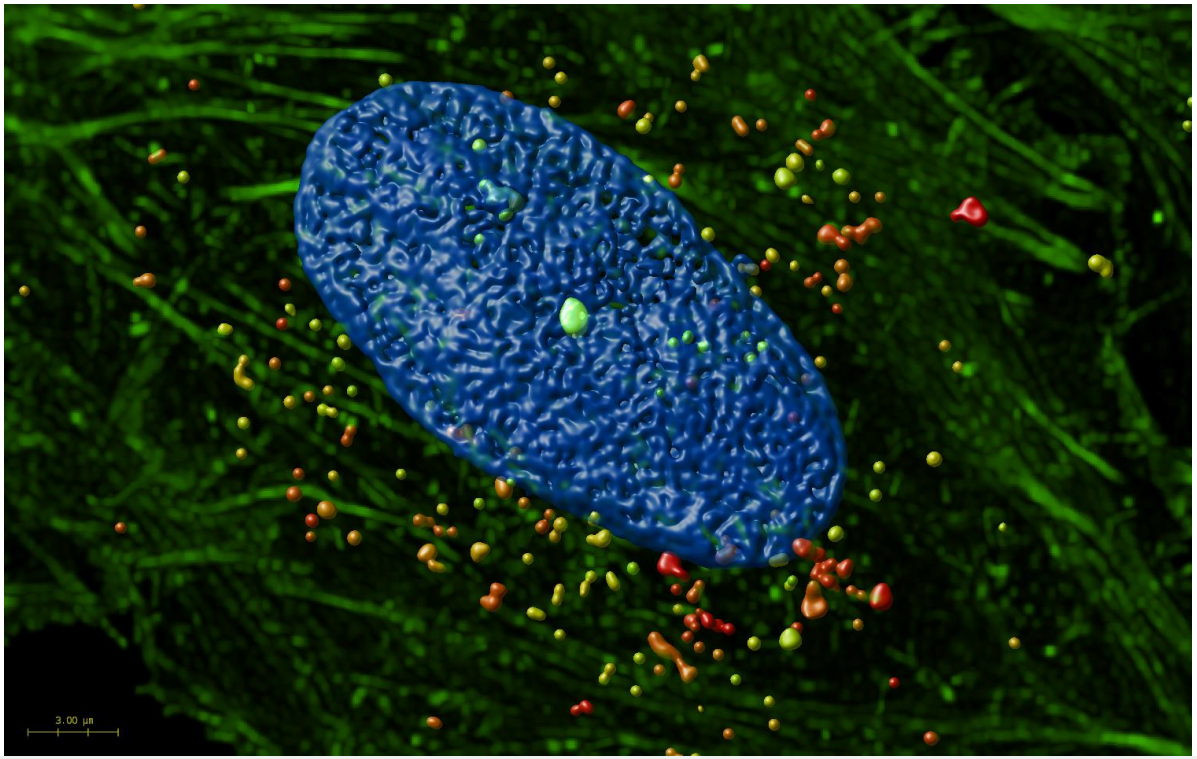


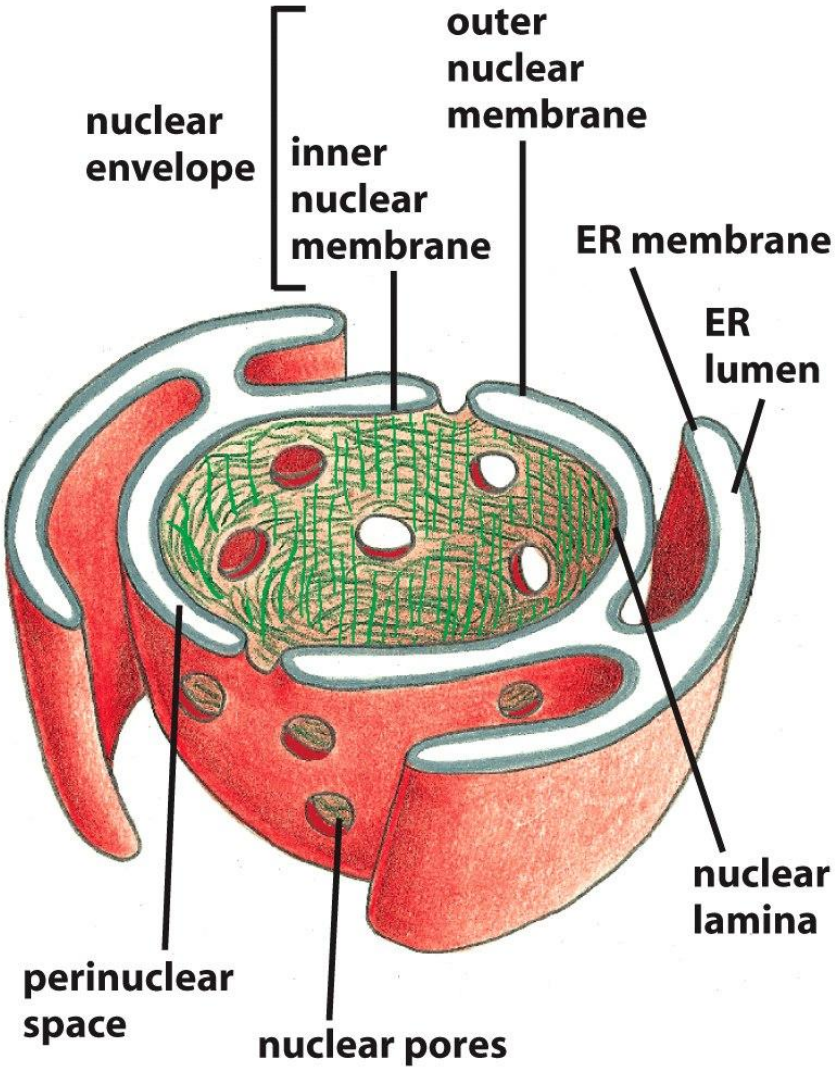

# Cellular and Tissue Functions
# May 03, 2019

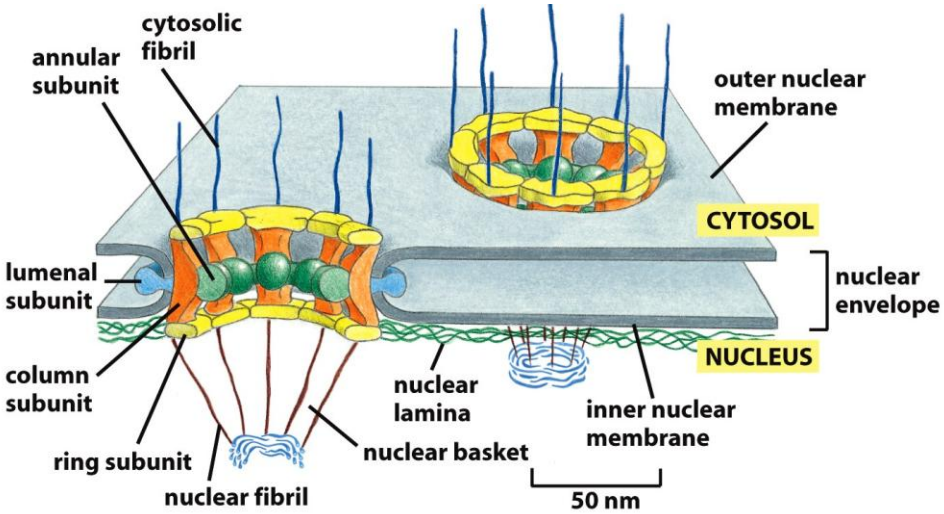
Dr. Annette Kraegeloh
INM - Leibniz Institute for New Materials

# Contents

- Intracellular Structures and Organelles
- Cell-Cell and Cell-Matrix Junctions
- Basal Lamina and Extracellular Matrix
- Structure and Functions of Important Cells and Tissues:
  - Connective Tissue Cells (Bone)
  - Epithelial Cells (Skin, Intestine, Airways)
  - Endothelial Cells (Blood Vessels)

# The Nuclear Envelope



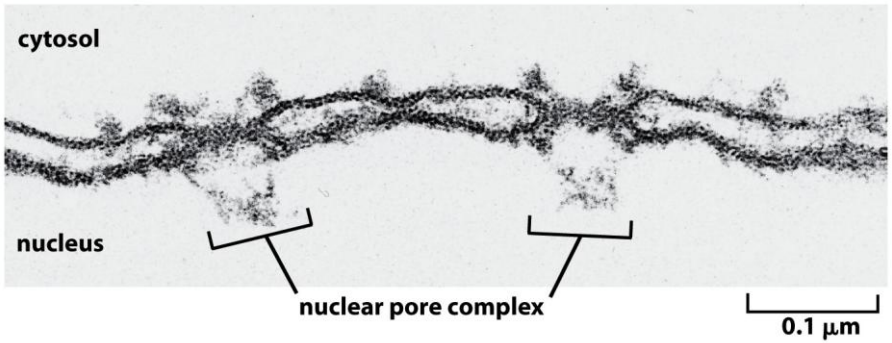








Figure 12-8, 12-9 *Molecular Biology of the Cell* (© Garland Science 2008)

# The Nuclear Envelope Disassembles During Cell Division

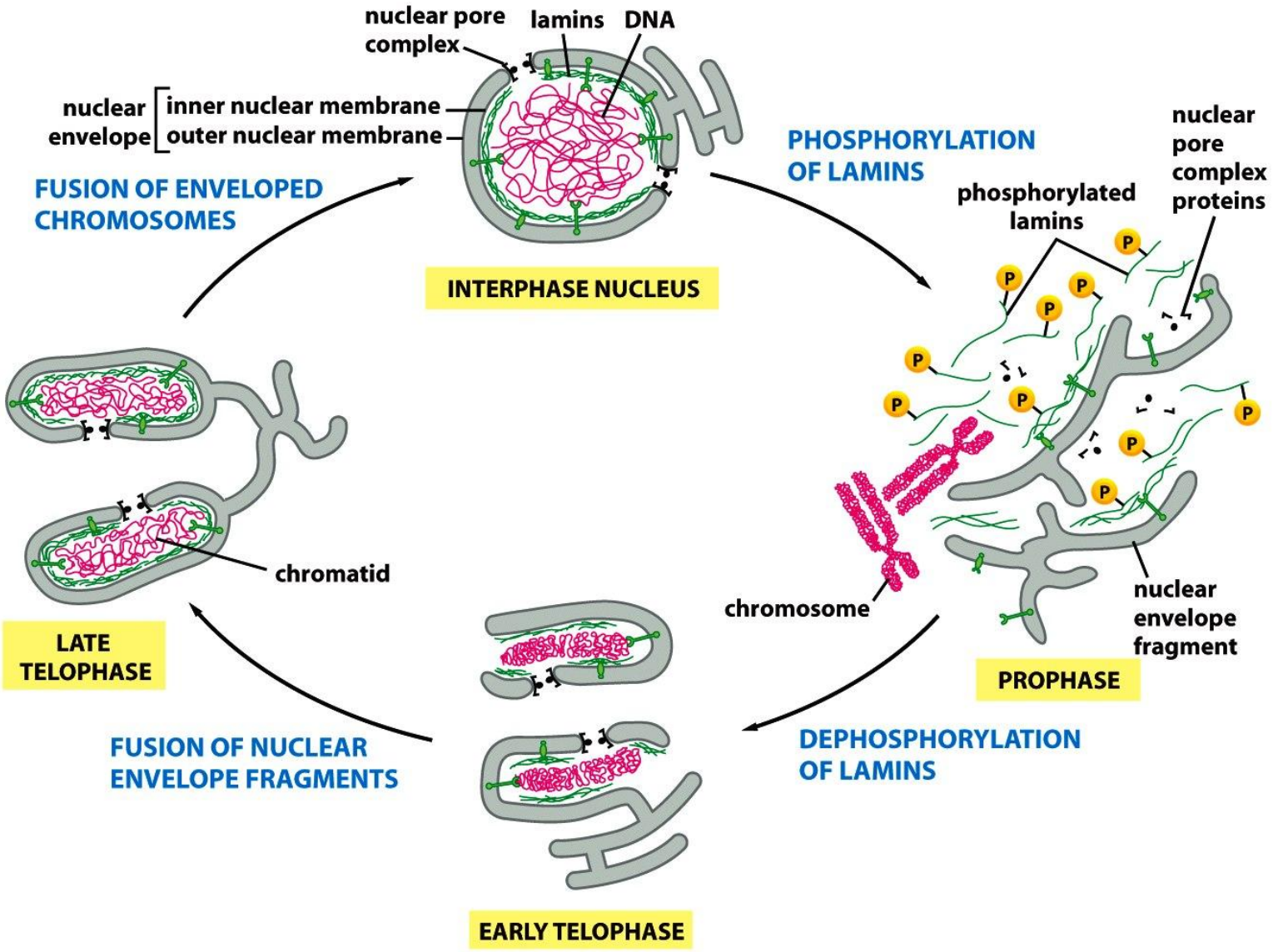







Figure 12-20 *Molecular Biology of the Cell* (© Garland Science 2008)

# Topological Relationship Between Compartments in Eukaryotic Cells

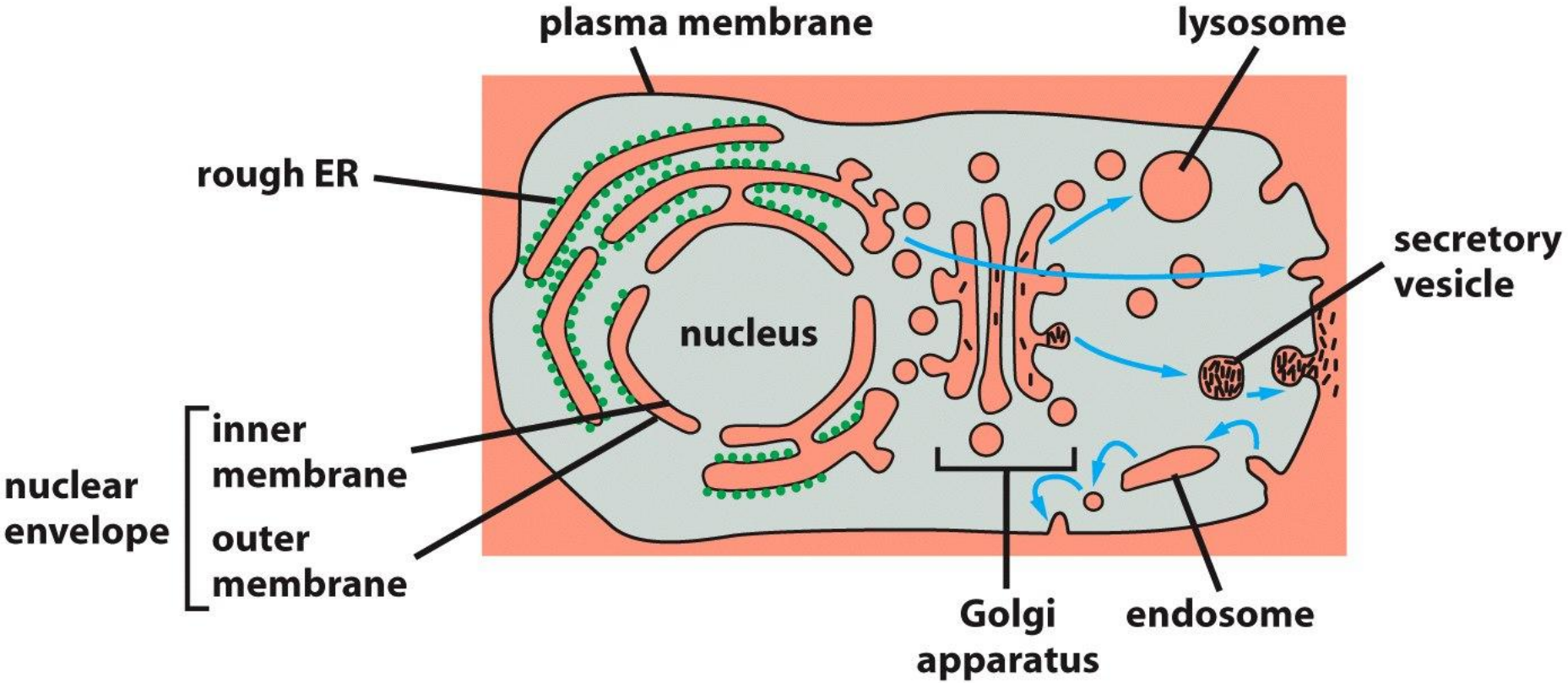





Figure 12-5 *Molecular Biology of the Cell* (© Garland Science 2008)

