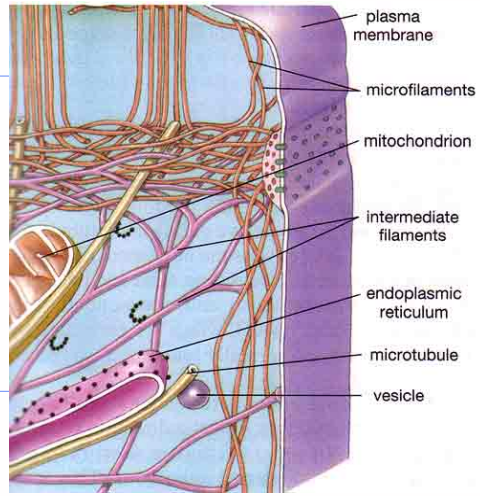
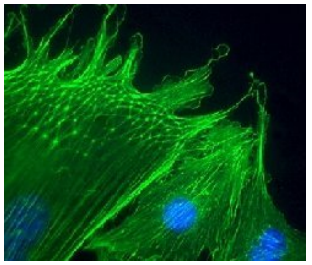
Chapter 6: Part III



Cytoskeleton - a network of fibers extending throughout the cytoplasm

- **Function**
  - **Structural support**
    - maintains shape of cell
      - Parts can be assembled and reassembled to change cell's shape
    - provides anchorage for organelles
  - **Cell motility**
    - Allows for movement of cells
    - Allows for movement of parts of cells such as organelles or cytoplasmic extensions like cilia or flagella
  - **Regulation of cell behavior**
    - organizes structures & biochemical activities of cell
    - Regulates and coordinates cell responses

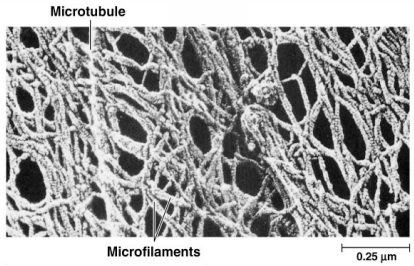


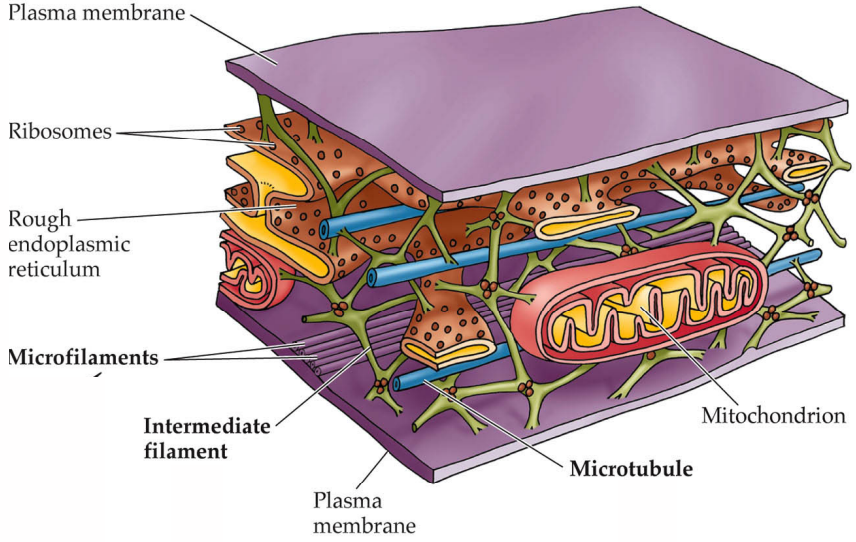
Cytoskeleton

- **Structure**
  - network of fibers extending throughout cytoplasm
    - 3 main protein fibers make up the cytoskeleton in Eukaryotic cells

