CHAPTER 10 LECTURE SLIDES

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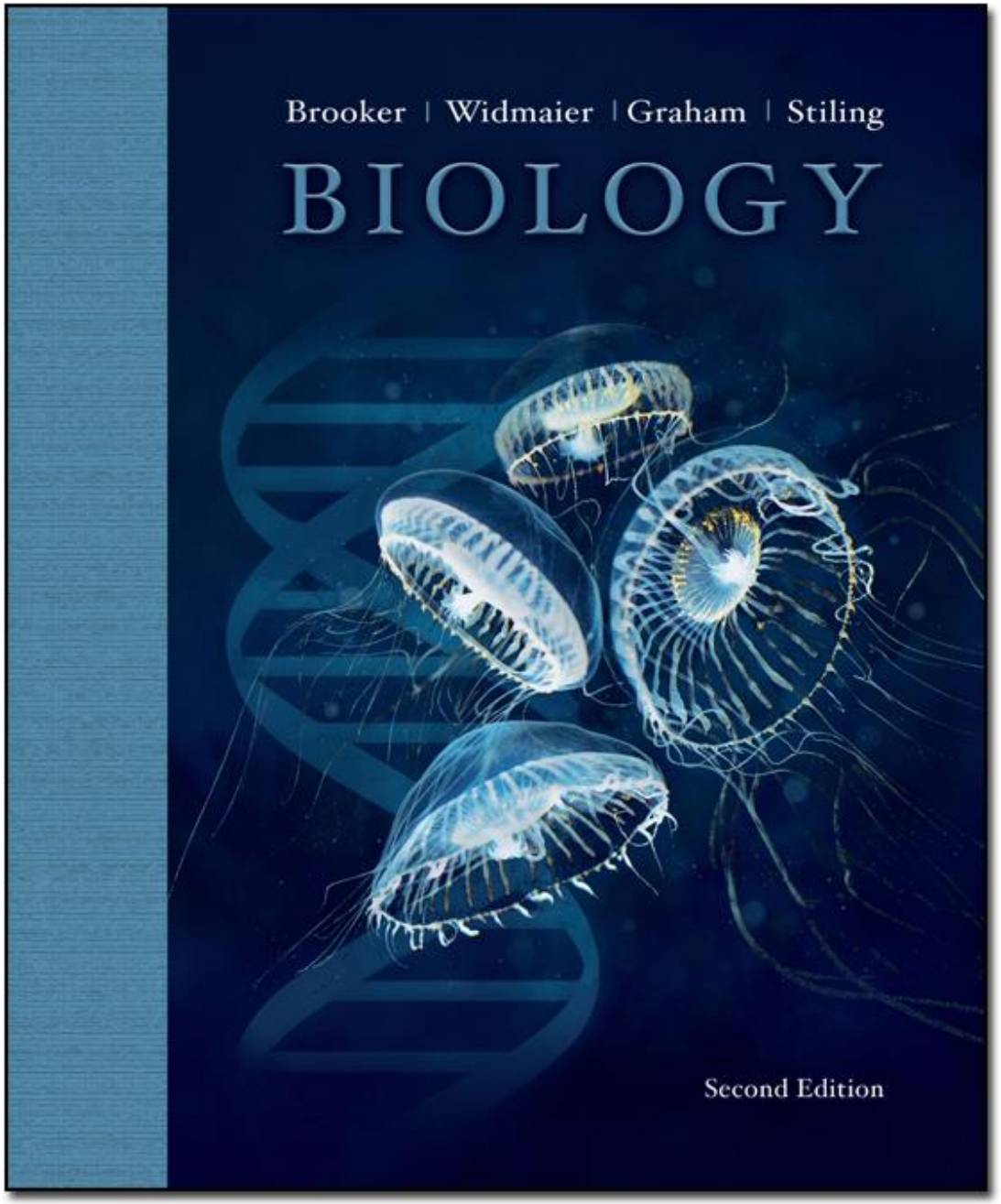


Multicellular

- Single organism composed of more than one cell
- Main benefit: the division of labor
  - Intestinal cells: nutrient uptake
  - Gametes: reproduction
- Larger genomes = larger proteomes
- Additional proteins for
  - Cell communication
  - Arrangement and attachment of cells
  - Cell specialization

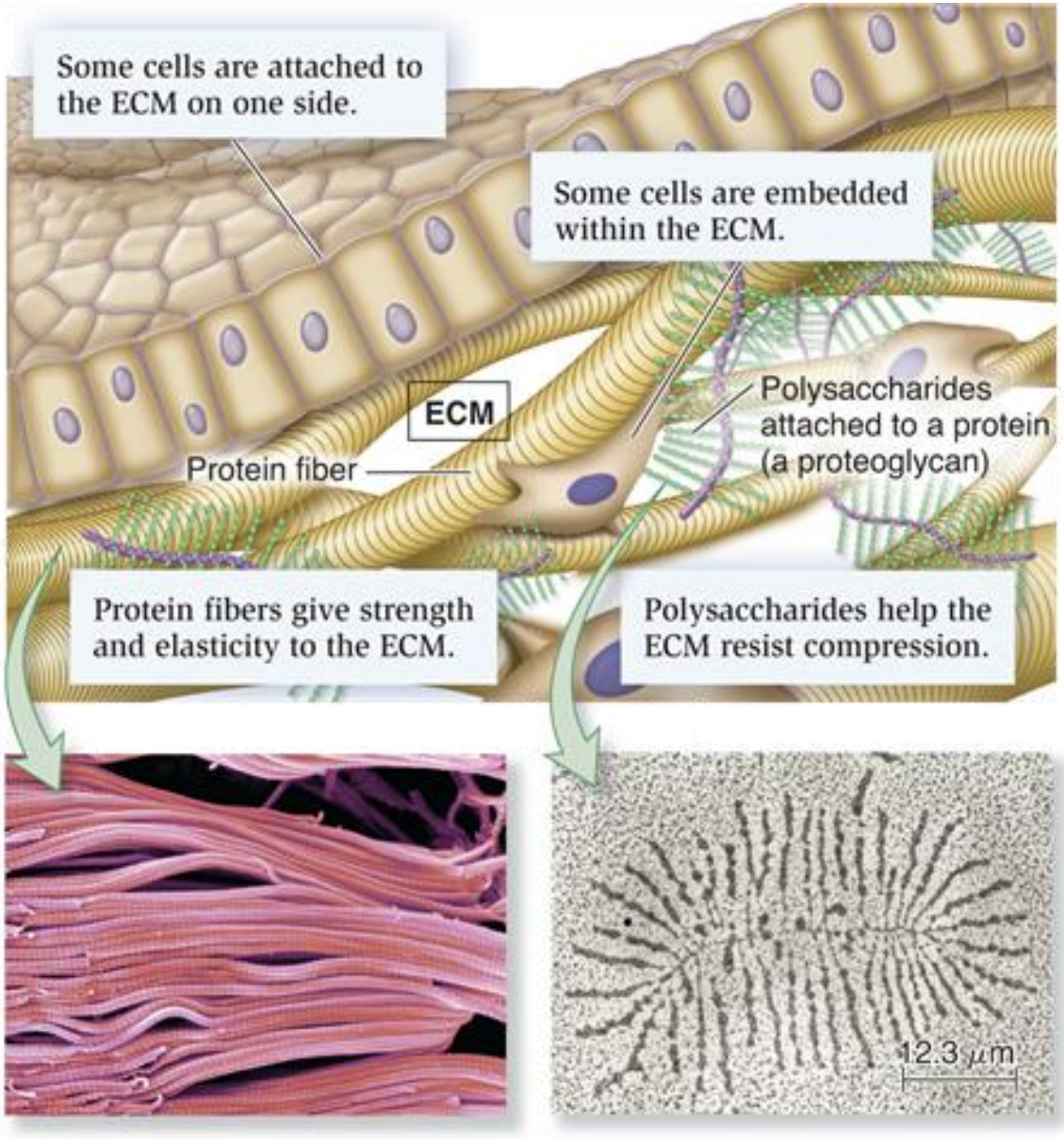
What lies around cells?