# Vesicle Budding and Fusing

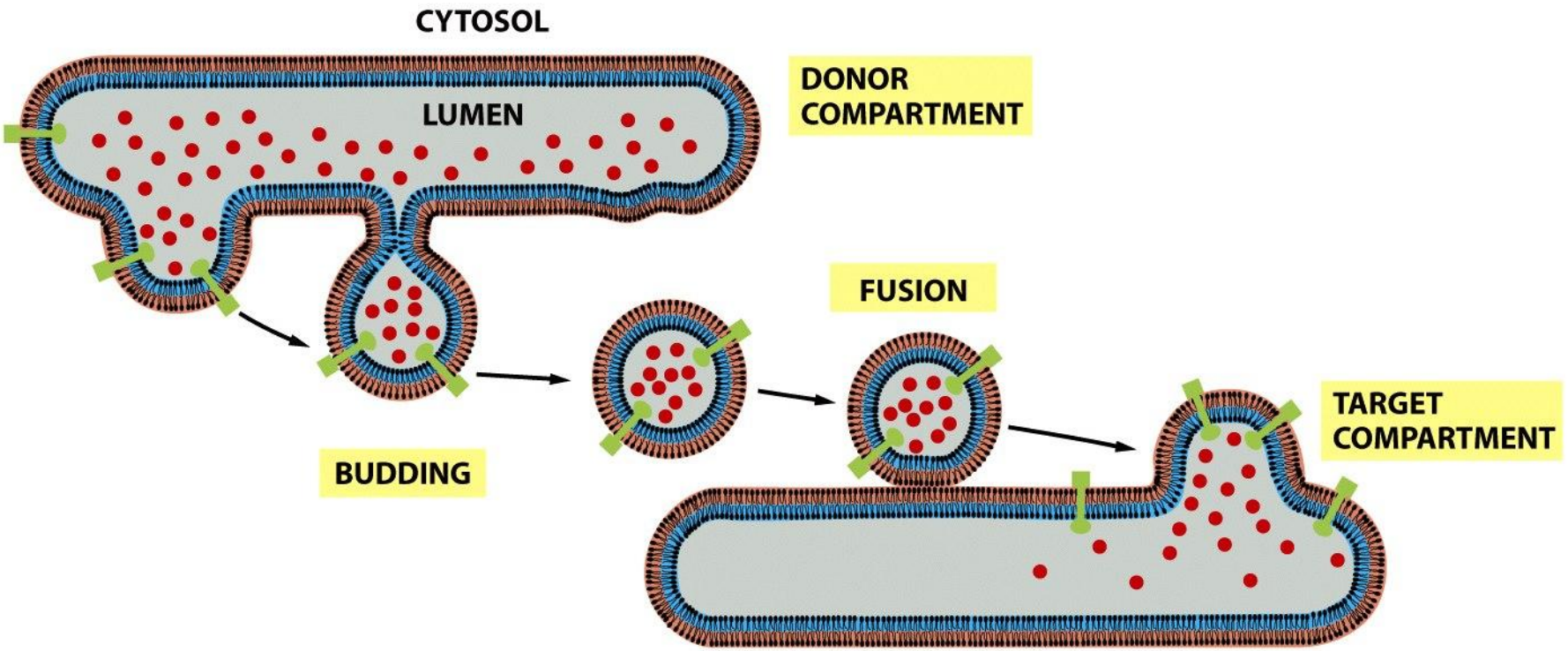





Figure 13-2 *Molecular Biology of the Cell* (© Garland Science 2008)

# Vesicular Transport in Eukaryotic Cells

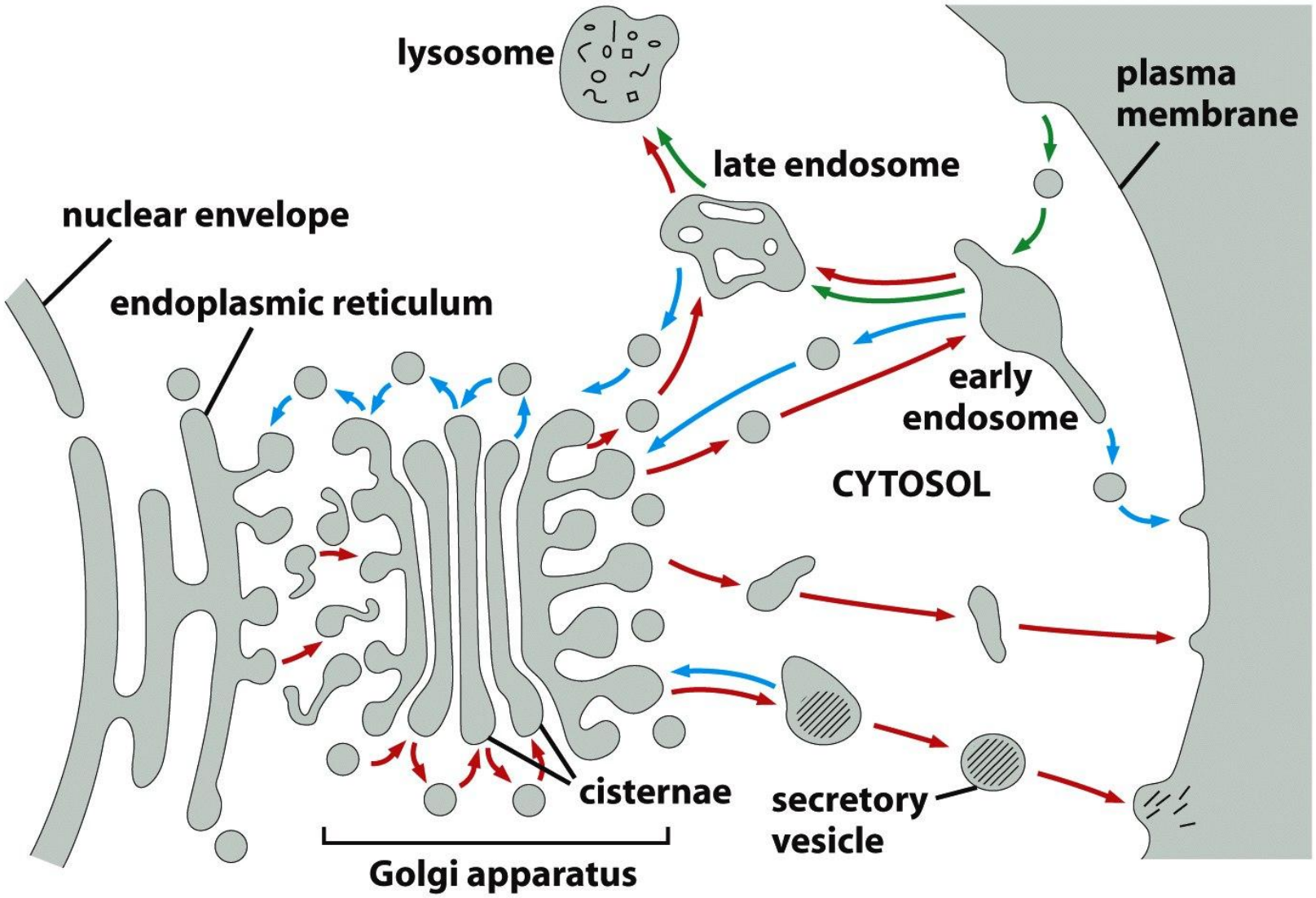
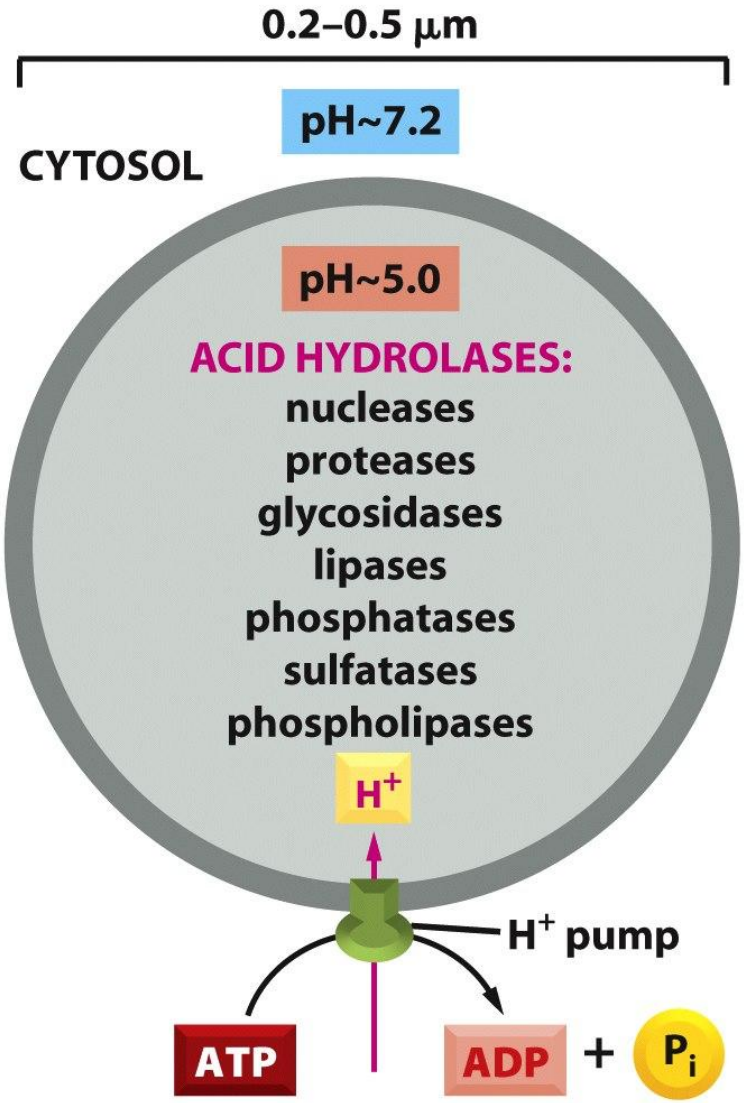







Figure 13-3b *Molecular Biology of the Cell* (© Garland Science 2008)

# Lysosomes Digest Macromolecules



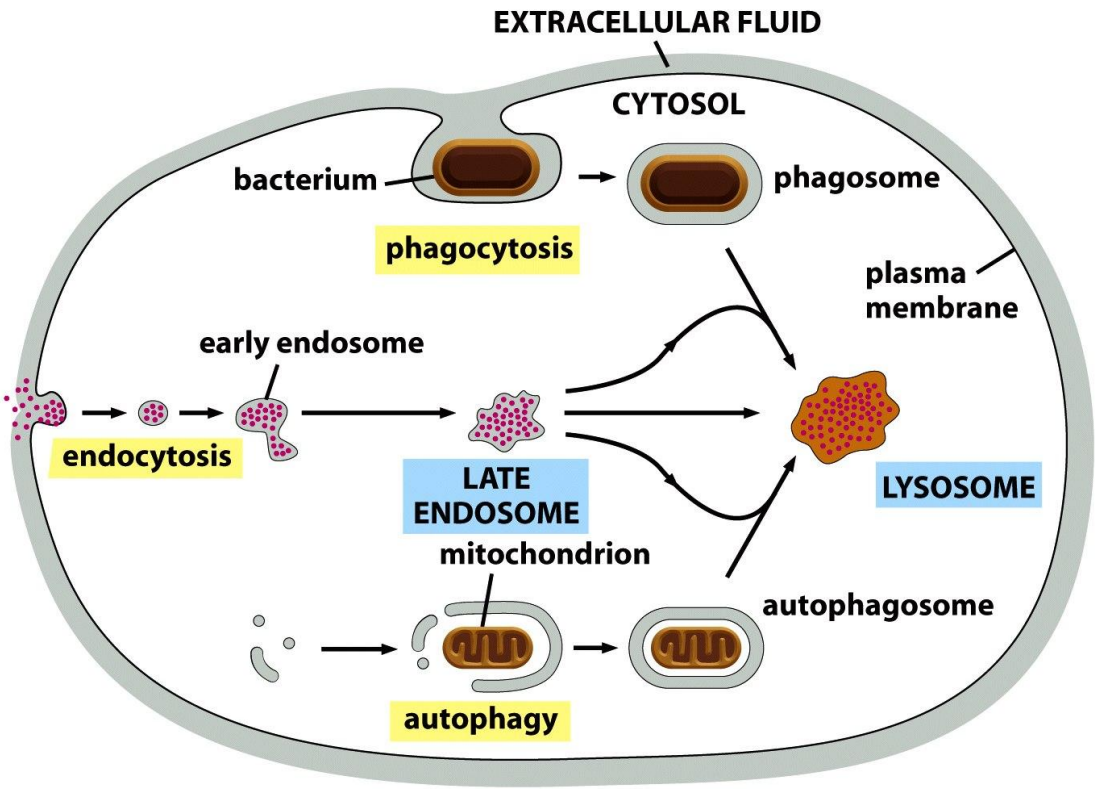



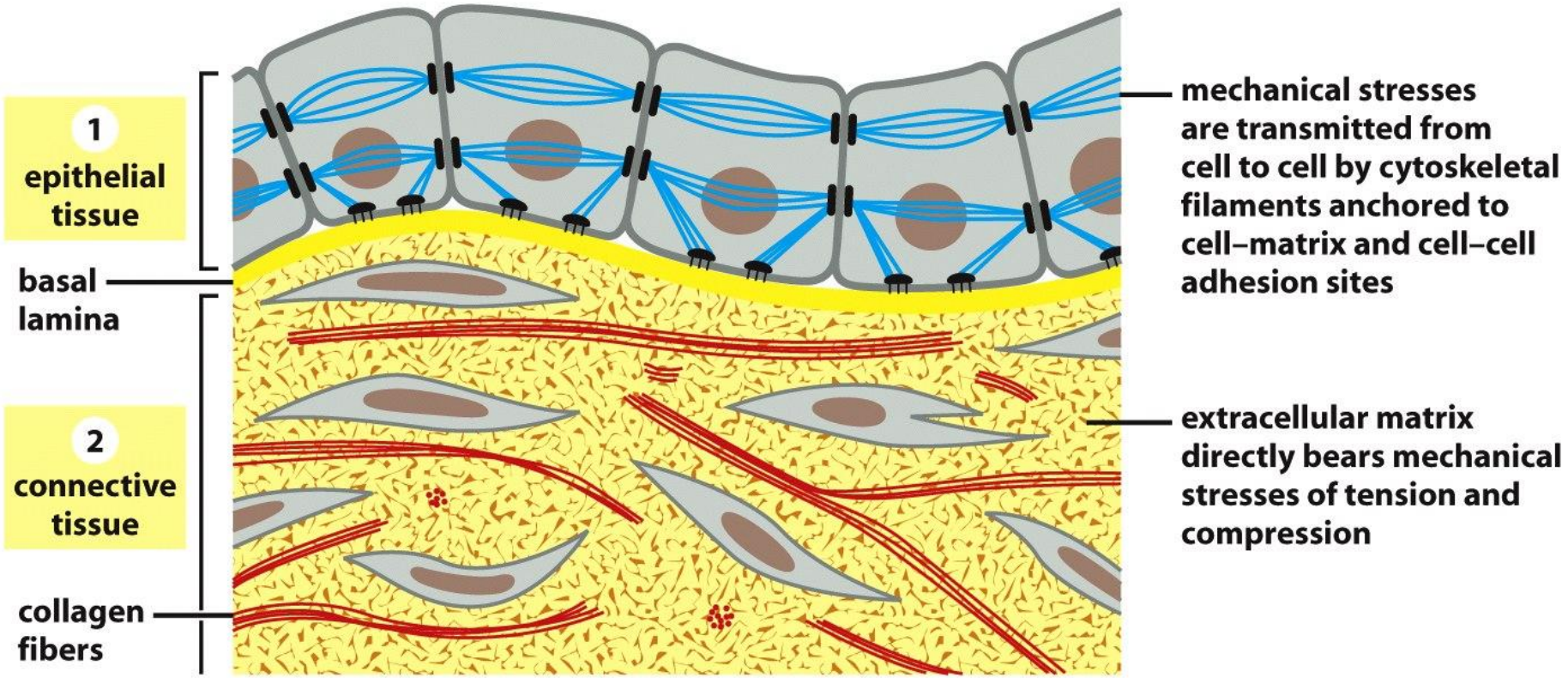







Figure 13-36, 13-42 *Molecular Biology of the Cell* (© Garland Science 2008)

# Animal Cells Are Bound Together to Form Tissues



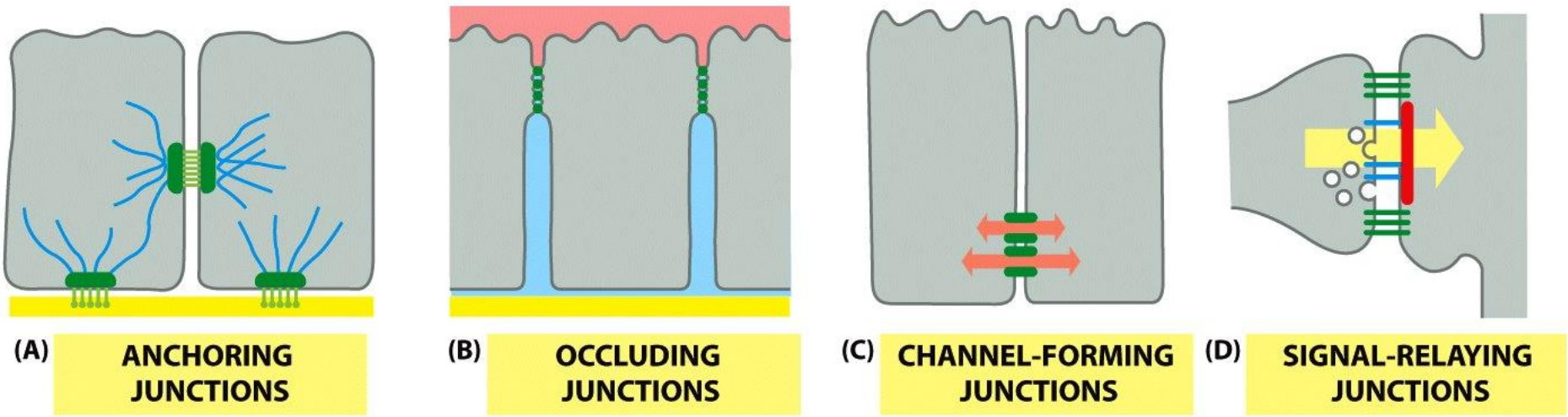

Two basic building strategies:

