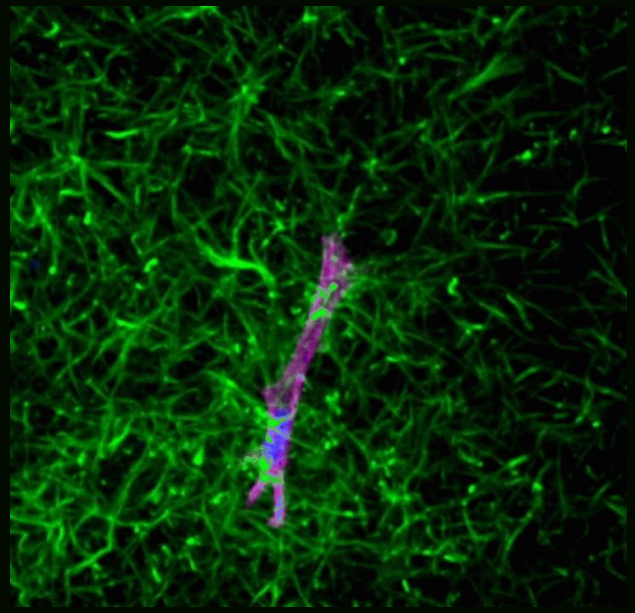
Cellular Environment and Adhesion



Chapter 20: Part II
BIOL 366
May 6, 2025
Matthew Ellis, PhD

Learning Objectives for Today's Lecture:

Upon completing this module, **you should be able to**:

- Describe the **extracellular matrix** (ECM) and its role in the cell's microenvironment
- Identify crucial components of the ECM and their functions
- Understand the roles of **junctional proteins** in intercellular stability and communication
- Review major concepts from Ch 16 Part II – Ch 20 for the exam next **Tuesday, May 13th, 10:30 am – 12:30 pm** in this room

Key Terms

Extracellular Matrix: Complex, dynamic network of proteins, sugars, and molecules that surrounds and supports cells

Collagen: Main structural protein in the extracellular matrix of the connective tissues

Elastin: Extracellular protein involved in endowing elastic recoil to tissues

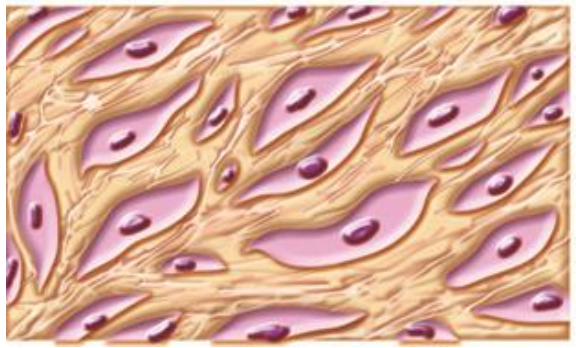
Fibronectin: Glycoprotein that plays an important role in cellular adhesion, differentiation, and growth

Integrin: Transmembrane protein involved in mechanotransduction

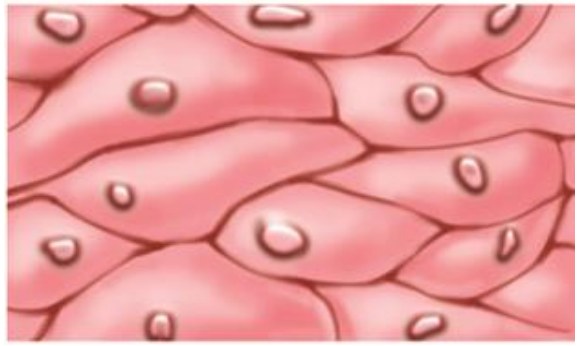
Tight Junction: Junctional complex preventing leakage of material between cells

Gap Junction: Channel between cells responsible for the direct relaying of intercellular signals

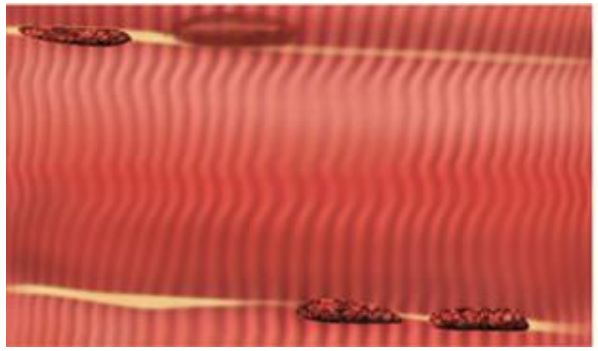
There are 4 basic tissue types defined by their morphology and function



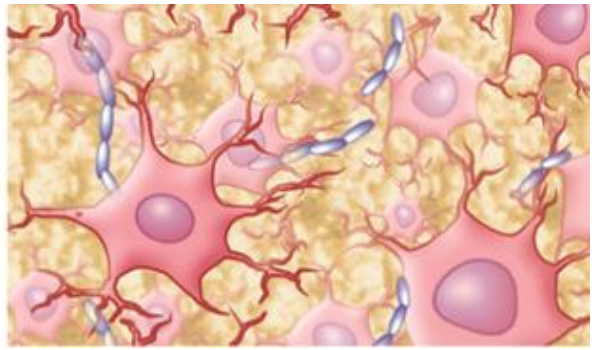
Connective tissue



Epithelial tissue



Muscle tissue



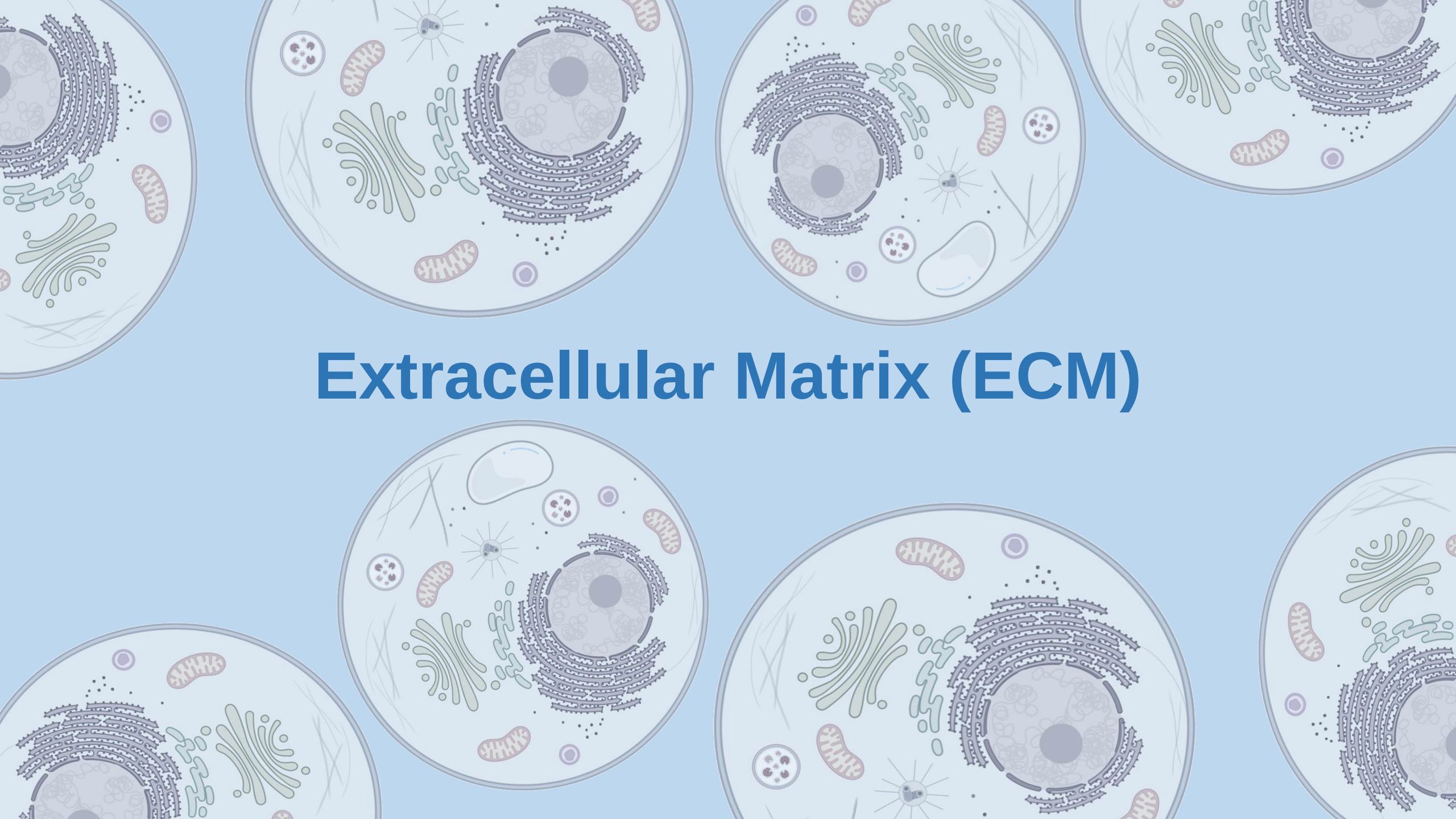
Nervous tissue

- Composed of cells with specialized functions
- Support and connect to other tissues and/or organs in the body
- Contain an extracellular matrix

Extracellular Matrix (ECM)

“outside of the cell”

“material that fills the space between cells”