- **Extracellular matrix (ECM)**
  - Network of material secreted from the cells forming a complex meshwork outside of cells
  - Pant cells → cell wall

- Major component of certain parts of plants and animals
  - Bone and cartilage of animals
  - Woody parts of plants

- Major macromolecules of ECM:
  - Proteins form large fibers
  - Polysaccharides give a gel-like character

- Important roles of ECM:
  - Strength
    - Skin, cartilage
  - Structural support
    - Bones
  - Organization
    - Tendons to bones connection
  - Cell signaling



SEM: collagen fibers

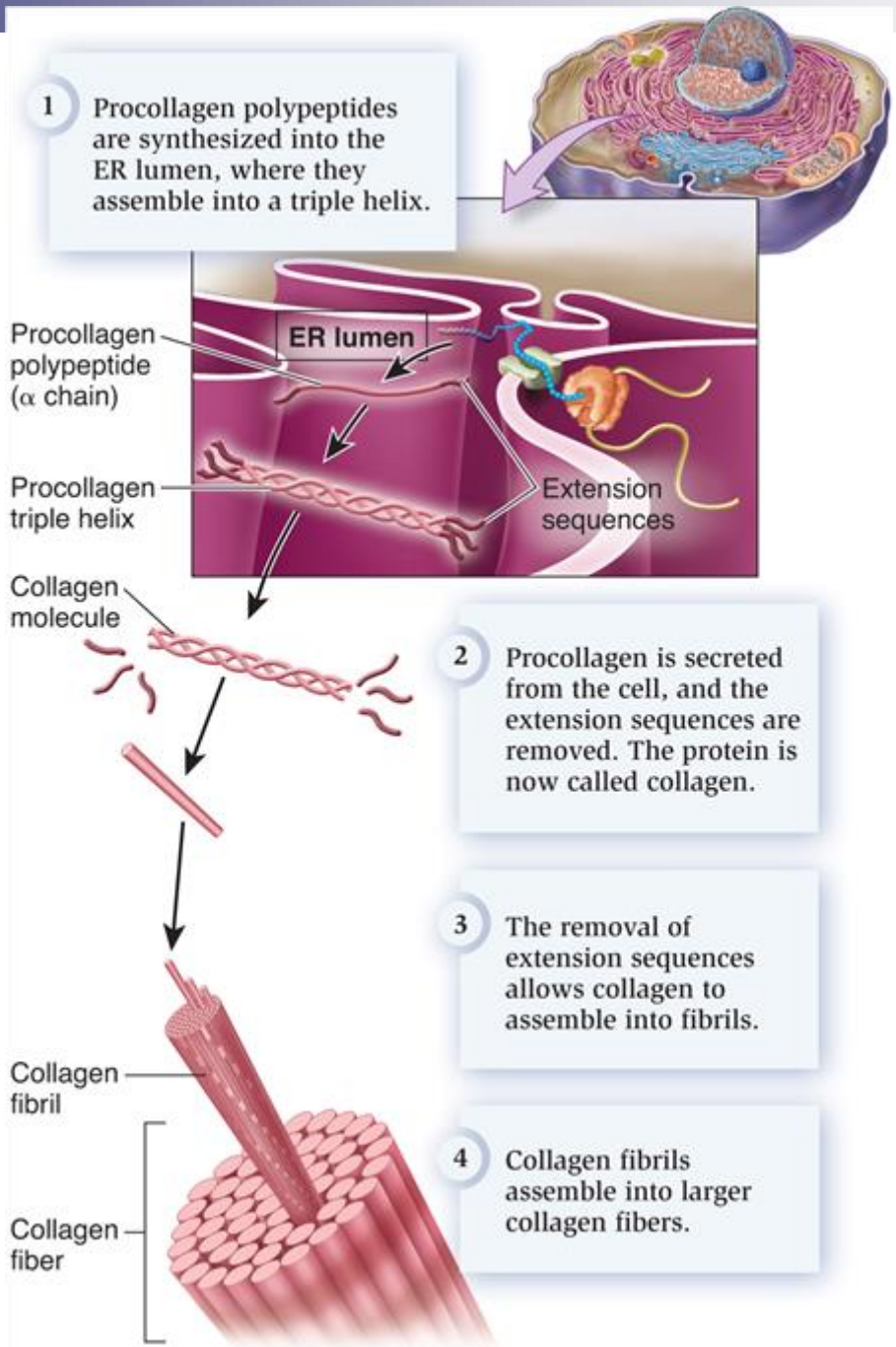
TEM: proteoglycans

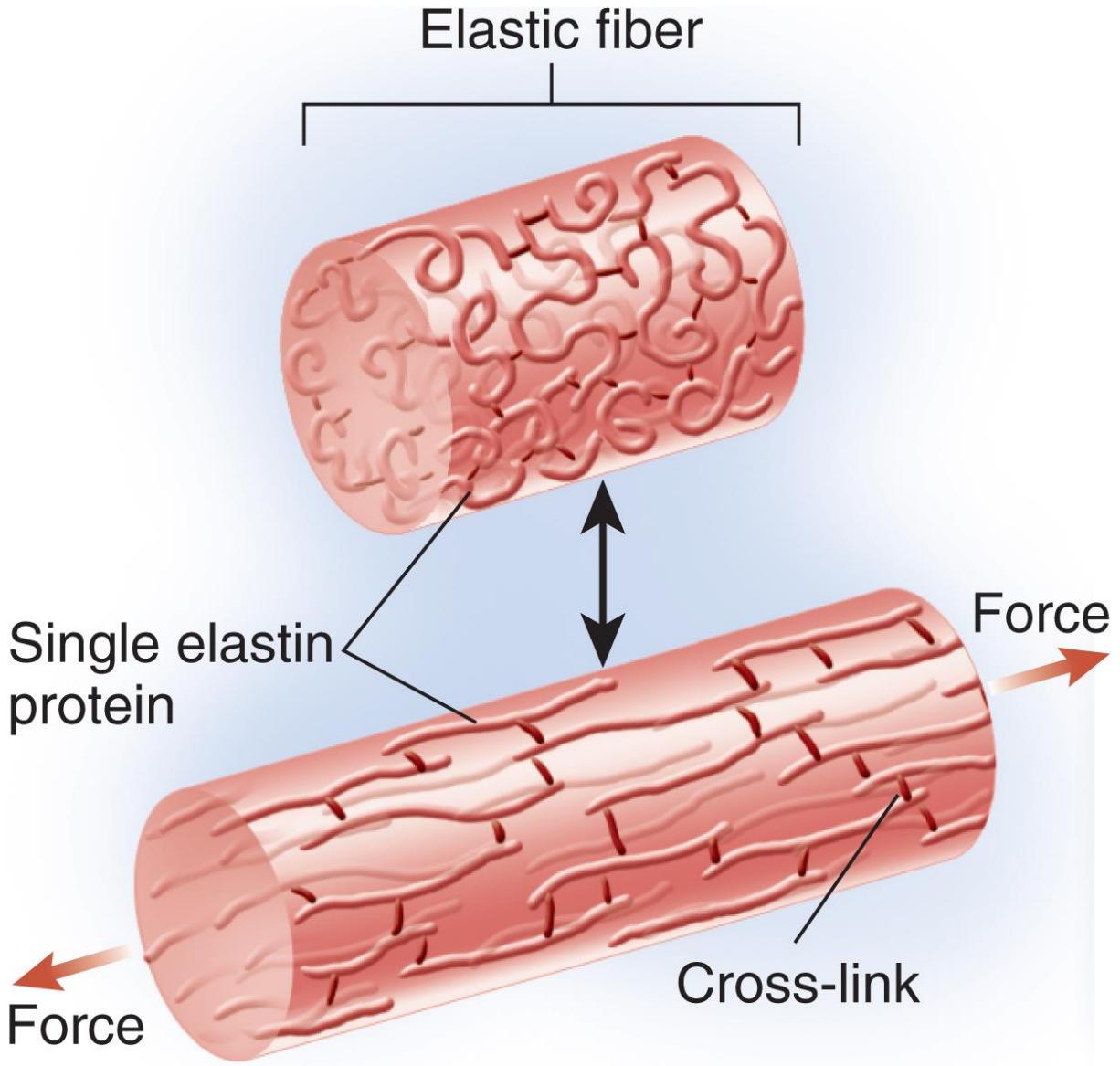
Proteins of ECM

- Structural
  - Collagen provides tensile strength
    - Main protein found in bone, cartilage, tendon, skin
  - Elastin provides elasticity
    - Expands and returns to original shape lungs and blood vessels, skin and elastic cartilage

- Adhesive
  - Fibronectin and laminin
  - Adhere ECM components together and to the cell surface
    - Binding sites for other ECM macromolecules and for cell receptors

Synthesis of Collagen





In the absence of a stretching force, the elastin proteins are in a compact conformation.

When subjected to a stretching force, the elastin proteins elongate but remain attached to each other via cross-links.

Collagens are a family of proteins that give animal cells a variety of ECM properties

- At least 27 different types of collagens in humans
- Many different genes encode procollagen
- Collagens all have a common triple helix structure
- Similar yet distinct amino acid sequence affects structure and function of collagen fibers
- Differential gene regulation controls which types of collagens are made
- Wrinkling a symptom of decreasing collagen synthesis with age

