

Epithelial tissue

Petr Vaňhara, PhD

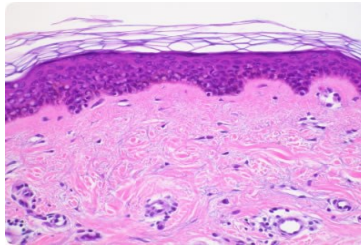
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Contemporary tissue classification

Based on morphology and function:

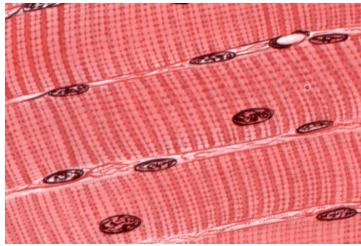
Epithelium



Continual, avascular layers of cells with different function, oriented to open space, with specific junctions and minimum of ECM and intercellular space.

Derivates of all three germ layers

Muscle

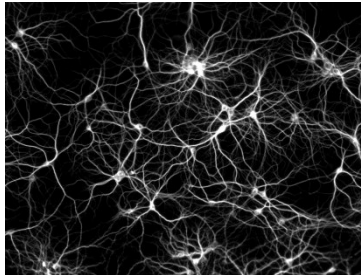


Myofibrils → contraction

Mesoderm – skeletal muscle, myocard, mesenchyme
– smooth muscles

Rarely ectoderm (eg. m. sphincter, m. dilatator pupillae)

Nerve

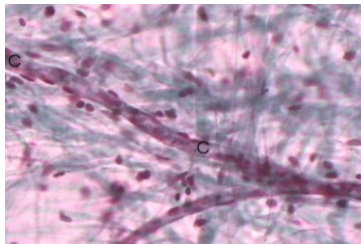


Neurons and neuroglia

Reception and transmission of electric signals

Ectoderm, rarely mesoderm (microglia)

Connective

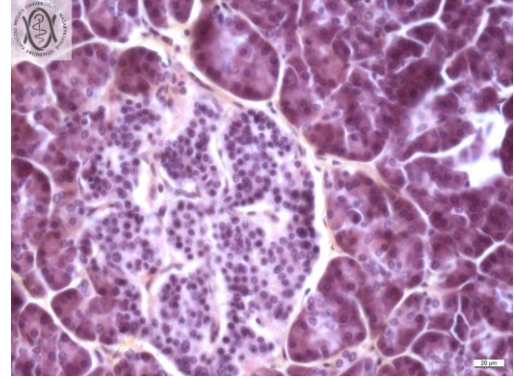
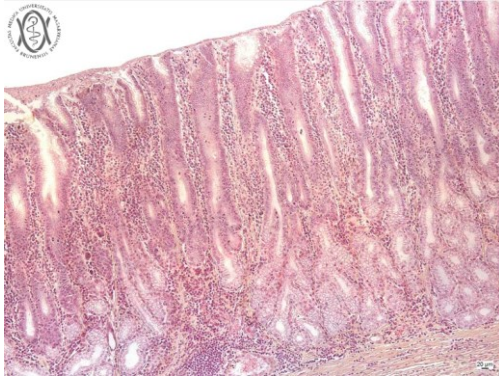
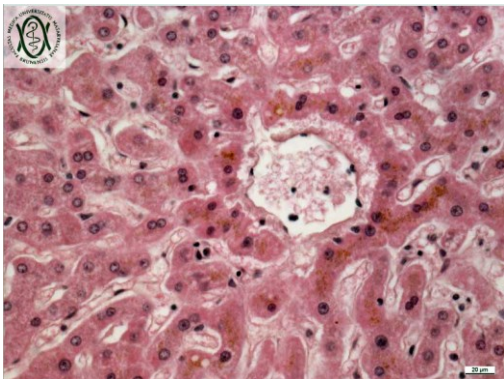
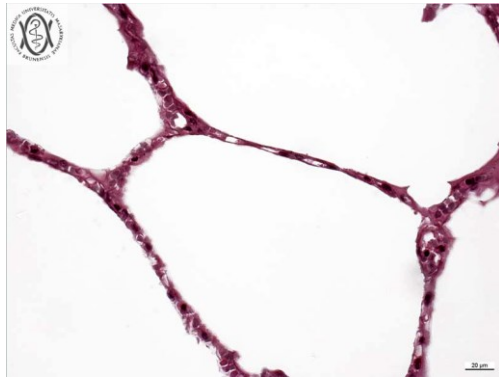
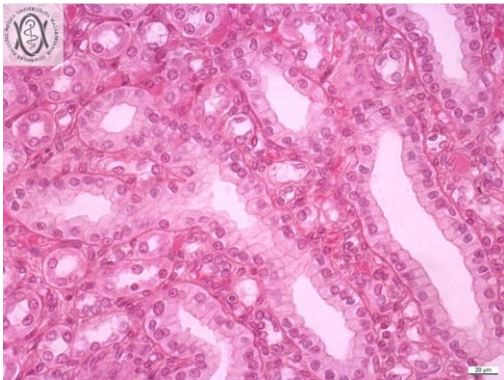
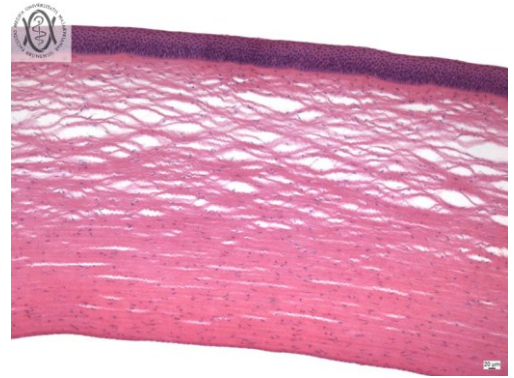
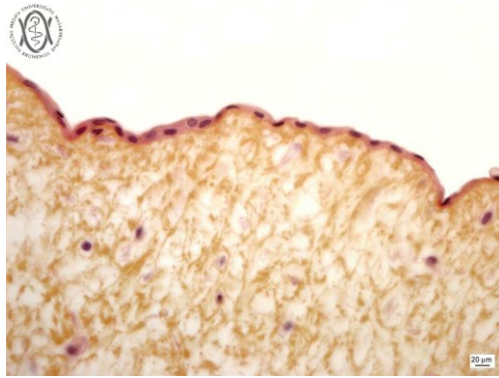
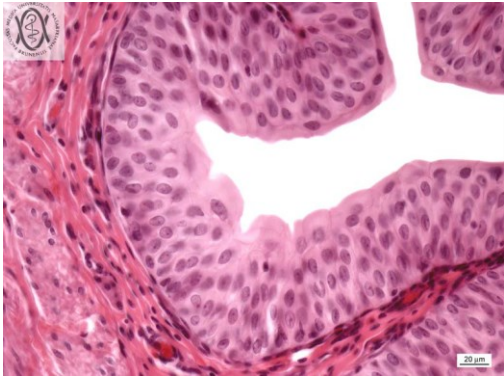


Dominant extracellular matrix

Connective tissue, cartilage, bone...

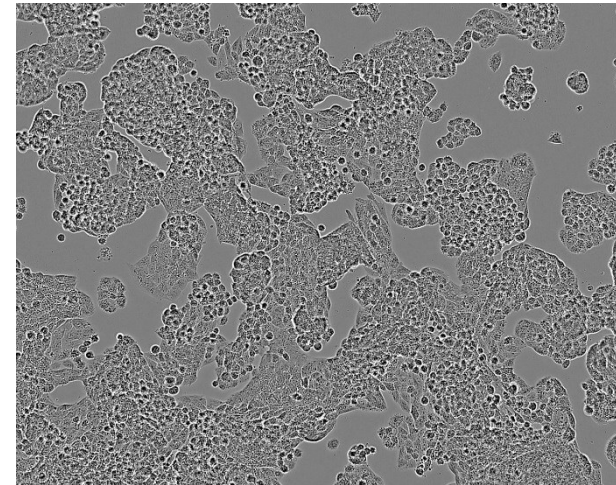
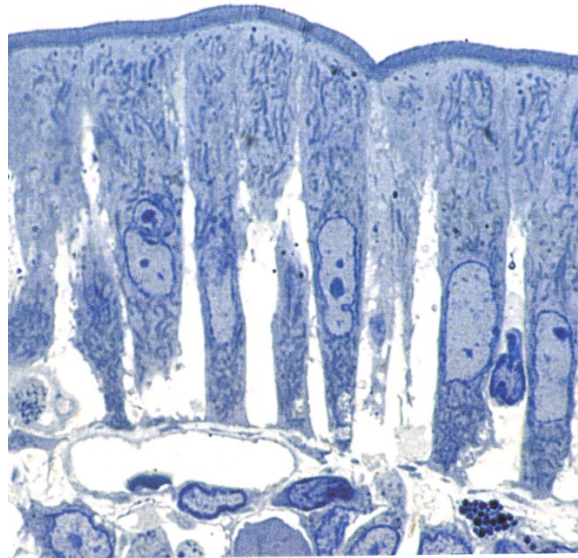
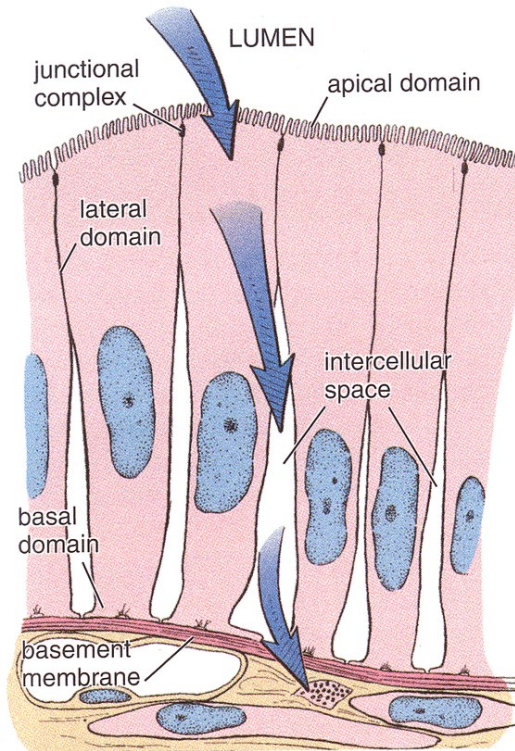
Mesenchyme

General characteristic of epithelial tissue

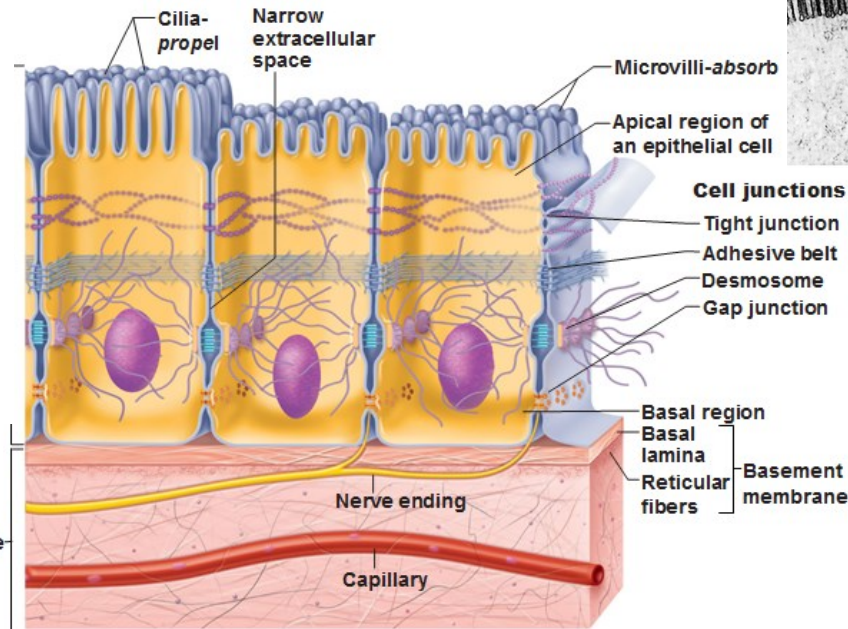
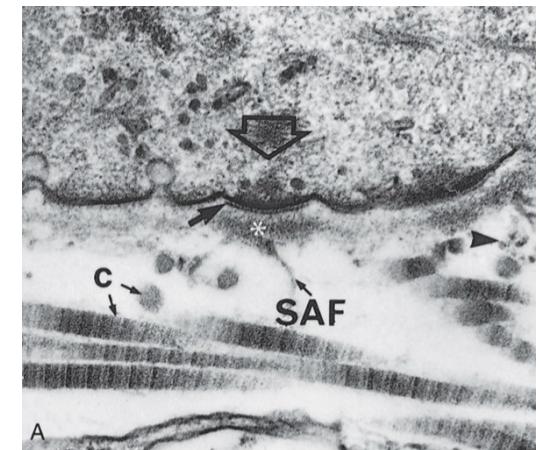
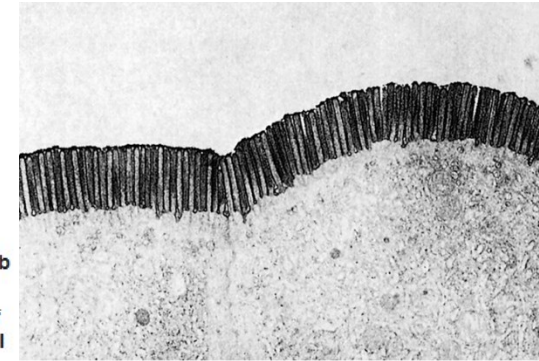


■ General characteristics of epithelial tissue

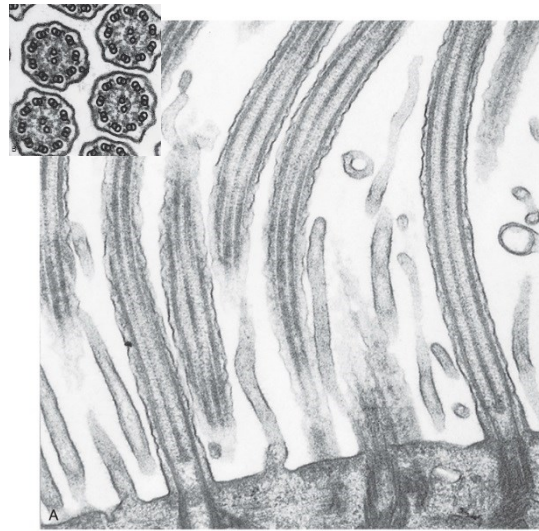
- Avascular (without blood supply) – nutrition by diffusion from a highly vascular and innervated area of loose connective tissue (*lamina propria*) just below the basement membrane
- Highly cellular – cohesive sheet or groups of cells with no or little extracellular matrix
- Typical morphology and cell connections



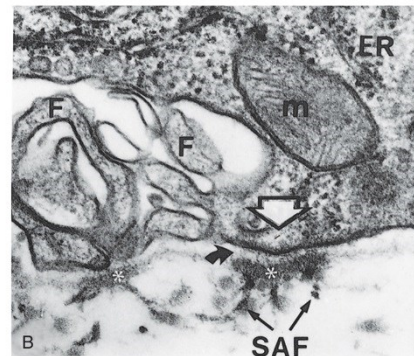
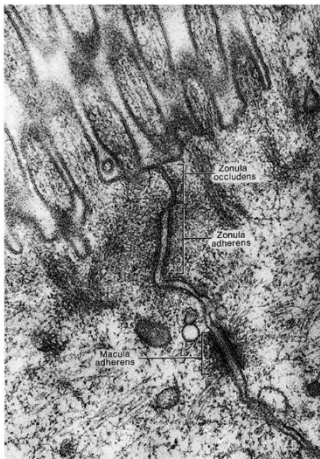
■ Hallmarks of typical epithelial cell



Connective tissue

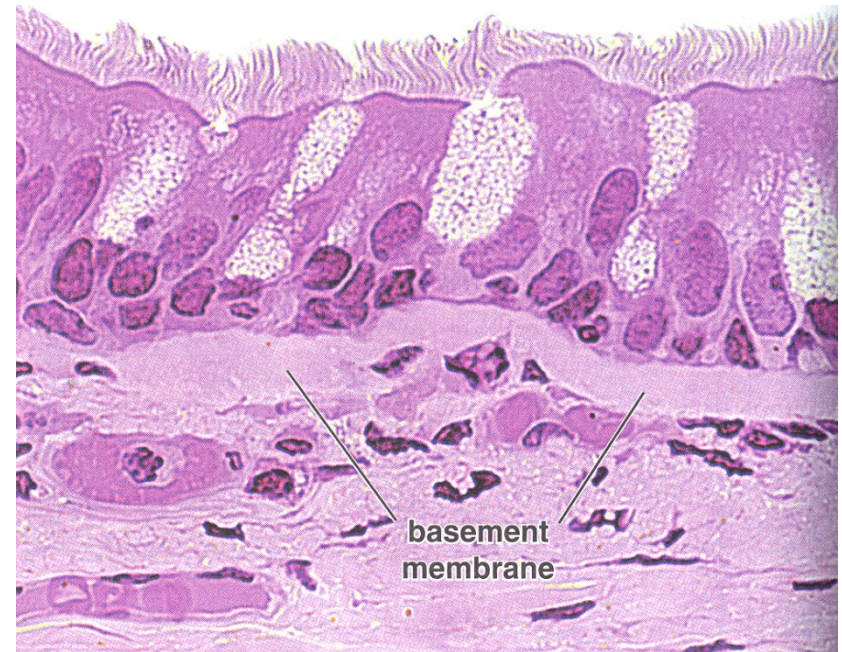
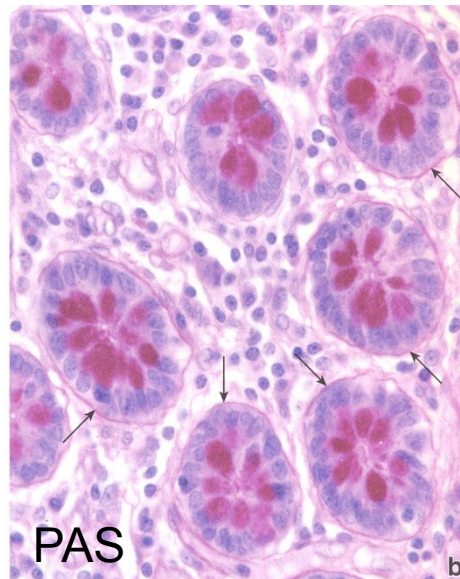
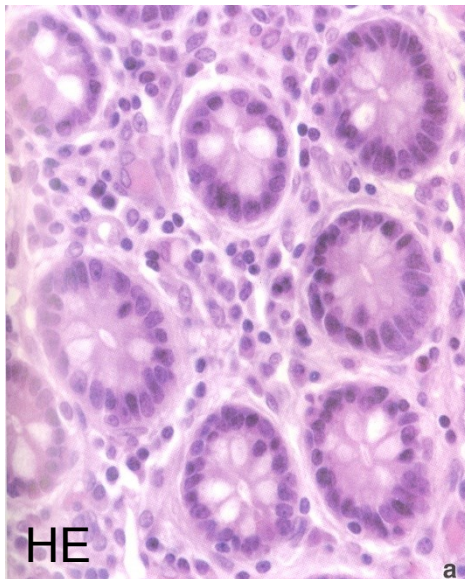
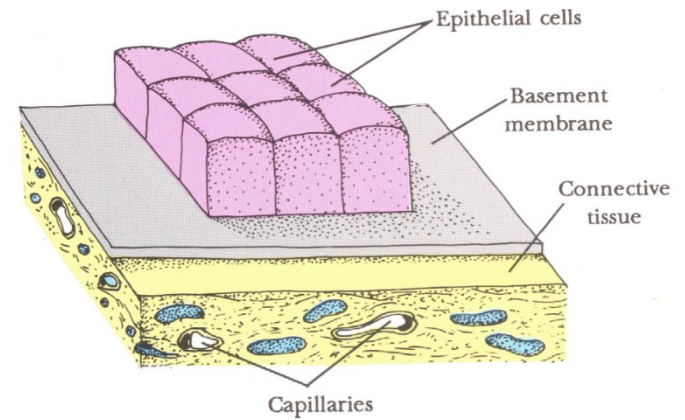


From Lesson TS, Lesson CR, Papero AA, Text/Atlas of Histology, Philadelphia: WB Saunders; 1988.



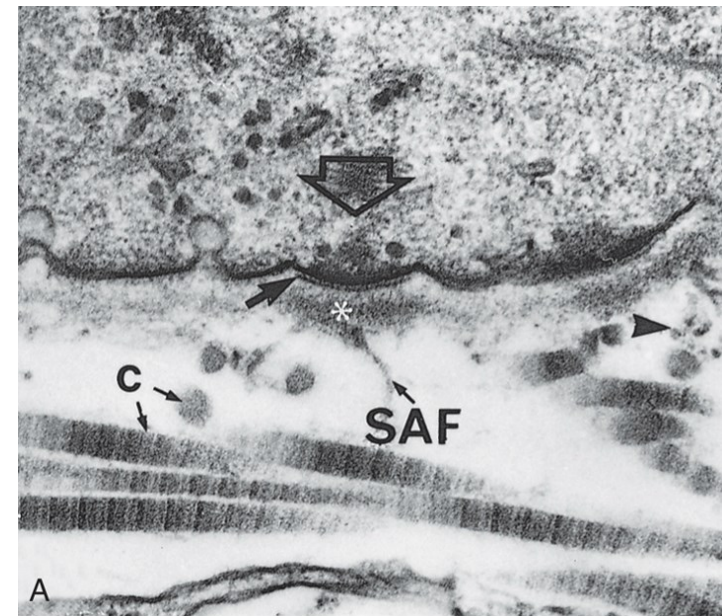
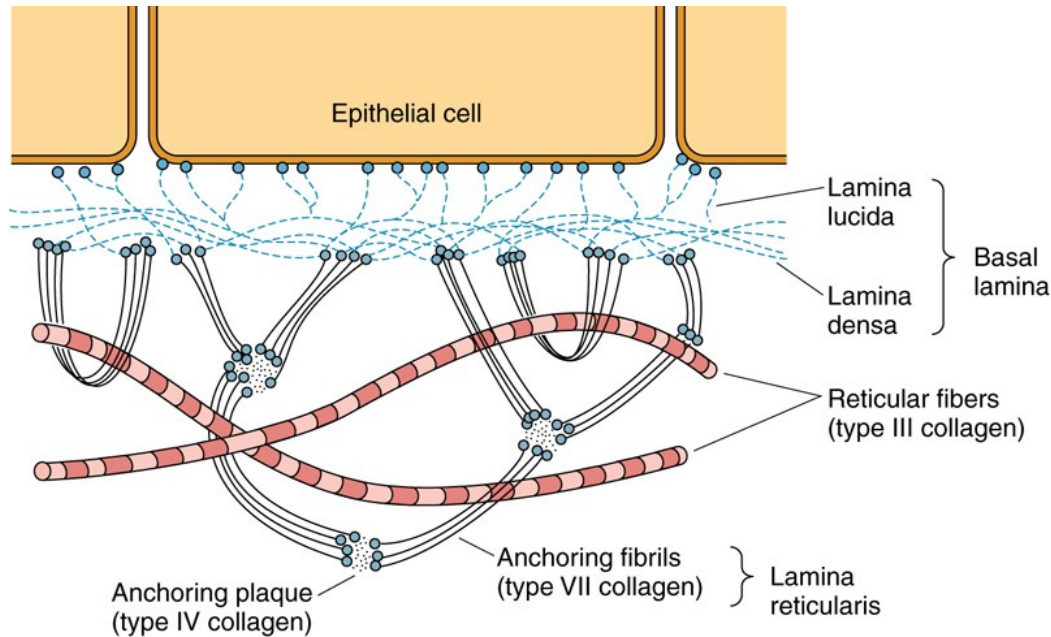
■ Basement membrane

- Attachment of epithelium to underlying tissues
- Selective filter barrier between epithelial and connective tissue
- Communication, differentiation

