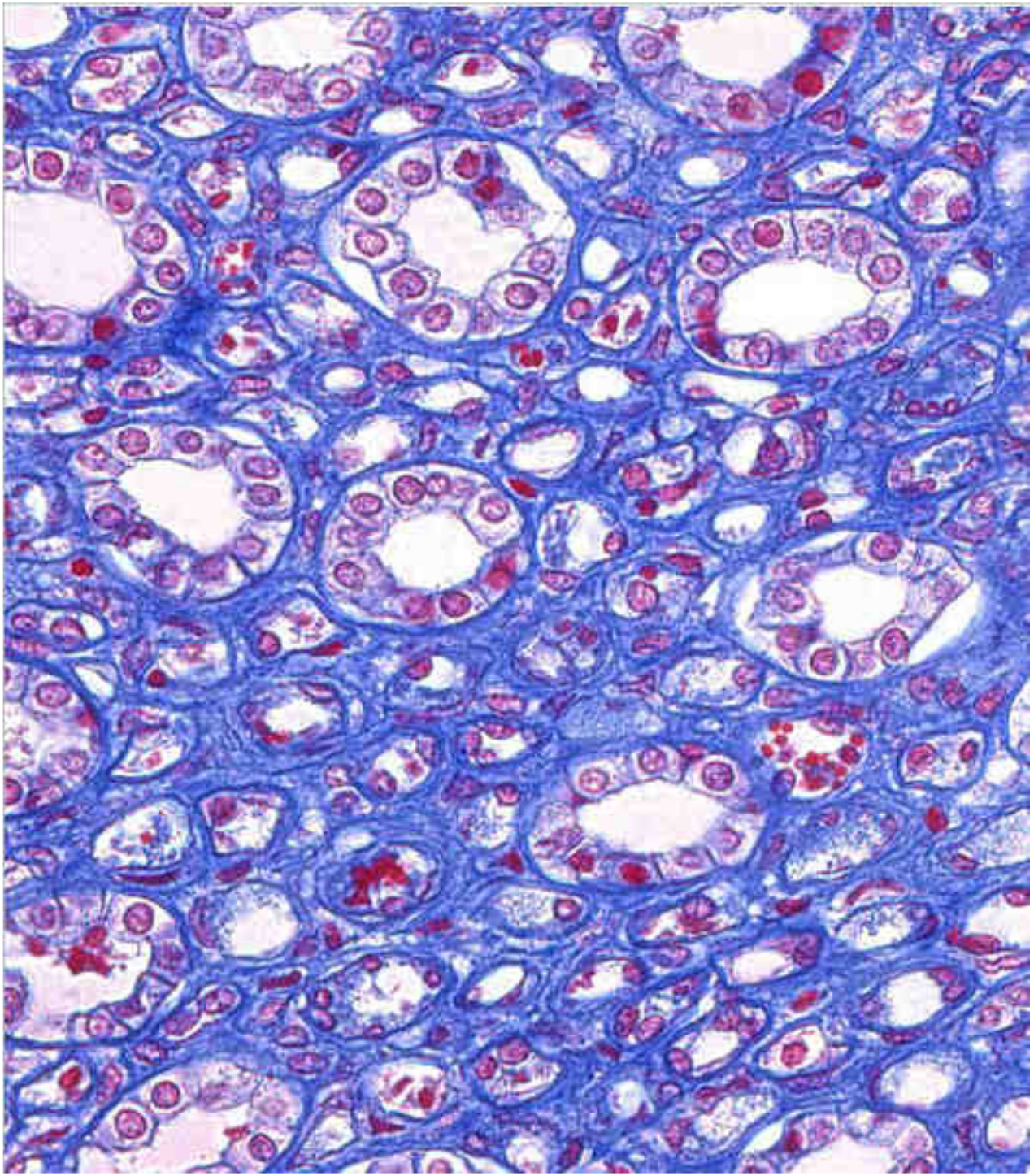

Epithelial tissue

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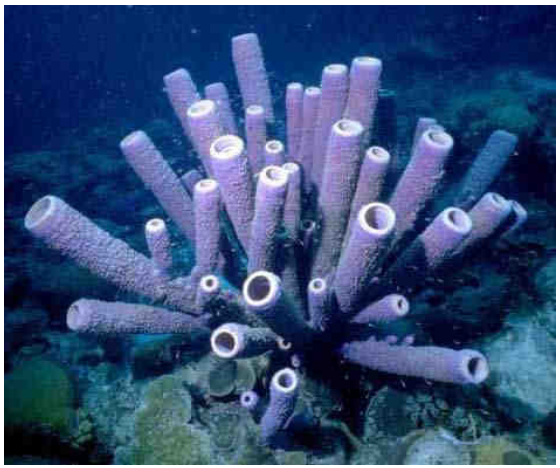
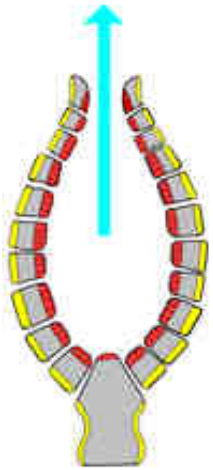
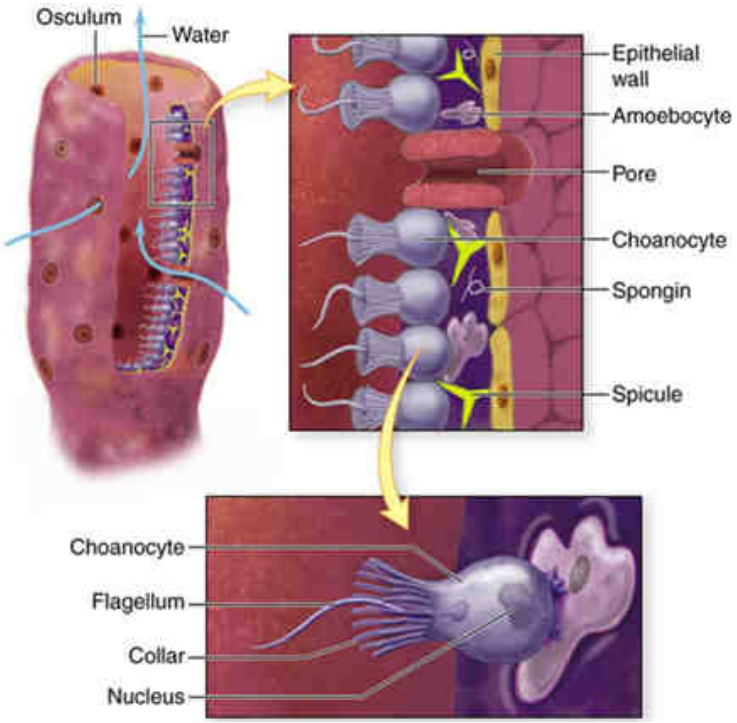
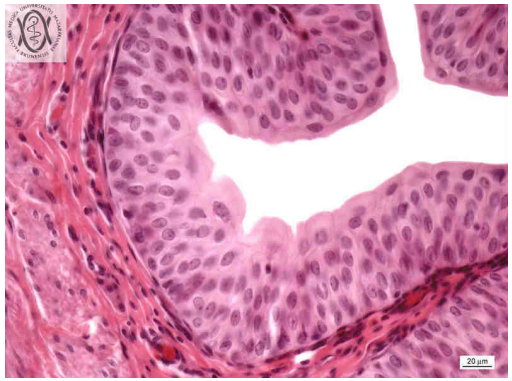
General characteristics of epithelial tissue - lessons from Sponges

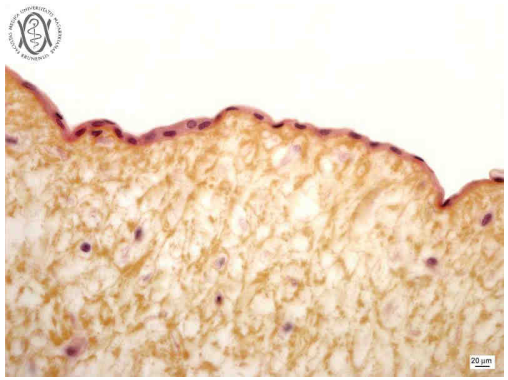
- Very early event and very novel innovation in Metazoa evolution
- From simple colonies of cells to highly specialized tissue structures
- Boundaries and interfaces
- Dividing of the body into separated compartments → separating individual milieu
- Lining of cavities or interfaces of open space
- Attachment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

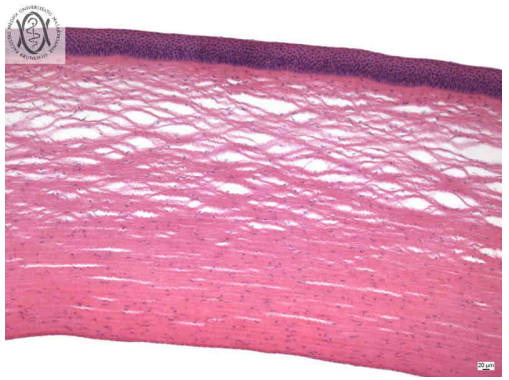


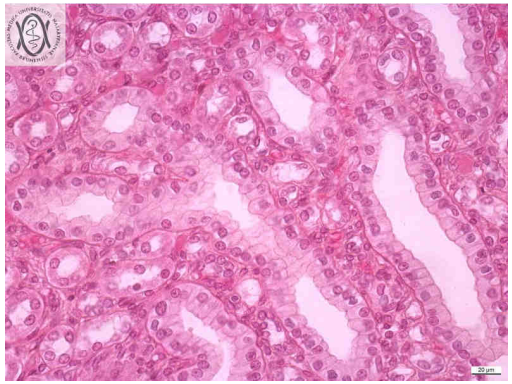


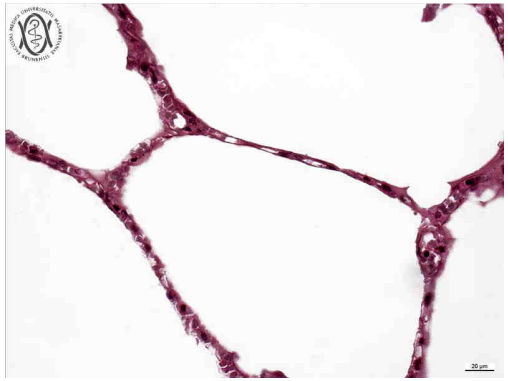


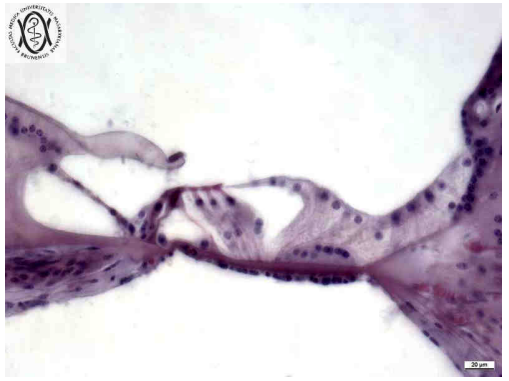


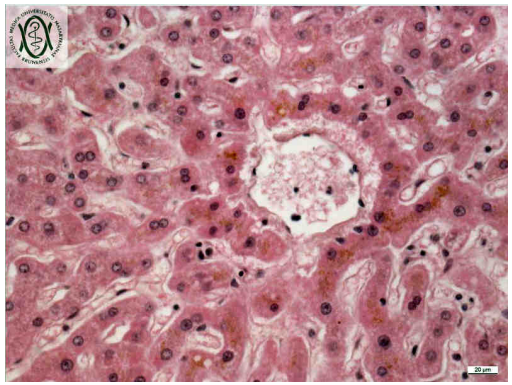


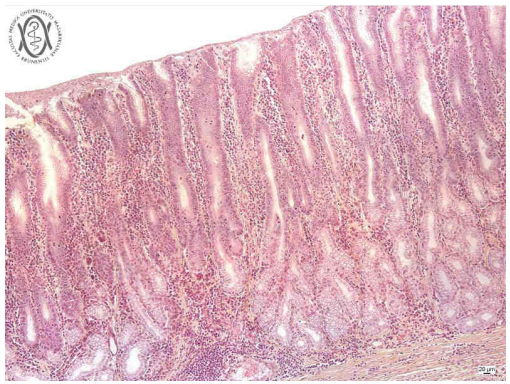


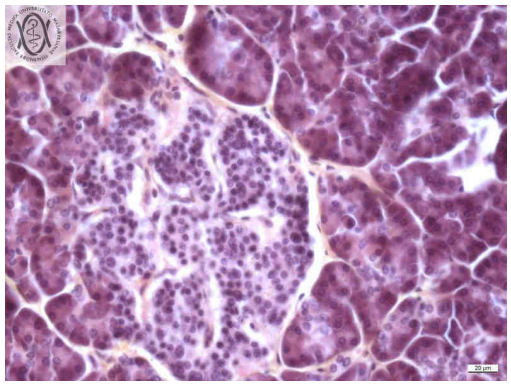






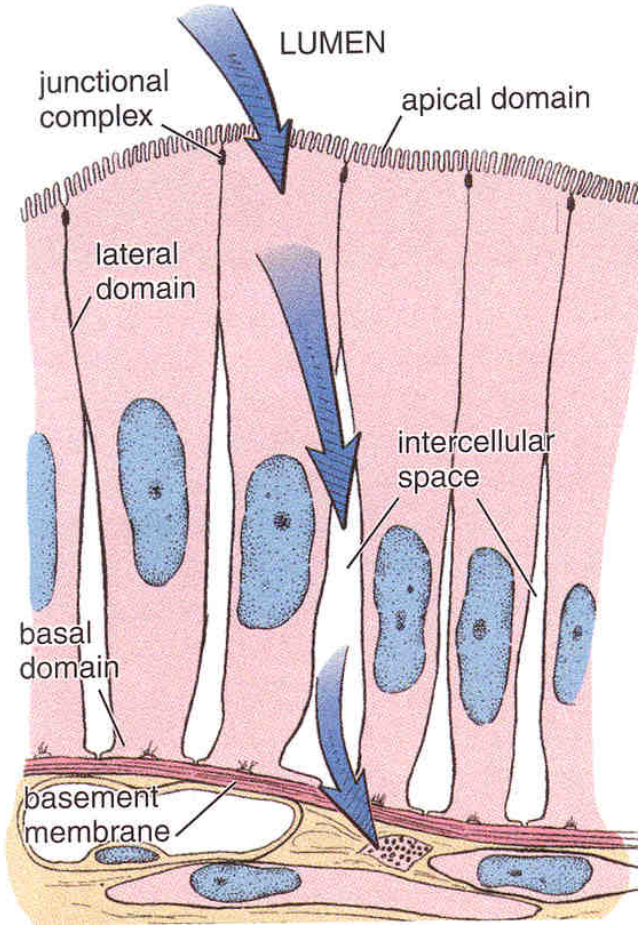


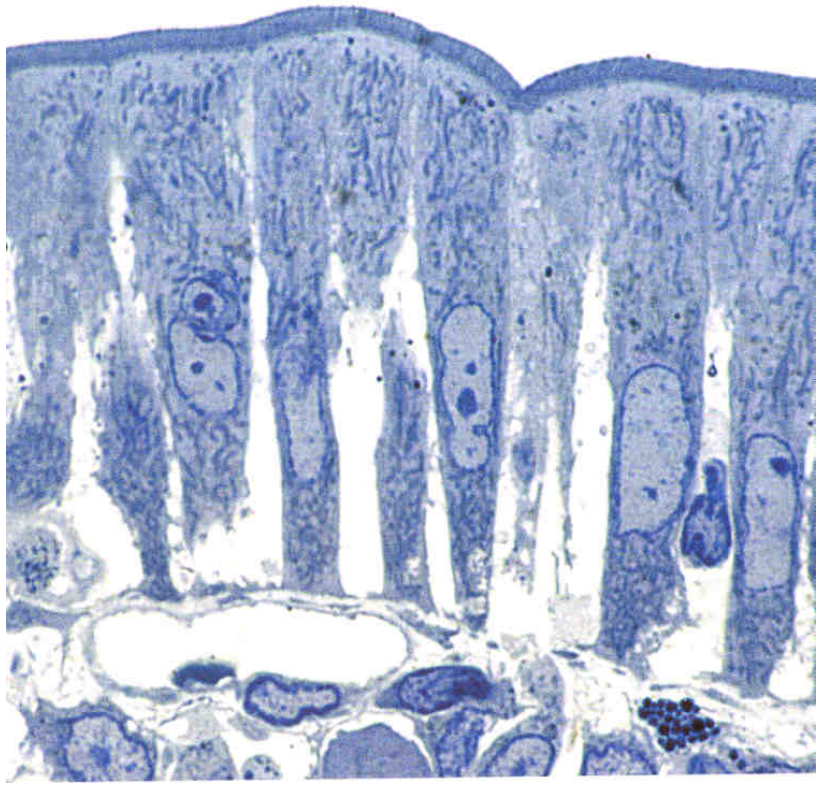




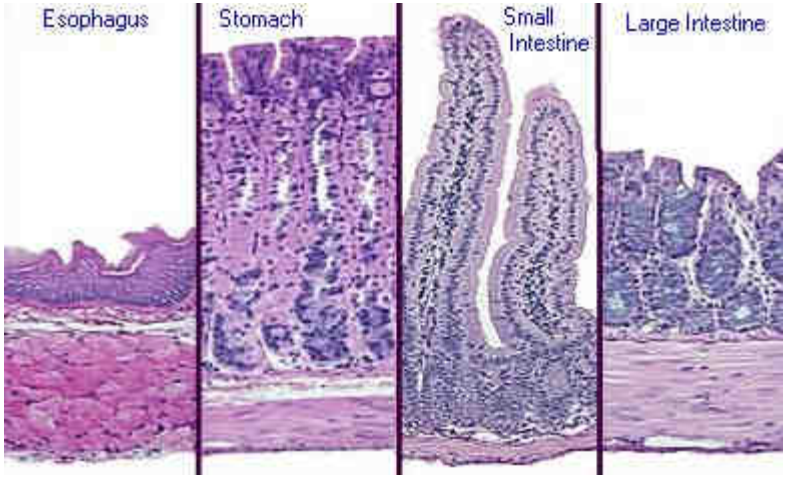
Hallmarks of epithelial tissue

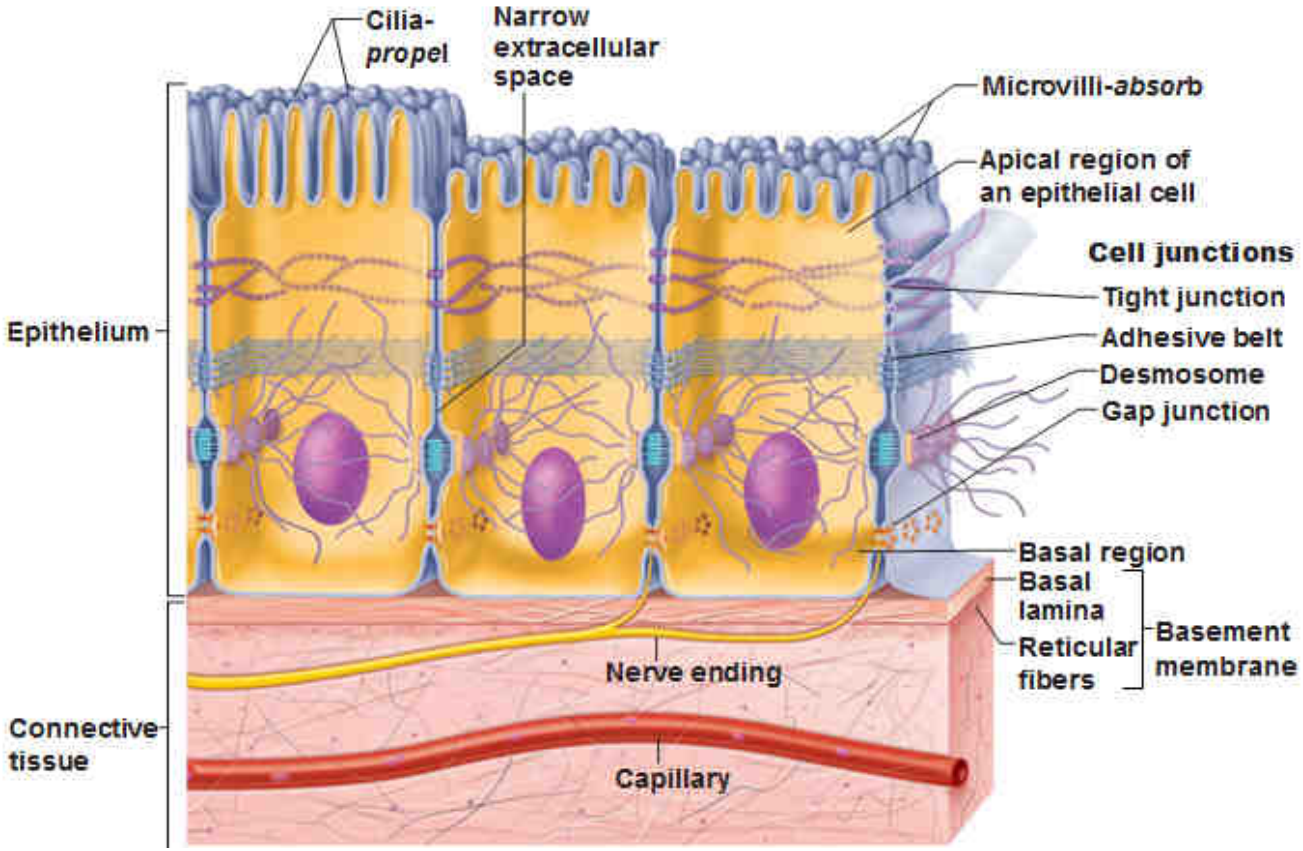
- Avascular (without blood supply) – nutrition by diffusion from a highly vascular and innervated area of loose connective tissue (*lamina propria*) just below the basement membrane
- Highly cellular – cohesive sheet or groups of cells with no or little extracellular matrix
- Typical morphology and cell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





- Hallmarks of epithelial cell

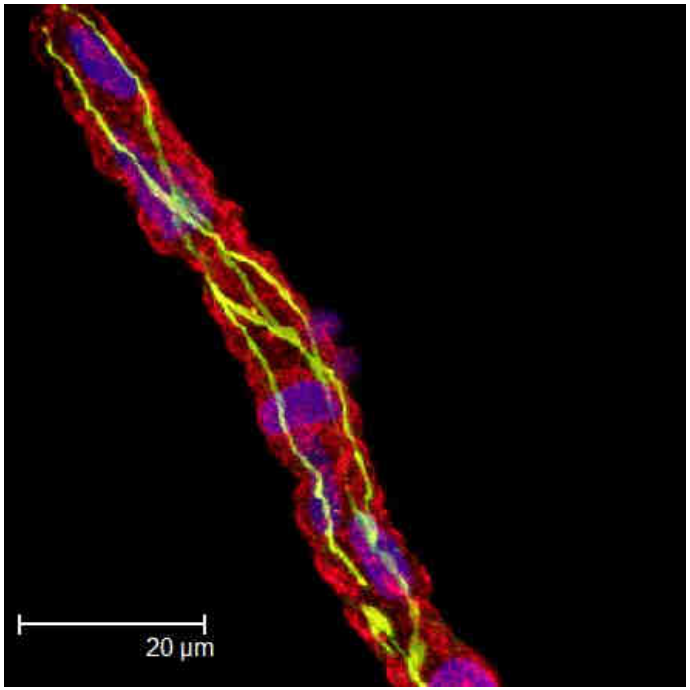


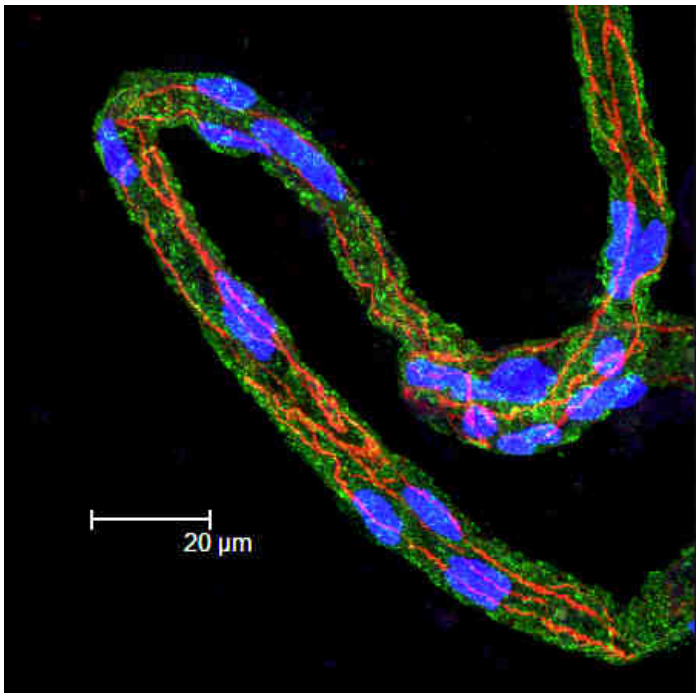


Diffusion barriers

– Epithelia separate intercellular spaces – compartmentalization

- intestine epithelium
- kidney epithelium
- secretory and duct parts of exocrine glands
- endothelium in brain capillaries (blood brain barrier)
- plexus choroideus (blood-liquor barrier)

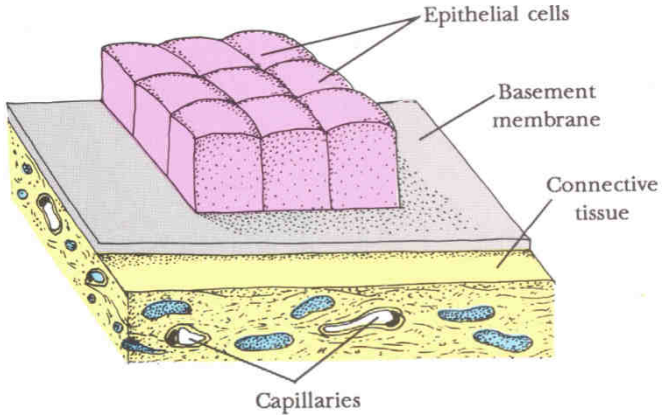


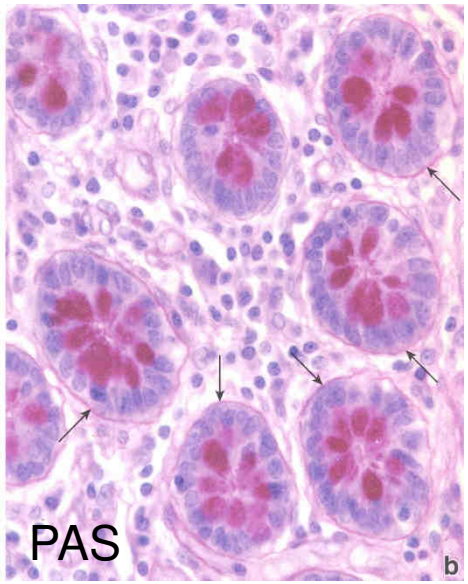


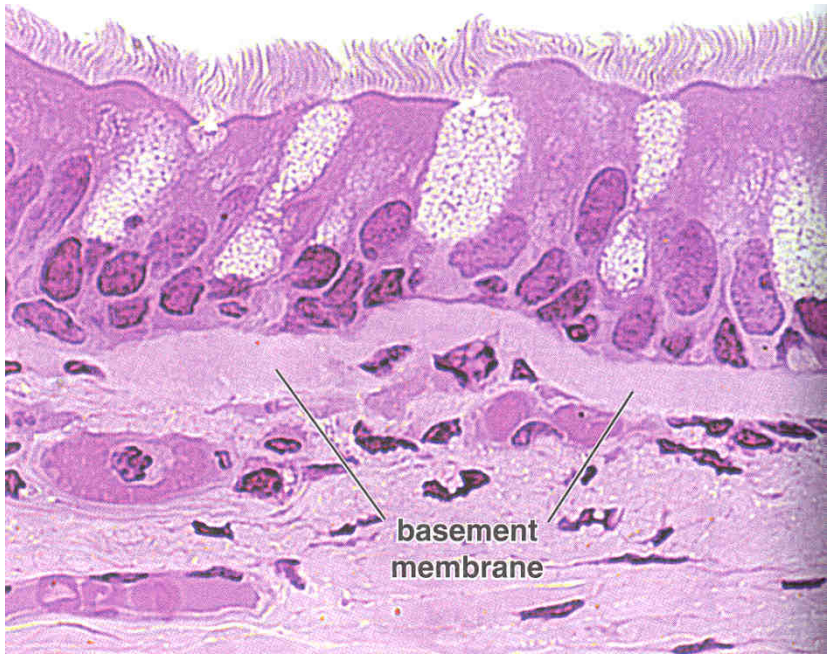
microvessel stained for focal adhesion kinase (green), zonula occludens 1 (red) and endothelial nuclei (blue)
http://commons.wikimedia.org/wiki/File:Brain_Microvessel.tif