Table 10.2 Examples of Collagen Types

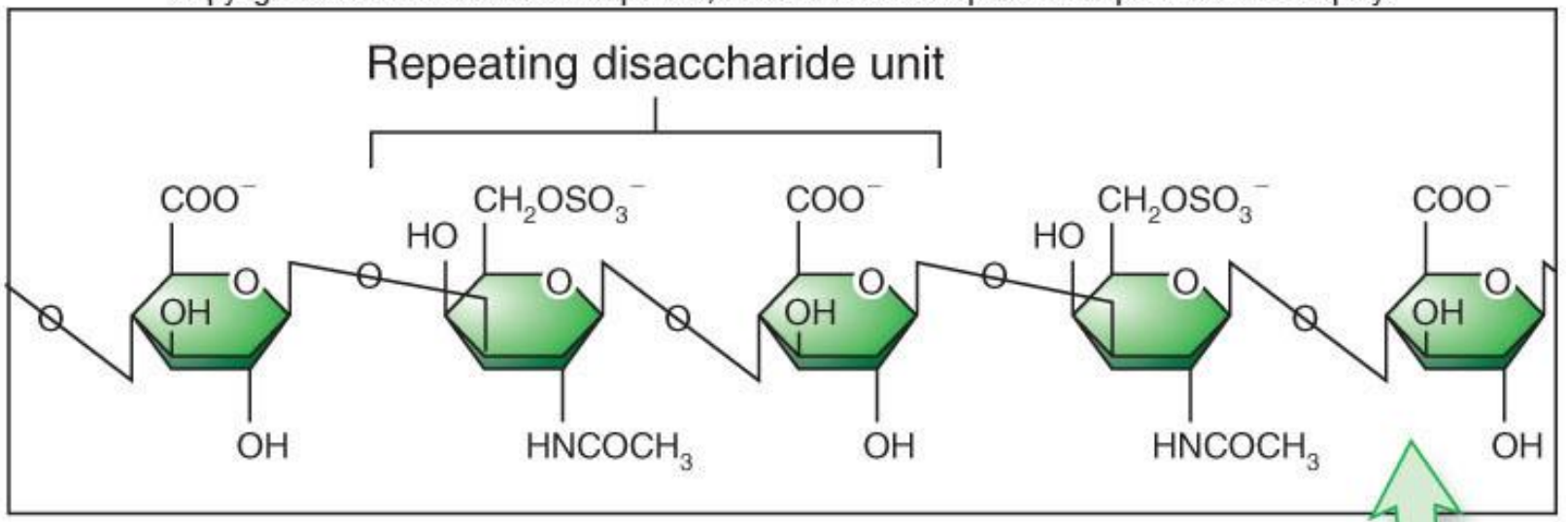
Type	Sites of synthesis*	Structure and function
I	Tendons, ligaments, bones, and skin	Forms a relatively rigid and thick fiber. Very abundant, provides most of the tensile strength to the ECM.
II	Cartilage, discs between vertebrae	Forms a fairly rigid and thick fiber but is more flexible than type I. Permits smooth movements of joints.
III	Arteries, skin, internal organs, and around muscles	Forms thin fibers, often arranged in a meshwork pattern. Allows for greater elasticity in tissues.
IV	Skin, intestine, and kidneys; also found around capillaries	Does not form long fibers. Instead, the proteins are arranged in a meshwork pattern that provides organization and support to cell layers. Functions as a filter around capillaries.

*The sites of synthesis denote where a large amount of the collagen type is made.

Polysaccharides in animal ECM

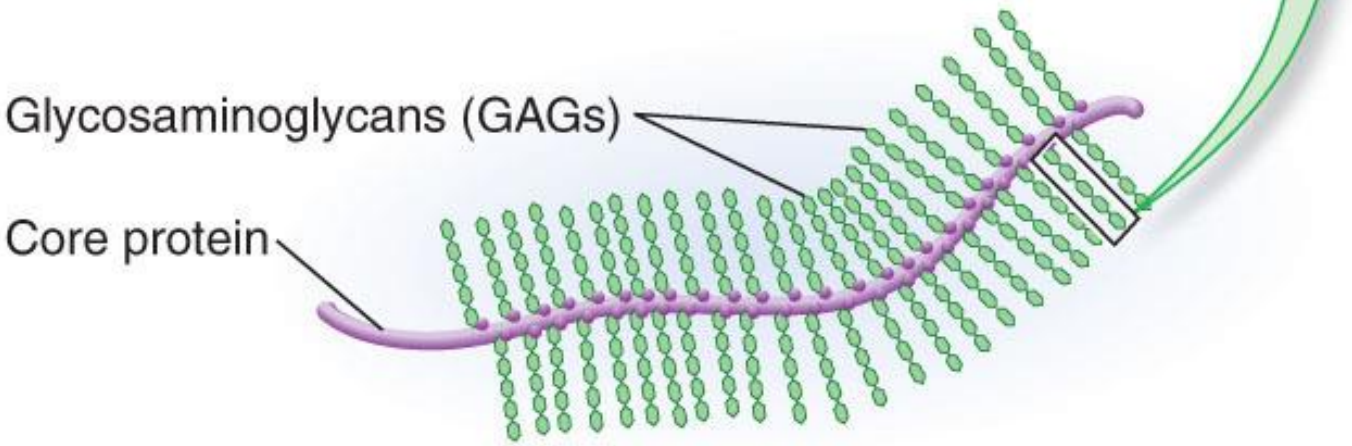
- After proteins, 2nd major component

- In vertebrates, the most abundant are **glycosaminoglycans (GAGs)**
  - Long, unbranched polysaccharides with a repeating disaccharide unit
  - Highly negatively charge attracts positive ions and water



Cartilage component

(a) Structure of chondroitin sulfate, a glycosaminoglycan



(b) General structure of a proteoglycan

- GAGs and proteoglycans resist compression
  - Form gel-like component
- Two GAG examples
  - Chondroitin sulfate – cartilage
  - Hyaluronic acid – found in skin, eyes, joint fluid
- Chitin important ECM in invertebrates
  - Exoskeleton – insects, such as crickets and grasshoppers, & shellfish, such as lobsters and shrimp
    - Molting

