Introduction to tissue biology and epithelial tissues

Prof. Özgür Çınar, M.D.

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"First, I am your professor, not your teacher. There is a difference. Up to now your instruction has been in the hands of teachers, and a teacher's job is to make sure that you learn… However, things are very different for a university professor. It is no part of my job to make you learn. At university, learning is your job — and yours alone. My job is to lead you to the fountain of knowledge. Whether you drink deeply or only gargle is entirely up to you."

Keith Parsons, Ph.D.

Professor of Philosophy,
College of Human Sciences and Humanities

University of Houston – Clear Lake

2

What is tissue?

Tissue: *Fr. tissu, woven; L. texo, to weave; Tr. doku*

Types

- Epithelium (epithelial tissue)
- Connective tissue
- Muscle tissue
- Nerve tissue
- Cartilage
- Bone
- Adipose tissue
- Blood

3

Epithelial Tissue

- is avascular
- covers body surfaces, lines body cavities and tubes
- constitutes glands
- works as receptors for the special senses (smell, taste etc.)

4

What are their functions?

- Protection
- Secretion
- Absorption
- Transportation (on the surface or transepithelial)
- Receptor/Sensory

5

Classification of Epithelial Tissue

6

Fill in the blanks

Shapes of the cells / Layer (one or more)	**Squamous** (Tr. Yassı)	**Cuboidal** (Tr. Kübik)	**Columnar** (Tr. Prizmatik, silindirik)	**Pseudostratified** (Tr. Yalancı çok katlı)	**Transitional** (Tr. Değişici)
Simple (Tr. Basit)					
Stratified (Tr. Çok katlı)					

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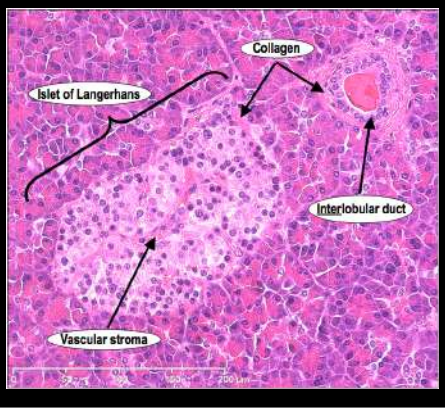
Epithelioid Tissue

Cells are closely apposed to one another but lack a free surface.

Ex: Leydig cells, islets of Langerhans, anterior lobe of pituitary gland



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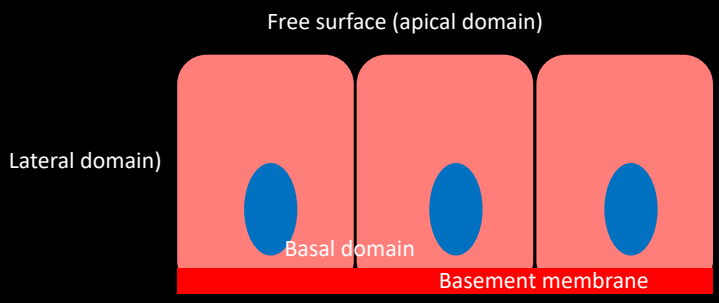
Do epithelial cells exhibit polarity?



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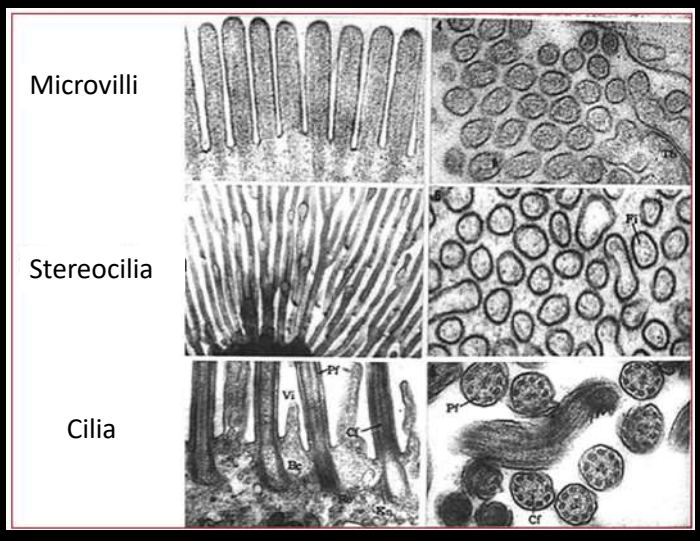
Surface modifications of apical domain



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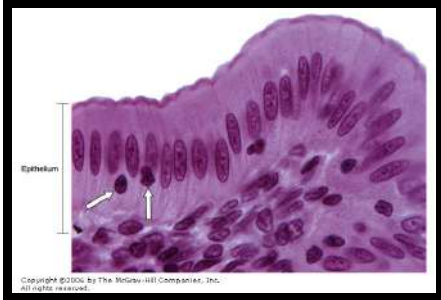
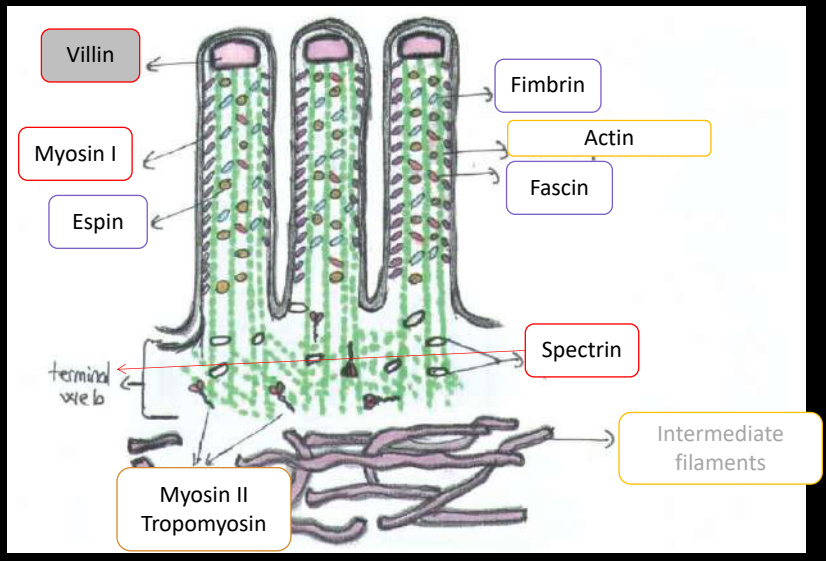
Microvilli (Sing. Microvillus)

Striated border
Brush border





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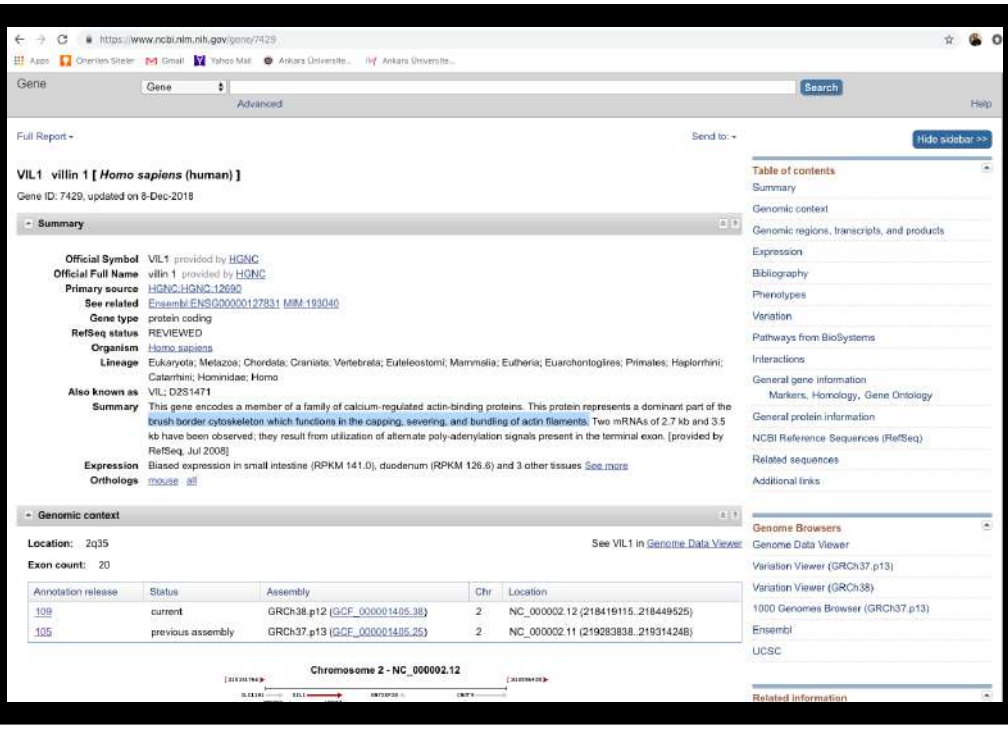

