

450BCH
Biochemistry of
Specialized Tissues

IV. Epithelial Tissues

Epithelium

- A sheet of cells that **COVERS** a body surface or lines a body cavity.
- **Examples:** outer skin, inner lining of stomach, respiratory tubes, lining of blood vessels, and most of the body's glands.

Epithelia

- Epithelial tissues arise from any of the 3 primary *germ layers* of the embryo
- **Ectoderm**
 - Skin
- **Endoderm**
 - Digestive tract
- **Mesoderm**
 - Peritoneal cavity, Blood vessels. Lymphatic vessels.

Function of Epithelia

- **Protection**

- Against wear and tear
- Keratin and mucous prevent drying

- **Filtration & absorption**

- Microvilli in kidney and intestine

- **Surface transport**

- Via cilia on cell surface

- **Secretion (all glands are epithelia)**

- Hormones. Digestive enzymes, mucus

- **Sensory reception**

How to classify epithelia

(1) Shape

(2) Number of layers

(3) Specialization

(4) Covering and lining vs. glandular

Classification of Epithelia

- **Number of layers**
 1. Simple (single layer)
 2. Stratified (more than one layer)

- **Cell Shape**
 1. Squamous – Plate-like
 2. Cuboidal – Shaped like cubes
 3. Columnar – Taller than wide

All Epithelia are Avascular

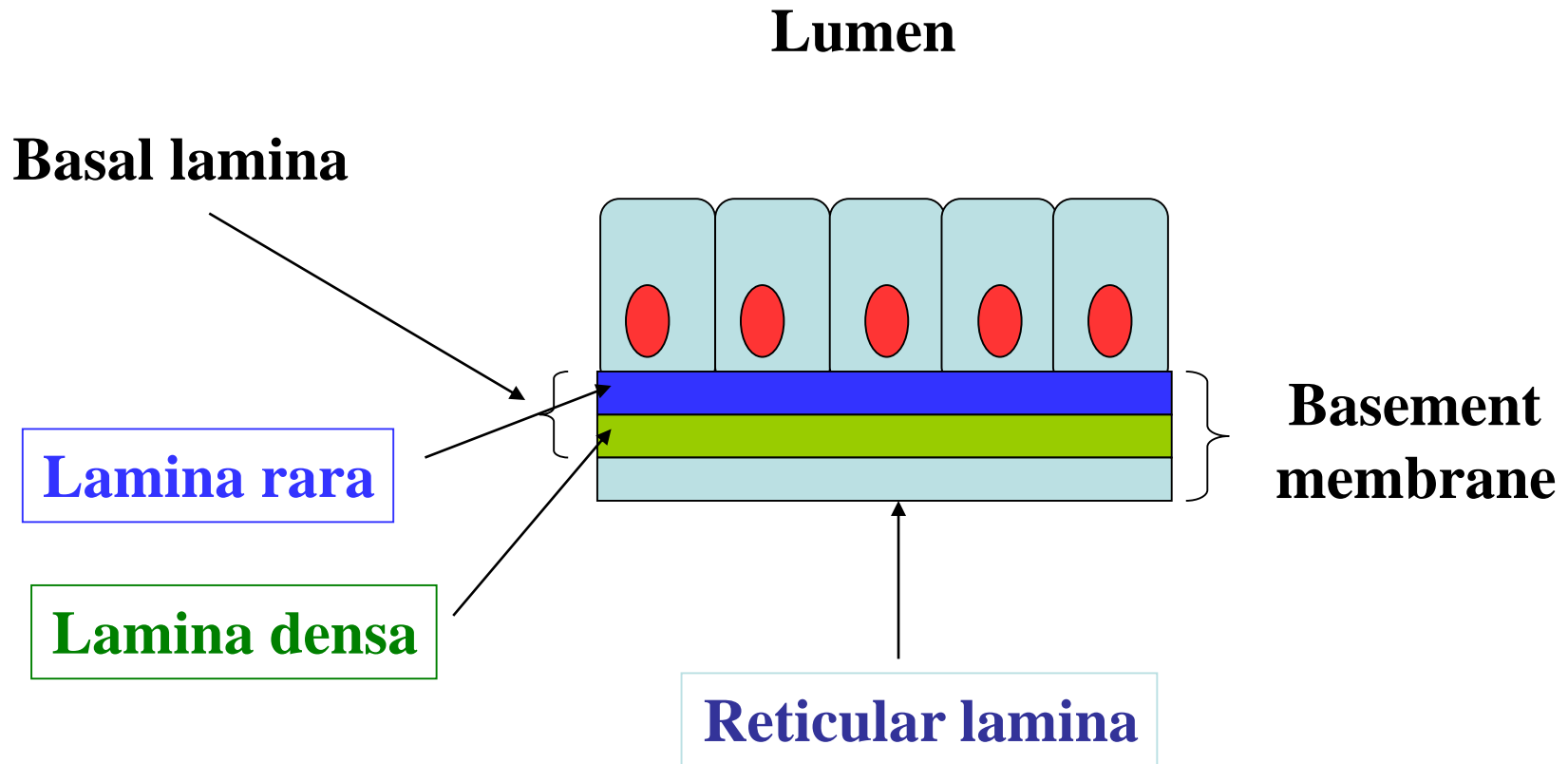
- Blood vessels supplying epithelia are found in the underlying connective tissue.
- Beneath the basement membrane

Basement membrane

- Lies between epithelium and underlying connective tissue.
- It is the external lamina (coat) for muscle and nervous tissue.

- Three layers:**
 - a) Top two from epithelia, also called basal lamina
 - Lamina rara (Lucida)
 - Lamina densa
 - b) Lowest from connective tissue.
 - Reticular lamina (Lamina fibroreticularis)

Basement membrane components



Parts of the basement membrane

- **Basal lamina**

- Type IV collagen
- Heparan sulfate
- Fibronectin and laminin

- **Reticular lamina**

- Type II collagen
- Also called reticular fibers

Function of the Basement membrane

- Structural *support* via cell-matrix adhesions
- Allow nutrients and waste to *diffuse*
- *Filter* for macromolecules (Kidney)
- Zone for *differentiation* and polarization of cells.
- Plays a role in *regeneration* by acting as a “highway” for cell migration.

Simple Vs. Stratified Epithelia

- **Simple**

- One layer of cells
- All cells touch basement membrane

- **Stratified**

- Two or more layers
- Only bottom layer of cells touch basement membrane.

Simple & Stratified

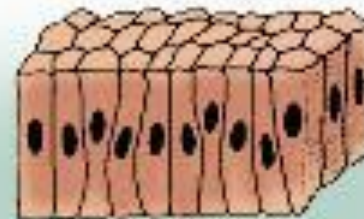
Types of Epithelium



Simple squamous

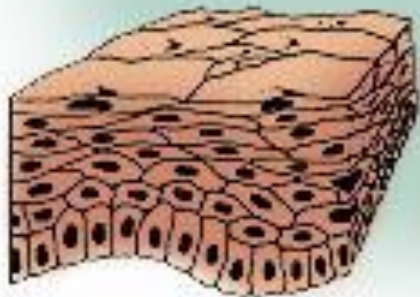


Simple cuboidal

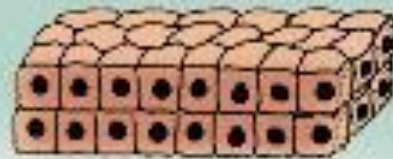


Simple columnar

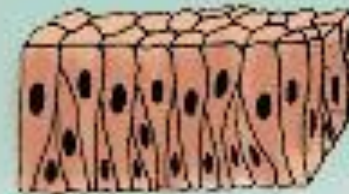
Transitional



Stratified squamous



Stratified cuboidal



Pseudostratified columnar

Simple Squamous Epithelia

- **Shape:** Flattened, scale-like, disc shaped nucleus
- **Function:** Exchange simple gases, protection
- **Place:** in kidney tubules, blood vessels, alveoli and lining major body cavities

Simple squamous epithelium

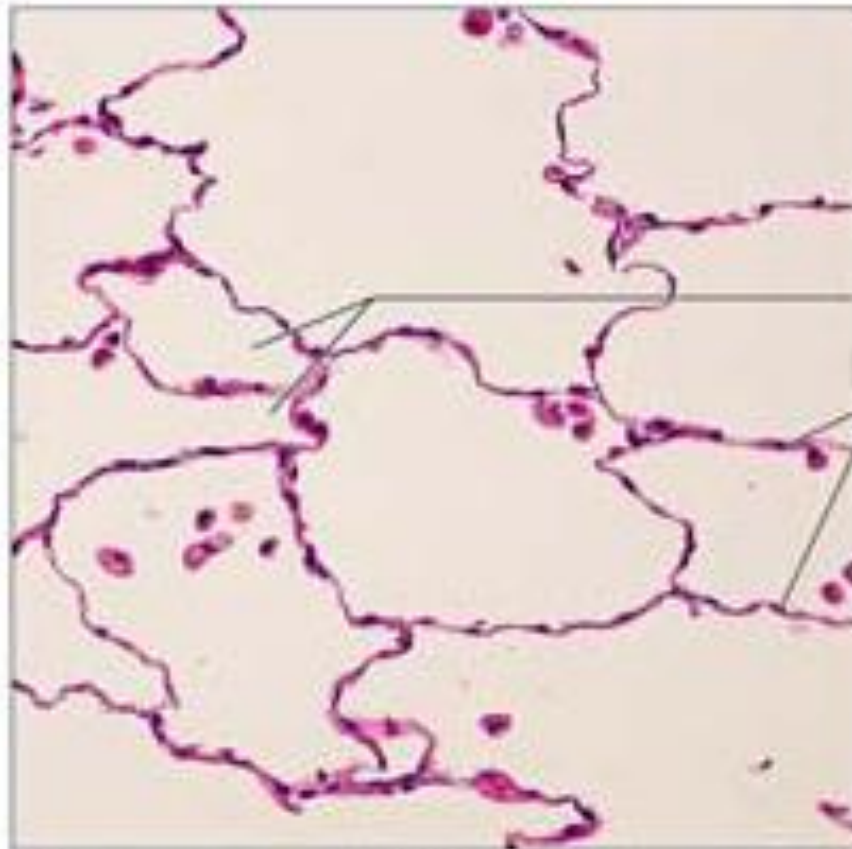
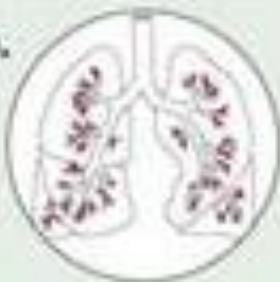
(a) Simple squamous epithelium

Description: Single layer of flattened cells with disc-shaped central nuclei and sparse cytoplasm; the simplest of the epithelia.