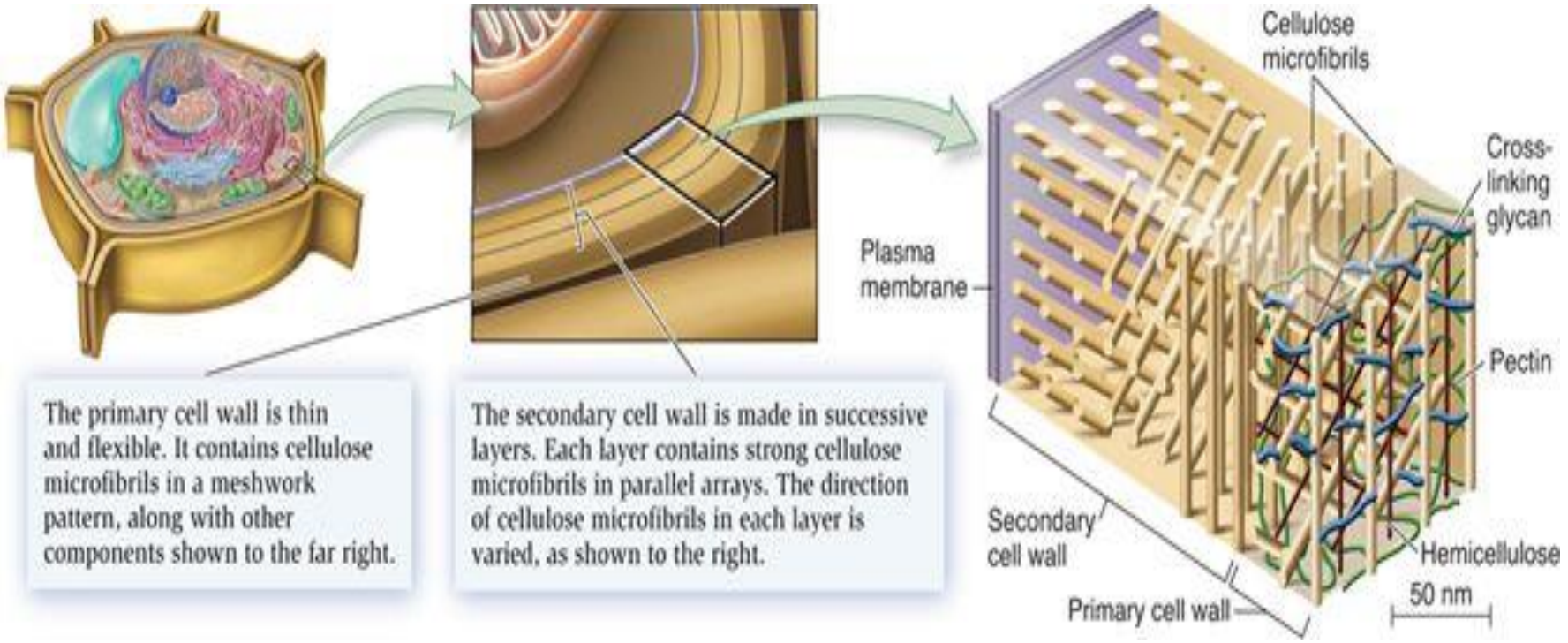
Plant cell walls

- Usually stronger, thicker and more rigid than ECM than in animals

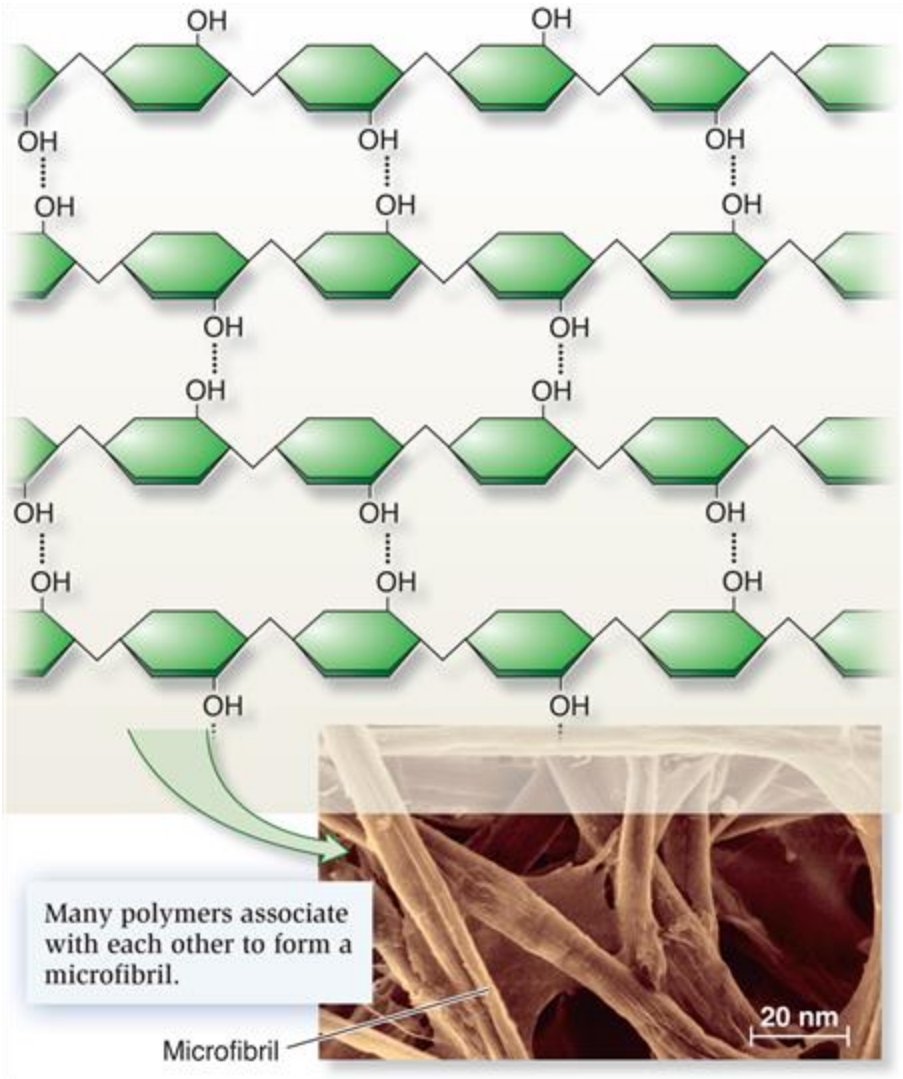
- Protective cell wall outside the plasma membrane
  - Rigidity for mechanical support
  - Maintenance of cell shape
  - Direction of cell growth
  - Protection against osmolysis

- Primary cell wall
  - Develops between newly made cells
  - Flexible and allows for size increase
  - Main macromolecule is cellulose + other types

- Secondary cell wall
  - After plant cell matures, deposited between plasma membrane and primary cell wall
  - Layers of cellulose and other components
  - More variable structure than primary cell wall

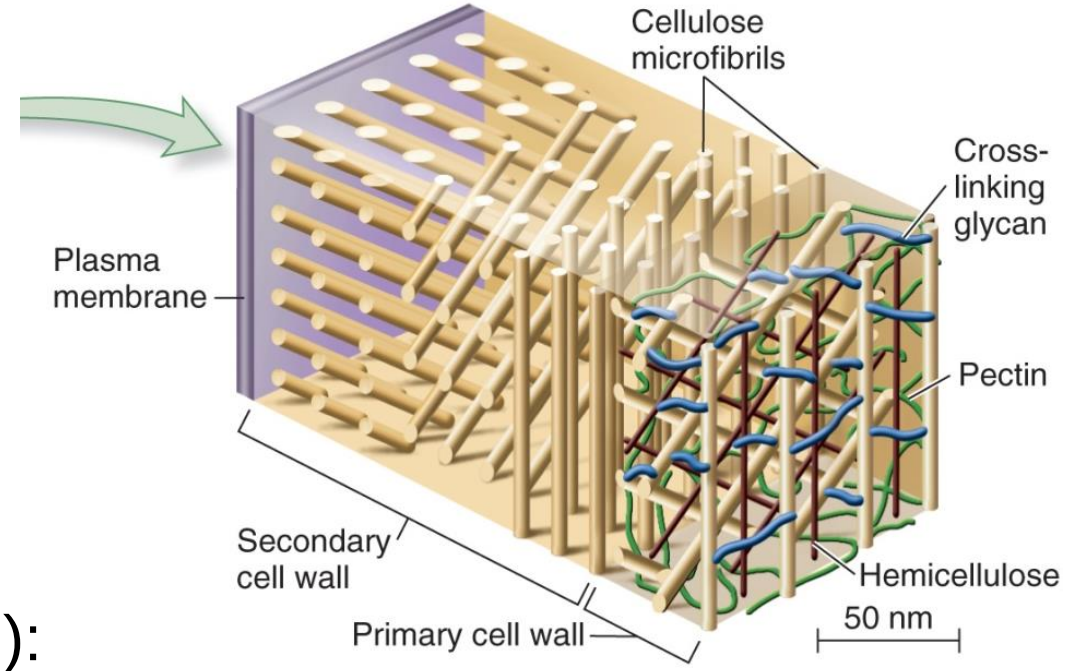


cellulose (tan),
hemicellulose (red),
cross-linking glycans (blue)
pectin (green)



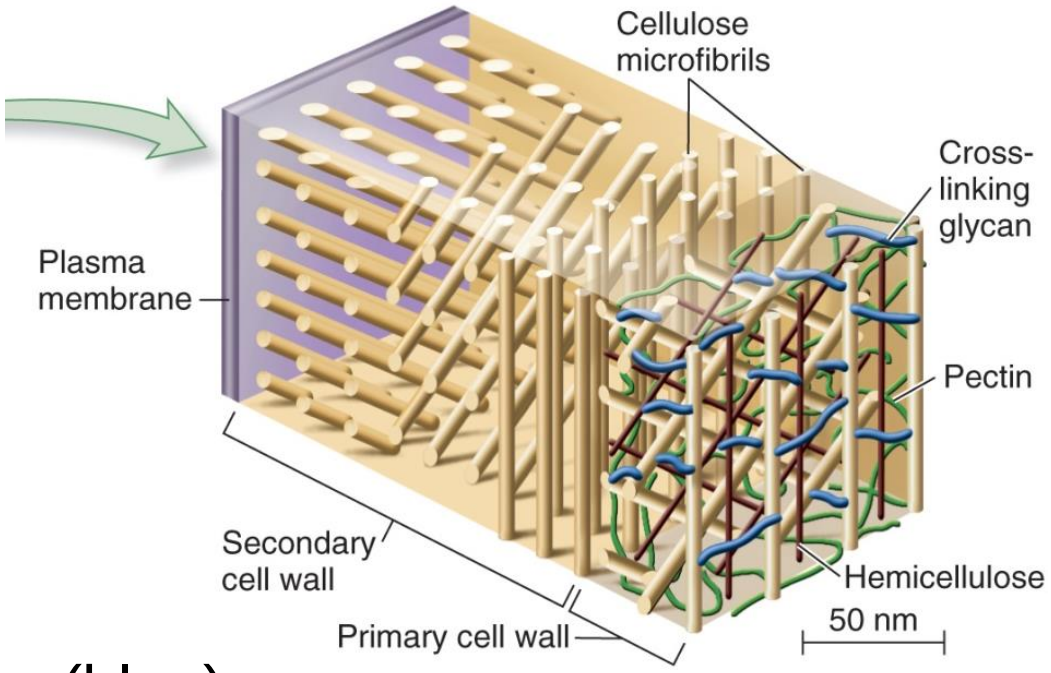
Structure of cellulose

Other components of primary cell wall:



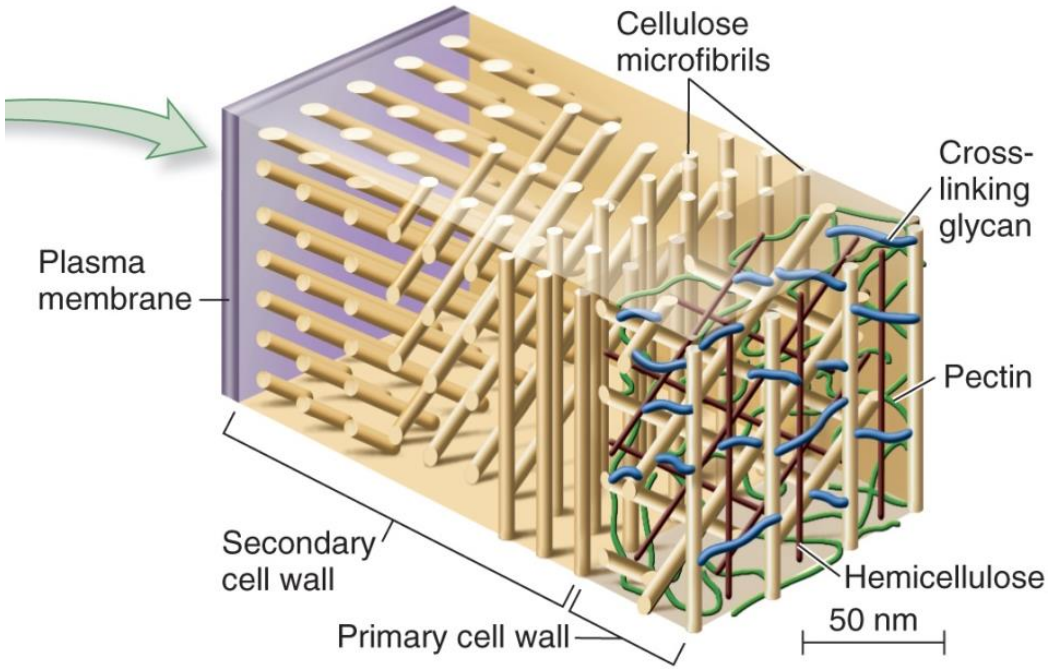
- Hemicellulose (red):
  - another linear polysaccharide,
  - Similar structure to cellulose, but contains sugars other than glucose
  - forms thinner microfibrils.

Other components of primary cell wall:



- Cross-linking Glycans (blue):
  - polysaccharides with branching structures
  - They cross-link and provide organization to the cellulose microfibrils.