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Stereocilia

Stereocilia are unusually long, branched microvilli.

They contain ezrin protein to anchor actin filaments to cell membrane.

They do not have villin protein.

Stereocilia of the sensory epithelium of the ear also derive from microvilli and are sensitive to mechanical vibration.

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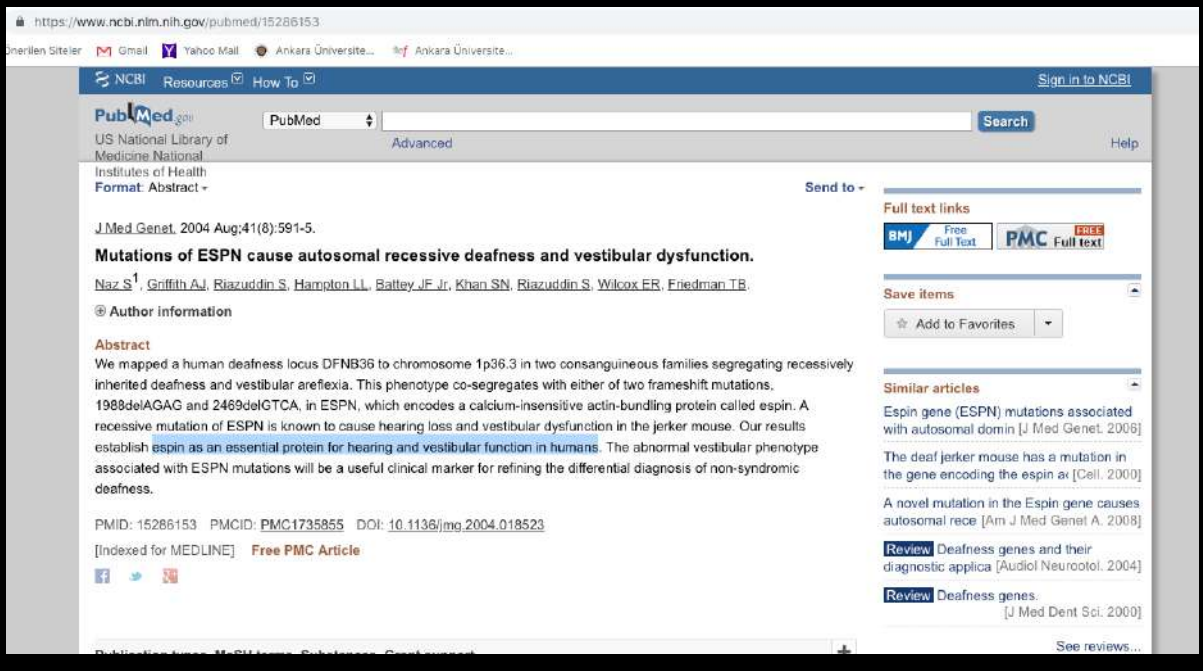

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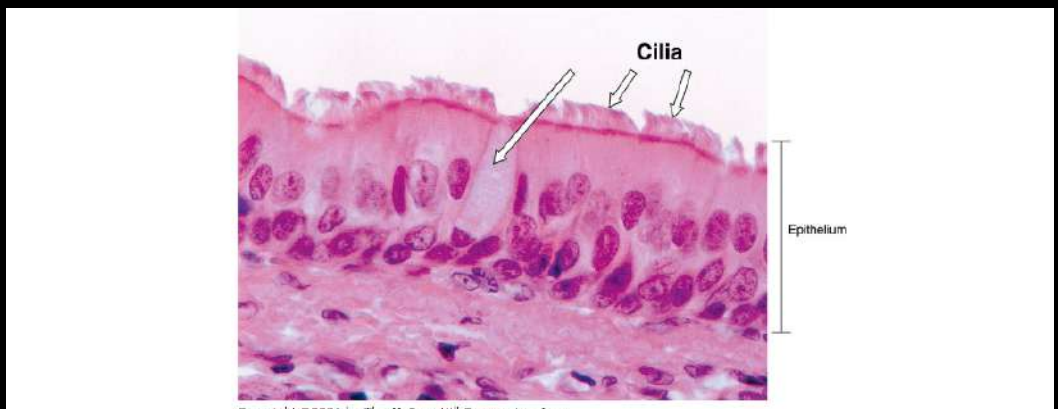
Cilia (sing. Cilium)



Pseudostratified columnar epithelium of the trachea, formed by long and short cells. As some cells do not reach the surface of the epithelium their nuclei are present in different heights of the epithelial layer. Mucus-secreting cells, called goblet cells (arrow), intermingle with ciliated lining cells. (Courtesy of PA Abrahamsohn.)

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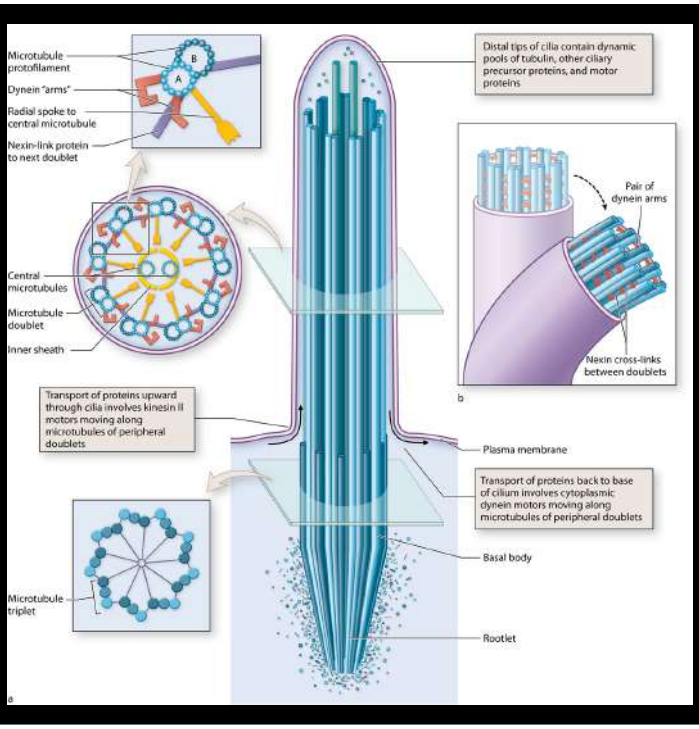
Cilia



