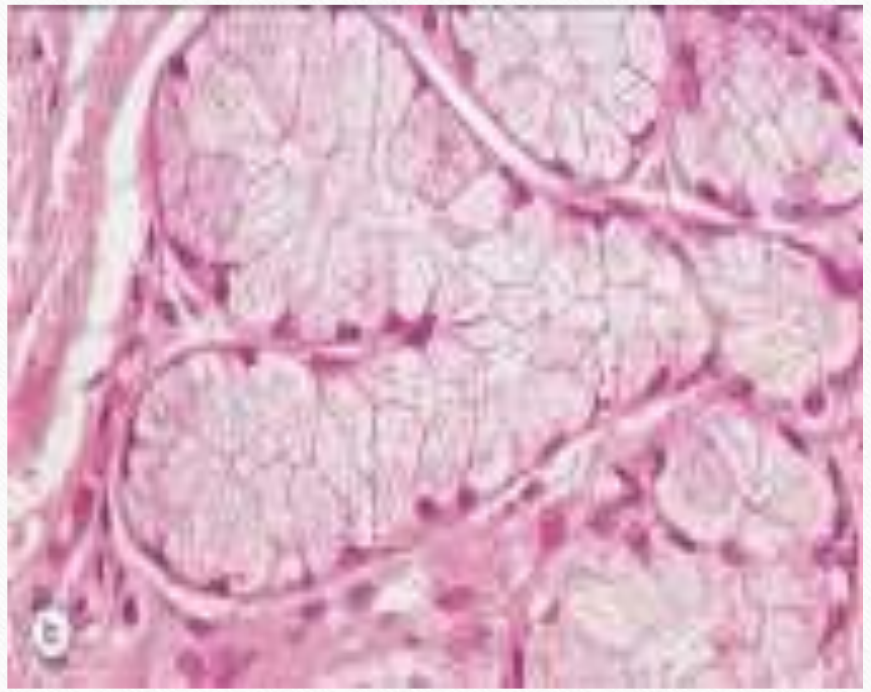
Mucin-secreting epithelial cells: contains greatly expanded Golgi system

- Mucins: mixture of glycoproteins and proteoglycans.

Features:

- Well-developed basal rER (stained faint blue) to the basal cytoplasm.
- Well-developed supranuclear Golgi for protein glycosylation
- Large secretory vesicles of mucins at cell apex impart an unstained vacuolated appearance to the apical cell cytoplasm.
- May be part of the surface epithelium which is called goblet cell.
- May aggregate into specialized glands.



- Four types of secretion by epithelial cells:
- Exocrine secretion:

Merocrine, apocrine, and holocrine: deliver through the apex of cell into a lumen.

- Endocrine secretion: secretion from the side or the base of cells into bloodstream.

Epithelial cells grouped into secretory glands:

- Gland: organized collection of secretory epithelial cells.
- Invagination of surface epithelial cells to form the straight or coiled ducts, or more complex, branched glands.
- Regions of glands are divided into specialized zones for the secretion of different products.