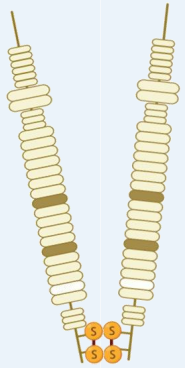
Extracellular Matrix (ECM)

The ECM is comprised of 3 main classes of proteins

Structural proteins

Collagens, Elastin

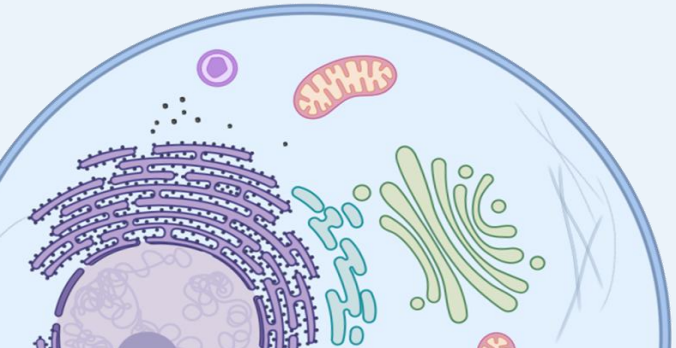
Adhesive glycoproteins



Fibronectin, Laminin

Proteoglycans

Aggrecan in cartilage



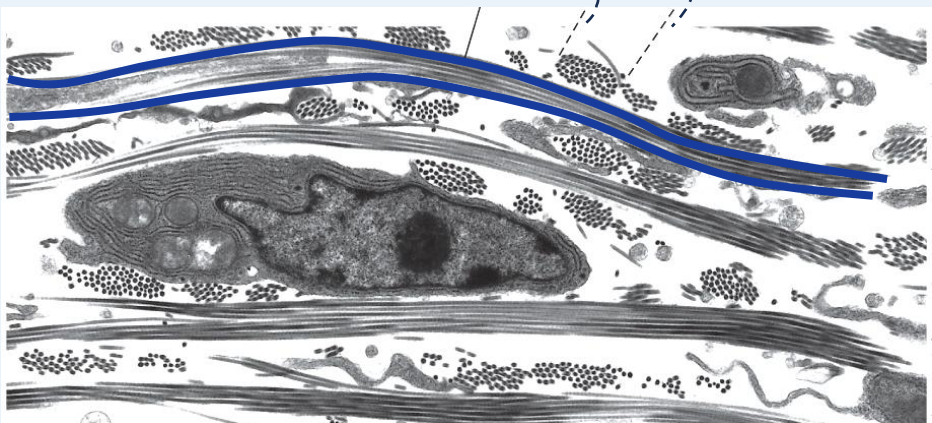
Collagens provide tensile strength in connective tissues

•Triple-stranded **collagen** molecule
•Diameter: 1.5nm

•**Collagen fibril**
•Diameter: 10-300nm

•**Collagen fiber**
•Diameter: 0.5-3μm

Collagen fiber

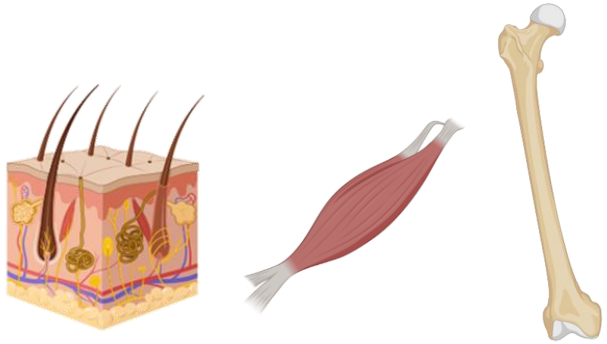


•Collagen molecules can bundle together to form fibrils

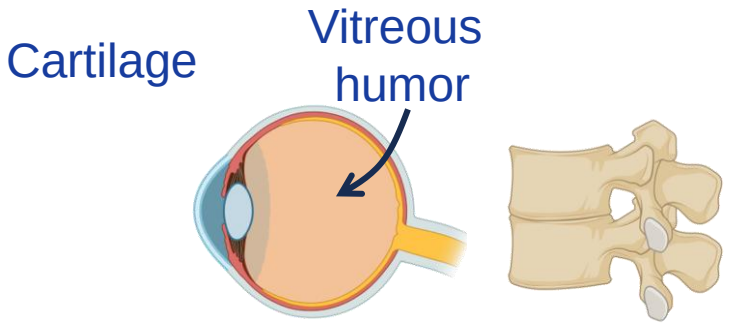
•Collagen fibrils can pack further into fibers

Different tissues express different types of collagens

Fiber-forming collagens



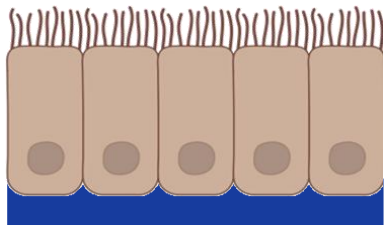
Type I **Collagen**

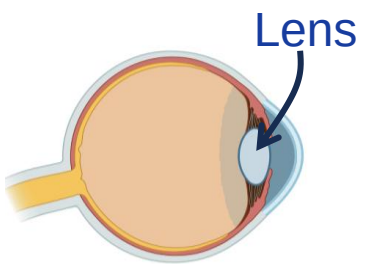


Type **II** **Collagen**

Type III **Collagen**

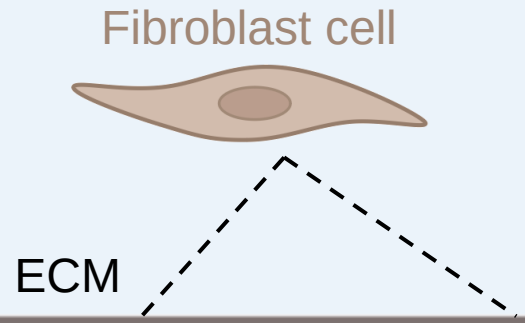
Collagens form networks & sheets

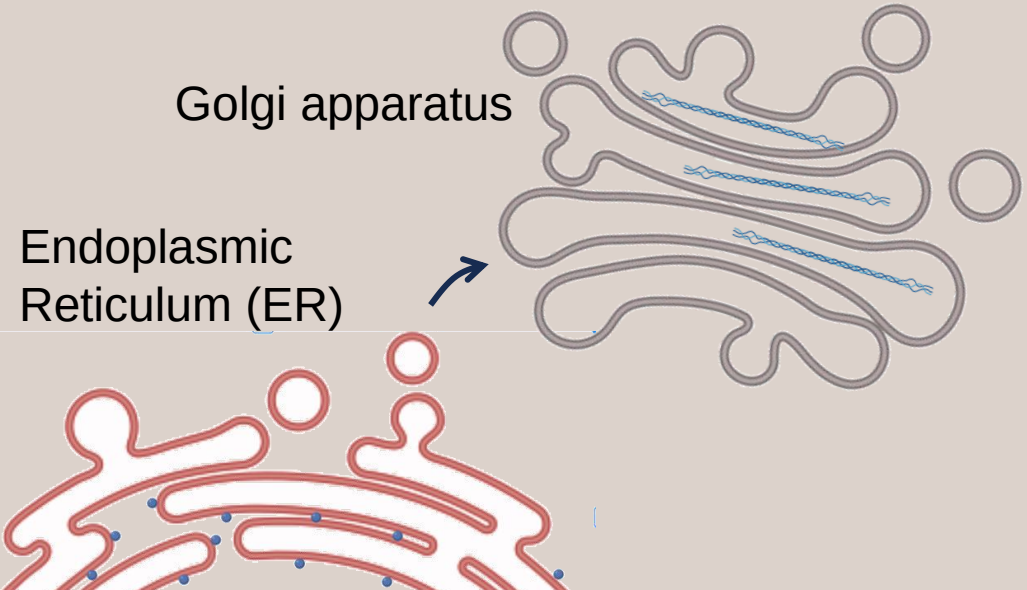


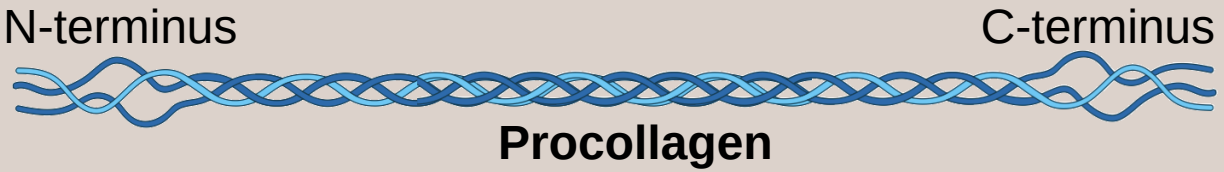


•Type IV **Collagen**

Collagens are primarily produced by fibroblasts and undergoes intra- and extracellular processing

