

Epithelial tissue

Petr Vaňhara, PhD

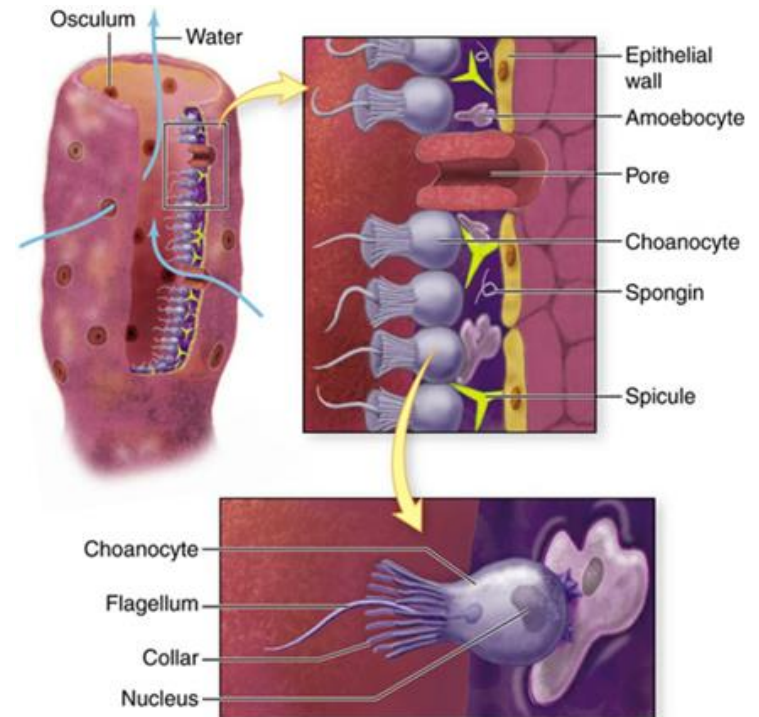
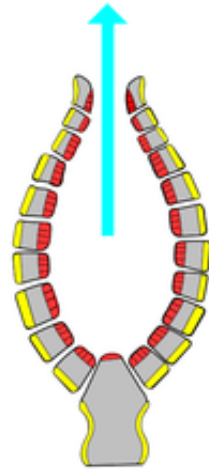
Dept. Histology & Embryology,
Faculty of Medicine MU

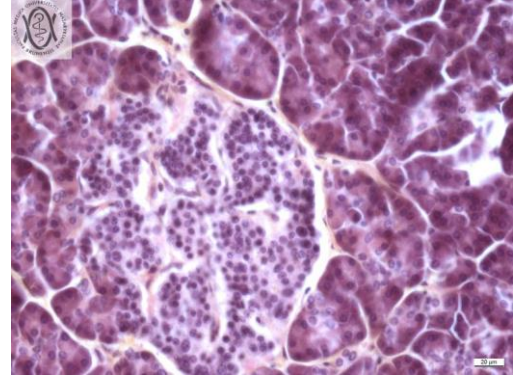
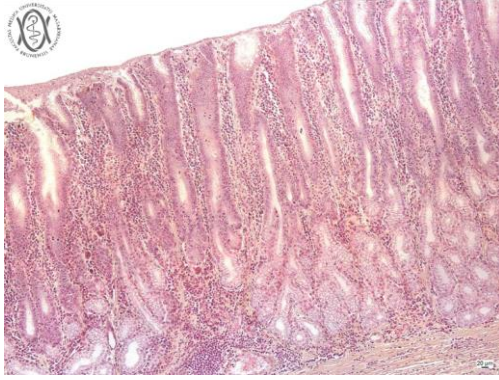
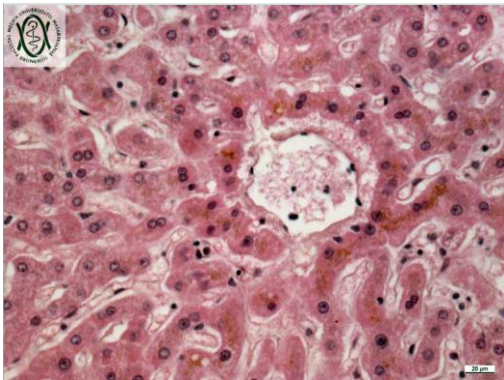
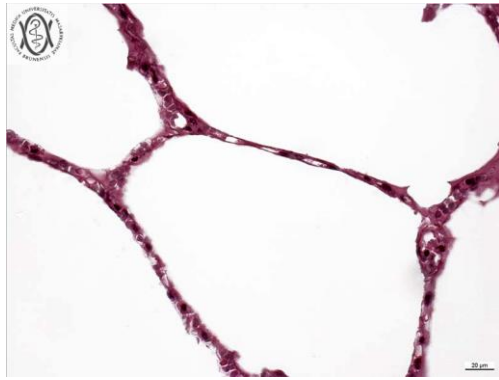
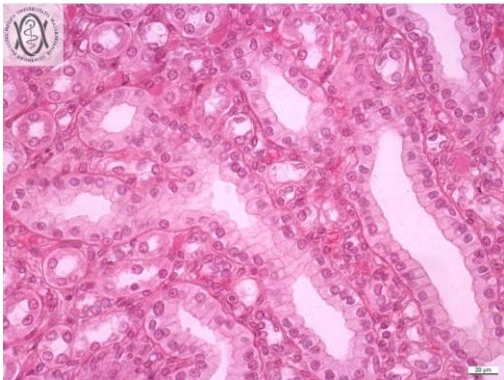
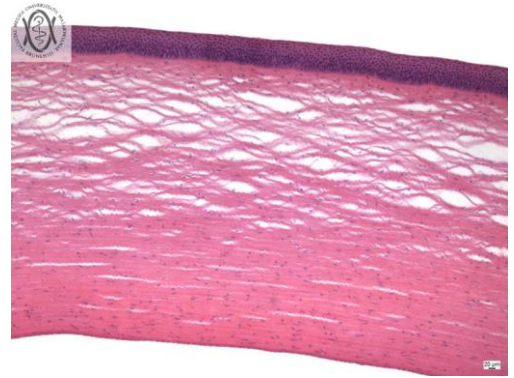
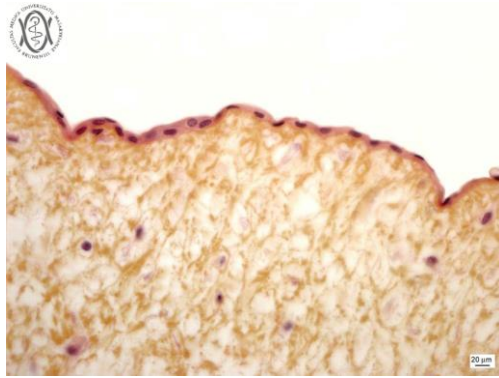
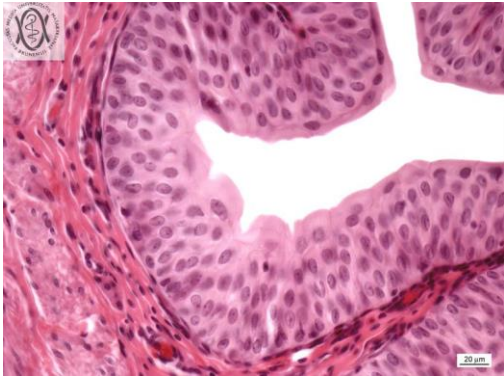
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■ General characteristics of epithelial tissue

- lessons from Sponges

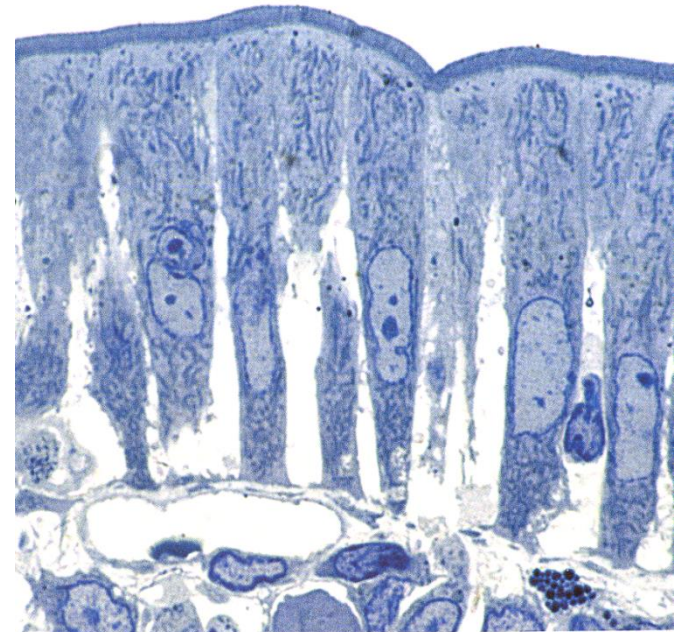
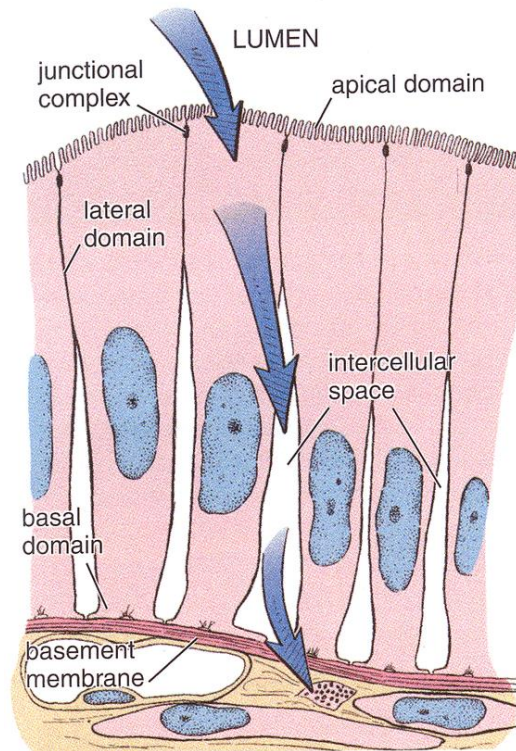
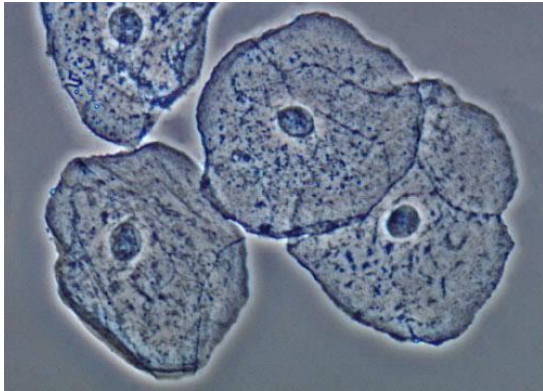
- Very early event and very novel innovation in Metazoa evolution
- From simple colonies of cells to highly specialized tissue structures
- Boundaries and interfaces
- Dividing of the body into separated compartments → separating individual milieu
- Lining of cavities or interfaces of open space
- Attachment and adhesion
- Basal membrane





■ 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



■ Classification of epithelial tissues

■ Morphology

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

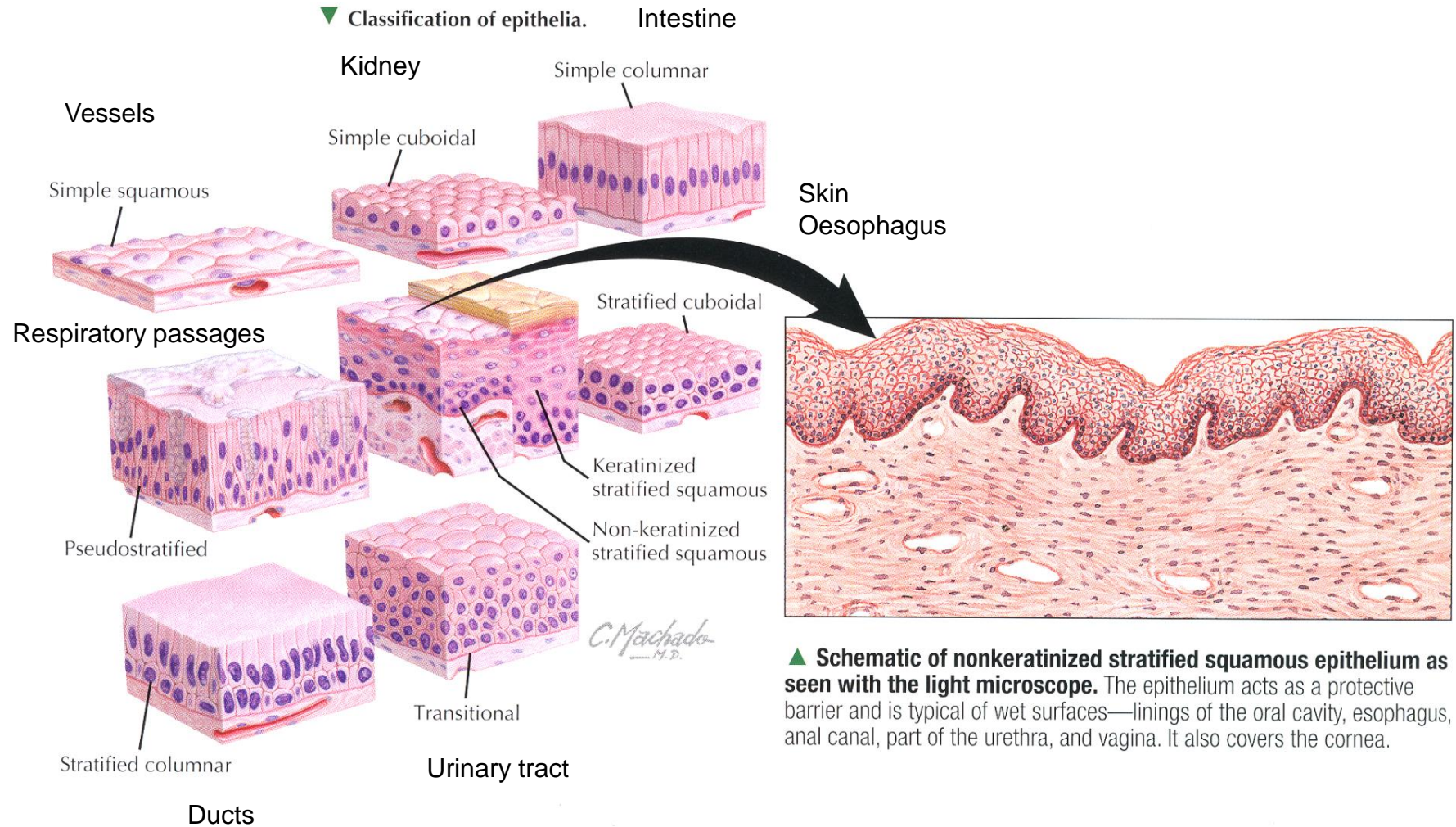
■ Function

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

Classification of epithelial tissues

1. Covering (sheet) epithelia

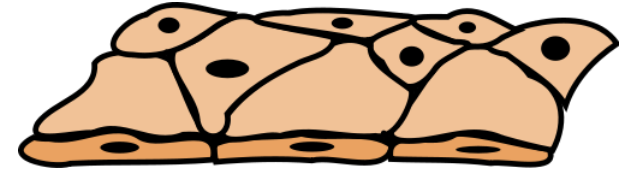
▼ Classification of epithelia.



▪ Simple squamous epithelium

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

} Selective permeability

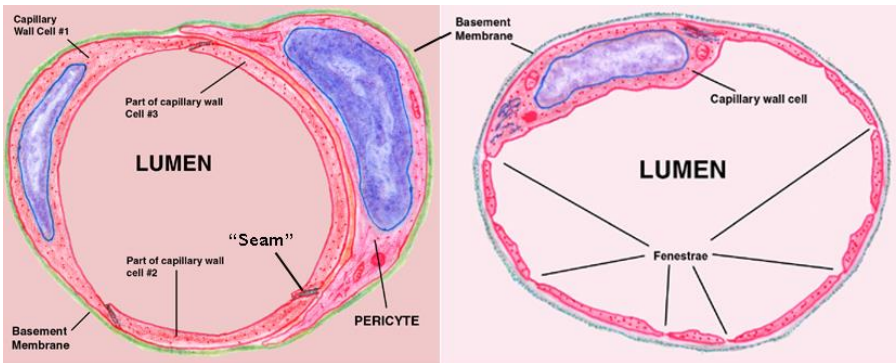
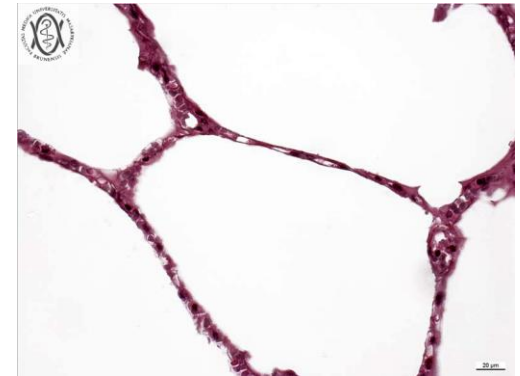


Endothelium.

heart, blood, and lymphatic vessels.

Mesothelium.

serous membranes - body cavities

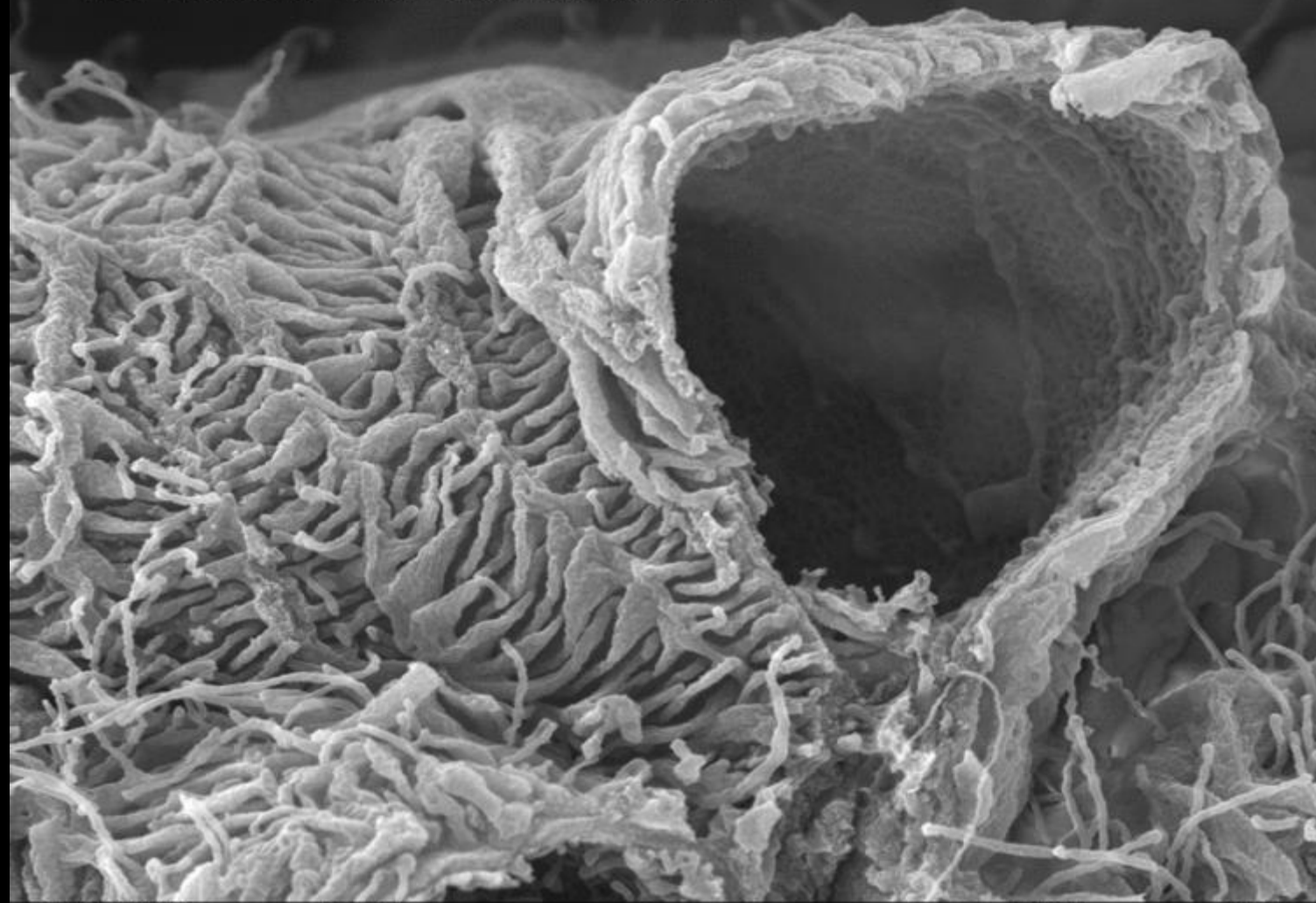


Closed or Continuous Capillary

Fenestrated Capillary



Kapillare des Glomerulums



x10000

2 μ m

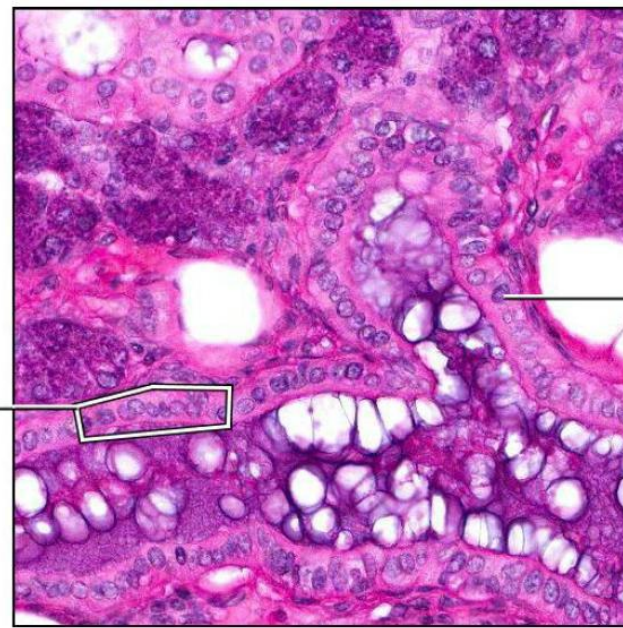
5kV

4mm

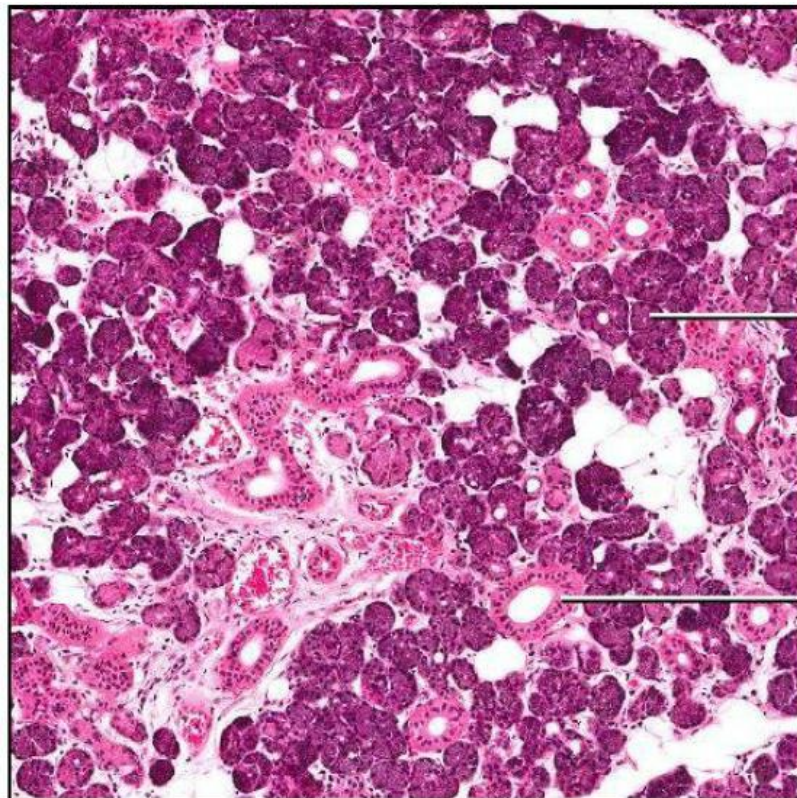
▪ Simple cuboidal epithelia

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

Simple cuboidal epithelium



Nucleus of cuboidal epithelium cell



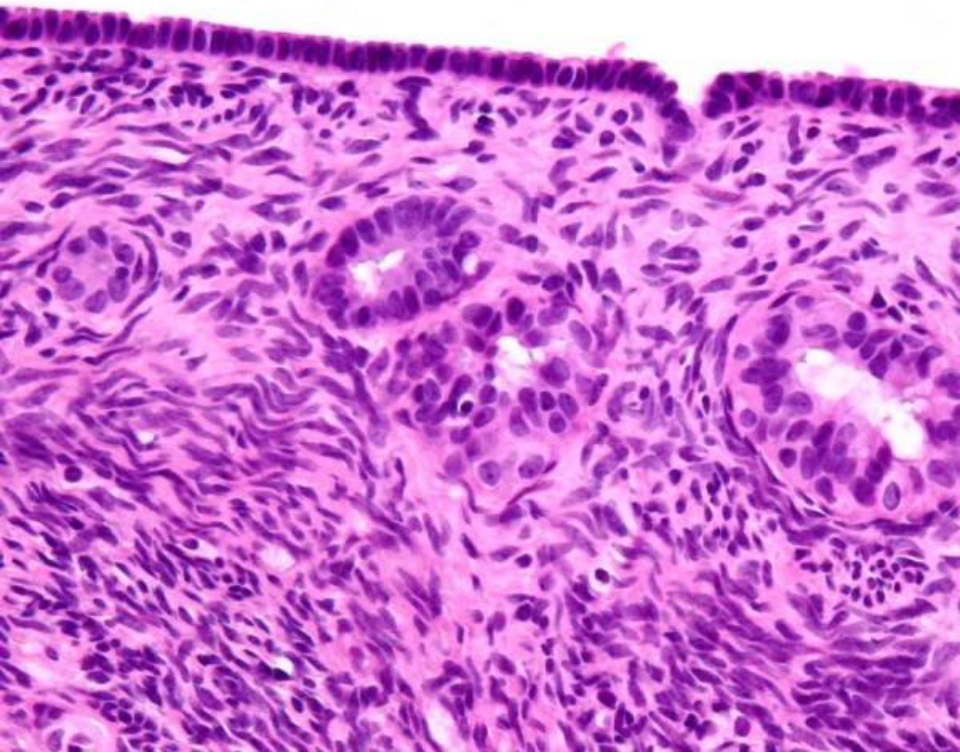
Serous acini

Simple cuboidal epithelium of intralobular duct

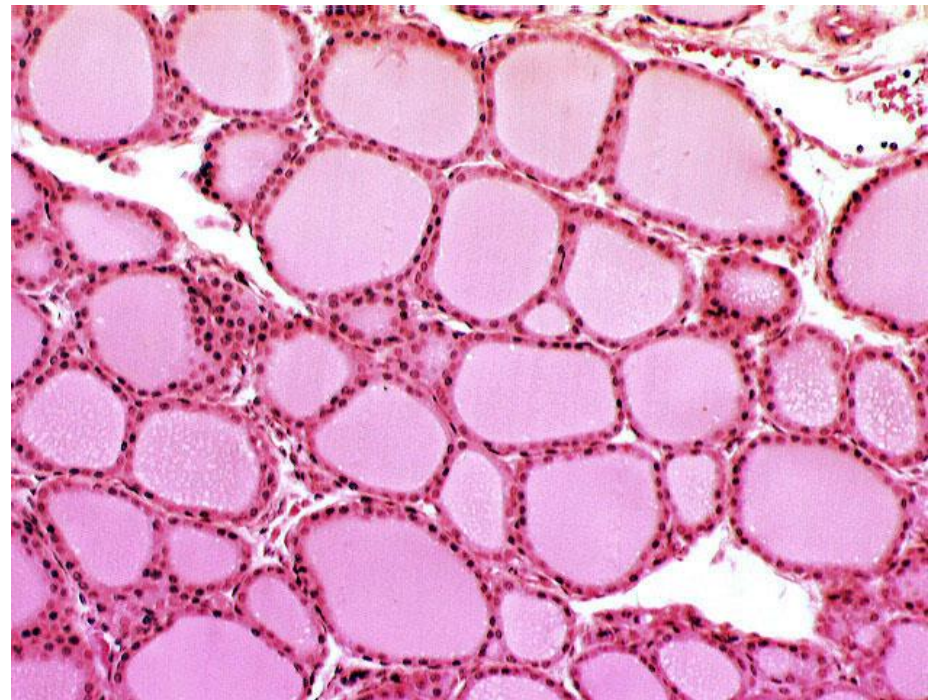
Examples:

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

Ovarian surface epithelium

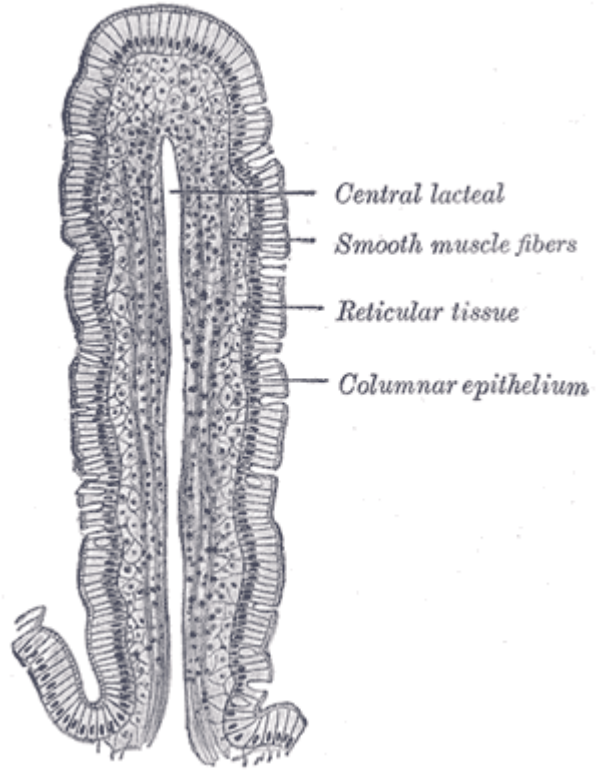
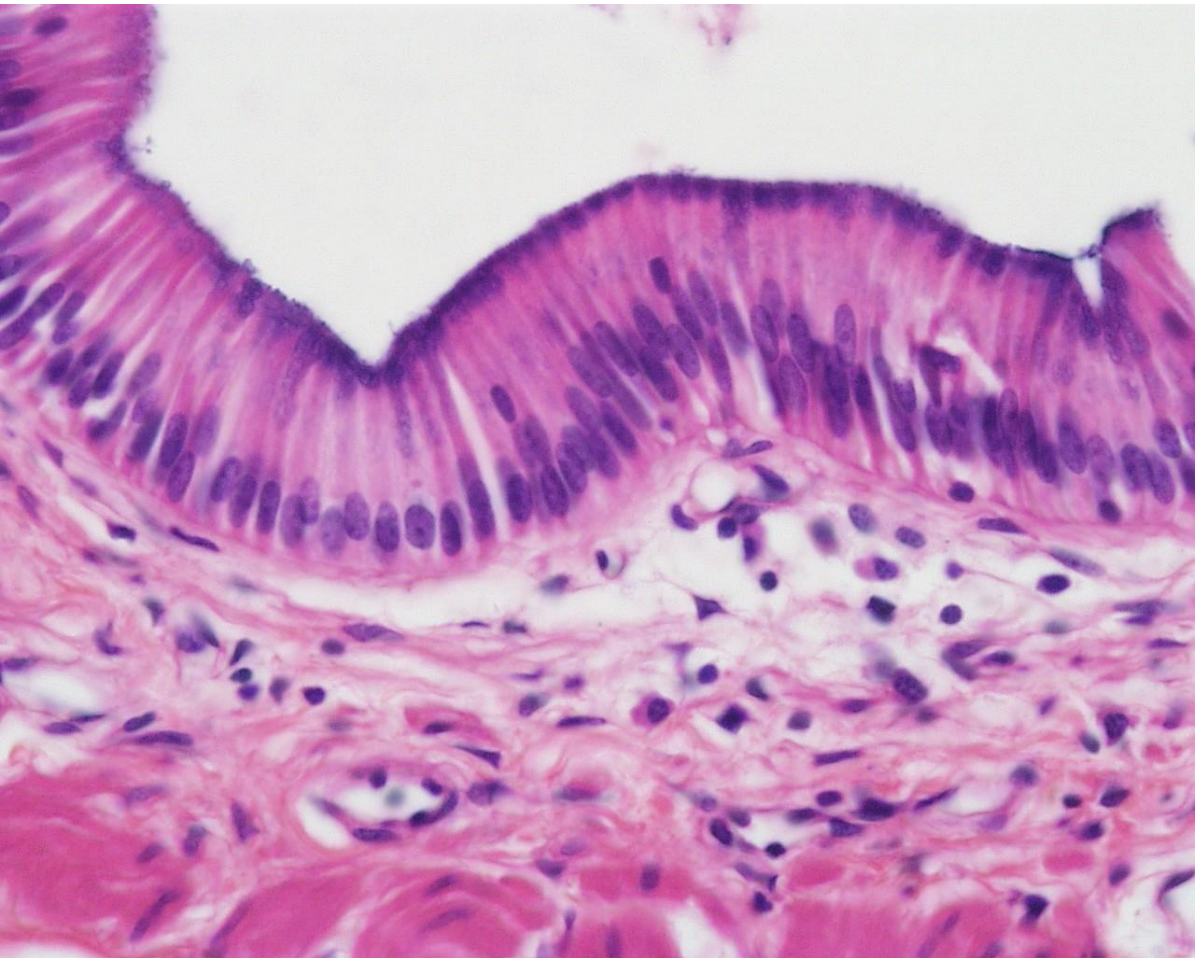


Thyroid follicles



Simple columnar epithelium

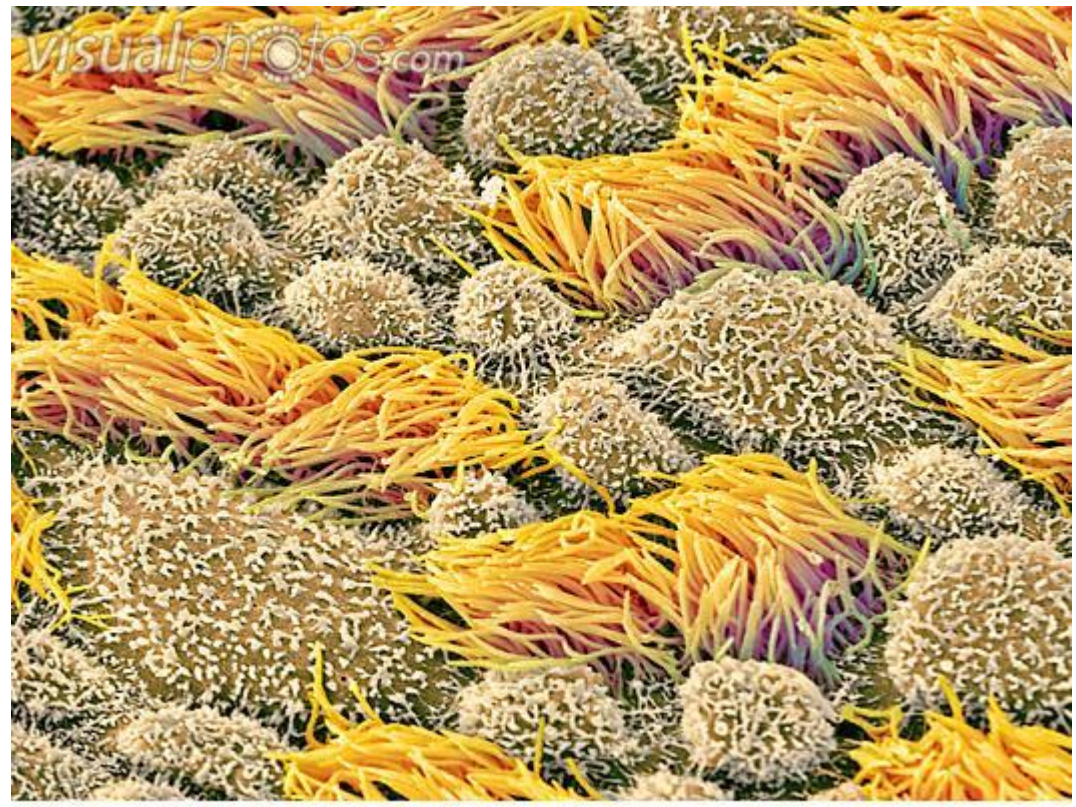
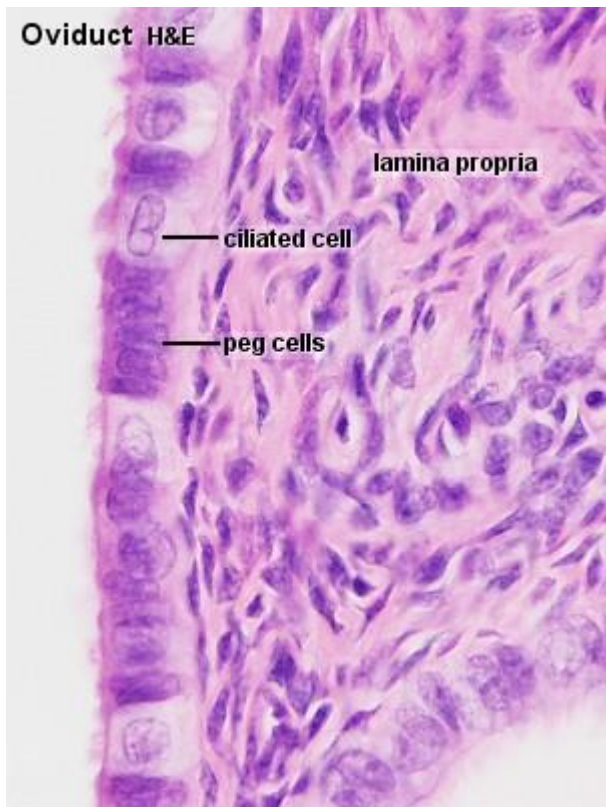
- Single layer of columnar cells with large, oval, basally located nucleus
- GIT
 - stomach
 - small intestine
 - large intestine



Resorption / Secretion

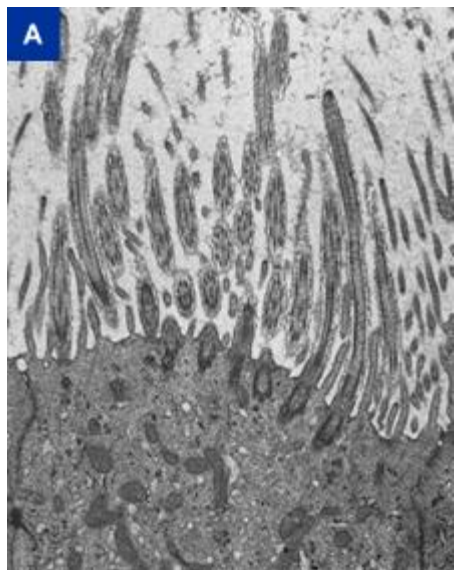
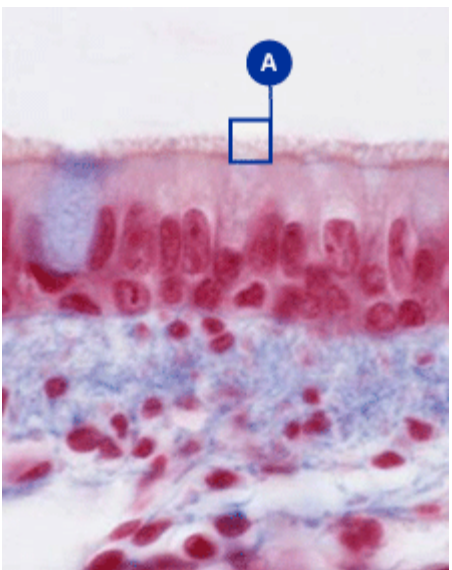
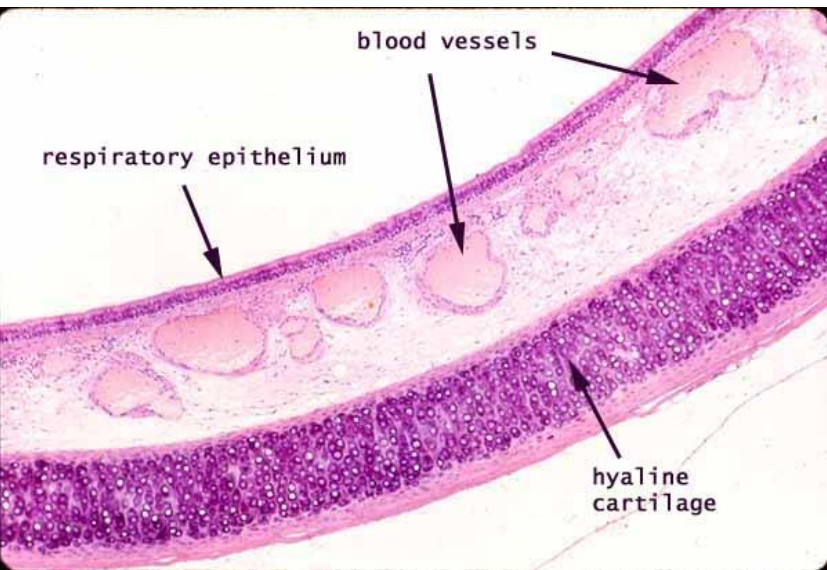
▪ **Simple columnar epithelium with kinocilia**

- Uterine tube
- flow of the oocyte towards the uterus



▪ **Simple columnar epithelium with kinocilia (also pseudostratified)**

- Upper respiratory passages
- Removes mucus produced by epithelial glands

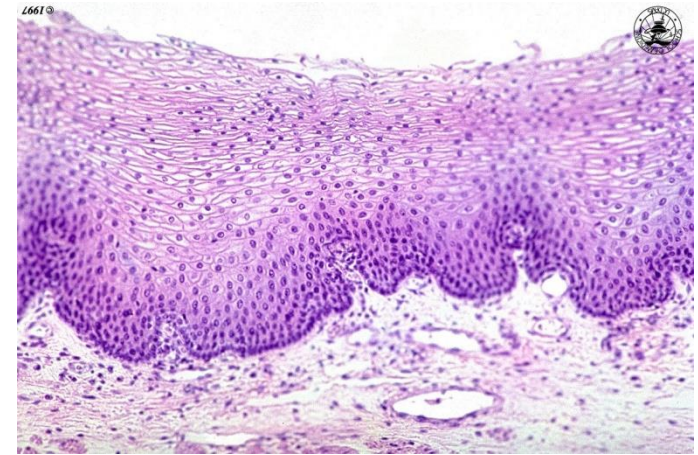
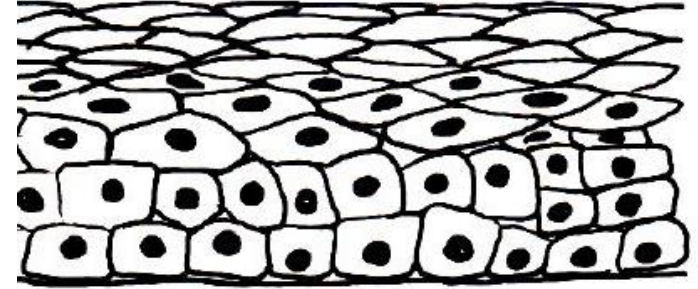


Other locations:

- 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



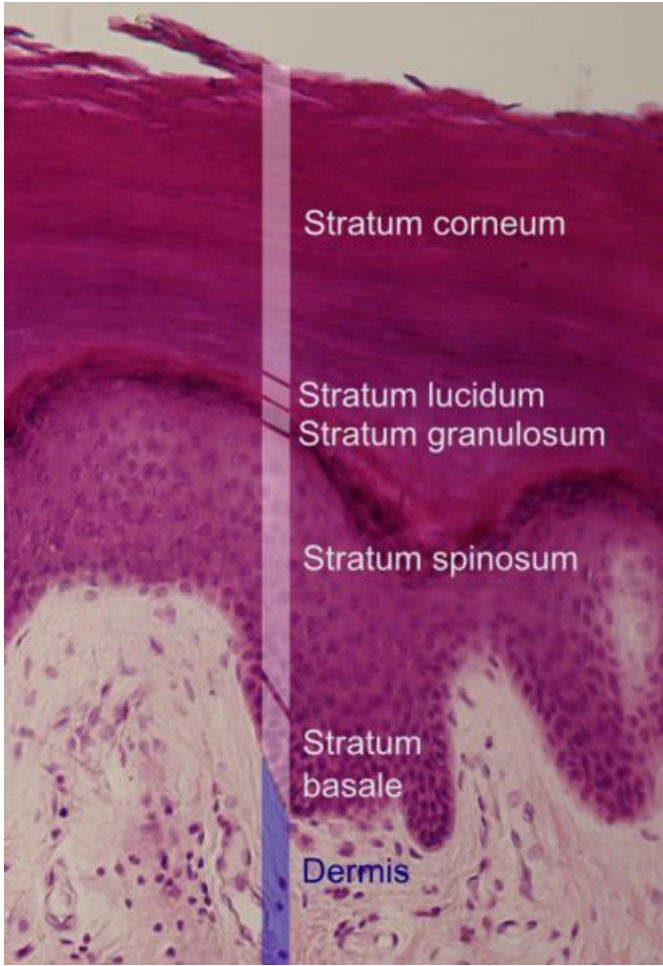
Keratinized vs. non-keratinized

Examples:

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

Stratified squamous epithelium

Keratinized

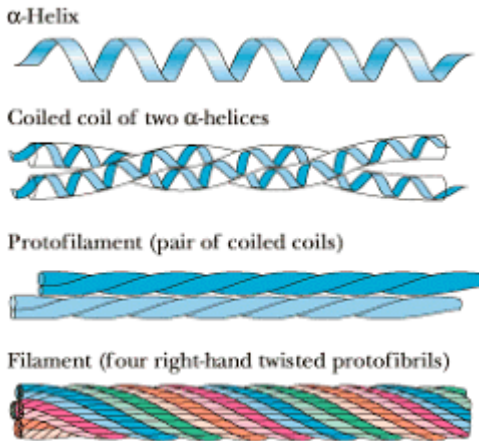
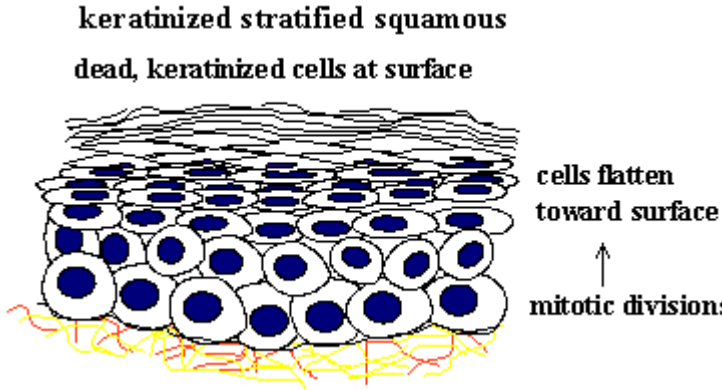


Skin (epidermis)
Nail

Keratins
Fibrous proteins, ~ 40 types
Very stable, multimeric

Disorders of keratin expression
– variety of clinical symptoms

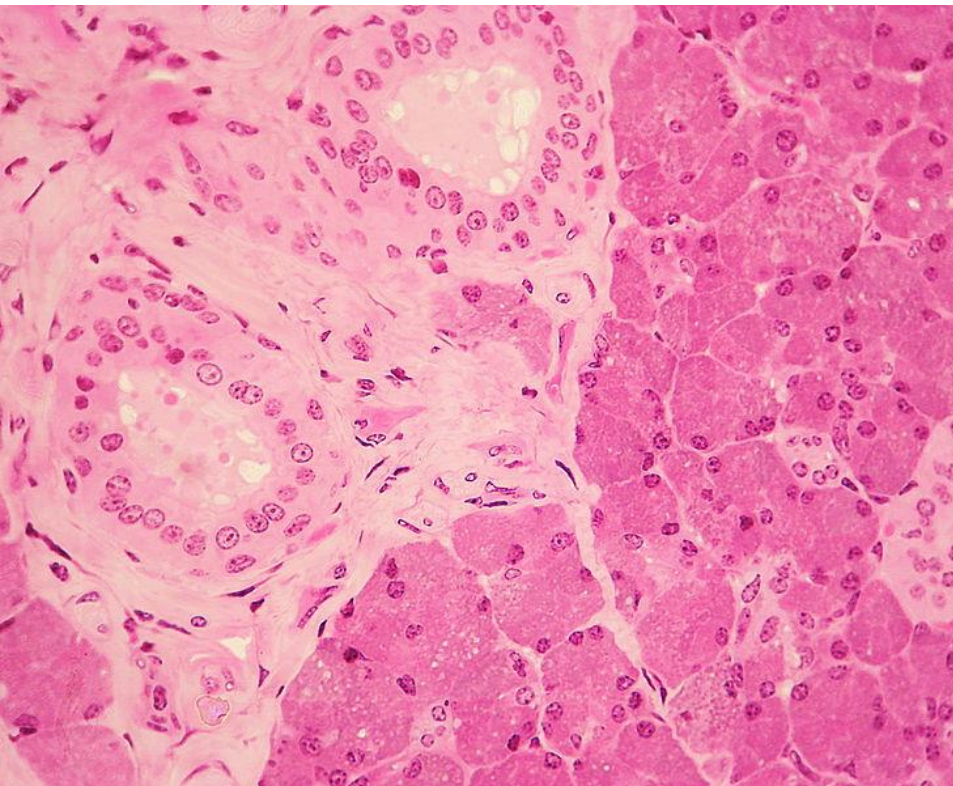
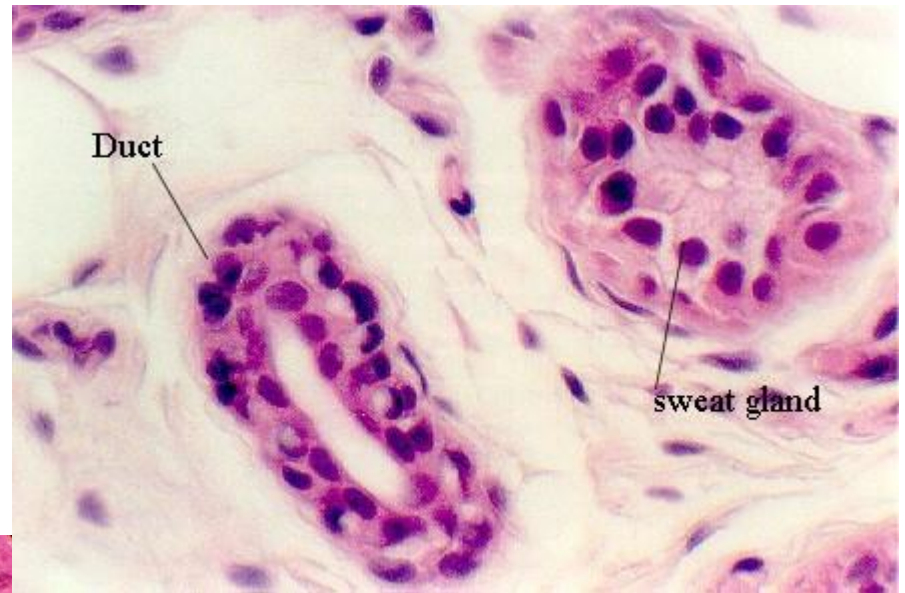
e.g. Epidermolysis bullosa simplex



▪ Stratified cuboidal epithelium

Large ducts of :

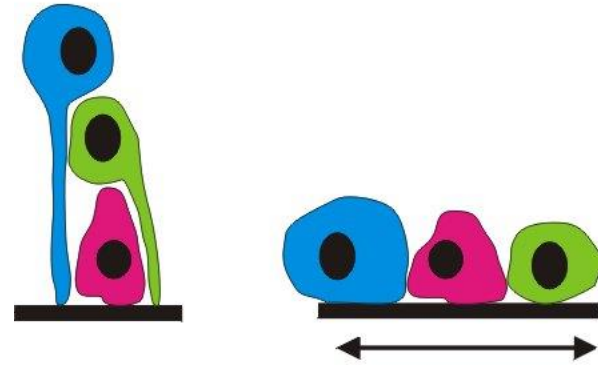
- sweat glands
- mammary glands
- salivary glands



▪ Transitional epithelium (urothelium)

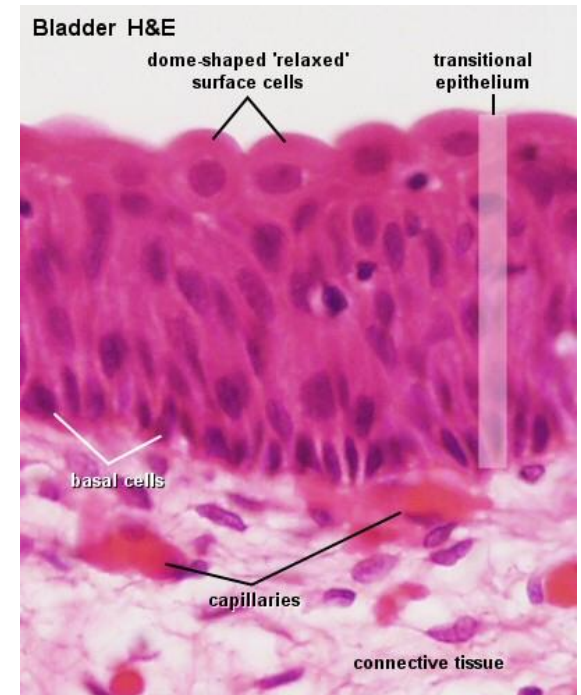
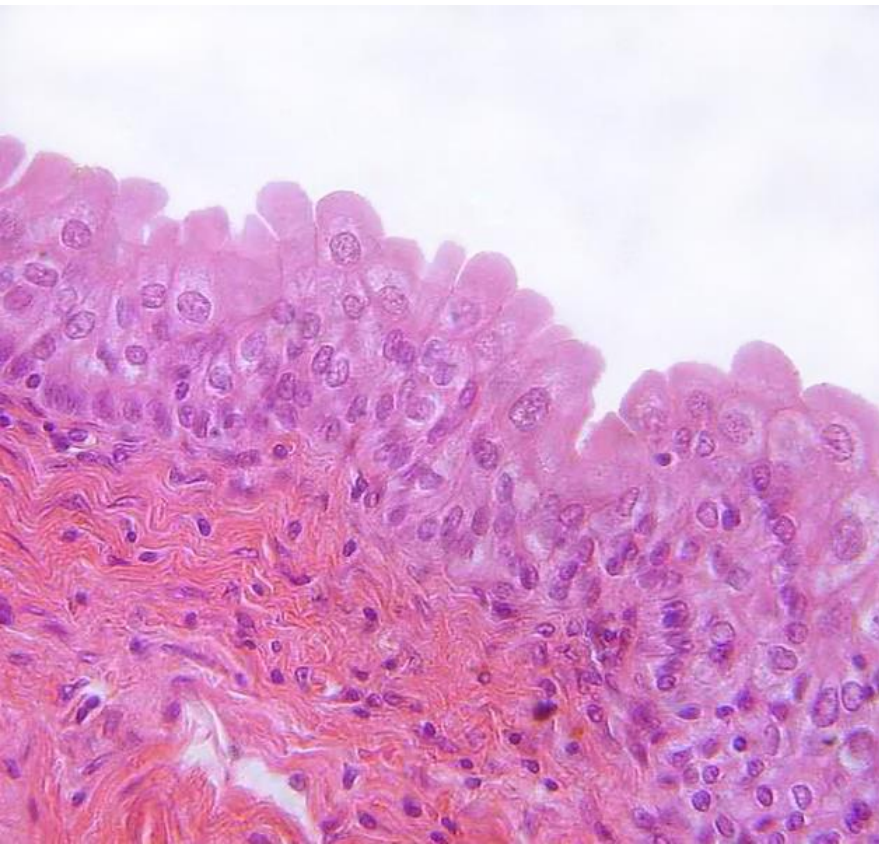
- Fluctuation of volume
 - organization of epithelial layers
 - membrane reserve
- Protection against urine

- Urinary bladder, kidneys, ureters



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

Basal cells
Intermediate layer
Surface cells



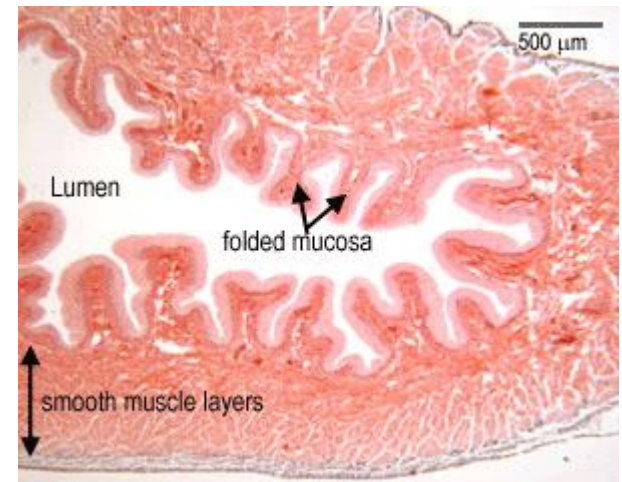
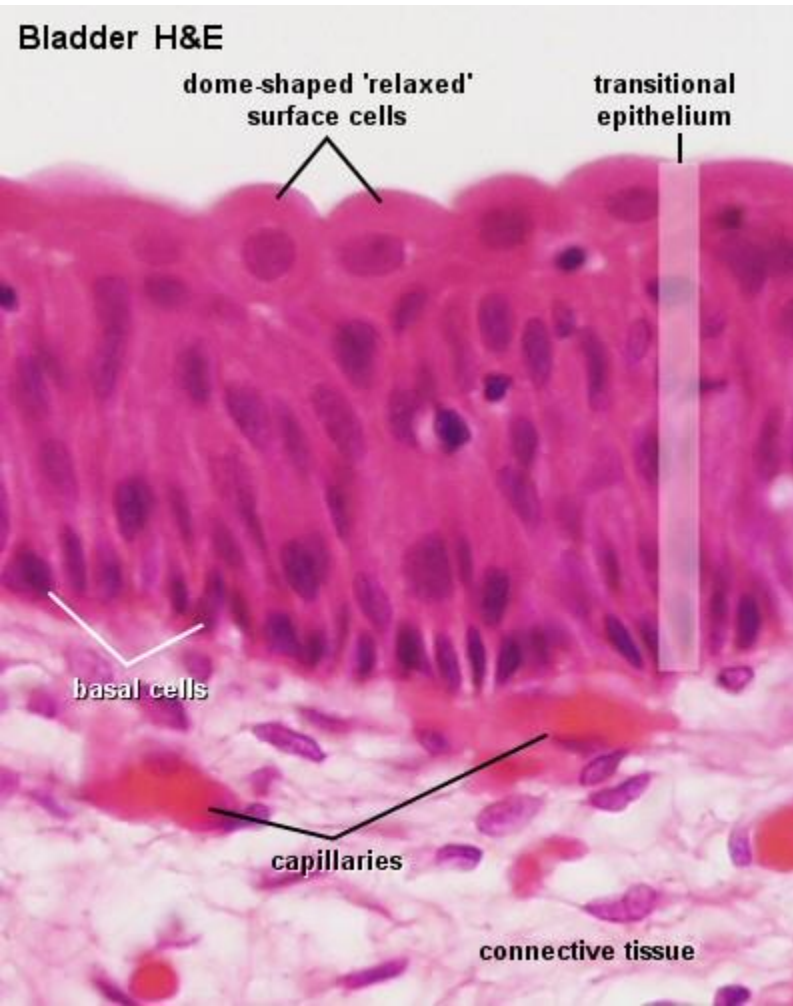
▪ Transitional epithelium (urothelium)

glycosaminoglycan layer (GAG) on the surface

- osmotic barrier
- antimicrobial properties

Barrier architecture:

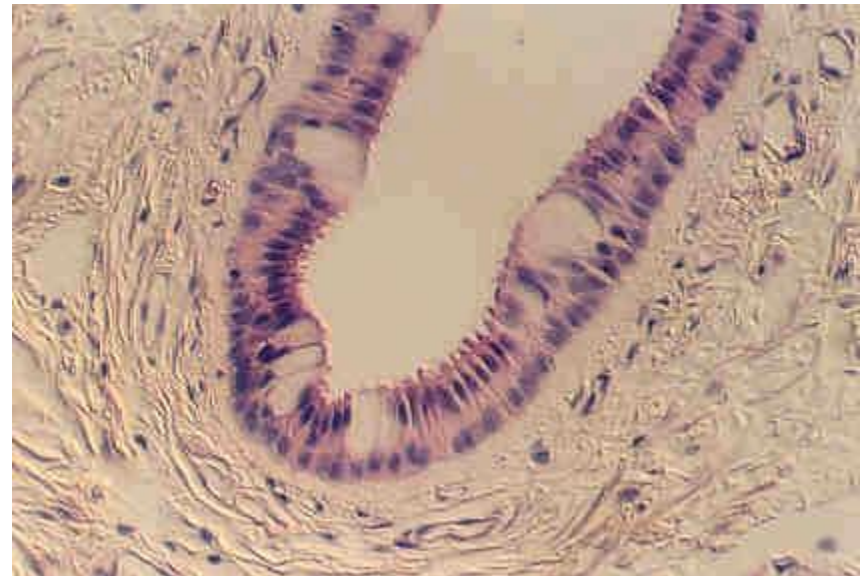
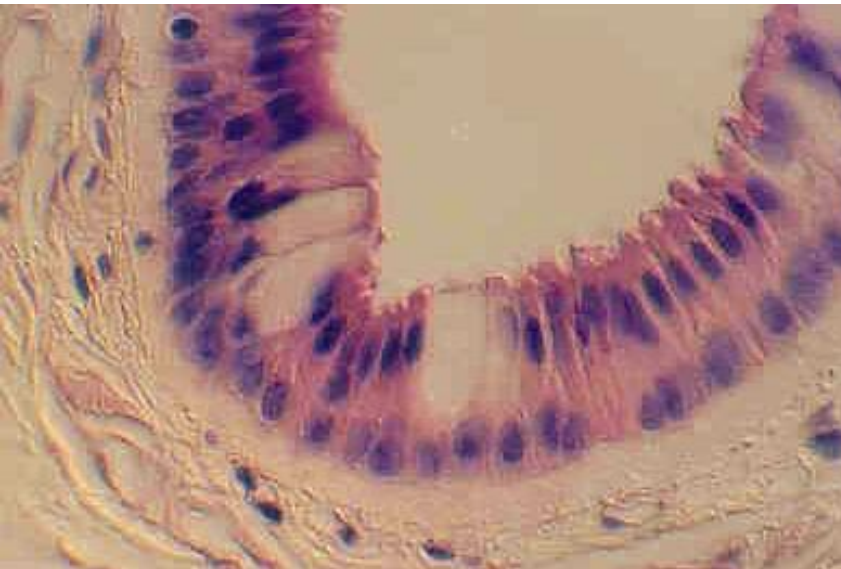
- GAG-layer
- surface cells (tight junctions), uroplakin proteins in the apical cell membrane
- capillary plexus in the submucosa