Function: Allows passage of materials by diffusion and filtration in sites where protection is not important; secretes lubricating substances in serosae.

Location: Kidney glomeruli and orpuscles; air sacs of lungs; lining of heart, blood vessels, and lymphatic vessels; lining of ventral body cavity (serosae).



Air sacs of lung tissue
Nuclei of squamous epithelial cells

Photomicrograph: Simple squamous epithelium forming part of the alveolar (air sac) walls (400 \times).

Simple Cuboidal Epithelia

- **Shape:** cuboidal with spherical nucleus
- **Function:** secretion and absorption
- **Place:** ovary, renal medulla, ducts

Simple Cuboidal Epithelia

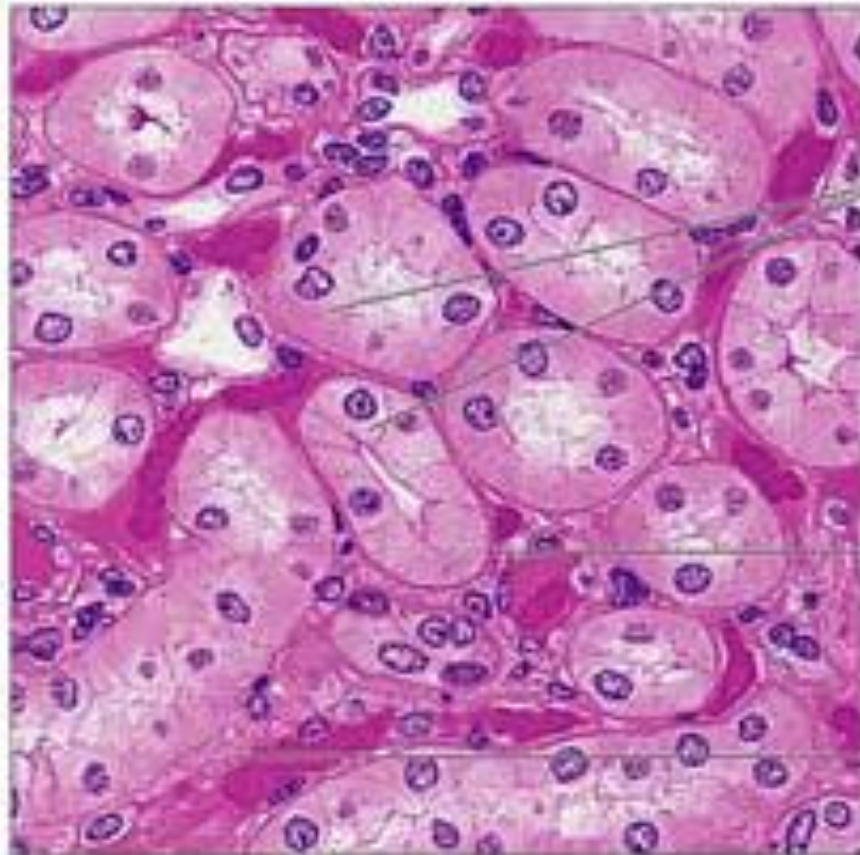
(b) Simple cuboidal epithelium

Description: Single layer of cubelike cells with large, spherical central nuclei.



Function: Secretion and absorption.

Location: Kidney tubules; ducts and secretory portions of small glands; ovary surface.



Simple cuboidal epithelial cells

Basement membrane

Connective tissue

Photomicrograph: Simple cuboidal epithelium in kidney tubules (400 \times).

Simple Columnar Epithelia

- **Shape:**

- Column shaped,
- Organelles located near luminal surface
- Nucleus near basement membrane
- Height varies by functional activity

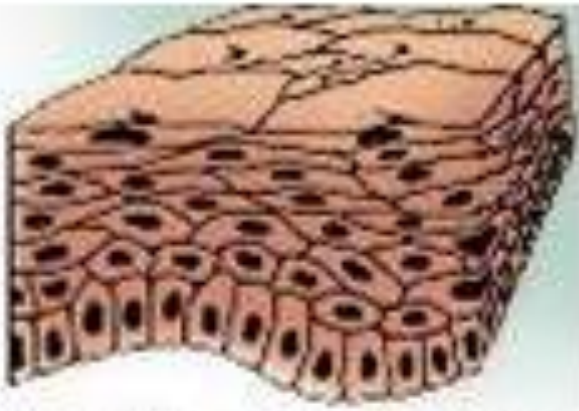
- **Function:**

- Absorption in small intestine
- Secretion in stomach

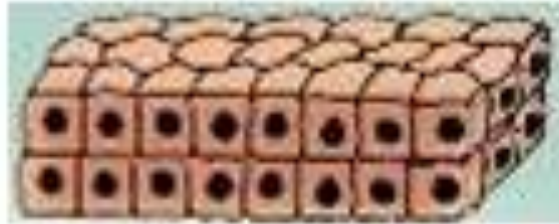
- **Place:** Small intestine and stomach

Simple Columnar Epithelia

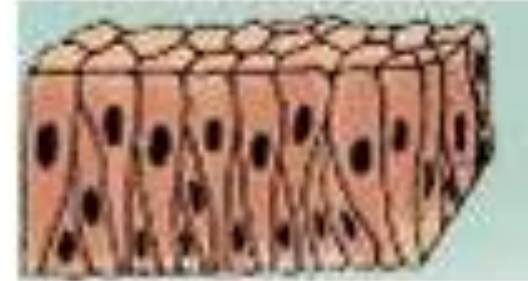
Stratified Epithelia



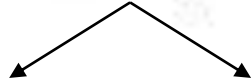
Stratified squamous



Stratified cuboidal

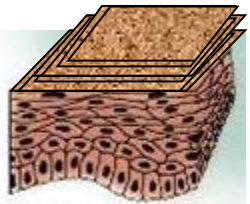


Pseudostratified

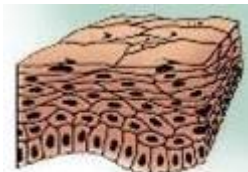


Keratinized

Non-Keratinized



Stratified squamous



Stratified squamous

Stratified Squamous Non-keratinizing Epithelia

- **Shape:**

- Several cell layer deep
- Cells toward basement membrane are cuboidal.
- Cells near lumen are flattened

- **Function:** Protects against abrasion in **moist areas**

- **Place:** Mouth, esophagus, vagina and anus

Stratified Squamous Keratinizing Epithelia

- Shape:**

- The same as non-keratinizing cells but with layers of keratin and dead cells on surface

- Function:** Protects against abrasion in non-moist areas

- Place:** Skin

- Thicker in areas prone to more abrasion

Stratified Cuboidal Epithelia

- **Rarely found**
- **Shape:**
 - Usually only two or three layers thick
 - Stronger than simple epithelium
- **Place:**
 - Found lining larger **ducts in salivary duct,** pancreas and sweat ducts

Stratified Cuboidal Epithelia

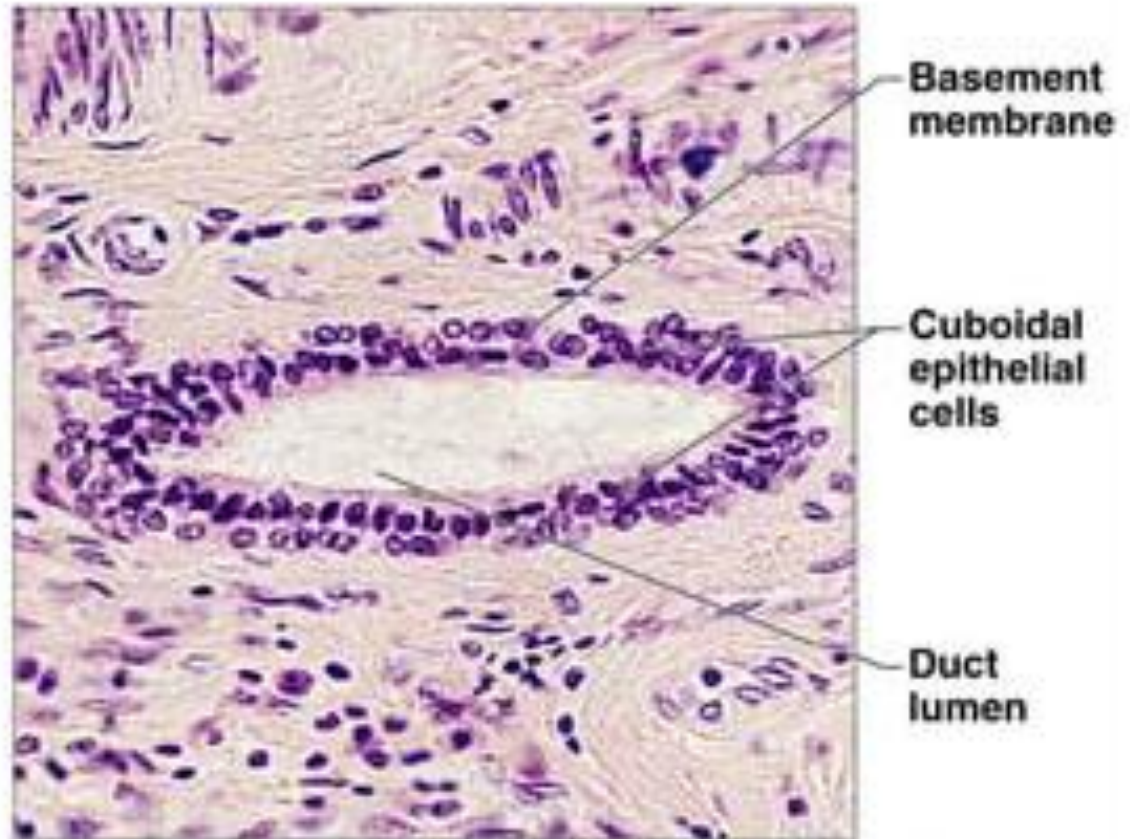
(f) Stratified cuboidal epithellium

Description: Generally two layers of cubelike cells.