Other components of primary cell wall:



- Pectins (green):
  - negatively charged polysaccharides,
  - attract water and have a gel-like character that provides the cell wall with the ability to resist compression

Cell junctions

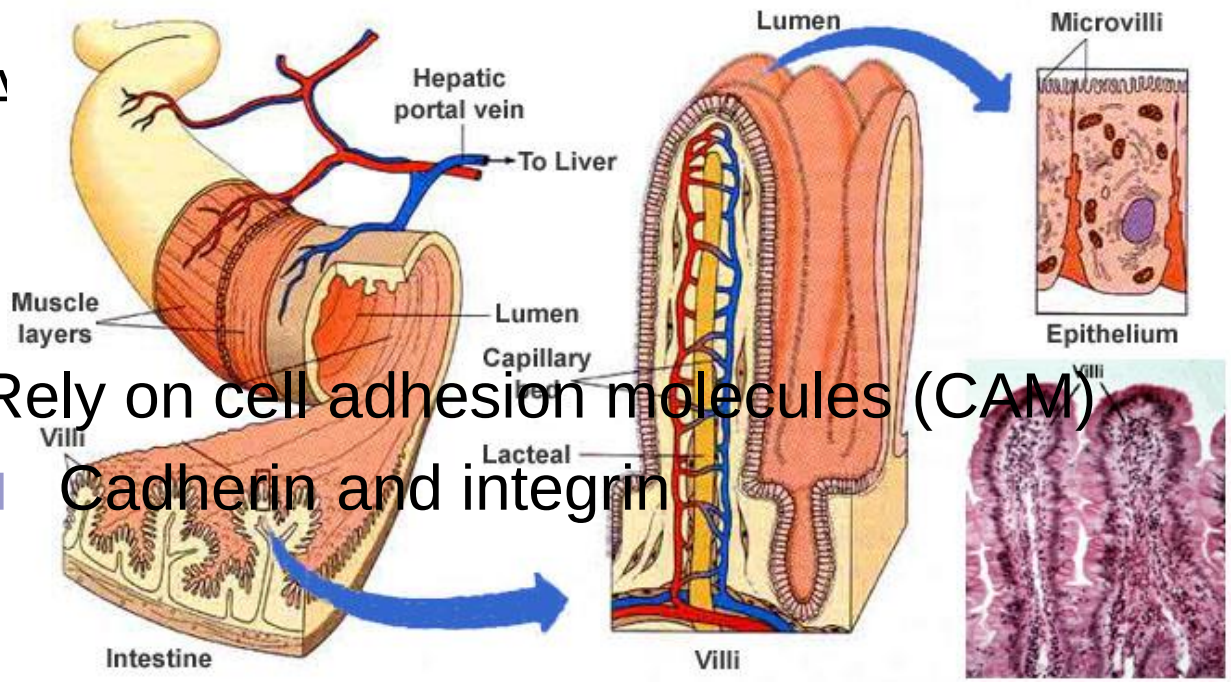
- Adhere cells to each other and to the ECM
- Animals cells have a more varied group of junctions
- In plants, cellular organization is different because of the rigid cell wall

Table 10.3 Common Types of Cell Junctions

Type	Description
Animals	
Anchoring junctions	Cell junctions that hold adjacent cells together or bond cells to the ECM. Anchoring junctions are mechanically strong.
Tight junctions	Junctions between adjacent cells in a layer that prevent the leakage of material between cells.
Gap junctions	Channels that permit the direct exchange of ions and small molecules between the cytosol of adjacent cells.
Plants	
Middle lamella	A polysaccharide layer that cements together the cell walls of adjacent cells.
Plasmodesmata	Passageways between the cell walls of adjacent cells that can be opened or closed. When open, they permit the direct diffusion of ions and molecules between cells.

Anchoring junctions (animal cell)

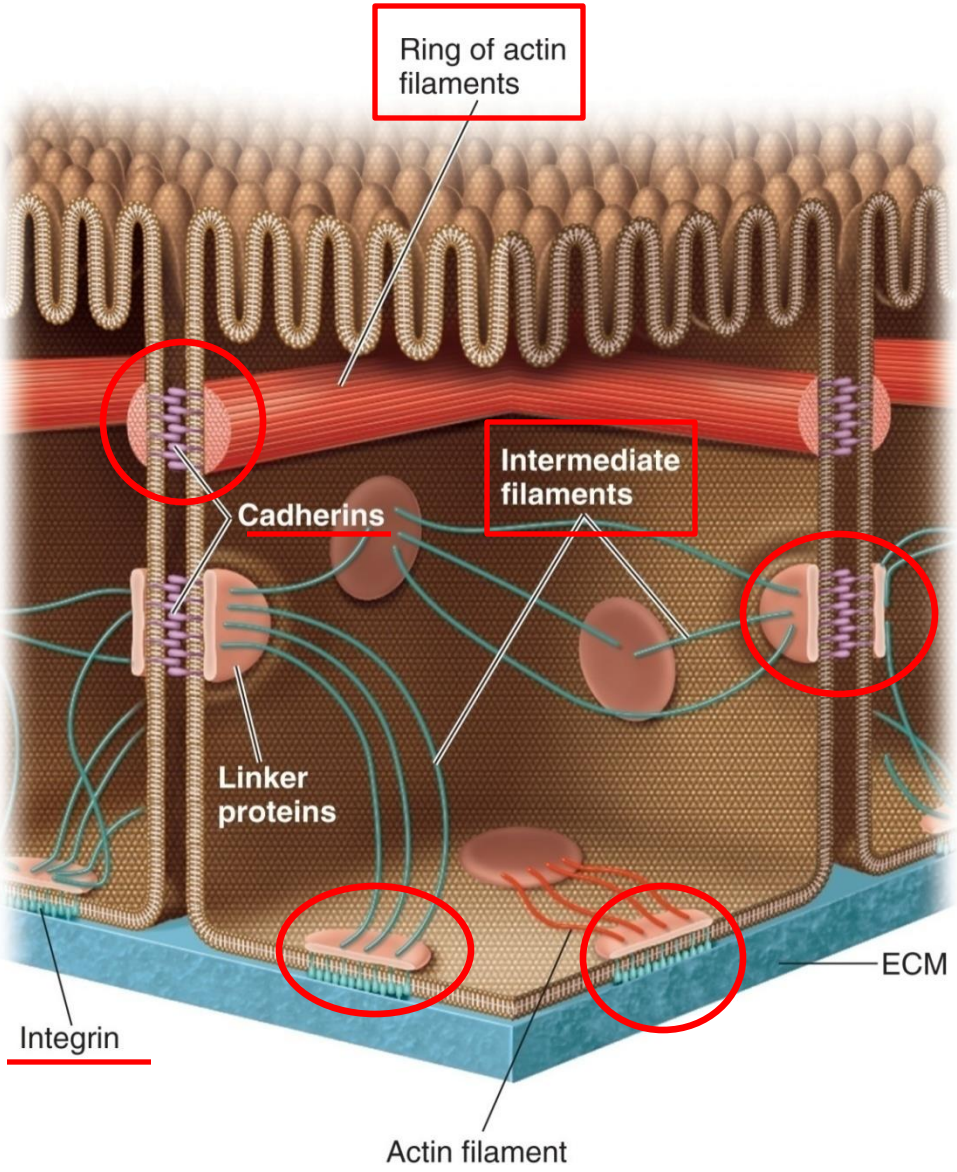
- A
  - ightly
- Rely on cell adhesion molecules (CAM)
  - Cadherin and integrin



- 4 main categories of anchoring junctions
  1. Adherins junctions
  2. Desmosomes
  3. Hemidesmosomes
  4. Focal adhesions

Adherens junctions
connect cells to each other & to actin filament via cadherins

Hemidesmosomes
Connect intermediate filaments of cells to the extracellular matrix via integrins



Desmosomes
connect cells to each other and to intermediate filaments via cadherins.

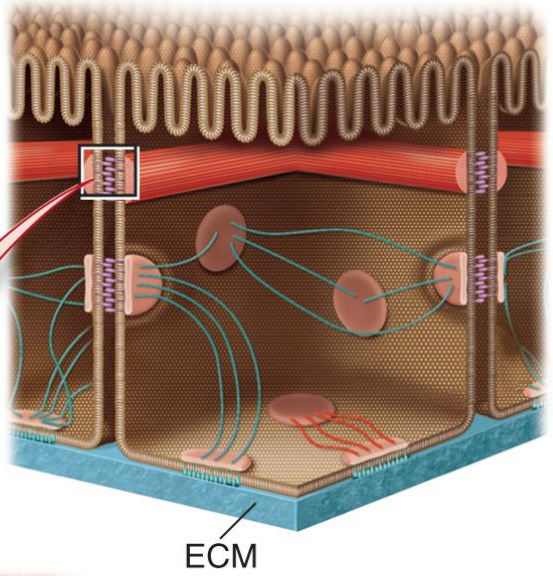
Focal adhesions
connect actin filaments of cells to the extracellular matrix via integrins.