▪ Stratified columnar epithelia

- several layers of columnar cells
- secretion / protection

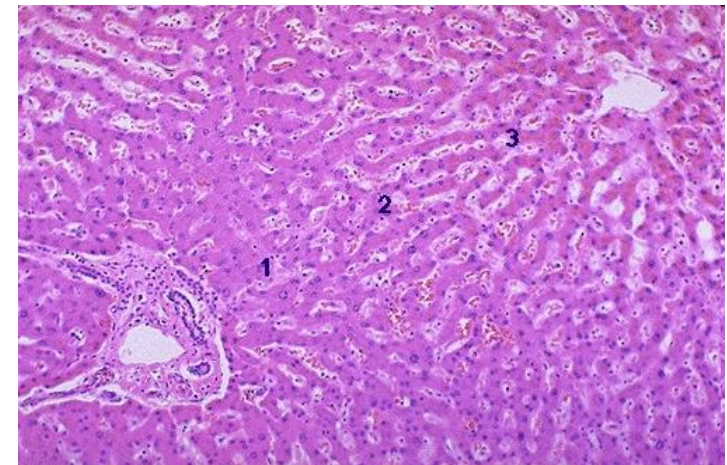
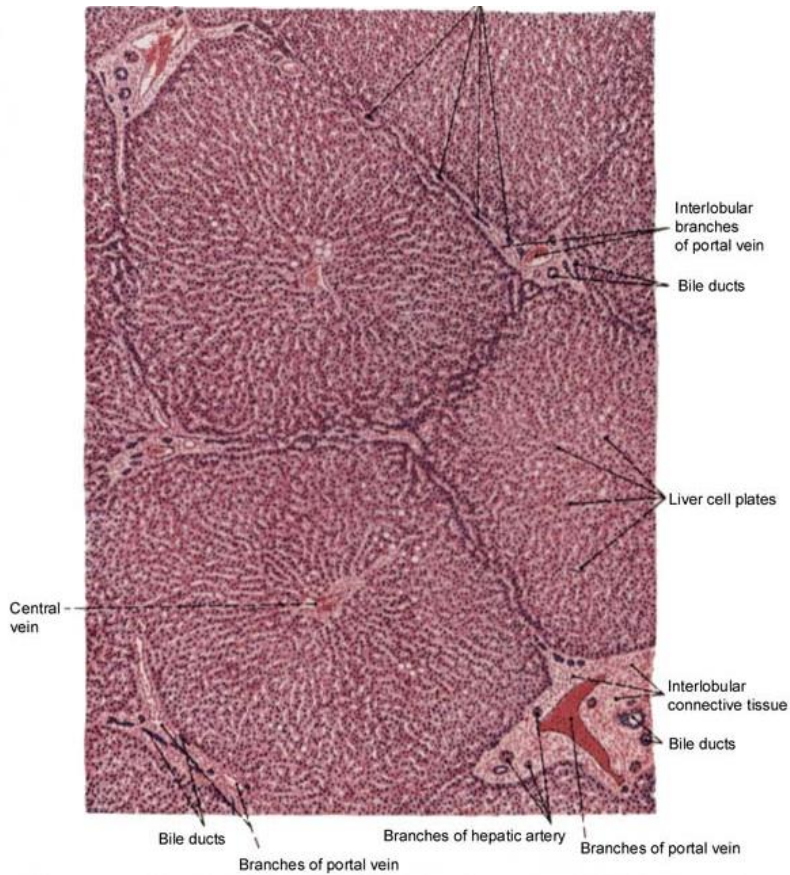
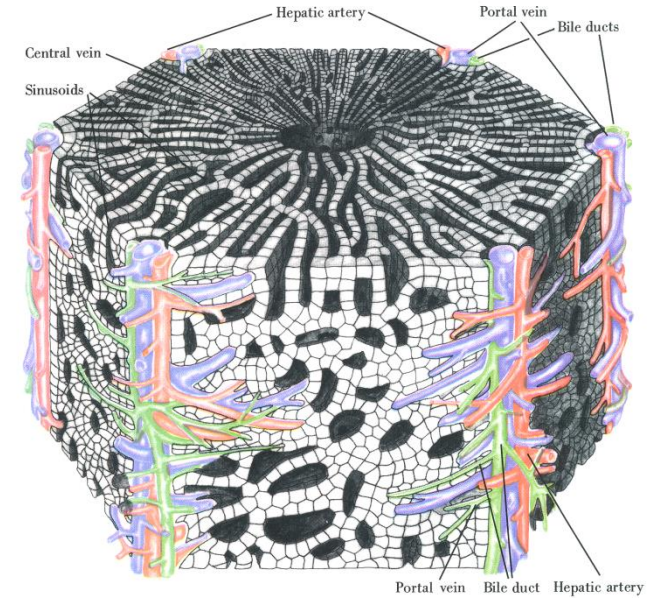
- ocular conjunctiva
- pharynx, anus – transitions
- uterus, male urethra, vas deferens
- intralobular ducts of salivary glands



■ Classification of epithelial tissues

2. Trabecular epithelium

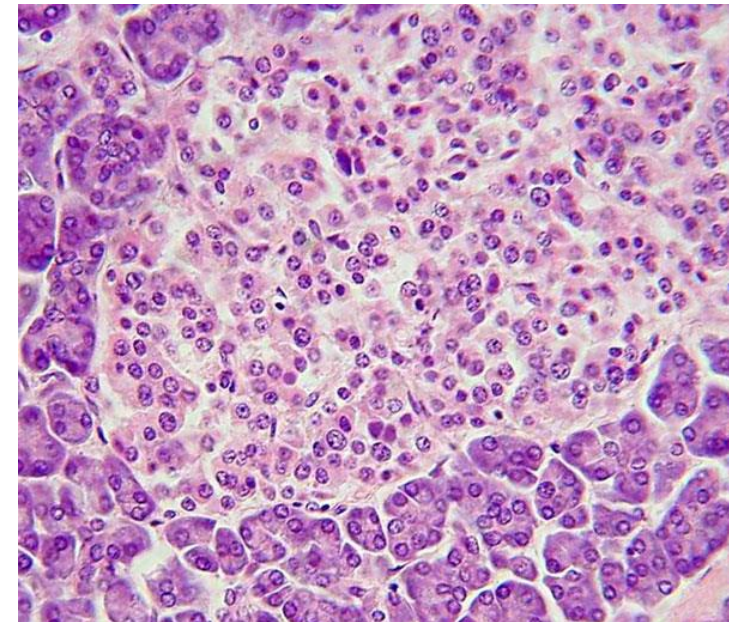
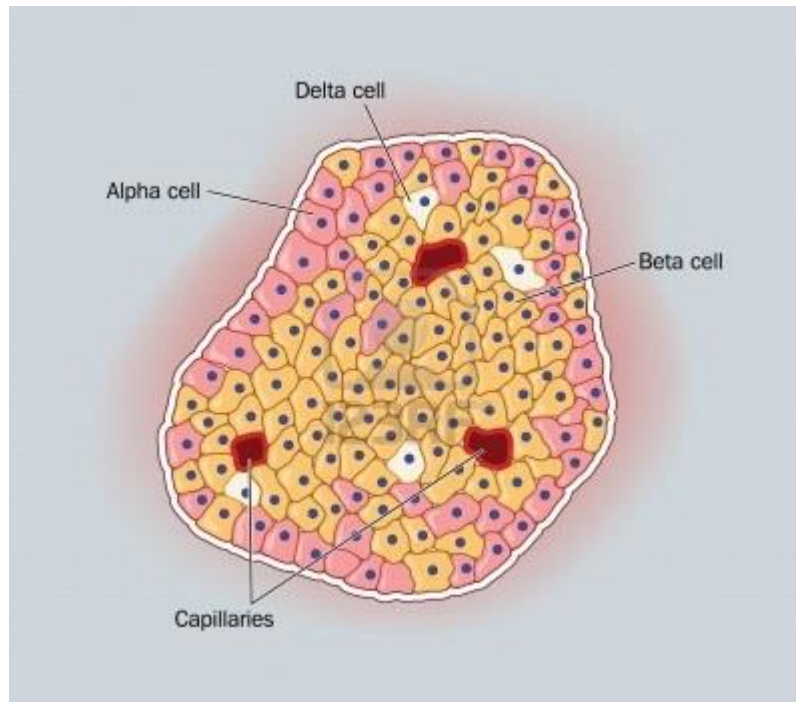
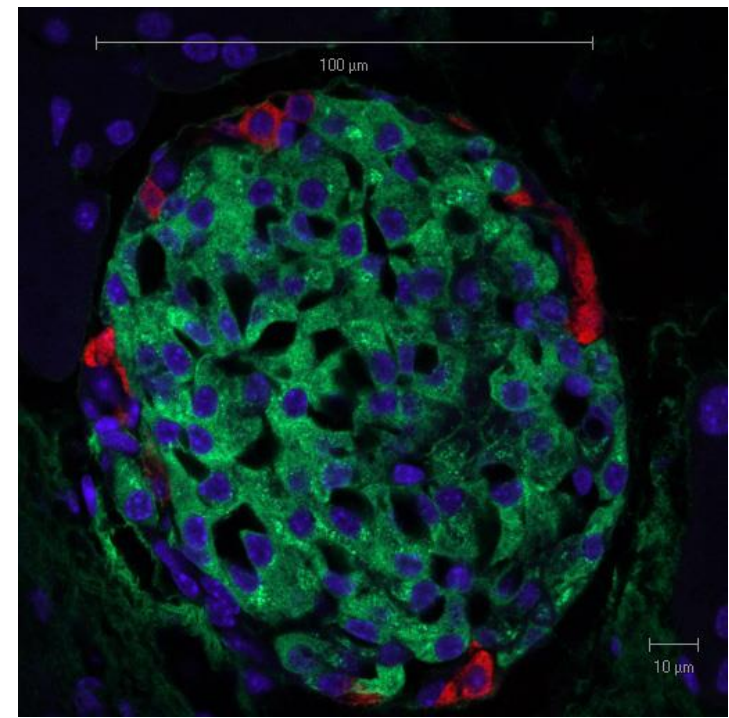
Liver – trabecules (cords) of hepatocytes



- **Endocrine glands**

Islets of Langerhans

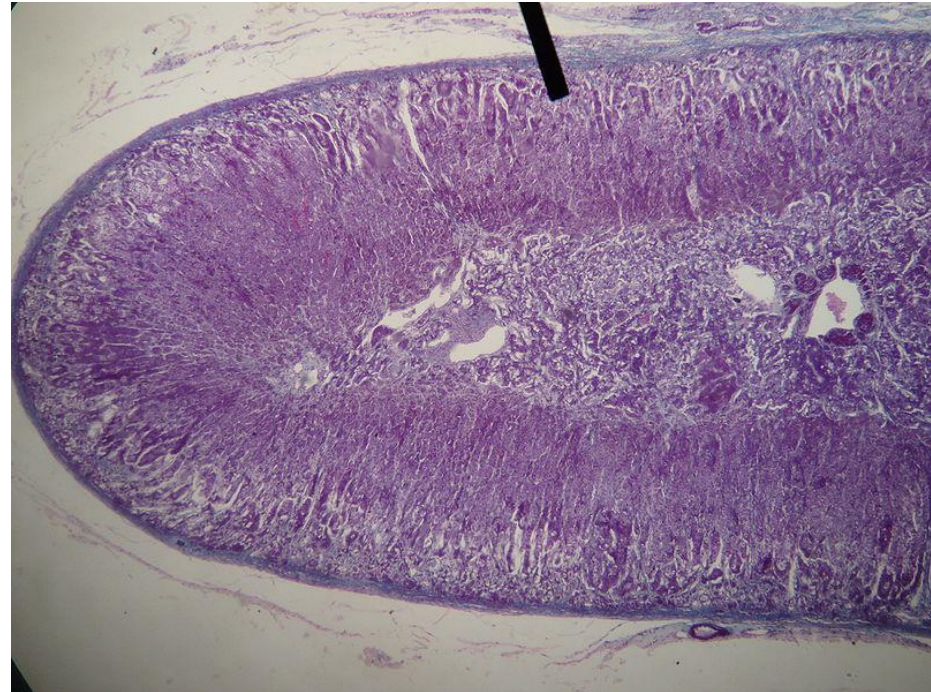
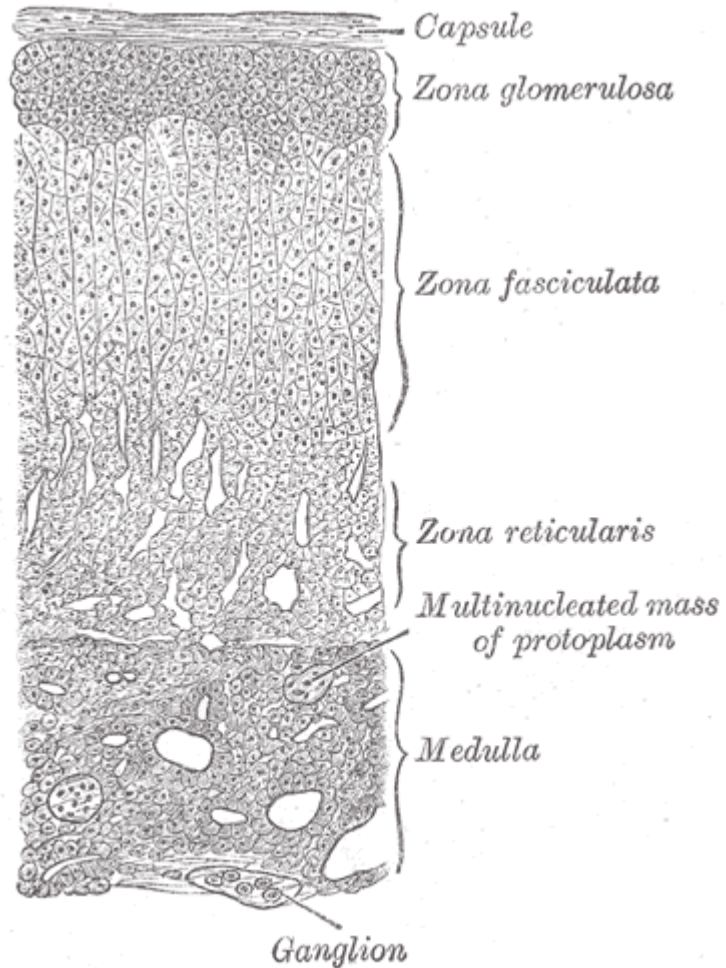
Cords of endocrine active cells



- **Endocrine glands**

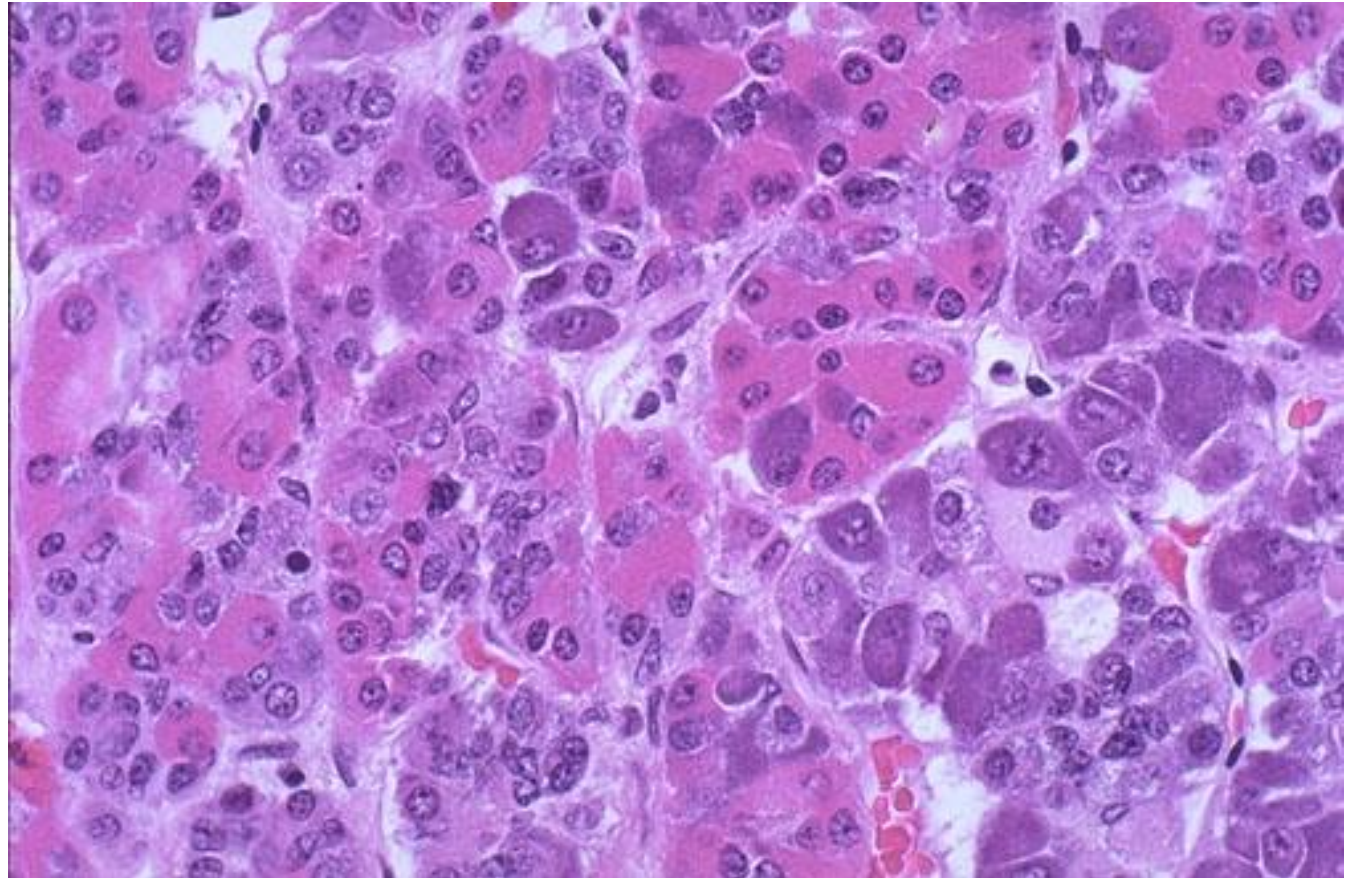
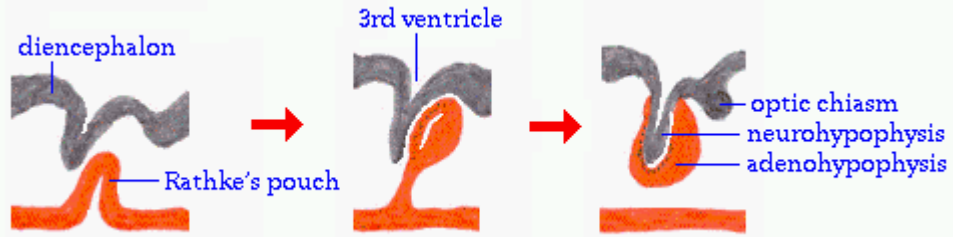
Adrenal cortex

Cortex of adrenal gland – epithelial cells in cords secreting corticoid



- Endocrine glands

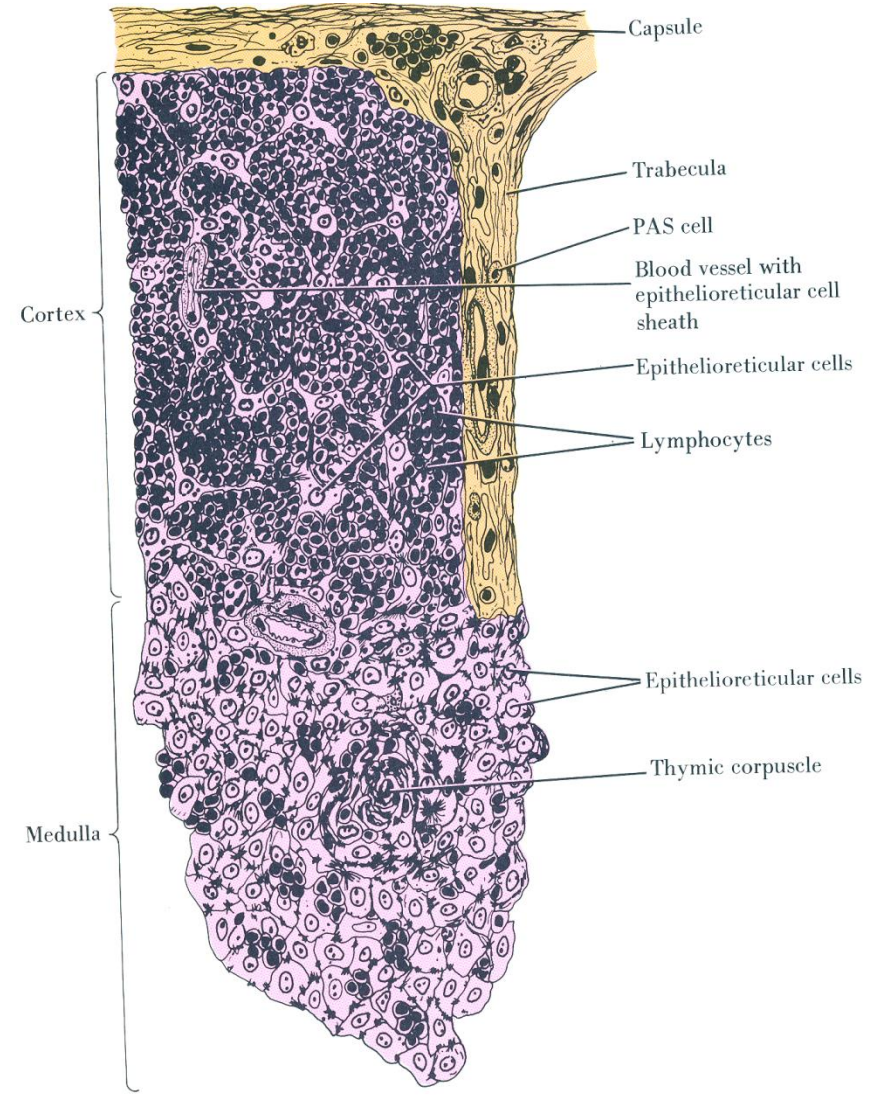
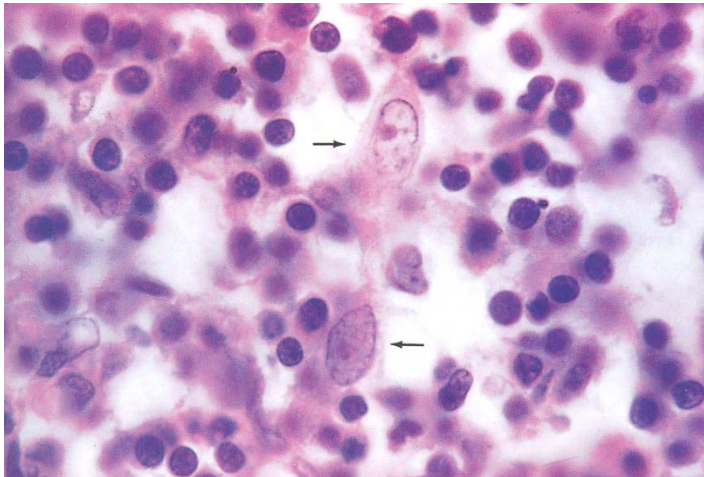
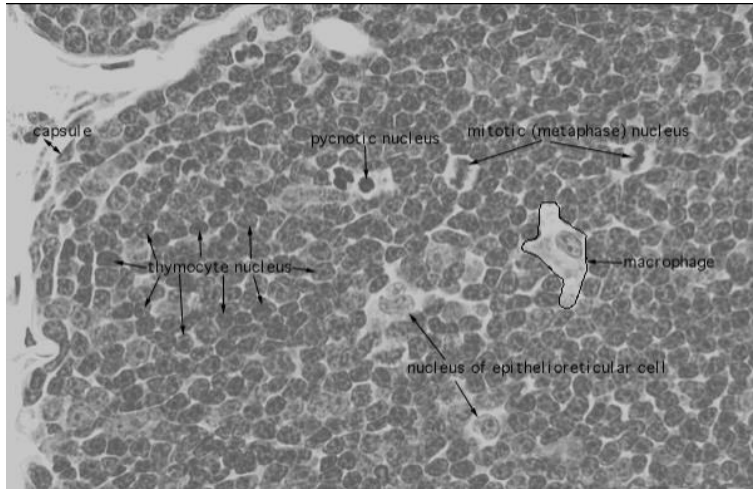
Adenohypophysis – anterior pituitary



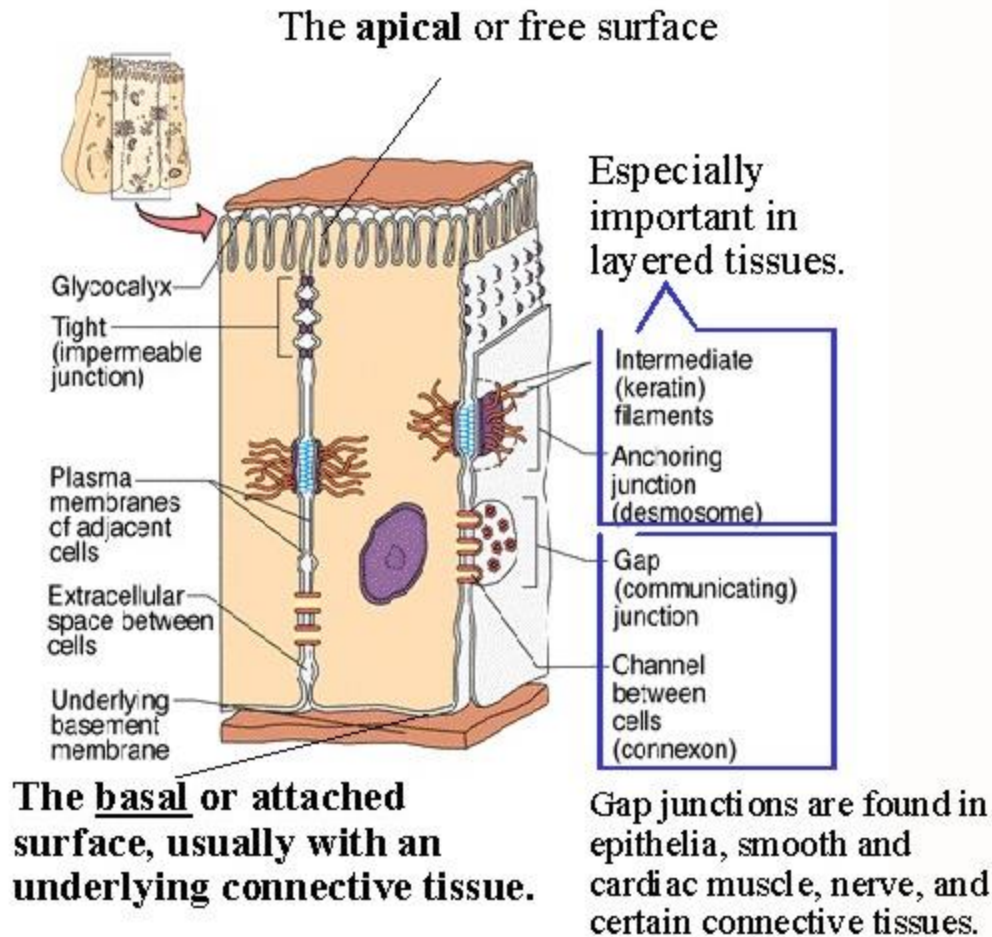
Classification of epithelial tissues

3. Reticular epithelium

Thymus

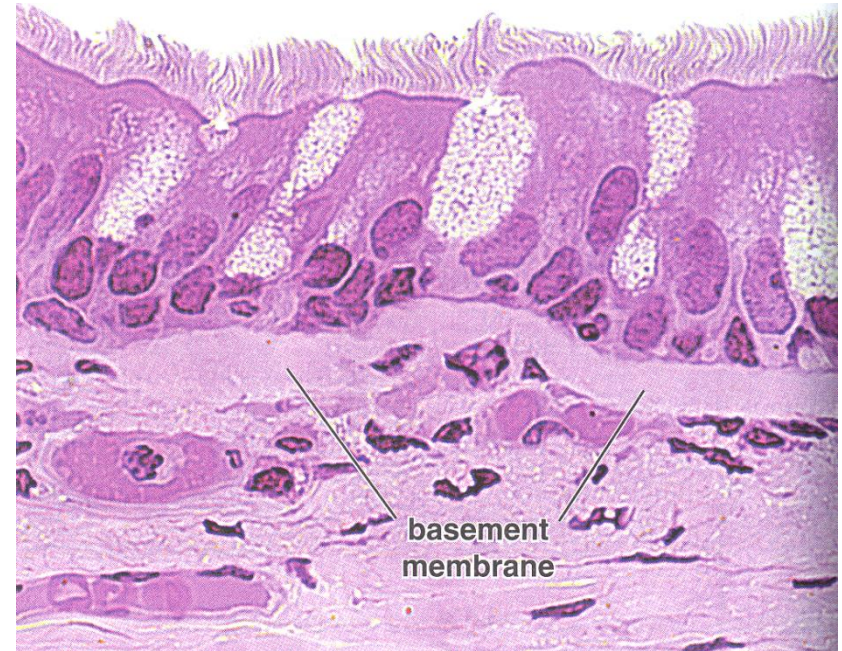
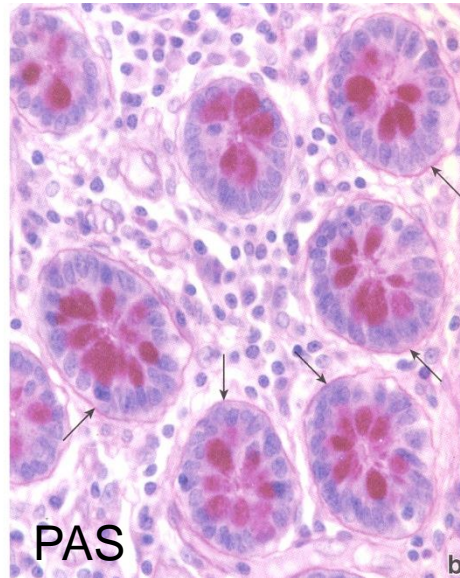
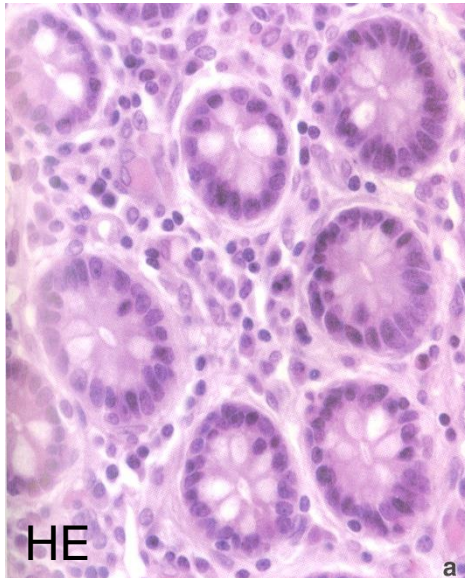
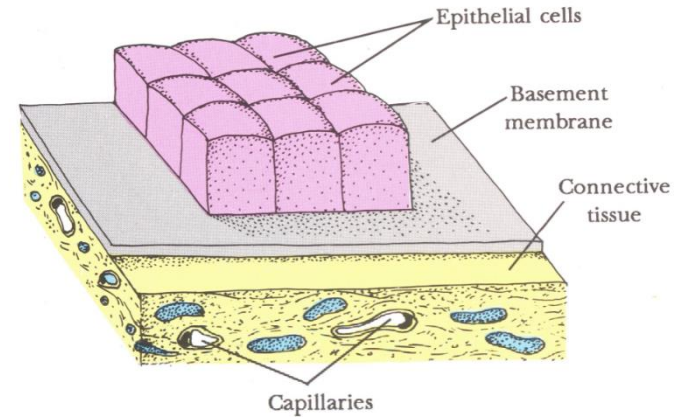