Basement membrane (*membrana basalis*)

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

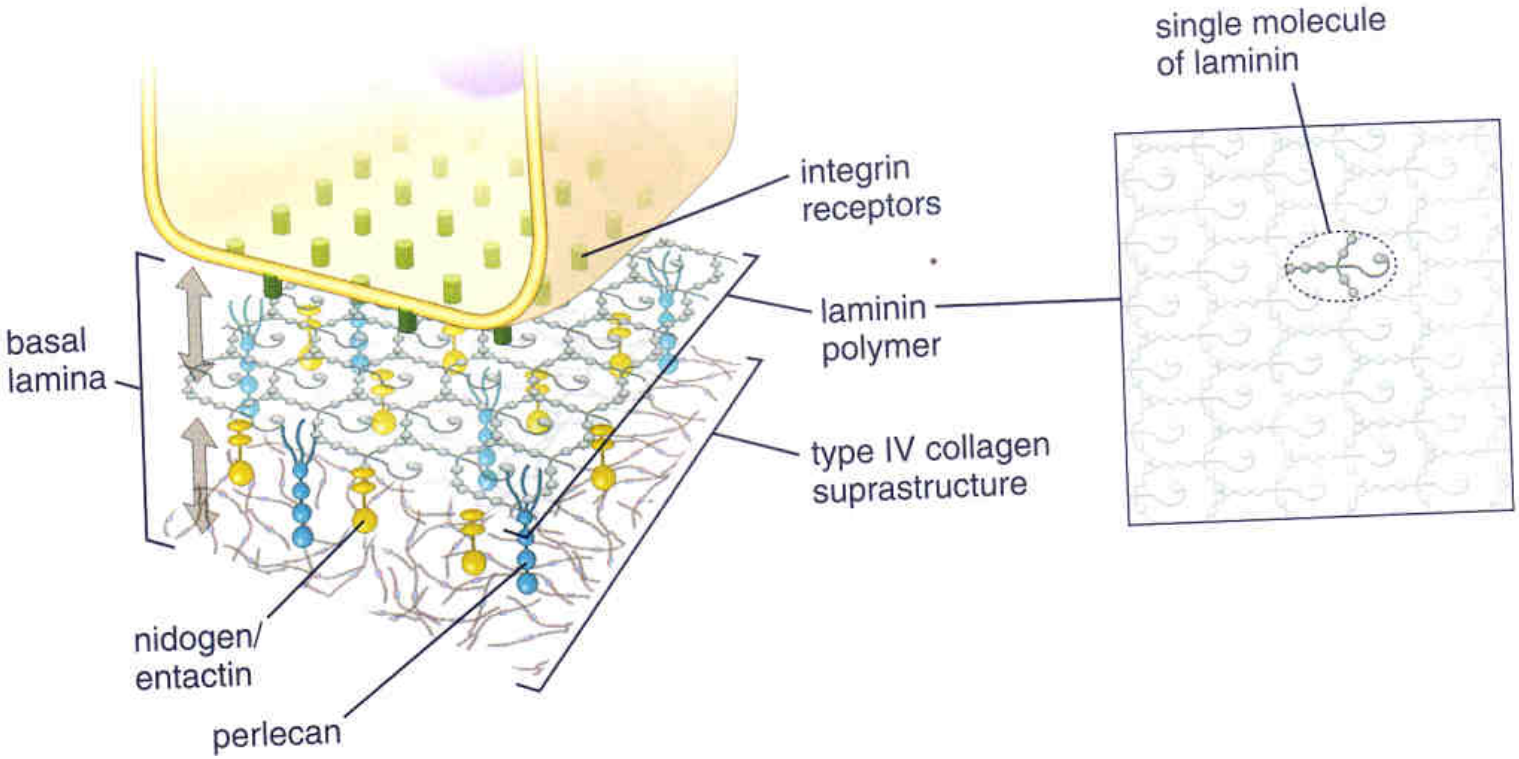




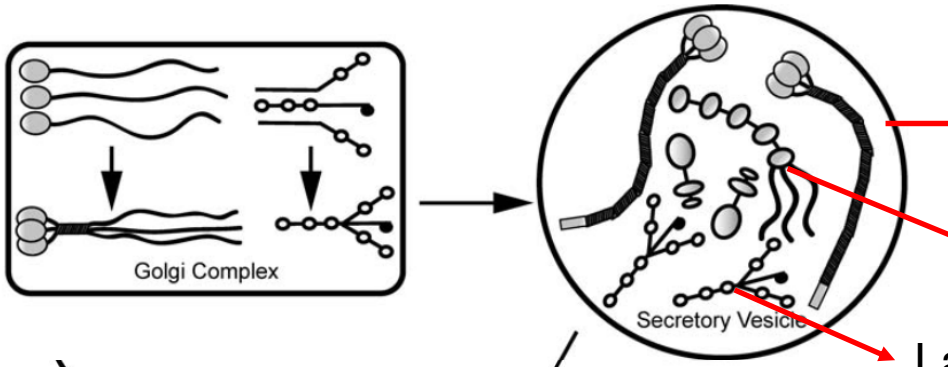


- Basement membrane matrix

- 50 – 100 nm
- Glycosaminoglycans – heparansulphate
- Laminin, collagen III, IV, VI
- Nidogen, entactin, perlecan, proteoglycans



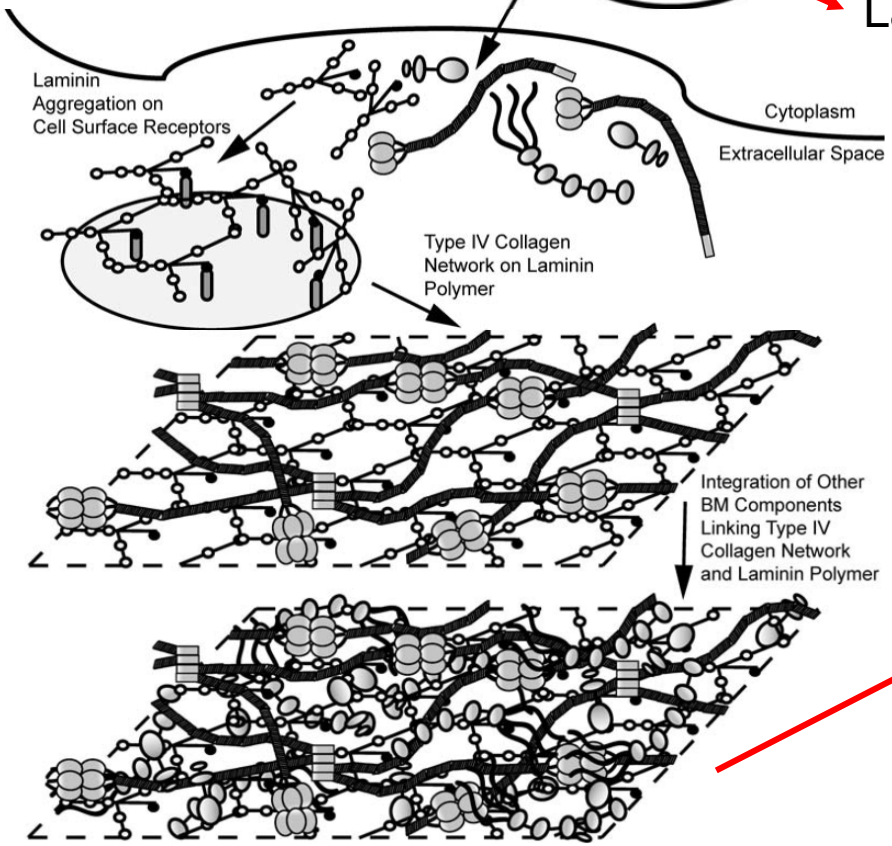
Basal membrane

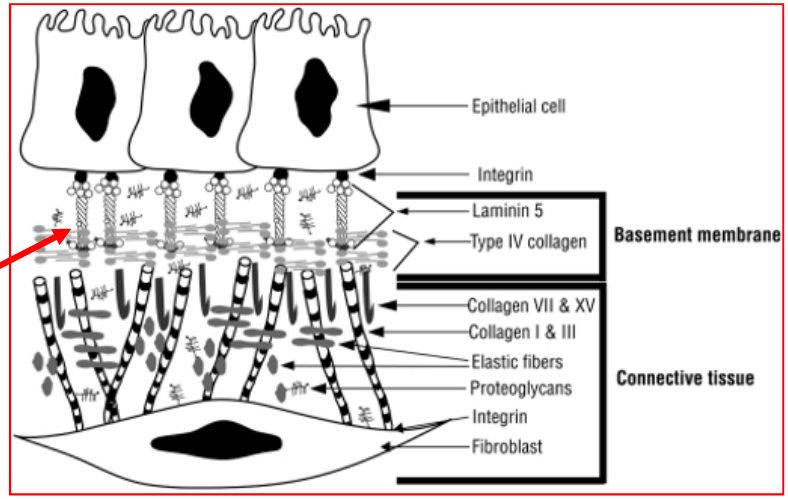


Kolagen IV

Perlecan,
Nidogen/Entactin

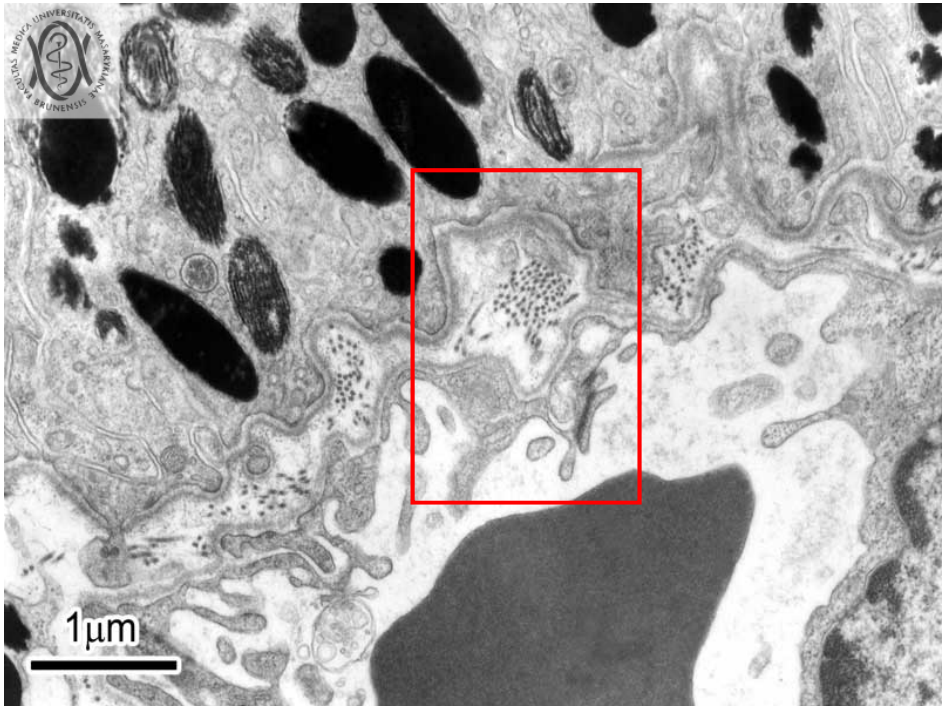
Laminin

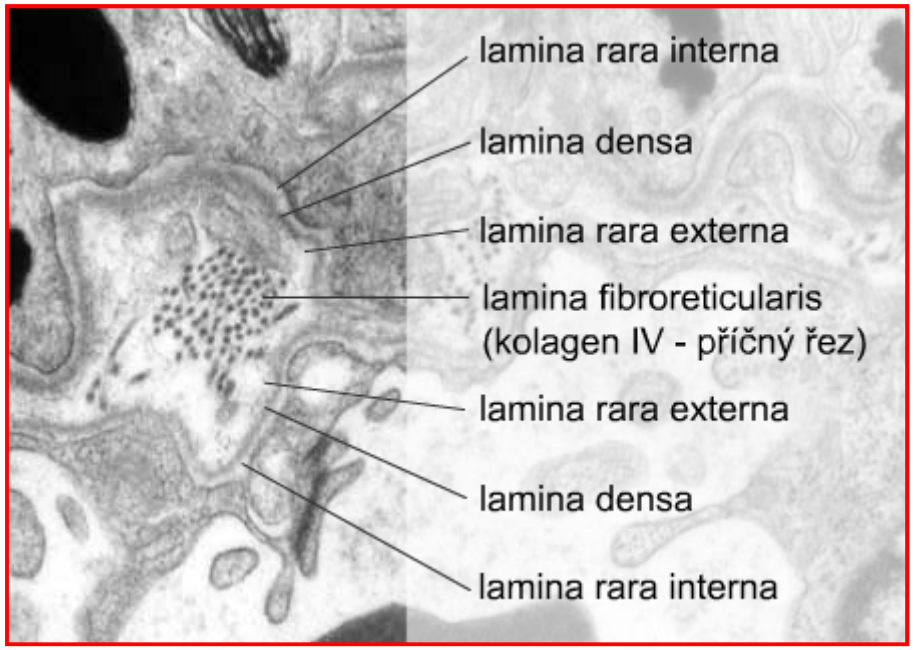




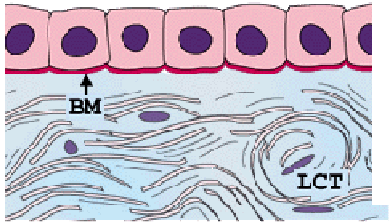
Dunsmore SE, Chambers RC, Laurent GJ. 2003. Matrix Proteins. Figure 2.1.2. In: Respiratory Medicine, 3rd ed. London. Saunders, p. 83; Dunsmore SE, Laurent GJ. 2007. Lung Connective Tissue. Figure 40.1. In: Chronic Obstructive Pulmonary Disease: A Practical Guide to Management, 1st ed. Oxford. Wiley-Blackwell, p. 467.

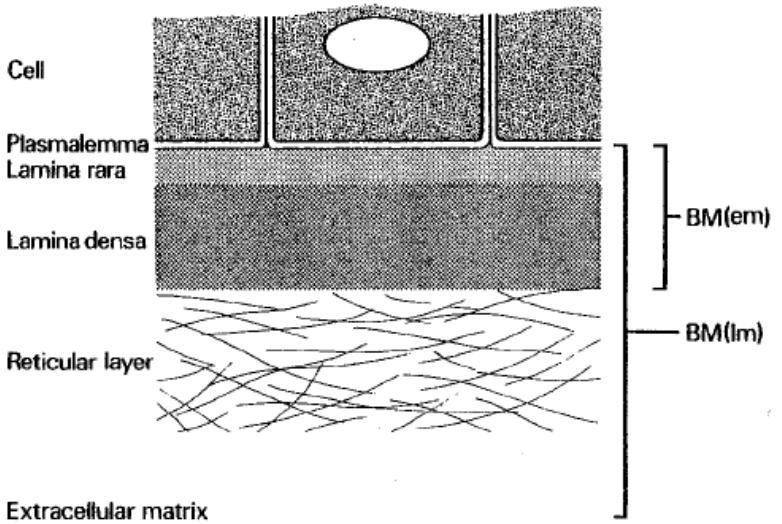
Basement membrane



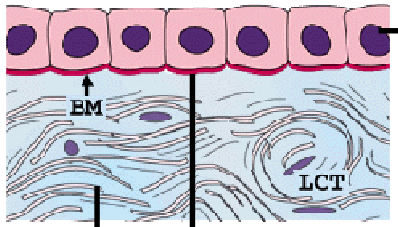


- Two basic layers
  - lamina basalis (basal lamina)
    - lamina densa,
    - lamina rara ext. et int.
  - lamina fibroreticularis

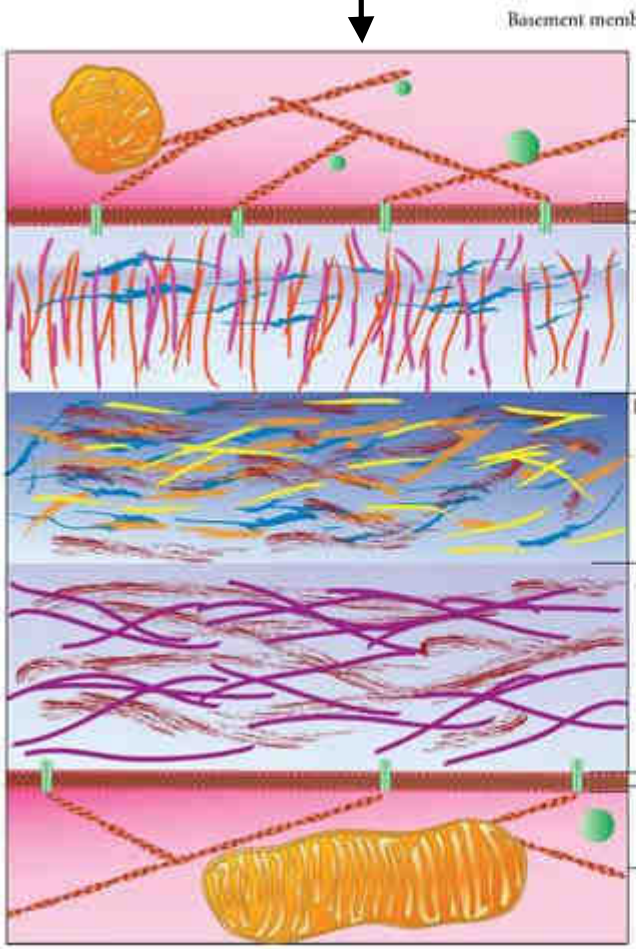




Architecture of basal membrane



BM



Basal lamina

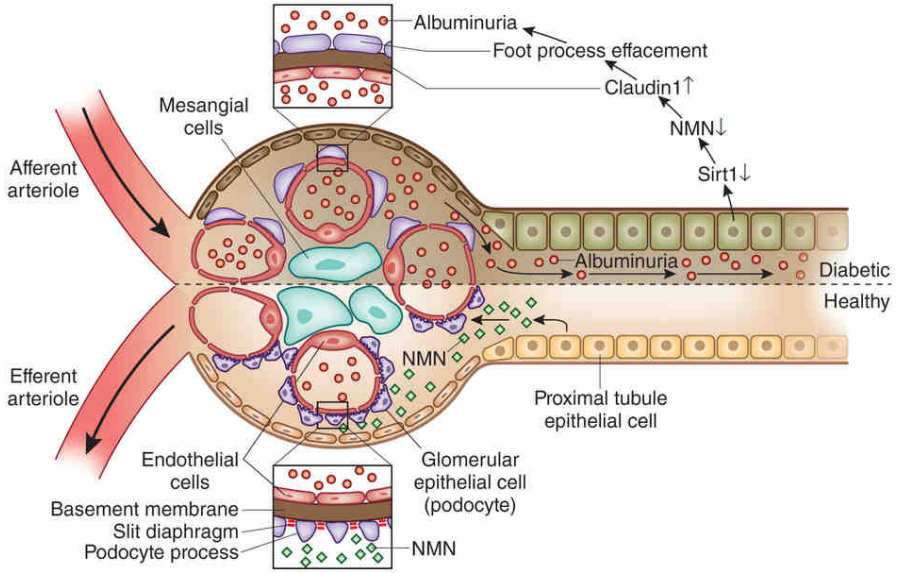
Epithelial cell and Basal lamina

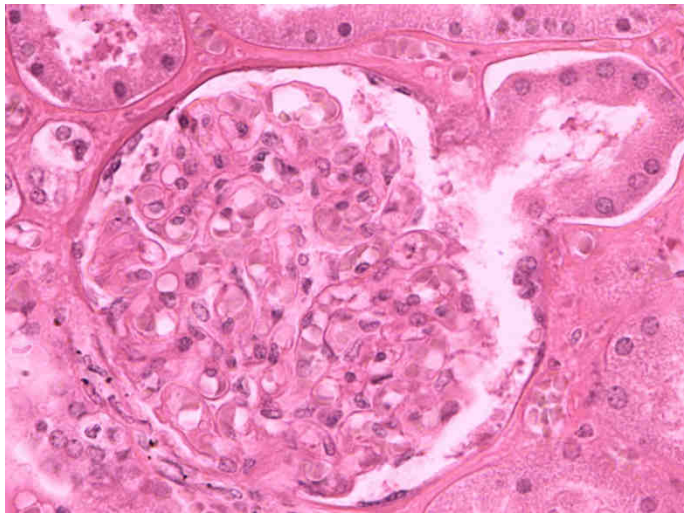
Lamina fibroreticularis

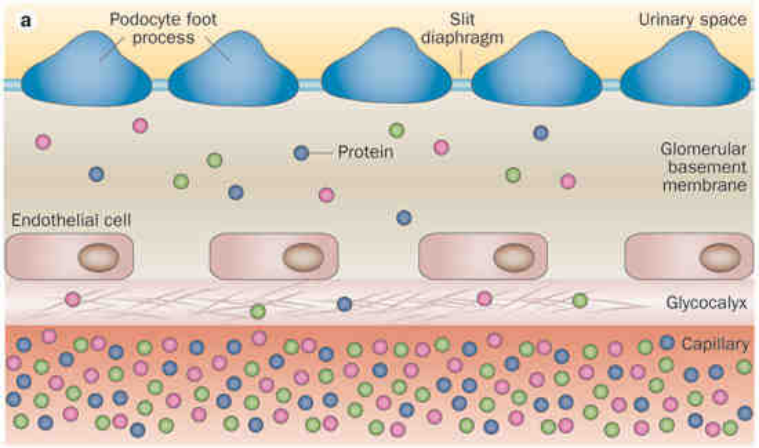
Fibroblasts

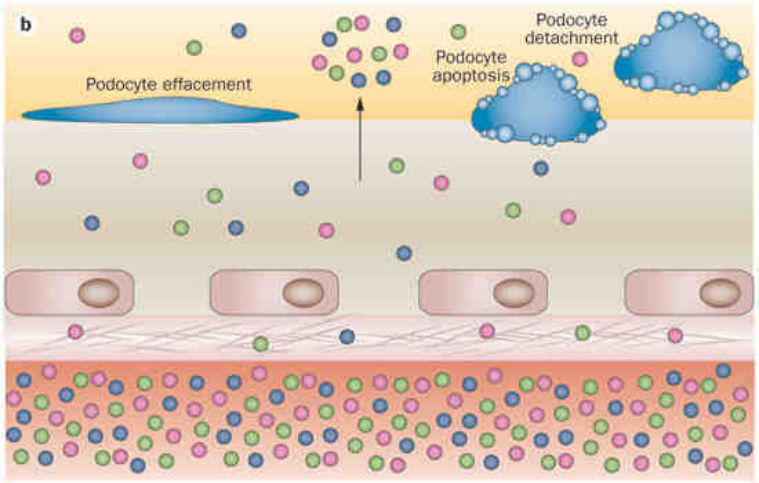
Epithelial layer + lamina propria = MUCOSA

- Basal membrane in corpusculum renis





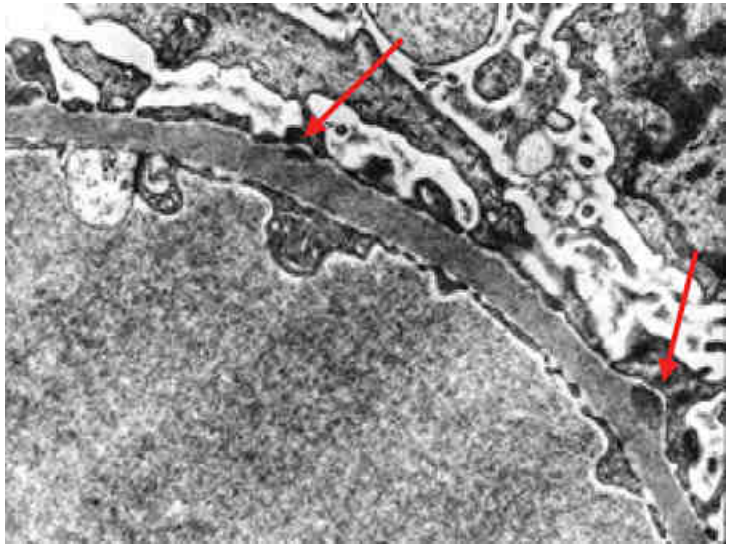


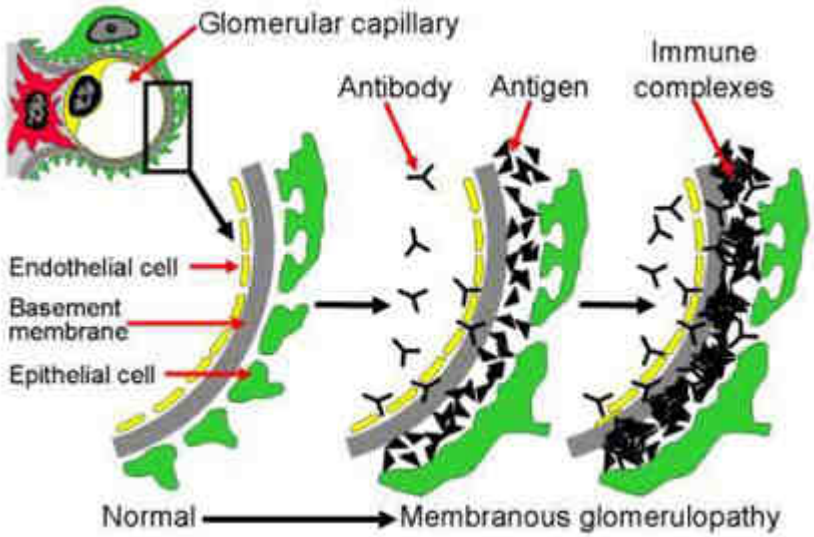


Basement membrane in corpusculum renis

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, hematouria, renal failure

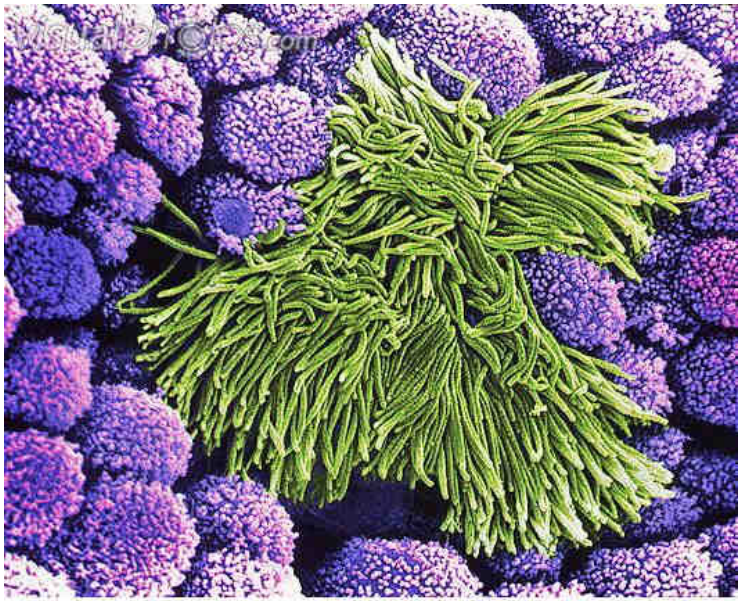


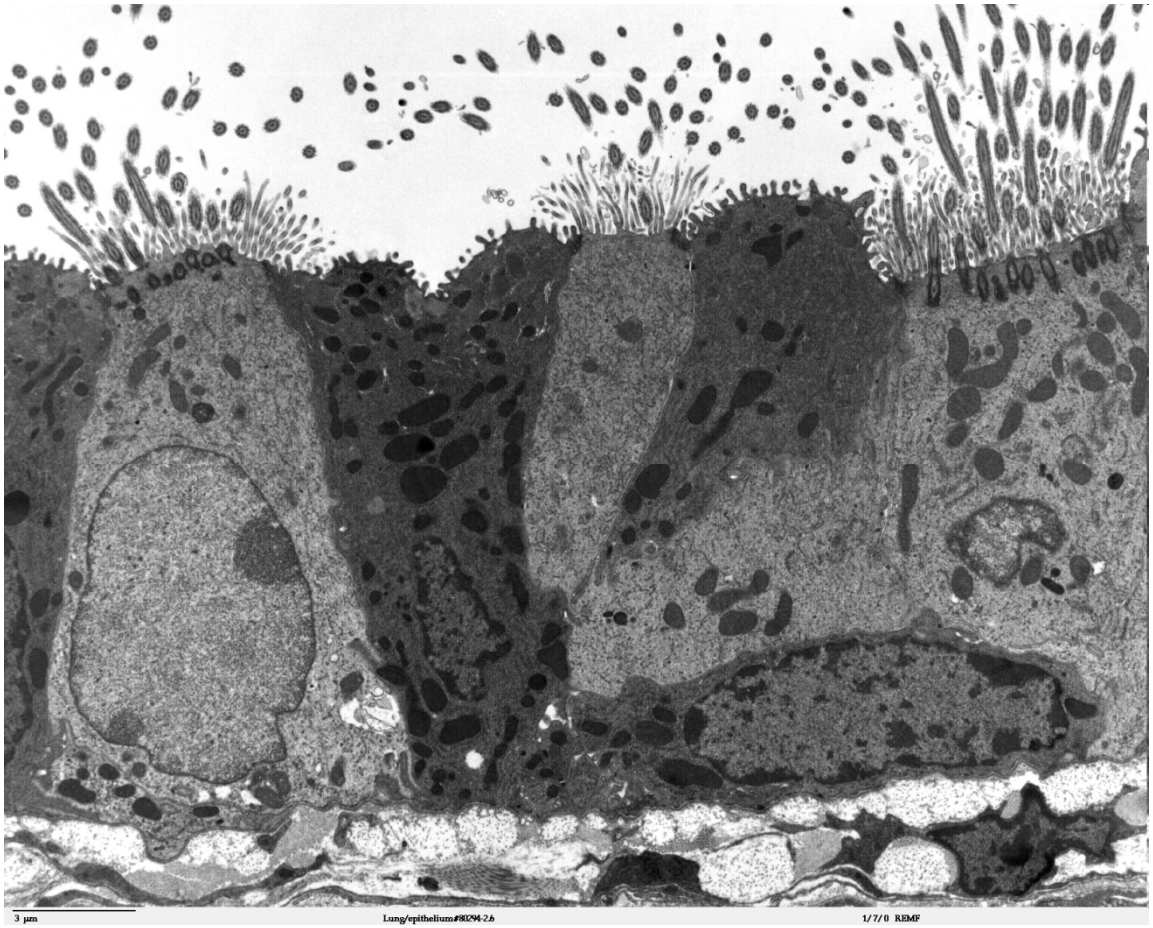


Classification of epithelial tissue

-Based on **morphology** (covering, trabecular, reticular)