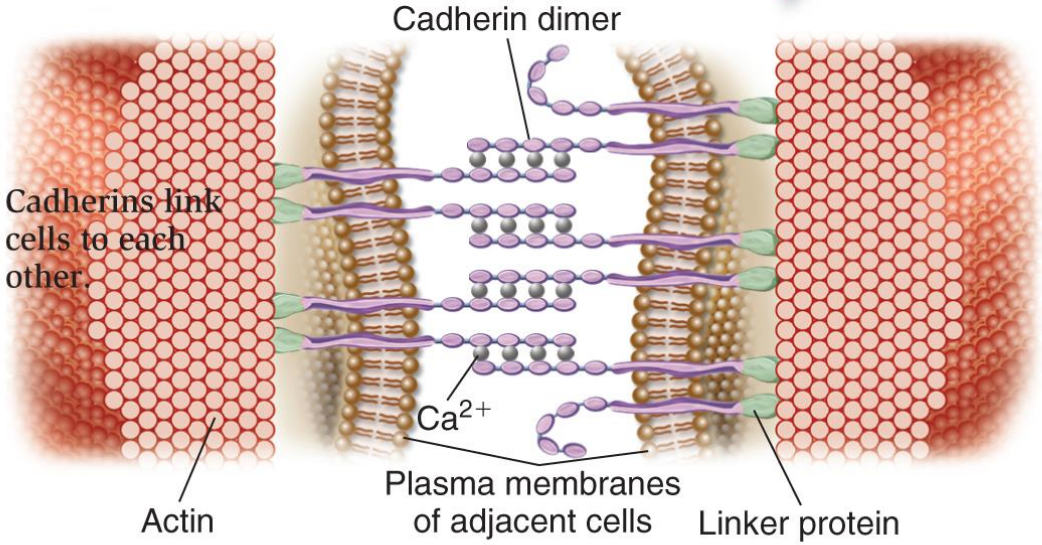
Cadherins

- CAMs that create cell-to-cell junctions

- Ca^{2+} dependent adhering molecule → cadherin

Extracellular domain of two cadherins, each in adjacent cells, bind to each other to promote cell-to-cell adhesion





(a) Cadherins

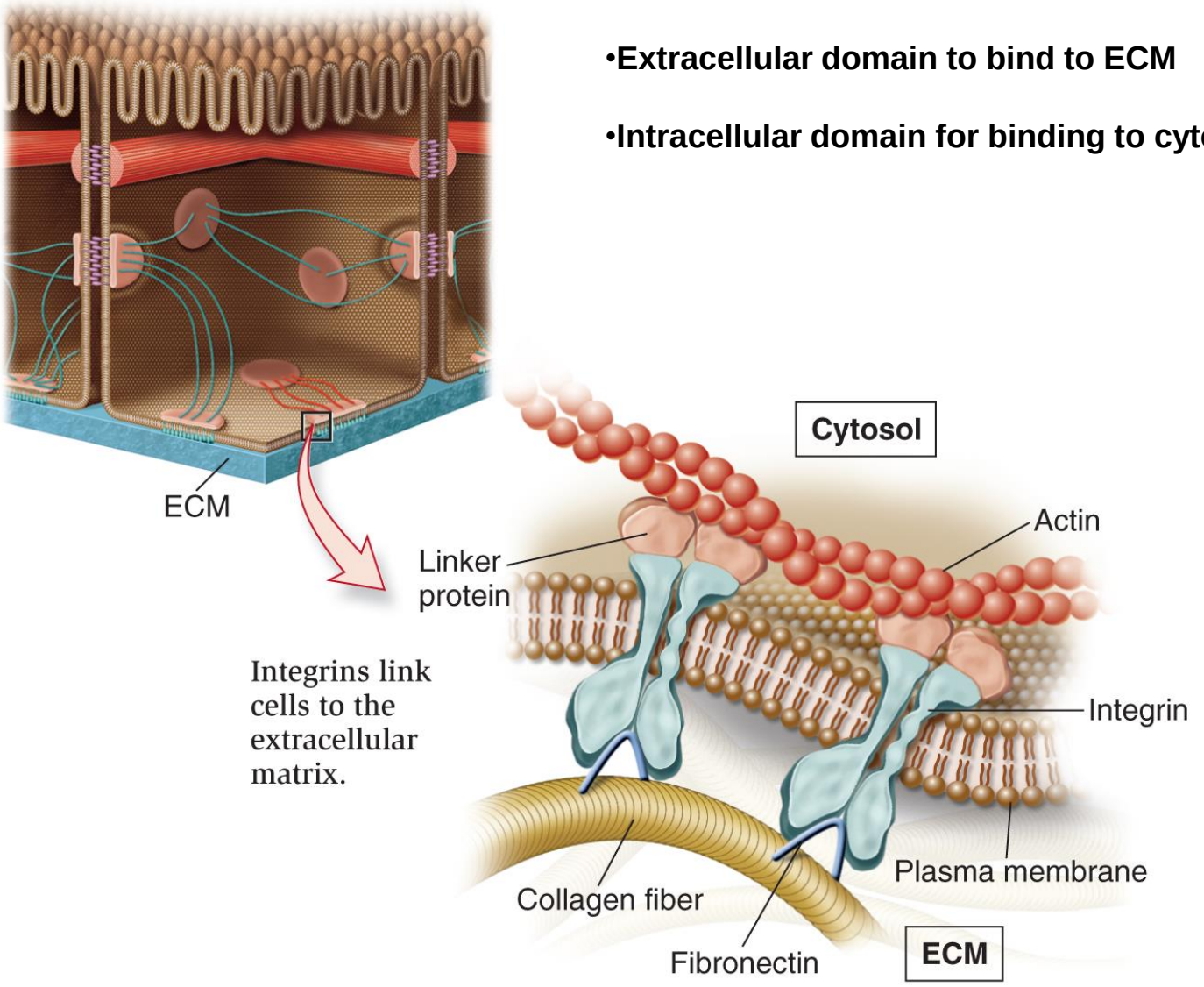
Inside the cell, linker proteins connect cadherins to the cytoskeleton

- There are several types of cadherins in a cell.
- By expressing only certain types of cadherins, each cell will only bind to others expressing same type
  - Homophilic binding or (like-to-like) binding mechanism.
  - E-cadherin only binds to E-cadherin…
- This phenomenon plays a key role in the proper arrangement of cells throughout the body

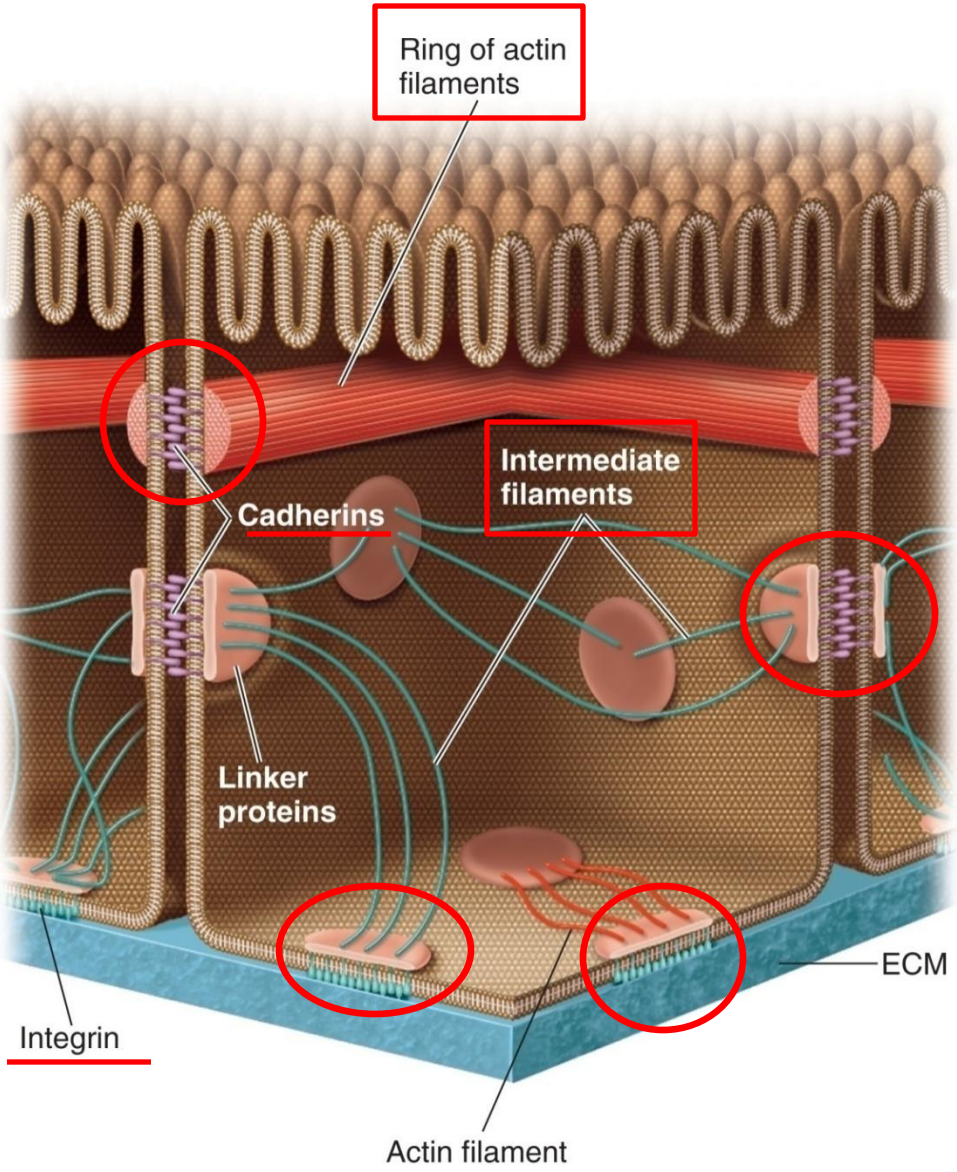
Integrins

- Group of cell-surface receptor proteins
- 2nd type of CAMS
- Creates connections between cells and ECM
- Do not require Ca^{2+} to function

- **Extracellular domain to bind to ECM**
- **Intracellular domain for binding to cytoskeleton**



(b) Integrins


Ring of actin filaments
Intermediate filaments
Cadherins
Linker proteins
ECM
Integrin
Actin filament

Tight junctions in animals

- Or occluding junctions
- Forms tight seal between adjacent cells
- Prevents material from leaking between cells

•Intestinal cells form a sheet that is one cell thick.