■ Hallmarks of epithelial cell

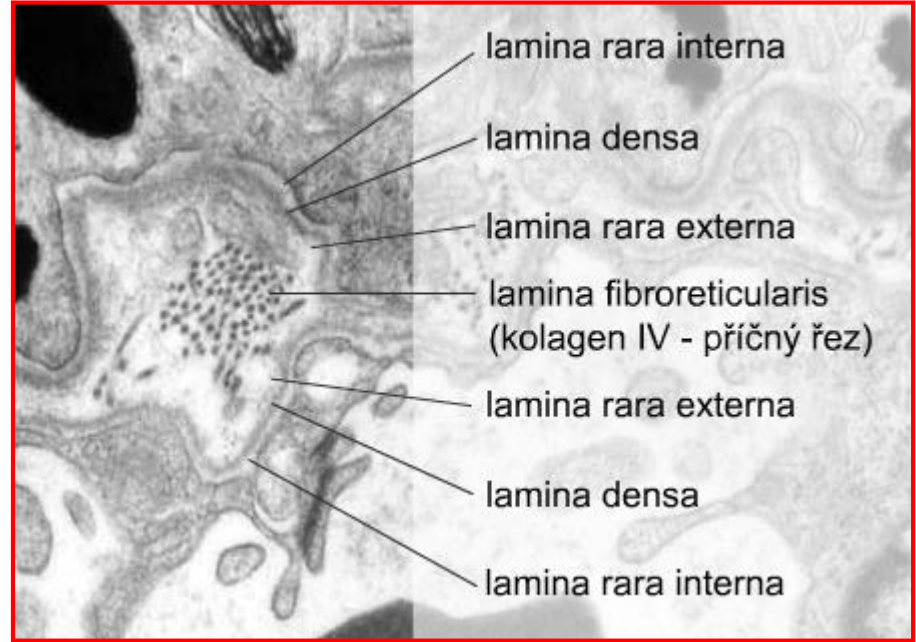
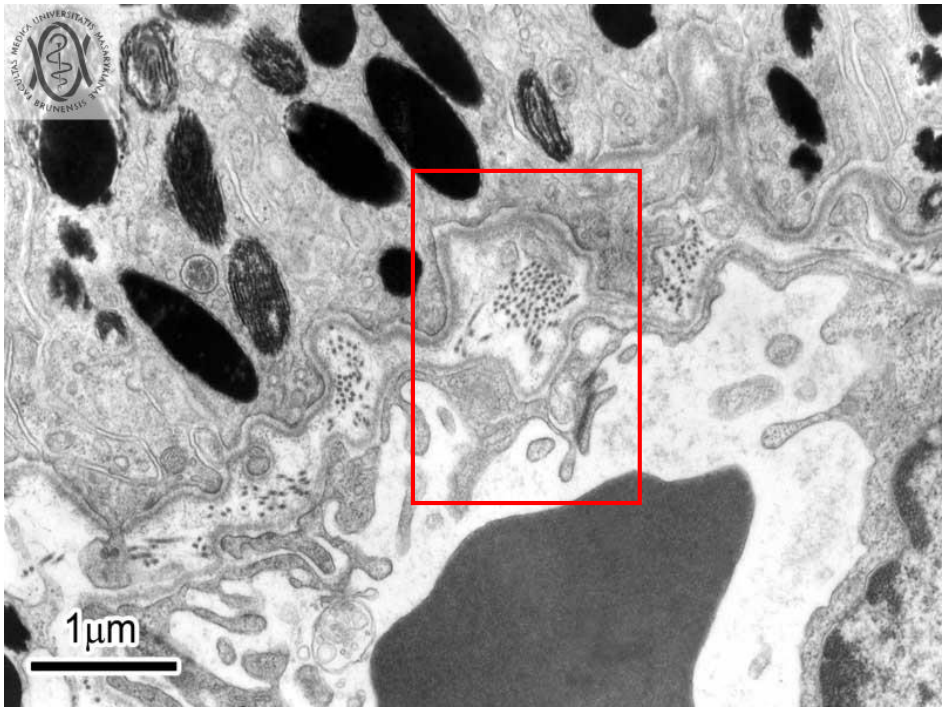


Basement membrane

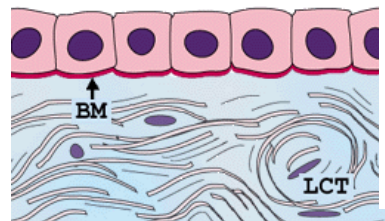
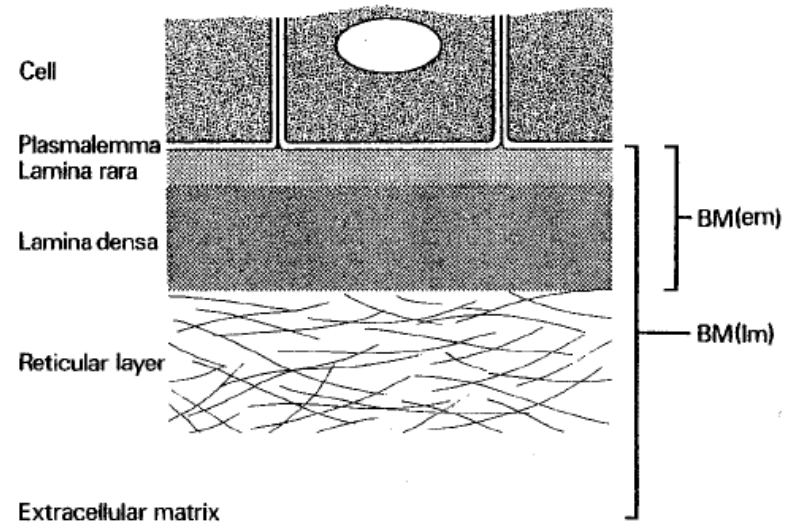
- Attachment of epithelium to underlying tissues
- Selective filter barrier between epithelial and connective tissue
- Communication, differentiation



Basement membrane

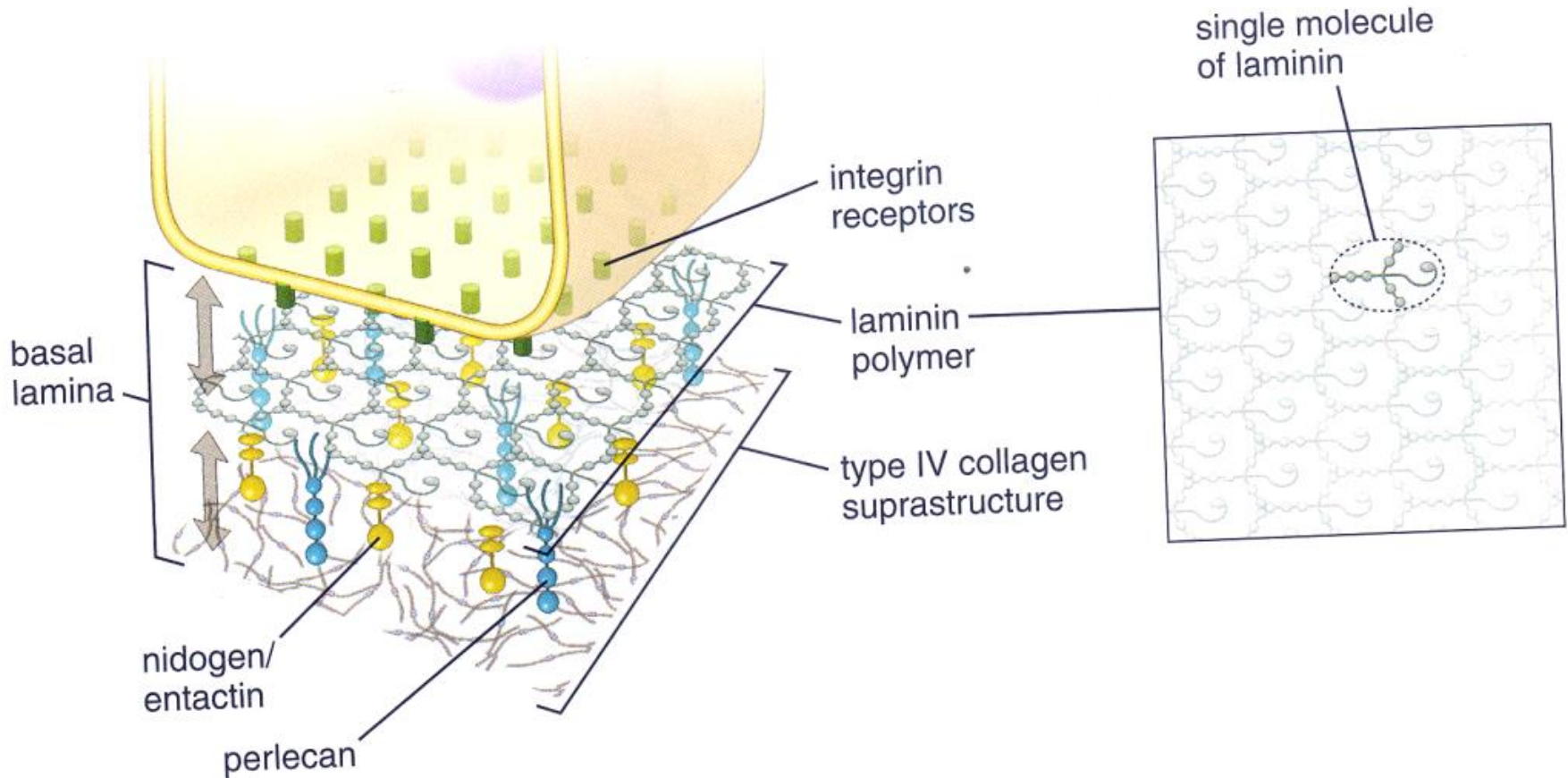


- Two basic layers
 - lamina basalis
 - lamina densa,
 - lamina rara ext. et int.
 - lamina fibroreticularis



Basement membrane

- Glycosaminoglycans – heparansulphate
- Laminin, collagen III, IV, VI



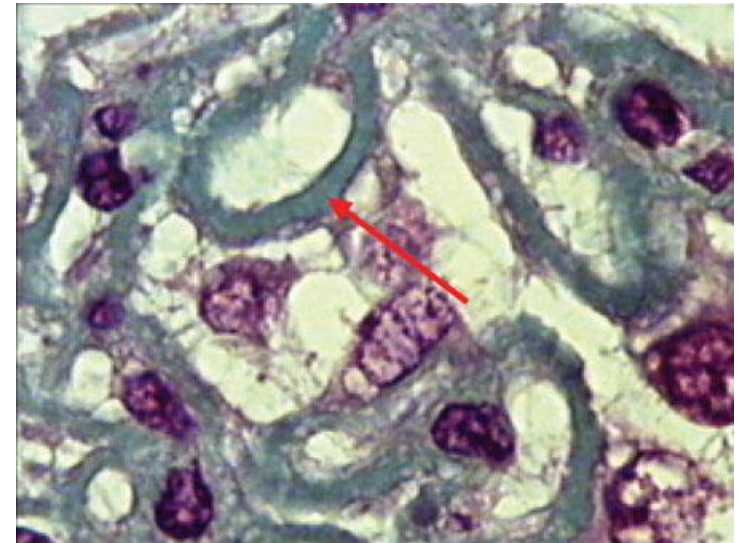
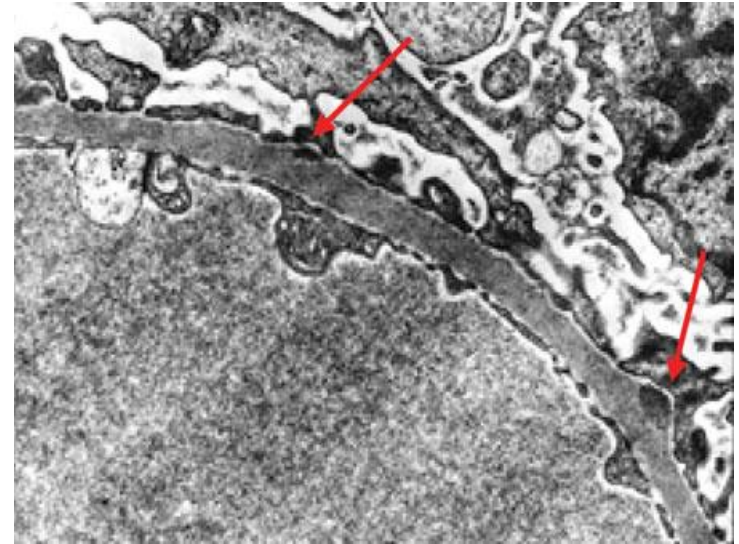
Basement membrane

Tissue specific distribution

- Descemet's membrane (under endothelial layer of cornea)
- Glomerular basement membrane (Bowman capsule)
- part of Bruch's membrane in retina
-

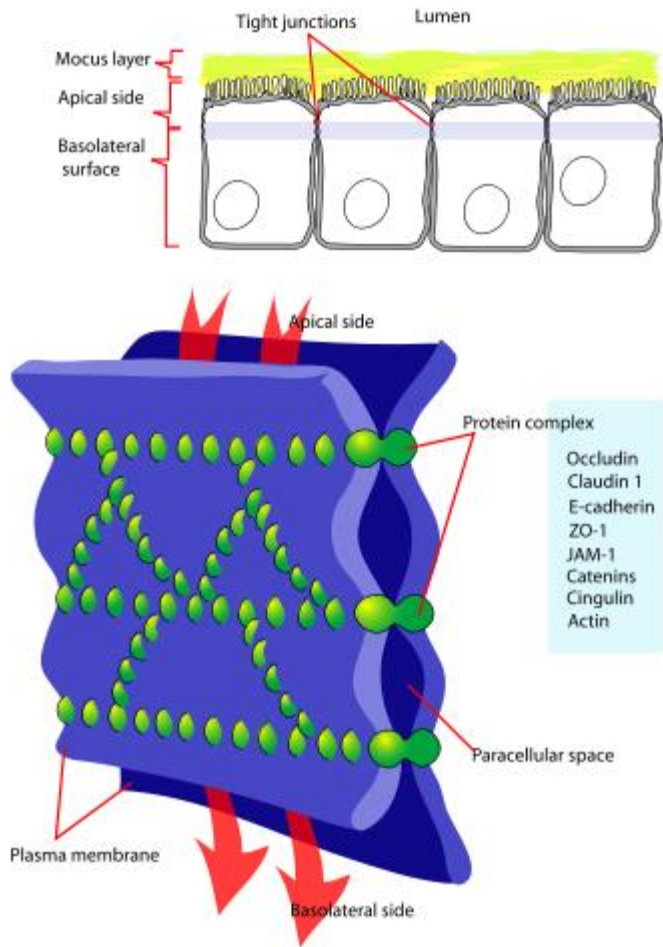
Pathology example- Membranous glomerulonephritis

- circulating antibodies bind to glomerular basement membrane
- complement (C5b-C9) complex forms and attacks glomerular epithelial cells
- filtration barrier is compromised
- proteinuria, edema, hematuria, renal failure



Modifications of cell membrane – cell junctions

Zonula occludens – a tight junction



An electron micrograph showing a cross-section of epithelial cells. A prominent feature is a row of occluding junctions, which appear as a dense, wavy band of material between the apical and lateral membranes of adjacent cells. The cells themselves are roughly polygonal and have a granular internal structure. The junctional complex is clearly visible as a distinct layer of electron-dense material.

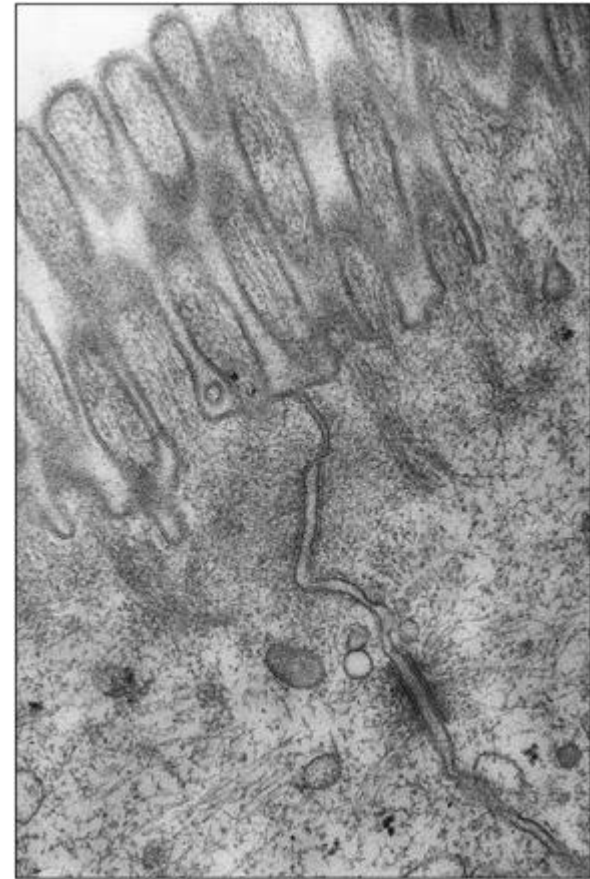
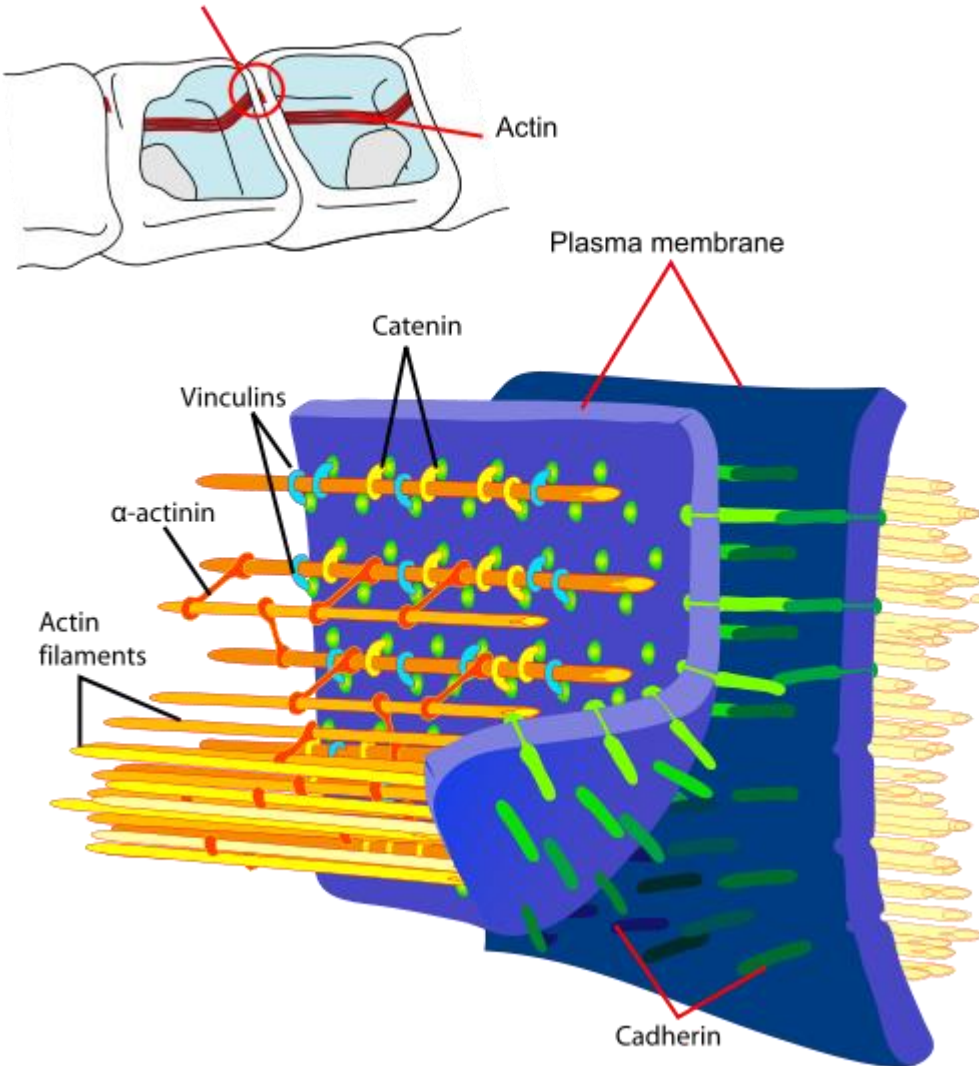
Like "strapping tape" with strands of fibrils connecting and strengthening the connection. These are integral membrane proteins

Occluding junctions

Modifications of cell membrane – cell junctions

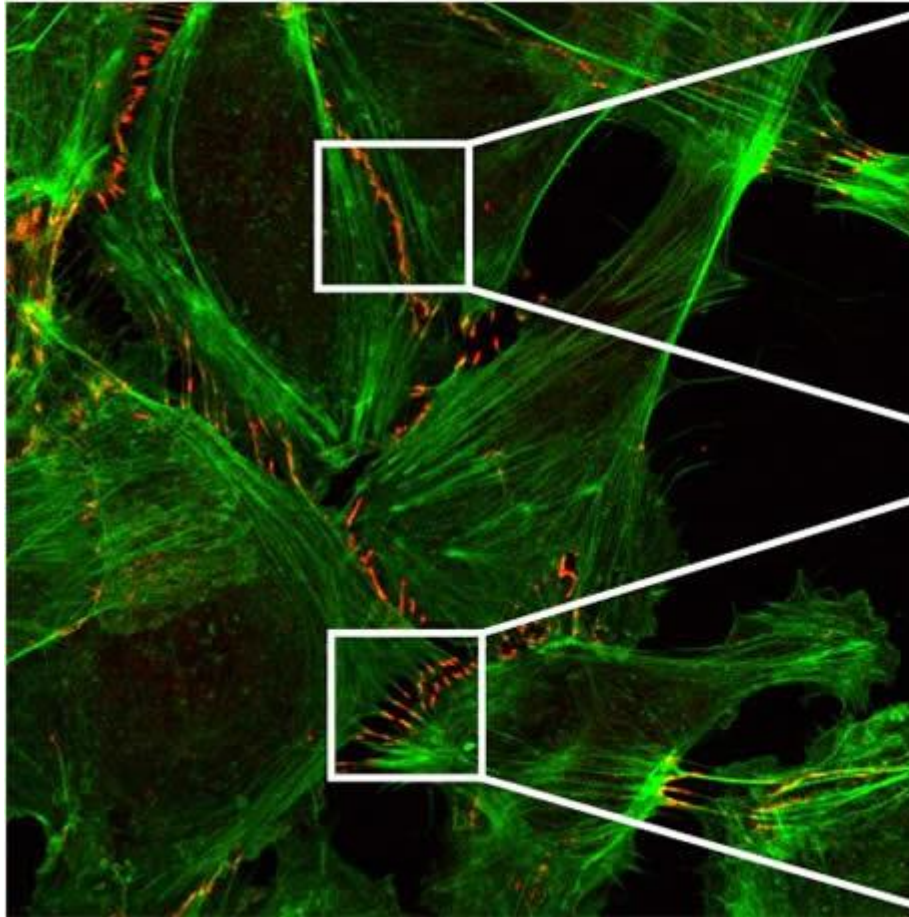
Zonula adherens

Adherens Junctions
(Zonula adherens)



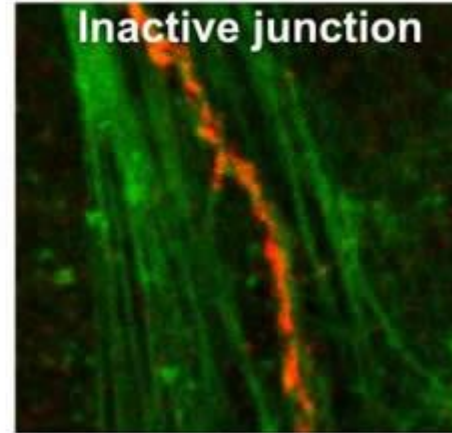
Cell adhesion is a regulated event

F-actin / VE-cadherin

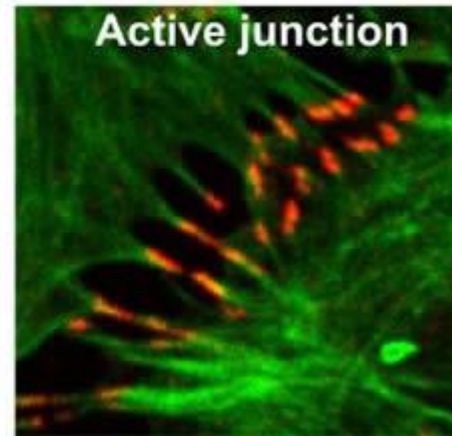


Zoom

Inactive junction

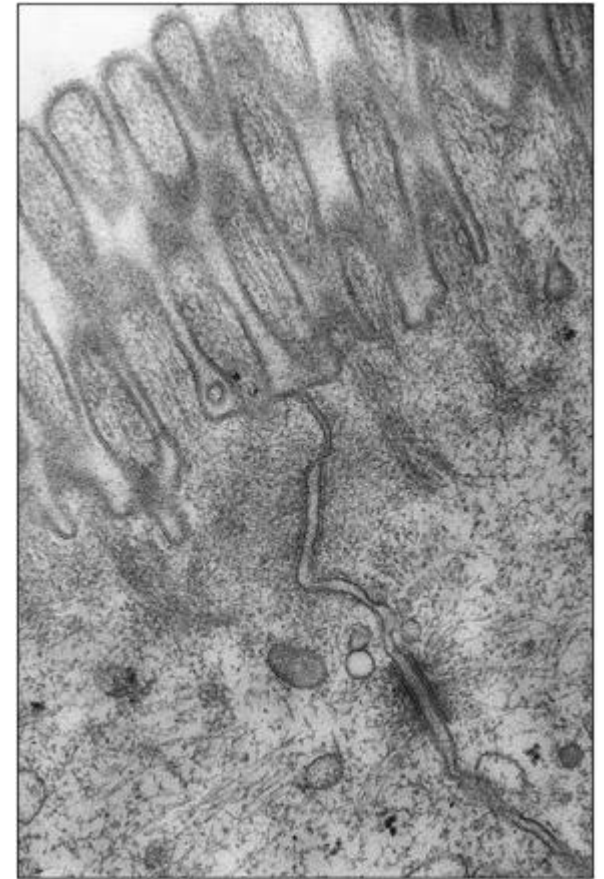
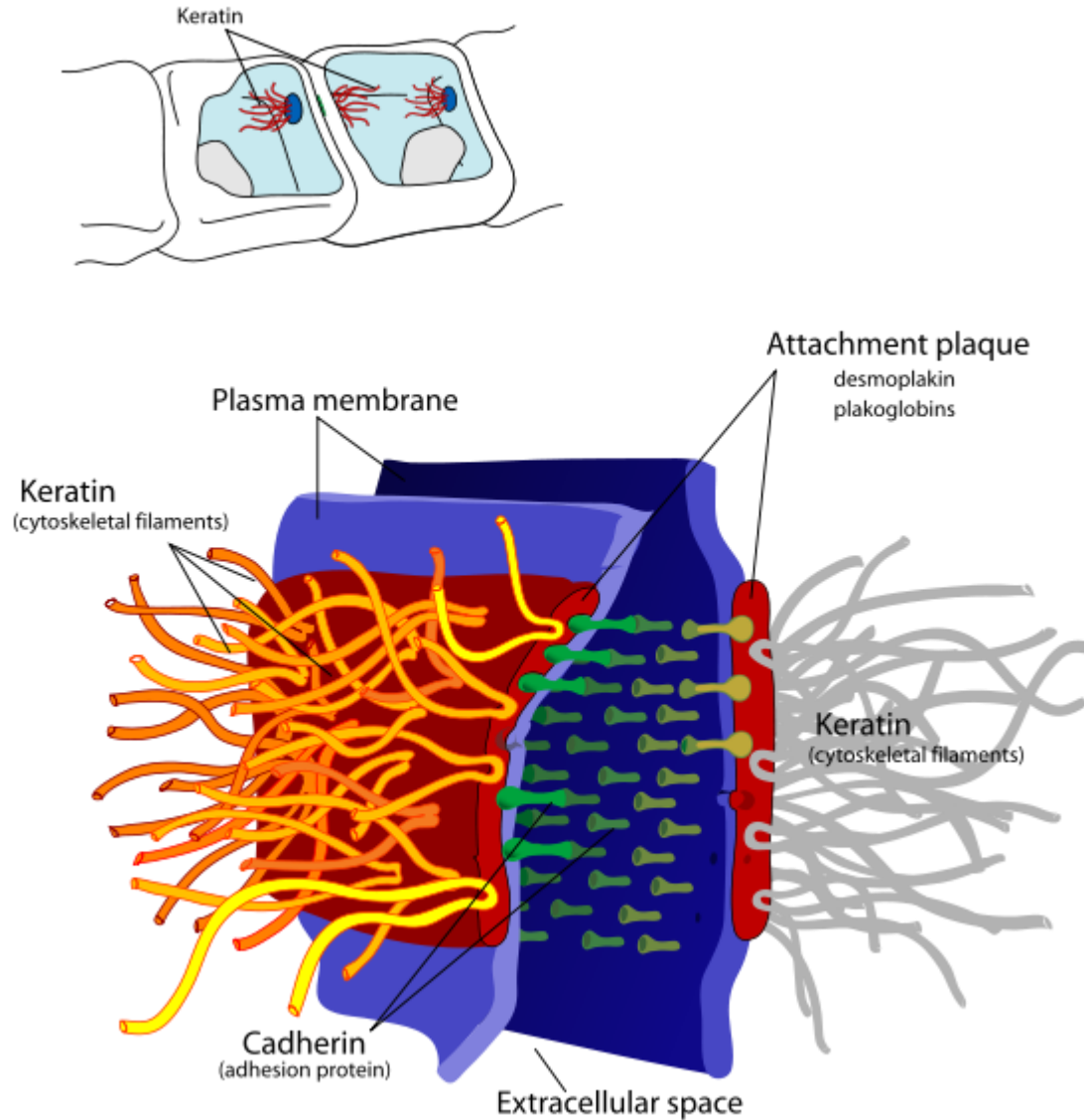