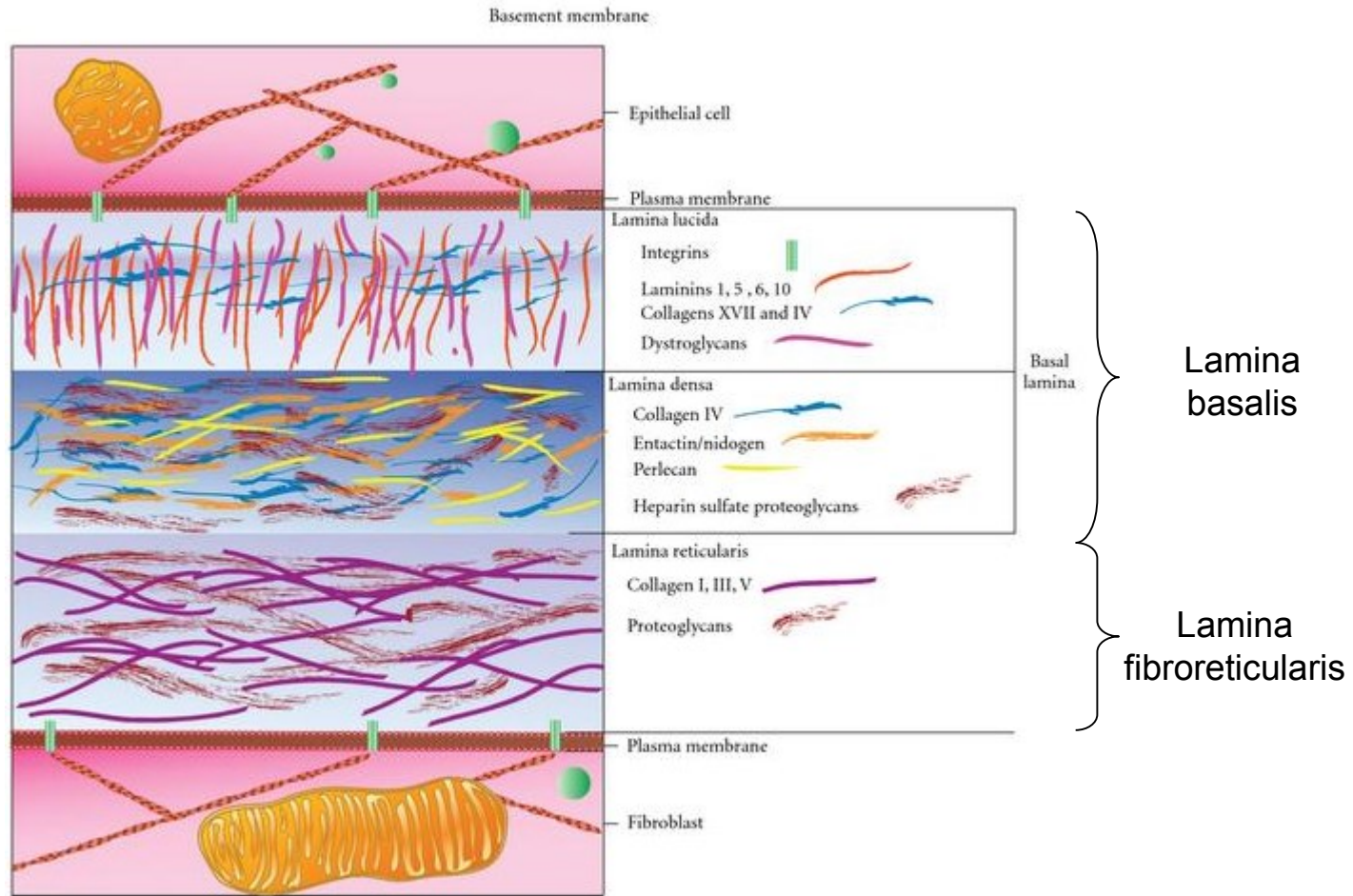
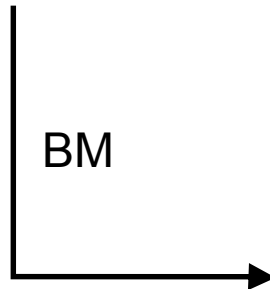
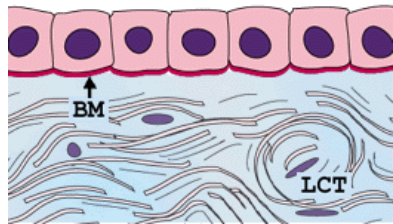


■ Basal lamina vs. basement membrane

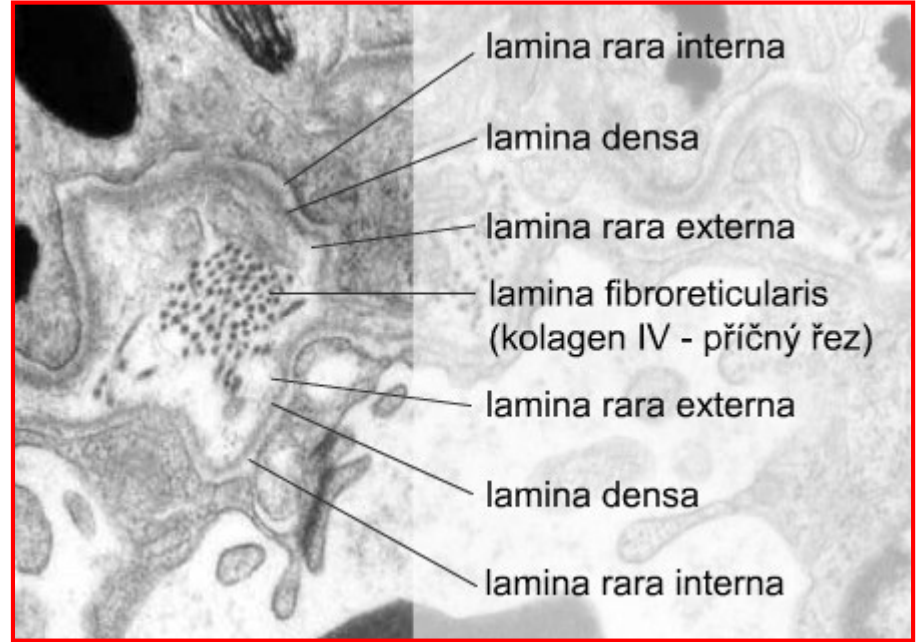
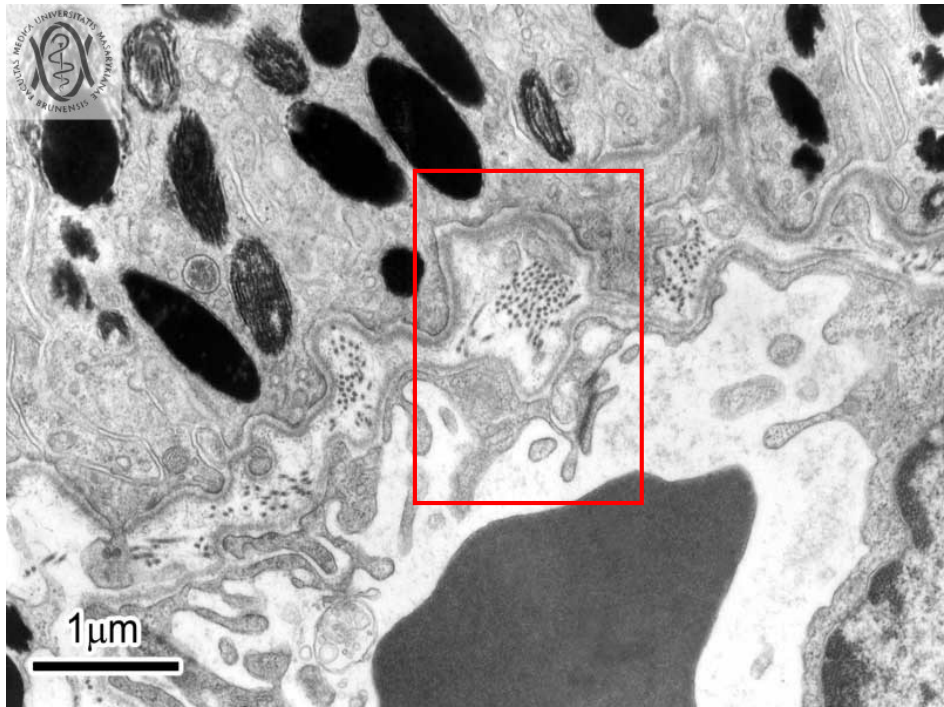
- 50-100nm
- Glycosaminoglycans – heparansulfate
- Laminin, collagen III, IV, VI,
- Nidogen/entactin
- Perlecan
- Proteoglycans



Architecture of basement membrane



■ Modifications of basement membrane architecture



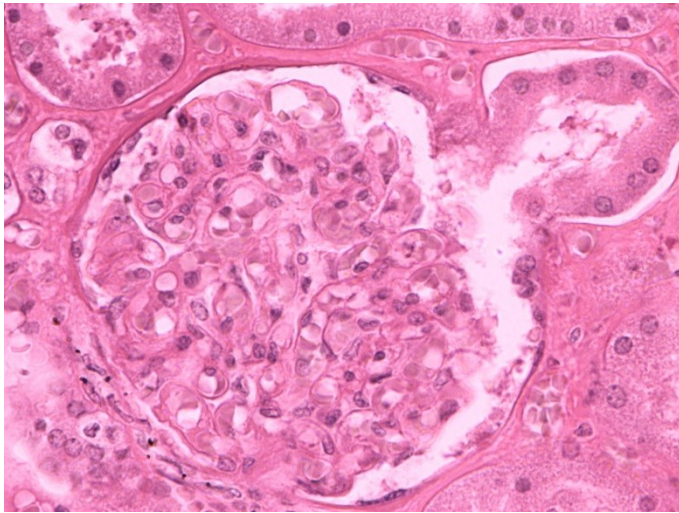
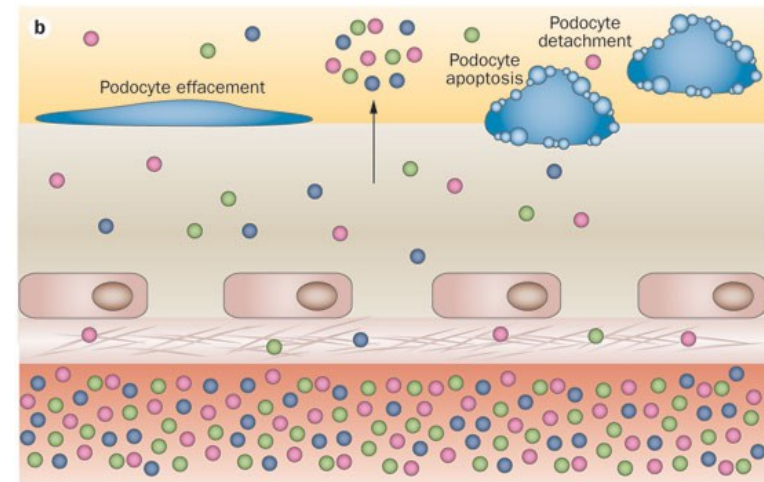
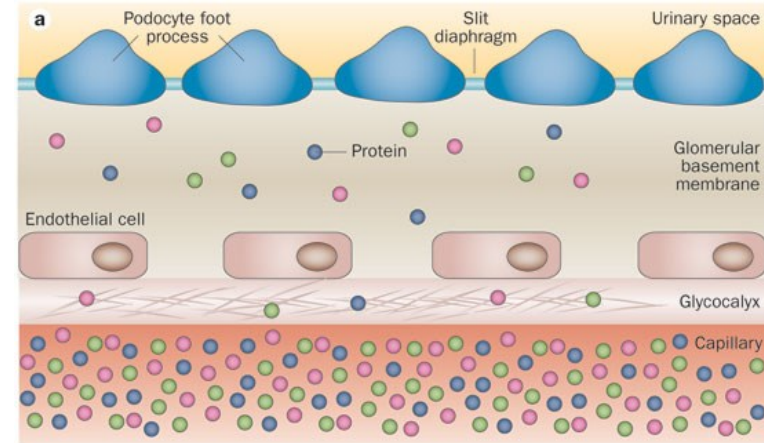
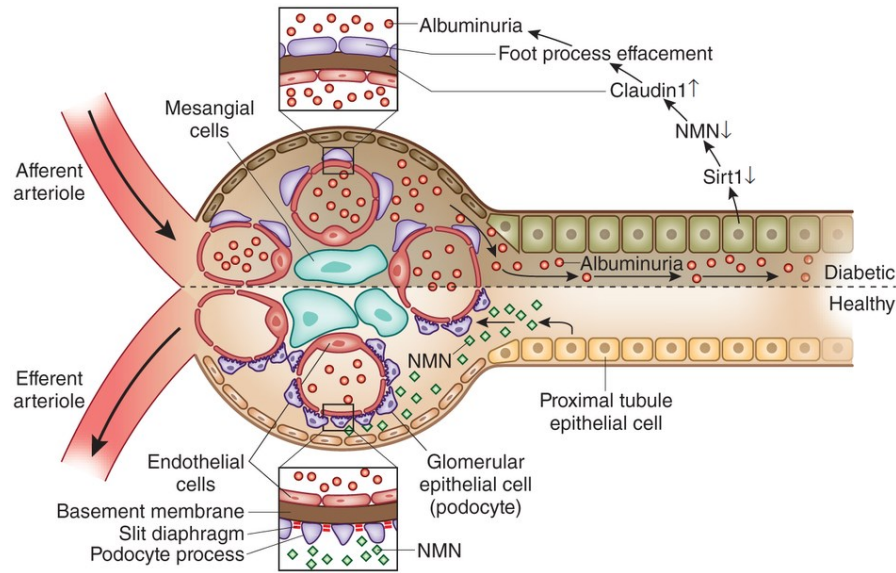
• Two basic layers

- lamina basalis
 - lamina densa,
 - lamina rara ext. et int.
- lamina fibroreticularis

• Tissue specific modifications

- Descemet membrane (cornea)
- Glomerular BM (Bowman's capsule)
- Part of Bruch's membran of retina
- ...

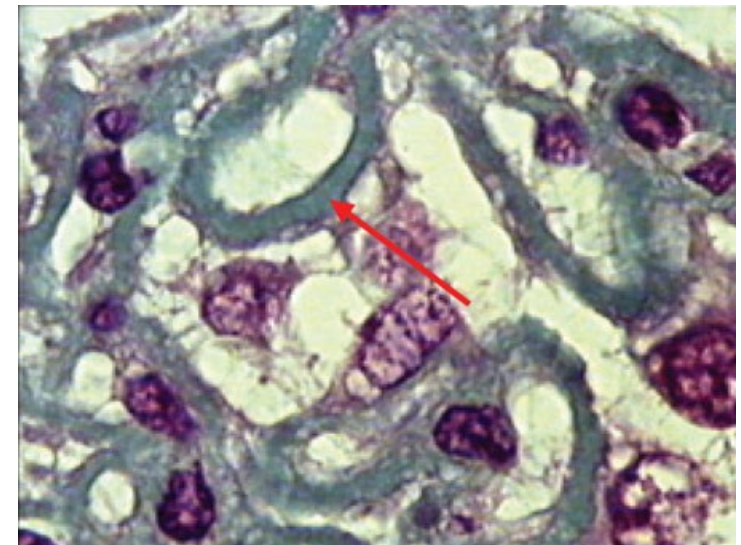
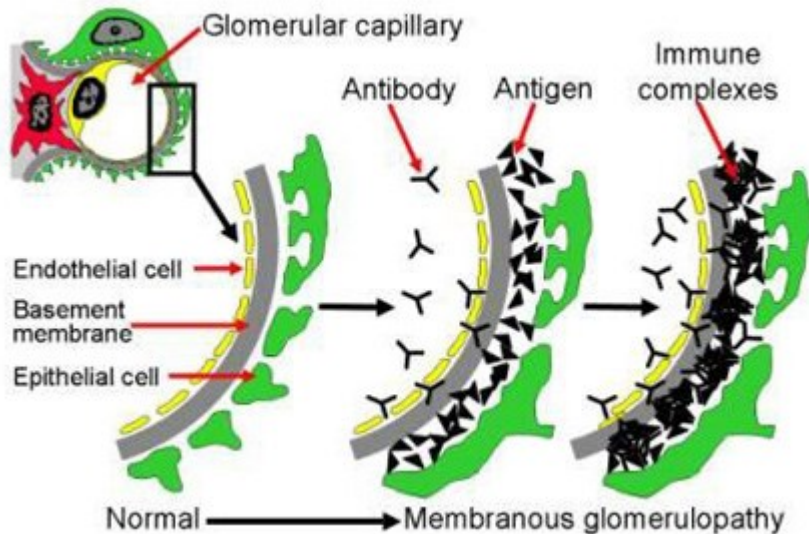
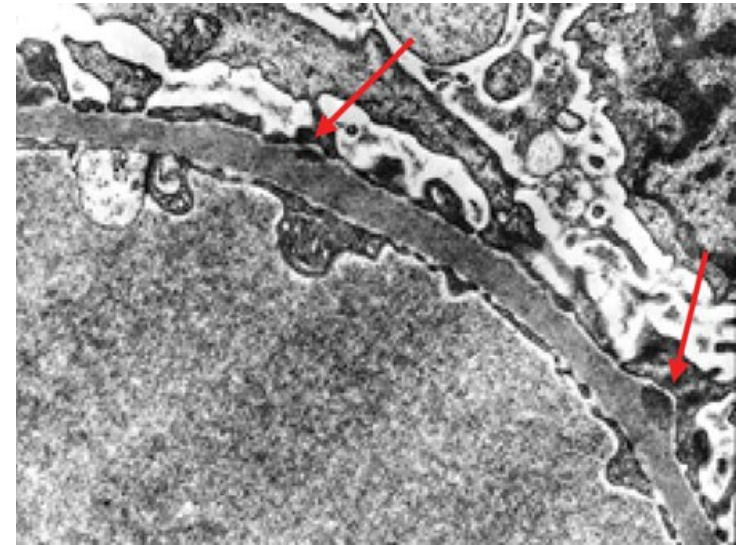
■ Basement membrane in corpusculum renis



■ Basement membrane in corpusculum renis

• Clinical correlations – Membranous glomerulonephritis

- circulating Abs bind to BM of capillary wall
- complement (C5b-C9) attacks glomerular endothelial cells
- filtration barrier compromised
- proteinuria, edema, hematuria, renal failure



Embryonic origin of epithelial tissues

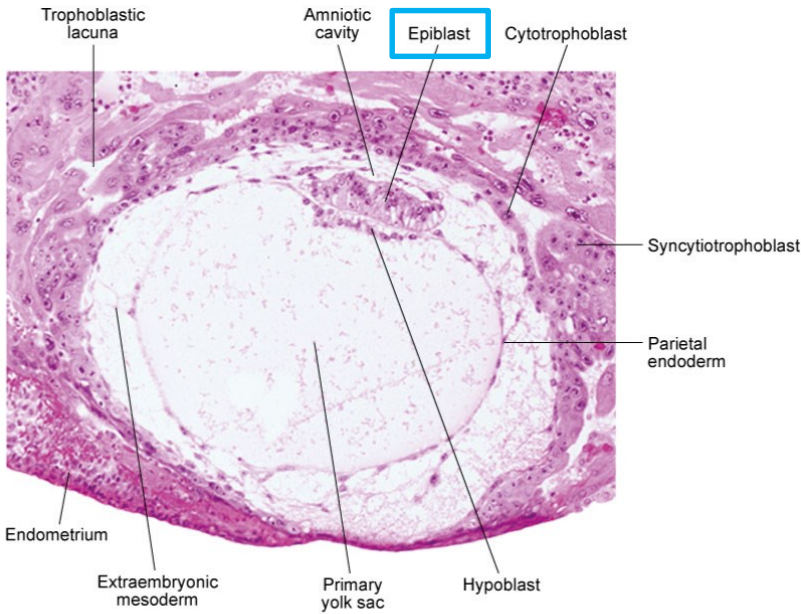


Fig. 5-3. Digital photomicrograph of a 12-day human embryo (Carnegie No. 7700) taken just as implantation within the endometrium is completed.

Courtesy of Dr. Ray Gasser.

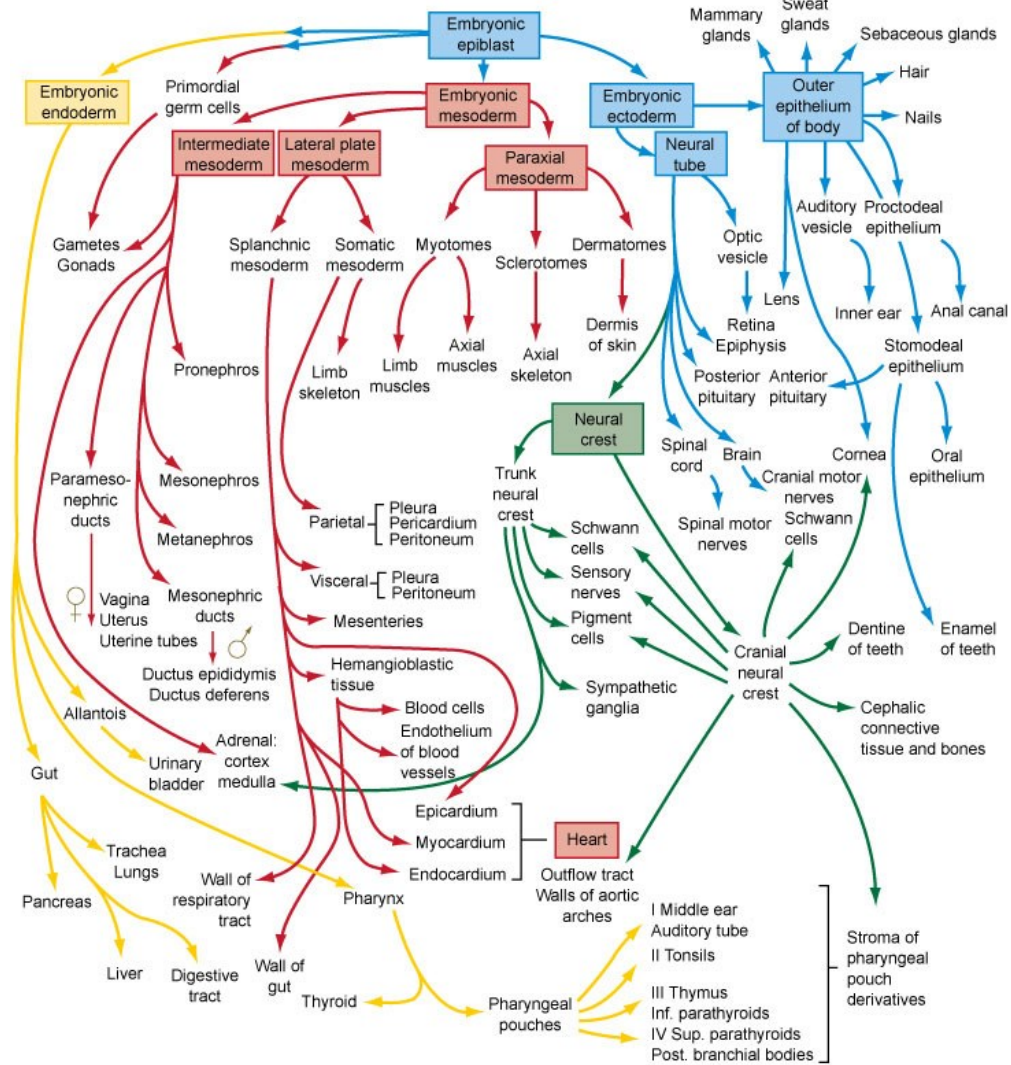


Fig. 6-27. Flow chart showing the formation of the organs and tissues of the embryo from the fundamental germ layers. The arrows are color-coded according to the germ layer of origin of the structure (see Fig. 4-1 for color code).