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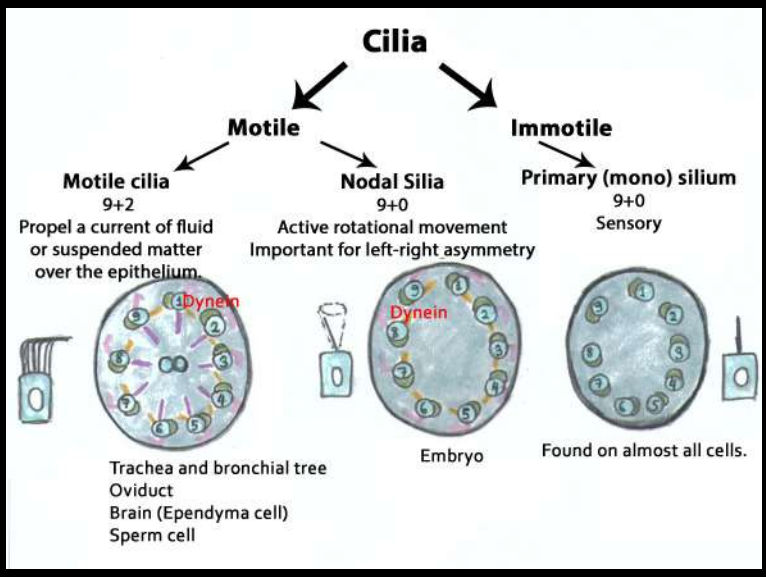

- Kartagener's syndrome

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Related disease - Polycystic Kidney Disease

In humans, mutations in two genes, ADPKD1 and ADPKD2, appear to affect development of these primary cilia, leading to polycystic kidney disease (PKD).

The proteins encoded by these genes, polycystin-1 and polycystin-2, respectively, are essential in the formation of the calcium channels associated with primary cilia.

This autosomal recessive disorder is characterized by multiple expanding cysts in both kidneys, which ultimately destroy the renal cortex and lead to renal failure.

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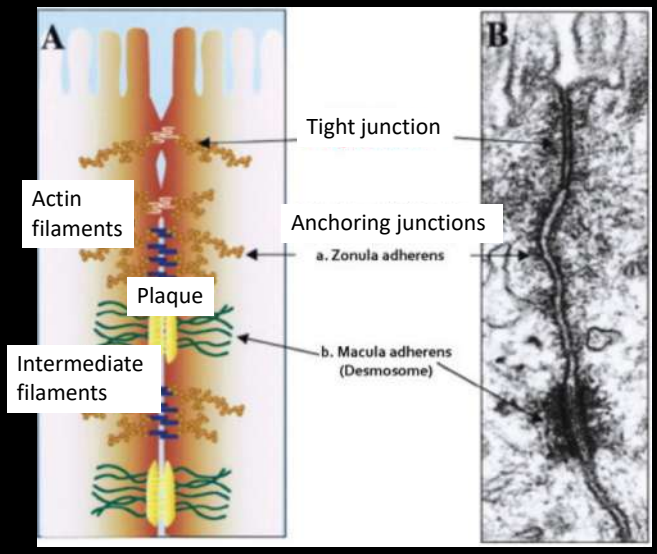
The Lateral Domain and Intercellular Junctions



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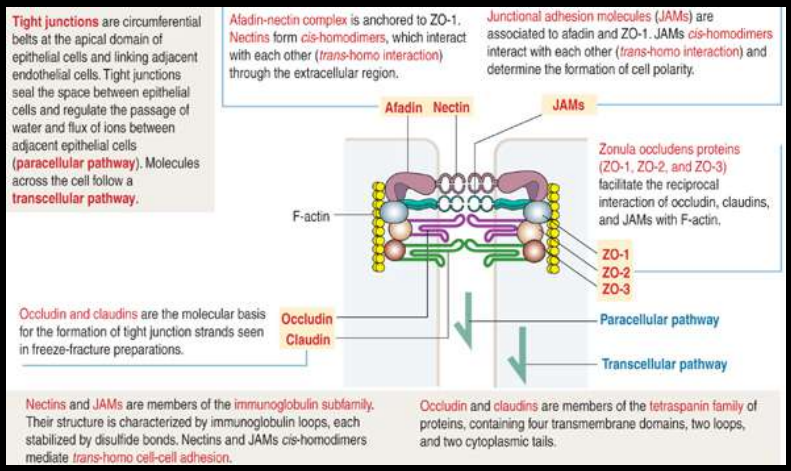
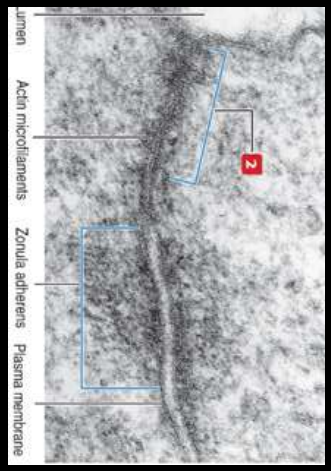
Tight (Occluding) Junction





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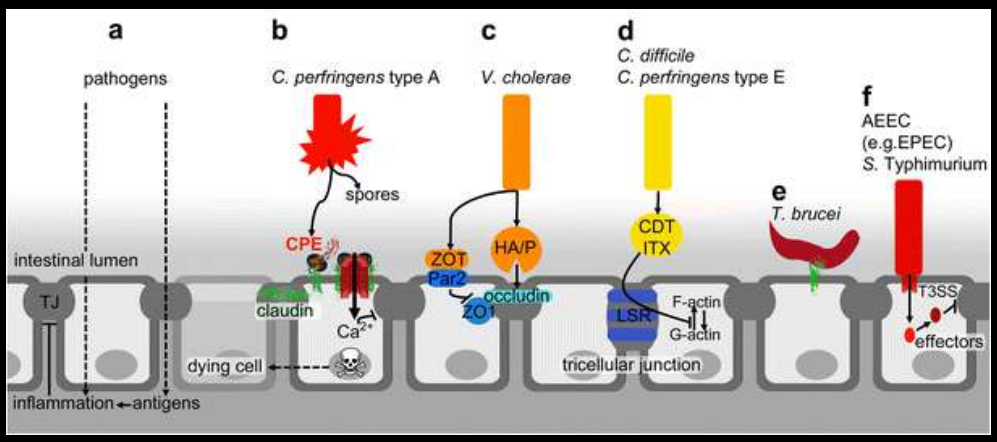
Tight (Occluding) Junction



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Adherens (Anchoring) Junction

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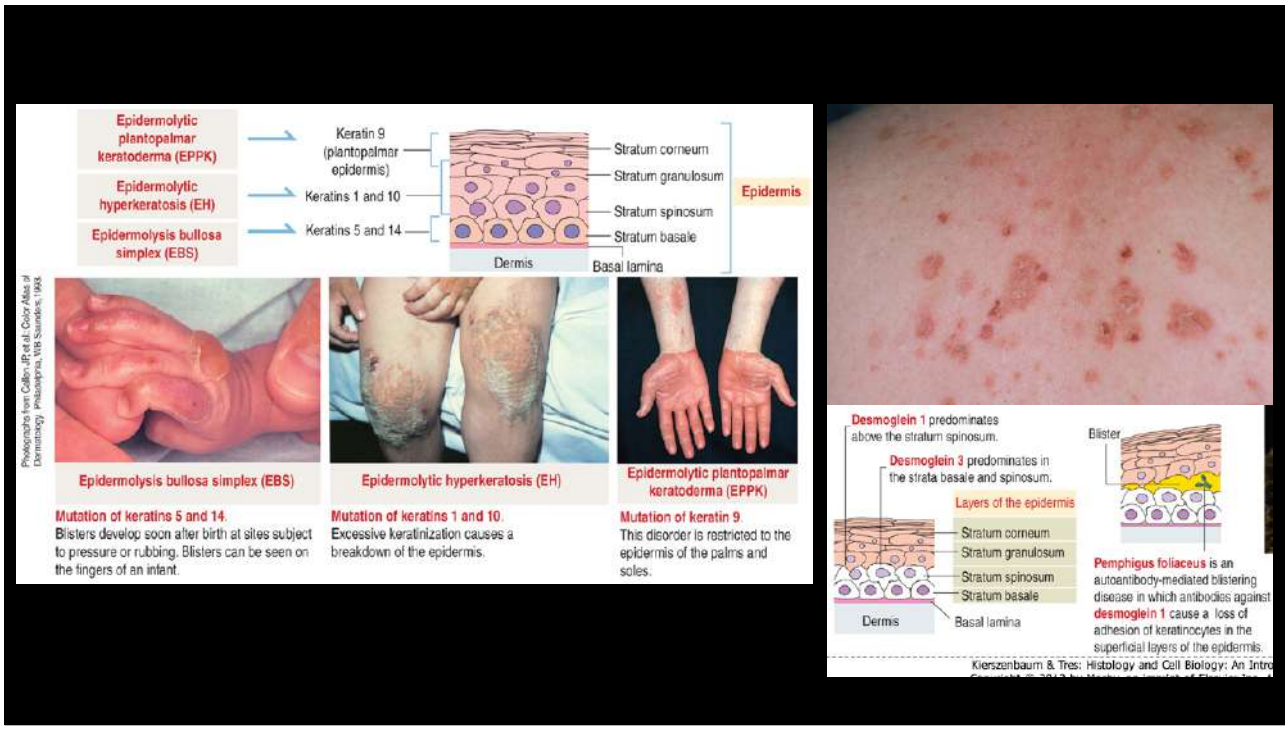