Function: Protection

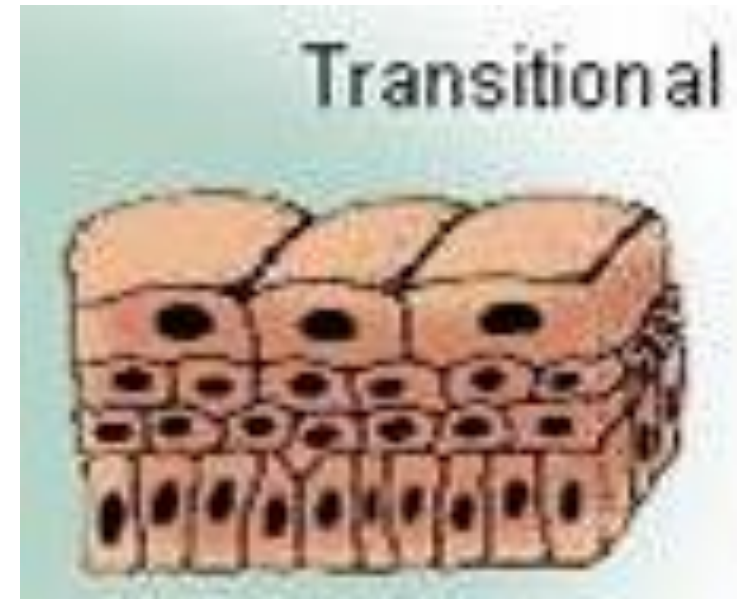
Location: Largest ducts of sweat glands, mammary glands, and salivary glands.



Photomicrograph: Stratified cuboidal epithelium forming a salivary gland duct (300 \times).

Transitional Epithelia

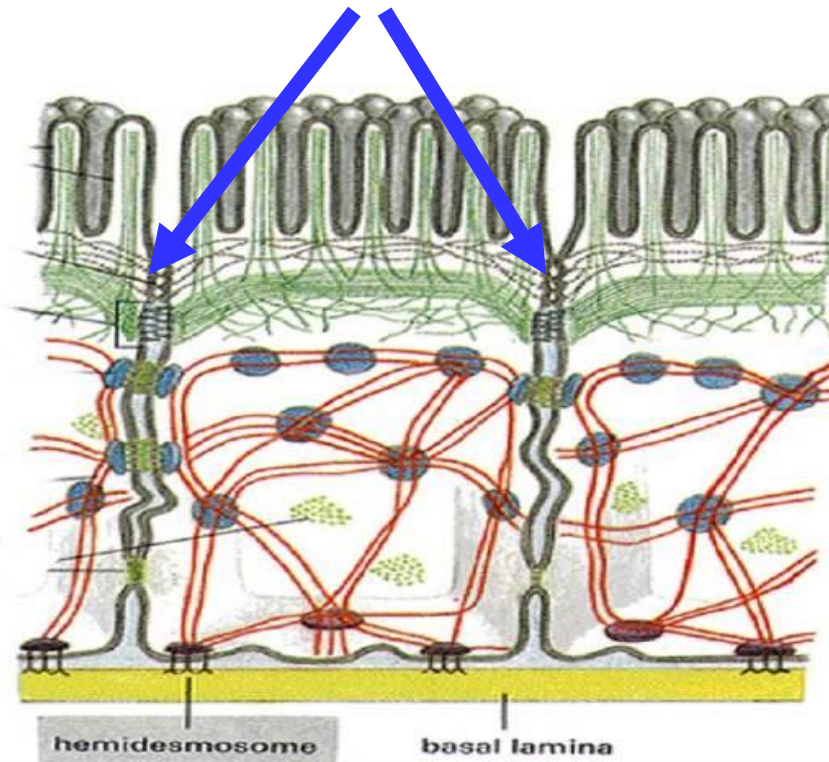
- Able to stretch and relax to accommodate urine in bladder
- Morphology changes depending on distention.
 - Round , scalloped edges when bladder is empty
 - Stretched-out, stratified squamous appearance when bladder is full



Epithelial cells are held together by intercellular junctions

- **Epithelia consist of closely apposed cells that are tightly linked both mechanically and functionally.**
- **Types of intercellular junctions :**
 - 1. Occluding junctions or Tight junction** (form seals and are impermeable)
 - 2. Adhering junctions or desmosome junction** (glue cells together and are associated with specific cytoskeletal elements)
 - 3. Communicating junctions or Gap junction** (permit x-talk)

1- Occluding or Tight junction (Zonula occludens)



- **Belt-like** junction that circumscribes the cell near its apical surface and **occludes** space between adjacent cells
- Forms a seal between cells,

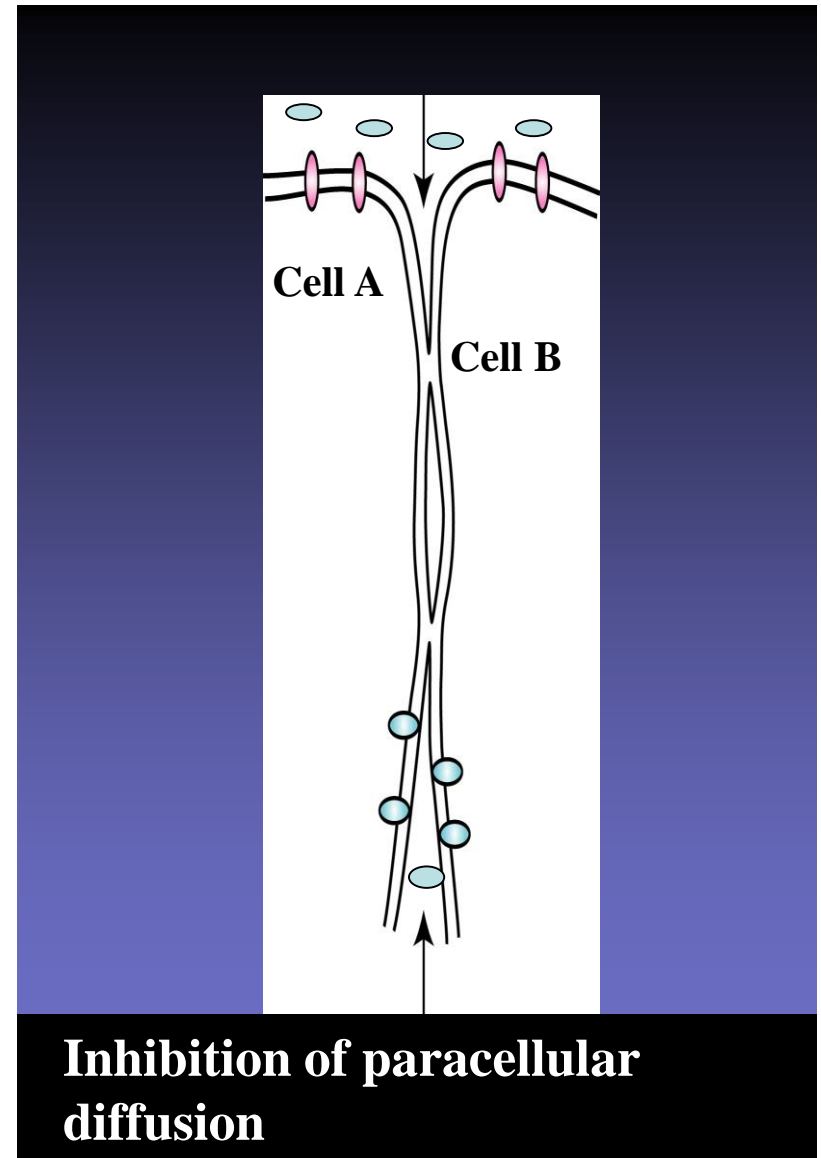
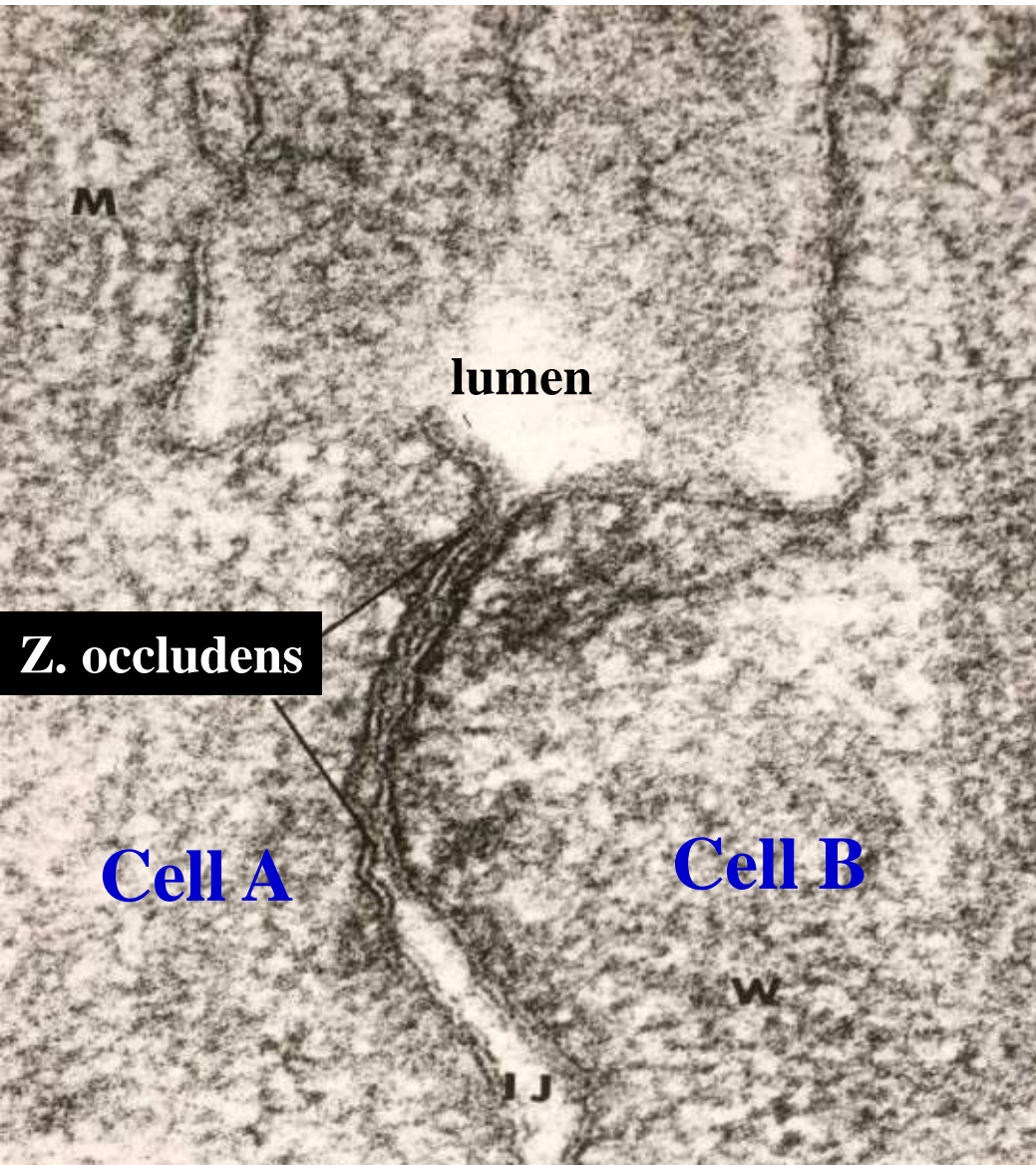
Tight junctions