1. microtubules
2. microfilaments
3. intermediate filaments

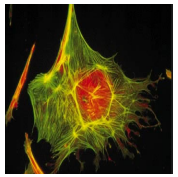
It's a matter of size…





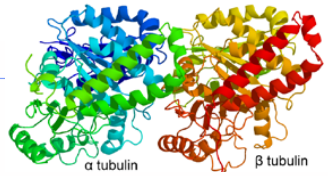
Evolutionary perspective

- Proteins that make up the fibers are very similar in all living things
  - from bacteria to humans
    - tubulin (found in all cells)
    - actin (found in all eukaryote cells - *only*)

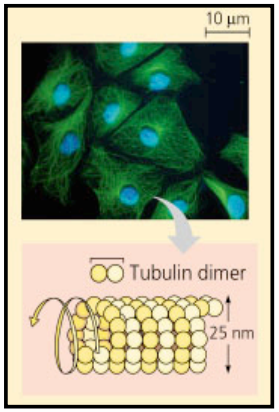


- When proteins are similar, the DNA of the genes for these proteins must be similar too.
  - This implies that these genes are both ancient and essential for life, playing a very important role.
    - Any mutations in the DNA that changed the protein's composition and shape too much may have caused these critical proteins not to work properly, and, therefore, that cell to not survive to reproduce and pass down variations of these genes to current organisms alive today.
      - *Genes for proteins who perform essential functions needed for life, therefore, are not tolerant to accumulating DNA mutations = these types of genes are said to be highly conserved*

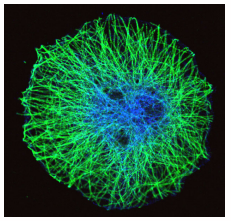
Microtubules



- Structure
  - thickest fibers
  - hollow rods about 25nm in diameter
  - constructed of globular protein, tubulin (a dimer of alpha & beta tubulin subunits)
    - *tubulin thus displays quaternary protein structure*
  - grow or shrink as more tubulin molecules are added or removed
    - *+ end can add and remove tubulin dimers at a fast rate*

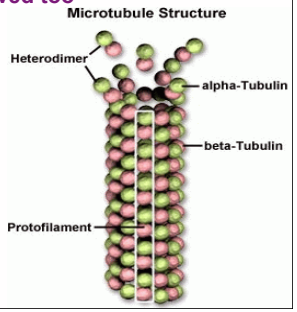


Microtubules



Function

- structural support & cell movement
  1. Maintenance of cell shape
     - Compression-resisting support structures
  2. Move chromosomes during cell division
     - Centrioles and centrosomes are involved too
  3. Serve as tracks that guide motor proteins carrying organelles to their destination
     - Use motor proteins myosin & dynein to move organelles along microtubules
  4. Allow for cell motility
     - Form the internal structure of cilia and flagella



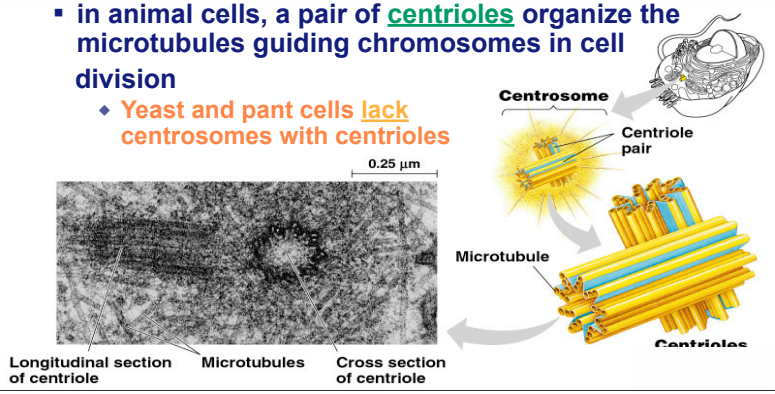
Centrioles & centrosomes

Microtubule-Organizing Centers

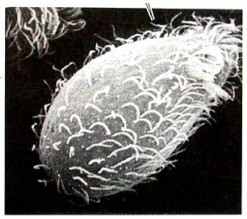
- The region from which microtubules grow, which are located near the nucleus is called the centrosomes