■ Embryonic origin of epithelial tissues

- derived from all three germ layers

Germ layer	Epithelial derivatives
Ectoderm	<ol style="list-style-type: none">1. Epidermis (stratified squamous keratinized epithelium)2. Sweat glands and ducts (simple and stratified cuboidal epithelium)3. Oral cavity, vagina, anal canal (stratified squamous non-keratinized epithelium)
Mesoderm	<ol style="list-style-type: none">1. Endothelium of blood vessels (simple squamous epithelium)2. Mesothelium of body cavities (simple squamous epithelium)3. Urinary and reproductive passages (transitional, pseudostratified and stratified columnar epithelium, simple cuboidal and columnar epithelium)
Endoderm	<ol style="list-style-type: none">1. Esophagus (stratified squamous non-keratinized epithelium)2. GIT (simple columnar epithelium)3. Gall bladder (simple columnar epithelium)4. Solid glands (liver, pancreas)5. Respiratory passages (ciliated pseudostratified columnar epithelium, ciliated simple columnar epithelium, cuboidal, squamous)

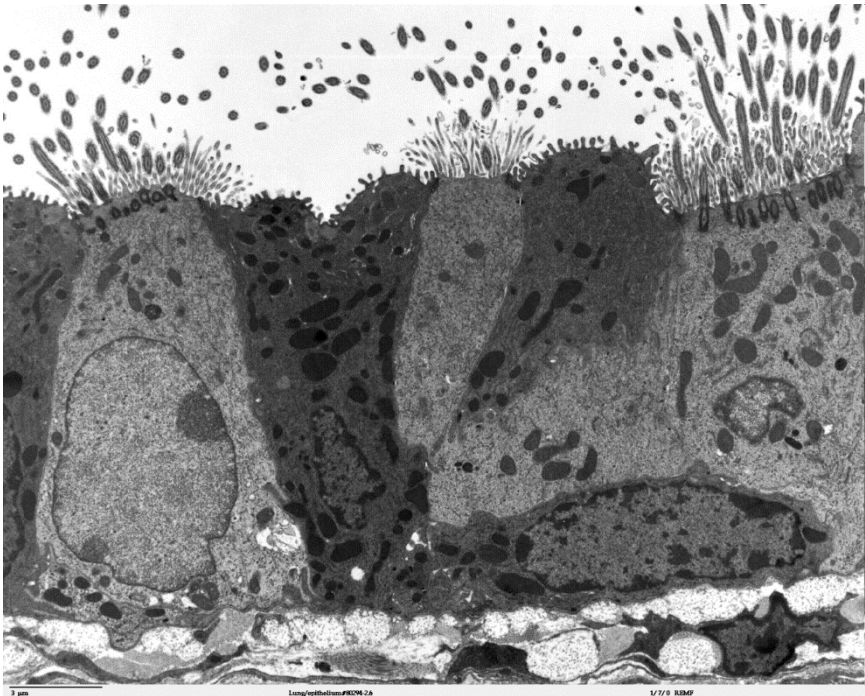
■ Classification of epithelial tissues

by morphology

by function

- Covering (sheet) epithelium
- Trabecular epithelium
- Reticular epithelium

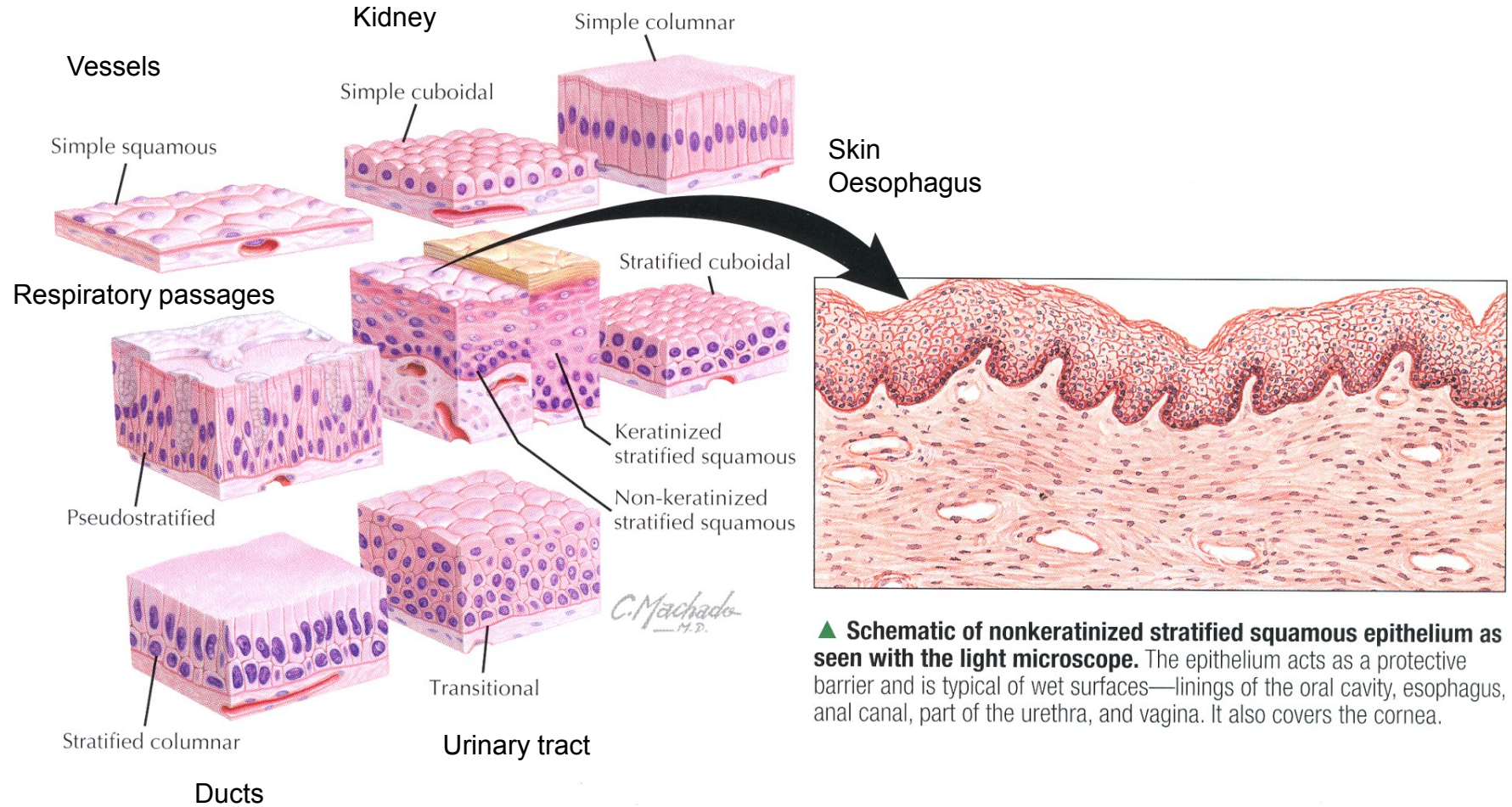
- Covering
- Glandular
- Resorptive
- Sensory
- Respiratory
- Alveolar
- Germinal
- ...



Morphology of epithelial tissue

- Classification of epithelial tissues
 - Covering (sheet) epithelia**

▼ Classification of epithelia. Intestine

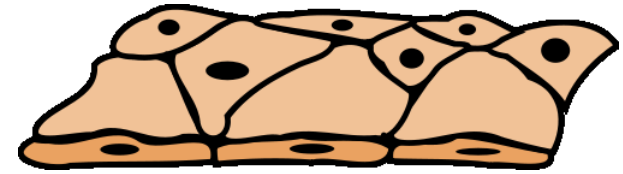


▲ **Schematic of nonkeratinized stratified squamous epithelium as seen with the light microscope.** The epithelium acts as a protective barrier and is typical of wet surfaces—linings of the oral cavity, esophagus, anal canal, part of the urethra, and vagina. It also covers the cornea.

■ Simple squamous epithelium

- Single layer of flat cells with central flat nuclei
- Capillaries
- Lung alveolus
- Glomerulus in renal corpuscle

} Selective permeability

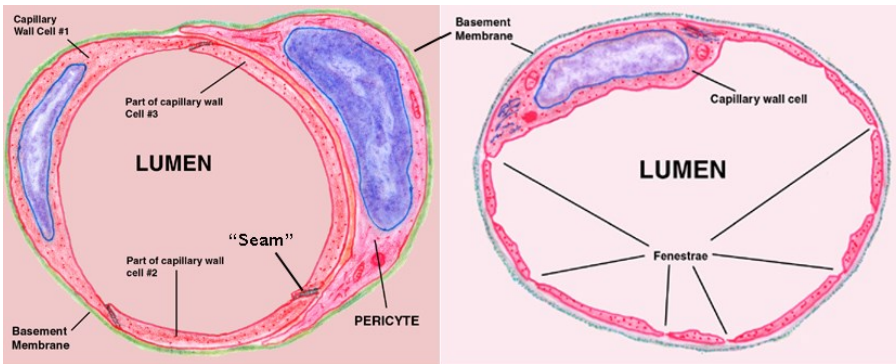
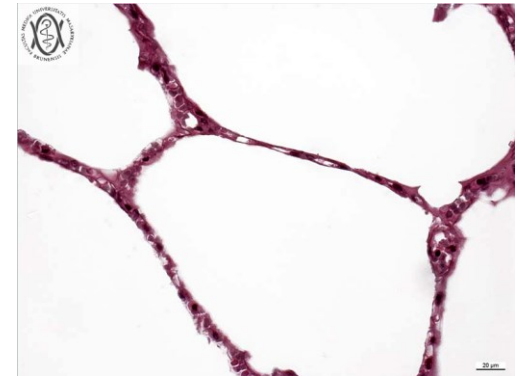


Endothelium.

heart, blood, and lymphatic vessels.

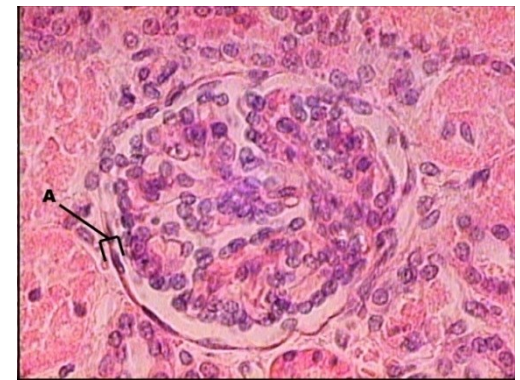
Mesothelium.

serous membranes - body cavities



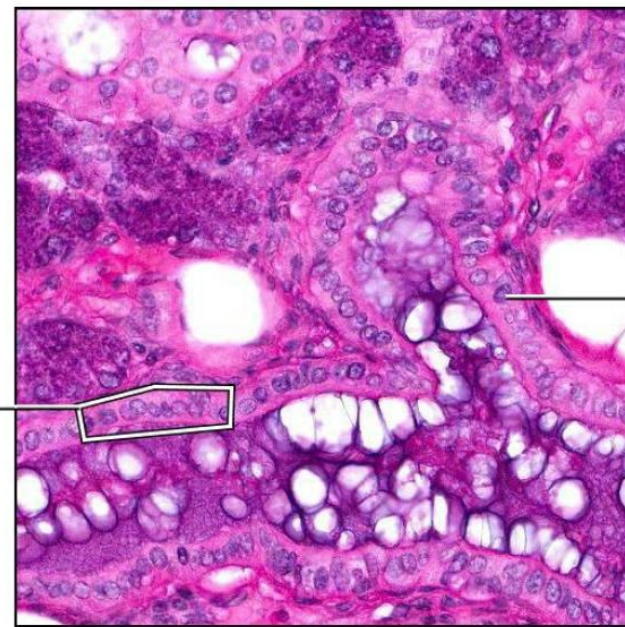
Closed or Continuous Capillary

Fenestrated Capillary



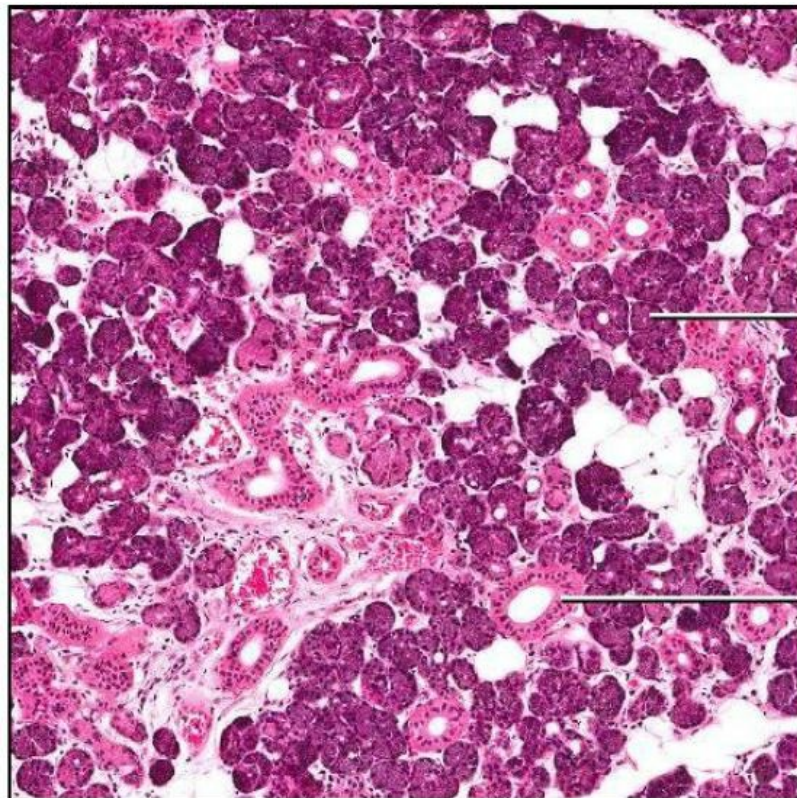
■ Simple cuboidal epithelium

- Single layer of cubic cells with large, spherical central nuclei
- Secretion or resorption



Nucleus of cuboidal epithelium cell

Simple cuboidal epithelium



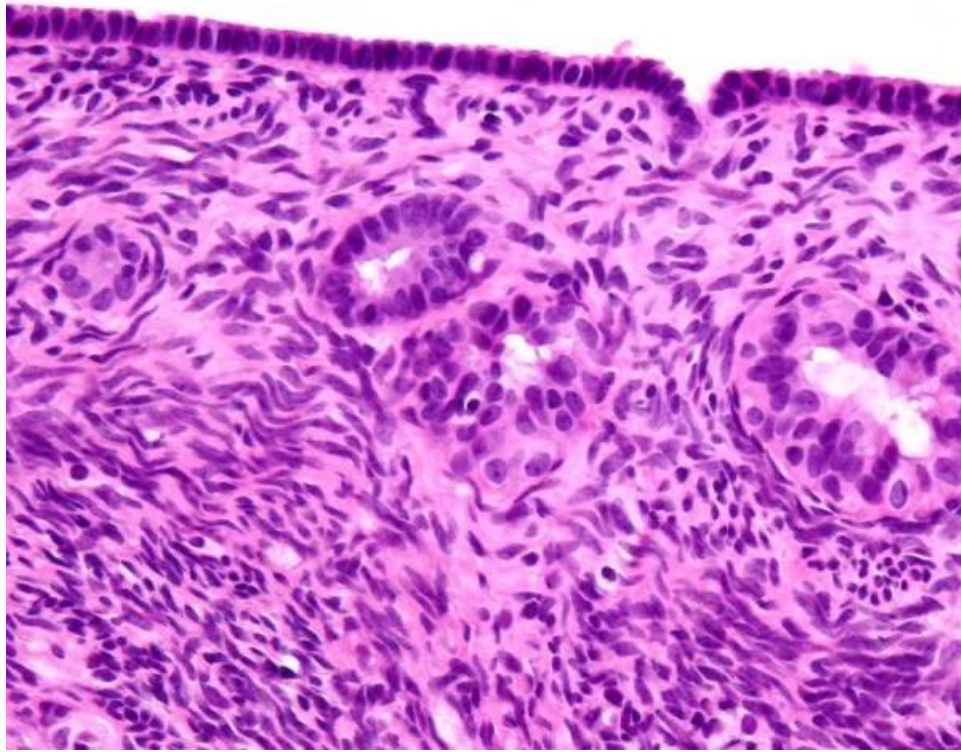
Serous acini

Simple cuboidal epithelium of intralobular duct

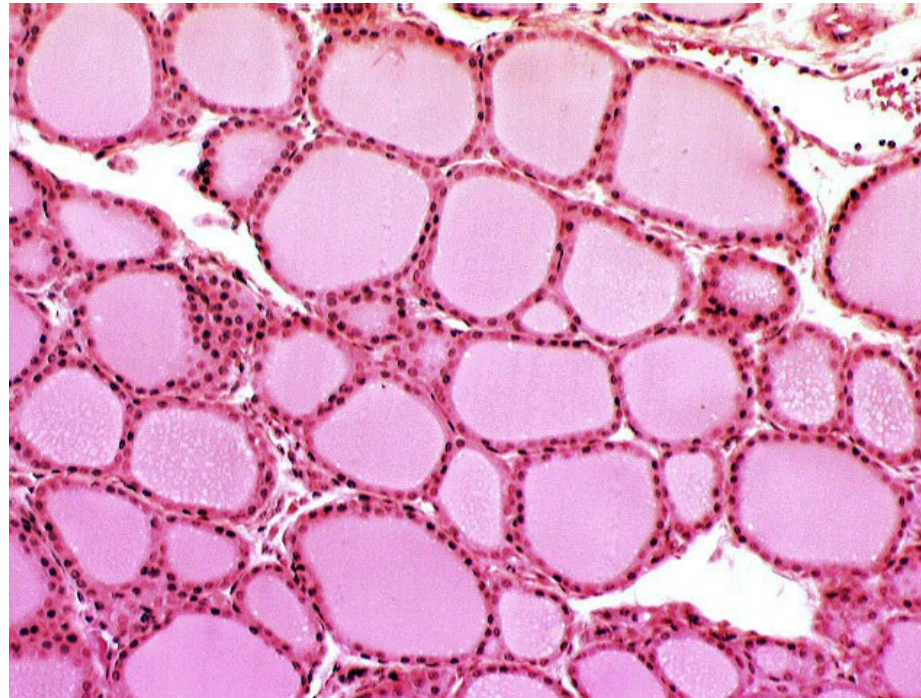
Examples:

- Ovarian surface epithelium
- Renal tubules
- Thyroid
- Secretion acini

Ovarian surface epithelium

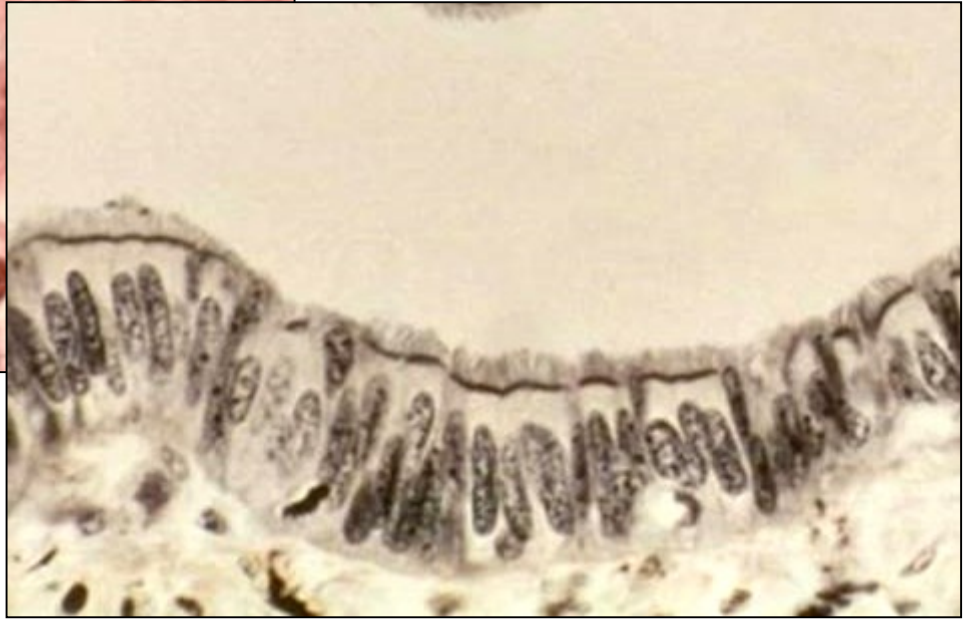
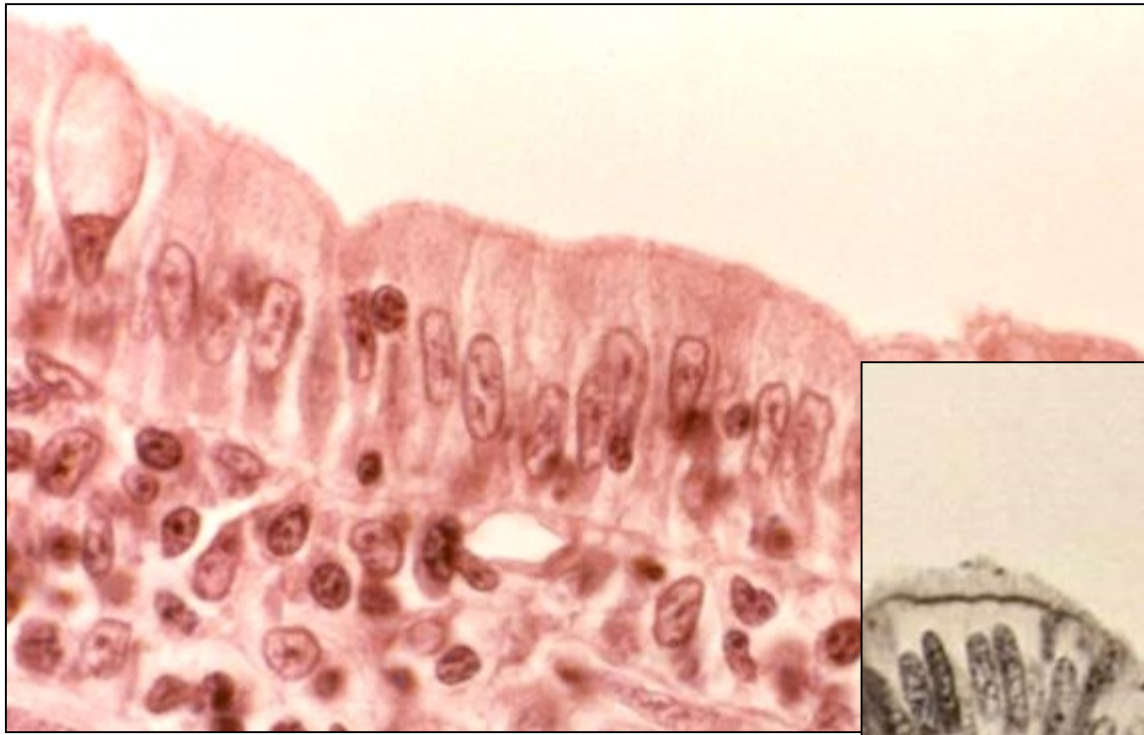
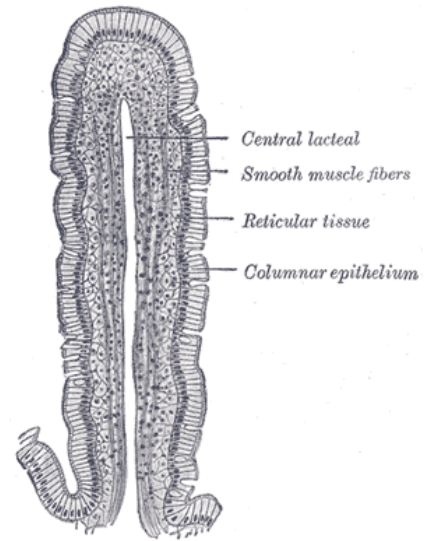