- Extracellular surfaces of two adjacent plasma membranes are jointed together so there is no extracellular space between them.
- Occurs in a band around the entire cell

Tight junctions (continuo)

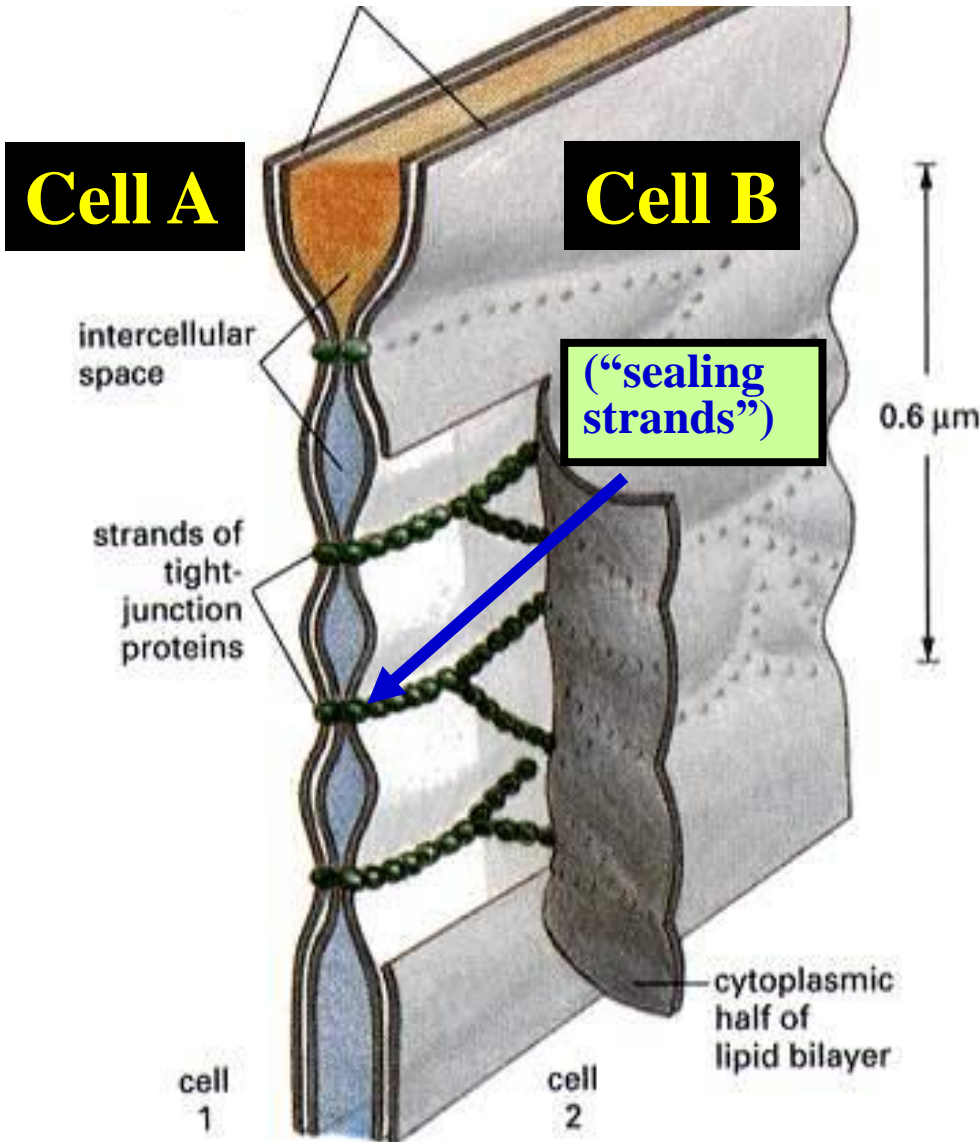
- Restrict the movement of most organic molecules between cells, but may leak small ions and water
- Not associated with any cytoskeletal components.

Tight junction (Zonula occludens)



Tight Junctions

Interacting plasma membranes
of 2 cells

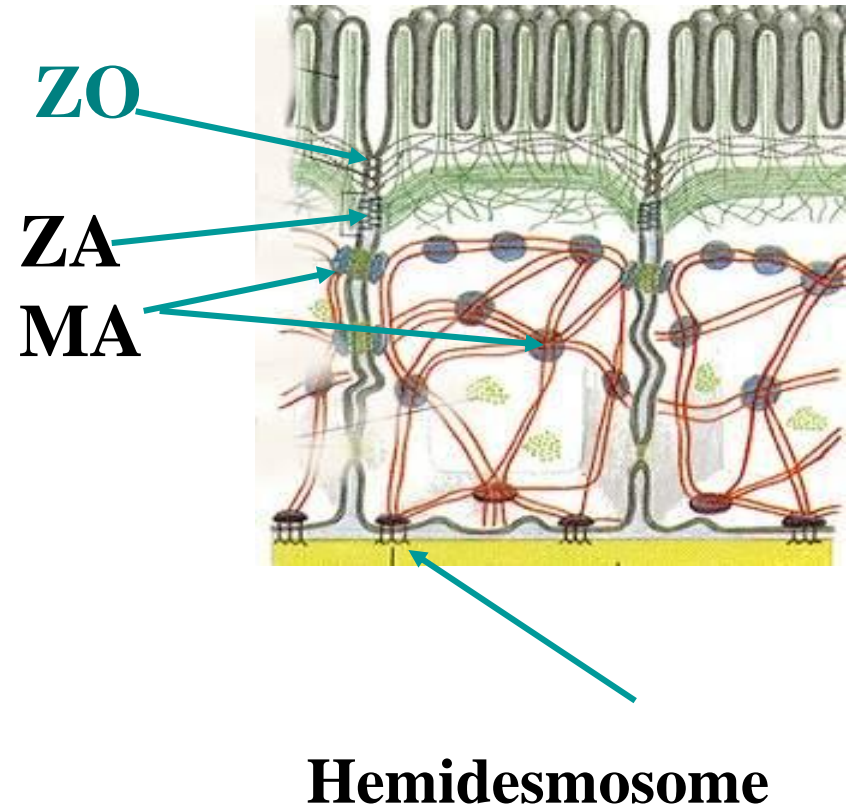


- Integral membrane proteins of two cells link across the extracellular space and occlude the space between the two cells. These proteins form “sealing strands”.

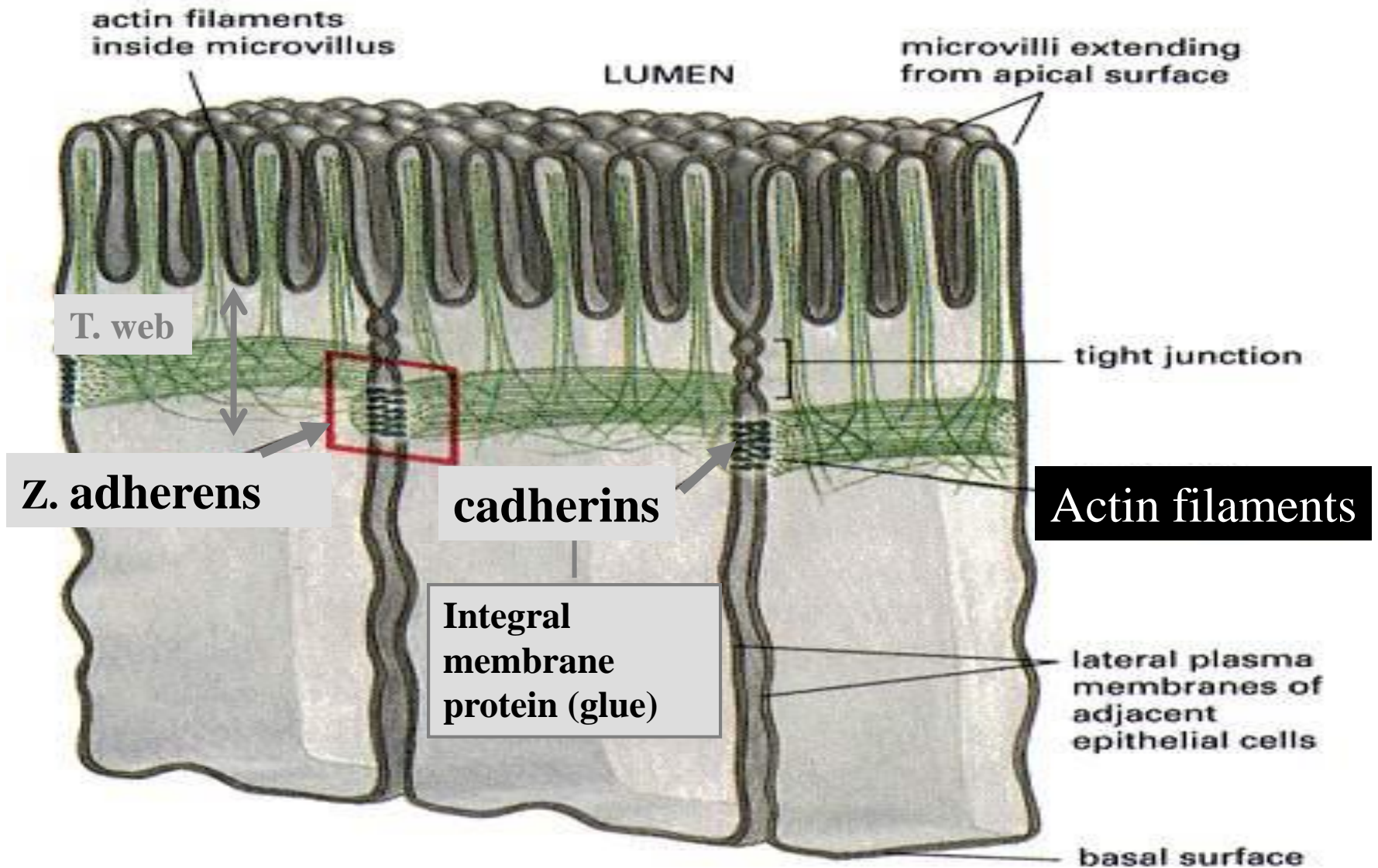
- **Occludin** is one of the integral membrane proteins involved.