•One side faces the intestinal lumen, and the other faces the ECM and blood vessels.

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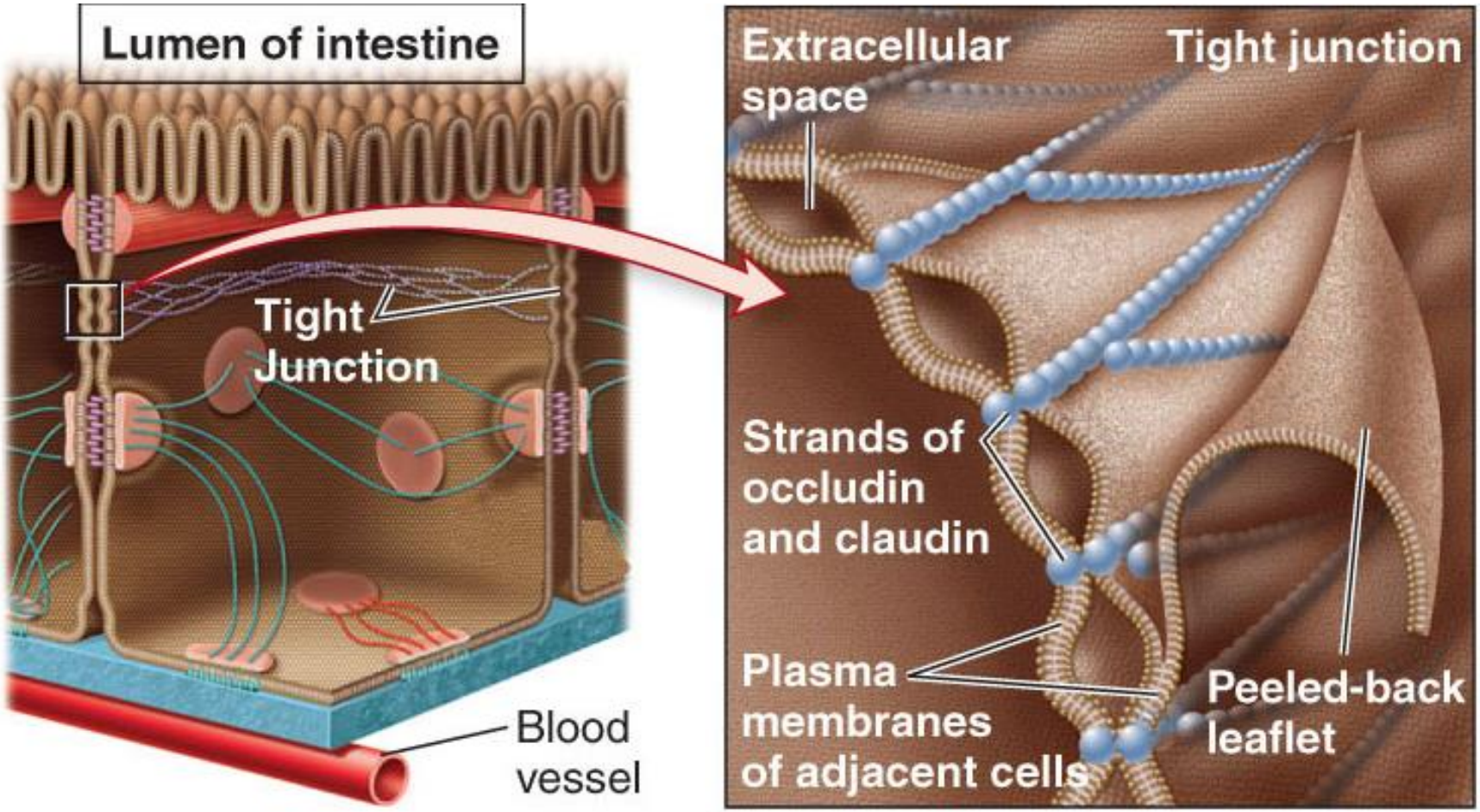
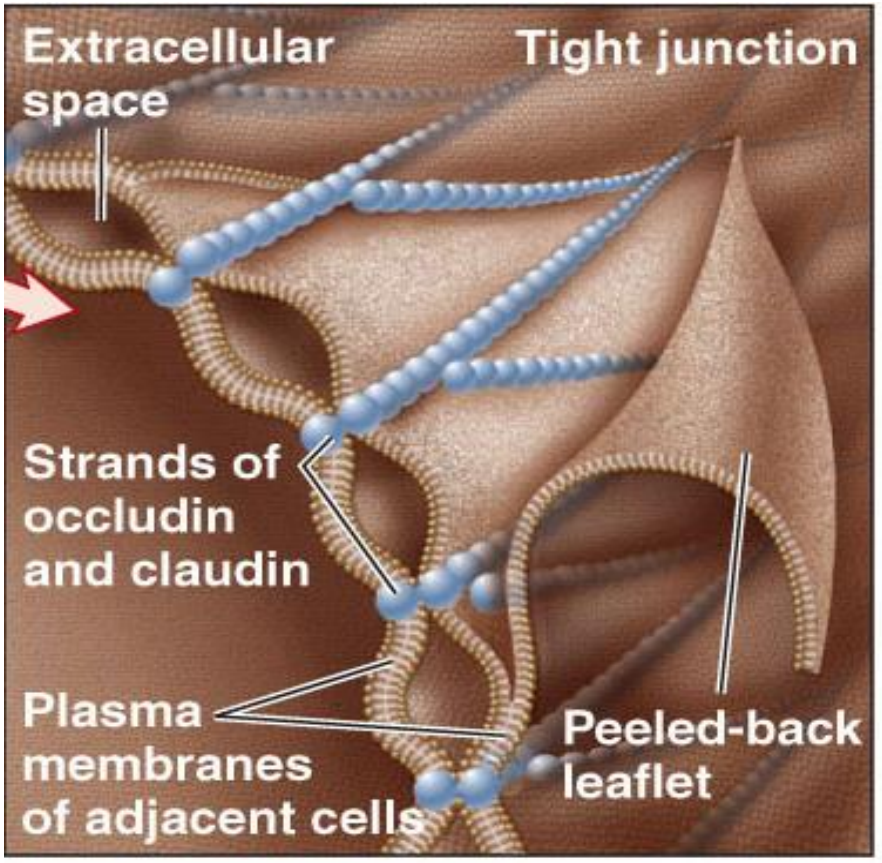


- Tight junctions
  - Made by **occludin** and **claudin**
  - Bind to eachother to form tight seal
  - Not mechanically strong, not bound to cytoskeleton



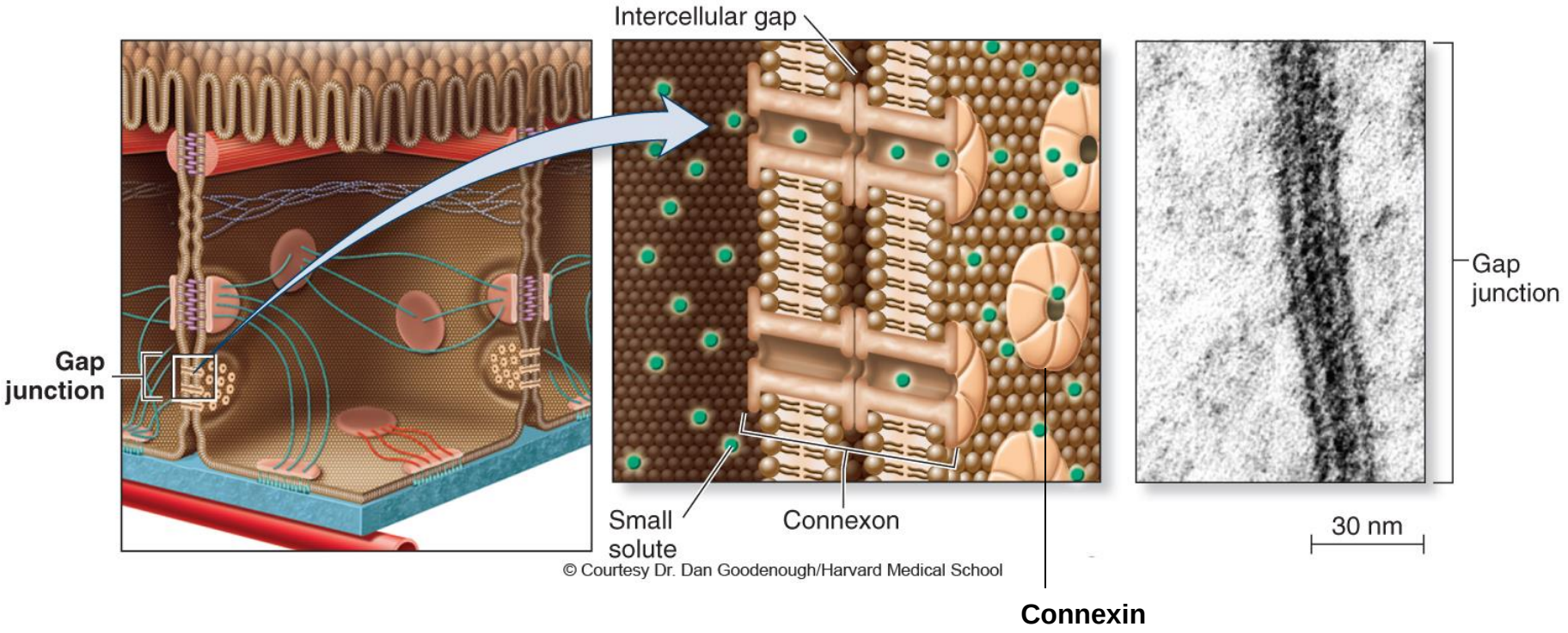
Gap junctions in animals

- Small gap between plasma membranes of cells at junction

- Abundant in tissues and organs where the cells need to communicate with each other.
  - cardiac muscle cells
  - Many gap junctions allow passage of ions
  - For muscular contraction

- A transmembrane channel called a **connexon** consists of 12 proteins called **connexins**.