Thyroid follicles



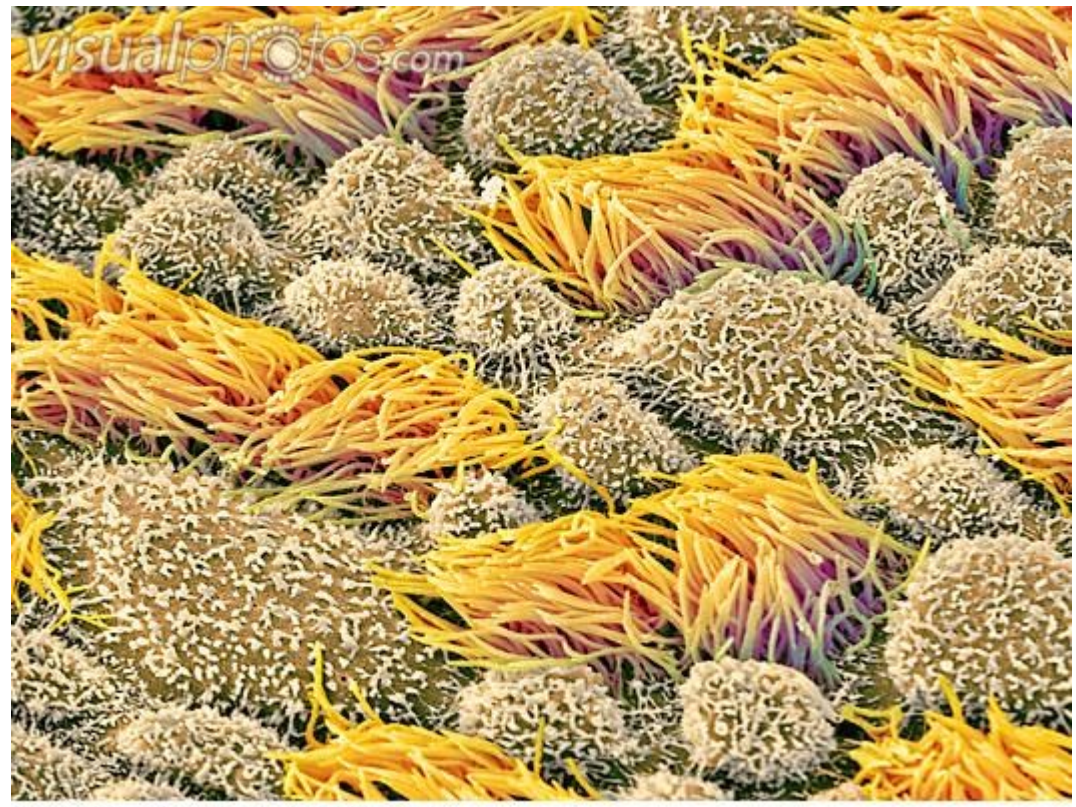
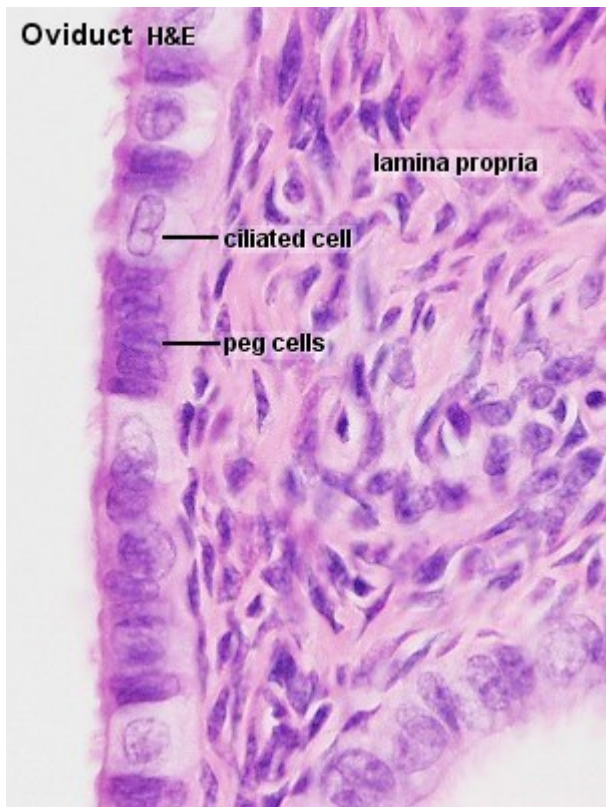
Simple columnar epithelium

- Single layer of columnar cells with large, oval, basally located nucleus
- GIT
 - stomach
 - small and large intestine
 - gall bladder



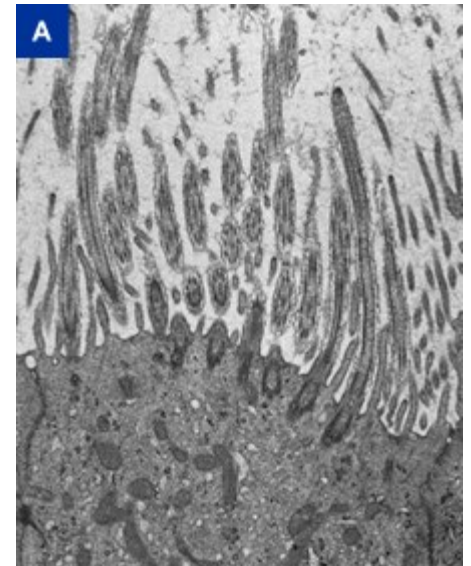
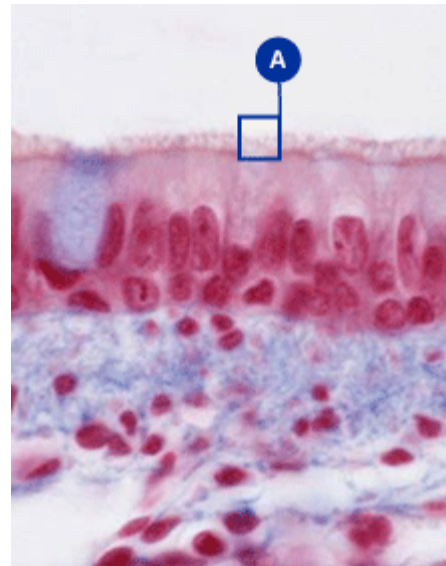
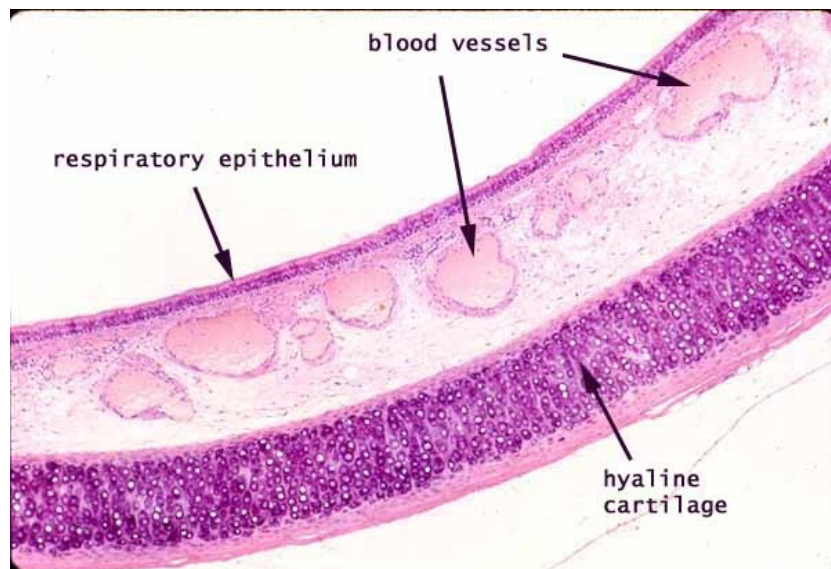
■ Simple columnar epithelium with kinocilia

- Uterine tube
- flow of the oocyte towards the uterus



Simple columnar epithelium with kinocilia (also pseudostratified)

- Upper respiratory passages
- Removal of mucus produced by epithelial glands

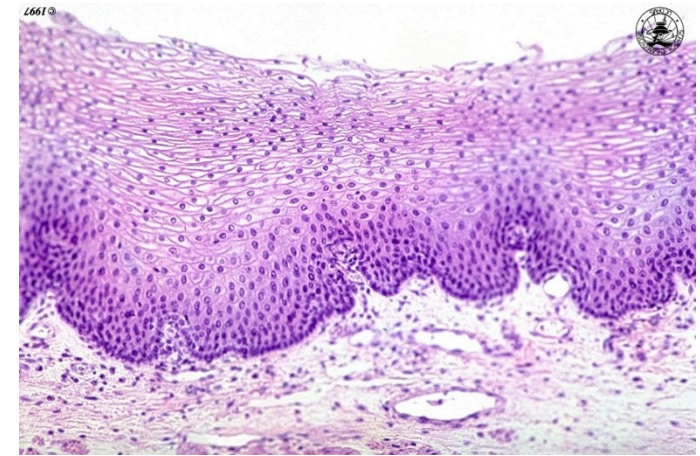
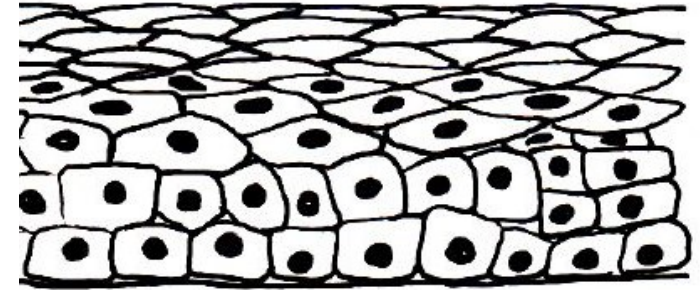


Other locations:

- Spinal cord ependyma
- Epididymis
- Vas deferens

▪ Stratified squamous epithelium

- Multiple layers of cubic cells with central nuclei, flattening towards the surface
- First layer in contact with BM, last layer – flat
- Constant abrasion
- Mechanical resilience
- Protection from drying
- Rapid renewal



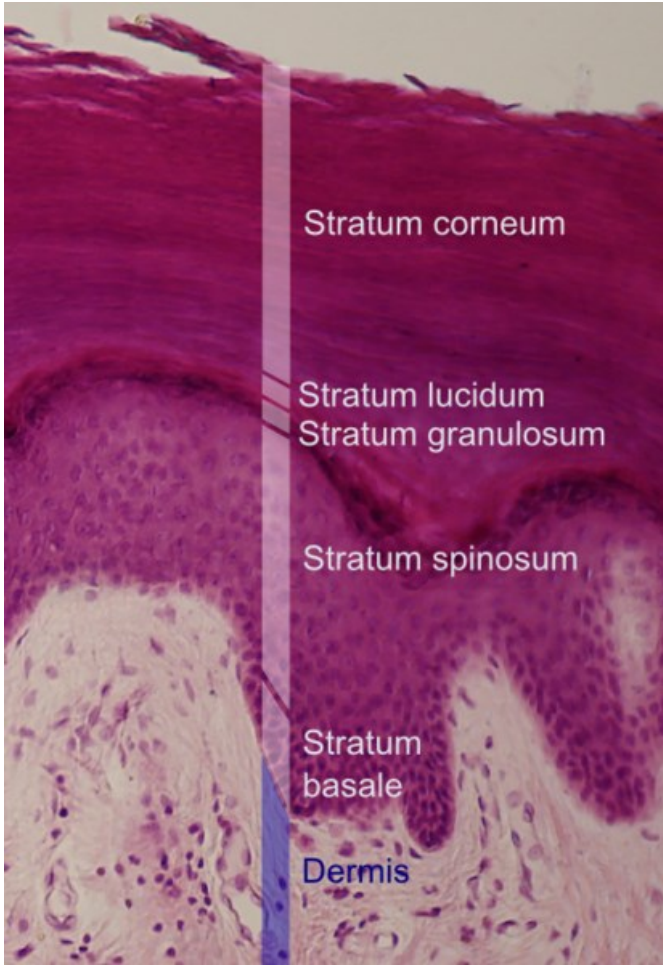
Keratinized vs. non-keratinized

Examples:

- Cornea
- Oral cavity and lips
- Esophagus
- Anal canal
- Vagina

Stratified squamous epithelium

Keratinized



Skin (epidermis)

Nail

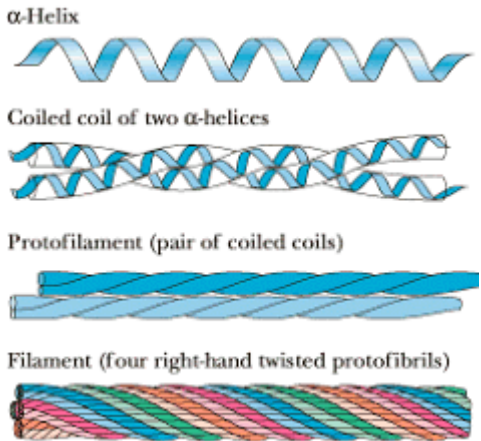
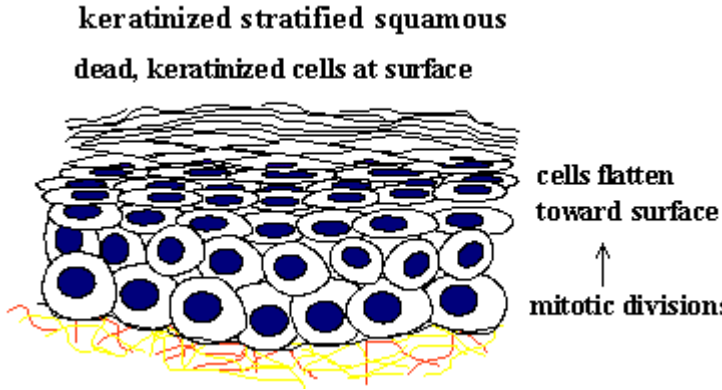
Keratins

Fibrous proteins, ~ 40 types

Very stable, multimeric

Disorders of keratin expression – variety of clinical symptoms

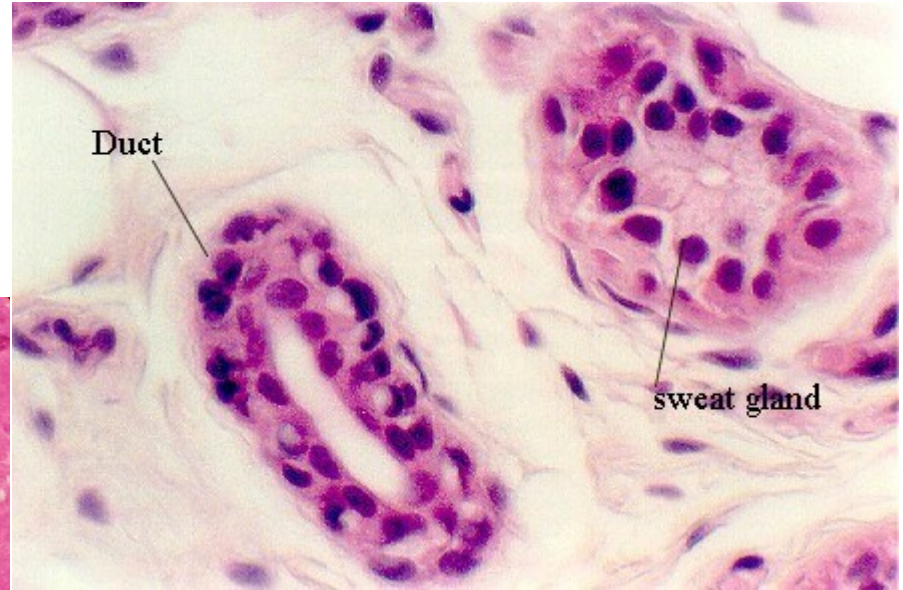
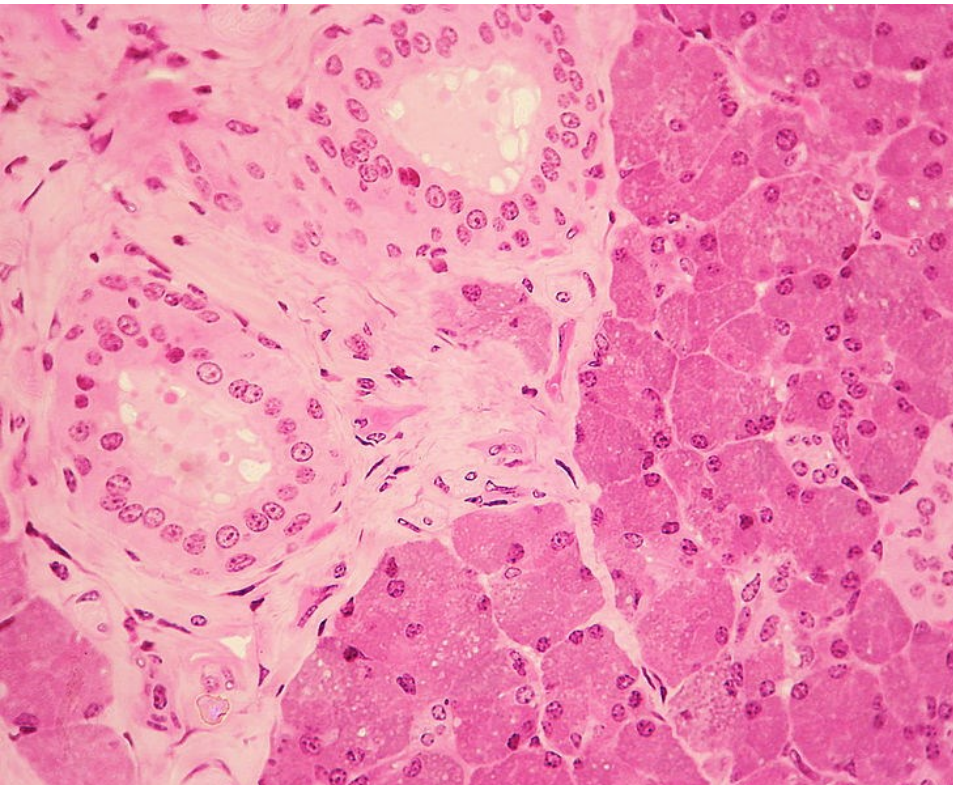
e.g. Epidermolysis bullosa simplex



■ Stratified cuboidal epithelium

Large ducts of :

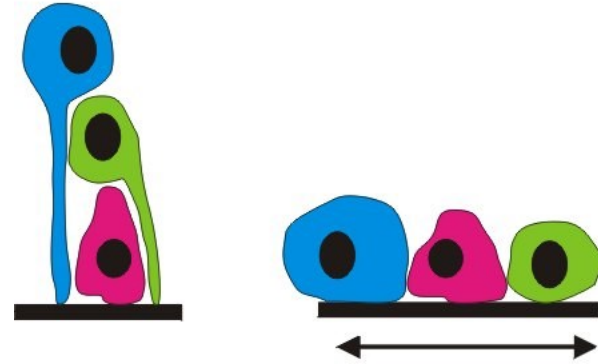
- sweat glands
- mammary glands
- salivary glands



■ Transitional epithelium (urothelium)

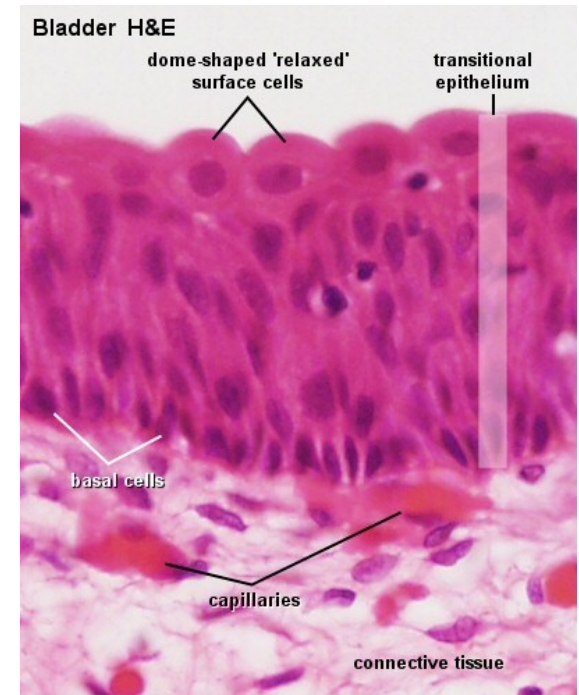
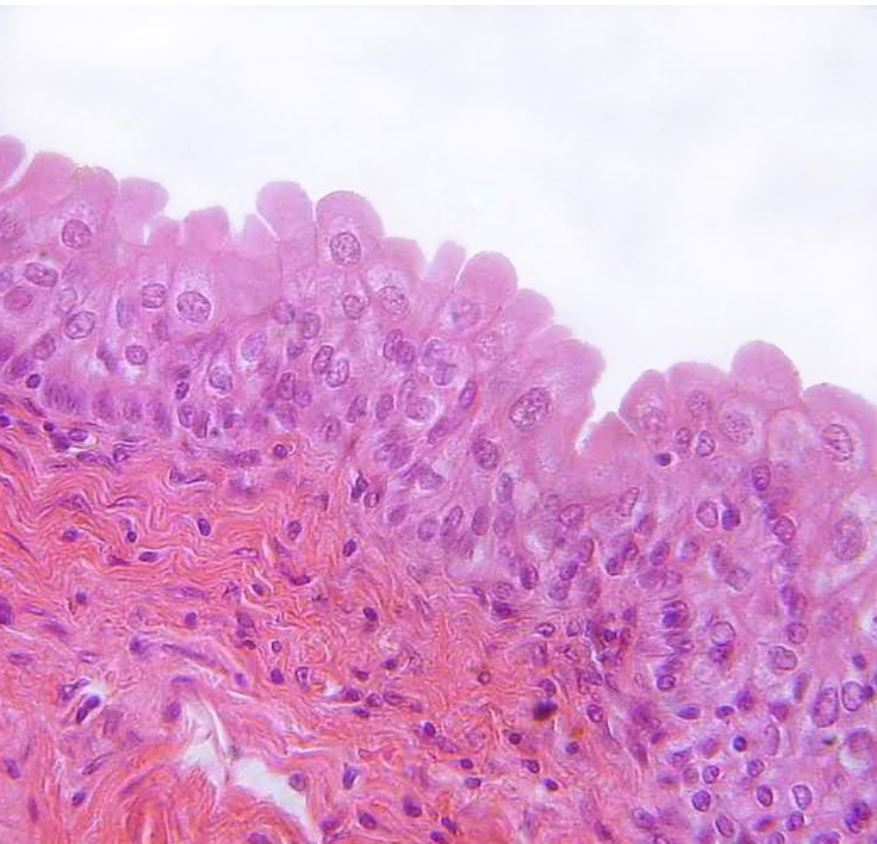
- Fluctuation of volume
 - organization of epithelial layers
 - membrane reserve
- Protection against hyperosmotic urine

- Urinary bladder, kidneys, ureters



Empty: rather cuboidal with a domed apex
Relaxed: flat, stretched

Basal cells
Intermediate layer
Surface cells



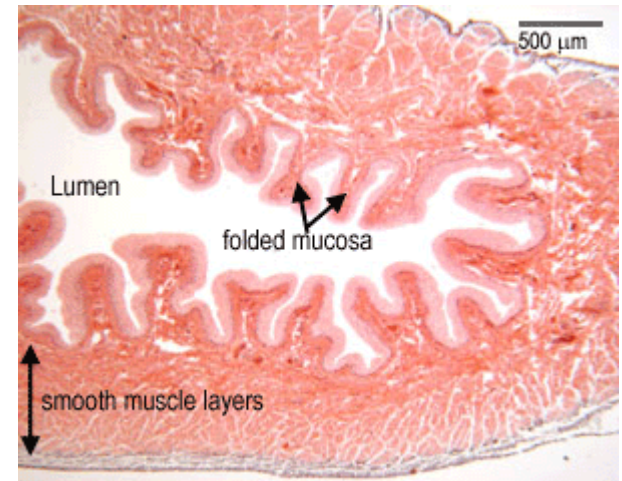
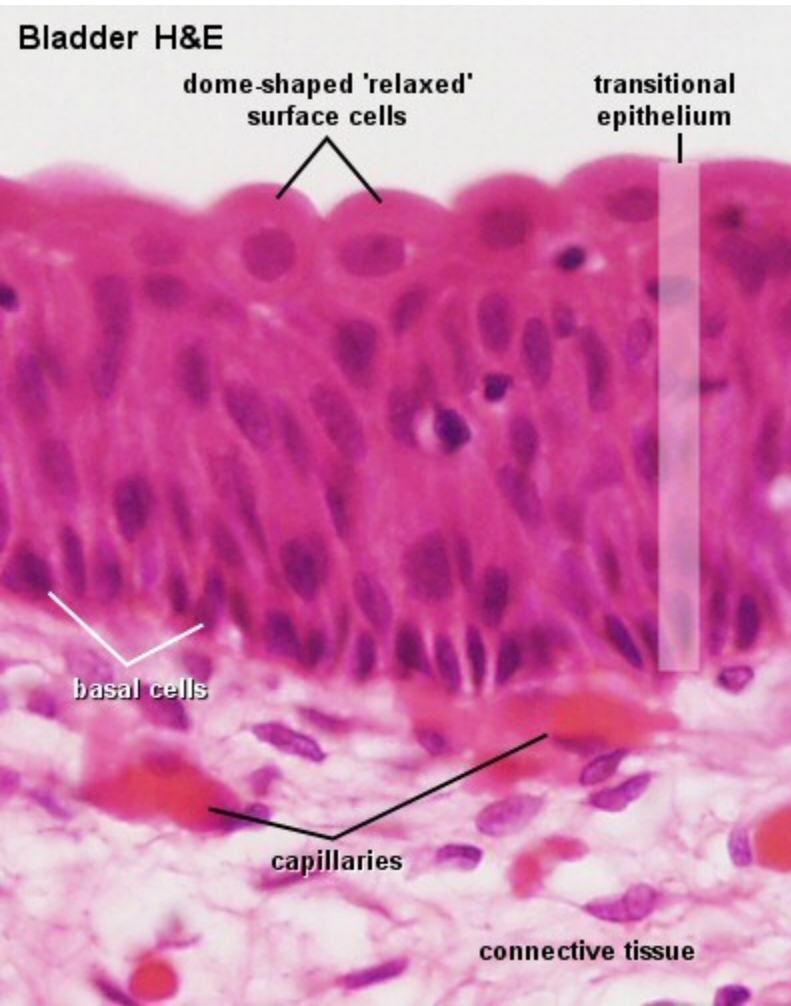
■ Transitional epithelium (urothelium)

glycosaminoglycan layer (GAG) on the surface

- osmotic barrier
- antimicrobial properties

Barrier architecture:

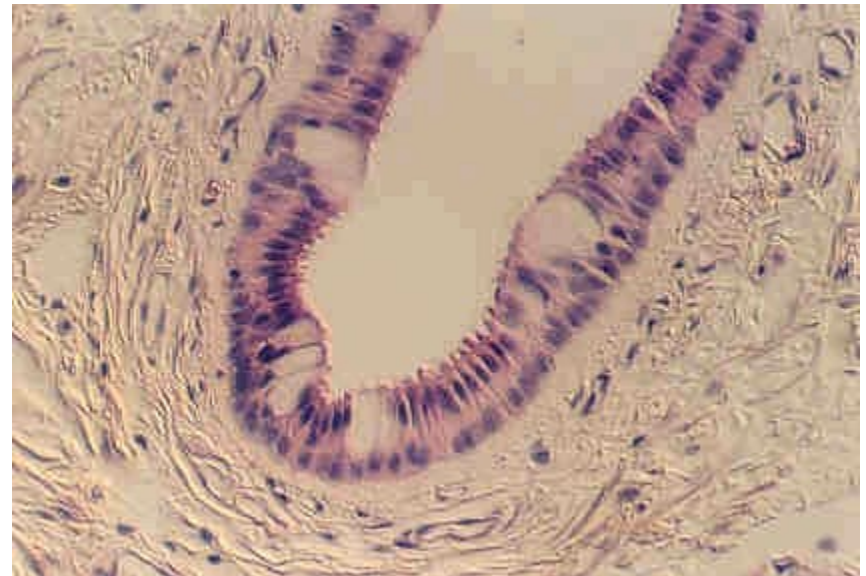
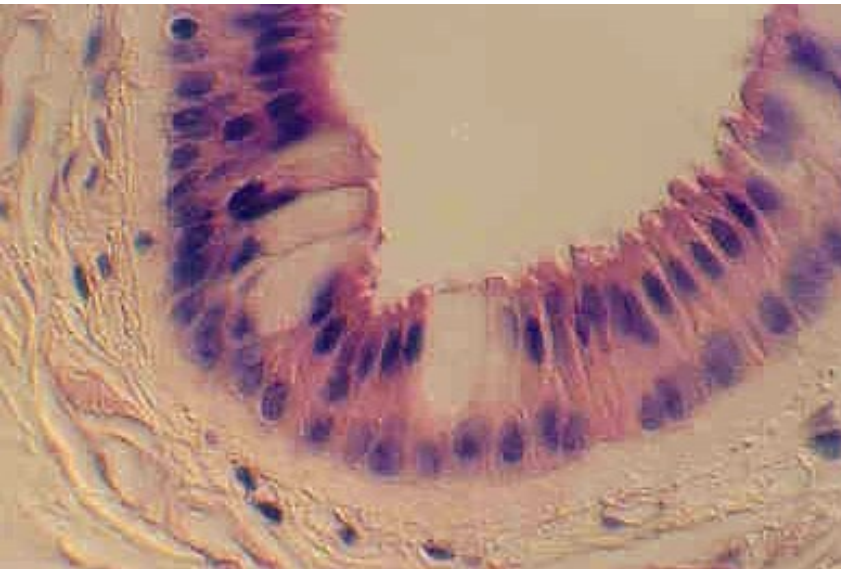
- GAG-layer
- surface cells (tight junctions), uroplakin proteins in the apical cell membrane
- capillary plexus in the submucosa



■ Stratified columnar epithelia

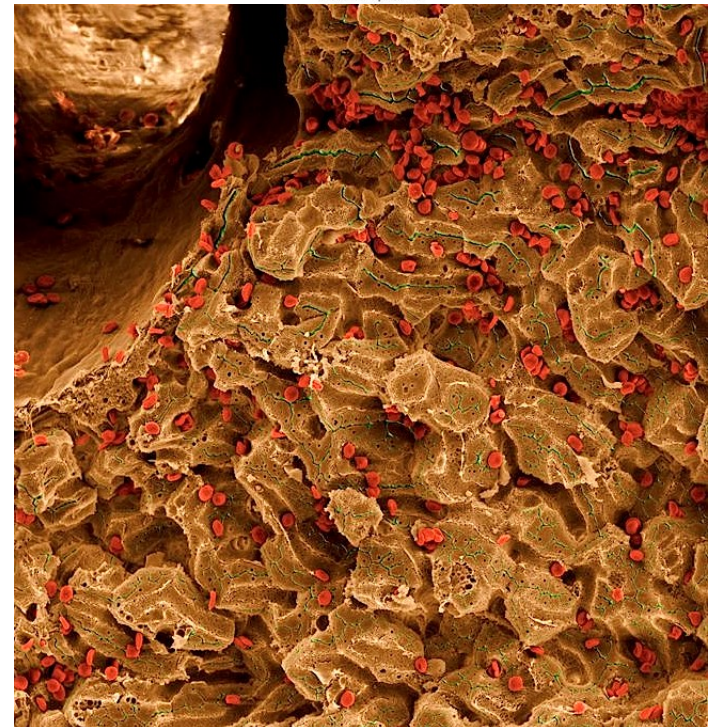
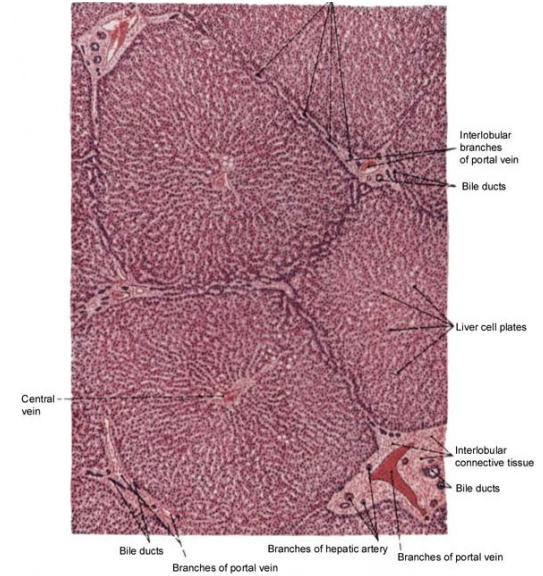
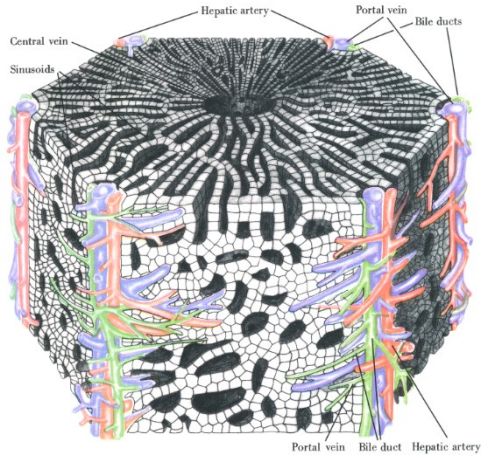
- several layers of columnar cells
- secretion / protection

- ocular conjunctiva
- pharynx, anus – transitions
- uterus, male urethra, vas deferens
- intralobular ducts of salivary glands



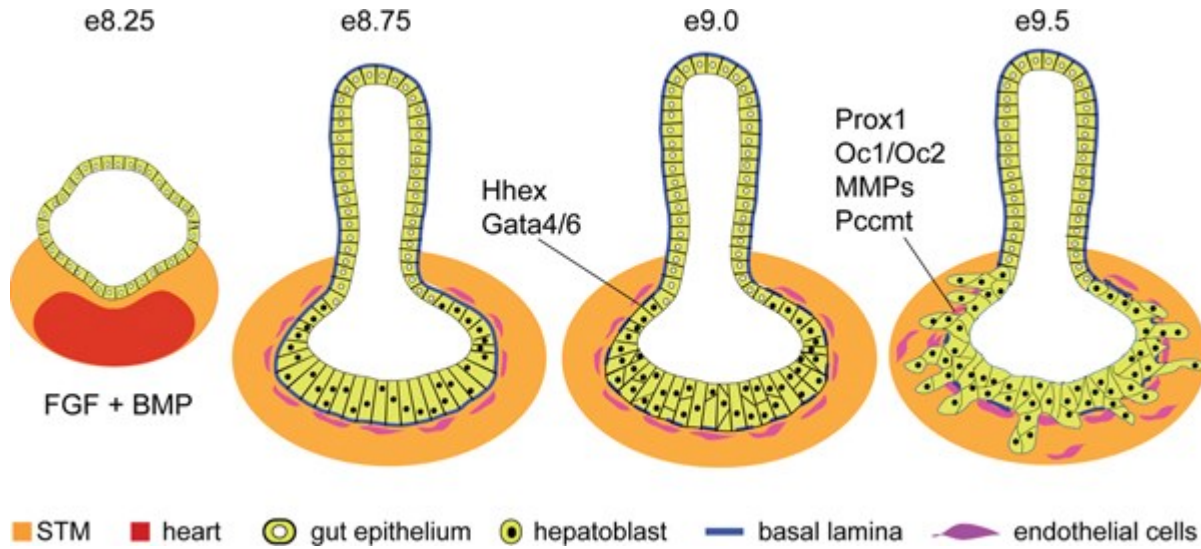
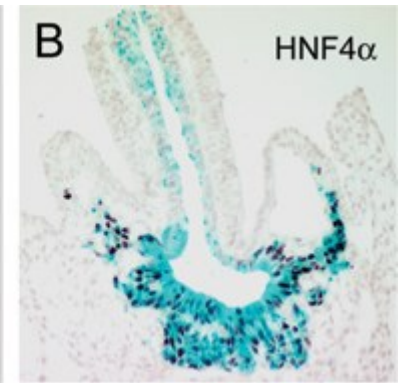
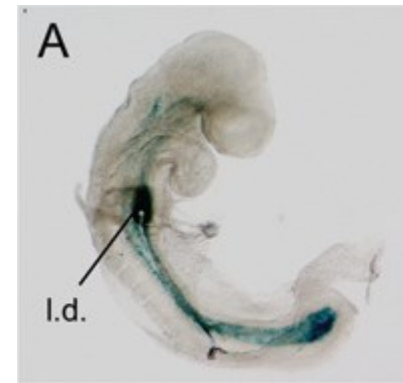
■ Classification of epithelial tissues

Trabecular epithelium

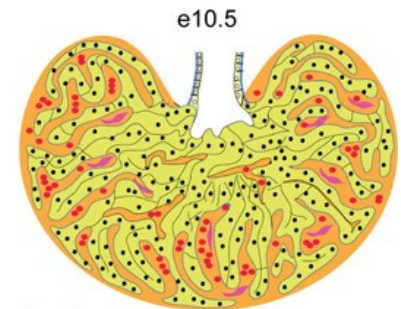


Trabecular epithelium

- Cords of hepatocytes

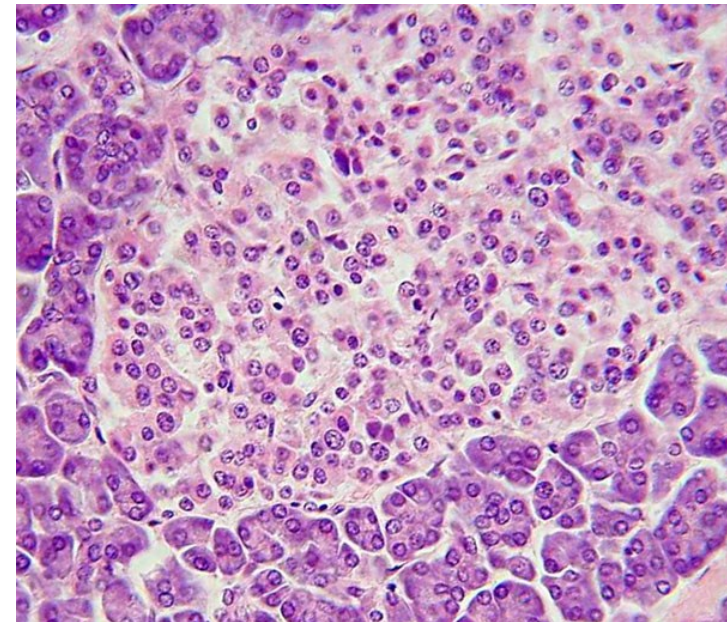
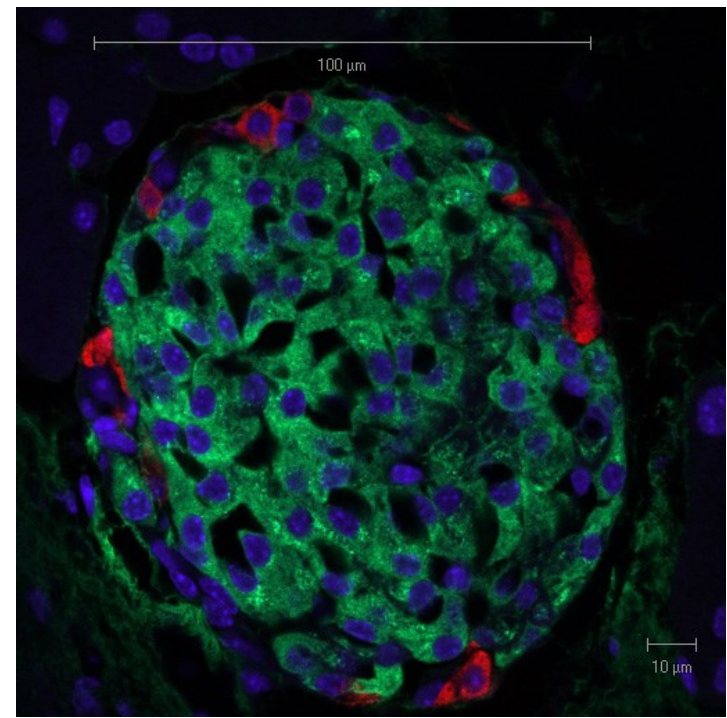
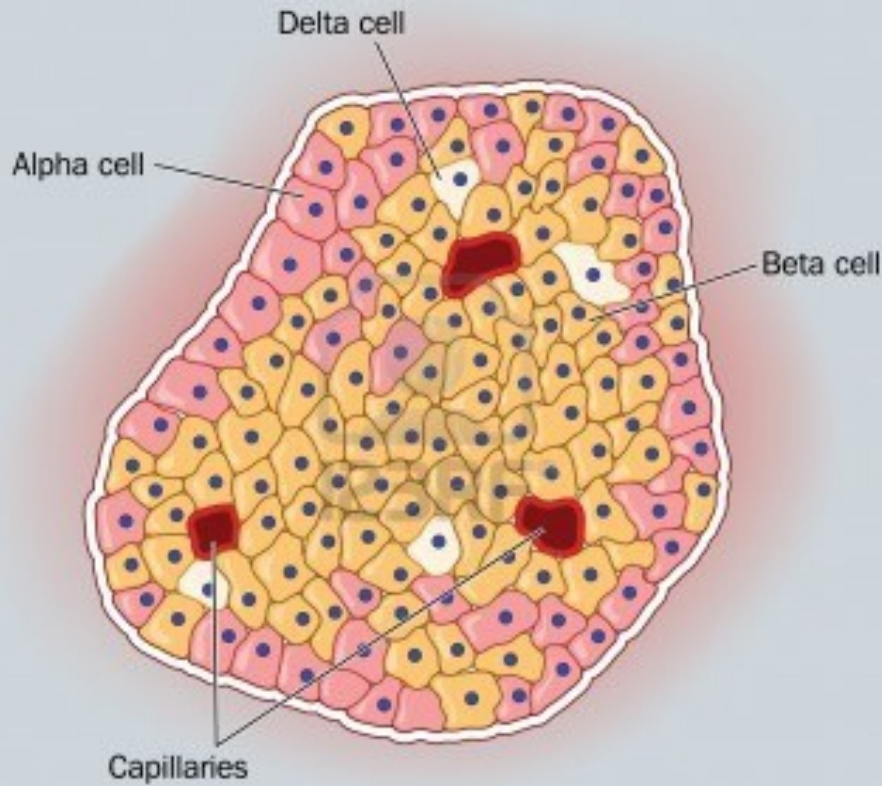


hepatoblasts:
 BMPR, FGFR, c-Met, TGFR,
 Pi3K, Sek1/JNK, Elf5, Arf6, Raf1
 Smad2/3, β -catenin, c-jun, Tbx3, $\text{NF}\kappa\beta$
 Foxm1b, Xbp1, Mtf-1



mesenchyme signals:
 BMP, FGF, HGF, Wnt, $\text{TGF}\beta$, RA
 Gata4, WT1, N-myc, Hlx, Lhx2

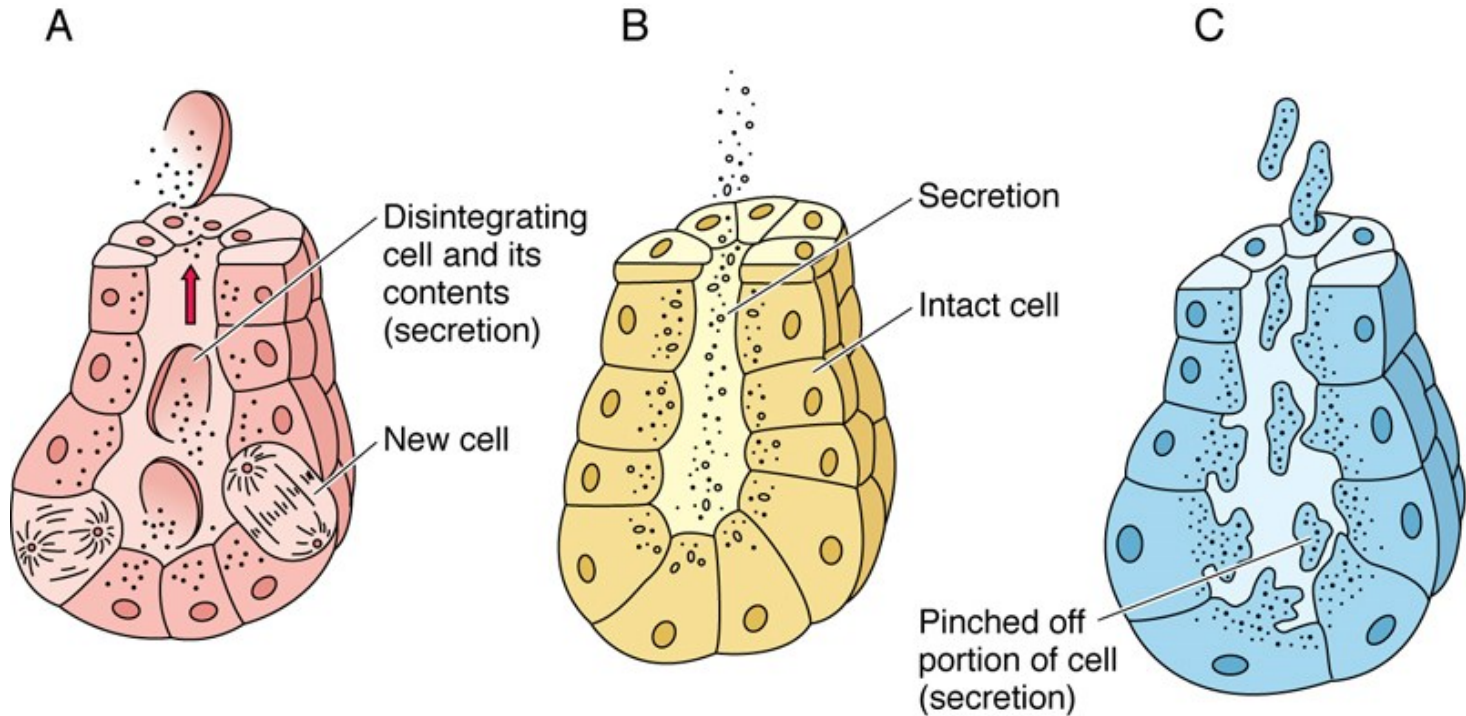
- **Endocrine glands** Islets of Langerhans
 Cords of endocrine active cells



Function of epithelial tissue

■ Glandular epithelium

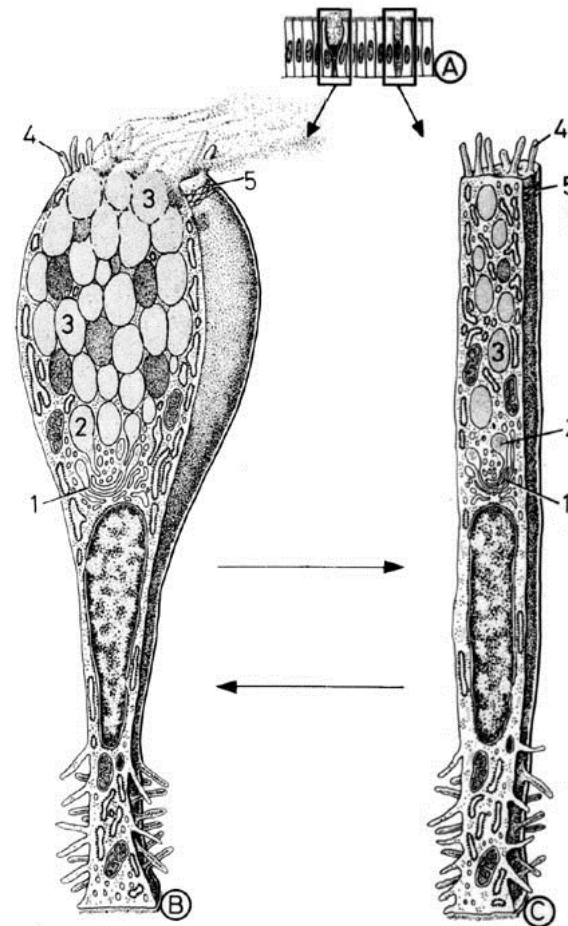
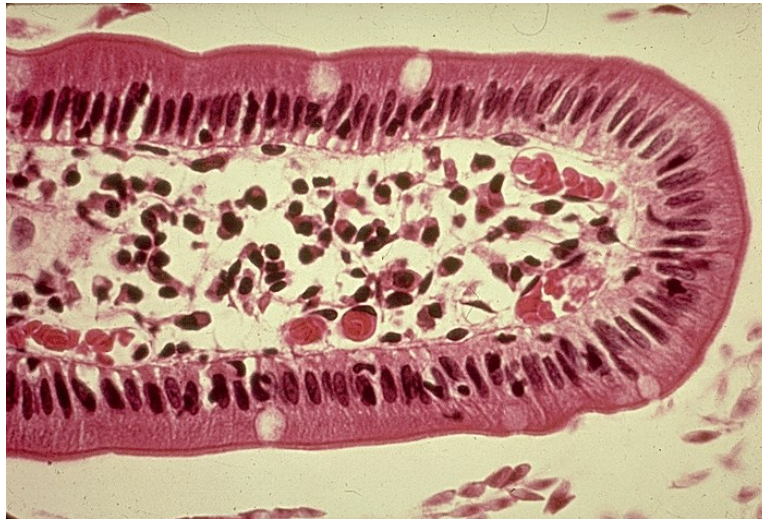
- Secret ↔ excret
- Process of secretion:



Holocrine × Merocrine × Apocrine

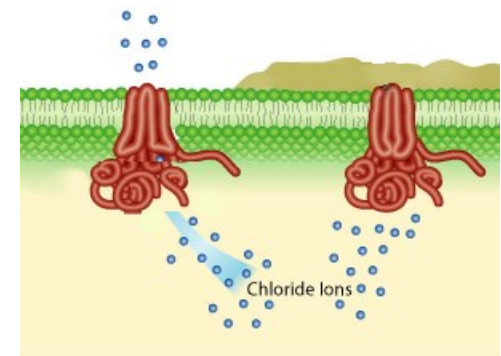
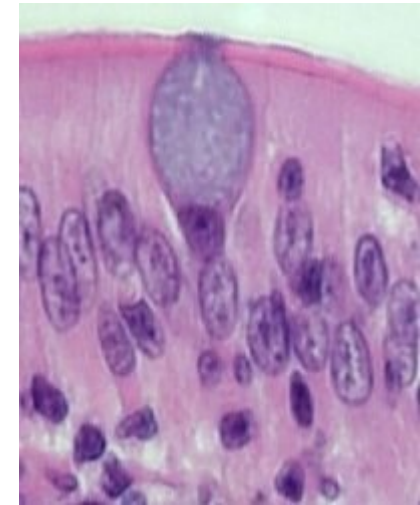
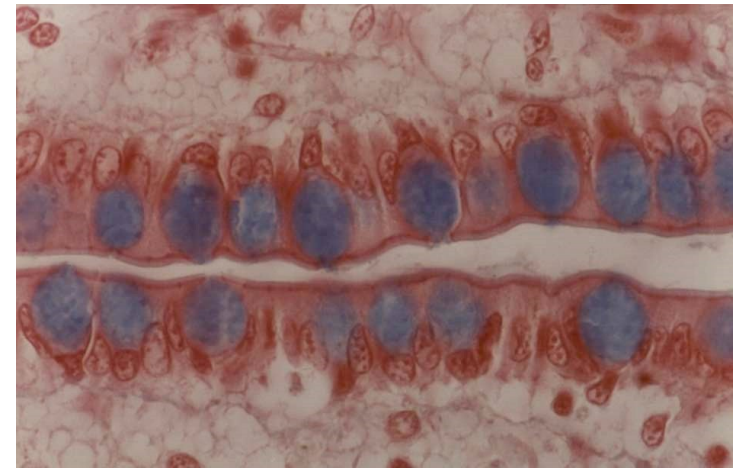
■ Glandular epithelium

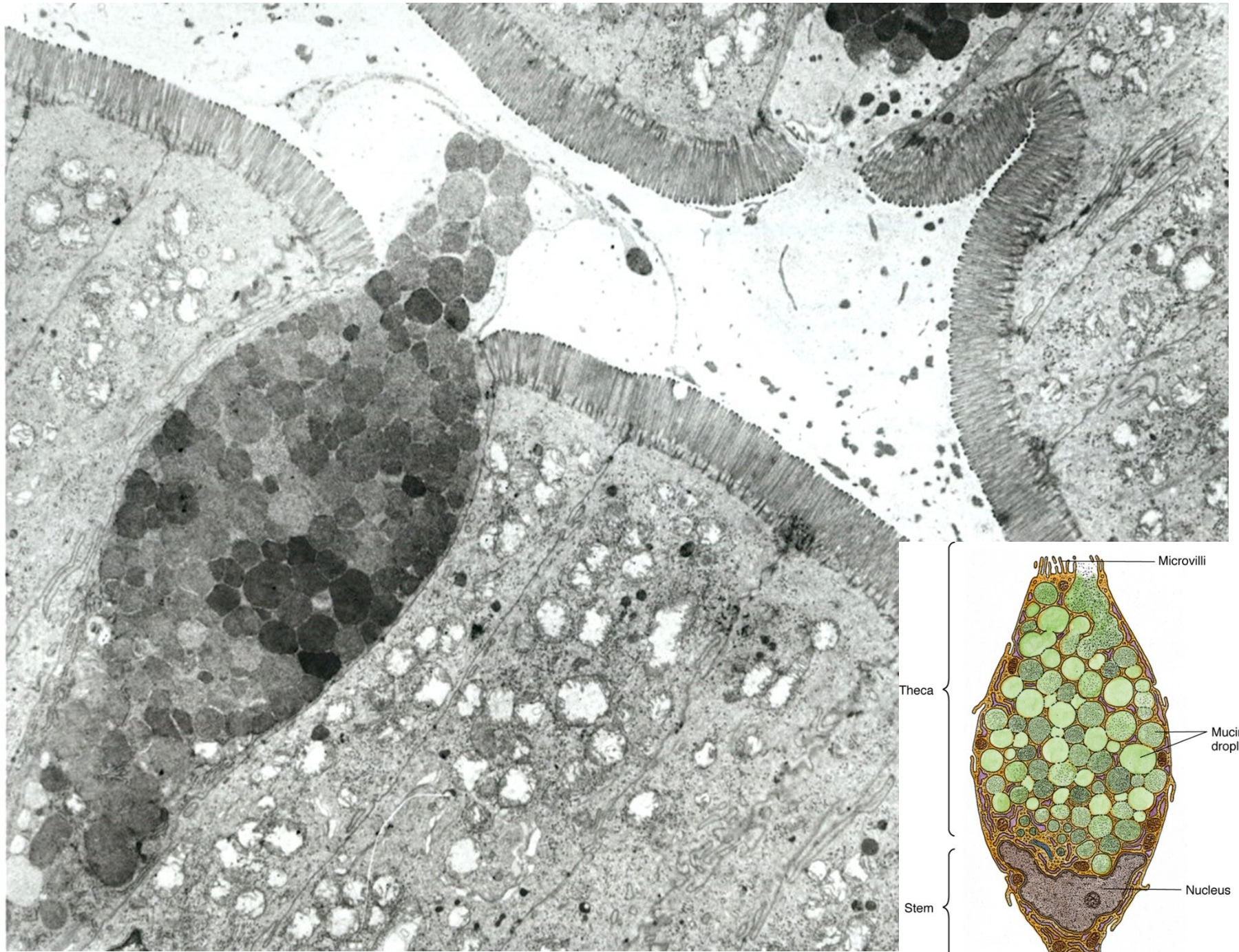
- Single cell glands
 - Goblet
 - Enteroendocrine



■ Goblet cells

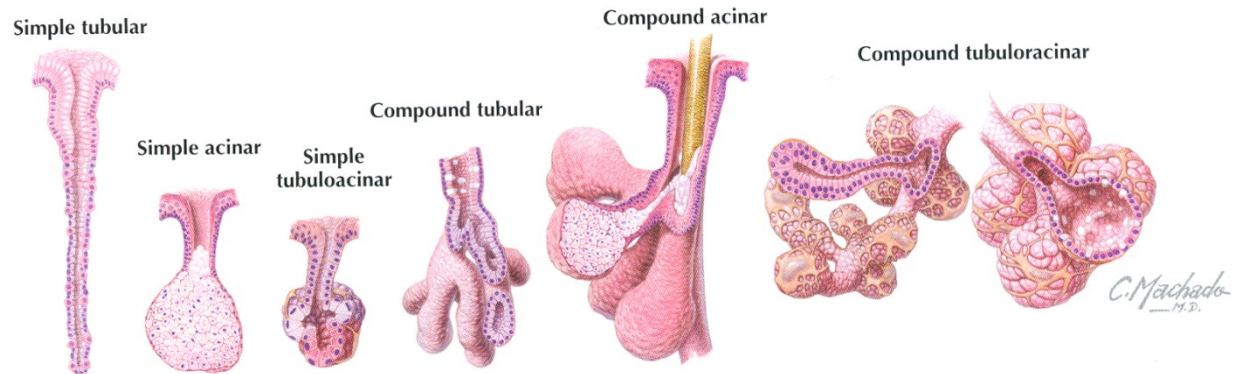
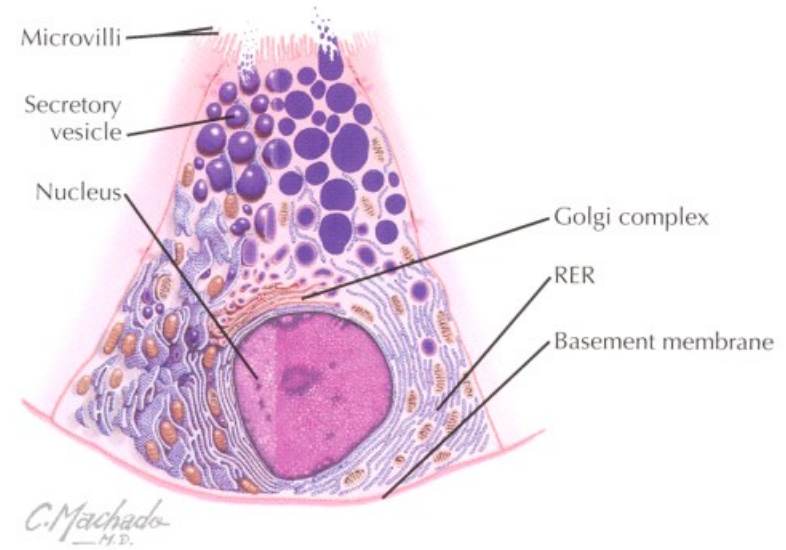
- Mainly respiratory and intestinal tract
- Produce mucus = viscous fluid composed of electrolytes and highly glycosylated glycoproteins (mucins)
- Protection against mechanic shear or chemical damage
- Trapping and elimination of particular matter
- Secretion by secretory granules constitutive or stimulated
- After secretion mucus expands extremely – more than 500-fold in 20ms
- Dramatic changes in hydration and ionic charge
- Chronic bronchitis or cystic fibrosis – hyperplasia or metaplasia of goblet cells





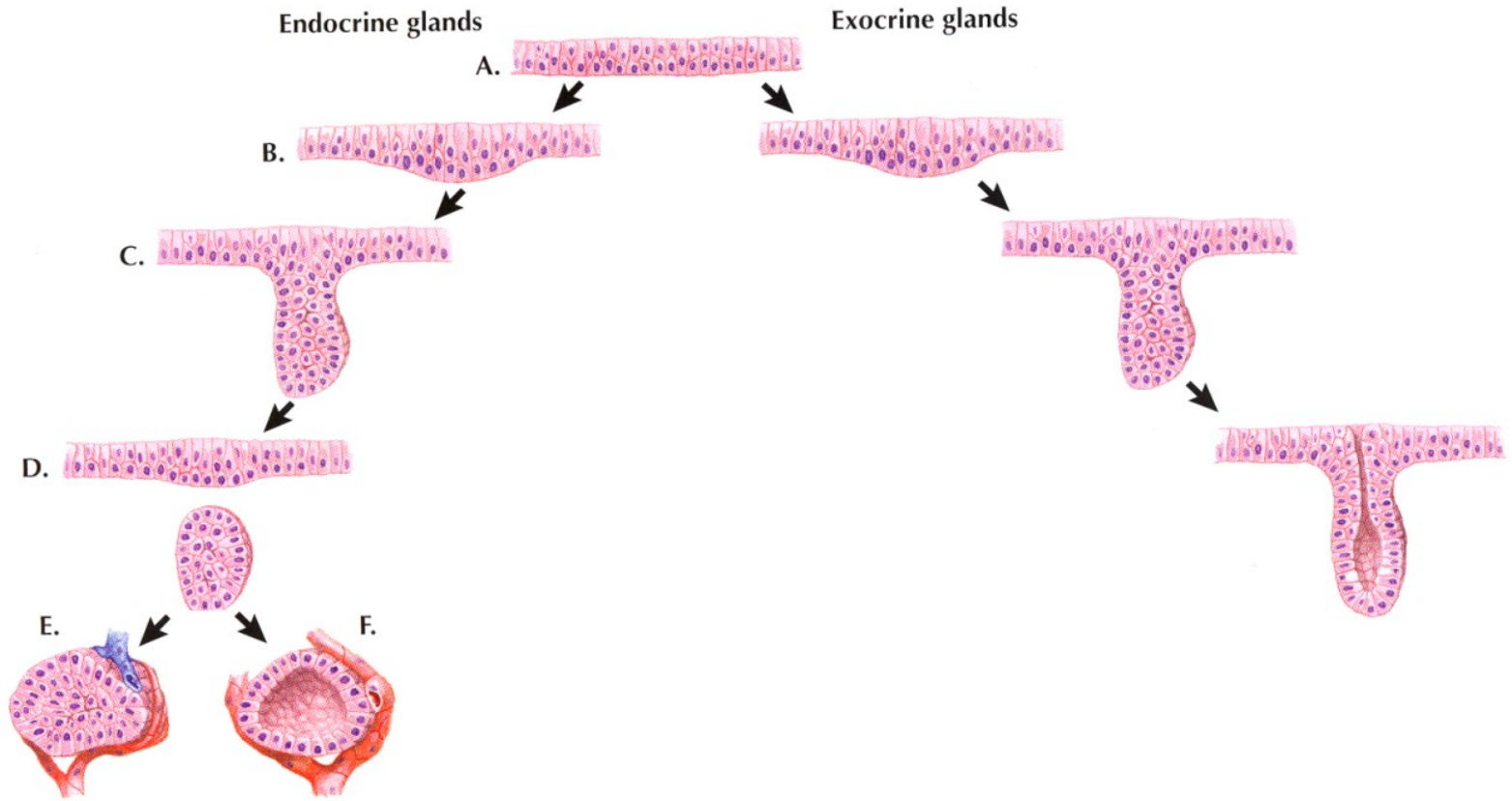
■ Multicellular glands

- Shape of secretion part
 - Alveolar (acinar)
 - Tubular
 - Tubuloalveolar (tubuloacinar)
- Branching
 - Simple
 - Branched
 - Compound
- Secretion
 - Mucous
 - Serous
 - Compound

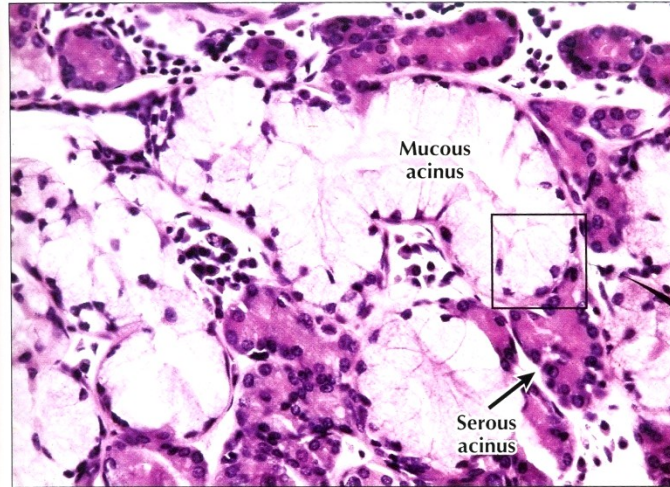


■ Multicellular glands

– Endocrine vs. exocrine

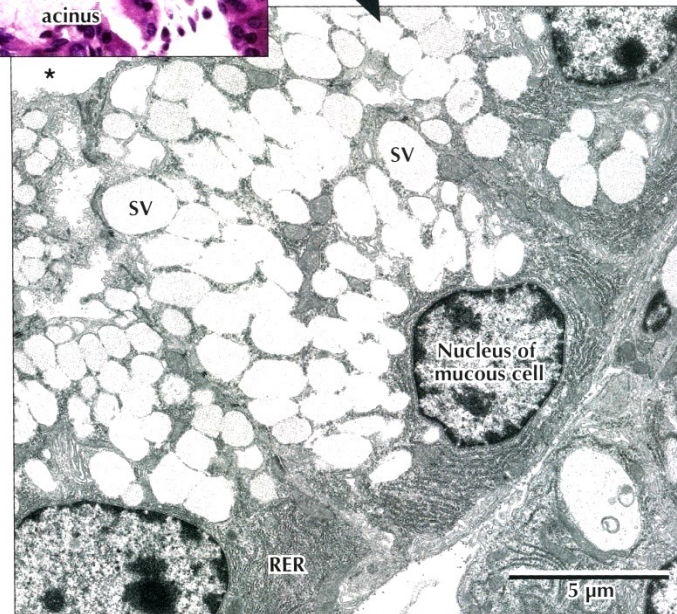


■ Mucous glands

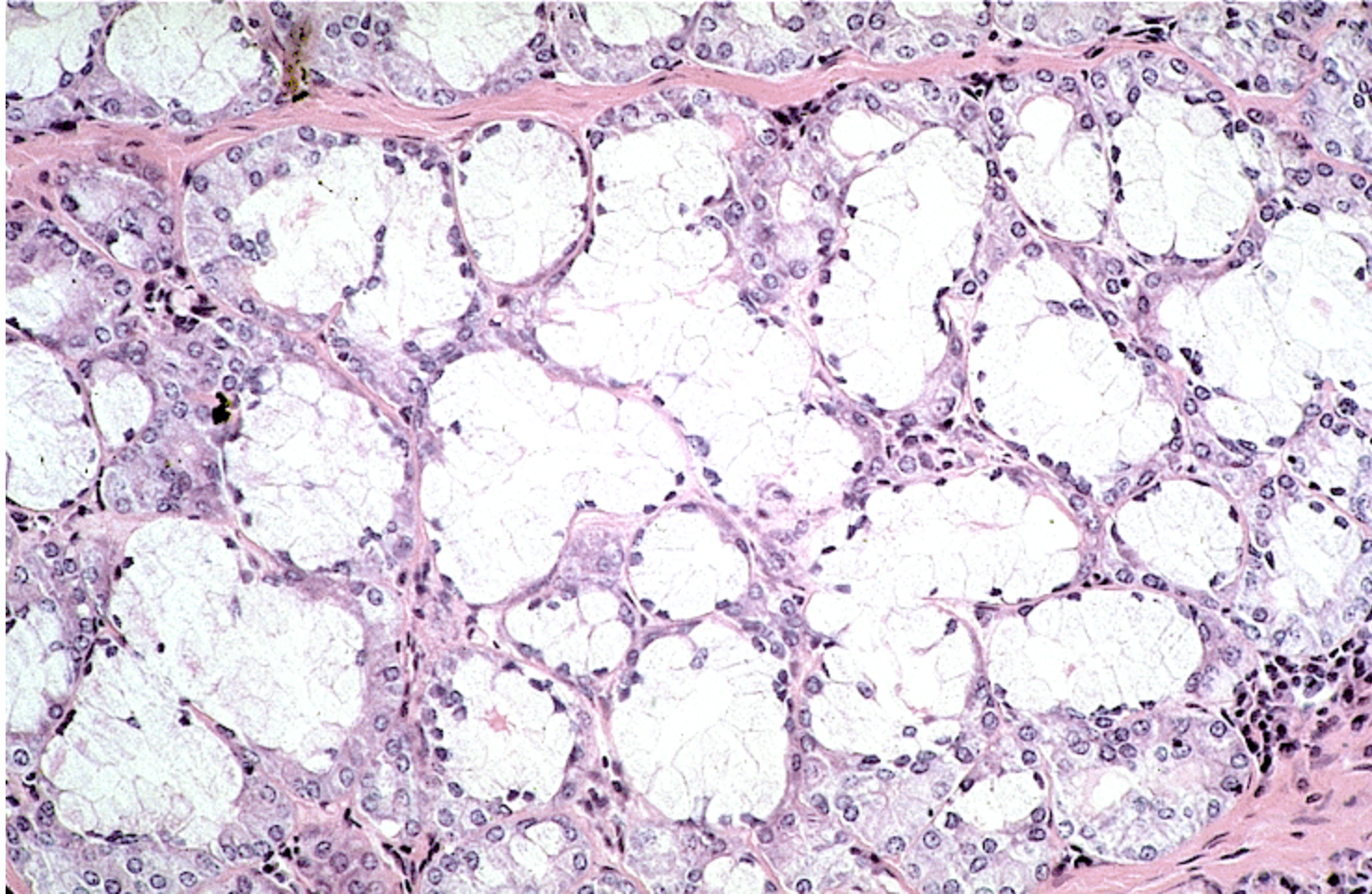


◀ **LM of part of a mixed seromucous gland in the trachea.** Several mucous acini with pale-stained mucous cells are seen. The basal nuclei are flat, and cells appear washed out because mucous droplets dissolved during specimen preparation. Darker stained serous cells in adjacent acini have more rounded basal nuclei. Serous cells are smaller than mucous cells. The square outlines the area of interest seen in the EM below. 295 \times . H&E.

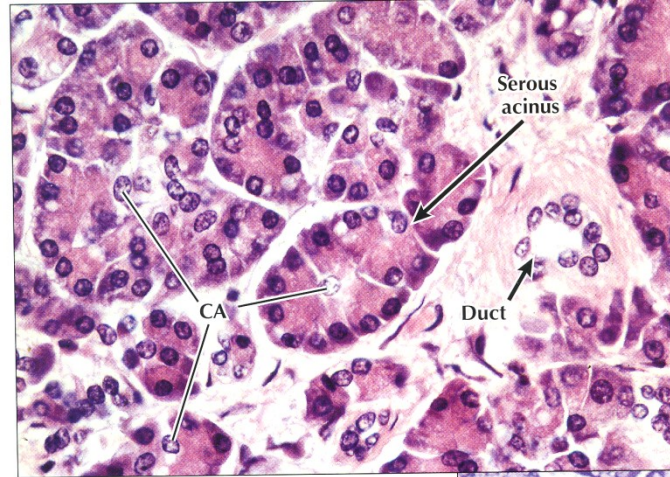
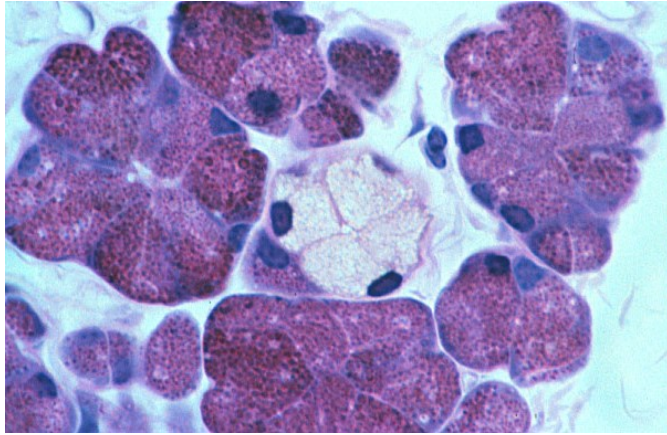
▶ **EM of part of a mucous acinus in a mixed salivary gland.** Parts of three mucous cells line the acinus lumen (*). Euchromatic basal nuclei have prominent nucleoli. Basal cytoplasm contains many profiles of rough endoplasmic reticulum (**RER**). Many large, electron-lucent secretory vesicles (**SV**) dominating the remaining cytoplasm are discharged by exocytosis into the acinus lumen. 5400 \times .



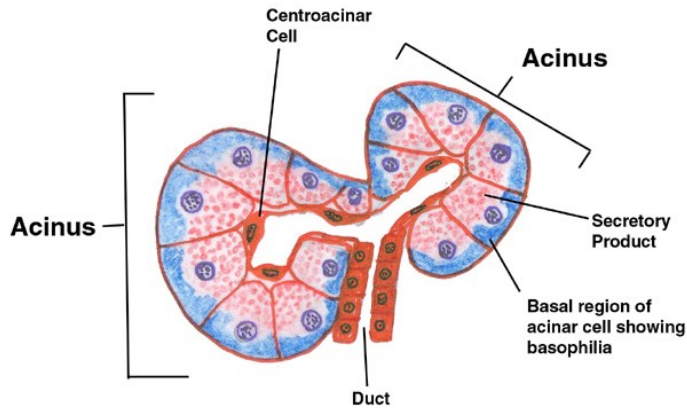
■ Mucous glands



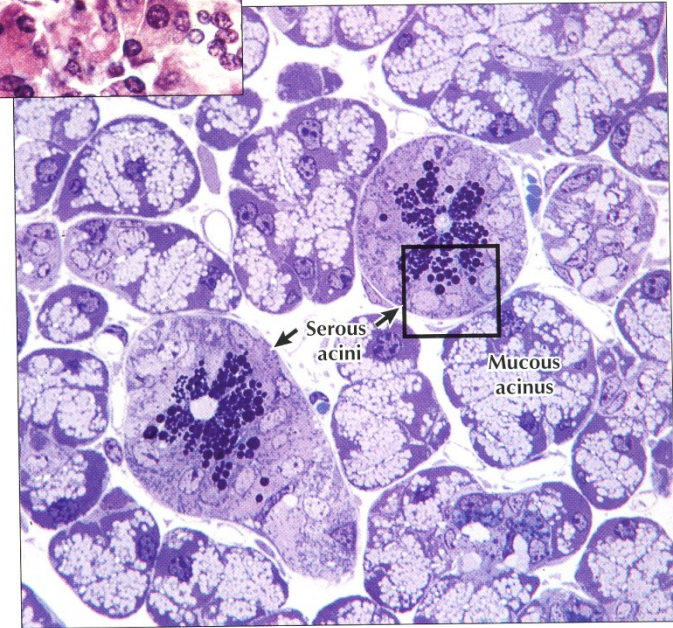
■ Serous glands



◀ **LM of part of the exocrine pancreas.** The exocrine part of the gland consists of closely packed spherical or pear-shaped serous acini. Several columnar to pyramidal acinar cells, with round basal nuclei, face a small central lumen in each **serous acinus**. Basal cytoplasm is basophilic; apical cytoplasm is more eosinophilic. Small clear centroacinar cells (**CA**) in acini centers help distinguish this purely serous gland from others, such as the parotid salivary gland. A small **duct**, in the connective tissue stroma, conveys secretions from acini to larger pancreatic ducts. 385 \times . H&E.