2- Adhering (anchoring) or Desmosome junctions

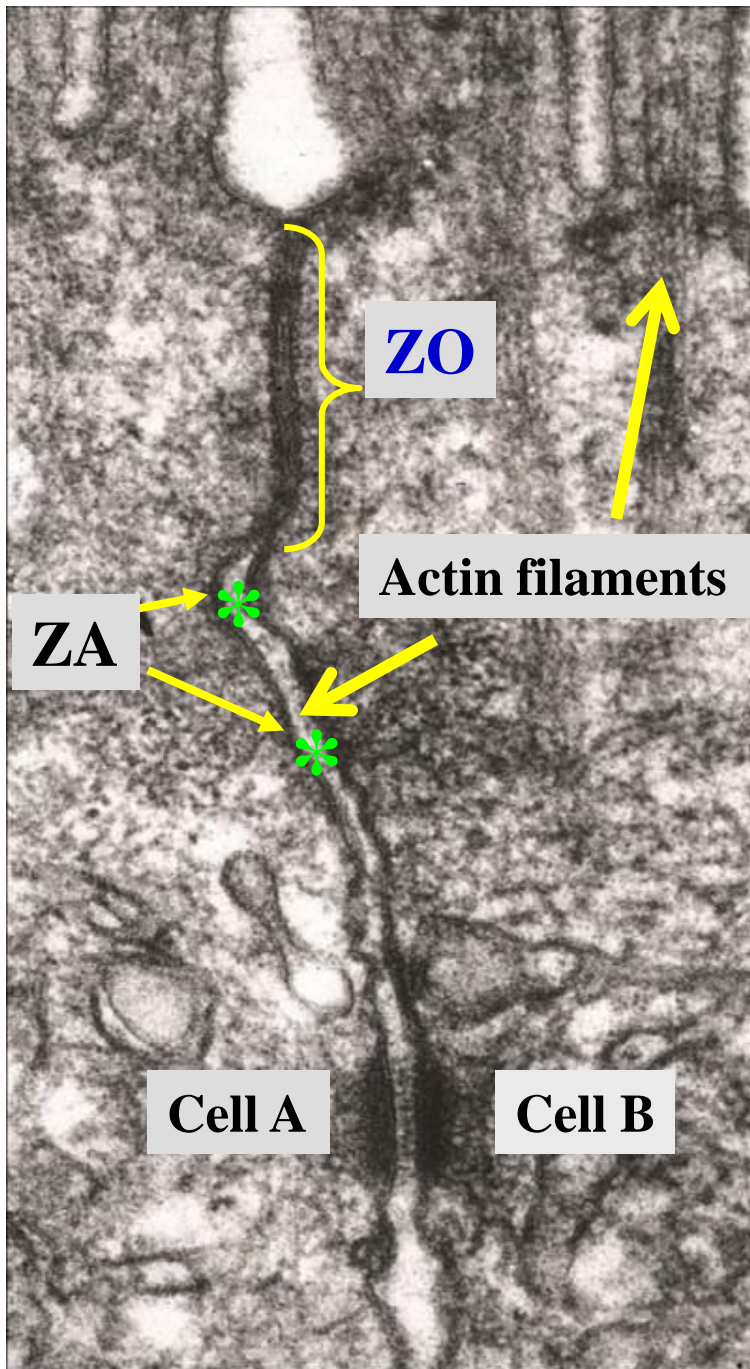
- **1- Actin filament attachment sites**
 - cell-cell adhering junctions (Zonula adherens)
- **2- Intermediate filament attachment sites**
 - a) cell-cell (Macula adherens = Desmosomes)
 - b) cell-matrix (Hemidesmosomes)
- **Associated with a “glue” that helps hold cells together**



Zonula adherens



Zonula adherens



- Belt-like junction which circumscribes the cell, usually near the apical surface.
- Mechanically links cells to one another (using ***Cadherins** as the “glue”).
- **Cadherins** are integral membrane glycoproteins that form homodimers and require Ca^{++} .
- Anchors the thin (**actin**) filaments of the cell to the **lateral plasma membrane** via attachment proteins within the cell.

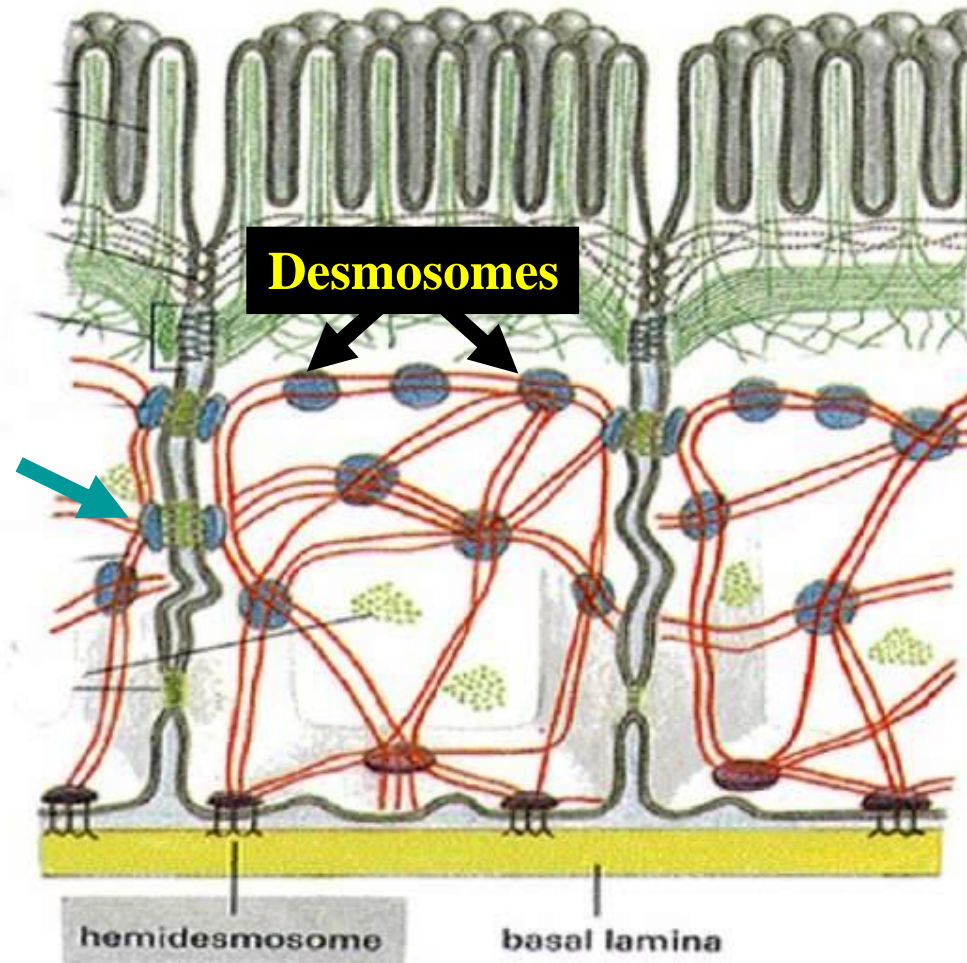
Belt desmosome

- Zonula adherens
- Another belt around the cell
- Below the tight junctions
- An anchorage junction
- Associated with actin filaments
- Space between membranes can be seen

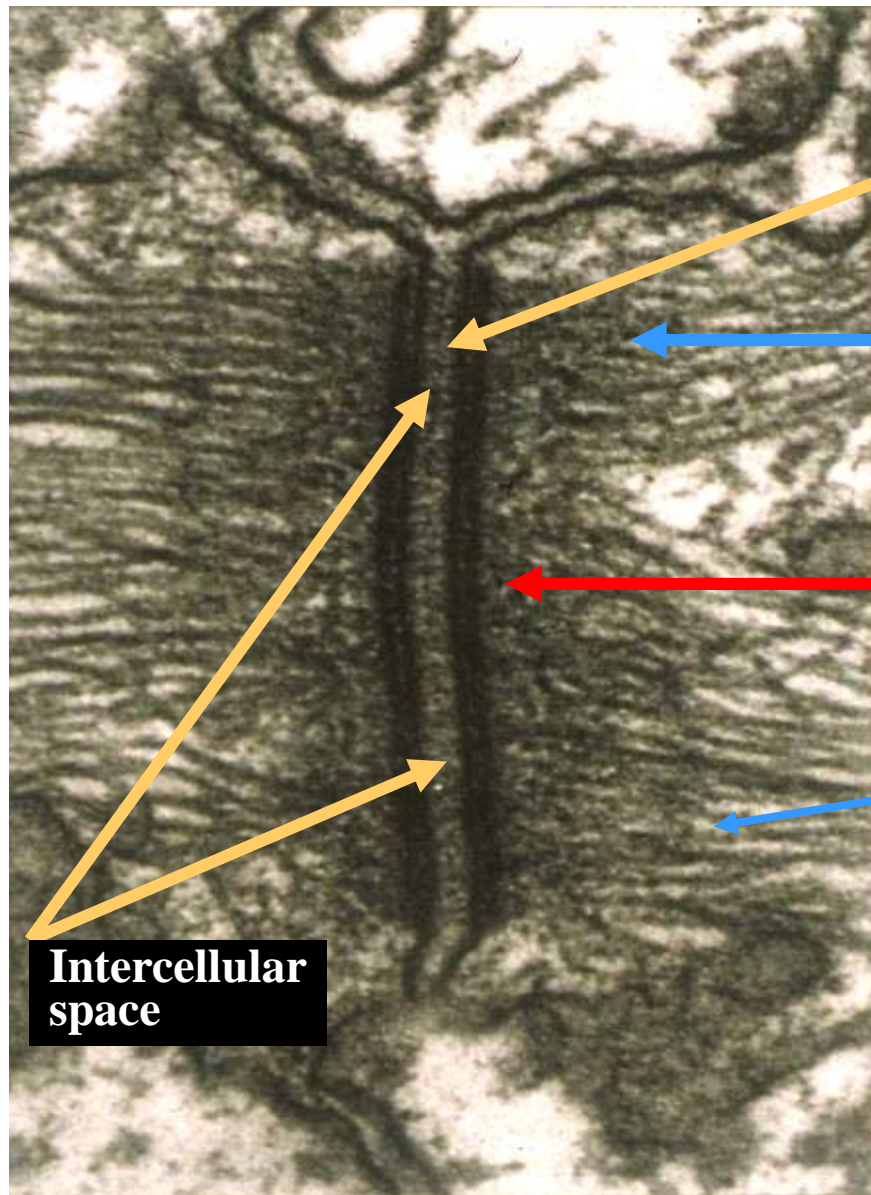
Spot Desmosomes

- A region between two cells where membranes are separated by 20 nm
- Dense accumulation of protein at the cytoplasmic surface of the membrane