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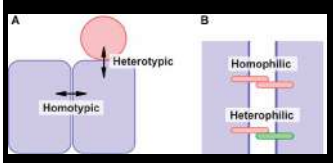
Cell adhesion molecules



- Calcium
  - Dependent
    - Cadherin
    - Selectin
  - Independent
    - Integrin
    - Immunoglobulin superfamily

Homophilic interactions

Heterophilic interactions
Leukocytes, endothelial cells

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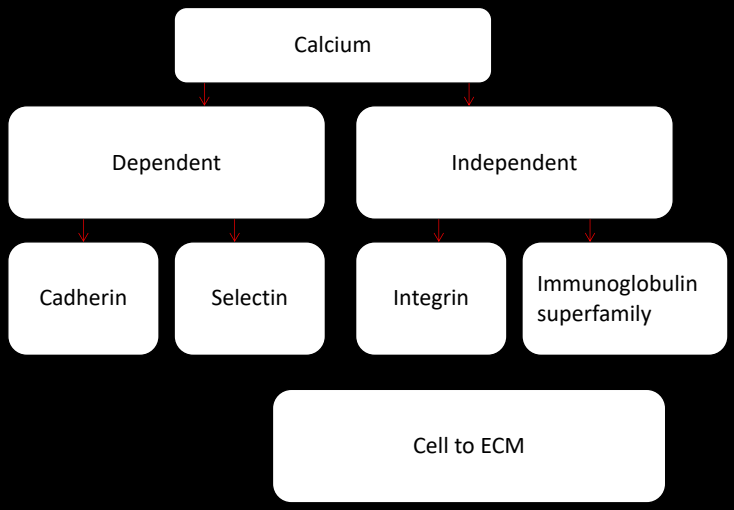
Cell adhesion molecules



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Immunoglobulin superfamily (Cellular Adhesion Molecules)

- Vascular,
- Inter-cellular,
- Neural,
- Cellular (C-CAM),
- Down Syndrome (DS-CAM),
- Platelet Endothelial (PE-CAM)
- Junctional Adhesions Molecules (JAM)

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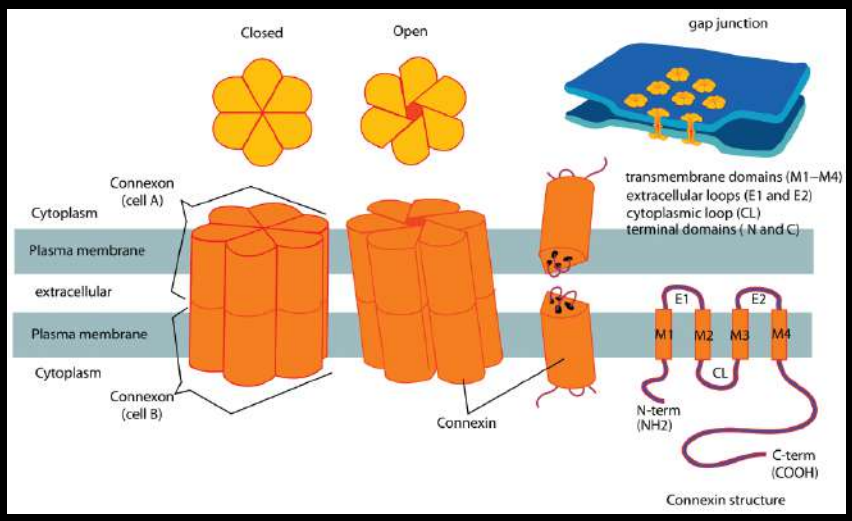
Communicating (Gap) Junction (Nexus)



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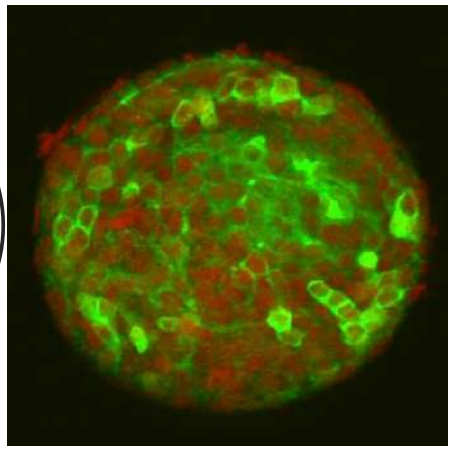
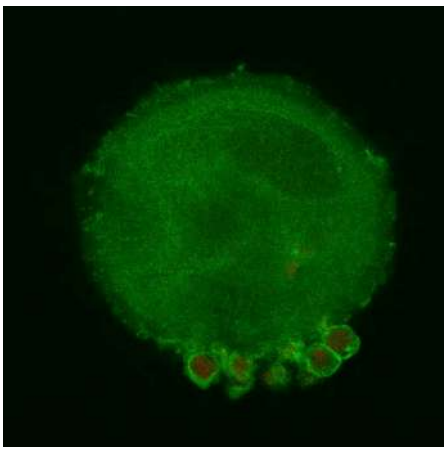
What is known?

GJs





Connexin 43

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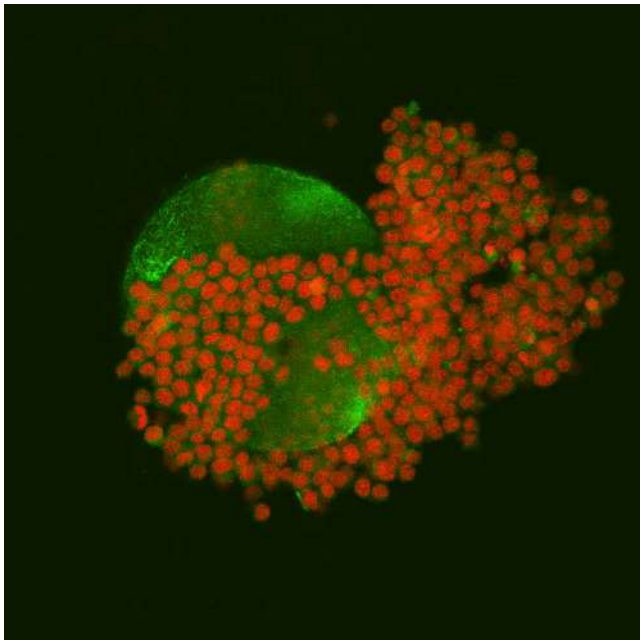
What is known?

GJs



Connexin 32

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What is known?