- the extracellular matrix, a network of secreted proteins and polysaccharide chains
- the cytoskeleton inside cells and cell-cell adhesions



Figure 19-1 *Molecular Biology of the Cell* (© Garland Science 2008)

# Cell Junctions in Animal Tissues




Four functions of cell-cell and cell-matrix junctions:

- anchoring junctions transmit stresses and are tethered to the cytoskeleton
- occluding junctions seal gaps between epithelial cells (barrier function)
- channel-forming junctions link the cytoplasms of adjacent cells (passageways)
- signal-relaying junctions allow signals to be relayed from cell to cell (synapses)

- all participate in signal transmission



Figure 19-2 *Molecular Biology of the Cell* (© Garland Science 2008)

# Cell Junctions in Animal Tissues

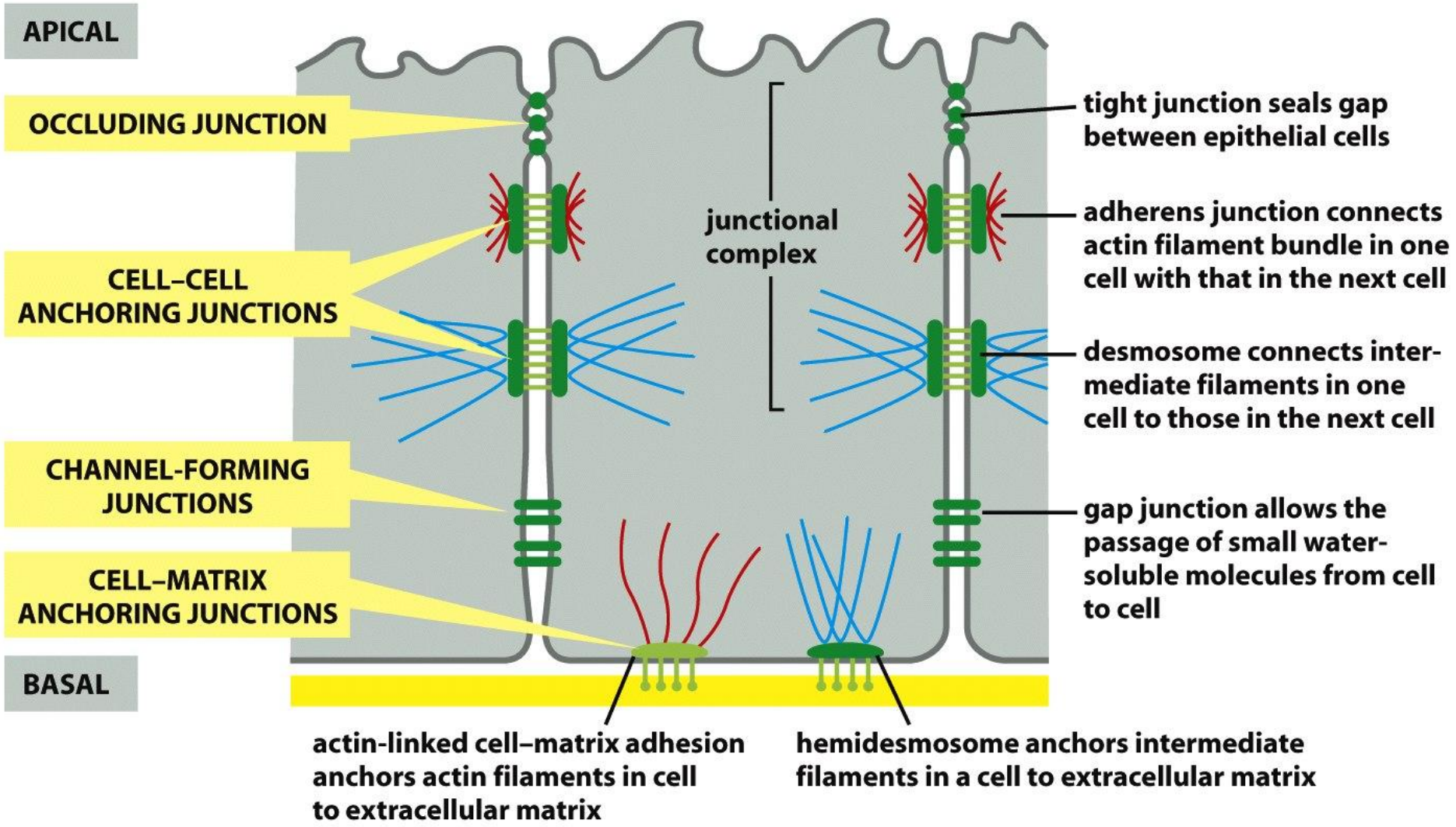









Figure 19-3 *Molecular Biology of the Cell* (© Garland Science 2008)

# Transmembrane Adhesion Proteins Link the Cytoskeleton to Extracellular Ligands

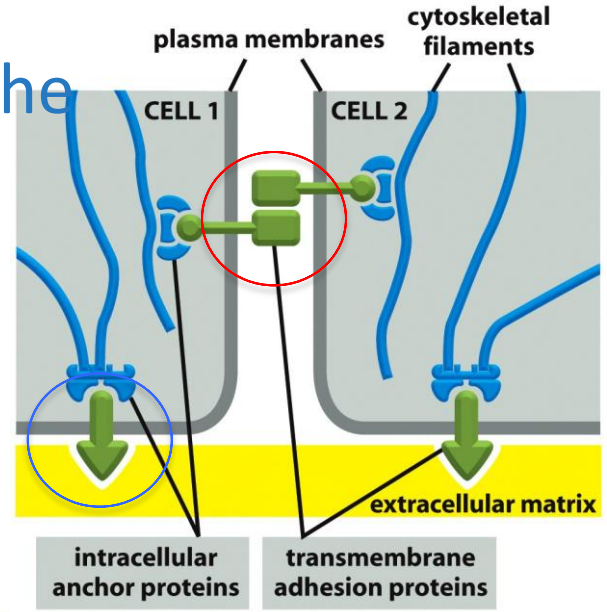


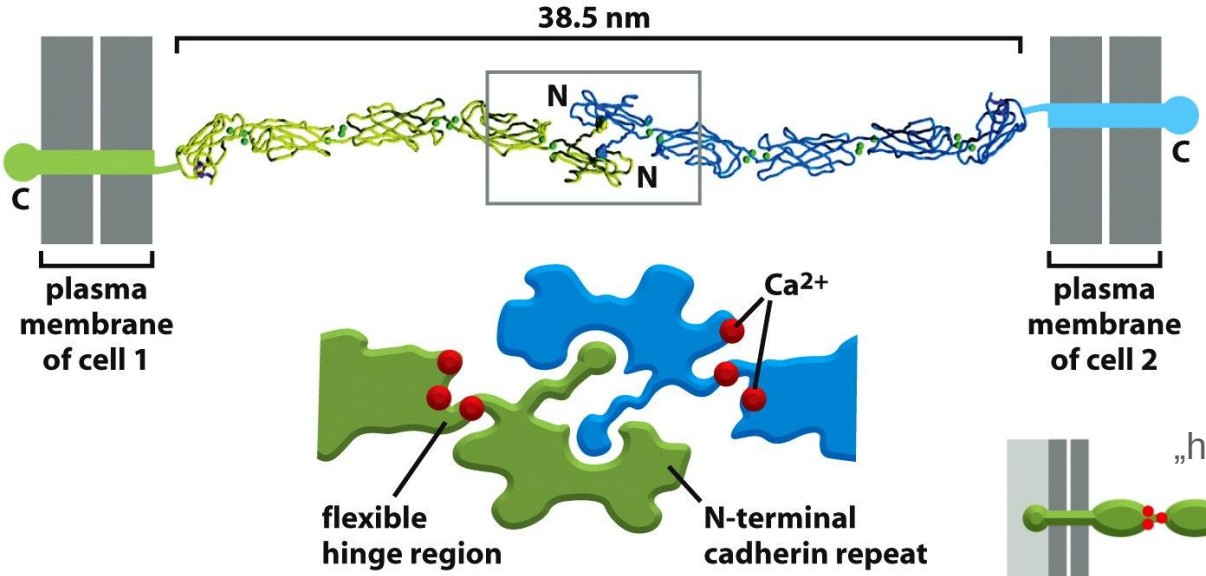

**Table 19–2 Anchoring Junctions**

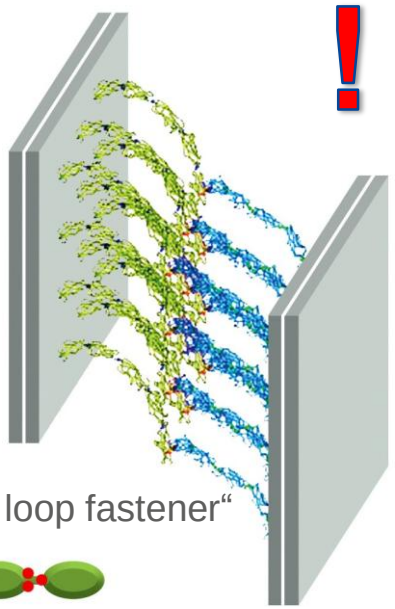
| JUNCTION | TRANSMEMBRANE ADHESION PROTEIN | EXTRACELLULAR LIGAND | INTRACELLULAR CYTOSKELETAL ATTACHMENT | INTRACELLULAR ANCHOR PROTEINS |
|---|---|---|---|---|
| ***Cell–Cell*** | | | | |
| adherens junction | cadherin (classical cadherin) | cadherin in neighboring cell | actin filaments | α-catenin, β-catenin, plakoglobin (γ-catenin), p120-catenin, vinculin, α-actinin |
| desmosome | cadherin (desmoglein, desmocollin) | desmoglein and desmocollin in neighboring cell | intermediate filaments | plakoglobin (γ-catenin), plakophilin, desmoplakin |
| ***Cell–Matrix*** | | | | |
| actin-linked cell–matrix adhesion | integrin | extracellular matrix proteins | actin filaments | talin, vinculin, α-actinin, filamin, paxillin, focal adhesion kinase (FAK) |
| hemidesmosome | integrin α6β4, type XVII collagen (BP180) | extracellular matrix proteins | intermediate filaments | plectin, dystonin (BP230) |



Table 19-2, Figure 19-4 *Molecular Biology of the Cell* (© Garland Science 2008)

# Cadherin Structure and Function

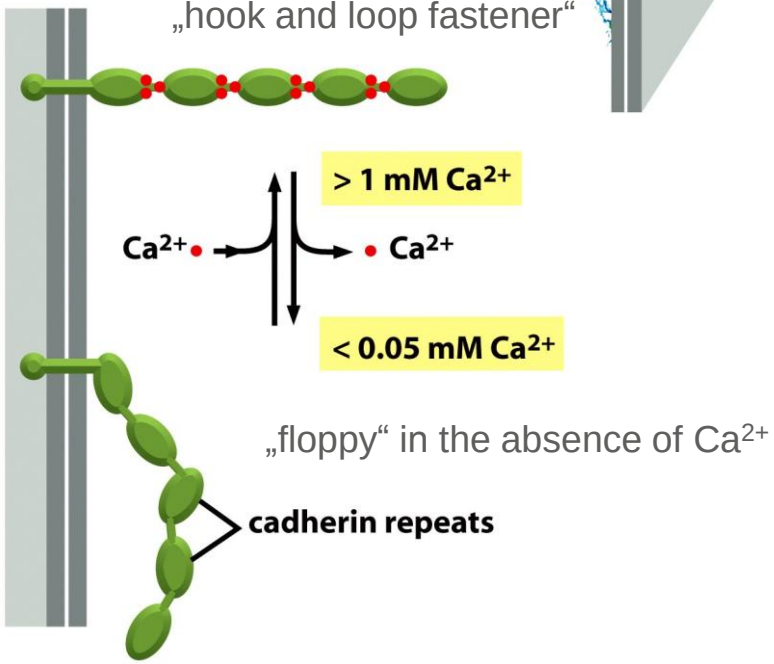


„hook and loop fastener“

end to end binding via insertion of knobs into pockets of the opposing cadherin molecule

strong attechment results from the formation of many such weak bonds




„floppy“ in the absence of $Ca^{2+}$



Figure 19-9 *Molecular Biology of the Cell* (© Garland Science 2008)

# Adhesion Belt in Intestinal Cells

formation of transcellular networks enables coordinated use of the cytoskeleton,
e.g. folding of epithelial sheets.

epithelial cells (e.g. intestinal epithelia) are polarized: basal and apical side

epithelia serve as permeability barriers, sealing is mediated by occluding junctions (e.g. tight junctions)

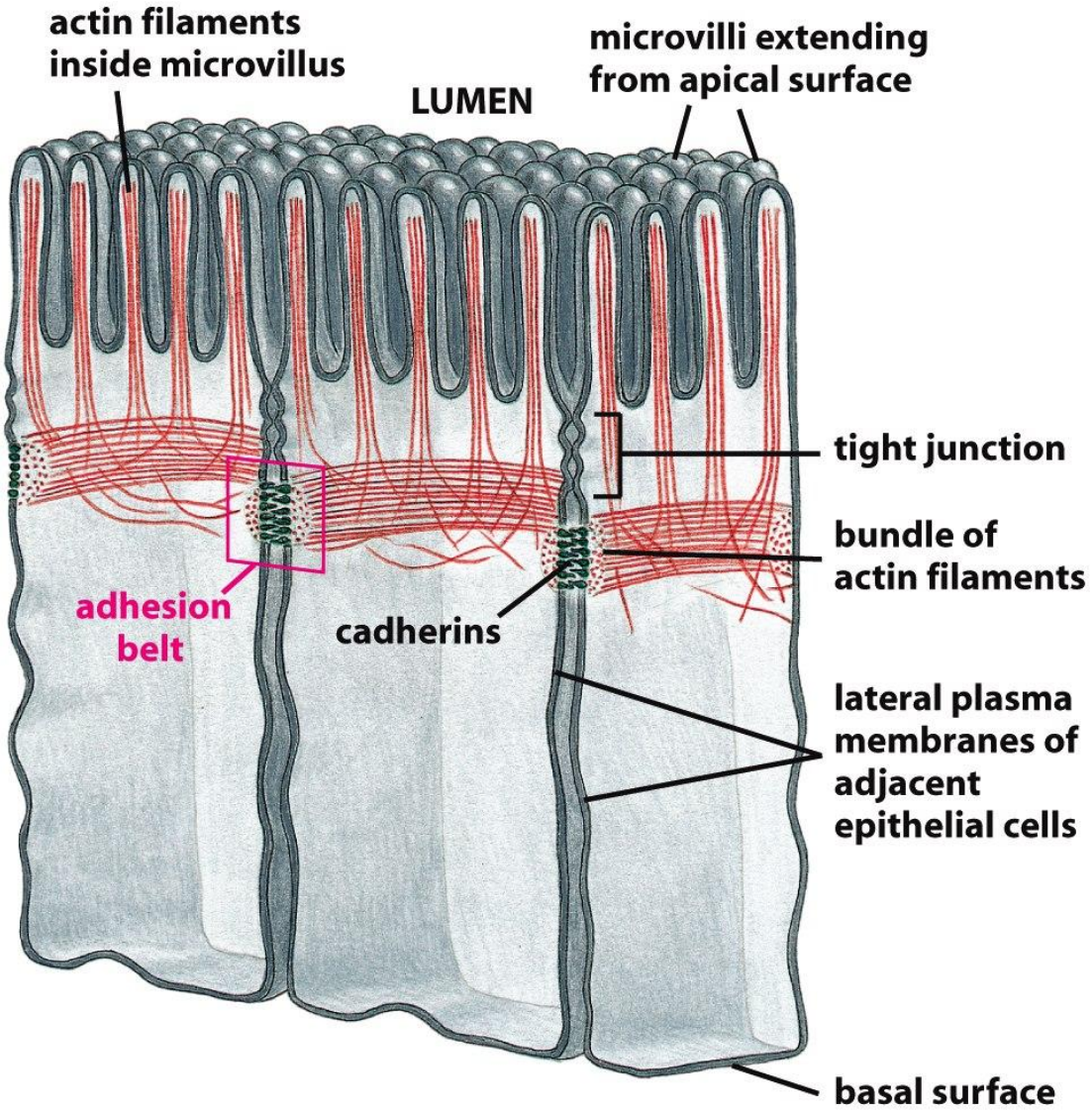
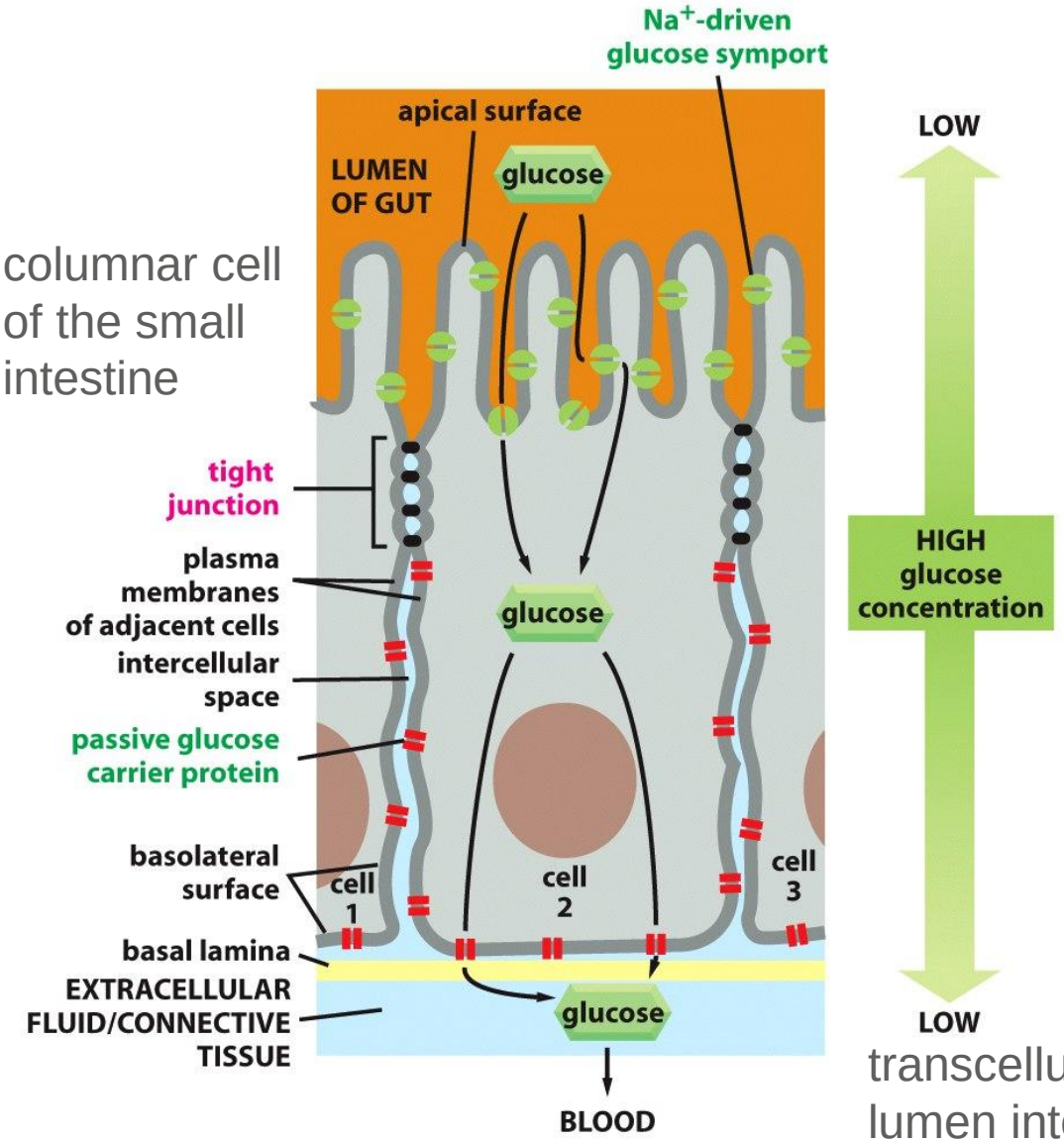