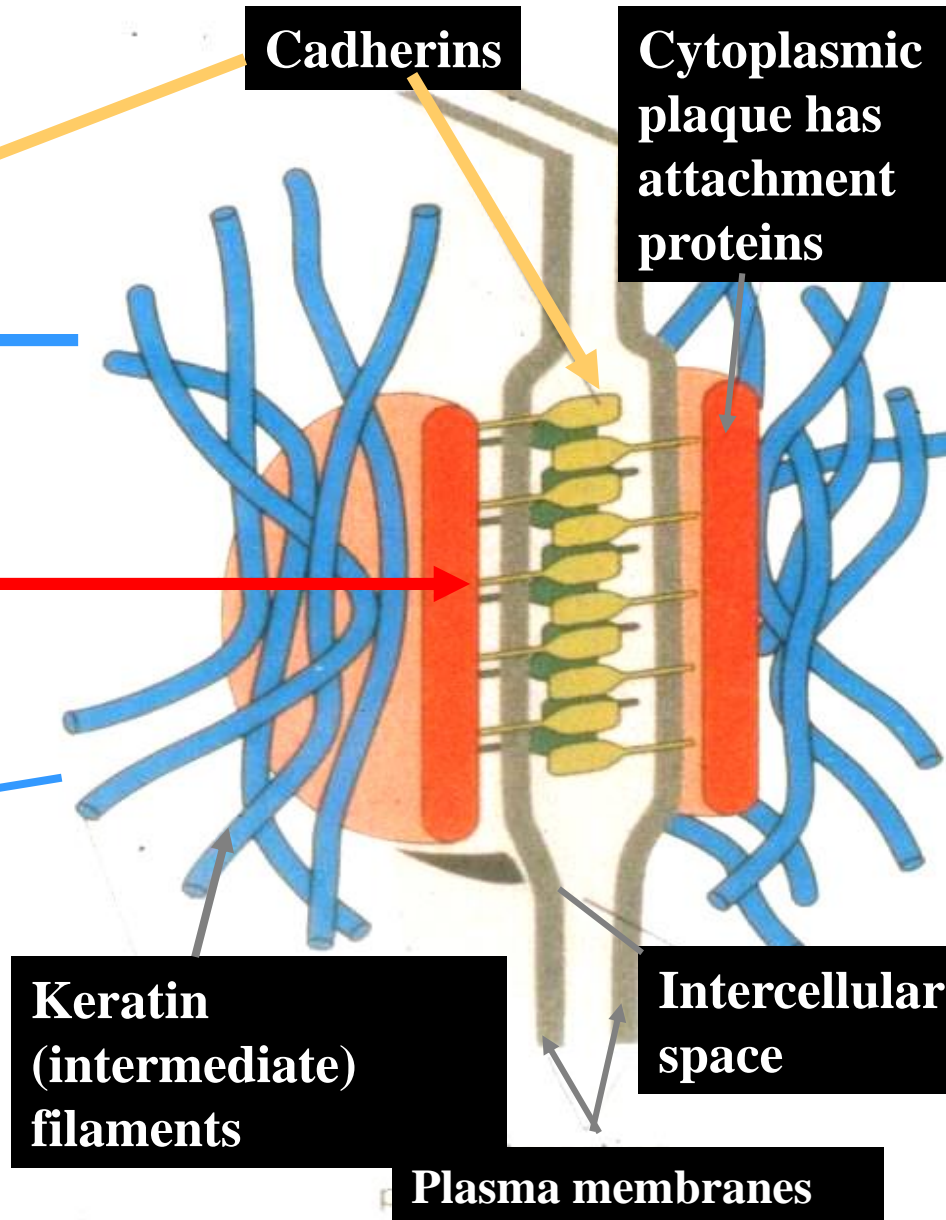
Desmosomes: “spot welds” that are abundant in epithelia that are exposed to much abrasion
Examples: stratified squamous epithelium of the gingiva, tongue, skin, oral mucosa



Desmosome (Macula adherens)



Intercellular space



Cadherins

Cytoplasmic plaque has attachment proteins

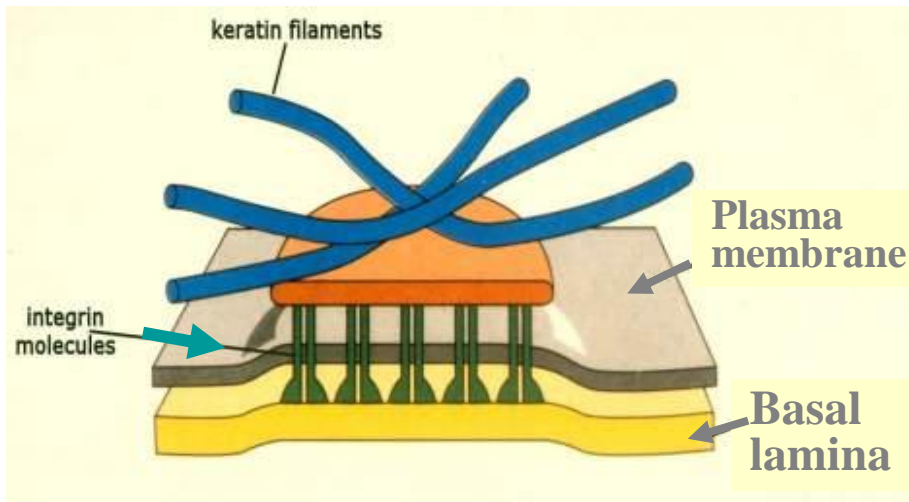
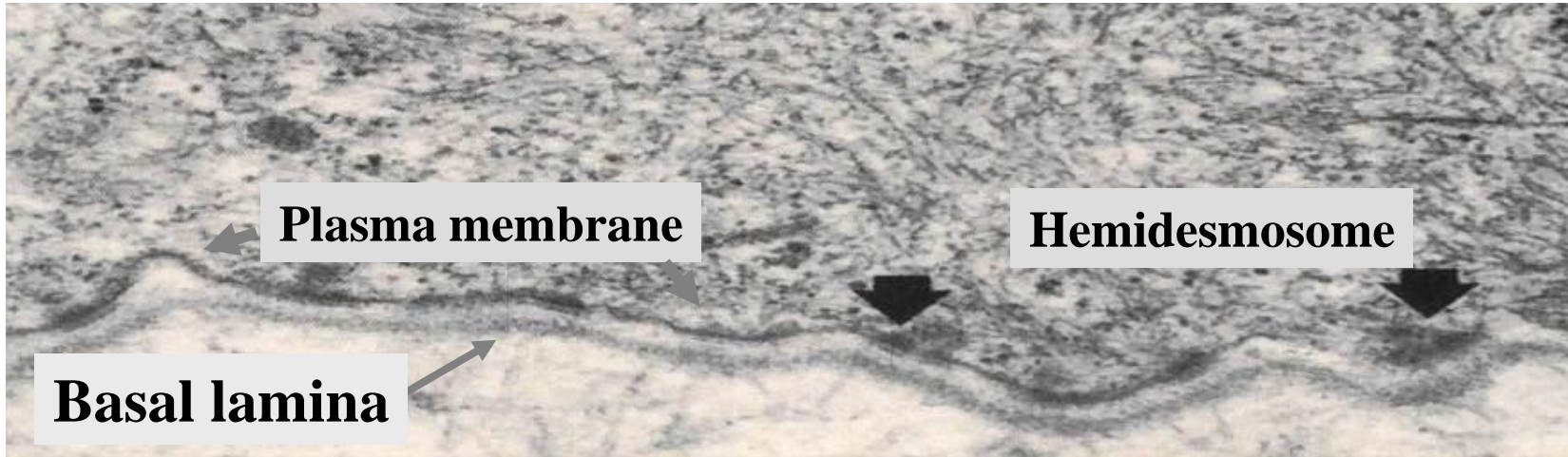
Keratin (intermediate) filaments

Intercellular space

Plasma membranes

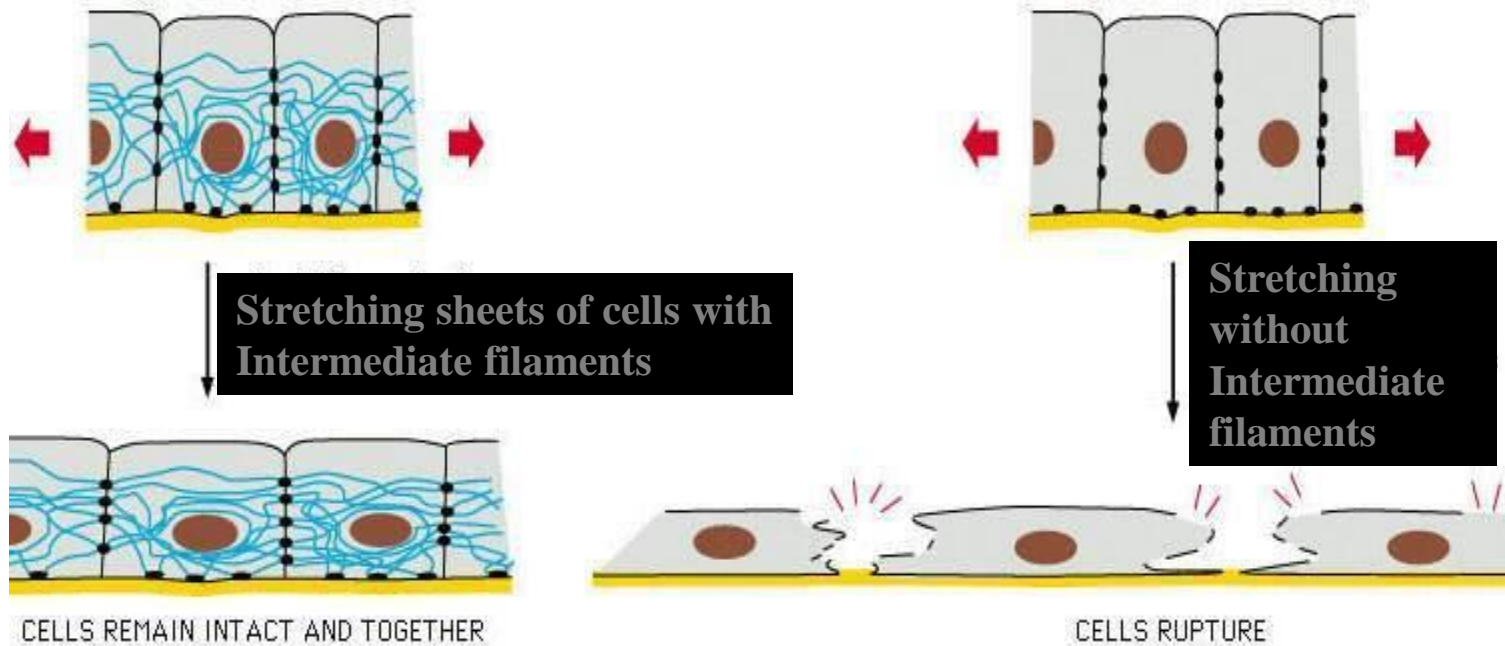
Hemidesmosomes

Found at **base** of stratified epithelia and connect the **basal** plasma membrane to the extracellular matrix via **integrins**