Active junction



Modifications of cell membrane – cell junctions

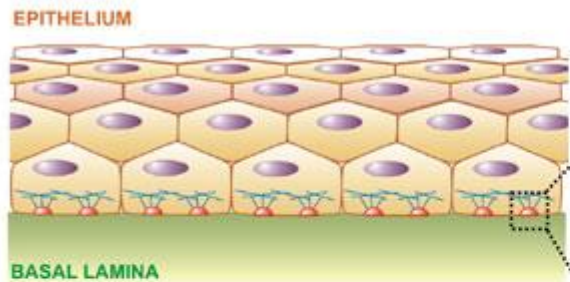
Desmosome - a spot junction



Modifications of cell membrane – cell junctions

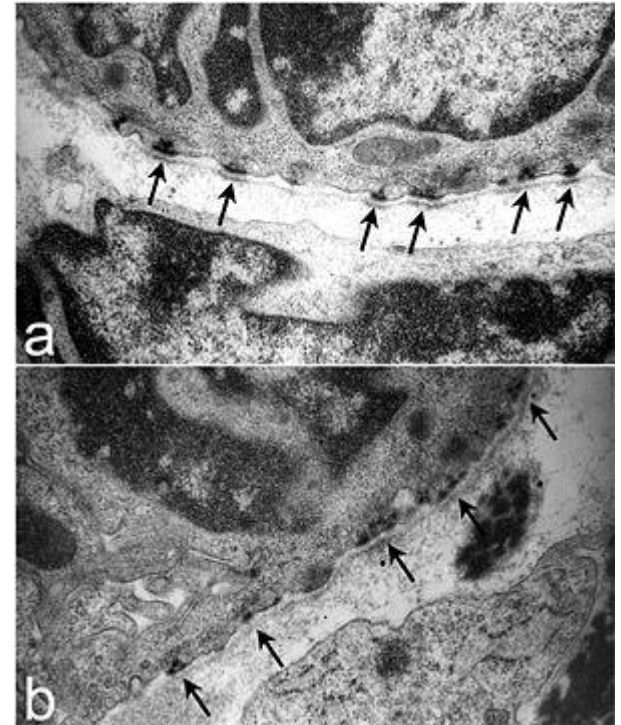
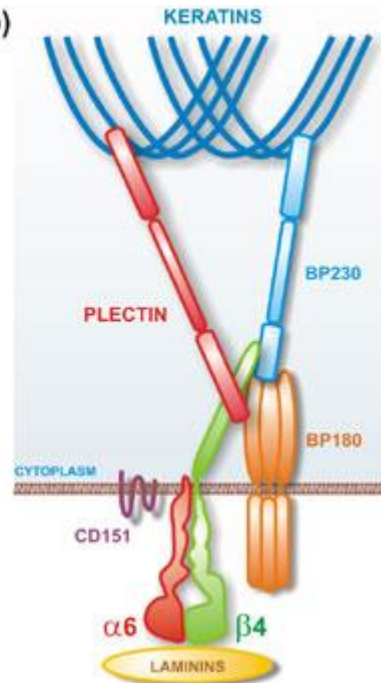
Hemi-desmosome - a spot junction

(a)



HEMIDESMOSOME

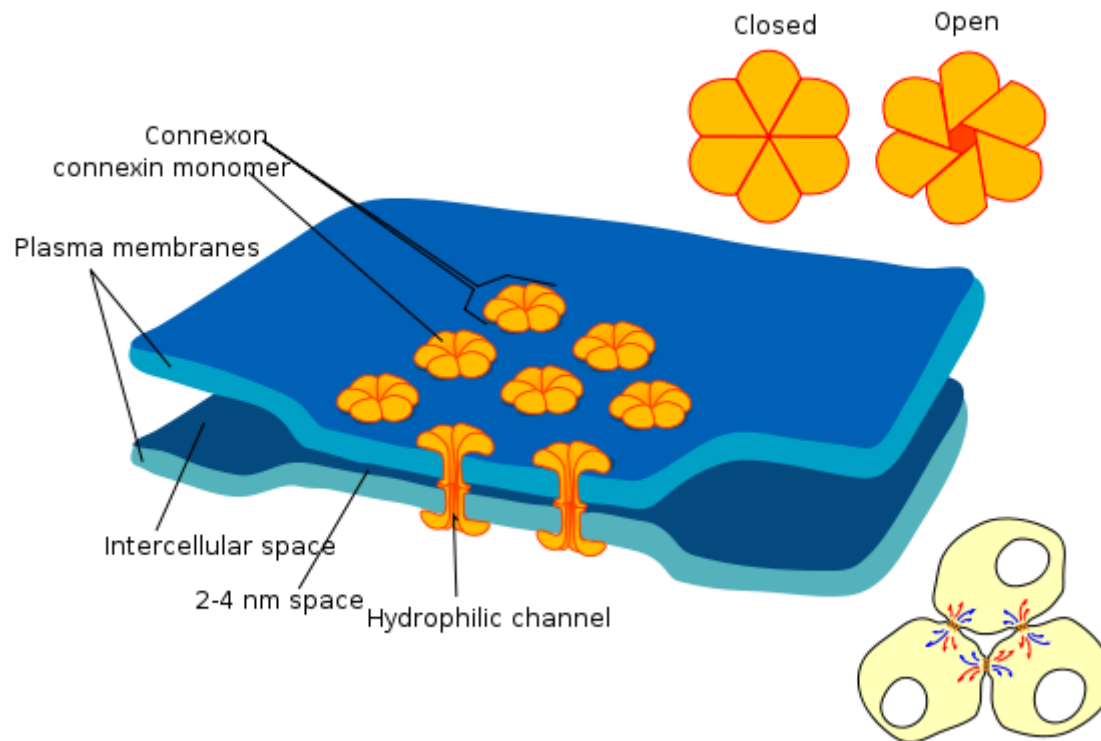
(b)



[doi:10.1186/1465-9921-7-28](https://doi.org/10.1186/1465-9921-7-28).

Modifications of cell membrane – cell junctions

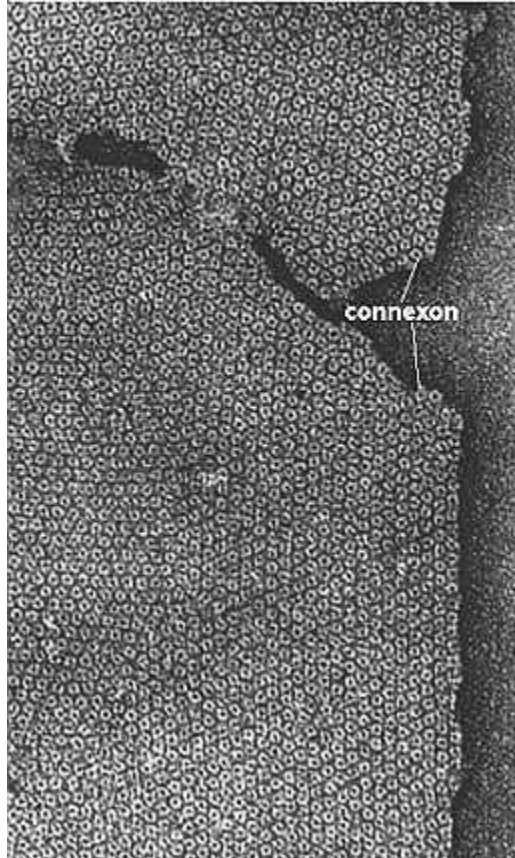
Nexus – gap junctions



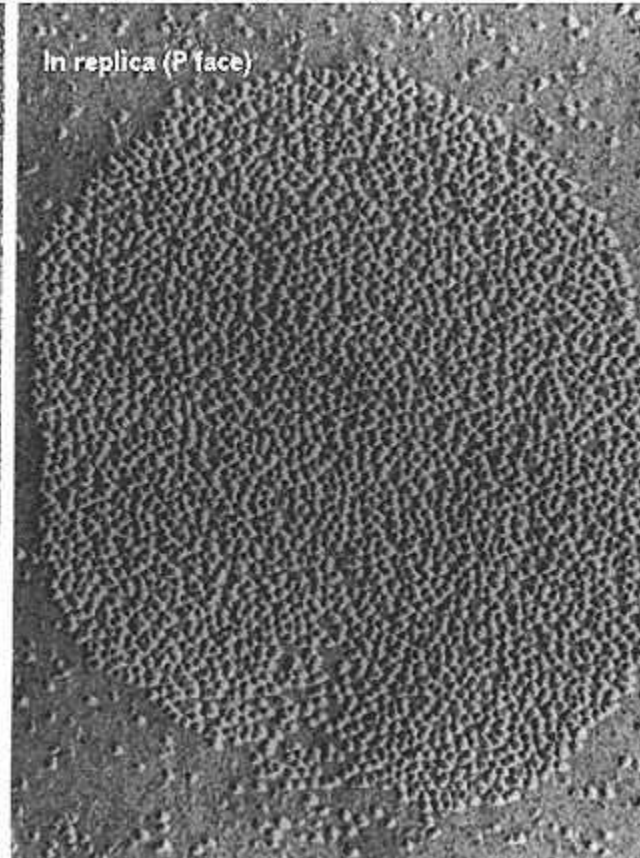
Modifications of cell membrane – cell junctions

Nexus – gap junctions

Isolated Gap Junctions--negatively stained



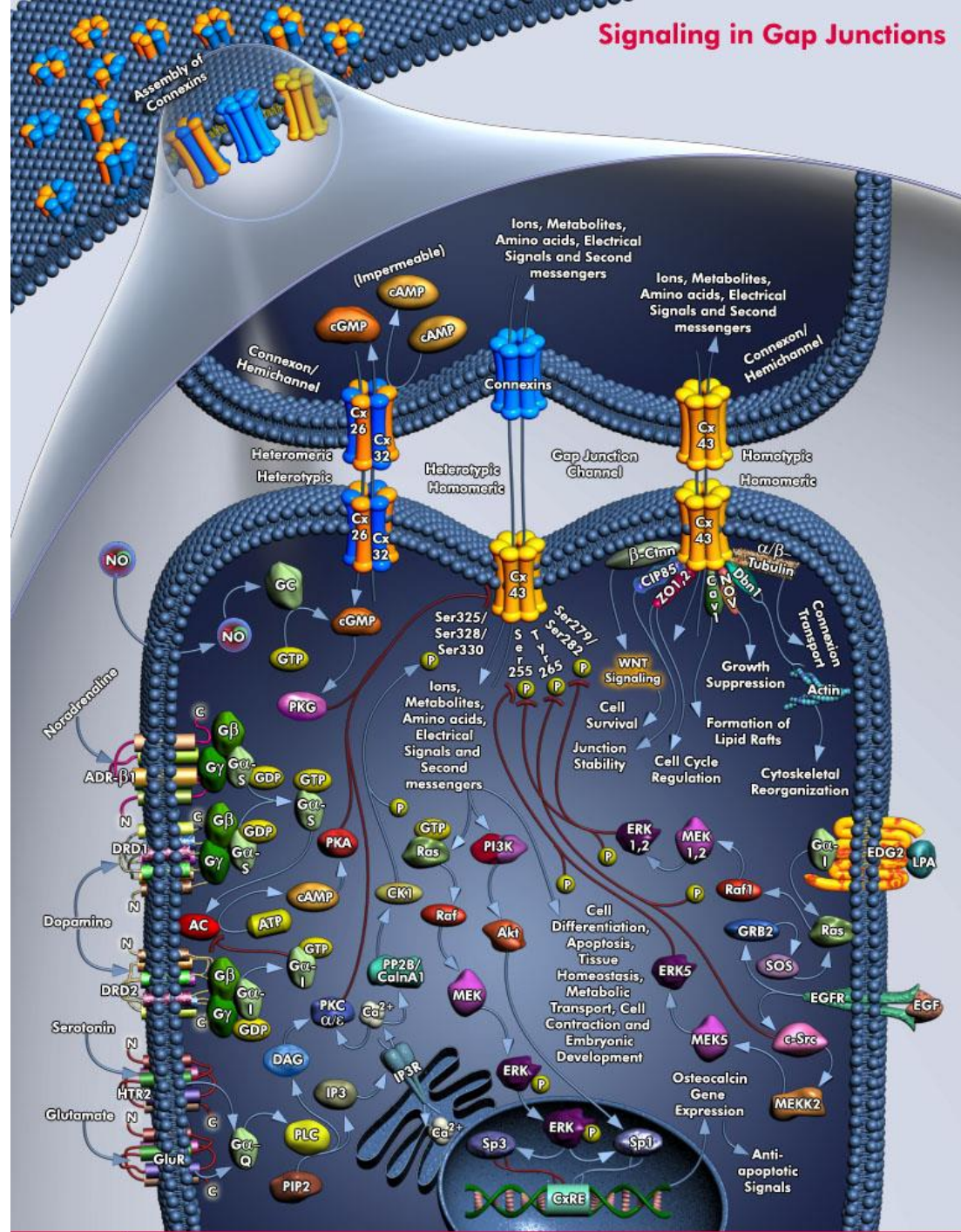
Replica of Gap junction (nexus)



Thin section-GJ

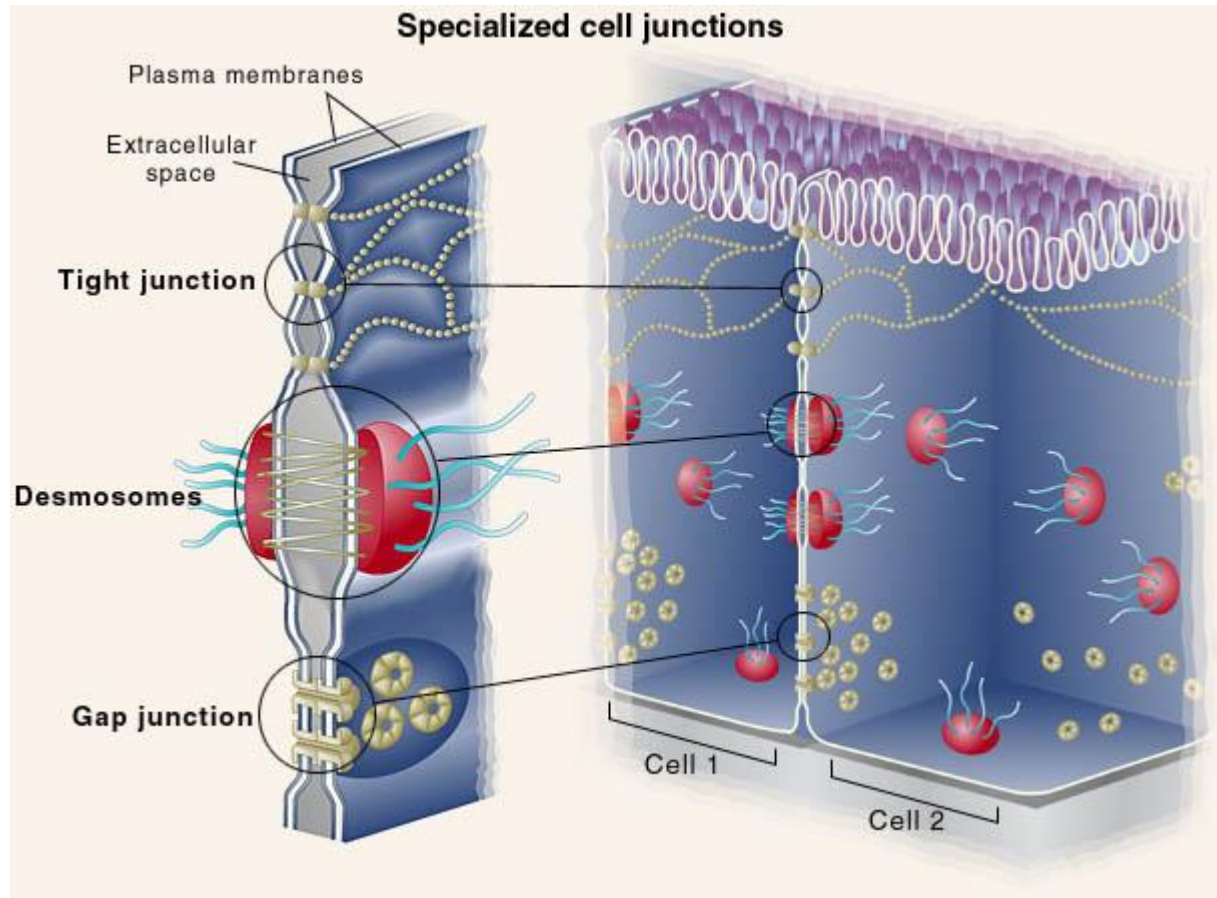


Signaling in Gap Junctions



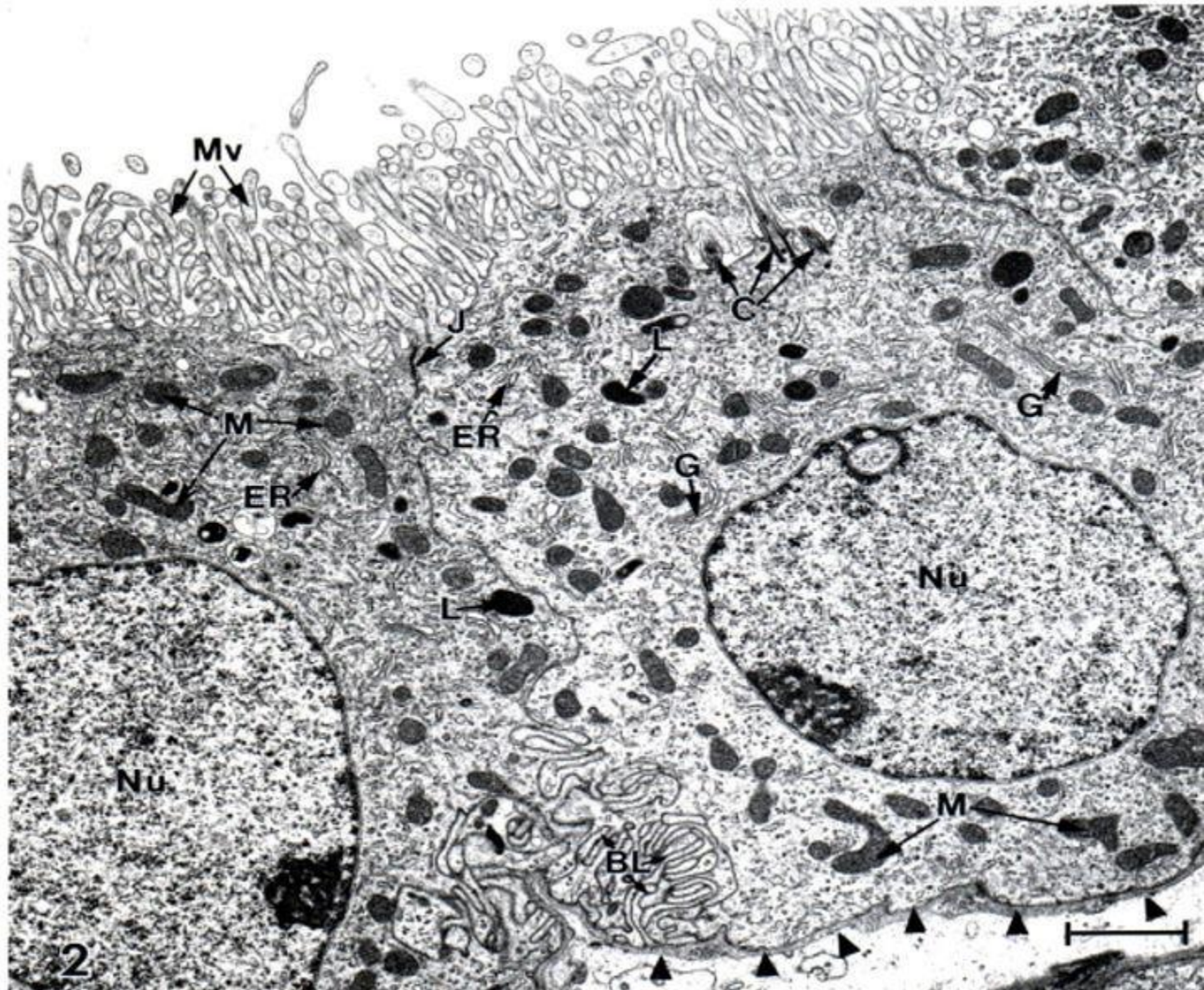
Modifications of cell membrane – cell junctions

Summary



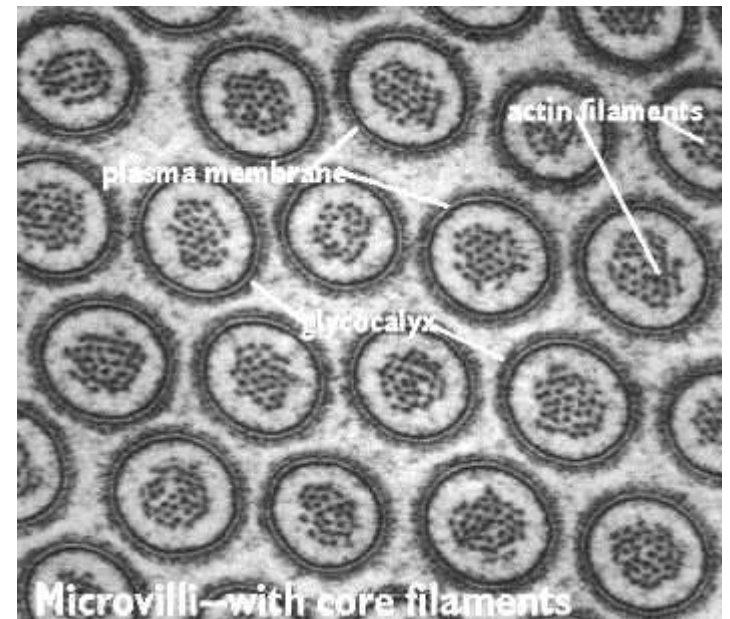
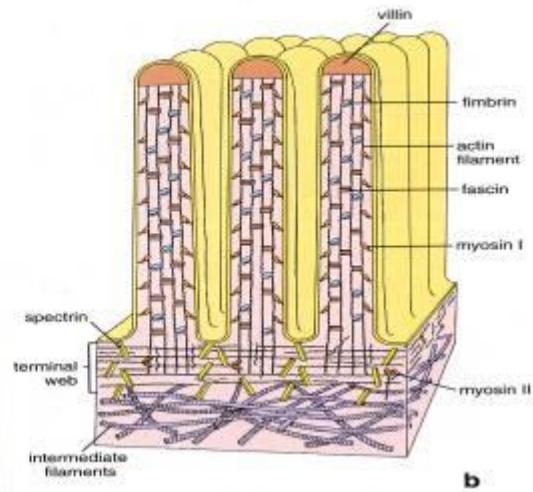
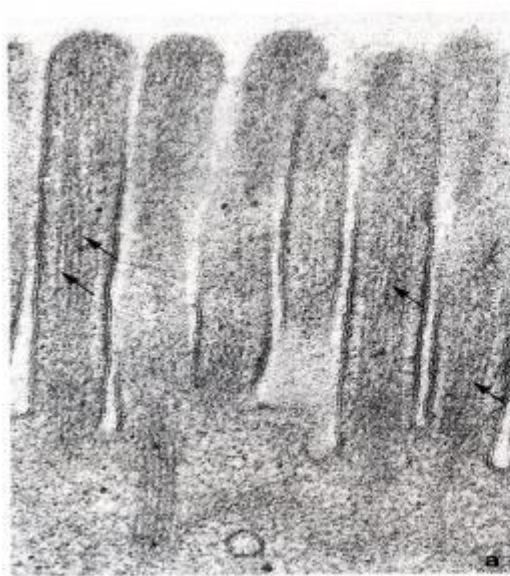
Modifications of cell membrane – basal cell surface

Basal labyrinth



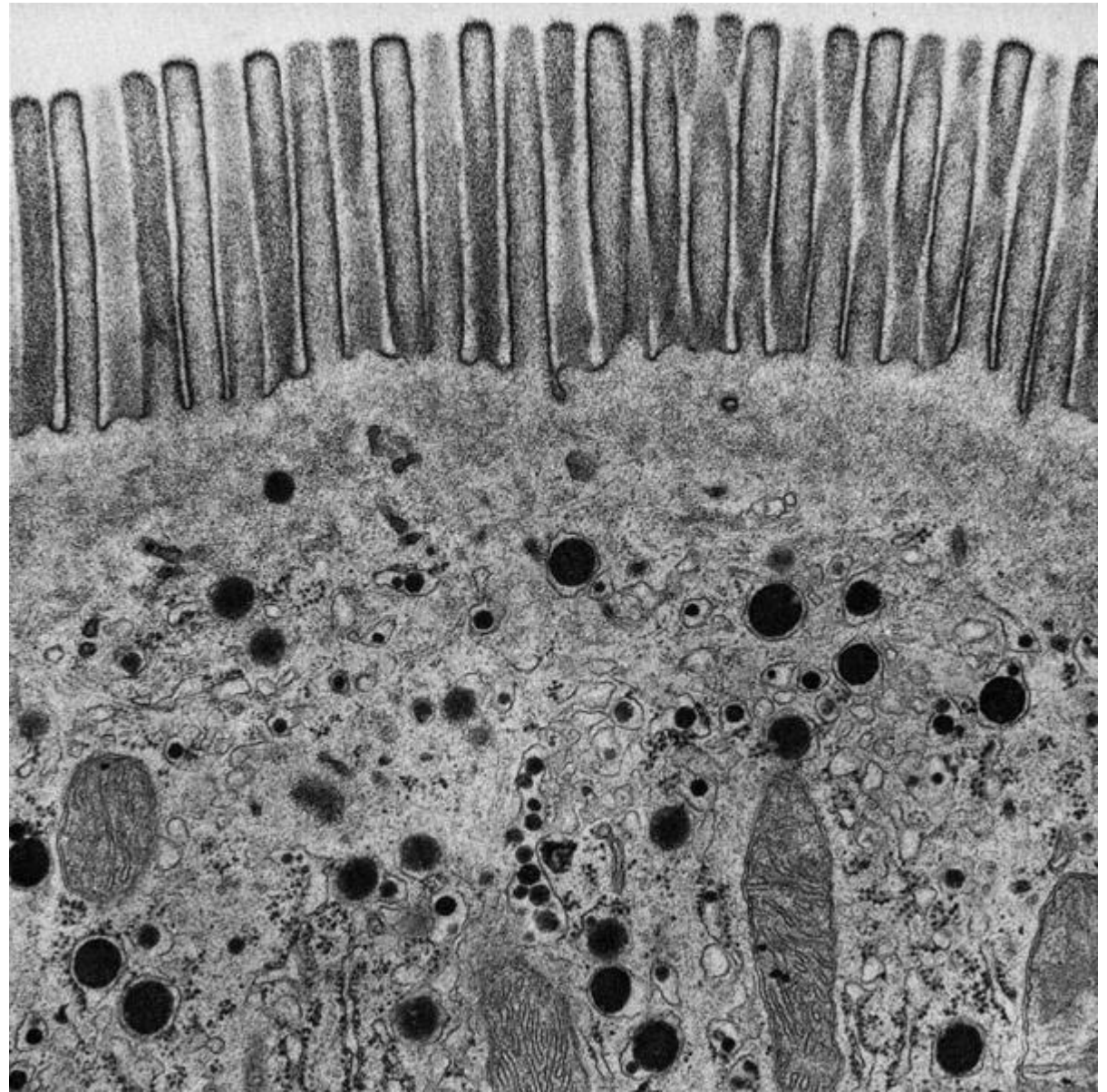
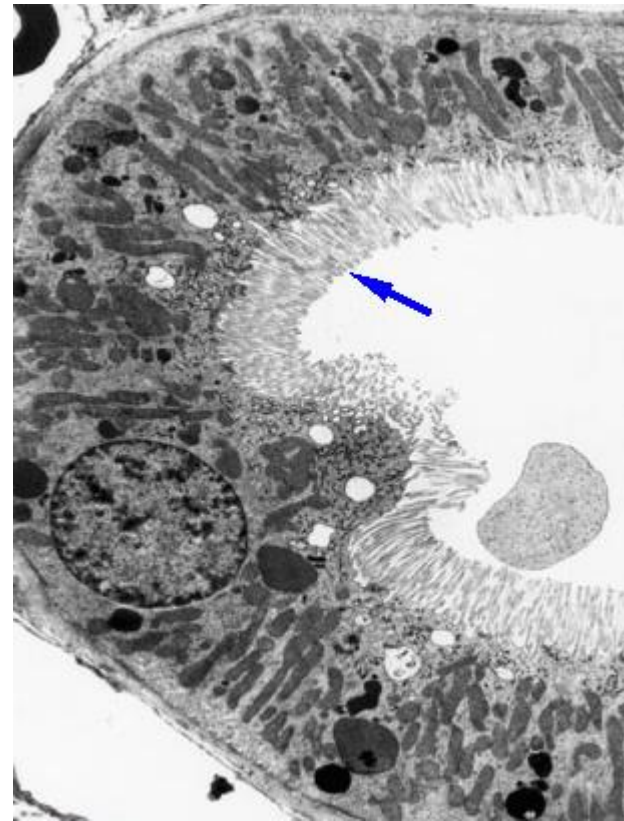
Modifications of cell membrane – apical cell surface