Cell Division

- in animal cells, a pair of centrioles organize the microtubules guiding chromosomes in cell division
  - Yeast and pant cells lack centrosomes with centrioles

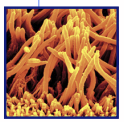


Cilia & flagella

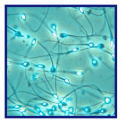


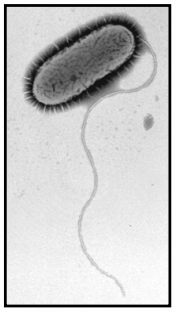
Microtubule-containing extensions of eukaryotic cytoskeleton

- Cilia = numerous & short ("hair"-like)
  - Move liquid past the surface of the cell
    - Ex: sweep mucus & debris out of the trachea [windpipe] of lungs
  - Can act as a signal-receiving antenna



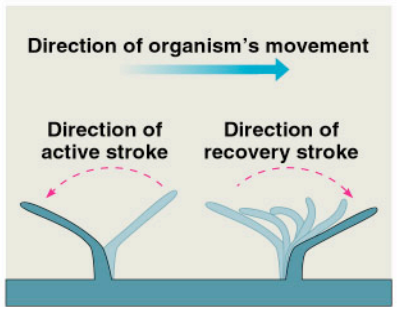
- Flagella = same width as cilia, 1-2 per cell & longer (whip-like)
  - Move unicellular & small multicellular organisms by rotating
    - Ex: flagellum of sperm cells

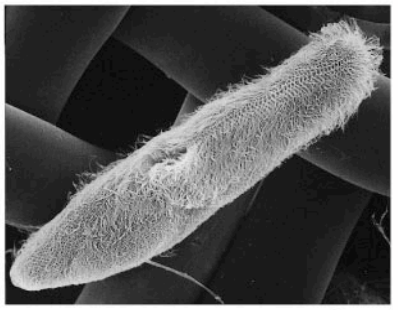




Cilia [in eukaryotes]

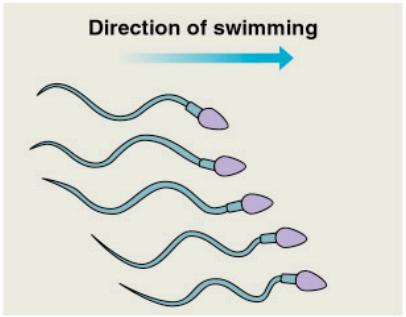
- Oar-like movement
  - alternating power & recovery strokes
    - generate force perpendicular to cilia's axis





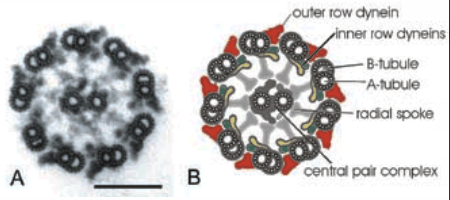
Flagella [in eukaryotes]

- Undulatory, snake-like movement in eukaryotes
  - force generated parallel to flagellum's axis

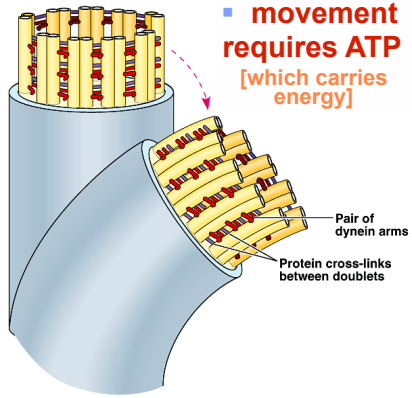


Cilia & Flagella

- Structure
  - remember 9+2 structure!
    - 9 pairs of microtubules around 2 single microtubules in center
  - bending of cilia & flagella is driven by the motor protein:
    - Dynein