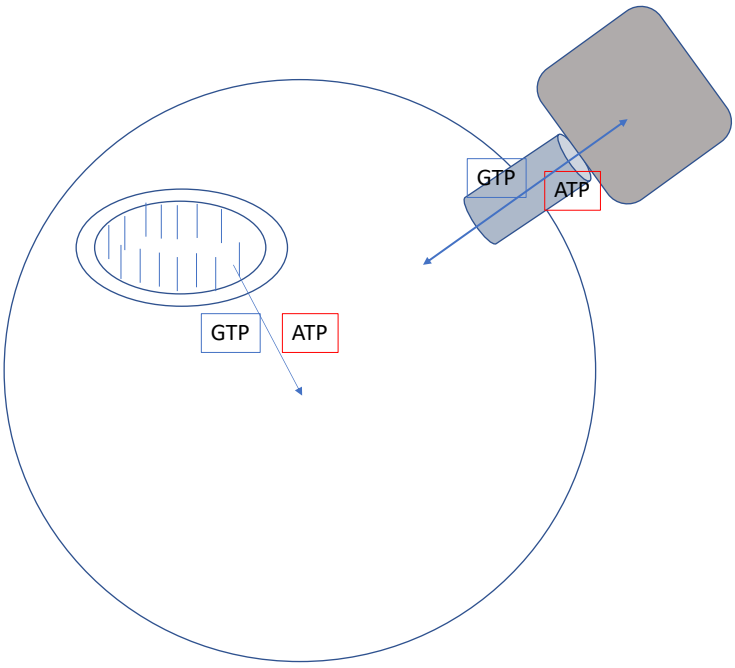

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Table 1
Genetic disorders caused by human connexin mutations.

Gene	Chromosome	Protein	Disorder(s)	OMIM
GJA1	6q22.31	Cx43	Craniometaphyseal dysplasia, autosomal recessive	218400
			Erythrokeratodermia variabilis et progressiva	133200
			Oculodentodigital dysplasia	164200
			Oculodentodigital dysplasia, autosomal recessive	257850
			Palmoplantar keratoderma with congenital alopecia	104100
			Syndactyly, type III	186100
GJA3	13q12.11	Cx46	Cataract	601885
GJA4	1p34.3	Cx37		
GJA5	1q21.2	Cx40	Atrial fibrillation, familial, 11	614049
			Atrial standstill, digenic (*GJA5/SCN5A*)	108770
GJA8	1q21.2	Cx50	Cataract	116200
GJA9	1p34.3	Cx59		
GJA10	6q15	Cx62		
GJB1	Xq13.1	Cx32	Charcot-Marie-Tooth neuropathy, X-linked 1	302800
GJB2	13q12.11	Cx26	Bart-Pumphrey syndrome	149200
			Deafness, autosomal dominant 3A	601544
			Deafness, autosomal recessive 1A	220290
			Hystrix-like ichthyosis with deafness	602540
			Keratitis-ichthyosis-deafness syndrome	148210
			Keratoderma, palmoplantar, with deafness	148350
			Vohwinkel syndrome	124500
			Porokeratotic eccrine ostial and dermal duct nevus	
GJB3	1p34.3	Cx31	Deafness, autosomal dominant 2B	612644
			Deafness, digenic, (*GJB2/GJB3*)	220290
			Erythrokeratodermia variabilis et progressiva	133200
GJB4	1p34.3	Cx30.3	Erythrokeratodermia variabilis et progressiva	133200
GJB5	1p34.3	Cx31.1		
GJB6	13q12.11	Cx30	Deafness, autosomal dominant 3B	612643
			Deafness, autosomal recessive 1B	612645
			Deafness, digenic (*GJB2/GJB6*)	220290
			Ectodermal dysplasia 2, Clouston type	129500
GJB7	6q14.3-q15	Cx25		
GJC1	17q21.31	Cx45		
GJC2	1q42.13	Cx47	Leukodystrophy, hypomyelinating, 2	608804
			Spastic paraplegia 44, autosomal recessive	613206
			lymphedema, hereditary, IC	613480
GJC3	7q22.1	Cx30.2		
GJD2	15q14	Cx36		
GJD3	17q21.2	Cx31.9		
GJD4	10p11.21	Cx40.1		
GJE1	6q24.1	Cx23		

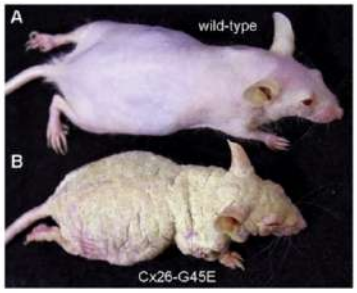

Fig. 1. A mouse model of KID syndrome. (A). A wild-type mouse of the SKH1 hairless strain. (B). An inducible transgenic SKH1 mouse expressing the Cx26-G45E mutation in keratinocytes develops the epidermal features of KID syndrome. See [166] for details.

KID: Keratitis-ichthyosis-deafness syndrome

M. Srinivas et al. / Biochimica et Biophysica Acta 1860 (2018) 192–201

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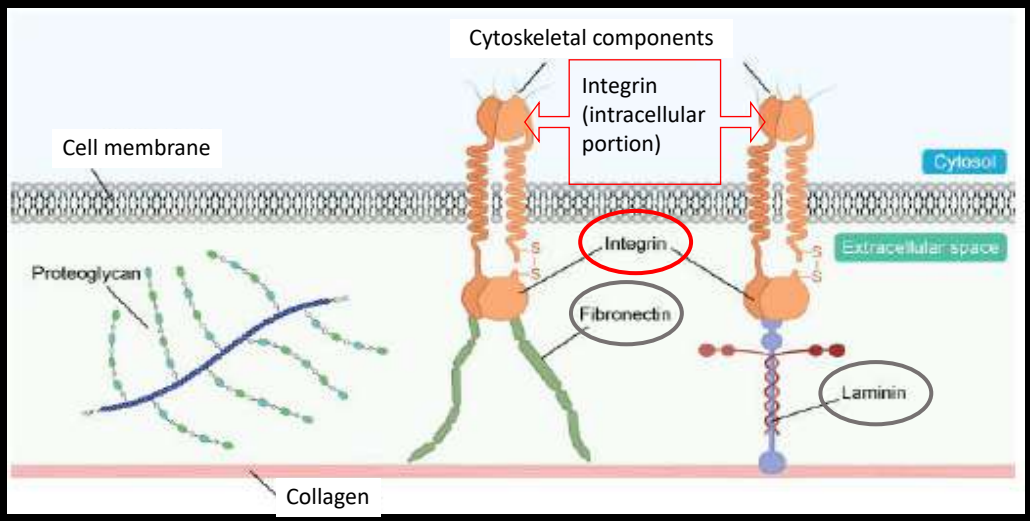
Basal domain and cell to ECM adhesions



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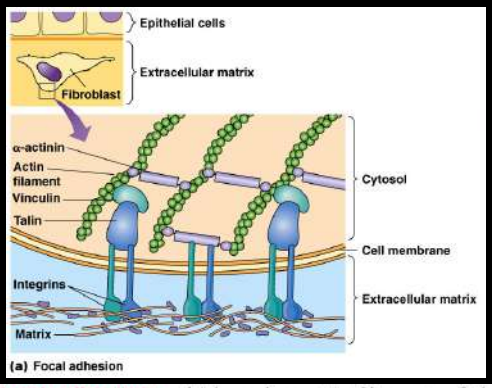
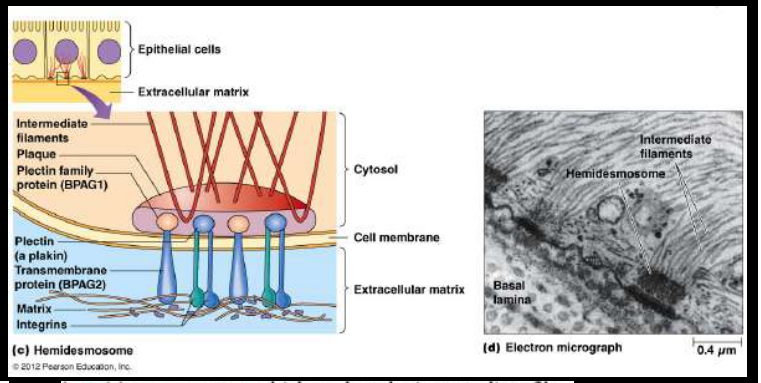
Cell to ECM adhesions: focal adhesion and hemidesmosome



focal adhesions, which anchor actin filaments of the cytoskeleton into the basement membrane; and



hemidesmosomes, which anchor the intermediate filaments of the cytoskeleton into the basement membrane.