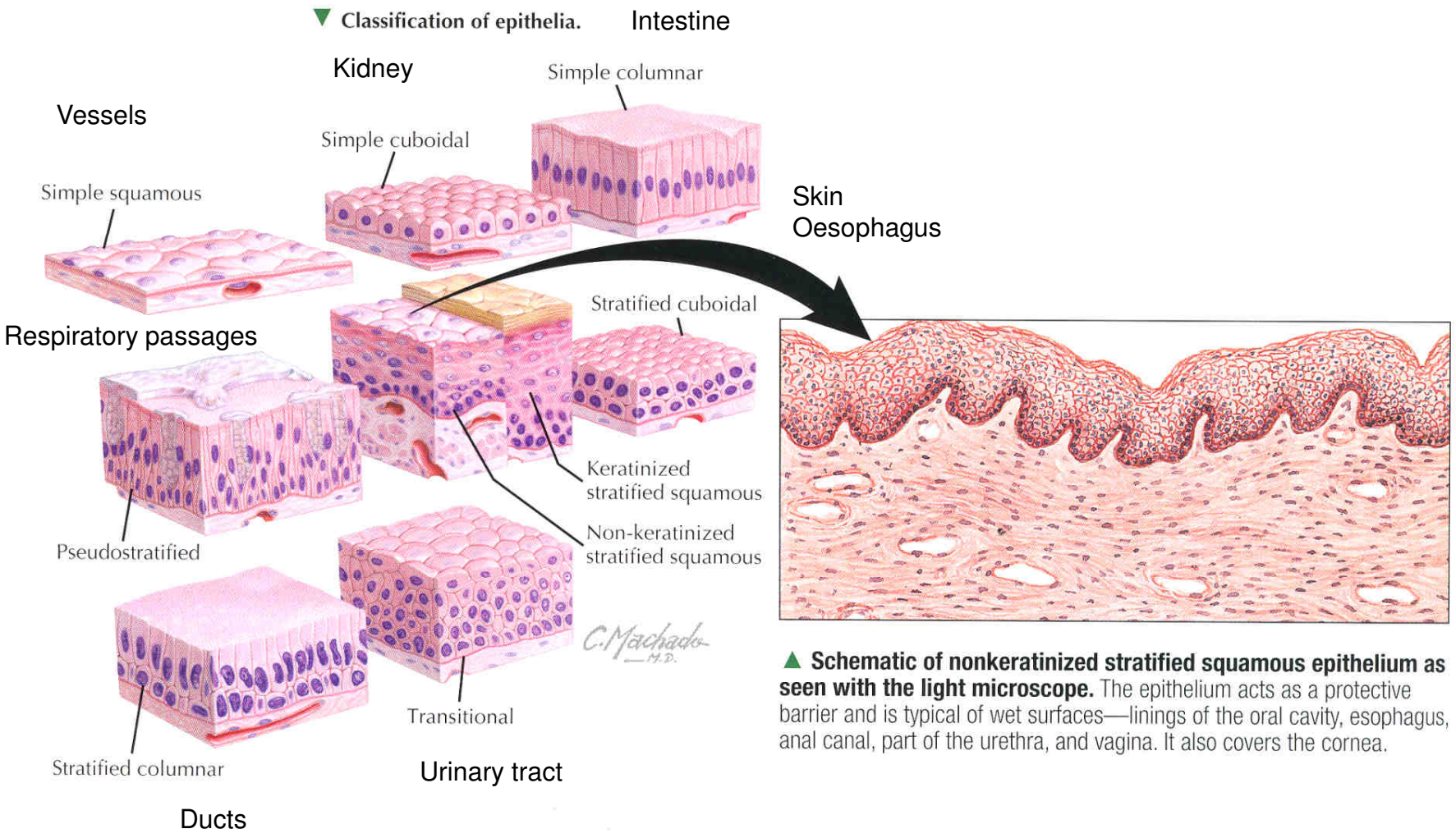
- Based on **function** (glandular, resorptive, sensory, respiratory)





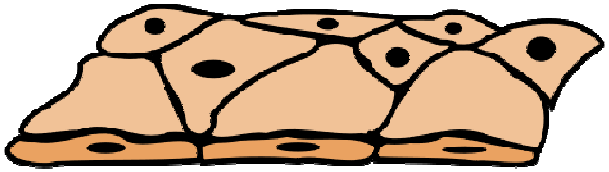
- Classification of epithelial tissues

1. Covering (sheet) epithelia



▲ **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**



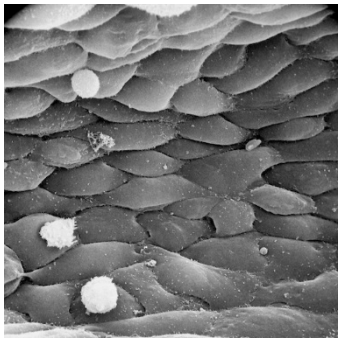
– Single layer of flat cells with central flat nuclei

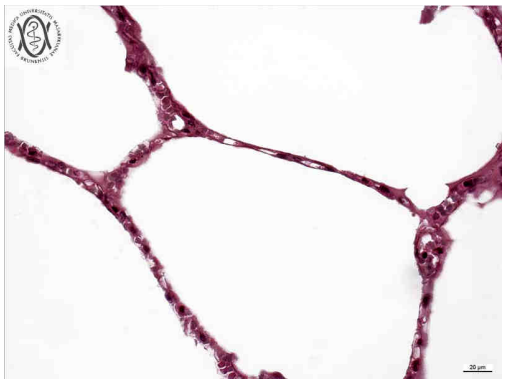
– Capillaries
– Lung alveolus
– Glomerulus in renal corpuscle

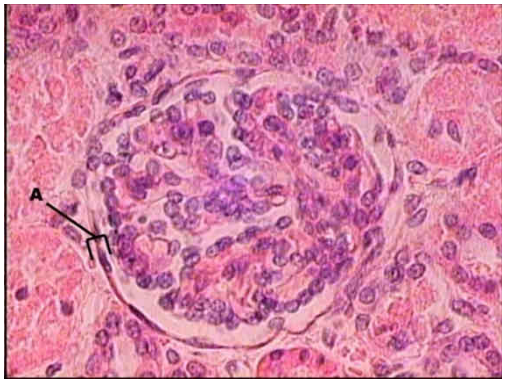
Selective permeabilty

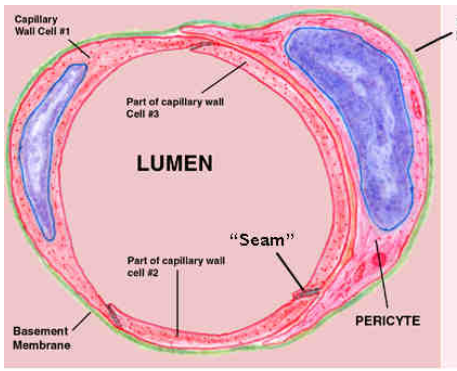
Endothelium.
heart, blood, and lymphatic vessels.

Mesothelium.
serous membranes - body cavities

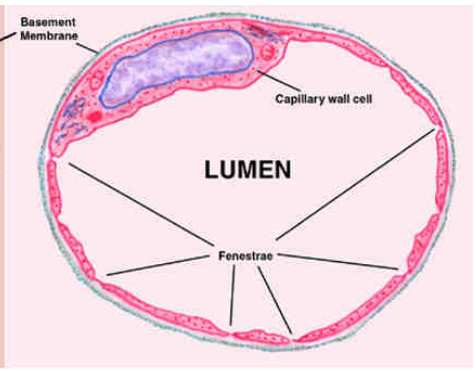








Closed or Continuous Capillary



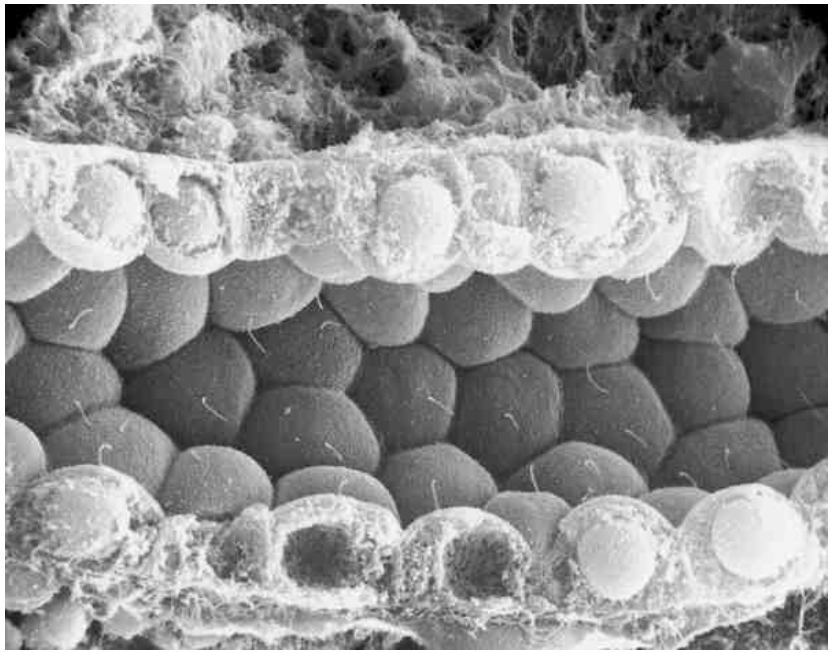
Fenestrated Capillary

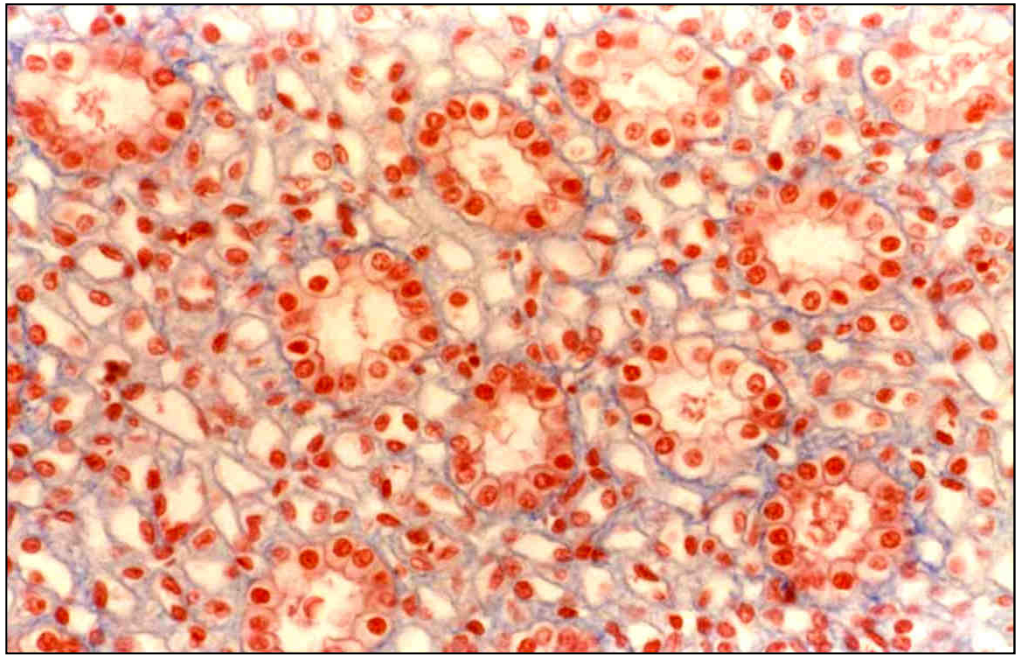

Kapillare des Glomerulums
x10000
2µm
5kV
4mm

- **Simple cuboidal epithelia**

– Single layer of cuboidal cells with large, spherical central nuclei

– Secretion or resorption

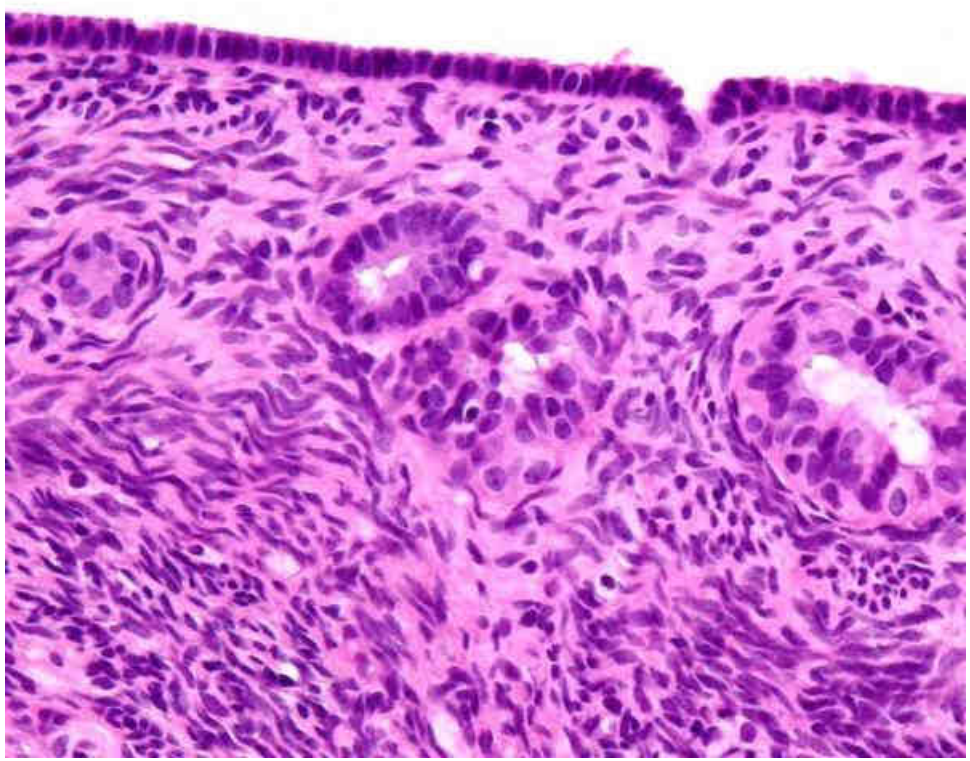




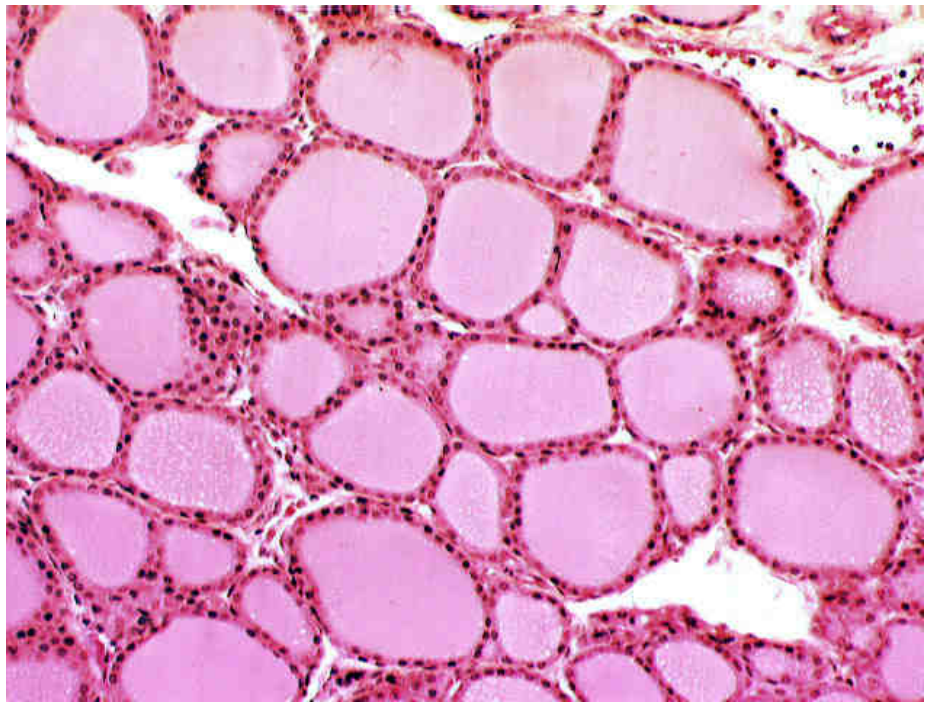
Examples:

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

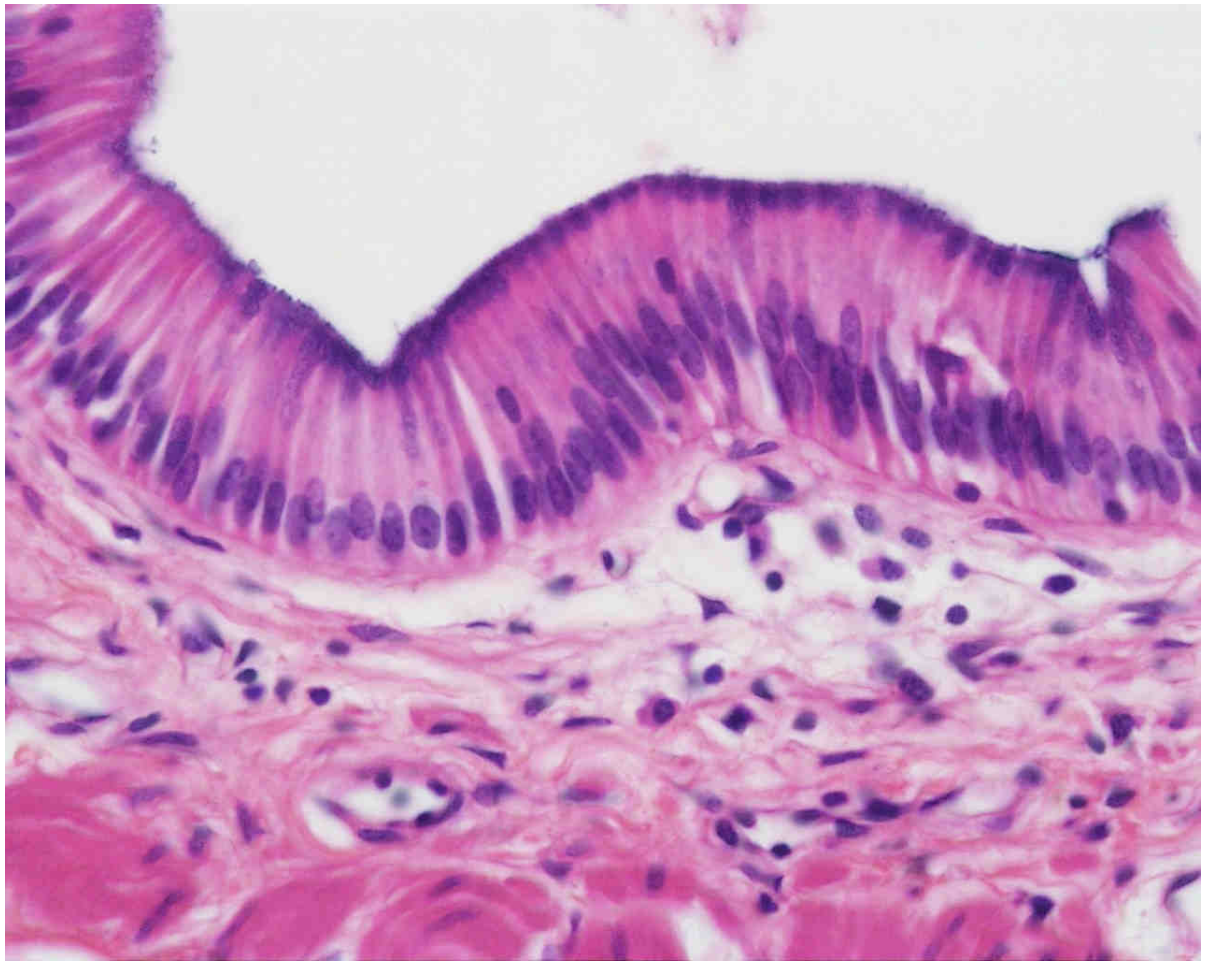
Ovarian surface epithelium

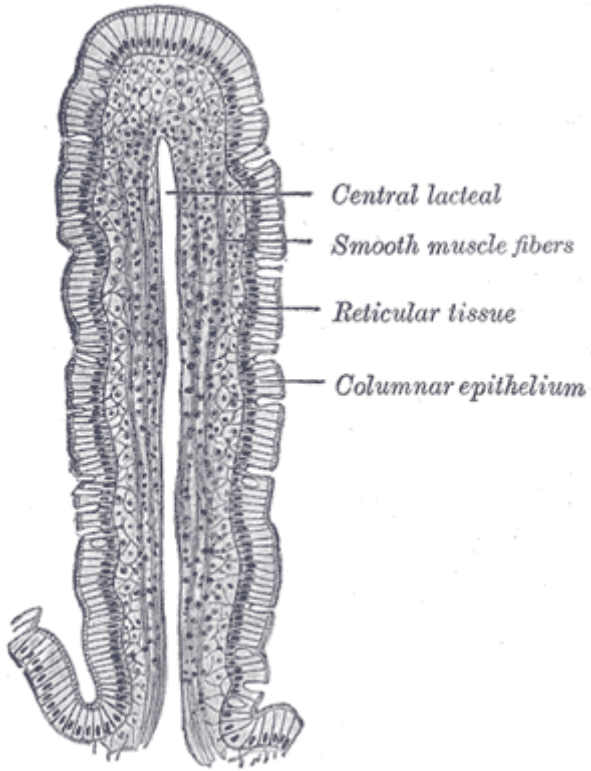


Thyroid follicles



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

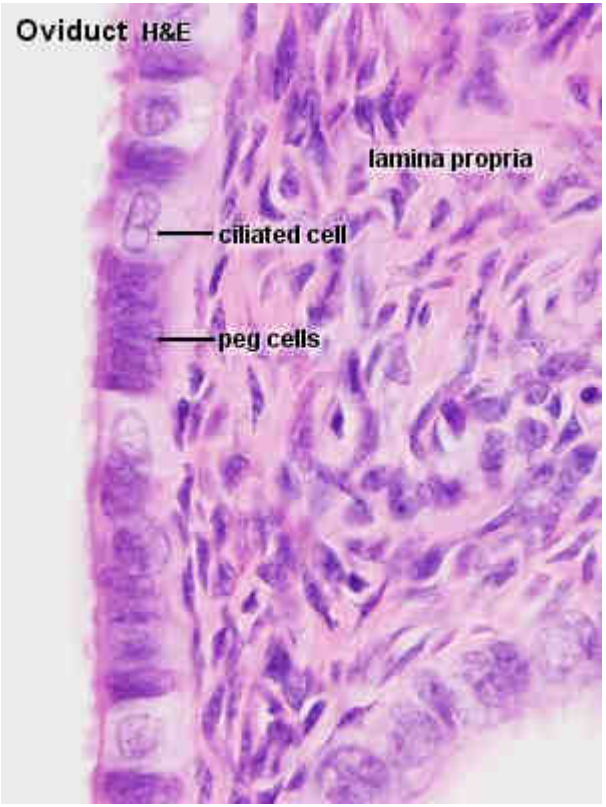


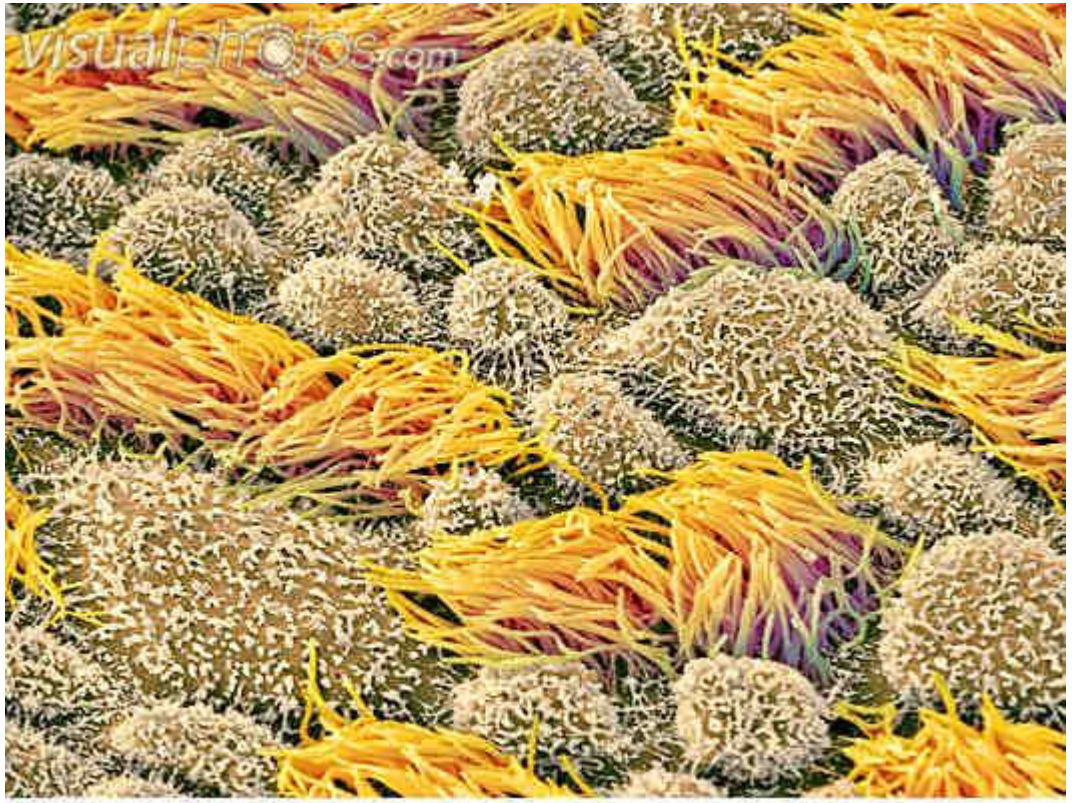


Resorption / Secretion

- **Simple columnar epithelium with kinocilia**

  – Uterine tube, epidydimis, respiratory passages

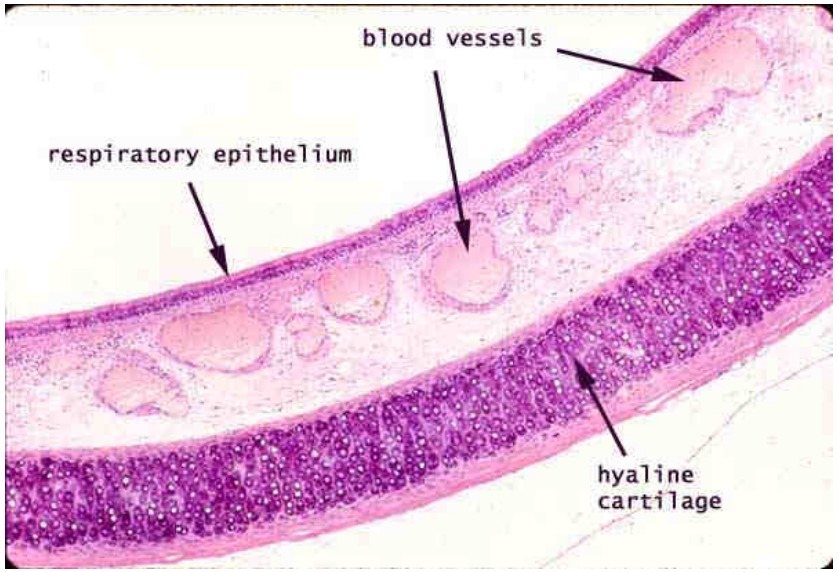


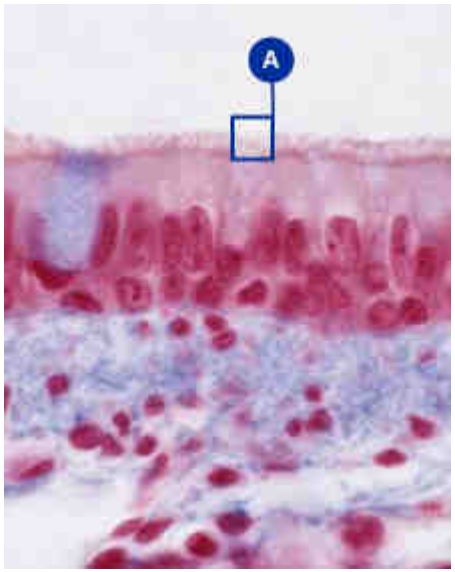


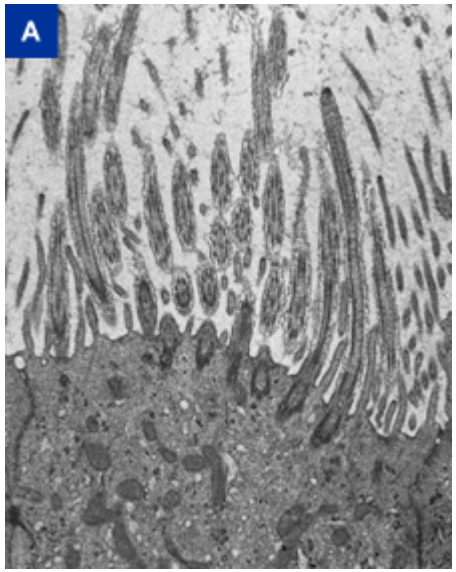
- **Simple columnar epithelium with kinocilia (also pseudostratified)**