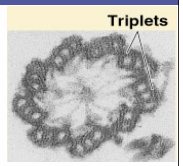


- movement requires ATP [which carries energy]

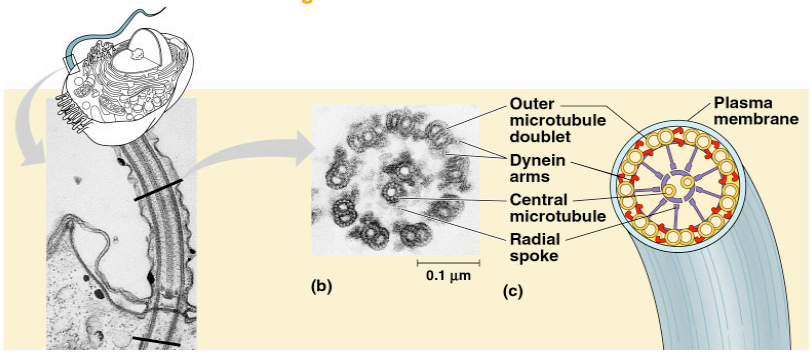


- Note: though prokaryotes have flagella too, they probably evolved separately & are not related as the prokaryotic flagella moves by rotation, not undulation, and is not made up of a 9+2 microtubule structures under the plasma membrane, but instead is a hollow cylinder made of a protein called flagellin

Cilia & Flagella

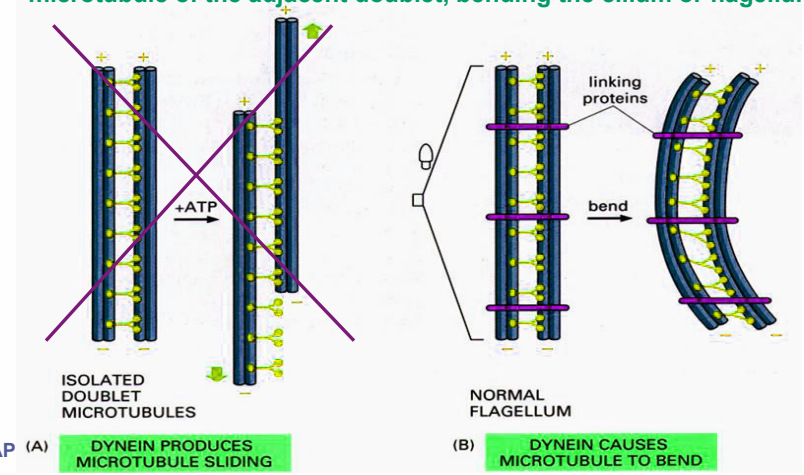


- The doublets and the central 2 tubules are held together by flexible cross-linking proteins
- Microtubules are anchored in the cell through a Basal Body (which has a similar structure to centrioles: 9 triplets of microtubules)
  - Microtubule doublets have attached motor proteins along their length that reach toward neighbor doublets



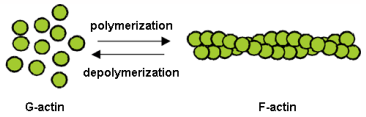
Cilia & Flagella Movement

With ATP providing energy, motor proteins walk along the microtubule of the adjacent doublet, bending the cilium or flagellum.

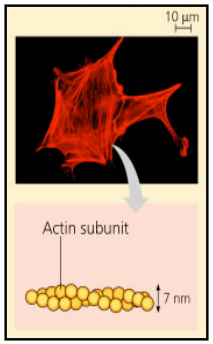


Microfilaments (actin filaments)

- **Structure**
  - thinnest class of fibers
  - solid rods of globular protein
  - twisted double chain of actin subunits
  - about 7nm in diameter