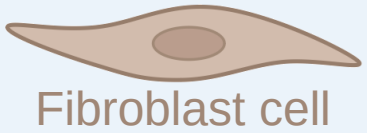




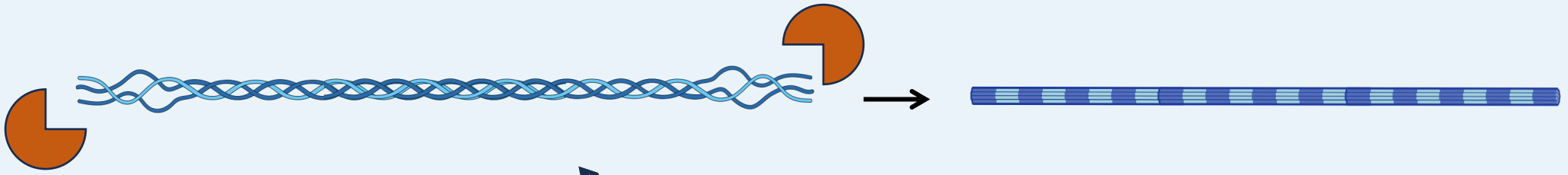


- Ribosomes synthesize **procollagen** (precursor form of collagen)
- **Procollagen** undergoes post-translational modifications in the ER and sorting in the Golgi

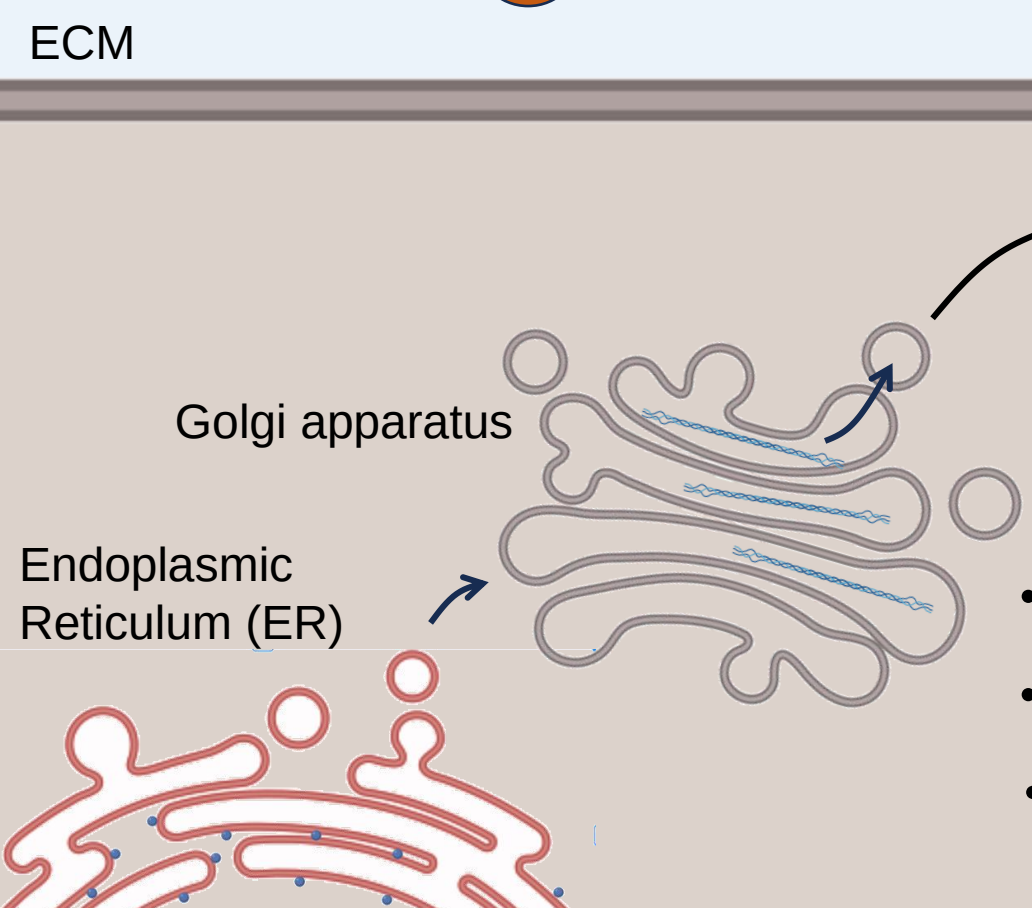
Collagens are primarily produced by fibroblasts and undergoes intra- and extracellular processing



Fibroblast cell

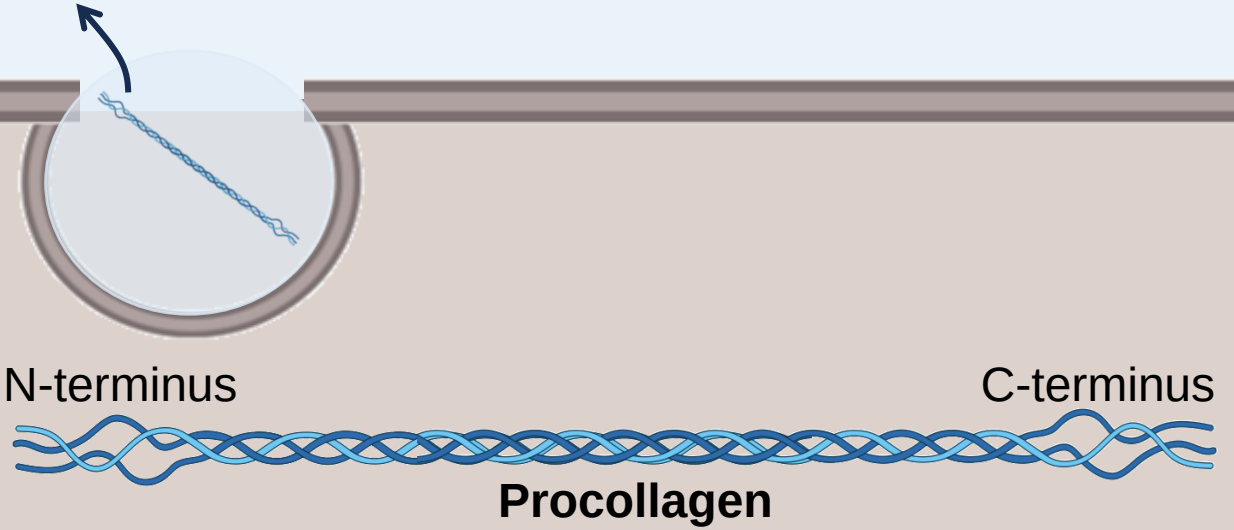


ECM



Golgi apparatus

Endoplasmic Reticulum (ER)