  – Upper respiratory passages

  – Removes mucus produced by epithelial glands



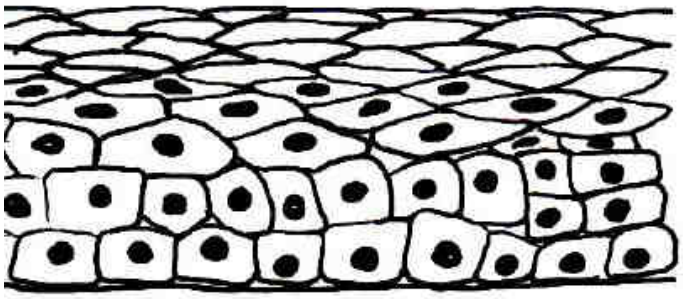




Other locations:

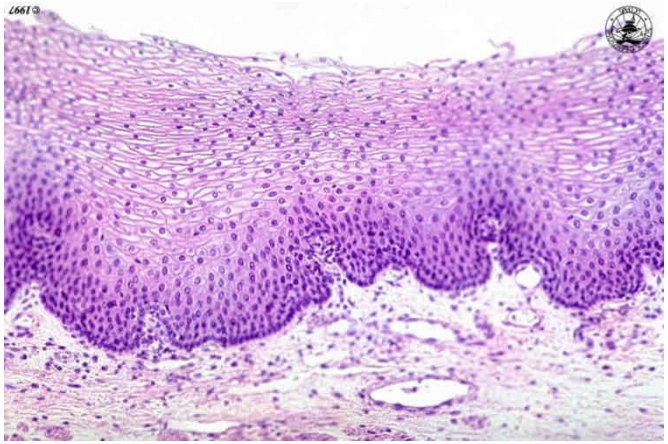
– Spinal cord ependyma
– Epididymis
– Vas deferens

- **Stratified squamous epithelium**



- Multiple layers of cubic cells with central nuclei, flattening towards the surface

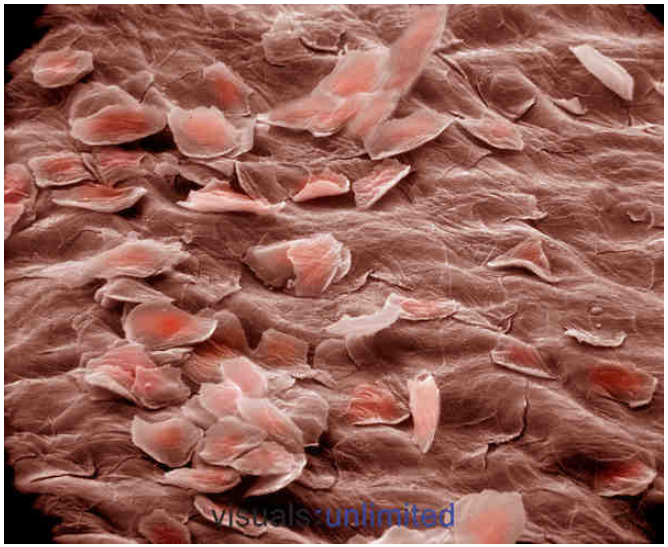
- First layer in contact with BM, last layer – flat



- Constant abrasion
- Mechanical resilience
- Protection from drying
- Rapid renewal

Keratinized vs. non-keratinized

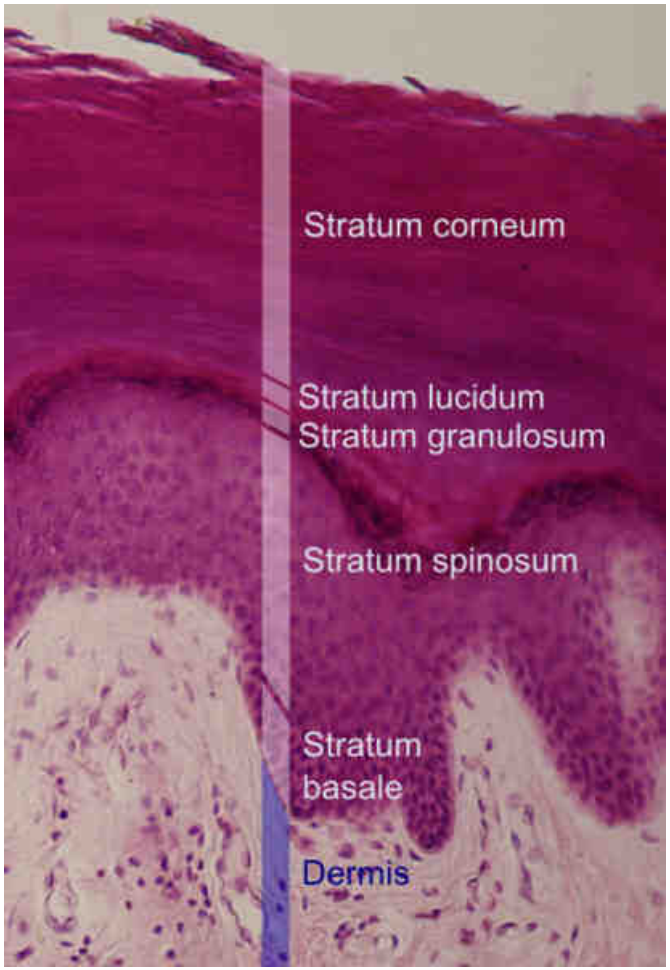
Examples:

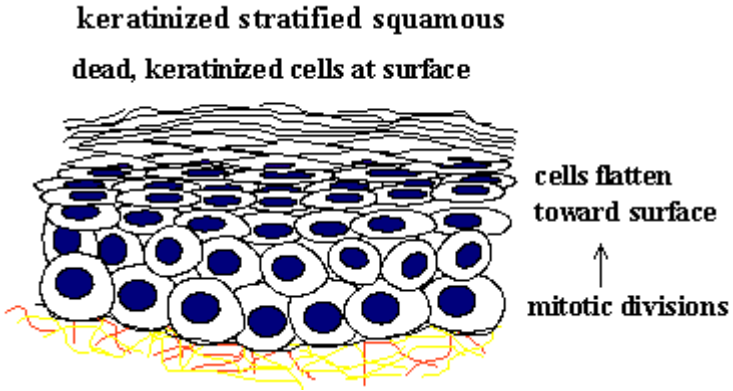


– Cornea
– Oral cavity and lips
– Esophagus
– Anal canal
– Vagina

- **Stratified squamous epithelium**

Keratinized





Skin (epidermis)

Nail

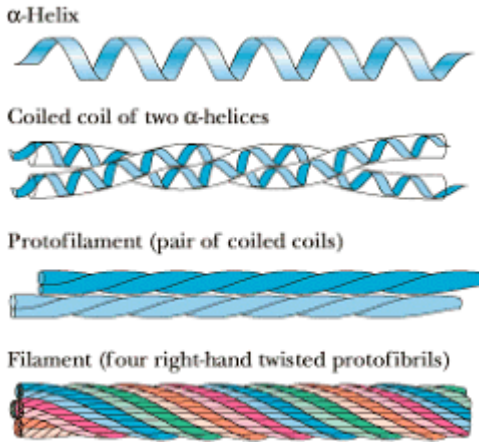
Keratins

Fibrous proteins, ~ 40 types

Very stable, multimeric

Disorders of keratin expression – variety of clinical symptoms

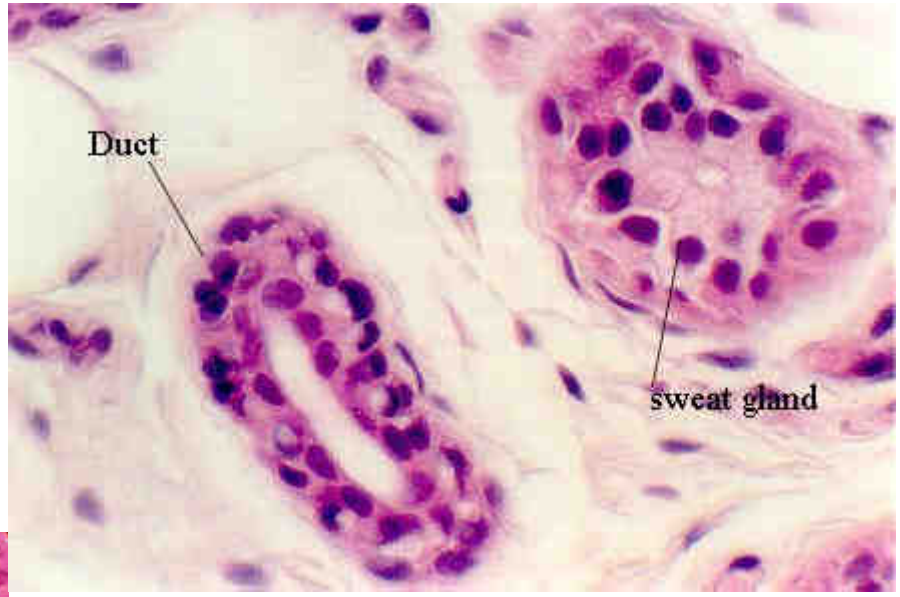
e.g. Epidermolysis bullosa simplex

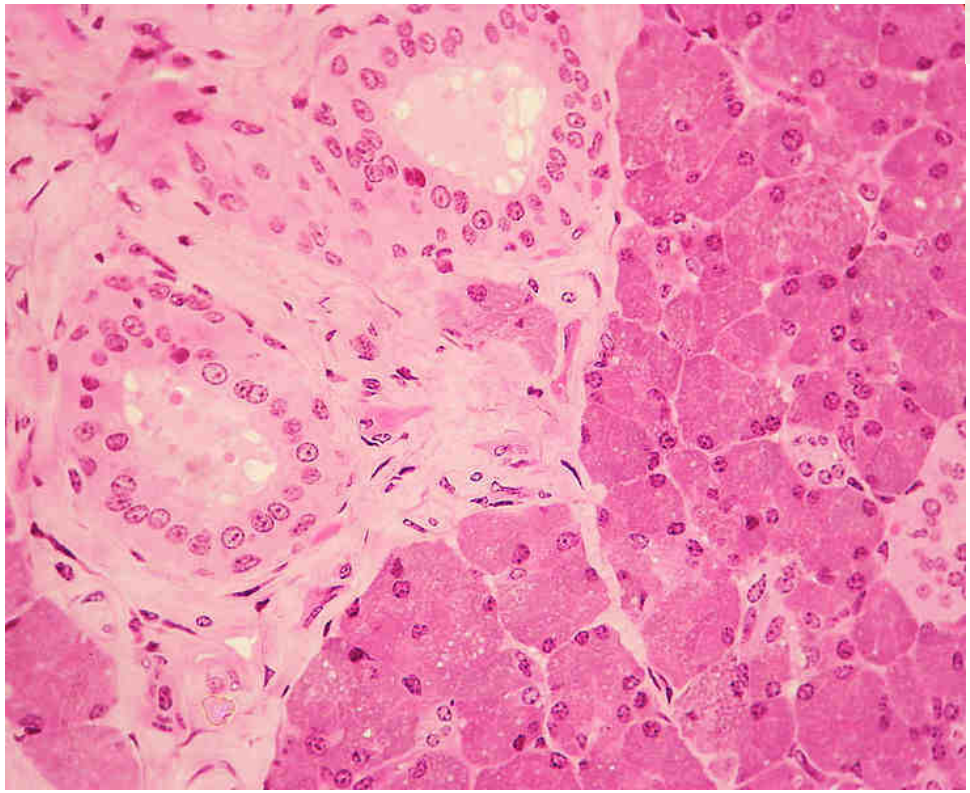


- **Stratified cuboidal epithelium**

Large ducts of :

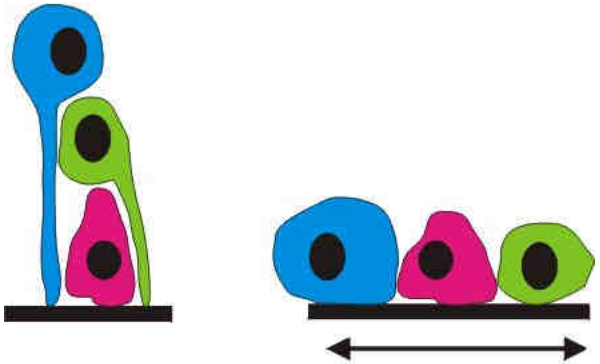
– sweat glands
– mammary glands
– salivary glands



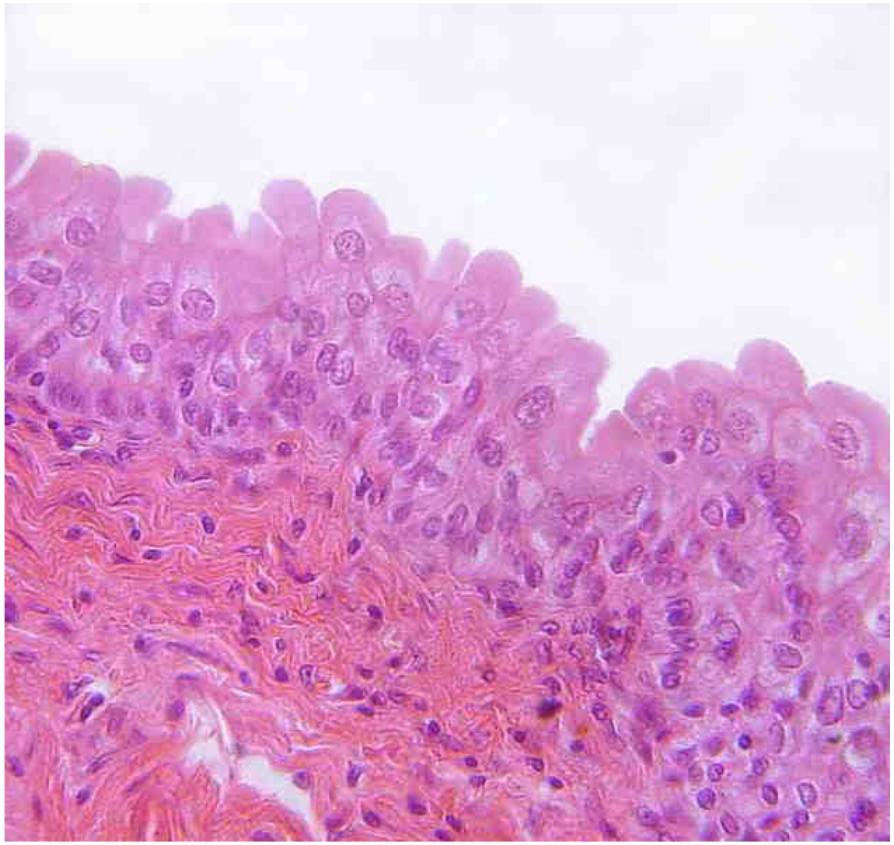


- **Transitional epithelium (urothelium)**

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

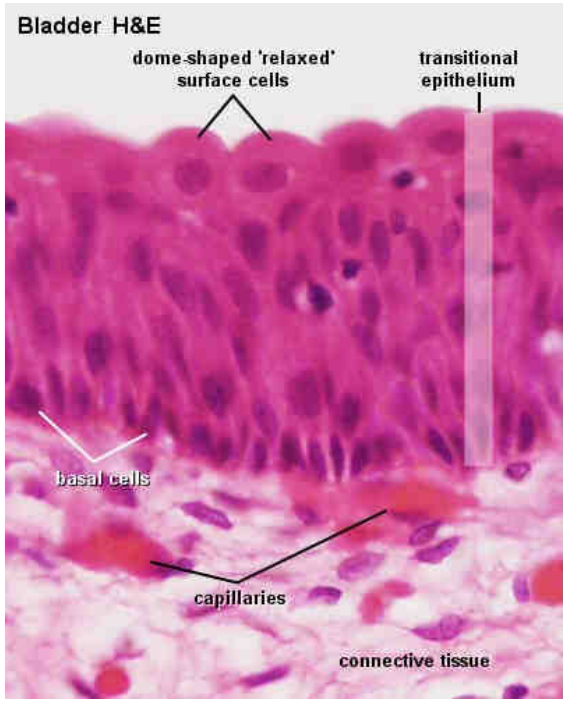


– Urinary bladder, kidneys, ureters



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

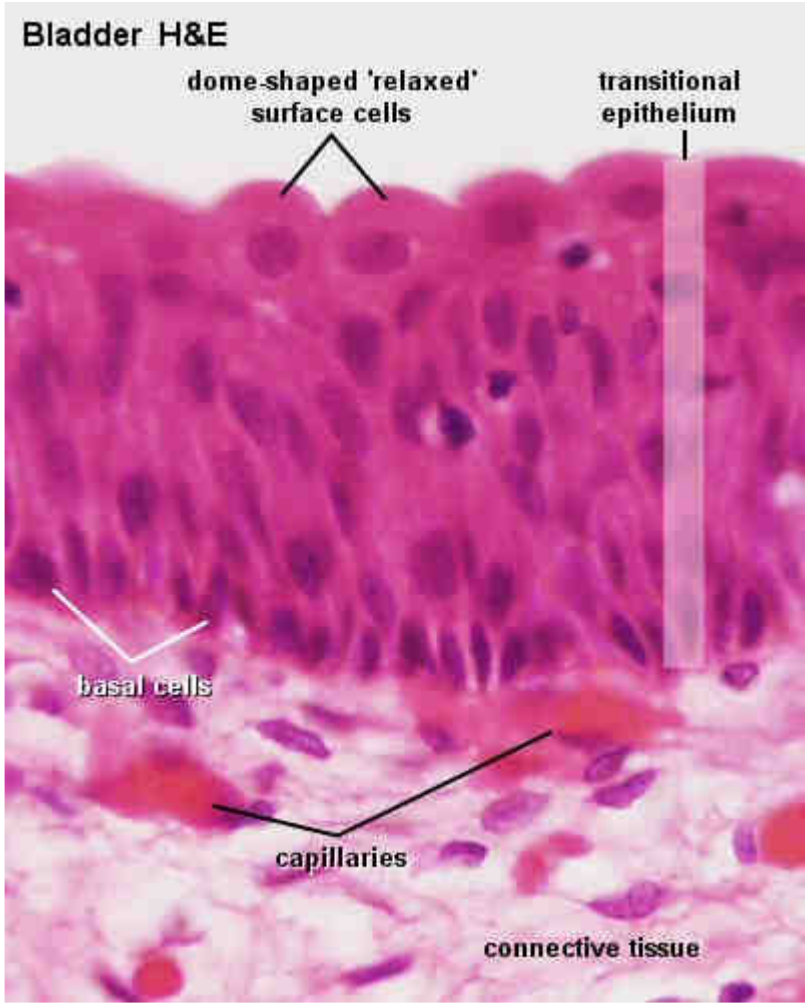
Basal cells
Intermediate layer
Surface cells



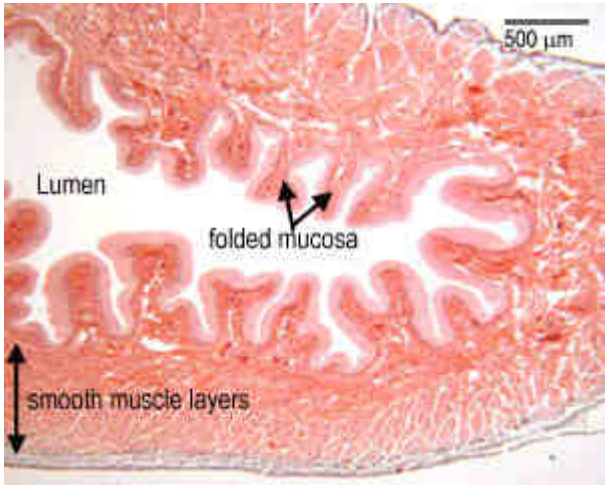
- **Transitional epithelium (urothelium)**

glycosaminoglycan layer (GAG) on the surface

– osmotic barrier
– antimicrobial properties



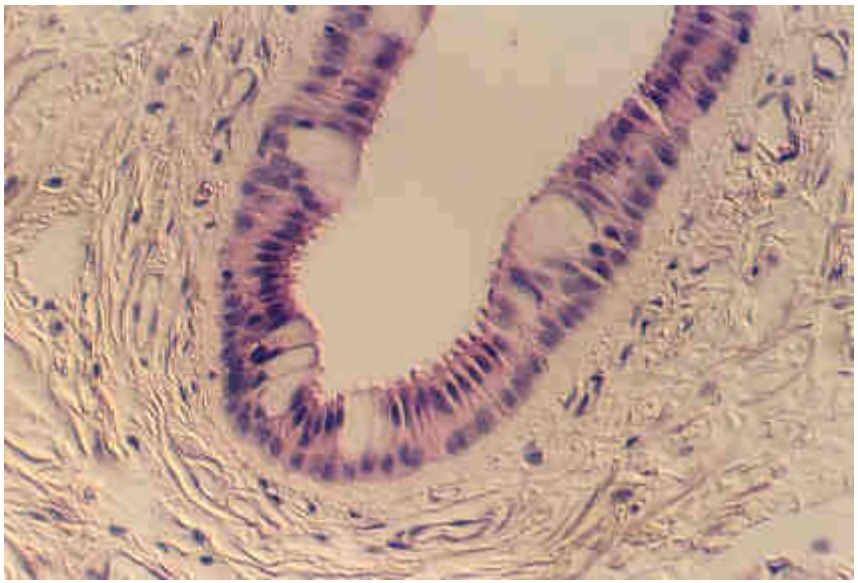
Barrier architecture:
– GAG-layer
– surface cells (tight junctions), uroplakin proteins in the apical cell membrane
– capillary plexus in the submucosa



- **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

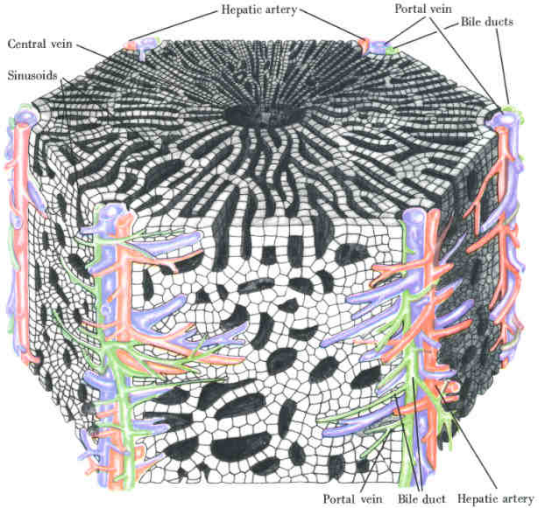


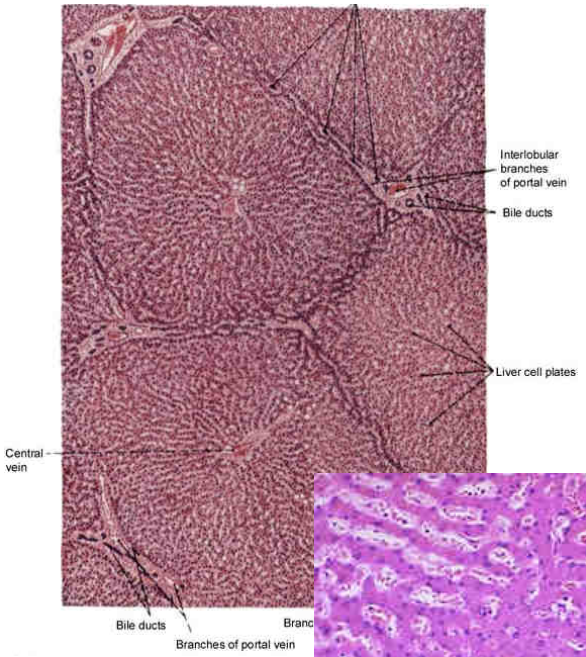
©http://www.cytochemistry.net/microanatomy/epithelia/salivary7.jpg

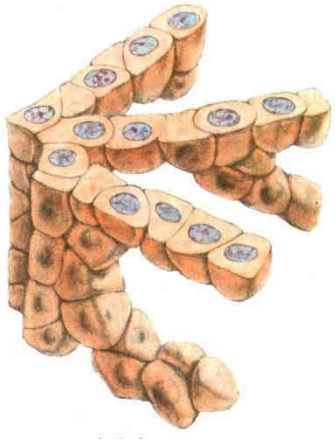
- Classification of epithelial tissues

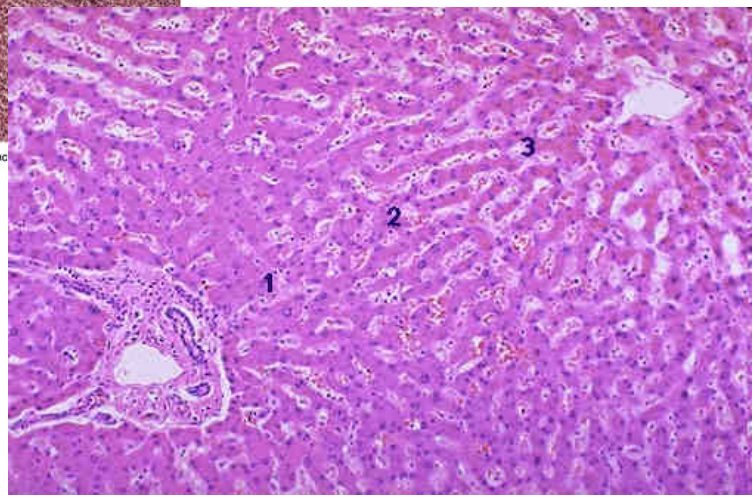
2. Trabecular epithelium

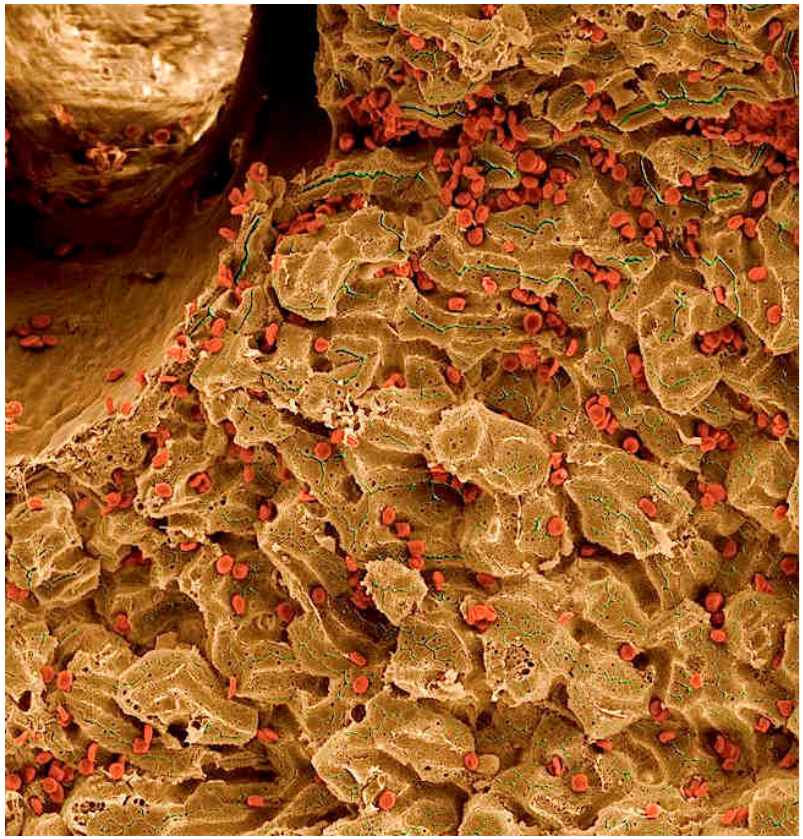
Liver – trabecules (cords) of hepatocytes