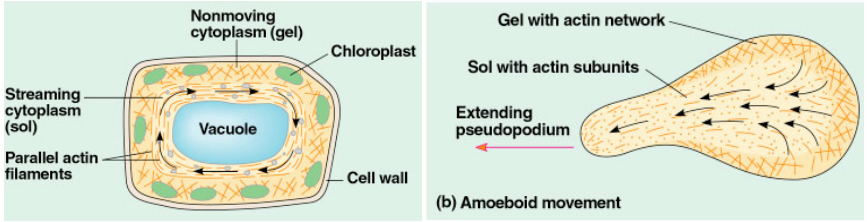


- **Function**
  - Maintain cell shape
    - Tension-bearing filaments
    - Form a 3-D network inside cells
  - Help cell change shape
  - Allow for cytoplasmic streaming
  - Allow for cell motility through pseudopodia
  - Play role in cell division *(making the cleavage furrow - more on this in ch.12)*
  - In muscle cells, actin filaments interact with myosin filaments to create muscle contraction



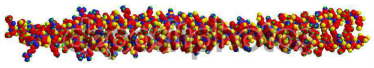
Microfilaments (actin filaments)

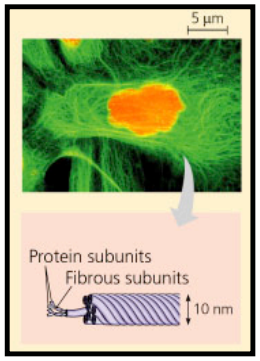
- **Involved in Dynamic (non-static) Cellular Process**
  - Actin filaments constantly form & dissolve making the cytoplasm more liquid or thick allowing cell movement
    - Ex: movement of *Amoeba using a pseudopodium.*
      - *Thick gel with microfilaments form on one end of the cell, pushing cell cytoplasm forward into plasma membrane extension called a pseudopodium.*
  - Myosin motors attached to organelles move along parallel actin filaments causing a phenomenon known as cytoplasmic streaming *(movement of certain organelles and cytoplasm around microfilament highways)* in plant cell cytoplasms.
    - speeds distribution of materials throughout cytoplasm



Intermediate filaments

- **Structure**
  - specialized for bearing tension
  - built from keratin family of proteins
    - same protein as hair
  - intermediate in size 8-12nm
- **Function**
  - Form the nuclear lamina *[underneath the interior of the nuclear envelope]* which provides shape and structure to the nucleus
  - Hold "cell structures" in place inside cell
  - More permanent fixtures of cytoskeleton
  - Reinforce cell shape & fix organelle location
    - Ex: nucleus is held in place by a network of intermediate filaments

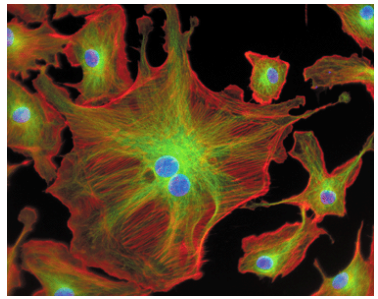


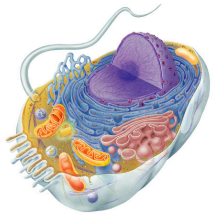


Summary

- **Microtubules**
  - thickest
  - cell structure & cell motility
  - tubulin
- **Microfilaments**
  - thinnest
  - internal movements within cell
  - actin, myosin
- **Intermediate filaments**
  - intermediate
  - more permanent fixtures
  - keratin