Microvilli



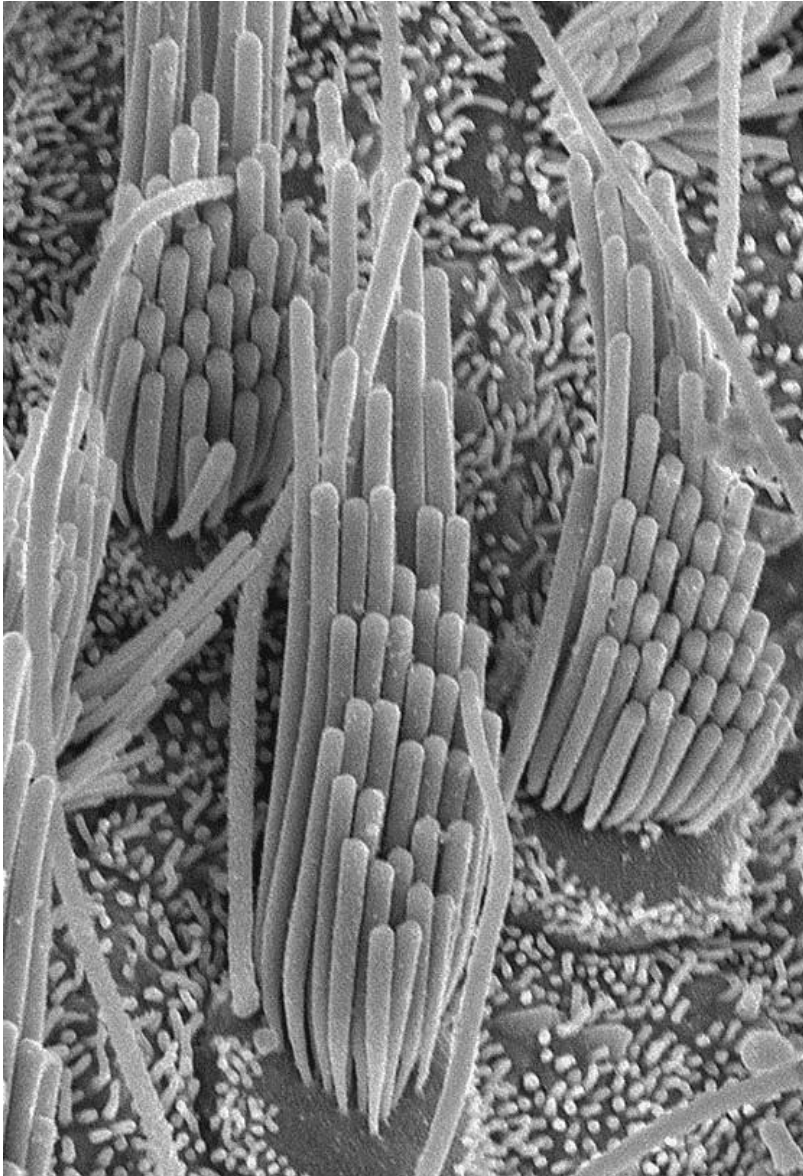
Modifications of cell membrane – apical cell surface

Brush border

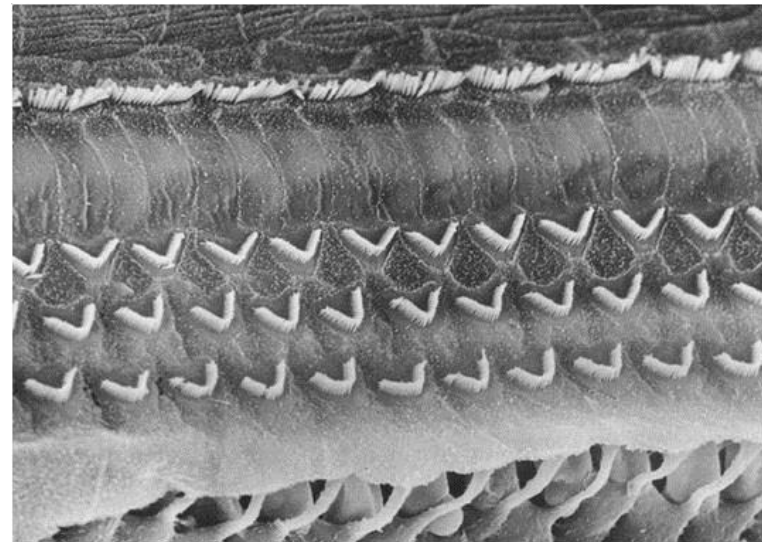


Modifications of cell membrane – apical cell surface

Stereocilia

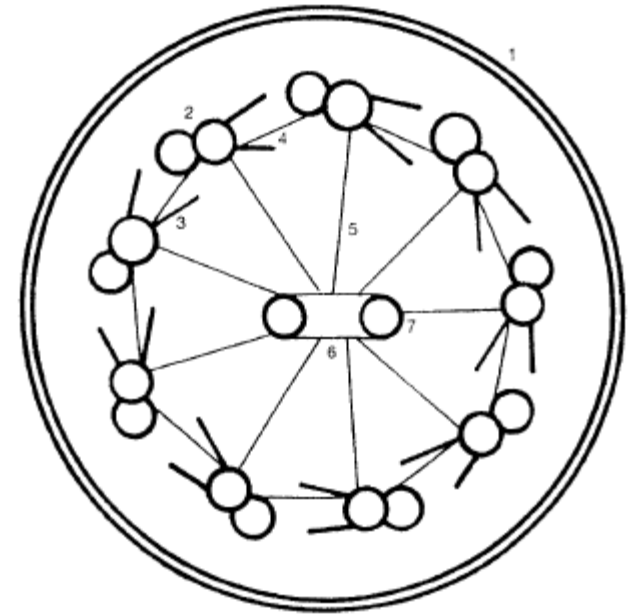
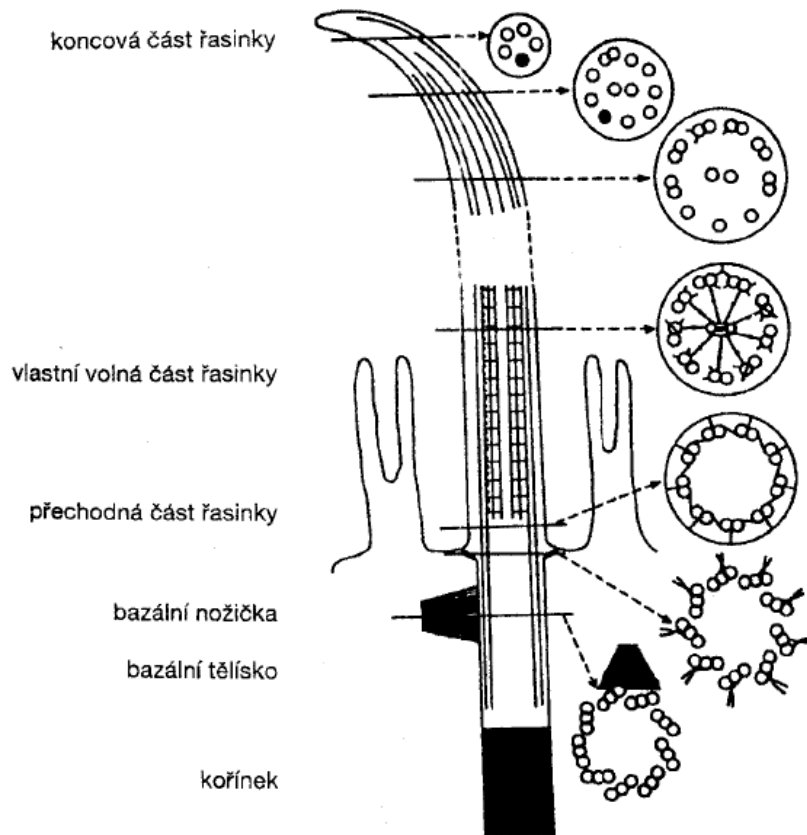


- e.g. inner ear
- not actively moving
- like microvilli, with parallel actin microfilaments
- sensory apparatus



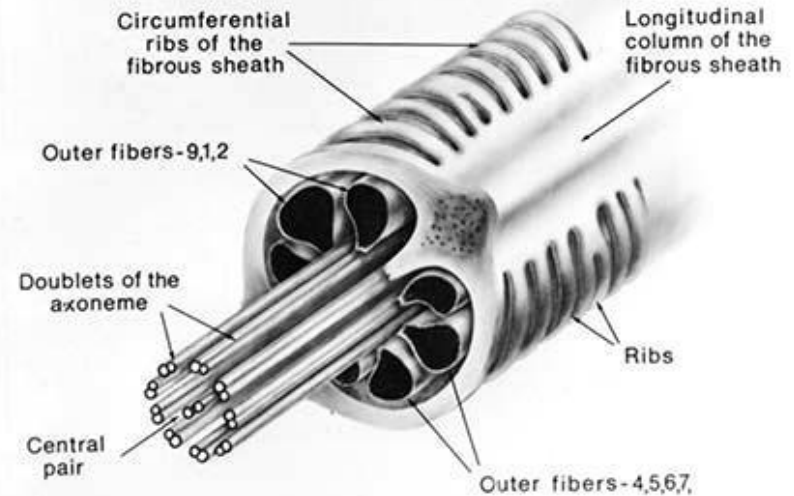
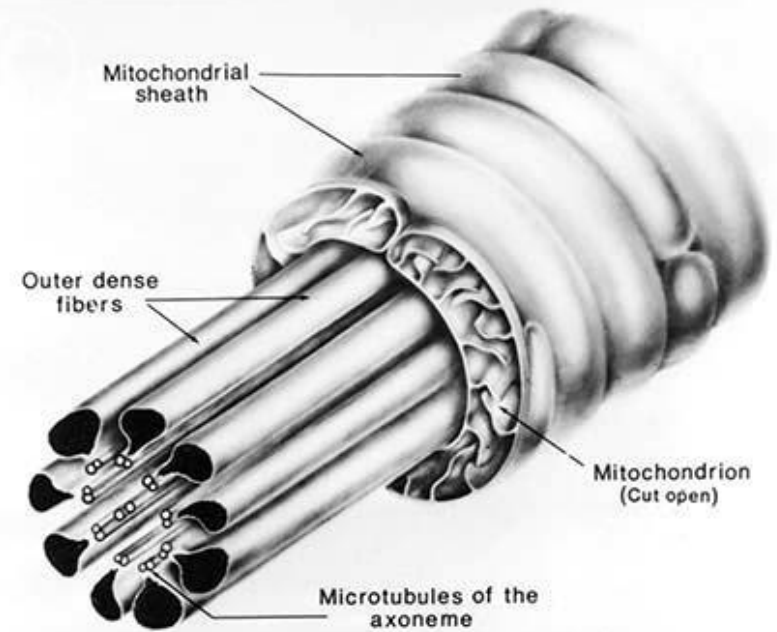
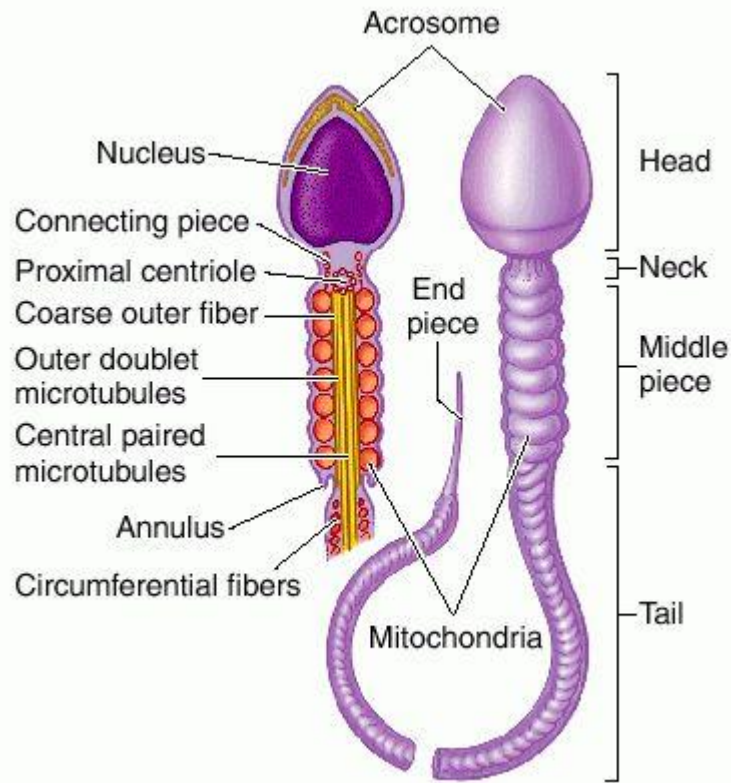
Modifications of cell membrane – apical cell surface

Kinocilia



Modifications of cell membrane – apical cell surface

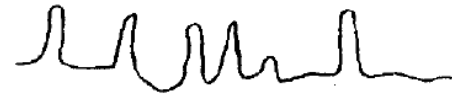
Kinocilia



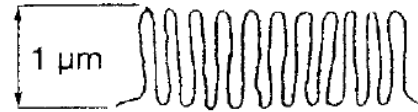
Modifications of cell membrane – apical cell surface

Summary

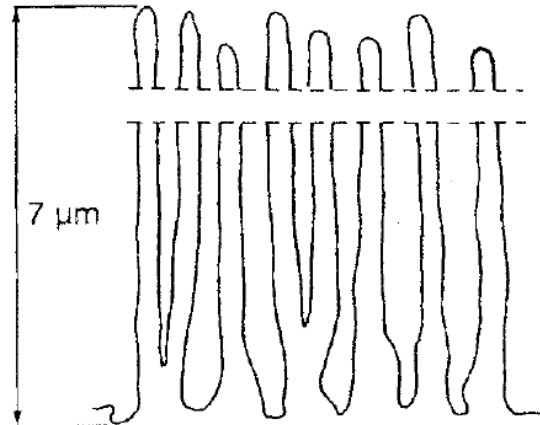
Microvilli



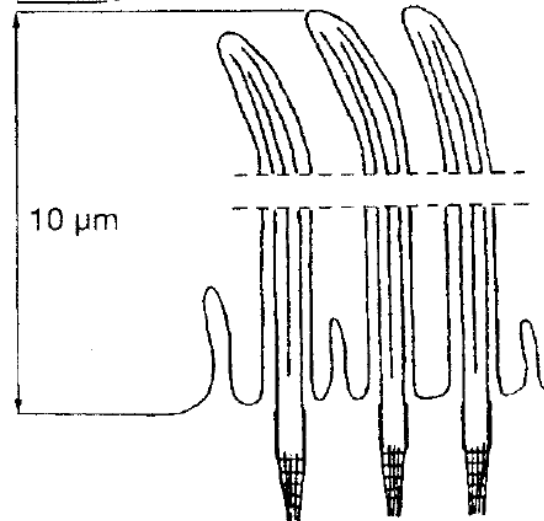
Brush border



Stereocilia



Kinocilia

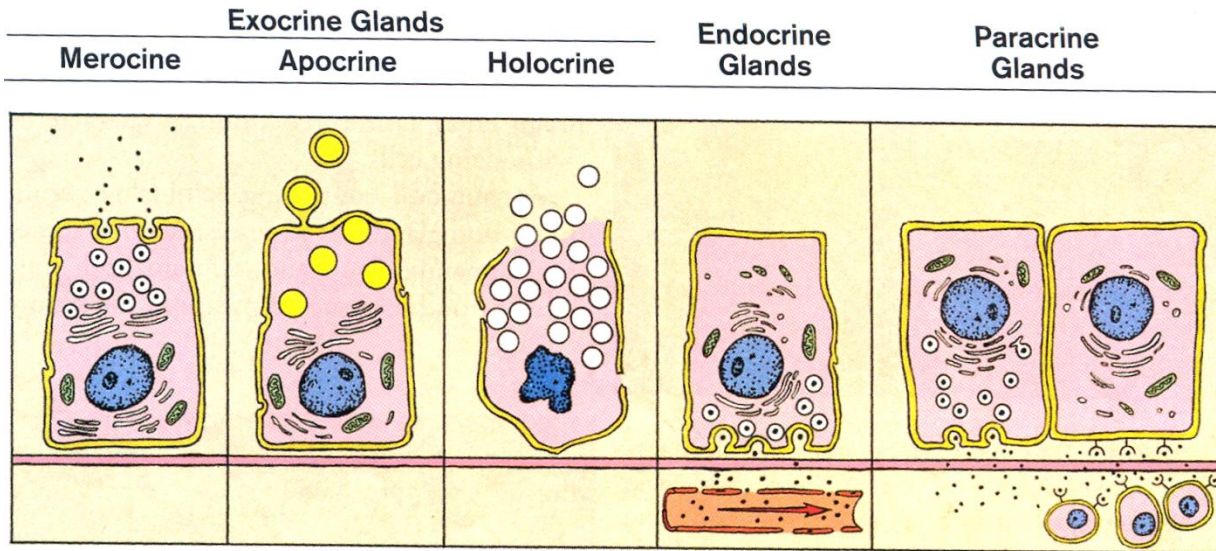


BREAK

10 min



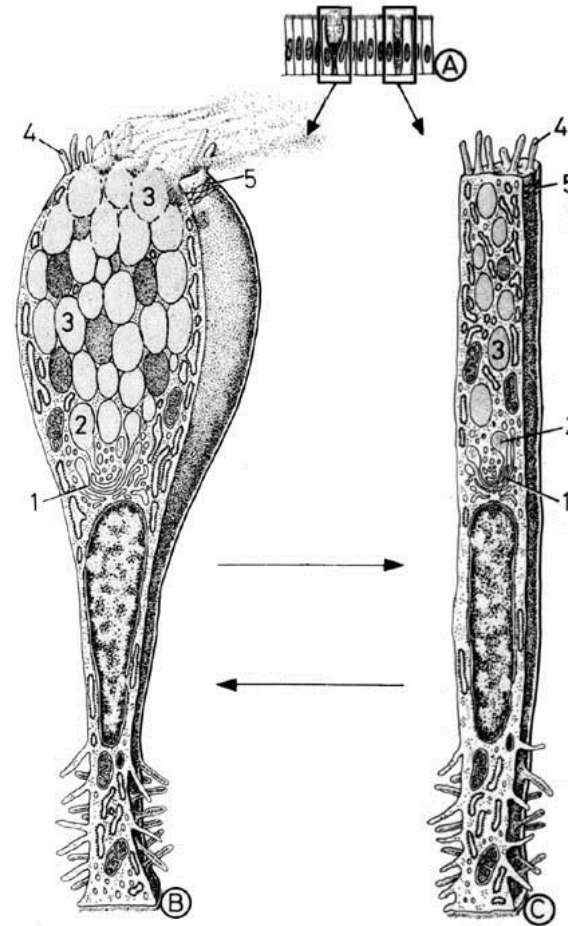
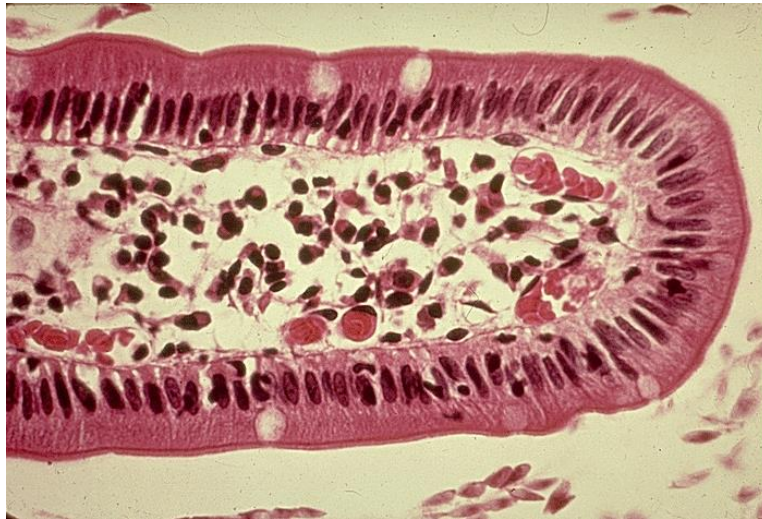
- Epithelium may posses a function
- Glandular epithelium
 - Secret ↔ excret
 - Process of secretion:



- **Glandular epithelium**

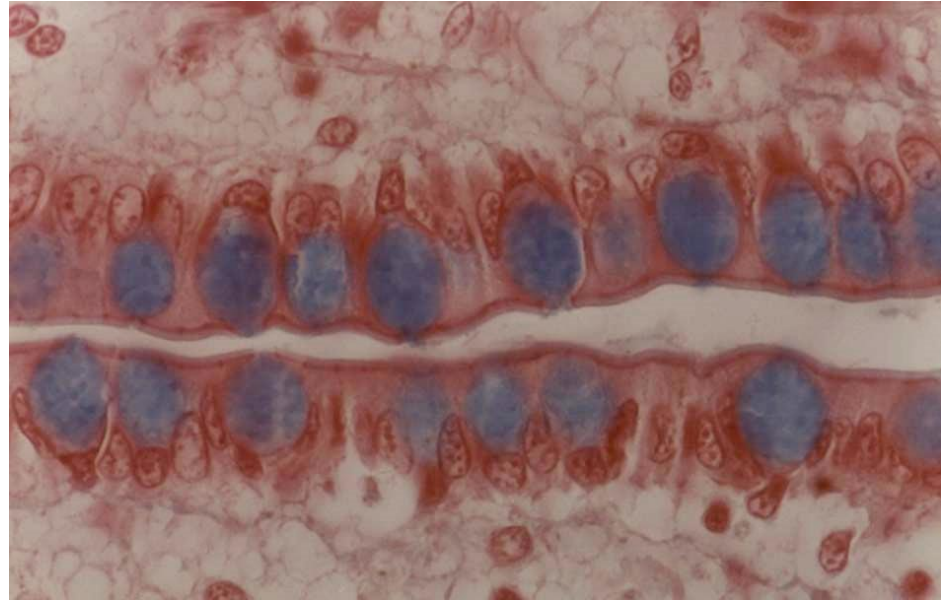
- **Single cell glands**

- Goblet
- Enteroendocrine



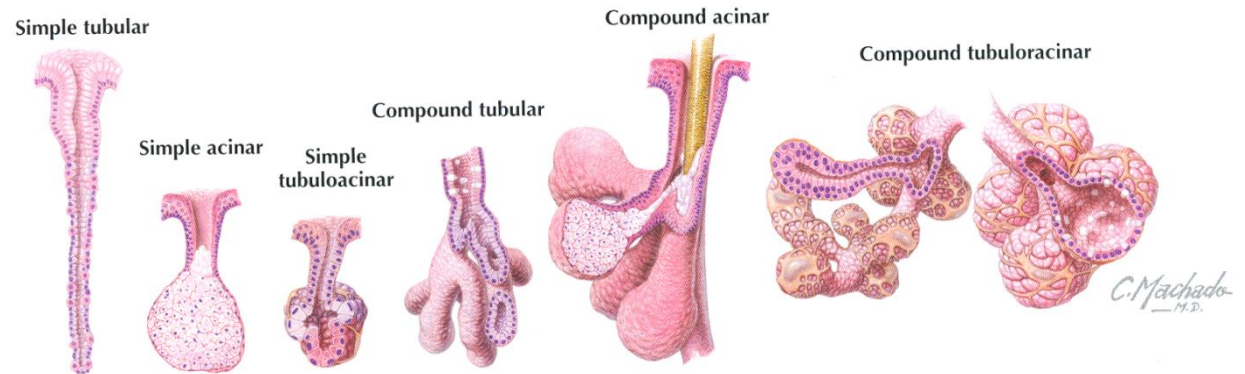
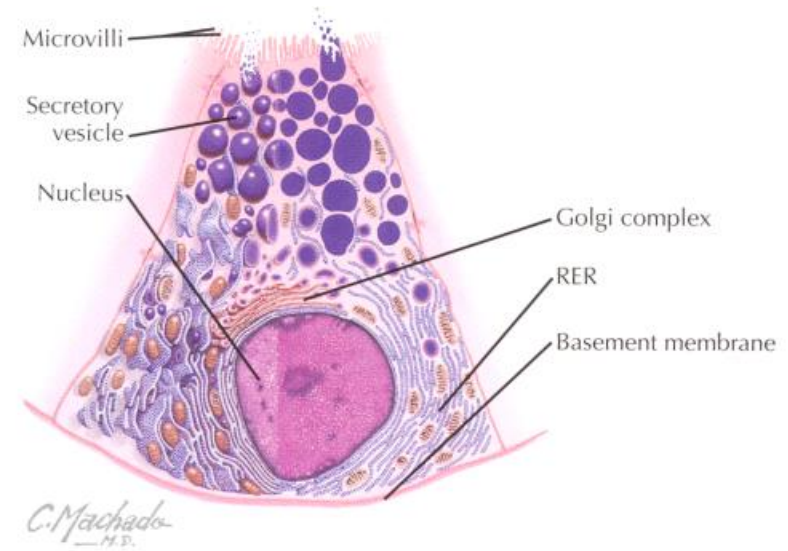
▪ Goblet cells

- 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

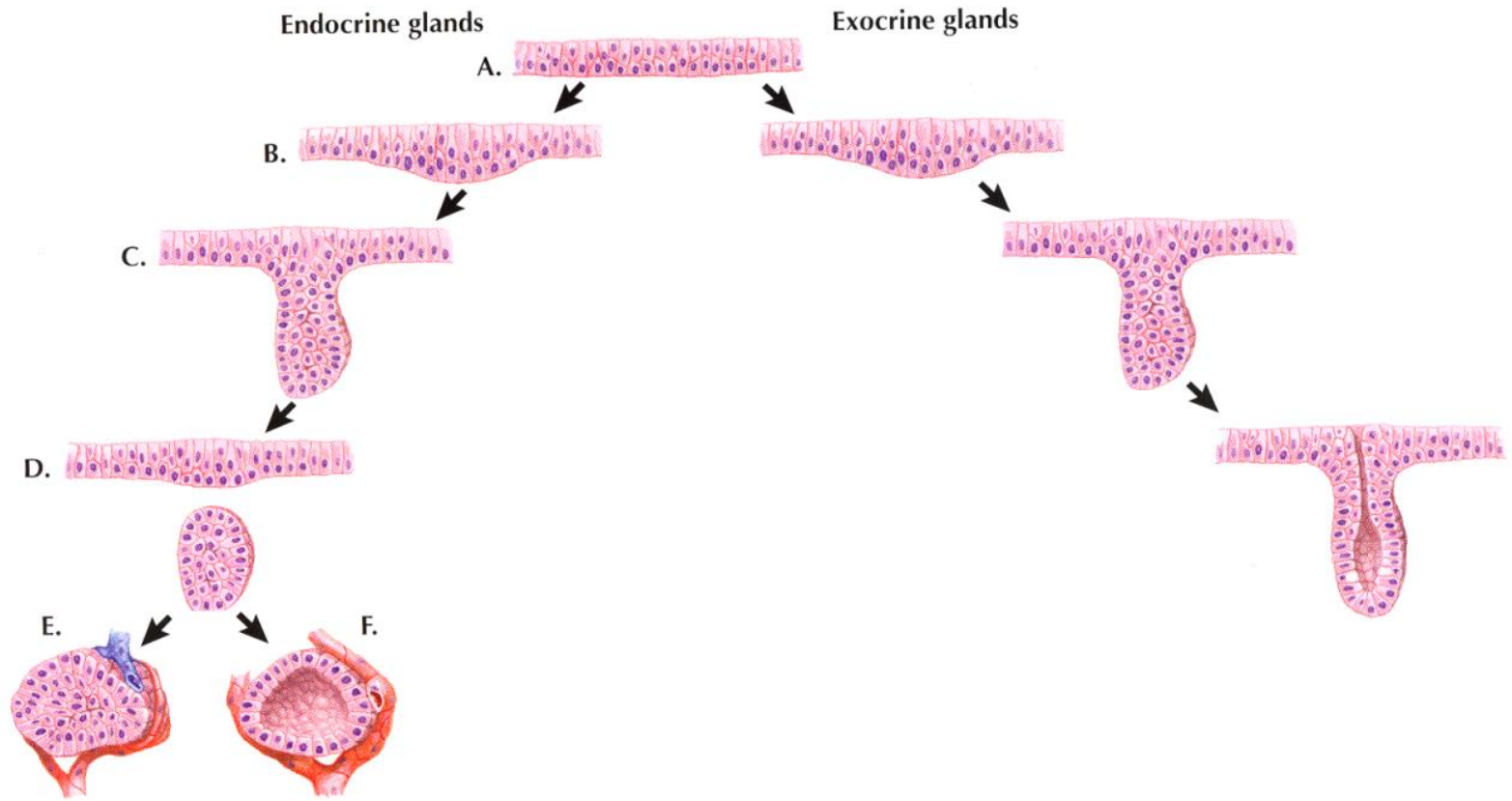


■ Multicellular glands

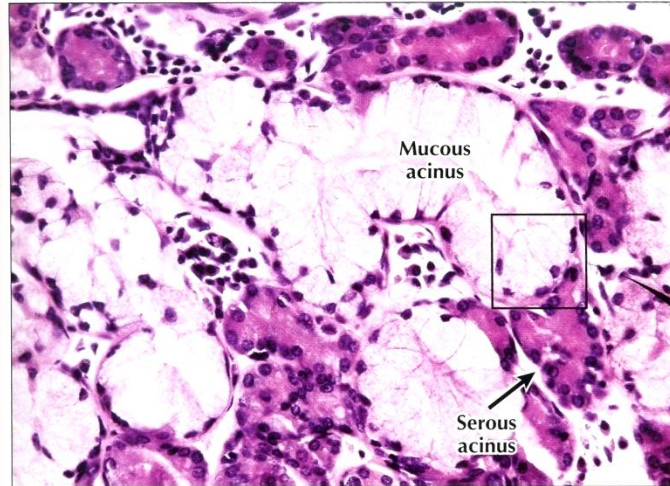
- Shape of secretion part
 - Alveolar (acinar)
 - Tubular
 - Tubuloalveolar (tubuloacinar)
- Branching
 - Simple
 - Branched
 - Compound
- Secretion
 - Mucous
 - Serous
 - Compound



- **Multicellular glands**
 - Endocrine vs. exocrine

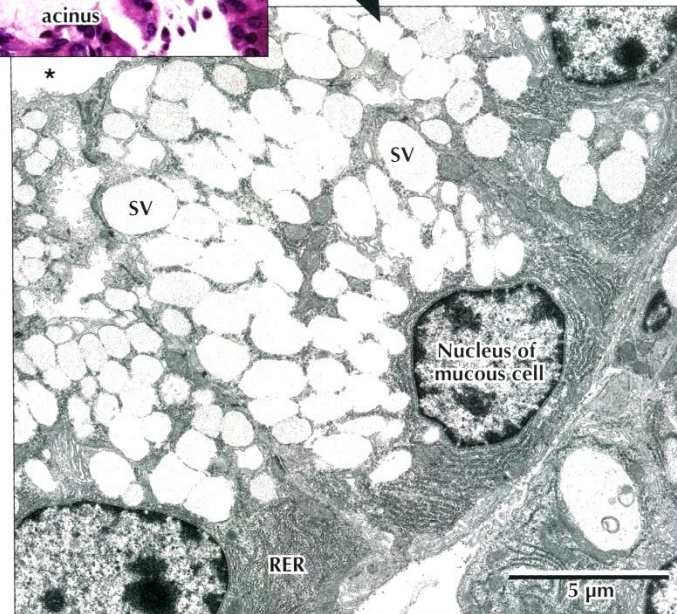


■ Mucous glands

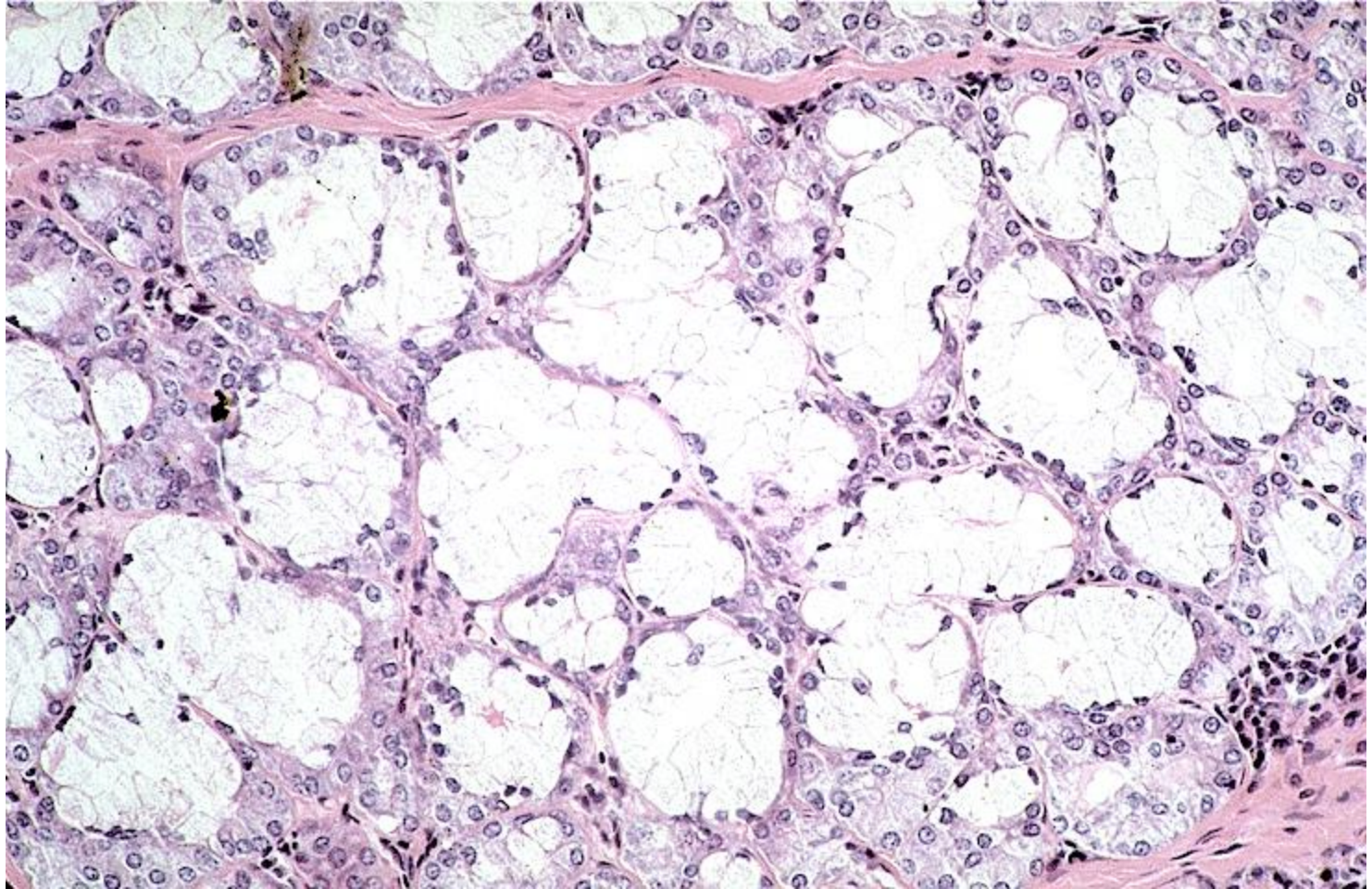


◀ **LM of part of a mixed seromucous gland in the trachea.** Several mucous acini with pale-stained mucous cells are seen. The basal nuclei are flat, and cells appear washed out because mucous droplets dissolved during specimen preparation. Darker stained serous cells in adjacent acini have more rounded 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.