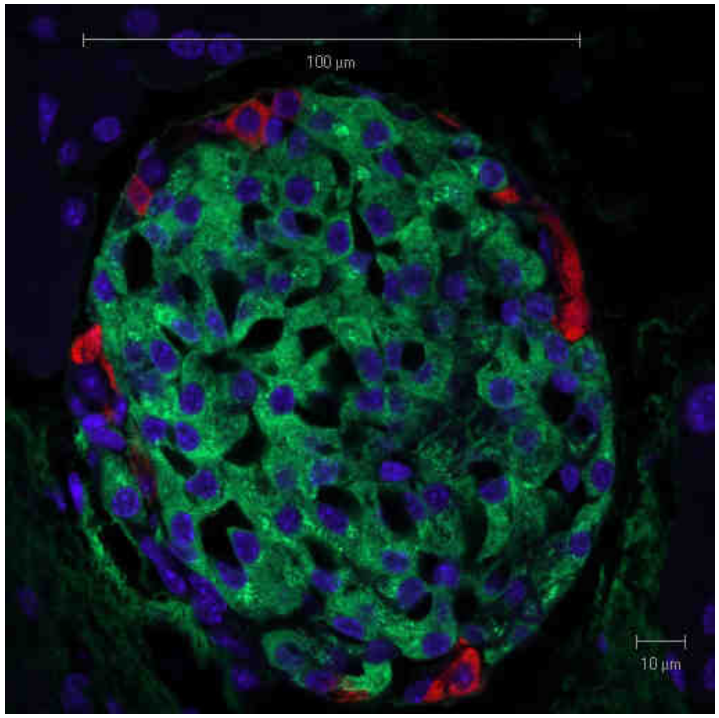


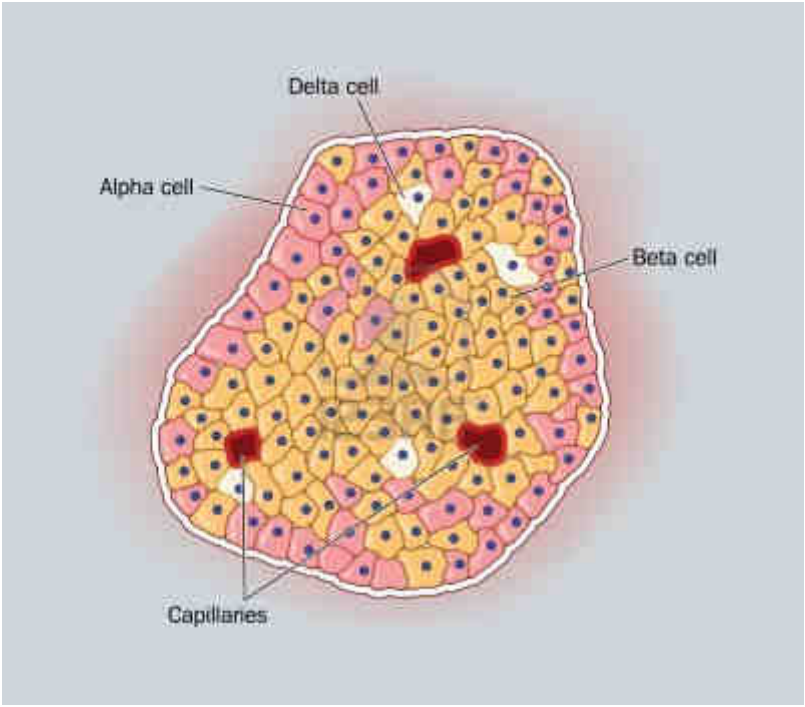


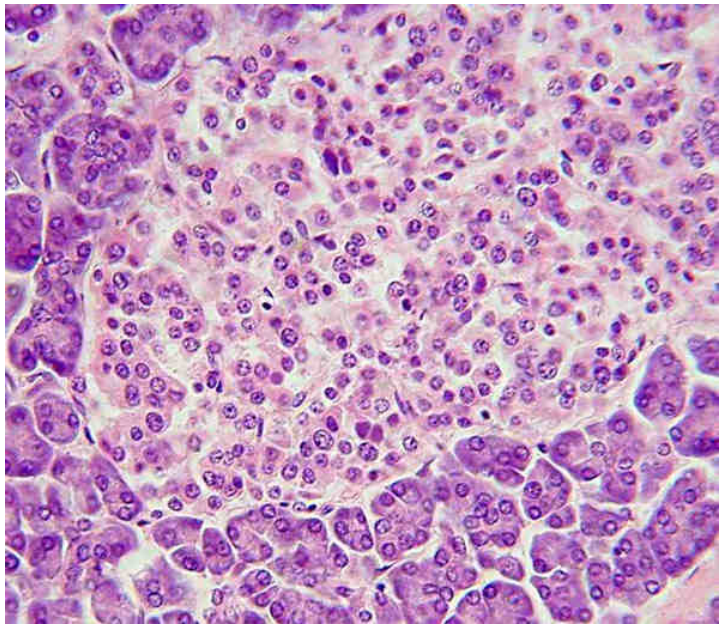
- **Endocrine glands**

Islets of Langerhans

Cords of endocrine active cells



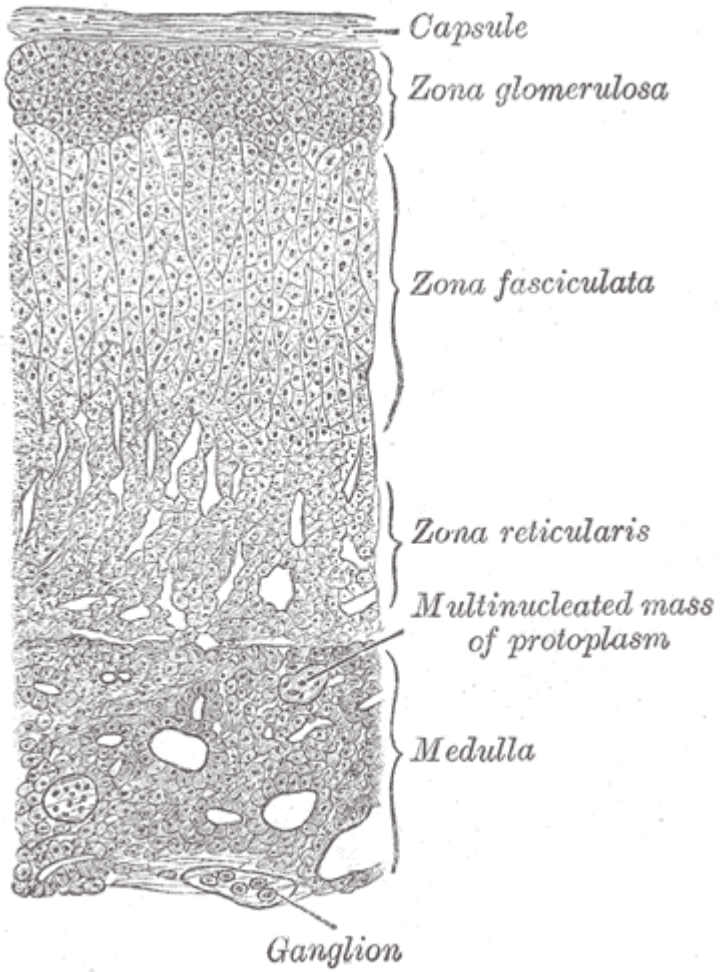


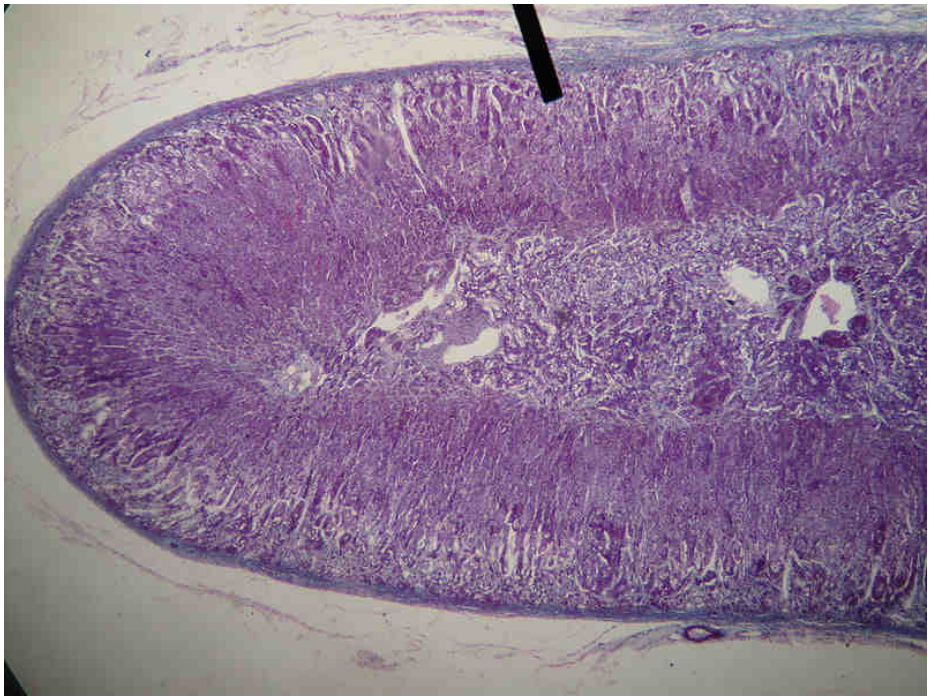


- **Endocrine glands**

Adrenal cortex

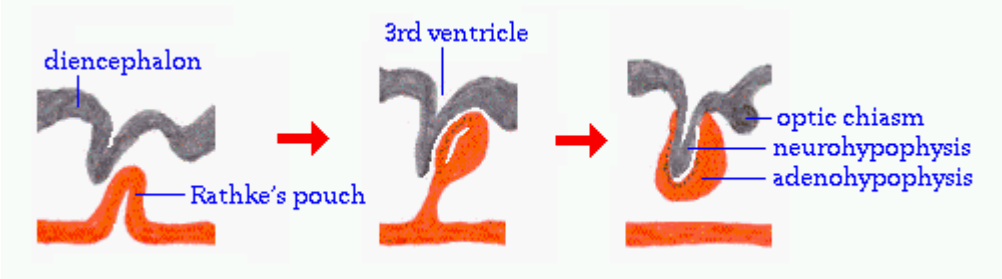
Cortex of adrenal gland – epithelial cells in cords secreting corticoid

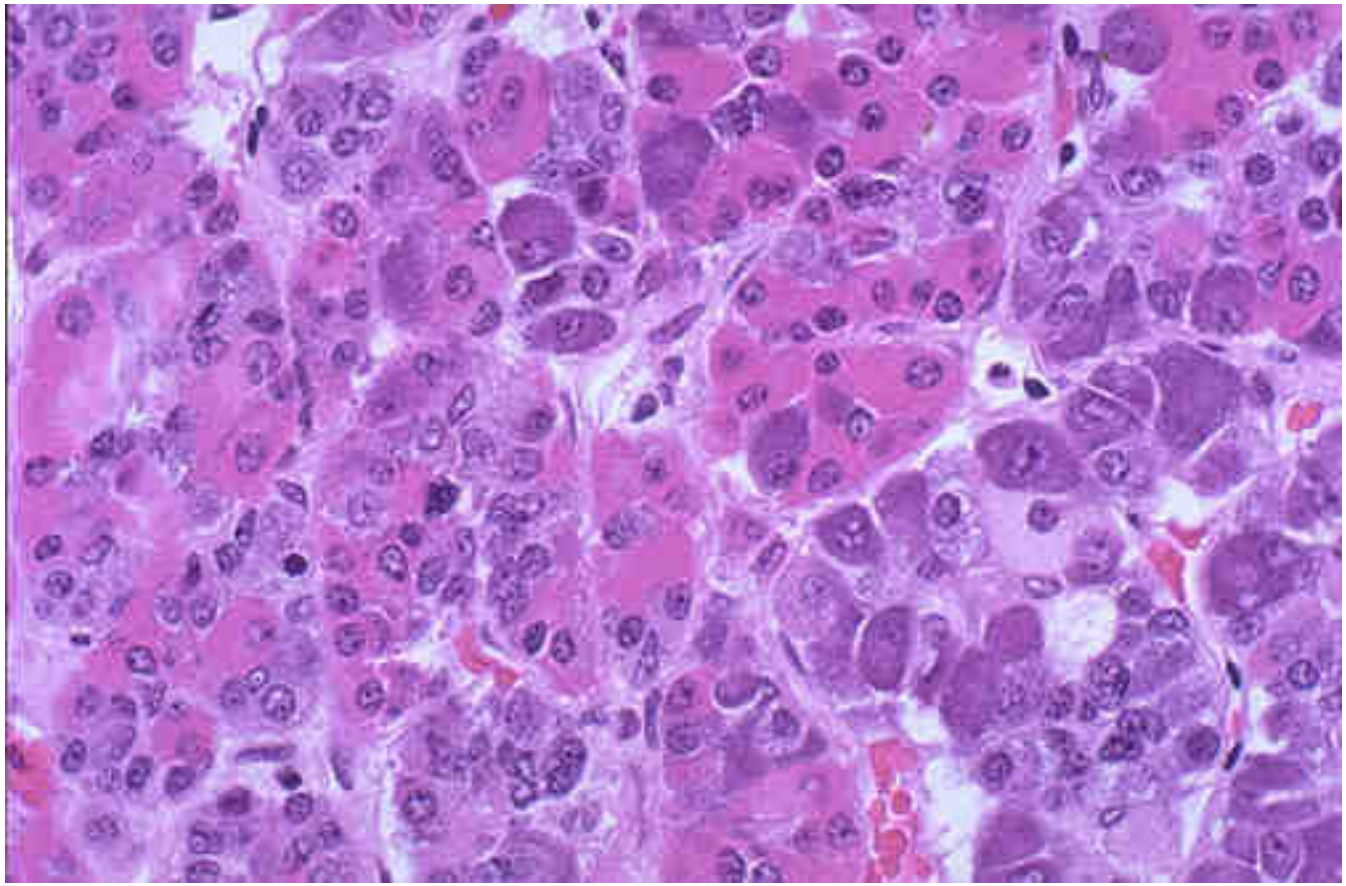




- **Endocrine glands**

Adenohypophysis – anterior pituitary

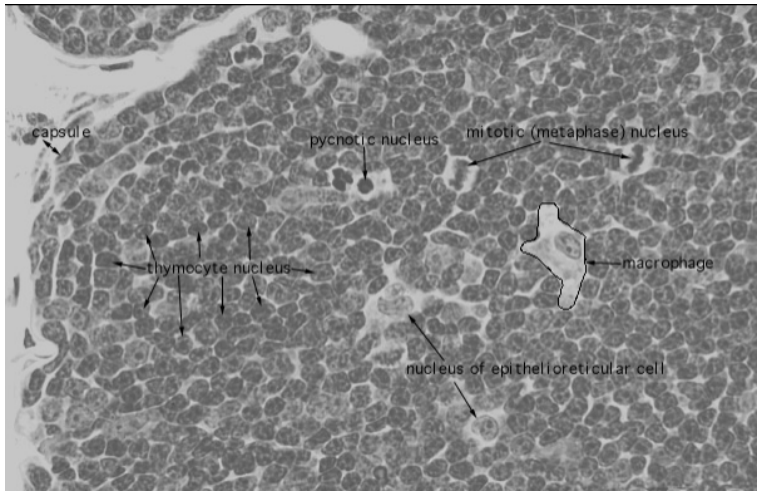


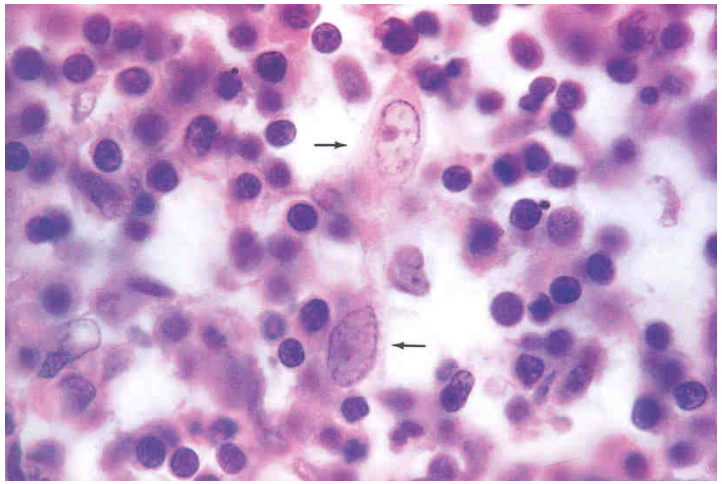


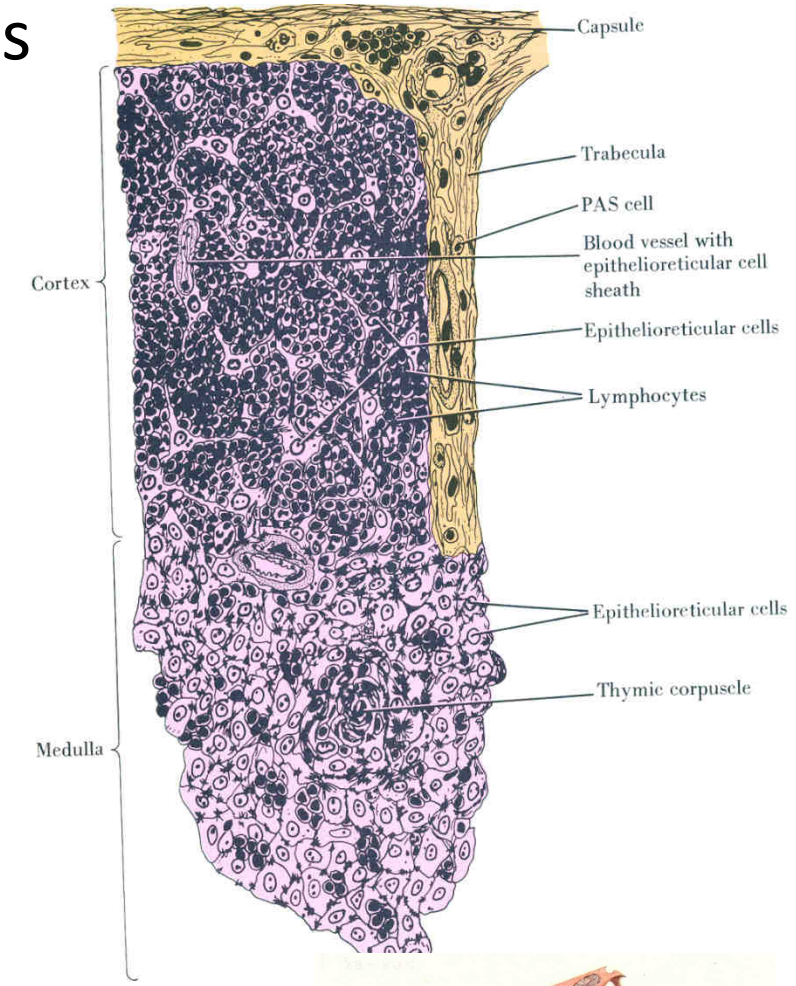
- Classification of epithelial tissues

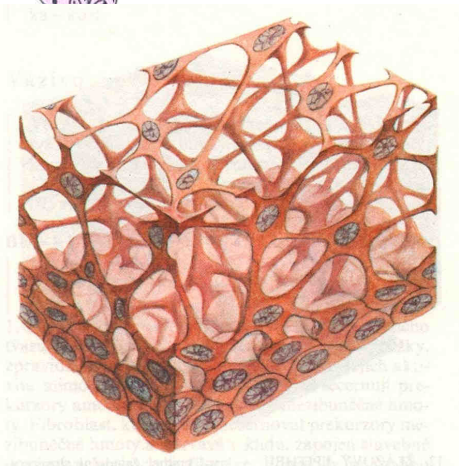
3. Reticular epithelium

Thymus - cytoreticulum

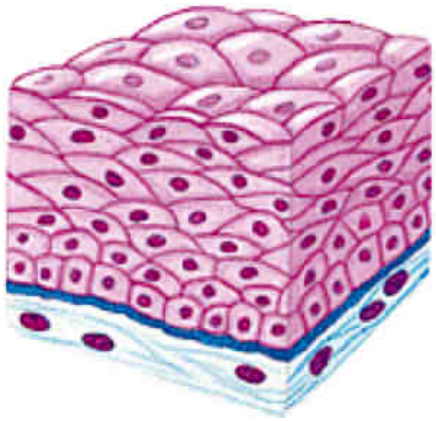




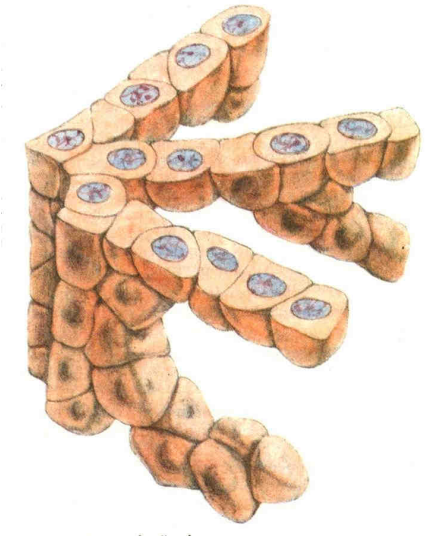




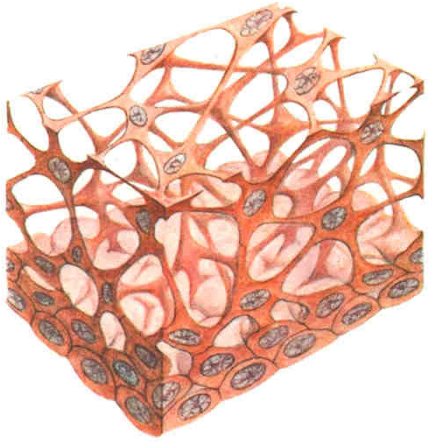
- Classification of epithelial tissues



Covering



Trabecular



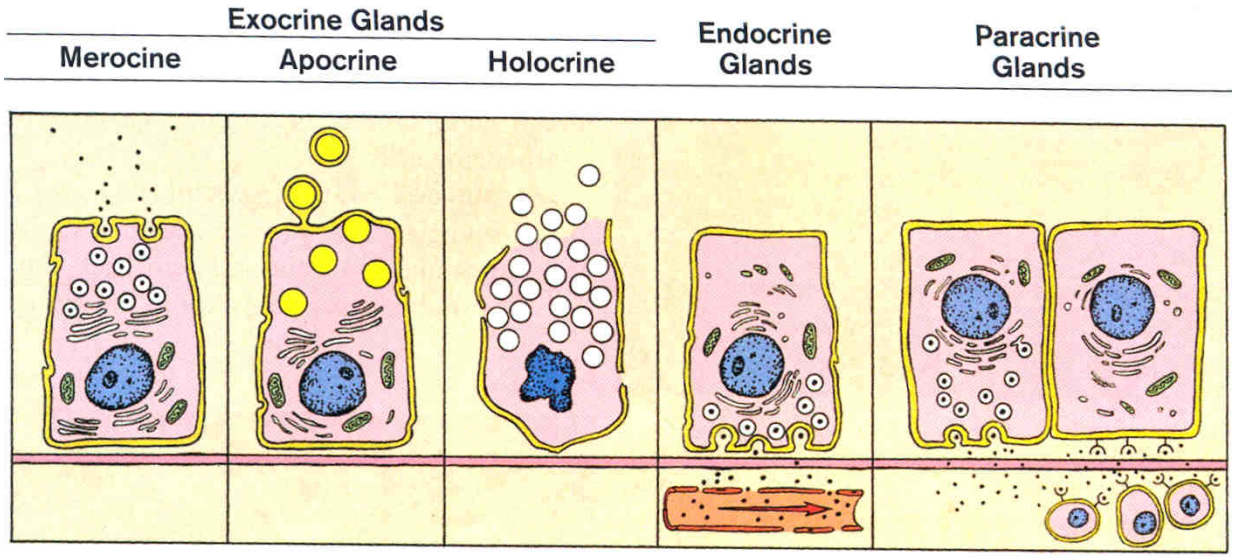
Reticular

BREAK

10 min

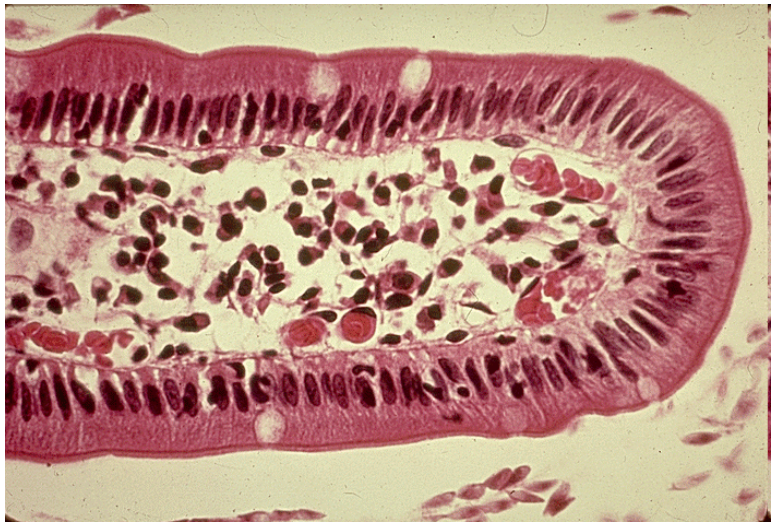
- **Epithelium may posses a function**
- **Glandular epithelium**

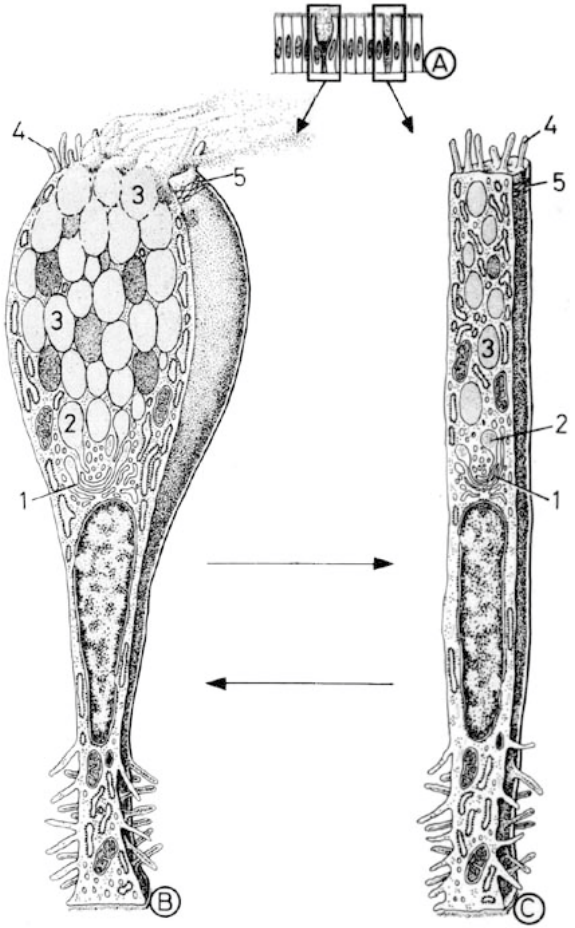
- Secret ↔ excret
- Process of secretion:



- **Glandular epithelium**

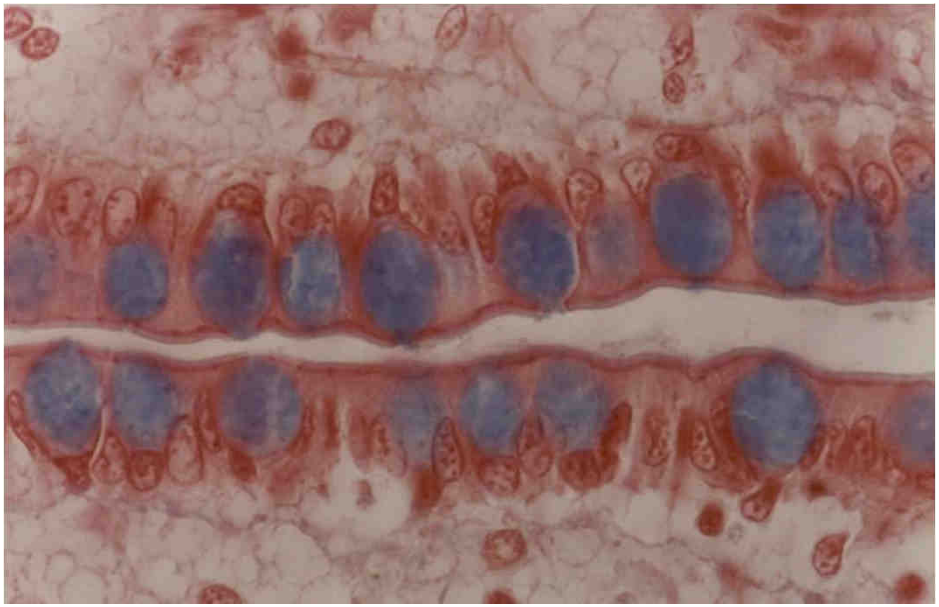
- **Single cell glands**
  - Goblet
  - Enteroendocrine





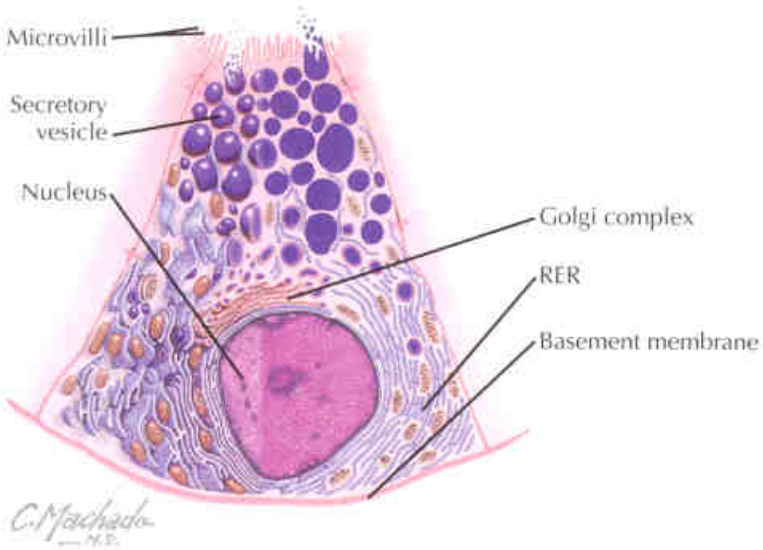
Goblet cells

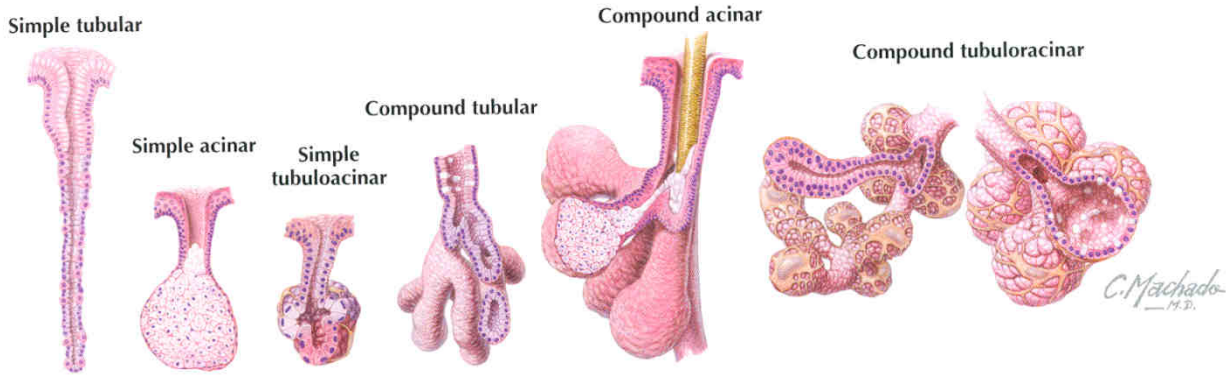
- Mainly respiratory and intestinal tract
- Produce mucus = viscous fluid composed of electrolytes and highly glycosylated glycoproteins (mucins)
- Protection against mechanic shear or chemical damage
- Trapping and elimination of particular matter
- Secretion by secretory granules constitutive or stimulated
- 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



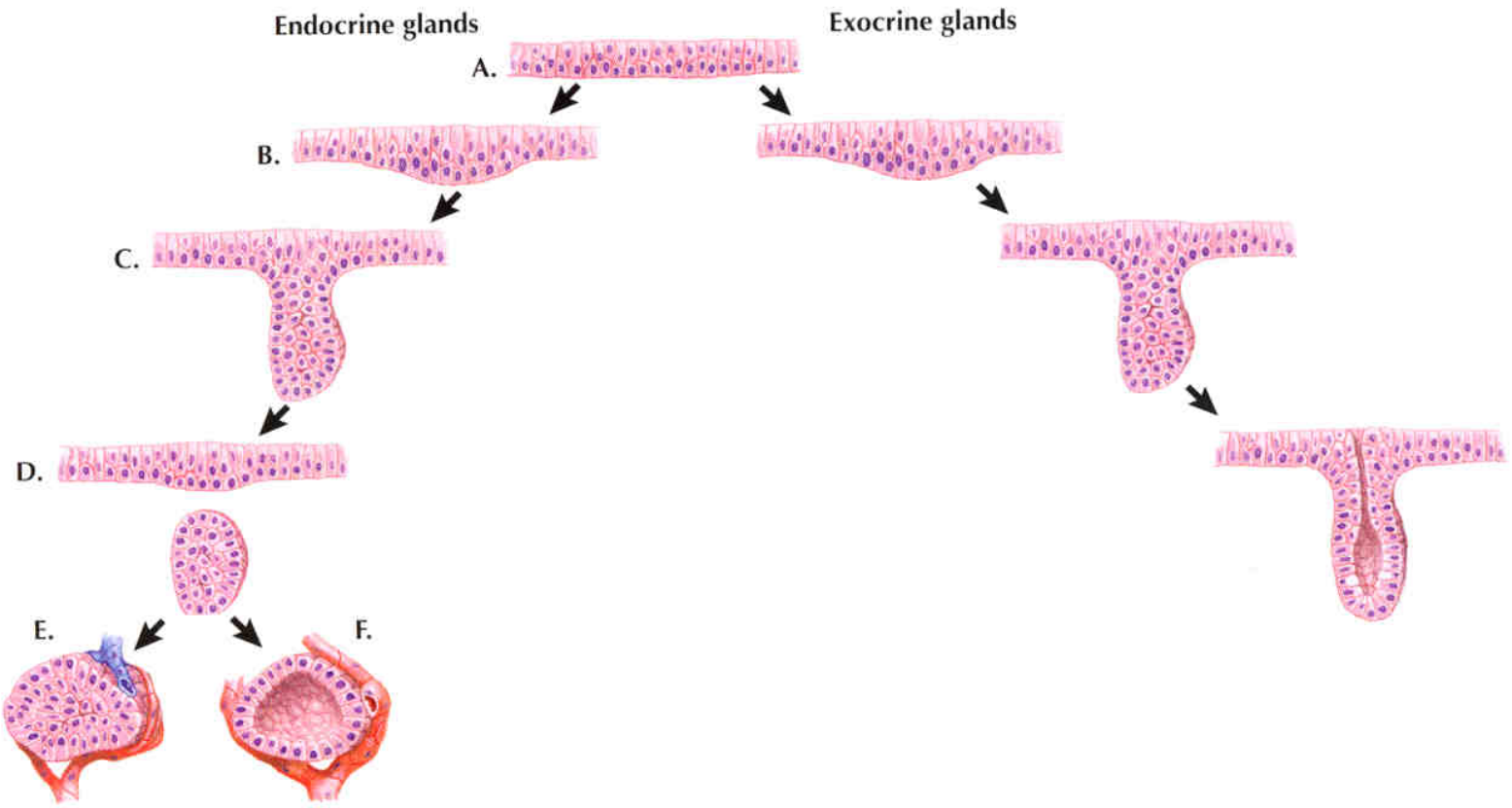
Multicellular glands

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



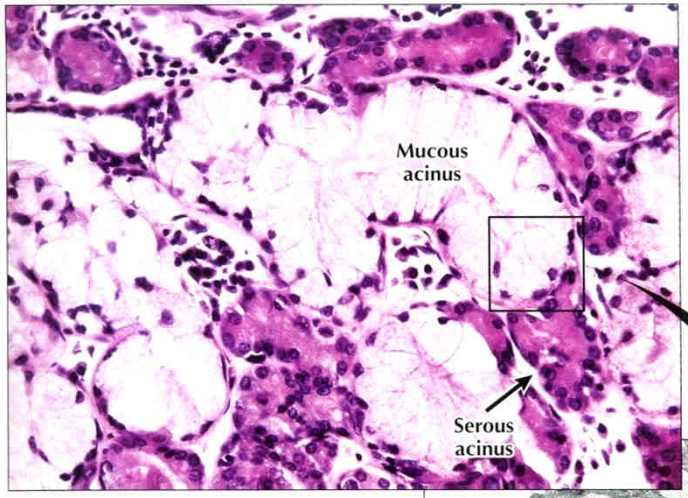


- **Multicellular glands**
  - Endocrine vs. exocrine

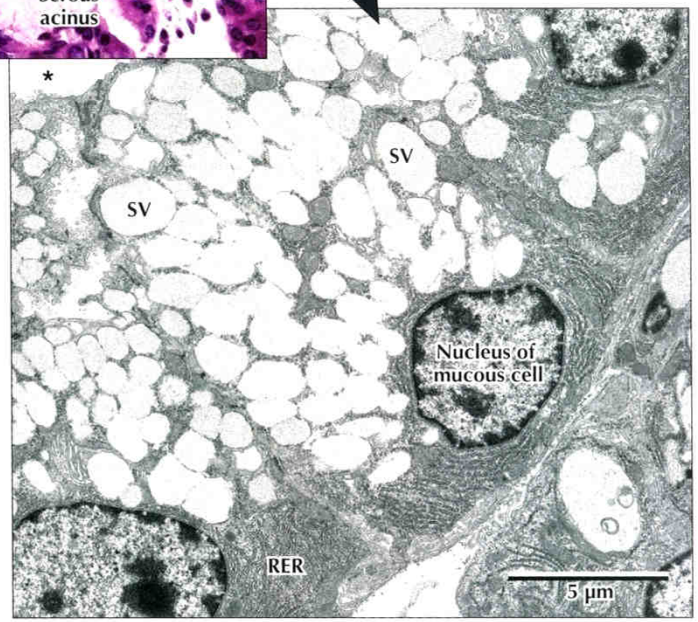


▪ Mucous glands

- Viscous secretion
- Tubular secretion compartments

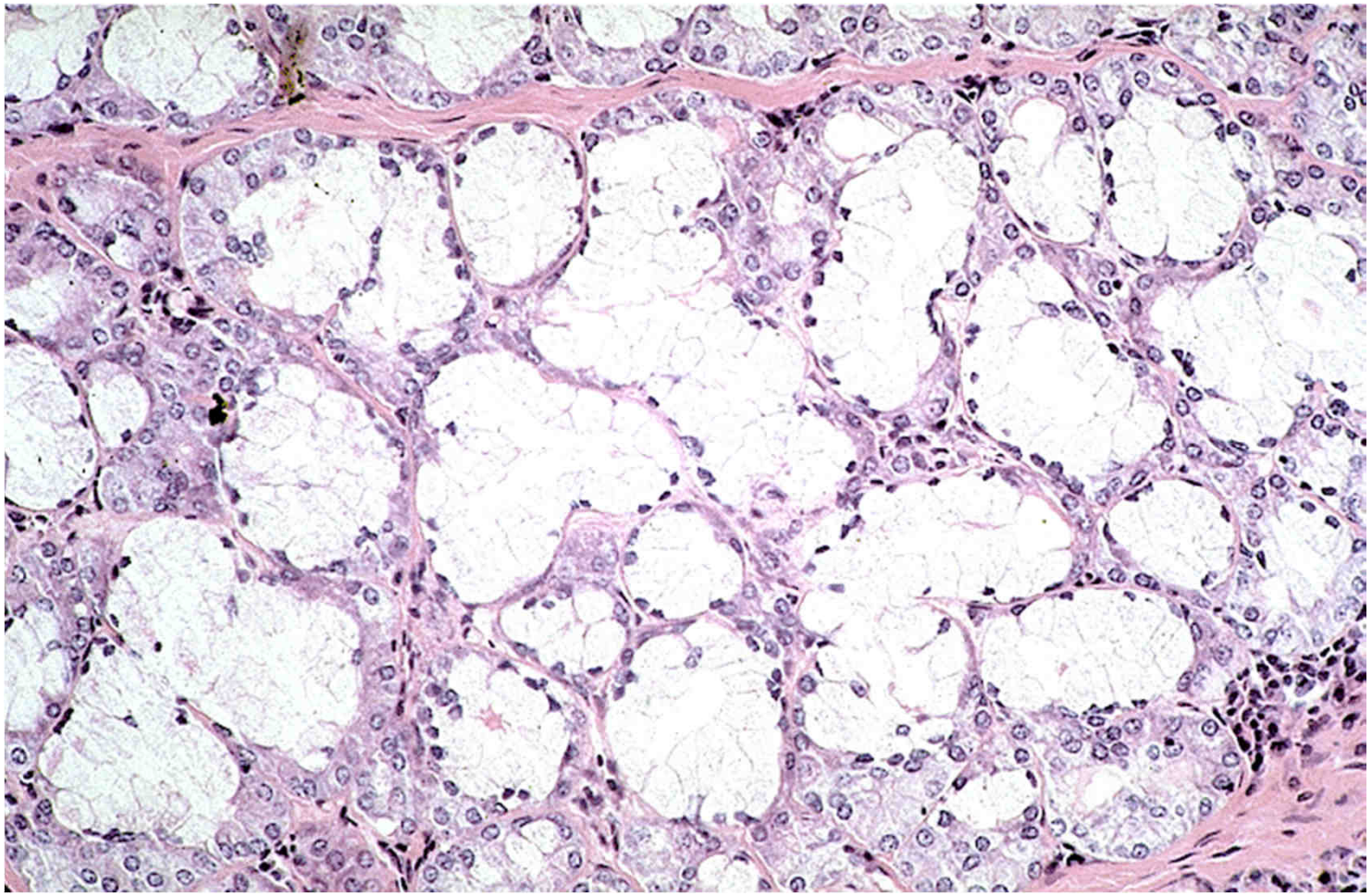


◀ **LM of part of a mixed seromucous gland in the trachea.** Several mucous acini with pale-stained mucous cells are seen. The basal nuclei are flat, and cells appear washed out because mucous droplets dissolved during specimen preparation. Darker stained serous cells in adjacent acini have more rounded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



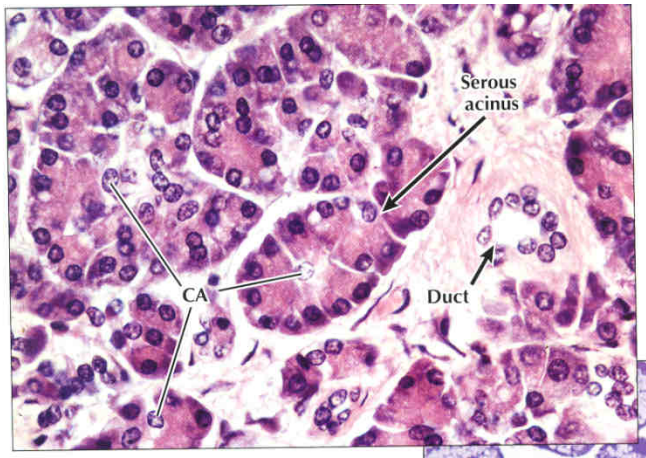
▶ **EM of part of a mucous acinus in a mixed salivary gland.** Parts of three mucous cells line the acinus lumen (*). Euchromatic basal nuclei have prominent nucleoli. Basal cytoplasm contains many profiles of rough endoplasmic reticulum (**RER**). Many large, electron-lucent secretory vesicles (**SV**)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

- **Mucous glands**

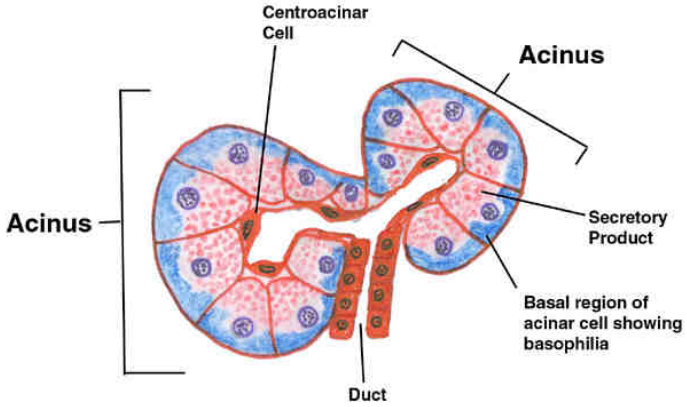


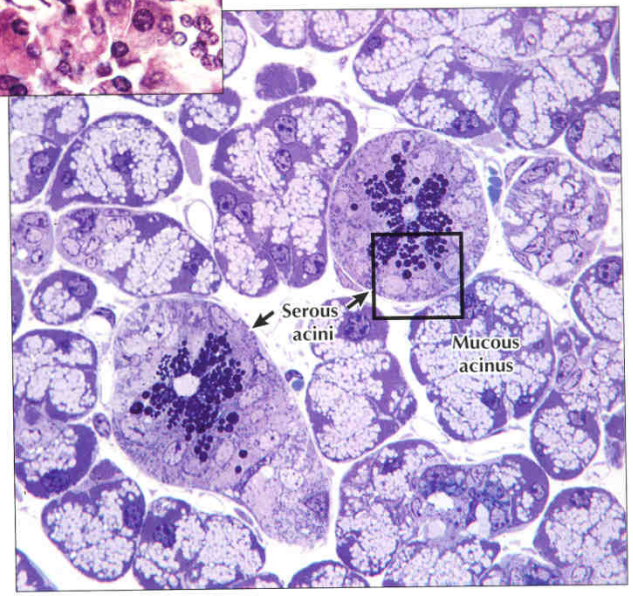
▪ Serous glands

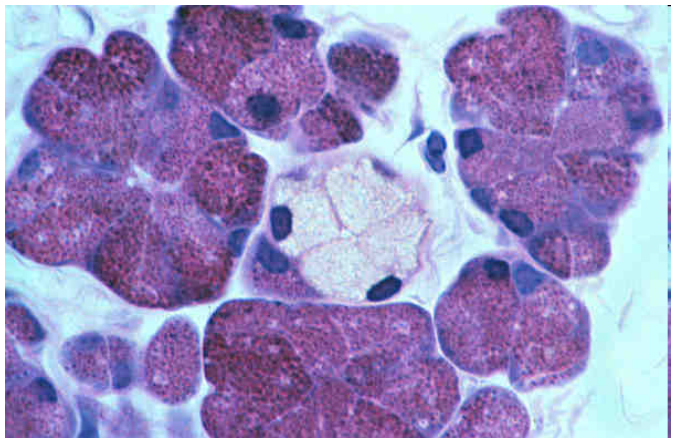
- Secretion rich in electrolytes
- Acinous secretion compartments



◀ **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×. *H&E.*

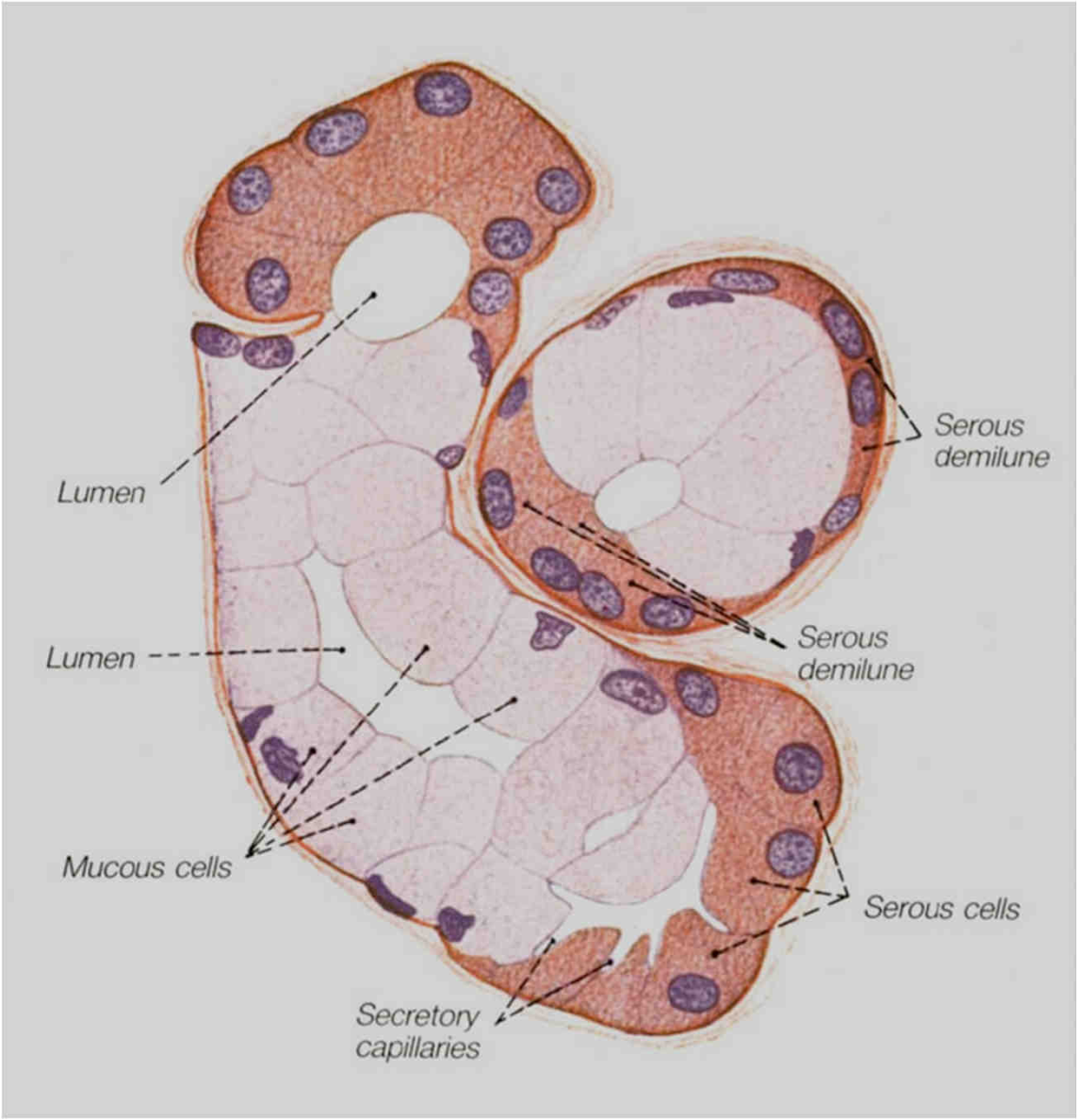


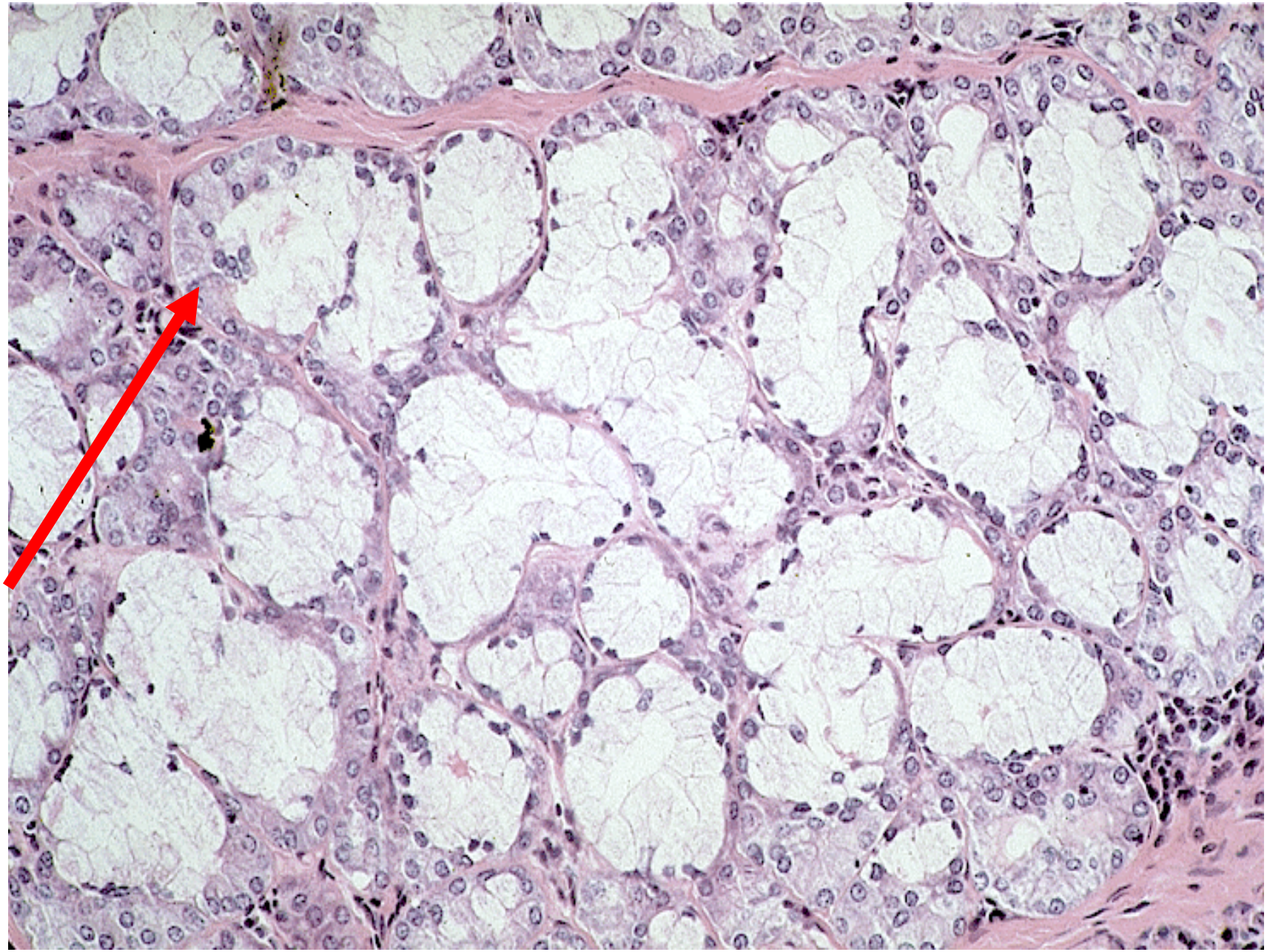




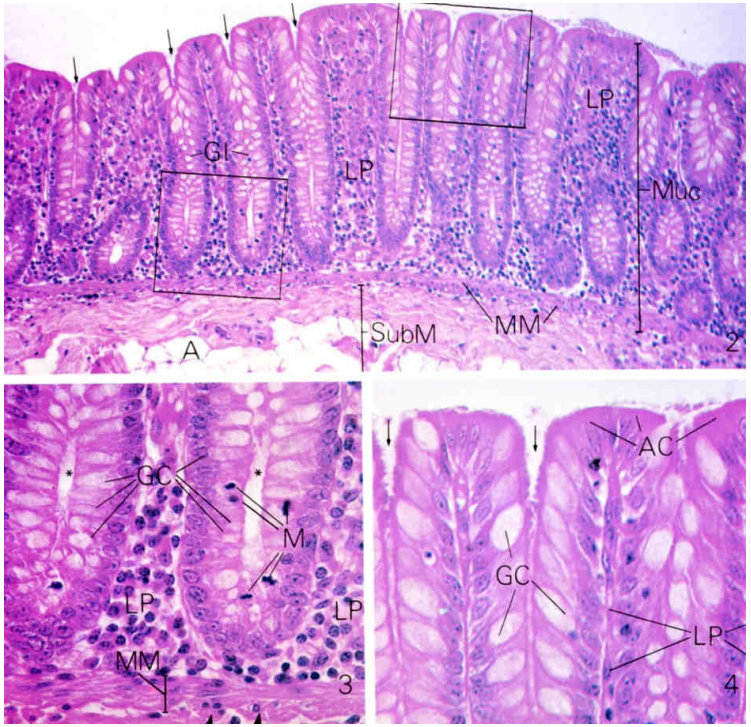
- **Compound glands**

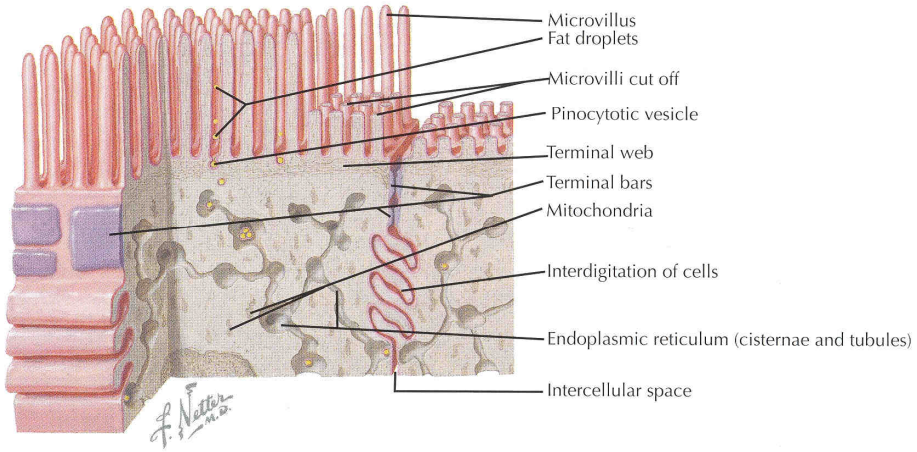
  - both serous and mucous
  - usually tuboacinous
  - both compartments individually or in combination (serous demilunes)