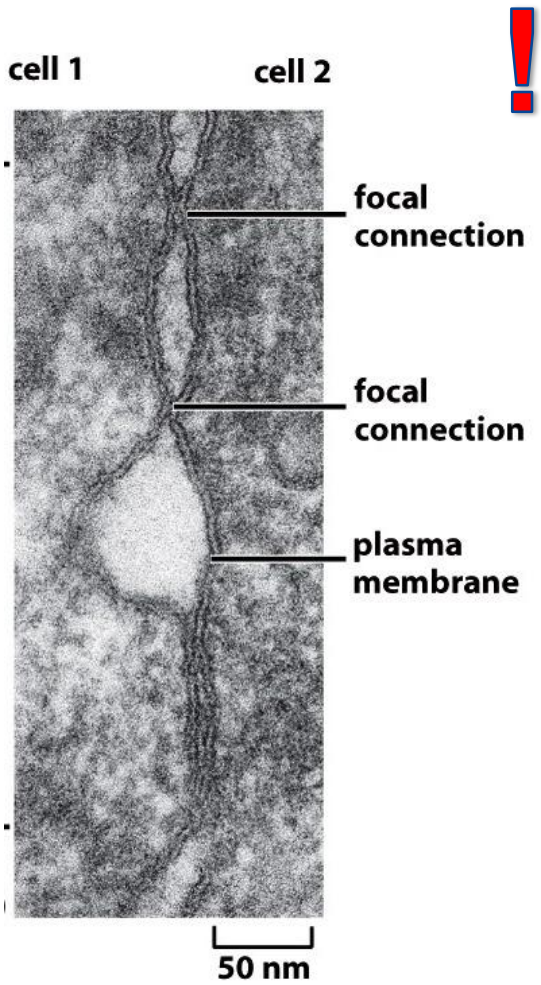



Figure 19-15 *Molecular Biology of the Cell* (© Garland Science 2008)

# Tight Junctions Form Seals and Fences

columnar cell of the small intestine



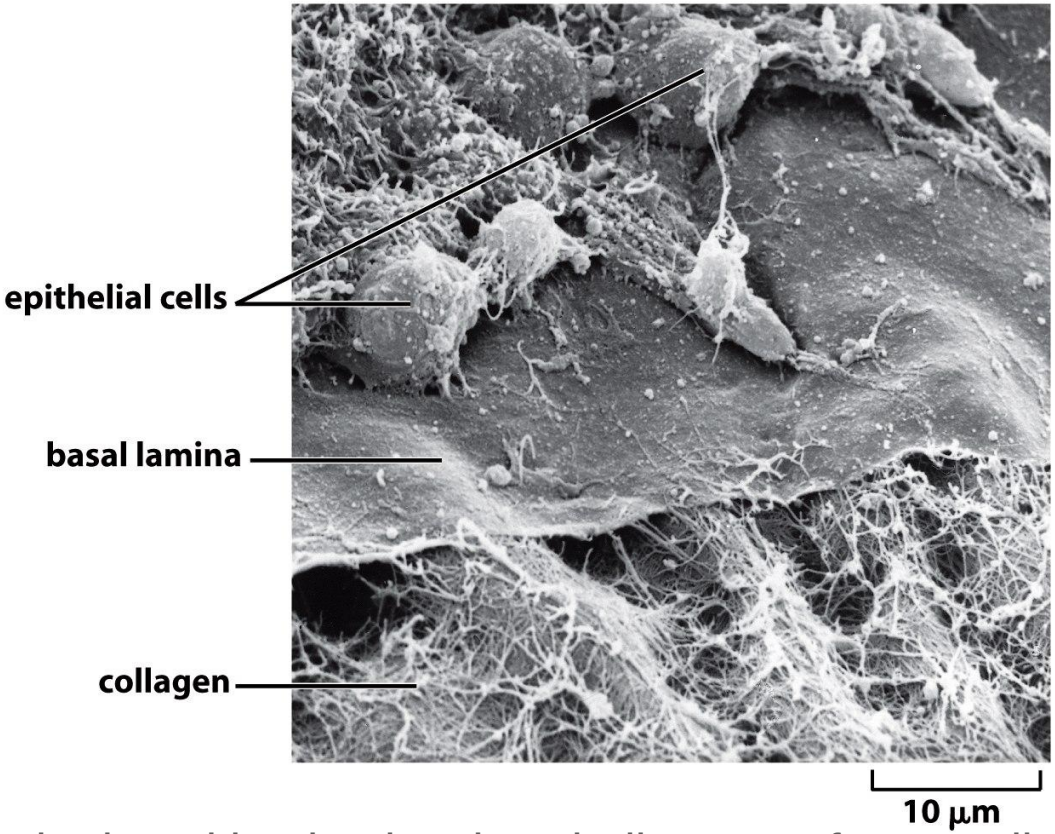

transcellular transport of glucose from the gut lumen into blood vessels (intestine)

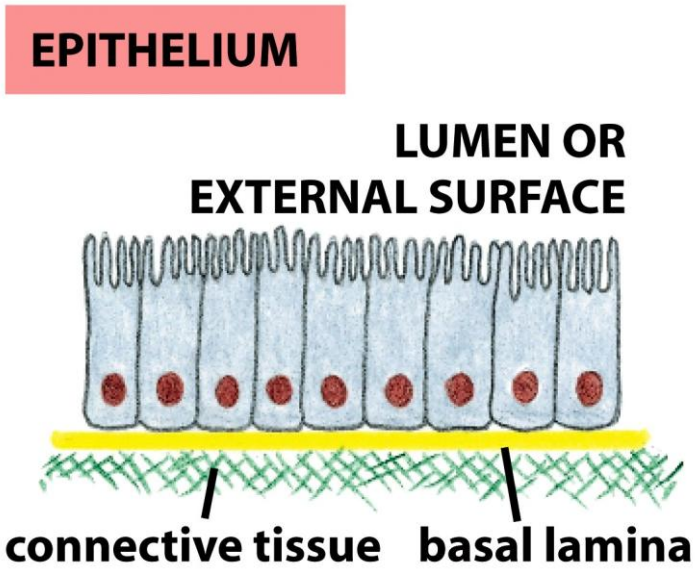




Figure 19-23, 19-25 *Molecular Biology of the Cell* (© Garland Science 2008)

# Basal Laminae Underlie all Epithelia



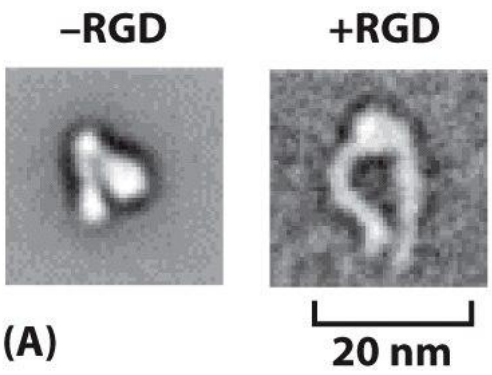

The basal lamina is a less bulky type of extracellular matrix.

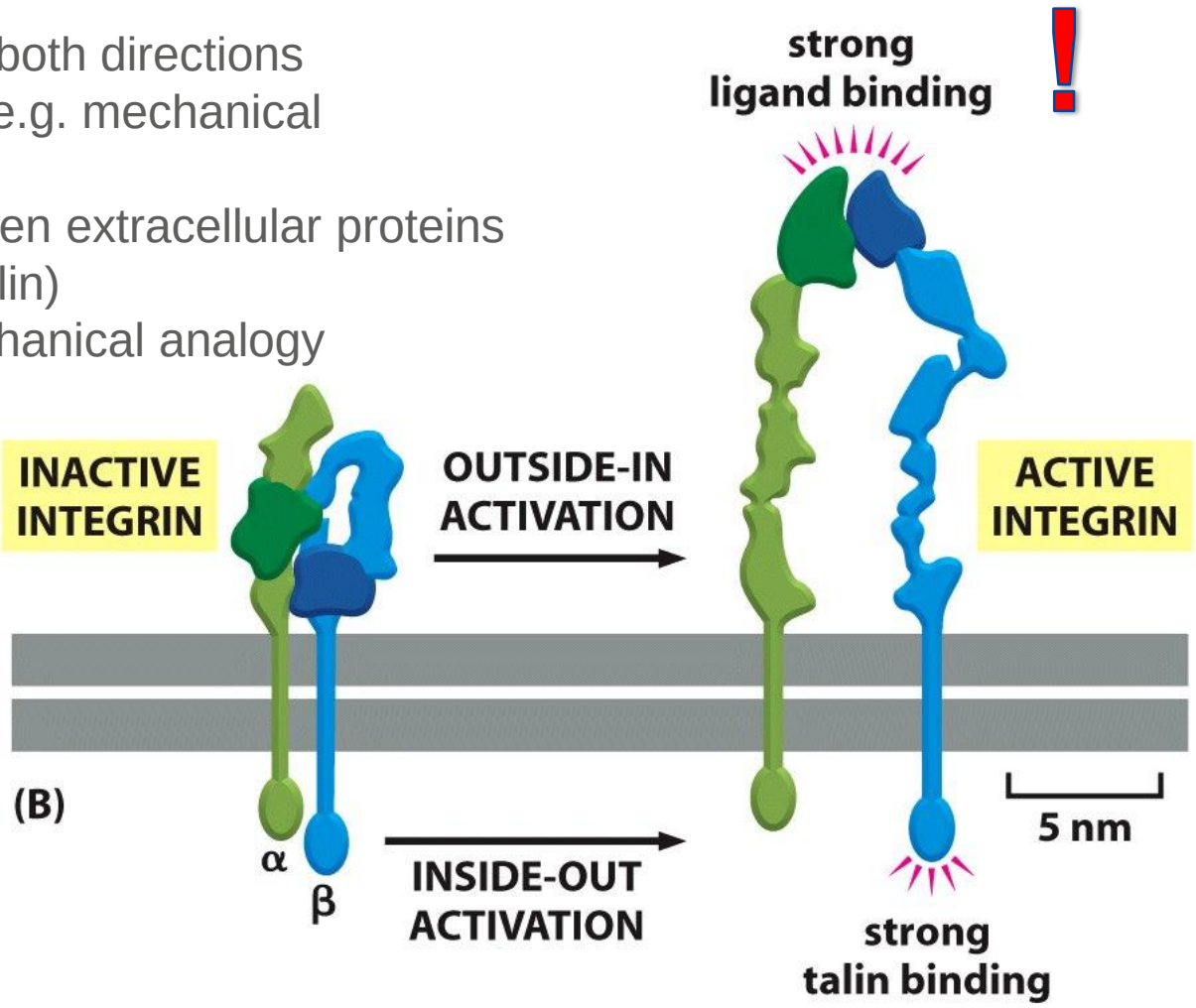
- mechanical connection between epithelia and underlying connective tissue
- influencing cell behaviour through matrix receptors (e.g. integrins)


Figure 19-40, 19-39 *Molecular Biology of the Cell* (© Garland Science 2008)

# Integrins Link Extracellular Matrix to the Cytoskeleton

-integrins transmit signals in both directions across the cell membrane, e.g. mechanical or molecular signals
- they mediate binding between extracellular proteins and the cytoskeleton (via talin)
- timber tongs provide a mechanical analogy

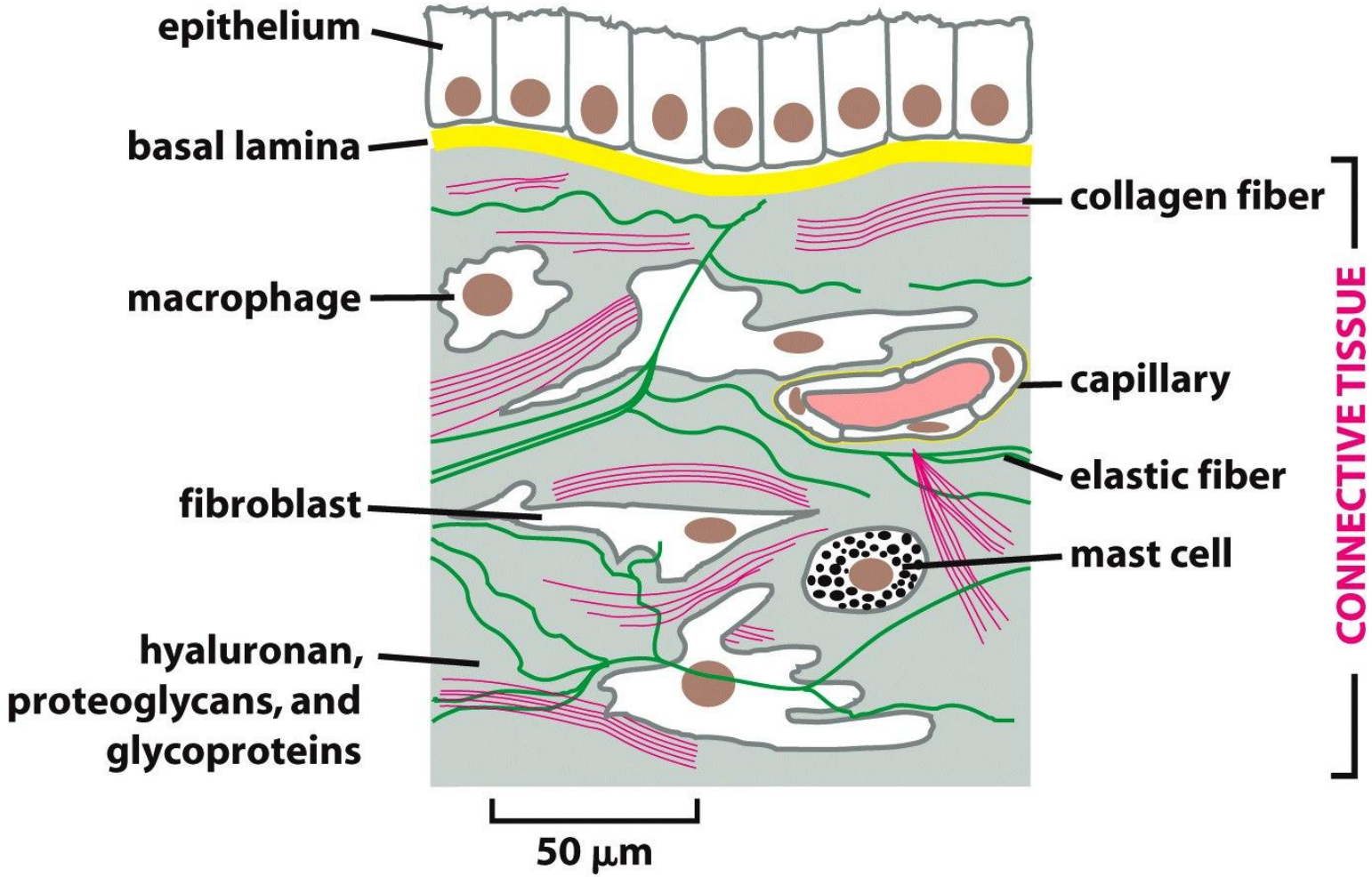



- making and breaking of such attachments are useful, e.g. during cell migration


Figure 19-48 *Molecular Biology of the Cell* (© Garland Science 2008)