Glue is **NOT** cadherins but **integrins**

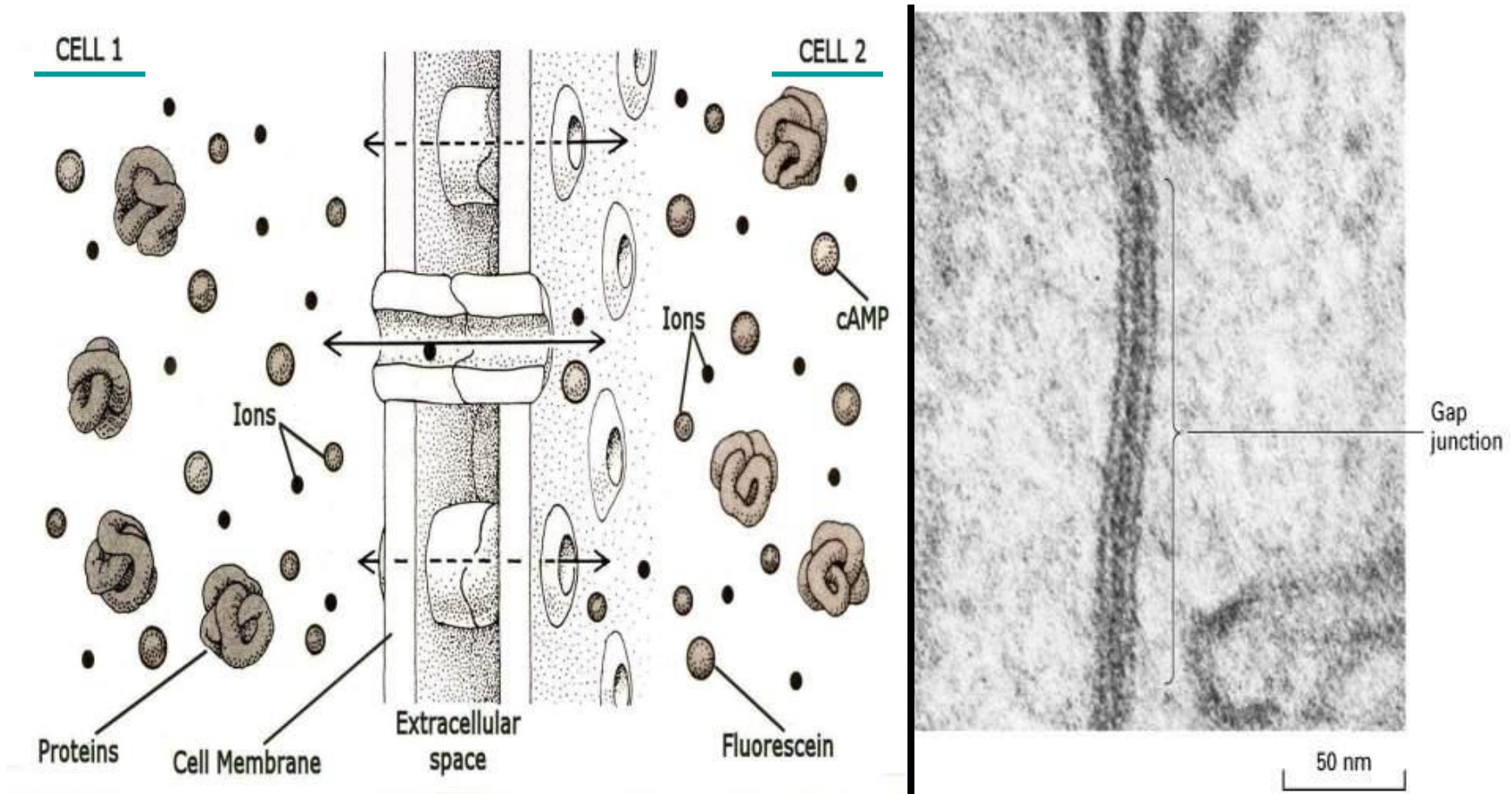
Desmosomes and hemidesmosomes



- **Desmosomes and hemidesmosomes are associated with intermediate filaments.**
- **The major function of intermediate filaments is mechanical support and strength**
- **Mutant cytokeratins cause blistering skin diseases due to failure to form filaments and weakening of epithelia**

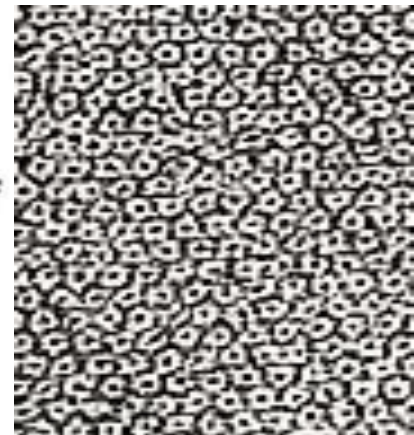
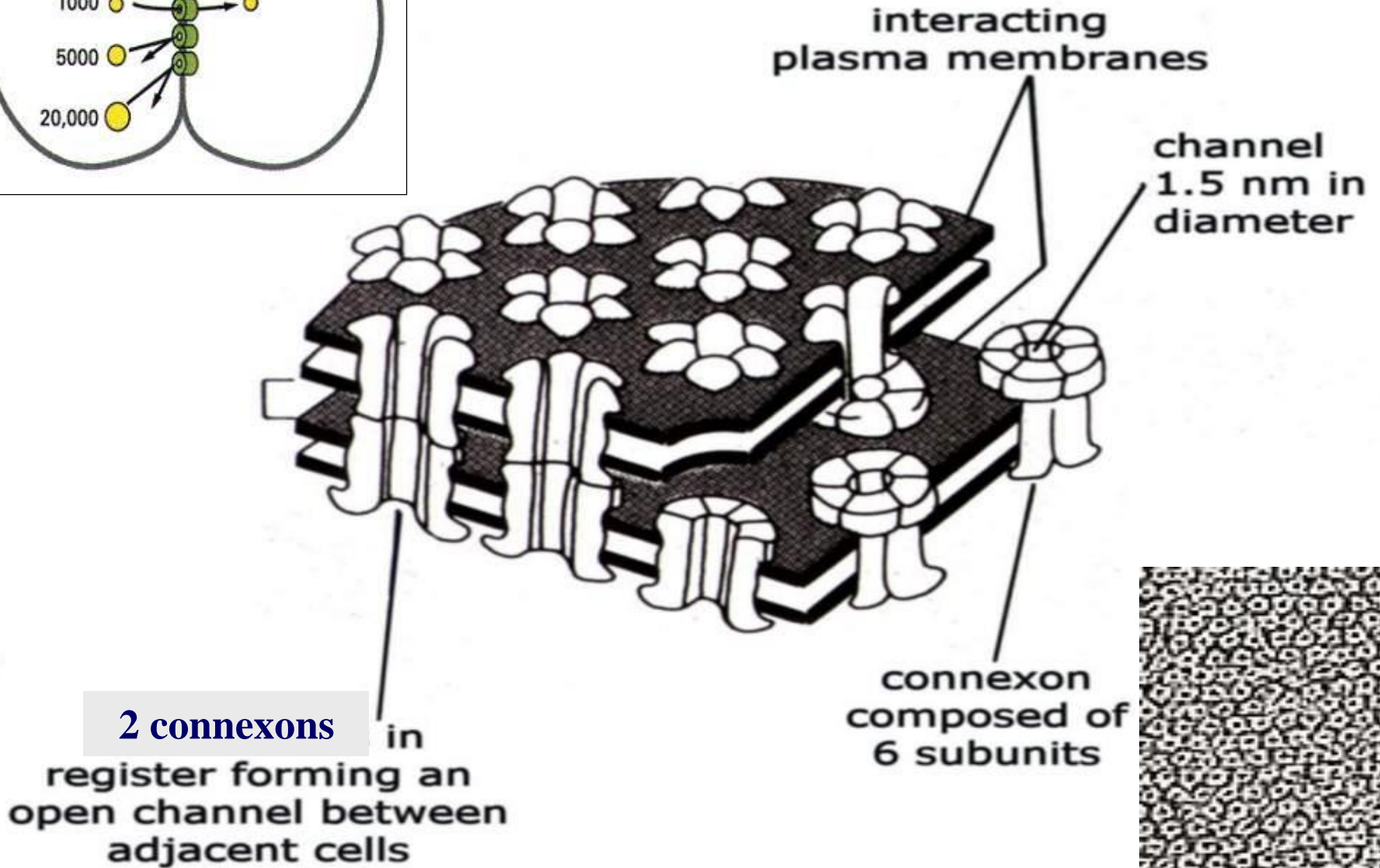
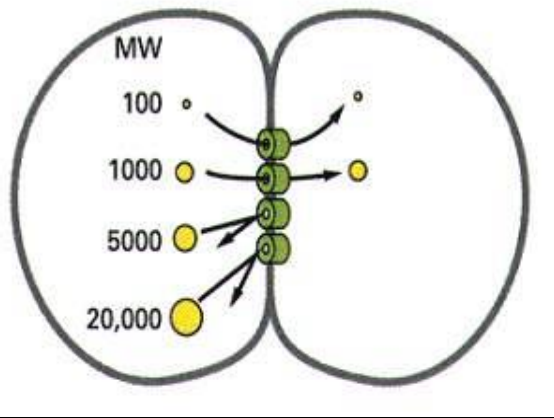
Gap Junction

(Communicating junction, Lo-resistance junction, Nexus)



• Allows ions and small metabolites (aa, sugars, hormones) to flow from cell-to-cell and thus coordinate cell activity.