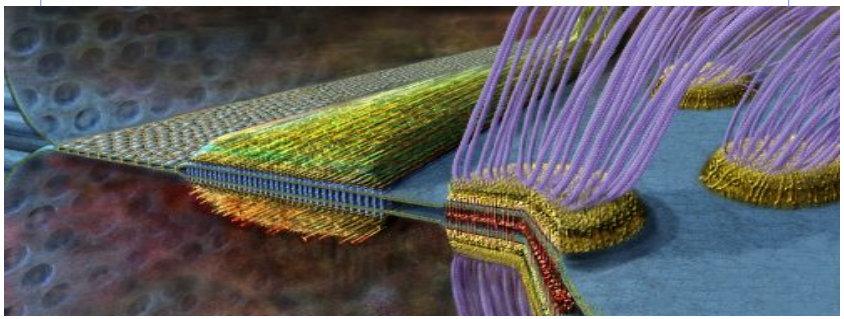
- actin
- microtubule
- nuclei





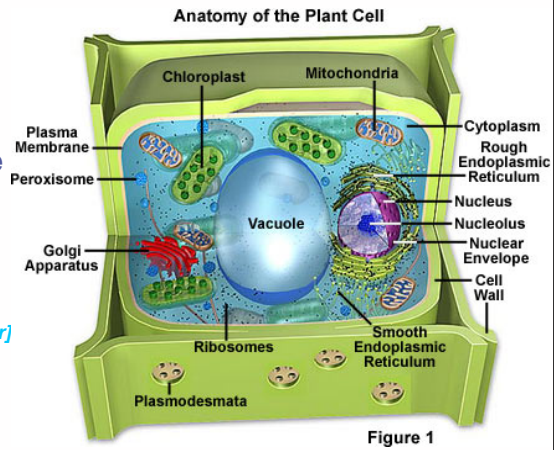
Cell Junctions

Where cells touch each other…

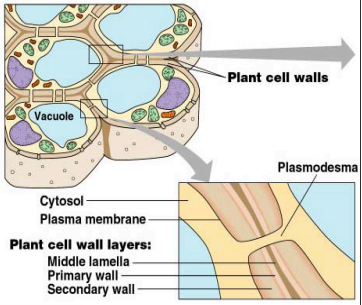


Plant cell wall

- **Function**
  - Protect plant cell
  - Maintain shape of cell
  - Prevent excessive uptake of water
  - Hold plant up against forces of gravity *[allows cells to stack on top of one another]*
    - Composed of cellulose and proteins

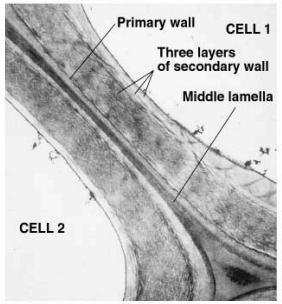


Plant cell wall Structure

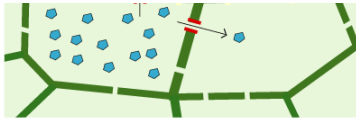


Composed largely of Cellulose, polysaccharides & proteins

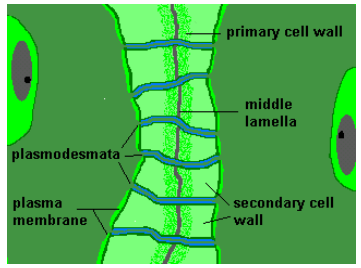
- primary cell wall
  - thin and flexible - *allows the cell expand and grow*
  - Secreted first by young plant cells
- secondary cell wall
  - Secreted in only some mature cells that stop growing further
  - This is another wall between plasma membrane and the primary wall - *creates an overall very thick area of cellulose outside the cell membrane for added structural support.*
- middle lamella = made of sticky polysaccharides (PECTINS)
  - "Glues" adjacent cells together



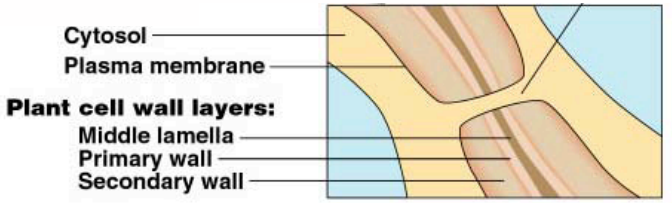
Intercellular junctions



- Plant cells
  - plasmodesmata
    - Cytoplasmic channels allowing cytosol with small dissolved solutes to pass between cells