# The Extracellular Matrix of Connective Tissues

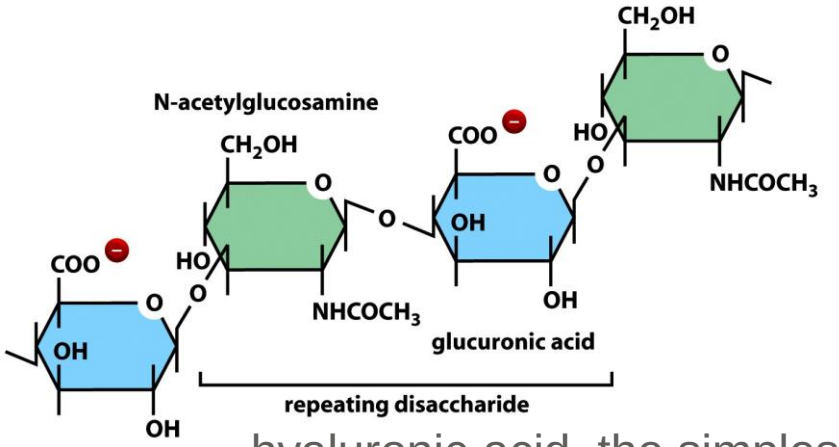



tissues are not made up by cells only, but also by the extracellular matrix: an organized meshwork composed of proteins and polysaccharides, bulky in bone, tendon, and the dermal layer of skin

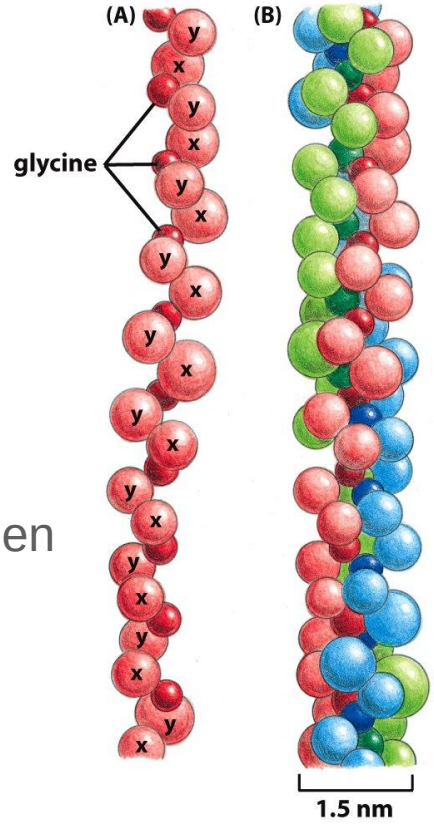


Figure 19-53 *Molecular Biology of the Cell* (© Garland Science 2008)

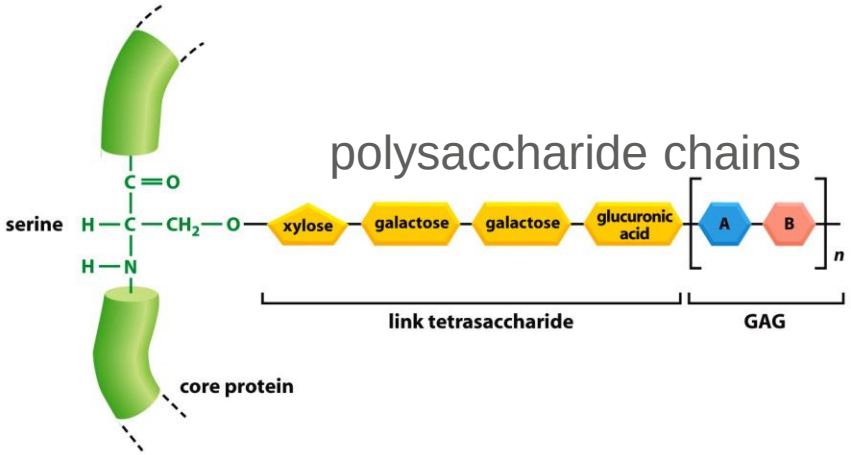
# Components of the Extracellular Matrix




hyaluronic acid, the simplest Glycosaminoglycan (GAG)




collagen




proteoglycan „ground substance“

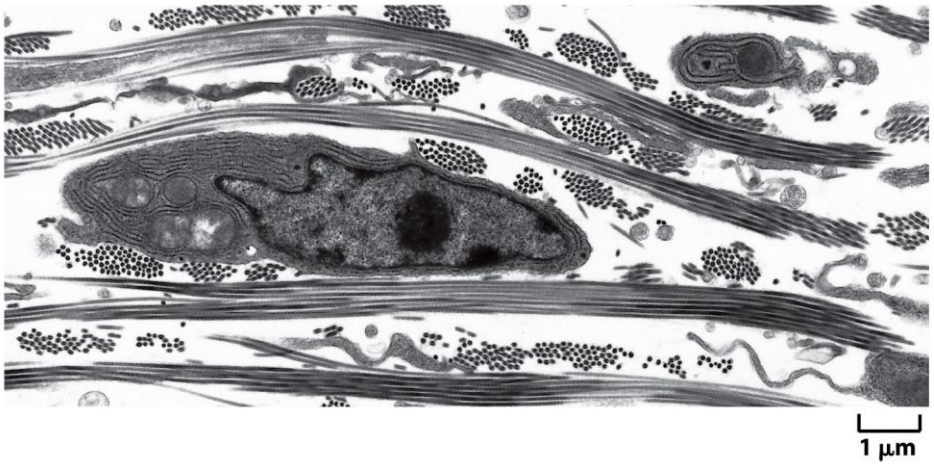
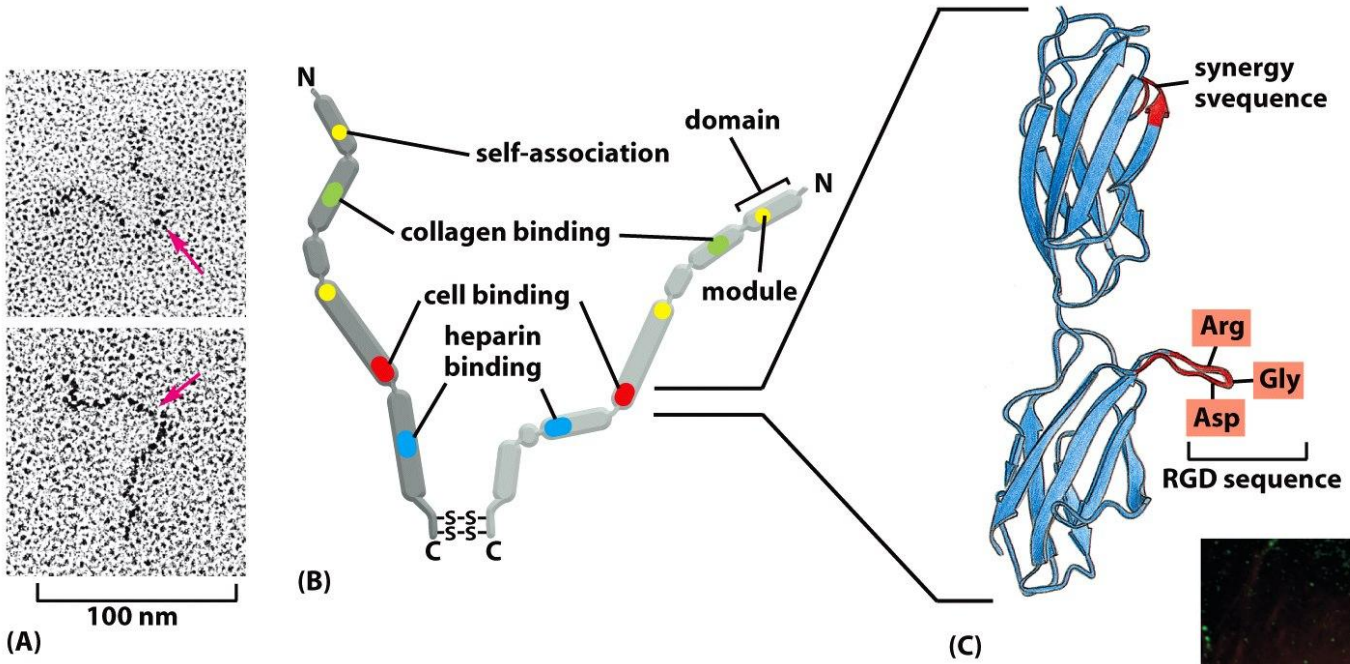





Figure 19-54, 19-58, 19-62, 19-63 *Molecular Biology of the Cell* (© Garland Science 2008)

# Fibronectin Attaches Cells to the Extracellular Matrix




fibronectin binds to integrins through RGD motifs

it accumulates at focal adhesions (sites of anchorage of actin filaments) outside the cells and becomes organized into fibrils (green) parallel to actin filaments in the cells (red)

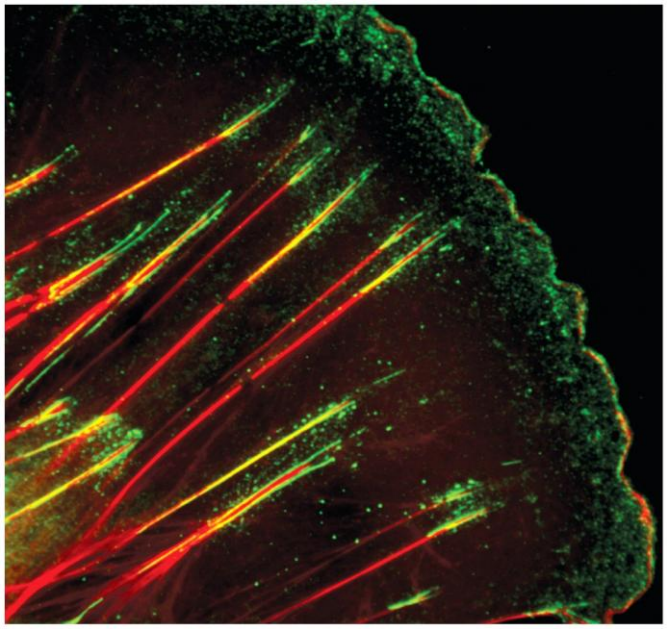








Figure 19-72, 19-74 *Molecular Biology of the Cell* (© Garland Science 2008)

# Connective-Tissue Cells

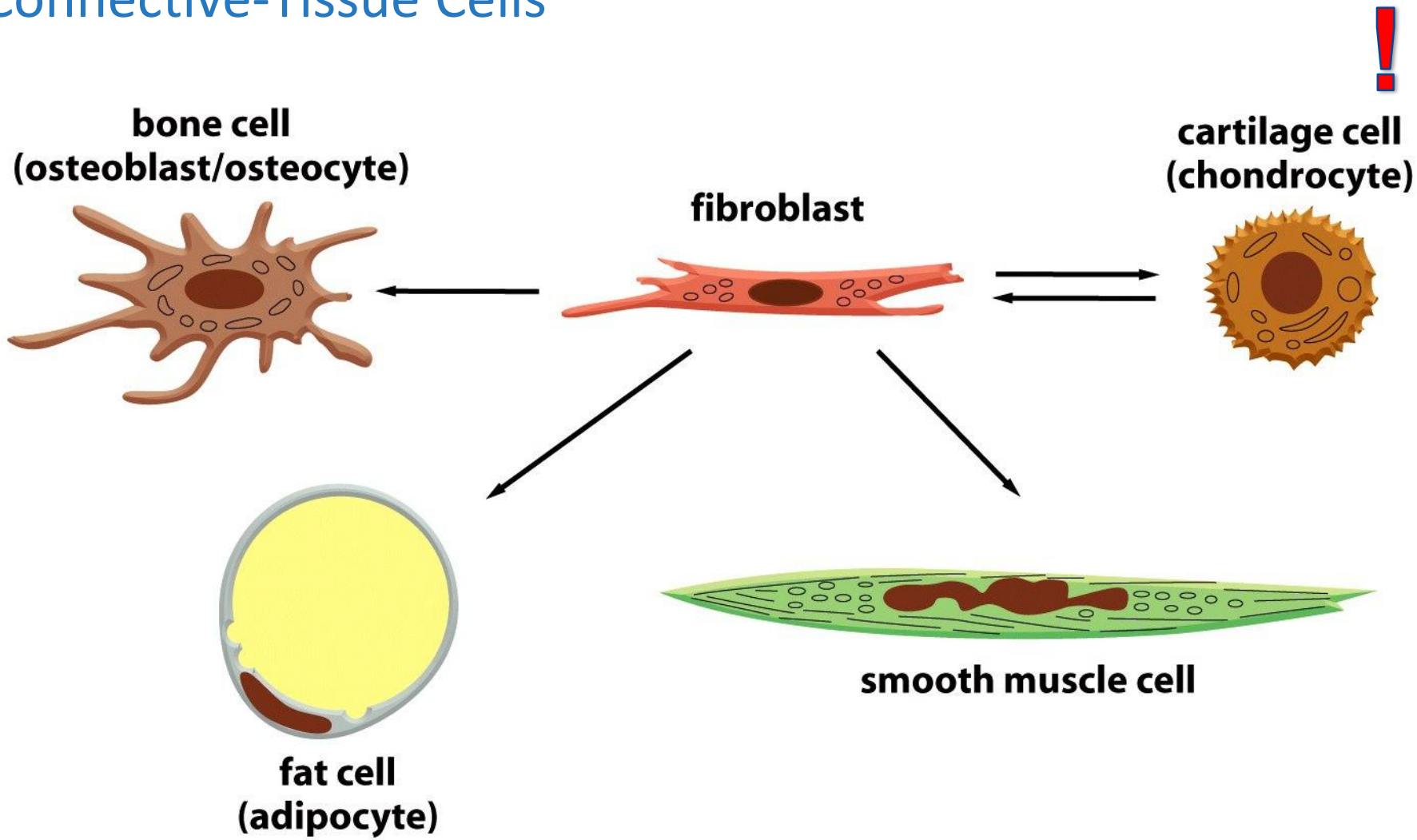
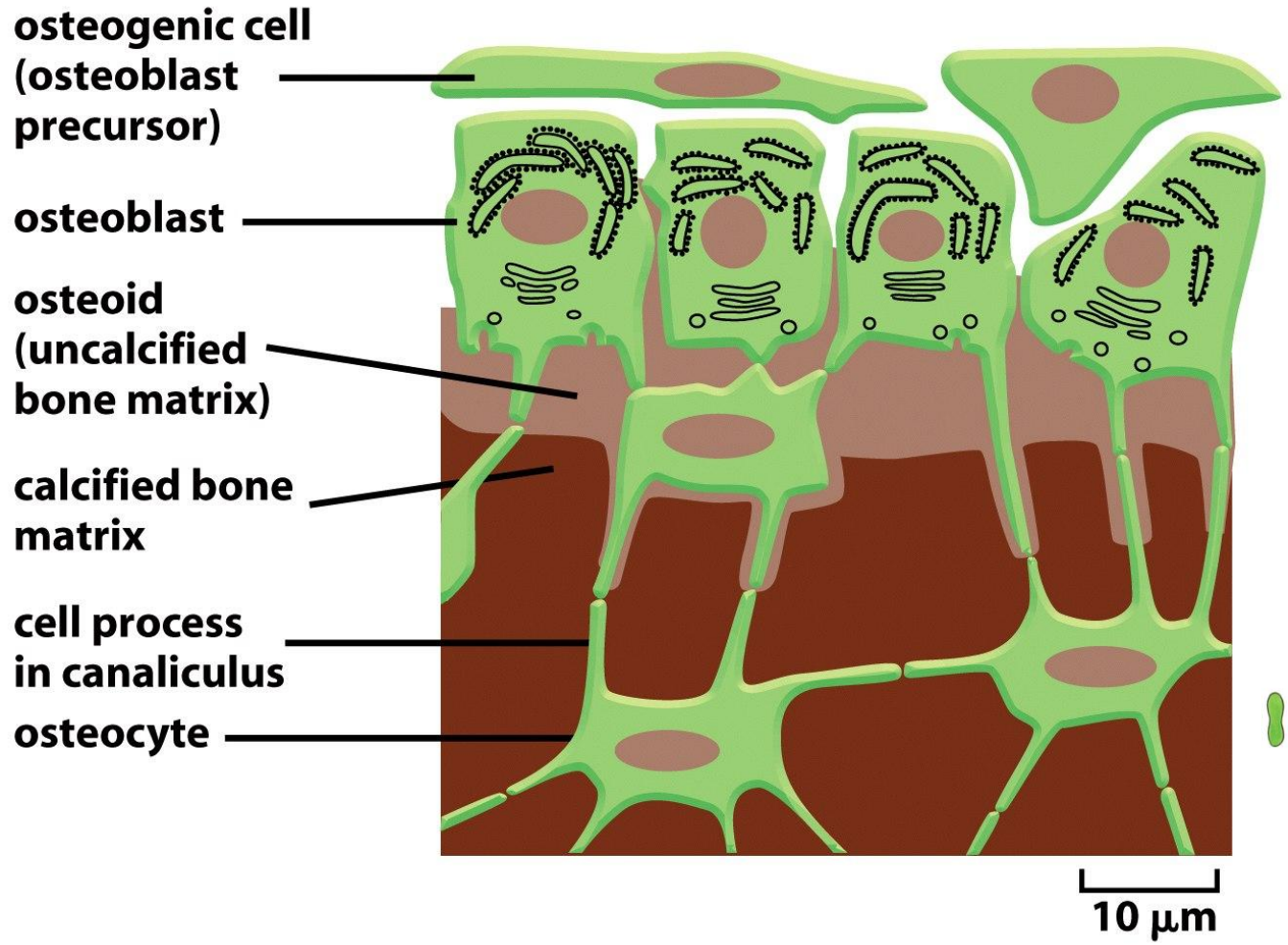
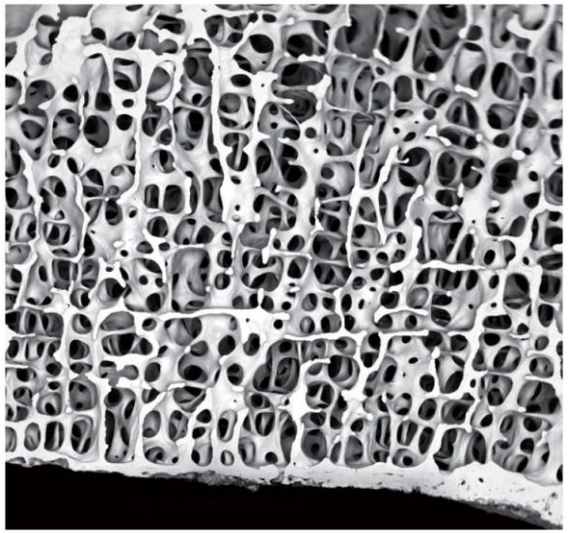