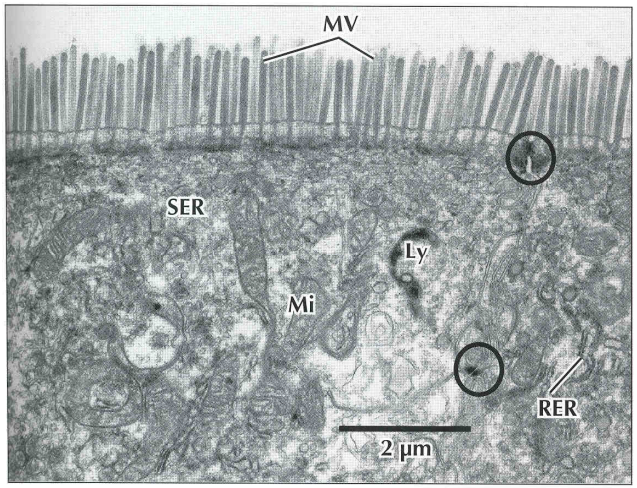


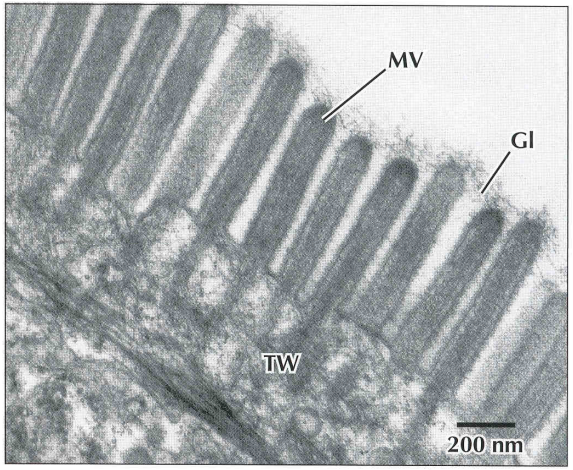


Resorptive epithelium

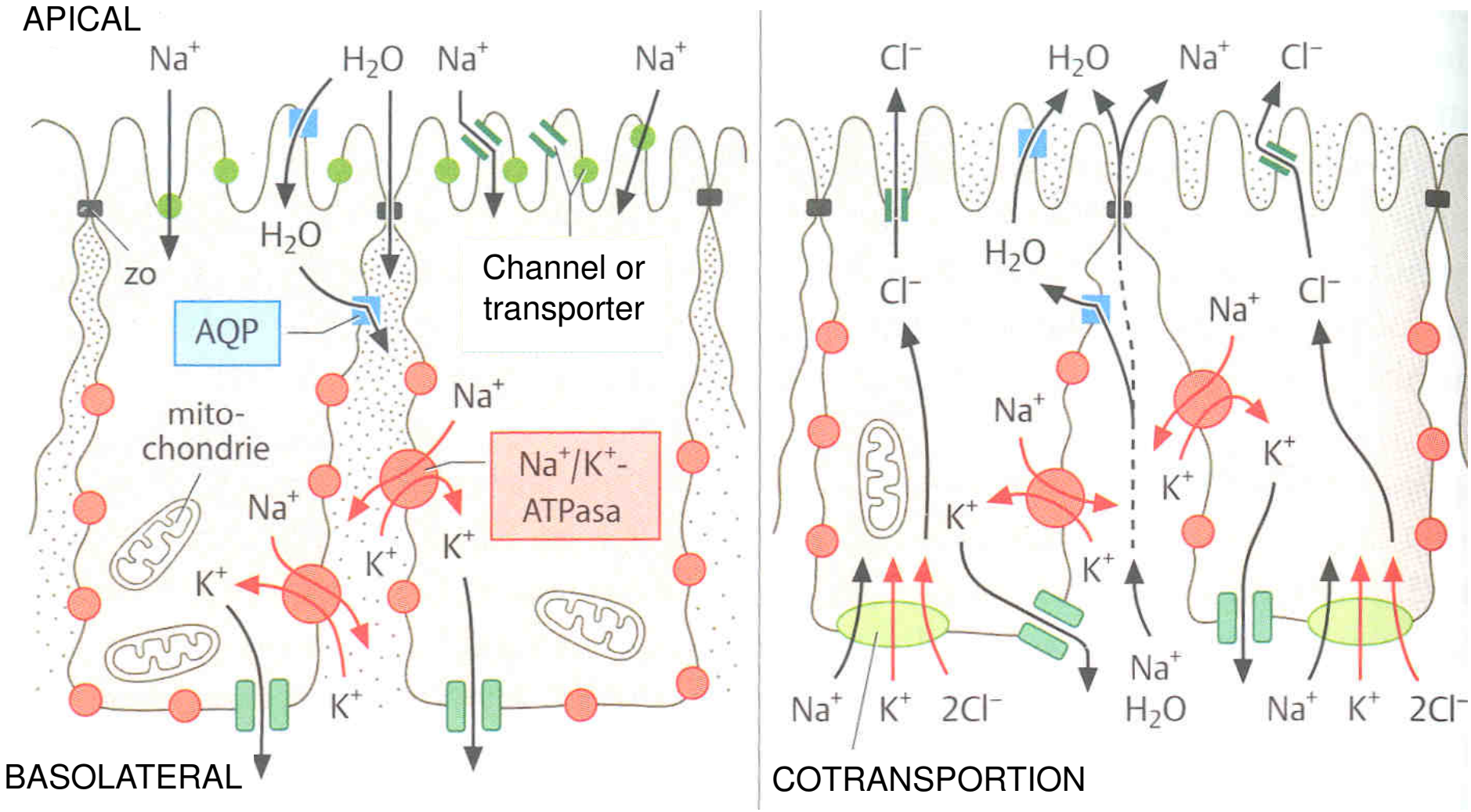








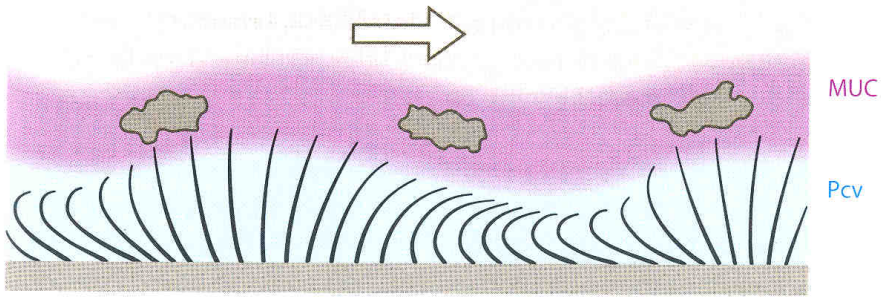
- **Resorptive epithelium**



WATER RESORPTION

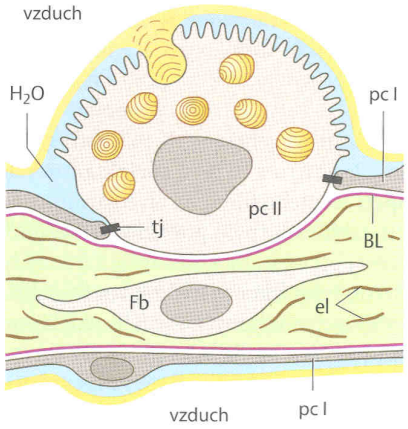
WATER SECRETION

Respiratory epithelium



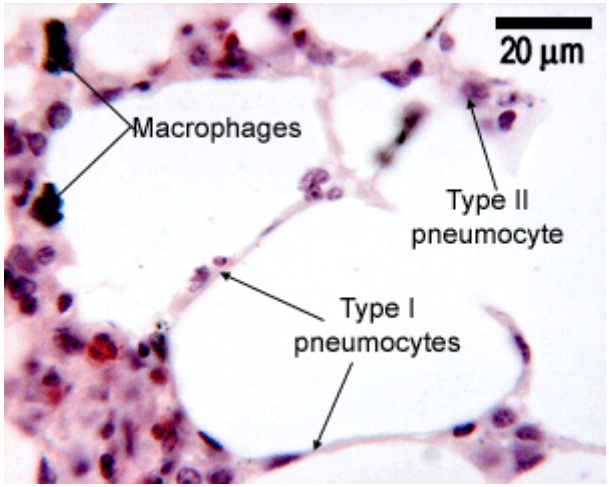
Respiratory passages

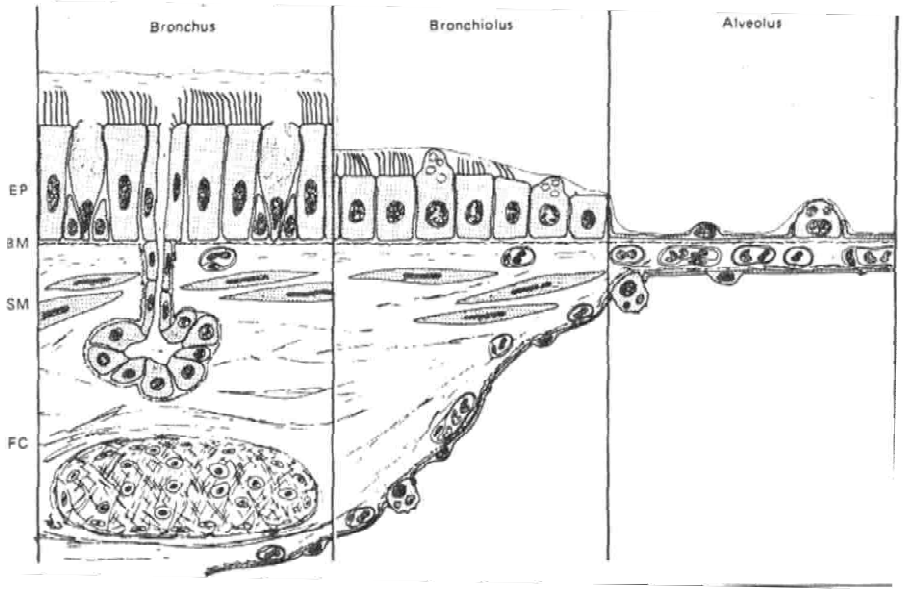
- Moisten, protect against injury and pathogen
- Remove particles by „mucociliary escalator“
- Pseudostratified columnar epithelium with cilia
- Basal cells- epithelium renewal



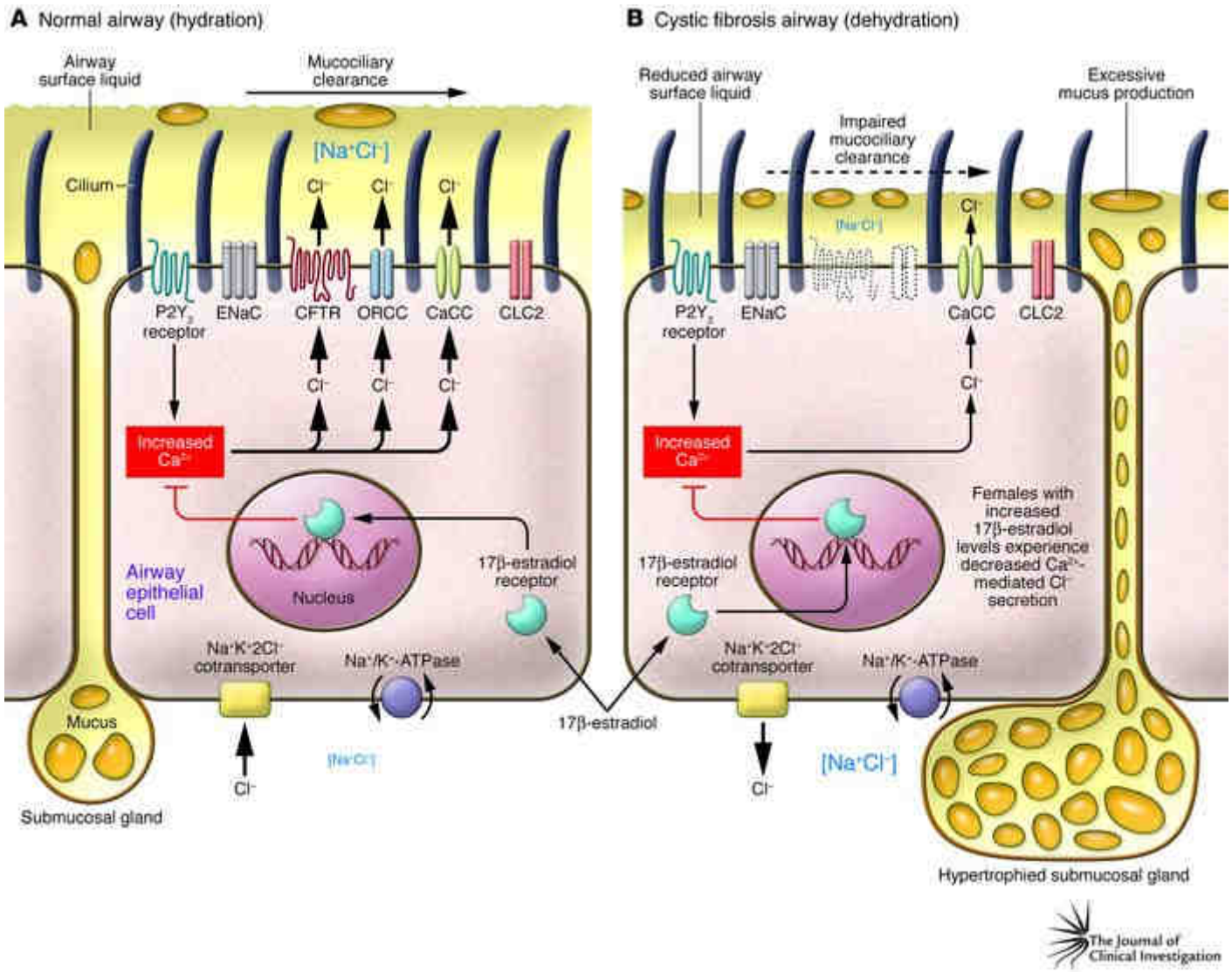
Alveolar epithelium

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





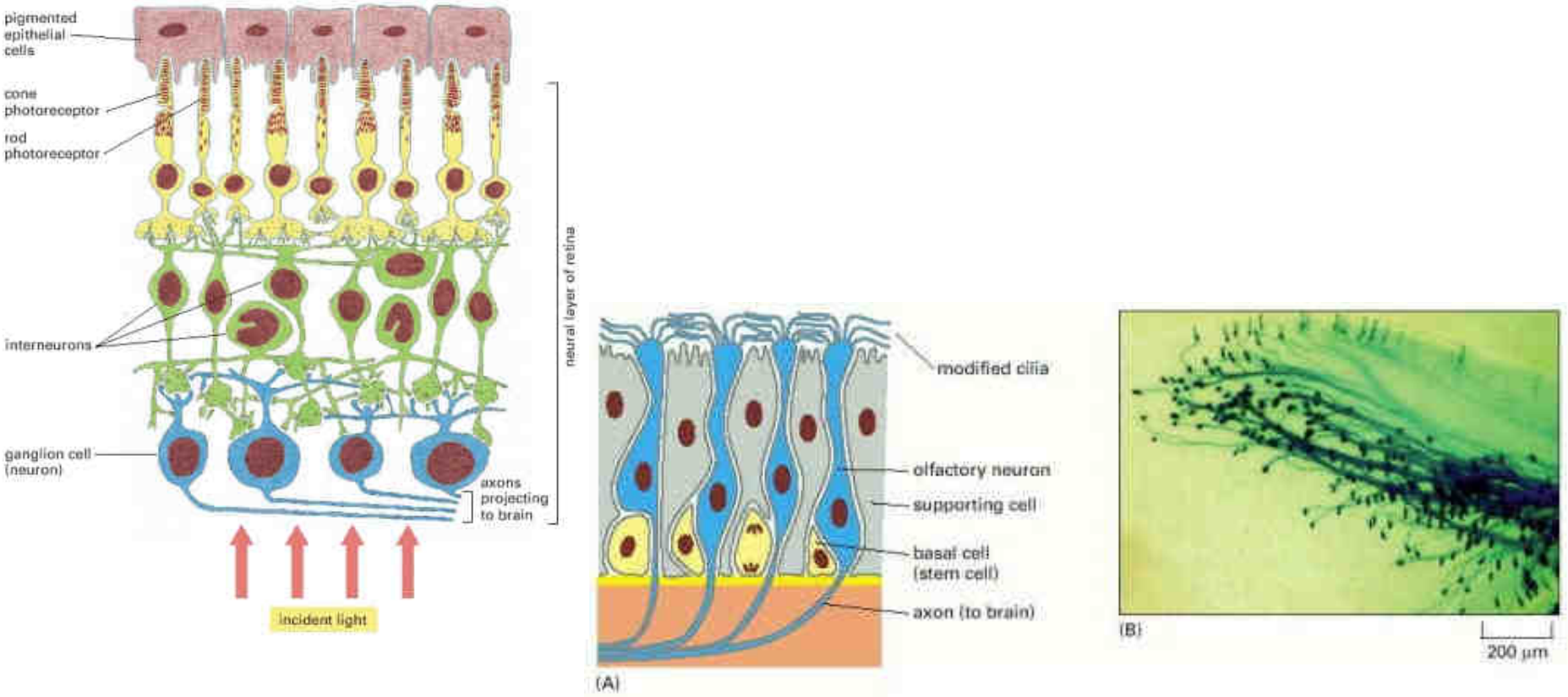
- **Respiratory epithelium**



Sensory epithelium

- Supportive and sensory cells

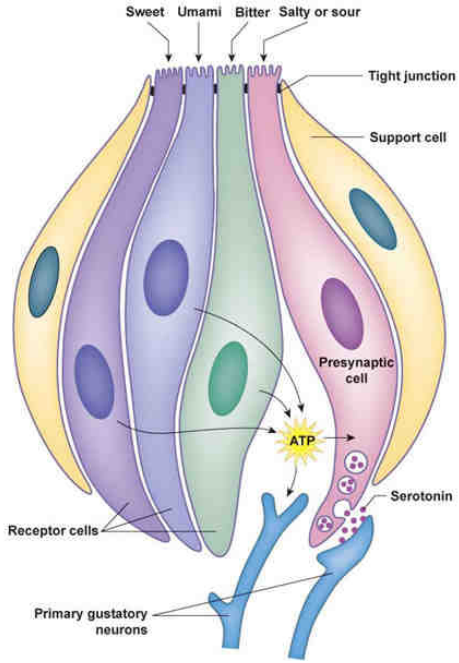
Primary sensory cells – directly convert stimulus to membrane potential
Receptor region, body, axonal process
Nasal epithelium (*regio olfactoria nasi*), **retina** (rods and cones)

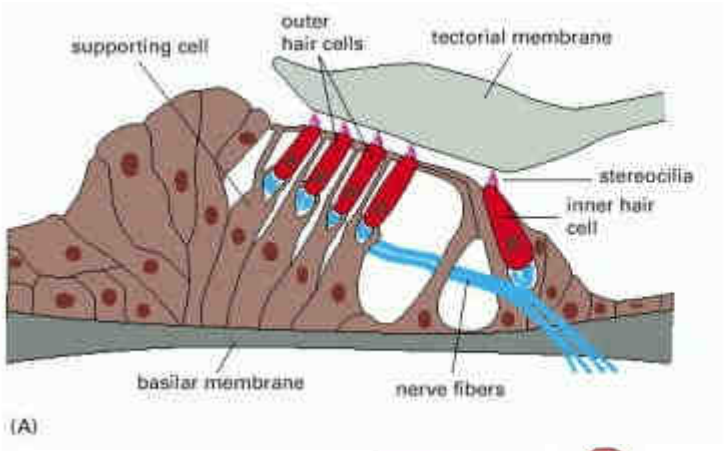


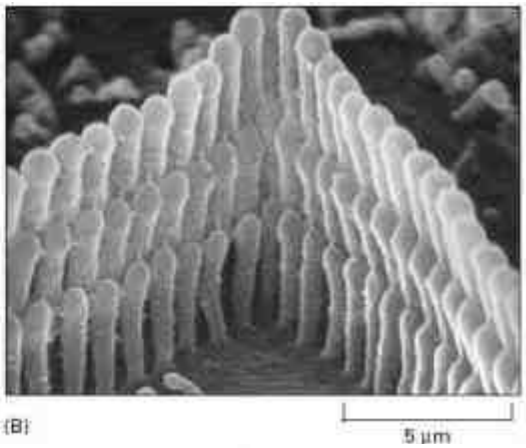
Sensory epithelium

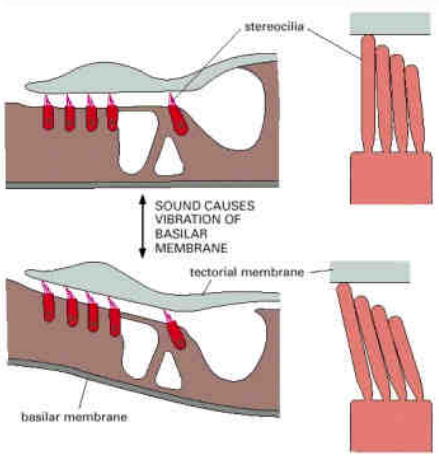
Secondary sensory cells
Receptor region and body
Signal is transmitted by adjacent neurons ending on secondary sensory cell

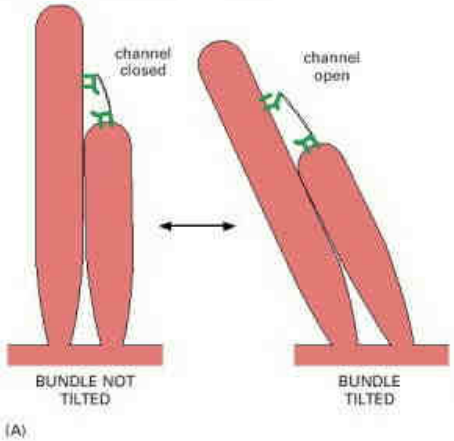
Taste buds, **vestibulocochlear apparatus**





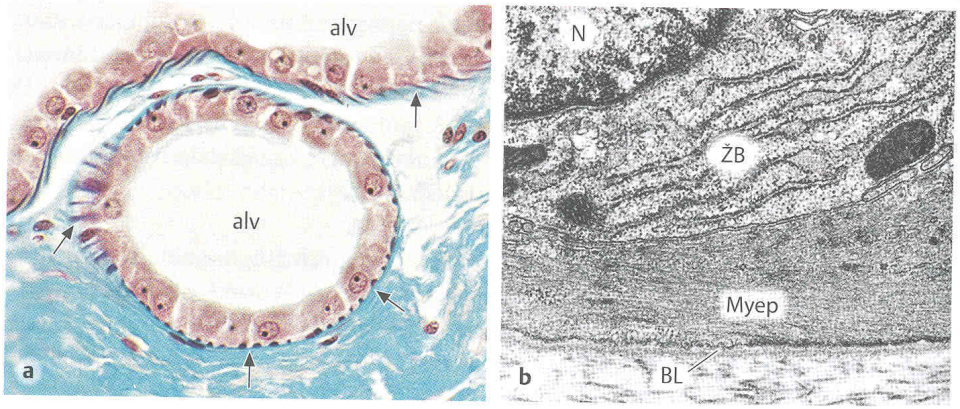


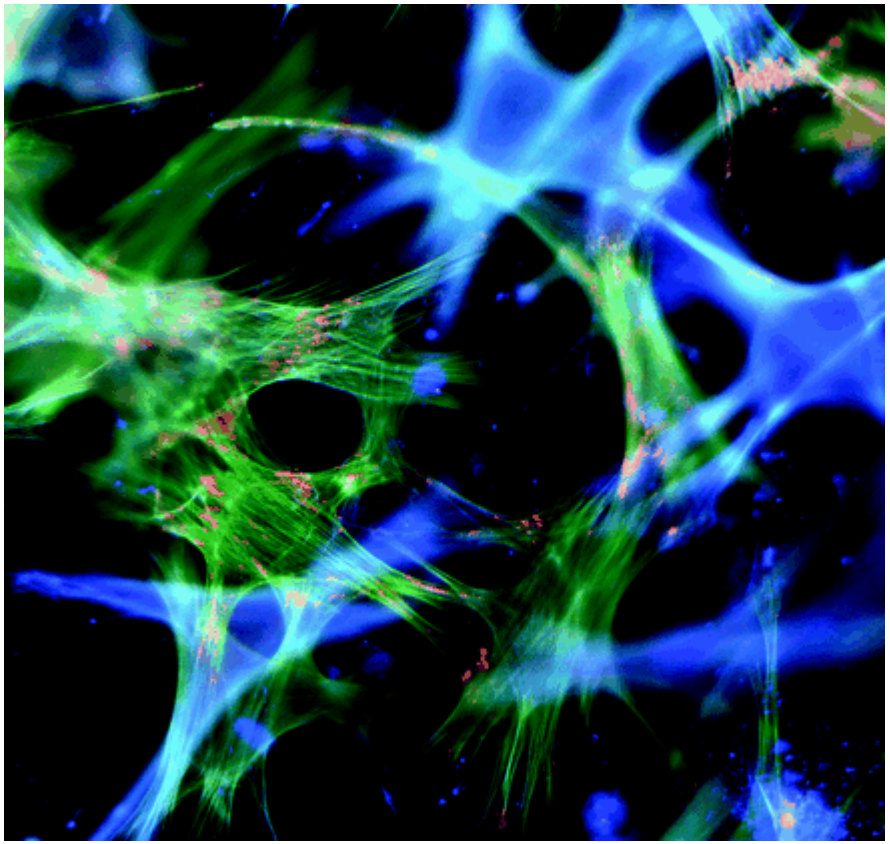




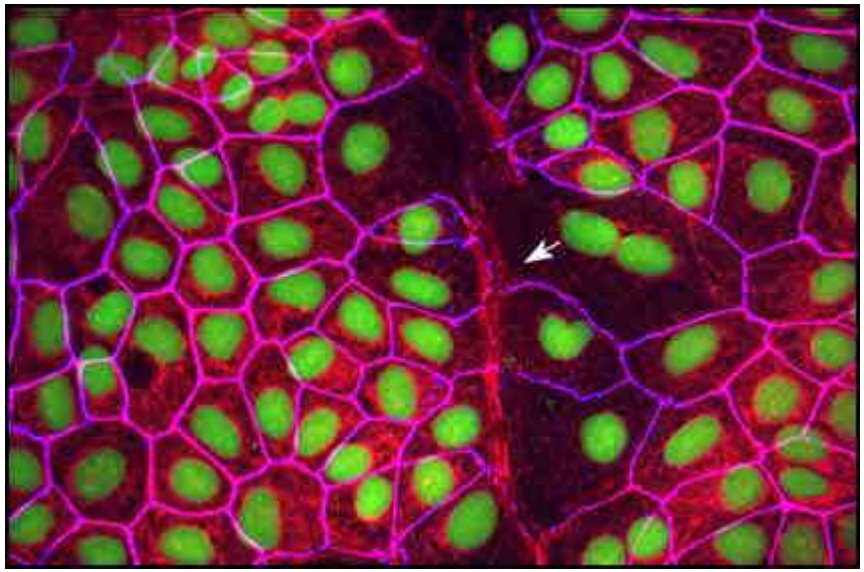
Myoepithelium

- Derived from epithelium (cytokeratin filaments, desmosomes)
- Biochemical properties of smooth muscle cells (α-actin, mysoin, desmin, gap junctions)
- Contraction upon nerve or hormonal stimulation
- Sweat and salivary glands – enhance secretion