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Basement membrane (basal lamina)

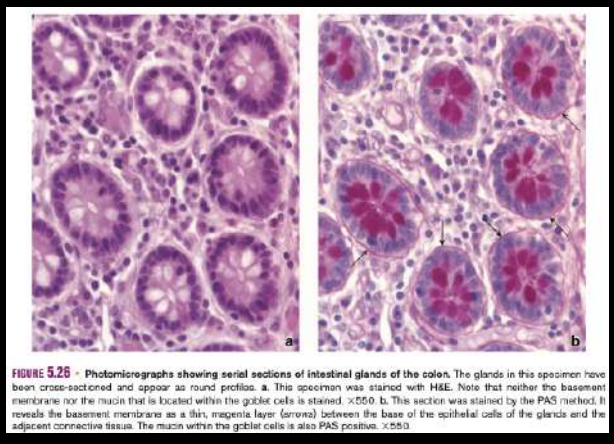
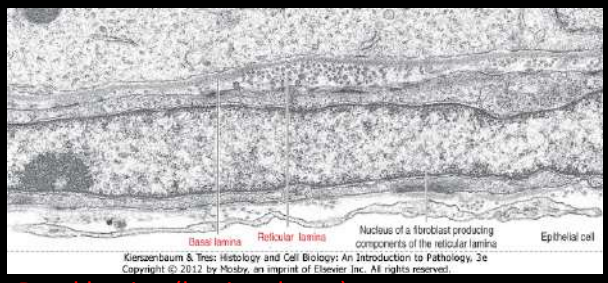


FIGURE 5.26 • **Photomicrographs showing serial sections of intestinal glands of the colon.** The glands in this specimen have been cross-sectioned and appear as round profiles. **a.** This specimen was stained with H&E. Note that neither the basement membrane nor the mucin that is located within the goblet cells is stained. ×550. **b.** This section was stained by the PAS method. It reveals the basement membrane as a thin, magenta layer (*arrows*) between the base of the epithelial cells of the glands and the adjacent connective tissue. The mucin within the goblet cells is also PAS positive. ×550.

The basal lamina in nonepithelial cells is referred to as the **external lamina**.



Basal lamina (lamina densa):

- 3- to 4-nm filaments
- composed of
- laminin, fibronectin, laminin receptors etc.
- type IV collagen, and other collagens
- various associated proteoglycans
- glycoproteins (entactin/nidogen)

Reticular lamina: type III collagen (reticular fibers)

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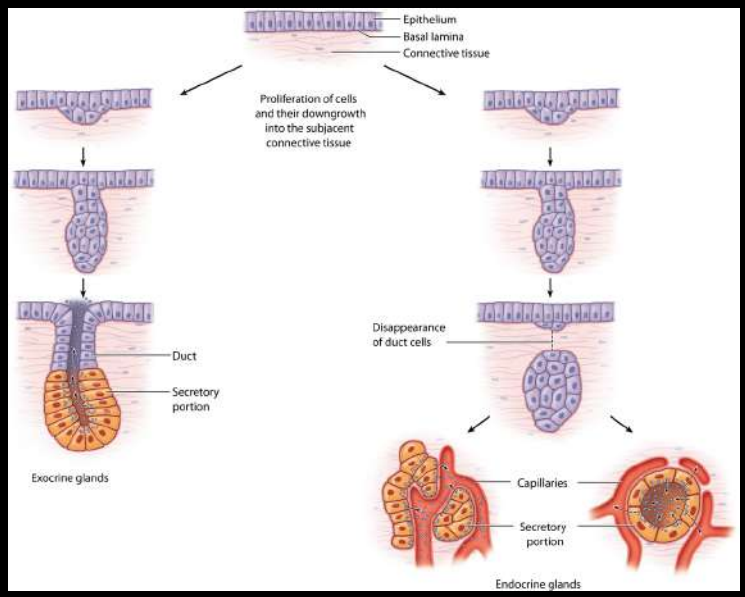
GLANDS (Tr. Bezler)



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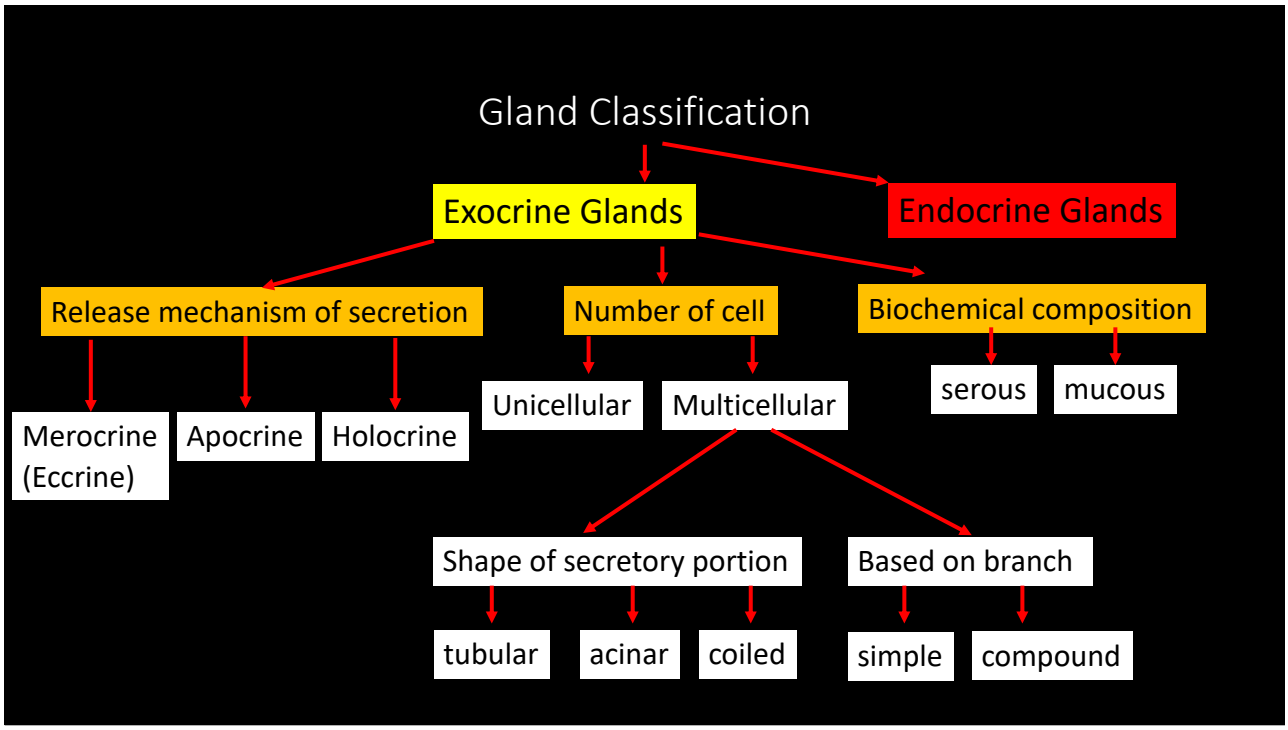
Gland Classification
Exocrine Glands
Endocrine Glands
Release mechanism of secretion
Number of cell
Biochemical composition
Merocrine (Eccrine)
Apocrine
Holocrine
Unicellular
Multicellular
serous
mucous
Shape of secretory portion
Based on branch
tubular
acinar
coiled
simple
compound