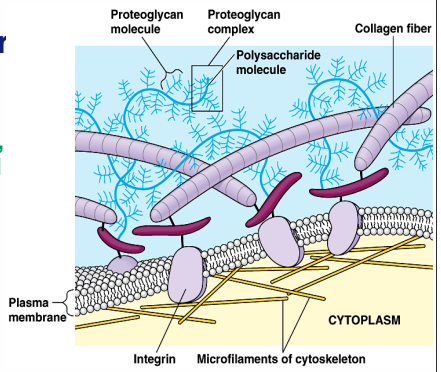
plasmodesmata



Animal cell surface - lack cell walls

They do have an Extracellular matrix (ECM)

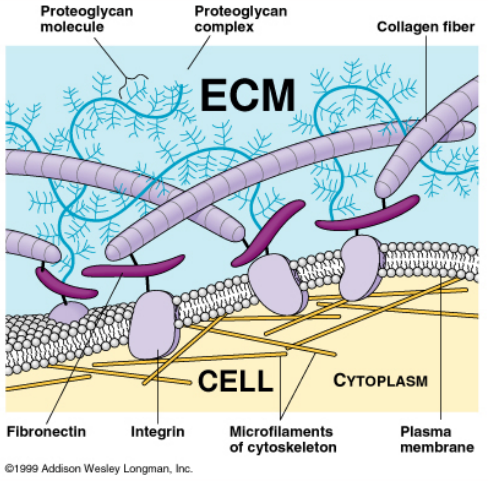
- network of glycoproteins, proteins, and carbohydrates sticking toward the outer side of the plasma membrane and secreted to the exterior of the cell that function in:
  - structural support of cell/tissue
  - cell adhesion of cells
  - cell movement & identification
  - regulation of cellular activities



- Most abundant fibrous protein in ECM: Collagen
  - Strong fibers secreted from certain cells to hold tissue together
- Collagen embedded in network of Proteoglycans
  - Small core protein with many carbohydrates chains covalently attached (95% carb-based)
  - Proteoglycan complexes: involve proteoglycans non-covalently attached to a large central carbohydrate *(see picture)*

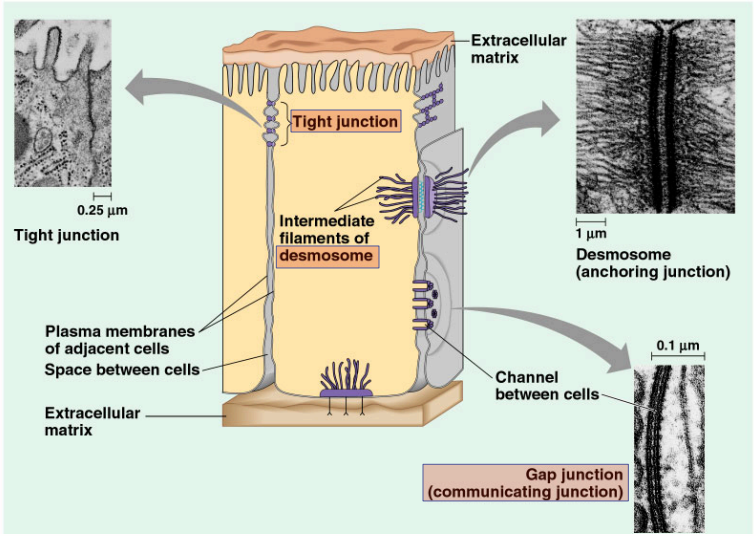
Parts of ECM

- Fibronectin
  - Glycoprotein
  - Bind to cell surface receptor proteins: INTEGRINS
- Integrins
  - Bind to proteins attached to microfilaments of the cytoskeleton.