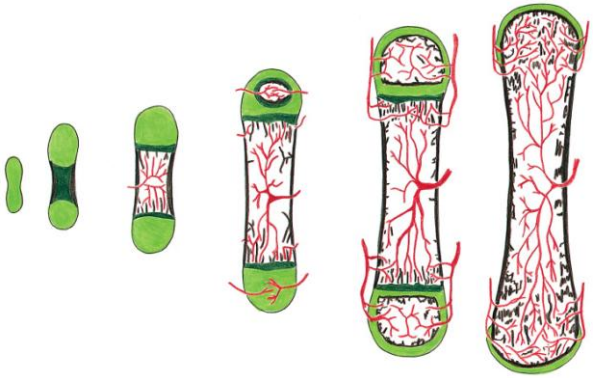



Figure 23-52 *Molecular Biology of the Cell* (© Garland Science 2008)

# Bone Matrix Is Made by Osteoblasts





adult bone has a plywood like structure of collagen fibers, resisting pulling forces and calcium phosphate particles, resisting compression



Figure 23-55, 23-56, 23-57 *Molecular Biology of the Cell* (© Garland Science 2008)

# Remodeling of Bone

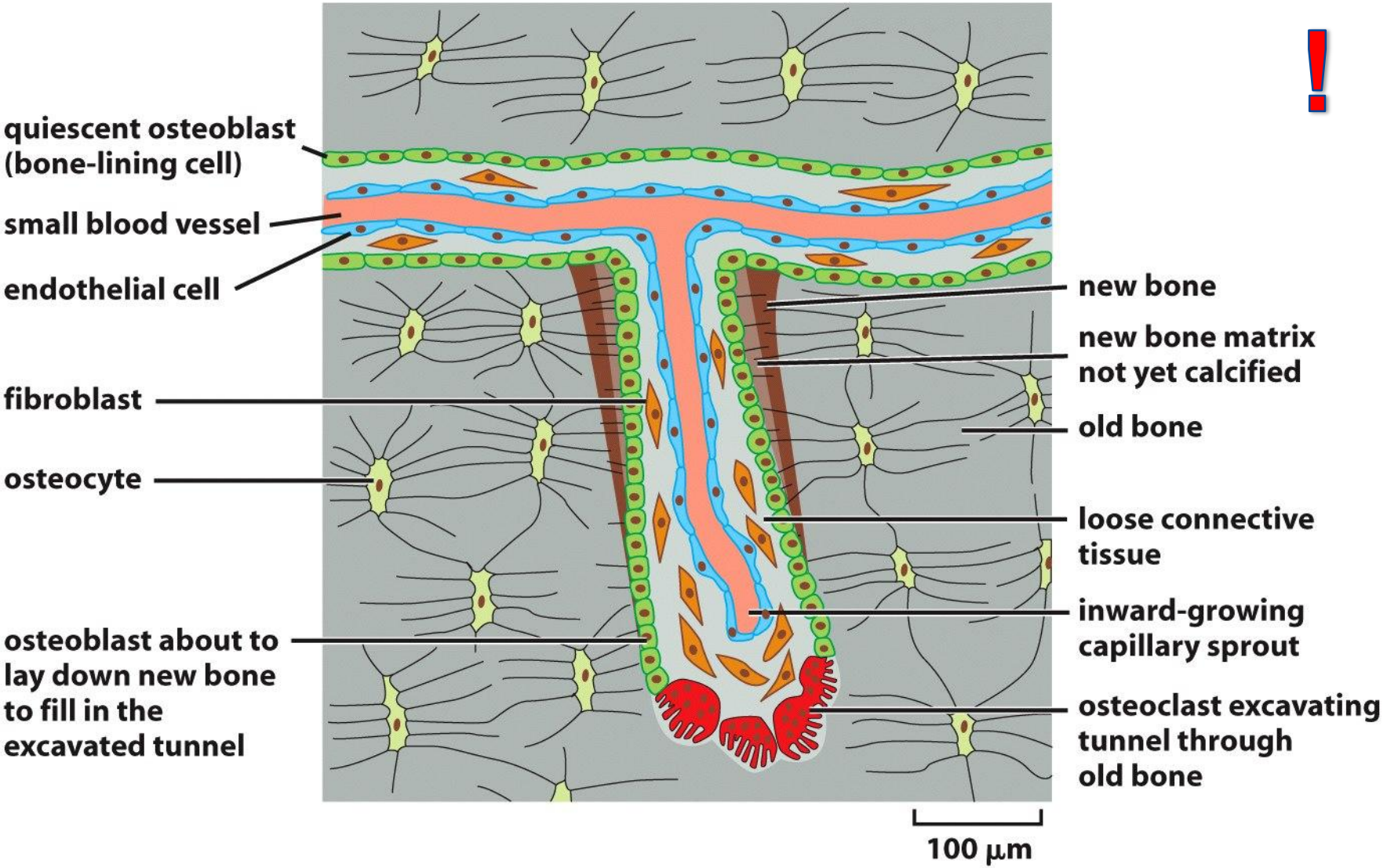









Figure 23-60 *Molecular Biology of the Cell* (© Garland Science 2008)

# Remodeling of Bone

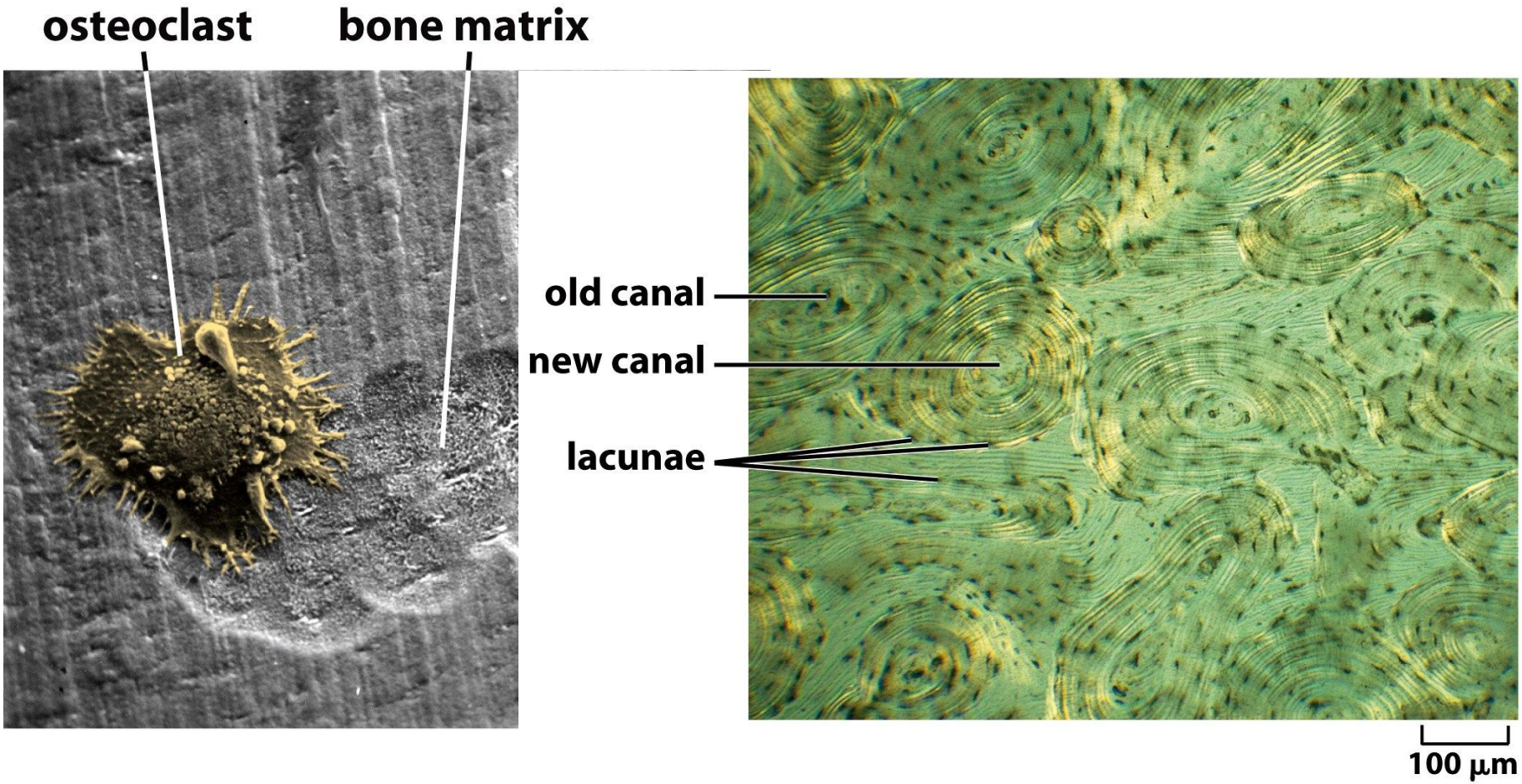
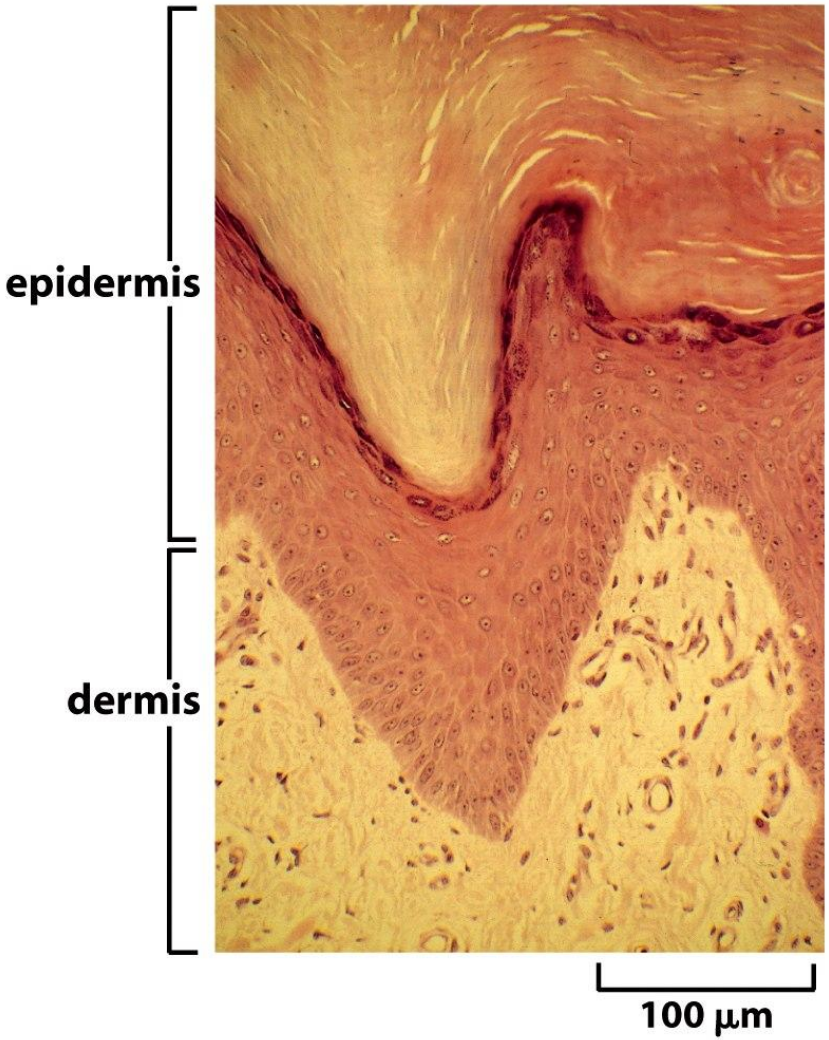
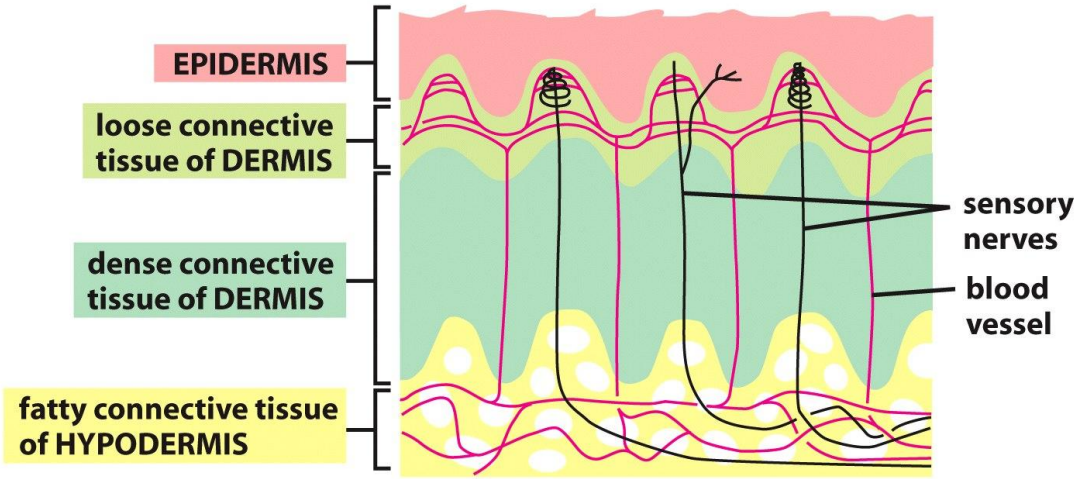





Figure 23-59, 23-61 *Molecular Biology of the Cell* (© Garland Science 2008)

# Skin Architecture




Epithelia (e.g. the epidermis of skin) make up 60% of the cells in vertebrates.
They enclose and partition the animal body, lining all surfaces and cavities and create compartments.