- Six connexin proteins in one cell align with six connexin proteins in an adjacent cell to form a connexon

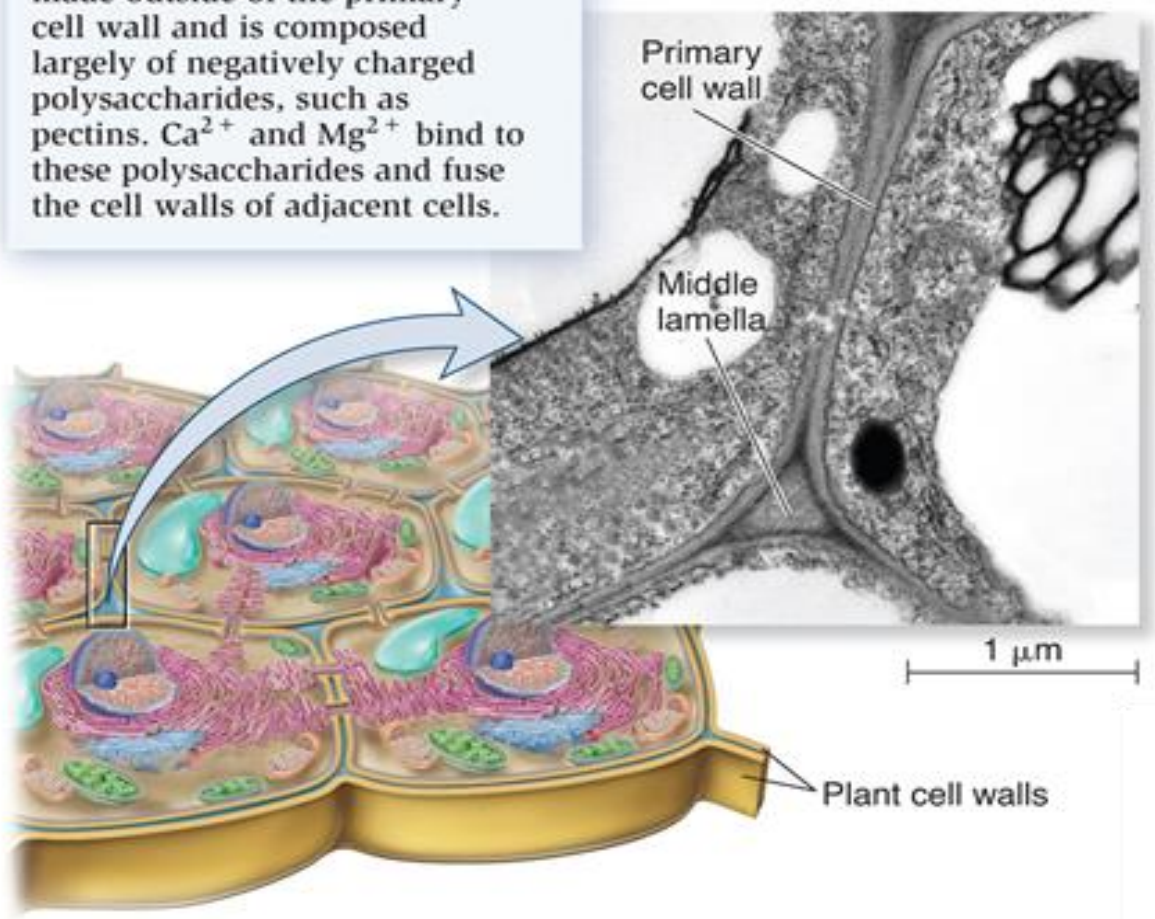


- Connexon allows passage of ions and small molecules
  - amino acids, sugars, and signaling molecules such as Ca^{2+}, cAMP
- Allow adjacent cell to share metabolites and directly signal each other

Middle lamella in plants

- Instead of using membrane proteins as junctions
- Plants use additional component of ECM to form cell-to-cell connections (middle lamella)
  - First layer to form when cells are dividing
  - Cement cell walls of adjacent cells together
- Middle lamella rich in pectins

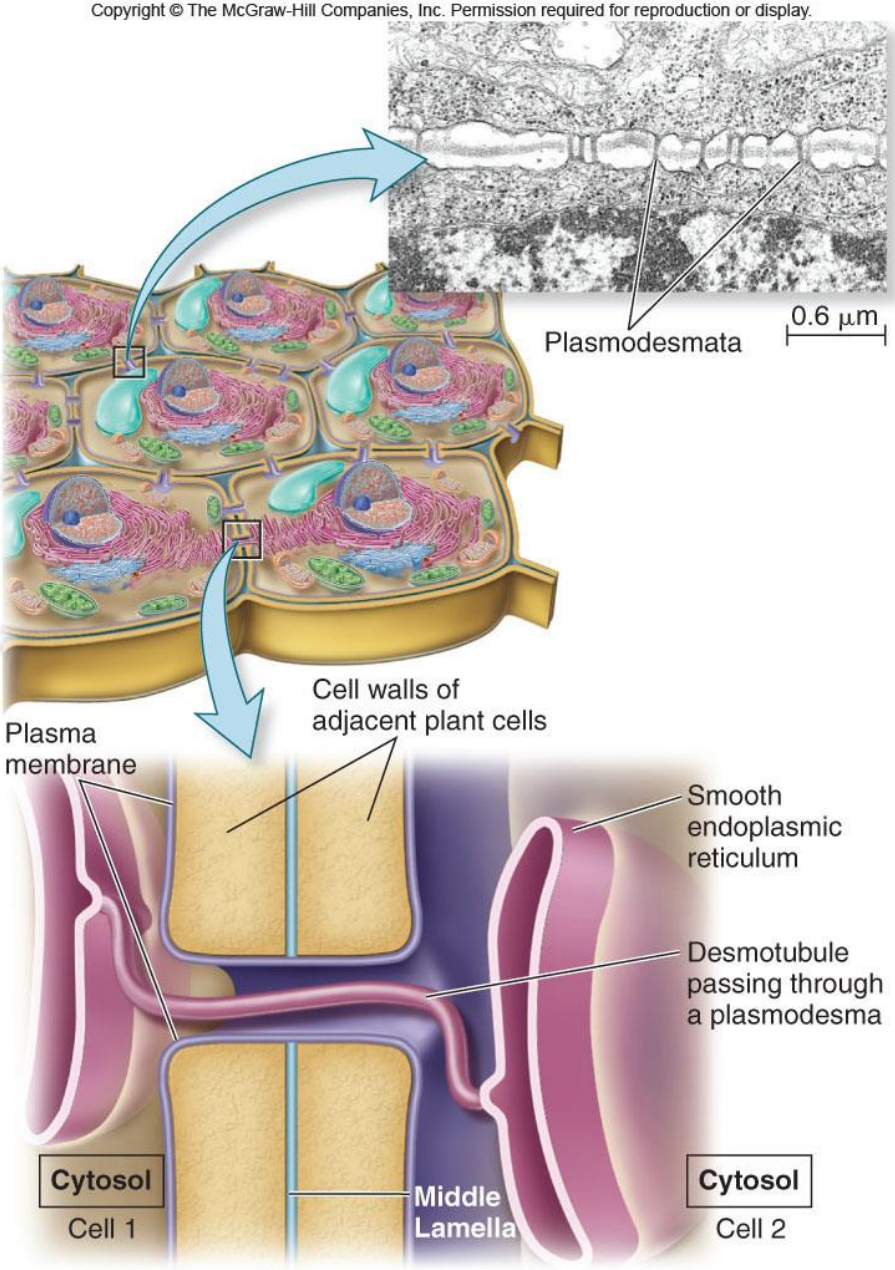
The middle lamella is a layer made outside of the primary cell wall and is composed largely of negatively charged polysaccharides, such as pectins. Ca^{2+} and Mg^{2+} bind to these polysaccharides and fuse the cell walls of adjacent cells.



- The process of fruit ripening illustrates the importance of pectins in holding plant cells together.
  - During ripening, the cells secrete pectinases, which digest pectins in the middle lamella as well as those in the primary cell wall.
  - the attachments between cells are broken, and the cell walls become less rigid.
  - a red ripe tomato is much less firm than an unripe tomato.

Plasmodesmata in plants

- Functionally similar to gap junctions
- Allow passage of ions and molecules between adjacent cells
- Different in that they are open channels where the cell membrane of one cell is continuous with adjacent cell membrane
- Desmotubule connects ER membrane of adjacent cells



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