N-terminus

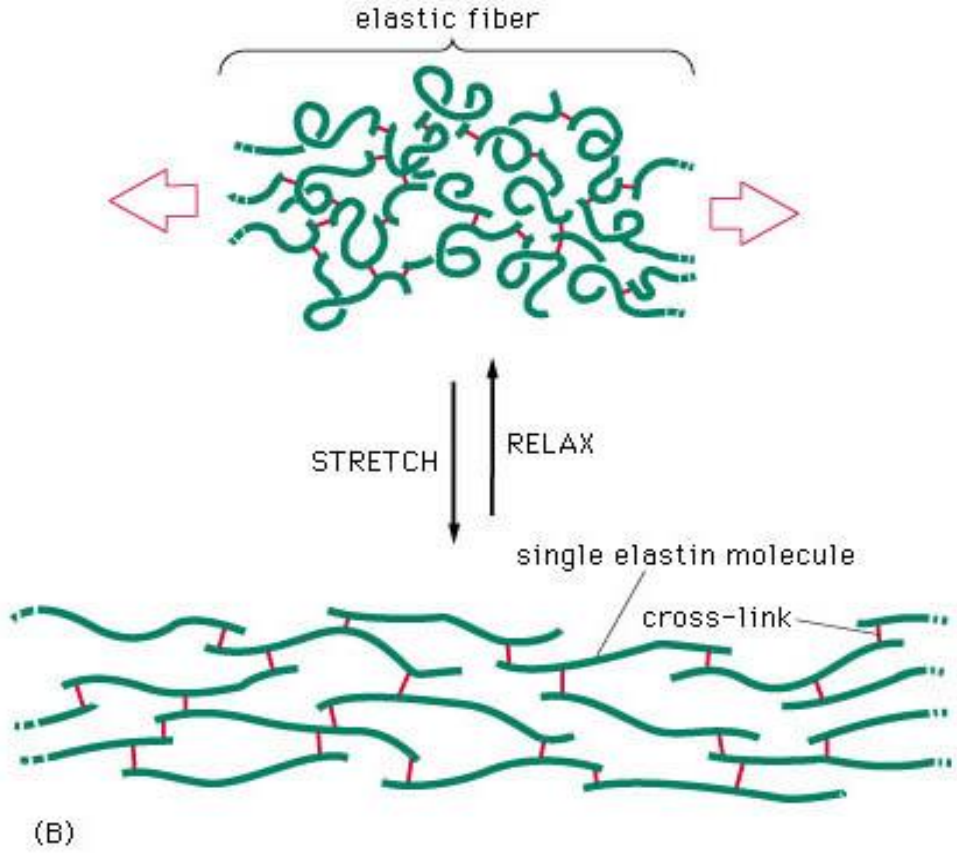
C-terminus

Procollagen

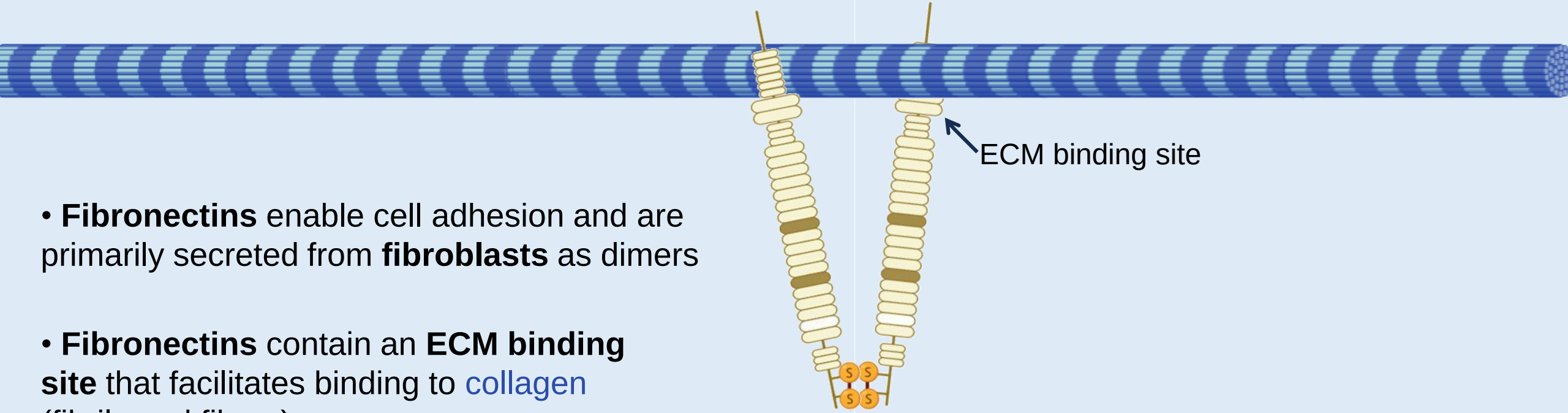
- **Procollagen** is secreted from fibroblasts via exocytosis
- **Procollagen proteinase** cleaves N- and C-terminal ends
- Collagen can self-assemble into **fibrils**

Elastin provides our tissues with recoil and elasticity

- A rubbery protein that helps tissues resume shape after stretching or contracting (recoil)
- Abundant in lungs, aorta (the largest blood vessel exiting heart), and skin
- Secreted in a precursor monomeric form
  - Is crosslinked and polymerized into elastic fibers with help of extracellular enzymes and glycoproteins
- Elastin is only produced in the perinatal stages of life, and has a half-life of around 60 years
  - This is why hypertension (high blood pressure) is a common occurrence in older individuals as their blood vessels have become less compliant and more rigid

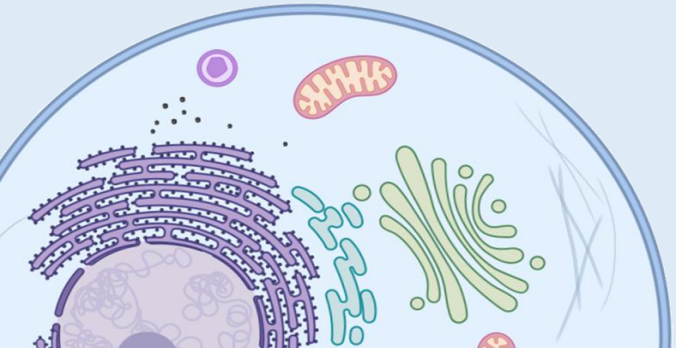


Fibronectins help organize Collagens in the ECM



• **Fibronectins** enable cell adhesion and are primarily secreted from **fibroblasts** as dimers

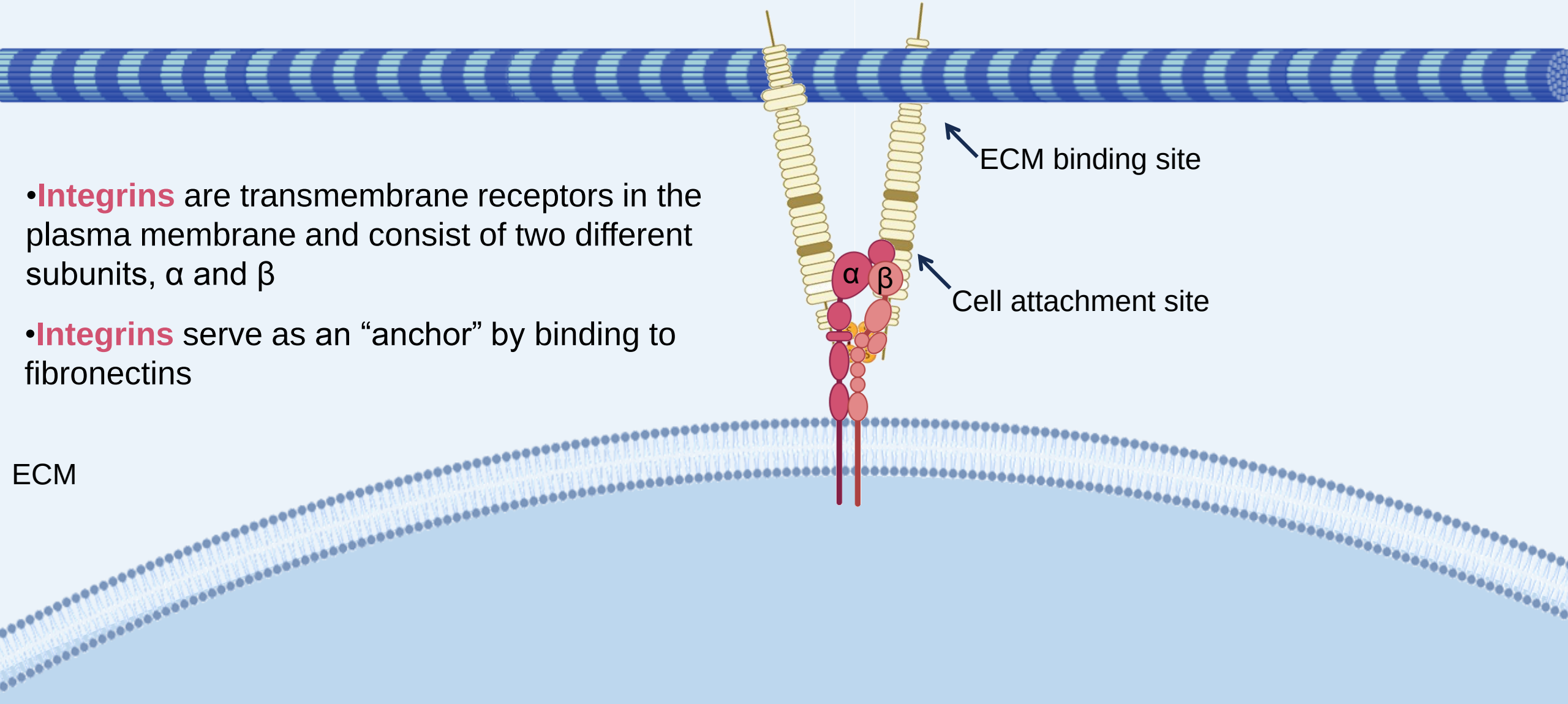
• **Fibronectins** contain an **ECM binding site** that facilitates binding to collagen (fibrils and fibers)



• Additional ECM proteins that **Fibronectins** bind to include proteoglycans, fibulins, integrins, thrombospondins…and many more!

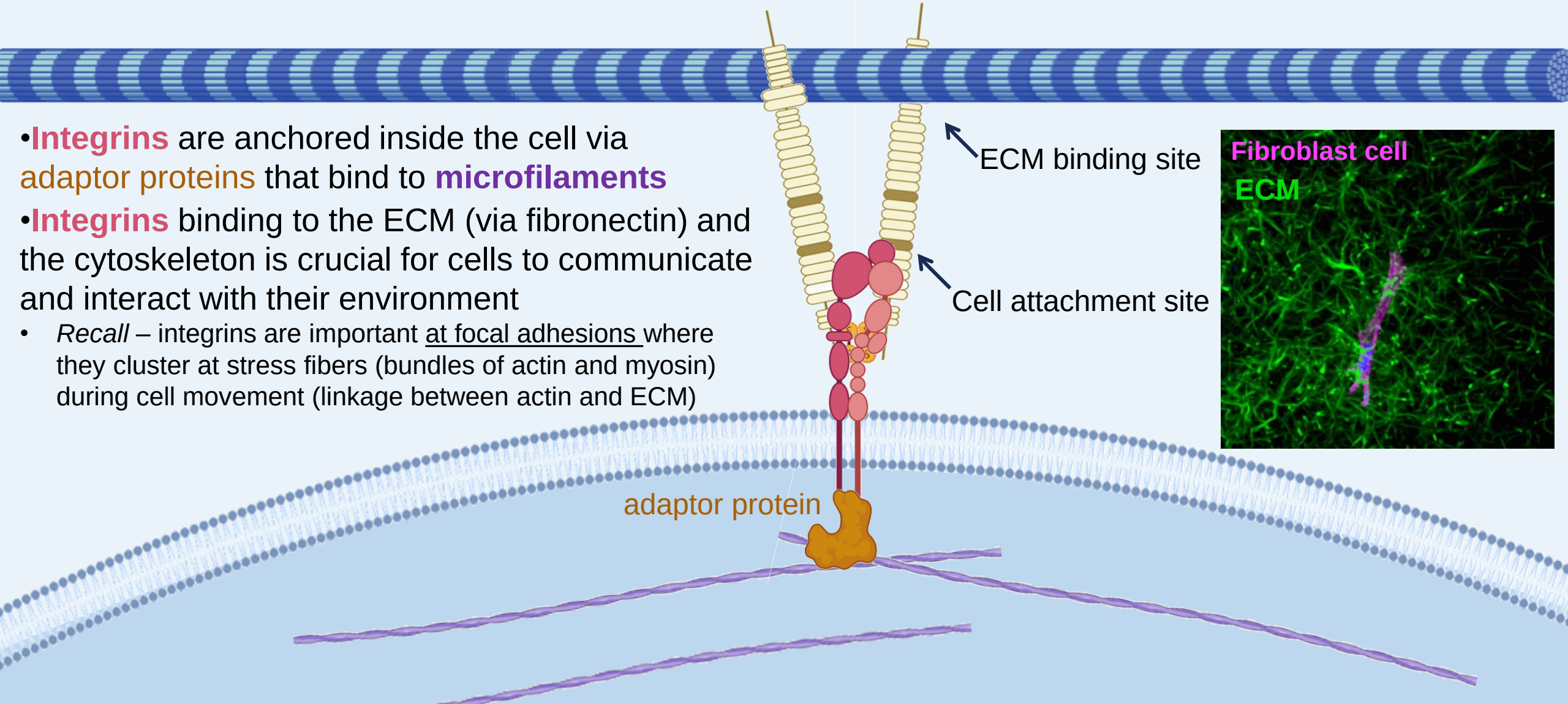
Integrins enable cellular attachment to the ECM