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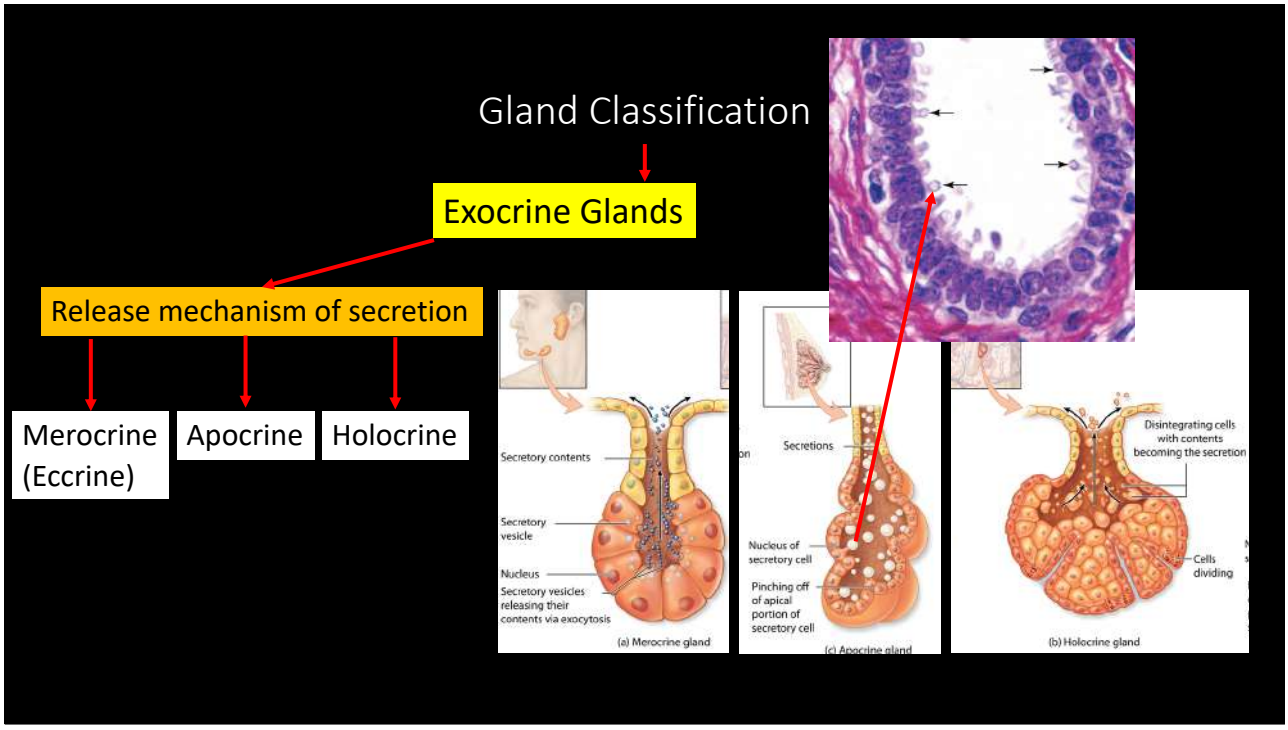
Gland Classification
Exocrine Glands
Release mechanism of secretion
Merocrine (Eccrine)
Apocrine
Holocrine
Secretory contents
Secretory vesicle
Nucleus
Secretory vesicles releasing their contents via exocytosis
(a) Merocrine gland
Secretions
Nucleus of secretory cell
Pinching off of apical portion of secretory cell
Disintegrating cells with contents becoming the secretion
Cells dividing
(b) Holocrine gland

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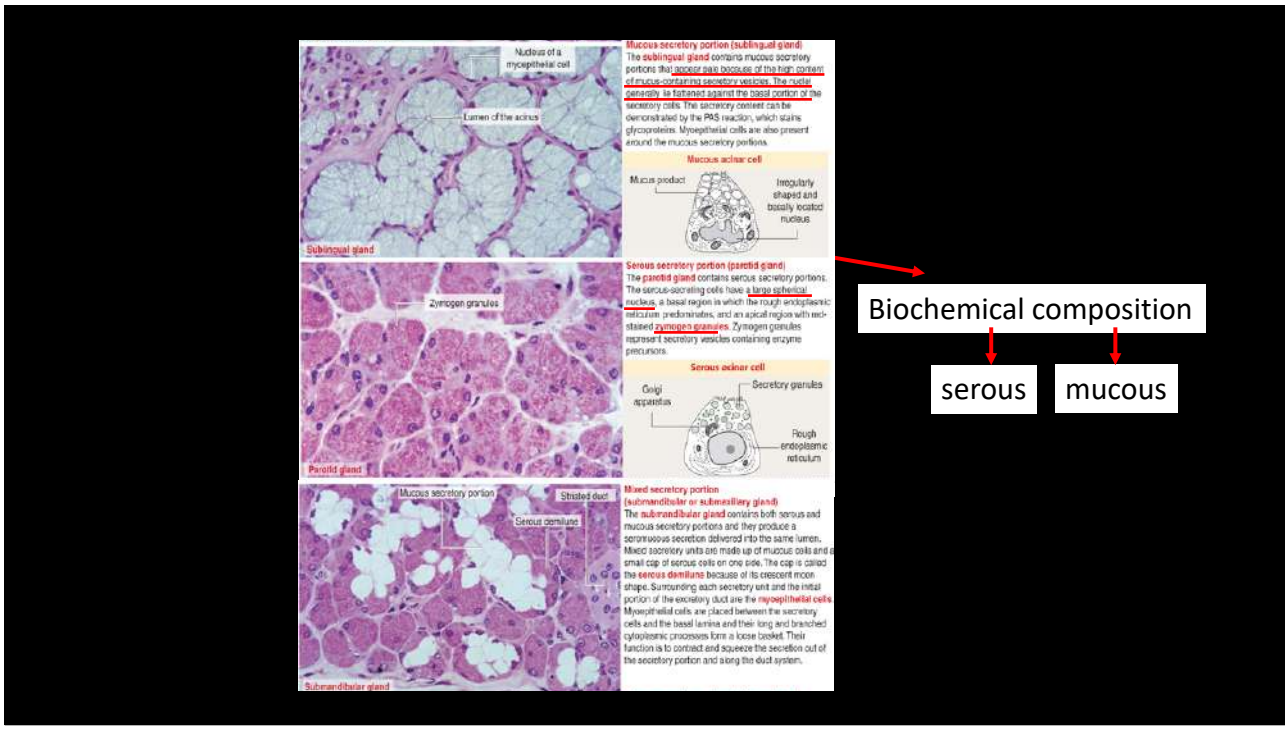
Nucleus of a myoepithelial cell
Lumen of the acinus
Sublingual gland
Mucous secretory portion (sublingual gland)
The sublingual gland contains mucous secretory portions that appear pale because of the high content of mucus-containing secretory vesicles. The nuclei generally lie flattened against the basal portion of the secretory cells. The secretory content can be demonstrated by the PAS reaction, which stains glycoproteins. Myoepithelial cells are also present around the mucous secretory portions.
Mucous acinar cell
Mucus product
Irregularly shaped and basally located nucleus
Zymogen granules
Parotid gland
Serous secretory portion (parotid gland)
The parotid gland contains serous secretory portions. The serous-secreting cells have a large spherical nucleus, a basal region in which the rough endoplasmic reticulum predominates, and an apical region with red-stained zymogen granules. Zymogen granules represent secretory vesicles containing enzyme precursors.
Serous acinar cell
Golgi apparatus
Secretory granules
Rough endoplasmic reticulum
Mucous secretory portion
Striated duct
Serous demilune
Submandibular gland
Mixed secretory portion (submandibular or submaxillary gland)
The submandibular gland contains both serous and mucous secretory portions and they produce a seromucous secretion delivered into the same lumen. Mixed secretory units are made up of mucous cells and a small cap of serous cells on one side. The cap is called the serous demilune because of its crescent moon shape. Surrounding each secretory unit and the initial portion of the excretory duct are the myoepithelial cells. Myoepithelial cells are placed between the secretory cells and the basal lamina and their long and branched cytoplasmic processes form a loose basket. Their function is to contract and squeeze the secretion out of the secretory portion and along the duct system.
Biochemical composition
serous
mucous