Figure 23-1 *Molecular Biology of the Cell* (© Garland Science 2008)

# Skin Architecture

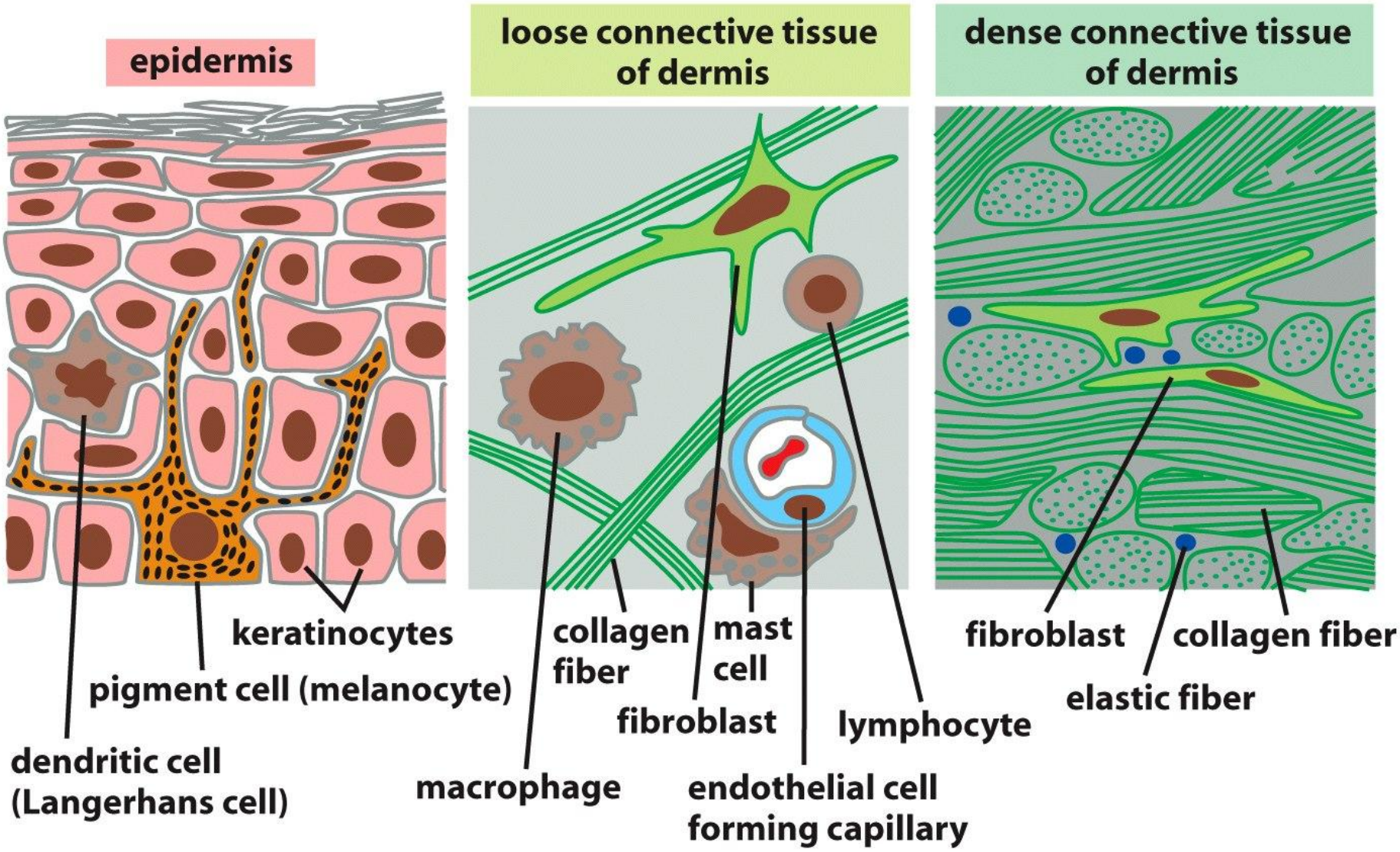









Figure 23-1 *Molecular Biology of the Cell* (© Garland Science 2008)

# Structure of the Epidermis

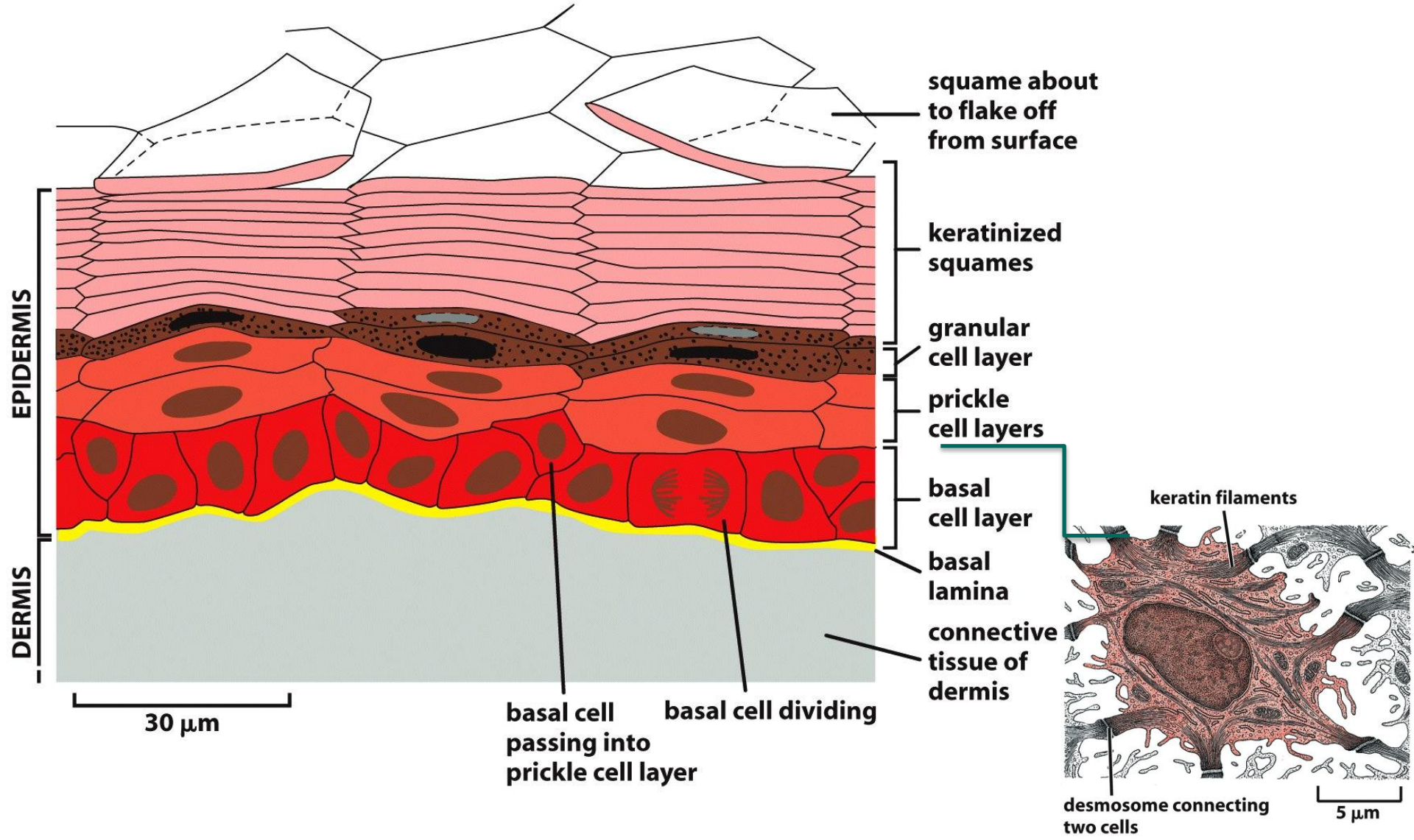


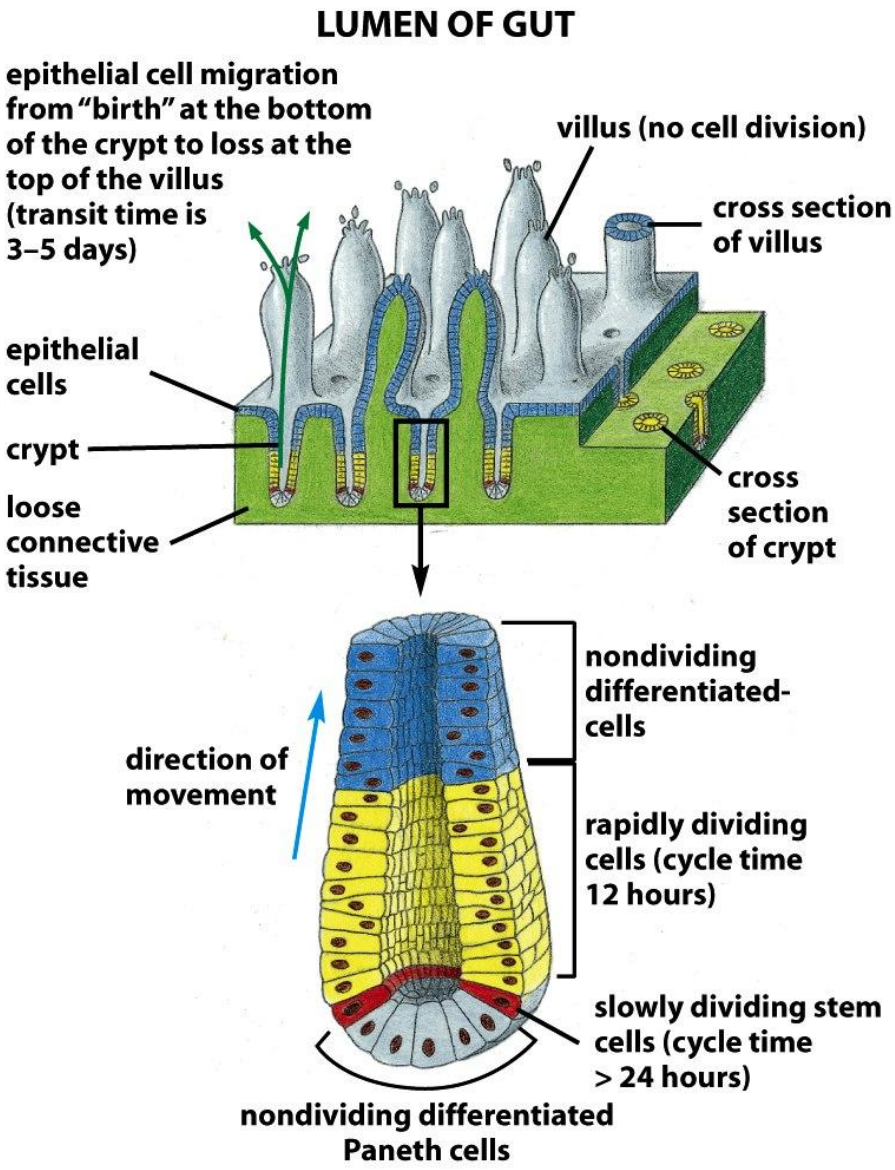







Figure 23-3, 23-4 *Molecular Biology of the Cell* (© Garland Science 2008)

# The Lining of the Small Intestine



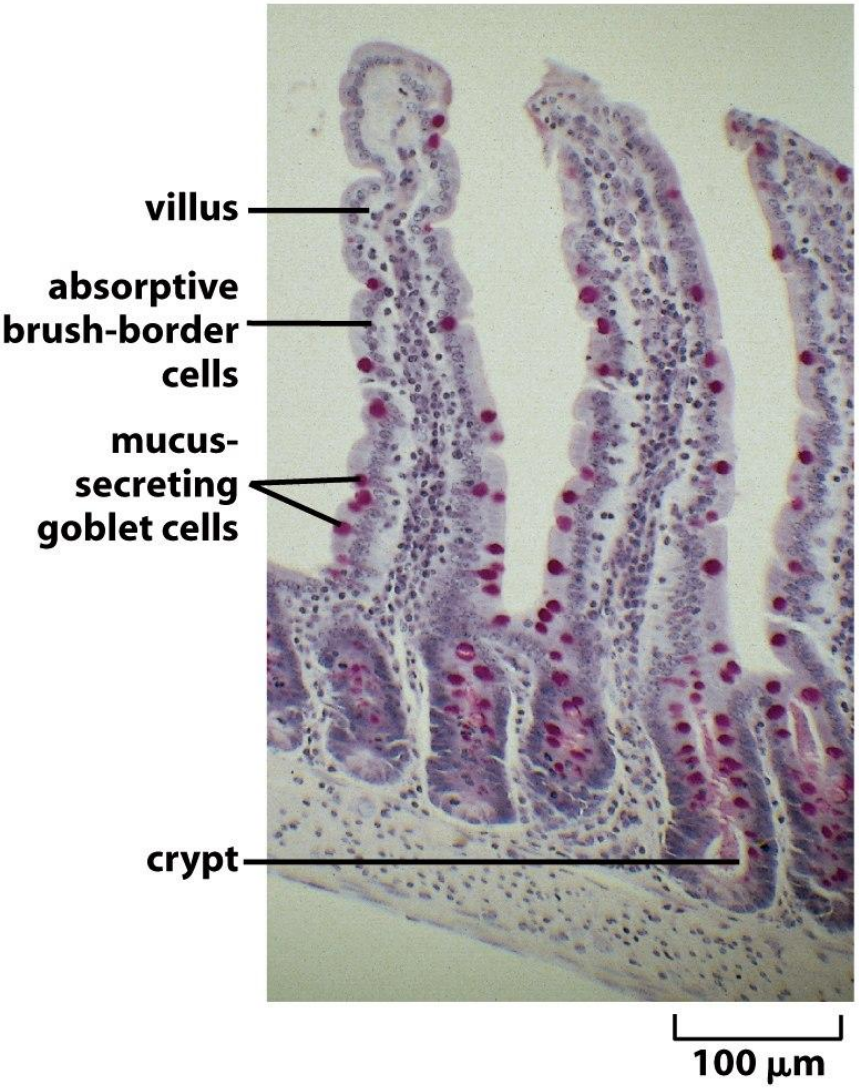










Figure 23-21 *Molecular Biology of the Cell* (© Garland Science 2008)

# Differentiated Cells in the Epithelial Lining of the Small Intestine

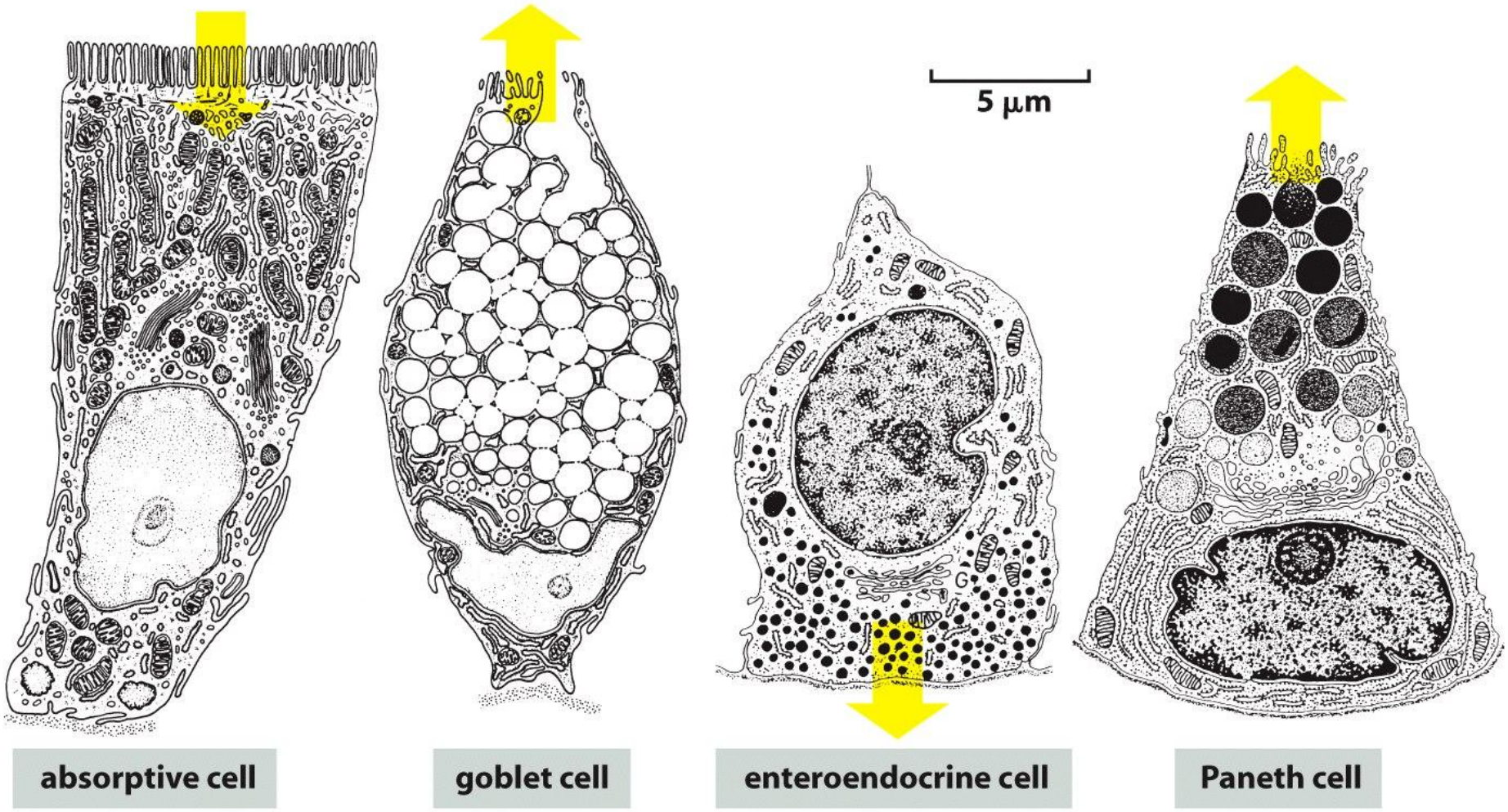





Figure 23-22 *Molecular Biology of the Cell* (© Garland Science 2008)