- **Integrins** are transmembrane receptors in the plasma membrane and consist of two different subunits, α and β
- **Integrins** serve as an “anchor” by binding to fibronectins



Integrins link the ECM to the cell's Cytoskeleton

- **Integrins** are anchored inside the cell via adaptor proteins that bind to **microfilaments**
- **Integrins** binding to the ECM (via fibronectin) and the cytoskeleton is crucial for cells to communicate and interact with their environment
  - *Recall* – integrins are important at focal adhesions where they cluster at stress fibers (bundles of actin and myosin) during cell movement (linkage between actin and ECM)

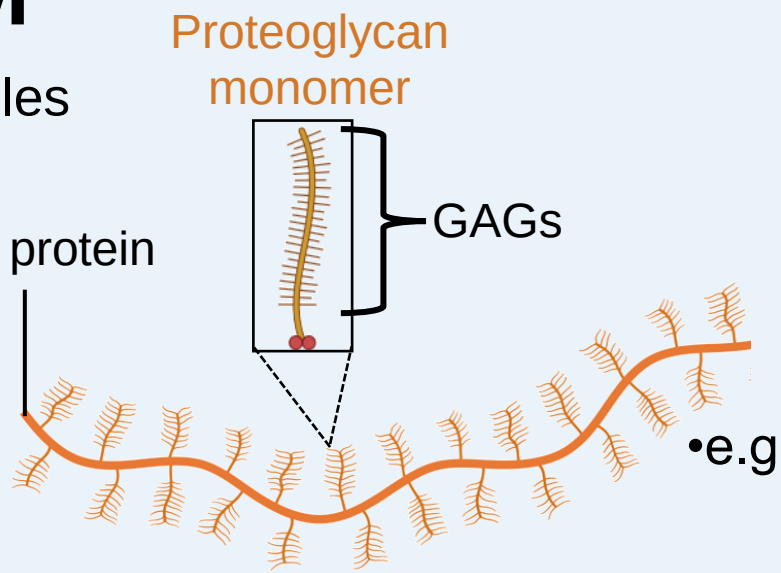


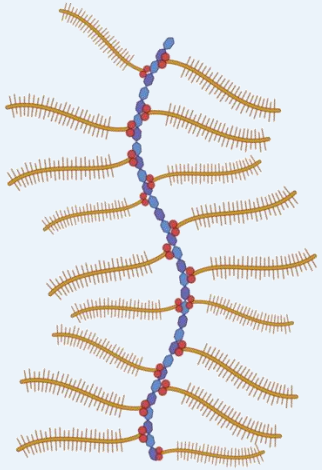
Proteoglycans form a gel-like substance in the ECM

•Proteoglycan = **core protein** + complex sugar molecules named **glycosaminoglycans (GAGs)**

•Proteoglycans form aggregates that can adopt extended conformations

• Provide a hydrated space around cells good for shock absorption (found in knees, joints)