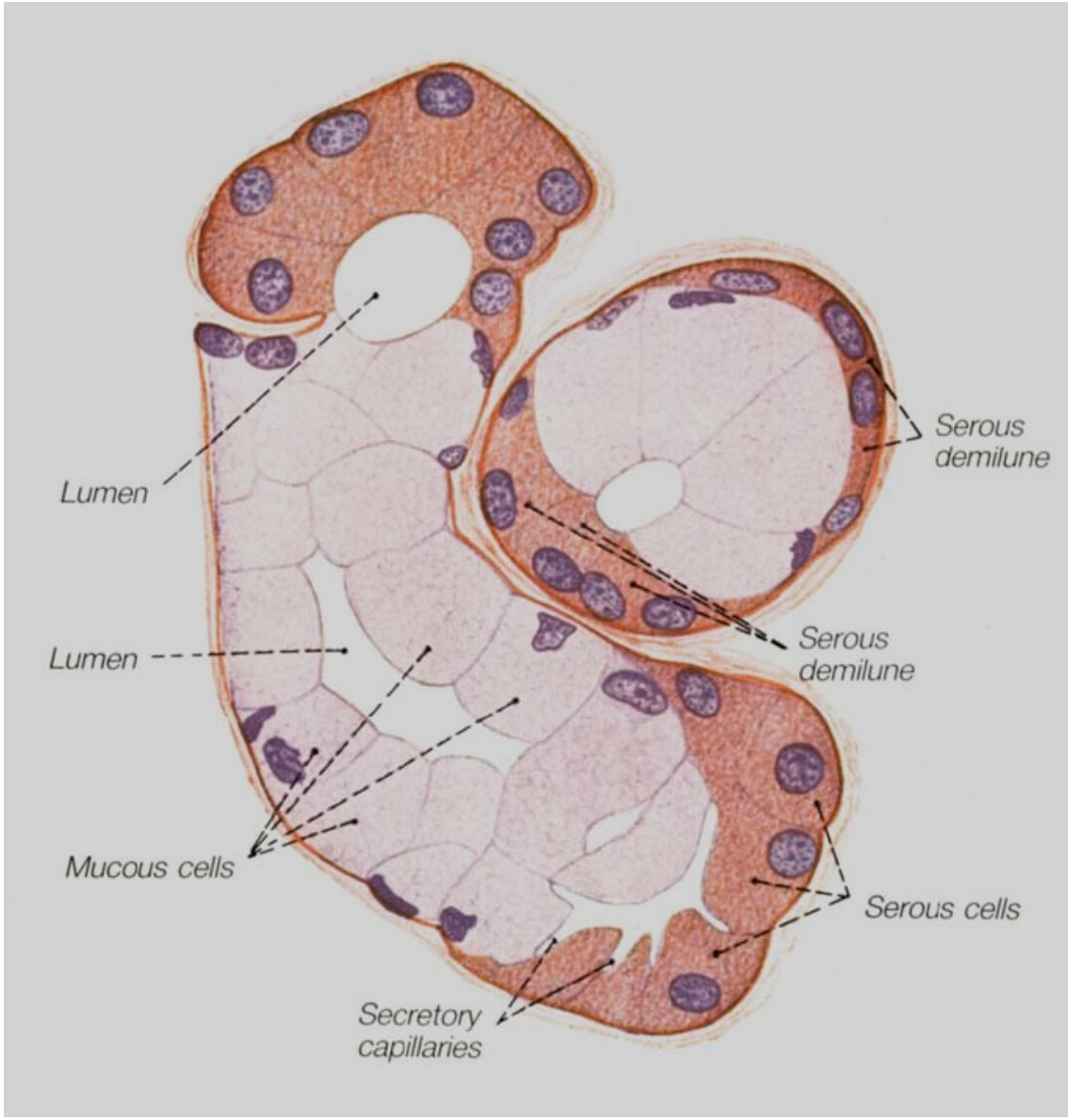


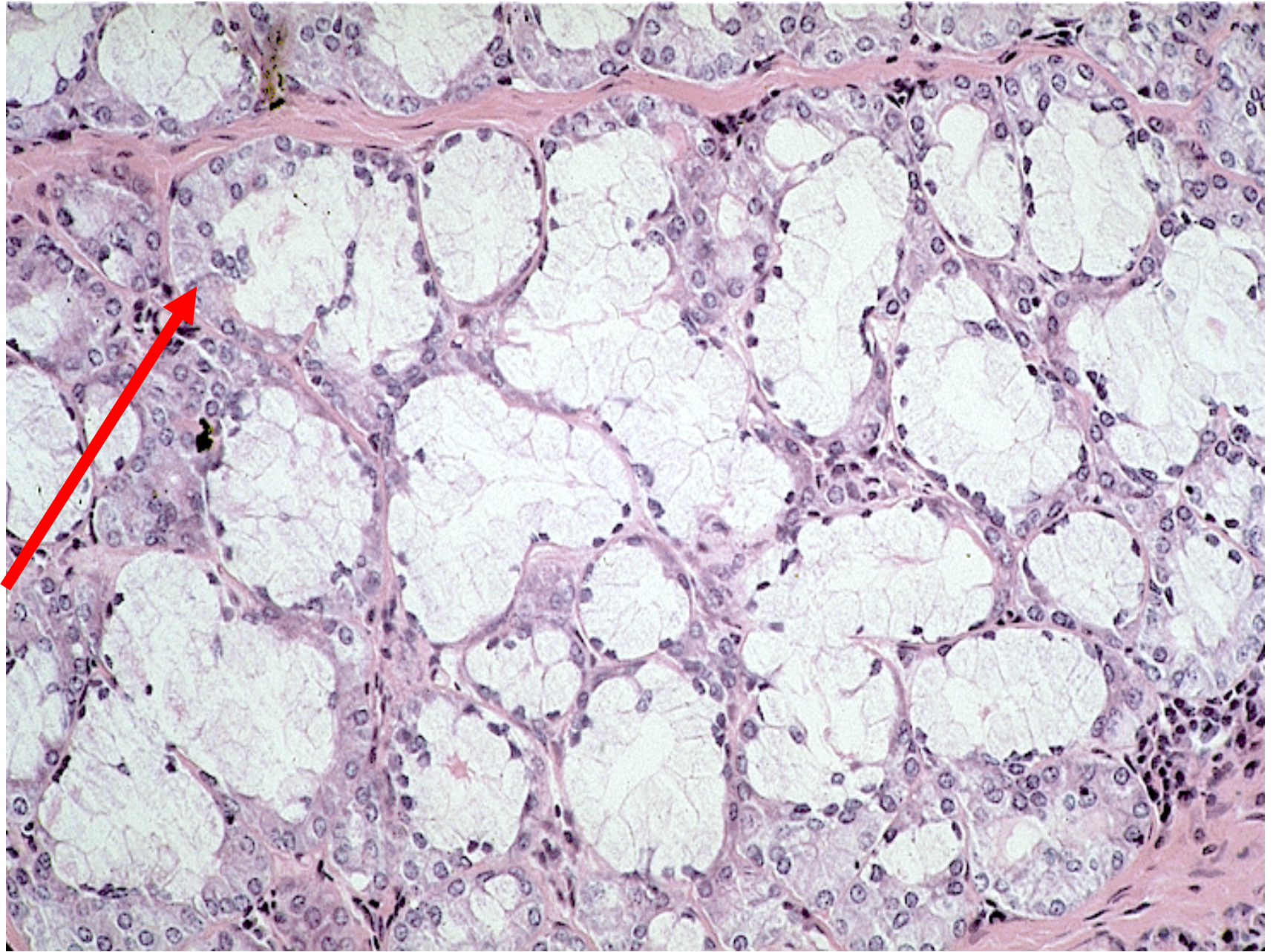
▶ **LM of part of a mixed salivary gland.** Several pale **mucous acini** surround two round **serous acini**. Serous cells have conspicuous, dark-stained secretory vesicles; mucous cells look vacuolated and washed out. EM in 2.15 shows the area in the square in detail. 600 \times . Toluidine blue, plastic section.



■ Compound glands

- both serous and mucous





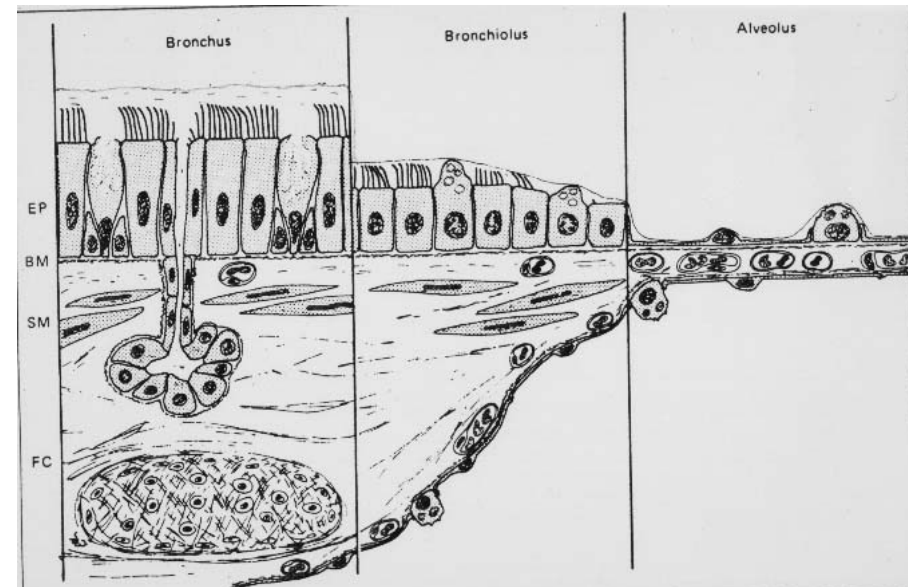
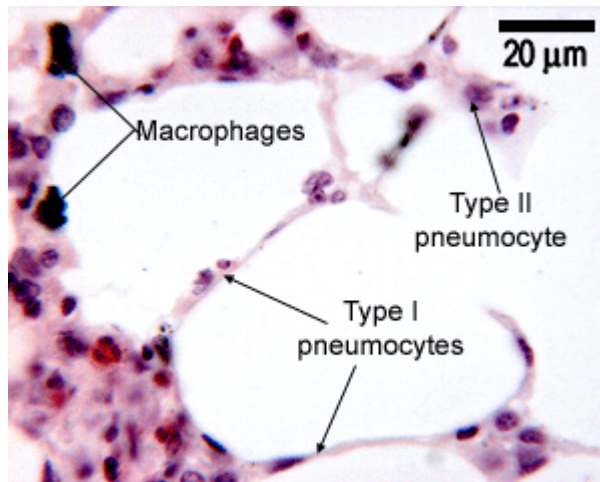
■ Respiratory epithelium

Respiratory passages

- Moisten, protect against injury and pathogen
- Remove particles by „mucociliary escalator“
- Pseudostratified columnar epithelium with cilia
- Basal cells- epithelium renewal

Alveolar epithelium

- Gas exchange
- Respiratory bronchiols, alveolar passages and alveoli
- Type I and II pneumocytes



■ Sensory epithelium

- Supportive and sensory cells

Primary sensory cells – directly convert stimuli to membrane potential

Receptor region, body, axonal process

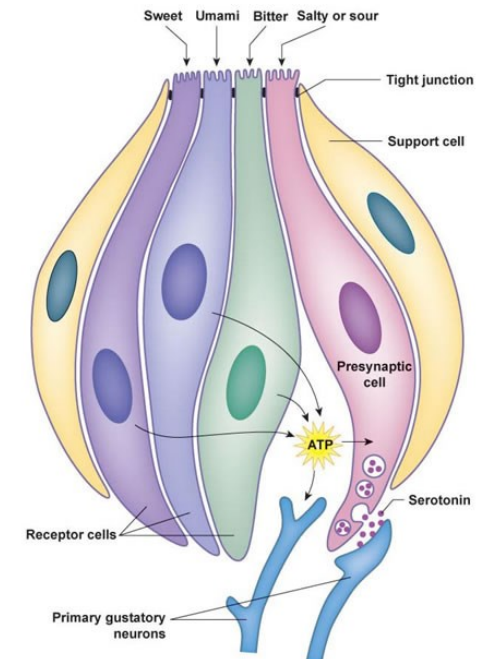
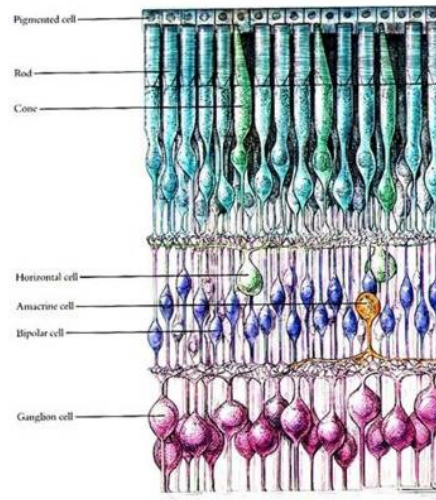
Nasal epithelium (*regio olfactoria nasi*), rods and cones

Secondary sensory cells

Receptor region and body

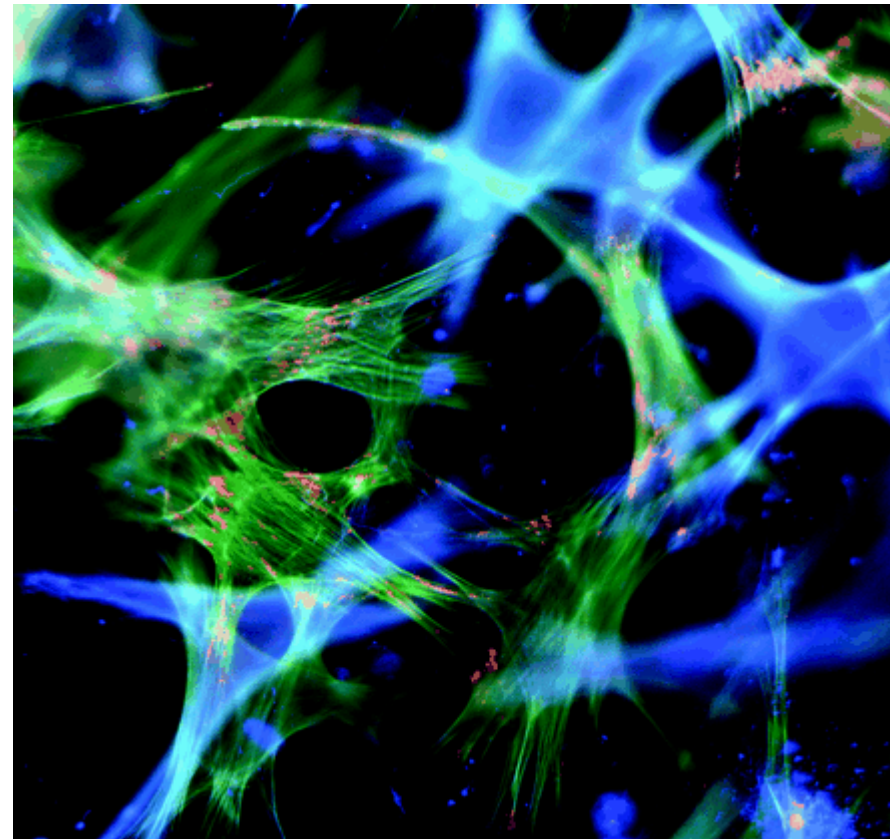
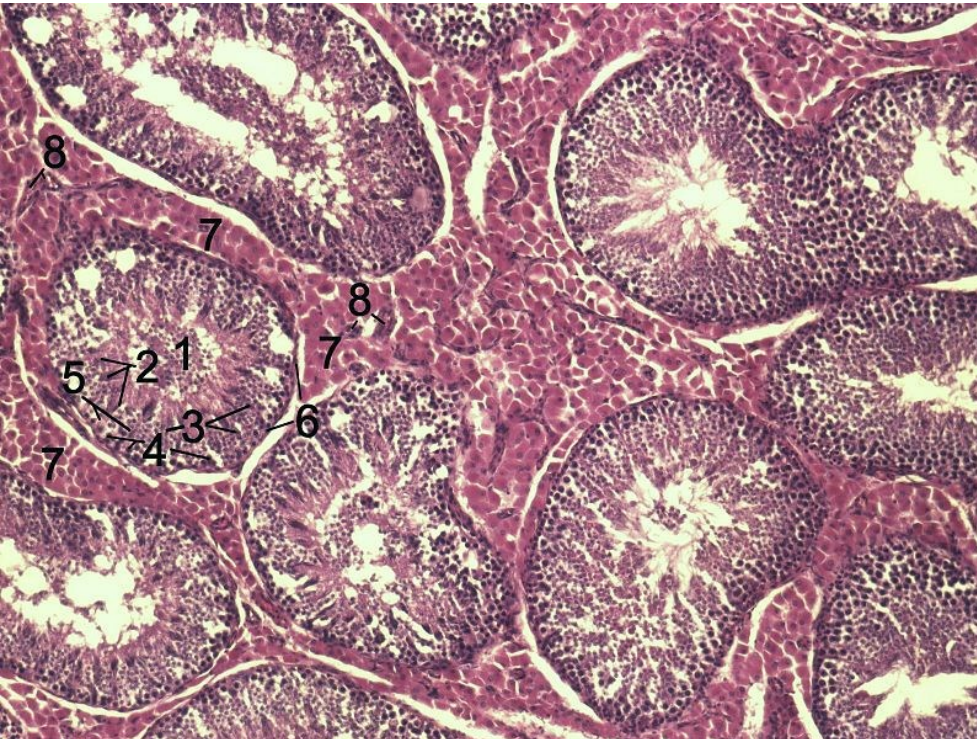
Signal is transmitted by adjacent neurons terminating on secondary sensory cell

Taste buds, vestibulocochlear apparatus



■ Myoepithelium

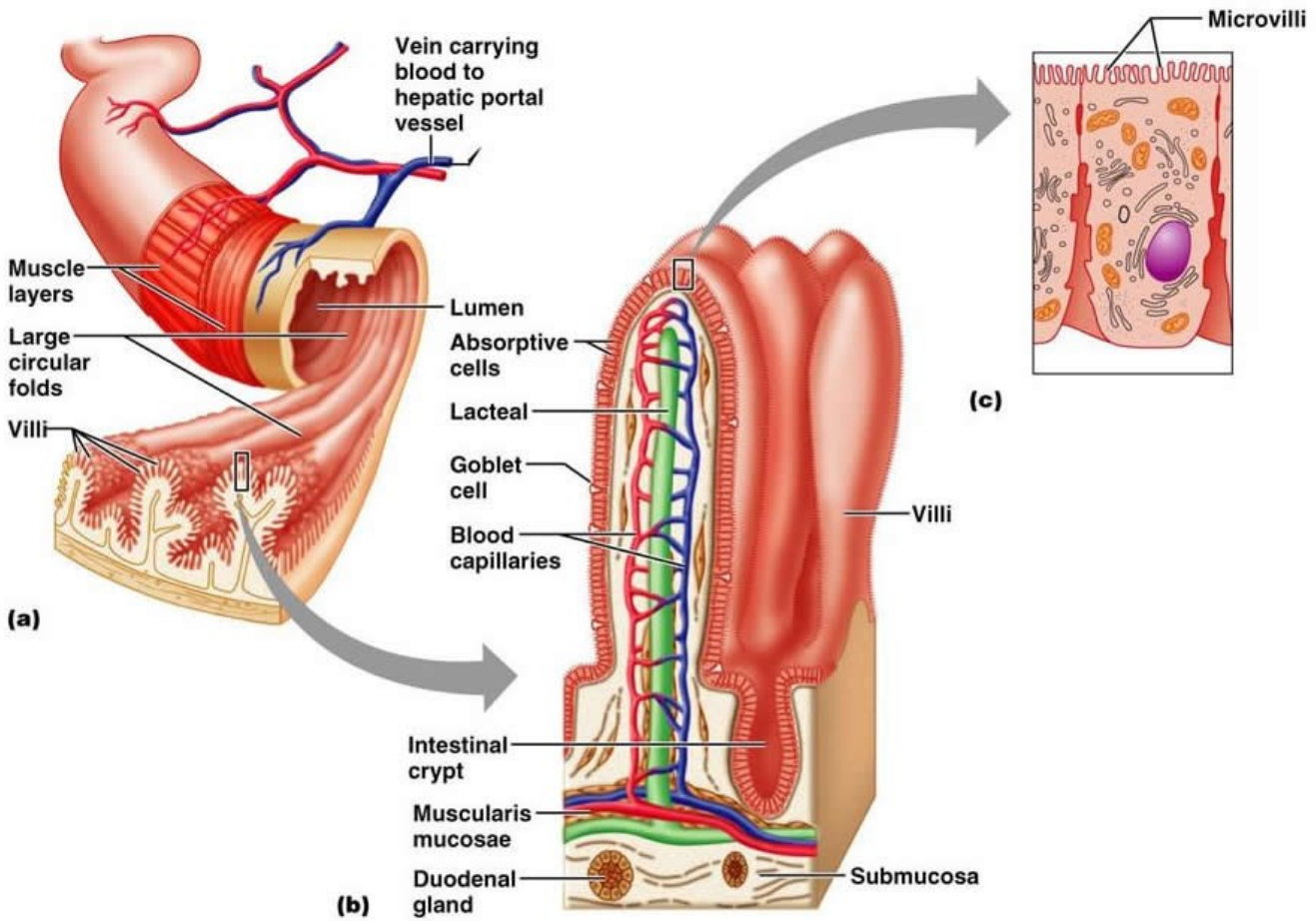
- Star-like or spindle cells
- Connected by nexus and desmosomes
- Actin microfilaments, myosin and tropomyosin
- Contraction
- Sweat and salivary glands – enhancing secretion



Regeneration of epithelial tissue

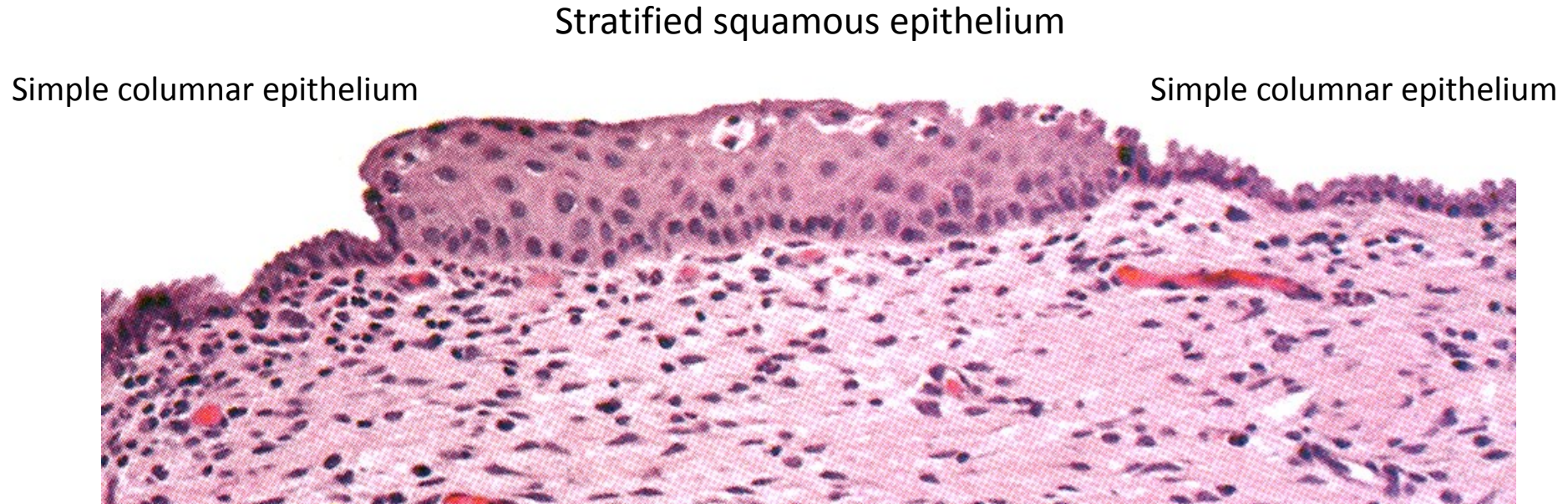
Different regenerative potential (epidermis × sensory epithelium of inner ear)
Multi- a oligopotent stem cells
Microenvironment – *stem cell niche*