Gap Junctions (intramembranous channels)



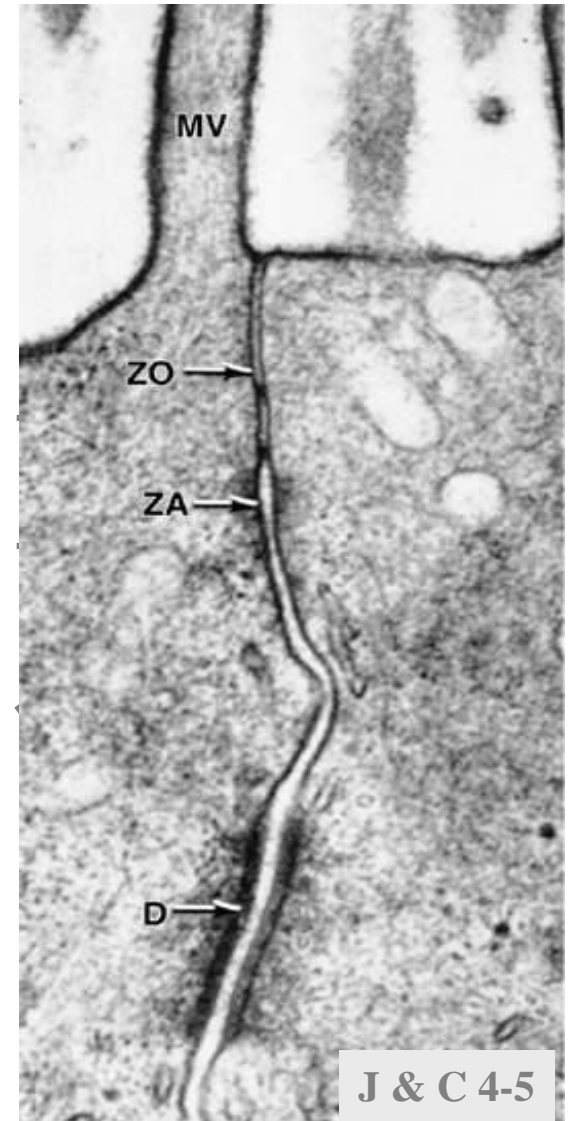
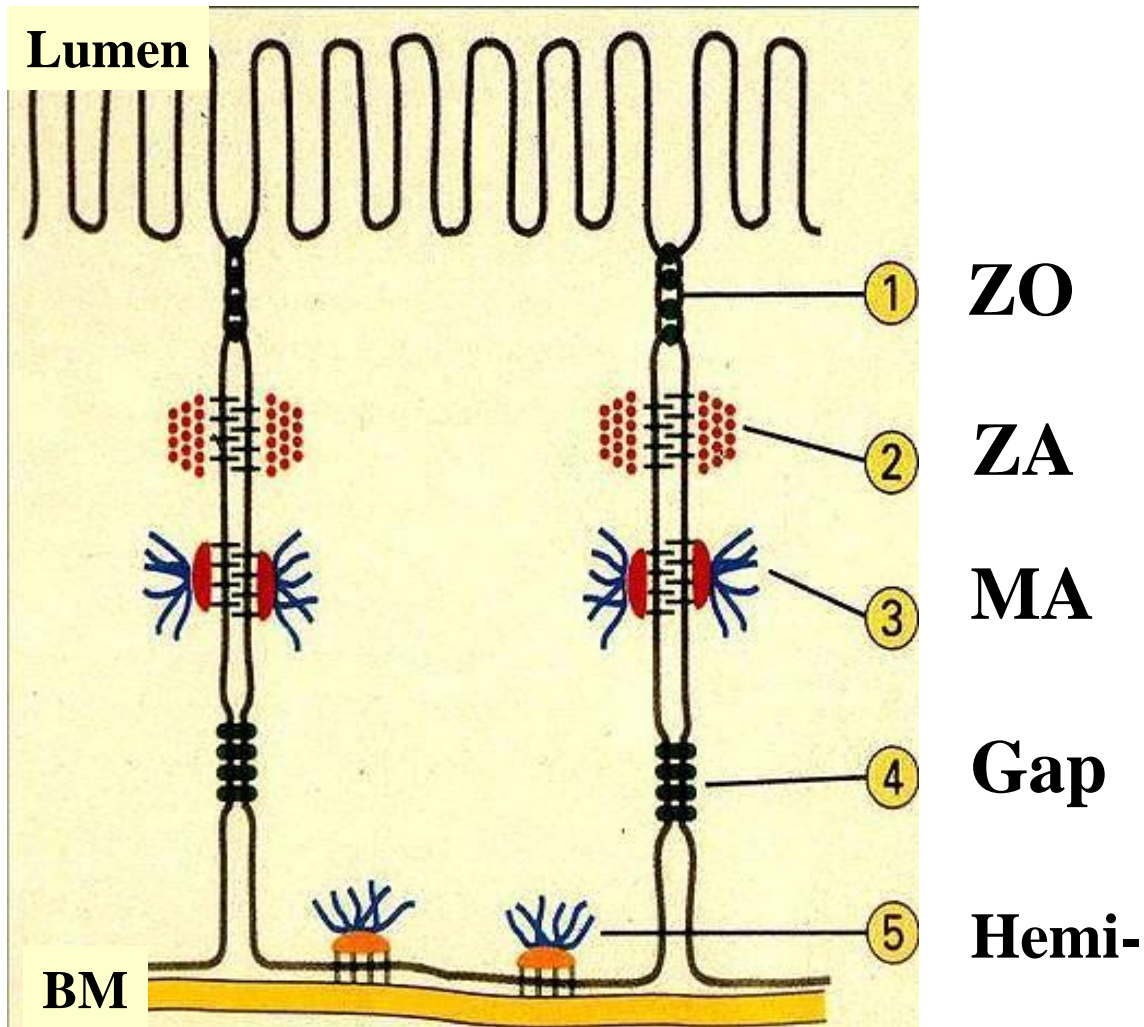
Gap junctions

- Protein channels link the cytosols of cells.
 - Passage of small molecules and ions (Na^+ , K^+)
 - Excludes large molecules
 - Allows chemical messengers to cross from one cell to another
 - Coordinates activities between cells.

Gap junction connexons

- A connexon is a cylinder with a central open pore
- One gap junction connexon is made up of six connexins
- The pore is a hydrophilic channel between two cytoplasms
- Plasma membranes come within 2-4 nm of each other

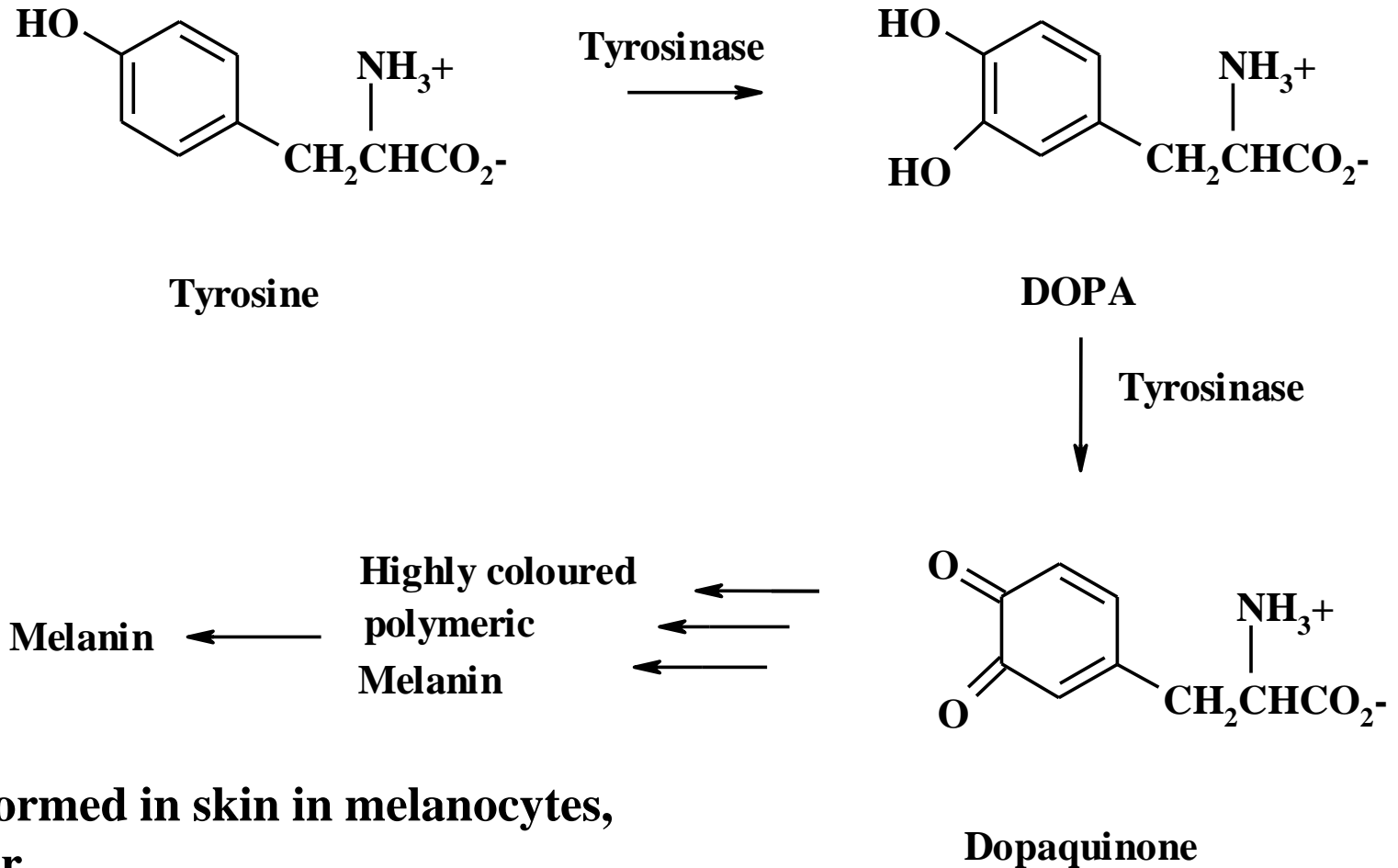
Summary of Intercellular Junctions



“Junctional Complex”: ZO, ZA & MA (in that order)

Junction	Fiber & glue	Function
ZO	occludin	Sealing
ZA	Actin, Cadherin	
MA Desmosome	Keratin/ Actin, Integrin	Adhering
Gap	Connexon	Communication
Hemi- desmosome	Keratin, Integrin	Adhering

Melanin formation



Melanin is formed in skin in melanocytes, eyes and hair

In skin, it protects against sunlight

Albinism: genetic deficiency of tyrosinase

www.albinism.org