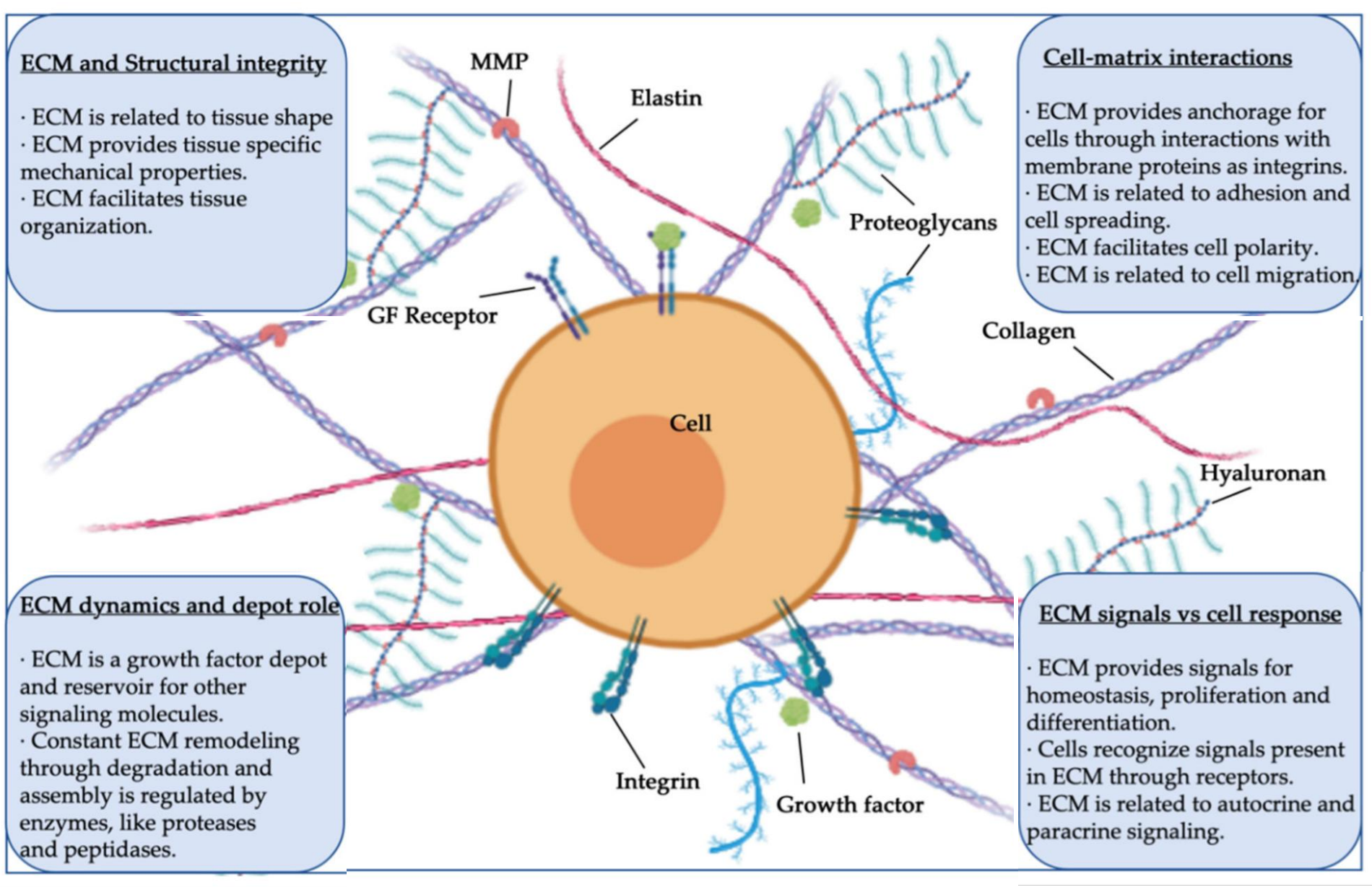




•e.g., **hyaluronic acid** is a **GAG**

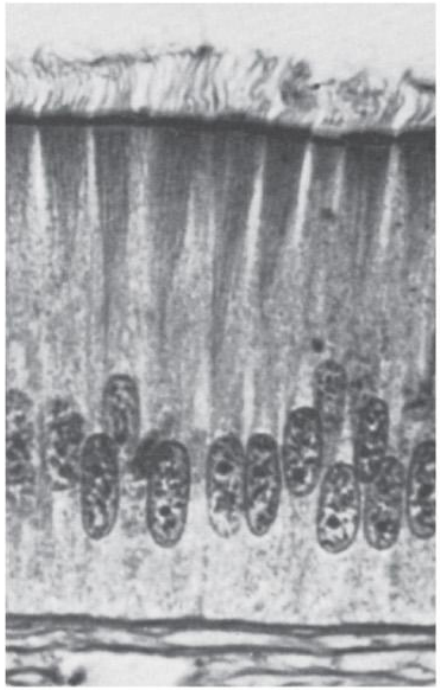
ECM

The extracellular matrix is dynamic

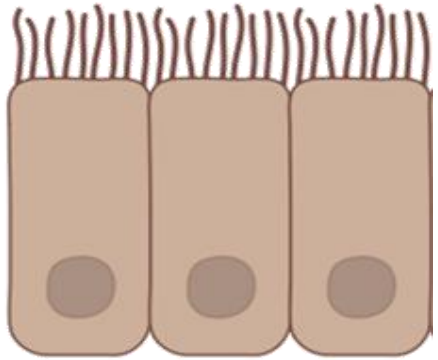


Epithelial cells pack together to form epithelial sheets in tissues

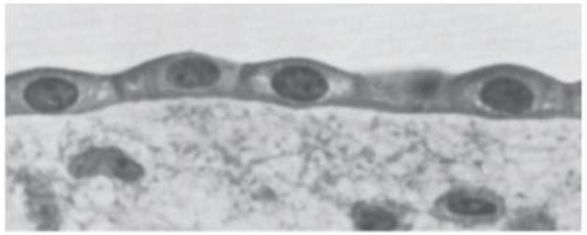
e.g., lungs



columnar

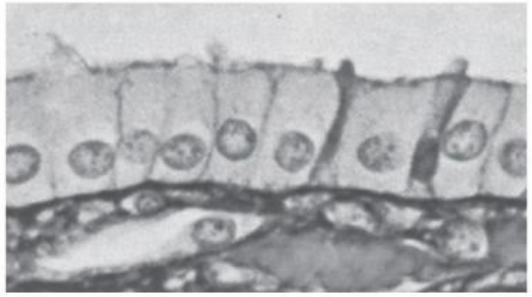


e.g., epidermis and nails

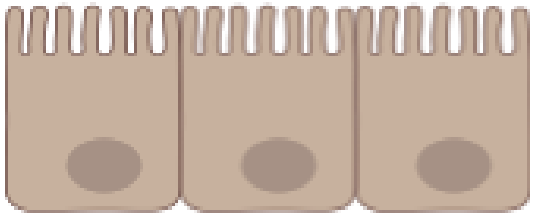


squamous

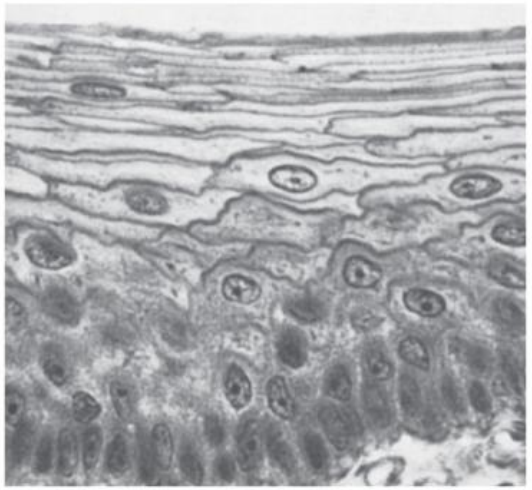
e.g., kidney tubules, eye



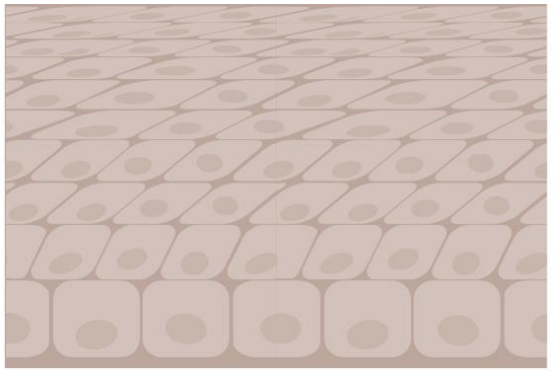
cuboidal



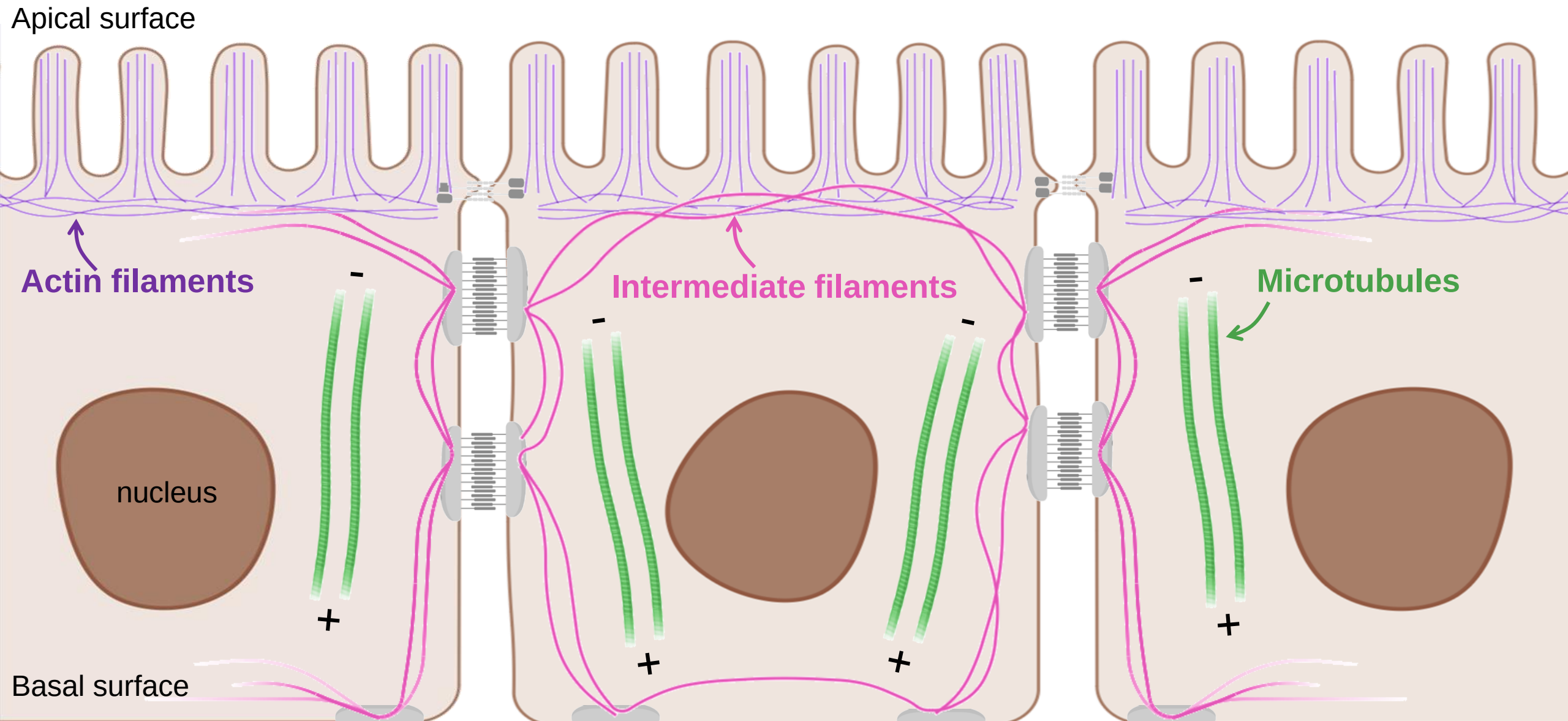
e.g., epidermis



stratified

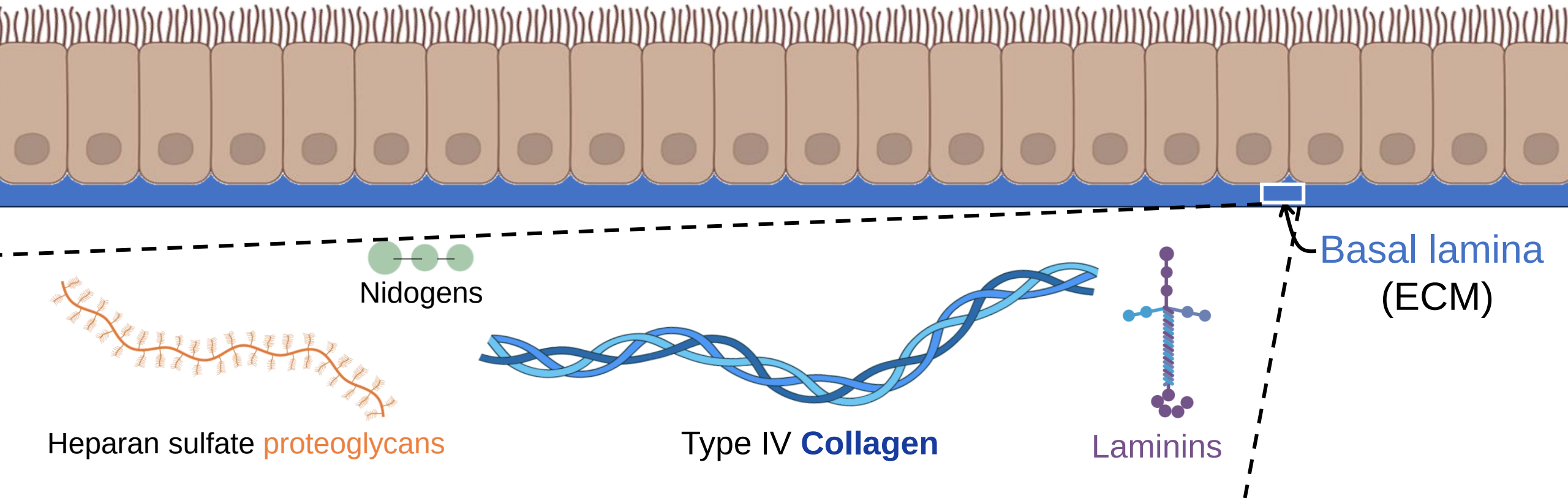


Epithelial cells are polarized primarily due to their cytoskeletal organization



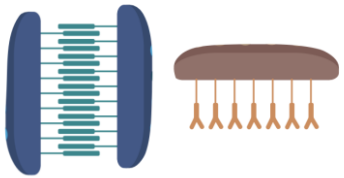
Epithelial sheets attach to the ECM via the basal lamina