Example: Regeneration of intestine epithelium



Plasticity of epithelial tissues

Metaplasia



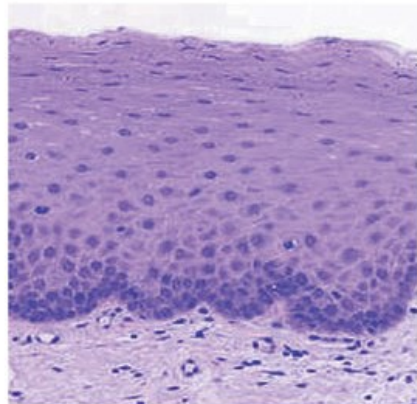
Squamous metaplasia of cervix uteri
Respiratory passages

Plasticity of epithelial tissues

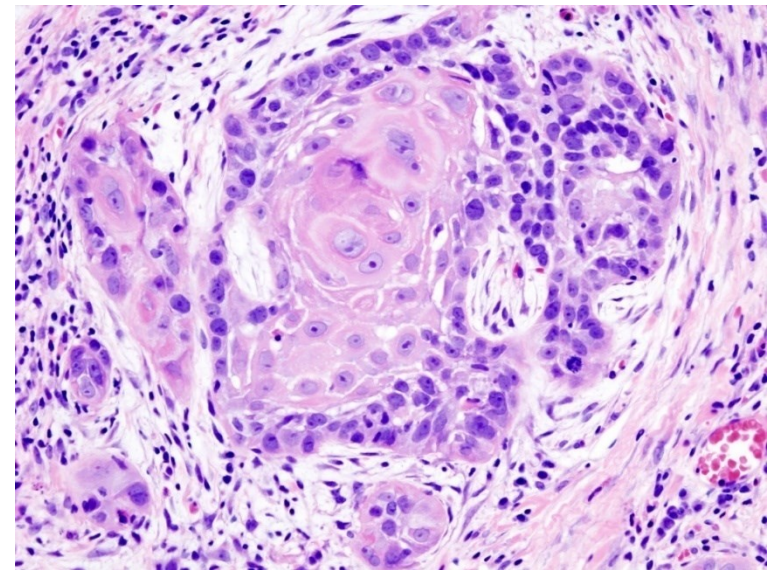
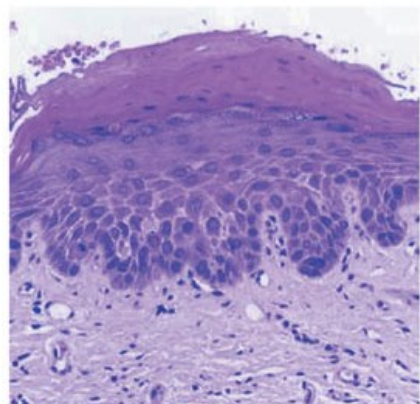
Metaplasia

Development of precancerous lesions

c Normal oral mucosa

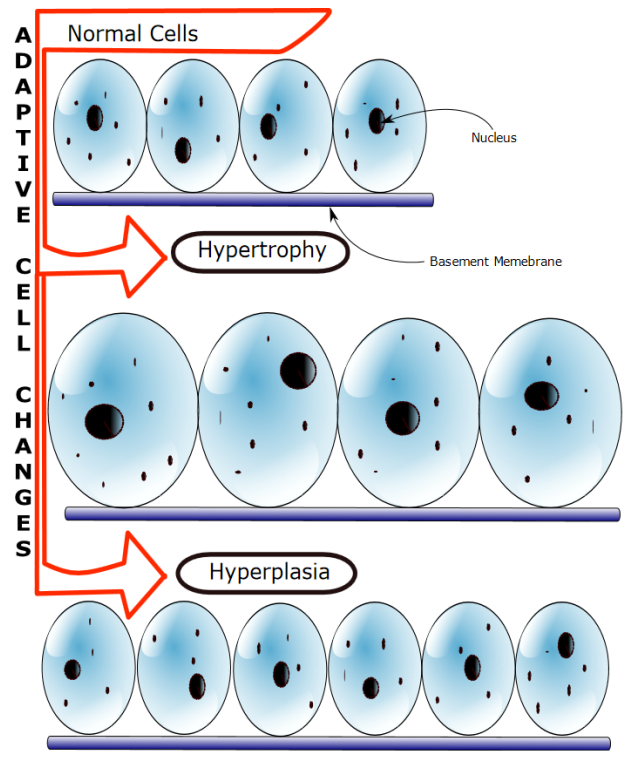


d Moderate dysplasia

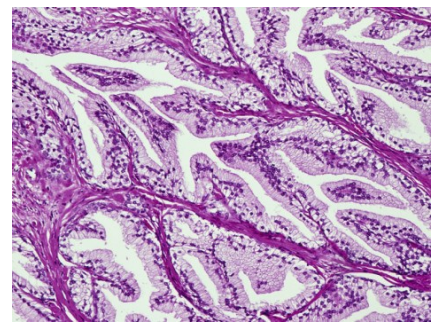


Plasticity of epithelial tissues

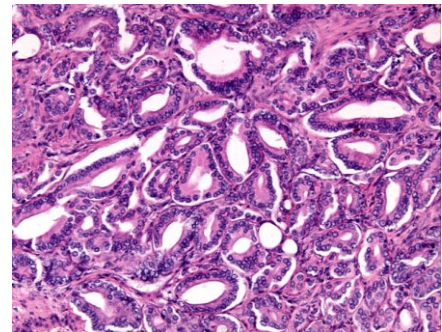
Hyperplasia



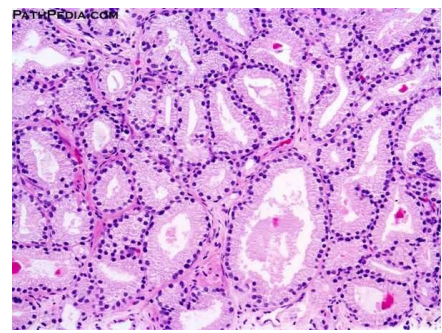
Normal prostate



Hyperplasia of prostate glandular epithelium

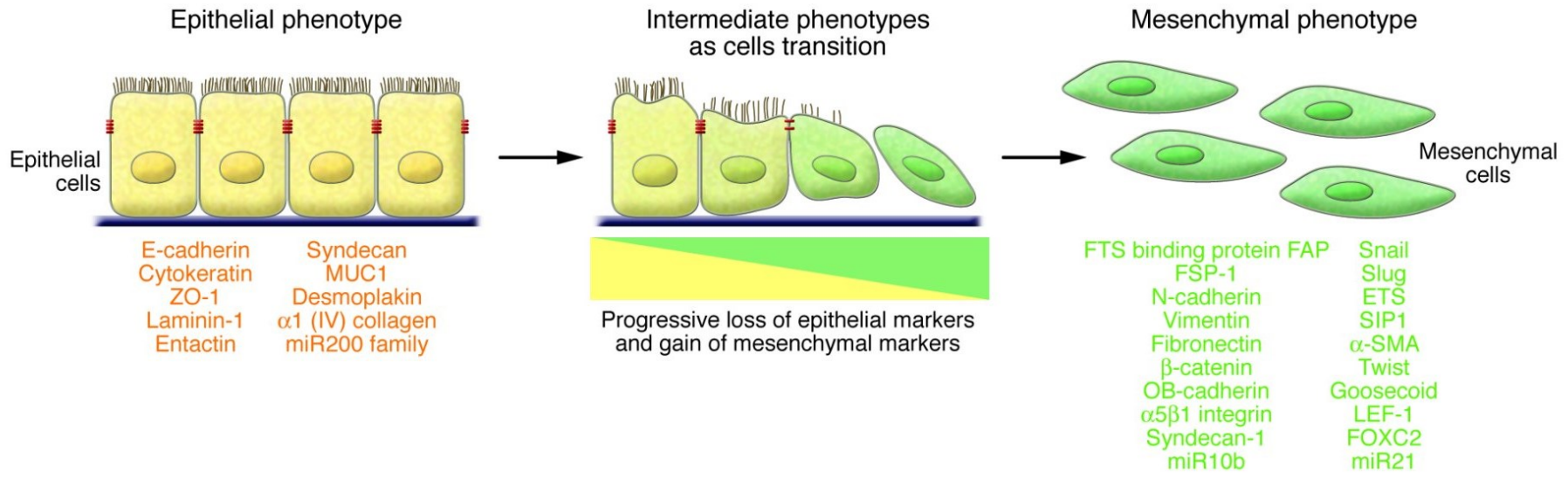


Prostate adenocarcinoma

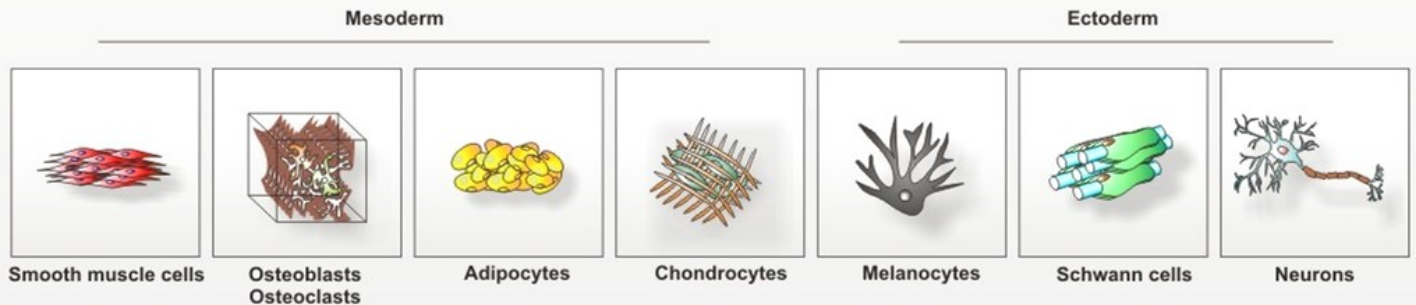
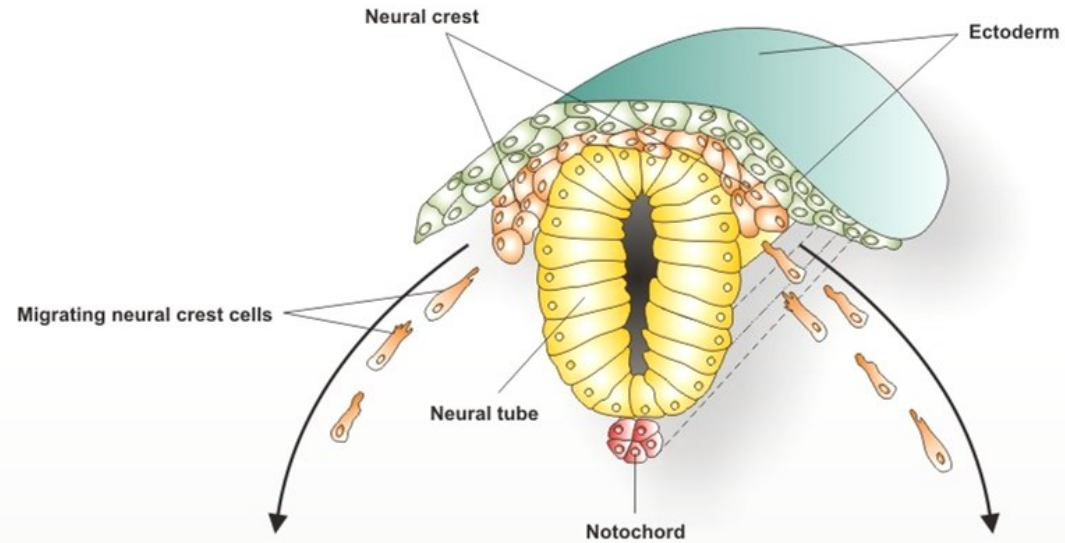
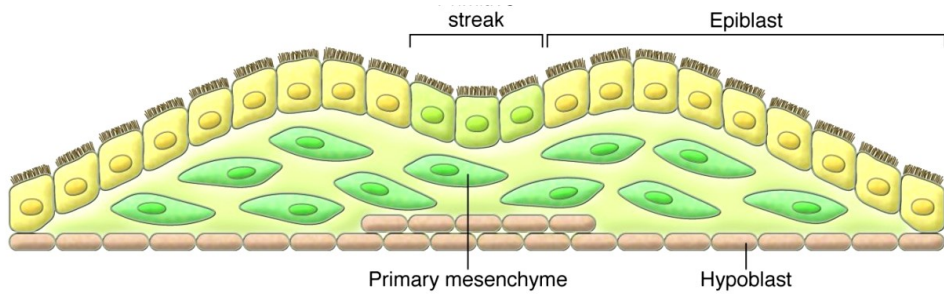


Plasticity of epithelial tissues

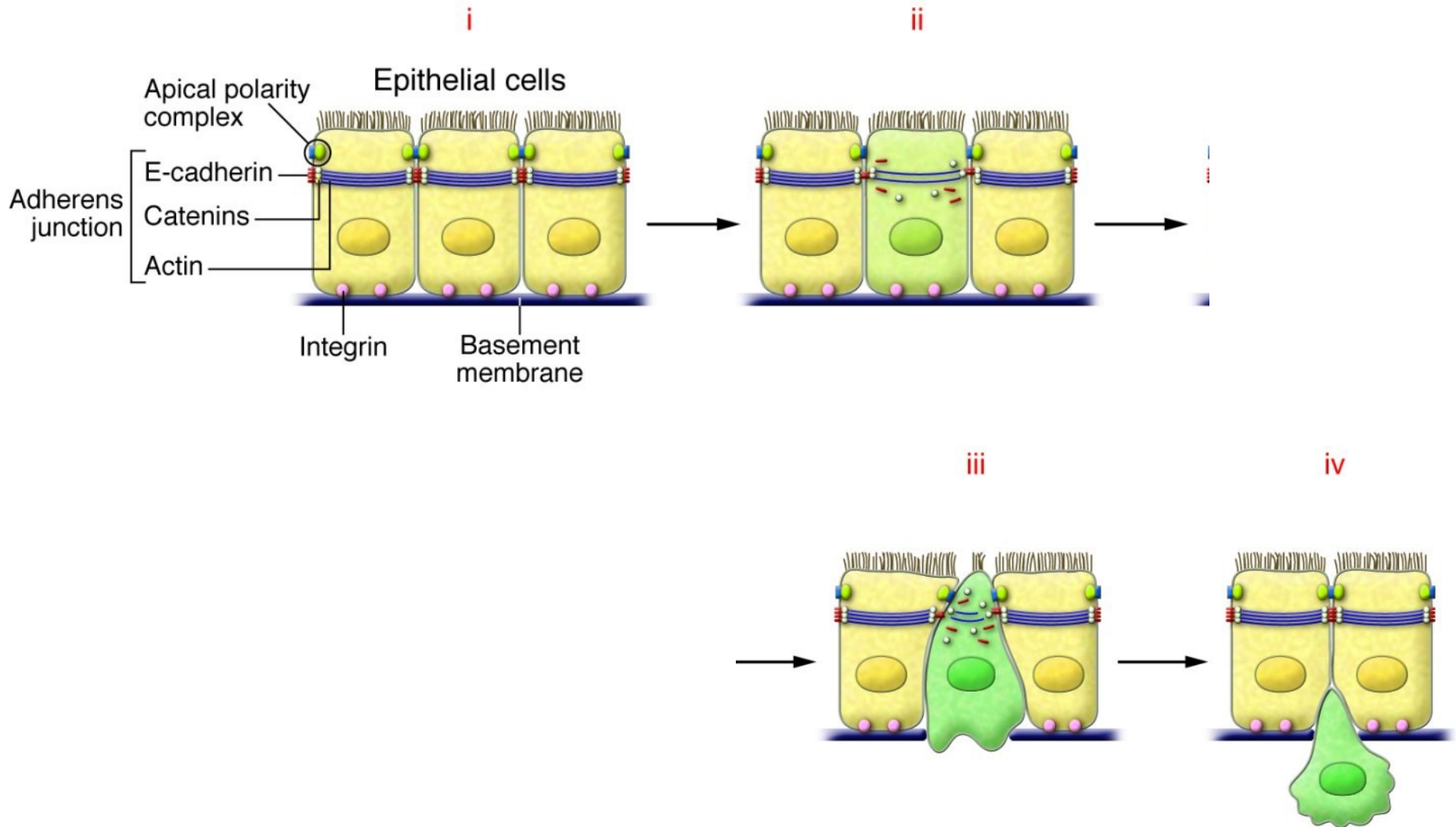
Epithelial to mesenchymal transition (EMT)

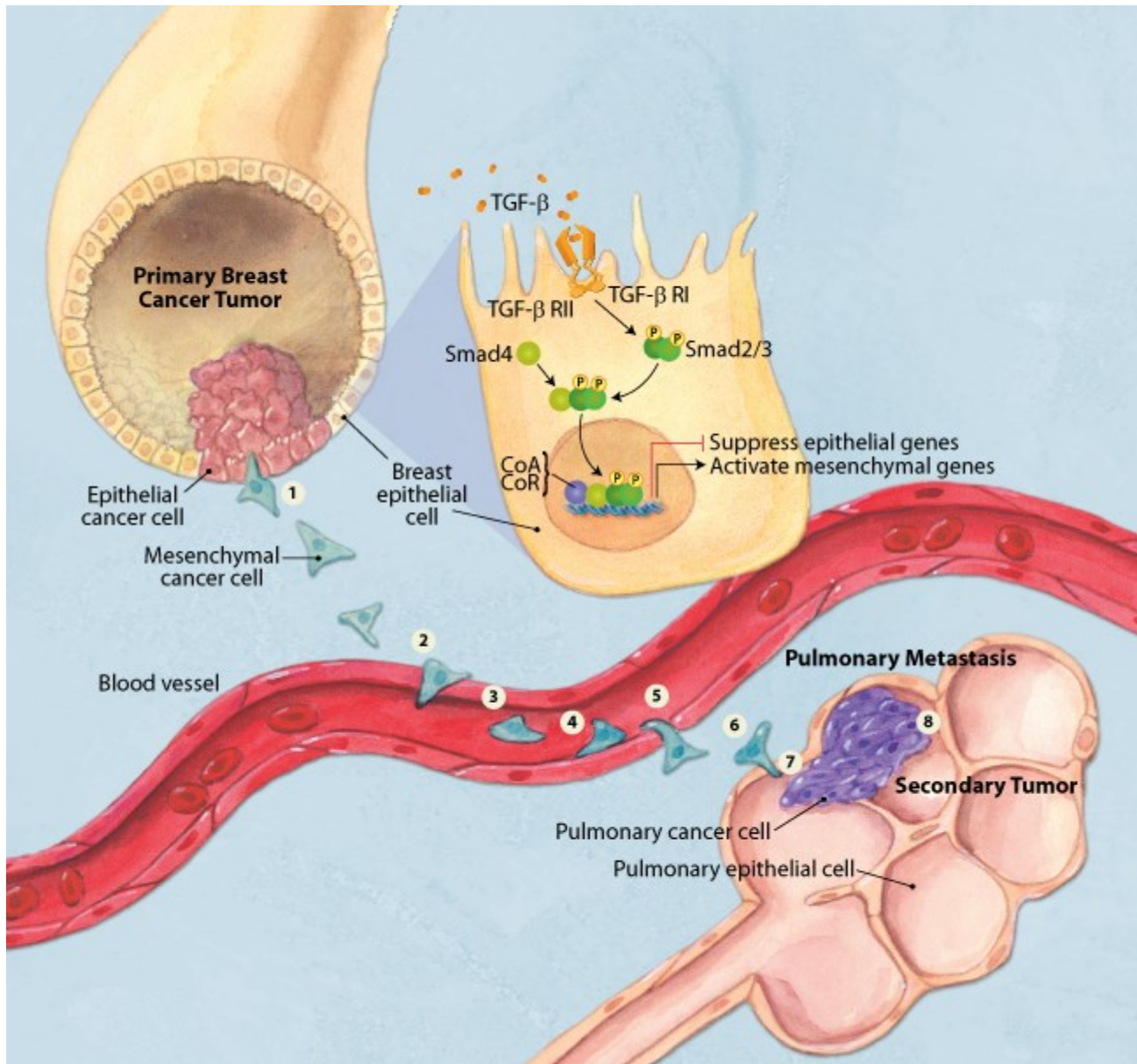


EMT in embryonic development



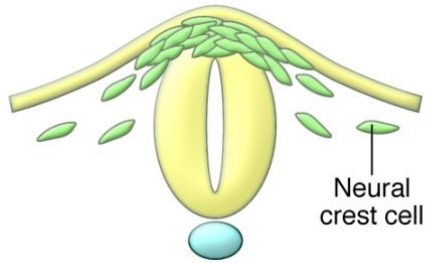
EMT in tumor dissemination



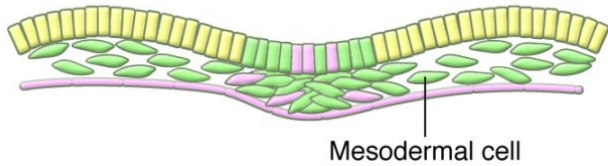


EMT

Embryos

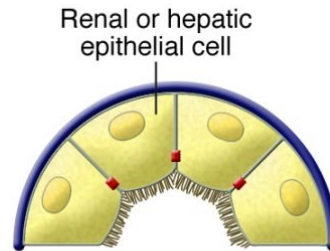


EMT inducers
Physiological expression

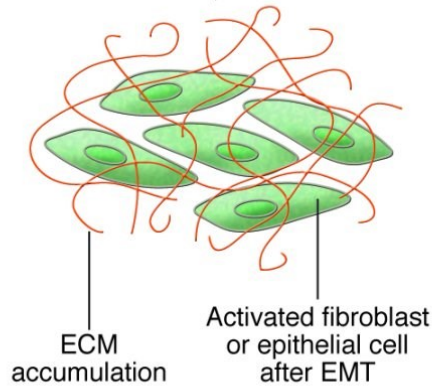


Epithelial cells
Mesenchymal cells

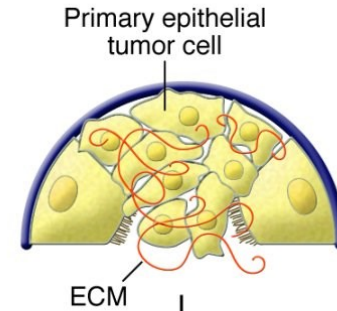
Fibrosis



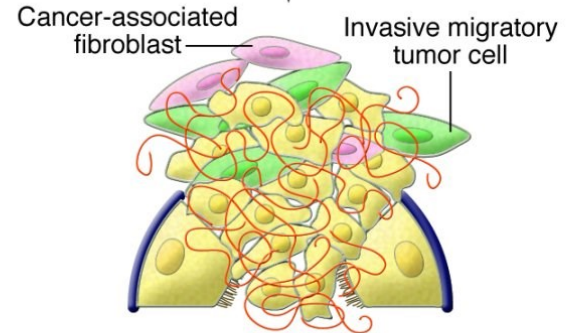
EMT inducers
Aberrant activation



Tumor progression



EMT inducers
Aberrant activation



Thank you for attention

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<http://www.med.muni.cz/histology/petr-vanhara/>

<http://www.med.muni.cz/histology/education/>