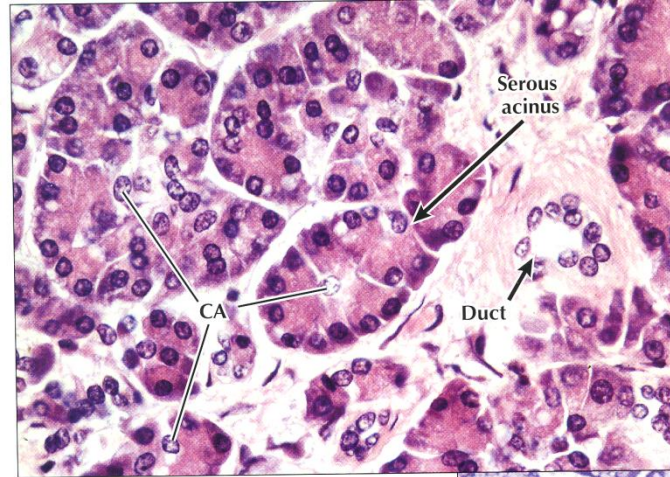
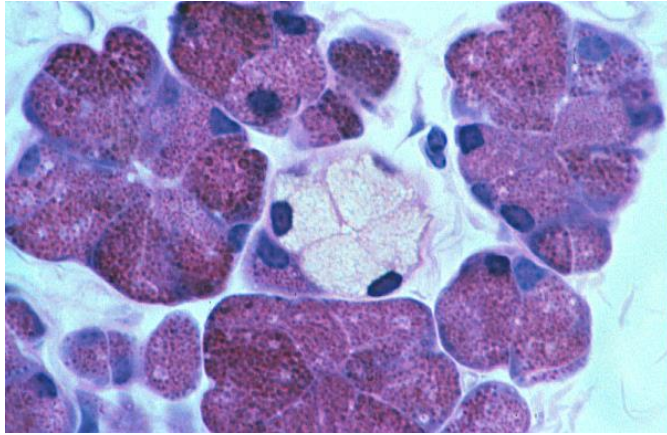
▶ **EM of part of a mucous acinus in a mixed salivary gland.** Parts of three mucous cells line the acinus lumen (*). Euchromatic basal nuclei have prominent nucleoli. Basal cytoplasm contains many profiles of rough endoplasmic reticulum (RER). Many large, electron-lucent secretory vesicles (SV) dominating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



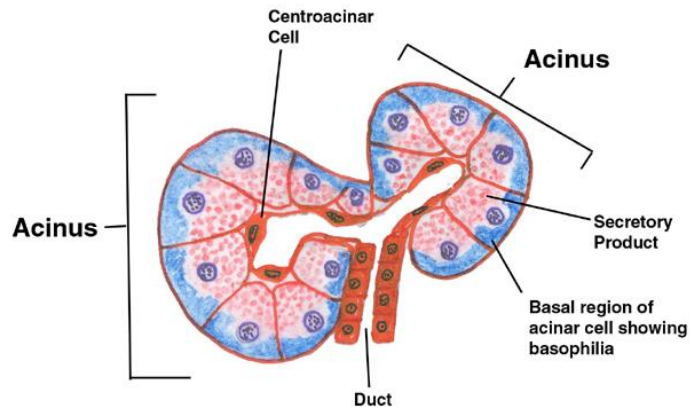
- **Mucous glands**



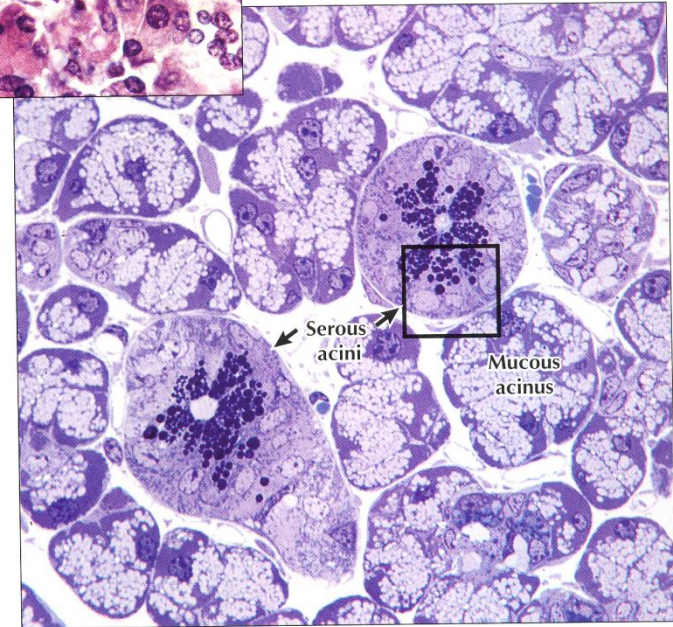
■ Serous glands



◀ **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.

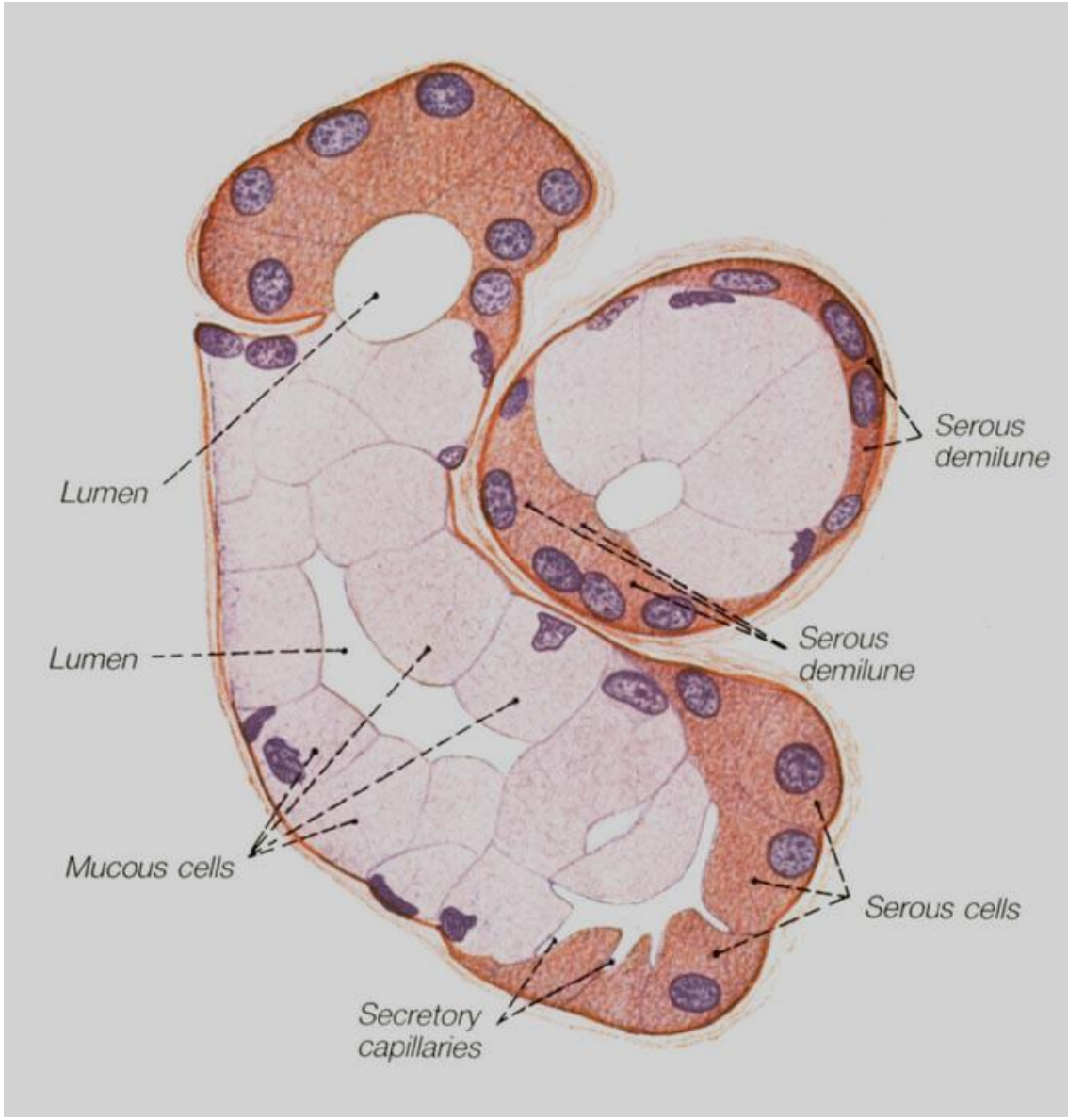


▶ **LM of part of a mixed salivary gland.** Several pale **mucous acini** surround two round **serous acini**. Serous cells have conspicuous, dark-stained secretory vesicles; mucous cells look vacuolated and washed out. EM in 2.15 shows the area in the square in detail. 600 \times . Toluidine blue, plastic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



▪ **Compound glands**

- both serous and mucous





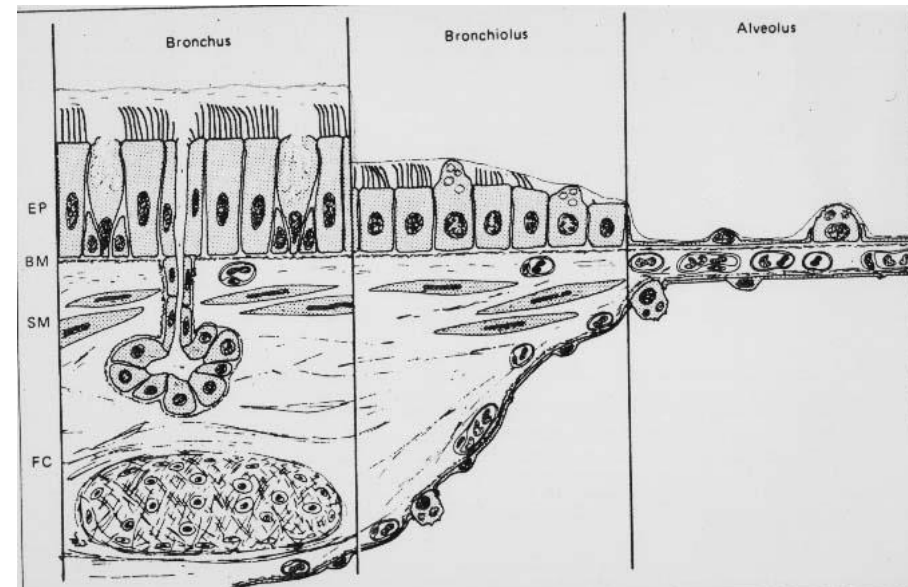
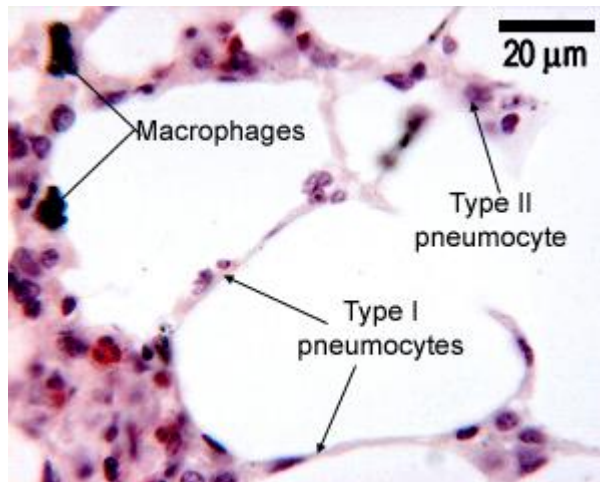
▪ Respiratory epithelium

Respiratory passages

- Moistens, 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 stimulus to membrane potential

Receptory region, body, axonal process

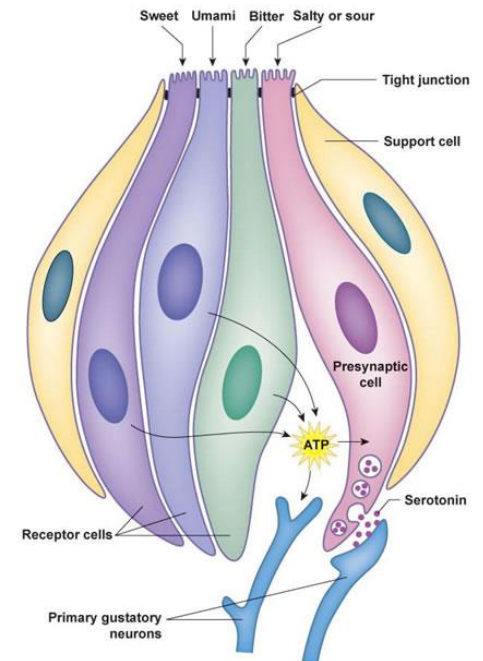
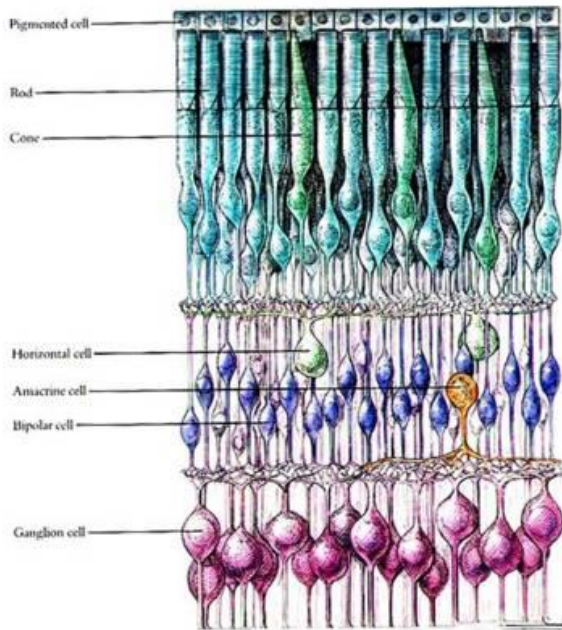
Nasal epithelium (regio olfactoria nasi), rods and cones

Secondary sensory cells

Receptory region and body

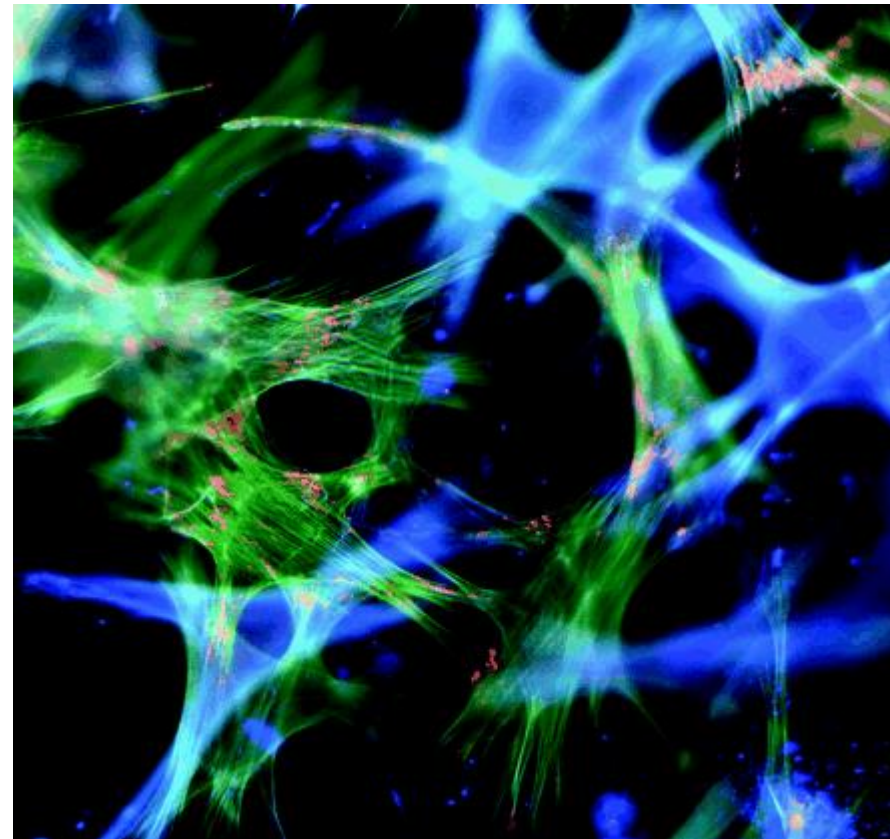
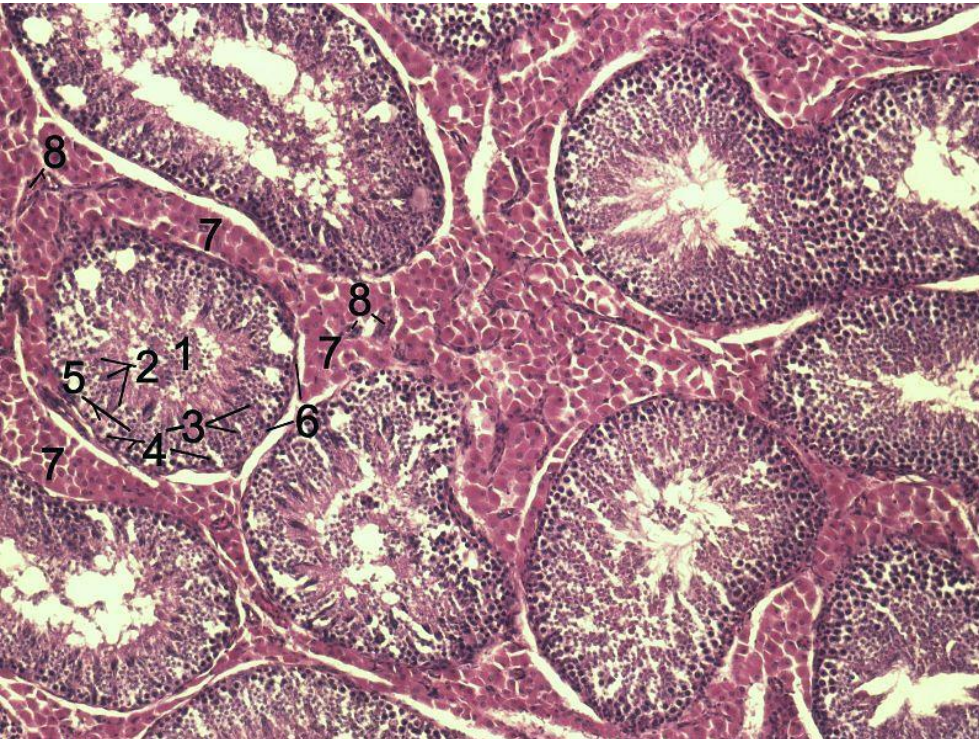
Signal is transmitted by adjacent neurons ending on secondary sensory cell

Taste buds. vestibulocochlear apparatus



■ Myoepithelium

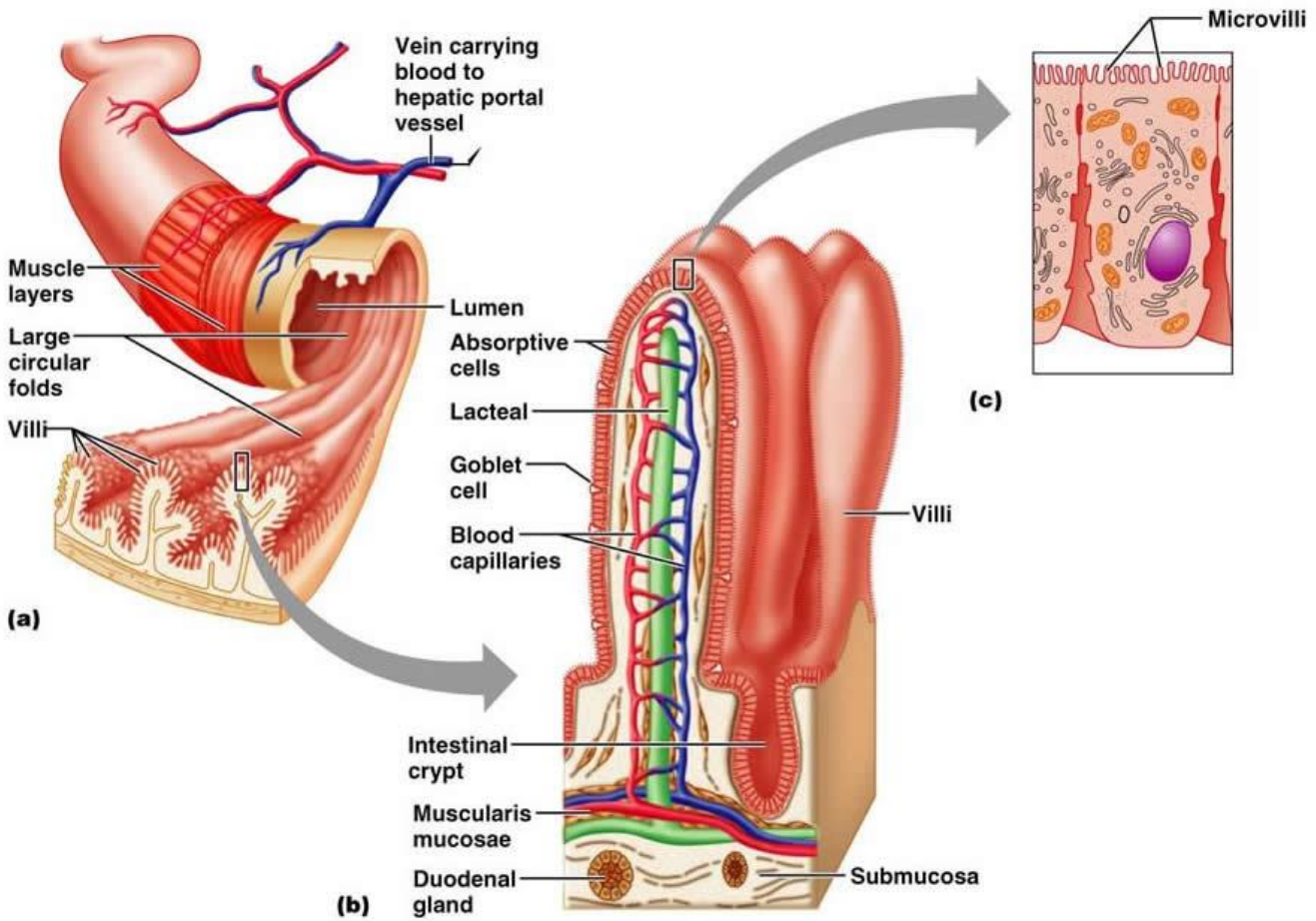
- Star-like or spindle cells
- Connected by nexus and desmosomes
- Actin microfilaments, myosin and tropomyosin
- Contraction
- Sweat and salivary glands – enhance secretion



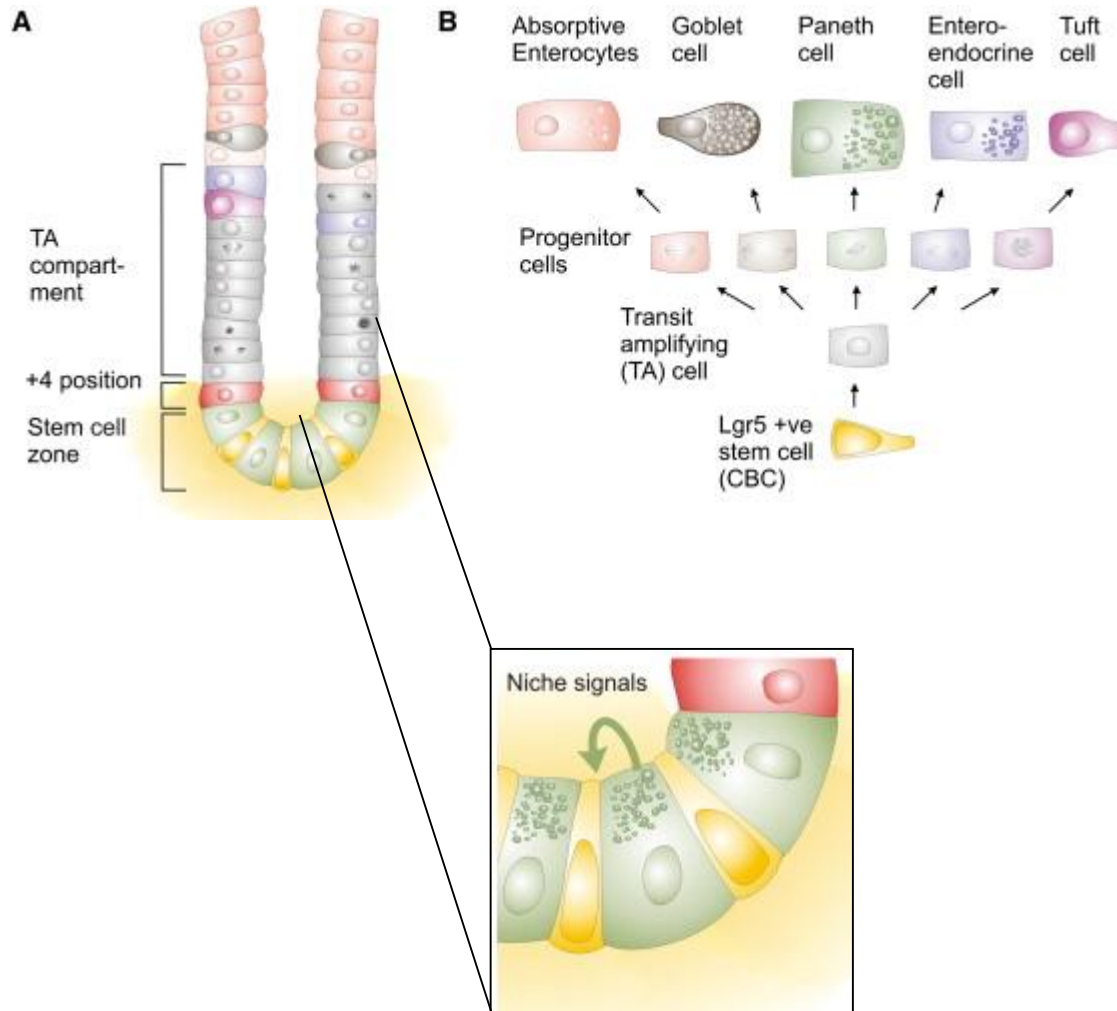
Regeneration of epithelial tissue

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

Example: Regeneration of intestine epithelium

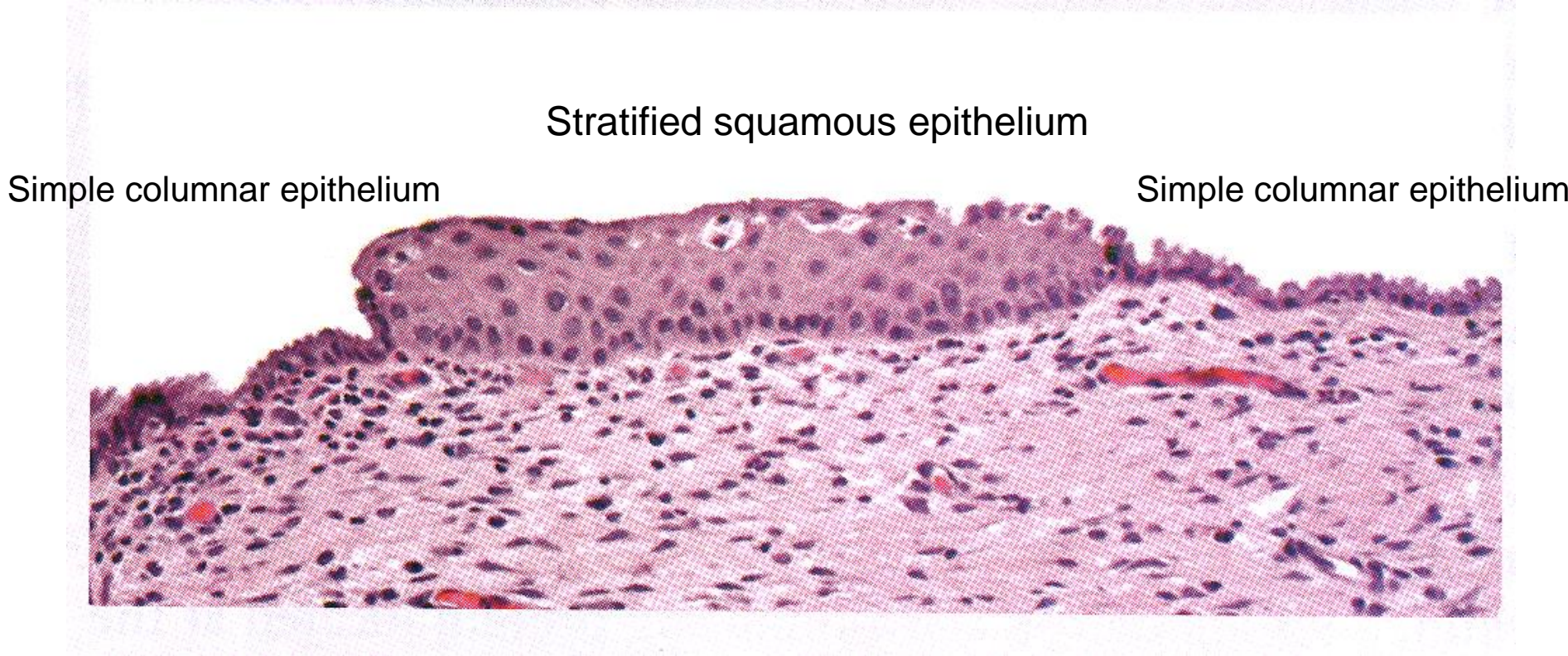


Example: Regeneration of intestine epithelium



■ Plasticity of epithelial tissues

Metaplasia



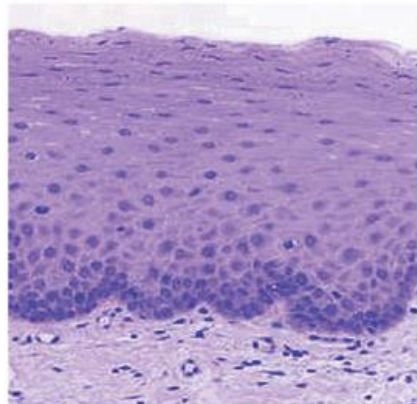
Squamous metaplasia of cervix uteri
Respiratory passages