- The basal lamina is a thin layer of ECM primarily made up of **type IV collagen**
- Laminins, nidogen proteins, and heparan sulfate proteoglycans are also located in the basal lamina

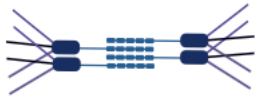


Epithelial cells are joined together by 4 types of junction proteins

Desmosomes

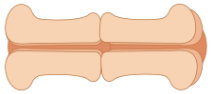


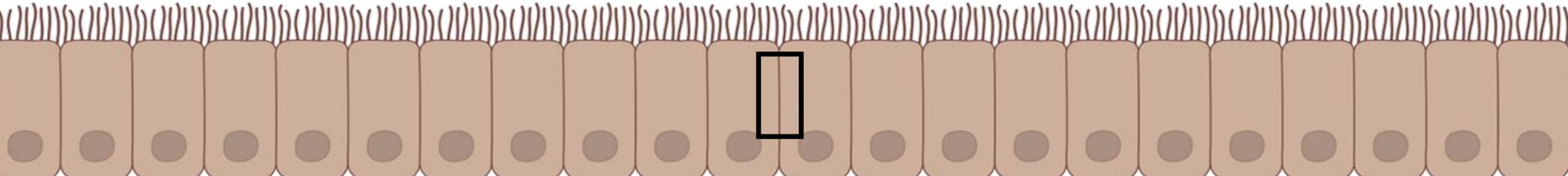
Adherens junctions



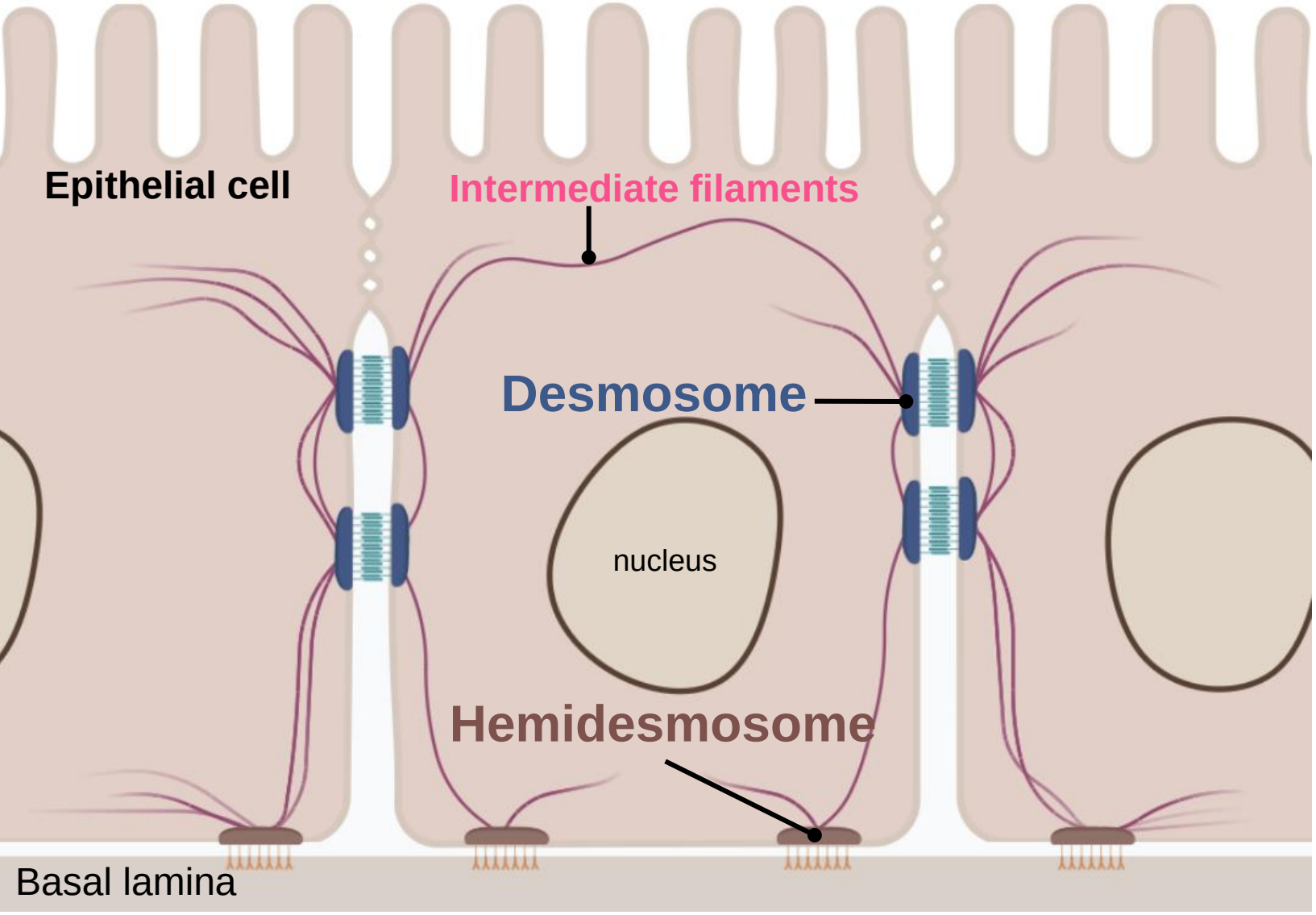
Tight junctions

Gap junctions



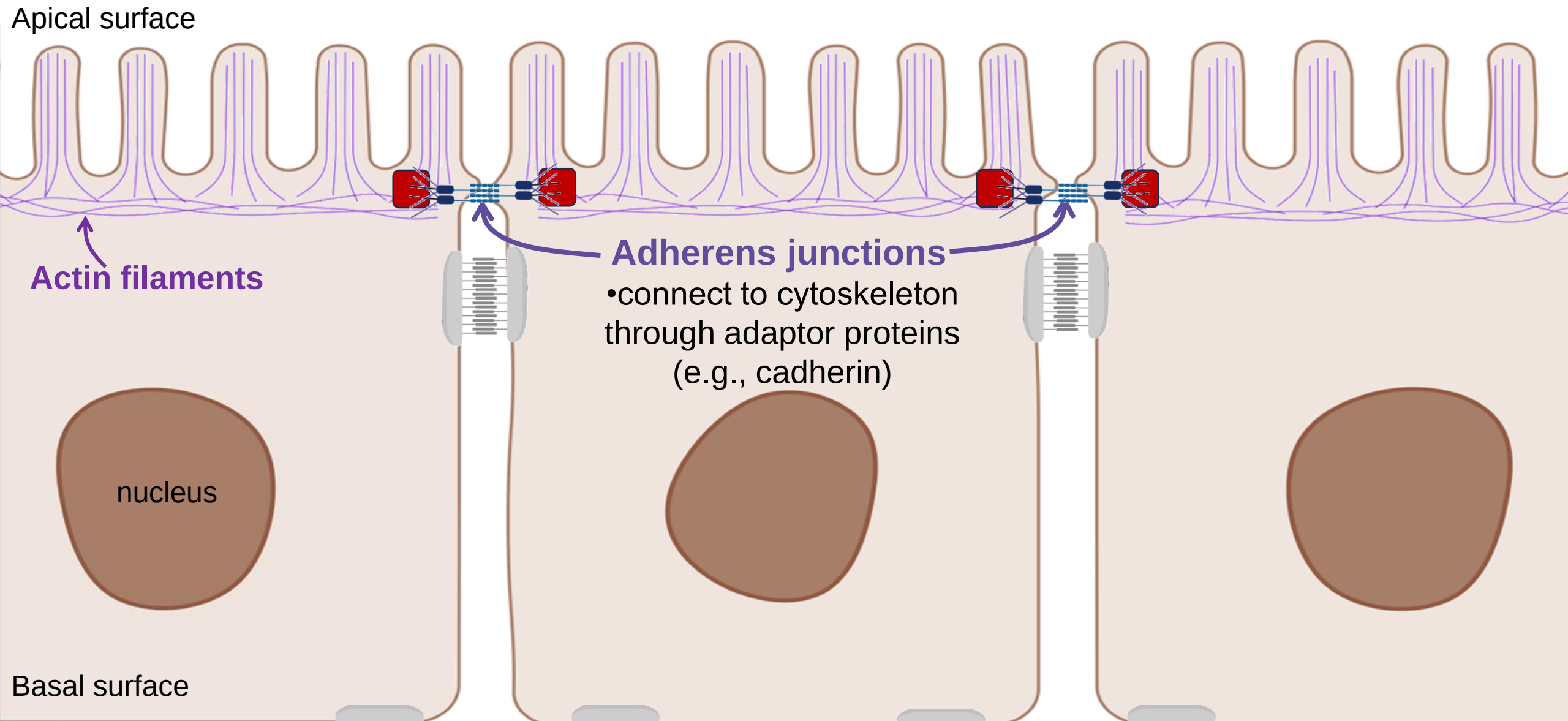


Recall: Intermediate filaments are anchored to the cell membrane by adhesive proteins called desmosomes