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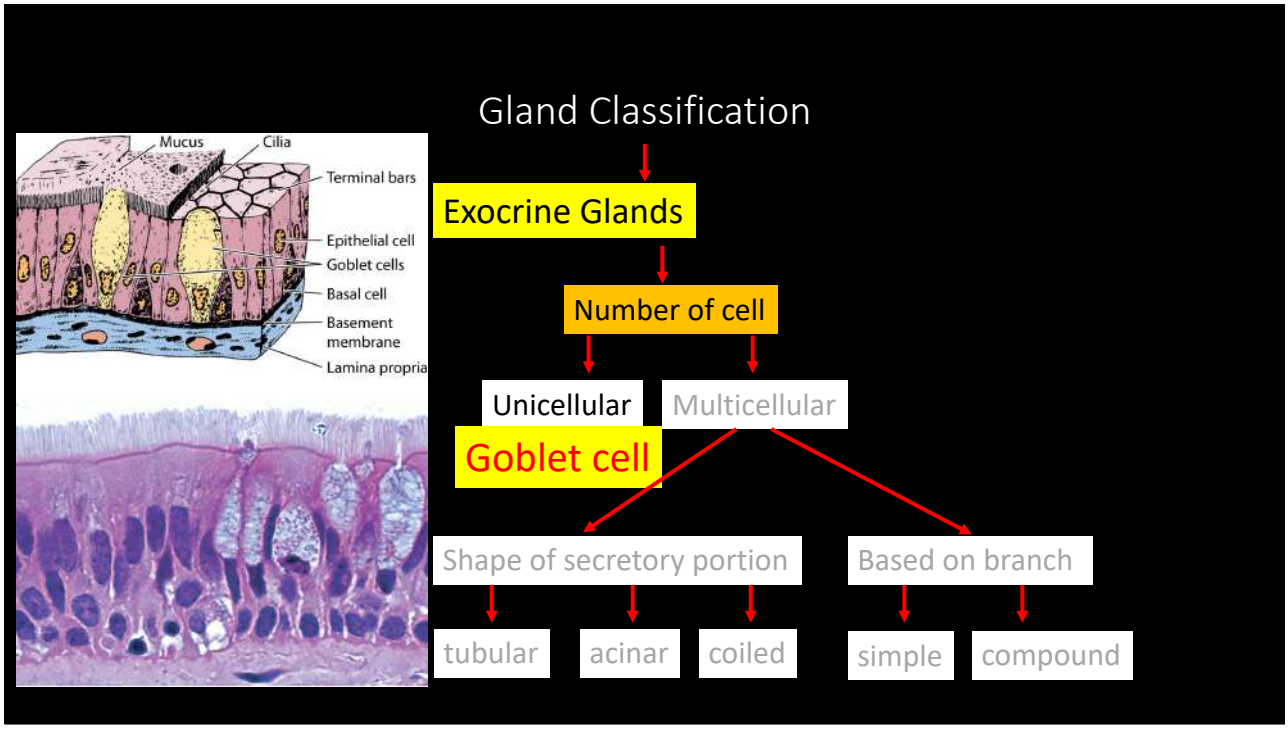
Gland Classification
Exocrine Glands
Number of cell
Unicellular
Multicellular
Goblet cell
Shape of secretory portion
tubular
acinar
coiled
Based on branch
simple
compound
Mucus
Cilia
Terminal bars
Epithelial cell
Goblet cells
Basal cell
Basement membrane
Lamina propria

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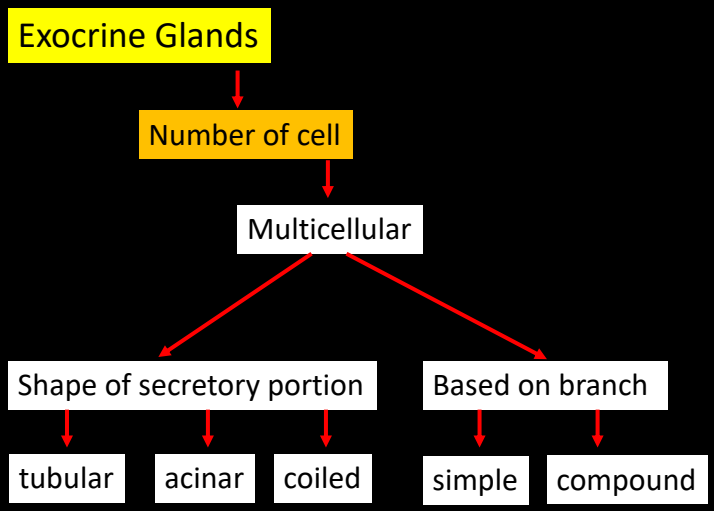
Gland Classification



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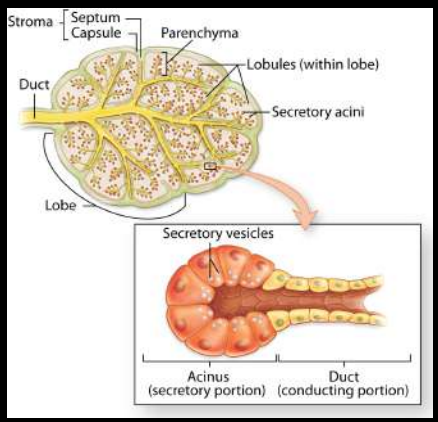
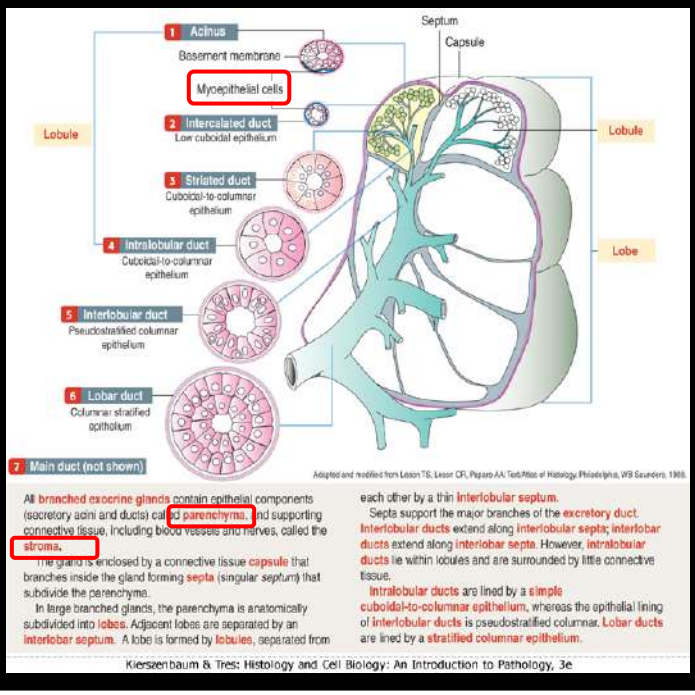
Structure of an exocrine gland





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