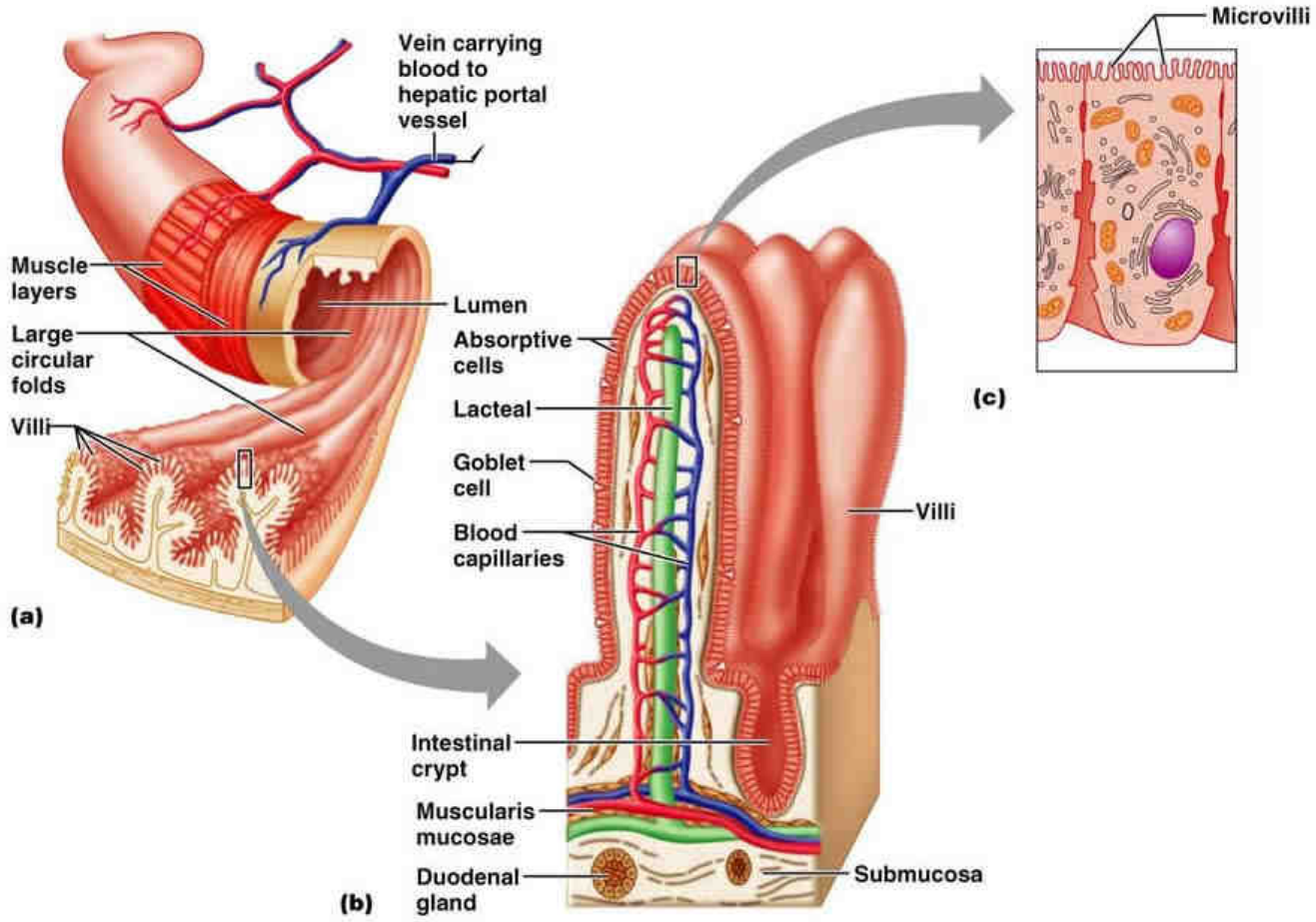
Regeneration and plasticity of epithelial tissue

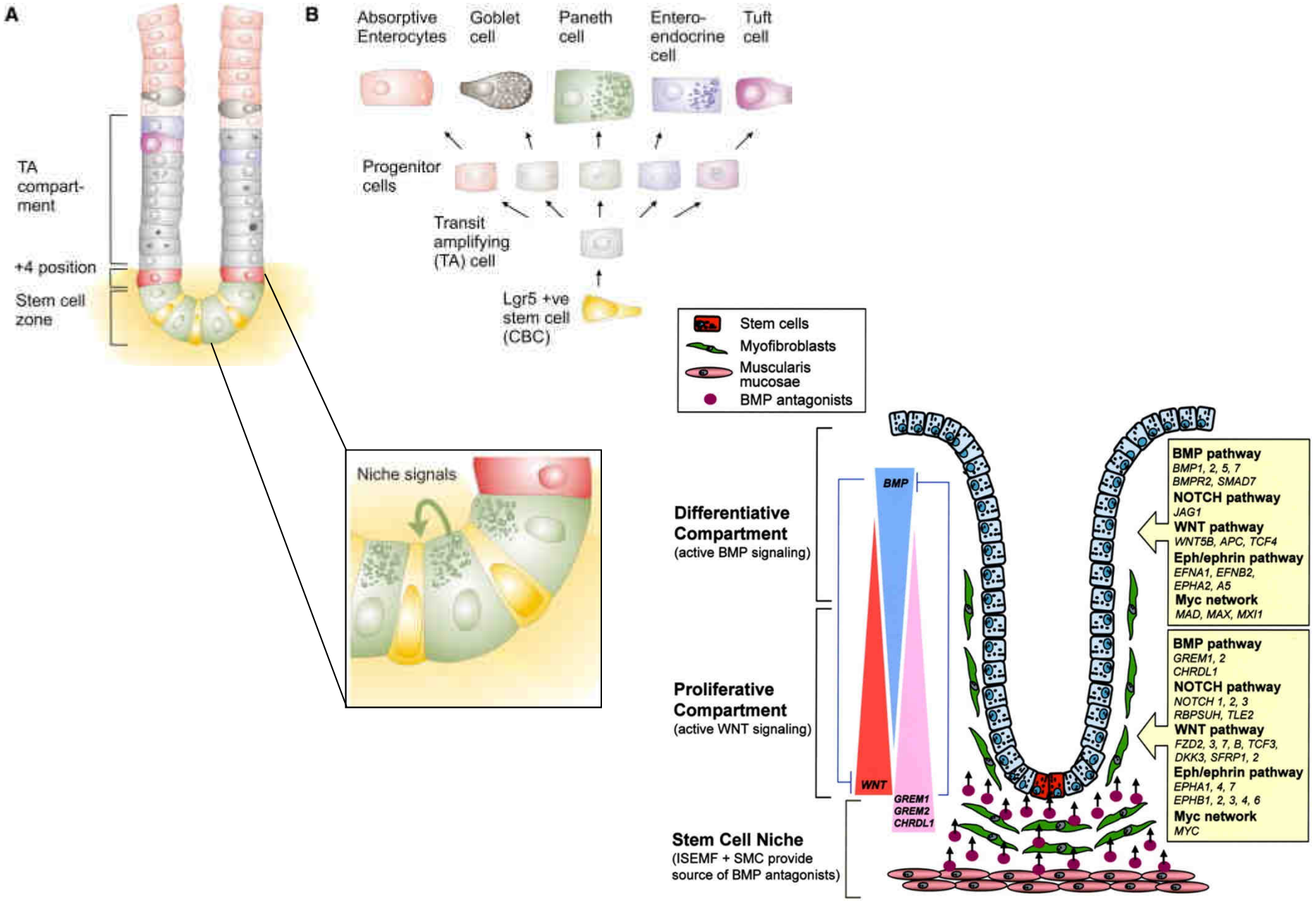


Regeneration of epithelial tissue

Different epithelia have different capability of regeneration
(epidermis × inner ear sensory epithelium)
Multi- a oligopotent stem cells
Microenvironment – *stem cell niche*

Example: Regeneration of intestinal epithelium



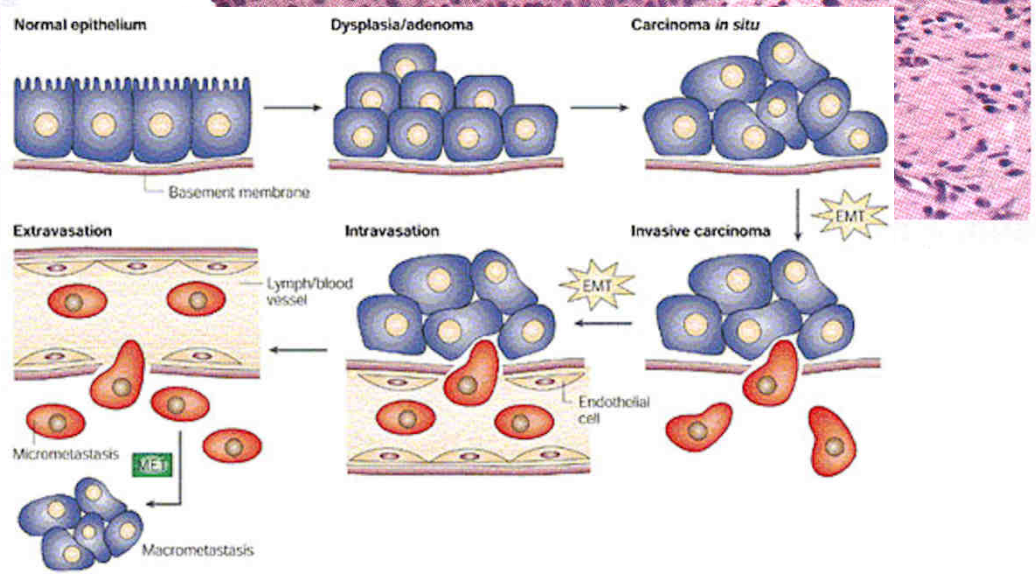

A
TA compart-ment
+4 position
Stem cell zone
B
Absorptive Enterocytes
Goblet cell
Paneth cell
Entero-endocrine cell
Tuft cell
Progenitor cells
Transit amplifying (TA) cell
Lgr5 +ve stem cell (CBC)
Niche signals
Stem cells
Myofibroblasts
Muscularis mucosae
BMP antagonists
Differentiative Compartment
(active BMP signaling)
Proliferative Compartment
(active WNT signaling)
Stem Cell Niche
(ISEMF + SMC provide source of BMP antagonists)
BMP
WNT
GREM1
GREM2
CHRDL1
BMP pathway
BMP1, 2, 5, 7
BMPR2, SMAD7
NOTCH pathway
JAG1
WNT pathway
WNT5B, APC, TCF4
Eph/ephrin pathway
EFNA1, EFNB2,
EPHA2, A5
Myc network
MAD, MAX, MXI1
BMP pathway
GREM1, 2
CHRDL1
NOTCH pathway
NOTCH 1, 2, 3
RBPSUH, TLE2
WNT pathway
FZD2, 3, 7, B, TCF3,
DKK3, SFRP1, 2
Eph/ephrin pathway
EPHA1, 4, 7
EPHB1, 2, 3, 4, 6
Myc network
MYC

Clinical correlations - Metaplasia

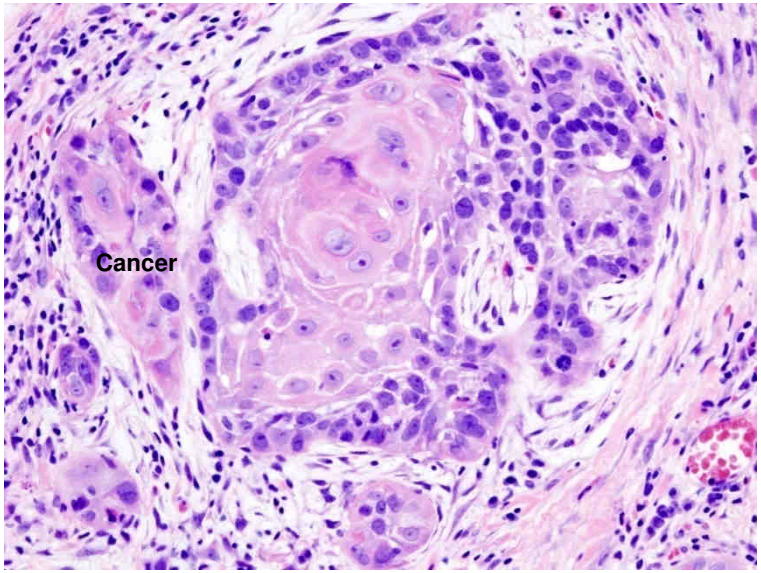
Clinical correlations – Epithelial to mesenchymal transition

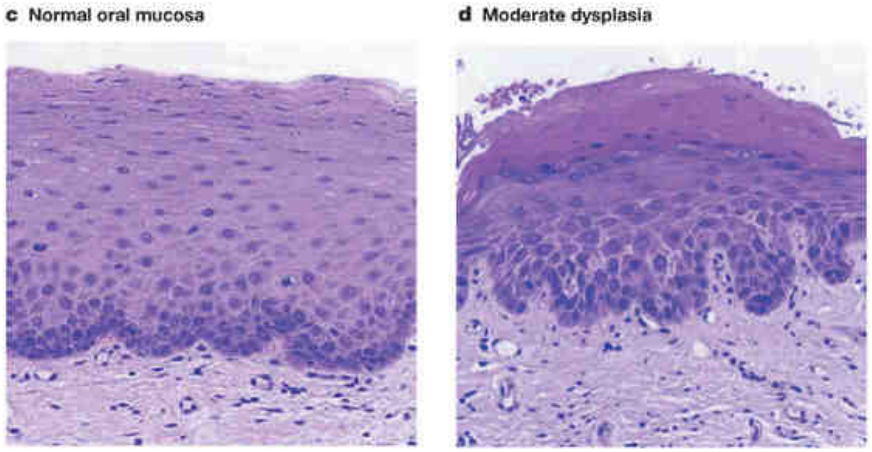
Stratified squamous

Squamous metaplasia of the uterine cervix



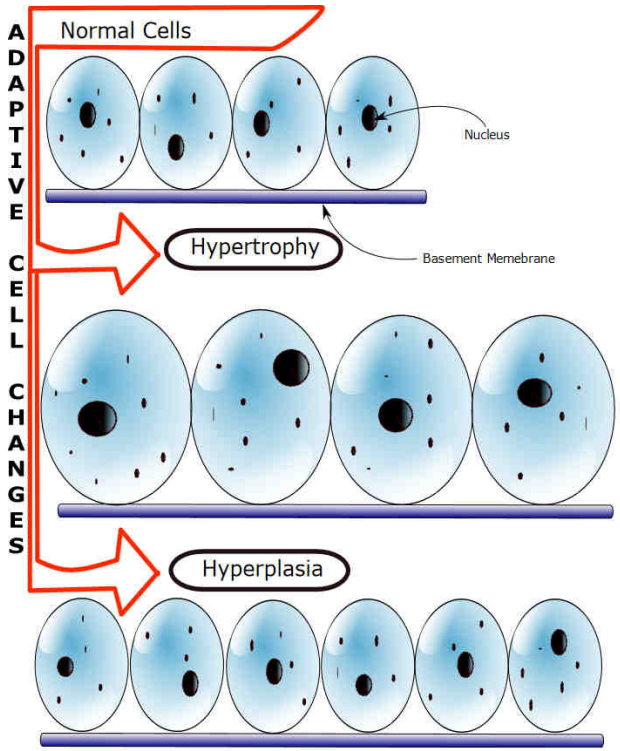
Simple columnar



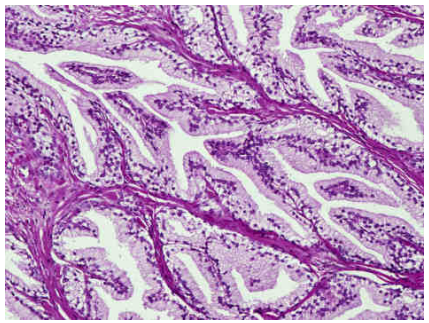


Plasticity of epithelial tissue

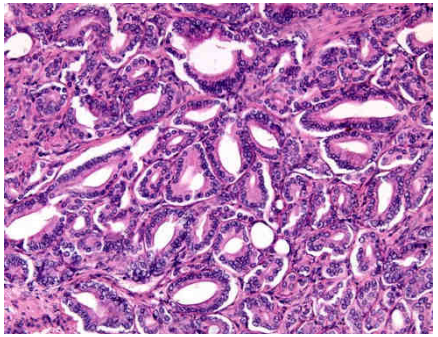
Hyperplasia



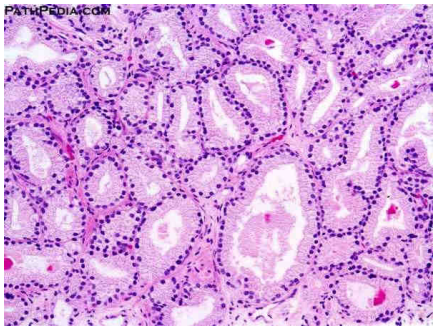
Normal prostate



Hyperplasia of glandular epithelium



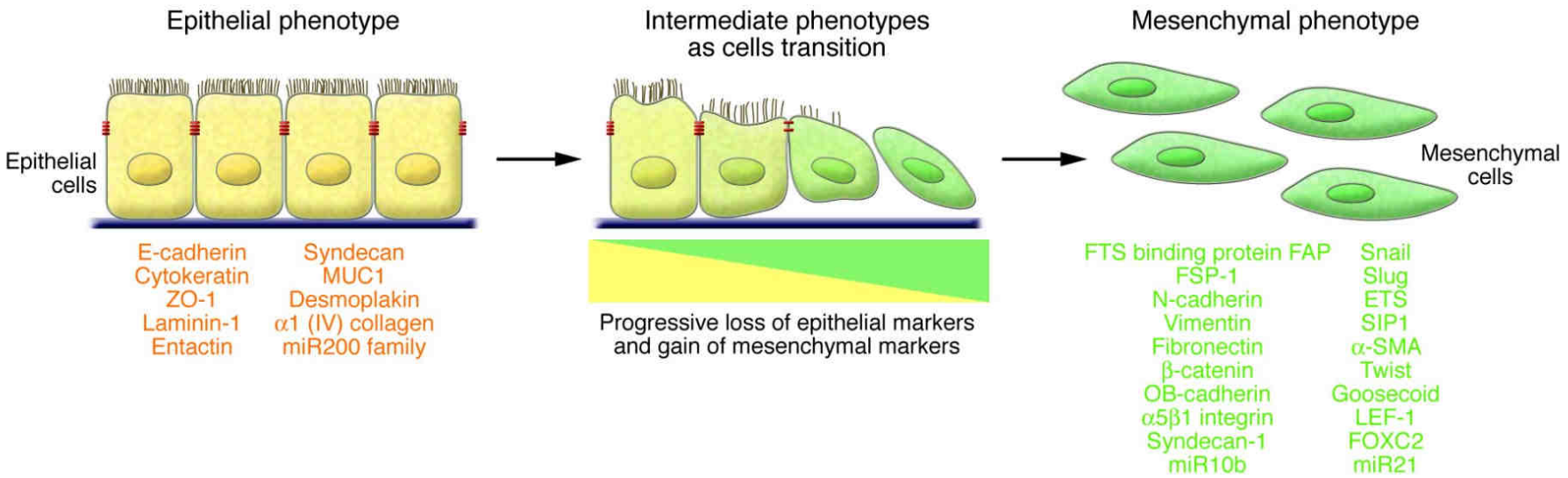
Prostate cancer



Wikipedia.org; http://radiology.uchc.edu

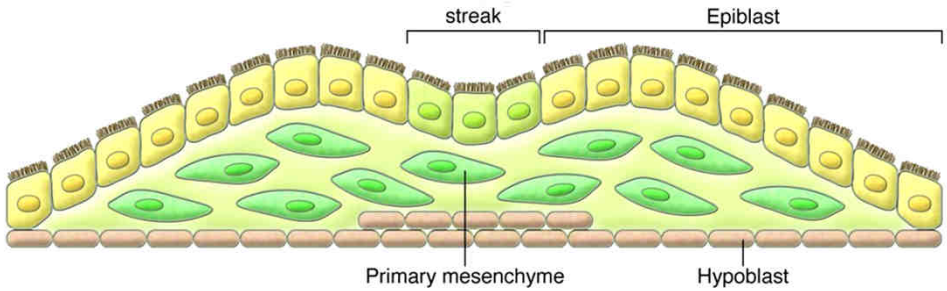
Plasticity of epithelial tissue

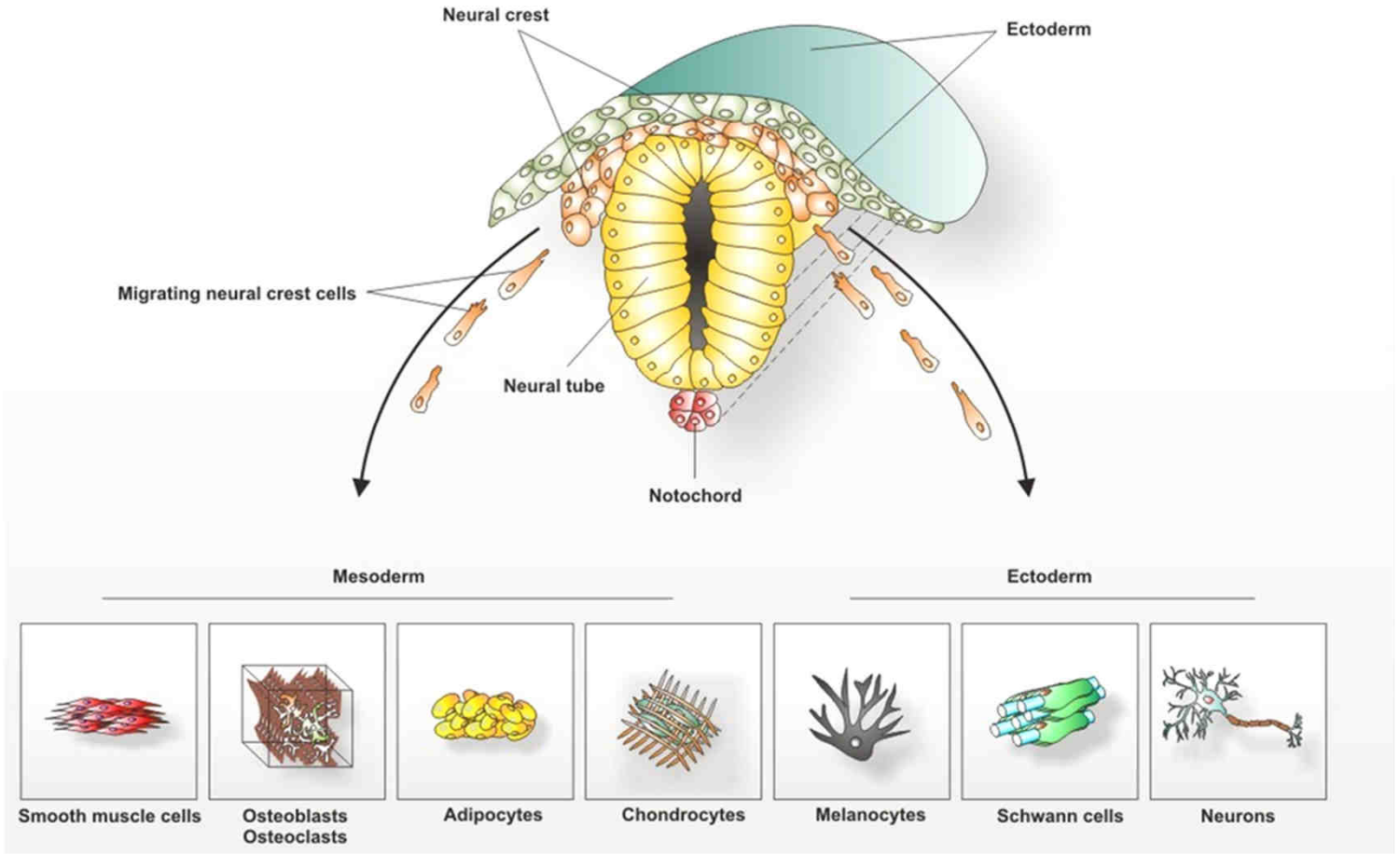
Epithelial – to mesenchymal transition (EMT)

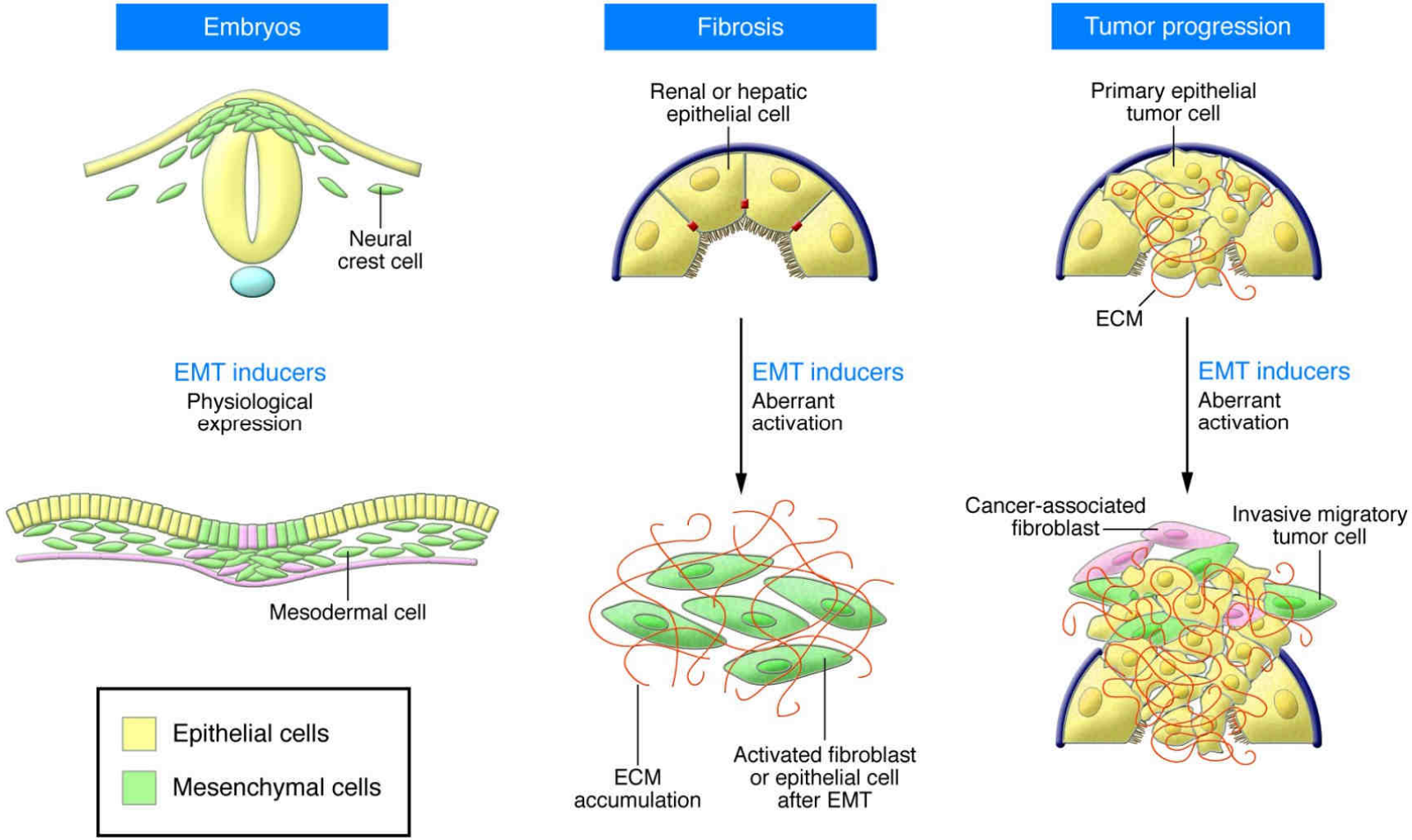


J Clin Invest. 2009;119(6):1420–1428. doi:10.1172/JCI39104.

EMT in embryonic development







J Clin Invest. 2009;119(6):1438–1449. doi:10.1172/JCI38019.

Thank you for attention

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http://www.med.muni.cz/histology