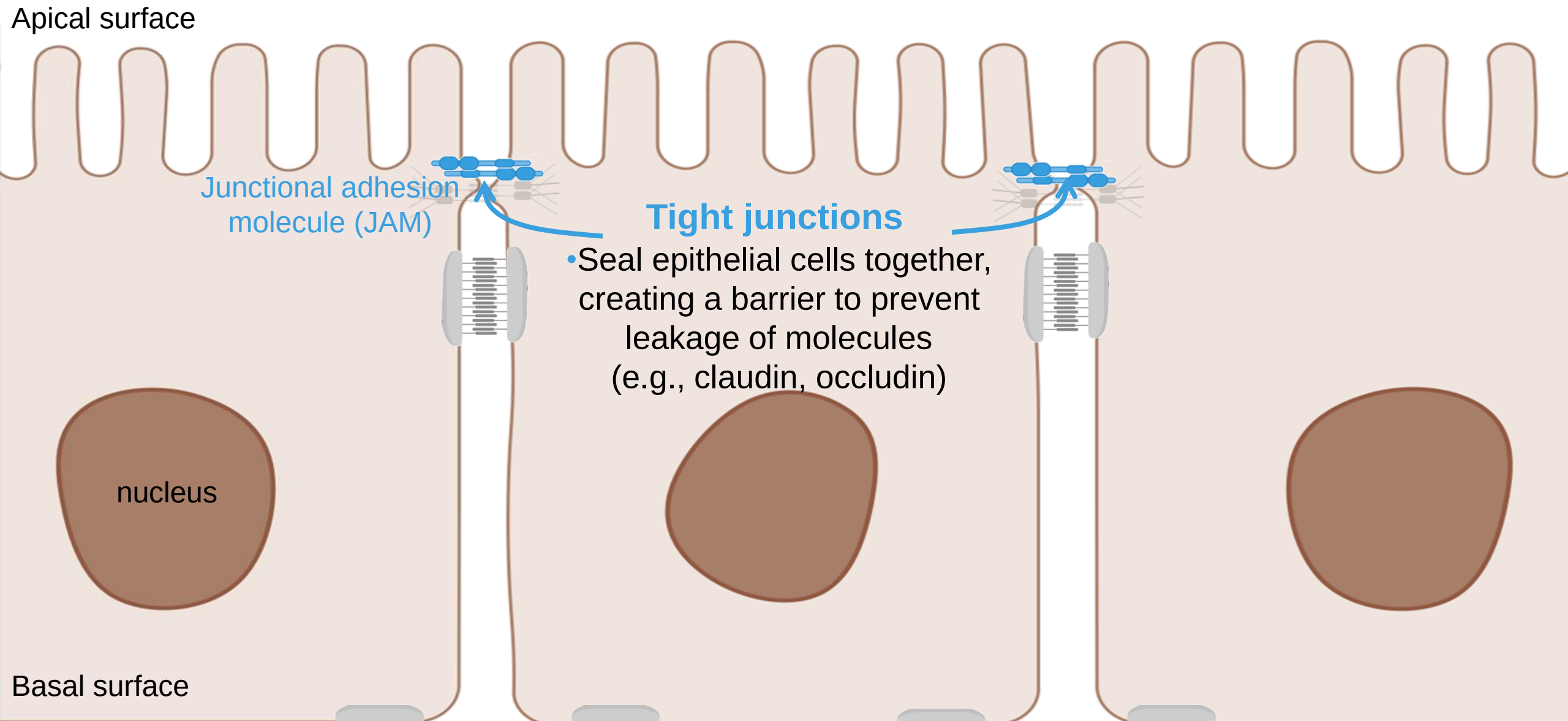


- **Desmosomes** attach to intermediate filaments to mediate **cell-cell adhesion**
- **Hemidesmosomes** attach to intermediate filaments and to the **basal surface of epithelial cells**
- **Desmosomes** and **hemidesmosomes** help cells resist mechanical forces

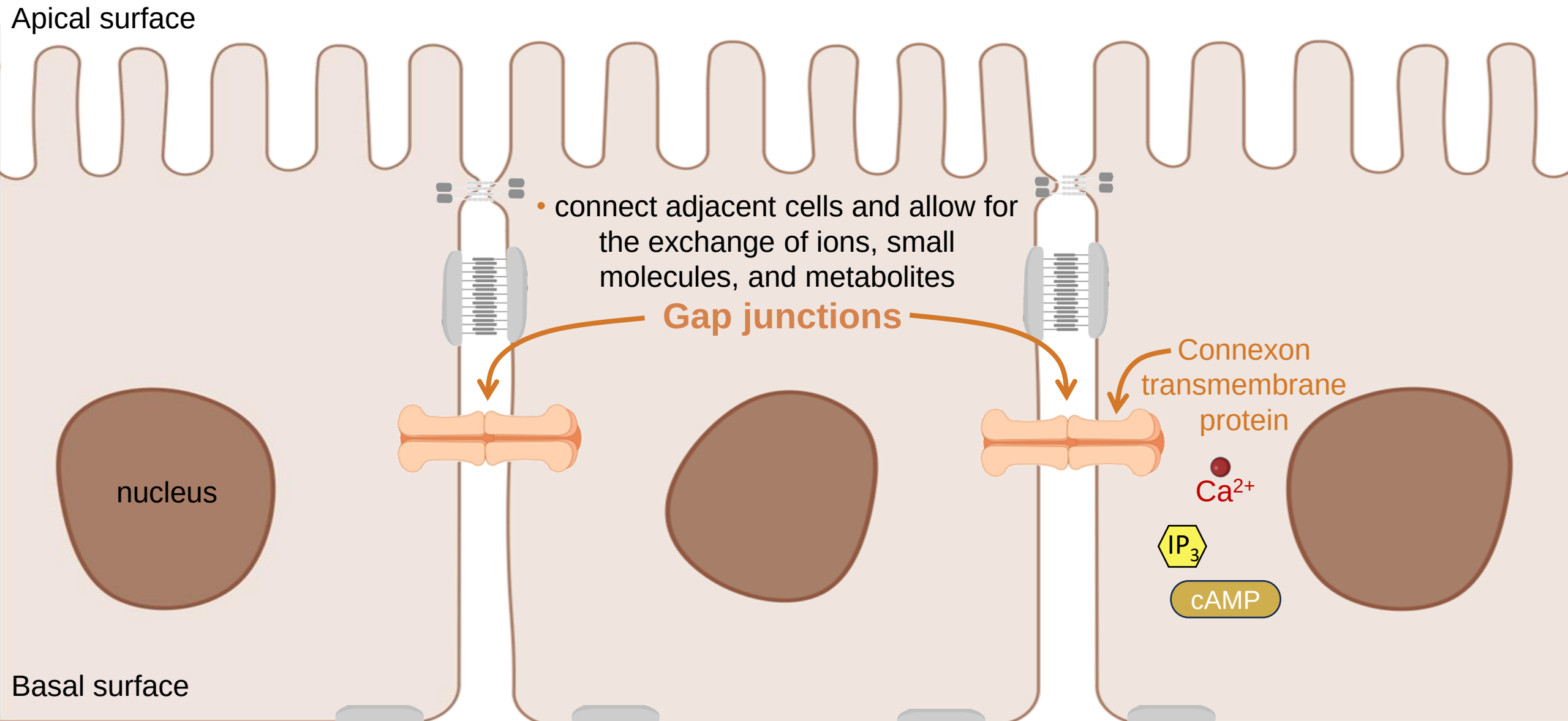
Adherens junctions connect cells via actin bundles as a form of cell-to-cell communication



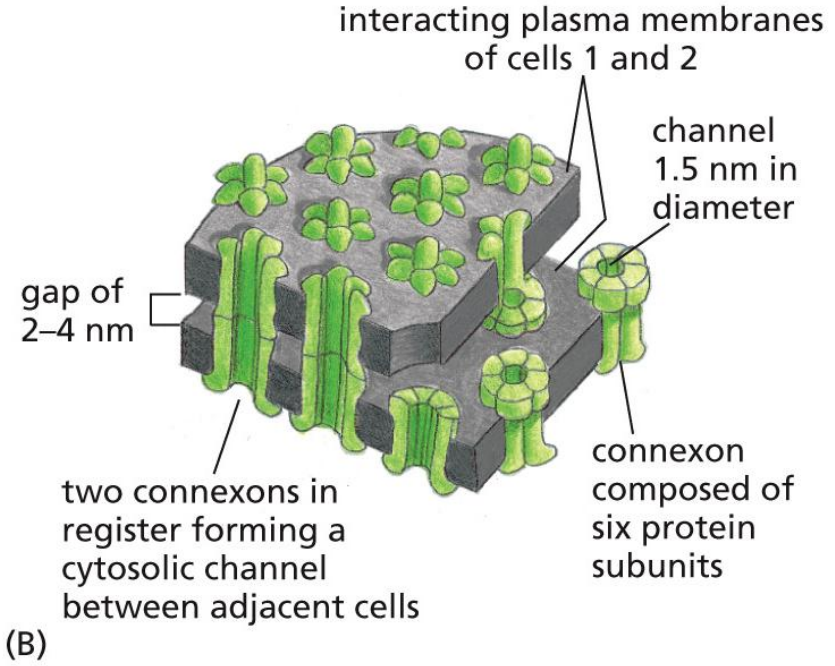
Tight junctions prevents the leakage of molecules between epithelial cells



Gap junctions
allow for direct communication between cells



Gap Junctions are also responsible for the propagation of electrical waves in the heart for coordinating the heartbeat



Metacognitive Reflection Form