# Respiratory Epithelium

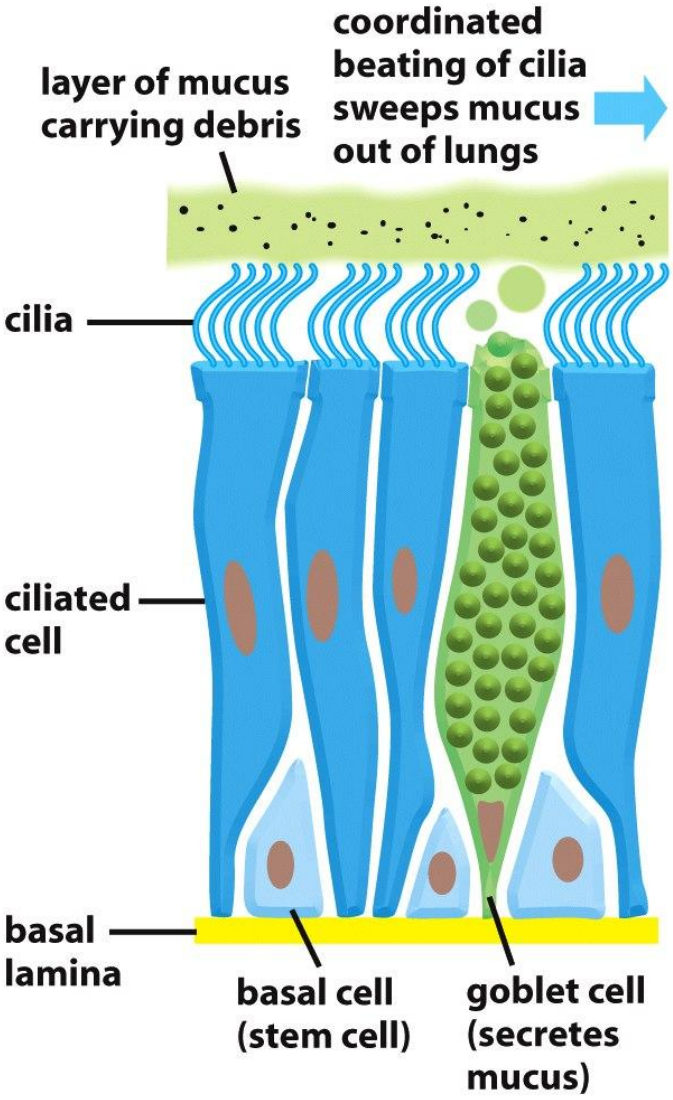









Figure 23-20 *Molecular Biology of the Cell* (© Garland Science 2008)

# Alveoli

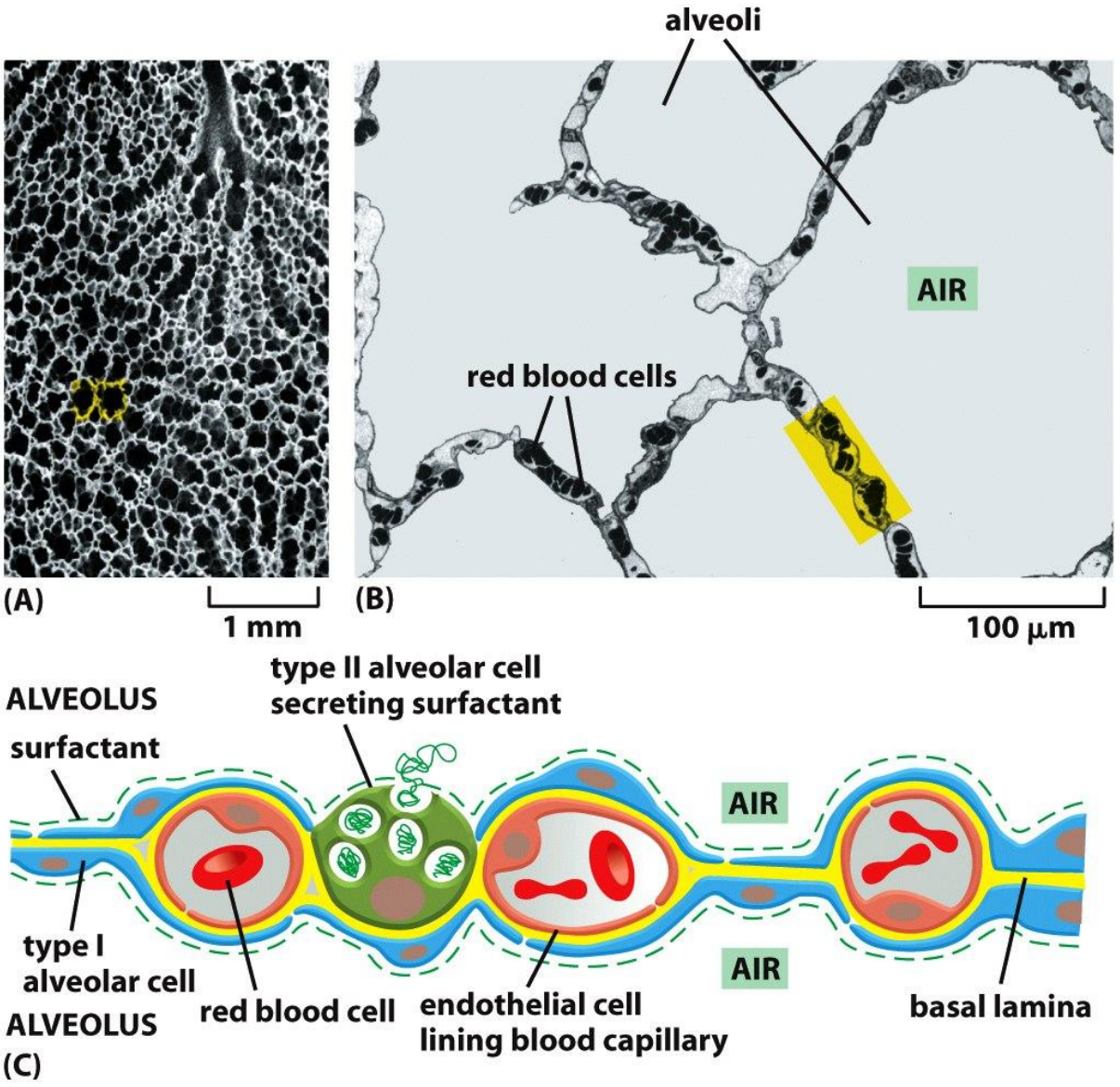


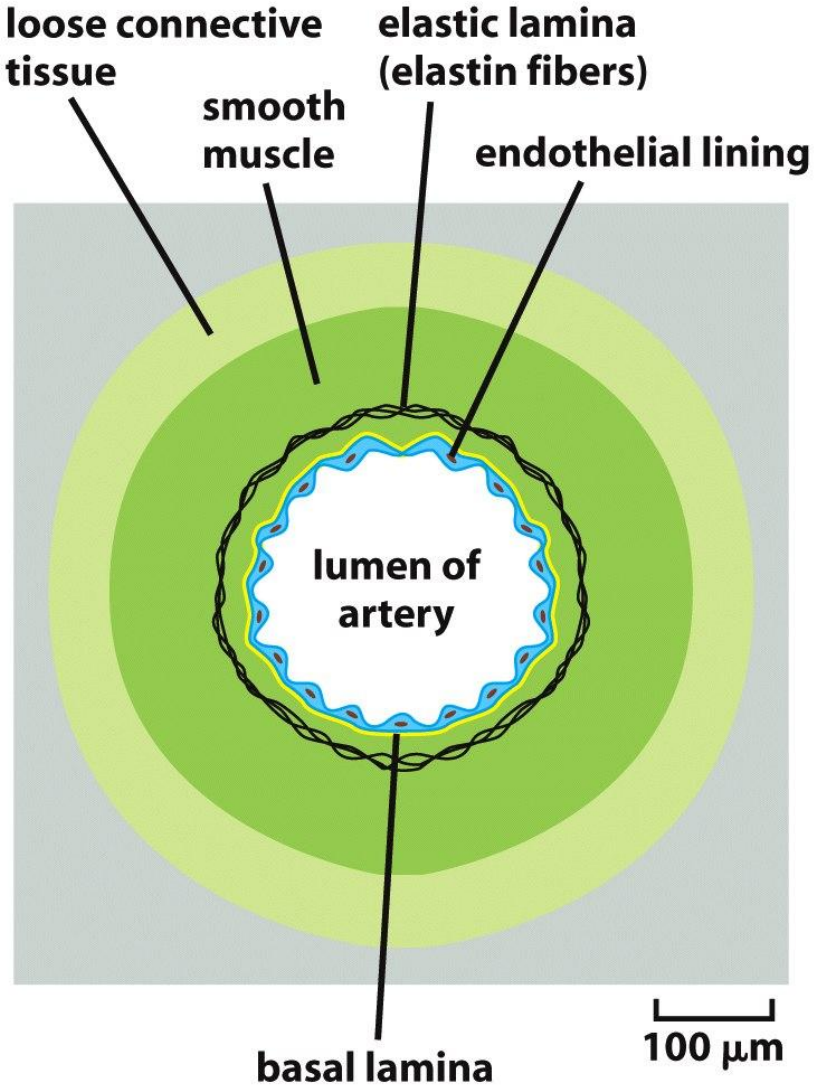







Figure 23-19 *Molecular Biology of the Cell* (© Garland Science 2008)

# Endothelial Cells Line Blood Vessels



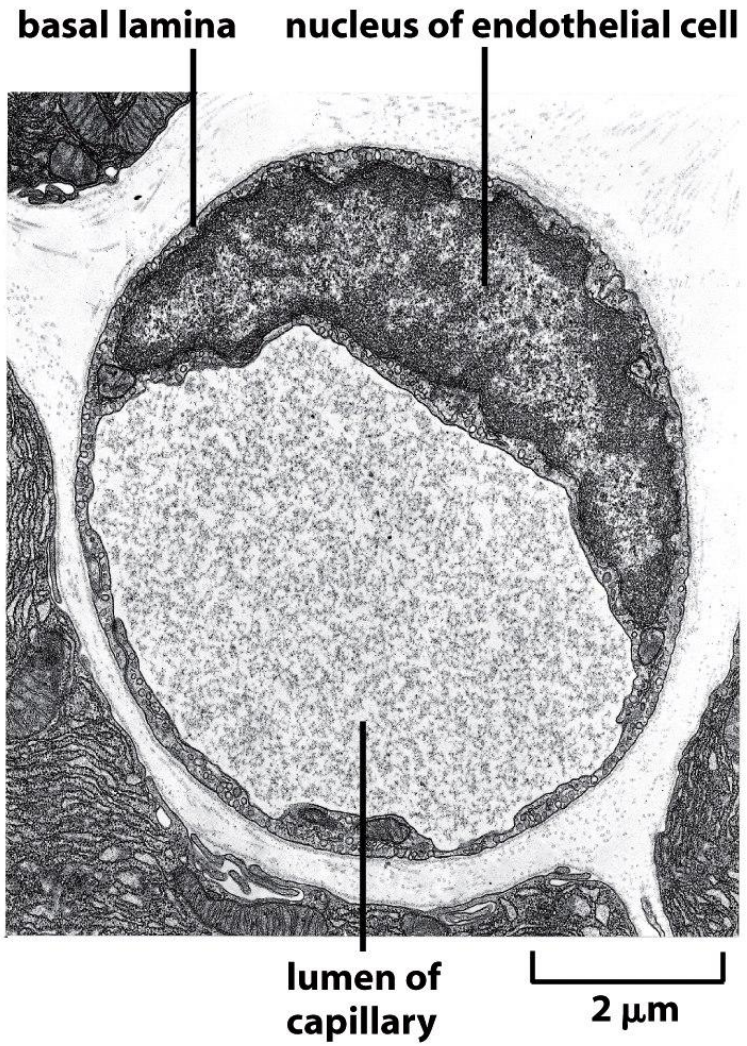








Figure 23-30, 23-31 *Molecular Biology of the Cell* (© Garland Science 2008)

# Blood Vessel Growth is Triggered by Lack of Oxygen

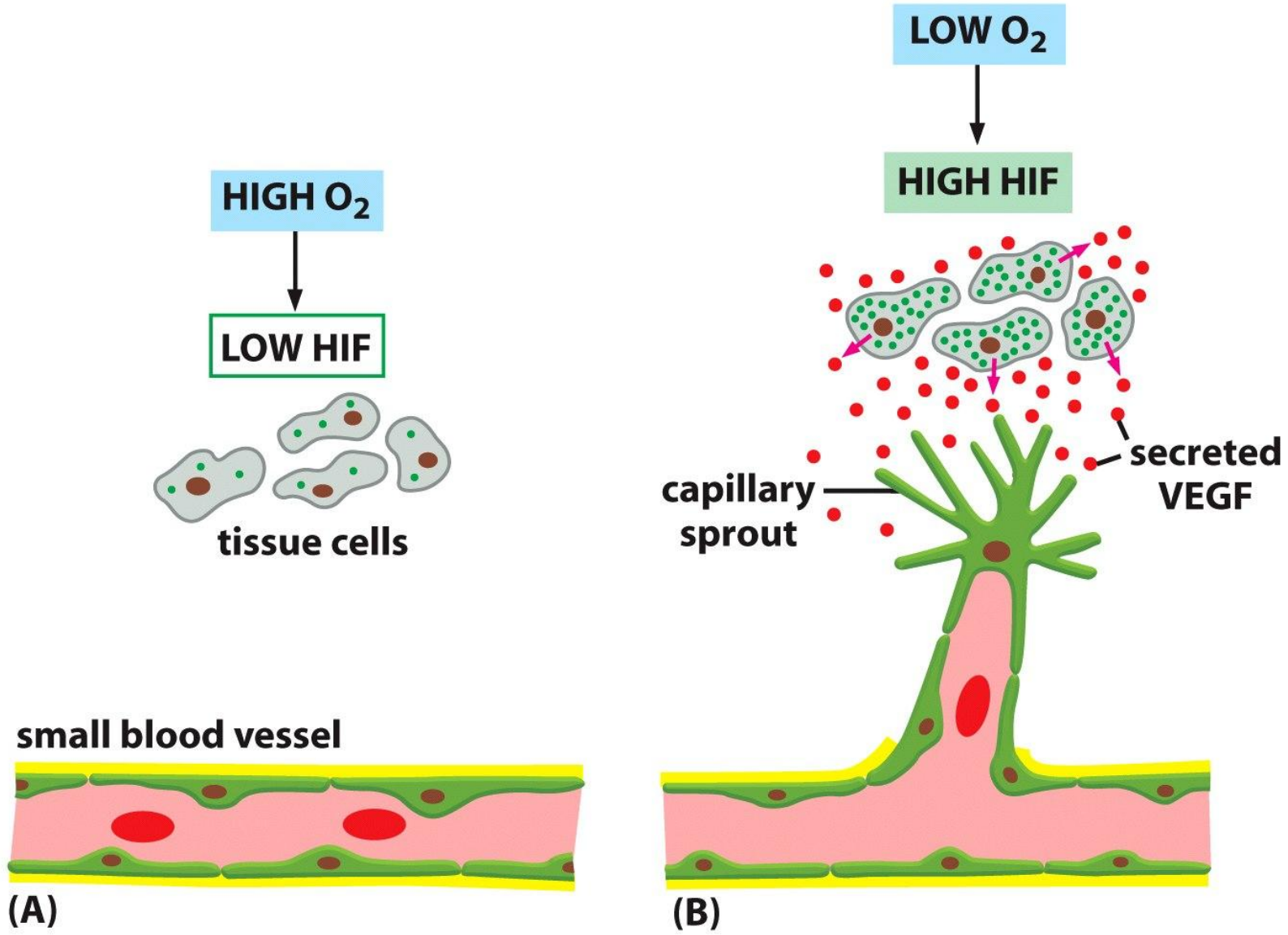









Figure 23-35 *Molecular Biology of the Cell* (© Garland Science 2008)

# Questions

- Intracellular Structures and Organelles:
  - What is the structure and function of the nucleus?
  - How is intracellular transport mediated? What is the function of lysosomes?

- Cell-Cell and Cell-Matrix Junctions:
  - What are cadherins and integrins? Describe the function of cell junctions

- What is the extracellular matrix, how is it composed, what is fibronectin? what is the basal lamina?

- Illustrate structure and functions of important cells and tissues:
  - Connective Tissue Cells (Bone)
  - Epithelial Cells (Skin, Intestine, Airways)
  - Endothelial Cells (Blood Vessels)

# Literature

**Books:**

- ❑ Molecular Biology of the Cell, ed. Alberts et al. (2008), Garland Science

# Next Lecture: May 10, 2019

**Polymer Networks by Dr. Jiaxi Cui**

# Topics and Schedule

| | | |
|---|---|---|
| Introduction*/Biological Building Blocks | krae | 12.4 |
| Karfreitag | - | 19.04. |
| Molecular Machines and Subcellular Organisation | krae | 26.4. |
| Cell and Tissue Functions | krae | 03.5. |
| Polymer Networks | cui | 10.5. |
| Biomaterials | krae | 17.5. |
| Liquid-Repellent Surfaces | hen | 24.5. |
| Brückentag (Christi Himmelfahrt) | - | 31.5. |
| Basics of Electron Microscopy | da | 7.6. |
| Demonstration Electron Microscopy | koc | 14.06. |
| Brückentag (Fronleicham) | - | 21.6. |
| Nano Bio Analytics at INM | fi | 28.6. |
| Biomedical Applications of Nanoobjects | krae | 5.7. |
| Nanosafety | krae | 12.7. |
| Written examination (Klausur) | | 19.7. |

*biological basics, materials and material bio aspects, analytics, no lecture