- Fibronectin & Integrins cooperate to transmit info and signals between exterior of the cell & its interior
- ECM thus influences cell & gene activity

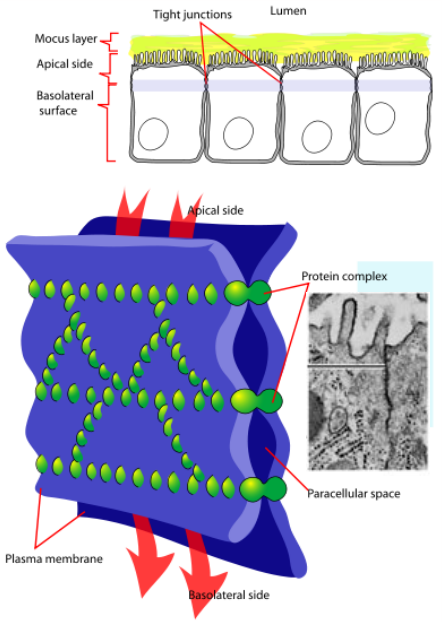
Intercellular junctions in animals



AP

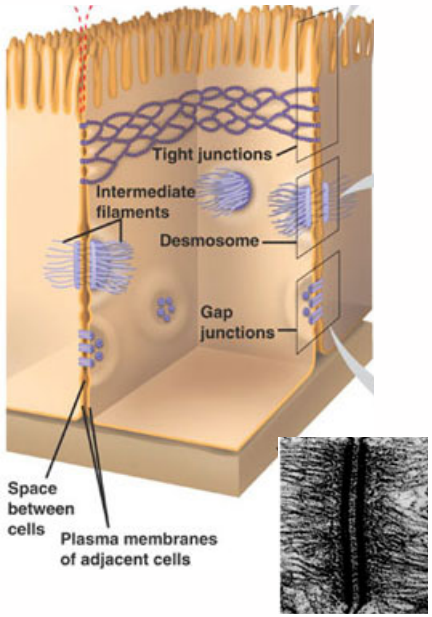
Tight junctions

- Tight junction proteins function to hold membranes of adjacent cells tightly bound together
  - Forms barrier between cells (seal)
- Important in preventing leakage of extra-cellular fluids across a layer of epithelial cells such as your skin by stopping the liquid from being able to flow in between two cells
  - In the digestive tract, digesting food (and all particles / pathogens / toxins) cannot leak into the abdominal cavity, but is forced to enter by crossing the membrane of cells that line the intestine so the body only absorbs what it wants to ideally.



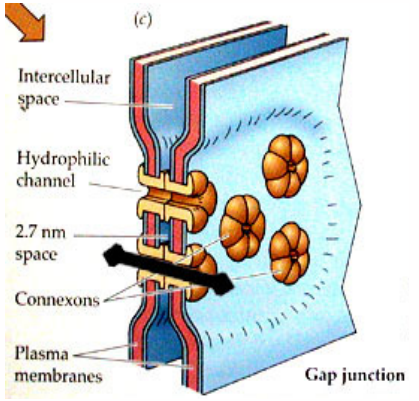
Desmosomes

- Anchoring Junctions
  - fasten two cells together in strong sheets
- Intermediate filaments made of keratin anchor the desmosome in the cytoplasms of two cells
  - Ex: desmosomes hold muscle cells together so when one cell contracts and changes shape it pulls neighboring cells (who themselves are contracting) with it so the muscle contracts as a whole unit instead of all cells contract independently and letting go of one another.

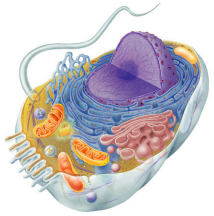


Gap Junctions

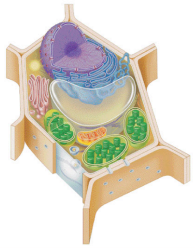
- Communicating junctions
- Proteins of gap junctions form connected pores between two cells, making cytoplasmic channels
  - Allow cytoplasmic movement between adjacent cells
    - Similar to plasmodesmata
- Allows passage of hydrophilic ions, sugars, amino acids, and small molecules
  - Allows for communication between cells like in heart, muscle and embryos



AP Biology



A cell is a living unit greater than the sum of its parts



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