■ Plasticity of epithelial tissues

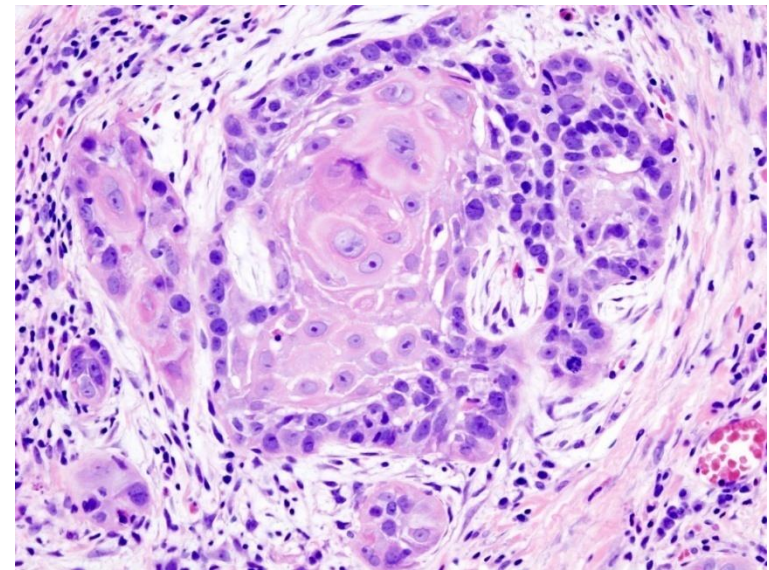
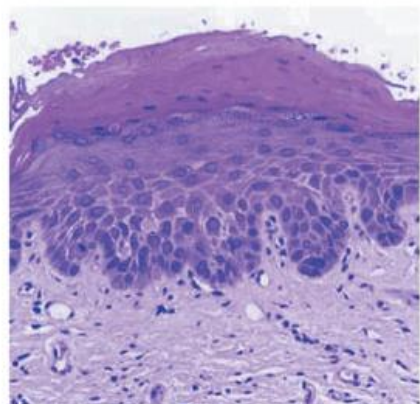
Metaplasia

Development of precancerous lesions

c Normal oral mucosa

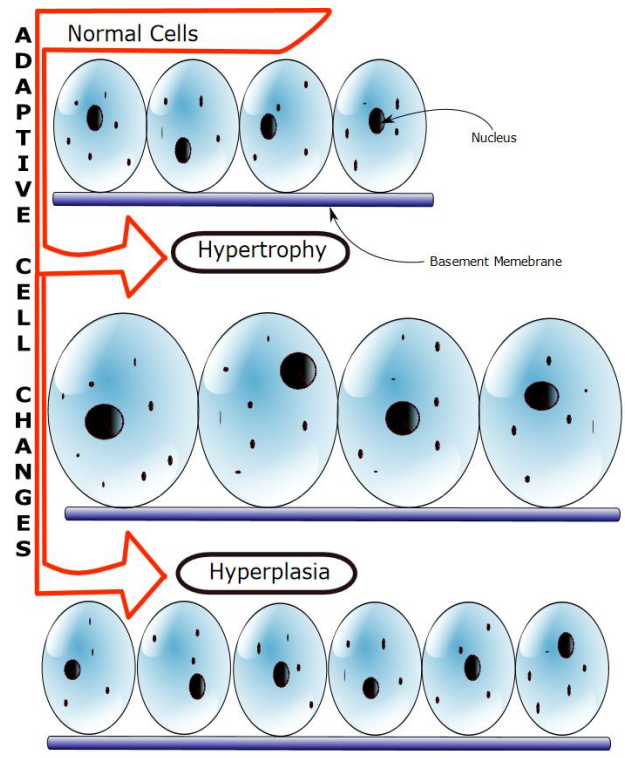


d Moderate dysplasia

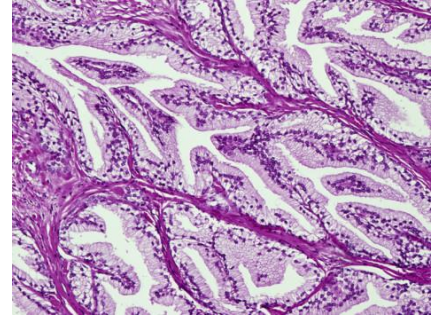


Plasticity of epithelial tissues

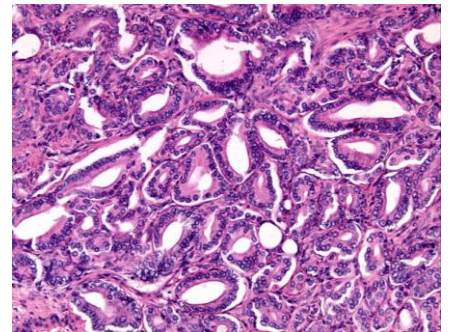
Hyperplasia



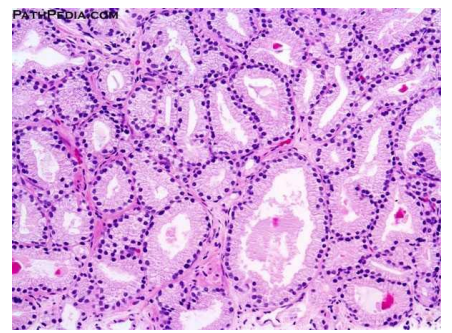
Normal prostate



Hyperplasia of prostate glandular epithelium

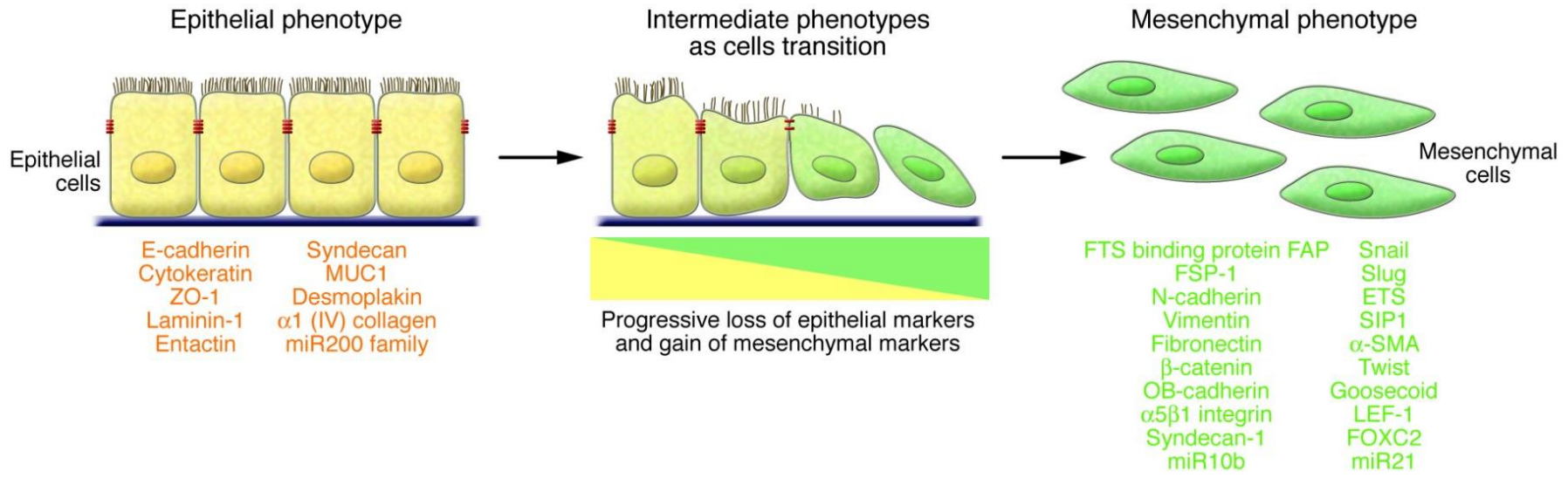


Prostate adenocarcinoma

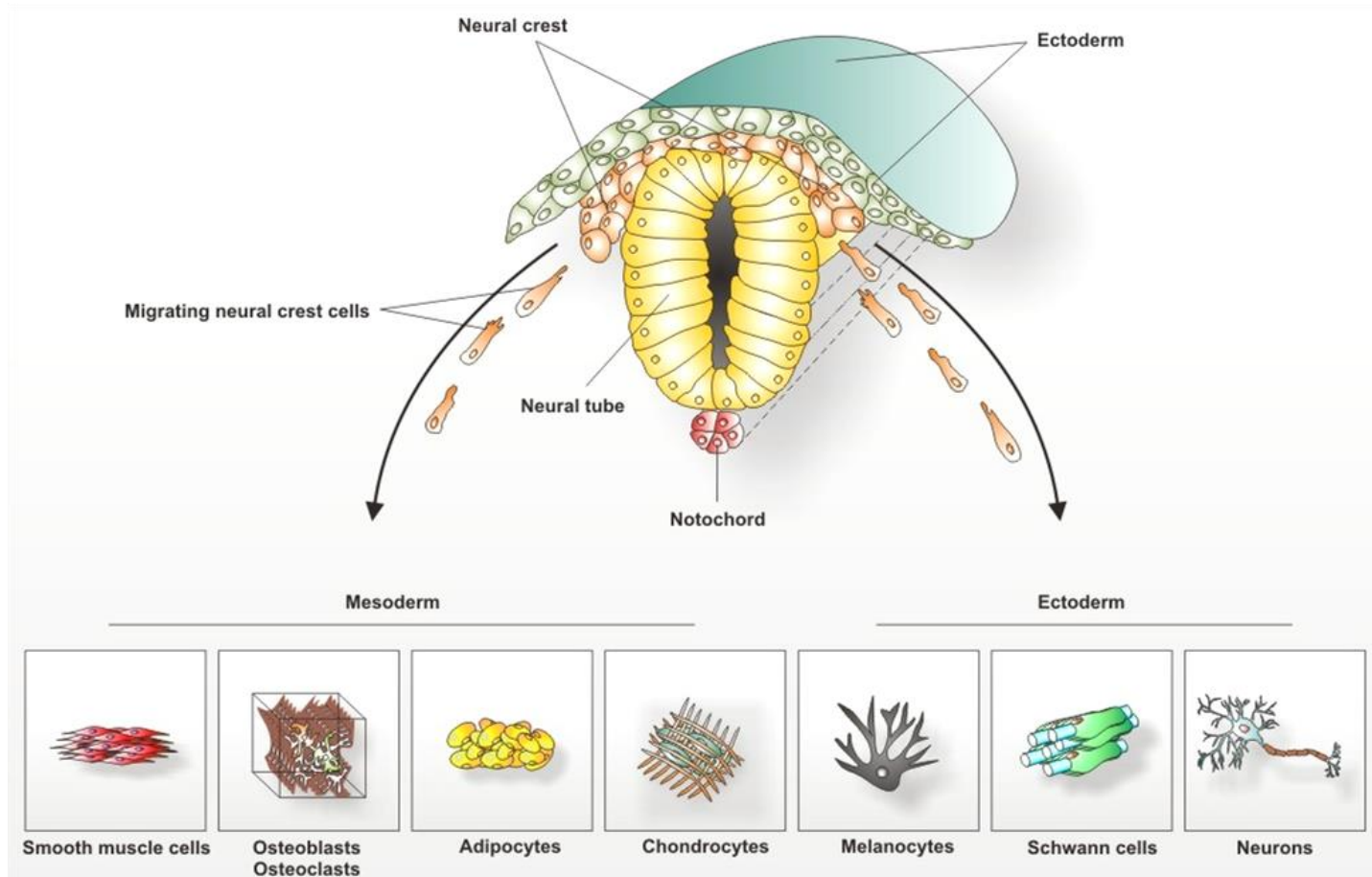
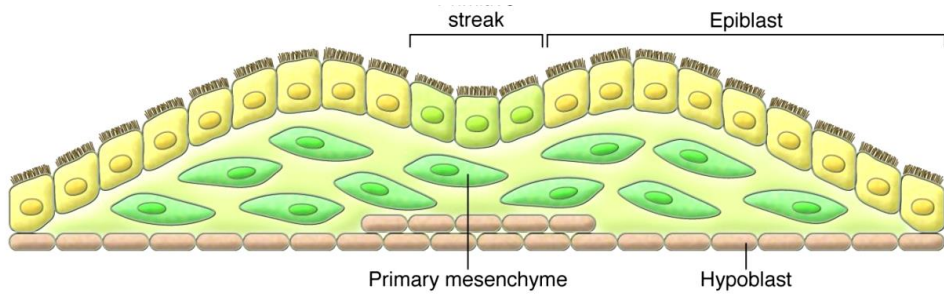


Plasticity of epithelial tissues

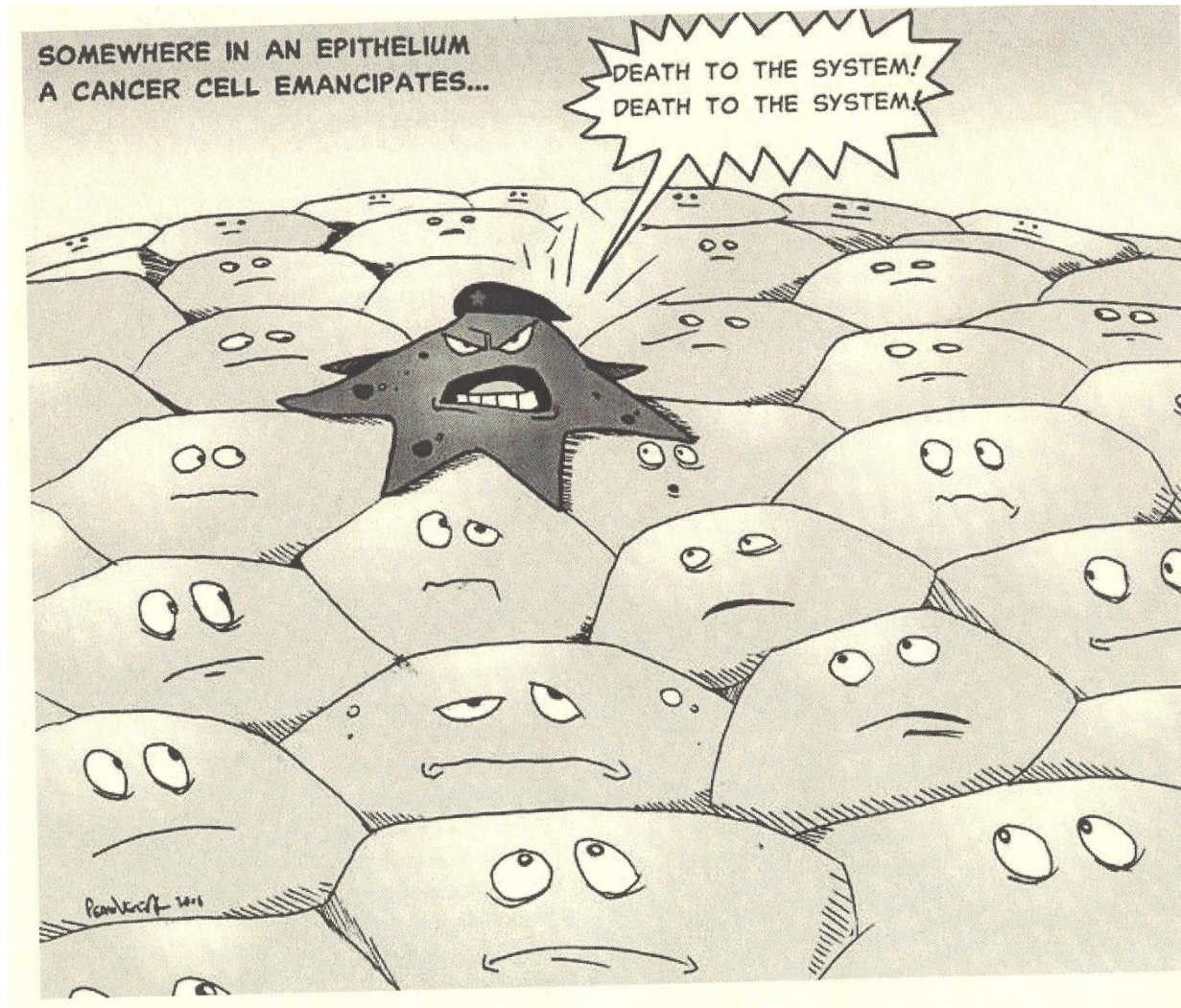
Epithelial to mesenchymal transition (EMT)



■ EMT in embryonic development

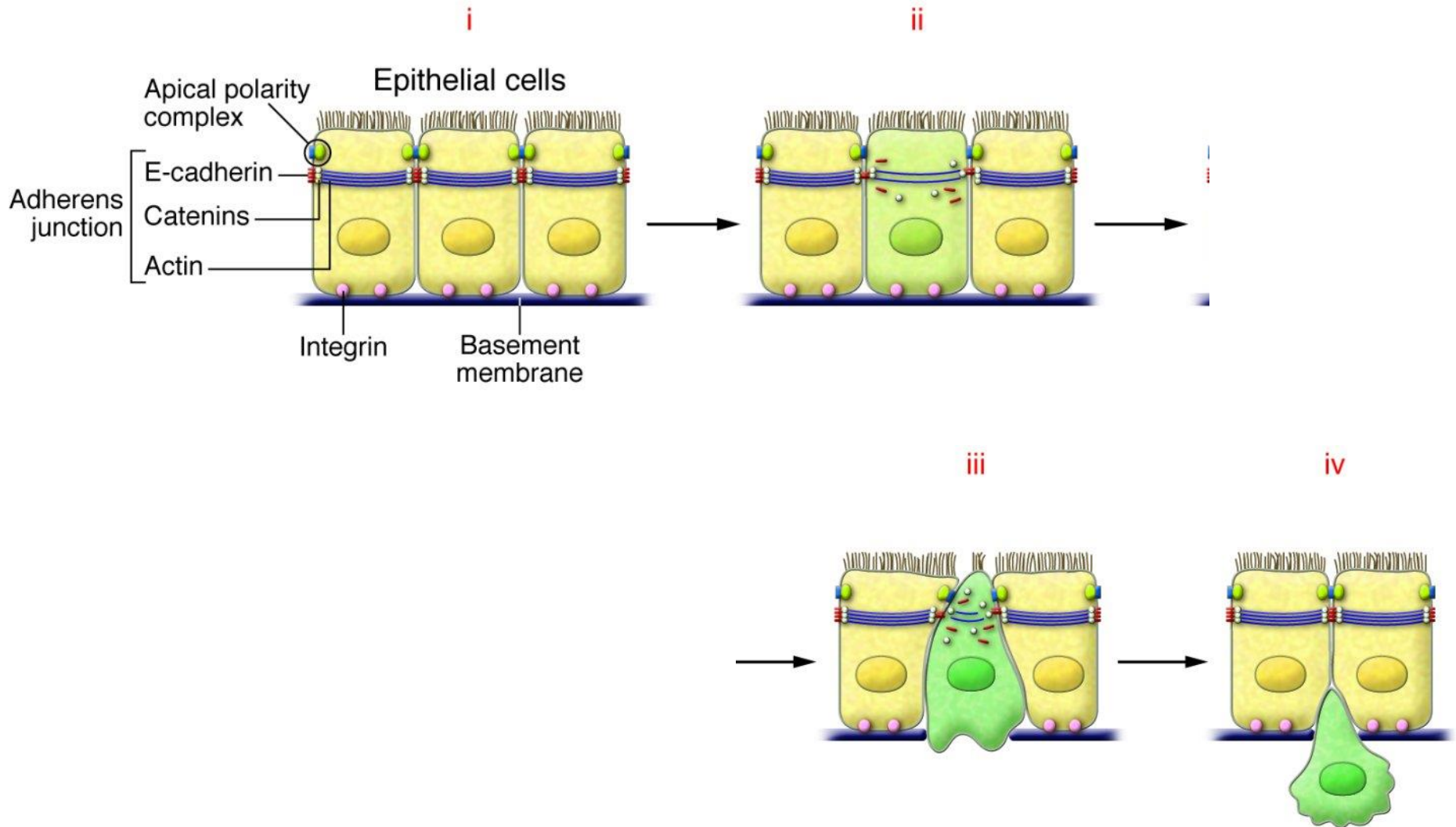


Plasticity and regeneration of the epithelial tissue...

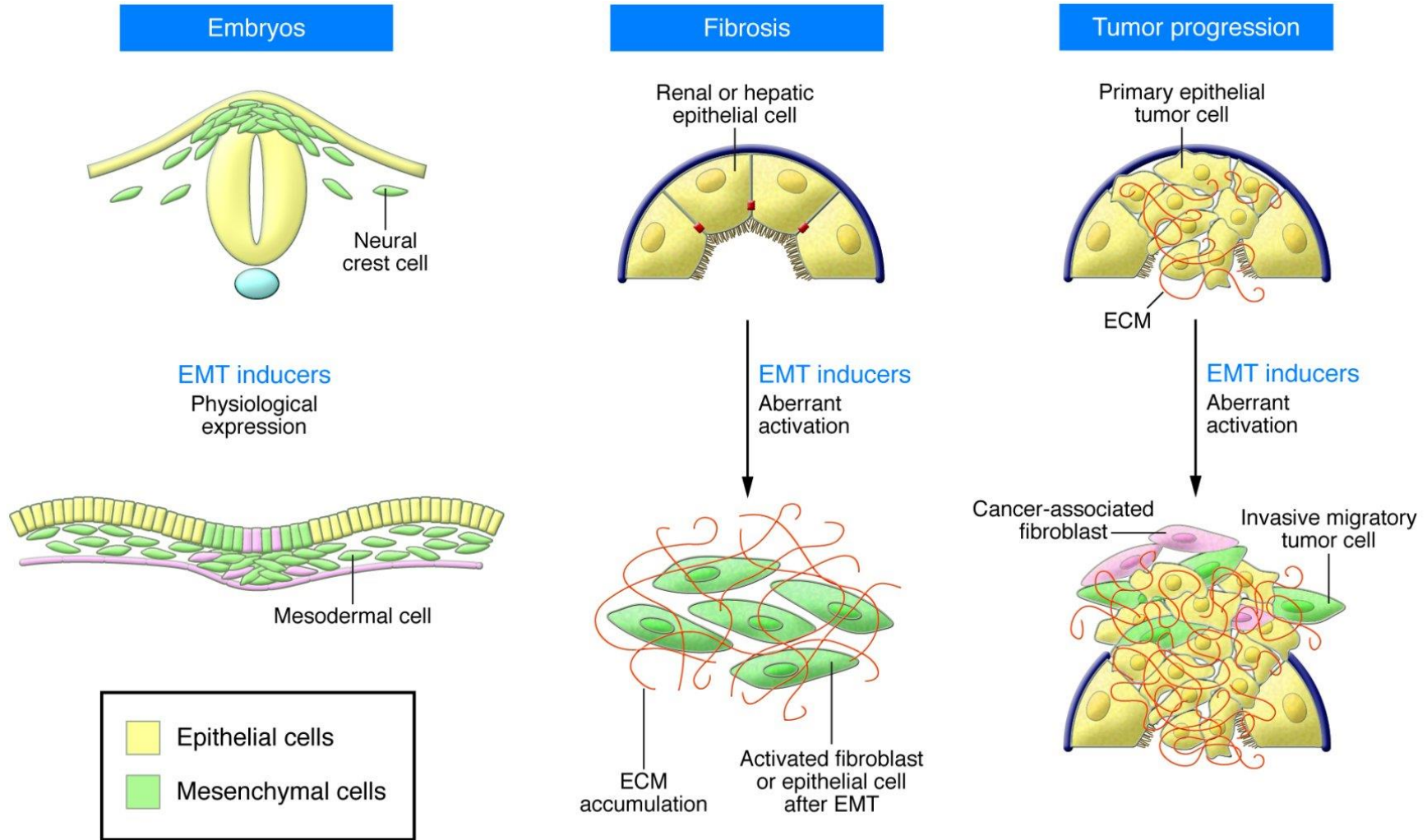


... has also a reverse side

■ EMT and tumor dissemination

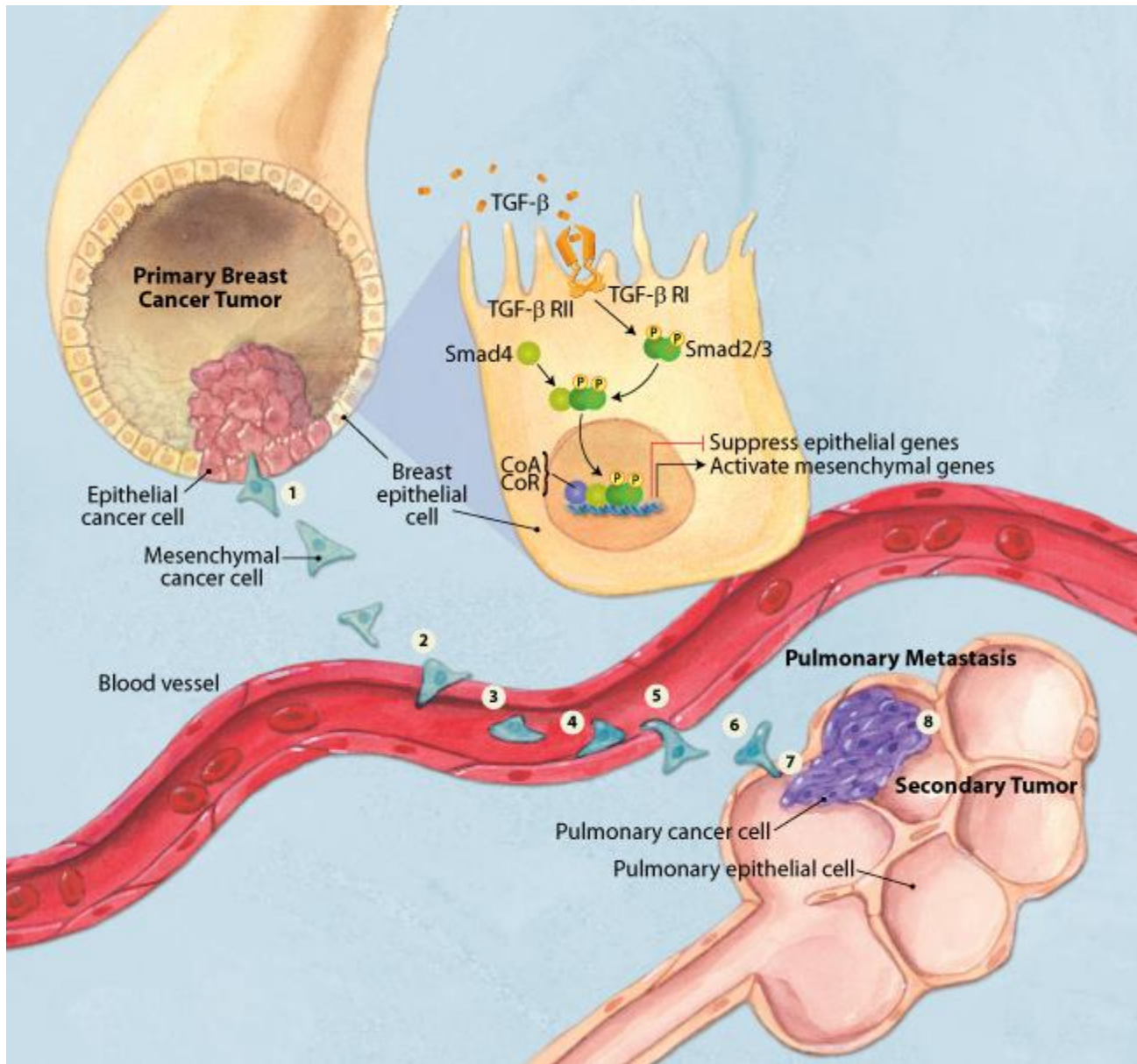


■ Cancer development and regeneration share common mechanisms



Clinical correlations – Epithelial to mesenchymal transition

Cancer



Thank you for attention

pvanhara@med.muni.cz

<http://www.med.muni.cz/histol/histolc.html>

